Mircea Brăban - coordinator

SEED - SCIENCE BY EXPERIMENTS THROUGH EUROPEAN DIALOG

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SCIENCE BY EXPERIMENTS THROUGH EUROPEAN DIALOG

ȘIMLEU SILVANIEI

Mircea Brăban – coordinator

SEED Science By Experiments Through European Dialog

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ȘIMLEU SILVANIEI

Dear reader!

You have in your hands a book which is the result of a three years partnership between seven European schools, partnership implemented within the Lifelong Learning Programme, Comenius actions, in 2006-2009 and declared ***STAR PROJECT*** by the European Commission for its high-quality outputs. The school development project I am writing about is named "***Science By Experiments Through European Dialog***", acronym SEED, and has been accomplished with a collection of end products of which one is this experimental book. Turning over its pages you will discover the work done during three years by seven teams of teachers, from six European countries: Austria, France, Greece, Italy, The Netherlands, Romania (one of the two schools involved being the coordinating school), in order to promote experimental activities in the classroom for the following subjects: Biology, Chemistry and Physics.

Moreover, you will discover how groups of teachers form seven different schools joint forces to finish a great partnership, how the group was welded during the three years of project, how international collaboration lead to a synergy capable to provide valuable end products, allowing in the same time the teachers to "learn by doing" and to get enriched due a great exchange of good practices. You will see different teaching approaches for the mentioned subjects, you will discover differences in treating the same subject, all these giving the sense of diversity but in the mean while you will discover unity and consensus in which some themes might be approached by teachers of the same subject.

Although Biology, Chemistry and Physics are taught in all the involved schools there are differences in teaching these subjects. Collaboration between professionals from the same subject lead to a list of experimental activities which are done in the classroom (or which can be done), for each subject, in order to better demonstrate the presented concepts, scientific laws or processes taught in the Science lessons. This extended list is a first glance in the curriculum of each participating school being in the same time a working tool for the teachers who can extend their experimental work with the ones they don't use to do in the class but which might be useful according to other teachers. This list is only the first step in the work accomplished in the project. From the list created for each subject, teachers have selected some experiments which were described on special experimental sheets, on a common layout, agreed during the project's implementation. These experimental pages give a real insight on the work done in the classroom for each participating school. Different approaches are joined together in a collection of 134 Biology, Chemistry and Physics experiments chosen, presented, developed and described together within the partnership which lead finally to this book which intends to be a book for any secondary European school where Sciences are taught, a book created as a curricular auxiliary, a supporting instrument for a European Science teacher willing to add a better insight for the subject he is teaching.

The seven partners involved and their teams working on the project's end products were:

1. Romania, Șimleu Silvaniei; Colegiul Național "Simion Bărnuțiu" (coordinating school)
Mircea BRĂBAN - Chemistry
Florin BUTUȘINĂ -Physics
Daniela BUTUȘINĂ -Physics
Ildikó GÁSPÁR - Biology

2. Austria; HTL Dornbirn
Herbert HUG – head of informatics department
Michael GRUNWALD – head of chemistry department
Cornelia LEDERLE – Physics
Roland ZARWASCH – Physics
Kurt GRÜNBERGER – Chemistry

3. France; Saint Quai Portrieux, Bretagne; Lycée Professionnel Hôtelier "La Closerie"
Jean-Yves LeClech - Chemistry
Yvon Larhantec
Phillippe LE GUENNEC
Maria-Francoise CARIOU - English

4. Greece; Thessaloniki; Vassiliadis Private Gymnasium Thessaloniki
Klitos CHATZIGEORGIOU – Headmaster
Apostolos VALSAMIDIS – Physics
Kostas ROMANIDIS – Mathematics
Gregory MOUTSIOS – Informatics

5. Italy, Palermo, Sicily; Liceo Psico Pedagogico e Linguistico „Danilo Dolci“
Maria Orsolina MENDOLA – Headmaster
Eugenio MARGAGLIOTA – Biology, Chemistry
Maria Concetta CORRENTI - English
Gabriella GIUNTA – English
Vincenzo TERESI – Physics
Paolo IGNACCOLO – Physics

6. The Netherlands; Cappele aan den IJssel; Christelijke Scholengemeenschap Comenius College
Niek BOGAARD - School coordinator
Jan DE SCHIPPER - Physics
Tijs VAN'T VERLAAT - Chemistry
Daan VAN DER HAAR - Biology

7. Romania, Șimleu Silvaniei; Colegiul Tehnic "Iuliu Maniu"
Alina Sanda BRĂBAN - Chemistry
Olimpia POP - Physics
Liliana PAȘCA - Biology

The partnership **main aims and expected impact**, focused on different target groups were:

Aims and impact concerning students:
- Better knowledge of sciences and of the way an experiment is conducted and interpreted through the created material during the years.
- ICT skills development by creating models of experimental sheets (html or other web supported presentations sheets), information sessions on internet and by working on the final products (CDROM and webpage conception, elaboration and assembly).
- Enrichment in the domain of foreign languages (English) by working out the experimental sheets.
- Development of the aesthetic sense in presentations elaboration in order to make a quality material for the envisaged book (one of the end products).

Aims and impact concerning teachers:
- Better knowledge of the European sciences curriculum by comparing it during the meetings and working together with colleagues from foreign countries on the joint material.
- Wider applicability of the experimental methods in the school at the natural sciences lessons by including experiments from other schools.
- Improvement of English as communication and information tool by using email communication and research on Internet for new applicable experimental methods.
- ICT skills development by communicating via internet, creating webpage and html files, research on Internet

Aims and impact concerning the school:
- Elaboration of a new teaching tool which can be developed and used in the future.
- Ensuring a new European dimension of the school's activities.
- A better place for the school in the educational market through international partnerships.

In order to achieve the stated aims and expected impact the following **activities** are envisaged:

- Joint cooperation activities during the project meetings organized during the three years of the project in order to manage the project, monitoring the project and evaluate the intermediary and final results.
- Creating three joint lists with experimental activities which are realized/can be realized in the partner school for the following subjects: Biology, Chemistry and Physics. These lists give an insight of the European curriculum for the Science subjects pointing out similarities and differences concerning the way Biology, Chemistry and Physics are taught in different countries.
- Choosing from the experimental lists a number of experiments to be described, for each subject, as presentations on a specially created layout, presentations which will be reunited in a booklet at the end of the project.
- Designing the web page of the project in which the partnership will be described, the steps done in order to accomplish the final products will be presented and the final experimental sheets will be available for the public.

- Creating a software capable to manage all the created experimental sheets when the user if off-line, as an additional result done in order to increase the usage of the envisaged end products.
- Dissemination activities which will ensure the penetration of the project's results in other school and for other stakeholders.

The presented activities already sketch the structure of the envisaged **end-products created during the partnership**:

- Experimental book in English as a new teaching tool containing all the experimental sheets elaborated by all the partners (with the help of the students) during the three years of project (common, specific and new but applicable experiments in the science lessons)
- the SEED CDROM containing information about all the partners, all the experimental sheets in all languages, photos about the meetings and working sessions during the three years of the project, assembled by the Greek partner Vassiliadis Private Gymnasium Thessaloniki, as a simple dissemination tool, ready to be printed and used by other interested institutions that will be the dissemination target.
- the official webpage of the project as a dissemination tool for a wider public; containing information about all the partner schools, the aims of the project, the activities carried on, the teachers and students involved and, most important, the created experimental sheets. The page was initially hosted by HTL Dornbirn at http://seed.htldornbirn.vol.at and later moved on the web site of the coordinating school: Colegiul Național "Simion Bărnuțiu" Simleu http://www.colegiu-simleu.ro.

Six project meetings were organized during the project in order to ensure proper and direct collaboration between the professionals all working to accomplish the assumed end products.

The first project meeting was organized in **Șimleu Silvaniei, Romania** at the coordinating school, the school who first came with the idea of the project and at its partner. During the period **11th-15th November 2006** five delegations from the partner schools were received by a joint team composed by the members of both Romanian schools involved in the project: **Colegiul Național "Simion Bărnuțiu" and Colegiul Tehnic "Iuliu Maniu"** giving the involved teams the opportunity to meet for the first time and to start a partnership which will last three years. Also a representative from a non granted partner from **Gymnazium Zilina, Chech Republic**, was present trying to keep close, even if they were not funded, and to join in the second year the

partnership. All the details concerning the future collaboration, the activities, the next meetings, the role of each partner were jointly agreed during the meeting. Cultural visits organized in the free time in Șimleu Silvaniei and Cluj Napoca, meeting with the mayor of the host city were adding more colour to the very busy schedule.

The second project meeting organized at **Lycée Professionnel Hôtelier "La Closerie"** in **France, Saint Quai Portrieux (Bretagne) in 24th-29th April 2007** was in the same time intermediary evaluation session for the work done so far, while the teams were assuming other tasks for the coming year. The leit motif of the meeting is brainstorming … many questions are raised by the teams, answers are expected and proposed by different team members. The work on the end products started for the Chemistry and Biology experimental sheets. During the working sessions multi-national teams are formed spontaneously according to their subject taught and their needs to share experience. The cultural visits organized in the free time are giving the guests a sense of what Briton

means, how they cope with the nature and the daily life.

In the second year it was the turn of **HTL Dornbirn**, **Austria** to host the third project meeting in **13th-18th November 2007**. All the partners gathered around the table to discuss their work done in the first year, to assess their experimental files created so far, to hear the partners' opinion about the work done so far and to plan the next steps in the project. It's the meeting where the web page of the project was born, where relevant materials are gathered as information presented therein and the structure was jointly agreed and further developed. The feeling of belonging to a really great group, already started in the first meetings, is more and more strong giving evidence to a high quality partnership, to a committed group of professionals who know what to do, who understand the need which is behind the project and who show willingness to do their work at very high standards. Apart of the proud having later the project declared STAR PROJECT by the European Commission it was a great feeling to see how the group has welded, how people were committed to quality outputs and how strong relationships were build over the years between the team members. More than working on the project you could feel a strong social approach creating bonds which were to last.

The project went further on with the fourth meeting at the Italian's partner school: **Liceo Psico Pedagogico e Linguistico "Danilo Dolci", in Palermo, Italy (5th-11th April 2008)**. Presentations of different experimental activities in Physics and Chemistry were alternating with work done in the project to further assess the experimental sheets for all three subjects: Biology, Chemistry and Physics. similarities and differences are observed by the participants both in school and in the life of Sicilians further enriching each participant.

The third year of the project gave the opportunity for the fifth project meeting at -3,0 m bellow the sea level, in the region of Rotterdam. Being hosted by **Christelijke Scholengemeenschap Comenius College in Cappele aan den IJssel, The Netherlands, in 11th-16th November 2008**, the reunited teams have done the final evaluation of all the created experimental sheets, were finishing the discussions and information gathering process for the website, hosted by HTL Dornbirn, and started discussions about the design, structure and content of the SEED software as additional pedagogical tool. Social and cultural activities were alternating with working sessions giving the participants an insight of the Dutch life, economy, politics and way of living.

Finally, it was the Greek's turn to host all the participants during the sixth and final project meeting at **Vassiliadis Private Gymnasium, Thessaloniki, Greece (31st**

March 5th April 2009). Final evaluation and checking the functionality of the SEED web site and of the SEED software (on a CD-ROM) was done. Evaluation covered multiple aspects of the project's management and implementation. Discussions were done on how the elaborated end products will penetrate the education system, on local level, for each partner. Different dissemination methods were taken in account, allowing each team to spread over their positive experience and the results of a three-year multinational collaboration.

Due to the very positive feeling of all participants concerning the ending project, discussions were done, about further developments of the subject SCIENCE in the framework of another future European project illustrating the partners' commitment for international collaboration, for school development trough European instruments and for keeping close with the partners who become friends.

Browse this book, apply what you consider interesting, give further the information you think is worth applying or spreading and try to feel the commitment, the friendship and the personal satisfaction of the authors emanating from this book's pages! I remain grateful to all our partners who invested effort, time and their professional knowledge in order to accomplish this partnership giving at the end this final product.

project coordinator; Mircea BRĂBAN, PhD

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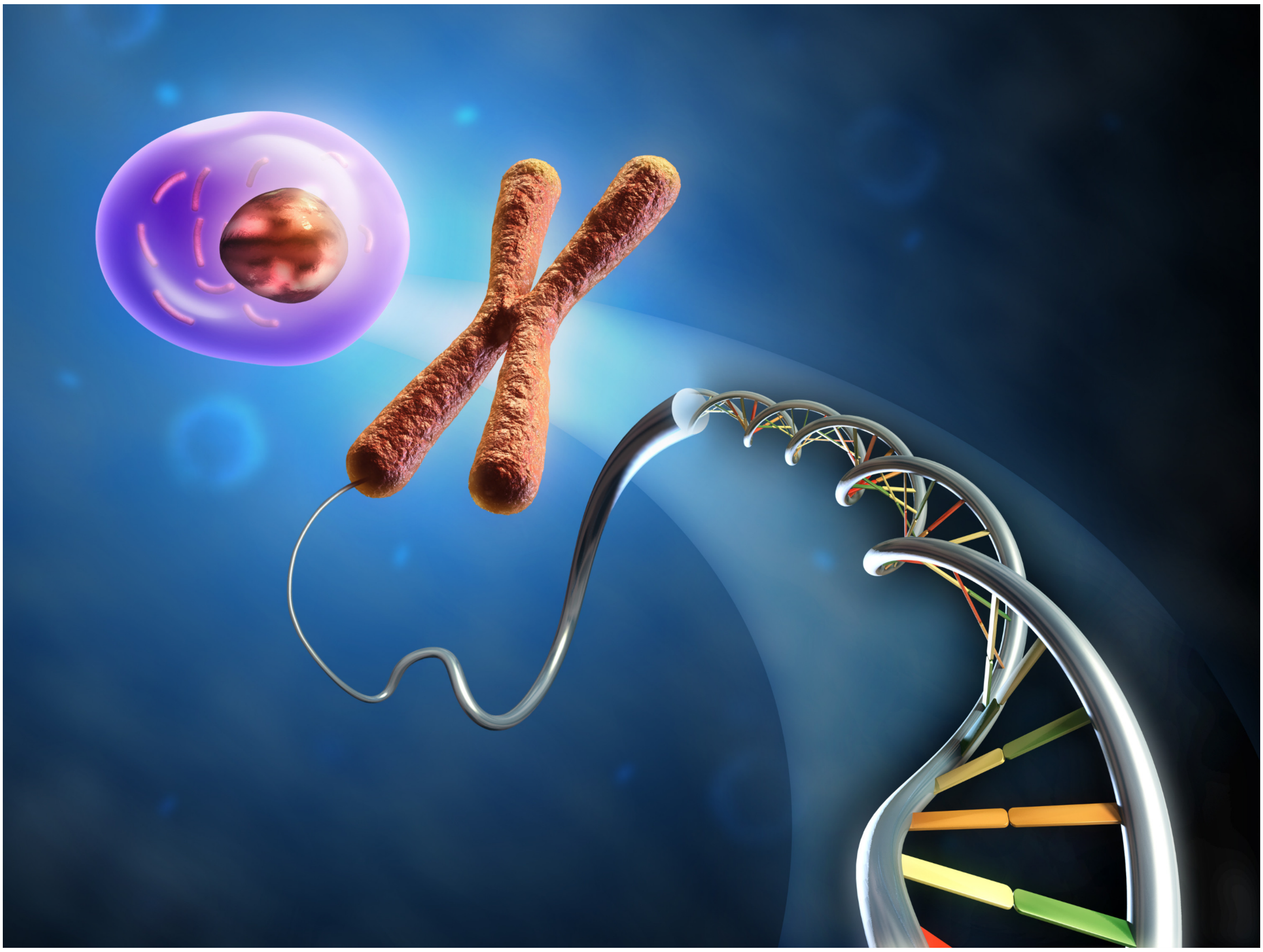
BIOLOGY

CHEMISTRY

PHYSICS




Biology

EXPERIMENT 1 DETECTION OF THE RIGHT STARCH IN DILUTED CACAO

CHAPTER: Microscopy

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects: typical shapes of starch-grains in different plants, microscopically technical science

Different approaches:

a. pupils practice: students work in pairs to carry out the experiments (the Comenius approach)

b. demonstration practice by the teacher (in this practice not efficient, and so not recommended)

Level: gymnasium, atheneum, havo (aged 12-17)

Time: one lesson of 50 min.

Main question: With which starch the cacao is diluted?

Materials, methods

Each pair is receiving or has to get a microscope – enlarging the object till 10 x 40 – including a microscope-lamp, drawing paper, microscopic preparation material like a preparation-needle, a pair of tweezers, filter paper, object-slides, and cover glasses.

Furthermore, each pair is receiving about half a ml. of the special prepared cacao (by teacher or technician): cacao, diluted with starch-grains from one plant-species.

There are 5 different sorts of starch available in the classroom (5 different species) to compare.

- Make microscopic slides of starch from the five different species. Take a little bit of starch out of the pot with a small spatula. Put it on the slide and blow. The remaining starch is enough for making a micro slide. Use water for a better light-refraction
- Observe the different slides at 10x40 and make a drawing of each slide. Try to recognize the typical remarks of each species
- Make a microscopic slide of the diluted cocoa (with water)
- Observe at 10x40 and compare the starch you find with the five drawings.
- Answer the main question

EXPERIMENT NR 2 PROTOZOA

CHAPTER: TAXONOMICS

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects:

Construction of some protozoa – esp. ciliates: different organelles, feeding, locomotion, the water- balance by the contractile vacuole.

Different approaches:

a. pupils practice: students work in pairs to carry out the experiments (the Comenius approach)
b. demonstration practice by the teacher (by means of a microscopic projector)

Level: gymnasium, atheneum, havo (aged 12 – 17)

Time: one lesson of 50 min.

Materials, methods

Cultivation

The teacher or technician (or the pupils) cultivate protozoa 4-5 days before the practice by putting hay (or some grass) in beakers with tap water. You can add some “flower-water” from a vase for a greater variety of protozoa.

Each couple is receiving a microscope (enlarging the object till about 400x), different slides, cover-glasses, a micro-pipette, filter-paper, a pair of tweezers, a preparation needle, drawing paper.

On the surface of the water in de beaker is a film of protozoa.

- Take one drop of that film with your micro-pipette (or the backside of the tweezers) and put it on the slide with a cover glass I the usual way (use your preparation-needle and filter paper)
- Adjust your microscope. Choose the right diaphragm and first a enlarging of 100x
- You can draw now one greater protozoon – most probably Paramecium caudatum, and point out the main organelles.
- Describe and explain the moving on the paramecium.
- Make a drawing of two other protozoa by an enlarging of 400x. Search their names and point out the main organelles
- Most protozoa in your slide are from the species Paramecium caudatum.
  Make several drawings of the contractile vacuole – several stadia. Explain its activity. What is the frequency in your vacuole?
- Try to find a conjugation of two paramecia. Make a drawing.
- Try to find a splitting paramecium. Make a drawing.

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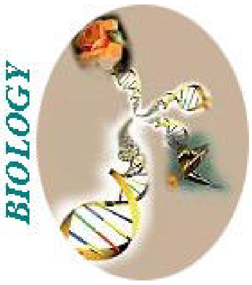
EXPERIMENT 3 SAP PLANT CIRCULATION

CHAPTER: Nutrition

PROPOSED BY: Colegiul Tehnic "*Iuliu Maniu*", Simleu Silvanei, ROMANIA



Theoretical aspects:

The life of the plants is closely related to the circulation and distribution of the crude sap and elaborated sap. The circulation of the crude sap (the water filled with mineral salts) is absorbed by the root hair thanks to a absorption mechanism that can be passive or active, and then transported through xylem to the leafs.
The circulation of the elaborated sap, composed of sugars amino-acids, takes place through phloem, from leafs to root.

Different approaches:

a) The activity will be in 2 groups:
-1st group will study the role of the wooden veins in the driving of the brute sap.
-2nd group will study the elaborate sap circulation through the liberian vessels.

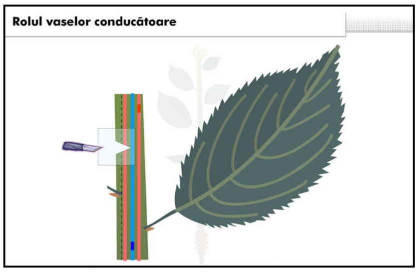
b) Demonstration practice by the teacher.

TIME: 40 minutes

1st group

Materials, apparatus:

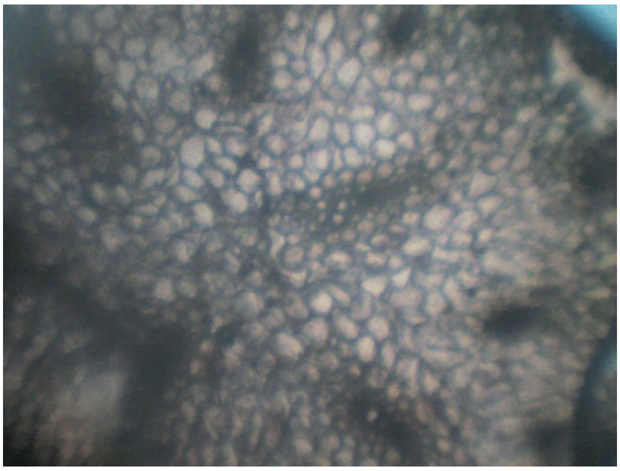
- 1 knife
- 3 branches of scrub *Sambucus ni,ra* or *Rosa canina*
- 3 glasses with water
- Galanthus nivalis
    - eozine solution
    - microscope



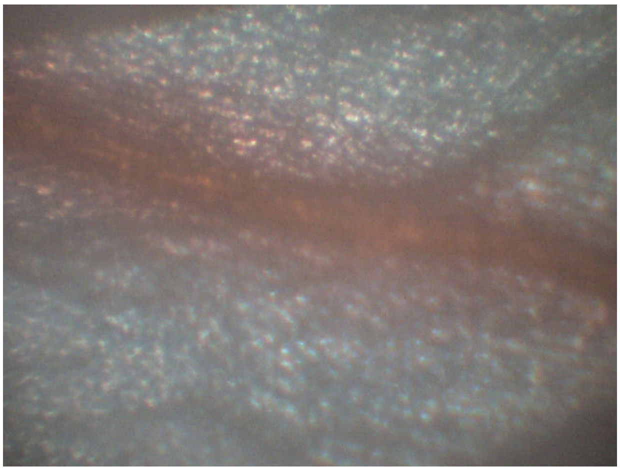
Individual tasks: One will do annular sections through the different structures of the scrub branches, namely the bark (A), phloem (B) and to the third branch through the bark, xylem and phloem (C), then observe consequences on those 3 branches. Place *Galanthus nivalis* in a glass of water containing an eosin solution. Observe the plant after 3 hours. Realize sections through stem and petals. Observe the xylem at the microscope.

Galanthus nivalis

Data collection:



Section of the stem in *Galanthus nivalis*



Section of the petal *Galanthus*

Results: In the case of the branch in which one cut out the bark, xylem and phloem(C) supervene the sear of this xylem tissue, because the circulation of water and mineral salts is suspended.

In cases A and B, the branches develop normally.

At *Galanthus nivalis* sections we observe that the xylem is colored in red.

2nd group

Materials, apparatus:

- a plant with leafs; for example *Pelargonium*
- a dissection blade
- tinfoil
- iodine solution

Individual tasks:

One will section the nervures in one half of the leaf, after the exposure of the plant to light, then cover the leaf with tinfoil; next day immerse the leaf in iodine.

Interpreting the results

The part of the leaf in which the nervures are sectioned will turn blue, because the starch could not be transformed in soluble carbohydrates, which would be evacuated from the leaf, as it happened in the part with intact nervures.

Explanation and conclusions:

The circulation of the sap assures the functional chaining of the plants organs, being separated through the xylem for the crude sap and through the phloem for the elaborate sap.

EXPERIMENT 24 ACTIVITY OF KATALASIS AT DIFFERENT TEMPERATURES

CHAPTER: Biochemistry - enzymes

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects: influence of temperature on enzyme activity, indication of enzyme activity by the amount of reaction production.

Different approaches:

a. pupils practice: students work in pairs to carry out the experiments (the Comenius approach)

b.demonstration practice by the teacher

Level: gymnasium, atheneum, havo (aged 15, 16, 17)

Time: one lesson or 50 min.

Main question: What is the influence of temperature on the activity of katalasis?

NB: the pupils have to write down a hypothesis

Materials, methods

Katalasis is an enzyme, present in every living cell. It “removes” the dangerous hydrogen peroxide: 2 H_2O_2 –> 2 H_2O + O_2.

Each pair receives 8 test tubes in a rack, 25 ml. Hydrogen peroxide solution (3%) in a small beaker, half a potato, and a stopwatch. Also available in the classroom: a “french-fries –potato-cutter” to cut bars with the same thickness, water baths.

We check the enzyme-activity at 6 temperatures: 0, 10, 20, 30, 40 and 50 degrees Celsius. Each pair has to check 4 (out of 6) temperatures, pointed by the teacher.

The total class results of the 6 temperatures appear on the blackboard at the end of the lesson.

- Pour 5 ml of hydrogen peroxide in each tube.
- Fill four little beakers (100ml.) for about 60 percent with water of the right temperature:
  0 degrees – crushed ice
  10 degrees – tap water with some ice
  20 degrees - mixture tap water with some hot water from the boiler
  30 degrees - same procedure

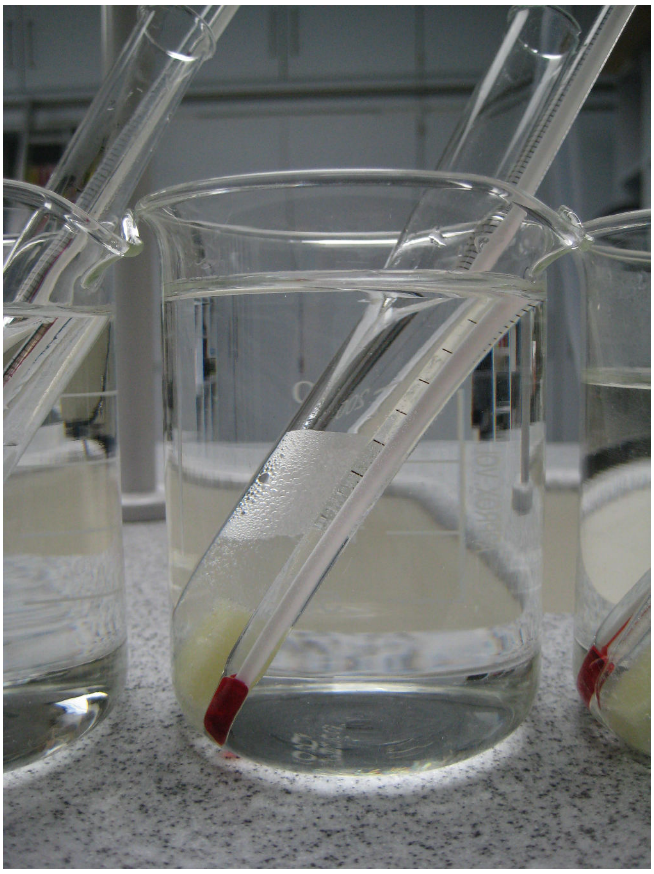
40 degrees – same procedure or Bunsen burner!
50 degrees - same procedure or Bunsen burner!

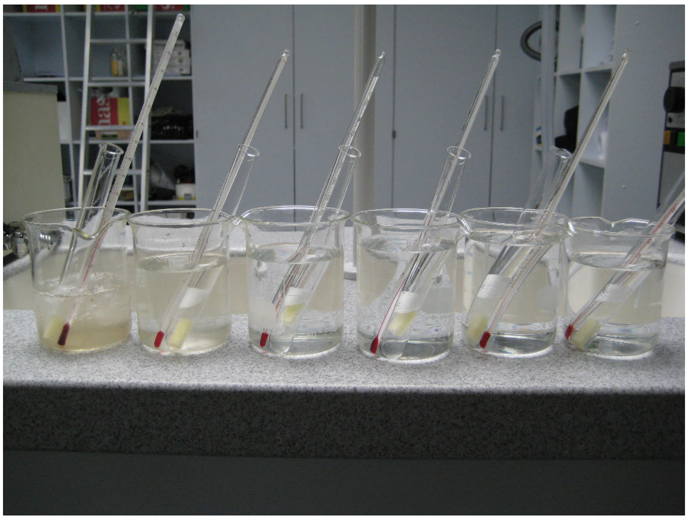
- Put a thermometer in every beaker and keep the temperature on the same level by adding hot or cold water or ice. Or use the burner.

NB: for the 3 higher temperatures 30, 40, 50 degrees you can also use water baths!

- Put each tube (with H_2O_2) in a beaker for min. 6 min., so the hydrogen peroxide has got the right temperature
- Put in each of 4 other empty tubes a stick of potato (use the cutter) with a length of 2 cm and put the tubes in the beakers also for about 6 min. to get the right temperature
- Now you take the potato-stick out of the tube, put it in the hydrogen peroxide and start the stopwatch
- On the surface of the solution a layer of foam/froth is arising. Question: What causes this foam?
- After 3 min. you measure the thickness of the foam-layer (in mm). It indicates the enzyme-activity.
- Do the same with the other 3 sticks.
- You can write the results on the blackboard

Make – for over a week – a scientific report of the total class results with graphics and right conclusion.





EXPERIMENT 4 STARCH DIGESTING ENZYMES IN WASHING POWDER

CHAPTER: Biochemistry - enzymes

PROPOSED BY: C.S.G. „COMENIUS COLLEGE”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects: enzyme activity, influence of temperature, Indication reaction on starch

Different approaches:

a. pupils practice: students work in pairs to carry out the experiments (the Comenius approach)

b.demonstration practice by the teacher

Level: gymnasium, atheneum, havo (aged 16,17)

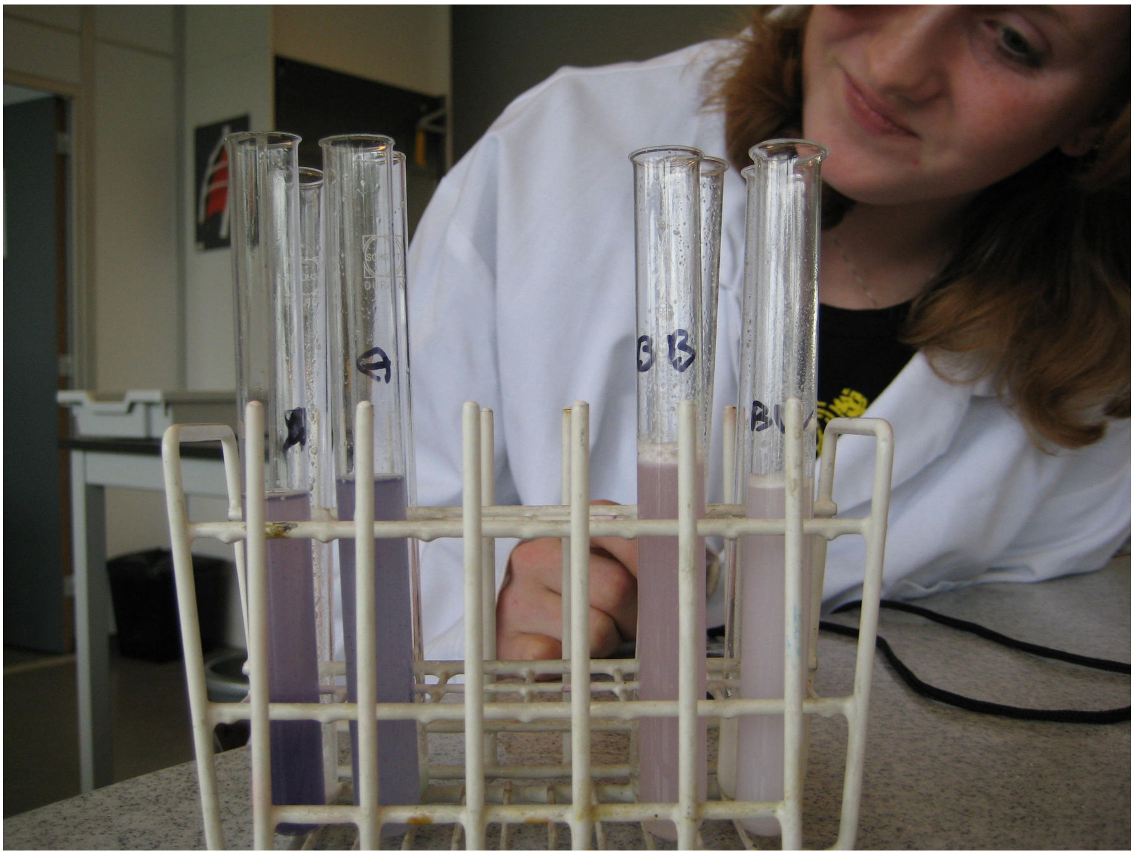
Time: one lesson or 50 min.

It is recommended that the pupils design a part of the experiment themselves in a previous lesson to create greater understanding. Also some pilot experiments can be done in that lesson to determine the amounts of starch solution and washing powder.

Materials, methods

Each couple is receiving (or has to get from a central table) a test-tube rack with 8 test tubes, four 10 ml. beakers with different washing powders (each about 1 ml), a 10 ml beaker with 10 ml starch solution (0.1 %), about 5 little plastic pharmacy measuring tubes (8ml), a stopwatch and a 50 ml beaker with demineralized water. In the classroom are two water baths.

- Put 1 ml starch solution in each of four tubes and add four drops of a light iodine solution to each tube. Now you have 4 blue colored starch solutions.
- Make a ‘solution’ of each washing powder: put 0.5 ml washing powder and 16 ml. Demin water in a tube. Shake it for 20 seconds and let it stand for two min.. You see deposit powder on the bottom. Pour about 8 ml of the solution above in a test tube – this is your washing powder solution.
- You now have four washing powder solutions – measure 1 ml of each solution in a tube.
- Put the tubes with wp-solutions and starch solutions in a water bath of 30 degrees Celsius
- Pour each of that 4 1-ml-wp-solutions in a tube with 1 ml blue starch-solution – at the same time (2 persons = four hands).
- Measure the discoloring time of each washing powder.
- Each couple has to write his results on the board, so the official results are the total class results
- You now can conclude which washing powder has the most starch digesting activity.



EXPERIMENT 5
ROLE OF THE ENZYMES FROM SALIVA

CHAPTER: Biochemistry

PROPOSED BY: Colegiul National
"Simion Barnutiu", Simleu Silvanei,
ROMANIA

Theoretical aspects:

The digestion process having a chemical effect in mouth is realized through the enzymes we find in saliva (Amylase, maltose); they have a hydrolytic action upon the starch (i.e. the starch is decomposed in dextrin, meaning – monosaccharide).

Different approaches:

a) students practice: groups of 4 students should carry out this experiment;
b) practical demonstration carried out by the teacher;

Time: 40 minutes and then, additional 10 minutes for observing the results and for drawing conclusions.

Materials, apparatus:

1. Prepare a solution consisting of boiled starch (water+starch); this becomes transparent and sticky (adhesive).
2. Introduce 4 tubes (A,B,C,D) into a warm water bath at 37°C. Put 6 cm^3 of starch solution in each tube.

The content of the tubes is:

A: starch solution + fresh saliva;
B: starch solution;
C: starch solution + boiled saliva;
D: water + fresh starch + boiled saliva.

4. Half content from each tube is replaced in other tubes (a, b, c, d) which are introduced in the same water bath.
5. The next step is to put a few drops of I+KI solution in the A,B,C,D tubes.
6. Read the results after 15-20 minutes.

Experimental procedure:

1. What is the colour of precipitates in the A,B,C,D tubes? What about the colour in a,b,c,d tubes?
2. Does saliva have any actions upon fresh starch?
3. What does fresh saliva contain? Are the enzymes destroyed by boiling the saliva?
4. What is starch transformed by fresh saliva in?
   What is the colour when sugar gets in contact with Fehling solution?

After 15-20 minutes

Content	**Of the**		**Tubes**	**Interpretation of the results**
	I+KI solution		Fehling solution	
A	Yellowish	a	Red precipitate	Starch has been transformed into sugar
B	Bluish	b	No precipitate	Starch hasn't been transformed
C	Blue	c	No precipitate	Boiled saliva does not transform starch
D	Blue	d	No precipitate	Fresh saliva does not transform fresh starch.

Conclusions

Starch decomposition into simpler saccharides starts into our mouth and it is produced by salivary amylase (ptyalin). Up to the final phase of maltose, the decomposition is produced by the enzyme called maltase which has different intermediate stages – dextrines. Maltose has its best effect at 37°C. By boiling it, the enzyme is destroyed and hydrolysis does not take place anymore.

EXPERIMENT 6 DEMONSTRATING THE PRESENCE OF THE CHLOROFILE IN LEAVES

CHAPTER: Nutrition

PROPOSED BY: Colegiul Tehnic "*Iuliu Maniu*", Simleu Silvanei, ROMANIA

Theoretical aspects:

The assimilator pigments are localized in the green organs of the plants, in the assimilator tissue to the chloroplasts level and have a role in a realization of the a process of photosynthesis in the green plants. The chloroplasts encompass the chlorophyll a and b, colored in green, orange carotene pigments and xanthophylls, which are yellow.

Different approaches:

a) pupil practice : cuples of two students do the (the Comenius approach)
b) demonstration practice by the teacher

Time: 50 minutes

Materials, apparatus:

- fresh leaves of nettle *Pelargonium zonale* , Spinacia oleracea
- test tube
- heating source
- filter paper
- proof spirit of 90%
    - benzene or benzine
- Erlenmeyer flask
- balance
- pipet
- graduated glass cylinder

Safety precautions:

Careful how you handle benzene it's volatile and flammable! Avoid the inhalation of benzene vapors!! It's toxic and carcinogenic!!!

Experimental procedure:

The pupils shall weight 10g of fresh leafs, then shall be chopped, shall blend then with alcohols , shall boil to the little flame until it will get a liquid of greenness, and the colorless leafs.

The blend is filtered through the filter paper.

5ml of the extract is poured in a test tube and then pour 2-3 ml benzene or gas and a few drops of water.

The blend is then agitated, thereto left at rest, for the separation of assimilator pigments in the head has the greenness, (chlorophyll a and b) and of the carotene yellowish pigments in the bottom (carotene, xanthophylls).

Then through paper chromatography is achieved the separation of assimilator pigments from blends.

Individual tasks:

1) You weigh 5 g of which leafs, which must be chopped, then put in a Erlenmeyer glass across which is added the proof spirit until it covers completely the leafs.
2) Boil the blend on a source of heat until the leafs don't expose their greenness.
3) The obtained solution is filtered through filter paper.

Interpreting the results

The band of paper distinguished a range of colors, from orange, yellow and green by the degree of absorption: carotene (orange, yellow) xanthophylls, (green bluish) chlorophyll a, chlorophyll b(green yellowish).

Explanation and conclusions:

In the green plants, besides chlorophyll a and b one can find another categories of pigments namely the carotene and xanthophylls; these are noticed in the autumn when the green pigments disappear, the leafs drop, and the color extends from red orange to yellow.

References:

Baciu I. Fiziologie E.D.si P. 1977.
Boldor O.- Fiziologie plantelor si E.D. si P. 1981

EXPERIMENT 7

DIFUSSION THROUGH THE MEMBRANE

CHAPTER: Cell

PROPOSED BY: Liceo Danillo Dolci, Palermo, ITALIA

Theoretical aspects:

It is necessary to start from the following basic theoretical aspects:
a) The membrane works as a selective filter; in fact small molecules can go through it (for example wate, ione, glucose). But big molecules can't (for example starch) .
b) One of the main substances which go through inside and outside the cell. The water potential determines the direction of water.
c) Diffusion involves a random movement of molecules or ions and determines a clear flow according to a concentration gradient.
d) Osmosis is the diffusion of water through a membrane which permits the passing of water, but prevents the movement of many solutes.
e)The clear movement in osmosis occurs from an area of smaller concentration of solute (hypotonic environment) and consequently of bigger water potential to a bigger concentration of solute (hypertonic environment) and consequently of a smaller water potential

Different approaches:

In the experiments it is important to consider the inner properties of cellular membrane.

Materials, apparatus:

0 cm, of tube for dialysis (5 cm diameter)

- 1 strong cotton thread
- 4 200ml bechers, short shaped
- 1 little glass tube
- 1 funnel and filter paper
- 2 droppers
- 1 glass stick
- 1 test tube
- 1 pipette
- Bunsen lamp
- 1 tripod support
- 1 refrattaris wire gauze
- glucose
- soluble starch
- fehling liquid (A,B)
- tincture of iodine
- distiller water

Safety precautions:

Careful with the manipulation of instruments!

Experimental procedure:

Make a 8% p/p glucose solution.

Make a starch solution, dissolving in beaker one spoon of starch, soluble in water; hot and let it boil for 1-2 minutes, until the liquid is clear and, after making it cold, filter in beaker. Prepare a pouch with the tube for dialysis, get into the pouch 5ml of glucose solution and 10ml of starch solution, get the little glass tube into the pouch. Get the pouch into a beaker containing distilled water and add some drops of tincture of iodine.

After about 10 minutes, the solution inside the pouch becomes dark blue (the starch solution with iodine produces this colour).

That does not occur inside the pouch

Evidently iodine has gone inside, through the membrane, but starch has not been able to go outside; at the same time glucose goes outside the pouch, through the membrane.

In order to check the second crossing, you have to test the presence of glucose in the liquid of the beaker.

For this purpose, stir in the test tube a few millilitres of liquid with the Fehling reactive (2 ml of solution A + 2 ml solution B): you will obtain a blue solution for the presence of Cu^{2+}

Hot the test tube on the Bunsen lamp.

You will observe the formation of a red-yellow precipitate Cu_2O.

Explanation and conclusions:

You can observe the osmotic phenomenon also in a macroscopic way; in fact now the pouch is puffed out because of the water passed inside it, and the liquid in the little tube is clearly increased

References:

Progetto modulare, Post Baracchi, Tagliabue Lattes 2007

EXPERIMENT 8 PHOTOSYNTHESIS

CHAPTER: Plant Physiology-Metabolism

PROPOSED BY: C.S.G. „COMENIUS COLLEGE”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Level: gymnasium, atheneum, havo upperclasses (15, 16, 17 years)

Theoretical aspects:

- carbon assimilation reaction
additional assimilation from glucose till starch
principals of a scientific experimental approach
indicative color reactions

Different approaches:

a. pupils practice: groups of two students carry out the experiment (the Comenius approach)
b. demonstration practice by the teacher

Time: 50 min.

Safety precaution:

pupils are working with fire and ethanol! So, in a full class of pupils (max. about 30 pupils) you need at least two coaches (teacher and Technician)., Ventilate the room, but avoid any wind (at the flames).
Warm the ethanol “au bain marie” (in surrounding water).
Close the oxygen supply when you don’t need the burner for a few minutes: you create a clear, very visible flame. After the experiment the pupils put the left chemicals in a special bottle.

Materials, methods

One pelargonium plant (for instance *Pelargonium Zonále*) has been lightened by a 45W spot lamp above the plant (distance 60 cm) for about 8 hours.
Eight leaves are – during the lightening – packed in aluminium folia: The “dark leaves”. Each pair of pupils is receiving half a dark leave an half a lightened leave.

Furthermore, the couples receive a wooden pincher, a Teclu burner, a large lab glass (diam. about 10 cm) and a small lab glass (diam. about 5 cm), a Petri dish (10 cm), 10 ml. of a solution of iodide in a KI solution and about 20 ml of ethanol (96%).

Both leaves are boiled in 3 cm of water in a large lab glass for about 5 min.. Keep the leaves with the wooden pincher under water. After this the cell membranes are broken.
Then you pick up the leaves with your pincher and put them in a small lab glass, half filled with ethanol.
You put this small glass, attached to the pincher, in the large lab glass with the hot water.
The ethanol glass is now stable. Boil the leaves in the alcohol for about 5 min.. The chlorophyll is dissolving in the ethanol.

The bleached leaves are put in the Petri dish with iodine solution and spread out. After a few minutes the "light leaves" has turned blue purple. The "dark leaves" are still bleached.

NB: each pupil has to make a scientific report of this experiment.

EXPERIMENT 9 OSMOSIS PHENOMENA IN POTATOE BARS

CHAPTER: Plant Physiology

PROPOSED BY: C.S.G. „COMENIUS COLLEGE”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects: diffusion, osmosis, semi (selective) permeability of cell membranes, turgor, plasmolysis

Different approaches:
a. pupils practice: students work in pairs to carry out the experiments (the Comenius approach)
b. demonstration practice by the teacher (by means of a microscopic projector)

Level: gymnasium, atheneum, havo upperclasses (15, 16, 17 years)

Time: first one lesson of 40 min., and then an additional 10 min. for measuring the results (after a few hours)

Materials, methods

Each pair receives 35 ml 1M/l solution of glucose, 12 ml. of an unknown solution of glucose, 7 test tubes in a rack, a measuring pipette, a pair of tweezers, a large potato which the pupils cut in bars with the same thickness by means of a “French-fries potato-cutter” in the centre of the classroom. Furthermore, a small knife with which they cut 7 bars in a length of 60 mm.

- Make a series of 6 glucose-solutions in the tubes, each 10 ml with the following molarities: 0.0, 0.2, 0.4, 0.6, 0.8, 1,0 Mol/l.
- In each tube you put a potato-bar.
- In the seventh tube you put 10 ml of solution X and a 60 mm bar
- After 1 – 3 hours (all the pupils at the same time) you see a decreasing length of bars in the series of tubes. Take the bars from the tubes (with a pair of tweezers) and measure the length of the bars; also the length of bar X.
- Measure the stiffness of the bars in the illustrated way (in mm).

  NB: when the bending is large, the stiffness is small.

  Each pupil has to write an experiment report. In that report you make graphics of length and stiffness in relation to the molarity of the solution.
- Explain that one or two bars have turned longer, and several bars have become shorter.
- The difference between 0.0 and 0.4 Mol/l is much larger than between 0.6 and 1.0 Mol/l Why?
- What is the molarity of solution X? Give an explanation

EXPERIMENT 10

DIALYSIS IN AN ARTIFICIAL INTESTINE – PERMEATION OF DIFFERENT NUTRIENTS

CHAPTER: Physiology (biochemistry)

PROPOSED BY: C.S.G. „COMENIUS COLLEGE"; CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects:

Permeation properties of the small intestine and qualitative determination of nutrients

Different approaches:

a. pupils practice: pupils work in pairs to carry out the experiments (the Comenius approach).
b. demonstration practice by the teacher

Level: gymnasium, atheneum, havo (aged 12 – 17)

Time: 50 min.

Main question:
Which nutritious substances (out of the given 5 examples) do pass the intestine membrane?)

NB: the pupils have to write down a hypothesis

Materials, methods

Each couple is receiving a 50 ml beaker, a little measuring cylinder glass, a piece (25 cm) of flexible dialysis tube – dialysis membrane 31 with about the same permeation as the small intestine, 2 paperclips, 5 ml of vitamin C solution (0,1%), 5 ml starch solution (0.1%), 5 ml glucose solution (0.1 %), 0.5 gr. albumin and 5 ml salt solution (NaCl), a few ml of ninhydrine solution,
Fehling solution, DCPIP solution, iodine solution and a solution of silver nitrate.
NB: it is recommended that the pupils take their materials themselves from a central table.

- Fold one end of the tube two times, and put a paperclip at the end
- Fill the tube for about 60% with a mixed solution of starch, glucose, vitamin C, albumin and salt
- Close the other end of the tube, also by means of folding and the use of a paperclip
- Hold the tube in a U-form and wash the outside with tap water and distilled water.

- Take the little beaker with about 20 ml distilled water and hang the U-shaped tube in the beaker – with both end outside the beaker – for about 20 min.
- Take the beaker and pour about 1 ml from the ‘water’ in each of 5 test tubes.
- Use in each test-tube one of the five indication solutions: 1. ninhydrin, 2. Fehling, 3.DCPIP 4.iodine, 5. silver nitrate Heat the tubes 1 and 2
- NB: indication reactions:

1 + heating – blue : protein
2 + heating – orange/red: reducing sugars – glucose
3 the solution turns colorless – vit C
4 the solution turns blue – starch
5 the clear solution becomes white-troubled (AgCl) and then it slowly turns dark in the light.

- Which nutritious substances passed the membrane?
- So, was your hypothesis correct?
- What physiological differences exist between the permeation through this artificial membrane and the permeation through the membranes from a living intestine?

EXPERIMENT 11

PLASMOLYSIS, DEPLASMOLYSIS

CHAPTER: Physiology

PROPOSED BY: Colegiul National "*Simion Barnutiu*", Simleu Silvanei, ROMANIA

Theoretical aspects:

- The aim of this experiment is to know/understand the process of plasmolysis and deplasmolysis as well as the semi-selective –permeability of cell membranes and osmosis phenomena.

Different approaches:

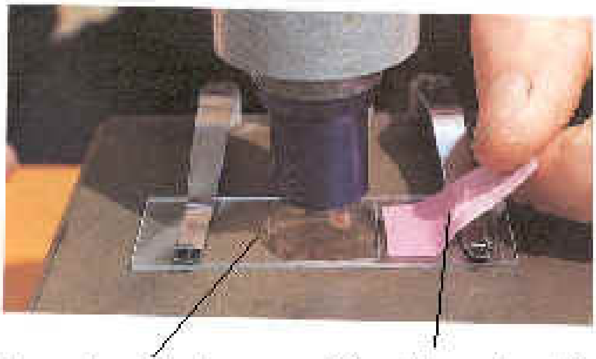
a) Students practice: 2 students carry out the experiment;
b) Practical demonstration carried out by the teacher.

Time : 50 minutes

Materials, apparatus:

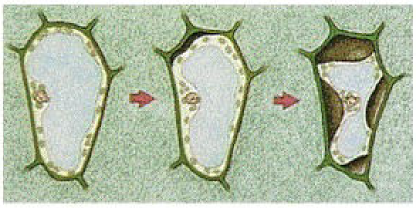
onion bulbs, concentrated lactose solution or sodium chloride (NaCl), scalpel, tweezers, paper filter, slides and lamella, microscope, pencil, notebooks.

Experimental procedure:



Put a drop of salt solution here.

Draw the salt solution into the slide with a little piece of filter paper



1. Take a fragment of the superior epidermis from modified leaves of an onion bulb and put it on a slide in a drop of natrium chloride solution.
2. Cover the slide with a lamella and place it under the microscope.
3. Describe what you observe and take notes in your copybook.

The protoplasm detaches from the cellulosic wall because of the hypertonic solution which at its turn causes to the cell a loss of water and molecular contraction.

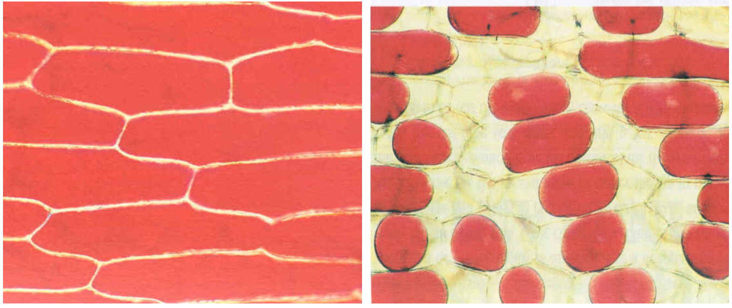
4. Follow-up the detachment of protoplasm from the cellulosic wall. At the beginning (2-3 min.) the detachment occurs only on certain sections having a concave shape (concave plasmolysis) and then, progressively follows the rest of detachment in 10-15 minutes, taking in the end the spheric shape or lenticular shape (convex plasmolysis).
5. Replace the sodium chloride solution with water. Add a drop of water on a side of lamella and using a filter paper you should absorb the sodium chloride solution on the opposite side. What do you notice? Draw it in your copybooks!

Observation:

1. How is the sodium chloride solution?
2. What happens in the first 2-3 minutes? What about the other 10-15 minutes?
3. What did you notice when you replaced the sodium chloride solution with water?
4. Do you have any explanations for protoplasm normalization? (it gets back to normal). How do you call this process?

Explanation and conclusions:

Plasmolysis is the process in which the molecular volume decreases by losing a certain amount of water produced by the osmosis phenomenon. (Shrinking of plant cells by osmotic loss of cytoplasmic water).



Deplasmolysis is caused by the substitution of sodium chloride with water. Because the cellular juice is highly concentrated it absorbs water, the vacuole increases its volume, it tightly attaches to the cellular wall in plasmatic membrane changing back to initial shape.

EXPERIMENT 12 WATER QUALITY RELATED TO SOME ABIOTIC FACTORS

CHAPTER: Biochemistry/Ecology

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects: indication reactions, influence of some abiotic factors in an ecosystem

Different approaches:

- **a**. pupils practice in the field – pupils work in pairs to carry out the experiment on location. (the Comenius approach)
- b. pupils practice in school with samples taken from the field
- c. demonstration practice in the field
- d. demonstration practice in school with samples taken from the field

Level: gymnasium, atheneum, havo (aged 13- 17)

Time: 40 min. (except traveling time)

Precautions: - for the silver nitrate solution – use drop-bottles
- pour all the used solutions in a waste-bottle and put other used materials in a waste-sack

Materials, methods

The practice should be done in an area with several ditches or brooks, ponds, lakes, rivers etc.
Choose 4 different “waters” – not directly connected with each other. Give them a number: spot 1 – 4.
The pupils work in pairs

A. Salt – chloride

Question: what is the influence of salt (NaCl) on plants and flowers? Give an explanation.

In low river-areas by the sea (for example Holland) there is a threat of too much salt in rivers and connected waters. Especially in dry periods when the water-mark is low. Seawater enters the rivers and connected waters.

A second cause of salty water is the industries with extreme pollution (for example the Rhine river).
A third cause is the sprinkling of salt on roads during the winter. A great deal of that salt is coming in the different waters.

Put 7 ml. Water from each spot in a little plastic pharmacy-tube (8 ml.) and add 10 drops of a silver nitrate solution. When there is a white troubling of the water that is slowly becoming dark (at the end of the total practice) the water contains chloride – mostly NaCl. The amount of dark precipitate is an indication for the amount of salt in the water.

B. Clearness of water

Question: what is the influence of water-clearness on plants and animals? Give an explanation.
Each pair receives a secchi-disc on a rope that is attached to a long stick – like a fishing-rod
Every 10 cm there is a knot on the rope
Let the disc sink in relative deep water on each spot. Notice the number of knots when the disc is going out of sight. This depth is an indication of clearness.

C. pH

The ideal pH is about 6.6. A deviation of more than 0.5 is dangerous for organisms.
Question: Why?
In stagnant or swampy waters mostly the pH is far to low: the water is dead. This is true especially in waters with a lot of organic deposit.
Question: Why?
Sometimes on spots with drains of soap-water the pH is to high.
We use pH measuring paper with an accuracy of 0.2 or 0.3.
Dip the paper for one second in the water, wait a few seconds and compare the indication-color with the standard-scale. Do this for each spot.

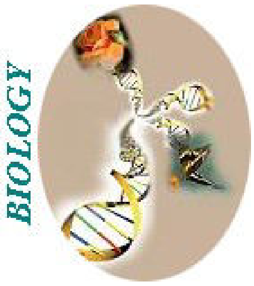
D. Temperature

Cooling water from factories can warm open water (by 1 – 6 degrees)
Question: Why can fish die in water with a temperature that is several degrees higher than normal?
Use a thermometer on a rope with knots (every 10 cm) attached to a stick.
Measure each spot (for about 2 min.) on a depth of 20 cm and on the maximum depth.

Combine all the results of the four spots and draw your conclusions.
NB: the current of the water (leaf, stopwatch) and the amount of oxygen in the water (small chemical set) can be measured too in the field.

EXPERIMENT 13 BACTERIA ARE EVERYWHERE

CHAPTER: The presence of Bacteria



PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects:

the distribution of bacteria, the multification-speed, several types of bacteria, the need of a blank, the size of bacteria.

Different approaches:

a. pupils practice: pupils work in pairs to carry out the experiments (the Comenius approach).

b. demonstration practice by the teacher

Level: gymnasium, atheneum, havo (aged 12 – 17)

Time: in the first lesson 30 min. to infect the dishes, in the second lesson (after min. 3 days) 30 – 50 min.

Safety precautions:

1. don’t open the dishes with colonies of bacteria (except for the last optional part with the microscope – keep the opening time restricted to just a few seconds, and don’t touch the bacteria)
2. work with a mask
3. destroy the colonies after the experiment (f.e. by high temperatures in the incubator)

Main question: How contaminated with bacteria are the searched media, objects etc.?

Materials, methods

Each couple is receiving 5 Petri dishes (diam. 10 cm) with an agar agar medium, sterile

Instruments like (packed) blood lancets and cotton wool sticks to transport bacteria from the object to the Petri dish. Optional: a microscope with a 100x oil-immersion lens.

Each dish is labeled with a small empty sticker. Write down on each sticker the relevant data: your name and class, name and date of infection.

- One dish stays unopened: this is the blank for the agar medium – the control for the sterility of the agar
- The agar from the other four dishes is put in contact with resp. 4 different "objects" – ctly or indirectly by touching/rubbing the object with your sterile instruments, and then touching the agar (just the surface).

  You can choose every object" that is interesting for its possible bacterial contamination. For instance : soil, tap water, aquarium water, water from a vase of flowers, your spittle, your teeth, your fingers (washed and none-washed), plaster, toilet-scat, toilet door handle, the air in the classroom (dish open for 10 min.) etc.

  But notice:
- First put on a dust mask
- Work with sterile blood lancets and cotton wool sticks
- When you have to open a dish to infect the agar medium with one of the objects, do it fast, and keep the dish upside down
- Put the infected dish – still upside down – in an incubator at 35 degrees Celsius for 3 days.

NB: another blank is recommended – the blank for opening time: some bacteria could enter the dish (from the air) in that handling time.

- In the next lesson you study the bacterial colonies by drawing them on a thin paper sheet.
- First you draw the dish circle by putting the dish on the paper. Than you put the paper cicle on top of the dish (upside down) and you trace the colonies.
- Count the number of colonies and the number of different bacteria (different color)
- Write down your observations and conclusions

When there is time left, make slides of some bacteria and study them by an enlargement of 10x100 (with oil-imersion).

EXPERIMENT 14 KIDNEY OF THE PIG

CHAPTER: Nutrition

PROPOSED BY: Colegiul Tehnic "*Iuliu Maniu*", Simleu Silvanei, ROMANIA

Theoretical aspects:

The excretion represents a metabolic process through which the organism eliminates the residual toxic substances. The morphofunctional unit of the kidney is the nephron that has the role in the urine formation.

The macroscopic observation of the kidney structure can be realized on a pig's kidney.

Different approaches:

c) pupil practice : couples of two students do the (the Comenius approach)
d) demonstration practice by the teacher

Time: 40 minutes

Materials, apparatus:

- pig kidney from the shop or slauther-house
- dissection instruments
- moulding of the kidney
- Magnifying glass
- knife

Safety precautions:

Careful with the manipulation of instruments!

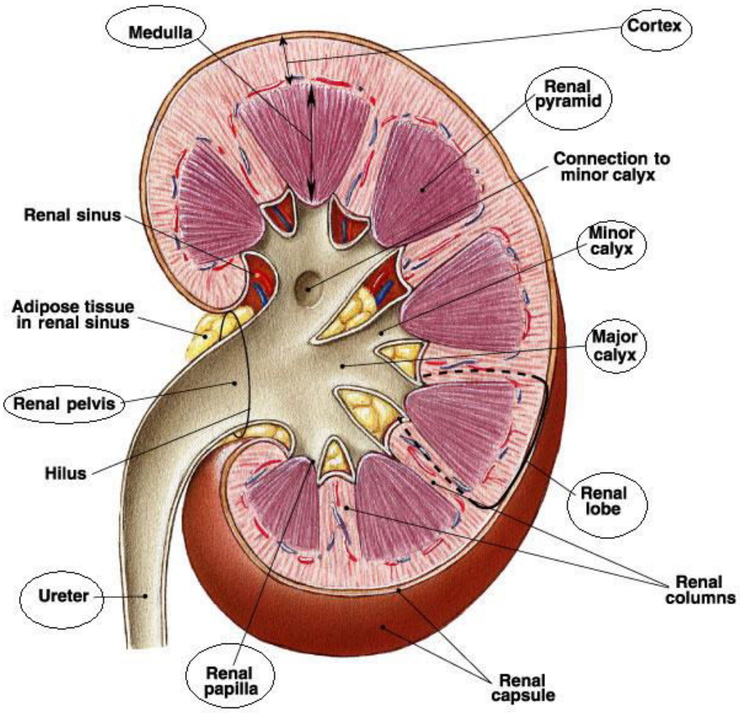
Experimental procedure:

Wash the kidney!

- the Observe the external conformation: the shape, size, the hile, renal vessels, the urethra, nerves, the renal conjunctive capsule.

Individual tasks:

2) Realize a section of the kidney in the length of the median line starting from a convex part toward concave one , obtaining two equal halfs.
3) Observe the structures and then realize a drawing of the renal sinus, renal pelvis and calices.
4) Observe the zones (cortex, medulla) with renal pyramids, in top of which it can be observed with the loupe the orifices of the collecting tubules in comparison with the moulding .



Data collection:

- the form of the kidney
- dimension
- cortex- brown, red, granular in aspect
- medulla- with red open striated appearance ,
- pyramid Malpiqhi
- renal lobes

Explanation and conclusions:

At the level of the kidney it realizes three important processes of the excretion:
- glomerular ultrafiltration through which result the primary urine
- tubular reabsorption at the urinifers tubules level of the active or passive nephron
- the tubular secretion in keeping homeostasis in the organism
- the destruction of the nephron determines the renal failure

References:

1.Stoica M. Mihailescu I. , Lucrari practice de anatomie si fiziologie animala,1974 Editura Didactica si Pedagocica 1974 Bucuresti.
2.Suciu M. Popescu, Lucrari practice de zoologie 1975 Editura Didactica si Pedagocica Bucuresti 1975

EXPERIMENT 15 THE MAMMAL HEART

CHAPTER: Blood and circulatory system

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Level: gymnasium, atheneum, havo upperclasses (16,17 years)

Theoretical aspects: understanding the human heart
A-V valves, content and thickness of walls of left and right ventricle and left and right atrium.
- Connection with vena cava (p. and s), aorta, pulmonary artery, pulmonary veins.
- Situation of the left and right coronary artery
- Three-dimensional structure of the heart

Different approaches:

a. pupils practice – 2 students on one heart: This is the Comenius approach
b. demonstration practice by the teacher

Time: 50 min.

Material, Methods:

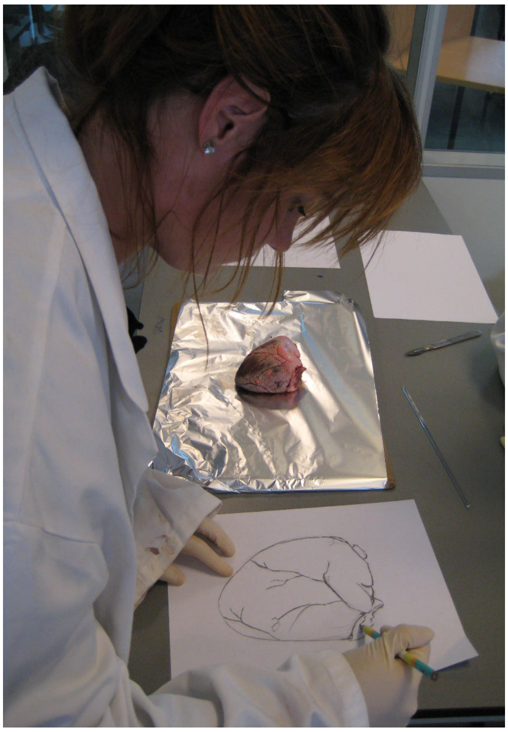
Each pair of pupils needs a scalpel, probe stick, (lead) pencil, drawing paper, measuring staff, pair of latex gloves, dissecting top covered with aluminum foil.
Furthermore: a biology book with pictures of the heart to compare with, list of criteria for a good bio-drawing and last but not least: a Lamb heart from the butcher or the slaughter house.

INSTRUCTION: External
Put the heart on the aluminum foil, pointing to you and a little bit to the right (“seen from the paper”: left)
Make a drawing at natural size. Point out: left and right ventricles and atria (partly cut away by the butcher), left and right coronary artery, aorta, pulmonary vein.

INTERNAL
- Cut the heart open parallel to the base (alu-paper) from the “point” to the atria.
- Fold back the upper piece and make a drawing at natural size.
- Point out left ventricle and right ventricle (compare the wall thicknesses), left atrium, right atrium, a-v valves, attach tendons, Heart papilla, heart artery valves.
- Determine the thickness ratio of left and right ventricle wall.

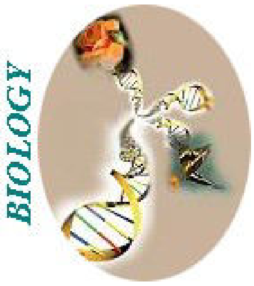
- Try to determine the position of the (three-dimensional) the position of the right ventricle by probing or by feeling with your finger. Where is situated the largest part?
- Probe with your probe stick or spatula the great blood vessels above the heart. Discover in which part of the heart the end of the stick appears and find out the name of these vessels.
- Lift a a-v valve (thin membranes!) with your spatula. Now you have a clear sight on the circle-shaped valve. Try the same with ventricle- artery valves. What is the difference compares with

a-v valves?
Nearby the ventricle – aorta valve the coronary arteries “start”. You have to search very well, and then you‘ll find very small openings. Try to probe them and make a detail drawing.



EXPERIMENT 16 THE PIG'S EYE - *dissection*

CHAPTER: *Anatomy Analyzers*



PROPOSED BY: Colegiul National "*Simion Barnutiu*", Simleu Silvanei, ROMANIA

Theoretical aspects:

The aim of this experiment is to understand the human eye;

- the eye consists of 3 structures: 1. the sclera with cornea;
  2. the choroid with ciliary body and the iris;
  3. the retina.

- in the middle of the eye there is the pupilla; with the help of the iris muscles the pupilla adjusts its diameter depending on the quantify of light which passes through the eye.

- behind the iris we can find a biconvex lentilla – the lens.

Different approaches:

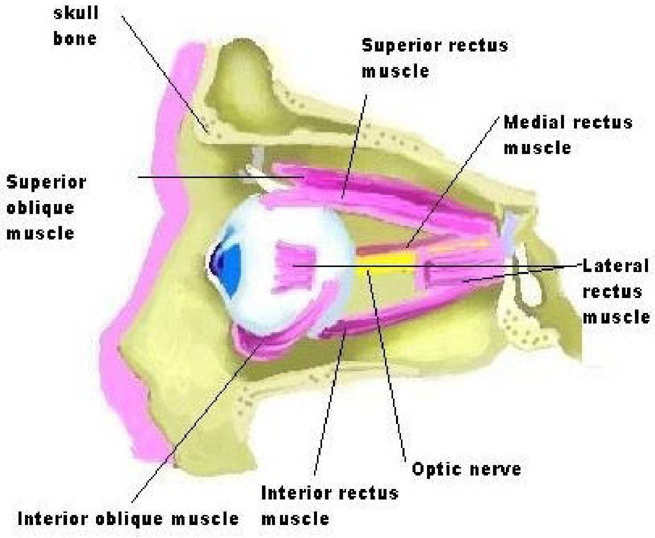
c) Students practice: 2 students work on one eye;
d) Practical demonstration carried out by the teacher.

Time : 50 minutes

Materials, apparatus:

- Pig and bovine eyes, dissection case, book, artificial eye (cast), poster, an atlas with the eye, pencils, drawing paper.

Experimental procedure:

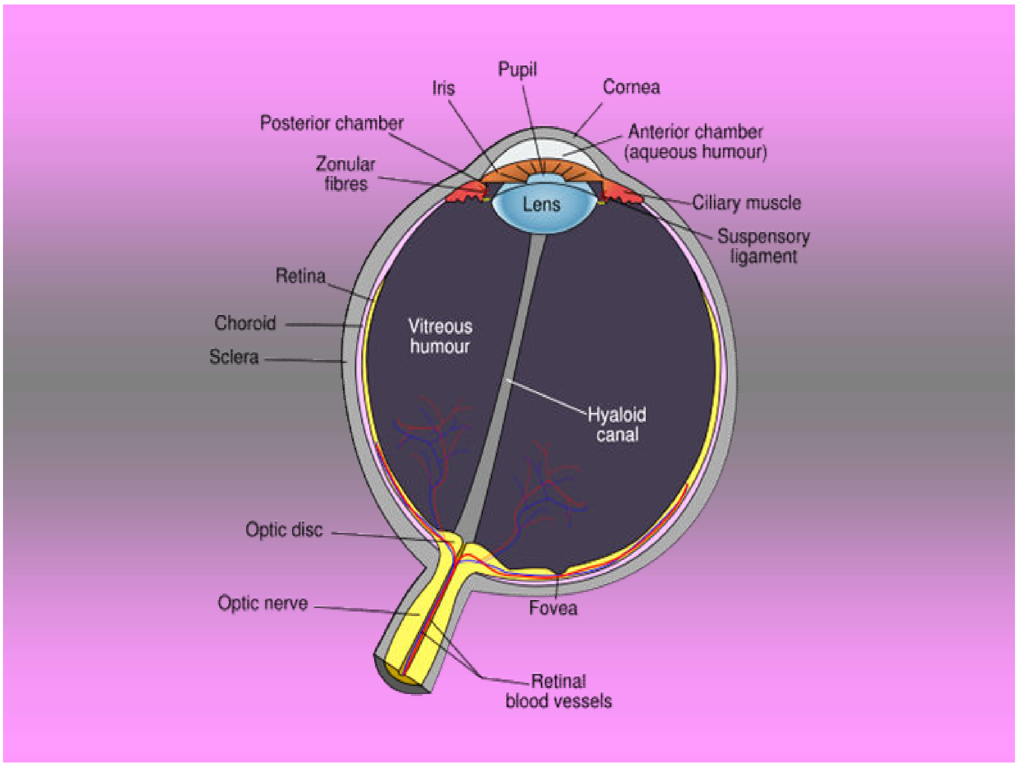


External: - students should observe the protecting organs – the eyelids, then the lacrimal gland in the external angle;

Furthermore, students could notice the six extrinsic muscles of the eyeball and the optic nerve.

Internal:

1. The eyeball dissection begins with its cleaning from fat and conjunctive tissue up to the first leyer (Lat.*tunica)*: the sclera (having a white-grey colour with a fibrous and opaque structure with a building and transparent cornea);
2. Cut the sclera using a scalpel or a shaving blade on the equatorial line avoiding to cut the eyeball;
3. The next step is to cut a circular line in sclera using sharp scissors and section it towards the emergent side of the optical nerve;



4. Take a look on the internal side of the sclera and of the choroidal membrane;
5. On the side next to the sclera you can notice the brown-coloured choroids; on the side next to retina the choroids's colour is black because of the strong adherence between retina and the choroid.
6. Now, using a scissors you should cut the eye up to cornea removing the sclera and the choroid. The aqueous humor flows out from the previous chamber;
7. remove the iris and behind it you will find the lens;
8. Take the lens and place it on a written paper: what do you notice?
9. The think that you observe after removing the lens is the transparent vitreous body;
10. Remove the vitreous body and then you can see the eye ground:
    - Retina with the yellow stain and the blind stain;
    - Blood vessels

Explanation and conclusions:

1. Which are the transparent media than you could point out during the dissection?
2. What is the dioptric system of the eye?

Which are the main parts of the eye and what is their role?

EXPERIMENT 17 BRASSICA NAPUS FLOWER

CHAPTER: Sexual reproduction in plants

PROPOSED BY: Colegiul Tehnic "*Iuliu Maniu*", Simleu Silvanei, ROMANIA

Theoretical aspects:

The flower of the angiosperms is a short branch with metamorphosed leafs, adapted for the sexual process with consecutive appearance of the fruit and seed. A typical flower is formed by: peduncle, receptacle, perianth -P (floral envelope), androecium-A and Gynoecium-G. The perianth could be simple, when all the floral elements are the same type or color, so-called perigon-P, or bidifferentiated into calyxes (sepals)-K and corollas(petals)-G. Androecium represents the male part of the flower (totality of stamens), while gyneceum, the female part, comprise all the carpels, which can be singles or fused.

The representing of the flower structure can be realized with the help of the floral formula that utilize letters, numbers and conventional marks. The floral diagram represents the graphic projection on horizontal of the floral elements.

The flower of Brassicacea (Cruciferae) family, respectively Brassica napus is of type 4 and is cultivated for the tuberous roots and oleaginous seeds. The flowers are yellow disposed in raceme, the fruit is called siliqua, and from the seeds is extracting oil used at making soap, margarine, oil for motors; also, the tuberous root is utilized for animal food.

Materials, apparatus:

- Brassica napus flowers from the herbarium or fresh
- Pencil and a compass with pencil
- Botanic books
- Mould flower at angiosperms

Safety precautions:

It is important the observation and representation of the correct position of the sepals, the petals in alternation of these on the circles also the utilization of a pencil different as color in comparation with the pencil wich has been marked.

Possible sources of errors:

- Indefferenting the correct position of the sepals and petals
- The delimitation of the intial circles not being evidetionated in the marking of the floral elements
- The realization of some concentical circles too small or too close

Experimental procedure:

In consequence of the flower observation from the herbarium and fresh, recognize the type of inflorescence, the element equability, the flower structure, respectively the disposal of these components at Brassica napus.

The realization of the flower formula using the marks, numbers, leters and the realization of the flower diagram.

Individual tasks:

1. Observe and recognize the component parts of the flower from Brassica napus

2. Using the compass with the pencil, mark 6 concentric circles and split them into 4, taking 2 perpendicular plans one over the other. The number of circles is equal with the number of the elements cycles from a flower ,in our case hexacilical.
3. Reprezent with the black pencil the sepals on the extern circle and then the ones from the intern circle
4. On the third circle 4 petals in alternant with the sepals
5. On the fourth circle the 2 external lateral stamens, alternate with the petals and opposite at the internal sepals.
6. On the fifth circle 4 internal stamens closed two by two
7. On the sixth circle represent the bicarpels gynoecium
8. Erase the circles that you marked with the black pencil for not giving the impression that the floral elements are intergrowned.

Data collection:

4 green sepals, 4 yellow petals, 4 stamens disposed 2 on a circle 4 on the next represents the manlike part of the flower , the gynoecium is inferior formed out of two intergrowned carpels is the feminine part of the flower.

Write the floral formula that in this case is:

$$\uparrow K_{2+2}\ C_{4}\ A_{2+4}\ G_{\underline{(2)}}$$

Interpreting the results:

In consequence of the realization of the floral formula at brassica napus has this zigmorfian asymmetry , hermaphroditic , the perianth formed from 4 green sepals disposed altern the flower.

Explanation and conclusions:

Brassica napus is a brienal species, dioic, the flowers are disposed in inflorescence named racem. In consequence of the fecundation it forms the milicv fruit with seeds rich in oil, used for the soap fabrication , margarine, motor oil, green forage for animals, for tuberosity roots.

References:

Botanic pupils books, Editura Corin, 2001 Baciu I.-Fiziologie, Editura Didactica si Pedagogica 1997,

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EXPERIMENT 18 FISH - WHITING

CHAPTER: Anatomy

PROPOSED BY: Colegiul National "*Simion Barnutiu*", Simleu Silvanei, ROMANIA

Theoretical aspects:

- the purpose of this experiment is to study the external morphology of fish;
- the relationship between the structure and the functions of the body in order to establish the stages of adaptation to the environment;

Different approaches:

a) students practice – 2 students work on one fish;
b) practical demonstration carried out by the teacher.

Materials, apparatus:

- Fresh fish – zander/pike-perch (Lucioperca sandra);
  - pike (Esox lucius);
  - barbel (Barbus barbus);
  - perch (Perca fluviatilis) or other species.
- Dissection tray, dissection case, corks, pins, glass plate, lens, cotton balls, gauze.

Experimental procedure – dissection:

1. Place the fish in a dissection tray with the ventral side upwards; fasten the fish under the swimmers/wings in pins using corks;

2.Using the tweezers catch the skin of the fish in front of the anus, make a transverse cut before the tweezers, then cut the side of the body on the median line up to the pectoral swimmers (wings); keep cutting it up to the pectoral cavity;
3. Take a look into the abdominal cavity; lift the gut/intestine with the tweezers and fasten it aside; you will notice the stomach which looks like a dilation of the anterior intestine and, as well, will see the liver deeply lobed.
4. Stretch the digestive tube outside the body and you can see the air bladder which has a hydrostatic function;
5. Lift the bladder and the genital organs and fasten them on each side of the body; below them you will observe the kidneys stuck on the spine; they look like two dark red stripes. On each side of the bladder you can notice the genital glands like oval sacks: the white-yellowish testicle and the grey-greenish ovaries through which you can see the roe;
6. If you want to see the gills make two cuts in the opercula region. Lift the operculum with the tweezers and you can see the gills which look like dark red brachial slides (Fig.2 The opening of the brachial cavity);
7. Cut a little piece from gills and place it in a glass plate which contains water and then take a look using the lens. What do you notice?

Explanation and conclusions:

In the brachial chamber only the first 4 pairs of brachial septa carry out gills. The gills are made of brachial slides and these are made of brachial lamella.

EXPERIMENT 19 DROSOPHILA GENETICS

CHAPTER: GENETICS

PROPOSED BY: C.S.G. „COMENIUS COLLEGE”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects: monohybrid (and dihybrid) crosses, F1, F2, Dominance, recessivity, sex linkage, Development of Drosophila (insect) from egg to adult, anatomy of insects

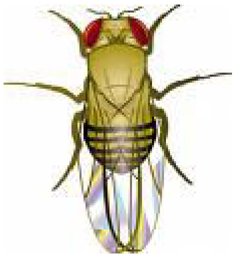
Different approaches:

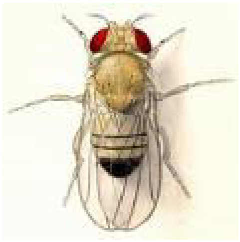
a. pupils practice: students work in pairs to carry out the experiments (the Comenius approach)
b. demonstration practice by the teacher

Level: gymnasium, atheneum, havo (aged 15,16,17)

Time: 3 lessons of 50 min.

Main question: What are the proportions of Drosophila varieties in F1 and F2 in some crosses. Is it “Mendel-like”?





Materials, methods

Preparations (by the teacher or technician)

You can order (by internet) different varieties of Drosophila melanogaster (fruit-fly)

1. You can use “wild” and “vestigial” (short wings) for the first round of 3 heredity practice lessons
2., In stead of these varieties or in addition to these varieties you can use “wild” and “red eye” (sex linked) or a dihybrid cross: “wild” x “ebony, vestigial” (dark, short wings).

4-5 weeks before the practice the teacher or technician (and perhaps the pupils) has to breed every variety from about 10 received Drosophila to about 200 Drosophila in different breeding-tubes.
Once in about 14 days you have to change the nurtrition/matrix: Drosophila instant medium.
You can breed in an incubator at 25 degrees Celsius.
Two weeks before the practice you have to start gathering virgins from the varieties for the intended cross: anaesthetize the Drosophila in the tube by ether and remove the adults.

The eggs, larvae (both in the matrix) and pupae (sticked to the glass) remain. Now you have to gather adults, fresh out of the pupae. Therefore, you take the adults max. every 8 hours out of the tube, because after 9-10 hour they begin to mate. Keep male and female fly's separate.
On a normal working day, the procedure is:
Early in the morning you gather the adults and dispose them. Then after 4-5 hours you gather the first virgins, and again after 4-5 hours you gather some virgins. So, after 1 – 2 weeks you have enough virgins to start the crosses.

Pupils practice

The pupils work in pairs. Each pair receives an empty breeding tube with matrix, an empty tube without matrix, two small brushes to move the Drosophila, an anaesthetizer (small milk-bottle with cotton wool and ether, funnel and sieve) and a pocket-lens.

Lesson 1
Each pair first receives an anaesthetized male and female out of the "wild"-tube.

- Make a drawing of one fly
- Make drawings of the differences between male and female Drosophila and notice them. NB: you have to recognize male/female without pocket-lens!

- Brush the fly's in the empty tube. The teacher is collecting them.

- Now you get from the teacher two virgins "wild" and two male Dros. "vestigial" or: Two virgins "vestigial" and two male Dros "wild"
- Notice the differences between "wild" and "vestigial"
- Brush them in the new tube with matrix and put a swab of cotton wool on top. Keep the new tube horizontal so that the anaesthetized flies can not stick in the matrix! Later, when they are lively, the tube is set vertically in the incubator (by the teacher). Notice on the tube: name, cross, date.
  NB: after 7 days, the parents are removed from the tube, so that mating with children is impossible. The first F1-Dros. are coming out of the pupae after 9-10 days. After 14 days there is an amount of 60-100 Drosophilas in the tube.

Lesson 2 – 14 days after lesson 1
You have received your cross-tube with flies and a new tube with matrix.
Now you can count the result of the cross P: wild x vestigial that means the F1

- To anaesthetize the fly's, you have to open the anaesthetizer, put the funnel on it, "knock" the fly's down in their tube, remove the cotton wool and knock the fly's (bottom up) in the funnel on the sieve. Don't let the fly's escape!
- Count and select the flies on sex and variety.
- Choose 3 male and 3 female Drosophila and brush them into the new tube.
- Write down your results on the blackboard
- Notice all class-results in your report.

NB: after 7 days, the new F1 parents are removed from the tube

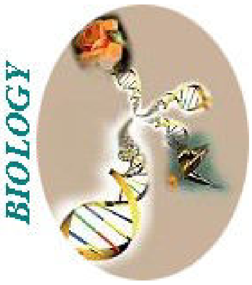
Lesson 3 – 28 days after lesson 1
You have received your second cross-tube: F1 x F1

- Count the results: F2, on sex and variety
- Brush them back in their tube
- Write down your results on the blackboard
- Notice all class results

Make a report of the total Drosophila-practice. (for the next week)

EXPERIMENT 20 DNA ISOLATION FROM KIWI FRUIT

CHAPTER: DNA, RNA



PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects:

- some motivation and illustration in a very abstract theoretical chapter
- properties of cell membrane, nucleus membrane and nucleus proteins some chemical aspects of DNA

Different approaches:

a. pupils practice: pupils work in pairs to carry out the experiments (the Comenius approach).
b. demonstration practice by the teacher

Level: gymnasium, atheneum, havo upperclasses (16, 17 years)

Time: 50 min.

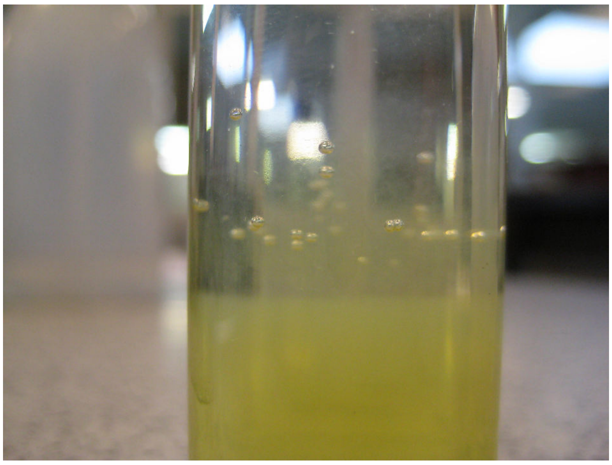
Materials, methods:

Each couple is receiving salt (NaCl), a 400-ml lab glass, a 250 ml lab glass, a measure cilinderglass – 10 ml, a wide test-tube (2 – 3 cm), shampoo, distilled water, kiwi fruit, mortar and pounder, a water bath – 60 degrees Celsius, paper filter, a 10 ml pipette, ice cold ethanol (at the beginning still in the freezer), a stopwatch or clock, a balance and a Pasteur – pipette.

1. First you put three grams of salt in the 400-ml lab glass and add 10 ml shampoo and 100 ml distilled water. Stir it all.
2. Then peel a kiwi fruit and cut it in little pieces. Pound it in your mortar.
3. Stir the pounded kiwi through the mixture of water, salt and shampoo.
4. Put the glass exactly 50 min. in the water bath – 60 degrees.
5. Filter the mixture through a paper filter and put the filtrate in a 250-ml lab glass: this is your extract.
6. Put 10 ml of the kiwi-extract in the wide test-tube.
7. Put 10 ml ice-cold ethanol from the freezer in the measuring cylinder.
8. Keep the tube tilt and – very carefully! – pour the ethanol on the extract. It is necessary that they don’t mixture.
9. Let the tube stand still for three min.
10. You wait till you see on the boundary plain between ethanol and extract a kind of gelatine with gass bells and white flakes. **This is DNA.** After a while the wad of DNA is lifted through the gass bells. You can keep it out of the tube with your Pasteur pipette.

Some questions:

1. Which cell particles are smashed in the mortar by nr 2?
2. Which cell particles are smashed by the shampoo?
3. Salt is altering the structure of proteins. What effect has salt on the chromosomes? (3)
4. In kiwi cells, there is a protein splitting enzyme that splits the chromosome proteins. Explain why it is important that the kiwi mixture is exactly 15 min. in a water bath of 60 degrees Celsius.
5. DNA is not split up by this water bath because it has a stable structure. Explain that stable structure of DNA.




250 ml
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± 0.5ml
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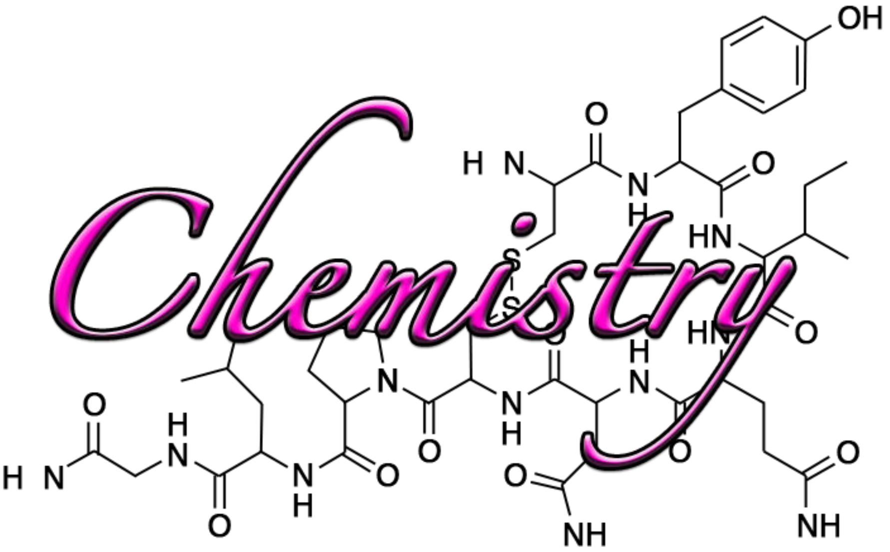
Chemistry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EXPERIMENT NR. 1

REACTION BETWEEN SULPHUR AND IRON

CHAPTER: Chemistry, constitution of the matter

PROPOSED BY: L.P. “La Closerie” St Quay-Portrieux, FRANCE

Theoretical aspects:

1) Show the difference between a mixture of two substances and the product obtained by chemical reaction of these two substances. (Difference between a physical phenomenon and a chemical phenomenon)
2) Check the mass is same as before

Materials, apparatus, chemicals:

- Iron filings
- Flowers of sulphur
- Scales
- Bunsen burner
- Magnet

Safety precautions:

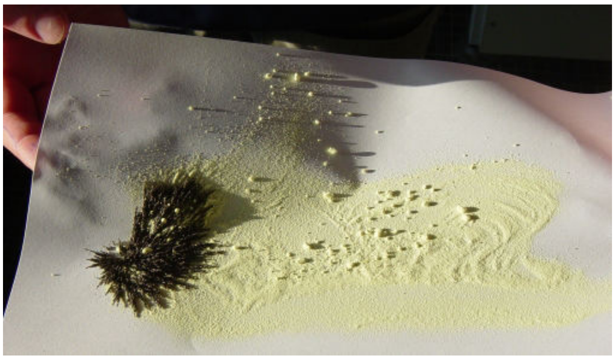
Not to breathe the vapors of combustion. A part of the used sulphur could be burned evolving SO_2 which is is an irritant gas, toxic in great concentrations in the air.

SO_2

Experimental procedure:

a) Using the scales measure 28 g iron and 16 g sulphur.
b) Carefully mix the two substances on a sheet of paper.
c) Place the magnet under the sheet of paper and to try to get the two substances separate.
d) Once again mix iron and sulphur in a cupel.
e) Light using the Bunsen burner.
f) Once the combustion is over and the product cooled, replace it on the sheet of paper and proceed to C again.
g) Determine the mass of the new product.

Sulphur mass (g)	Iron mass (g)	Mass of product (g)
8	14	



Interpreting the results

A chemical reaction radically changes the nature of the original substances (the new product has neither the same color, nor the same consistency and it is not magnetic any more.)

There is also the possibility of testing the effect of HCl on Fe, S and FeS.
Possible sources of mistakes:

1) purity of the substances.
2) inaccuracy of measures of mass.
3) oversight of the vapors of combustion (sulphur oxides) during measurements of masses.
4) necessity of having very fine filings to ensure a good combustion.

Explanation and conclusions:

S + Fe --> FeS

EXPERIMENT NR. 2

REACTION OF SODIUM WITH SULPHUR

CHAPTER: SODIUM - PROPERTIES

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU"; Şimleu Silvaniei, ROMANIA

Theoretical aspects:

Sodium is a very reactive metal. Studying the chemical properties of sodium we can illustrate by experiment its reaction with water, sulphuric acid, different nonmetals as chlorine, bromine, oxygen, sulphur, etc. Because it's a very reactive metal these reactions occur with great speed, some of them are explosive if great quantities of sodium are used. The reaction between sodium and sulphur is a redox reaction.

Different approaches:

No different approaches are taken in consideration during this experiment!!! It is a demonstrative experiment ilustrating the danger of different chemicals when people don't know the properties of the substances!

Materials, apparatus, chemicals:

Metallic sodium, sulphur, crucible, glass rod, source of heat, asbestos plate

Safety precautions:

The experience should carried out with great care in a hood. In the final phase stay at least at 1.5 m from the place of the reaction. Only small amounts of sodium should be used (not greater than a pea). After taking the sodium from its container put back the remained piece and close the lid. Petrol is volatile and flammable. Safety glases and leader gloves should be used. The evolved SO_2 gas is toxic and irritant. Avoid breathing in this gas. Metallic sodium is corrosive, never touch it and avoid its contact with water

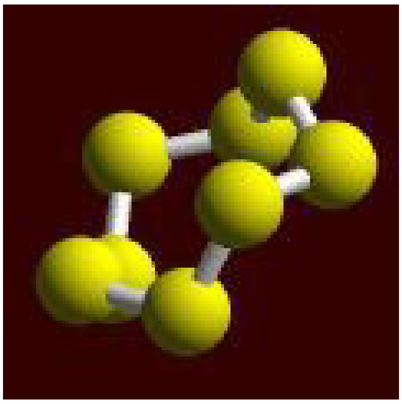
Na, SO_2

in reaction with water

evolved SO_2

Experimental procedure:

The experiment itself is very simple but due to the strong exotemicity of the reaction and to the toxicity of the side products this has to be done with great care. Take on a filter paper a small amount of sodium, not greater than a pie. Put away the container with sodium! Mix the taken sodium in a crucible with a pinch or two of sulphure. Put the mixture on an asbestos plate in a well-ventilated hood and heat it.



Individual tasks:

Observe the sodium during the heating process. Describe the reaction when this occurs. Explain the fume produced during the experiment. Write down the chemical reaction between the two elements and establish the coefficients by using the redox model and by considering the sulphur as a S8 molecule!

Explanation and conclusions:

In the begining we are able to see how sodium is melting and sulphur also start to melt. Once the reaction started this is very violent, having a great exotemicity. During the reaction sodium sulphure is produced. The reaction equation is the following.

$$16\ Na + S_8 \longrightarrow 8\ Na_2S$$

Because of the heat evolved a part of the sulphur is burning giving sulphur dioxide which appears as a fume. Because this gas is toxic and corrosive the reaction should take place in a well ventilated hood.

Being a redox reaction where the sodium acts as a reducing agent and the sulphur as an oxidizing agent this reaction is used in sodium/sulphure batteries to generate electricity.

Waste disposal:

The reaction product is treated with water in order to react all the remained sodium, then the solid could be disposed in a container for collecting less toxic solid waste or to the garbage.

References:

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2. http://en.wikipedia.org/wiki/Hazard_symbol
3. http://ull.chemistry.uakron.edu/erd/
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EXPERIMENT NR. 3
STATES OF MATTER, SOLUTIONS AND COLLOIDS

GENERAL AND INORGANIC REACTIONS

Proposed by: HTL-Dornbirn, AUSTRIA

CHEMISTRY

Theoretical aspects:

During the first lessons of chemical education students get to know the basic characteristics of the states of matter (solid, liquid and gaseous); they should learn to distinguish between elements, compounds and mixtures and recognize the differences between heterogeneous and homogenous materials consisting of one or more than one phase. Frequently, they are confused and mix up the different expressions, until they have been shown some impressive examples.

Different approaches:

The following consecutive series of experiments tries to show matter in different states and in different types of mixtures (solutions and colloids). It is suited for a repetition or exercise after having explained the basic expressions.

Materials, apparatus, chemicals:

Chemicals:

- Iodine (I_2)
- n-Pentane (Petroleum ether)
- Trichloromethane (chloroform)
- Detergent solution (for household cleaning purpose, e.g. dish wash)
- Tap water

Materials and apparatus:

- Reagent tubes with rubber stopper
- Bunsen burner
- Spatula
- 3 measuring pipettes (25 mL) with a … ball

Safety precautions:

Iodine is corrosive to skin and eyes. Trichloromethane is noxious to health. n-Pentane is flammable. Wear safety goggles and rubber gloves. When handling organic solvents, be sure that the Bunsen burner is turned off.

I_2

$CHCl_3$

n-Pentane

Waste disposal:

The remaining emulsion contains chlorinated solvent and has to be disposed separately (collection vessel for halogenated organic liquids).

Experimental procedure:

1. Put some Iodine in the reagent tube using the spatula, show the element in the solid state to the students.
2. Heat the reagent tube with caution on the Bunsen burner till violet vapor is set free, close the tube with the stopper. Show the students that only a gaseous state occurs, no liquid is observed (sublimation process). While cooling down, observe the resublimation process. Turn off the Bunsen burner.
3. Pour some milliliters of water in the tube, close with the stopper and shake. A small part of Iodine is dissolved in the water, forming a yellow solution, the greater part remains unsolved. Recognize the main attributes of this mixture (homogeneous mixture = solution, it may be colored, but must be clear!). Also observe the two phases (one solid phase = pure matter, one liquid phase = mixture of water and iodine).
4. With a pipette, transfer some milliliters of trichloromethane into the mixture, close the tube with the stopper, shake with caution and open the stopper for pressure adjustment. Observe the formation of two liquid phases (two solutions). Iodine is dissolved mainly in the organic phase (violet color).
5. With another pipette, transfer some milliliters of pentane to the surface of the water phase. A third liquid phase appears (sometimes remaining iodine is dissolved in this phase). Close the tube, shake with caution and open the stopper for pressure adjustment. Depending on the amount of pentane added, the third phase disappears partly or totally, because it is miscible with trichloromethane.
6. Add some drops of detergent solution to the mixture, close the tube, shake with caution and open the stopper for pressure adjustment. Now a colloidal mixture of all compounds may be observed (suspension and/or emulsion, a turbid instead of clear liquid!). After some moments, the phases separate again, depending on the amount of detergent added.

Sources of errors:

Do not shake the mixtures vigorously as the fugacity of the organic solvents may cause high pressure inside the closed tube.

References:

Joesten M.D., Wood J.L.: World of Chemistry, 2nd edition, Saunders College Publishing, 1996

EXPERIMENT NR. 5
THIN LAYER CHROMATOGRAPHY OF BALLPOINT AND FELT-TIPPED PEN INKS

GENERAL AND INORGANIC CHEMISTRY

CHEMISTRY

PROPOSED BY: HTL-Dornbirn, AUSTRIA

Theoretical aspects:

The original meaning of the expression “chromatography” is “writing with colors” (“chroma” and “graphein” are Greek words). Nowadays we define it as a separation process based on sorption, distribution and ion exchange processes. Thin layer chromatography (TLC) is a quite simple but very effective method for the separation of many chemical components – not only colored substances. The separation process is mainly influenced by three parameters: The sample compounds, the solvent and the sorption material. In TLC the sorption material consists of a layer of silica gel, alumina, cellulose, …(0,1 – 0,25 mm) fixed on a plate of glass, a foil of aluminium or polyester.

Different approaches:

The original meaning of the word “chromatography (writing with colors)” may be demonstrated in a short experiment, where a single dot is drawn with a black ball point pen in the middle of a circular filter paper. Then some drops of different liquids (water, ethanol …) are put slowly on this point, and the black color seems to “split” in different colors which run out with different speeds.

In this experiment ballpoint and felt-tipped pen inks are applied on a TLC plate, the compounds are separated by a solvent (mixture) in a separation chamber. After drying the chromatogram, running distances from the starting point are measured and the chromatographic retention factors are calculated.

Materials, apparatus, chemicals:

Chemicals:

- Trichloromethane (Chloroform)
- 2-Propanone (Acetone)
- 1-Butanol
- Concentrated Acetic acid, w=98-99 %

Materials and apparatus:

- Silica gel TLC foil, (e.g. POLYGRAM SIL G by Macherey-Nagel, Germany)
- Ball point pens and/or felt-tipped pens
- Separation chambers: Simple glass pots (250 mL) from the household (e.g. for storing jam) with screwing cap may be used
- Pasteur pipettes
- Exhausting chamber (if available)
- Measuring cylinders (25 mL)

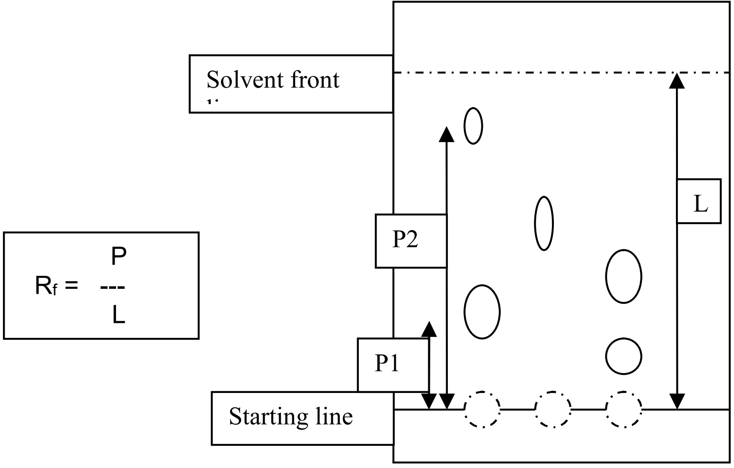
Note: Macherey-Nagel company (Düren, Germany) offers a “TLC micro set” for beginners, which contains all the materials for these any many other experiments (www.mn-net.com, approx. 200 €).

Safety precautions:

2-Propanone is highly inflammable and noxious to health. Trichloromethane and 1-Butanol are noxious to health. Concentrated Acetic acid (w=98-99 %) is very corrosive. Wear safety goggles and rubber gloves.

Experimental procedure:

- Cut out a rectangular piece from the TLC plate material (7 x 4 cm). Do not touch the separation layer with your fingers.
- With a pencil draw a starting line with 3 starting marks 1.5 cm from the short side of the plate (see figure below). Do not press the pencil with pressure on the plate, as this may destroy the layer.
- On each of the starting marks, draw a small dot with one of the pens or put a drop of a liquid ink using a Pasteur pipette. Let dry for some minutes.
- Put a mixture of Trichloromethane and 2-Propanone (1 + 1, v/v) in the separation chamber (height of liquid in the chamber: Not more than 1 cm). Close with the screwing cap. *Liquid inks may be separated by using a mixture of 1-Butanol/Conc. acetic acid/Water (12 + 3 + 5, v/v).*
- Put the plate in the chamber and close it. Do not move the chamber during the following separation process (10 min).
- Before the solvent front line has reached the top of the plate, stop the separation process by removing the plate from the chamber. With a pencil, draw a line on the plate where the solvent front line was detected.
- Let the chromatogram dry for some minutes (in an exhaustion chamber or at the open window).
- Calculate the "retention factors R_f" of each compound by measuring the "running distance" from the starting line to the middle of each coloured dot (distances *P1, P2, …*) and the distance from the starting line to the solvent front line (distance *L*):



Retention factor values are between 0 and 1 and may be used for describing the quality performance of the separation of compounds, independent of the size of the plate.

Waste disposal:

The content of the separation chamber is poured in a collecting vessel for halogenated organic solvents.

EXPERIMENT NR. 5B
CHOICE OF SEPARATION METHOD - COLORED SUBSTANCES THROUGH CHROMATOGRAPHY

CHAPTER: Purification procedures

PROPOSED BY: Liceo Socio- Psico - Pedagogico-Linguistico “Danilo Dolci”, Palermo, ITALY

Theoretical aspects:

Discussion of the theoretical aspects or if different approach is chosen presenting a problem to the students asking them to find a solution to solve the “problem”.
The chromatography is a technique used to separate the solutes in a solution. In this testing it is required to be able to choose, operating properly, the most suitable method to separate the components of some mixtures among the common use products.

Different approaches:

Giving the students some hints what approach could be used for the coming experimental session: in our case having an accurate choice method of separation. In the experiment is necessary to recognize the material intrinsic properties.

Materials, apparatus, chemicals:

-Equipment for filtration
-Various solvents and eluents such as distilled water, ethyl alcohol, acetone, ammonia, carbon tetrachloride.
-Filter paper
-Bunsen furnace with trivet and wire gauze
-black Bic, red Bic and blue Bic
-fountain pen inks
-Pelikan 4001 ink
-Filter paper to chromatography
-spinach green leaves
-pestle and mortar
-small tank or other material to chromatography
-acetone
-ethanol
-ligroin

Safety precautions:

Pay attention: lots solvents and eluents are inflammable and therefore if we use solvents and eluents different from water it is necessary to keep them far from the Bunsen furnace or other heating sources.

Experimental procedure:

According to the different approaches chosen by the group giving them some information about how should the students interfere with the materials and what ways should they take to reach the end point. It is proposed the experiment with three inks: black Bic, red Bic and blue Bic.
After having cut the filter paper according to the container dimension, with a pencil we draw a line to 2 cm from the edge. We mark on the line a point with the blue Bic ink, and repeat it with the red Bic and the blue inks in 2 different positions.

Individual tasks:

After having allowed drying the chromatogram to the air, we notice different gangs.

As eluent can also used a mixture of:

n-***butane : ethanol: ammonia to 3,5% m/m***

Relationship 60 20 20

The ammonia solution must be prepared by diluting 13,5 mL of NH_3 to 28% with water up to 100mL.

We repeat the experience with other types of ink.

Pour into the tube acetone till to a high of 1 cm from the bottom. Put the paper in a vertical position, close the container and wait that the acetone arrives to capillarity till to 2 cm from the higher bottom.
After having left to dry the chromatogram in the air, we notice different colored bands.

1. Tell the students what to do and how to collect the experimental data and where they should focus their attention.
2. Tell the students what to try to obtain letting them to do the experimental in their way.
3. Reproducing it artificially even more times and in different conditions the observed phenomenon, carrying out the appropriate measures.
4. If the analysis of the collected data with the experimentation allows to verify the started hypothesis.

Interpreting the results

We will let the students to write down their observations and make some conclusions after observing the events happened during the experiment.
In this way we are stimulated their ability of integrating information from different areas.
Interpreting which verifies the started hypothesis, at the end of the experience.
The students have interpreted the resoults and the whole procedure.

Explanation and conclusions:

This experience let to put into relation the theoretical knowledge obtained on the separation methods with operative results

References:

1. A. Paolo Pistarà; *Moduli di chimica ,laboratorio;* ED. Atlas; 2006

EXPERIMENT NR. 9

PREPARING A SALT BY USING SALT SOLUTIONS AND PRECIPITATION REACTIONS

CHAPTER: REACTIONS with SALT SOLUTIONS

PROPOSED BY: C.S.G. „COMENIUS COLLEGE"; CAPELLE A/D IJSSEL, THE NEDERLANDS

Theoretical aspects:

When you dissolve a salt in water you get two hydrated ions.
For example:

$$NaCl_{(s)} \rightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$$

When you mix two salt solutions there are the following possibilities for the ions.
1 - the four ions stay in solution (solution is clear) as hydrated ions
2 - two of the ions form a salt which is not soluble in water and the other two ions stay in solution (solution is not clear) as hydrated ions
3 - the four ions form two insoluble salts (solution is not clear).

To separate the salts in possibility 2 you use the methods of filtration (or centrifugation) and evaporation.

Different approaches:

This experiment can be by a single student or it can be done by a group of 2 or 3 students.
This experiment is carried out in the chemistry classroom

Materials, apparatus, chemicals:

- Test tubes
- A set of standard salt solutions 0,1 M.

Hints:
1 The student must take so much volume of the 0,1 M solutions that the proportion of the amount of the ions in mol are in accordance with the coefficients in the reaction equitation. <u>(If you don't know ask your teacher or the teaching assistant)</u>

2 The students should use a table in which they can read a salt is or is not soluble in water. (BINAS TB 45 A)

Safety precautions:

- Use a white laboratory coat
- Use a pair of safety glasses
- Long hair must be tied up

Experimental procedure:

- Add a solution of a lead salt to a solution of an iodide salt
- Take care that only one insoluble salt appears!!
  Salt solution 1 ....   Salt solution 2....................
- Describe what you see when you mix these two solutions
- Filtrate the suspension and dry the salt with the filter
- Evaporate (in the cupboard with a suction apparatus) the filtrate in a beaker glass. Do this with a small flame or with an electrical heating plate on a low level. When the water is evaporated the remains on the bottom of the beaker glass are the salt.

Before reaction

After reaction

Interpreting the results

Give a short description and explanation of what you see and what salts you have made in this experiment.

Explanation and conclusions:

- Give the reaction eqautation which takes place when you mix the solutions.
  Before reaction
  .... $_{(aq)}$ and .... $_{(aq)}$)
  Reaction equitation .... $_{(aq)}$ + ... $_{(aq)}$ → .... $_{(s)}$

- Give the reaction eqautation which takes place during the evaporation.
  Before evaporation
  .... $_{(aq)}$) and .... $_{(aq)}$)
  Reaction equitation .... $_{(aq)}$ + ... $_{(aq)}$ → .... $_{(s)}$

Waste disposal:

You should throw the solutions and the solid substances into the waste barrel for heavy metals.

References:

Pulsar Chemie HAVO Superstructure Part 1 Chapter 4 (especially paragraph 4) Wolters Noordhof Groningen ISBN 9001-31091-5

Pulsar Chemie HAVO Superstructure workbook Chapter 4 (especially instruction 34) Wolters Noordhof Groningen ISBN 9001-31092-3

EXPERIMENT NR. 10
THE HIGH REACTIVITY OF THE IONIC COMPOUNDS IN SOLUTIONS

PROPOSED BY: Liceo "D. Dolci", Palermo, ITALY

Theoretical aspects:

This experience is the result of the theoretical-practical experience of materia and its transformation. The students have got to a solution in a complete accord: solving the problem with a labs experience.

For instance making the reaction of $BaCl_2$ (barium chlorine) Na_2SO_4 (sodium sulphate) we can foresee a double exchange reaction: $BaSO_4$ (barium sulphate) and 2NaCl (sodium chlorine). This reaction takes place only at the status of reagents with the constitution of the white precipitate of BaSO4 (sulphate of barium) and not of NaCl because it is very soluble in the water.

Different approaches:

In the experiments it is necessary to recognize the mater intrinsic properties, in our case the ionic compounds.

For example the $LiNO_3$ nitrate of lithium is a ionic molecule, NH_4NO_3 has got the same properties. It is difficult the reaction of two ionic compounds at the solid status while it is possible in water solution, cations and anions can move freely. For this reason the cat ions of a compound can react with the anions of another one, originating a third solid compound which is not generally soluble in water where it deposits (precipitate)

Materials, apparatus, chemicals:

- distilled, water
- chloride of sodium and sulphate of sodium, solid
- solution of chloride of sodium 1 mole and sulphate of sodium, 1 mole , about ten ionic compounds.
- 2 glass sticks
- 7 droppers
- 1 spatula
- 10 test tubes with their containers

Safety precautions:

To realize this kind of experience it is necessary to know the objects and the labs materials which usually are in a laboratory, then it is good to pay attention at the way you move inside it, as there are some dangerous and fragile materials: For this reason you must pay more attention than in the classroom.

Experimental procedure:

In a small watch glass you mix chloride of sodium and sulphate of sodium, solid. You fill the test tube for a third of its capacity, with a water solution of barium chloride 1 M; you add some drops of a solution of sulphate of sodium. Each group work chooses 4 solutions of ionic compounds 1 M. The six hypothetical reactions of possible double exchange are written, you go ahead with the experimental tests, and you take note: in the positive cases you write the name of the compound which precipitates and the ions which provoked it.

Individual tasks:

The experimental method is based on labs activities, the first phase you point out the phenomenon you want to study, second phase you express a hypothesis, that is possible theories which explain the causes, the developments and the effects of the investigated phenomenon). Third phase which must be obtained with the experimental control, reproducing it artificially even more times and in different conditions the observed phenomenon, carrying out the appropriate measures Fourth phase, if the analysis of the collected data with the experimentation allows verifying the stated hypothesis

Interpreting the results

This way the students have interpreted the results and the whole procedure which verifies the starting hypothesis, at the end of the experience.

Explanation and conclusions:

Here is the pertinent answer which explains and closes the experiment:
a discussion is arranged in the classroom, to evaluate the achieved results of the various groups. It is evident that writing down the reactions is different from carrying them out

If the students have seen differences between the reactions at the solid status and at the solution status between barium chloride and sodium sulphate.
Which reactions at double exchange they have conjectured
Which reactions they have acted

References:

The students have been helped by Mr Alonzo, the don of the Agraria College of Palermo University. Thanks him we had the opportunity to see the experiment in every phase.

EXPERIMENT NR. 11
IDENTIFICATION OF DIFFERENT IONS BY PRECIPITATION REACTIONS

CHAPTER: The IONS

PROPOSED BY: L.P. “La Closerie” St Quay-Portrieux, FRANCE

Theoretical aspects / Problematics:

How would it be possible to check that a mineral water contains the ions indicated on the label?
When is it necessary to check the presence of certain ions in water? (possible pollution, swimming pool, limestone in water, ETC)

Different approaches:

A few tests of the presence of ions have been studied in theory before during lessons:
- color of the solution
- test with the flame
- test of presence of H^+ and OH^- by indicators or pH-meter.

Materials, apparatus, chemicals:

- Test tubes, pipettes and chemicals:
- Baryum Chloride
- Silver nitrate
- Ammonium oxalate
- Sodium hydroxide
- Zinc sulfate
- Calcium Sulfate
- Copper sulfate
- Sodium chloride
- Iron chloride
- Iron Sulfate

Safety precautions:

Precautions must be taken when using sodium hydroxide. It is a corrosive reagent which may produce severe burns and permanent eye damage. Avoid the skin and eye contact with these reagents. Wear protective glasses and gloves.

NaOH

Ba

Cu is harmful for the environment Ag solutions have anti microbial effect

Experimental procedure / Individual tasks:

Pour approximately 3 cm^3 of each solution to be analyzed (see table below) in a test tube
Add a few drops of reagent.
Do not stir!
Observe and supplement the table below:

Ion	Reagent	Observation
sulphate SO_4^{2-}	Baryum Chloride	White precipitate of Baryum Sulfate
Chloride Cl^-	Siver Nitrate	White precipitate of Silver Chloride
Calcium Ca^{2+}	Ammonium oxalate	White precipitate of Calcium Oxalate
Copper Cu^{2+}	Sodium Hydroxyde	Blue precipitate of Copper Hydroxyde
Iron II Fe^{2+}	Sodium Hydroxyde	Green precipitate of Iron II hydroxyde
Iron III Fe^{3+}	Sodium Hydroxyde	RustY precipitate of Iron III hydroxyde
Zinc ZN^{2+}	Sodium Hydroxyde	White precipitate of Zinc hydroxyde

Interpreting the results and conclusion:

The level chosen for this experimentation only allows qualitative analyses.
The white precipitates can be kept for 1 hour (even more) with an aim to showing to the students the specific blackening of the Silver Chloride.

EXPERIMENT NR. 12
RECOGNITION OF SOME IONS IN THE FLAME

CHAPTER: Chemistry, recognition of ions

PROPOSED BY: L.P. “La Closerie”; St Quay-Portrieux, FRANCE

Theoretical aspects:

Find a method of determining the presence of some metal ions, otherwise than by the traditional method of the precipitate.

Materials, apparatus, chemicals:

- Distilled water
- Sodium chloride
- Potassium hydroxide
- Lithium chloride
- Calcium chloride
- Copper sulfate
- Spray(s) for samples of perfume
- Bunsen burner

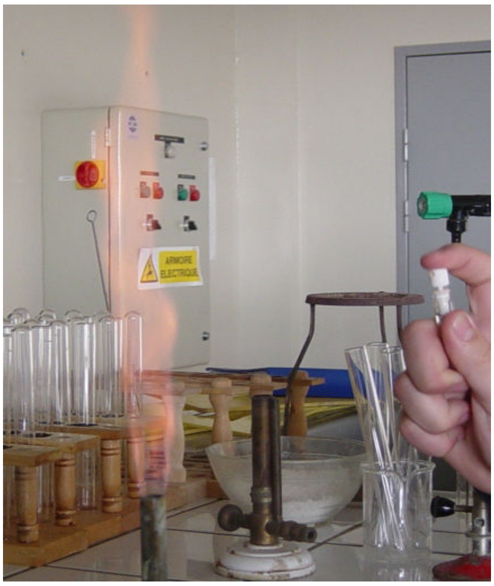
Safety precautions:

Not to be on the trajectory of the jet. Potassium hydroxide is extremely corrosive. Avoid the skin and eye contact with this reagent. Wear protective glasses and gloves.

KOH

Experimental procedure:

h) Prepare a solution of approximately 10^{-1} M of salt to be studied.
i) Take the spray apart and introduce approximately 2 ml into the tank.
j) Set back the spray and spray the solution at approximately 30 cm from the top of the flame..



Products	Color
Li^+	Bright red
Na^+	Yellow
Ca^{++}	Orange
K^+	Violet
Cu^{++}	Green

Interpreting the results

The spray needs to be perfectly cleaned, in particular after the use of NaCl. The burner must be adjusted to provide a rather high flame and a good combustion (“clear” flame)

EXPERIMENT NR. 14

REACTION OF Na WITH WATER

CHAPTER: METALS, SODIUM

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU" Şimleu Silvaniei, ROMANIA

Theoretical aspects:

Sodium is a very reactive metal. It reacts very easy with oxygen from the air, for that it must be kept under petroleum or under silicon oil. To demonstrate its great reactivity we are going to analyze the sodium-water system observing how these two substances are reacting together.

Materials, apparatus, chemicals:

Crystallizing dish, Funnel, Filter paper, Water, Sodium, Phenolphthalein

Safety precautions:

NaOH

Na

due to the evolved H_2

Do not touch Sodium with the hand. The crystallizing dish where the reaction with water takes place must be covered with a funnel. Do not use big pieces of Sodium (bigger than a pea size), a big piece of Sodium could lead to an explosion causing severe injuries!!! Wear protective gloves, a laboratory coat and safety glasses.

Experimental procedure:

Extract with the pincers a piece of Sodium from the bottle it is kept (under petroleum) and put it over the filter paper. Cut with a knife a small piece (a pea size) of Sodium.

Introduce the piece of Sodium into a crystallizing dish which contains water and 2 or 3 drops of phenolphthalein (alcoholic solution). What do you notice? Observe where the piece of Sodium is in the water system! What conclusions could you draw respective to the density of this metal. Observe the shape of the metallic piece before dropping in the water and during the reaction. Also observe what's happening with the metal during the reaction.

Interpreting the results:

Sodium reacts violently with water at room temperature. During the reaction a gas (hydrogen) is evolved.
The solution from the crystallizing dish becomes carmine red. The result is sodium hydroxide which has a pronounced basic character and gives the red colour of the acid base indicator.

$$2\,Na + 2\,H_2O \longrightarrow 2\,NaOH + H_2\uparrow$$

The reaction is strongly exothermic: The piece of sodium melts (melting point of sodium: 97.8 °C) and take a spherical form. If the piece of sodium used is big the heat transferred to the local environment ignites the hydrogen that is produced.

The hydrogen burns with a bright flame. ATTENTION!!! Special safety precautions have to be taken because the reaction could be violent and melted sodium or sodium hydroxide solution could be spread out of the crystallizing dish due to an explosion of the evolved hydrogen.

Explanation and conclusions:

The reaction is a good example to demonstrate the metallic character of the alkaline elements. Their reaction with water occurs rapidly in comparison with earth alkaline elements when the reaction is not so violent (see Mg in hot water). Iron requires 350°C to react with water while other metals are stable with water (Cu, Ag, Au, Hg, Pt …). This demonstrates that alkaline elements have the strongest metallic character in the Periodic System.

References:

1. Nenitescu, C.D.,*Chimie anorganica*, Ed Didactica si Pedagogica, Bucuresti,1966
2. http://en.wikipedia.org/wiki/Hazard_symbol
3. https://www.reagentworld.com/products/pro_detail.asp?

REACTION NR. 15

REACTION OF Na WITH H_2SO_4

CHAPTER: METALS, SODIUM

PROPOSED BY: COLEGIUL NATIONAL "Simion Bărnuţiu" Şimleu Silvaniei, ROMANIA

Theoretical aspects:

Sodium is a very reactive metal. It reacts very easy with oxygen from the air, for that it must be kept under petroleum or under silicon oil. To demonstrate its great reactivity, we are going to analyze the sodium-sulphuric acid system observing how these two substances are reacting together.

Materials, apparatus, chemicals:

Test tube, Clamps, Filter paper, Sodium, Concentrated sulphuric acid

Safety precautions:

H_2SO_4

Na

due to the evolved H_2

evolved SO_2

Do not touch sodium with the hand. The test tube has to be fixed with a clamp on a stand and if possible do the reaction in a ventilated hood. Do not use big pieces of Sodium (it has to be smaller than a pea size), a big piece of Sodium could lead to an explosion causing the spread out of the concentrated sulphuric acid and of the melted sodium causing severe injuries!!! Wear protective gloves, a laboratory coat and safety glasses.

Experimental procedure:

Extract with the pincers a piece of sodium from the bottle where it is kept (under petroleum) and dry it over a filter paper. Cut with a knife a small piece (smaller than a pea size) of sodium. Introduce the piece of sodium into a test tube fixed on a stand, test tube which contains 2-3 mL of concentrated sulphuric acid. What do you notice? Observe al the changes occurred during the reaction! What conclusions could you draw respective to the reactivity of this metal. Also observe what's happening with the metal during the reaction. Try to feel the smell after the reaction took place. What is this?!?!

Interpreting the results:

Sodium reacts violently with sulphuric acid at room temperature. During the reaction a gas (hydrogen) is evolved which ignites and often causes a small explosion in the test tube (see figure 2).

$$2\,Na + H_2SO_4 \longrightarrow Na_2SO_4 + H_2$$

During the reaction a white smoke could be observed. This is due to the evolution of the SO_2 from the sulphuric acid due to a parallel reaction where the sodium is oxidized by the acid transforming it in SO_2 and water (see figure 3).

$$2\,Na + 2\,H_2SO_4 \longrightarrow Na_2SO_4 + SO_2 + 2\,H_2O$$

Figure 1.

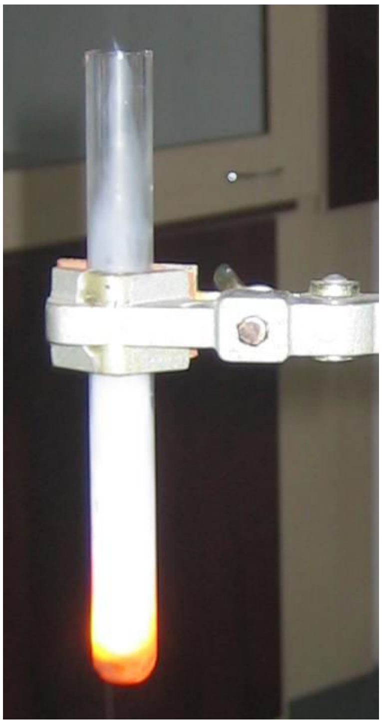


Figure 2.

Figure 3.

The reaction is strongly exothermic. The evolved heat is transforming the reaction zone in an incandescent space.

The hydrogen burns with a bright flame. ATTENTION!!! Special safety precautions have to be taken because the reaction could be violent and melted sodium or concentrated sulphuric acid solution could be spread out of the test tube due to the explosion of the evolved hydrogen.

Explanation and conclusions:

The reaction is a good example to demonstrate the metallic character of the alkaline elements. Their reaction with concentrated sulphuric acid occurs much rapidly in comparison with This demonstrates that alkaline elements have strong metallic character being oxidized by different proton donor substances.

References:

1. Nenitescu, C.D.,*Chimie anorganica*, Ed Didactica si Pedagogica, Bucuresti,1966
2. http://en.wikipedia.org/wiki/Hazard_symbol
3. https://www.reagentworld.com/products

EXPERIMENT NR. 16

COOLING MIXTURES – ENDOTHERMIC REACTIONS

CHAPTER: Thermodynamics

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU" Şimleu Silvaniei, ROMANIA

This experiment will give, the students, the opportunity to notice a typical endothermic reaction and make some thermodynamic calculations on the given process.

Theoretical aspects:

Studying thermodynamics in school there is a part when students are asked to give examples of reactions whose thermal effect is obvious. Generally, many examples are given but most of them are exothermic reactions. This is of course normal because in an exothermic reaction the products are more stable than the reagents. Chemical reactions which occur with heat absorption are much rare BUT NOT UNCOMMON. The following experimental session will demonstrate how effective could be, in cooling, an endothermic reaction.

Materials, apparatus, chemicals:

Erlenmeyer flask; Ammonium thiocyanate, Barium hydroxide, Hydrochloric acid solution. Thermometer.

Safety precautions:

$Ba(OH)_2$, NH_3

NH_4SCN, HCl

Barium compounds are toxic. The barium hydroxide and hydrochloric acid is corrosive. Potassium thiocyanate is harmful. Because NH_3 is evolving use a well ventilated hood. Wear protective gloves, a laboratory coat and safety glasses.

Experimental procedure:

Weight 2 g of barium hydroxide octahydrate and 4 grams of ammonium isothiocyanate in two separate beakers (fig 1). Pour the content of a beaker in the other beaker; insert the sensor of the thermometer while carefully mixing the two solids. Put the beaker on a wet wooden plate and wait for a while (fig.2).

Read the temperature shown by the thermometer –you will notice this is dropping fast. When you notice the temperature dropped enough and it's in the negative zone (measuring on Celsius scale) raise the beaker. You will notice that the wooden plate is frozen on the bottom of the beaker due to the sudden drop of the temperature (fig. 3).

Figure 1

Figure 2

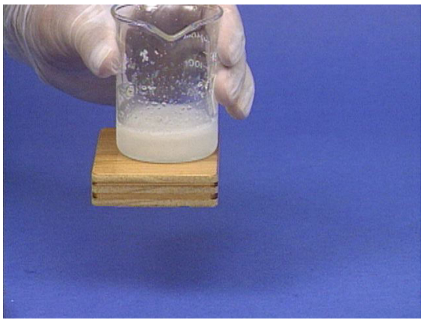


Figure 3

Interpreting the results:

The chemical reaction could be written as follows:

$Ba(OH)_2$ *$8H_2O$ + $2NH_4SCN$ → $Ba(SCN)_2$ + $2NH_3$ + $10H_2O$

The reaction is generally occurring with any ammonium salt but it's most spectacular with ammonium isothiocyanate. Try to do this mixing barium hydroxide with ammonium chloride! The reaction will be:

$Ba(OH)_2$ *$8H_2O$ + $2NH_4Cl$ → $BaCl_2$ + $2NH_3$ + $10H_2O$

The evolved ammonia gas could be identified by its pungent odor, by a reaction colour with litmus paper or by keeping at the beaker an open glass with concentrated solution of hydrochloric acid. The solid ammonium chloride is formed in a form of a fume over the reaction zone.

Explanation and conclusions:

The standard enthalpy of formation for $Ba(OH)_2$ □$8H_2O$ is very low**:** $H_f^\circ = –3345\ kJ\ mol^{–1}$ while for the products it's much higher: (H_f° H_2O = $–286\ kJ\ mol^{–1}$ and $H_f^\circ NH_3$ is $-46\ kJ\ mol^{–1}$) This gives a positive balance of the thermodynamic reaction. Also during the reaction, a gas (NH_3) and a liquid (H_2O) is formed which also requires energy from outside to take place.

Absorbing energy from outside the surrounding temperature is dropping and due to the fact that the beaker is on a wet wooden plate this energy absorption will determine the freezing of the water this keeping together the plate and the beaker.

Waste disposal:

The barium salt has to be collected in a tank for toxic inorganic salts. Transforming the barium salt in a less soluble one, by reacting it with Na_2SO_4 is a good, environment protecting, solution.

References:

1. Nenitescu, C.D.,*Chimie anorganica*, Ed Didactica si Pedagogica, Bucuresti,1966
2. http://en.wikipedia.org/wiki/Hazard_symbol
3. https://www.reagentworld.com/products/pro_detail.asp?
4. http://jchemed.chem.wisc.edu/JCESoft/CCA/CCA3/MAIN/ENDO2/PAGE1.HTM

EXPERIMENT NR. 17
THE USE OF NITRATE AND NITRITE INDICATING STRIPS

CHAPTER: Water

PROPOSED: Colegiul National "Simion Barnutiu", Şimleu Silvaniei, ROMANIA

Theoretical aspects:

Nitrates form when microorganisms break down fertilizers, decaying plants, manures or other organic residues. Usually plants take up these nitrates, but sometimes rain or irrigation water can leach them into groundwater. Although nitrate occurs naturally in some groundwater, in most cases higher levels are thought to result from human activities. Common sources of nitrate include:

- fertilizers and manure,
- animal feedlots,
- municipal wastewater and sludge,
- septic systems, and
- N-fixation from atmosphere by legumes, bacteria and lightning.

Romania is a country where many water sources are rich in nitrates. This is one of the reasons why the population is using more and more water from commercial sources. But there are still a great number of people who are using for cooking water from their own sources (families and even larger communities in rural or small urban areas). But unfortunately, many fountains have a high level of nitrates (which should be under 45 mg/L). According to some research done in this field entire regions could be found where the nitrate content is 5 times even 10 times more than the allowed level. Some water sources contain even nitrite ions whereas their presence is not allowed in drinking water. The presence of nitrate ions is not necessarily due to the wrong use of fertilizers, but it's a consequence of the chemical composition of the soil and other layers above the soil. So, against this we could not fight in order to lower the content in these ions! We could only take care not to use for drinking or cooking those sources which are contaminated. There is a general tendency to have the deep waters rich in nitrates so these sources should be first avoided.

Due to these conclusions, there is important to raise knowledge among the students in upper secondary classes concerning the quality of the drinking water, concerning the risk of using contaminated water and how this could be avoided. It's very illustrative when a group of students are taking with them samples of the water they are using home and after analyzing it in a 30 second experiment they have quantitative results about its quality.

The method could be extended to the analysis of different vegetables being well-known the extensive use of fertilizers to grow lettuce, tomatoes, cucumbers and other vegetables in green houses in outer season.

Materials, apparatus, chemicals:

- Different water samples
- Nitrate or nitrate/nitrit test strips
- Different vegetables (tomatoes, cucumber, salad etc.)

Safety precautions:

No safety precautions should be taken in consideration as the work is done with normal water samples or vegetable slices and color test strips. Depending on the indicator used to make the strips some of them should be kept in a cool place (in fridge under 8°C) so it's important not to forget them in laboratory after doing the experiments!

Experimental procedure:

The use of the test strips is very simple. They have to be immersed in the water samples and to compare their color with the scale. Also moisten with vegetable fruits they can provide information about their nitrate content.

Interpreting the results

The absence of the color indicates no nitrate content. This content could be accepted up to 45 mg/L. Above this level the water is not suitable for drinking.

The nitrite content should be zero with negative coloring reaction.

The nitrite content of vegetables is regulated by European Commission Regulation No. 563/2002 which establish a maximum content of nitrate ions in lettuce up to 4500mg/kg or in spinach up to 3000mg/kg depending on the time of harvest and the place where cultivated.

Explanations and conclusions:

High nitrate levels in water can cause methemoglobinemia or blue baby syndrome, a condition found especially in infants under six months. The stomach acid of an infant is not as strong as in older children and adults. This causes an increase in bacteria that can readily convert nitrate to nitrite (NO_2). Do not let infants drink water that exceeds 45 mg/l NO_3. This includes formula preparation.

Nitrite is absorbed in the blood, and hemoglobin (the oxygen-carrying component of blood) is converted to methemoglobin. Methemoglobin does not carry oxygen efficiently. This results in a reduced oxygen supply to vital tissues such as the brain. Methemoglobin in infant blood cannot change back to hemoglobin, which normally occurs in adults. Severe methemoglobinemia can result in brain damage and death.

Healthy adults can consume fairly large amounts of nitrate with few known health effects. In fact, most of the nitrate we consume is from our diets, particularly from raw or cooked vegetables. This nitrate is readily absorbed and excreted in the urine. However, prolonged intake of high levels of nitrate is linked to gastric problems due to the formations of nitrosamines. N-nitrosamine compounds have been shown to cause cancer in test animals. Studies of people exposed to high levels of nitrate or nitrite have not provided convincing evidence of an increased risk of cancer.

References:

1. Nenitescu, C.D.,*Chimie anorganica*, Ed Didactica si Pedagogica, Bucuresti,1966
2. http://www.ext.colostate.edu/PUBS/crops/00517.html

EXPERIMENT NR. 18
REACTION RATE, INFLUENCE OF CONCENTRATION ON THE REACTION BETWEEN H_2SO_4 AND $Na_2S_2O_3$

CHAPTER: REACTION RATE

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU" Şimleu Silvaniei, ROMANIA

The purpose of this experiment is to determine the influence of the reagent's concentration on the rate equation for the reaction between sodium thiosulphate and sulphuric acid.

Theoretical aspects:

The rate of a reaction is the speed at which a reaction happens. The rate of change in the concentrations of the reactants and products can be used to characterize the rate of a chemical reaction. If a reaction has a low rate, that means the molecules combine at a slower speed than a reaction with a high rate. Some reactions take hundreds, maybe even thousands of years while other can happen in less than one second. The rate of reaction depends on the type of molecules that are combining. Reactions happen, no matter what. Chemicals are always combining or breaking down. The reactions happen over and over but not always at the same speed. A few things affect the overall speed of the reaction and the number of collisions that can occur.

Concentration: If there is more of a substance in a system, there is a greater chance that molecules will collide and speed up the rate of the reaction. If there is less of something, there will be fewer collisions and the reaction will probably happen at a slower speed.

Temperature: When you raise the temperature of a system, the molecules bounce around a lot more (because they have more energy). When they bounce around more, they are more likely to collide. That fact means they are also more likely to combine. When you lower the temperature, the molecules are slower and collide less. That temperature drop lowers the rate of the reaction.

Pressure: Pressure affects the rate of reaction, especially when you look at gases. When you increase the pressure, the molecules have less space in which they can move. That greater concentration of molecules increases the number of collisions. When you decrease the pressure, molecules don't hit each other as often. The lower pressure decreases the rate of reaction.

Different approaches:

For determining the influence of the concentration on the reaction rate we may lead the discussion in two directions:
1. The concentration of a reagent or a reaction product is instantly measured during a reaction, several times and the reaction rate is calculated as $v=\Delta C/\Delta t$ where C is the concentration and t is the time elapsed between two measurements. 2. We start a reaction measuring the time until a change could be observed in the medium. This change could be associated to a certain level of concentration and thus used to stop the measured time and express the reaction rate in function of this visualized change.

Materials, apparatus, chemicals:

Test tubes, solutions of concentrated H_2SO_4 *and* $Na_2S_2O_3$ (aprox. 2-4%), stop clock, pipettes

Safety precautions:

Great attention has to be given to the concentrated sulphuric acid solution due to its corrosive properties even with the biological tissues and on different surfaces. If sulphuric acid is dropping on the skin wash with lots of water, several minutes, eventually use an alkaline creme to protect the skin.
The reaction generates SO_2 which is an irritant gas, toxic in great concentrations in the air. This is one of the reasons why we use only diluted solutions of thiosulphate.

H_2SO_4, SO_2

Experimental procedure:

The intention of the procedure is to determine the reaction rate. This could be done in different ways according to the approach used. **Measuring the reaction rate means measuring the variation of the concentration of a component from the reaction**. If we use the classical approach we look for the moment when sulphur synthesized during the reaction reach a certain concentration which determine the reaction medium to become milky than opaque with a cream color. By determining the moment when the liquid in the test tube is becoming opaque, that means we are not able to see through the test tube the water drops which are on the opposite side of the tube we can very exactly determine the moment when a certain concentration of sulphur is reached. We don't know which this concentration is, but we do know every time we start from zero and we reach always the same value, that means the difference of the two concentrations is the same and the rate of the reaction will be only in function of the time needed to reach that status

Individual tasks:

Make a solution of thiosulphate by measuring 2-3 grams of $Na_2S_2O_3$ and dissolve this in 100ml of water. Take a sample of 10 ml put it in a test tube which is wet outside. Take another test tube and measure 4 ml of H_2SO_4 50%. Pour rapidly the acid in the first tube and measure the time until you are not able to see the water drops on the exterior of the tube. This moment will be the final moment of the time measuring. Note the time in a table. Concentrations may be adjusted in order to have longer of shorter time of reaching the required sulphur concentration. Previous attempts have to be done by the teacher.

In the next steps do the same with a mixture of the previous solution of thiosulphate obtained and distilled water. Always the amount of the thiosulphate solution has to be 10 ml!!! That means the next experiment will contain 9 ml of the basic solution of $Na_2S_2O_3$ and 1 ml of water, the third 8 ml $Na_2S_2O_3$ and and 2 ml of water and so on... Observe the time needed to reach the standard point. Note all the data in the next table.

Please notice that the same experiment could be done by using a standard solution of $Na_2S_2O_3$ varying the concentration of the H_2SO_4 taking always in account that identical volumes of solutions should be used

Interpreting the results

The reaction could be represented as following!

$$Na_2S_2O_3 + H_2SO_4 \longrightarrow Na_2SO_4 + SO_2 + S + H_2O$$

If we use different starting concentrations we will have different times in which the opaque suspension is obtained. Note all the experimentl data and the measured times in the following table.

ml H_2SO_4	**ml $Na_2S_2O_3$**	**ml H_2O**	**Total volume (V)**	**ml $Na_2S_2O_3$/V**	**Time elapsed (t)**	**v=k*1/t**

Represent graphicaly the dependence of the reaction rate with the concentration!

As the concentration decreases, the time needed to reach the same amount of the sulphur in suspension is .... That means diluting a solution will lead to a .... reaction rate. This means the reaction rate is .... with the concentration of the reagents. Try the same series of experiments with different starting concentrations, varying both concentrations of the reagents! Establish the coefficients of the chemical reaction using the *redox method!*

Explanation and conclusions:

This is a redox reaction which starts from two different colorless solutions because both reagents are water soluble and gives a suspension because the generated sulphur is not water soluble generating thus a white colored suspension. The reaction rate is not very high so in the first moments of the reaction we are not able to see the change in the solution. After a few seconds, or dozens of seconds the sulphur concentration reaches a value which is observable the suspension being milky than opaque. The moment when the solution is opaque could be very simple determined by observation. By observing the same change for different reactions we can consider the reaction rate only in function of the time elapsed to reach the certain concentration.

The reaction can be made using hydrochloric acid instead of sulphuric acid

Waste disposal:

The solution is poured down the drain after checking its pH and eventually neutralized with diluted NaOH solution.

References:

http://www.chem4kids.com/files/react_rates.html
http://www.york.ac.uk/org/seg/salters/chemistry/ResourceSheets/thiosulphate_acid.PDF
http://en.wikipedia.org/wiki/Hazard_symbol

EXPERIMENT NR. 23

CATALYTIC DECOMPOSITION OF HYDROGEN PEROXYDE

CHAPTER: REACTION RATE

PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU" Şimleu Silvaniei, ROMANIA

The purpose of this experiment is to illustrate the influence of different catalyst on the rate of different reactions observed in the laboratory. Apart of the acquainting students with different reaction systems they will be asked to show the usefulness of these reactions and their applications in every day life.

Theoretical aspects:

Catalytic reactions occurs everyday around us. Not all are observable but their importance is crucial. Most of the chemical processes which occur in living systems are catalysed. A catalyst is a substance which could lower the activation energy of a chemical process, leading thus to a higher reaction rate. This is specific for every chemical system; one catalyst could be very active in a system and completely inactive in a different system. In this experimental session the decomposition of the hydrogen peroxide is studied in different catalytic environments. Comparison between different catalytic effectiveness is done.

Materials, apparatus, chemicals:

100 mL Erlenmeyer flask, 250mL measuring cylinder, H_2O_2 solution (30%), $FeCl_3$ solution (30%), MnO_2, blood

Safety precautions:

Manganese oxide is harmful. Iron trichloride is corrosive. Hydrogen peroxide is extremely oxidising and corrosive. Avoid the skin and eye contact with these reagents. Wear protective glasses and gloves. When the reaction is done with blood special safety precautions should be taken in order to avoid contamination and it's advisable not to use human blood.

MnO_2,

H_2O_2 solution

H_2O_2 and $FeCl_3$

Experimental procedure:

In a 100 mL Erlenmeyer flask pour 10 mL of hydrogen peroxide solution (30%) and add a small amount (a pince) of MnO_2. Observe the changes and measure the reaction time.

The same amount of hydrogen peroxide poured in another 100 mL Erlenmeyer flask is treated with a drop or two of $FeCl_3$ solution (5%). Measure the time and observe all the phases of the reaction.

The third experiment will be done in a high measuring cylinder where over 10 mL of hydrogen peroxide solution (30%) you will add a few mL of beef or pork blood.

Do the same experiment with Fe_2O_3 and note all your observations.

Individual tasks:

Write down all the observations made during the process in the correlation with the changes observed during the addition of different substances in the concentrated hydrogen peroxide solution. Try to write down the equations of the chemical reactions. Complete the following table with the observations done.

Reagent added	**Changes observed**	**Time of the reaction (in sec.)**
H_2O_2		
H_2O_2 and $FeCl_3$		
H_2O_2 and MnO_2		
H_2O_2 and blood		
H_2O_2 and Fe_2O_3		

Interpreting the results

We observe different catalytic systems and their actions to the same reagent –the hydrogen peroxide-. This substance is rapidly decomposing in the presence of MnO_2. The decomposition reaction is exothermic and due to its great reaction rate suddenly a great quantity of heat is evolved which vaporize a certain amount of water which can be seen as a fume column above the Erlenmeyer flask (see fig.1).

When hydrogen peroxide decomposition is catalyzed by $FeCl_3$ it needs and induction time than suddenly it's decomposing very fast, forming yellowish foam which is so abundant than it's coming out from the flask. The same observation could be observed concerning the exothermicity. The reaction rate is not that big as for the MnO_2 system therefore no water vapors are formed (see fig. 2).

With blood abundant foam is formed due to the proteic organic content of the blood. The enzymes from the blood are catalyzing the decomposition reaction, oxygen is evolved and the protein from the blood is denaturated which gives the abundant foam coming out from the measuring cylinder.

Waste disposal:

The iron chloride solutions and the manganese dioxide suspension have to be collected in a tank for less toxic inorganic salts. The foam emerged from the reaction of the blood with the hydrogen peroxide could be poured down the drain.

References:

1. Fatu S., Costin C., Toescu A., *Manual de Chimie pentru clasa a XII a*, Ed. Didactica si Pedagogica, Bucuresti,1998
2. http://en.wikipedia.org/wiki/Hazard_symbol
3. https://www.reagentworld.com/products/

EXPERIMENT NR. 23

AUTOCATALITIC REACTION – OXIDATION OF Na,K TARTRATE WITH HYDROGEN PEROXYDE Co catalysed

CHAPTER: REACTION RATE

PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU" Şimleu Silvaniei, ROMANIA

The purpose of this experiment is to illustrate the influence of different catalyst on the rate of different reactions observed in the laboratory. Apart of the acquainting students with different reaction systems they will be asked to show the usefulness of these reactions and their applications in every day life.

Theoretical aspects:

Catalytic reactions occur everyday around us. Not all are observable but their importance is crucial. Most of the chemical processes which occur in living systems are catalysed. A catalyst is a substance which could lower the activation energy of a chemical process, leading thus to a higher reaction rate. This is specific for every chemical system; one catalyst could be very active in a system and completely inactive in a different system. In this experimental session, a study of the Seignette salt decomposition will be conducted using hydrogen peroxide solutions in the presence of the cobalt salts.

Materials, apparatus, chemicals:

Beaker, Na, K tartrate solution 10% (Seignette salt), H_2O_2 solution (5%), $CoCl_2$ solution (1%)

Safety precautions:

Cobalt salts are toxic and dangerous for the environment. Hydrogen peroxide is extremely oxidising. Avoid the skin and eye contact with these reagents. Wear protective glasses and gloves.

$CoCl_2$,

H_2O_2 solution

Experimental procedure:

Put in a beaker 12mL of Na,K tartrate solution 10% ($KNaC_4H_4O_6.4H_2O$) and heat it to 70°C. Add 8mL of H_2O_2 solution (5%). Observe what is happening in the system. Add a few drops of $CoCl_2$ solution (1%) and observe the changes. Pay attention to the color changes and observe the intensity of the gas evolved during the reaction.

Individual tasks:

Write down all the observations made during the process in the correlation with the color changes. Try to write down the equation of the chemical reaction and establish its coefficients. Observe the role of the Co (II) ions and the change of its oxidation status during the reaction.

Interpreting the results

When no cobalt(II) ion is added, the reaction proceeds slowly, we are able to see some gas evolution from the oxidizing reaction of the Seignette salt by the hydrogen peroxide, but the rate gradually increases after adding a few drops of pink $CoCl_2$ solution which is acting as a catalyst. The CO_2 evolution is now faster. Because the H_2O_2 is oxidizing de Co(II) ions in Co(III) the solution becomes green and the CO_2 production is increasing dramatically due to the higher catalytic action of the Co(III) ions to the system. After the Seignette salt is completely oxidized and the hydrogen peroxide is consumed the color of the solution turns from green back to pink as the Co(III) is reducing to Co(II).

Waste disposal:

The cobalt chloride solutions have to be collected in a tank for toxic inorganic salts.

References:

1. Fatu S., Costin C., Toescu A., *Manual de Chimie pentru clasa a XII a*, Ed. Didactica si Pedagogica, Bucuresti,1998
2. http://en.wikipedia.org/wiki/Hazard_symbol
3. https://www.reagentworld.com/products/

EXPERMENT NR. 26

ELECTROLYSIS OF $CuSO_4$ WITH C ELECTRODES

CHAPTER: Chemistry, constitution of the matter.

PROPOSED BY: L.P. “La Closerie” St Quay-Portrieux, FRANCE

Theoretical aspects:

We search to observe the transformation of a pure substance -Copper sulphate- in a water solution into new products. (Observing differences between pure simple substances and pure complex substances).

This experiment can be undertaken in complement of the electrolysis of water. The interest of sulphate is to reveal copper which is an easy metal to recognize..

Materials, apparatus, chemicals:

- Copper sulphate in a water solution
- Generator 12 V.DC
- Electrolyser with carbon electrodes..

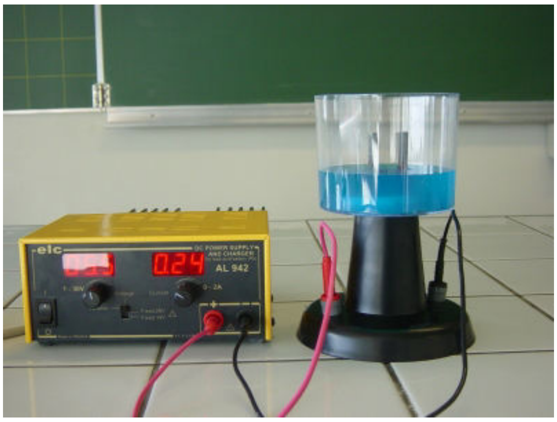
Safety precautions:

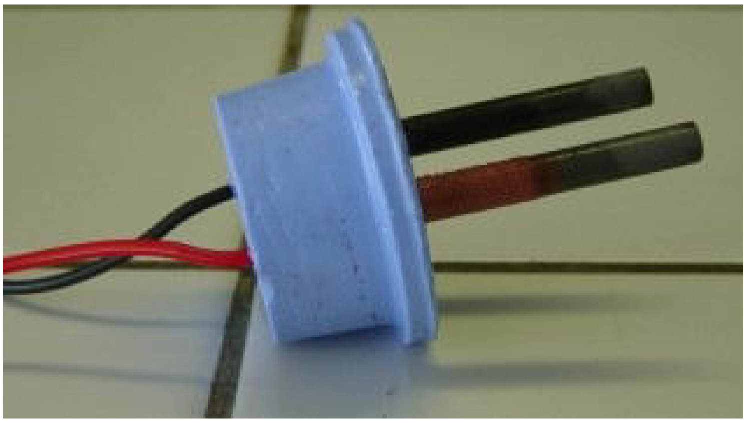
No particular danger other than that related to the use of a generator supplied with 220V. Copper sulphate is harmful when swallowed, it is corrosive and the contact with iron object has to be avoided. Avoid the skin and eye contact with these reagents. Wear protective glasses and gloves.

$CuSO_4$

Experimental procedure:

k) Draw the diagram of the experiment then check it.
l) Prepare the experience and check
m) Switch off and leave for a few minutes. (An electrolyser will be left connected during one day with the aim to recover the copper deposited on the electrode)





Interpreting the results

The electric current reduces the Cu^{2+} of the CuSO4 and reveals one of its components (Cu)

$Cu^{++} + 2e^{-} \rightarrow Cu$

By stabilizing the intensity with 250 mA, one obtains about 590 mg of Cu per hour i.e. 14.1 g of copper in one day. (250 x 64 x 3.600 / 96.500).
One can also plan to recover the gas which is released on the other electrode but this is of little interest in this experiment.

Sources of possible mistakes:

It is difficult to recover Copper accurately by scraping.
It is difficult to keep electric current stable during one whole day…

EXPERIMENT NR. 27

ELECTROLYSIS OF KI WITH PHENOLPHTHALEIN AND STARCH

CHAPTER: Redox reaction -Electrolysis

PROPOSED: COLEGIUL NATIONAL SIMION BARNUTIU, Şimleu Silvaniei, ROMANIA

Theoretical aspects:

Transformation of a pure substance -Potassium iodine- in a water solution into new products. This experiment can be undertaken in complement of the electrolysis of water. The interest of potassium iodine is to reveal iodine and hydrogen.

Materials, apparatus, chemicals:

- Potassium iodine in a water solution
- Generator 12 V
- Electrolyser with carbon electrodes
- U shaped tube
- Phenolphthalein
- Starch

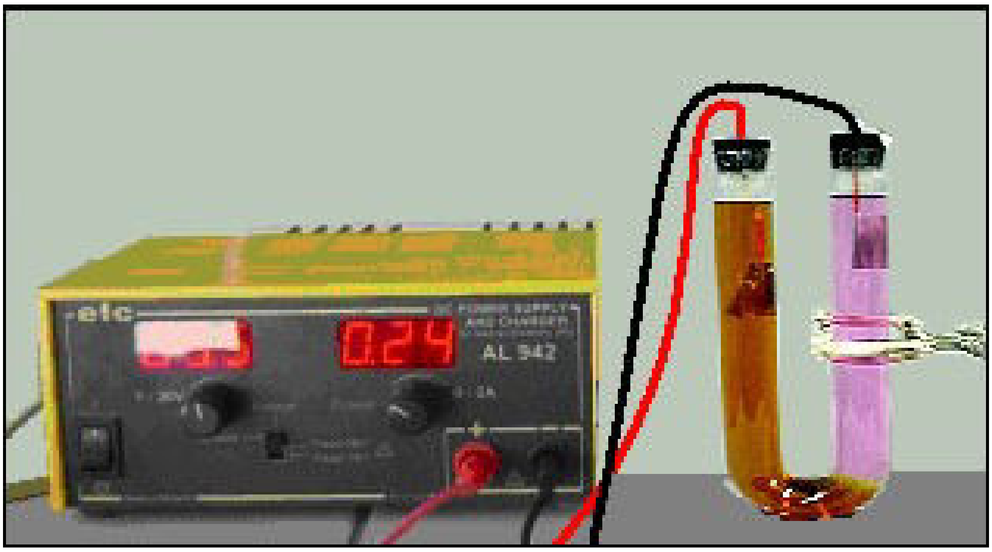
Safety precautions:

General safety rules have to be applied when using the generator supplied with 220 V. Precaution when manipulating the chemical glassware. Potassium iodide is an irritant substance. It has to be kept in a well-ventilated place and away from incompatible substances.

KI

Experimental procedure:

Realize a montage like the one in the picture below.
Introduce a potassium iodine solution in the U-shaped tube.
Add a few phenolphthalein drops in the cathodic space and some starch solution in the anodic space.
Switch on and leave the montage for a few minutes.
Extract with the pipette approximately 1 mL solution from the anodic space and drop it into a test tube which contains 1 mL chlorophorm. Stir the test tube. What do you notice?



Interpreting the results

In the cathodic space phenolphthalein turns to red color due to the presence of an alkali.
In the anodic space the solution becomes brown due to the formed iodine. If starch solution is added in this area the medium turns in black or in blue-green depending to the concentration of the starch solution.
In the initial solution there are the following species: K^+, I^- , H_2O
Chemical reactions that take place at the electrodes:

$$(+)\ 2\ I \longrightarrow I_2 + 2\ e^- \qquad \varepsilon^0_{ox} = -0{,}54\ V$$

$$(-)\ 2\ H_2O + 2\ e^- \longrightarrow H_2 + 2\ HO^- \qquad \varepsilon^0_{red} = 1{,}23\ V$$

The global reaction is:

$$2\ KI + 2\ H_2O \xrightarrow{\text{electrolysis}} I_2 + H_2 + 2\ KOH$$

Explanations and conclusions:

From the electrolysis of Potassium iodine solution we obtain iodine, hydrogen and Potassium hydroxide.

Iodine results at the anode and can be extracted with the aid of chlorophorm. Its color in this solvent is brown.

Hydrogen results at the cathode. Potassium and hydroxide ions from the solution form Potassium hydroxide (a very powerful base) which turn phenolphthalein (the acid base indicator) to a red color.

References:

1. Nenitescu, C.D., *Chimie anorganica*, Ed Didactica si Pedagogica, Bucuresti,1966

EXPERIMENT NR. 32

BURNING METAL POWDERS IN FLAME

CHAPTER: General chemistry

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU" Şimleu Silvaniei, ROMANIA

Theoretical aspects:

The metallic character is determined (by comparison) by the students after they are able to write down the electronic structure of the row1 – row3 elements. One of the consequence of learning the structure of the electronic shell is to compare different properties of two elements based on the electronic structure (volume, ionization energy, chemical and electrochemical character, possible oxidation states, electro negativity, etc). Semi quantitative determinations of the metallic character could be done by observing the behavior of the metal powders in flame. As the sparks are more abundant and more luminescent we can say the metallic character is more evident.

Materials, apparatus, chemicals:

Bunsen burner or another open fire device, metallic powers (Fe, Mg, Al, Cu, Zn), spatula

Safety precautions:

Mg powder

Precautions have to be taken when operating with the magnesium powder which is extremely reactive. Don’t use large quantities of this metal, don’t look straight in the burning zone and keep closed the flask containing this metal. Wear protective gloves, a laboratory coat and safety glasses.

Experimental procedure:

Take on a spatula a small quantity of the following metallic powders: Zn, Fe, Mg, Cu, Al and pour it slightly over an open flame. Observe the behavior of each metal in the flame and write down your observations in Table 1. Take care when reacting the Mg! Only small quantities should be used!

Figure 1 Cu in flame

Figure 2 Fe in flame

Figure 3 Zn in flame

Interpreting the results:

Complete the following table marking all the observations done during the experiment:

Nr.	Metal	Experimental observations	Conclusions
	Mg		
	Fe		
	Cu		
	Zn		
	Al		

The reactions which occur in flame are simple oxidation reaction induced by the high temperature and helped by the small size of the metallic powder.

$4 Fe + 3 O_2 \rightarrow 2 Fe_2O_3$ $2 Zn + O_2 \rightarrow 2 ZnO$ $2 Cu + O_2 \rightarrow 2 CuO$

When reacting the Mg powder with oxygen, due to its great reaction capacity, the burning is very fast giving an intense light. This reaction was used in the past as a flash for taking photos is a low luminosity media.

Analyzing the aspect of the sparks we can conclude that the metallic character is as higher as the luminosity of the sparks is bigger. In the case of the five metals used the metallic character is decreasing in the order: Mg > Al > Zn > Fe > Cu

Waste disposal:

The metal oxides could be collected as a solid powder and disposed in the household waste..

References:

1. http://en.wikipedia.org/wiki/Hazard_symbol

EXPERIMENT NR. 33

TITRATION OF AN IRON(II) SOLUTION WITH POTASSIUM PERMANGANATE SOLUTION

CHAPTERS:

- HOW MUCH MATTER

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ";CAPELLE A/D IJSSEL, THE NETHERLANDS

Research Question:

Examine the percentage of iron (II) sulfate in “pesticide against moss”.

pesticide against moss

green in the garden

If your grass in your garden has much moss you can fight it by using a pesticide against moss.

Theoretical aspects:

The working substance in this pesticide is:” Iron(II)sulfate”.
For this examination you do a quantitative analysis. You use the oxidizer potassium permanganate in an acid solution.
The permanganate ion reacts as an oxidator with the half reaction:
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$
The iron(II) ion in iron(II)sulphate reacts as a reducing agent with the half reaction:
$Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$

Different approaches:

A

You must buy the pesticide at a centre where they sell all kinds of products you can use for the wellness of your garden.
If you can’t find this product you can use “***MOHR’S salt*** “ with the formula $(NH_4)_2FeSO_4.7H_2O$ for the practical experiment

B

This experiment is done by a titration. We have chosen for the method “titration by weight” Then you need a hypodermic syringe to add the permanganate solution. It is also possible to add the permanganate solution by means of a burette.

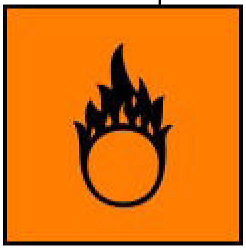
Materials, apparatus, chemicals:

Balance
Hypodermic syringe or burette
Distilled water
Beaker
Magnetic stirring apparatus
Magnetic flea

Pesticide against moss or ***MOHR’S salt*** with the formula $(NH_4)_2FeSO_4.7H_2O$.

Sulfuric Acid   1 M

Potassium permanganate   0,050 M (precisely known in 3 decimals)



Safety precautions:

- Use a white laboratory coat
- Use a pair of safety glasses
- Long hair must be tied up

Experimental procedure:

Weigh in a beaker 1,5 g pesticide against moss or 0,5 g Mohr’s salt. The quantity must be known in 3 decimals. Add approximately 20 ml of distilled water and 10 ml of 1 M sulfuric acid and dissolve the pesticide or the Mohr’s salt. Fill an injection syringe with a volume of 10 mL with 0,050 M potassium permanganate solution. Weigh this filled injection syringe.

Drop under continuous stirring so much of the potassium permanganate solution in the beaker till the solution in the beaker at once gets a light pink colour. This colour must stay for 10 seconds. When you have reached this light pink color you again weigh the injection syringe with the permanganate solution.

This experimental procedure is carried out three times.

For the density of the potassium permanganate solution you take 1,000 g mL^{-1} so that you can write that amount in grams is equal to the amount in ml.

Measure Results:

A

	Exp. 1	Exp. 2	Exp. 3
Beaker with pesticide or salt	………g	………g	……….g
Beaker empty	………g	………g	……….g
	----------	----------	-----------
Mass of pesticide or salt	………g	……….g	………..g

B

	Exp. 1	Exp. 2	Exp. 3
Injection syringe at the beginning	……….g	………g	……….g
Injection syringe at the end	………g	………g	……….g
	----------	----------	-----------
Mass of added $KMnO_4$ solution	………g	……….g	………..g

Interpreting the results

To calculate the percentage of iron(II)sulfate it is necessary to look at:

1. The total reaction equation
2. The rate at which mol iron(II) ions and mol potassium permanganate ions react with each other.

The steps you have to make are:
g MnO_4^- → mL MnO_4^- → mol MnO_4^- → mol Fe^{2+} → mol $FeSO_4$ → g $FeSO_4$ → % $FeSO_4$

Give for the three experiments an average value for the percentage of FeSO4.

Explanation and conclusions:

Compare the percentage of $FeSO_4$ you find by experimenting with the given percentage of the pesticide against moss (or with the theoretical percentage of $FeSO_4$ in Mohr's salt).
Give a conclusion for your experiment after the comparison.

Waste disposal:

The solutions must be disposed of in the waste barrel for heavy metals.

References:

Pulsar Chemie HAVO Superstructure Part 2 Chapter 8 and 9 (especially page 48)
Wolters Noordhof Groningen; ISBN 9001-31150-4

Pulsar Chemie HAVO Work out book part 2 Chapter 9 (especially page 28) Wolters Noordhof Groningen; ISBN 9001-31152-0

www.tuinkrant.com

EXPERIMENT NR. 33

POLAR AND APOLAR MATERIALS (most solvents)

CHAPTER: WATER

PROPOSED BY: C.S.G. „Comenius College ”; CAPELLE A/D IJSSEL, THE NEDERLANDS

Research Question:

To find out if polar and a-polar materials can dissolve (mix) together.

Theoretical aspects:

There are three kinds of molecular substances.

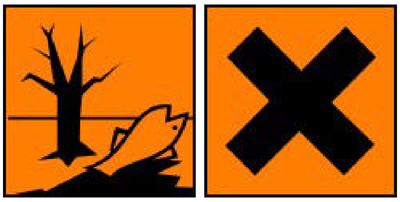
- **Category A**: Polar substances with molecules which can form together “hydrogen bridges”. These molecules contain OH or NH groups.
- **Category B:** A-polar substances with molecules which cannot form together “hydrogen bridges”. Between these molecules you have only the “van der Waals or molecular forces”.
- **Category C**: Substances with molecules which have a polar part which can form “hydrogen bridges” and an a-polar part where only work the “van der Waals or molecular forces”.

In this experiment we use all the three described substances.

Materials, apparatus, chemicals:

Test tubes
Marker
Distilled water
Methanol, Hexane, 1-Pentanol, Paraffin oil

Iodine



Safety precautions:

- Use a white laboratory coat
- Use a pair of safety glasses
- Long hair must be tied up

Experimental procedure:

PART 1

Fill 4 test tubes for a 1/4 part with the solvent distilled water. Mark with a marker the level of the water in these test tubes.

Add to the first test tube the same amount methanol, to the second test tube the same amount 1-pentanol, to the third test tube the same amount paraffin oil and to the fourth test tube a grain of iodine.

Shake the test tubes and look if the substances dissolve in (mix with) the water.

If you see a troubled solution or if you see two liquid layers the substance does not dissolve or mix. Look also if the marked line on the test tube is on the place of the dividing line of the two liquids.

PART 2

Repeat this experiment with hexane as solvent instead of water.

The results:

Put the observations of your experiments in the table

Solvent	Methanol	Paraffin oil	1-Pentanol	Iodine
Water				
Hexane				

Use for the solubility (mixing) the words: “good, moderate or bad”.

Interpreting the results

Here you have to divide the substances you have used in the three kinds of molecular substances mentioned under theoretical aspects.

Explanation and conclusions:

Try with the observations and the way you divide the substances to give, with a motivation, answer on the following questions:

- Can you mix polar substances?
- Can you mica polar substances?
- Describe when a substance, which contain polar and a-polar properties, mix with respectively a polar solvent and with an a-polar solvent.

Waste disposal:

The used materials must be disposed in the waste barrel for organic materials.

References:

1. Pulsar Chemie HAVO Superstructure Part 1 Chapter 6 Wolters Noordhof GroningenISBN 9001-31091-5

2. Pulsar Chemie HAVO Superstructure workbook Chapter 6 Wolters Noordhof Groningen ISBN 9001-31092-3

EXPERIMENT NR. 36

THE INFLUENCE OF SOLVENTS ON THE COLOR OF IONS

CHAPTER: WATER

PROPOSED BY: C.S.G. „Comenius College ”;CAPELLE A/D IJSSEL, THE NETHERLANDS

Research Question:

Does a solvent give a color to different ions solubilised in them?!?

Theoretical aspects:

When you can dissolve a salt in a solvent the salt will be divided in his positive and negative ions. The molecules of the solvent surround the ions in the solution. In some cases the solution is colored by the surrounded ions.

Materials, apparatus, chemicals:

Clean and dry test tubes; Copper(II)chloride; Cobalt(II)chloride; Calcium chloride; Distilled water; Ethanol

Cu, Co salts

Ethanol

Safety precautions:

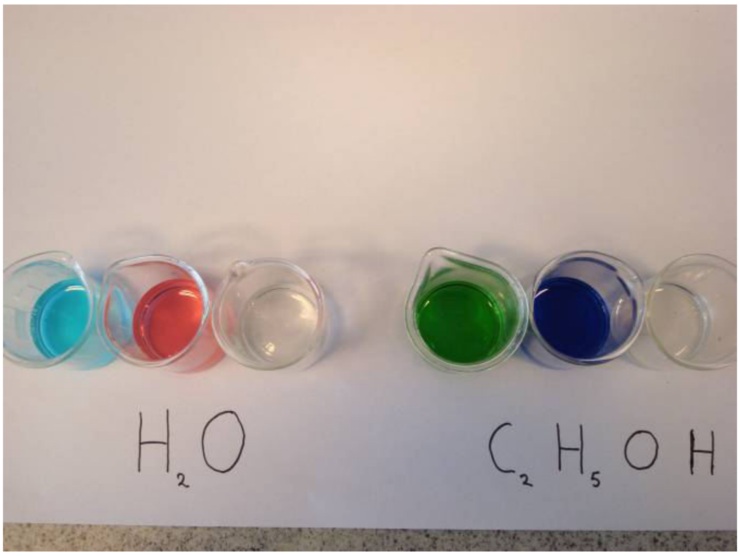
- Use a white laboratory coat
- Use a pair of safety glasses
- Long hair must be tied up

Experimental procedure:

- 1 Put in a test tube **(A)** 3 ml distilled water. Dissolve in this water a spatula point copper(II)chloride.
- 2 Put in a test tube**(B)** 3 ml ethanol. Dissolve in this ethanol a spatula point copper(II)chloride.
- 3 Pour half of the ethanol solution in another test tube **(C)** and add some drops of distilled water to this solution.
- **4** Notice the colors of the solution in the test tubes **A, B and C.**

Repeat the experiment (1 t/m 4) but now with the salt cobalt(II)chloride. After working with cobalt(II)chloride do the experiment again but then you use calcium chloride.

Photo Cu^{2+}, Co^{2+} and Ca^{2+} in water and ethanol!!!



The results

Write in the table the colors of the solutions of the three experiments.

Salt	Water	Ethanol	Ethanol + drops water
Copper(II)chloride			
Cobalt(II)chloride			
Calciumchloride			

Interpreting the results

Fill in the table:

Salt	Formula of the ions in water	Color of the water solution	Color of the ethanol solution
Copper(II)chloride			
Cobalt(II)chloride			
Calciumchloride			

Derivate from this table which ion causes the color in the solution with respectively water and ethanol as solvent.

Explanation and conclusions:

1. Give an explanation for the difference in color when we work with water and with ethanol. Use by the explanation a picture in which you show the ion (formula and charge) surrounded by one or two molecules of the solvent.
2. Also give an explanation for the change in color you see when you add some drops of water to the ethanol solution.

Waste disposal:

The used materials must be disposed in the waste barrel for heavy metals.

References:

1. Pulsar Chemie HAVO Superstructure Part 1 Chapter 6 Wolters Noordhof Groningen ISBN 9001-31091-5
2. Pulsar Chemie HAVO Superstructure workbook Chapter 6 Wolters Noordhof Groningen ISBN 9001-31092-3

EXPERIMENT NR. 36

ORGANIC ANALYSIS – LASSAIGNE REACTION

CHAPTER: Organic chemistry

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU" Şimleu Silvaniei, ROMANIA

The following experimental procedure is one of the first experiments done in the chemistry laboratory when starting the study of the organic chemistry. The aim of this experiment is to demonstrate the presence of N, S and X (halogens) in an organic substance. In the following experimental sheet the Lassaigne reaction is described using as principle the mineralization of the organic substance with sodium.

Theoretical aspects:

The organogene elements could be identified via color reactions following specific procedures. There are several procedures for identifying the halogens or the nitrogen element, also for carbon but not all of them are obvious or simple enough in order to be used by upper secondary students. Mineralization with sodium of an organic substance containing N (nitrogen), S (sulphur) and X (halogen) is leading to the formation of NaCN, Na_2S and NaX which are recognizable using specific reagents. The NaCN will be identified as iron hexacyanoferrate (III) giving a specific blue coloration or even blue precipitate known as Berlin blue. The ionic sulphure formed is identified by using soluble lead compounds when a black coloration or precipitate is formed. The halogens are precipitated using silver nitrate preceded by the acidification of the solution in order to eliminate the S^{2-} and CN^- ions.

Materials, apparatus, chemicals:

Bunsen burner, 25 and 50 mL beakers, small test tube, funnel, filter paper, distilled water, Sodium, $FeSO_4$, $FeCl_3$, HNO_3 cc., $AgNO_3$, $Pb(NO_3)_2$,

Safety precautions:

Na, HNO_3,

$Pb(NO_3)_2$

$FeSO_4$, $FeCl_3$

$AgNO_3$,

Soluble lead compounds are toxic. The sodium and concentrated nitric acid are corrosive. The iron salts are harmful. Silver nitrate is dangerous for the environment due to its microbial effect. During the reaction smoke is evolved therefore the use of a well ventilated hood is advised. Wear protective gloves, a laboratory coat and safety glasses.

Experimental procedure:

An organic substance (aprox. 0,2 g) containing halogen, nitrogen and sulphur is put in a small test tube together with a pea size piece of sodium. The mixture is heated on an open flame, the sodium melts and is reacting violently with the organic compound. If it's difficult to find a compound which contains all three elements (N, S and X halogen) a mixture could be used. Bring to red the test tube with the remains of the reaction mixture and immerge it in a beaker containing 20-30 mL of distilled water. The glass is broken and the content will be dissolved in water. Filter the solution from the burned rests and from the broken glass and split it in three parts:

Part 1. Nitrogen identification: Add a drop of a diluted solution of $FeSO_4$ (or just a tiny crystal) and then add a drop of a diluted solution of $FeCl_3$. If the original substance was containing nitrogen the solution will be colored in blue.

Part 2. Sulphur identification: Add a few drops of lead nitrate solution. If the original substance contains sulphur a black color or precipitate is formed.

Part 3. Halogen identification: Add a small amount of concentrated nitric acid to the solution and boil it. Then add a drop of silver nitrate solution. If the original substance contains halogen white or yellowish precipitate is formed.

Interpreting the results:

The nitrogen and the carbon of the analyzed substance form cyanide, during the mineralization with sodium. This reacts with the iron (II) sulphate generating a complex $Na_4[Fe(CN)_6]$ which is a yellow substance and not easily identified in water solutions. Adding a few drops of iron (III) solution a specific cyan color appears, called Berlin blue, characteristic for the iron (III) salt of the complex: $Fe_4[Fe(CN)_6]_3$.
$Na + \text{organic (C,N)} \rightarrow NaCN$
$6NaCN + FeSO_4 \rightarrow Na_4[Fe(CN)_6] + Na_2SO_4$
$3Na_4[Fe(CN)_6] + 4FeCl_3 \rightarrow \mathbf{Fe_4[Fe(CN)_6]_3} + 12NaCl$

The sulphur of the organic substance forms sodium sulphure Na_2S. Reacting with lead ions the S^{2-} ions form a black precipitate
$Na + \text{organic (C,S)} \rightarrow NaS$
$Na_2S + Pb(NO_3)_2 \rightarrow \mathbf{PbS} + 2NaNO_3$

The concentrated nitric acid added to the solution is necessary in order to avoid false reactions due to the presence of NaCN and Na_2S. These salts are transformed in volatile acids with HNO_3 so they are eliminated by boiling the solution. Halogeno ions are not forming their acids during the acidification with nitric acid so they are identifiable with silver nitrate solution.
$Na + \text{organic (C,X)} \rightarrow NaX$
$NaX + AgNO_3 \rightarrow \mathbf{AgX} + NaNO_3$

An aglomerated white preicitate is due to the presence of chlorine ions. A crem precipitate demonstrates the presence of bromine while a fine yellowish precipitate indicates the presence of the iodine in the original substance

Waste disposal:

The silver containing solutions are collected in a special tank used for collecting silver rests. The other solutions due to the presence of lead and cyanide have to be collected in a tank for toxic compounds.

References:

1. S Fatu and Co; *Manual de chimie clasa a X-a,* EDP Bucuresti, 1999
2. http://en.wikipedia.org/wiki/Hazard_symbol
3. https://www.reagentworld.com/products/pro_detail.asp?

EXPERIMENT NR. 37

TO PROVE OUT AND DETERMINE THE GRADE OF CRYSTALWATER IN A HYDRATE

CHAPTER: WATER.

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ” CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects:

When a salt crystallizes from a salt solution, the water molecules can be built in the crystalgrate of the salt under certain circumstances. This water has been built in as „crystal water” and the salt is called „a hydrate”.
In this experiment we use: Sodium carbonate. decahydrate – Na_2CO_3. 10 H_2O.

Sodiumcarbonate. decahydrate – Na_2CO_3. 10 H_2O

Different approaches:

- **These experiments can be carried out by a group of at least two students.**
- **The qualitative experiment is done with several groups in a chemistry class room**
- **The quantitative experiment is done in the school laboratory under the supervision of the teaching assistant.**

Materials, apparatus, chemicals:

<u>Qualitative experiment</u>

- **blue copper sulphate and crystal soda (Na_2CO_3. 10 H_2O)**

- **a flow-over tube with a cork**

- porcelain bowl
- some new test-tubes
- gas burner

Quantitative experiment

- crystal soda ($Na_2CO_3 . 10\ H_2O$)

- dry new test-tubes
- gas burner
- balance

Safety precautions:

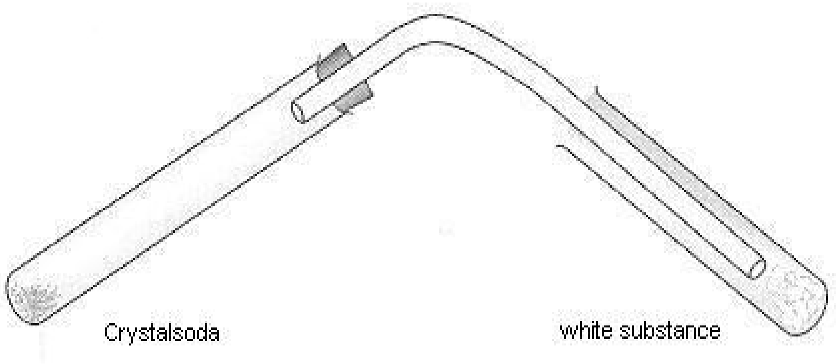
- Use a white laboratory coat
- Use a pair of safety glasses
- Long hair must be tied up

Experimental procedure:

The student(s) should first carry out the qualitative and afterwards the quantitative experiment.

Qualitative experiment:

- Heat a little spoon blue copper sulphate in a porcelain bowl till there is no change. Use a small blue flame.
- Let the white solid substance which is exist cool down
- Divide the white substance over two dry and clean test-tubes.
- Add a drop of water to the first test-tube. Feel the outside bottom of the test-tube.
- Heat a little spoon of crystal soda in a clean and dry test-tube. Close this test-tube with a flow-over tube and let this flow-over tube in the small tube with the white solid substance. (see the image)



Quantitative experiment:

- Weigh the mass of a dry test-tube
- Put a spoon of crystal soda in the dry test-tube and weigh the mass again (The test-tube must be filled for 20 %)

- **Warm the dry test-tube filled with crystal soda. If the contents of the test-tube are liquid you must continue the heating. Use a hot blue flame then. Continue heating till there is no change more.**
- **Let the test-tube cool down. Weigh the test-tube with the dry substance after cooling.**
- **Write all the weighed mass in the table under „Interpreting the results”.**

Interpreting the results

Qualitative experiment:

Describe what you have observed and explain what happens during the experiments

Quantitative experiment:

- **Describe your observations en explain what happens.**
- **Table with mass:**

Mass test tube .... g
Mass test tube with crystal soda .... g
Mass crystal soda .... g

Mass test tube after heating .... g
Mass substance after heating .... g

Mass crystal soda - mass substance after heating :........... ... g

Explanation and conclusions:

Qualitative Experiment:

- **What is the difference between the blue and white copper sulphate.**
- **Give the reaction equitation of the heating of the blue copper sulfate.**
- **Which substance can you prove with the white copper sulphate.**
- **What is the substance which comes out of the over-flow tube when you heat the crystal soda? Explain your conclusion.**

Quantitative experiment:

- **By heating the crystal soda the solid substance becomes liquid first. Give an explanation why the substance becomes liquid.**
- **Calculate the mass percentage crystal water in the crystal soda with the mass, you have noticed in the table during the experiment**
- **Compare the percentage of crystal water you have calculated with the theoretical percentage of crystal water which followed from the formula of the crystal soda.**
- **If there is a difference between these two percentages try to give an explanation for this difference.**

Waste disposal:

The copper sulfate must be disposed of in the waste barrel for heavy metals. The crystal soda can be flushed down the sink.

References:

Pulsar Chemie HAVO Superstructure Part 1 Chapter 6 (especially paragraph 4) Wolters Noordhof Groningen ISBN 9001-31091-5

Pulsar Chemie HAVO Superstructure workbook Chapter 6 (especially instruction 37 and 42) Wolters Noordhof Groningen ISBN 9001-31092-3

EXPERIMENT NR. 39
PREPARATION OF DIFFERENT SOLUTIONS HAVING AN ACCURATE CONCENTRATION

CHAPTER: SOLUTIONS

PROPOSED BY: Liceo “D. Dolci“; Palermo, ITALY

Theoretical aspects:

In the first part of this experiment you have to prepare a solution with molar concentration. You start with a commercial solution whose percentage concentration in weigh and density are known. In the second part, you have to check if the solution has been prepared with care; in fact you can deduce the solution’s molar concentration through the value of its density.

Different approaches:

In the experiments it is important to consider the inner properties of materia. In our case solutions having an accurate concentration .

Materials, apparatus, chemicals:

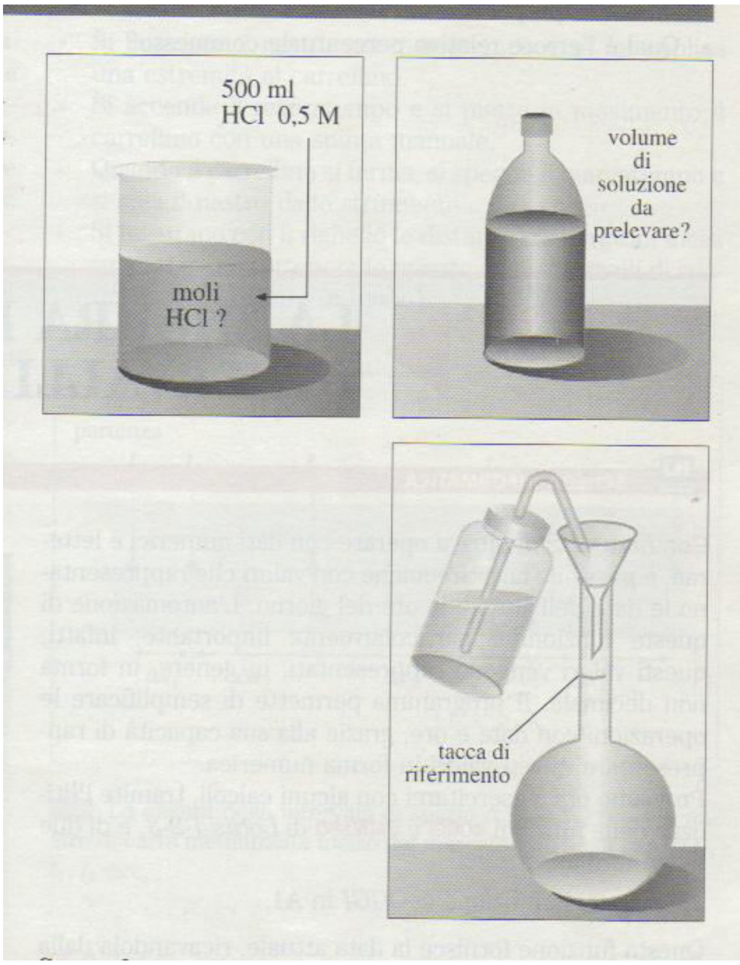
- concentrated hydrochloric acid (HCl)
- a 500 mL volumetric flask
- distilled water
- a spray
- a funnel
- a pipette or graduated cylinder
- a stactometer
- 2 100 mL beakers
- a burette or a densitometer

Experimental procedure:

Part 1: the molar concentration of the concentrated solution of HCl is determined. the data about its percentage concentration in weigh, and its density are indicated on the containing bottle label. Since our aim is the preparation of 500ml of a substance 0,5 M, we calculate the moles of HCl, necessary to the preparation of the final solution. (Picture up on the left). The moles are extracted from the concentrated solution of HCl. Therefore, since its molar concentration has been determined, we calculate the volume of the concentrated solution of HCl we need to extract (picture up on the right). Once we know that value, we pass to the practical phase, pouring little more than 300mL of distilled water into the volumetric flask (picture below)

We extract, through a pipette, the necessary concentrated solution of HCl, which is poured into the volumetric flask. We pour some more distilled water into the volumetric flask, until the volume is 500mL, so that the inferior meniscus of the liquid can touch on the indicated notch, it is necessary that the last drops of distilled water are added by a stactometer. We have just prepared 500mL of solution 0,50 of HCl.

Part 2: we determine the density of the solution we have prepared, that is to say we measure the mass of 50mL of solution and we make the following calculation: d=m/v; We can deduce the molar concentration of the solution through the density value we have obtained; so can verify whether the preparation of the solution has been accurate phenomenon you want to study.



Individual tasks:

The experimental method is on the basis of labs activities, the first phase you point out the phenomenon you want to study. Second phase you express an hypothesis, that is possible theories which explain the causes, the developments and the effects of the investigated phenomenon

Interpret the results. This way the students have interpreted the results and the whole procedure which verifies the starting hypothesis, at the end of the experience.

Third phase which must be obtained with the experimental control, reproduce it artificially even more times and in different conditions the observed phenomenon, carries out the appropriate measures.

Fourth phase, if the analysis of the collected data with the experimentation allows to verify the stated hypothesis.

References:

Laboratorio di scienza della materia. Moduli & e metodi. C:E:Arnoldo Mondadori Scuola. 2001, AA. F. Randazzo, P. Stroppa.

EXPERIMENT NR. 40

pH MEASUREMENT OF VARIOUS SOLUTIONS

CHAPTER: Acids and Bases

PROPOSED BY: L.P. “La Closerie” St Quay-Portrieux, FRANCE

Theoretical aspects:

There are two objectives to this lesson:
1) To classify solutions in everyday usage according to their pH
2) To notice the evolution of the pH according to the dilution.

Different approaches:

Three possibilities are offered to the students for the study of the acidity of the products:

1) pH Paper
2) Liquid indicators (Héliantine, phenolphthalein, blue of bromothymol, …)
3) pH-meter.

The first two methods are not easy to use because they are not precise enough and because they cannot be implemented with coloured or pasty products

Materials, apparatus, chemicals:

- pH-meters
- test tubes
- distilled water
- Various household products to be analysed (cleaning agents, toothpaste, cosmetics)
- Various beverages and fruit juices

Safety precautions:

Depending on the products to be analysed. Take care of products which have very low or very high pH in order to avoid skin contamination and eventually burns.

Experimental procedure / Individual tasks:

The products will be used pure. Each group of students must supplement the table below (or part of the table, depending on the time spent on the experiment). After each measurement, the pH meter has to be thoroughly cleansed.

Product	pH
Lemon	0,8
Orange juice	2
White vinegar	2
Grapefruit juice	2
Milk	7
Toilet scaling substance	1
Toothpaste	9
White wine	3
After shave lotion	2
Rosé wine	3
Ajax for window panes	10
Mr Propre	12
Coke	2
Fluorinated toothpaste	6
Red wine	2
Decap'for ovens	13
Beer	4,2

Interpreting the results and conclusion:

The experiment verifies the presence of chemicals in the products, not the quantity of those chemicals. The values of the pH may vary: for example, the pH of the lemon juice varies from 0.8 to 3 depending on the chosen lemon. This does not have any significance for the classification of the products. Most of the drinks proved to be acid. On the other hand the detergent products were mostly basic.

Having to dilute the pasty products makes the measurements difficult as the pH varies according to dilution; for example, the measures will vary for toothpaste: one group of students may work on this with the objective of showing that the pH varies of a unit when dilution varies “by” 10.

EXPERIMENT NR. 42

TITRATION OF HCl WITH $NaOH$

CHAPTER: ACIDS - BASES

PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU" Şimleu Silvaniei, ROMANIA

The purpose of this experiment is to understand the acid/base titration concept and to see the effect of the neutralization process on the pH.

Theoretical aspects:

Acid base reactions occur in every day life all around. We are sometimes even not aware this is happening around us. The reaction is very rapid and many times not very visible. The effects of the reactions are, on the contrary, very visible and they influence our daily life. That's why we propose in this sheet the elaboration of an experiment in which we are studying the interaction between an acid and a base, both strong, measuring the variation of a very important parameter for life: the pH during the reaction between these two reagents. Our aim is to draw the curve of the pH of an acid solution when this is neutralized with a strong base.

Different approaches:

The students are asked to draw the titration curve during the neutralization of a strong acid with a strong base! Several approaches could be taken in account:

1. *Experimental* To a certain amount of cM hydrochloric acid solution we add mL by mL a cM of sodium hydroxide and we measure each time the resulted pH with a pH paper. We note in a table the dependence of the pH with the amount of the added sodium hydroxide.
2. *Experimental* To a certain amount of cM hydrochloric acid we add an universal indicator and then we are adding drop wise a cM solution of sodium hydroxide measuring both the volume of the base and the pH of the resulted solution.
3. *Experimental* A certain amount of a hydrochloric acid (with an unknown concentration) is titrated with a 0.1M solution of sodium hydroxide. The pH is measured each time using a pH-meter and a curve is drawn by using both the volume of the added base and the measured pH.
4. *Theoretical*. We are doing chemical calculation on a solution having a certain concentration of hydrochloric acid and a certain amount of sodium hydroxide added to this solution. We establish the excess of the acid or base, the amount of the hydroxide or hydronium ions and their concentration in the final solution. We determine theoretically the pH of the solution and we draw the curve pH=f(vol $NaOH$ added).

Materials, apparatus, chemicals:

Beaker, 0,1M solutions of $NaOH$ and HCl, fenolftaleine, pH meter, magnetic stirer.

Safety precautions:

Hydrochloric acid and sodium hydroxide are extremely corrosive. Avoid the skin and eye contact with these reagents. Wear protective glasses and gloves. Working with electrical devices could lead to electrical shocks if the devices are not used as designed.

NaOH
HCl

Experimental procedure:

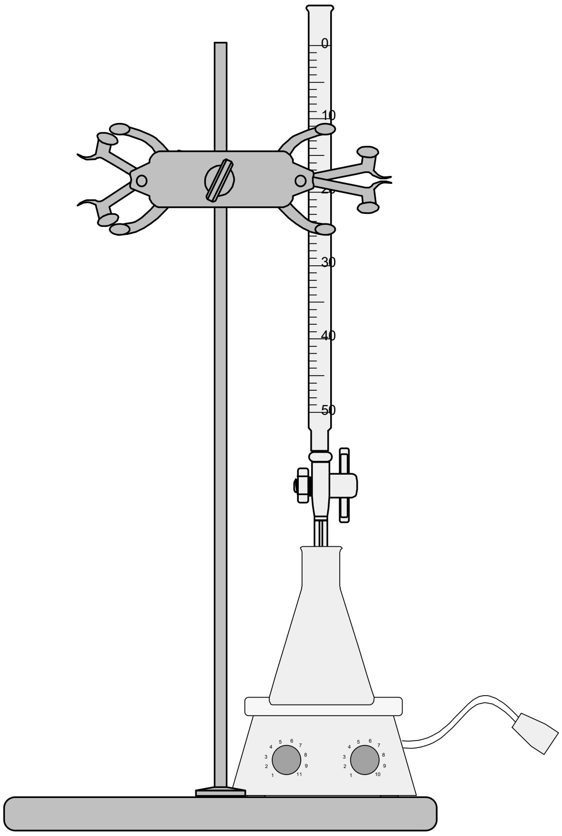
On a magnetic stirrer put an Erlenmeyer flask containing 25 mL of 0.1 M hydrochloric acid solution. Add a drop of an ethanolic solution of phenolphthalein and put in the flask a magnetic rod. Place all these under a burette containing a solution of 0.1M of sodium hydroxide. Put the sensor of a pH-meter in the flask. Turn on the pH-meter after a previous calibration. Add drop wise the base to the acid solution. Mark in each step the pH of the solution and the amount of the added base. Use more base than needed for the neutralization of the acid in order to be able to draw the titration curve even for a great excess of the base.

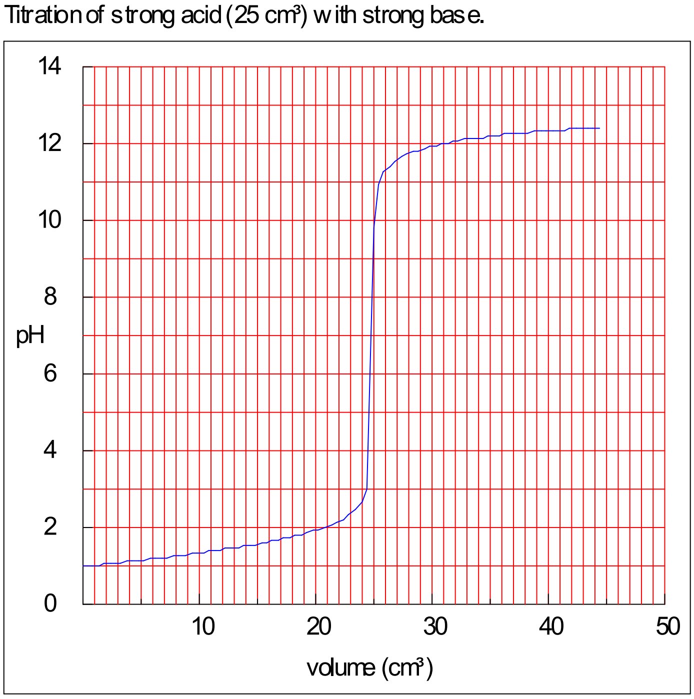
Individual tasks:

Prepare the 0.1M hydrochloric acid and 0.1M sodium hydroxide solutions. Assemble the titration apparatus, connect the pH-meter and make the titration. Note in your book, in every step, the total amount of the added base and the pH of the solution. Draw the curve pH=f(vol NaOH added) using the measured values from the experimental part.

After drawing the curve on the collected date, launch the *titration.exe* software and make the same experiment on the computer letting the machine to draw the titration curve. The reagents and their concentration could be setup at the begining of the simulation. Make a comparison between the two curves.

Interpreting the results





The neutralization curve has a inverse Z shape. We observe that adding 99% of the necessary reagent will raise the pH of the solution only with 1-2 units whereas the next 1% of the reagent will determine the curve to jump from the value 3 to value 11. Then even after a great excess of the base added to the solution the pH will not exceed the value 12,5. This very steep part of the curve permit the use of an acidic indicator (as methyl orange pHi = 4.4) or a basic indicator (as phenolphthalein pHi = 9.2) in order to mark the equivalence point during the titration.

Explanation and conclusions:

Drawing the titration curve we will observe its specific shape. This is due to the fact the pH is a logarithmic measure of the concentration of the hydronium ion. Therefore, for a very small excess of acid or base the pH is still far from the value 7 and the titration never occur in such a way that in a moment we have a neutral solution. With a drop of a reagent the pH will raise suddenly from value ~3 to the value ~11 giving the specific shape of the neutralization curve.

Waste disposal:

The solution could be poured down the drain after neutralizing them with HCl or NaOH according to the needs.

References:

1. Robert J. L., University of Jamaica and Andrew G.B. Leeds University, GB
2. Albu, Petrescu, Cosma, *Manual de Chimie pentru clasa a Xa*, Ed. Didactica si Pedagogica, Bucuresti,1994
3. http://en.wikipedia.org/wiki/Hazard_symbol

EXPERIMENT NR. 43

TITRATION CURVE OF H_3PO_4 WITH KOH

CHAPTER: ACIDS BASES

PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU" Şimleu Silvaniei, ROMANIA

The purpose of this experiment is to illustrate the real behaviour of a polybasic acid when titrated with a strong base as KOH. The variation of the pH is analysed according to the content of the titration medium which is a buffer solution.

Theoretical aspects:

Buffer solutions play an important role in the living organisms. One of the main buffer couple in the warm blooded organisms is the phosphate couple, in both ionisation degrees. Phosphoric acid is an interesting example of relatively weak acids, having three ionisation steps. The ionisation steps of this polyacid could be visualised through the titration process. pH variations have to be observed in more than one equivalence point due to the polyprotic character of the titrated acid. Phosphoric acid is used in alimentation being present in different beverages. Therefore its behaviour has to be known and understand in different conditions.

Materials, apparatus, chemicals:

Beaker, 0,1M solutions of KOH and H_3PO_4, phenolphthalein, pH meter, magnetic stirrer, burette

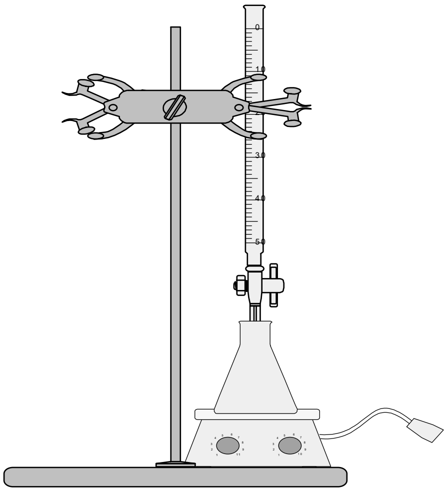
Safety precautions:

Phosphoric acid and potassium hydroxide are corrosive. Avoid the skin and eye contact with these reagents. Wear protective glasses and gloves. Working with electrical devices could lead to electrical shocks if the devices are not used as designed. Special attention should be paid toward the pH meter and its sensor made of glass. Avoid mechanical socks of the glass sensor.

KOH

H_3PO_4

Experimental procedure:



On a magnetic stirrer place an Erlenmeyer flask containing 20 mL of 0.1 M phosphoric acid solution. Add a drop of an ethanolic solution of phenolphthalein and put in the flask a magnetic rod. Place all these under a burette containing a solution of 0.1M of potassium hydroxide. Put the sensor of a pH-meter in the flask. Turn on the pH-meter after a previous calibration. Add drop wise the base to the acid solution. Mark in each step the pH of the solution and the amount of the added base. Use four times more base solution and pay attention at the pH changes when the added base solution is 20mL, 40 mL and 60mL in order to be able to draw the titration curve even for a great excess of the base.

Individual tasks:

Proceed to the titration process. Pay attention to the position of the burette in order to avoid the reagent to be poured out from the Erlenmeyer flask. This will cause errors in measuring the volume of base.

Interpreting the results

In the titration process there are 2 mmol of acid titrated. Due to the three hydrogen atoms of the phosphoric acid there are several pH jumps on the titration curve. Once the first hydrogen has been lost from the acid due to the neutralisation process we have a first pH jump at about 20 mL of KOH solution added to the flask (aprox. 2 mmol of added base). This is happening from pH=2 to pH=5. Continuing the neutralisation process by involving the second hydrogen atom of the acid there is a second pH jump (between 8 and 12) when we reach the double of the base volume added to the system (40 mL of base 4 mmol added in total. Due to the slight acidity of the third hydrogen of the phosphoric acid the third pH jump is not obvious, it has to happen at around 60 mL of KOH solution added to the system.

Explanation and conclusions:

The titration curve has a specific shape where the equivalence points at the first and second ionisation step are clearly observed and the third one is almost masked in the titration curve not being visible. The first pH jump is the biggest one and is in accord with the strongest pKa of the titrated acid. Looking at both graphs we found strong similarities between the experimental graph (fig.1) and the computer simulated one (fig. 2)

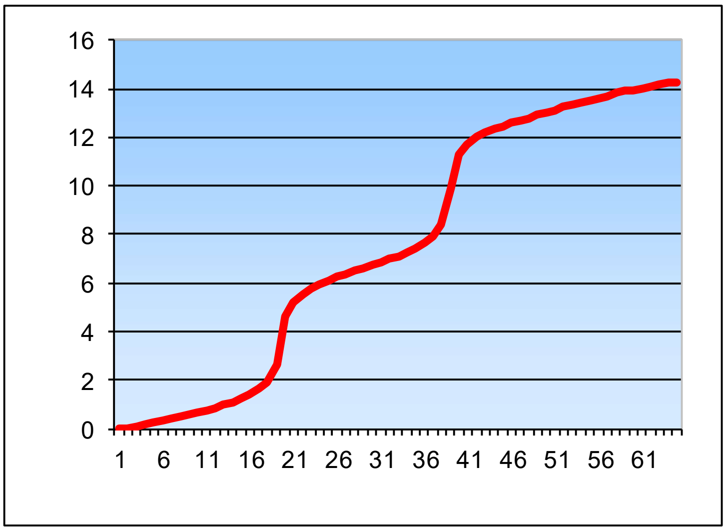
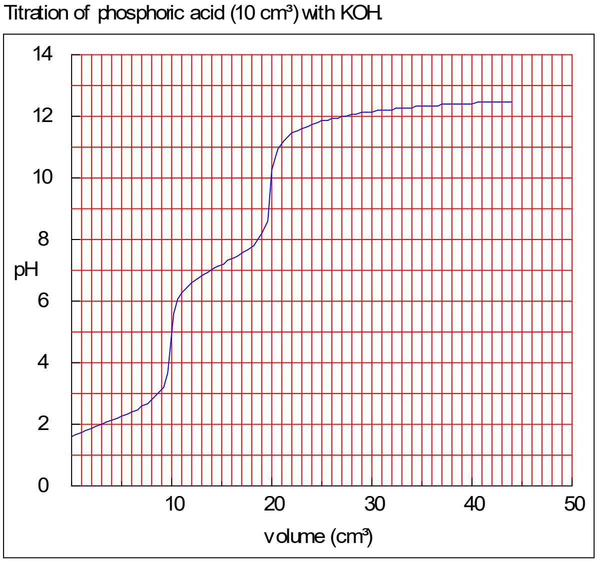


Fig. 1



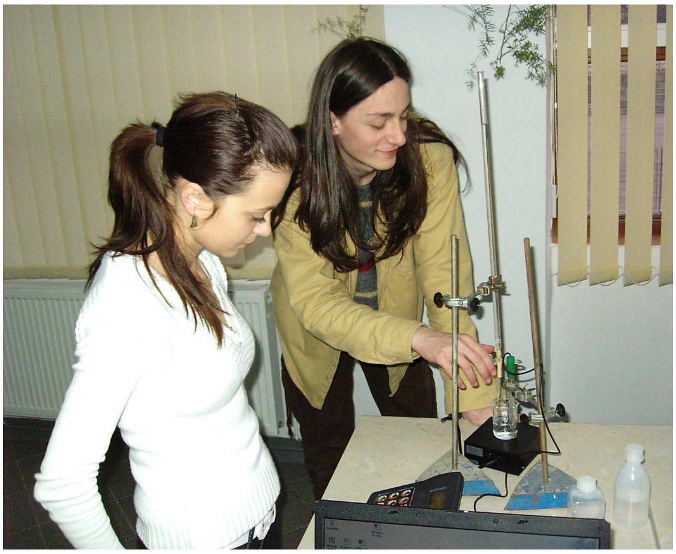


Fig. 2

Waste disposal:

The solution could be poured down the drain after neutralising them with HCl or KOH according to the needs.

References:

1. Albu, Petrescu, Cosma, *Manual de Chimie pentru clasa a Xa*, Ed. Didactica si Pedagogica, Bucuresti,1994
2. http://en.wikipedia.org/wiki/Hazard_symbol

EXPERIMENT NR. 51

TO DETERMINE WHICH OXIDIZER OR REDUCING AGENT IS THE STRONGEST

CHAPTER: REACTIONS AND CURRENT

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ";CAPELLE A/D IJSSEL, THE NETHERLANDS

Research Question:

A

- Which reducing agent is the strongest: Zn or Pb?
- Which oxidizer is the strongest: Zn^{2+} or Pb^{2+}?

B

- Which oxidizer is the strongest: Cl_2, Br_2 or I_2 ?
- Which reducing agent is the strongest: Cl^-, Br^- or I^- ?

Theoretical aspects:

A reducing agent is a substance that can donate one or more electron(s). The more easily a reducing agent can do this the stronger the reducing agent is.

An oxidizer is a substance that can take up one or more electron(s). The more easily an oxidizer can do this the stronger the oxidizer is.

The half reactions are:

$$Ox + ne^- \rightarrow Ox^{n-}$$

$$Red \rightarrow Red^{n+} + ne^-$$

You can see that when there is an exchange of electrons an oxidizer must react with a reducing agent. This is called a redox reaction. Hereby the oxidizer changes into a reducing agent and the reducing agent changes into an oxidizer.

When a redox reaction takes place you can say:

STRONGEST RED. + STRONGEST ROX. → WEAKER OX. + WEAKER RED.

A well known example is the reaction of iron with H+ ions (which are present in an acid solution)

$$Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$$

Half reaction equations for oxidizers and reducing agents you find in the BINAS date book in table 48.

Materials, apparatus, chemicals:

A

Beaker

A piece of zinc and a piece of copper.

Zinc nitrate solution 1 M Lead nitrate solution 1 M

B

Chlorine water, bromine water and an iodine solution (0,1 M)

Solutions of NaCl, KBr and KI   0,1 M
Starch solution
Drop pipette
Test tubes

Safety precautions:

- Use a white laboratory coat
- Use a pair of safety glasses
- Long hair must be tied up

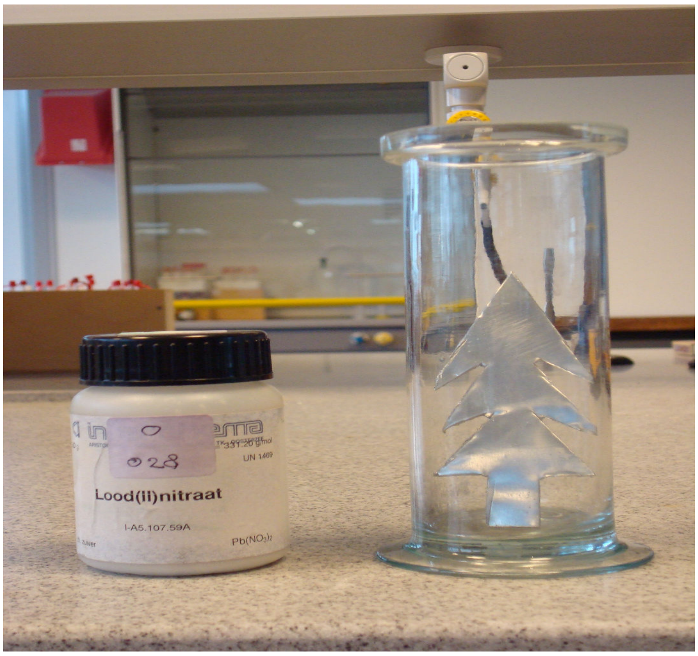
Experimental procedure:

A

Pour the lead nitrate solution into a beaker. Then you put a piece of zinc into the beaker. You can take a grain of zinc or a piece of zinc in the shape of a tree. You must take care of that the piece of zinc is totally under the liquid level.

Do the same with the zinc nitrate solution and a piece of lead.

Wait for 10 minutes and see if you can observe a change at the surface of the zinc and the lead. Write down what you observe.



Tree of zinc in cylinderglass

Cylinder filled with lead nitrate solution

B

Pour respective the sodium chloride solution, the potassium bromide solution and the potassium iodide solution into 3 test tubes.

Write the color of these 3 solutions in the scheme. Do the same for the chlorine water, the bromine water and the iodine solution (0,1 M).
Put some drops chlorine water in the three test tubes with a drop pipette.
See if the colour in the 3 test tubes changes and write down the colors in the scheme.
Repeat this experiment with bromine water and later with the iodine solution (0,1 M).
N.B.
If you doubt if the yellow/brown color is from bromine or from iodine you can add some drops of a starch solution. A starch solution gives with iodine, I_2 (aq), a dark blue colour.

SCHEME

	Reducing agents	$Cl^{-}_{(aq)}$	$Br^{-}_{(aq)}$	I^{-} (aq)
Oxidizers	Colour			
Cl_2 water		xxxxxxxx		
Br_2 water			xxxxxxxx	xxxxxxxx
I_2 solution				

Interpreting the results

Both in the case of **A and B**:
Give the two half reactions and with these half reactions the total redox reaction when you observe a change in the color.

Explanation and conclusions:

Give here, with a motivation, the answers on the research questions.

Waste disposal:

The solutions used in case A must be disposed of in the waste barrel for heavy metals. The solutions of case B can be disposed in the normal waste-pipe.

References:

1. Pulsar Chemie HAVO Superstructure Part 2 Chapter 9 (especially page 35 till 40) Wolters Noordhof Groningen ISBN 9001-31150-4

2. Pulsar Chemie HAVO Working book part 2 Chapter 9 (especially experiment 14 and 30) Wolters Noordhof Groningen ISBN 9001-31151-2

EXPERIMENT NR. 62

SOAP AND THE TENSION OF THE SURFACE OF WATER - FORMING OF MICELLES

CHAPTER: WATER

PROPOSED BY: C.S.G. „Comenius College”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Research Question:

What is the influence of soap to the floating ability on water, to the dispersion of substances over the surface of water and to the solubility of a-polar substances in water?

Theoretical aspects:

The formula of natural soap is $C_{17}H_{35}COONa$.
When you dissolve this soap in water it is divided into ions:

$$C_{17}H_{35}COONa_{(s)} \rightarrow C_{17}H_{35}COO^{--}_{(aq)} + Na^{+}_{(aq)}$$

The molecules of all kind of soaps and detergents are in the solid phase and in the dissolved phase build up in a similar way. The molecules exist out of two parts.
One part is soluble in water. This part is called: “The hydrophilic head”.
The other part is not soluble in water and is called: The hydrophobic tail”.

Schematically can you imagine this: ----------------------------------O
tail head

Well known natural soaps are sodium- and potassium stearate.

Here is the hydrocarbon chain ($C_{17}H_{35}$) the “hydrophobic” part and the COO^{-} head the “hydrophilic” part.
When you dissolve the soap, you find the stearate ions at the surface of the water and the hydrocarbon tails are above the water surface. When there is no place more at the surface of the water you find the $C_{17}H_{35}COO^{-}$ ions on a way the tails are directed to each other so that they form a “hydrofobic” area. This we called a ball of tails. On the outside of the tails you find the COO^{-} heads. These heads are hydrated by water molecules so that they can be dissolved in water. On this way, the $C_{17}H_{35}COO^{-}$ ions form “micelles” in the water.

The dirty parts on your clothes or on your hands exist of substances from which the molecules cannot form hydrogen bridges with water because they are a-polar.
With the help of such a “micelle” the (a-polar) dirty part can be enclosed and then the dirty part can dissolve in the water and the dirty part will be removed from your clothes or from your skin.

Materials, apparatus, chemicals:

A dry clean bowl of glass (diameter 20 cm), black pepper powder, a soap solution (concentrated), a flat pin of copper; colored lamp oil; a 2,5 L beaker.
Magnetic stirrer, magnetic flea.

Safety precautions:

- Use a white laboratory coat
- Use a pair of safety glasses
- Long hair must be tied up

Experimental procedure:

This experiment is to be divided in three parts.

Part 1

Put in a dry, clean bowl of glass a layer of water. Put down carefully a flat pin of copper on the surface of the water so that the pin keeps floating.
Let carefully, so far as possible, fall down a drop of the soap solution in the water and observe what happens.

Part 2

Put in dry, clean bowl of glass a layer of cold water. Sprinkle the black pepper powder on the surface of the water.
Let in the middle of the pepper spot, carefully fall down a drop of the soap solution and observe what happens.

Part 3

Fill the beaker half with water. Pour on the water a very thin layer of colored lamp oil. Try by stirring to mix the lamp oil with the water. Stop stirring and observe what happens.
Then you add a dash of the soap solution and try by stirring to mix the lamp oil and the water. Stop stirring and observe what happens. Have especially a look on the color of the water layer.

Observations:

Describe for every part of the experiment your observations.

Part 1: …………………. **Part 2:** …………………… **Part 3:** ……………………………

Photo of the pin and the pepper and the influence of soap.

Before adding soap. **After adding soap**

Explanation:

Give for every part of the experiment an explanation.

Part 1:
Explain why the pin of copper floats on the water and explain what happens after adding the soap solution.
Part 2:
Explain the influence of the soap solution on the pepper spot.
Part 3:
Explain the influence of the soap solution by trying to mix the lamp oil and the water.

Waste disposal:

Only the used materials of part 3 must be disposed in the waste barrel for organic materials.

References:

1. Pulsar Chemie HAVO; Superstructure Part 1; Chapter 6; Wolters Noordhof Groningen, ISBN 9001-31091-5

2. Pulsar Chemie HAVO; Superstructure workbook; Chapter 6; Wolters Noordhof Groningen,ISBN 9001-31092-3

REACTION NR. 64
"THERMIT" REACTION
CHAPTER GENERAL AND INORGANIC REACTIONS

Proposed by: HTL-Dornbirn, AUSTRIA

Theoretical aspects:

One of the most impressive ways to show the amount of energy (enthalpy) which is set free in chemical reactions, especially in reduction-oxidation processes, is the "Thermit" experiment. Alumina reacts in a mixture with Iron(II, III)oxide forming Alumina oxide and pure Iron metal; the reacting mixture heats up to more than 1500 °C so that liquid iron is pouring out of the reaction vessel. Railway companies use this process commercially for welding railway tracks.

Different approaches:

The aspects of performing this experiment (only by an experienced chemistry teacher) are multiple:

- demonstrating the amount of energy which is set free in chemical reactions (reaction enthalpy)
- example for a reduction-oxidation process (the occurring reactions are quite simple to be set up also for "beginners")
- show experiment for "special" lessons

Materials, apparatus, chemicals:

Chemicals:

- "Thermit" mixture and igniting charge (purchasing information: www.phywe.com, catalog no. 31 920.50, 31 921.05; or www.vcoe.or.at, "Thermit-Set", information only in German)

Materials and apparatus:

- Flowerpot (fireclay), 8.5 cm high, upper diameter 9 cm, with a hole in the bottom
- Stand with 2 clamp rings (see figure below)
- Sheet-metal pail, min. 12 L volume, diameter min. 30 cm, half of the volume filled with dry (!) sand
- Alumina or copper coin
- Bunsen burner or portable micro gas burner
- Reagent tube holder
- Safety goggles, fireproof gloves

Safety precautions:

The pail and the stand are placed on a stone or tiled floor with no burnable materials at a distance of less than 2 m. All materials (Thermit mixture, flowerpot, sand) must be dry, as the enormous heat may cause rapid evaporation of the water from wet parts like an explosion. For each demonstration use a new flowerpot, as the heat causes cracks in the fireclay material.

Experimental procedure:

1. Assemble the stand as shown in the figure. The flowerpot is supported in its position by the upper stand ring and is set up on the lower stand ring (which has a lower diameter than the upper ring) just straight above the middle of the pail. The vertical distance between lower stand ring and upper end of the pail must not be more than 40 cm. Close the hole in the flower pot with the coin and fill in the Thermit mixture carefully (not more than 4 cm filling height). Fill the pail with sand and dig a deepening in the middle so that the liquid metal stream is collected there and does not come in contact with the sidewall.
2. Remove all burnable materials from the potentially dangerous area (2 m distance), put on the safety goggles und gloves. Hold the igniting charge with a reagent tube holder and light it using the burner. Place the burning igniting charge carefully in the middle of the flowerpot and press is slightly into the Thermit mixture, release it and move back instantly.
3. The reaction starts immediately; after a few seconds the coin at the bottom of the pot melts and liquid iron pours down in a stream into the pail. Wait until the reaction has completely finished before approaching the pail.
4. After cooling down, the raw iron bulk is shown to the students; it may be tested for magnetism.

Waste disposal:

All materials may be disposed in the household waste.

References:

1. Obendrauf V.: Chemie und Schule (Salzburg) 16 (2001), vol. 3, pp. 7-10

EXPERIMENT NR. 65

DETERMINATION OF K_B OF CH_3COO^-

CHAPTER: STRONG AND WEAK ACIDS AND BASES

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NETERLANDS

Theoretical aspects:

$CH_3COO^-(aq)$ + $H_2O(l)$ <--> $CH_3COOH(aq)$ + $OH^-(aq)$

$K_b = [CH_3COOH] \times [OH^-] / [CH_3COO^-]$

$pOH = 14{,}0 - pH$

$[OH^-] = 10^{-pOH}$

$[CH_3COOH] = [OH^-]$

$[CH_3COO^-] = 0{,}1 - [OH^-]$

Materials, apparatus, chemicals:

CH_3COONa (s) ; KH_2PO_4 (s) ; $Na_2HPO_4.2H2O$ (s) ; $NaHCO_3$ (s); Na_2CO_3 (s).

pH meter
Measuring glasses

Safety precautions:

Not necessary

Experimental procedure:

The student should measure the pH of a 0,1 M CH_3COONa solution

Calibrate the pH meter
Before you measure the pH of the 0,1 M sodiumacetate (sodiumethanoaat) solution you must calibrate the pH meter with two buffer solutions : one of pH = 7,0 and one of pH = 10,0.
You can use solutions you can buy.
It is also possible to prepare this solutions.

Preparing buffer solutions.
Solution with pH 7,0
Dissolve 1,36 g KH_2PO_4 (s) and 1,77 g $Na_2HPO_4.2H2O$ (s) in 400 ml water and put this in a measuring glass of 500 ml and fill up exactly till 500 ml.
Solution with pH 10,0
Dissolve 4,20 g $NaHCO_3$ (s) and 5,3 g Na_2CO_3 (s) in 400 ml water and put this in a measuring glass of 500 ml and fill up exactly till 500 ml

Preparing a 0,1 M CH_3COONa solution:
Dissolve 8,20 g CH_3COONa (0,1 mol) in 0,5 L water.
Put this solution completely in a measuring glas of 1,0 L and fill up exactly till the volume of 1 L.

Explanation and conclusions:

The student should calculate the K_b of the base CH_3COO^- and compare the value of K_b with the value mentioned in a book with chemical tables.
When the calculated value deviates much, he should mention causes for the difference.
Here the student must look at:
A temperature
B exactness of the pH measure
C exactness of preparing the solutions

EXPERIMENT NR. 66
TO DEMONSTRATE AN INTERMEDIATE PRODUCT BY THE WORKING OF A CATALYST

CHAPTER: Reaction rate

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NEDERLANDS

Research Question:

Give with the colors of the cobalt ions a more specific definition of a catalyst than is mentioned under the theoretical aspects.

Theoretical aspects:

The short definition of a catalyst is:

> “A substance which accelerate the speed of a chemical reaction”.

The potassium sodium tartrate is oxidized by hydrogen peroxide. By this reaction will be formed carbon dioxide and water. Without using a catalyst this reaction will run down slowly.

The reaction is catalyzed by Co $^{2+}$ ions. The Co $^{2+}$ ion is oxidized by hydrogen peroxide into Co $^{3+}$. The Co $^{3+}$ ion forms an intermediate product with the potassium sodium tartrate. This intermediate product reacts further and by this reaction will be formed carbon dioxide water and Co $^{2+}$ ions.

Different approaches:

You can choose for two approaches:

A Only an explanation with the observations of the experiment

B The same as under A but now you give also a theoretical explanation for the redox reactions which take place.

Materials, apparatus, chemicals:

5 gram potassium sodium tartrate (Seignette salt)
Cobalt (II) chloride
10 ml 30 % hydrogen peroxide
1,0 L Erlenmeyer flask
Bunsen burner.

Safety precautions:

- Use a white laboratory coat
- Use a pair of safety glasses
- Long hair must be tied up

The 30 % hydrogen peroxide solution is strong a very oxidizer therefore caution has to be taken. Cobalt salts are harmful for environment and they are toxic.


$CoCl_2$,

H_2O_2 solution


Experimental procedure:

Dissolve the potassium sodium tartrate (Seignette salt) with 100 ml water in the beaker.
Heat the solution till 50 ^{0} C. Then you add 10 ml 30 % hydrogen peroxide solution.
Look if there take place a reaction!!

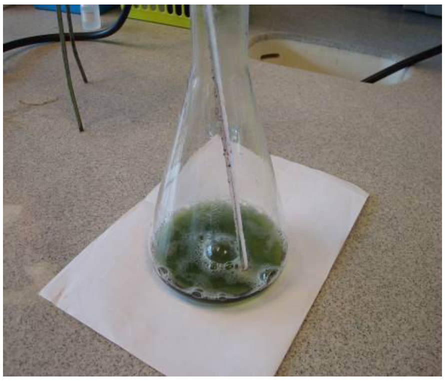
Now you add **carefully** a spoonful of the pink cobalt(II)chloride. You must do this carefully because the reaction can run down violent!!!
Have a good look to what happens. The experiment is ended when there don't change anything in the solution.

Observations:

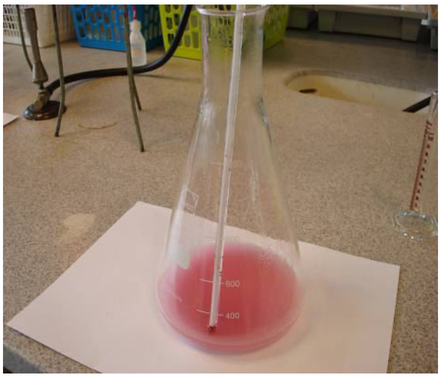
	COLOR	**Liberation of CO_2**
Solution before adding $CoCl_2$		
Solution after adding $CoCl_2$		
Solution at the end of the experiment		

Photo before, during and after the reaction

Before



During



After

Explanation and conclusions:

Approach A

Give answer on the following questions by using your observations:

1 Is there a reaction without using cobalt chloride?
2 Is Co $^{2+}$ ion participating in the reaction?
3 Will the Co $^{2+}$ ions be used during the reaction?

Try now, with these answers, to give a new and more precious definition of a catalyst.

Approach B

Do the same as under approach A and give also answer on the following questions:

4 Give the reaction equitation of the redox reaction between potassium sodium tartrate and hydrogen peroxide?
5 Try to find in the library of on internet information of the intermediate product of Co $^{3+}$ ions and potassium sodium tartrate?

Waste disposal:

The used materials must be disposed in the waste barrel for heavy metals.

References:

1. Pulsar Chemie VWO Superstructure Part 2 Chapter 11 Wolters Noordhof Groningen ISBN 9001-31154-7

EXPERIMENT NR. 71

THE DETERMINATION OF THE IRON(III) QUALITY IN GROUNDWATER

CHAPTER: CHEMICAL ANALYSIS

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Theoretical aspects:

Groundwater can be ferrous, that means there are iron salts present. These salts are not causing harm, but they influence the taste disadvantageous. In this experiment we measure the concentration Fe^{3+} in the groundwater.
The experiment is based on the reaction between a solution with Fe^{3+} in a KSCN-solution:

$Fe^{3+}(aq) + SCN^{-}(aq) <---> FeSCN^{2+}(aq)$

The solution that results from the reaction has a red color, caused by the $FeSCN^{2+}$ ions
The higher the concentration Fe^{3+}, the higher the concentration $FeSCN^{-}$, the more red the color of the solution will be. The intensity of the red color is therefore a half-measure for the quality to $Fe^{3+}(aq)$

Different approaches:

- The experiment is presented to the student as an open instruction
- The student gets a instruction in which the experiment is describes integral

Materials, apparatus, chemicals:

A standard solution which must contain by liter 10 mg Fe^{3+} and
Approximately 20 mL concentrated hydrochloric acid.
An unknown water sample
Possible iron(III)salts: $Fe(NO_3)_3$ or $FeCl_3$.

2 M KSCN solution and 1 M HCl

concentrated hydrochloric acid

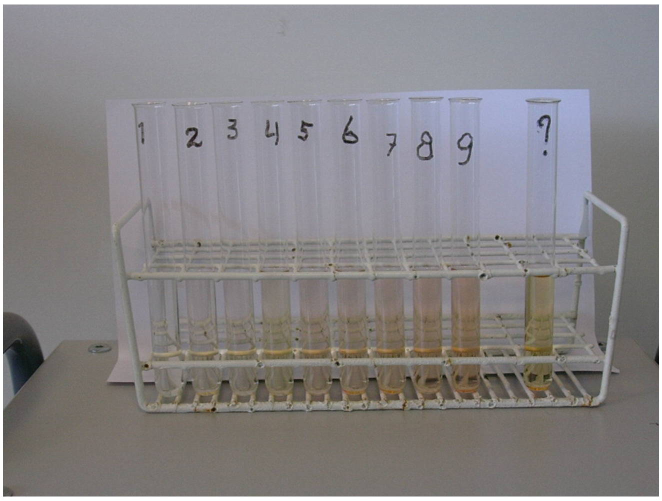
Safety precautions:

It can occur that the oxidizer which you add to oxidize iron ions to Fe^{3+} ions react with the SCN^- ions and that thereby some of the toxic HCN (hydrocyanic acid) arises. Then you must work in the cupboard with a suction apparatus.

HCN (hydrocyanic acid)

Experimental procedure:

The student should make a series of solutions of increasing Fe^{3+} (aq) concentration. In nine test-tubes he should pour 1, 2, 3 etc. mL of the iron(III) standard solution.
To these solutions he should add an excess KSCN solution (1 mL)
With distilled water he should fill up every test tube to a total volume of 10 mL.
Thus, he gets a series of increasingly red colored solutions: the comparison range.
From the water he examined he should pour 5 mL in a test tube and
add 2 mL hydrochloric acid. After that 1 mL KSCN solution and 2 mL distilled water. Then he has to compare the color of the solution in the test tube with the colors of the comparison series. If the water sample which is examined is turbid, he should first filter it.



Individual tasks:

The student should determine the concentration of Fe^{3+} in the water sample by comparison of the color of the water sample with the serial of colored solutions.

EXPERIMENT NR. 72

QUALITATIVE ANALYSES OF WATER, SUGAR, STARCH, PROTEIN AND FAT IN WHITE CUSTARD

CHEMISTRY

CHAPTER: FOOD

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NETHERLANDS

Research Question:

Can you point out water, sugar, starch, protein and fat in white custard?

White custard

Dairy products

Theoretical aspects:

This experiment is typical an example of qualitative analysis. The observation what happens with the reactants is the most important. For that reason there is given no description of theoretical aspects. (see under different approaches)

Different approaches:

You can choose for:

- only the qualitative analysis
- a combination of the qualitative analysis and the extra charge to give, so far as possible, the theoretical background for each experiment. (inclusive the reaction equitation)

Materials, apparatus:

Beakers and measuring glasses of different size

Overflow tube
White custard
Water bath
Test tubes
Filter
Bunsen burner
Filter paper

Chemicals:

I_2 solution 1 %
NaOH solution 10 %
$Na_2CO_3.\ 10H_20_{(s)}$
$NaOH_{(s)}$

C_6H_{14} (l)
C_2H_5OH (l)

$CuSO_4$(s)
$CuSO_{4.}$ 5H2O (s)
$CuSO_4$ 0,1 M
$CuSO_4$ 0,3 M

Seignette salt (Na,K salt of 2,3-dihydroxybutandioic acid or Na,K-Tartrate)
Citric Acid (s Sudan III indicator)
Three reagents you have to prepare:

1 Haines reagent

To prepare the Haines reagent you dissolve

- 25 g $CuSO_{4.}$ 5H2O (s) in 100 ml water
- 50 g citric acid in 50 ml water
- 388 g $Na_2CO_3.\ 10H_20$ in 400 ml water

Let the solutions cool down.

- Add the citric acid solution to the potassium carbonate solution
- Wait until there is no more gas that comes free.
- Add the copper sulfate solution and fill up to 1 L.
- The solution must be dark blue and clear. (You can eventually filtrate the precipitation)

2 Fehling's reagent (consist of an A and B solution)

Fehling A

0,3 M $CuSO_4$ solution

Fehling B

Dissolve 35 g Seignette salt and 10 g sodium hydroxide in 100 ml water.

3 Sudan III solution

You can prepare the Sudan III solution as follows:

- Put 75 ml C_2H_5OH (l) in a warm bath of water
- Add, while you stir, 05 g Sudan III indicator
- Fill it up to 100 ml with warm distilled water
- Make a homogeneous solution and let it cool down. (You can eventually filtrate the prepared solution)

Safety precautions:

- Use a white laboratory coat
- Use a pair of safety glasses
- Long hair must be tied up

Experimental procedure:

A To point out water

(when there is water present the color of white copper sulfate changes into blue)

You can choose for two methods:

1 Pour some white custard in test tube. Put an overflow tube with a cork on the test tube. The other end of the overflow tube come in another test tube in which there is on the bottom a spatula point of white copper sulfate.

Heat carefully the test tube with the white custard till there come some drops of a solution in the test tube with the white copper sulfate. Notice a color change.

2 You put a filter paper in a filter and place this on a test tube in which there is a spatula white copper sulfate. Heat in a beaker a small amount of the white custard till 50 ^{0} Celsius and pour the heated white custard on the filter paper. Notice a color change when there falls out of the filter some drops of a solution liquid.

For the next experiments it deserves recommendation to pour some ml water to an amount of the white custard and make it homogeneous and fluid

B To point out sugar

(when there is sugar present the color changes into orange-red in both methods)

You can choose for two methods:

1 Pour 5 ml white custard in a test tube. Add 5 ml Haines reagent and heat it carefully in a warm water bath. Notice when the color changes.

2 Pour 5 ml white custard in a test tube. Add 3 ml Fehling A solution and 3 ml Fehling B solution. Put the test tube in a warm water bath and notice if the color changes.

C To point out starch

(when there is starch present the color changes into blue-black)

Pour 5 ml white custard in a test tube. Pour some drops of the iodine solution and notice if the color changes

D To point out protein

(when protein is present the blue color changes into violet)

Pour 5 ml white custard in a test tube. Add 3 ml 10 % sodium hydroxide (be careful!!!).

Then add 3 ml 0,1 M copper sulfate and mix it good. Notice the color before and after mixing.

E To point out fat

(When fat is present you get an orange color)

Pour 5 ml white custard in a test tube. Add 5 ml hexane. Close the test tube with a cork and shake it intensive. After shaking let the test tube be in rest till there are two liquid layers.

Pour the upper layer (the hexane) in a clean test tube. Add some drops Sudan III solution and notice if there is change in color.

RESULTS

Qualitative results

Experiment	Color change from	……….	into	………….
A 1		……….	into	…………..
A 2		……….	into	…………..
B 1		……….	into	…………..
B 2		……….	into	…………..
C		……….	into	…………..
D		……….	into	…………..
E		……….	into	…………..

Explanation and conclusions:

A Qualitative explanation.

Give for each experiment your conclusion about the presence of the nutrients in white custard.

A	water	present / absent
B	sugar	present / absent
C	starch	present / absent
D	protein	present / absent
E	fat	present / absent

B Theoretical explanation

Try to find, for each experiment, the theoretical explanation of the change in color.
Use to find this explanation the internet.

Waste disposal:

The solutions must be disposed of in the waste barrel for heavy metals.

References:

1. Pulsar Chemie HAVO Superstructure Part 2; Chapter 8 and 9 (especially page 48); Wolters Noordhof Groningen; ISBN 9001-31150-4
2. Pulsar Chemie HAVO Work out book part 2 Chapter 9 (especially page 28) Wolters Noordhof Groningen ISBN 9001-31152-0

EXPERIMENT NR. 75

THE LAW OF DEFINITE PROPORTIONS

CHAPTER: General chemistry

**PROPOSED BY: Liceo “D. Dolci “
Palermo, ITALY**

Theoretical aspects:

This experience is the result of the theoretical and practical experience of matter and its transformation. The students have got to an equal solution that is solving the problem with a labs experience. The aim of this experience is to verify the definite proportions. We take into account the reactions between the copper and the oxygen of the air which gives the oxide, of copper as a product.

On this occasion, the attention is put on the measurable aspects and particularly, on the relationship in mass between copper and oxygen.

Different approaches:

In the experiments we must recognize the intrinsic properties of matter. In this case the law of definite proportions.

Materials, apparatus, chemicals:

- copper powder
- China capsule
- Technical balance
- Brunsen burner, with three-legged stand and rack
- Spatula

Safety precautions:

To realize this kind of experience it is necessary to know the objects and the labs materials which usually are in a laboratory, then it is good to pay attention at the way you move inside it, as there are some dangerous and fragile materials: For this reason you must pay more attention than in the classroom.

Experimental procedure:

In a China capsule we weigh about 5 g. of power copper. We take note of the mass of the reagent, carefully possibly till centigrams.

The capsule with the copper on the rack of the three-legged stand is put over the Bunsen cooker and it is warmed for about 30 minutes at low flame. After making the capsule be colder you weigh it and write the value of the mass, you heat it for other five minutes and then you check the mass. If it is identical to the previous one it may be considered finished, otherwise it must be heated for other five minutes. It means that we have to repeat the operations till we realize the mass is constant for two following weighs.

Individual tasks:

The experimental method is on the basis of labs activities, the first phase you point out the phenomenon you want to study. Second phase you express an hypothesis, that is possible theories which explain the causes, the developments and the effects of the investigated phenomenon

Interpreting the results

This way the students have interpreted the results and the whole procedure which verifies the starting hypothesis, at the end of the experience.

Third phase which have to be obtained with the experimental control, reproduce it artificially even more times and in different conditions the observed phenomenon, carries out the appropriate measures. Fourth phase, if the analysis of the collected data with the experimentation allows to verify the stated hypothesis.

Explanation and conclusions:

Here’s the pertinent answer which explains and finishes the experiment once it has been individualized the collected substance: In this experience, there are a lot of opportunities to make mistakes so the most reliable mass between copper and oxygen the value in mass is obtained from the average of all the reports obtained by the classroom.

EXPERIMENT NR. 86
SUBSTITUTION REACTIONS OF THE ETHYNE

CHAPTER: Alkynes

PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU", Şimleu Silvaniei, ROMANIA

The purpose of this experiment is to illustrate some of the chemical properties of the acetylenes – the substitution reaction by a transitional metal complex.

Theoretical aspects:

The ethynyl radical, CHC*, is a more electronegative group than that formed by carbon atoms joined by either a double or a single bond. Thus, the hydrogen attached to the carbon-carbon triple bond in ethyne, or in any alkyne where the carbon-carbon triple bond is situated at the end of a carbon chain, is able to separate from the rest of the molecule as a hydrogen ion, so that the alkyne shows acidic properties. The electronegative carbon is able to retain both electrons from the broken covalent bond. A significant result of this bonding is that ethyne can form compounds with metals and so be distinguished from alkenes by chemical means.

Materials, apparatus, chemicals:

Test tubes, beakers, calcium carbide, rubber stopper, glass tubes (U shape), Tollens reagent freshly prepared, filter, funel, source of heating.

Safety precautions:

Silver nitrate causes burns and is a powerful oxidizing agent that may assist fire. Tollens' reagent is very unstable if dry and also has been shown to explode if solutions are left for several hours. Concentrated ammonia is extremely damaging to eyes. Even contact with dilute ammonia solution can lead to serious eye damage Harmful if swallowed or inhaled and in contact with skin.

NH_3
NaOH
$AgNO_3$

Tollens

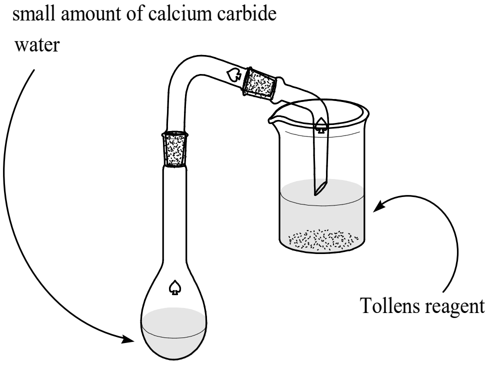
CaC_2, Ag_2C_2

acethylene

Experimental procedure:

First you have to prepare the Tollens reagent. This reagent should be used always in fresh form. DO NOT KEEP IT FOR DAYS!

The preparation is made as follows. To a certain amount of 0,1M solution of $AgNO_3$ add a small amount of 1M NaOH solution. Then add drop wise some NH_3 solution until the medium will become colorless and crystal clear. Then prepare the apparatus shown in the right. Instead of the round bottomed flask you can use a large test tube stoppered with a rubber stopper in which has an U shape glass tube is it. Put a few pieces of calcium carbide in the water and allow the evolved gas (acethylene) to be bubbled in the beaker containing the Tollens reagent.



Filter the formed precipitate and dry it for further demonstration. **The teacher** will take small amount of this solid and allow getting hot on a heated plate. Because the reaction medium tends to form bubbles a long enough test tube or round bottomed flask should be use for the synthesis of the C_2H_2.

Individual tasks:

Observe the changes (and note these changes in your notebook) which occur when you prepare the Tollens reagent and when you react the acethylene with this reagent. Describe the behavior of the silver acethylide when heated.

Interpreting the results

The reactions during the formation of the Tollens reagent could be represented as following!

$$2\,AgNO_3 + 2\,NaOH \longrightarrow Ag_2O + H_2O + 2NaNO_3$$
$$Ag_2O + H_2O + 4NH_3 \longrightarrow 2\,[Ag(NH_3)_2]OH$$

This is a water soluble silver complex with oxidizing properties. In this case is not the oxidizing power of the reagent but the properties of the acethylene which gives the reduction reaction.

In the round bottomed flask calcium carbide added to water reacts giving acethylene which is a gas and therefore it goes through the pipes in the beaker containing the Tollens reagent.

Explanation and conclusions:

The hydrogen connected to a carbon atom involved in a triple bond is easily replaced by other electrophylic species (positive charged species) because of the properties of the carbon atom carrying it. It is a general property of acethylenes, the marginal ones, to participate to substitution reactions. The substitution can be made by sodium (directly) or by other transitional metals (in their complex form). The Tollens reagent is reacting with the acethylenes giving a salt called *acethylide*. The transitional metal acethylides are not water soluble so they are formed in aqueous solutions as a precipitates.

$$HC\equiv CH + 2\,[Ag(NH_3)_2]OH \longrightarrow AgC\equiv CAg + 4NH_3 + 2H_2O$$

The silver acethylide precipitate is very unstable once it is dryed therefore on heating it decomposes with a violent explosion.

Waste disposal:

The solution is **not** poured down the drain because of the toxicity of the silver salts. This solution should be collected in a container used for collecting silver waste.

References:

1. Nenitescu, C.D.,*Chimie organica*, Ed Didactica si Pedagogica, Bucuresti,1966
2. Albu, Petrescu, Cosma, *Manual de Chimie pentru clasa a Xa*, Ed. Didactica si Pedagogica, Bucuresti,1994
3. http://en.wikipedia.org/wiki/Hazard_symbol

EXPERIMENT NR. 89

ALCOHOLS AS REDUCING AGENTS

CHAPTER: REDOX REACTIONS

PROPOSED BY: C.S.G. „COMENIUS COLLEGE ”; CAPELLE A/D IJSSEL, THE NETHERLANDS

CHEMISTRY

Research Question:

Which alcohols are reducing agents?

Theoretical aspects:

Some alcohols are weak reducing agents.
They only react with strong oxidizers like oxygen or potassium permanganate (in acid environment) or potassium dichromate (in acid environment).

When using the MnO_4^{-} ion in acid environment the purple color of the MnO_4^{-} ion changes into the colorless Mn^{2+} ion.
By using the yellow/orange $Cr_2O_7^{2-}$ ion in acid environment you see a change into a green solution of the Cr^{3+} ion.

The transpher for the alcohols when they react as a redactor in combination with an oxydator are:

primary alcohol	→ aldehyde	→ alkane acid
secondary alcohol	→ alkenon	→ no further reaction
tertiary alcohol	→ no reaction	

Alcohols and reagents

Different approaches:

When you will avoid any risk it is to prefer to use only the method with potassium permanganate, because the substance potassium dichromate in solid form is very poisonous.
But it can be said that by working with a 0,1 M potassium dichromate solution the risk is neglectable.

Materials, apparatus, chemicals:

The solid substance $K_2Cr_2O_7$

0,1 M $K_2Cr_2O_7$ + 0,1 M $KMnO_4$

1 M H_2SO_4

Methanol (1), Ethanol (2), 1-Propanol (3), 2-Propanol (4), 2-Methyl, 2-Propanol (5)

Beakers of different size
Bunsen burner
Test tubes

Safety precautions:

- Use a white laboratory coat
- Use a pair of safety glasses
- Long hair must be tied up

Experimental procedure:

Put together 25 ml 0,1 M $KMnO_4$ solution and 25 ml 0,1 M H_2SO_4. Do the same with 25 ml 0,1 M $K_2Cr_2O_7$ and 25 ml 0,1 M H_2SO_4.

Number the test tubes with the numbers used under the chapter “Materials etc”.

Add from each alcohol 2 ml in a numbered test tube. Then you add to each test tube 5 ml of the acid potassium permanganate solution. Heat eventually the 5 test tubes in a warm water bath.

Notice if you see a change in the color.

Repeat this procedure with the 5 alcohols and the acid potassium dichromate solution.

Results:

With the $KMnO_4$ solution:

Alcohols	**Color in the begin**	**Color after some time**
Methanol (1)		
Ethanol (2)		
1-Propanol (3)		
2-Propanol (4)		
2-Methyl, 2-Propanol (5)		

With the $K_2Cr_2O_7$ solution:

Alcohols	**Color in the begin**	**Color after some time**
Methanol (1)		
Ethanol (2)		
1-Propanol (3)		
2-Propanol (4)		
2-Methyl, 2-Propanol (5)		

Reaction equation:

Give the half reactions for the two oxidizers and give the half reaction for the alcohols which react as reducing agent in the case of a color changes.

Explanation and conclusions:

Give the answer on the research question and write down the group of alcohol for the used alcohols.

Waste disposal:

The solutions must be disposed of in the waste barrel for heavy metals.

References:

Pulsar Chemie VWO Superstructure Part 2 Chapter 13 Wolters Noordhof Groningen
ISBN 9001-31154-7

EXPERIMENT NR. 92

WINE DISTILLATION

CHAPTER: Purification procedures

CHEMISTRY

PROPOSED BY: Liceo Socio- Psico -Pedagogico-Linguistico“Danilo Dolci”, Palermo, ITALY

Theoretical aspects:

This experience is the result of the theoretical and practical knowledge of the various statuses of matter and its transformation. The students have realized how important is to solve the problems in a lab through experiments

Different approaches:

In the experiments it is important to consider the inner properties of matter. In our case those of ethylic alcohol. Despite it is the consequence of volume and mass. That is $d= m/V$. which allow us to identify the different substances

Materials, apparatus, chemicals:

Distillation device: easy distillation balloon, pipe condenser for the water of refrigeration entry and going out, collecting box, thermometer put on the cover, china little balls
Bunsen beak
Trivet with net
Sustain pole and piliers
50 cm3 graduated cylinder
50 cm3 beaker
Scale
Graduated cylinder with water salted solution

Safety precautions:

Safety precautions: to realize the experience in the lab it is necessary to know the objects and various materials which usually are in a lab then it is good to pay attention how you move in it as there are some fragile and sometimes dangerous materials. For this reason the attention used here must be higher than that used in the classroom

Experimental procedure:

Experimental procedures: Assemble the whole apparatus for distillation. Determine the density of the solution since the beginning. Pour 100 cm 3 of salted water solution into the distillation balloon. Fire the Bunsen beak at low flame and heat with caution. Observe the distillation temperature. How does the temperature change durino the process? Put about 50 cm 3 of the distilled solution in the graduated cylinder whose mass has already been measured. Establish the density of the collected liquid.

Individual tasks:

In the first phase we observe the phenomenon we want to study, in the 2nd phase we state an hypothesis, that is theories which possibly explain the causes, the developments and the effects of the considered phenomenon. They are often expressed in maths formulas

In the 3rd phase they must obtain with the experimental test , then reproducing artificially even more times the phenomenon , with the right measures. In the 4th phase the analysis of the collected data allows to verify the formulated hypothesis

Explanation and conclusions: here it is the answer which explains the experiment, once Identified the collected substance as distil, consulting a form about the density of the main liquids it is clear that it is ethylic alcohol

Interpreting the results

After comparing the liquid density put in the graduated cylinder and the solution density they have asked themselves the following questions: Can we say it is the same liquid?

Interpreting the results at the end of the experience the students have interpreted the results and the procedures:

- they could identify the distilled material through the comparison of its density with those of the main liquids
- they recognize the condenser in a distillation apparatus
- assemble the instruments for a simple distillation
- to do the distillation of a solution in a correct way
-

Explanation and conclusions:

Explanation and conclusions: here it is the answer which explains the experiment, once identified the collected substance as distil, consulting a form about the density of the main liquids it is clear that it is ethylic alcohol.

References:

The students have been helped by Mr Alonzo, the don of the Agraria College of Palermo University. Thanks him we had the opportunity to see the experiment in every phase.

The Don of the Agrarian College of Palermo University Mr. Giuseppe Alonzo gave his contribution allowing the teachers and the pupils involved in the project sto use the University labs.

EXPERIMENT NR. 94

SYNTHESIS OF FRUIT ESTERS

CHAPTER: ORGANIC REACTIONS

CHEMISTRY

PROPOSED BY: HTL-Dornbirn, AUSTRIA

Theoretical aspects:

Esters are condensation products of acids and alcohols, e.g.:

$CH_3\text{-}COOH + CH_3\text{-}CH_2\text{-}OH \rightarrow CH_3\text{-}COO\text{-}CH_2\text{-}CH_3 + H_2O$

Ethanoic acid + Ethanol → Ethyl-ethanoate + Water

They play an important role in biochemical substances (e.g. fats, ATP, bee wax…).
Esters of low carbon acids and alcohols have an characteristic smell and are part of aromas in fruits and plants. Since fruit esters are easy to synthesize, they play an important role in food industry.

Different approaches:

The esterification is an acid catalysed equilibrium reaction. In equilibrium state the acid and the alcohol dominate, only a little amount of ester exists. To shift the equilibrium to the side of the ester either the water must be removed or activated carbon acid derivates must be used.

In professional organic synthesis there are two common ways of producing an ester:

1. Azeotropic water removal with benzene in special apparatus
2. Use of acid chlorides or acid anhydrides instead of the common carboxylic acids.

In this experiment concentrated sulfuric acid (H_2SO_4) serves as a catalyst and water remover.

Materials, apparatus, chemicals:

Chemicals:

- Organic Carboxylic acids (Methanoic acid, Ethanoic acid, Butanoic-acid Benzoic acid, Salicylic acid) $w \approx 100\%$
- Alcohols (e.g. Methanol, Ethanol, Pentan-1-ol) not diluted!
- Concentrated sulfuric acid ($w(H_2SO_4)=96\text{-}98\%$)
- Sodium carbonate
- water

Materials and apparatus:

- test tubes
- Bunsen burner
- 100ml beakers
- boiling chips

Safety precautions:

Concentrated Sulfuric acid is very corrosive. Wear safety goggles and rubber gloves while examining the experiment!
Methanoic acid is corrosive.
Ethanoic acid is corrosive.
Butanoic acid is noxious to health and has an offensive smell.
Methanol is toxic and inflammable.
Ethanol is inflammable and noxious to health.
Pentan-1-ol is noxious to health.

H_2SO_4

CH_3COOH

$HCOOH$

C_3H_7COOH

CH_3OH

Experimental procedure:

Put 1ml carboxylic acid and 2ml alcohol in to a test tube and mix them well. Add 1ml concentrated sulfuric acid and a boiling chip to this mixture. Heat the mixture carefully with the Bunsen burner till it is gently boiling (ATTENTION: Never hold the test tube opening in the direction of other people!). Let the mixture cool down 1 minute and pour it in the 100ml beaker with the sodium carbonate to neutralize the sulfuric acid. Dilute the mixture with water (up to the Volume of approximate 20ml) and smell the product.

The following mixtures have characteristic smells:

Carbon acid	**Alcohol**	**Ester**	**Smells like**
Methanoic acid	Ethanol	Ethyl-methanoate	rum
Ethanoic acid	Ethanol	Ethyl-ethanoate	nail polish remover
Ethanoic acid	Pentan-1-ol	Pentyl-ethanoate	banana
Ethanoic acid	Pentanol	Pentyl-butanoate	pear
Butanoic acid(*)	Ethanol	Ethyl-butanoate	pineapple
Salicylic acid	Methanol	Methyl-salicyloat	tooth paste
Benzoic acid	Ethanol	Ethyl-benzoate	peppermint

(*) because of the offensive smell of Butanoic acid this reaction should only be done by experienced students!

Waste disposal:

The content of the beaker can be poured into the sink.

EXPERIMENT NR. 102

GLUCOSE OXIDATION – FEHLING REACTION

CHAPTER: SUGARS

CHEMISTRY

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU", Şimleu Silvaniei, ROMANIA

The purpose of this experiment is to the properties of glucose through its oxidation reactions which could be used as identification reactions of this sugar.

Theoretical aspects:

The glucose has a aldehyde group which could be oxidized by different oxidizing agents. The most common reagents which could oxidize this sugar are the very weak ones which are not attacking the rest of the molecule, transforming the aldohexose in a pentahydroxilic acid called *gluconic acid*. The Tollens reagent and the Fehling reagent are both very weak oxidizers but they give specific reactions with aldoses (especially with glucose). This specificity motivates the study of these two reactions in order to establish an identification method of glucose.

Materials, apparatus, chemicals:

Test tubes, glucose, Fehling reagent freshly prepared (sodium hydrixide, copper sulphate, sodium and potasium tartrate), heating source.

Safety precautions:

Sodium hydroxide and copper sulphate are corrosive. Avoid the skin and eye contact with these reagents. Wear protective glasses and gloves. Sodium hydroxide can cause severe burns. Copper sulphate is harmful when swallowed

NaOH

$CuSO_4$

Fehling

Experimental procedure:

First you have to prepare the Fehling reagent too. **FEHLING** This reagent is easily made by mixing equal amounts of Fehling I and Fehling II solutions. The first solution is a concentrated copper sulphate solution (7 g of $CuSO_4*5H_2O$/100 mL of water) and the second one is a very alkaline solution of Seignette salt –sodium and potassium tartrate- made by mixing 35g of sodium and potassium tartrate with 10g of NaOH dissolved in 100mL of solution. By mixing both solutions a clear intense blue solution is formed.

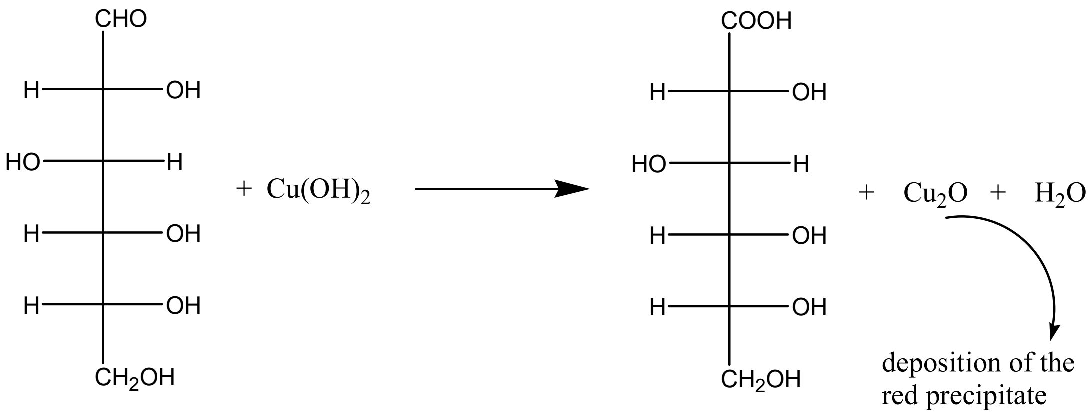
Then the reaction between glucose and the Fehling reagent has to be performed. For this to a few mL of glucose solution is mixed with a few mL of Fehling reagent and the mixture is heated. Observe the changes occured in the test tube.

Individual tasks:

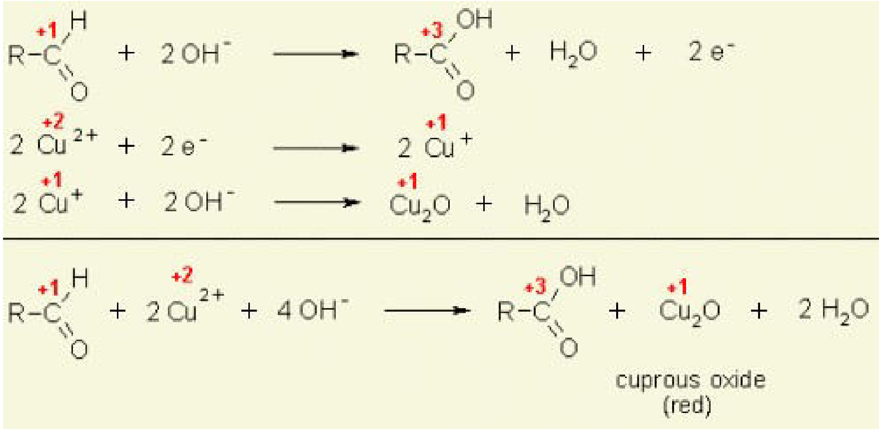
Describe the experiments carried out for preparing the Fehling reaction and the reduction of the glucose. Write down and establish the coefficients for the occurred reactions. Describe the utility of this reaction!

Explanation and conclusions:

The Fehling reagent is an oxidizer and the glucose is a reducing sugar because the presence of the aldehyde group. The glucose will be oxidized at the aldehyde and being transformed in *gluconic acid*. The reaction is as follows:



The copper hydroxide, which is in a soluble form due to the complexation of the copper ions with the tartrate salts, will be reduced to the red copper oxide. The reaction is very sensitive and it was used to determine the presence of the glucose in urine at the people suffering from *diabetes melitus*. The reaction medium is passing through different colors due to the result of mixing the initial blue color of the solution with the formed red precipitate.



$$R-\overset{+1}{C}(=O)H + 2\,OH^- \longrightarrow R-\overset{+3}{C}(=O)OH + H_2O + 2\,e^-$$

$$2\,\overset{+2}{Cu}{}^{2+} + 2\,e^- \longrightarrow 2\,\overset{+1}{Cu}{}^{+}$$

$$2\,\overset{+1}{Cu}{}^{+} + 2\,OH^- \longrightarrow \overset{+1}{Cu_2}O + H_2O$$

$$R-\overset{+1}{C}(=O)H + 2\,\overset{+2}{Cu}{}^{2+} + 4\,OH^- \longrightarrow R-\overset{+3}{C}(=O)OH + \overset{+1}{Cu_2}O + 2\,H_2O$$

non heated reaction mixture

heated reaction mixture

Waste disposal:

The solution coming from the Fehling reaction should be collected in a container for less toxic inorganic waste.

References:

1. Nenitescu, C.D., *Chimie organica*, Ed Didactica si Pedagogica, Bucuresti,1966
2. Albu, Petrescu, Cosma, *Manual de Chimie pentru clasa a Xa*, Ed. Didactica si Pedagogica, Bucuresti,1994
3. http://en.wikipedia.org/wiki/Hazard_symbol
4. www.didiersvt.com/cd_1s/html/c8/c8a1p2.htm
5. http://www.experimenten.nl/images/zilverspiegel/erlenmeyer.jpg; http://www.uni-r.de/Fakultaeten/
6. H.W. Roesky, K. Mockel, *Chemical curiosities, Spectacular Experiments and Inspired Quotes, 1996* VCH Verlaggesellschaft, D 69451, Weinheim, Germany

EXPERIMENT NR. 104

NITROCELLULOSE (GUN-COTTON)

CHAPTER: ORGANIC CHEMISTRY

PROPOSED BY: HTL-Dornbirn, AUSTRIA

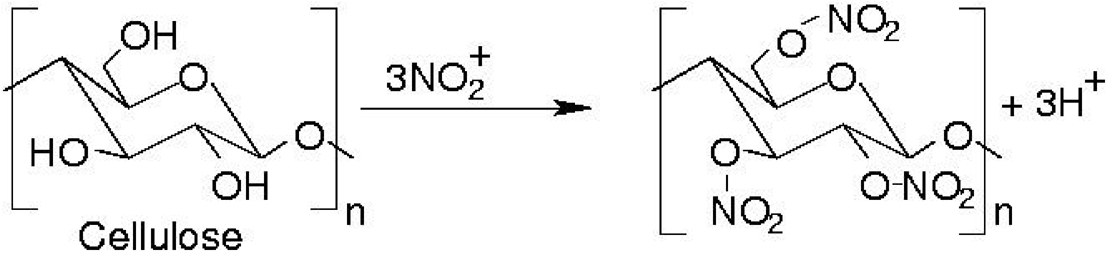
Theoretical aspects:

About 10% of commercially produced nitric acid is used in a mixture with sulfuric acid (nitrating acid) for the nitration of organic compounds. Uses include the production of nitrobenzene (starting material for aniline), nitroglycerine (dynamite) and picric acid. The nitration of cellulose produces either celluloid (low nitration) or gun-cotton (high nitration). Celluloid was one of the first synthetics and was widely used in film industry although it is no longer employed, due to its high inflammability.

The approach:

The nitrating agent in this reaction is not nitric acid itself, but rather the nitryl cation NO_2^+ which results from an acid-base reaction of the strong sulfuric acid with the nitric acid, which in this case acts as base! The hydroxyl groups of the cellulose are nitrated with the nitryl cation NO_2^+. Depending on the number of hydroxyl groups that are nitrated, the reaction leads to celluloid (low nitration) or gun-cotton (high nitration).

$O_2NOH + H_2SO_4 \rightarrow NO_2^+HSO_4^- + H_2O$



Materials, apparatus, chemicals:

Chemicals

- 40ml concentrated Sulfuric acid ($w(H_2SO_4)=98\%$)
- 20ml concentrated Nitric acid (fuming)
- 2g cotton wool
- (sodium hydrogen carbonate-solution 84g/Liter)
- crushed ice

Materials and apparatus:

- 2x 150ml beakers
- plastic bowl for the ice bath
- glass rod
- bucket
- crucible tongs
- thermometer
- pH paper

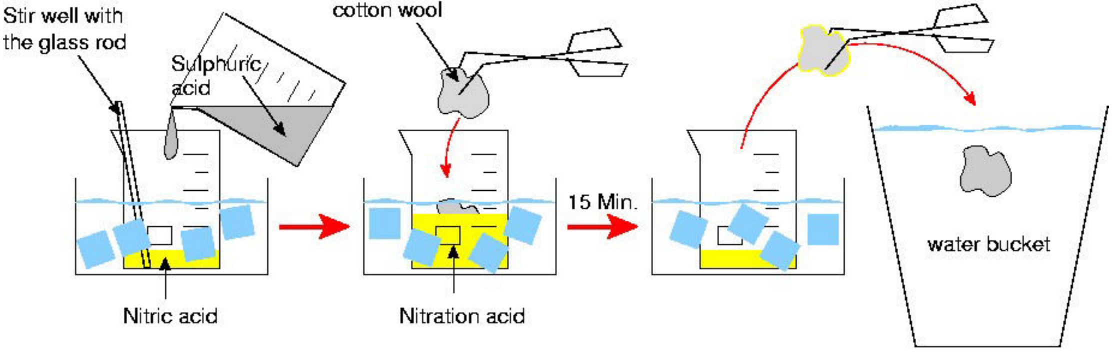
Safety precautions:

Concentrated sulfuric acid and concentrated nitric acid are very corrosive and oxidizing liquids. The mixing of the two acids causes strong development of heat with partial generation of nitrogen oxides. The nitrating acid is dangerous! Nitrocellulose is highly inflammable and pressure-sensitive. Always wear safety goggles and rubber gloves while examine the experiment. The generation of the nitrating acid and the nitration must be done in a well working fume hood.

Wet Nitrocellulose with more than 10% humidity is not inflammable and explosive and can be transported without danger.

Experimental procedure:

All procedures must be done in a well working fume hood. Fill in one 150ml beaker stored in a fitting ice bath the fuming nitrous acid. Add the sulfuric acid in small portions to the nitric acid and stir well. When the nitration acid is cooled down (If necessary, add more ice to the ice bath!) immerse the cotton wool in the nitration acid with the crucible gripper. Wait for 15 minutes till the reaction is finished. Remove the cotton wool and immerse it in a bucket full of water. Wash the nitrocellulose with a lot of water, till the wash water is acid free (pH-paper!). Eventually you can destroy the acid through neutralization with a sodium hydrogen carbonate-solution. Squeeze out the cotton wool and spread out on an absorbent cellulose cloth for drying (48h).



Burning the nitrocellulose: Light a small piece of pure cotton wool and nitrocellulose with the Bunsen burner and observe the difference. Use the crucible tongs to hold the pure cotton wool and nitrocellulose!

Interpreting the results:

Cellulose is hard to burn, that is why protective clothing in laboratories is always made of pure cotton and never of synthetics. In contrast, nitrocellulose takes flame with ease and burns like wild fire with the production of Carbon monoxide (CO), Carbon dioxide (CO_2), Nitrogen, and water. The reason for this is that the powerful oxidant is directly bound to the organic material. In pure cotton the oxidant oxygen can only act on the surface of the cotton fibers.

Waste disposal:

Dilute the nitration acid (H_2SO_4/HNO_3) highly and pour it into the sink. Nitrocellulose is an explosive and must be destroyed completely after the experiment!

References:

[1] R. Meyer, Explosivstoffe, Verlag Chemie, Weinheim 1985, p.207
[2] F. R. Kreißl, O. Krätz, Feuer und Flamme, Schall und Rauch, Verlag Chemie, Weinheim, **2003** p.114f

EXPERIMENT 107

RECOGNIZING THE PROTEINS - BIURET REACTION

CHEMISTRY

CHAPTER: AMINOACIDS - PROTEINS

PROPOSED BY: COLEGIUL NATIONAL "SIMION BARNUTIU" Şimleu Silvaniei, ROMANIA

In this experimental work students will find out how to prepare a solution of a soluble protein, how to recognize very easily the protein solutions and they will interpret in a new way the coordinative bond.

Theoretical aspects:

The proteins are based on amino acids, this means they are organic compounds containing nitrogen. The amino groups of the amino acids are responsible for the creation of the peptide bond which is the basis of the protein molecule. Due to its specific properties the amino group is determining not only the structure of the protein but also its specific properties.

Materials, apparatus, chemicals:

An egg as a source for soluble proteins, distilled water, NaOH, $CuSO_4$,

Safety precautions:

NaOH is corrosive, avoid eye and skin contact with these solutions. Copper ions are irritant, corrosive for active metals and dangerous for the environment. Sodium hydroxide can cause severe burns, may cause serious permanent eye damage. Copper sulphate is harmful when swallowed.

NaOH

$CuSO_4$

Experimental procedure: Individual tasks:

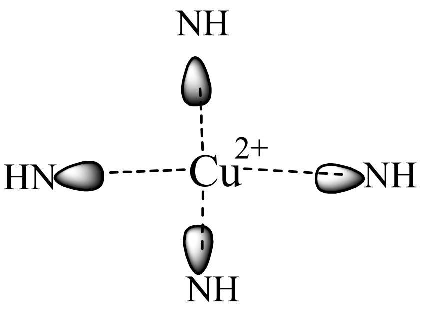
Prepare 100mL of NaOH 0.1 M solution. For this you have to calculate the necessary amount of the base.

Prepare 100 mL of $CuSO_4*5H_2O$ 0.2M solution. Take care when calculating and measuring the necessary amount of the salt because this is a crystalohidrate.

In a test tube pour a few mL of the soluble protein solution followed by a few drops of NaOH solution. Don't use concentrated solutions in order to avoid the denaturation of the protein due to high ionic strength.

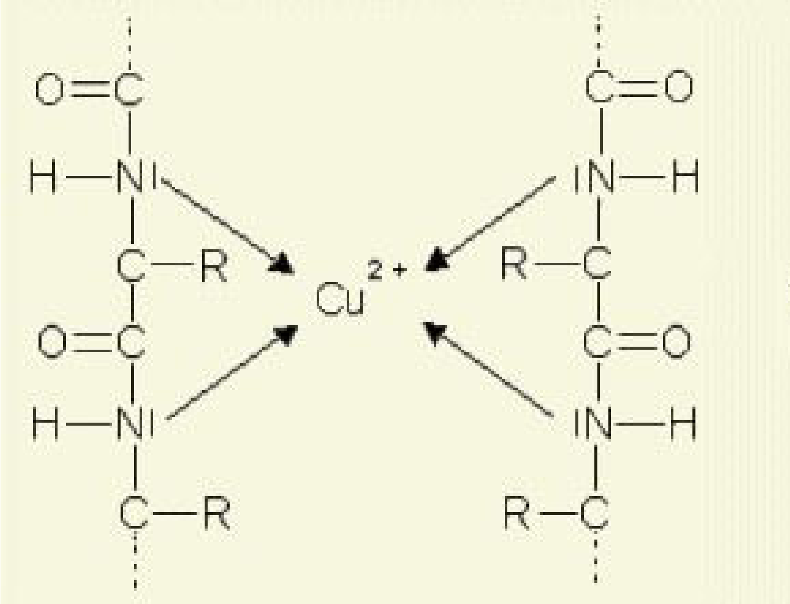
To the alkaline solution add a few drops of $CuSO_4$ and mix the resulting solution. Note the differences you notice after each step!

Interpreting the results



Explanation and conclusions:

The nitrogen atoms of the peptide bonds, due to their lone pair, form coordinative bonds with the cupric ion. The complex has a square planar symmetry and a blue-violet color. Its structure is similar to the biuret complex therefore the coordination of Cu^{2+} with protein is called in the same way. The color is specific and it's very easy to recognize it.



(1)

The same reaction occurs with the proteins of the skin if you prepare a Bordeaux solution to fight against fungi in the vineyards. The Bordeaux solution is a mixture of $CuSO_4$ and $Ca(OH)_2$. With this solution you have to spray the vine to avoid mildew. If a drop of this solution is reaching your hand that place will become violet due to the reaction if the alkaline solution of $CuSO_4$ with the protein from the skin.

Waste disposal:

The copper sulphate solutions have to be collected in a tank for less toxic inorganic salts.
Avoid pouring out the protein solution in the drain because the pipes could be clogged.

References:

1. Nenitescu, C.D.,*Chimie organica*, Ed Didactica si Pedagogica, Bucuresti,1966
2. Albu, Petrescu, Cosma, *Manual de Chimie pentru clasa a Xa*, Ed. Didactica si Pedagogica, Bucuresti, 1994
3. http://en.wikipedia.org/wiki/Hazard_symbol
4. http://www.uni-r.de/Fakultaeten/nat_Fak_IV/Organische_Chemie/Didaktik/Keusch/D-Biuret-e.htm

EXPERIMENT NR. 109
DETERMINATION OF PLASTIC MATERIALS AND FIBRES

CHAPTER: ORGANIC REACTIONS

PROPOSED BY: HTL-Dornbirn, AUSTRIA

Theoretical aspects:

The end of the 20th century may be characterized as the “plastics age” - the use of synthetic polymers in plastic articles and fibres has been growing more and more all over the world. Commonly used plastic materials are e.g. polyethylene for bags, foils etc. and polypropylene for protecting materials. Polyethyleneterephthalate is used in bottles, polystyrene for insulating materials und food/beverages cups, polyvinylchloride in packing materials. Textiles were in former times only manufactured from natural polymers, e.g. cotton, wool, silk .., but since the 1950s synthetic fibres have been spreading in almost any application of garments and home textiles. Polyester, polyamide and polypropylene as well as regenerated cellulosic fibres (viscose, lyocell) are found in many textile articles.

Different approaches:

The following tests for plastics and fibres may be carried out at the beginning of the chapter “polymers and fibres” to motivate the pupils and find the connection to applications in products of everyday life. Alternatively, if the tests are performed after having discussed chemical structures, the different behaviour of the polymers may be attributed to chemical properties, e.g. content of C, H, N and O influencing the burning behaviour, presence of halogen atoms causing high density etc.

Materials, apparatus, chemicals:

Chemicals:
- Sodium chloride (NaCl)
- Sodium thiosulphate ($Na_2S_2O_3$)
- Deionized water

Materials and apparatus:
- Copper wire (electrical cable with insulation removed)
- Bunsen burner
- Beakers (250 or 400 mL)
- Pincers for holding the samples
- Plastic materials, textile yarns/threads from garments or technical textiles

Safety precautions:

Some polymers (polyethylene and polypropylene) are melting in the hot flame, drops of burning material are falling down and may cause serious damage to skin or table-tops.

Waste disposal:

The liquids are poured into the sink; solid materials may be disposed in the household waste.

Experimental procedure:

1. Burning tests: Hold a piece of sample to the flame of the Bunsen burner and observe the behaviour of the flame (colour, formation of soot). Remove the material from the flame and try to describe the smell of the burnt sample. Also observe whether the sample is still burning outside the flame.

Some typical observations are listed below:

Material	Burning behaviour	Smell
Polyethylene (PE) and Polypropylene (PP)	Burns in and outside the flame, blue flame, melting drops are burning	Like a candle
Polyethyleneterephthalate (PET), Polyester (PES)	Burns in the flame, yellow flame with soot, melting drops, remaining material brown	Aromatic
Polystyrene (PS)	Burns in the flame, yellow flame with plenty of soot particles	Aromatic
Cotton (CO)	Burns in the flame, light coloured flame, grey ash remaining	Like burning paper
Wool (WO), Silk (SI)	Does not burn well, black-grey remaining material	Like burnt hair
Viscose (CV) and Lyocell (CLY)	Burns in the flame, light coloured flame, grey ash remaining	Like burning paper
Polyamid (PA): nylon, perlon	Burns in the flame, blue flame, melting drops, remaining material yellow-brown	Like burnt hair

2. Beilstein´s test: Heat the clean copper wire in the burner and press it against the surface of a sample of polyvinylchloride (PVC). Then hold the copper wire with the burnt material to the flame – a green coloured flame is observed only in the presence of halogenated materials (copper reacts with the chlorine forming copper chloride). Use small amounts and perform the test in an exhausting chamber if available. Noxious gases (HCl) and small amounts of chlorinated aromatic compounds are produced during this test.

3. Determination of the raw density: Prepare saturated solutions of Sodium chloride and Sodium thiosulphate in two beakers. An additional beaker is filled with deionized water. Put pieces of the plastic samples in the beakers and observe whether they stay at the surface or go down to the bottom according to the density of the liquid.

Testing Liquid:	Staying at the surface:	Going down to the bottom:
Water	Polyethylene, Polypropylene	All the other materials
Sodium chloride solution (Density of solution: 1,18 g/cm^3)	Polyethylene, Polypropylene, Polystyrene, Polyamide	Polyvinylchloride, Polyethyleneterephthalate
Sodium thiosulphate solution (Density of solution: 1,4 g/cm^3)	All materials	Some types of polyvinyl chloride

Note: Plastics are technical products and may contain impurities and additives as well as occluded gases (air). Therefore the density of different products made of the same polymer may vary considerably. The described method is also used for the separation of (recyclable) polymer materials from mixed waste.

EXPERIMENT NR. 112

SUPERABSORBENT POLYMERS IN DIAPERS

CHAPTER: SHOW EXPERIMENTS

Proposed by: HTL-Dornbirn, AUSTRIA

CHEMISTRY

Theoretical aspects:

Modern baby diapers contain Superabsorbent polymers (SAP), that can absorb and retain extremely large amount of a liquid relative to its own mass. These polymers absorb the urine of the child, and keep the skin of the baby dry.

These Superabsorbent polymers are commonly made from the copolymerisation of acrylic acid (Propenoic acid) and the sodium salt of the acrylic acid. This cross-linked polymer can swell extremely and absorb aqueous solutions very efficiently.

Materials, apparatus, chemicals:

- baby diapers (eg: super dry; ATTENTION: Not all diapers contain SAPs!)
- a large plastic bag
- 100ml beaker

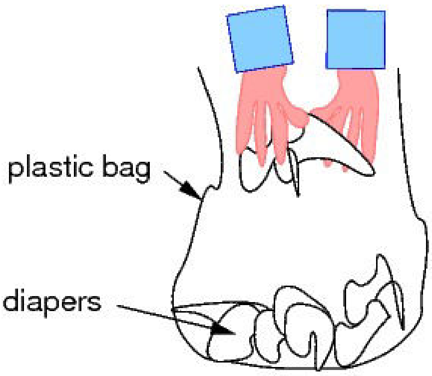
Safety precautions:

Do not swallow the Superabsorbent powder!!! No other precaution should be taken.

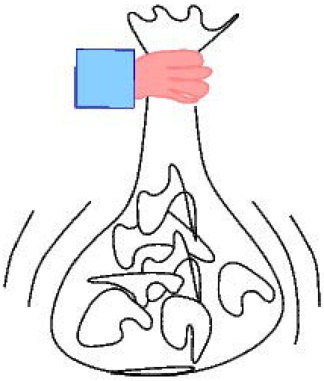
Experimental procedure:

Extraction of the super absorber:

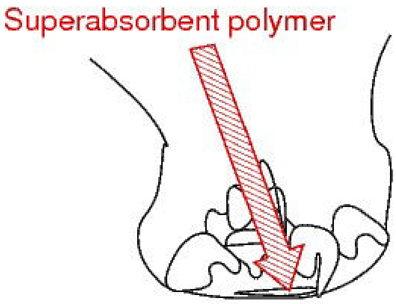
Tear two or three diapers to small pieces inside the plastic bag. Close the plastic bag and shake it well. At the bottom of the plastic bag you will find a white light weighted powder, the Superabsorbent polymer (also called slush powder).



Tear the diapers to pieces!

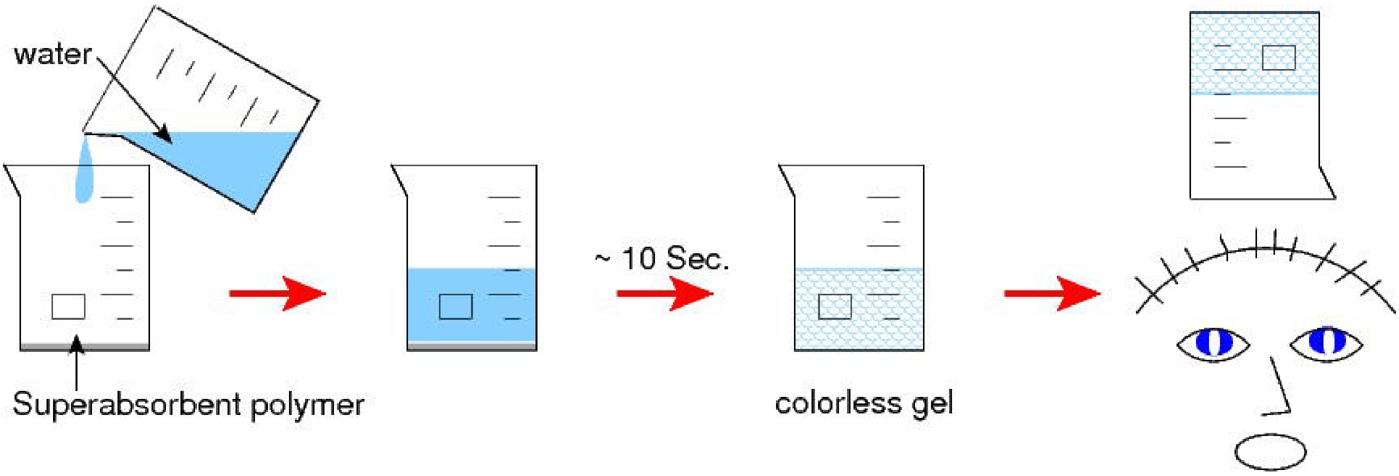


Close the plastic bag and shake it well!



Experiment:

Transfer the superabsorbent polymer powder into the 100ml beaker (Only the bottom of beaker shall be covered with the powder!). Pour about 50ml water inside the beaker and wait about 10 seconds. The super absorber will swell extremely and will absorb the whole amount of water. You can put the beaker up side down (for brave people: over your head!) and no water will get out of the beaker.



Waste disposal:

The content of the beaker can be can be disposed in the normal house waste container.

References:

http://en.wikipedia.org/wiki/Superabsorbent_polymer

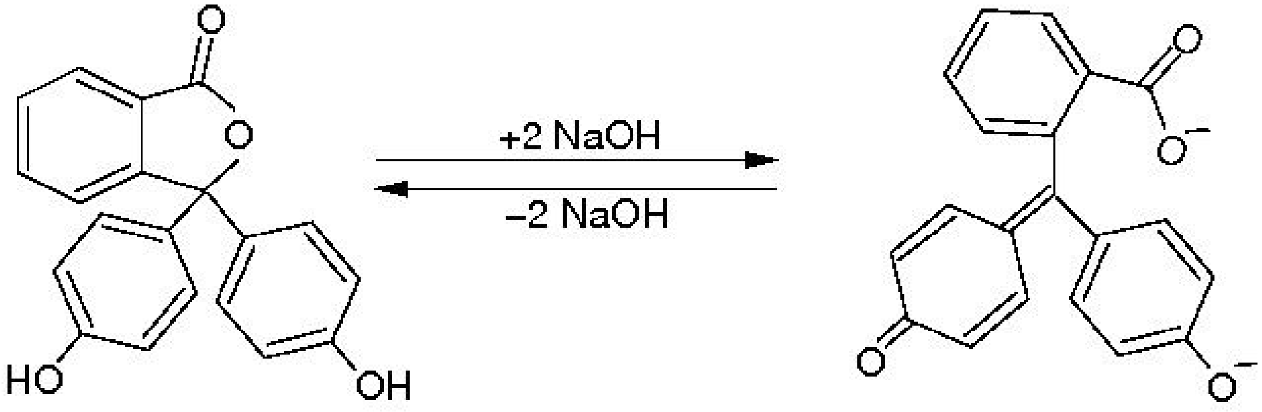
EXPERIMENT NR. 113
SYTHESIS OF PHENOLPHTHALEINE
CHAPTER: ORGANIC CHEMISTRY

PROPOSED BY: HTL-Dornbirn, AUSTRIA

Theoretical aspects:

Acid-base indicators are organic compounds, that change their color depending on the H^+-concentration (pH-Value). Acid-base indicators are often used in acid and base titrations to indicate the endpoint of the titration. The change of the color is effected by a structural change of the indicator molecule caused by protonation/deprotonation processes.

One of the most prominent indicator is phenolphthalein. Phenolphthalein is a triphenylmethane dye. Below pH~8 phenolphthalein forms a lactone structure. This lactone is not planar and has no large conjugated π-electron system. Therefore, this structure is colorless. Above pH ~10 phenolphthalein forms a chinoide structure. This molecule has a pink color caused by the planar fully conjugated π-electron system.



lactone structure
colorless

chinoide structure
red/violet

Phenolphthalein can be easily synthesized by condensation of phthalic anhydride with two equivalents of phenol under acidic conditions (hence the name). This synthesis was discovered in 1871 by Adolf von Bayer.
Phenolphthalein is insoluble in water, and is usually dissolved in ethanol for use in experiments.

Materials, apparatus, chemicals:

Chemicals:
- 0.5g phenol
- 0.4g phthalic anhydride
- concentrated sulfuric acid ($w(H_2SO_4)$=96-98%)

- ethanol
- NaOH-Solution (c(NaOH) = 0.1 mol/L)
- HCl-Solution (c(HCl) = 0.1 mol/L)

Materials and apparatus:
- test tube
- Bunsen burner
- 100ml beaker

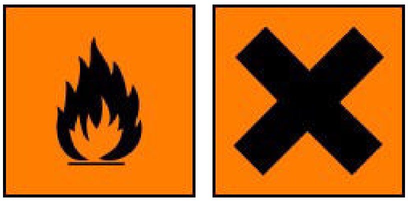
Safety precautions:

Phenol is toxic! Avoid any contact with skin. Concentrated Sulfuric acid is very corrosive. Ethanol is inflammable and noxious to health. Wear safety goggles and rubber gloves while examine the experiment!

Phenol

Sulphuric acid

Ethanol



Experimental procedure:

Melt 0.5 g phenol and 0.4 g phthalic anhydride in the test tube carefully.
Add four drops of concentrated sulfuric acid to the molten mass.
Heat (not boil!) the mixture carefully for 1-2 minutes. The molten mass changes the color from white to red brown.
Let the content of the test tube cool down to room temperature. Add 3 ml Ethanol.
Pour the ethanolic phase into the flask with 20 ml sodium hydroxide solution. The color of the solution changes to the typical violet color (see figure 1.). With hydrochloric acid the solution in the beaker can decoloured (see figure 2.) .

Waste disposal:

Dilute the content of the test tube and pour it into the sink.

References:

E. Guby, F. Richter, -A. Seidl Organische Chemie (Lehrbuch für die oberen Klassen der allg. bildenden höheren Schulen, Franz Deuticke Verlag Wien; 1981, Seite 222

EXPERIMENT NR. 116

THE HELL OF THE JELLY BEAR

CHAPTER: SHOW EXPERIMENTS

PROPOSED BY: HTL-Dornbirn, AUSTRIA

Theoretical aspects:

At 400°C potassium chlorate disproportionates to potassium chloride and potassium perchlorate. Potassium perchlorate decomposes rapidly to oxygen and potassium chloride [1].

$4\ KClO_3 \rightarrow 3\ KClO_4 + KCl$
$3\ KClO_4 \rightarrow 6\ O_2 + 3\ KCl$

Since the active oxygen can evaporate, it is important to add the jelly bear directly after the melting of the potassium chlorate. The main reaction is the oxidation of the gelatine (a polypeptide) and the sugar of the jelly bear by the potassium chlorate to carbon dioxide, nitrogen oxides and water vapour. These nascent gases create a strange sound like a humming bear, and let the jelly bear “dance” in the test tube.

Materials, apparatus, chemicals:

Chemicals:

- 10g potassium chlorate ($KClO_3$)
- jelly bear

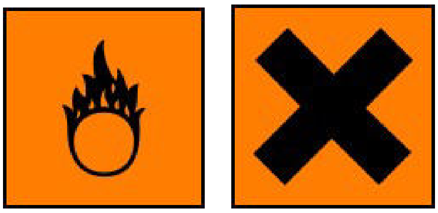
Materials and apparatus:

- large test tube (length approx. 20 cm, diameter 3 cm)
- Bunsen burner
- laboratory stand
- clamp and clamp holder
- crucible tongs

Safety precautions:

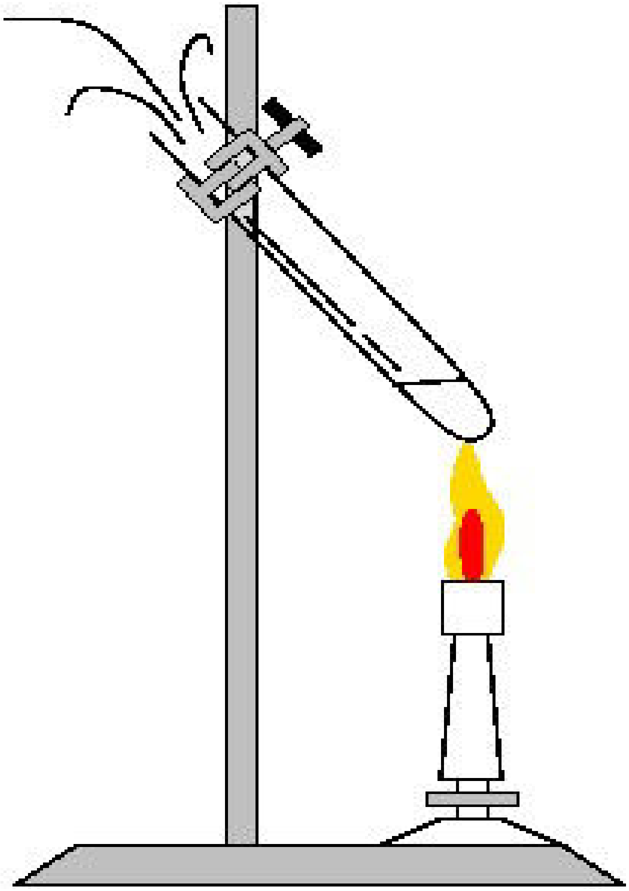
Potassium chlorate is a strong oxidizing agent and noxious to health. Wear safety goggles and rubber gloves while carry out the experiment. Keep distance to the audience, because the nascent gases can throw hot potassium chlorate out of the test tube.

$KClO_3$



Experimental procedure:

Darken the room! Melt 10g potassium chlorate in a slightly slanted fixed test tube to a clear viscous liquid with a Bunsen burner. Remove the burner quickly and throw the jelly bear with the crucible tongs into the test tube. The jelly bear starts to “dance” and burns under a blue coloured flame. This process is assisted by strange humming and murmuring.



Waste disposal:

Dilute the content of the test tube and pour it into the sink.

References:

[1] Holleman-Wiberg, Lehrbuch der Anorganischen Chemie, Walter de Gruyter, Berlin, New York **1995**, p. 480
[2] D.M Sullivan, J. Chem. Educ. 69 **1992** 326

EXPERIMENT NR. 117
EXPLOSION OF ACETHYLENE
CHAPTER: SHOW EXPERIMENTS

Proposed by: HTL-Dornbirn, AUSTRIA

CHEMISTRY

Theoretical aspects:

Calcium carbide (CaC_2) reacts with water, to gaseous acetylene and $Ca(OH)_2$ (Wöhler 1862):

$CaC_2 + 2H_2O \dashrightarrow C_2H_2 + Ca(OH)_2$

This is the basis of the industrial production of acetylene, and is the major industrial use of calcium carbide. Acetylene and the oxygen of the air react to give carbon dioxide and water in an explosive way:

$2C_2H_2 + 3O_2 \dashrightarrow 4CO_2 + H_2O$

Materials, apparatus, chemicals:

Chemicals:
- Calcium carbide (CaC_2)
- Water

Materials and apparatus:
- A Can (500 ml) with a small hole in the bottom of it
(You can buy empty cans in a shop for painting equipment. No screw caps!)
- Spatula
- Pasteur pipette

Safety precautions:

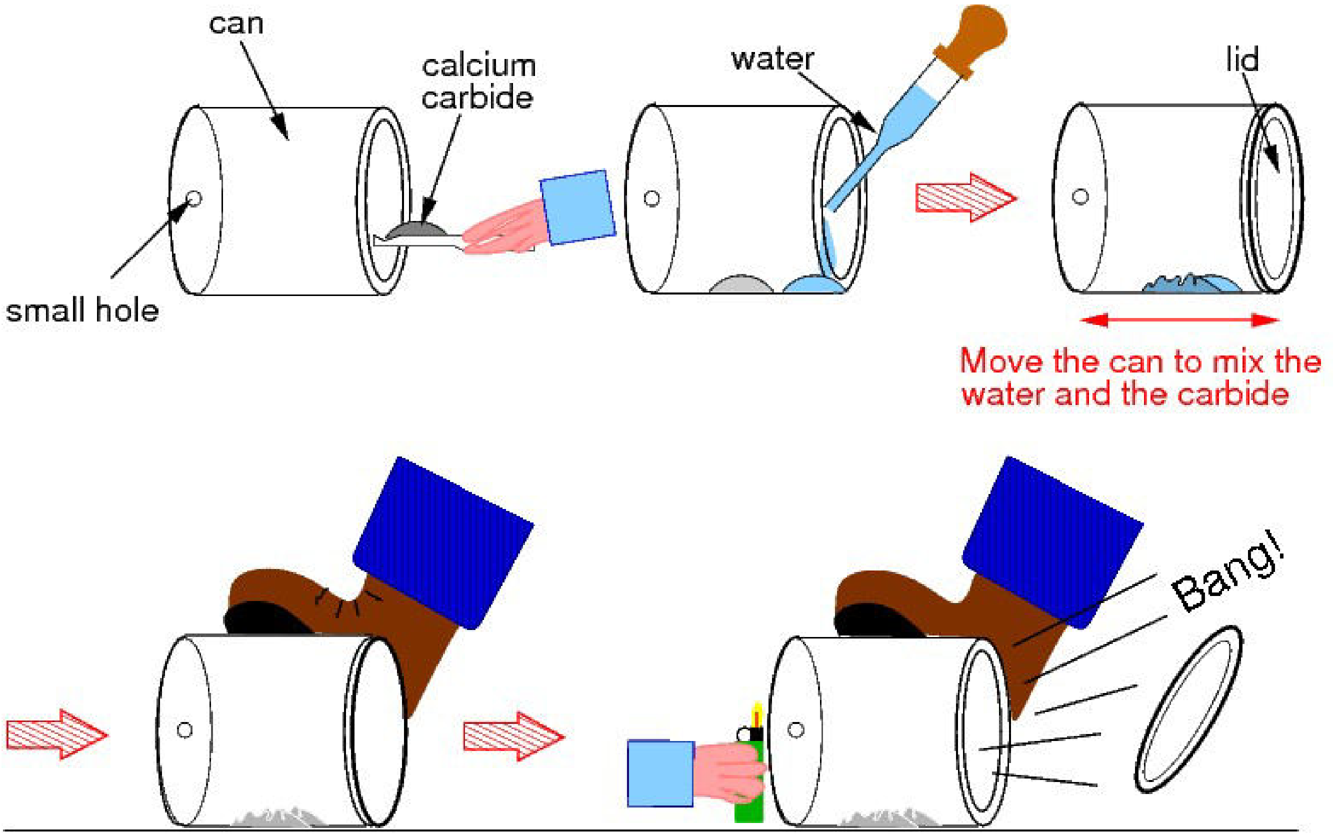
Calcium carbide may be harmful if inhaled, swallowed or in contact with skin.
Contact with skin may cause severe irritations or burns. Calcium carbide reacts violently with water liberating highly flammable gas (Acetylene). Acetylene/oxygen(air) mixtures are very explosive.
Be sure that no person stands close to the can, especially in front of the lid of the can, which squeezes out and flies through the air while the experiment. This experiment produces a very loud bang. Do not examine it inside small rooms to avoid the risk of ear injuries. Warn the audience and give them the advice to open the mouth while the explosion takes place. For the people carrying out the experiment hearing protection is highly recommended.

CaC_2,

acethylene

Experimental procedure:

Put a spatula of the calcium carbide in the can (Since commercial carbide varies in the amount of available calcium carbide it is important to determine the real amount of the necessary carbide with preliminary experiments!) Drop
about 2 ml of water close to the carbide and close the can with the lid quickly.
Move the can carefully, so that the water can react with the calcium carbide. Lay the can on the floor and fix it by standing with a foot on it!
A second person holds a lighter close to the small hole in the bottom of the can. The acetylene/oxygen mixture is ignited and the resultant overpressure inside the can squeeze out the lid. This produces a loud “bang” and the lid flies through the air.



Waste disposal:

No waste disposal is necessary.

References:

1. http://en.wikipedia.org/wiki/Hazard_symbol
2. https://www.reagentworld.com/products/

EXPERIMENT NR. 118
FLASHES UNDER WATER
CHAPTER: SHOW EXPERIMENTS

PROPOSED BY: HTL-Dornbirn, AUSTRIA

Theoretical aspects:

Flashes are normally generated in gaseous systems like air. There is also the possibility to generate flashes under water in the phase border between concentrated sulfuric acid and ethanol. The sulfuric acid and the ethanol don't admix, because of the large density difference (ρ(Ethanol) = 0,8 g/cm^3, ρ(H_2SO_4 conc.) = 1,8 g/cm^3).

Different approaches:

$KMnO_4$ reacts with the sulfuric acid under the formation of the highly explosive Mn_2O_7 (That's the reason why this experiment is carried out as a phase border experiment):

$2KMnO_4 + H_2SO_4 \rightarrow Mn_2O_7 + K_2SO_4 + H_2O$

This Mn_2O_7 decomposes to manganese dioxide (brownstone) and oxygen

$2Mn_2O_7 \rightarrow 4MnO_2 + 3O_2$

The generated oxygen oxidizes the ethanol on the border under sparks to carbon dioxide and water.

$CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

Materials, apparatus, chemicals:

Chemicals:

- 4ml absolute Ethanol
- Potassium permanganate $KMnO_4$
- 2ml concentrated Sulfuric acid (w(H_2SO_4)=96-98%)

Materials and apparatus:

- test tube
- test tube rack
- 5ml pipette
- spatula

Safety precautions:

Concentrated Sulfuric acid is very corrosive. Wear safety goggles and rubber gloves while carrying out the experiment.

H_2SO_4
$KMnO_4$

Ethanol

$KMnO_4$

Experimental procedure:

Pour 2ml concentrated sulfuric acid in the dry test tube. Overlay this phase with 4ml ethanol (Hold a pipette with ethanol close to the sulfuric acid surface and let the alcohol flow slowly into the test tube). There must be a phase border between the sulfuric acid and the ethanol layer (ATTENTION: Mixing of the two phases causes high temperature. The mixture can spurt out!). Put a small amount of Potassium permanganate granules in the test tube and observe what happens. (ATTENTION: Do not throw too many granules in the test tube, because the reaction can get out of control, and the mixture spurts out of the test tube!)

Interpreting the results:

The Potassium permanganate granules sink to the phase border between the sulfuric acid and the ethanol layer. After a while gas bubbles and sparks can be observed and the phase border is colored in various colors from violet to brown (manganese in different oxidizing states!).

Waste disposal:

Pour the liquid in a beaker, which is filled with 200ml water (ATTENTION: The ethanol can inflame!). Decolorize the solution with sodium sulfite and dispose it in the aqueous heavy metal waste.

References

H.W. Roesky, K. Möckel, *Chemische Kabinettstücke*, Verlag Chemie, Weinheim **1984**

EXPERIMENT NR. 119

SYNTHESIS OF "GOLDEN COINS"

CHAPTER: SHOW EXPERIMENTS

PROPOSED BY: HTL-Dornbirn, AUSTRIA

Theoretical aspects:

Making gold out of other substances was one of the major aims of alchemy. A lot of approaches were made in order to make gold out of cheap materials. Today we know that it's impossible to make gold from other substances than gold with chemical reactions. One of the easiest producible substance which looks like gold is brass.

The approach:

In strong alkaline media zinc reacts under generation of hydrogen to Sodium tetrahydroxo zincate.

$$Zn + 2\ H_2O + 2NaOH \rightarrow Na_2[Zn(OH)_4] + H_2\uparrow$$

In the following course of the reaction, zinc refines on the copper surface. After polishing with a soft cloth a silver zinc surface remains on the copper coin. With the heat of the Bunsen burner the zinc and the copper of the coin reacts to gold colored brass. (The brass layer is very thin and vanishes after a short time, because the layer's rubbed off)

Materials, apparatus, chemicals:

Chemicals:

- Small copper disc or Copper coin
- 25 g Zinc powder (coarse-grained)
- 4 g Sodium hydroxide (NaOH)
- water

Materials and apparatus:

- 100ml beaker
- 100ml porcelain dish
- Bunsen burner
- glass rod
- crucible tongs
- tripod
- wire gauze
- absorbent cellulose cloth

Safety precautions:

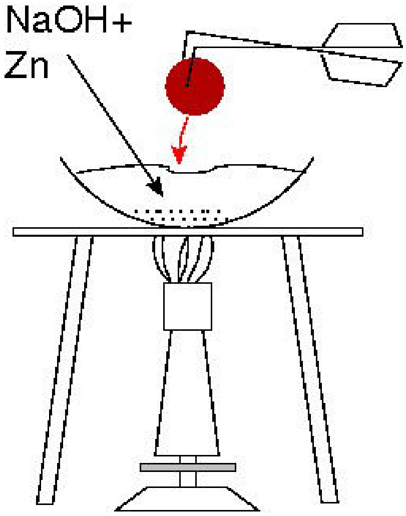
Concentrated Sodium hydroxide is very corrosive. Wear safety goggles and rubber gloves while examining the experiment.

NaOH

Experimental procedure:

Solve 4g Sodium hydroxide in 50ml water in a 100ml beaker (c(NaOH)=2 mol/L).

Put the porcelain dish on the wire net. Put 25 g Zinc powder and the Sodium hydroxide solution inside the bowl. Heat this suspension carefully and stir well with the glass stick until it starts to boil gently (ATTENTION: boiling delays!).
Lay the copper coins with the crucible tongs in the suspension. After half a minute, the coin gets a silver colored cover. Take the coin out of the dish with the crucible tongs and clean it properly under running water. Dry the coin with an absorbent cellulose cloth. The result is a "silver coin".



Heat the "silver" coin in the flame of the Bunsen burner. The color is changing from silver to gold. Let the coin cool down.

Waste disposal:

Dilute the solution and pour it into the sink.

References:

F: R. Kreißl, O: Krätz, Feuer und Flamme, Schall und Rauch, Verlag Chemie, Weinheim 2003, p.227f

EXPERIMENT NR. 121

GLUCOSE OXIDATION - SILVER MIRROR

CHAPTER: SUGARS

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU" Şimleu Silvaniei, RO

The purpose of this experiment is to the properties of glucose through its oxidation reactions which could be used as identification reactions of this sugar.

Theoretical aspects:

The glucose has an aldehyde group which could be oxidized by different oxidizing agents. The most common reagents which could oxidize this sugar are the very weak ones which are not attacking the rest of the molecule, transforming the aldohexose in a pentahydroxilic acid called *gluconic acid*. The Tollens reagent and the Fehling reagent are both very weak oxidizers but they give specific reactions with aldoses (especially with glucose). This specificity motivates the study of these two reactions in order to establish an identification method of glucose.

Materials, apparatus, chemicals:

Test tubes, glucose, Tollens reagent freshly prepared (silver nitrate, sodium hydroxide, ammonia), heating source

Safety precautions:

Sodium hydroxide is corrosive. Avoid the skin and eye contact with these reagents. Wear protective glasses and gloves. Silver nitrate causes burns and is a powerful oxidizing agent that may assist fire. Tollens reagent is very unstable if dry and also has been shown to explode if solutions are left for several hours. Concentrated ammonia is eye damaging

NaOH

$AgNO_3$

Tollens

NH_3

Experimental procedure:

First you have to prepare the Tollens reagent. This reagent should be used always in fresh form. DO NOT KEEP IT FOR DAYS! The preparation is made as follows. To a certain amount of 0,1M solution of $AgNO_3$ add a small amount of 1M NaOH solution. Then add drop wise some NH_3 solution until the medium will become colorless and crystal clear.

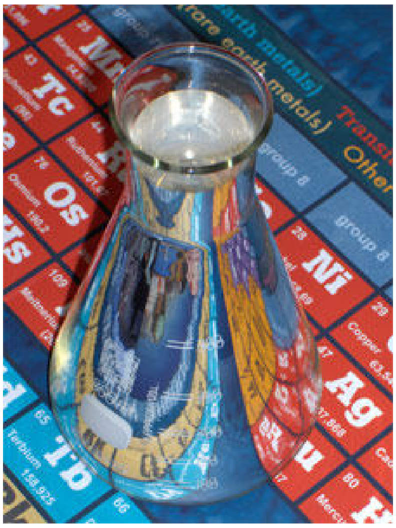
Then prepare a solution of glucose by disolving a pinch of this sugar in a few mL of water, in a very clean test tube or a round bottomed flask. Put a few mL of Tollens reagent in another test tube and warm up both solutions at aprox. 60 ºC. Then add the Tollens reagent to the glucose solution, mix it very well and allow standing.

Individual tasks:

Describe the experiments carried out for preparing the Tollens reaction and the reduction of the glucose. Write down and establish the coefficients for the occured reactions. Describe the utility of this reaction.

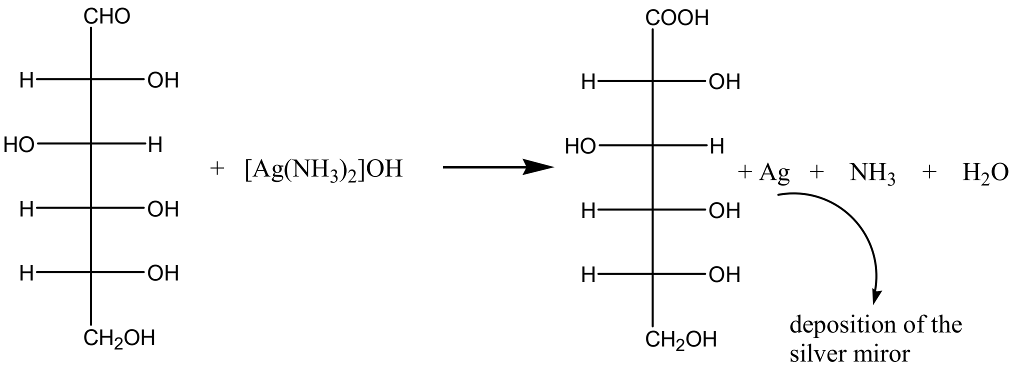
Interpreting the results

The Tollens' test is important in carbohydrate chemistry, for proof of structure. The test is specific for reducing sugars. Fructose is also capable of reducing Tollens' solution, and is thus classified a "reducing sugar". Under alkaline conditions fructose is converted into glucose therefore the Tollens reaction is positive for fructose too even if this sugar is not a reducing one (it will transform itself in glucose which is a reducing sugar).



Explanation and conclusions:

The Tollens reagent is an oxidizer and the glucose is a reducing sugar because the presence of the aldehyde group. The glucose will be oxidized at the aldehyde end being transformed in *gluconic acid*. The reaction is as follows:



If the concentration of the solutions was high enough the reduced silver will be deposited as a silver mirror in the test tube. If the concentration is not very high a black color will appear in the solution, the typical color of the atomic silver. This serves also as identification reaction.

Waste disposal:

The solution from the Tollens reaction is **not** poured down the drain because of the toxicity of the silver salts. This solution should be collected in a container used for collecting silver waste.

References:

1. Nenitescu, C.D.,*Chimie organica*, Ed Didactica si Pedagogica, Bucuresti,1966
2. Albu, Petrescu, Cosma, *Manual de Chimie pentru clasa a Xa*, Ed. Didactica si Pedagogica, Bucuresti,1994
3. http://en.wikipedia.org/wiki/Hazard_symbol
4. http://www.experimenten.nl/images/zilverspiegel/erlenmeyer.jpg
5. H.W. Roesky, K. Mockel, *Chemical curiosities, Spectacular Experiments and Inspired Quotes, 1996* VCH Verlaggesellschaft, D 69451, Weinheim, Germany

EXPERIMENT NR. 129
DECOMPOSITION OF NITROGEN TRIIODIDE

CHAPTER: REDOX REACTIONS

PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU" Şimleu Silvaniei, ROMANIA

Theoretical aspects:

The redox reactions are numerous and many of them are very important in the biological tissues. These reactions undergo with electron transfer so we always have a couple of reducing process and oxidizing process. In this section, a spectacular experiment is proposed in order to study a redox decomposing reaction. The student will learn about the hazard of working with dangerous chemical, how easily some of them are decomposing and will apply the rules for establishing the coefficient of a redox reaction.

Different approaches:

No different approaches are taken in consideration during this experiment!!! It is a demonstrative experiment illustrating the danger of different chemicals when people don't know the properties of the substances!

Materials, apparatus, chemicals:

Test tube, filter paper, funnel, Erlenmeyer flask, stand with rod, iodine, concentrated NH_3, diethyl ether, ethanol

Safety precautions:

The experience should be carried out only by the teacher. Explosive substances are obtained which can lead to injury by inexperienced chemists. Safety glasses and leader gloves should be used. The final part of the experiment should be made in a well ventilated hood in order to avoid the iodine vapors to be spread in the laboratory.

I_2, NH_3

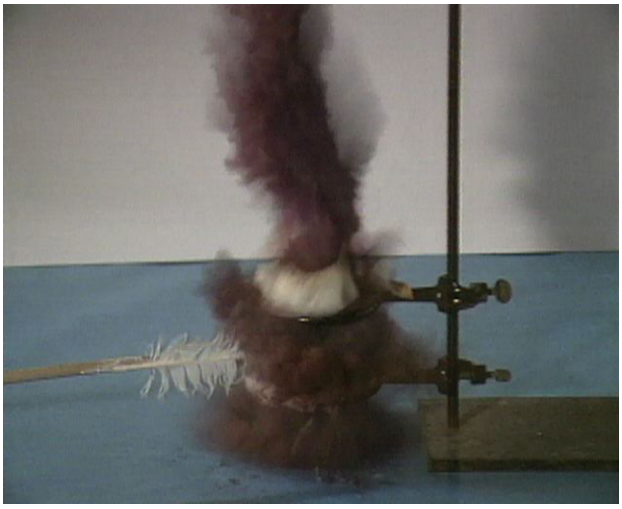
diethyl ether

NI_3NH_3

ethanol

Experimental procedure:

This is another example of a redox reaction which occurs very rapidly, in an explosive way. Solid iodine is placed in a test tube and a certain amount of concentrated NH_3 solution is added. The mixture is allowed to stand for a few hours or shake it very well in order to allow the reagents to meet each other while iodine is still solid not being soluble in water or ammonia solution. The solid precipitate should be filtered off while wet. Because the materials are not used in a stoechiometric rate the excess of iodine should be dissolved by washing the precipitate with ethanol. Please take in consideration to avoid open fire. The precipitate is allowed to get dry or it is treated with diethylether to dry it rapidly. **AFTER IT GET DRY DON'T MOVE IT ANYMORE.** It is enough to touch the compound with a feather or just to shake it a little in order to get a violent and very loud explosion.



Individual tasks:

Take a small amount of iodine and place it in a test tube containing several ml of concentrated ammonia. Observe the physical properties of the iodine and of the ammonia solution. Mention any changes observed during the mixing procedure of both reagents. Describe the final product. Allow it to stand overnight. Next day filter the precipitate and then allow the teacher to do the rest. Describe the color of the ethanol used to wash the precipitate, the decomposition reaction of the nitrogen triiodide, what it is formed during the reaction, how the reaction was initiated.
Establish the coefficients of the reaction using the redox method. Consider the nitrogen triiodure as an adduct.

Interpreting the results:

The reaction could be represented as following!

$$NI_3{*}NH_3 \longrightarrow I_2 + N_2 + NH_3$$

Explanation and conclusions:

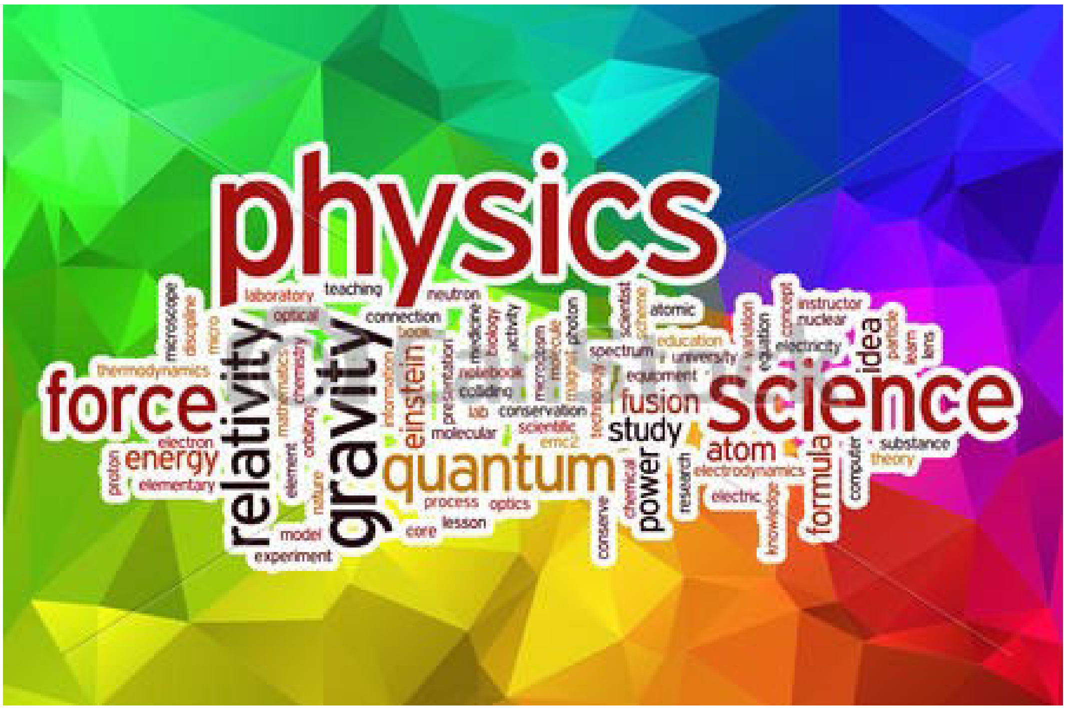
This is a redox reaction of a very unstable compound which decomposes with explosion. The observed violet fume is due to the iodine formed. Gaseous nitrogen is formed which is very stable and all solid products instantly are transformed in gases that's why the reaction is so violent.

Waste disposal:

Iodine should be neutralized with thiosulphate solution $Na_2S_2O_3$ or with Na_2SO_3 and then poured down the drain.

References:

1. H.W. Roesky, K. Mockel, *Chemical curiosities, Spectacular Experiments and Inspired Quotes, 1996* VCH Verlaggesellschaft, D 69451, Weinheim, Germany
2. http://en.wikipedia.org/wiki/Hazard_symbol
3. http://ull.chemistry.uakron.edu/erd/


physics
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science
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neutron
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nuclear
concept
particle
lens
substance
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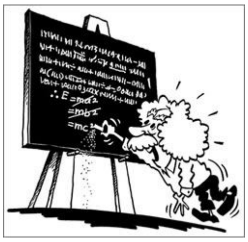
EXPERIMENT NR. 2 WAY-TIME-DIAGRAMS



CHAPTER: Mechanics

PROPOSED BY: HTL Dornbirn, AUSTRIA

Theoretical aspects:

One very commonly used way to visualize dependencies in physics are diagrams. Although diagrams have an immense relevance in the communication on physical effects, it is often hard to gather their large amount of information especially for pupils.

The intention of way-time-diagrams is to connect every position with the specific time information. All these data points together result in a continuous curve expressing the back and forth of the motion. Moreover the inclination of the curve shows the instantaneous velocity and shape gives the type of moving.

Different approaches:

One of the most difficult facts is that a length in a diagram is not always presenting a length information but duration, velocity and a large number of different quantities.
Thus in this experiment a diagram with human data points will arise just by taking „snap-shots” from the scene.
Moreover this „human diagram” will allow deducing the velocity of the probands and will lead to a discussion on errors in experiments.

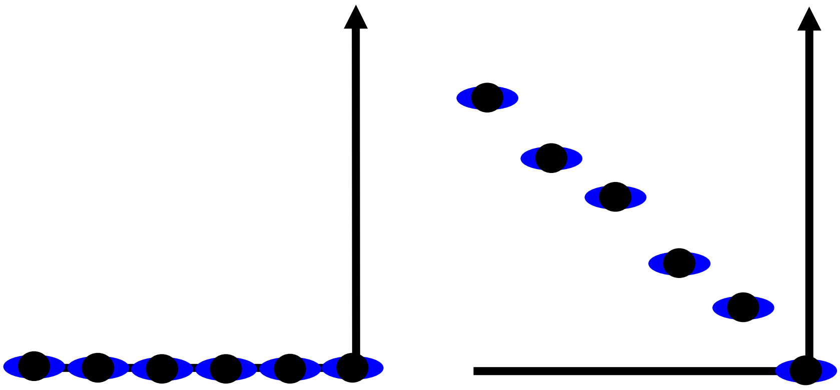
Materials, apparatus:

- a number of people
- large place (yard or gym)
- clock
- measuring tape and / or yard stick

Experimental procedure:

A number of people are standing in a line – one beside the other. When the command „start” is given by the „clock” all of them are starting to walk side by side until they hear the command „now” or „stop” which will be given every second by the „clock”. With the first signal only the first „data point” in the line stops exactly where he or she is, with the next signal the second one stops and so on.

Together with the starting line, the moving direction and the last positions of the probands a diagram is emerging.



Individual tasks:

Four different tasks have to be done by the students *during* the experiment itself:

- the clock: A student has to give acoustic signals every few seconds
- the minute taker: He or she has to take notes on the times and length measurements
- the measurement taker(s): Students taking the length between the finally standing "data points"
- the (moving) data points: Groups of the remaining students have to start in a line and move forward according to the description in the experimental procedure.

The following tasks have to be done *after* the experiment in order to interpret the results:

- calculate the absolute distance from the starting line on base of the measurements
- plot the data points in a diagram with the axis time and way
- find the best straight line through the data points and mark it

Data collection:

During the experiment, the first two columns will be filled in – afterwards the last columns has to be calculated by accumulating the values of the second column.

time [seconds]	distance from the previous neighbor [meter]	distance from starting line [meter]

Indicate the sources of errors

A very important point is to consider the possible and occurring errors. When the data points do not really fit very well on a straight line in the diagram then it is very easy to start a discussion on the reasons thus the errors in the experiment.

Possible errors are:

- Inaccurate measurements were taken.
- Where is the start and stop of the measurement (back or front of the feet)?
- Where do the probands have to stop when they are just in the middle of a step?
- What is about slightly different walking velocities of the probands?

Interpreting the results:

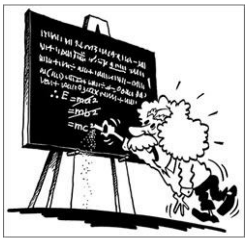
The collected data points have to be converted in a diagram and completed with the best fitting straight line. (In principle we get the graph of a linear function.)

To deduce the inclination of our fitted line a rectangular triangle will help (hypotenuse at the determined line): Taking care on the quantities of the corresponding axis the calculation of the inclination (k) will lead to the definition of velocity: $k = \frac{\Delta s}{\Delta t} =: v$

Explanation and conclusions:

The way-time-diagram has the two axis "way" (s) and "time" (t). Pay attention on the unity – a length on a time axis represents seconds, minutes, hours, days or another unity of time.

The inclination of the graph in a way-time-diagram gives the velocity – faster movements result in steeper inclinations.



EXPERIMENT NR. 4
GRAVITATIONAL ACCELERATION
CHAPTER: MECHANICS

PROPOSED BY: Comenius College Capelle aan den IJssel, THE NETHERLANDS

Theoretical aspects:

The research objective of this experiment is to make a graphical description (curves) of a falling ball. With the help of the y, t^2 - curve we can deduce the gravitational acceleration.

For a falling ball without friction the mathematical formula is:
$y = 0{,}5 \cdot g \cdot t^2$.
with y : falling distance (m).
t : time (s).
g : gravitational acceleration (m/s^2).

Newton's second law: $F = m \cdot a$
with F : force (N)
m: mass (kg)
a : acceleration (m/s^2).

Fig 1.

Materials, apparatus:

- Electromagnet (fig. 2).
- Light gate (fig. 4).
- Ruler.
- Electronic counter that can be started and stopped with electric pulses (fig. 3).

Experimental procedure:

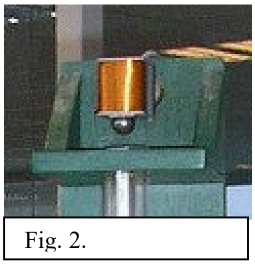


Fig. 2.

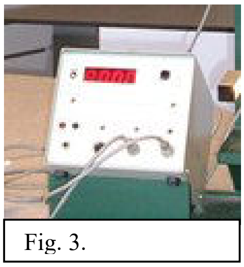


Fig. 3.

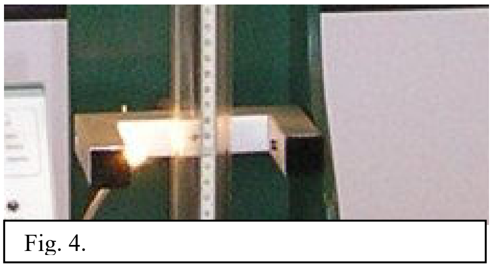


Fig. 4.

The steel ball is placed under the electromagnet (fig. 2). The movement starts when switching off the current in the electromagnet. With the same switch a starting-pulse is given to the clock (fig. 3). A light gate (fig. 4) produces the stopping-pulse for the clock as soon as the ball passes. The time of the movement can be read from the display of the clock. Measure this three times; then change the drop distance several times by moving the light gate up- or downwards. Measure three times every distance. Fill in the results in the data collection table.

Data collection:

y (m)	t_1 (s)	t_2 (s)	t_3 (s)	$t_{average}$ (s)	$t_{average}^2$ (s^2)

Indicate the sources of errors and determining errors

Compare the values of t_1, t_2, t_3 and $t_{average}$ and estimate the errors in the measurements. Give a physical explanation for these errors.

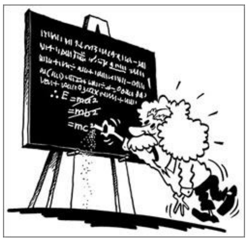
Interpreting the results

1. Calculate the average values of the times for every distance. Calculate also the square of $t_{average}$. Complete the data collection table.
2. Draw a $y, t_{average}$ curve (= curve 1).
3. Draw a $y, t_{average}^2$ curve (= curve 2).
4. Explain why a drop without friction has a fixed acceleration.
5. Give the mathematical relation of y and t.
6. Explain the shape of curve 2.
7. Calculate the gravitational acceleration using curve 2.

Explanation and conclusions:

Compare the gravitational acceleration with the real value (as mentioned in your study book). If there is a difference, give an explanation.

EXPERIMENT NR. 5 RELATION BETWEEN PLACE AND TIME OF A FALLING OBJECT WITH THE HELP OF A TICKER TAPE



CHAPTER: Mechanics

PROPOSED BY: General Gymnasium Vassiliadis Private School, Thessaloniki, GREECE.

Theoretical aspects:

When a body is set free from a height H over the ground, then this will fall into the ground on at vertical accelerated course. The resistance of the air being disregarded, the movement of the body is related only to the weight of the body W. This movement shall be straight, constantly accelerated without having an initial speed, and a constant acceleration which is equal to the acceleration of the gravity g.

The velocity v and the distance which has been tracked may be calculated by the relations:

$v=gt$ (1) and $y = gt^2/2$ (2)

The aim is to have an experimental study of the movement of the free fall and to get the relation (2).

Different approaches:

There are many other different approaches, like to measure the distance and the time with the help of photo gates.

Materials, apparatus:

- support basis
- one bar of 1m and one of 25cm
- two staplers
- timer
- paper tape
- cohesive tape
- a disc-pulley
- a ruler of 1m
- a weight
- and a clamp

Experimental procedure:

We proceed with the experimental device as shown in the picture. We set the timer on and we let the weight fall. If the traces of the timer on the paper tape are clearly seen we proceed with the measuring.

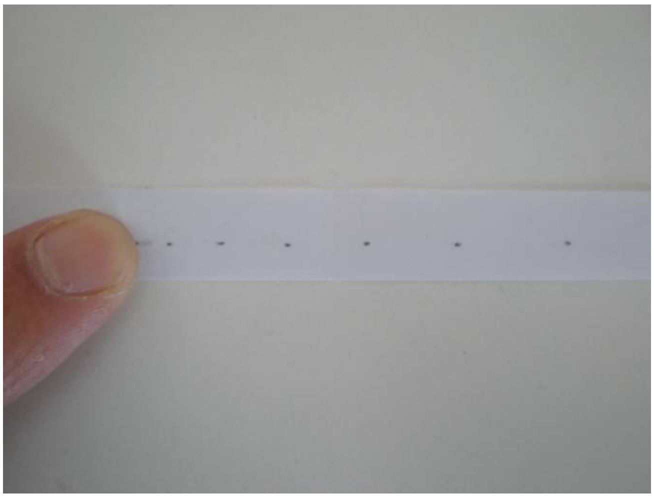
We take the paper tape and we note the position O on the 1st mark that can be clearly seen. Then, we note the positions 1, 2, 3, ... on the paper tape, marked every 10 dots. Using the ruler we measure the distances of the positions 1, 2, 3,... from the beginning O and we record the prices on column 1 of table 1.

The period of the timer T=0,02 s, is the time between two successive dots. Between the position O and the position 1 there are 10 dots, so the time shall be $t_1=10 \cdot 0{,}02= 0{,}2$

sec.

Between the position O and the position 2 the time shall be t_2= 20 · 0,02= 0,4 sec.
Between the position O and the position 3 the time shall be t_3= 30· 0,02= 0,6 sec.
We note the prices of the different times on column 2 of table 1.

Images of the apparatus or how it is conducted



Data collection:

Table 1

	Column 1 **y(cm)**	Column 2 **t(sec)**
1		
2		
3		
4		
5		
6		
7		

Indicate the sources of errors and determining errors

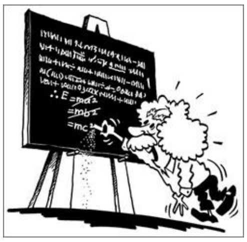
It is possible that the marks are not clearly seen on the paper tape, and therefore, the distances between positions 1, 2, 3 ... are not measured correctly. For this reason, we repeat the experiment two or three times.

Interpreting the results

Using the prices of column 1 and 2 of table 1 we form the diagram y-t.
From the form of the curve on the diagram y-t, we verify the relation $y=1/2\, g\cdot t^2$

References:

1. Physics experiments (Ioannis Bouroutis)
2. Physics experiments (P. Kokotas, B. Karapanayiotidis, Ioannis Amaoutakis, Ioannis Karanikas), “Grigoris” Editions.



EXPERIMENT NR. 8
NEWTON'S SECOND LAW. RELATION BETWEEN FORCE AND ACCELERATION OF A HORIZONTAL MOVEMENT

CHAPTER: Mechanics

PROPOSED BY: General Gymnasium Vassiliadis Private School, Thessaloniki, GREECE.

Theoretical aspects:

The 2nd Newton Law confirms that the acceleration of a body is proportional to the force F that accelerates the body, and disproportional to its mass (m) : $a=F/m$
We want to experimentally verify the relation $a=F/m$.

The system of bodies that we have in the experimental arrangement (weight-carriage) is accelerated by the weight. The system has a constantly accelerated movement without initial speed. Its acceleration can be calculated with the use of a timer that records its movement on a paper tape.

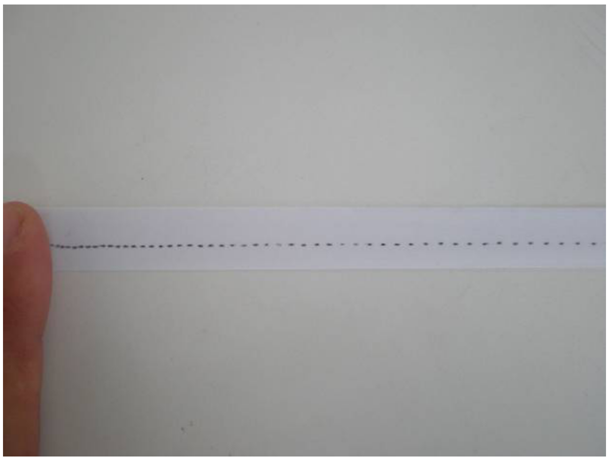
From the relation $x=at^2/2 \leftrightarrow a=2x/t^2$ we calculate the acceleration if we measure the displacement X and the corresponding time t.

Materials, apparatus:

- Timer
- Carriage
- Clamp
- pulley and cord
- weight (1kg)
- millimeter paper

Experimental procedure:

- We keep record of the period of the timer on the table (1). (i.e. T=0,02 sec)
- We measure the mass of the laboratory car and we note it on the table 1.
- then, we proceed with the experimental arrangement shown in the picture
- We set the timer on and we let the weight fall. The paper tape will record the movement of the weight-carriage system. Then, we stop the car before it bumps into the pulley and we turn off the timer.
- We take the paper tape and we note the 0 number on the first dot that can be clearly seen. Then, after this one, we note the 20th dot.
- We measure in meters the distance between the first and the 20th dot. We record the distance that we measured and the number of the dots on table 2.
- We repeat the first three steps two more times and we complete table 2.
- We calculate the time that the carriage needs to cover the distance that we have measured on the paper tape for each of three measurements that we have done using the same method. That means that we multiply the number of the dots with the period of the timer and we record the prices on table 2.

Data collection:

Table 1	
Period of the timer (sec)	
Mass of the laboratory car	

Table 2				
	Accelerating Force – Weight (N)	Number of dots	Time (sec)	Displacement(m)
1				
2				
3				

Table 3			
	Acceleration(m/s²)	Mass of the system (Kg)	ma
1			
2			
3			

Indicate the sources of errors and determining errors

The minor deviations between the prices of the m·a sum and the accelerating power, are probably due to an error in the measuring of the distance x between the 20 dots from the position x=0 as the dots might not be clearly seen.

Interpreting the results

Using the data on Table 2 and the relation $a = 2x/t^2$ we calculate the acceleration of the carriage for each of the three procedures. We record the prices on Table 3.

- We use a scale to weigh the mass of the system (carriage and weight) and we complete Table 3.
- We calculate the sum of the system's mass and we multiply it to its acceleration.
- We compare the prices of the m·a sum that we get, with the force that accelerates the system of the two bodies.

References:

1. Physics experiments (Ioannis Bouroutis)
2. Physics experiments (P. Kokotas, B. Karapanayiotidis, Ioannis Amaoutakis, Ioannis Karanikas), “Grigoris” Editions.

EXPERIMENT NR. 9 MOVING FORCES

CHAPTER: MECHANICS

PROPOSED BY: Liceo “D. Dolci”
Palermo, ITALY

Theoretical aspects:

In everyday life, the word work is used to refer to almost any kind of physical and mental activity, but it is different in science as work is said to be done when the point of application of a force moves and I is measured by the product of the force and the distance moved in the direction of the force.

Different approaches:

The world we live in abounds in energy in a variety of different forms: chemical mechanical, electrical, nuclear

Materials, apparatus:

Coal, oil, heat for steam turbines or internal combustion engines, water pumps, concave mirrors

Safety precautions:

To realize this kind of experience it is necessarily to know the objects and the labs materials which usually are in a laboratory, then it is good to pay attention at the way you move inside it, as there are some dangerous and fragile materials: For this reason, you must pay more attention than in the classroom.

Experimental procedure:

Anything which is able to do work is said to possess energy so we define energy the capacity to perform work.

Perhaps the most important energy is the chemical one. It is known the man’s utilization of the latent energy in coal or oil, released in the form of heat to drive stem turbines or internal combustion engines .

Hydro electric power installation means the production of electricity by dynamos driven by water turbines.

Windmills which convert the energy of wind into mechanical energy have long been in use for working water pumps as well as for milling grain or saving timber.

Solar energy thanks to concave mirrors is largely used nowadays.

We also use nuclear energy, resulting from the splitting of fission of the nuclei of certain atoms, as well as the fusion of nuclei.

Individual tasks:

In mechanics energy is measured in two ways: as kinetic energy or energy of motion, and potential energy or energy of position. An example of the former is the energy of a moving projectile such as a bullet or of a moving hammer head. These are able to do work by overcoming forces when they strike an object. Heat is also a form of kinetic energy since the heat of a body consists solely of the vibration of the molecules of which is composed. In this sense the difference between a cold soldering iron and a hot one is that the molecules of the latter are in a state of more violent agitation. In general, potential energy os the name given to the energy stored in bodies when we are raised above the hearth's surface. We could describe as potential energy a wound clock spring or a cylinder of compressed air

Einstein's theory of relativity= the mass and energy can be converted from one to another
Transformation of energy from one kind to another

The potential energy of a body raised above the earth's surface is equal to the work done against its weight in lifting it. The unity of of energy expended in moving a force of 1 Newton through a distance of 1 metre is called the Joule (j)

Power is defined the rate of doing work, which is the same as energy transferred per second. A power of 1 Joule per second is called 1 Watt

Data collection:

Energy expended =work=Force=Distance moved = Force X Displacement

THE SUM TOTAL OF MASS PLUS ENERGY IN THE UNIVERSE IS FIXED AND UNALTERABLE

POWER IS DEFINED AS THE RATE OF DOING WORK WHICH IS THE SAME AS ENERGY TRANSFERRED PER SECOND

The students or the teacher are making the measurements and marking the physical values in a table according to the needs of each experiment

Interpreting the results

Work is to be done when a force moves, and it is measured by the product of the force and the distance moved in the direction of the force. Work is the energy transferred in any process.

Explanation and conclusions:

Mechanical energy is measured as:

- kinetic energy or energy of motion
- potential energy or energy of position

The law of conservation of energy states that the sum total of energy of all forms in the universe is fixed and cannot be increased or decreased

The unity of energy is the joule
Power is the rate of energy transfer
The unit of power is the watt 1000 W = 1K W. 1 horsepower is approximately equal to 750 watts.

References:

1. Nuova Physica 2000 AAVV Le Monnier Fi
2. Physics AAVVHeinemann Educational Books London

EXPERIMENT NR. 10 HORIZONTAL THROW

CHAPTER:MECHANICS

PROPOSED BY: Comenius College, Capelle aan den Ijssel, THE NETHERLANDS

Theoretical aspects:

The aim of this experiment is to find out the relation between the horizontal and vertical covered distance of a horizontal throw.
The initial velocity v_0 can be derived from the results.

The following symbols are used (see also fig 1):
x : horizontal covered distance (in meters)
y: vertical distance (in meters)

Materials, apparatus:

- A bended tube (electricity tube)
- A steel bullet
- White paper
- Carbon paper
- A ruler

Experimental procedure:

See fig 1. A steel bullet is dropped in opening A of a bended plastic tube.

The bullet leaves the tube at opening B with a horizontal velocity v_0.

The movement of the bullet after leaving point B will be studied in this experiment. On the table, in the area where the bullet may land, we position a white sheet of paper covered with an upside-down carbon sheet. When the bullet hits the table, it marks the white paper with a dot.

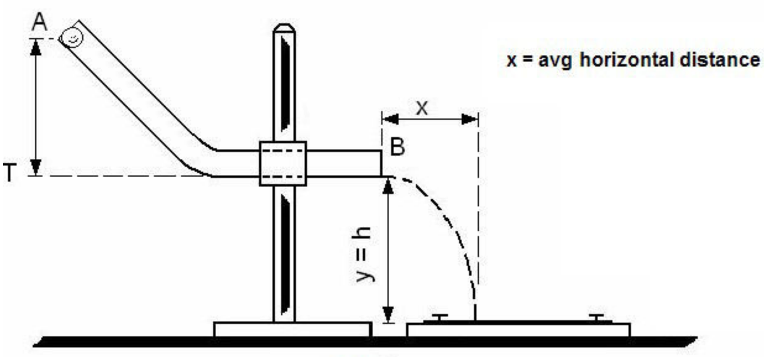


fig 1

The bullet will cover a distance x (horizontal). The distance x will depend on the height y of point B above the table. The height y is adjustable.

In this experiment, we find out the relation between y and x, and we calculate the starting speed v_0 at point B.

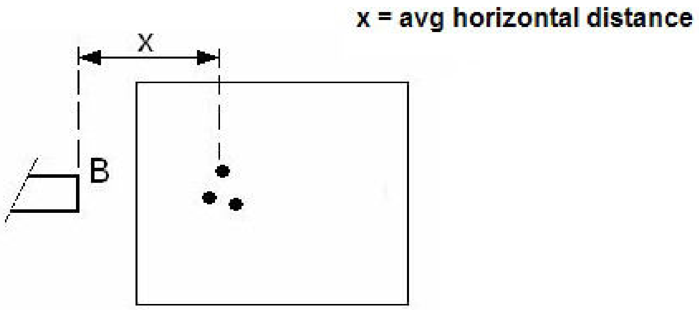


fig 2

Individual tasks:

Build the experimental arrangement of fig 1. Take y = 0,050 m and let the bullet run through the bended tube. Repeat this twice and measure the average horizontal distance. See also fig 2.
Repeat the measurements of x for 6 more values of y. Take the values of y as mentioned in table 1. x will be measured 3 times for every height. Fill all the results in table 1. Complete the columns of the table with the average value of x (= x_{avg}) and the values of y/x_{avg}^2

Data collection:

Table 1

y (m)	x_1 (m)	x_2 (m)	x_3 (m)	x_{avg} (m)	x_{avg}^2 (m^2)	y/x_{avg}^2 (1/m)
0,050						
0,100						
0,150						
0,200						
0,300						
0,400						
0,500						

Interpreting the results

1. Give the formula that fits the horizontal movement if no friction is assumed.
2. Give the formula that fits the vertical movement if no friction is assumed.
3. Draw the graph of y and x_{avg}. Take x_{avg} on the horizontal axis and y on the vertical axis downwards. Explain the shape of the curve.
4. Draw the graph of y and x_{avg}^2. Take y horizontal and x_{avg}^2 vertical upwards. Derive a formula for the relation of y and x from your results. Explain the shape of the curve with the given formulas in 1. and 2.
5. Derive v_0 from the graph in 4.

EXPERIMENT NR. 11 DETERMINATION OF FREE FALL TIME / REACTION TIME

CHAPTER: Mechanics

PROPOSED BY: HTL Dornbirn, AUSTRIA

Theoretical aspects:

The equally accelerated movement is the only necessary prerequisite: $s(t) = \frac{1}{2} \cdot a \cdot t^2 + v_0 \cdot t + s_0$

Materials, apparatus:

- ruler
- wall / vertical plane

Experimental procedure:

One person holds the ruler at the upper end. The other person points at the lower end but does not touch it – arrange a distance of around a centimeter between the finger and the ruler. The first person drops the ruler at a random time and the second one has to catch it by pressing it against the wall. The distance covered by the ruler has to be read from the scale.

Individual tasks:

- Execute one test run for every person!
- Each experimenter has to drop and to catch respectively the ruler ten times.
- Then calculate the appropriate reaction time with the upper formula – starting point s_0 and velocity v_0 are null and the gravitational acceleration is $g = 9.81\frac{m}{s^2} \approx 10\frac{m}{s^2}$.

Data collection:

Free fall distance (measured):

#	1	2	3	4	5	6	7	8	9	10
experimenter 1										
experimenter 2										

Free fall time (calculated):

#	1	2	3	4	5	6	7	8	9	10
experimenter 1										
experimenter 2										

Indicate the sources of errors

- Advanced warning of the experimenter (for example by blinking), distracted or not concentrated experimenter – may end with a ruler being too short.
- Insufficient space between ruler and “catching finger” → friction effects

Explanation and conclusions:

Every object will fall freely when not relying on or being hold by anything.
The reaction time in expected situations is below one second.

EXPERIMENT NR. 16 DETERMINING THE COEFFICIENT OF FRICTION BY THE METHOD OF THE INCLINED PLAN

CHAPTER: Mechanics

PROPOSED BY: **General Gymnasium Vassiliadis Private School. Thessaloniki, GREECE.**

Theoretical aspects:

The purpose of the experiment is to determine the coefficient of friction. Friction is the force which develops between two moving surface areas or tending to move. We use the maximum value of static friction by observing the block movement on the inclined plan. The weight force is analysed in two vertical components, one of which is opposite to N (vertical reaction) and the other opposite to static friction as soon as the block starts moving.

Different approaches:

Measurements are verified by using the horizontal level with the help of a pulley on which we hung different blocks of masses and calculate the coefficient of friction among the blocks being used on the same inclined plan. The calculations were made according to relations. Therefore, F=B

Materials, apparatus:

(a) wooden rectangular parallelepiped blocks
- 1 metal block , - 1 roughly squared cork , - different weight masses , - string
(b) 1 pulley, - scales, - wooden inclined plan with an incorporated protractor

Safety precautions:

None.

Experimental procedure:

According to the different approaches chosen by the group some information is given about how the students should interfere with the materials and what ways they should take to reach to the end point. Initially the block on the inclined plan is used by recording the angle on which it starts moving. The coefficient of friction is equal to the angle of lead tangent calculated with the help of a list of trigonometric numbers. Repeating the procedure with blocks of both different material and mass, the results are recorded in a table. To verify the results the horizontal level according to the procedure described in different approaches is used.

Images of the apparatus or how it is conducted

Data collection:

Inclined plan			
Metal-Wood			
	Weight (N)	Angle φ (Degrees)	tan φ=n
1			
2			
3			
4			
5			
			Total average

Inclined plan			
Wood-Wood			
	Weight (N)	Angle φ (Degrees)	tan φ=n
1			
2			
3			
4			
5			
			Total average

Inclined plan			
Cork-Wood			
	Weight (N)	Angle φ (Degrees)	tan φ=n
1			
2			
3			
4			
5			
			Total average

Indicate the sources of errors and determining errors

Errors provocated by the experimenter are

- The measurements of the angle by the experimenter
- The calculation of weight where g is approximated

Errors during measurements are

- Of the indications of the goniometer
- Through the recorded indications of the masses, in relation with their real mass as well as errors provoqued by the calculation of the lead tangent.

Interpreting the results

By interpreting the results, we must verify the original theoretical view that the coefficient of friction μs is irrelevant to the weight mass of blocks, which neither depends on their size nor on the area of tangent surfaces. We must notice that the μs coefficient of friction coincided both on the horizontal and the inclined surfaces as it only depends on the tangent surface.

Explanation and conclusions:

Due to the bad condition of the tangent surface of the materials, deviations have been observed to our measurements. Therefore, we calculated the absolute and the relative error in every measurement. The coefficient of friction is irrelevant to weight and the area of tangent surfaces.

References:

1. Physics experiments (Ioannis Bouroutis)
2. Physics experiments (P. Kokkotas, B. Karapanayiotidis, Ioannis Amaoutakis, Ioannis Karanikas, Ioannis Kourelis) « Grigoris » Editions
3. Students experiments in Physics, "Phywe" Edition

EXPERIMENT NR. 16B DETERMINING THE COEFFICIENT OF FRICTION USING THE METHOD OF INCLINED PLAN

CHAPTER: MECHANICS

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU"; Şimleu Silvaniei, ROMANIA

On an inclined plan with a variable angle is set an object that can glide with friction.
At small angles the object does not move because $F_f= G_t=mg\sin\alpha$.
At large angles the object glides and $F_f= \mu N= \mu mg\cos\alpha$.
There is a critical angle at which the transition from static friction to dynamic friction is realized, in this case :
$F_f=mg\sin\alpha_c= \mu mg\cos\alpha_c$, in this case $\mu=tg\alpha_c$

Materials, apparatus:

Inclined plan with a pulley at one end and accessories: trolley, cuboids as wooden objects, connecting wires, hooks (5 g each) and perforated discs (known masses).

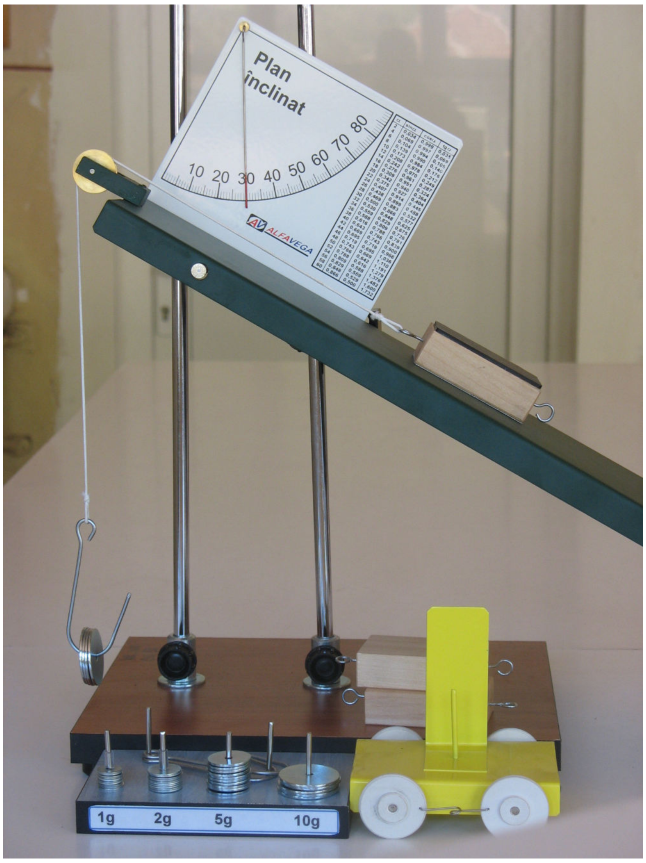
Safety precautions:

There is no need for safety precautions.

Experimental procedure:

Using an inclined plan with a variable angle and an object on it, we start varying the angle until the object starts gliding uniformly.

Images of the apparatus or how it is conducted



Individual tasks:

We fix the vertical rod on the horizontal board and then we mount the inclined plan on using the thimbles like in the picture above.

We chose one of the parallelipipedic objects and we put it on the inclined plan.

We vary slightly the angle of the plan and we give it a little knock from time to time, until the objects start gliding uniformly.

In this moment, we read (or determine) the critical angle of the plan. The tangent of this angle represents the friction coefficient.

We do several measurements, and for each one we write down the results in the table below.

We repeat the experiment for different objects.

Data colection:

Nr det.	α_c (grade)	$\mu=tg\alpha_c$	$\mu_{average}$	Notes
1				
2				
3				
4				

Indicate the sources of errors

Errors provoked by the experimenter

- the subjective determination of the critical angle
- errors in reading the divisions on the scale

Errors due to the imprecision of the apparatus:

- the low precision of the measuring scale
- the imprecision of the gradated scale
- variations of the mass of the discs when compared with the value marked on them.

Errors due to the imprecision of the method

- the transition from static friction to dynamic friction

Interpreting the results

The friction coefficient obtained through this method must be compared with other results, obtained through different methods, but using the same objects and working surfaces. An average friction coefficient between the different results using different methods must be calculated.

Explanation and conclusions:

This method of determining the friction coefficient does not have a high level of precision. It's role is to highlight the phenomena and not necessarily its value.

References:

1. Panaitoiu, L.,Chelu, I.,*Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972

2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995

3. http://www.olimpiade.ro

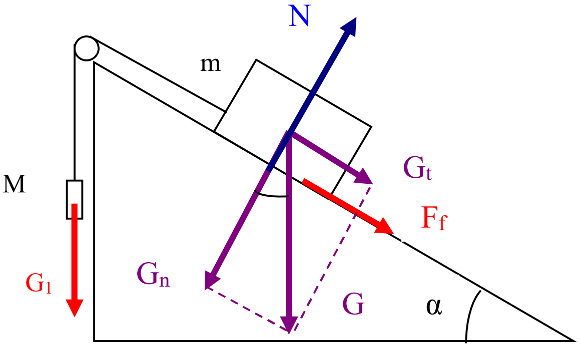
4. http://www.didactic.ro

EXPERIMENT NR. 18 DETERMINING THE EFFICIENCY OF AN INCLINED PLAN

CHAPTER: MECHANICS

PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU"; Şimleu Silvaniei, ROMANIA

Theoretical aspects:



On an inclined plan with a variable angle is set an object that can glide with friction. A non-extensive wire and a pulley connect this object to another one with the mass M, like in the figure. At a certain value of M, the object starts gliding uniformly. The efficiency of the inclined plan is the fraction between the useful work and the consumed work.

$\eta=L_u/L_c=mgh/G_1 l=mh/Ml=(m\sin\alpha)/M$ (1)

Materials, apparatus:

Inclined plan with a pulley at one end and accessories: trolley, parallelipipedic wooden objects, connecting wires, hooks (5 g each) and perforated discs (known masses).

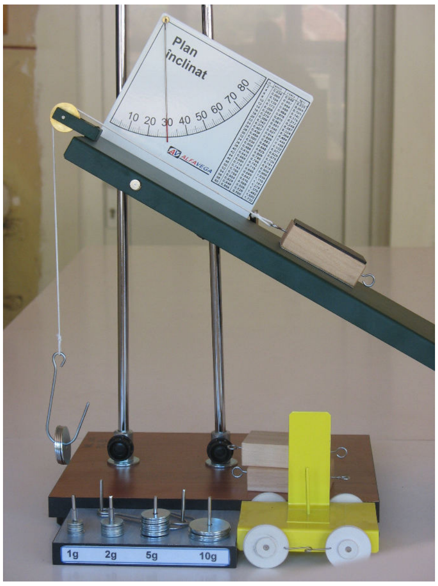
Safety precautions:

There is no need for safety precautions

Experimental procedure:

Using an inclined plan with a variable angle and a system of objects, like in the figure, on it, we attach to the hook perforated discs and we knock gently from time to time the plan, until the objects start gliding uniformly. At this moment, we read the angle α, the values of the masses m and M and we calculate the efficiency of the plan using the formula obtained above (1).

Images of the apparatus or how it is conducted



Individual tasks:

We fix the vertical rod on the horizontal board, and then we mount the inclined plan on using the thimbles like in the picture above.

We chose one of the parallelipipedic objects and we put it on the inclined plan. Through the pulley and the wire we connect it to the hook. We write down in the table the value of the angle and the mass of the object (the mass is marked on it).

We add perforated discs and we knock gently the plan until the system starts gliding. We write down in the table the value of M.

We calculate the efficiency of the plan using the formula determined at the firs point (1).

We do several measurements at different angles and we analyze the dependency of the efficiency to the angle. For each measurement, we write down the results in the table below.

We repeat the experiment for different objects.

Data collection:

Nr det.	α_c (grade)	m (g)	M (g)	η	Notes
1					
2					
3					
4					

Indicate the sources of errors

Errors provoked by the experimenter

- the subjective determination of the critical angle
- errors in reading the divisions on the scale

Errors due to the imprecision of the apparatus:

- the low precision of the measuring scale
- the imprecision of the gradated scale
- variations of the mass of the discs when compared with the value marked on them.

Errors due to the imprecision of the method

- the transition from static friction to dynamic friction

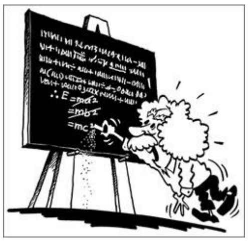
Interpreting the results

For the same object m, but at different inclinations, we see that the dependency of the efficiency has a sinusoidal shape.

References:

1. Panaitoiu, L.,Chelu, I.,*Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972
2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995
3. http://www.olimpiade.ro
4. http://www.didactic.ro

EXPERIMENT NR. 19 DETERMINATION OF THE ELASTIC CONSTANT K = F / X



CHAPTER: Mechanics

PROPOSED BY: General Gymnasium Vassiliadis Private School. Thessaloniki, GREECE.

Theoretical aspects:

It has been ascertained that when elastic blocks are deformed, they create forces. Studying the force-deformation relation, Hook, concluded the relation F= kx where F represents the force created by the deformed spring,(x) its deformation and (k) the proportion constant which is called the spring constant (or hardness). By this experiment, the pupils will verify this relation and determine its different value constant for three different springs.

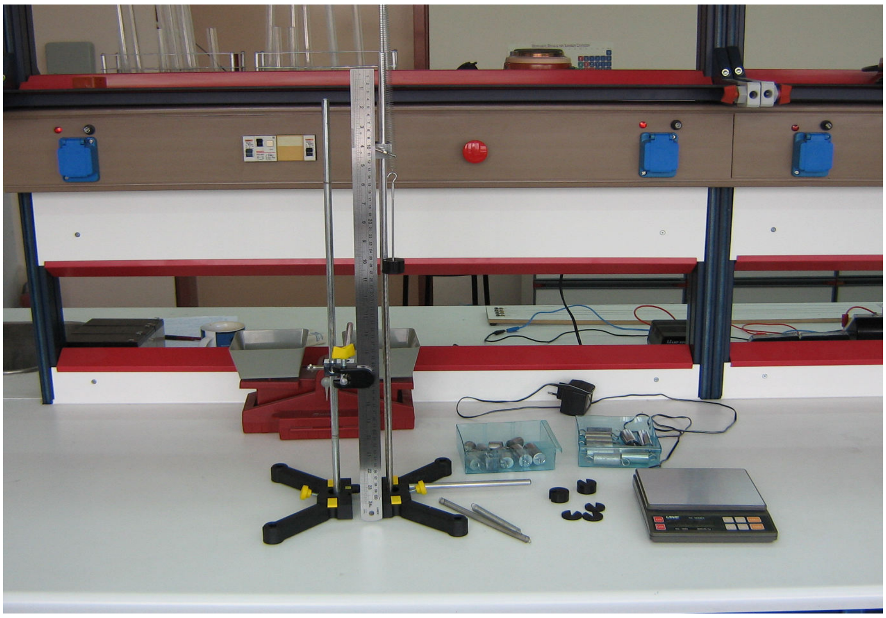
Materials, apparatus:

- 2 metal rods in a vertical position
- 50 cm gradated scale
- 100 gr masses
- 50 gr masses
- 10 gr masses
- suspension point of the spring
- springs of different hardness
- 1 electronic precision balance with 0,1 gr accuracy

Safety precautions:

None.

Experimental procedure:



The support base is bind with the metal rods on which the meter and the springs are supported. The meter is placed in a position so that the beginning of measurement of the length coincides with the lowest end of the spring. Hanging the weights at the end of the spring, as it is shown in the photos / pictures, elongation is recorded. By repeating the same procedure for the three different springs, three different tables and force-deformation diagrams are created where the paired values are recorded, belonging to a straight line.

Data collection:

Spring 1			
	Weight (N)	Deformation (m)	k=F/Δl (N/m)
1			
2			
3			
4			
5			
			Total average

Spring 2			
	Weight (N)	Deformation (m)	k=F/Δl (N/m)
1			
2			
3			
4			
5			
			Total average

Spring 3			
	Weight (N)	Deformation (m)	k=F/Δl (N/m)
1			
2			
3			
4			
5			
			Total average

Indicate the sources of errors and determining errors

Errors provoked by the experimenter are

- The measurements of the deformation of the spring on the gradated scale
- The calculation of weight, where g is approximated

Errors during measurements are

- Low precision of the gradated scale
- Imprecision of the indications of the gradated scale
- Through recorded indications of the masses in relation with their real mass

Interpreting the results

After measuring elongation with the same weights in every spring, you must notice that the quotient of the division between weight gravity and spring elongation remains constant for every spring. After measuring elongation of the suspension springs for the different masses, notice that the quotient of the weight along with the elongation they caused, remains constant and different for every spring. Constant (k) of the spring can be calculated from diagrams F and the inclination of the straight line with axis.

Explanation and conclusions:

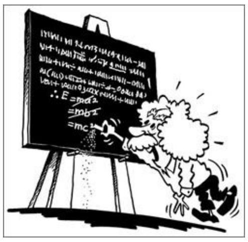
By observing the results you come to the conclusion that the value of the constant k calculated, remains the same for any block hung on the spring, therefore k is a natural constant which is different in every spring and remains its basic characteristic.

References:

1 Physics experiments (Ioannis Bouroutis)
2 Physics experiments (P. Kokkotas, B. Karapanayiotidis, Ioannis Amaoutakis, Ioannis Karanikas, Ioannis Kourelis) « Grigoris » Editions
3 Students experiments in Physics, "Phywe" Edition

EXPERIMENT NR. 19

DETERMINATION OF THE ELASTIC CONSTANT

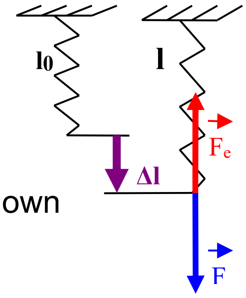


CHAPTER: MECHANICS

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU"; Şimleu Silvaniei, ROMANIA

Theoretical aspects

If a force deforms elastically a spring, then the deformation is proportionally with the deformation force, the elastic constant being $k = F/\Delta l$, after the law of elastic deformation.



Materials, apparatus:

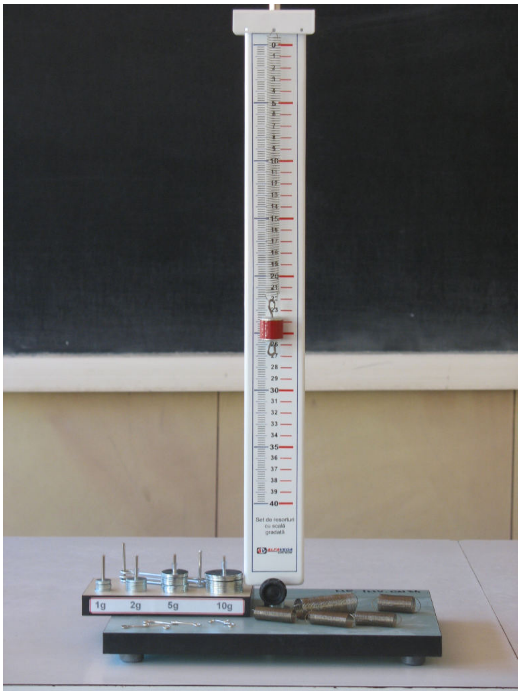
Set of springs, gradated scale and accessories, hooks, perforated discs (known masses),
metallic rod, connecting elements for the springs.

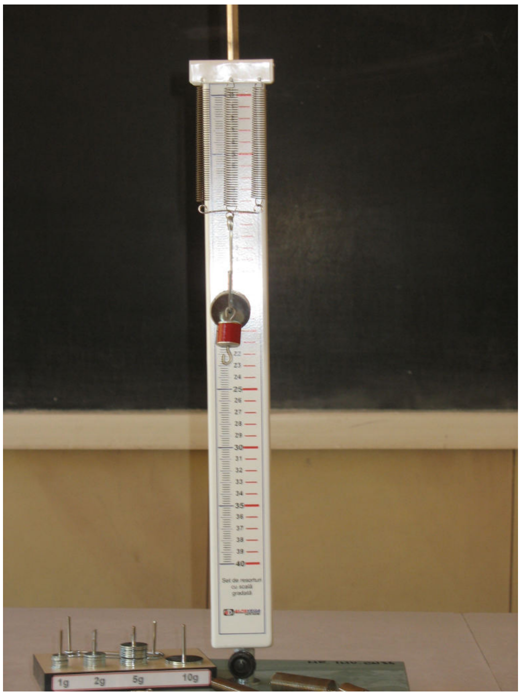
Safety precautions:

There is no need for safety precautions.

Experimental procedure:

Knowing the mass of the disc that is attached to the spring and the deformation is produces we can determine the elastic constant of the spring.
Also we can verify the dependency between the elastic force and the deformation. We can study the connection in series and parallel of the springs.





Individual tasks:

We fix the vertical rod on the board and then we mount on the gradated scale like in the images above. You suspend the springs (later springs connected in series or in parallel), one at the time, and we attach to the hook the perforated discs. We take 4 measurements. For each one we note down the values for the initial length (l_0), the total mass (m) of the suspended discs, the final length (l), corresponding to the mass. We calculate the deformation force (F=G=mg), the deformation $\Delta l = l - l_0$ and the elastic constant $k = F/\Delta l$. The results will be noted in the chart below.

Data collection:

Nr. det	l_0 (mm)	m (g)	F=G (N)	l (mm)	Δl (mm)	k (N/m)	$k_{avearge}$ (N/m)
1							
2							
3							
4							

Do measurements for different springs or spring groups.

Indicate the sources of errors

Errors provoked by the experimenter

- errors in reading the divisions on the gradated scale
- g is approximated

Errors due to the imprecision of the apparatus

- the low precision of the gradated scale
- the imprecision of the gradated scale
- variations of the mass of the discs when compared with the value marked on them.

Errors due to the imprecision of the method

- the transition from static friction to dynamic friction

Interpreting the results

Draw the graphic of the function F=f(Δl), determine kavearge from the inclination of the graphic, tg(α) and compare the result with the one from the table.

Explanation and conclusions:

Using this experimental method of determining $k_{average}$ for a number of springs but also for groups of springs connected in parallel or series we can verify the theoretical relations for k_{serie} and $k_{parallel}$.

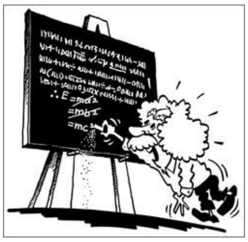
References:

1. Panaitoiu, L.,Chelu, I.,*Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972
2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995
3. http://www.olimpiade.ro
4. http://www.didactic.ro

EXPERIMENT NR. 21

DENSITY AND RELATIVE DENSITY

CHAPTER: MECHANICS



PROPOSED BY: Liceo "D. Dolci"
Palermo, ITALY

Theoretical aspects:

The mass of unit volume of a substance is called its density. The density of a sample of a given substance is therefore calculated by dividing the mass by the volume.
d=m|V ; m=Vxd; V=m/d
The mass of unit volume of a substance is called its density.

Different approaches:

The density of all common substances, solids, liquids and gases, and all chemical elements, have been carefully determined and are to be found recorded in books of physical and chemical constants.

Materials, apparatus:

Alcohol, a loop of cotton, water, coal
Burette, beaker, measuring cylinder, eureka can, spout, relative density bottle, funnel, stopper

Safety precautions:

to realize this kind of experience it is necessary to know the objects and the labs materials which usually are in a laboratory, then it is good to pay attention at the way you move inside it, as there are some dangerous and fragile materials: For this reason, you must pay more attention than in the classroom.

Experimental procedure:

An experiment to determine the density of alcohol

A Burette is filled with alcohol and its tap or clip opened and a little liquid allowed to run through in order to expel air from the pipe: The burette is then set up vertically in a stand and its reading noted.

A clean dry beaker is weighed and afterwards about 20 cm3 of liquid is run into it from the burette. The 2nd reading of the burette is noted and the beaker of liquid are weighed. By subtracting the mass of the empty beaker from the mass of the beaker plus liquid we obtain the mass of the liquid alone. We are now able to calculate the density of the liquid by dividing the mass by the volume.

The experiment should be repeated using different volumes of liquid each time, and a mean value for the density obtained. It will be found convenient to tabulate the result.

Individual tasks:

The relative density of a substance is the ratio of the mass of any given volume of it to the mass of an equal volume of water t
R.D. of a substance= mass of any given volume of substance / Mass of an equal volume of water

In accordance with the definition of relative density, we require to find the masses of equal volumes of the liquid and water. This is done by using a relative density bottle

One should avoid holding the bottle in the hand since the warmth of the hand will cause some of the liquid to expand out through the hole of the stopper and so lead to error

The relative density of a solid may be found by first weighing the water which it displaces from a Eureka can, and dividing the mass of the equal volume of water

Data collection:

Burette readings in cm3	Volume of liquid in cm 3	Mass of beaker and liquid in g.	Density of a liquid in g per cm3	

Mean value for density of alcohol= g per cm3= Kg per m3

The students or the teacher are making the measurements and marking the physical values in a table according to the needs of each experiment

Indicate the sources of errors and determining errors

When handling balsa wood one is struck by its extreme lightness, on the other hand the unusual heaviness of a bottle of mercury surprises a person who lifts it for the first time. This unexpected effect is due to their relative masses: i.e. 10 cm^3 of mercury has mass 136 g. but 10cm^3 of balsa wood has only 2 g. mass.

Interpreting the results

We will let the students (if possible) to write down their observations and make some conclusions after observing the events happened during the experiment. In this way we are stimulating their ability of integrating information from different areas.

The students can:

- define density and relative density of a substance
- draw a diagram of a relative density bottle and explain fully how it is used to find the relative density

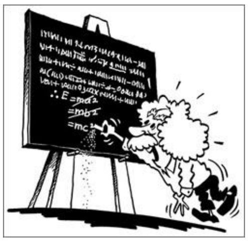
Explanation and conclusions:

1. The density of a substance is the mass of unit volume of it. Density is usually expressed in grams per cubic centimeter or Kg per cubic meter
2. The relation between the density, volume and mass of a piece of material is Density= Mass/Volume
3. The relative density of a substance is the ratio of the mass of any volume of it to the mass of an equal volume of water.
4. Thus R.D. of a substance = Mass of any given volume of the substance/mass of an equal volume of water = Density of substance/Density of water
5. Density in kg per m3=density in g per cm3x 1000

References:

1. Nuova Physica 2000 AAVV Le Monnier Fi
2. Physics AAVV Heinemann Educational Books London

EXPERIMENT 24a THE GRAVITATIONAL PENDULUM. DETERMINING THE PERIOD AND THE GRAVITATIONAL ACCELERATION

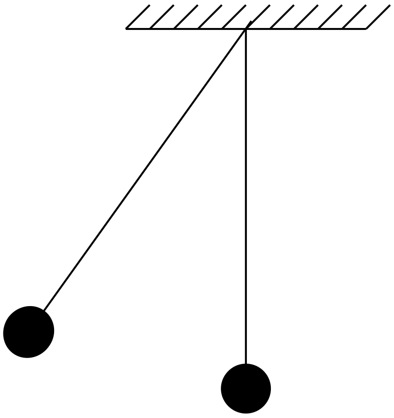


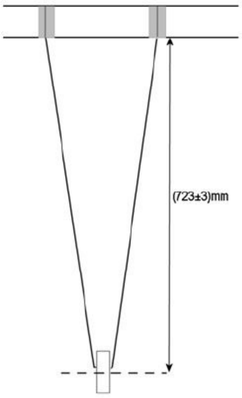
CHAPTER: MECHANICS

PROPOSED BY: COLEGIUL NATIONAL "SIMION BARNUTIU" Şimleu Silvaniei, ROMANIA

Different approaches:

According to the theory, the period of the gravitational pendulum is $T=2\Pi\sqrt{\frac{l}{g}}$, where l is the length of the pendulum and g is the gravitational acceleration.
Knowing the length of the pendulum and its period we can determine the gravitational acceleration after the formula: $g=\frac{4\pi^2 l}{T^2}$.
The period is experimentally determined by dividing the total time of oscillating to the number of oscillations performed. The length of the pendulum is measured using a measuring rule.





Materials, apparatus:

Pendulum support, small but heavy object, string, measuring rule, chronometer.

Safety precautions:

There is no need for safety precautions.

Experimental procedure:

We build the pendulum, we determine its period and we calculate the gravitational acceleration.

Individual tasks:

For better stability, a V pendulum is built (like in the figure) using a small object so that it can oscillate closely to the ground or the work area.

The angular amplitude of the pendulum has to be in the limits of small oscillations, approximately 5^0.

We start the pendulum and the chronometer. After we count N oscillations we stop the chronometer and we calculate the period after the formula: $T = \frac{\Delta t}{N}$..

Using the measuring rule we determine the length of the pendulum, then we determine the gravitational acceleration after the formula $g = \frac{4\pi^2 l}{T^2}$

We repeat the experiment several times varying the length of the pendulum.

Data collection:

Nr det	l (cm)	N	Δt(s)	T (s)	g(m/s²)	g mediu(m/s²)

Indicate the sources of errors

Errors provoked by the experimenter

- counting the number of oscillations
- inappropriate conditions, measurements during movement

Errors due to the imprecision of the apparatus:

- the low precision of the measuring rule

Errors due to the imprecision of the method

- the air amortization was neglected in calculating the period of the pendulum
- the pendulum does not oscillate in a plan, it has a slight rotation movement

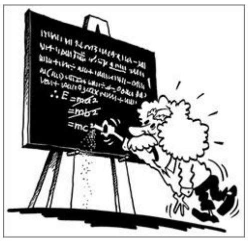
Interpreting the results

The method is not very precise as it is difficult to make the pendulum oscillate in the limit of small oscillations. Its imprecision is also caused by the inexact value of the period, in its calculation being neglected air friction.

References:

1. Panaitoiu, L., Chelu, I., *Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972
2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995
3. http://www.olimpiade.ro
4. http://www.didactic.ro

EXPERIMENT NR. 24B DETERMINING THE AVERAGE POWER NEEDED TO SUSTAIN THE OSCILLATIONS OF A PENDULUM



CHAPTER: MECHANICS

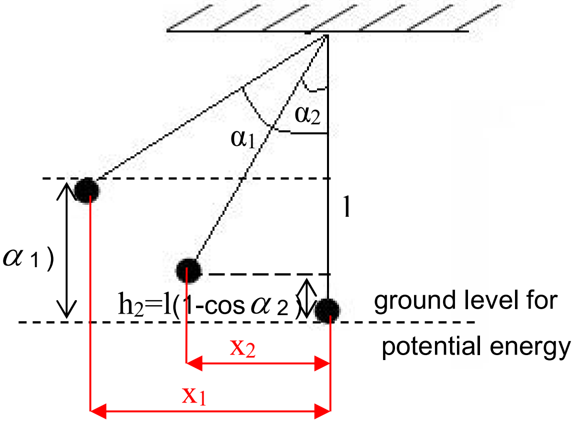
PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU", Şimleu Silvaniei, ROMANIA

Different approaches:

We need to determine the period of a gravitational pendulum and the average power needed to sustain oscillations at a constant amplitude. According to the theory, the period of the gravitational pendulum is $T=2\Pi\sqrt{\frac{l}{g}}$, where l is the length of the pendulum and g is the gravitational acceleration. The average power that has to be delivered to the system in order to maintain the oscillations at a constant amplitude has to be equal to the power lost in the free, amortized oscillations in air. $P=\frac{-\Delta E}{N\cdot T}$, where N is the number of oscillations. Due to the energy loss in N periods, the angular amplitude drops from α_1 to α_2.

$\Delta E=mgl[(1-\cos\alpha_2) - (1-\cos\alpha_1)] \Rightarrow -\Delta E=mgl(\cos\alpha_2 - \cos\alpha_1)$.

For 2 given values of α_1 and α_2, we count the number of oscillations needed for the angular amplitude to drop from α_1 to α_2, in order to determine the time t=NT in which this process occurs, time being necessary in determining the average power needed to sustain the oscillations.



Materials, apparatus:

A 10 g bolt nut, a string, measuring rule, A4 plotting paper, transparent adhesive tape

Experimental procedure:

We build the pendulum, we determine its period and we observe the drop of the angular amplitude in order to calculate the average power needed to sustain the oscillations.

Individual tasks:

For better stability, a V pendulum is built (like in the figure) using the nut bolt and attaching the string with adhesive tape to the edges of the work area, so that the nut bolt oscillates closely to the ground.

Using the measuring rule we determine the length of the pendulum. Using the formula $T=2\Pi\sqrt{\frac{l}{g}}$ we calculate its value.

The plotting paper is fixed under the pendulum. We mark on it the position of equilibrium of the pendulum.

We decide on the values of the initial and final angular amplitudes α_1 and α_2.

Knowing the length of the pendulum we calculate the positions of maximum elongations $x_1=l\sin\alpha_1$ and $x_2=l\sin\alpha_2$ and we mark them on the plotting paper.

We start the pendulum and we count the number of oscillations that it makes in the time the angular amplitude drops from α_1 to α_2.

Using the formula determined above we calculate the average power needed to sustain the oscillations.

We repeat the experiment several times varying the length of the pendulum and the initial and final angular amplitudes.

Data collection:

Nr det	l (cm)	T (s)	α_1 (°)	α_2 (°)	N	P (W)	$P_{average}$ (W)

Indicate the sources of errors

Errors provoked by the experimenter

- counting the number of oscillations between the 2 fixed positions α_1 and α_2.
- the approximate value of g
- inappropriate conditions, measurements during movement

Errors due to the imprecision of the apparatus:

- the low precision of the measuring scale
- the imprecision of the gradated scale

Errors due to the imprecision of the method

- the air amortization was neglected in calculating the period of the pendulum
- the pendulum does not oscillate in a plan, it has a slight rotation movement
- approximate maths

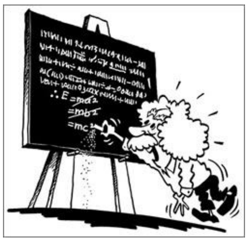
Interpreting the results

The method is not very precise as it is difficult to determine the exact number of oscillations between the two positions. Its imprecision is also caused by the inexact value of the period, in its calculation being neglected air friction. Even so, the result is a good indicator of the amount of energy loss during free, amortized air oscillations.

References:

1. Panaitoiu, L., Chelu, I., *Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972
2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995
3. http://www.olimpiade.ro
4. http://www.didactic.ro

EXPERIMENT NR. 35 CENTRIPETAL FORCE



CHAPTER: MECHANICS

PROPOSED BY: Comenius College, Capelle a/d IJssel, THE NETHERLANDS

Theoretical aspects:

For every change of velocity, a resulting force is needed, according to Newton’s second law. Therefore, a circular motion, even with a constant speed (a uniform circular motion), needs a resulting force. This force changes the direction of motion. The resulting force for a uniform circular motion is called the centripetal force, because it points towards the centre of the movement.

Examples of the centripetal force are many:

- A car needs the friction between the wheels and the road to turn, the friction gives the resulting force or the centripetal force.
- Bikers, runners and skaters “hang” in their curve in order to obtain the centripetal force.
- The moon keeps in a circular movement around the earth because of the gravity force.

The centripetal force F_C depends on the velocity v, the mass m of the moving body and the radius r of the curve.

In this experiment we will derive how F_C is related to v, m and r.

Materials, apparatus:

Plastic or rubber bottle-stops
Thin thread
Mass pieces
A glass tube
A piece of tape
See fig 1.

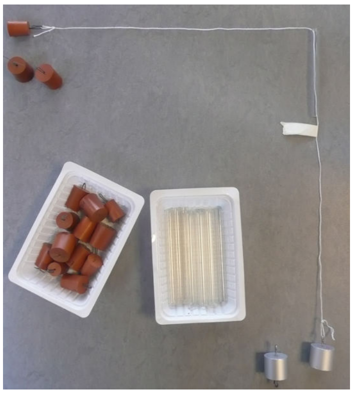


Fig 1

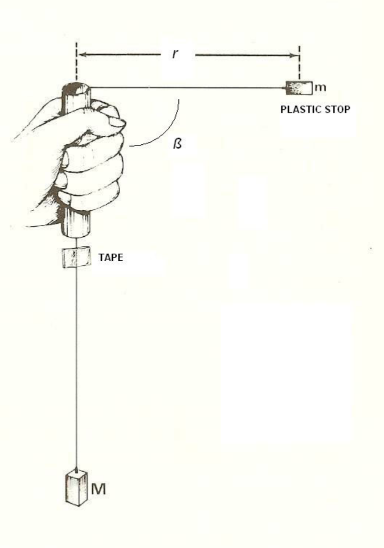


Fig 2

Experimental procedure:

See fig 2.

Pass the thread through the glass tube, attach a bottle-stop with mass m at one end of the thread. Hang a mass piece with mass M at the other end of the thread.

Stick a piece of tape on the thread so that the bottle-stop can turn with radius r. Take the glass tube in your hand and carefully move your hand in such a way that the plastic stop starts circling. Discover the right speed whereby the desired radius is obtained. The piece of tape should stay 2 or 3 mm below the bottom of the glass tube, and not touch the tube.

The resulting force on the circular motion of the stop is nearly equal to the gravital force $F_{G,\,M}$ on M. Try to find combinations of m, M and r whereby $\beta \approx 90^\circ$.

Measure, with a stopwatch, the time of 20 revolutions ($20T$). Calculate the period T.

Calculate v with the formula for the circular motion: $v = 2 \cdot \pi \cdot r / T$.

Tasks:

1. Start with m = 10 g and M = 20 g. Choose r = 30 cm.
2. Start the movement of the plastic stop and measure the value of $20T$ whereby the tape stays 2 or 3 mm under the glass tube. The tape should not touch the glass. Fill in the table. Repeat this measurement for better exactitude.
3. Keep r = 30 cm.
   Change M into 30 g, 40 g and 50 g and measure $20T$. Fill in Table 1.
4. Take M = 40 g. Keep r = 30 cm.
   Repeat task 2 for different values of m. Fill in Table 2.
5. Vary r with constant values of m and M, Try to find good combinations of m, M and series of r and T. Choose values of r between 25 cm and 60 cm. Fill in Table 3.
6. Calculate the values of v.

Data collection:

Table 1.

m (g)	M (g)	$F_{G,M}$ (N)	$20\ T$ (s)	T (s)	v (m/s)	v^2 (m^2 / s^2)	r (cm)
10	20						30
10	30						30
10	40						30
10	50						30

Table 2.

m (g)	M (g)	$F_{G,M}$ (N)	$20\ T$ (s)	T (s)	v (m/s)	r (cm)
10	40					30
	40					30
	40					30
	40					30

Table 3.

m (g)	M (g)	$F_{G,M}$ (N)	$20\ T$ (s)	T (s)	v (m/s)	r (cm)	$1 / r$ (1 / cm)

Interpreting the results

Make graphs of the measurements:

a. $F_{G,M}$ versus v. (Table 1)
b. $F_{G,M}$ versus v^2.
c. . (Table 2)
d. $F_{G,M}$ versus r. (Table 3)
e. $F_{G,M}$ versus r^2.

Conclusions

a. What is the relation between $F_{G,M}$ and v?
b. What is the relation between $F_{G,M}$ and m?
c. What is the relation between $F_{G,M}$ and r?

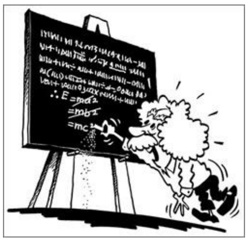
Explanation and conclusions:

Do your conclusions match with the equation $F_C = m \cdot v^2 / r$?
Mention the sources of error in this experiment.

References:

1. Natuurkunde Overal Havo NT3, ISBN 9789011044142
2. http://en.wikipedia.org/wiki/Centripetal_force

EXPERIMENT NR. 37 STATIONARY FORCES



CHAPTER: MECHANICS

PROPOSED BY: Liceo "Danilo Dolci" Palermo, ITALY

Theoretical aspects:

When you hit a ball with a bat, a force is exerted; a string supporting a picture exerts a force which should keep the picture quite still. When you open a door, you are exerting a force which has a turning effect. When we walk we are in stable equilibrium if not we may fall down.

Different approaches:

The previous examples are two of the numerous examples of forces. A very common force is the force due to gravity; this is the force which pulls us to the ground. The force of gravity on an object is called the weight of the object, and forces whether due to gravity or other causes, are measured in gf or kg or, much more commonly, in Newton (N). The force of gravity on a Kg mass is about 10 N.

Materials, apparatus:

A door, a rope, a girder, a balance

Safety precautions:

To realize this kind of experience it is necessarily to know the objects and the labs materials which usually are in a laboratory, then it is good to pay attention at the way you move inside it, as there are some dangerous and fragile materials: For this reason, you must pay more attention than in the classroom.

Experimental procedure:

In structural engineering and building, forces are encountered in girders or ropes such as those in cranes and suspension bridges. A simple force is that in a rope or string OB, when every force has a direction, as well as magnitude (size), and the direction of the force is always shown by an arrow in diagrams.

If an object is held on a smooth inclined plane by a rope acting up the plane, the tension acts up the plane, the tension prevents the weight from falling down and acts vertically. If a part of a girder system rests on a support

Wheel usually rotate about their centre and the turning effect of the force about the centre is called the torque or moment of the force about that axis or point. The axis or point is also called the fulcrum. When a door is opened it turns about the hinges; the fulcrum is thus the line passing through the hinges.

If a person weighs 600 N sits a point A 2 m from the rocking-point or fulcrum O, he cannot balance another person of 300 N at B, the same distance from O on the other side. The torque of 600 N about O is thus greater than the torque of 300 N about O. If the lighter person moves further along the see-saw from B, however he can counter –balance the heavier person at A: This occurs when he reaches C, where OC is 4 m.

If we are not careful when walking on slippery ground the vertical line through our centre of gravity may fall outside the feet: In this case we are unstable as our weight can pull us over, owing to the moment exerted about the feet, which is anticlockwise.

Individual tasks:

The moment or torque of a force about a point depends on two factors: the magnitude (size) of the force, the distance of the force from the turning point.
The rule for calculating the moment or torque is as follows:
Torque=force X Perpendicular distance
The perpendicular distance being that from the fulcrum to the line along which the force acts.
An object which moves further away from its position when displaced is said to be in an unstable equilibrium.

An object which returns to its original position when displaced, such as to a punch-ball on a stand, is said to be in stable equilibrium. An object which remains in its displaced position such as a ball rolled to another position on an horizontal plane, is said to be in neutral equilibrium.

Data collection:

The students or the teacher are making the measurements and marking the physical values in a table according to the needs of each experiment

Interpreting the results

We will let the students (if possible) to write down their observations and make some conclusions after observing the events happened during the experiment. In this way we are stimulating their ability of integrating information from different areas.
The 600 N Force at A tends to turn the beam about O in an anticlockwise direction. The 300 N force at B tends to turn the beam about O in a clockwise direction. The clockwise moment of the first is greater than the second and thus the beam will tilt about O in an anticlockwise direction. When the 300 N is moved to C, it follows that the clockwise moment is exactly equal to the anticlockwise moment, and thus the beam will now balance and remain horizontal.
The lower the centre of gravity the more likely is stable equilibrium.
On this account racing-cars are built low and lamp –stands have heavy bases to bring down the centre of gravity. The centre of gravity of a bus with standing passengers on a bus is liable to be dangerously high. By regulation standing passengers are not allowed on the top of buses.

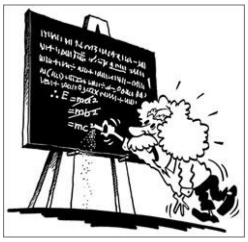
Explanation and conclusions:

Forces are measured in Newton or sometimes in Kgf, 1Kgf is the force of gravity on 1kg mass and is equal to about 10N
A force is represented in drawing by a straight line with an arrow on it; this is drawn in the direction along which the force acts, and the length of the line must represent to scale the magnitude of the force.
The torque or moment of a force is the turning effect of the force and is measured by:
Force X Perpendicular distance from fulcrum to the force.
When a lever is in equilibrium, the total clockwise moment about the fulcrum is equal to the total anticlockwise moment
The centre of gravity of an object is the point through which the whole weight appears to act.
An object is in stable equilibrium if it returns to its original position when slightly displaced; it is in an unstable equilibrium if it moves further away, and in neutral equilibrium if it remains in its displaced position. Generally, an object will tend to be in stable equilibrium if its centre of gravity is low and in unstable equilibrium if its centre of gravity is high.

References:

1. Nuova Physica 2000 AAVV Le Monnier Fi
2. Physics AAVVHeinemann Educational Books London

EXPERIMENT NR. 38 MECHANICAL BALANCE OF RIGID-SOLID – THE SUM OF PARALLEL FORCES OF SAME ORIENTATION



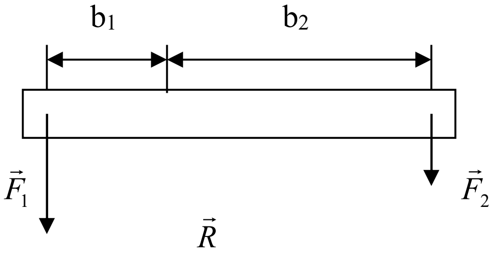
CHAPTER: MECHANICS

PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU" Şimleu Silvaniei, ROMANIA

Theoretical aspects:

The resulting force of 2 parallel forces that have the same direction and are working on the same object is another parallel force orientated the same way, its module being the sum of the 2 forces`modules. The origin of the resulting force divides the segment that unites the origins of the original forces in two segments of lengths in reverse proportions with the modules of the 2 forces.

$$F_1 \cdot b_1 = F_2 \cdot b_2$$



Materials, apparatus:

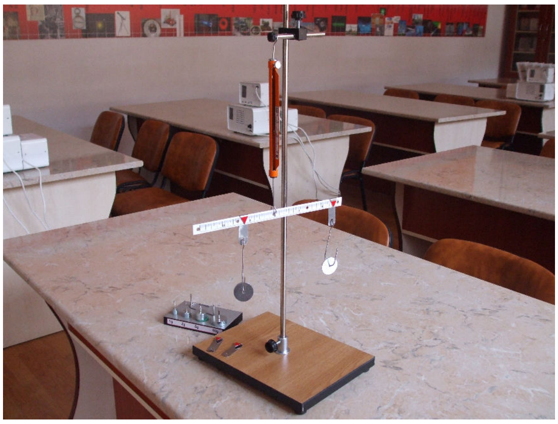
Horizontal support, vertical rod, fixing socket, dynamometer 2,5N,horizontal rod, gradated measuring rule with special hooks, hooks and perforated discs..

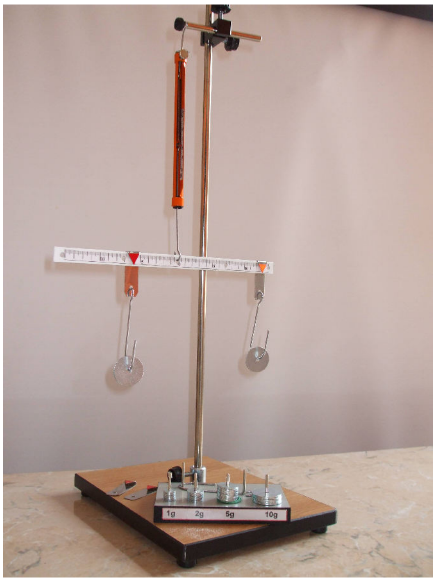
Safety precautions:

There is no need for safety precautions

Experimental procedure:

By attaching perforated discs on the 2 rods and balancing the measuring rule, with the use of a dynamometer we can measure a force equal to the resulting force of the 2, same orientated and parallel forces to which the weight of the measuring rule needs to be added.





Individual tasks:

We mount on the special hooks (from the measuring rule) regular hooks and perforated discs. Using the dynamometer we measure their weights, F_1 and F_2 .We suspend the measuring rule to the dynamometer in its weight center. If necessary, we balance it by moving one of the special hooks.

We read the indication of the dynamometer G_0. Next we attach the special hooks and the perforated discs to the measuring rule; we balance the measuring rule in a horizontal position by moving the discs on it.

By convention, R is the resulting force of F_1 and F_2 and R` is the force measured with the dynamometer.

We verify the indication of the dynamometer using the formula:

$$R=R'-G_0$$

We measure on the measuring rule the arms of the 2 forces and we verify the relation:

$$F_1 \cdot b_1=F_2 \cdot b_2$$

Data collection:

No. det	F_1 (N)	F_2 (N)	b_1 (m)	b_2 (m)	F_1 b_1 (Nm)	F_2 b_2 (Nm)	R' (N)	G_0 (N)	R (N)
1									
2									
3									
4									

Indicate the sources of errors

Errors due to the experimenter

- reading the divisions on the measuring rule
- reading the divisions on the dynamometer
- balancing the measuring rule in a horizontal position

Errors due to the precision of the instruments:

- low precision of the measuring rule
- imprecision in scaling the measuring rule
- low precision of the dynamometer

Inappropriate environment

- insufficient lighting
- uncomfortable position when measuring with the dynamometer, movement

Interpreting the results

The experiment confirms that the ratio of the forces is equal to the reversed ratio of their arms.

References:

1. Panaitoiu, L., Chelu, I., *Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972
2. Corega, C., Marinciuc, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995
3. http://www.olimpiade.ro
4. http://www.didactic.ro

EXPERIMENT NR. 39 EQUILIBRIUM OF FORCES

CHAPTER: Mechanics

PROPOSED BY: LP “La Closerie”, St Quay Portrieux, FRANCE

Theoretical aspects:

The aim of this experiment is to find out the equilibrium conditions of a solid subjected to the action of two forces if the weight is negligible compared to these two forces.

Different approaches:

The pupils should learn how to apply two forces on a solid having the possibility of varying easily the characteristics of these two forces. The first idea consists in using two dynamometers to act on the object via two strings. It is a method easy to put into practice but in which the dynamometer is used in an incorrect way. The second method, which is used here, uses the weight of marked masses, acting on the solid via pulleys. Knowing the role of the pulley and the relation weight/mass is necessary.

Materials, apparatus:

For each pupil

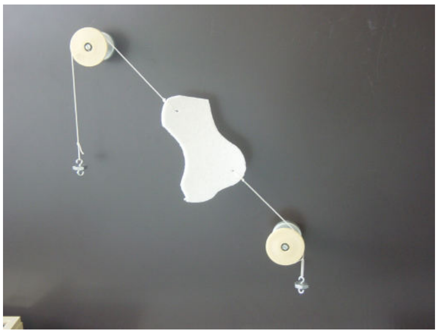
- A metal table
- Two magnetic pulleys
- Several marked masses including at least two 100g masses
- A small object made out of a light material (polystyrene for instance) to which two strings are attached through two small holes
- A digital camera (with PC and printer)

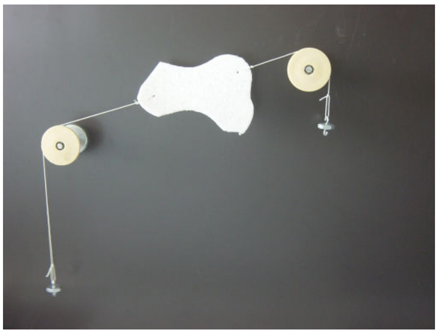
Experimental procedure - Individual tasks:

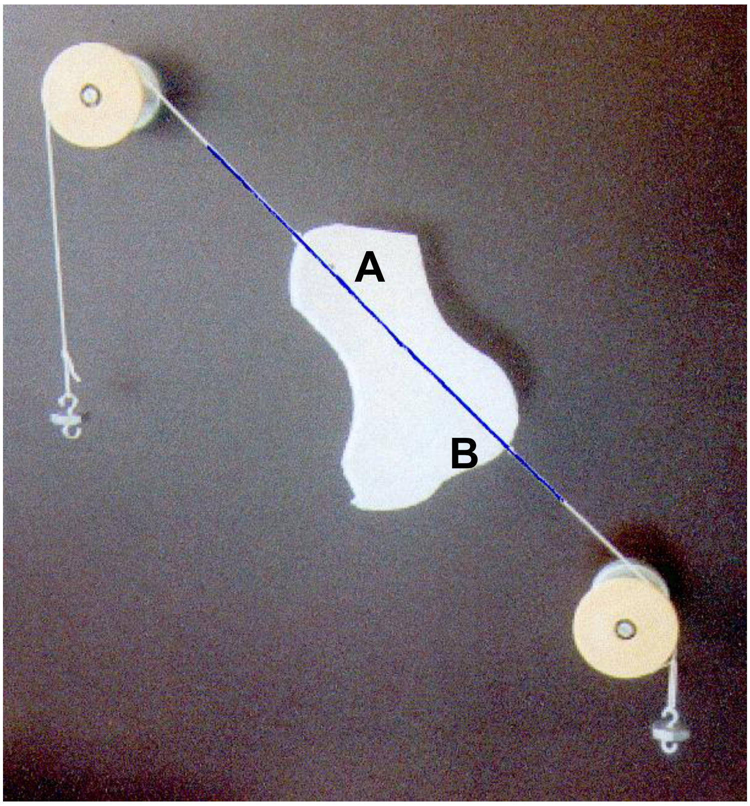
Each pupil must carry out the experiment varying the masses and the positions of the pulleys until obtaining a position of equilibrium.

When equilibrium is obtained, a photo of the device is taken and printed .Straight lines between A and B.

The table below is filled in.







Data collection:

Mass (G) Intensity of the force (NR) Point of contact Axis Direction

Mass (g)	Intensity of the force (N)	Point of contact	Axis	Direction

The students or the teacher are making the measurements and marking the physical values in a table according to the needs of each experiment

Explanation and conclusions:

In this experiment, the weight considered as negligible but this is not the correct reality. This leads to a further study of the action of three forces on a solid and to the study of the equilibrium of a body subjected to its weight and to the reaction of the support.

EXPERIMENT NR. 40 WORK ON A BICYCLE

CHAPTER: MECHANICS

PROPOSED BY: Comenius College Capelle aan den IJssel, THE NETHERLANDS

Theoretical aspects:

To research in this experiment:

1. Is the work (W_{muscle}) of the human force on the pedals of a bicycle equal to the work that the bicycle ($W_{bicycle}$) does on the road?
2. Does the answer to question 1 depend on which gear you choose?

Fig 1 The bicycle

Theory:
With the following definitions:

W = work in Joules,
F = force in Newton,
s = distance in meters,

the amount of work can be calculated with the formula $W = F \cdot s$ (if the Force and the distance have the same direction).

The circumference of a circle can be calculated with: $p = 2 \cdot \pi \cdot r$

p = circumference.
r = radius.

Different approaches:

Choose a method to measure and/or calculate:

- s_{muscle} (=distance covered by the pedal during one rotation).
- $s_{bicycle}$ (=distance covered by the bicycle during one rotation of the pedal).

Materials, apparatus:

- A bicycle, Instruments for measuring force and distances.
- Bottles of water to simulate the muscle force, Pieces of string.

Experimental procedure:

See fig 2.

- Count the teeth of the front- and rear toothed wheels.
- Hang some bottles on the pedal with the pedal in horizontal position (see fig 2) in order to get a force of 15-20 N on the pedal (=F_{muscle}).
- Determine the "muscle force" and the bicycle force.
- Determine the distance that the pedal covers during one rotation.
- Determine the distance that the bicycle covers during one rotation of the pedal.
- Repeat 1, 2, 3, 4 and 5 for the other two gears. (Change only the back toothed wheel.)
- Fill in all the results (in the table below).
- Calculate W_{muscle} and $W_{bicycle}$ and fill in (in the table below).

Fig 2. Measuring the Forces

Data collection:

Number of teeth of the rear toothed wheel	F_{muscle} (N)	F_{bicycle} (N)	$s_{\text{ muscle}}$ (m)	$s_{\text{ bicycle}}$ (m)	$W_{\text{ muscle}}$ (J)	$W_{\text{ bicycle}}$ (J)

Indicate the sources of errors and determining errors

1. Describe the method you used for measuring $s_{\text{ bicycle}}$.
2. Mention the sources of error that occur during:
   a. Measuring the $F_{\text{ bicycle}}$.
   b. Measuring the $s_{\text{ bicycle}}$.

Interpreting the results

Notice the possible errors before you draw conclusions on the research questions.

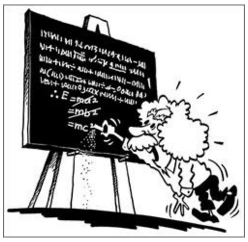
Explanation and conclusions:

What are your conclusions on the research questions?
Explain your conclusions.

References:

1. Natuurkunde Overal havo voor de tweede fase Havo NG/NT 1 Chapter 4

EXPERIMENT NR. 46 DETERMINING THE CENTER OF GRAVITY OF A PLANE FIGURE



CHAPTER: Mechanics

PROPOSED BY: LP La Closerie, St Quay Portrieux, FRANCE

Theoretical aspects:

The goal is to find the center of gravity G of a plane solid (or comparable) i.e. the point where the weight applies, resulting from the weight of the various constituent points of the solid forces. A second goal in connection with mathematics is to find the position of the barycentre of a plane figure.

Different approaches:

An intuitive way to find G consists in holding the object balanced on the tip of the finger. This method is interesting because it makes it possible “to feel” the weight and its weight of application but it is not very precise and sometimes impossible to implement (case of the torus for example)

Materials, apparatus:

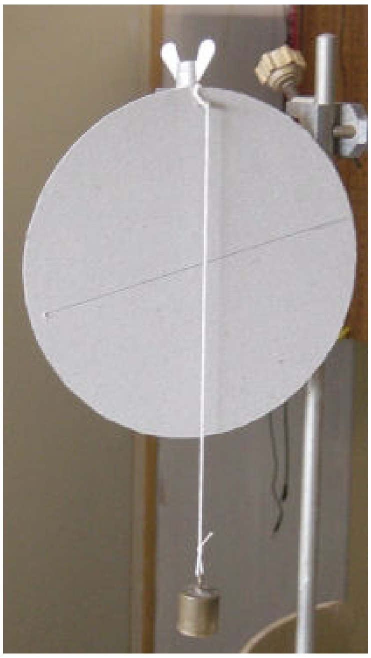
- A rectangle, a triangle, a disc and a toroidal object made out of strong paperboard
- A lead line
- A stand
- A ruler

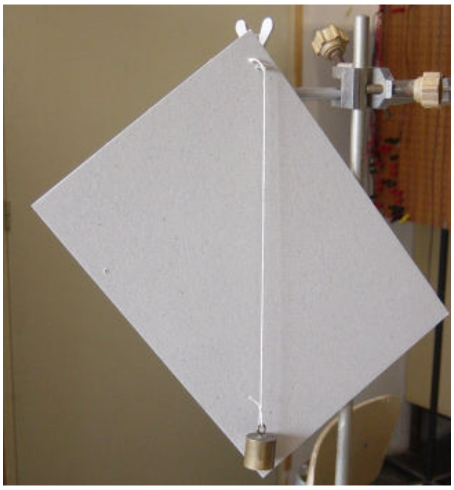
Safety precautions:

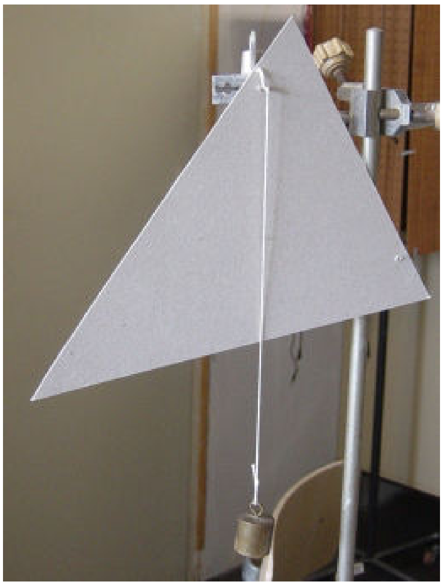
No special precautions.

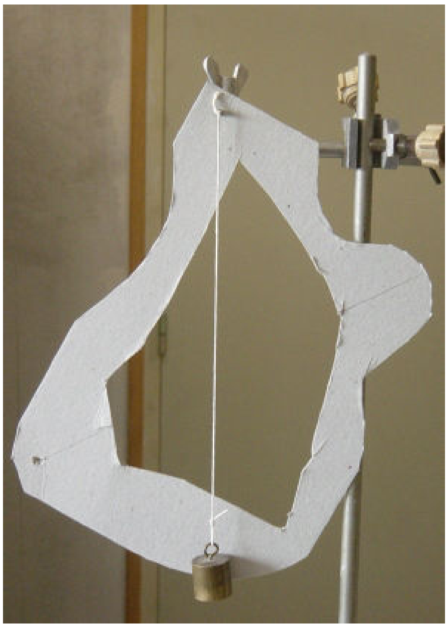
Experimental procedure / Individual tasks:

- Hang each solid by one of the holes bored on its circumference.
- Hang the lead line at the same place in order to determine the vertical axis.
- Mark this axis with the pencil.
- Repeat the process/operation starting from the other holes.
- Check, if possible, the position obtained using the tip of the finger.
- Draw:
  1) the diagonals on the rectangle,
  2) the medians on the triangle,
  3) two diameters on the disc;









Data collection:

solide	Position of G
Triangle	Barycenter
Rectangle	Intersection of the diagonals
Disc	Center
Torus	Not atérialisable

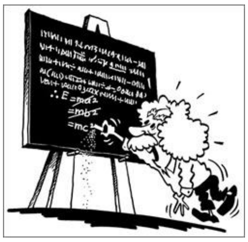
Indicate the sources of errors and determining errors

1) Inaccuracy due to the layout of the vertical axes (stabilization of the lead line and of the paperboard while drawing the lines)
2) Necessity of holes of a certain diameter on the edge of the solids.

Explanation and conclusions:

The main interest of this experiment is to show an example of the use of the rule of balance for a solid subjected to the action of two forces

EXPERIMENT NR. 47 THE RELATION BETWEEN THE RESULTING FORCE, THE COVERED DISTANCE AND THE FINAL VELOCITY OF A SYSTEM



CHAPTER: MECHANICS

PROPOSED BY: Comenius College, Capelle aan den Ijssel, THE NETHERLANDS

Theoretical aspects:

The aim of this experiment is to find a relation between the resulting force on a moving system, the covered distance and the final velocity of that system.

Formulas used:

$W = F \cdot s$

W : Work of the resulting force (J)

F_{res} : Resulting force (N)

s : distance (m)

$F_z = m \cdot g$

F_z : gravity force (N)

m : mass (kg)

g : gravital acceleration (m/s^2)

$E_{kin} = \frac{1}{2} \cdot m \cdot v^2$

E_{kin} : kinetic energy (J)

m : mass (kg)

v : speed (m/s)

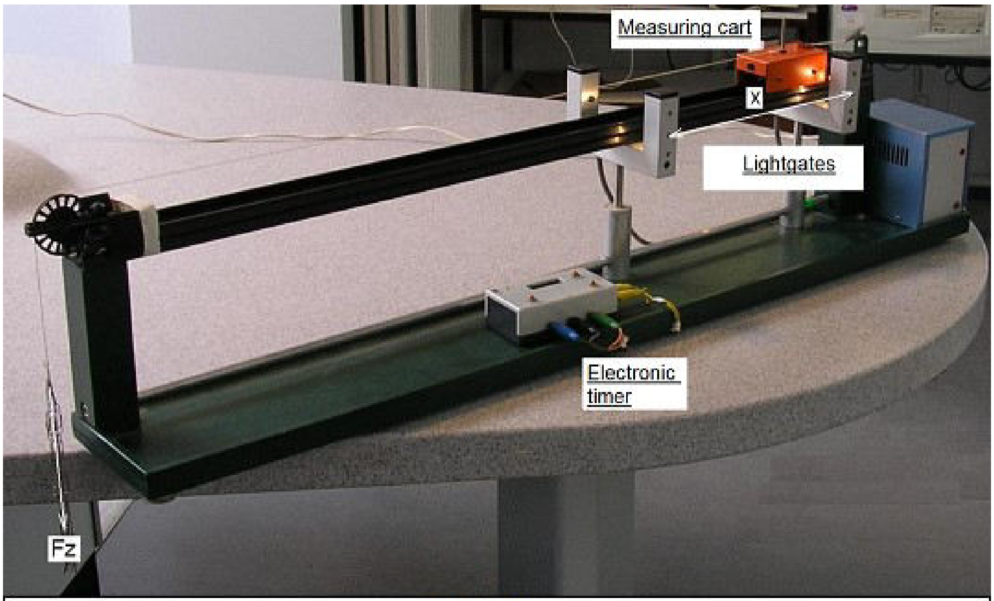


fig 1

Materials, apparatus:

See fig 1.

- A low-friction track with a cart, e.g. an air track arrangement.
- Two light gates and an electronic timer
- A balance
- Paperclips

Experimental procedure:

Connect the cart to the 20 paperclips by a thin thread. The thread runs over a pulley.
This way the gravitational force F_z on the paperclips is used as an accelerating force on the system. See also fig 1.
The two light gates are connected to the timer. The first lightgate gives a starting pulse and the second one stops the timer. If the lightgates are well positioned the timer will show the time that the cart needs to run a chosen distance s.
With the measured time and the distance the average velocity v_{avg} and the final speed v_{max} will be calculated. The relation of F, s and v_{max} can be derived from the measurements.

Individual tasks:

Measure the mass of 20 paperclips and the mass of the cart.
Position the lightgates at a 20 cm distance. Be sure that the first lightgate is passed by the cart right after the beginning of the movement, thus v_0 = 0 m/s.
Reset the timer and measure the time that the system needs for 20 cm of movement. Fill in table 1, column 2
Repeat the measurement twice. Fill in table 1, column 2 and 3.
Repeat 3. and 4. for all distances mentioned in the table. Fill in table 1, column 2, 3 and 4.

Data collection:

Table 1.

s (m)	Δt_1 (s)	Δt_2 (s)	Δt_3 (s)	Δt_{avg} (s)	v_{avg} (m/s)	v_{max} (m/s)	W (J)	E_{kin} (J)
0,20								
0,40								
0,60								
0,80								

Interpreting the results

1. Complete the table with the average time Δt_{avg}, the average speed v_{avg} (m/s) and the final speed v_{max}. Fill in the table, column 5, 6 and 7.
2. Calculate the work (in Joule) done by the resulting force (= gravital force on the paperclips).
3. Calculate E_{kin}. (The mass in the formula is the total mass of the cart and the paperclips).
4. Give the relation of F_z, s and v_{max}.

EXPERIMENT NR. 48 WAVE TANK

CHAPTER: Vibrations and Waves

PROPOSED BY: HTL Dornbirn, AUSTRIA

Theoretical aspects:

A large number of principles and effects may be illustrated with the wave tank:

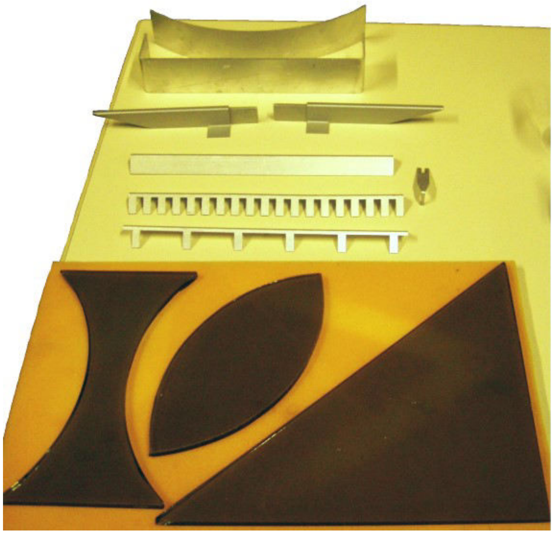
- Huygens principle:
  Each point of a wave front is the source of a new elementary wave (circle and sphere respectively). The interference of the elementary waves results in the detectable wave.
- Diffraction
  Waves can also be detected in the geometric shadow – generally the behavior of waves behind barricades.
- Refraction
  The direction of waves changes according to Snell's law: $\frac{\sin(\alpha_1)}{\sin(\alpha_2)} = \frac{n_2}{n_1}$
- Reflection
  The incident angle is the same as the reflected one.

Different approaches:

You may use the wave tank to visualize the effects already known from geometric optics namely refraction and reflection – and to connect them in the memory of the students with the fundamentals of wave effects.
The experiments can also be used to visualize the basics of the Huygens principle and further on to explain the listed effects with the theory of waves.

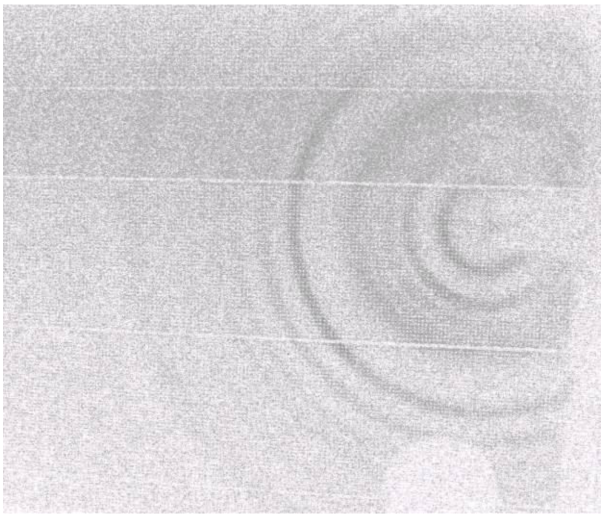
Materials, apparatus:

- wave tank with a mirror at the bottom (and borders diminishing the reflection)
- spotlight (and power supply)
- actuator (and power supply)
- tripods
- sources of disturbance – single point, number of points arranged in a line, continuous line (middle parts in the image on the right side)
- barricades with adjustable gap and of different shape respectively (upper parts)
- glass objects of different shape – to diminish depth (lower parts)



Experimental procedure:

The tripods are used to place the spotlight and the actuator above the water surface (see left picture below).
The mirror on the bottom of the basin will reflect the light to the ceiling where everybody can easily observe the results of the experiments (see right picture below) – even better than directly on the surface. Do not forget to darken the room.
The actuator has to be positioned that the disturbance elements just slightly dip on the water surface.
The water height has to be adjusted that the glass objects are fully covered with a thin layer of water when placed on the mirror.



Individual tasks:

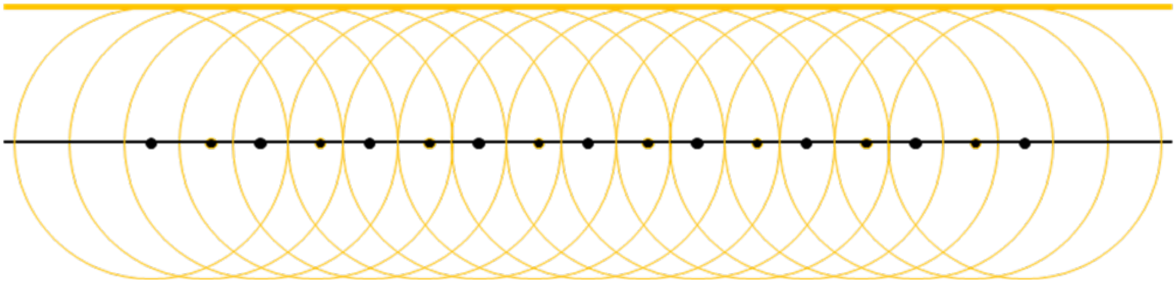
- Demonstrate Huygens principle:
  - first use the single disturbing element,
  - continue with the elements lining up a number of disturbing points.
- Demonstrate diffraction:
  - use the disturbing element for linear waves and the barricades with the gap (place the latter rather near the wave source),
  - adjust the gap for different widths (around a wavelength and much larger).
- Demonstrate reflection:
  - use the disturbing element for linear waves and the different barricades (straight and curved) in the back of the wave tank,
  - place the straight barricade parallel to the wave fronts,
  - place the straight barricade inclined,
  - place the curved barricade with the bending towards the incoming waves,
  - place the curved barricade with the bending in the opposite direction.
- Demonstrate refraction:
  - use the disturbing element for linear waves and the different glass elements,
  - place the triangular glass element in the back of the wave tank, the short sides towards the borders of the tank and the longest side towards the incoming waves,
  - place the glass element resembling a convex lens in the middle of the basin,
  - place the glass element resembling a divergent lens in the middle of the basin.

Indicate the sources of errors

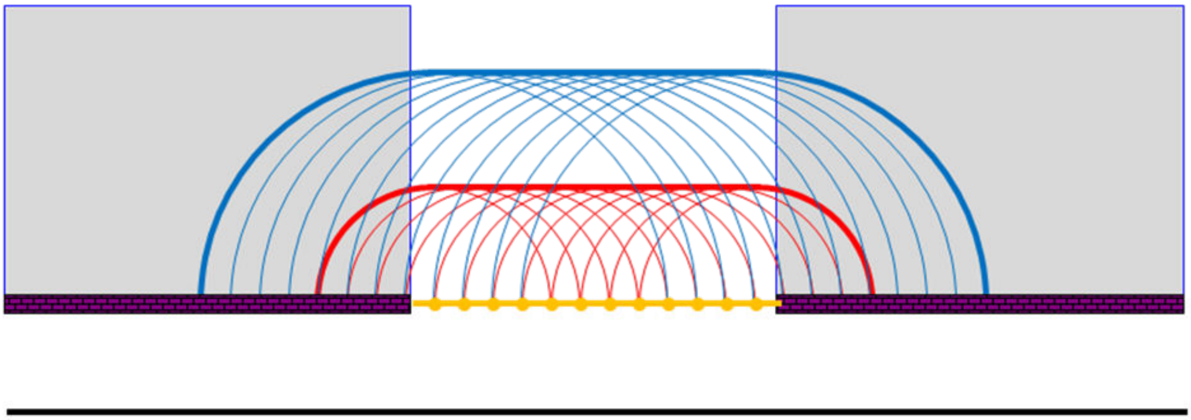
- The spotlight is used with a large incline – some waves are difficult to see.
- The actuator is not adjusted completely horizontally – the distribution element for linear waves is not working correctly.
- The actuator is dipping in too deep – the surface tension will prevent the disturbing elements from dividing from the water surface and thus from creating good waves.
- The waves passing outside the objects and being reflected from the borders of the wave tank may cause confusing results – try to avoid them.

Interpreting the results:

1. Huygens principle:
    a. The single point of disturbance causes elementary thus circular waves.
    b. When the number of disturbing points increases then the front is getting straighter and the different phases of the elementary waves in the region behind interfere destructive therefore are finally not visible.
    The sketch below shows the first starting line (black); every point of this line is the source of an elementary wave – one period later (yellow) the elementary waves shown as circles interfere and result in nearly linear front waves on both sides.



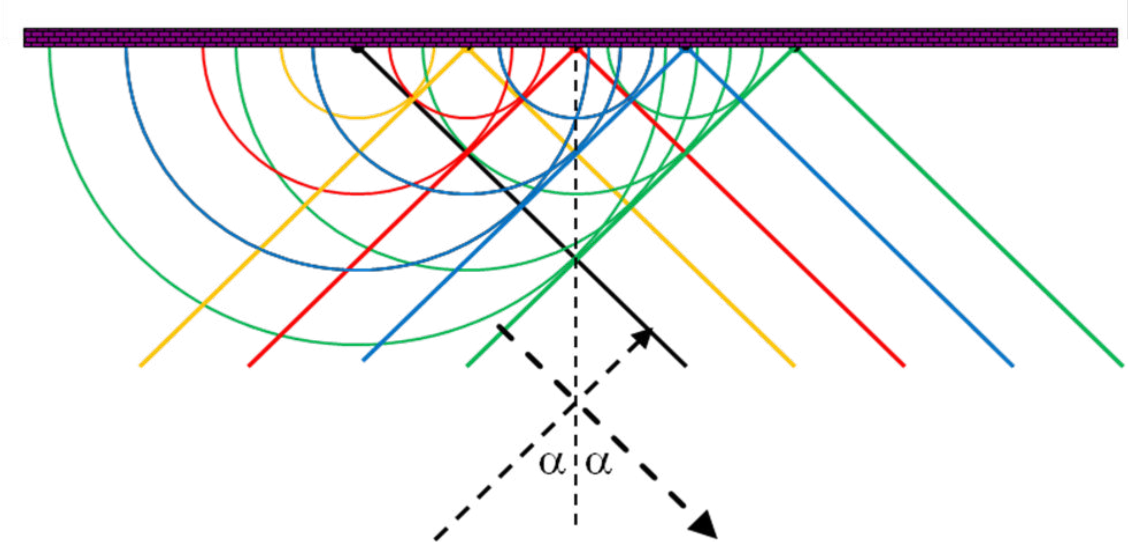
2. Diffraction:
    a. The sketch gives an idea what's happening. The linear wave is approaching the barricades (black). One period later (yellow) it reaches the level of the barricade. Every point of the line is the source of elementary waves shown one period later (red) and two period later (blue) as the elementary waves of the model (thin) and the visible waves (thick).
    It is clearly visible that the waves extend into the geometric shadow.



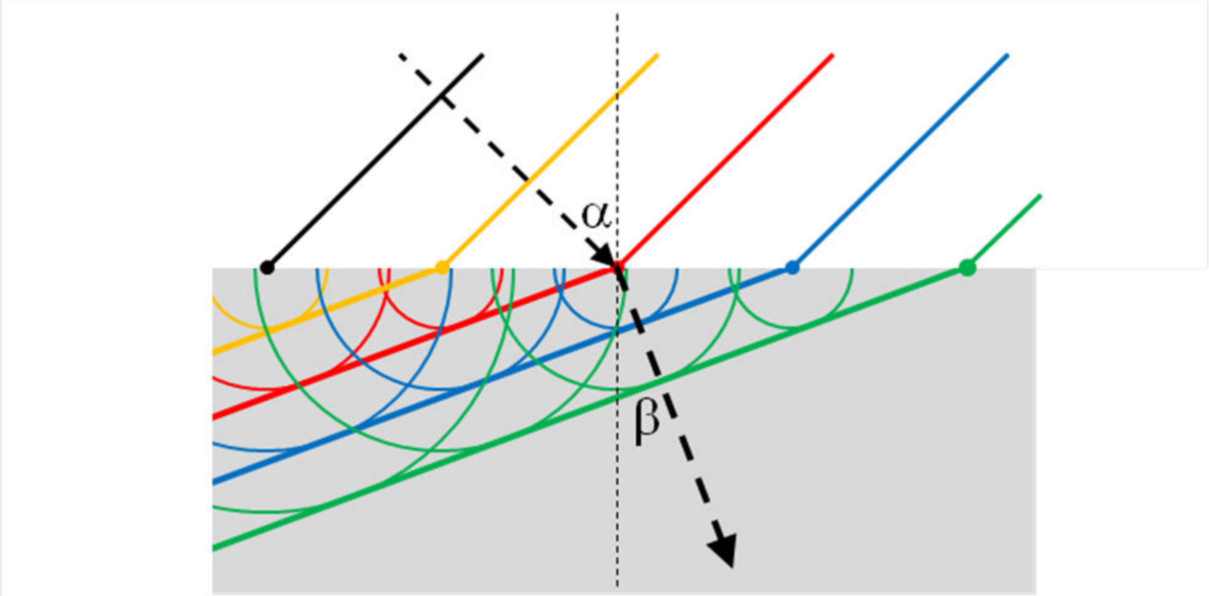
    b. A small gap results in nearly circular waves in the back of the barricade. Larger gaps show a linear part in the middle.
3. Reflection:
    a. The sketch on the next page points out what's happening from the point of view of Huygens wave theory. The colors code the different times: start (black), one period later (yellow), two period later (red), three period later (blue) and four period later (green). The incoming wave is moving from the lower left to the upper

right. When the wave is reaching the barricade there are circular waves spreading out according to Huygens and interfering to a new wave front.
For a moving version demonstrating reflection and refraction simultaneously see http://www.walter-fendt.de/ph14e/huygenspr.htm (Status: 23.12.2008).

b. The linear wave fronts are reflected and move backwards interfering with the incoming waves – use just a little number of wave fronts to point out the effects.
c. The law of reflection gets visible when the moving direction is considered.
d. The linear wave is transformed into a curved wave front with the same bent as the barricade.
e. The linear wave front is concentrated and interferes heavily in a special region around the expected focal point.



4. Refraction
   a. Again the sketch points out what's happening according to Huygens. The incoming wave is moving from the upper left to the lower right. When the wave is reaching the boundary of the two different materials there are circular waves spreading out according to Huygens and interfering to a new wave front. The wave length in the second media (the one with the higher refractive index) is shorter since the velocity is smaller.



   b. The water waves base on circulating water cylinders below the surface. When the depth is diminished only smaller wavelength can exist.
   At the border of the glass triangle Snell's law of refraction can be detected.

c. The fronts of the incoming linear waves are concentrated and interfere heavily in the region of the focal point.
d. The fronts of the incoming linear waves are spreading out in a curved way reminding on a circle with the center behind the divergent lens.

Explanation and conclusions:

Most optical effects discussed in school base on the model of electromagnetic waves. Thus all of them may be explained on base of the principle which was expressed by Christian Huygens in 1678.

EXPERIMENT NR. 50 RELATION BETWEEN WAVE VELOCITY, TENSILE FORCE AND MASS PER METRE IN A STRING

CHAPTER: VIBRATIONS and WAVES

PROPOSED BY: Comenius College Capelle aan den IJssel; THE NETHERLANDS

Theoretical aspects:

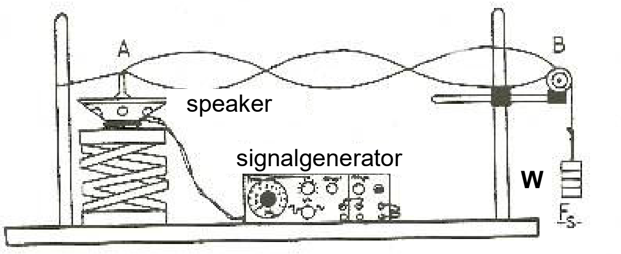


Fig. 1.

Fig. 2.

The aims of this experiment are:

1. To determine the sequence of resonance frequencies of different strings.
2. To deduce the relation between the wave velocity, the tensile force and the string-mass per metre.

Theory:
The relation between frequency, wave velocity en wavelength is given by: $v = f \cdot \lambda$.

f : frequency (Hz)
v : wave velocity (m/s)
F_s : tensile force (N)
m/l : string mass per metre (kg/m)
λ : wavelength (m).

Materials, apparatus:

See fig. 1 and 2:

- Signal generator.
- Speaker.
- String.
- Weights.
- Ruler.

Safety precautions:

Be careful with the loudspeaker: too much voltage may harm the speaker!

Experimental procedure:

The signal generator produces a sinusoidal signal with an adjustable frequency and amplitude. The built-in amplifier transforms the signal to a sufficient voltage level for the speaker. The cone of the speaker will then vibrate harmonically. The vibration is transferred to point A of the string (fig. 1). The wave that runs through the string reflects at the ends A and B. The original wave and the reflected waves interfere with each other. For specific frequencies (the resonance frequencies of the string) there will be resonance in the string: then we see a standing wave in the string consisting of nodes (a node is a spot on a standing wave where the medium does not move) and antinodes (an antinode in a standing wave is the region where the medium is in motion). A and B are considered as nodes in these waveforms of the string. (fig 2).

Experiment 1:
Changing the frequency *f* and observing the waveform shows the sequence of resonance frequencies of each string.

Experiment 2:
Vary the frequency until one complete wavelength appears in the string. The wavelength λ can be measured in the string and the frequency *f* is to be read on the signal generator. With these data we can calculate *v*. Changing the weights (see W in fig 1) varies the tensile force F_s. Different values of tensile force cause different wave velocities. The relation between *v* and F_s can be deduced from the results of this experiment.

Experiment 3:
Choose one of the strings. Measure the mass and the length of it. Calculate *m*/*l.* Produce a wave in the string. Change the frequency until one complete wavelength appears. Repeat this for every string. Calculate *v* for each string and deduce the relation between *v* and *m*/*l.*

Individual tasks:

Experiment 1.
Choose a string, calculate *m*/*l*, measure the length AB of the string, determine *Fs*.
Increase the frequency (start with f = 0 Hz) until a stable pattern appears in the string. Write this resonance frequency *f* in the table and draw the pattern. Search about 5 possible frequencies.
Calculate λ and write down in table 1.

Experiment 2.
Choose one string. Adjust the string from A to B to a length of 1,00 m.
Increase the weight W with the given mass-pieces. Calculate *Fs* and write this in table 2.
Adjust the frequency so that one complete wavelength occurs in the string. Read *f* on the signal generator and calculate *v*. Fill in table 2. Repeat this for different values of *Fs*.

Experiment 3.
Take a fixed *Fs* in this experiment and vary *m*/*l* by using different strings. Determine *v* as in experiment 2. Complete table 3.

Data collection:

Table 1

Length AB = ……..m; *Fs* = ………..N; *m*/*l* = ………………kg/m		
f (Hz)	Drawing of the pattern in the string.	*λ* (m)

Table 2

m/*l* = ………………kg/m; l_{AB} = 1,00 m; *λ* = 1,00 m			
Fs (N)	$\sqrt{F_S}$ (N$^{1/2}$)	*f* (Hz)	*v* (m/s)

Table 3

F_s = ………N; l_{AB} = 1,00 m; *λ* = 1,00 m			
m/*l* (kg/m)	$\frac{1}{\sqrt{\frac{m}{l}}}$ $\left(\frac{1}{\sqrt{\frac{kg}{m}}}\right)$	*f* (Hz)	*v* (m/s)

Interpreting the results

1. Give a mathematical expression for the sequence of resonance frequencies (harmonics) of the vibrating string in experiment 1.
2. Make a v, $\sqrt{F_S}$ - diagram (exp 2). What is the relation between *v* and $\sqrt{F_S}$?
3. Draw a v, $\frac{1}{\sqrt{\frac{m}{l}}}$ - diagram (exp 3). What is the relation between *v* and $\frac{1}{\sqrt{\frac{m}{l}}}$?

Explanation and conclusions:

1. Explain whether the results match the formula $v = c \cdot \sqrt{\frac{F_S}{m/l}}$.
2. Calculate the value of the factor *c* in this formula.

References:

1. An explanation of standing waves can be found on:
http://id.mind.net/~zona/mstm/physics/waves/standingWaves/standingWaves.html

EXPERIMENT NR. 52 USING A LFG A LOUDSPEAKER A MICROPHONE, AN OSCILLOSCOPE AND A TUNING FORK

CHAPTER: Acoustics

PROPOSED BY: LP La Closerie, St Quay Portrieux, FRANCE

Theoretical aspects:

Goal: to find the characteristics which make it possible to distinguish two musical instruments playing the same note. (In other words: which are the characteristics of a sound).

Different approaches:

Using real instruments gives oscillograms too difficult to decode. To make the readings easier a GBF and a tuning fork may be used.

Materials, apparatus:

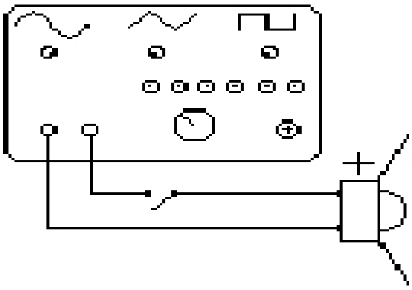
- 1 LFG
- 1 Loudspeaker
- 1 microphone
- 1 tuning fork
- 1 oscilloscope

Safety precautions:

Precautions related to the use and manipulation of the equipments connected to the 220V national network.

Experimental procedure / Individual tasks:

Carry out the assembly as shown below by initially choosing a sinusoidal signal, a frequency of 500 Hz and a “comfortable” sound volume.
Then fill out the table below.
In the column “comment” the following information must be noted: the instrument evoked by the sound, the variation of intensity according to the tension and the height of the sound



Then carry out the second assembly and supplement the second table.

Data collection:

Frequency (Hz)	Shape of signal	Tension (V)	Comments
500	Sinusoidal	1,5	
400	Sinusoidal	1,5	
500	Sinusoidal	3	
400	Sinusoidal	3	
500	square	1,5	
500	triangular	1,5	

Instrument	Shape of the curve
Tuning fork	
Voice	

Indicate the sources of errors and determining errors

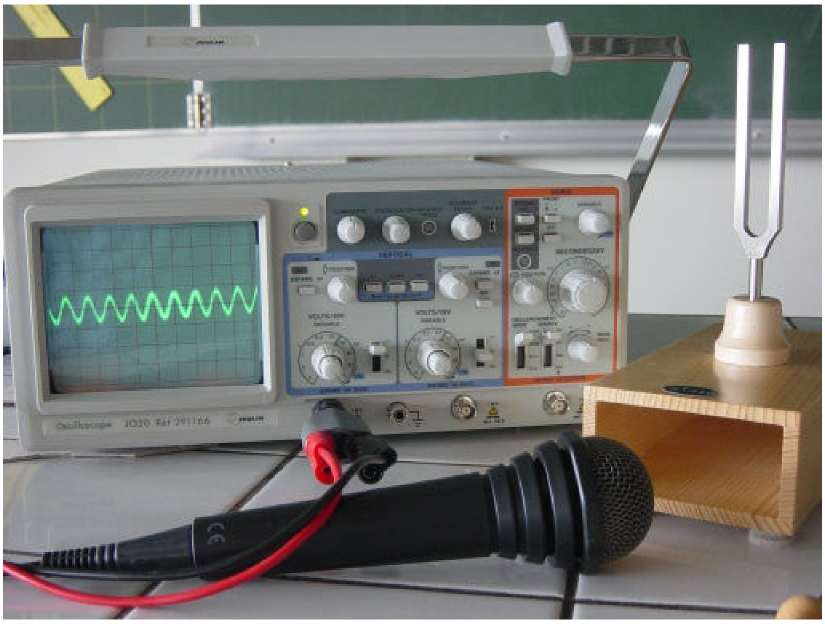
This experiment is only qualitative and is not really subjected to the risks of errors others than handling.

Interpreting the results and conclusion

This experiment makes it possible to help special needs students understand the concept of tone (related to the shape of the signal), of height (frequency) and of intensity (power).

References:

1. Frederic Diaz (ac. Besancon); CAP Sciences physiques industriels et tertiaires, Delagrave 2007.



EXPERIMENT NR. 54 DOPPLER EFFECT: PLAYING SOUND WAVES

CHAPTER: Vibrations and Waves

PROPOSED BY: HTL Dornbirn, AUSTRIA

Theoretical aspects:

Christian Doppler found the explanation of the effect causing a sound to be detected with a higher frequency if the source is approaching and a lower frequency if the source is departing. Sound can be described by waves – using the pressure variations in the transport medium. There are mainly two quantities used for the description of waves: frequency (f, unity Hertz) and wavelength (λ, unity meter). They depend on each other and the propagation speed: $v = \lambda \cdot f$

Different approaches:

There are two different cases which have to be considered:

- The effect is emerging only at the point of detection that is when the observer is moving.
- The effect is already generated at the source point that is when the source is moving.

The experiments will help to get an idea of these phenomena by involving the students directly and connecting the theory with physical experiences (advantageous especially for the haptic type of learners).

Materials, apparatus:

- a number of people
- large place (yard or gym)
- clock

Experimental procedure:

The “source” is sending the “wave maxima” in regular intervalls in the direction of the observer. The observer is counting the “wave maxima” passing in a specific time slice.

There are five different experiments to cover all possibilities:

1. The observer and the “source” are not moving either
2. The observer is moving in the direction of the “source”. The “source” is standing still.
3. The observer is moving away from the “source”. The “source” is still resting.
4. The “source” is moving in the direction of the observer. The observer is standing still.
5. The “source” is moving away from the observer. The observer is still resting.
6.

Individual tasks:

There are four different tasks which have to be done by the students during the experiment:

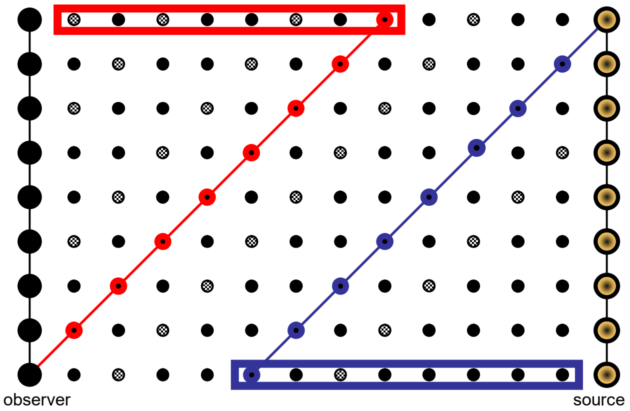
- the source: A student has to send his or her colleagues (the wave maxima) in the direction of the observer. In those experiments when he or she has to move the source has to walk very slowly (like setting one foot directly in front of the other and so on)
- the observer: A student has to count all the passing students (the wave maxima) in the fixed time slice. When the observer has to move this has to be very slowly again.

- the minute taker: He or she has to take notes on the times and counted numbers. Moreover this person is requested to observe the distances of the walking “wave maxima” and to note the differences especially between experiments 1-3 and 4 and 5.
- the wave maxima: The rest of the students represent the pool of wave maxima. As soon as they are sent from the “source” they have to move straight forward with normal walking speed.

Sketch of the experiments: There are always shown eight periods, thus from one row to the next the wave maxima have moved exactly their wavelength. Some noteworthy things have been marked (see text)

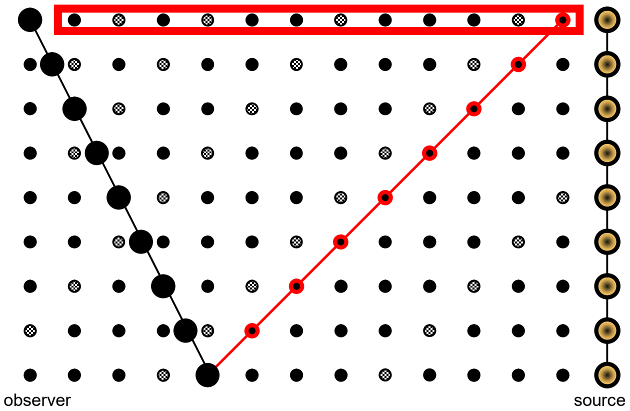
Experiment 1

$$v_{source} = v_{observer} = 0 \quad \Rightarrow \quad f_{source} = f_{observer}$$



Experiment 2

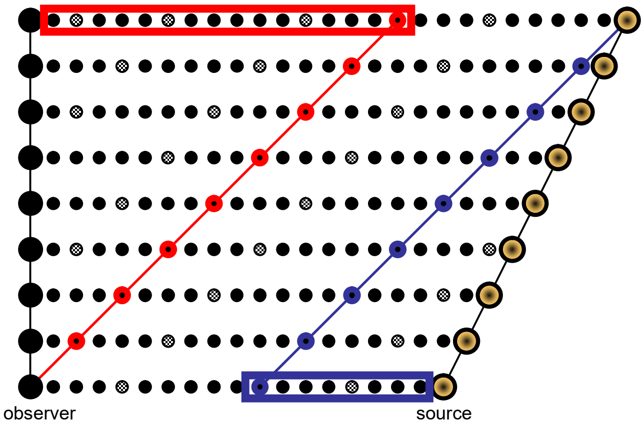
$$v_{source} = 0 \quad v_{observer} > 0 \quad \Rightarrow \quad f_{source} < f_{observer}$$



Experiment 3

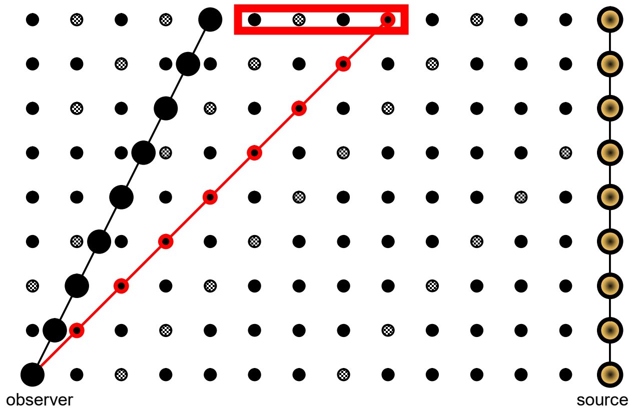
Experiment 4

$$v_{source} > 0 \quad v_{observer} = 0 \quad \Rightarrow \quad f_{source} < f_{observer}$$



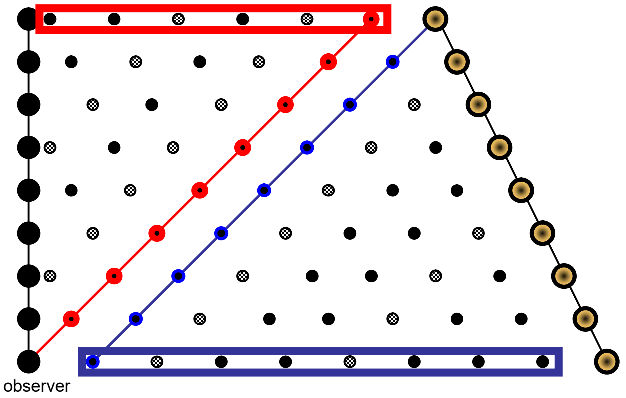
Experiment 5

$$v_{source} = 0 \quad v_{observer} < 0 \quad \Rightarrow \quad f_{source} > f_{observer}$$



$$f_{observer} = f_{source}\left(1 + \frac{v_{observer}}{v_{wave}}\right)$$

$$v_{source} < 0 \quad v_{observer} = 0 \quad \Rightarrow \quad f_{source} > f_{observer}$$



$$f_{observer} = f_{source}\frac{1}{1 - \frac{v_{source}}{v_{wave}}}$$

Data collection:

experiment number	observation time	number of waves (peoples) passed at the observer	frequency (column 3 / column 2)
1			
2			
3			
4			
5			

Indicate the sources of errors

The most difficult points in the realization of the experiments are:

- the “wave maxima” should walk around the same speed each
- the pool of unused “wave maxima” has to accompany the “source” and the “wave maxima” have to stay prepared to be send without delay (Depending on the size of the group they will have to hurry to get back to the pool after passing the observer!)
- the observer and “source” have to walk *very* slowly
- the observer must not start the observations (counting) before the first “wave maxima” have made their way from the “source” to the observers position
- the space between observer and “source” has to be adequate especially in experiment 2 and 4
-

Interpreting the results:

First of all the frequencies of the different experiments have to be compared and ordered (for example the experiments 2 and 4 show a higher frequency …). Additionally the changes of the distances of the “wave maxima” thus the changing wavelengths have to be pointed out.
It is necessary to recapitulate and discus:

- experiment 1: the “wave maxima” reach the observer in exactly the same way than they have left the “source” only delayed due to the distance
- experiment 2: the observer meets more “wave maxima” since he or she takes a part of their way

- experiment 3: less “wave maxima” can catch up the leaving observer
- experiment 4: the “wave maxima” are accumulated in front of the advancing source – smaller wavelength relate to higher frequencies ($v = \lambda \cdot f$)
- experiment 5: the distance of the moving source is added to the wavelength – larger wavelength end in lower frequencies

Explanation and conclusions:

When the observer and source are moving in the direction of each other the frequency is rising otherwise the frequency is reduced.

- If the observer is moving to or away from the source of the sound he or she is collecting more or less of the propagating wave maxima, that is why the frequency is rising or decreasing.

$$f_{observer} = f_{source}\left(1 + \frac{v_{observer}}{v_{wave}}\right)$$

- If the source is moving to or away from the observer, waves of smaller and larger wavelength respectively will propagate (although the source is still sending with the same frequency).

$$f_{observer} = f_{source}\frac{1}{1 - \frac{v_{source}}{v_{wave}}}$$

EXPERIMENT NR. 55 DOPPLER EFFECT: VELOCITY DETERMINATION

CHAPTER: Vibration and Waves

PROPOSED BY: HTL Dornbirn, AUSTRIA

Theoretical aspects:

Christian Doppler found the explanation of the effect causing a sound to be detected with a higher frequency if the source is approaching and a lower frequency if the source is departing. Sound can be described by waves – using the pressure variations in the transport medium. There are mainly two quantities used for the description of waves: frequency (f, unity Hertz) and wavelength (λ, unity meter). They depend on each other and the propagation speed: $v = \lambda \cdot f$

Different approaches:

This effect allows determining the velocity of passing cars only due to the changing frequency of their horn sound. Since it is the source of sound which is moving the necessary calculations will base on the formula $f_{observer} = f_{source} \dfrac{1}{1 - \dfrac{v_{source}}{v_{wave}}}$

This experiment connects experiences of our everyday life with theoretical aspects. It allows not only to deal with qualitative analysis but with exact numbers – nevertheless the students are interested in the results.

Materials, apparatus:

- own acquisition of Doppler sound
    - vehicle with horn
    - microphone and recorder (electronic data!)
    - large place (acceleration – constant velocity around acquisition place – slow down; horn sound allowed)
    - program to show the electronic data of the sound in time versus wavelength (not time versus amplitude) for example “Sonic Visualiser”
- using given output (page 2)
    - copy of the diagram
    - ruler, pencil, calculator

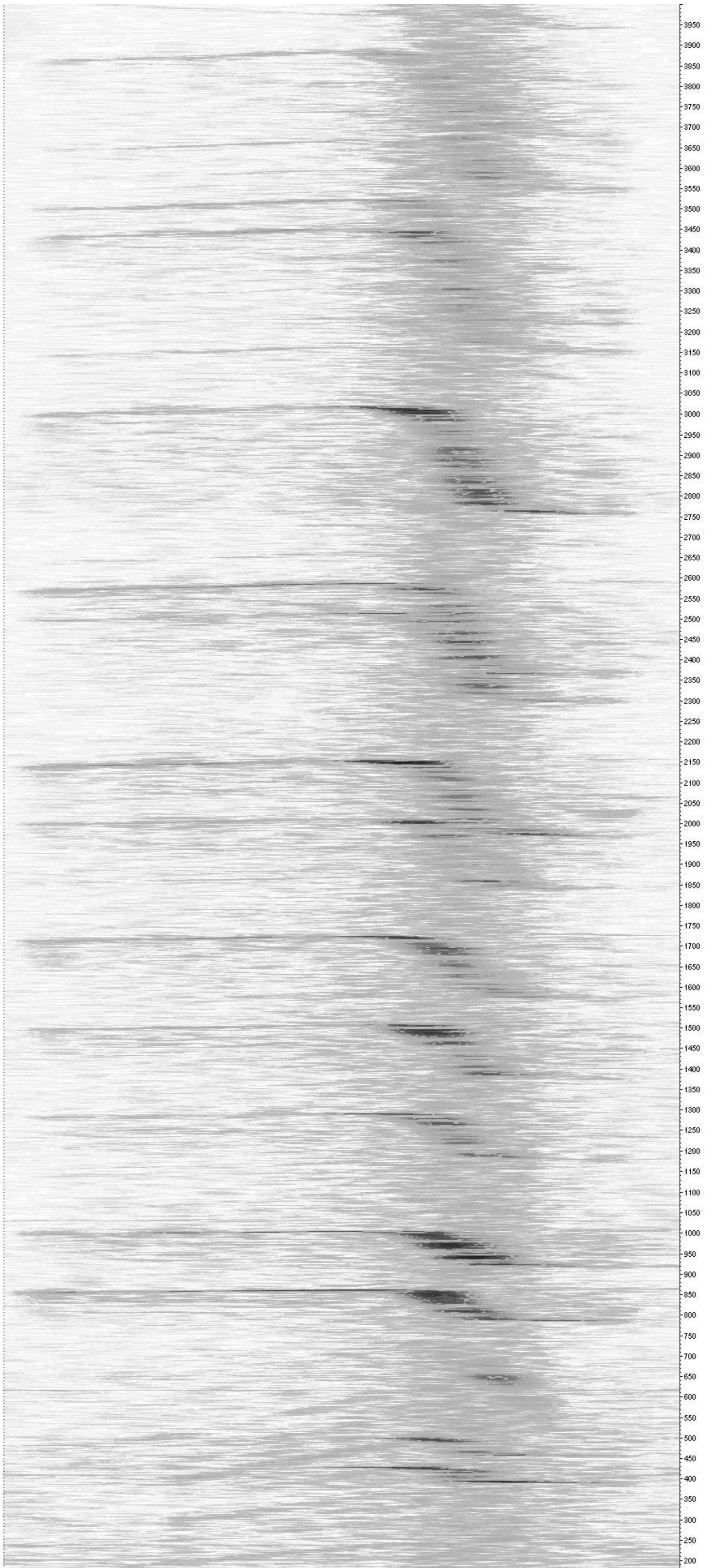
Safety precautions:

Take care on traffic rules and save driving when gathering the basing sound data.

Experimental procedure:

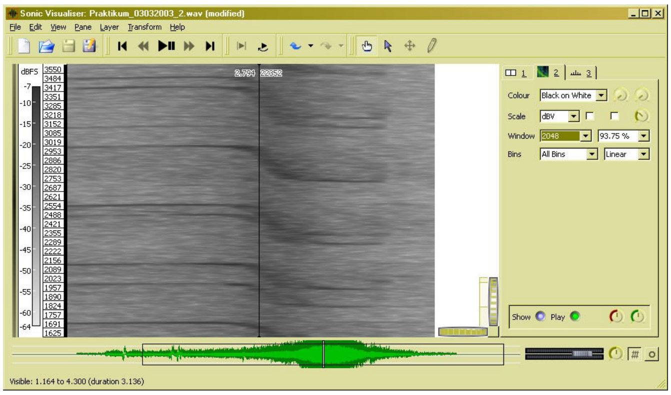
1. Acquisition of the sound data:
   A car or other vehicle has to pass the acquisition station with constant velocity and a constant horn sound. It is beneficial if the horn has many harmonics.
   The recording has to span an interval of a few seconds from before to a few seconds after passing the acquisition station thus overall around half a minute.
   The sound data have to be visualized by a frequency spectrum (not amplitude spectrum). The results will depend on the accuracy of this visualization.

2. Preparation for the interpretation:
   Search for a number of response curves and determine the frequency before and after the passage (when the frequency drops suddenly).



Individual tasks:

- First of all the sound has to be recorded and the data converted to a frequency spectrum.



Sonic Visualiser: Praktikum_03032003_2.wav (modified)

Colour: Black on White

Scale: dBV

Window: 2048, 93.75 %

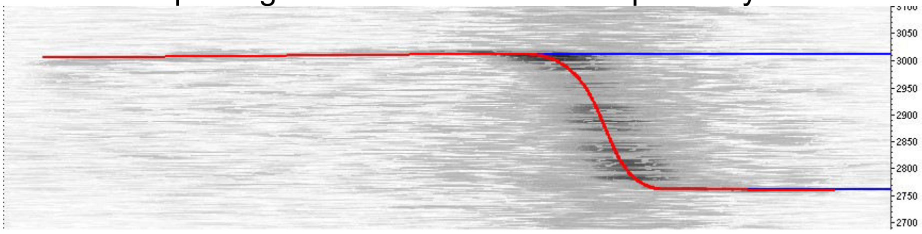
Bins: All Bins, Linear

Visible: 1.164 to 4.300 (duration 3.136)

A sample rate of 22 kHz and a depth of 16 bit like the “Audiorecorder” of Windows is using will definitely be sufficient for the recording.

The resulting wav-files then can be opened with the “Sonic Visualiser” and an appropriate visualization will arise after some tries (→ open the frequency spectrum with the menu item Layer – Add Spectrogram and adjust the parameters as well as the interesting extract)

- Afterwards the response curve (red) has to be identified and the frequencies (blue) before and after the passage have to be determined precisely.



- The formula of the theory have to be adjusted for the necessary calculation:

$$\left.\begin{aligned} f_{before} &= f_{source}\frac{1}{1-\dfrac{v_{source}}{v_{wave}}} \\ f_{after} &= f_{source}\frac{1}{1+\dfrac{v_{source}}{v_{wave}}} \end{aligned}\right\} \quad v_{source} = v_{wave}\cdot\frac{1-w}{1+w} \quad when \quad w = \frac{f_{after}}{f_{before}}$$

- It is recommended to use more than one response curve to get an idea of the feasible accuracy by comparing the different results. That is the reason a horn with a large number of harmonics is beneficial.

Data collection:

measurement	frequency before passage	frequency after passage	velocity
1			
2			
3			
4			

Indicate the sources of errors

- If the velocity is not really constant during the recording an inclination of the response curve will occur and influence the results.
- If the visualization is bad the results will probably get pretty poor.
- Take care the records spans some seconds before and after the passage – otherwise there will be problems to calibrate the data.

Interpreting the results:

The frequency recorded when the vehicle is approaching is higher than the one emitted from the source since the sound waves get compressed due to the motion of the source. When the vehicle has passed the frequency drops since the wavelength is expanded again due to the motion of the source. The drop does not really happen exactly in a moment but over a few seconds – this is founded in the dimensions of the vehicle which is the sound box for the horn.
The calculated velocity depends on the velocity of sound which has dependencies on humidity and pressure itself.
A similar experiment is possible with records of passing cars in a formula 1 race. However, those response curves are not that definite.

Explanation and conclusions:

Using the frequency enhanced and lowered by the Doppler effect when a source of sound is passing allows to determine the velocity: $v_{source} = v_{wave} \cdot \frac{1-w}{1+w} \quad when \quad w = \frac{f_{after}}{f_{before}}$

The accuracy can be diminished to a few percent when more than just one response curve is used.
A similar method is used in the CW[1]-radar which has one field of application in the speed monitoring of the police.

References:

- Sonic Visualiser – Freeware for Windows XP and MacOS X UB (http://www.dontcrack.com/freeware/downloads.php/id/4488/software/Sonic-visualiser/ status: 20.6.2007)

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[1] CW … continuous wave

EXPERIMENTNR. 56 INTERFERENCE OF WAVES: FLIP-BOOK OF STATIONARY WAVES

CHAPTER: Vibration and Waves

PROPOSED BY: HTL Dornbirn, AUSTRIA

Theoretical aspects:

A stationary wave is generated if two waves identical in frequency and amplitude are moving in the opposite direction. Where these waves meet their interference creates a stationary wave.

Different approaches:

In this experiment the students are asked to plot the interference of two waves.

Constructing the Flip-book will help especially those students which are members of the haptic type of learners. Moreover this gives the time to think about the bases of interference and to assimilate this important fundament of the theory of waves. Additionally the students end up with a flip-book they can show around and which may help them later on to remember the topic.

Materials, apparatus:

- copy of the diagrams (page 2-4)
- pencil, cutter, binder

Experimental procedure:

The templates present one wave moving from right to left (continuous line) and the second wave with the same speed in the opposite direction (dotted line).

The students have to plot the interference of the two waves on the left side into the boxes on the right side by summing up the two single amplitudes for a sufficient number of points and finally construct the overall curve (another wave). This has to be done for every single template. Afterwards the boxes have to be cut out and arranged in the right order. Finally they have to be fixed together and then the film can start.

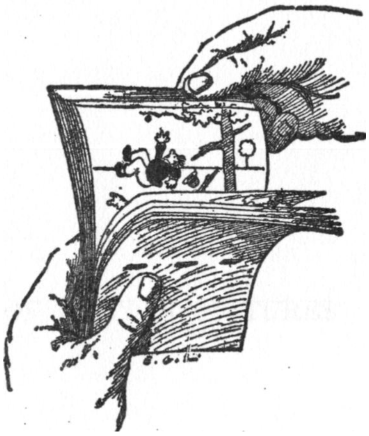
Indicate the sources of errors

- Plotting the interfering curve often does not work in the very first box. – It was usefully to demonstrate it ones on the blackboard or the overhead projector.
- If the single snapshots are directly put on each other it is difficult to run through them without stop – better the single papers are overlapping a little bit.

Explanation and conclusions:

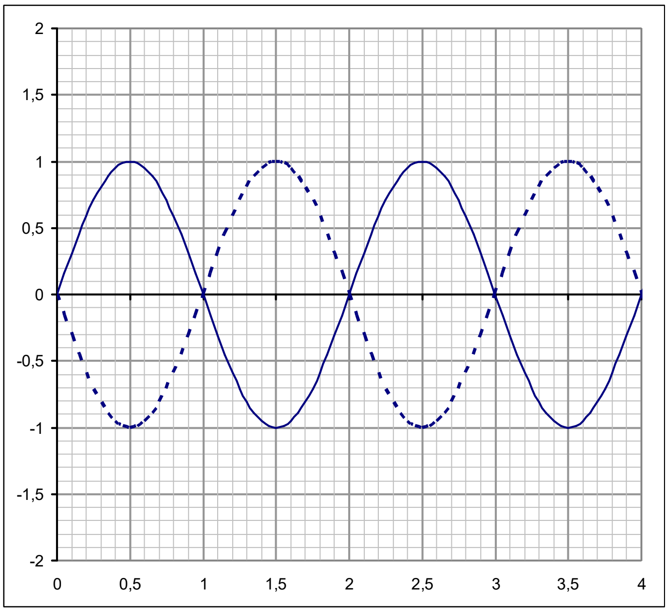
The flip-book shows a little film:

- On the left side one wave is moving to the left and an identical one moving in the opposite direction.
- On the right side a stationary wave is going up and down. (Since the students have constructed this wave by themselves from the waves on the left they will remember on the correlation much better.)



References:

http://upload.wikimedia.org/wikipedia/en/9/99/Kineograph.jpg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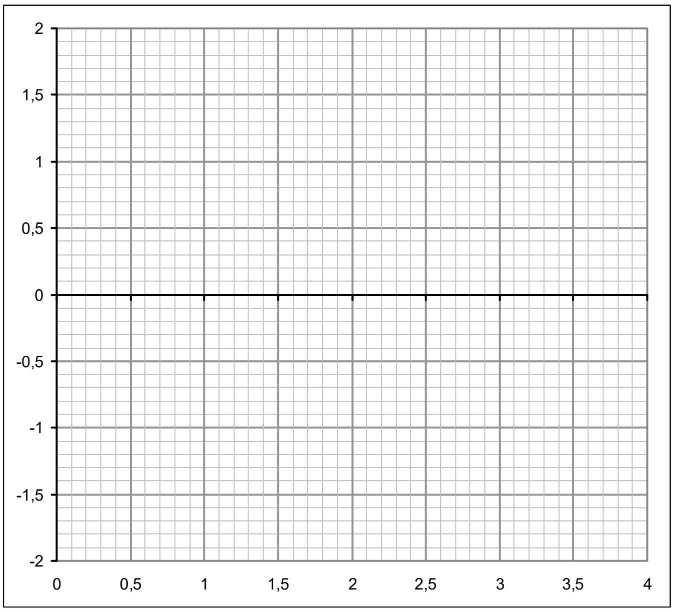
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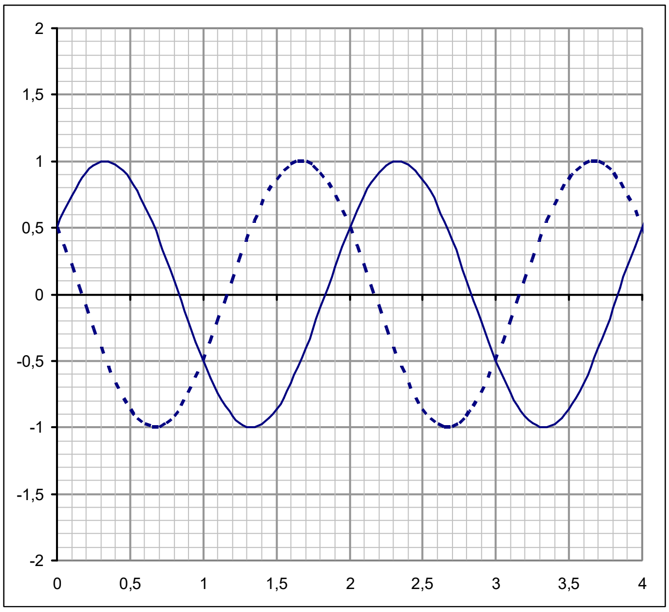
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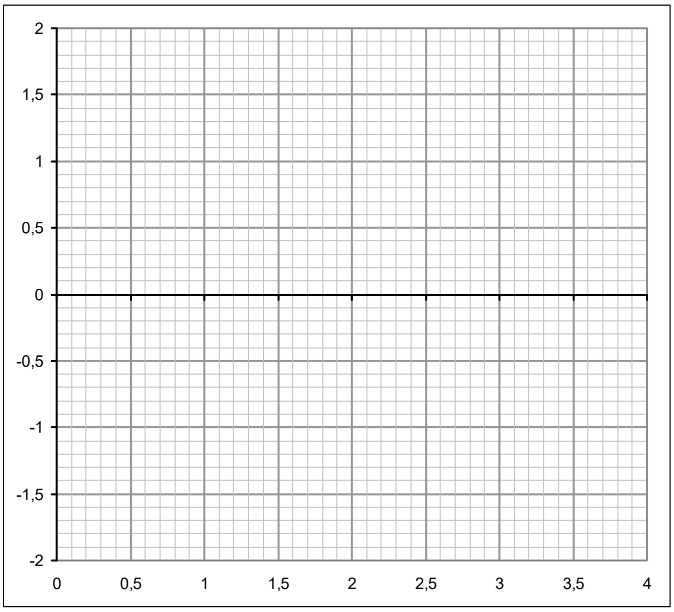
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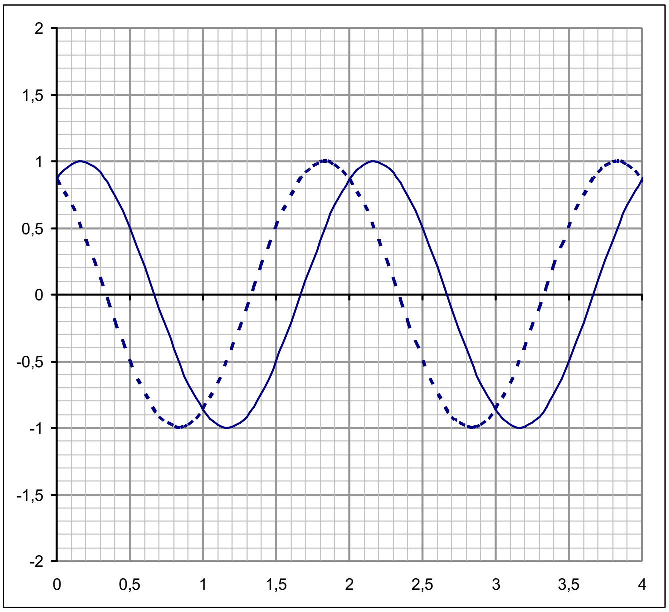
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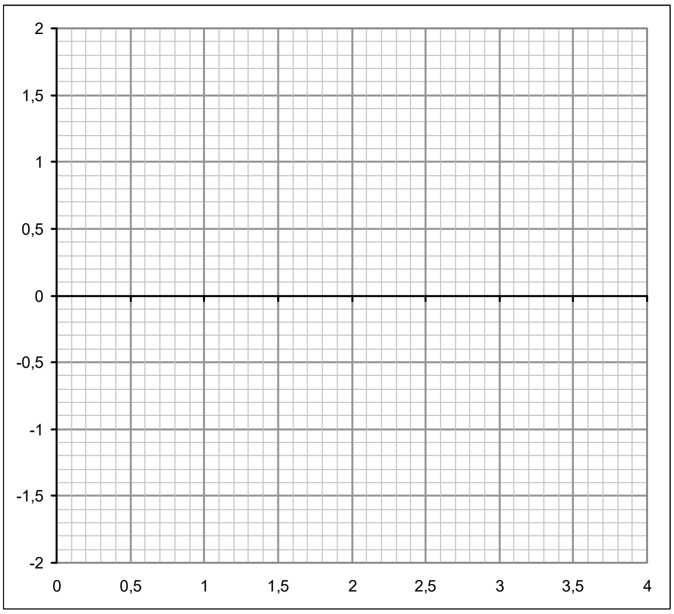
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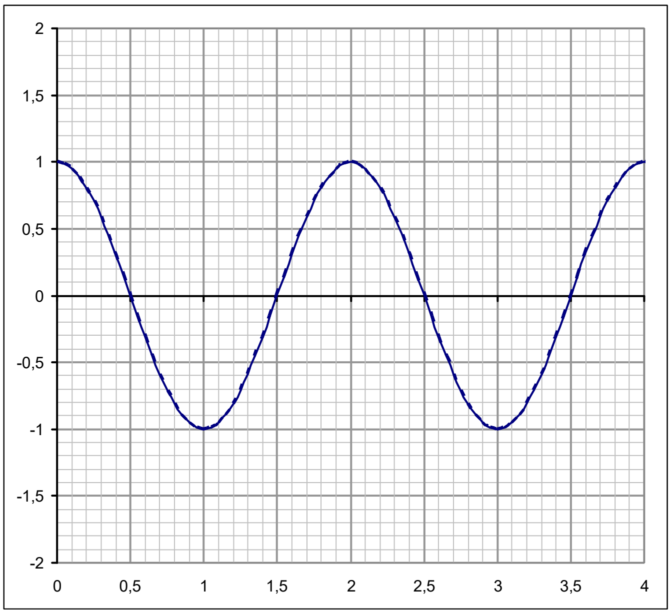
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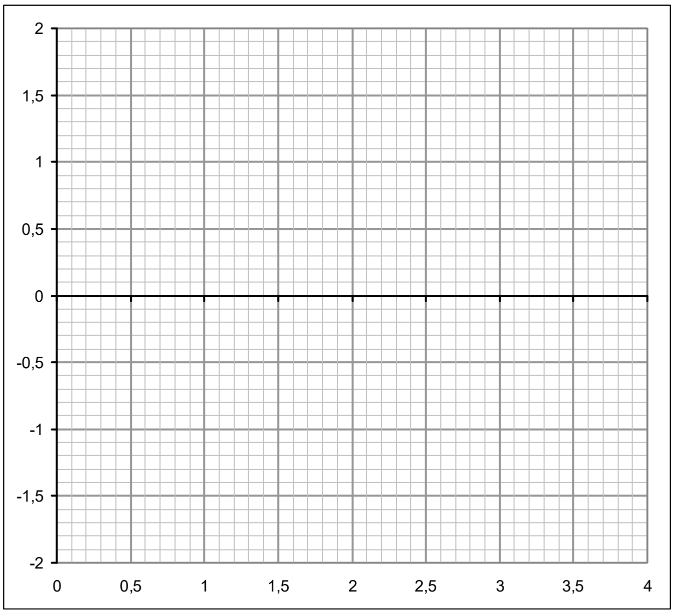
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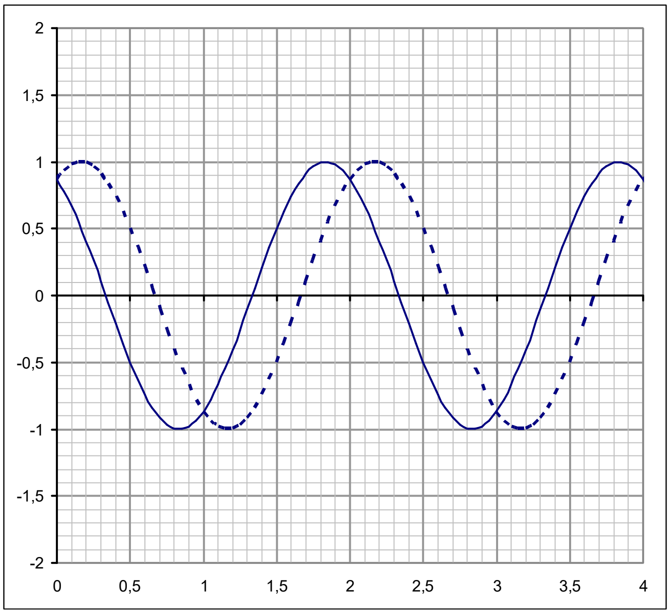
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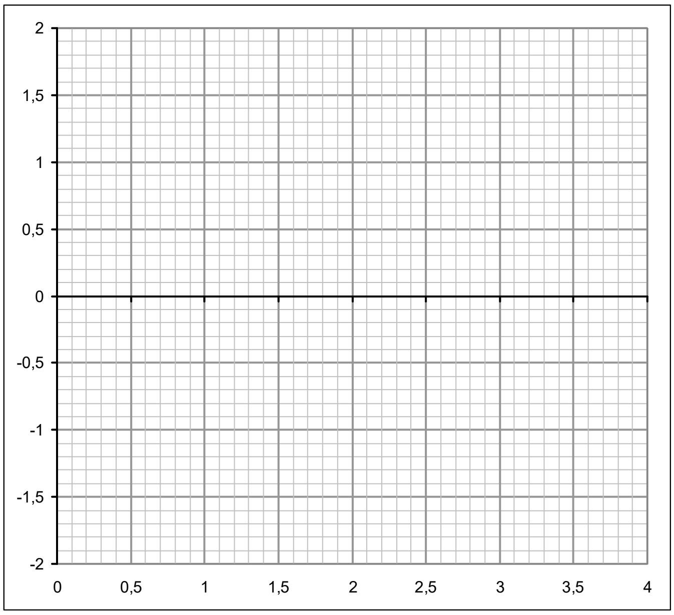
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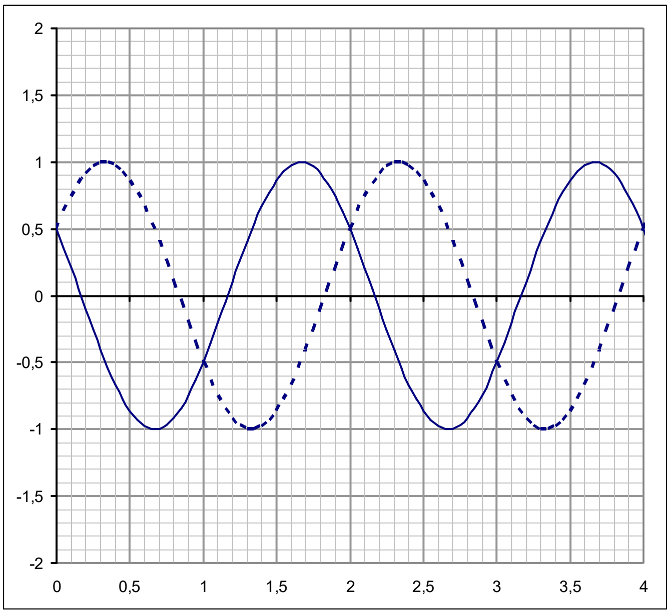
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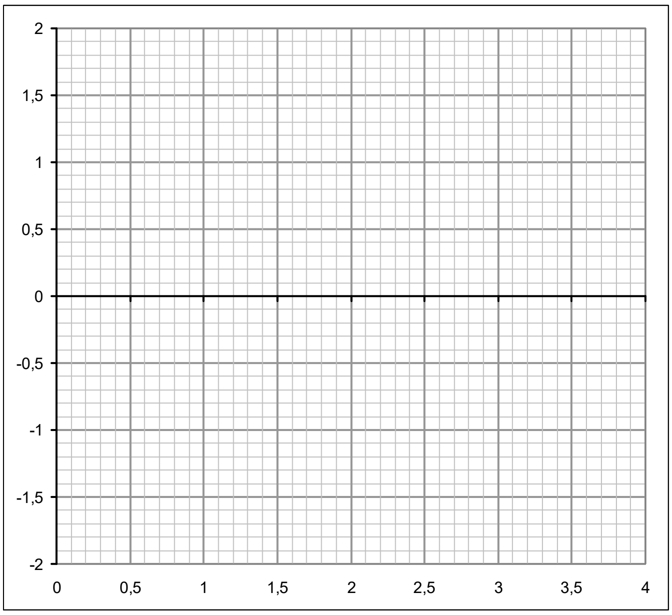
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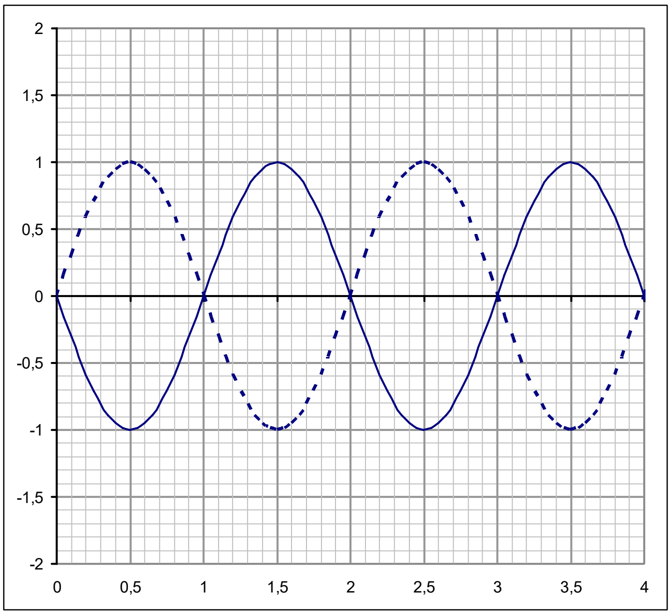
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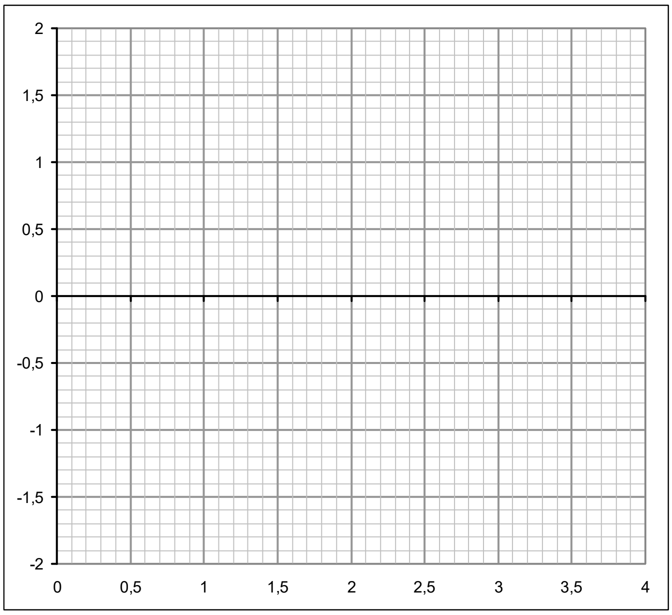
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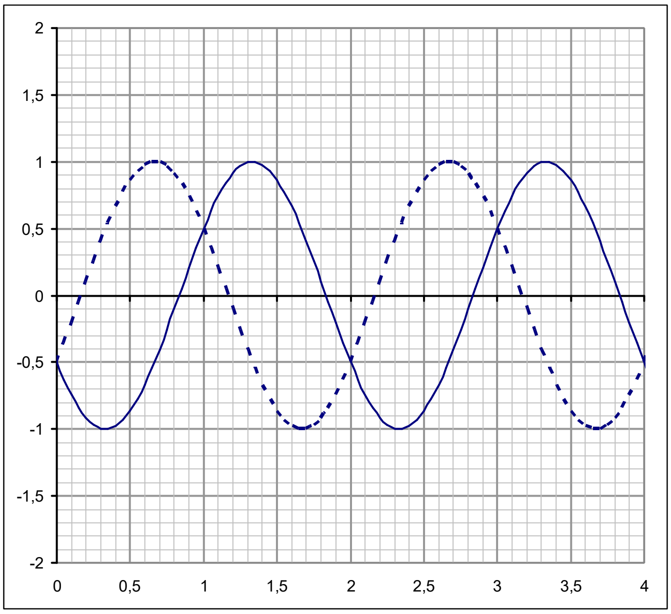
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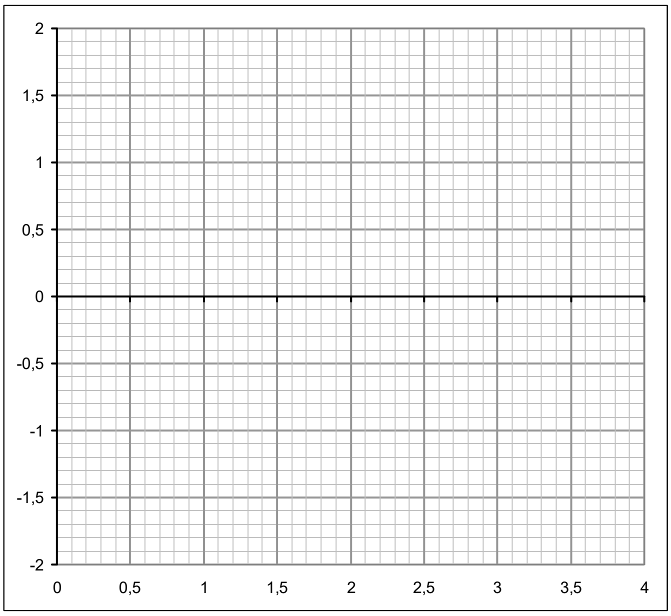
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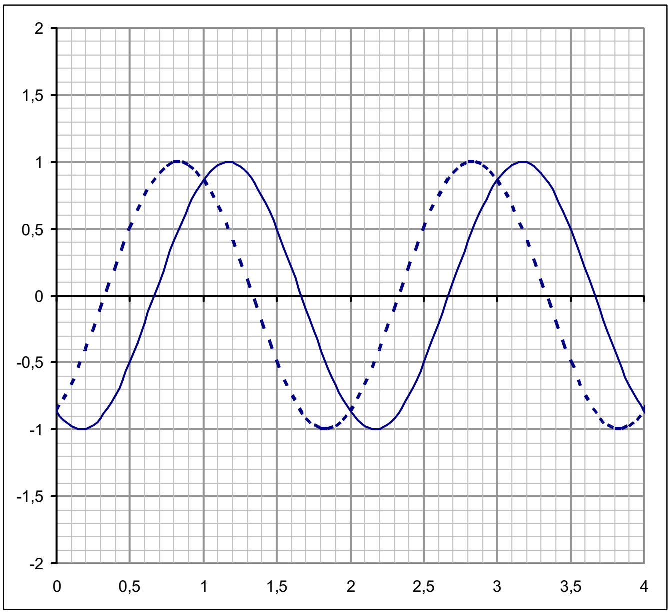
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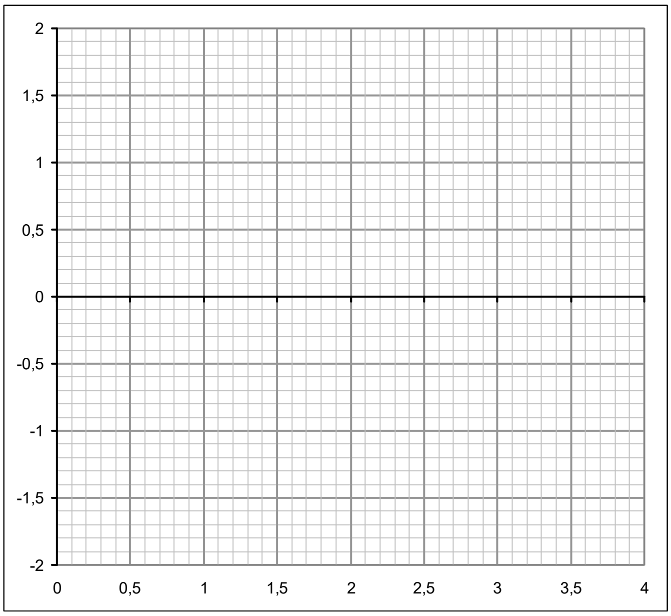
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EXPERIMENT NR. 58

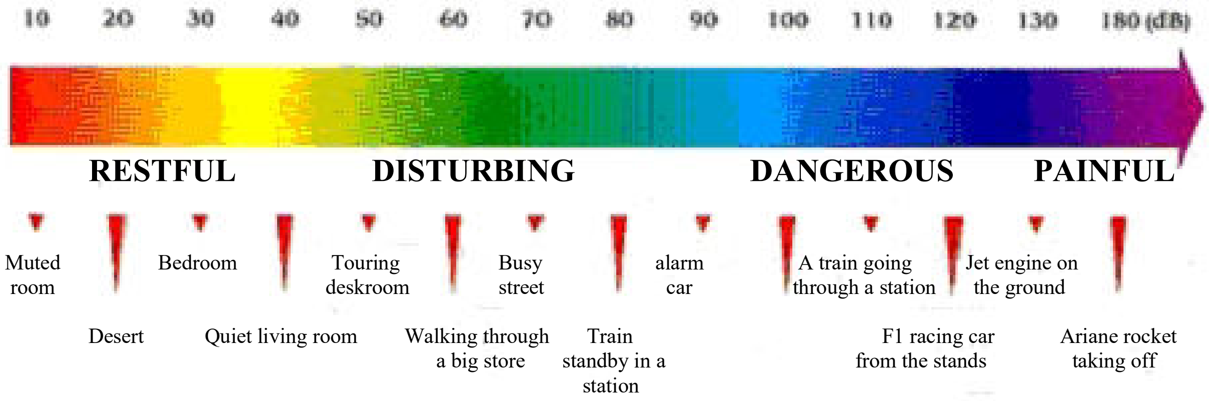
USE OF A SONOMETER

CHAPTER: Waves

PROPOSED BY: Lycée La Closerie, St Quay Portrieux, FRANCE

Theoretical aspects:

A sound transports energy. The level of sound intensity characterizes the power of this sound. It is measured with a sonometer and is expressed into Bel (B) or more frequently in decibel (dB).



To protect oneself from noise one uses phonic insulators which decrease the acoustic level of intensity. The goal of this experiment is to classify some materials according to their insulating capacity.

Materials, apparatus:

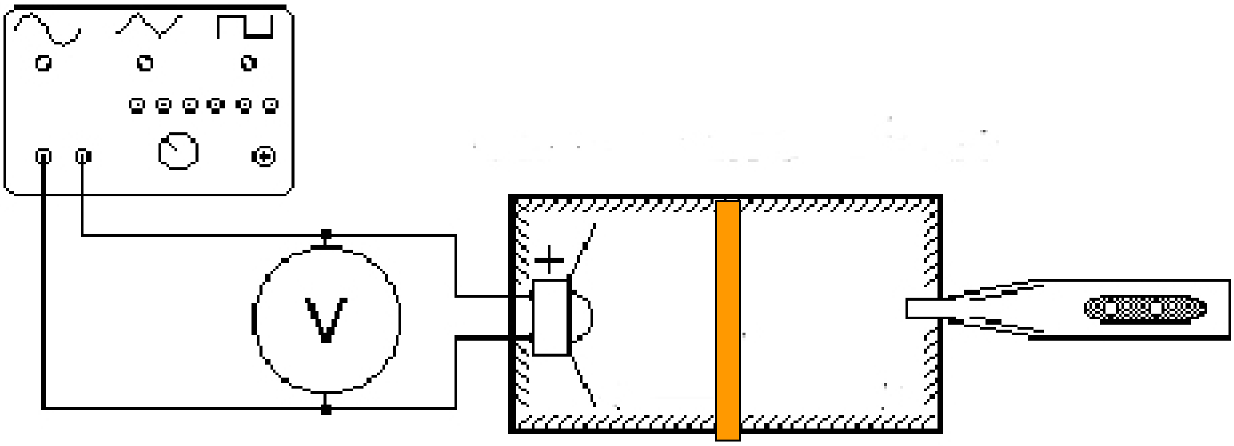
- A LFG
- A switch
- A voltmeter
- A loudspeaker
- A sonometer
- A phonic box
- Plates of the same thickness in polystyrene, plaster and chipboard

Safety precautions:

No particular safety instructions

Experimental procedure / Individual tasks:

Carry out the assembly below regulating the frequency on 400 Hz and the tension on 3 V. Then fill in the table below.



Data collection:

Equipment	Intensity (dB)
Air	
Chipboard	
Polystyrene	
Plaster	

Indicate the sources of errors and determining errors

The aim of this experiment is to compare the capacity of soundproofing of different materials. The possible errors are of little or no influence.

Interpreting the results / Conclusion:

Depending of the students' level, the teacher may have students work on one material only with variations in the frequencies. The aim is not to work about logarithmic scales.

References:

1. Frederic Diaz (ac. Besancon); CAP Sciences physiques industriels et tertiaires, Delagrave 2007.

EXPERIMENT NR. 59 OSCILLATION TIME OF AN OSCILLATING MASS-SPRING COMBINATION

CHAPTER: VIBRATIONS and WAVES

PROPOSED BY: Comenius College, Capelle aan den Ijssel, THE NETHERLANDS

Theoretical aspects:

The aim of this experiment is to find the relation between *T, m* and *C* of an oscillating mass-spring combination.

T: oscillation time (in seconds)
m oscillating mass (in kg)
C: spring constant in (N/m)

The spring-constant *C* is used in the formula $C = F / x$.

C: spring-constant
F: force, deforming the spring
x: extension of the spring (in meters), with $x = \ell - \ell_0$.

$F_z = m.g$, with $g = 9{,}81\ \text{m/s}^2$

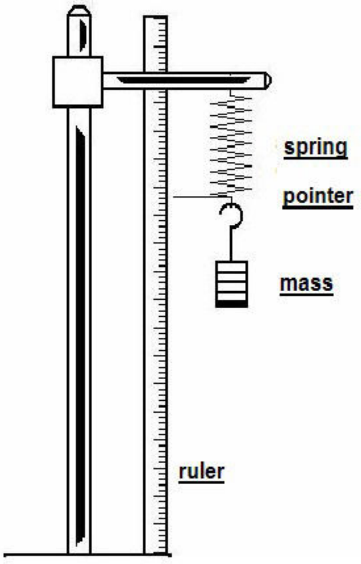


fig 1

Materials, apparatus:

See fig 2.

- Springs
- Mass holder (50 g) with mass pieces (50 g each)
- A ruler
- A stopwatch

fig 2

Experimental procedure:

Build the experiment as drawn in fig. 1. Be sure that the pointer at the lower end of the spring points in the direction of the ruler in order to measure the length of the spring. The mass holder and the mass pieces can be attached to the spring.

In the first part of this experiment we measure the extension of the spring as a function of the mass. Then we calculate the spring constant.

Secondly we measure again on two serial connected springs (fig 2) and we calculate the spring-constant of the combination of two springs.

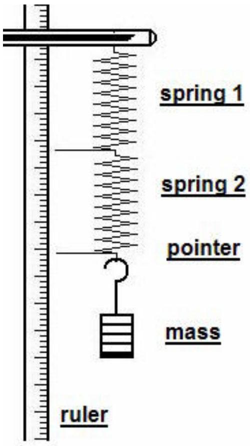


fig 3

Finally we remove the ruler and make the mass-spring combination oscillate. We measure the oscillation time of different mass-spring combinations. Variation of the mass and the number of springs lead to the relation between *T, C* and *m*.

Individual tasks:

A. The spring-constant of one spring.

See fig. 1.
Measure the length of the spring ℓ_0.
Put the empty mass-holder under the spring. Measure the new length ℓ of the spring. Calculate the force *F* on the spring and the extension *x* of the spring. Repeat this with other mass-pieces in the holder and complete table 1.

B. The spring-constant of two serial connected springs.

See fig. 2.
Vary the masses and measure the length of the spring combination. Fill the measurements in table 2.

C. The relation of *T* and *C*.

Remove the ruler. Hang 250 g under one spring. Pull the mass downwards a little and let go. The mass spring combination will oscillate now. Measure the oscillation time of several periods. Let's take 20 periods with an oscillation time Δt. The oscillation time *T* is than Δt / 20. Repeat this for 2, 3 and 4 serial connected springs and complete table 3.

D. The relation of *T* and *m*.

Take one spring. Measure *T* for different masses. Complete table 4.

Data collection:

Table 1

ℓ_0 = ________ m				
m (kg)	*F* (N)	ℓ (m)	*x* (m)	*C* (N / m)
0,050				
0,100				
0,150				
0,200				
0,250				

Table 2

ℓ_0 = ________ m				
m (kg)	*F* (N)	ℓ (m)	*x* (m)	*C* (N / m)
0,050				
0,100				
0,150				
0,200				
0,250				

Table 3

m = 0,250 kg			
Number of springs	C (N /m)	$1/\sqrt{C}$ ($1/\sqrt{\text{m}}$)	T (s)
1			
2			
3			
4			

Table 4

1 Spring	C = N/m	
m (kg)	$\sqrt{m}$ ($\sqrt{\text{kg}}$)	T (s)
0,050		
0,100		
0,150		
0,200		
0,250		

Interpreting the results

1. Draw the graph of F and x with the results of table 1 and 2.
   Derive the spring-constant of one spring and of two connected springs from the graphs.
2. Make a graph of T and $1/\sqrt{C}$ with the results of table 3. Derive the relation between T and $1/\sqrt{C}$ from the graph.
3. Make a graph of T and $\sqrt{m}$ with the results of table 4. Derive the relation between T and $\sqrt{m}$ from the graph.
4. Derive a formula that describes the relation of T, m and C.

EXPERIMENT NR. 60 VIDEO ANALYSIS ON MOVEMENTS

CHAPTER: VIBRATIONS and WAVES

PROPOSED BY: Comenius College Capelle aan den IJssel, THE NETHERLANDS

Theoretical aspects:

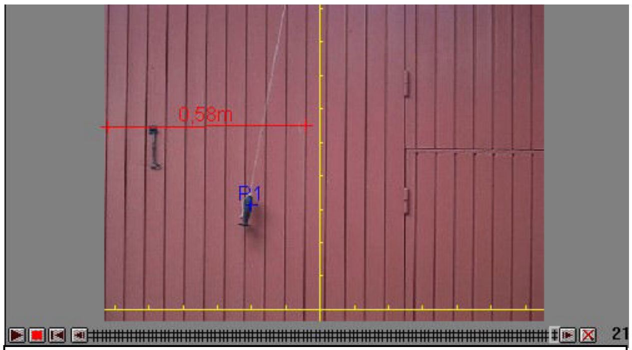


Fig 1 Video window.

In this experiment we make a short video of an oscillating object.
With the help of the computerprogram Coach (by C.M.A. Amsterdam, the Netherlands) we determine the properties of the movement:

- Is the oscillation harmonic?
- What are the values of the oscillation time *T* and the amplitude *A*?
- What is the mathematical function that fits best with the movement?

Theory:
The *x*,*t* diagram of a harmonic oscillation is a sinusoïd.
Generally, the oscillation time is given by: $T=2\pi\sqrt{(m / C)}$ with $C=F / x$.
For a pendulum, the oscillation time is given by: $T=2\pi\sqrt{(l / g)}$.

Different approaches:

Place an object with a well known length near the oscillation. This makes it possible to reconstruct the scale factor of your video images.
Film your object in such a way that there is only little optical deformation (or no deformation at all).
Be sure that the number of frames/s fits with the frequency of your moving object.

Materials, apparatus:

- Choose your own oscillating object (already existing or construct something).
- PC with Coach 5 or Coachthuis (downloadable).
- Camera (a schoolcamera, a webcam, camera in your cell-phone,..).
- If needed: conversion program: (The Coach program needs a video in avi or mpeg4).

Experimental procedure:

1. Learn how to work with Coach5 (Videometing) with an existing video.
2. Choose an oscillating object and make a film of it. The length should be at least 5 or 6 periods of the oscillation.
3. If needed: convert the video to avi or mpeg4.
4. Import the video in the program Coach (videometen).
5. Make a *x*,*t* curve of the movement.
6. Analyse the movement: is it harmonic, is there friction, what is the frequency, ..
7. One of the program options is function-fit. Try this with your video.

8. Another program option is to derive the slope of the *x*,*t* curve. Try to find out the maximal speed with this option.

Screenshots of the Coach-program:

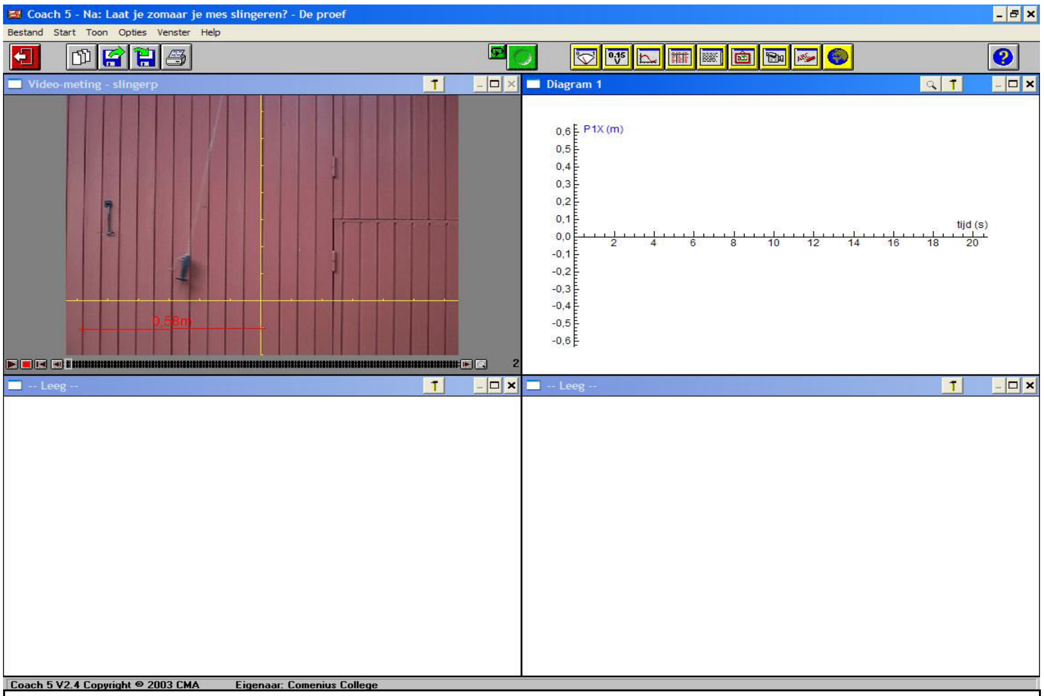
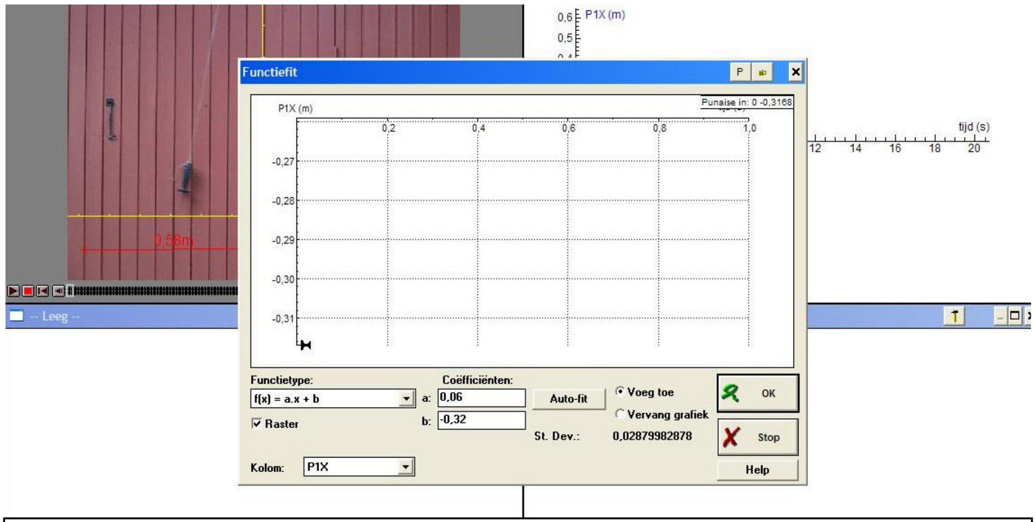


Fig 2 The screen is divided into 4 sections: upperleft a window for the video, upperright the diagram. The other parts of the screen can be used for text, images, tables, diagrams etc.



Functietype: f(x) = a.x + b

Coëfficiënten: a: 0,06 b: -0,32

☑ Raster

● Voeg toe ○ Vervang grafiek

St. Dev.: 0,02879982878

Kolom: P1X

Fig 3 For several options pop-up screens appear. In this example the “function-fit”option pop-up screen.

Explanation and conclusions:

Describe the characteristics of the captured video. (F.e. Is the oscillation harmonic? If so, what is the mathematical formula that describes the movement? What is the frequency? Is there any friction and loss of mechanical energy?)

References:

For a free download of the Coach demo program:
http://www.cma.science.uva.nl/english/Software/Coach5/coach5demo.html

EXPERIMENT NR. 62 DETERMINING THE REFRACTIVE INDEX OF A MATERIAL

CHAPTER: OPTICS

PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU"; Şimleu Silvaniei, ROMANIA

Theoretical aspects:

Using an optic prism at a minimum deviation we can determine the refractive index of the material from which the prism is made.

$$n=\frac{\sin(A+\delta_{\min})/2}{\sin A/2}$$

Materials, apparatus:

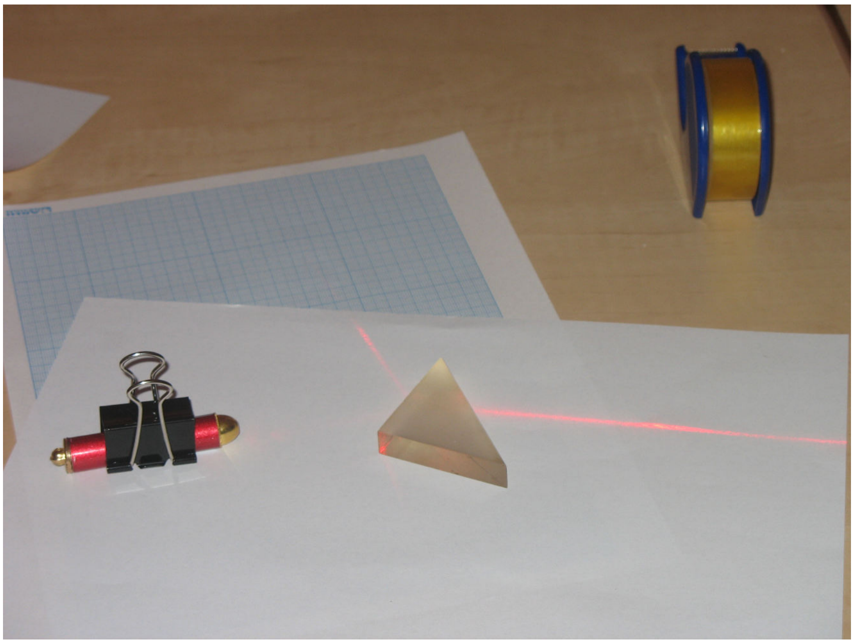
Optic prism with the section an isosceles triangle with a 90 degrees angle, pointer laser, protractor, measuring rule, a white sheet of paper, scotch tape, millimeter paper, clamps to fix the laser pointer.

Safety precautions:

Do not look straight into the light of the laser and do not point the laser to someone else!

Experimental procedure:

We rotate the prism and we determine the angle of deviation in different positions in order to determine the angle of minimum deviation.
From the graphic of δ=f(i) we can determine the minimum deviation and using the formula obtained at the first point(1) we can calculate the refractive index of the material from which the prism is made of.



Individual tasks:

We measure the angle of minimum deviation of the light of the laser through the prism after 2 consecutive refractions on the corresponding faces (hypotenuse and other face). We repeat the experiment at least 10 times at different incident angles.
We represent graphically the dependency of the angle of deviation with the incident angle.
Using the graphic we determine the angle of minimum deviation.
We determine the refractive index of the material using the first formula (1).

Data collection:

Nr det	*I* *(grade)*	Δ *(grade)*
1	0	total reflection
2	10	32
3	20	27
4	30	25
5	35	25
6	40	25
7	50	28
8	60	31
9	70	35
10	80	41

Indicate the sources of errors

Errors caused by the experimenter

- Errors caused by the imprecision in centering the visible laser fascicule on the surface of the paper.
- errors in reading the angles

Errors due to the imprecision of the apparatus:

- the low precision of the protractor.

Errors due to the imprecision of the method

- we have the width of the emergent fascicule.

Interpreting the results

At normal incidence ($i=0^0$) appears the phenomena of total reflection on the second side of the prism, this proves that the refractive index is at least or even greater than 1,41 (the critical angle is smaller than 45^0)

Explanation and conclusions:

This method is remarkably precise though its simplicity. The reason is that the errors in positioning the prism affect very little the determined value, considering the fact that the angle of minimum deviation is all most constant for angles between 30^0...40^0.

References:

1. Panaitoiu, L., Chelu, I., *Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972
2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995
3. http://www.olimpiade.ro
4. http://www.didactic.ro

EXPERIMENT NR. 63 LENSES ON THE OPTICAL BENCH, FOCAL DISTANCES

CHAPTER: OPTICS

PROPOSED BY: COLEGIUL TEHNIC „I. MANIU”, Şimleu Silvaniei, ROMANIA

Theoretical aspects:

The work will show the obtaining of images with the help of lenses and the determination of the focal distance with the help of lens formula.

$\frac{1}{f}=\frac{1}{x_2}-\frac{1}{x_1}$, where x_1 = the difference of the objective against the lens

X_2 = the distance of the image against the lens

Materials, apparatus:

- light source
- convergent and divergent lenses,
- screen,
- optical bench

Safety precautions:

The students are made aware about the fact that they are working with electronic devices and they must respect the rules of protection related to the use of 220V current.

Experimental procedure:

The teacher asks the students to achieve the necessary experimental device for the determination of the focal distance of lenses, to do the necessary measurements and the experimental data must be written in the chart. Using the measured values and the lens formula we obtain the value of the focal distance.

Data collection:

Number of determination	**x_1 (cm)**	**x_2 (cm)**	$f = \frac{x_1 x_2}{x_1 - x_2}$	f (average)
1.				
2.				
3.				
…				

Indicate the sources of errors

- errors in measuring the distances
- lens imperfections

Interpreting the results

In the experiment we use convergent lenses. In order to determine the focal distance of a lens we use a convergent system associating different convergent lenses which permit to obtain a real image on a white screen.

$$\frac{1}{F} = \frac{1}{f_c} + \frac{1}{f_d}$$

Where f_c is the focal distance of a convergent lens

f_d is the focal distance of a divergent lens

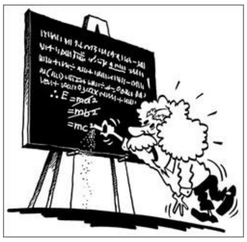
Explanation and conclusions:

The focal distance of a lens is important in creating les associations or constructing different optical instruments. The method is accessible for students and we may obtain quite accurate values.

References:

1. Manual cls. a IX-a, C. Mantea, editura All 2002

EXPERIMENT NR. 64 TOTAL INTERNAL REFLECTION AND THE LAW OF REFRACTION



CHAPTER: Optics

PROPOSED BY: **General Gymnasium Vassiliadis Private School; Thessaloniki, GREECE.**

Theoretical aspects:

The purpose of the experiment (refraction) is to verify the Snell's law ($n_1 \sin\theta_1 = n_2 \sin\theta_2$) during the refraction of the light when it runs through two different transparent materials. Where n_1 is the refractive index of the air and n_2 is the refractive index of the glass or other transparent material (fig 1). The exact same phenomenon is noticed on the back course direction of the light, from the glass to the air.

However, when the light runs through the glass, the refractive index being n_2 ,and through the air, the refractive index being n_1 a new phenomenon may occur (second experiment) which is called total internal reflection (fig 2), and is the same with that of the reflection of light on a mirror (fig 3). The total internal reflection phenomenon can be noticed on very hot days when the temperature is over 35^0 C, on the asphalted road cement, as well as on the desert.

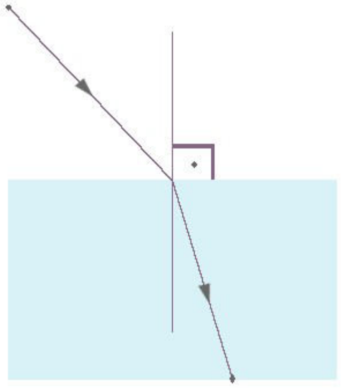


Fig.1

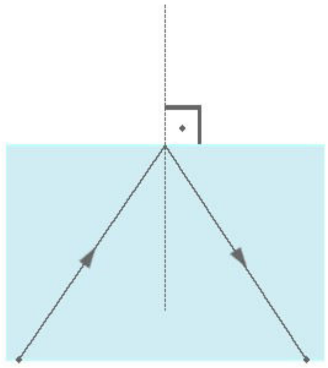


Fig.2

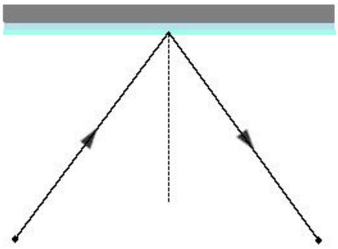


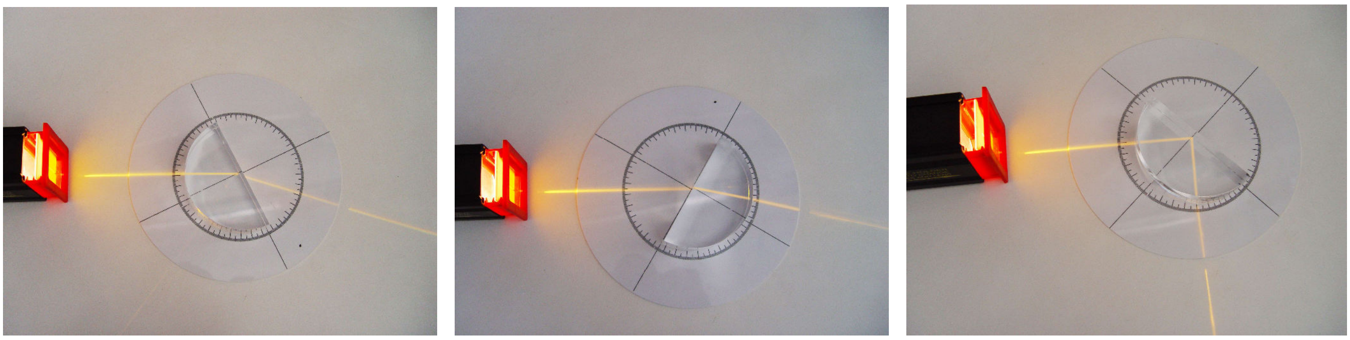
Fig.3

Different approaches:

The Snell's law can be verified by the experiment of the apparent elevation of objects that are in water.

Materials, apparatus:

- angle measuring disc
- transparent semi-cylindrical solid made of glass
- a narrow light beam of a red heat lamp



Experimental procedure:

Refraction: First, we put a transparent semi-cylindrical solid on an angle measuring disc, having its plane surface on top of one of the two vertical axis of the disc. Then, we direct the light beam to the center of the angle measuring rule, where it meets the plane surface of the transparent material.

When we change the direction of the light beam, we record the various values of the angle of the light, using the vertical axis on the plane surface, before and after its passing through the transparent material. (Note: if we reverse the direction of the light we record the same angle values).

Total internal reflection:

On the course of light, from the transparent material to the air, we note that the light beam does not come from the transparent plane and return to the initial material, when the angle becomes bigger than a typical angle value which is called critical angle θ_{cr}.

By recording the angles which are formed between the light beam and the vertical axis, we note that they are equal, so we have total internal reflection.

Data collection:

Refraction			
Material 1…………		Material 2…………	
Angle 1	Sinθ_1	Angle 2	Sinθ_2

Total internal reflection	
Material 1…………	Material 2…………
Angle 1	Angle 2

Indicate the sources of errors and determining errors

Errors on the measurements are:

- False reading of the indications on the angle measuring disc.
- Due to light dispersion, we do not have an exact angle value, but a short range of values.
- Minor angle deviations could be noted as the temperature of the air throughout the realization of the experiment could vary.

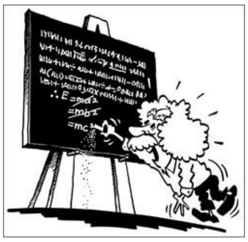
Interpreting the results

We ask the students (if possible) to write down their observations and draw some conclusions after observing the events occurred during the experiment. That way, we stimulate them to integrate information from different areas.

Explanation and conclusions:

From the different values of the angles that we recorded throughout the realization of the first experiment we get that $\sin\theta_1/\sin\theta_2$=constant, which consorts with the Snell's law.

EXPERIMENT NR. 66 LIGHT INTERFERENCE.YOUNG DEVICE -DETERMINING THE WAVELENGTH



CHAPTER: OPTICS

PROPOSED BY: Colegiul National "Simion Barnutiu"; Şimleu Silvaniei, ROMANIA

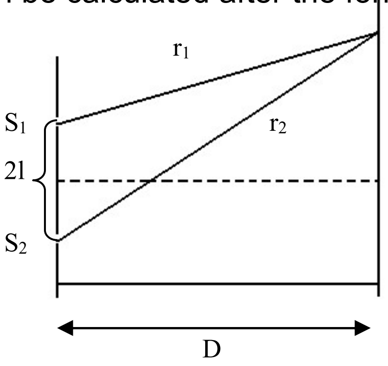
Different approaches:

Light interference is the phenomena of composing two or more coherent light waves in the same place.

Two waves are coherent if the phase difference between them is constant. In order to obtain coherent light waves we separate 2 waves form the same monochromatic source.

In the area where the two waves overlap a figure of interference appears. It consists of minimums and maximums of light intensity. The distance between two consecutive minimums or maximums represents the interfrange, which can be calculated after the formula:

$$\boxed{i = \frac{\lambda D}{2l}}$$



Materials, apparatus:

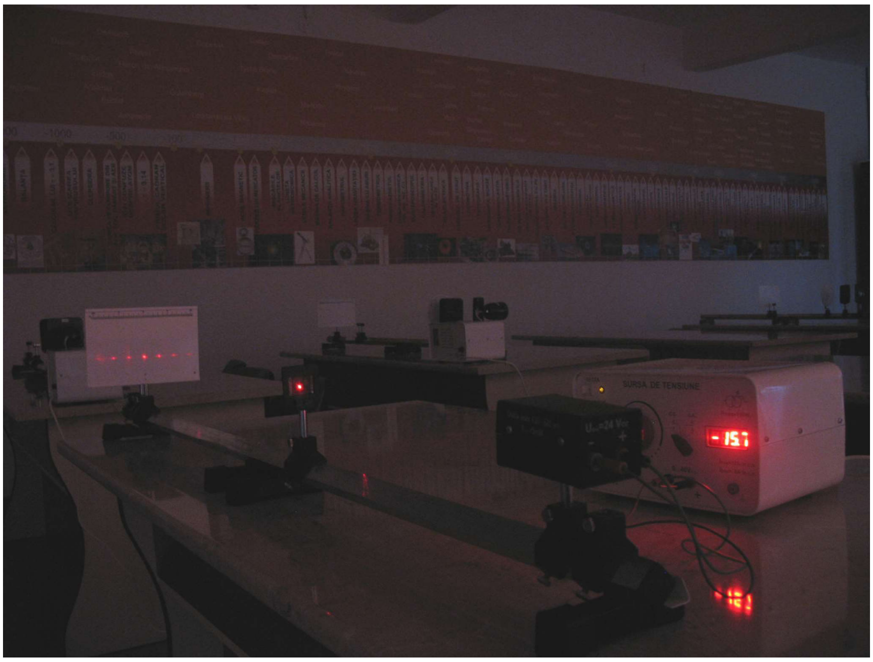
DC Dual current source, monochromatic light source (L.A.S.E.R), slot device, screen, measuring ruler.

Safety precautions:

Do not look straight into the laser’s light.

Experimental procedure:

In front of the light source we mount the slots device to obtain 2 coherent light waves. We observe the interference on the screen. We measure the interfrange.



Individual tasks:

Connect the laser to the current source. Mount the slots device in front of the light source. Mount the screen t a greater distance from the light source. Turn on the current source. Move the screen closer or farther until you obtain the clearest figure of interference. Using the measuring rule measure the interfrange, the distance between the screen and the slots device (D). Note down from the slots device the distance between the slots (2l). Repeat the experiment several times.

Data collection:

No.	2l[mm]	i [mm]	D[m]	λ[m]	$\bar{\lambda}$ [m]
1					
2					
3					
4					

Indicate the sources of errors

Errors provoked by the experimenter

- observing the best interference figure

Errors due to the imprecision of the apparatus:

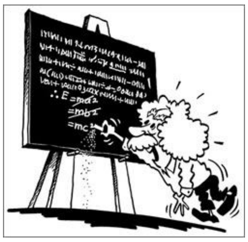
- the low precision of the measuring ruler

References:

1. Panaitoiu, L.,Chelu, I.,*Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972

2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995

EXPERIMENT NR. 67 DETERMINATION OF THE WAVELENGTH OF A LASER



CHAPTER: OPTICS

PROPOSED BY: Comenius College
Capelle a/d IJssel, THE NETHERLANDS

Theoretical aspects:


fig 1

If sunlight falls on a CD or DVD we see a nice coloured pattern. See fig 1. This is an example of the diffraction of light. White sunlight consists of all rainbow colours. On the CD all colours get a different diffraction and reflect in different directions. Besides that, every colour is split in more than one beam and can be seen more than once.

In this experiment we investigate monochromatic light (light of one wavelength) that falls on an optical grating. A grating is a slide with a large number of regularly ordered slits. On the screen behind the grating we will see a number of light spots (in the colour of the laser light).
The laser light is split up by the grating in a number of thin beams. These beams leave the grating, forming angles α_n with the central beam. These are indicated as 1st order, 2nd order, … nth order-beams. See fig 2 and fig 3.

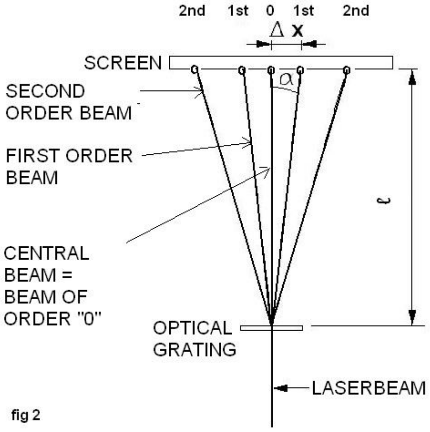


fig 2

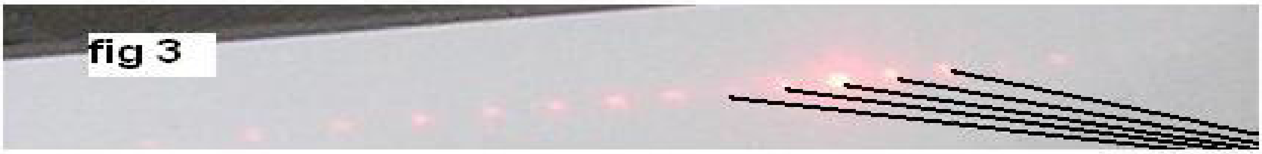


fig 3

The relation of the angle α_n, the wavelength λ of the laser light and the order number n is given by the equation:

$$d \cdot \sin \alpha_n = n \cdot \lambda$$

in which d is the distance between the slits on the grating.

If the value of the grating distance d is known, the wavelength λ of the laser can be calculated with the formula.
Inversely, if the wavelength λ of the laser is known, the grating distance d of an optical grating (or a piece of textile or a CD) can be derived with the same formula.

Materials, apparatus:

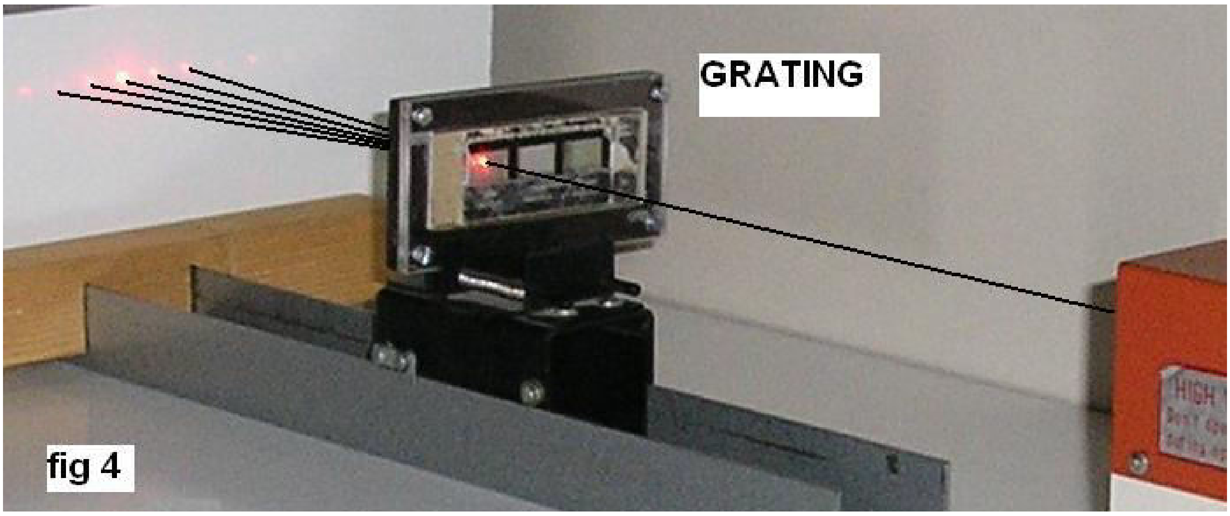


fig 4

See fig 4.
A helium neon laser.
Optical gratings.
A screen.
A ruler.

Safety precautions:

Make sure that no direct laser light enters your eyes. Direct laser light may harm your visual capability.

Experimental procedure:

Choose a grating, switch the laser on, produce a clear pattern on the screen, measure Δx and ℓ for the 1st and the 2nd order beams. See fig 4. Fill in and complete the table. Repeat this for all the given gratings.

Tasks:

1. On the slide are 3 gratings of 2400 lines / inch, 7500 lines / inch and 15000 lines / inch. Calculate d for every grating.
2. Measure the values of Δx and ℓ. See fig 2. Then calculate $\sin \alpha$. Fill in the table.

Data collection:

$\ell =$ m							
Number of lines (lines / inch)	d (m)	1st order			2nd order		
		Δx_1 (m)	$\sin \alpha$	λ (nm)	Δx_2 (m)	$\sin \alpha$	λ (nm)
2.400							
7.500							
15.000							

Interpreting the results:

With the formula: $d \cdot \sin \alpha_n = n \cdot \lambda$ we can find the value of λ.

1. Calculate λ for every measurement. Fill in the table.
2. Explain the differences in the calculated values of λ.

Indicate the sources of error and determine the errors

The wavelength λ is a property of the helium-neon laser and should be equal to 632,8 nm.

1. Compare your calculated λ's to the real value.
2. Calculate the relative errors.
3. Mention the sources of error.

References:

1. http://en.wikipedia.org/wiki/Diffraction
2. Natuurkunde Overal VWO NG/NT2, ISBN 9789011044203

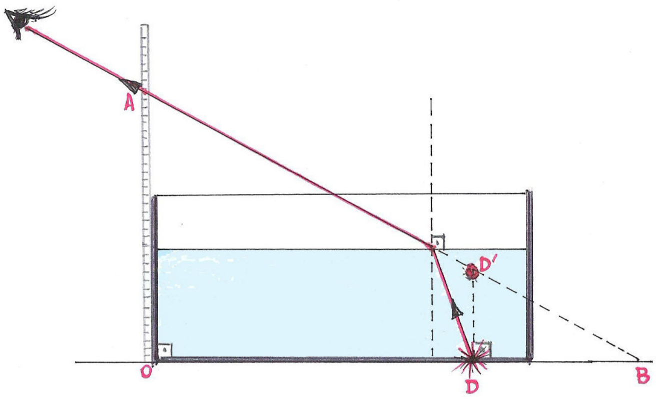
EXPERIMENT NR. 71 ELEVATION MEASUREMENT OF AN OBJECT IN WATER

CHAPTER: Optics

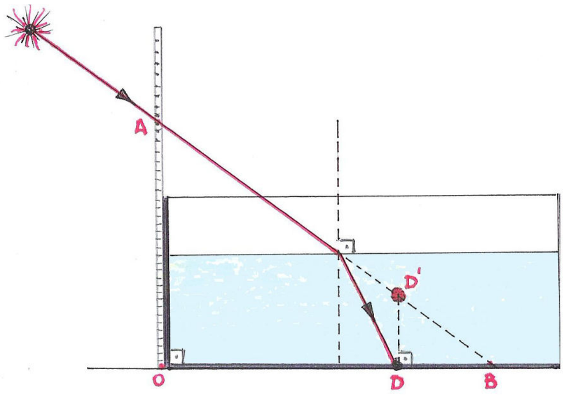
PROPOSED: General Gymnasium Vassiliadis Private School; Thessaloniki, GREECE.

Theoretical aspects:

The purpose of the experiment is to measure the apparent elevation which can be identified on various objects that are in water by an observer that stands out of water (figure 1). This phenomenon is noted due to the refraction of light when it runs between two different transparent materials.



(Fig.1)



(Fig.2)

Materials, apparatus:

- Support basis
- Laser beam
- Transparent glass vessel
- 3 measuring rulers
- Water

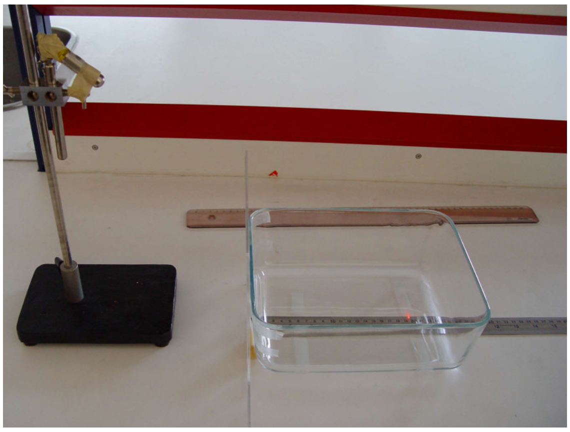
Experimental procedure:

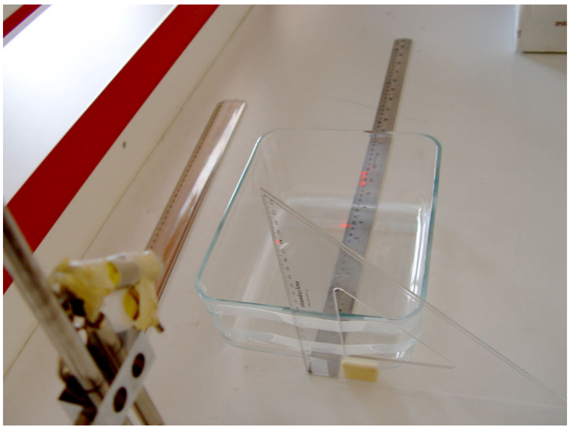
We fix the laser driver on the support basis so that we get bright spots on the vertical ruler (on the side wall of the vessel) and the horizontal ruler (at the bottom of the vessel), as appears on the pictures. We note the indications that we had recorded on the rulers.

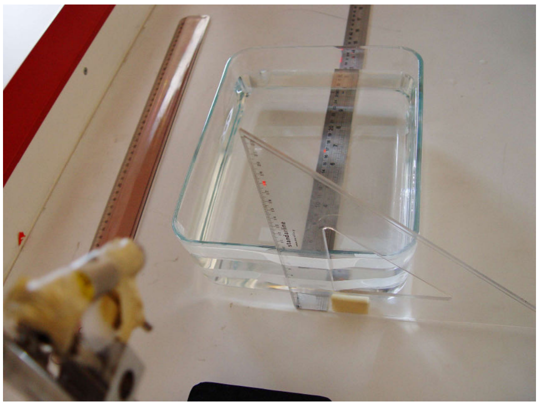
We fill the vessel with water and we record the water level on the third (vertical) ruler. We notice that the bright spot on the horizontal ruler has been moved. We take down the new indication.

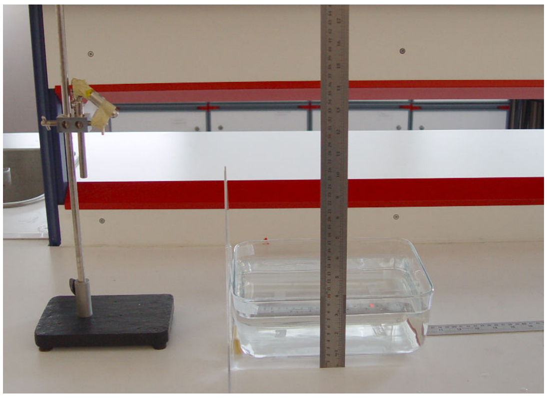
The calculation of the apparent elevation can be given by the equation: $DD' = OA \cdot DB / OB$. The experiment may be repeated for different water levels and have a new calculation of the apparent elevation.

Images of the apparatus or how it is conducted









Data collection:

Measurement	Indication OA	Indication OB	Indication OD	Calculations (relation)

Indicate the sources of errors and determining errors

- False reading of the indications on the rulers.
- The laser light source does not produce a point source indication, so there is a blurred indication area on the rulers
- Mathematical error on the calculation of the apparent elevation.
- Minor refractions of light on the course of its pass between the transparent ruler and the glass vessel.

Interpreting the results

Note: the water level has an effect on the value of the apparent elevation of an object, as can be seen on the figure; its standard of calculation stays the same, however.

Explanation and conclusions:

While observing the objects that are in water, we get different apparent elevations of the objects that are in different distances from the observer. The greatest the distance, the least the apparent elevation that appears. It also depends on the observer's position. This can be seen on the equation: $DD' = OA \cdot DB / OB$.

References:

1. Laboratory manual (Antoniou Nikolaos, Dimitriadis Panagiotis, Papamixalis Konstantinos, Papatsimpa Lambrini).

EXPERIMENT NR. 73 DOPPLER EFFECT AND KEPLER'S LAW

CHAPTER: Optics and Astrophysics

PROPOSED BY: HTL Dornbirn, AUSTRIA

Theoretical aspects:

- **Doppler effect in astrophysics:**
- Usually everybody has learned at any time about the Doppler effect concerning the changes of sound when an ambulance or another emergency vehicle is passing. People even do not have problems to identify the shift from higher to lower frequencies of a approaching, passing and leaving racing car. However this effect is not limited to sound waves – light waves show the same effect though the relativistic influences cannot be disregarded. Thus the formulas from the acoustic (see experiments to Doppler's effect in acoustic: 54 and 55) end in one single equation:

$$f_{observer} = f_{source}\sqrt{\frac{1+\frac{v_{observer-sourcet}}{v_{light}}}{1-\frac{v_{observer-sourcet}}{v_{light}}}}$$

- This fact is used intensively in astrophysics since electro-magnetic waves usually are the only accessible source of information from objects outside of our solar system. One message the arriving radiation is carrying with is the frequency and wavelength shift respectively.

- **Kepler's law:**
- Johannes Kepler set up three empirical laws concerning the movements in the solar system. The third one deals with the parameters of the orbit namely the period of circulation and the semi-mayor axis – the indicated ratio is a constant within every orbiting system (solar system with planets and planet system with moons respectively). The constant value is depending on the mass of the central object.

$$\frac{T^2}{a^3} = \frac{4\pi^2}{G \cdot m}$$ [2]

Different approaches:

The presented experiment concerning characteristics of the Saturn and its rings may be used for a quantitative and qualitative approach respectively.

- Qualitative: rotation direction of planet and ring, nature of the ring
- Quantitative: rotation velocity of the planet and the ring, mass of the planet

Both will be described later on.

Materials, apparatus:

- high resolution spectra image of Saturn (for example those on page 3)
- ruler, pencil and image processing tool respectively

---

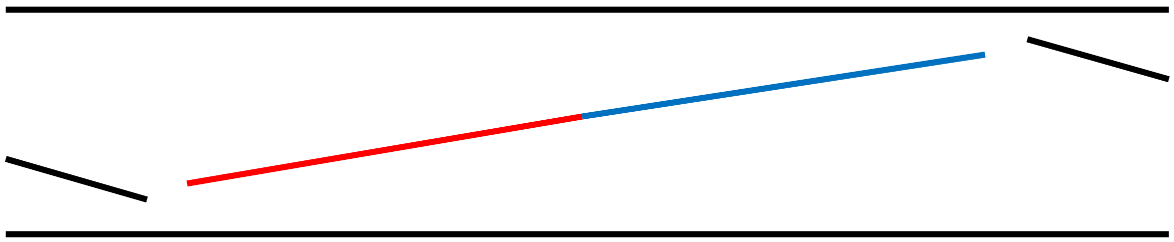
[2] This formula is based on the rotation velocity $v = \frac{2\pi \cdot r}{T}$ (in case of an exact circle) and the equation of centripetal force and gravitational force: $\frac{m_1 \cdot v^2}{r} = G \cdot \frac{m_1 \cdot m}{r^2}$ This may be transformed directly to the formula above.

Experimental procedure:

First of all it is necessary to learn about the meaning of the spectra image. Thus answer the following questions:

- What's recorded in the horizontal direction?
- What's recorded in the vertical direction?
- What's coded by the intensity?
- Where do the straight lines originate from?
- Where do the inclined lines originate from?

(The following exaggerated sketch of the important lines and the sketch in the lower part of the right image on the next page may be usefully.)



Additionally it is important to realize that in astrophysics angstrom (Å) is still very common in use for the unit of length: $1\ \text{Å} = 10^{-10}\ m$

(All values in the pictures of the next page are given in angstrom.)

Individual tasks:

Qualitative approach:

- In which direction is the ring rotating?
    - same as the planet
    - opposite to Saturn

  (Do not only relay on the arrows in the sketch of the next page but argument on base of the facts in the spectrum.)
- Does the ring of Saturn consist of a massive disc or of single particles?
    - massive disc → fixed rotation (the farther outside the __________)
    - single particles → Kepler rotation (the farther outside the __________)

  In which way the spectrum is able to answer the question?

Quantitative approach:

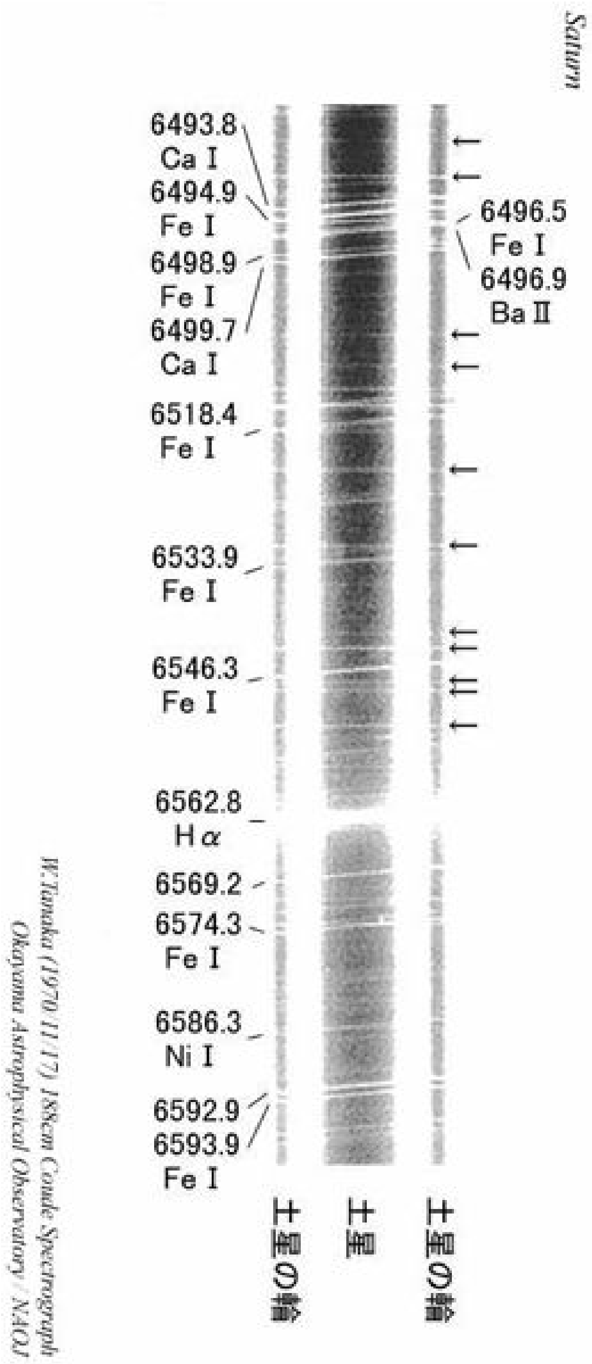
- What is the rotation velocity of Saturn at its equator?
    - Determine first the resolution of the spectrum!
      → nm (real) per mm (print) / nm (real) per pixel (image)
    - Determine the difference in wave length between the right and left edge of Saturn!
      → use at least two different lines
    - Determine finally the rotation velocity with the aid of the Doppler formula!

$$\frac{\frac{1}{4}\cdot\Delta\lambda}{\lambda_0}=\frac{v}{v_{light}}$$ [3]

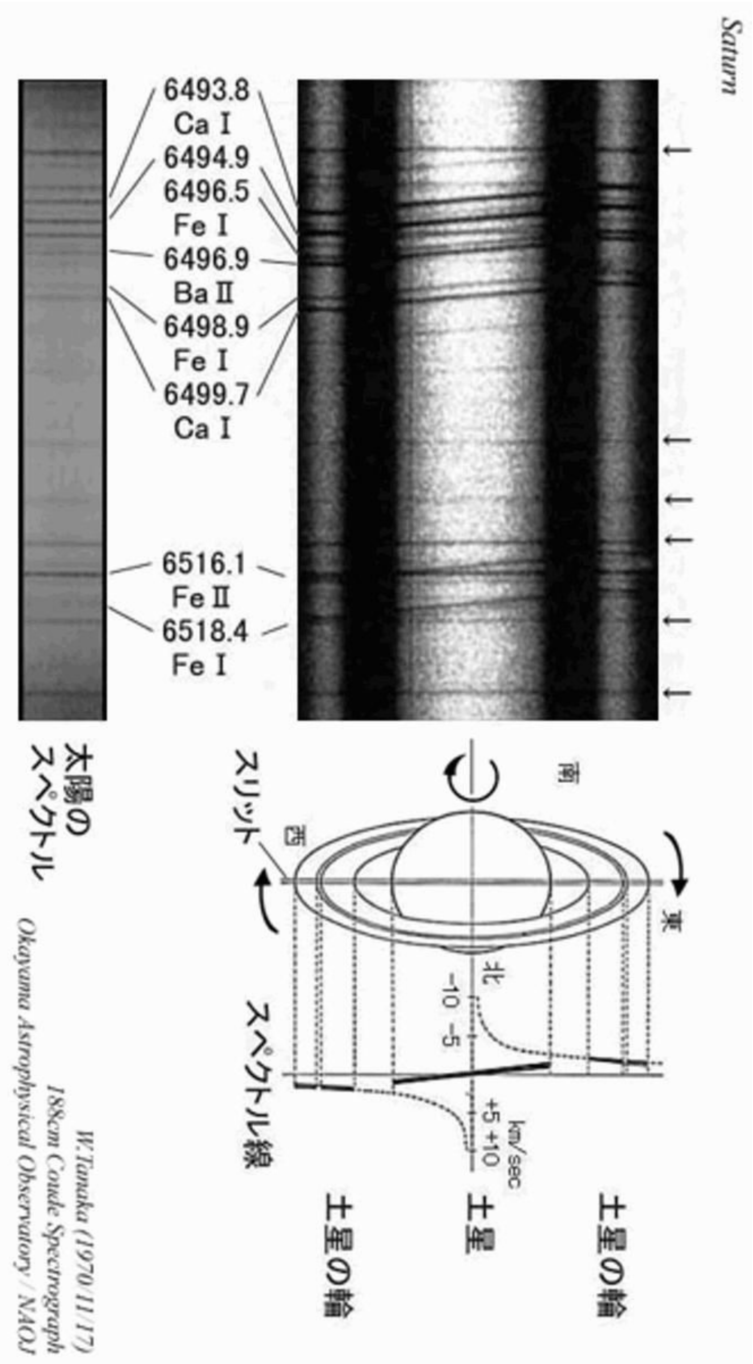
---

[3] The equation of the first page but using wave length instead of frequency ($f\cdot\lambda = v_{light}$) results in

$$\frac{\Delta\lambda}{\lambda_{source}}=\frac{\lambda_{source}-\lambda_{observer}}{\lambda_{source}}=1-\sqrt{\frac{1-\frac{v_{observer-source}}{v_{light}}}{1+\frac{v_{observer-source}}{v_{light}}}}\approx 1-\sqrt{\left(1-\frac{v_{observer-source}}{v_{light}}\right)^2}=\frac{v_{observer-source}}{v_{light}}$$



W.Tanaka (1970/11/17) 188cm Coude Spectrograph Okayama Astrophysical Observatory / NAOJ



W.Tanaka (1970/11/17) 188cm Coude Spectrograph Okayama Astrophysical Observatory / NAOJ

Where is the factor of a quater originating from?

- What is the rotation velocity of the Saturn ring (middle part)?
  - Determine the difference in wave length between the part of the ring on the left and right of Saturn! → use the average value
  - Determine the rotation velocity with the formula on the previous page!
- What is the mass of Saturn if the radius of the planet is assumed to be 60268 km?
  - Determine the spatial resolution on base of the diameter of Saturn! → km (real) per mm (print) / km (real) per pixel (image)
  - Determine the average radius of the ring!
  - Determine finally the mass of Saturn – the central mass of the orbiting system!

Data collection:

	difference (real)	difference (measured)	resolution
wave length	nm		
spatial	km		

Saturn	**Δλ (measured)**	**Δλ (real) [nm]**	**v** $\left[\frac{m}{s}\right]$
line 1			
line 2			
line 3			
average			
Saturn ring	**Δλ (measured)**	**Δλ (real) [nm]**	**v** $\left[\frac{m}{s}\right]$
line 1			
line 2			
line 3			
average			

	diameter (measured)	diameter (real)	period of circulation	central mass = mass of Saturn
Saturn ring				

Indicate the sources of errors

- Quality of the printout:
  It gets difficult to do precise measurements when using the copy of an original printout. With every further copy it gets worse.
- Quality of the spectrum:
  The measuring tasks are easier when the resolution of the spectrum is higher.
  → see for example the Saturn spectrum of the Lick Observatory (620-630 nm) in the references
- Precision and error of measurements:
  - In every task there will be problems to define where is the edge of the object and the middle of the line respectively. Therefore it is always a good idea to use marks as far from each other as possible – for example the very outermost adjustment lines.
  - Moreover even the precise handling of a ruler has to be taken into account namely the meter-reading (exactly perpendicular for every detail and even parts of the marked scale).

  → possibility for excessive error analysis

Interpreting the results:

For the answer of the questions in the section “Experimental procedure” see description in “Explanation and conclusions”.

Qualitative approach:

- The ring of Saturn is rotating in the same direction as the planet itself. This is indicated by the shift of the lines – those of the planet (middle region) as well as those of the ring (strips beside) are shifted towards smaller wavelength on the right side (blue shift) but towards larger wavelength on the left side (red shift). Thus the right region is approaching whereas the left side is moving away from the observer (see detailed discussion in the explanation section).
- The ring of Saturn consists of single particles.
  In case of a massive disc thus fixed rotation the rotation velocity of regions farther outside has to be larger thus the Doppler shift has to show larger displacements what’s contradictory to the inclination of the lines in the ring. They are horizontally or even slightly inclined in the opposite direction than the planets part.
  In case of single particles they will circulate according to the Kepler rotation thus with the velocity of $v = \sqrt{\frac{G \cdot m}{r}}$ (deducible from the equation of centripetal force and gravitational force, see footnote [1]). Therefore the rotation velocity is decreasing with increasing radius – the lines have to show the opposite inclination than the planet and that’s what they do.

Quantitative approach:

- The rotation velocity of Saturn is according to literature 10280 $\frac{m}{s}$.
  The resolution of an A4 printout of page 3 is slightly less than 0.085 nm per mm (left spectrum) and more than 0.045 nm per mm (right spectrum). Do not use the middle spectrum since it is just for calibration purpose.
  This will result in wavelength differences of 0.08-0.1 nm and thus rotation velocity between 9500-12000 $\frac{m}{s}$.
- The rotation velocity of the Saturn ring is according to literature 17 100 $\frac{m}{s}$ for the middle of the bright A ring (corresponding diameter: 258950 km).
  The wavelength difference deduced from the images is 0.15-0.17 nm and thus the rotation velocity is around 17500-19500 $\frac{m}{s}$.
- The mass of Saturn is according to literature 5.685 10^{26} kg.
  The resolution of an A4 printout of page 3 is somewhat above 12000 km per mm (left spectrum) and above 6300 km per mm (right spectrum).
  This will result in an average diameter of 245000-255000 km for the ring and thus a mass of 6-7 10^{26} kg – according to $\frac{T^2}{a^3} = \frac{4\pi^2}{G \cdot m} \rightarrow m = \frac{4\pi^2 \cdot a^3}{G \cdot T^2} \approx \frac{r \cdot v^2}{G}$ [4]; take care to use the right units!

Explanation and conclusions:

To start with the creation and meaning of a spectrum:

---

[4] $a \approx r$ and $T \approx \frac{2\pi \cdot r}{v}$ and the gravitational constant $G = 6.67 \cdot 10^{-11} \frac{m^3}{kg\ s^2}$

A spectrum is taken by pointing a telescope to an object. Then a slit is used to give only the light of one special orientation the possibility to reach the detector. Behind the slit there is a grid which splits the light according to the wave length using the effect of diffraction.

Thus a spectral image shows spatial information on one axis (horizontal in the given spectra) and has a wave length scale on the other axis (vertical in the given spectra). In the chosen spectra of the Saturn the position of the slit was laid through the equatorial plane of the planet cutting the rings on their very outer regions.

An always very important task is the calibration of the wave length scale. This is done on base of emission lines of one or more special lamps which may be visible at the outer edge of the spectral image (like in the spectrum of the Lick Observatory) or obtained as single images before or after the spectrum itself (as it is in the right example). Sometimes even the atmospheric absorption lines (see later in this text) are used for the adjustment of the scale.

There is a third source of information enclosed in the spectral images: The intensity at every point corresponds with the amount of energy for the special position and wave length. In the used examples, it is the brighter (right image) / the darker (left image) the more energy.

Doppler's effect in a spectrum:

The frequency and wave length shift respectively of the Doppler effect results in spectral lines shifted to larger frequencies thus smaller wave length (more blue ones) when the movement causing the effect is pointing towards the detector. When the movement is pointing away the spectral lines are shifted to larger wave length (more red ones).

Saturn spectrum:

The planet does not shine on its own but only reflects the sun light. Thus we get a continuous spectrum with the Fraunhofer lines (absorption lines due to absorption mechanisms in the corona). These waves reach the moving surface of Saturn – the first time the Doppler effect has to be applied since the moving areas sense a different wave length than emitted by the sun. The light is reflected – and again the Doppler effect has to be taken into account since the wave lengths detected with the spectrograph on earth are different to those emitted from the moving surface elements. By the way this is the reason for the factor of ½ in the formula of the rotation velocity. The other ½ originates from the fact that not the original wave lengths but those shifted to blue and to red respectively are compared. Since the projection of the rotation velocity in the line of sight is changing continuously the Doppler effect discussed above generates inclined lines.

Additionally, the Saturn spectrum shows some straight lines (completely horizontal). Their origin is in the earth's atmosphere – absorption lines of oxygen, iron and calcium. The most important ones are marked by arrows in the presented spectra.

Except from very expensive space expeditions and some nuggets of asteroids reaching the surface of the earth astrophysics only base on information gained from electromagnetic waves and radiation of some strange particles. However the experiment shows there is a large number of details deducible from one single spectrum.

References:

Saturn data from literature:

Helmut Zimmermann/Alfred Weigert: Lexikon der Astronomie, 4. Auflage, 1995-1999, Spektrum Akademischer Verlag GmbH, Heidelberg - Berlin

Images of Saturn spectrum used above:

http://www.shokabo.co.jp/sp_e/optical/solar/saturn/saturn.htm (Status: 11.7.2007)

High resolution spectrum of Saturn from Lick Observatory:

Sky and Telescope, V28, p278, 11/1964;
http://www.shopatsky.com/browseproducts/Rotation-of-Saturn-and-Its-Rings-Lick-Observatory-Photos.html (Status: 9.7.2007)

EXPERIMENT NR. 74 CARTESIAN DIVER

CHAPTER: Hydro- and aeromechanics

PROPOSED BY: HTL Dornbirn, AUSTRIA

Theoretical aspects:

The hydro- and aeromechanics base on the facts of liquids being uncompressible (at least in the ideal case) on contrary of gas which may be compressed.

The hydrostatic paradox defines that the pressure only depends on the depth but not on the amount of liquid above a position according to buoyancy.

These are the only theoretical aspects needed for the explanation.

Materials, apparatus:

- Cartesian diver (special figure or just a small lightweight flask with an opening at the lower end and already partly filled with water)
- glass cylinder full of water
- rubber plug

Experimental procedure:

The Cartesian diver is inserted into the filled glass cylinder which is than neatly closed by the rubber plug.

Now the plug is slightly pushed downwards.

Individual tasks:

- Use different strong forces to push on the plug – What happens?
  Have a special look at the bubble inside the figure in different depths!
- Try to bring the Cartesian driver to float in the middle of the glass cylinder – What is the problem?
- What's different when the figure has to float on a lower level?

Data collection:

The data collection of this experiment is not quantitative but qualitative:

task	observation (reaction)
no pressure on the plug	
small pressure on the plug	

stronger pressure on the plug	

Indicate the sources of errors

- Bubbles under the rubber plug
  → The small volume differences are split between the bubble inside the diver and those under the plug – thus the effect may be hardly seen any more.
- Too much water inside the Cartesian driver
  → The driver is not swimming or hardly lifting after releasing the pressure from the plug.
- Too little water inside the Cartesian driver
  → It is difficult to lower the driver by pressing the plug.

Interpreting the results:

The main observations are:

- Pushing slightly on the top of the plug results in a downward movement of the figure.
- As soon as the pressure is released the figure is rising again.
- The bubble inside the Cartesian diver is shrinking while descending.

The first considerations will probably circle around the buoyancy principle: In the beginning the buoyancy is greater than the gravitational force thus the diver is swimming. Pushing exactly with the right strength will bring the diver to float namely when the two forces reach the same amount. When pushing slightly harder the diver will continue sinking.

Reflecting more deeply may lead to the conclusions: The pressure from the plug is transferred to the water. Thus, the gas captured inside the Cartesian diver is slightly compressed until the pressure in the liquid is equal to the gas pressure hence allowing water to intrude into the Cartesian diver. Consequently, less water is displaced and thus buoyancy is decreasing resulting in a figure beginning to sink. Releasing the pressure has the opposite effect. When the figure is sinking the pressure is increasing additionally due to the depth enhancing the effect and accelerating the decline. This may produce difficulties to stop the diver on a special depth in the first attempt. Different floating depths can be arranged by varying the pressure on the plug.

Explanation and conclusions:

The pressure in the liquid is depending on the ambient, the hydrostatic and the additional pressure hence depending on the depth according to

$$p(h) = p_0 + \rho_{water} \cdot g \cdot h + p_{plug}$$

According to Boyle's law the bigger pressure results in a smaller gas volume of

$$V = V_0 \frac{p_0}{p} \approx V_0 \cdot \left(1 - \frac{\rho_{water} \cdot g \cdot h}{p_0} - \frac{p_{plug}}{p_0}\right)$$

The whole diver figure gains mass due to the additional water

$$\Delta V = V_0 \cdot \left(\frac{\rho_{water} \cdot g \cdot h}{p_0} + \frac{p_{plug}}{p_0}\right) \text{ thus } m_{diver} = m_0 + \rho_{water} \cdot \Delta V \, .$$

The resulting force composes from the steady buoyancy but increasing gravitational force

$$F = \rho_{water} \cdot V_{diver} \cdot g - m_{diver} \cdot g$$

Note:

The term corresponding to the hydrostatic pressure is negligible small $\rho \cdot g \cdot h \approx 1\,kpa$ for a depth of one decimeter (that's around one percent of the ambient pressure). A force of only ten Newton on the plug with a diameter of let say three centimeters will exceed the hydrostatic pressure of one kilopascal at least ten times.

EXPERIMENT NR. 75 AERODYNAMIC PARADOX

CHAPTER: Hydro- and aeromechanics

PROPOSED BY: HTL Dornbirn, AUSTRIA

Theoretical aspects:

The paradox of aero- and hydrodynamics bases on Bernoulli's equation which is valid for ideal fluids but also gives good assumptions for gas on low Mach numbers

$$\frac{\rho}{2}\cdot v^2+\rho\cdot g\cdot h+p=const.$$

Additionally, the application of flow patterns will be very usefully for the interpretation of the experiments: The lines indicate the direction of the gas and fluid flow respectively and their density give the velocity (the closer the faster).

Different approaches:

These experiments may be used as introduction to the topic just to arouse interest. They are usable for detailed analysis as well – especially when flow patterns are used.

Materials, apparatus:

- 2 sheets of paper
- hair-dryer
- table tennis ball

Experimental procedure:

The sheets of paper are held parallel in a small distance. Then blow in between them.

Start the hair dryer holding it vertical. Then set the ball in the air flow.
Tilt the machine slowly.

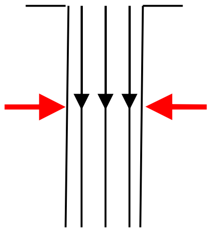
Indicate the sources of errors

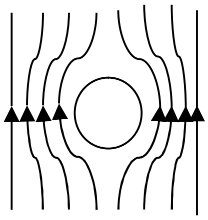
- The sheets are situated too far from each other and not parallel respectively.
- The used ball is too heavy compared to the air flow.

Interpreting the results:

The most important conclusion of Bernoulli’s equation is the faster the flow the lower the pressure.

In the first experiment, there is no remarkable velocity on the outer sides of the sheets but when the air flow is starting between the sheets due to blowing there is a velocity in-between lowering the pressure. Therefore, the sheets are forced inwards since the pressure from outside is higher than inside.





In the second experiment, the table tennis ball is first floating in the air flow of the hair dryer due to collisions of the air molecules with the object – at least in the vertical direction. The position in the middle of the beam is stabilized by the same principle as before: When the ball is leaving the central position the lines of the flow patterns are more dens on the other side – that is to say the velocity on that side is higher, the pressure lower and thus the ball is pushed back to the center. When the system is inclined the effect according to Bernoulli’s equation get’s even more important for the explanation.

Explanation and conclusions:

The same effect allows flying, is responsible for detached roofs and slammed doors during storms. It also causes crashes of ships passing very near each other and the quay wall respectively.

A large number of similar experiments exist:

- Hold a sheet horizontally and blow over it – the sheet will rise.
- Blow through two balls hanging just a few centimeters from each other – they will approach each other.
- Use a straw to balance the ball in the air flow – a little bit of practice will be needed.
- Put the ball and the adequate shaped filter respectively in a cone and blow from the narrow side – the object will not leave the cone. When using a constant flow fast enough the object will stay inside the cone even when hold upside done.

References:

1. http://www.christof-schowalter.de/physik/experimente/hydro.htm (Status: 14.12.2008)
2. http://leifi.physik.uni-muenchen.de/web_ph05/versuche/03aerodynamik/index.htm (Status: 14.12.2008)

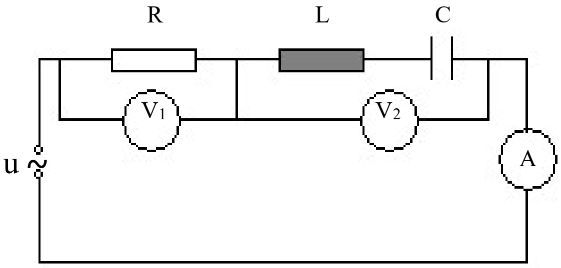
EXPERIMENT NR. 77A DETERMINING THE IMPEDANCE AND THE PHASE DIFFERENCE IN A SERIES RLC CIRCUIT

CHAPTER: ELECTRICITY

PROPOSED BY: COLEGIUL NATIONAL "SIMION BARNUTIU" ŞIMLEU SILVANIEI, ROMANIA

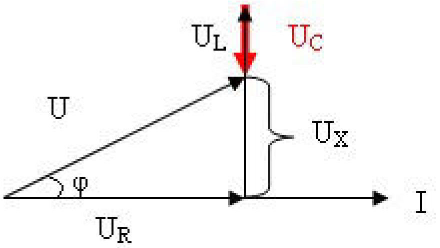
Different approaches:

According to the theory, in a series RLC circuit the impedance is $Z = \sqrt{R^2 + (X_L - X_C)^2}$ or $Z = \frac{U}{I}$.



Using the phase scheme of this type of circuit, the phase difference is:

$$tg\varphi = \frac{U_L - U_C}{U_R} \quad \text{or} \quad tg\varphi = \frac{U_x}{U_R}$$



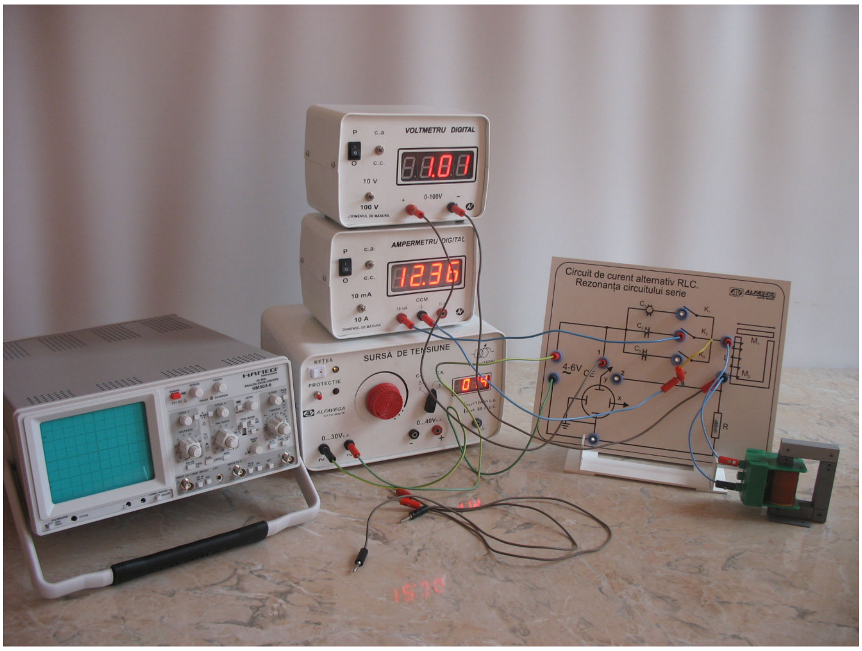
Materials, apparatus:

Alternative voltage source, ammeter, voltmeter, RLC series circuit board

Safety precautions:

General precautions should be taken in consideration when working with equipments connected to a source of power

Images of the apparatus or how it is conducted



Experimental procedure:

Measuring the intensity and the voltage on the components in the circuit we can determine the impedance and the phase difference between voltage and intensity.

Individual tasks:

We connect the voltage source to the circuit.
We connect one of the capacitors.
Next we connect in series with the source the ammeter and in parallel to the capacitor and the inductor the voltmeters.
Using the measured voltages and intensity, we calculate the impedance and the phase difference after the formulas: $Z=\frac{U}{I}$; $tg\varphi=\frac{U_L-U_C}{U_R}$
We repeat the experiment several times varying the voltage of the source and the capacitor.

Data collection:

Nr. Crt.	U[V]	I [A]	Z[Ω]	Z[Ω]	U_R[V]	U_X [V]	tgφ	tgφ
1								
2								
3								

Indicate the sources of errors

Errors due to the imprecision of the apparatus:
- the low precision of the ammeter and voltmeter
- variations of the voltage provided by the source

Errors due to the imprecision of the method
- the inductor is not ideal, it has inner resistance
- the connection wires` resistance was neglected
- the ammeter and the voltmeter are not ideal

References:

1. Panaitoiu, L., Chelu, I., *Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972
2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995
3. http://www.olimpiade.ro
4. http://www.didactic.ro

EXPERIMENT 77B ELECTRIC CELL FROM FRUITS

CHAPTER : Electricity making of a battery

PROPOSED BY: L.P. « La Closerie », Saint Quai Portrieux, FRANCE

Theoretical aspects:

The knowledge of the Volta battery can give the idea of testing the replacement of the hydrochloric acid by another ordinary liquid acid i.e. lemon juice. Then one can widen the research with various other edible plants and various metals with an aim to finding the most interesting triplet (metals, electrolyte) in order to make a battery.

This experiment also makes it possible to introduce the concept of the REDOX cell. It is an experiment in electricity and in chemistry.

Materials:

A Voltmeter
Various metal plates (Pb, Cu, Zn, Al, Sn,…)
Various fruits or vegetables: banana, apple, lemon, potato, orange,…

Safety precautions:

Experiment without any danger.

Experimental procedure, individual tasks:

Cut each fruit/vegetable into two.
In one of the halves, insert two one or two-centimetre-long metal plates separated by approximately three centimetres.
Measure the tension between the two plates with the voltmeter.

Data collection:

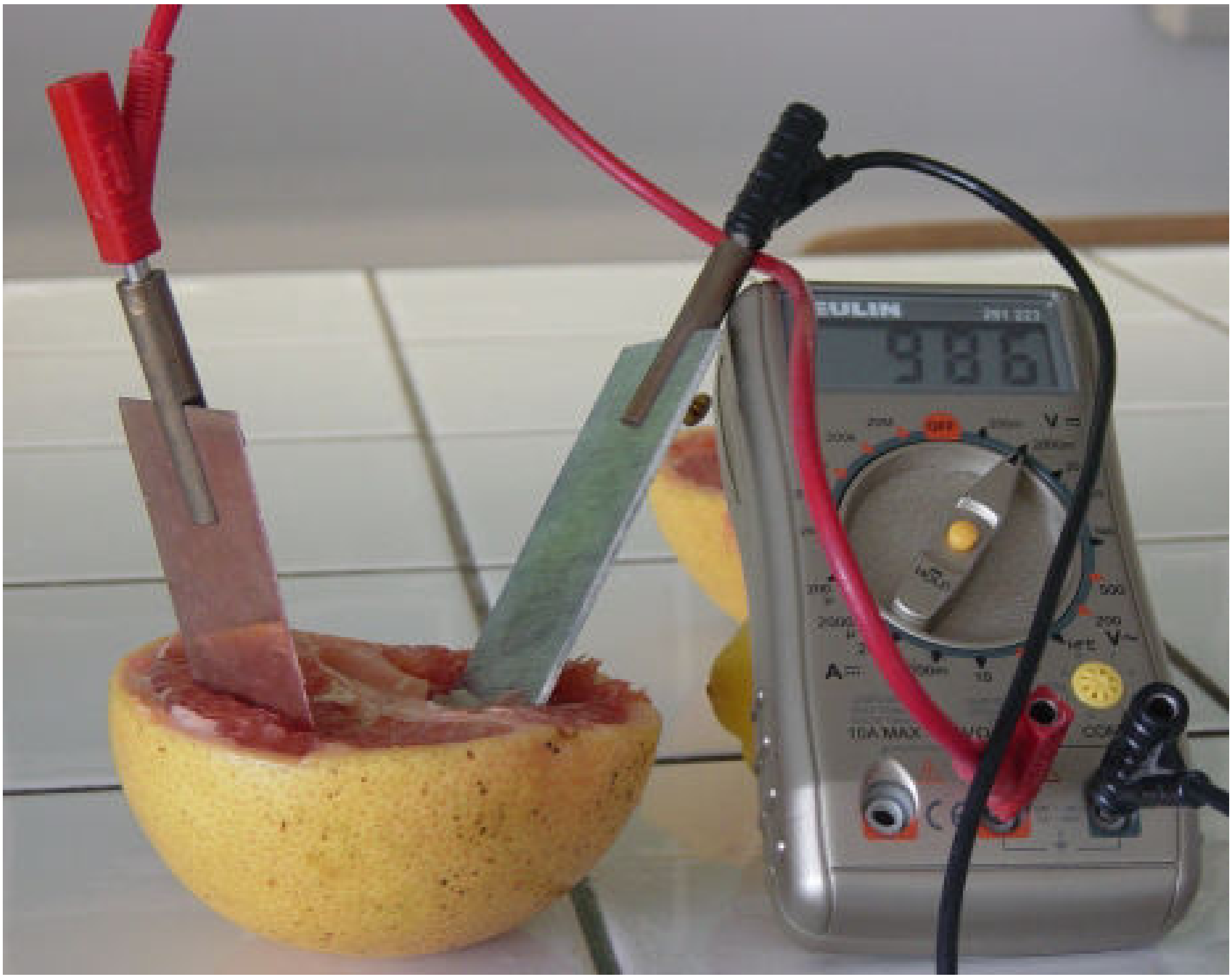
Métal1/Métal2	Pb/Cu	Pb/Zn	Pb/Al	Pb/Sn	Cu/Zn	Cu/Al	Cu/Sn	Zn/Al	Zn/Sn	Al/Sn
Lemon										
Potato										
Banana										
Apple										
Orange										

Interpreting the results

Beginning of the electrochemical classification of metals and redox cell. A thorough explanation is impossible at our students's level (CAP sector 4 and 7).

Possible sources of mistakes:

It is necessary to clean the plates thoroughly between two measurements. The tensions that have been measured very often depend on the quality of work of the students and remain of indicative value only.



EXPERIMENT 77C

BUILDING CIRCUITS WITH DC CURRENT

CHAPTER: Electricity

PROPOSED BY: General Gymnasium Vassiliadis Private School, Thessaloniki, GREECE.

Theoretical aspects:

During this experimental procedure, the way to build electric circuits with sources of direct current so as to supply different appliances is demonstrated.

Different approaches:

There are many considerably different ways to connect sources – resistors – energy consumers (motors). This experiment demonstrates only a few.

Materials, apparatus:

- cables
- direct current batteries
- a switch
- lamps
- a motor
- a voltmeter
- an ammeter

Safety precautions:

As long as batteries are used at a low tension value, there is no other reason of taking precautions.

Experimental procedure:

The simplest circuit we could possibly build , should include a source, a switch and a resistor (figure 1, picture 1). A voltmeter is connected at the edge of the source to measure its tension and an ammeter to measure its current intensity.

The second circuit contains two same sources connected in succession to measure their tension and intensity (figure 2, picture 2).

The third circuit contains two other same sources connected in parallel, measuring again their tension and intensity (figure 3, picture 3).

The forth circuit contains two same resistors connected in succession to measure their tension and intensity (figure 4, picture 4).

The fifth circuit contains two same resistors connected in parallel this time to measure their tension and intensity (figure 5, picture 5).

All the measurements are recorded in the table. The above experiments can be repeated with different tension and resistor values.

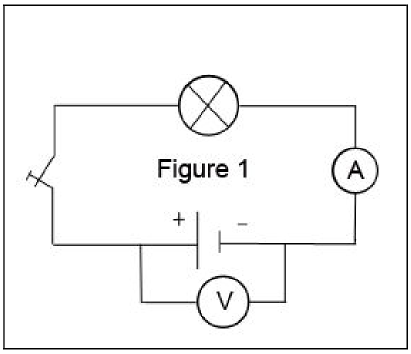


Figure 1

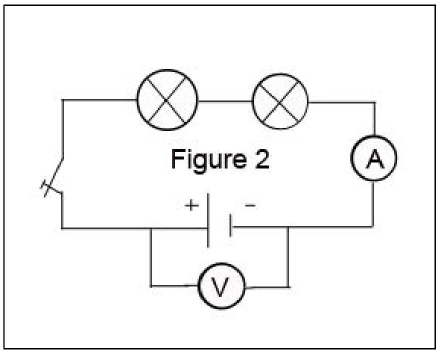


Figure 2

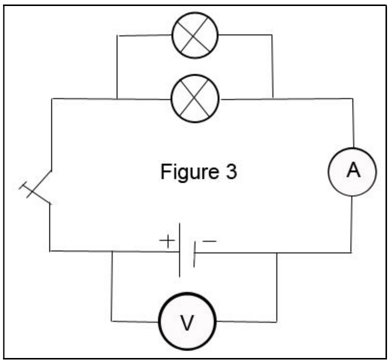


Figure 3

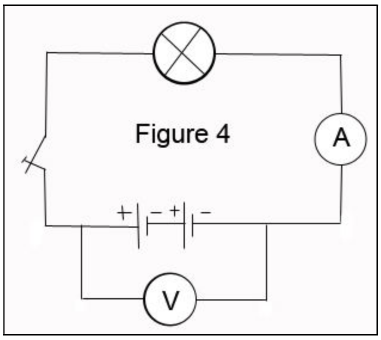


Figure 4

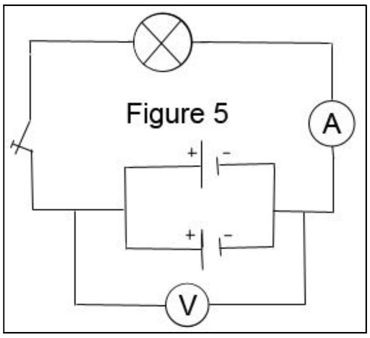
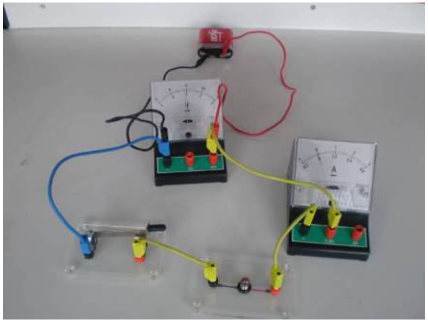
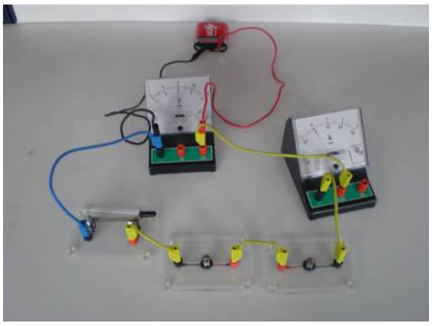
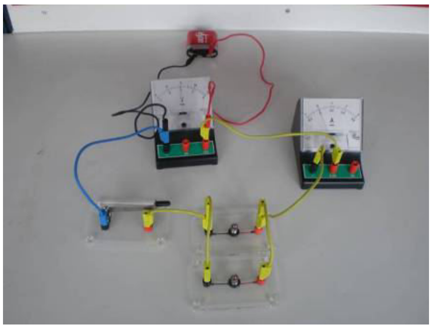


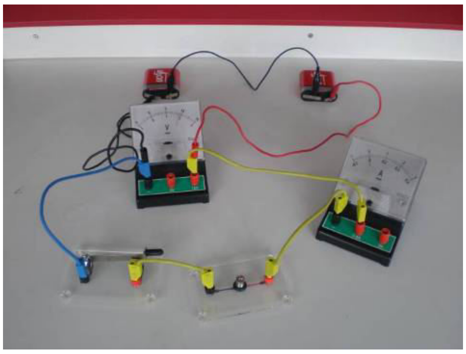
Figure 5

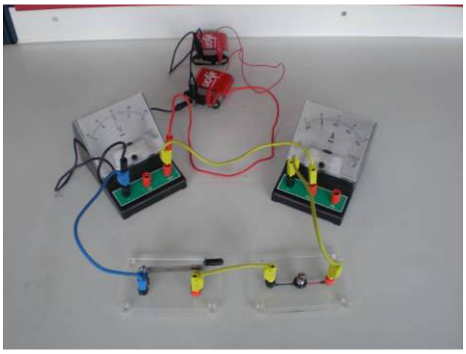
Images of the apparatus or how it is conducted


Picture 1


Picture 2


Picture 3


Picture 4


Picture 5

Interpreting the results

The values of voltage and intensity recorded are not only dependent on the resistor and source values but also on the way they are connected.

Explanation and conclusions:

In these experimental procedures, we only view different ways of building circuits, and we don’t collect data.

EXPERIMENT NR. 77D DETERMINING THE IMPEDANCE, THE PHASE DIFFERENCE IN A PARALLEL RLC CIRCUIT. OBSERVING CIRCUIT RESONANCE

CHAPTER: ELECTRICITY

PROPOSED BY: Colegiul National "Simion Barnutiu" Şimleu Silvaniei, ROMANIA

Different approaches:

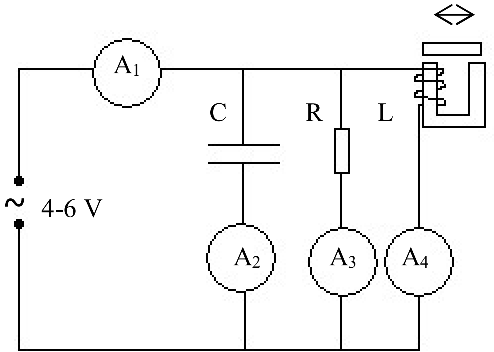
According to the theory, in a parallel RLC circuit

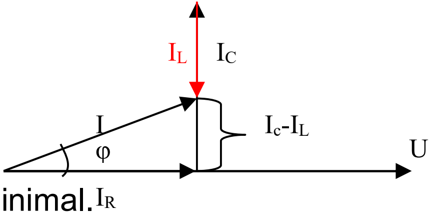
the impedance is $Z = \dfrac{1}{\sqrt{\dfrac{1}{R^2} + \left(\dfrac{1}{X_C} - \dfrac{1}{X_L}\right)^2}}$ or $Z = \dfrac{U}{I}$.

Using the fazorial scheme of this type of circuit, the phase difference is:

$$tg\varphi = \frac{I_C - I_L}{I_R}$$

When the intensity of the currents on the capacitor and coil are equal, the circuit has reached resonance.
In this situation the current through the rest of the circuit is minimal.





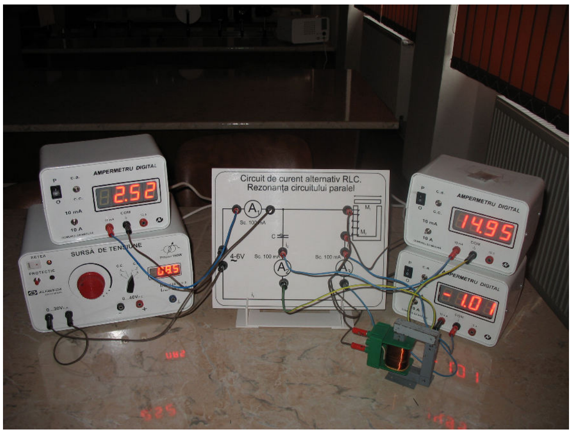
Materials, apparatus:

AC source, ammeters, RLC parallel circuit board

Experimental procedure:

Measuring the intensity and the voltage on the components in the circuit we can determine the impedance and the phase difference between voltage and intensity. In order to observe currents resonance, the coil`s inductance is varied by moving its core until the currents through the capacitor and coil are equal, and the current through the main circuit is minimal.

Images of the apparatus or how it is conducted



Individual tasks:

We connect the voltage source to the circuit.

Next we connect 4 ammeters, each one in series with the source, the coil, the capacitor and the resistance.

Using the measured intensities and the voltage indicated by the source, we calculate the impedance and the phase difference after the formulas:

$Z = \frac{U}{I}$, I is the intensity through the main circuit;

$tg\varphi = \frac{I_C - I_L}{I_R}$, I_C is the current through the capacitor and I_L the current through the coil.

We repeat the experiment several times varying the voltage of the source.

Data collection:

Crt.No	U[V]	I [A]	Z[Ω]	$\overline{Z}$ [Ω]	I_R[V]	I_C-I_L [V]	tgφ	$\overline{tg\varphi}$
1								
2								
3								

Indicate the sources of errors

Errors due to the imprecision of the apparatus:

- the low precision of the ammeter and voltmeter
- variations of the voltage provided by the source

Errors due to the imprecision of the method

- the inductor is not ideal, it has inner resistance
- the connection wires` resistance was neglected
- the ammeter and the voltmeter are not ideal

Explanation and conclusions:

When resonance is reached, the intensity of the current through the main circuit becomes minimal. Repeat the experiment for a parallel LC (see picture above) and observe that the intensity through the main circuit approaches zero.

References:

1. Panaitoiu, L., Chelu, I., *Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972

2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995

EXPERIMENT NR. 77E BUILDING CIRCUITS. MEASURING VOLTAGES AND CURENTS

CHAPTER: Electricity

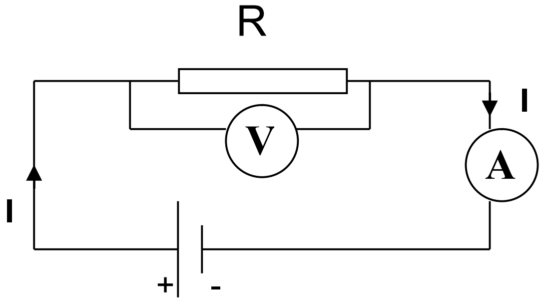
PROPOSED BY: COLEGIUL TEHNIC „I. Maniu” Şimleu Silvaniei, ROMANIA

Theoretical aspects:

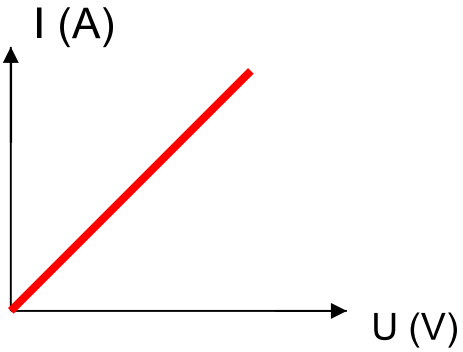
An electrical circuit contains:

- a source of tension (an electrical generator)
- a consumer (receptor)
- connecting wires

For the measuring of tension at the end of the consumer we must connect, in the same time, a voltmeter, and for the measuring of the electrical intensity we have to connect in series an ammeter (Scheme 1).



(1)



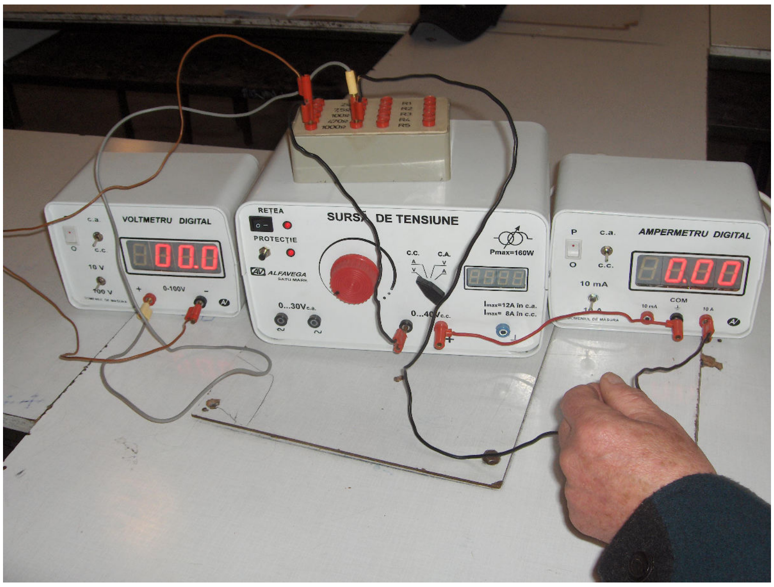
(2)

Materials, apparatus:

- power source; resistors;
- voltmeter; ammeter;
- connecting wires;

Safety precautions:

Because in this experiment the students are working with electric devices connected to different voltages precautions should be taken in manipulating these devices and general safety rules have to be respected when working with electric current.



Experimental procedure:

The teacher asks the students to make the circuit from the scheme, by respecting the correct way of connection of the electrical devices in DC.

Individual tasks:

The students measure the intensity of the electrical power in accordance with the applied electrical tension, and they have to write the results in the following table.

Data collection:

Number of determination	U (V)	I (A)	$R = \frac{U}{I}$ (Ω)	P= U*I (w)	Observation
1.					
2.					
3.					
…					

Indicate the sources of errors

Possible errors could occur and they are related to the liability of the measuring devices and the way the tension and the intensity of the electric current is measured by the students.

Interpreting the results

With the help of the obtained data we can make some determinations like:

- the electrical resistance of a resistor;
- the power disposed on the resistor;
- the drawing of the diagram **I = f (U)**

- looking at the I = f(U) curve we can observe:
    - the linear conduction of an Ohmic resistor
    - the angle of the graph is the conductance of the electric circuit (G) and in this case is the inverse of the electric resistance (R), G=1/R

- using this method different electrical assemblies could be done:
    - series and parallel grouping of the resistors
    - series and parallel grouping of the electric generators
    - verifying the laws of Ohm
    - verifying the laws of Kirchhoff

References:

1. C. Mantea *Fizica manual pentru clasa. a X-a*, editura ALL, 2002

EXPERIMENT NR. 78 VERIFYING THE OHM LAW

CHAPTER : Electricity

PROPOSED BY: **L.P. « La Closerie », Saint Quai Portrieux, FRANCE**

Theoretical aspects:

The aim of the experiment is to discover the relation between the voltage at the terminals of a resistance fed in D.C. current and the intensity that goes through it.

Various approaches:

1st method: direct layout of the strength property to the oscilloscope. a “heavy” method which makes it possible to visualize the linear relation well U = f(I).
2nd method (applied here): simultaneous use of an ammeter and of a voltmeter on a derivation.

Materials:

- A Voltmeter
- An ammeter
- A potentiometer
- A generator 12 V DC
- A switch,
- A resistance

Safety precautions:

Usual precautions related to the use of electric power

Experimental procedure, individual tasks:

The students must propose assembly diagrams. Two options are possible: long or short derivation. The two methods are accepted, the differences obtained in the data are negligible. Once the assembly has been made and checked, the table below will be supplemented.

Data collection:

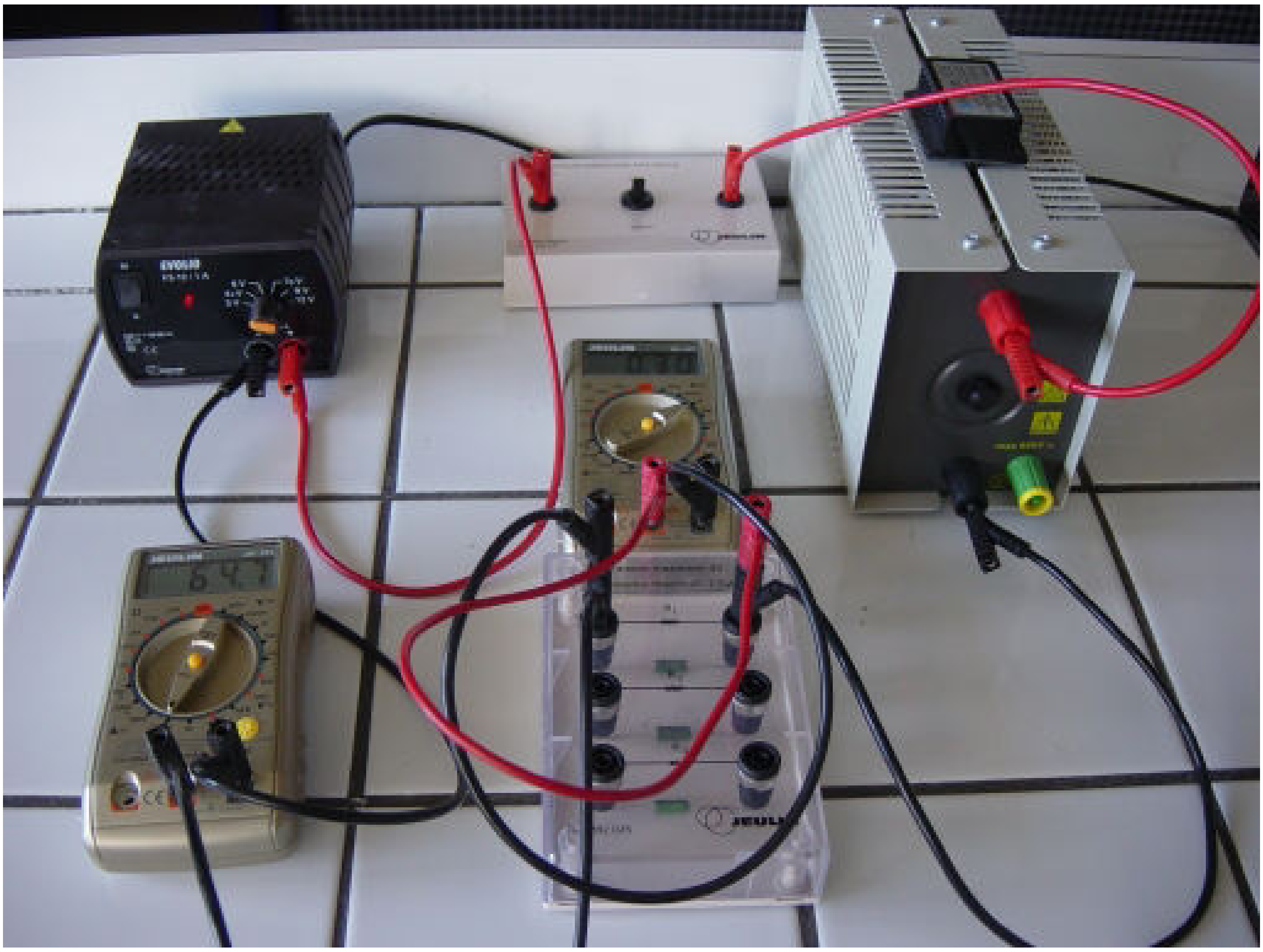
Position of the cursor	U (V)	I (A)	U/I
1			
2			
3			
4			
5			

Interpreting the results

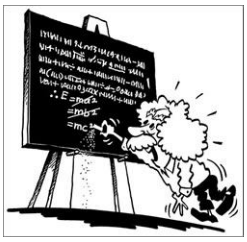
- For a pure resistance, the ratio U/I is constant
- R = U/I and is measured in Ohm
- In the case of the use of the oscilloscope, one notes that the characteristic is a line hence the same conclusion.
- It is possible not to mark the last column of the preceding table and to let the pupils test several possibilities.

Possible sources of mistakes:

Mistakes due to the precision of the apparatuses and especially, systematic errors due to the simultaneous use of the two measuring apparatuses: the voltmeter derives I and the ammeter which causes a voltage drop. But to use the apparatuses successively would lead to more important errors due to the variation of the current and would lengthen the experiment significantly.



EXPERIMENT NR. 79
THE FIRST AND THE SECOND LAW OF KIRCHHOFF



CHAPTER: Electricity

PROPOSED BY: **General Gymnasium Vassiliadis Private School. Thessaloniki, GREECE.**

Theoretical aspects:

The purpose of the experiment is to verify the first and the second law of Kirchhoff. According to the first one, the sum of the current intensity entering a node is equal to the sum of the intensity which exits it. According to the latter, following a close route in a circuit, the algebraic sum of the difference of dynamics in every two points in the circuit is equal to zero.

Materials, apparatus:

- connecting cables of low resistance
- 1 battery of continuous current (4,5, Volt)
- 1 voltage supplier of continuous current (6-7,5-9 Volt)
- resistance (47-100-120-220-470 Ohm.)
- 1 multimeter 3 voltmeters 3 ammeters 1 switch of insignificant resistance

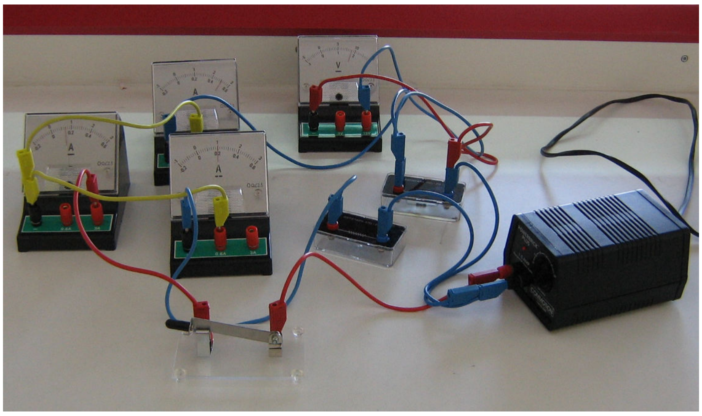
Safety precautions:

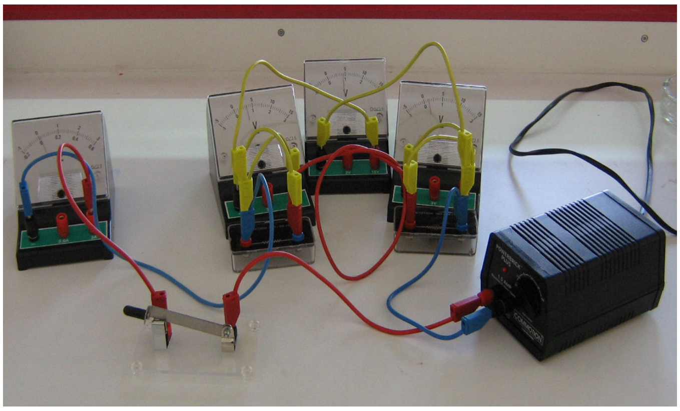
None. Because of very low voltage.

Experimental procedure:

To verify the first law of Kirchhoff a continuous current source is used connected with a switch and an ammeter. The whole system is in succession with a two-resistance system being connected in parallel and each resistance is connected in succession with an ammeter. The whole circuit is supplied with current and record the following measurements. To verify the second law of Kirchhoff a continuous current source is used, connected in succession with a switch and a two resistance system connected in succession as well. At the end of each resistance a voltmeter is connected respectively to measure the difference of dynamic loads and a third voltmeter in parallel to the whole circuit which is supplied with current and record the measurements.

Images of the apparatus or how it is conducted





Data collection:

1st Law						
	Experimental values					
	Vs (V)	R1 (Ohm)	R2 (Ohm)	I (A)	I1 (A)	I2 (A)
1						
2						
3						
4						

2nd Law						
	Experimental values					
	I (A)	R1 (Ohm)	R2 (Ohm)	V (V)	V1 (V)	V2 (V)
1						
2						
3						
4						

Indicate the sources of errors and determining errors

Errors provocated by the experimenter are

- Reading out the indications on the instruments (voltmeter, ammeter)

Errors during measurements are

- Low precision of the indication of the instruments
- Imprecision of the indications
- Through the recorded values of the resistance being used in relation with their real values which can be measured with a multimeter with quite good precision.

Errors provocated by the method of calculation are

- Internal resistance of instruments (voltmeter, ammeter)
- Increase of temperature of the resistance
- Resistance of the conductors used for connection.

Explanation and conclusions:

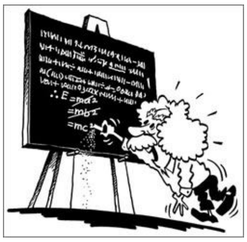
Through experimenting and measuring, we verify the first and the second law of Kirchhoff. Therefore, according to the first law we must prove $I = I1+I2$ and to the second one we must prove $V1+V2+Vs=0$

References:

Physics experiments (Ioannis Bouroutis)

Physics experiments (P. Kokkotas, B. Karapanayiotidis, Ioannis Amaoutakis, Ioannis Karanikas, Ioannis Kourelis)« Grigoris » Editions

Students experiments in Physics, "Phywe" Edition



EXPERIMENT NR. 80
ELECTRIC RESISTANCE, RESISTIVITY.VERIFYING R= ρ l / S

CHAPTER: Electricity

PROPOSED BY: General Gymnasium Vassiliadis Private School.Thessaloniki, GREECE.

Theoretical aspects:

The purpose of the experiment is to verify the relation R = ρ l / S by proving that the resistance of a conductor is in proportion with the length of (l) and in inverse proportion with the section area of (S), as well as her relation to resistivity (ρ), that is the main characteristic of the material out of which it consists of. Calculating resistance will be with the help of the Law of Ohm R = V/I, by measuring voltage (V) with voltmeter and the current intensity (I) with ammeter.

Different approaches:

Apart from the experiment being conducted with the help of a voltmeter and an ammeter, the resistance will be estimated with multimeter which will record its value directly.

Materials, apparatus:

- 3 conductors of length l = 1m (2 with Ni Cr material, 1 with Alferon material)
- 1 ammeter with ranges 0-0,6A, 0-3A
- 1 voltmeter with ranges 0-3V, 0-15V
- 1 power supply of continuous current with exit 3-4,5-6-7,5-9-12V
- 1 switch
- 6 conductors of very small resistance for the creation of the circuit
- 1 instrument to measure length
- 1 multimeter

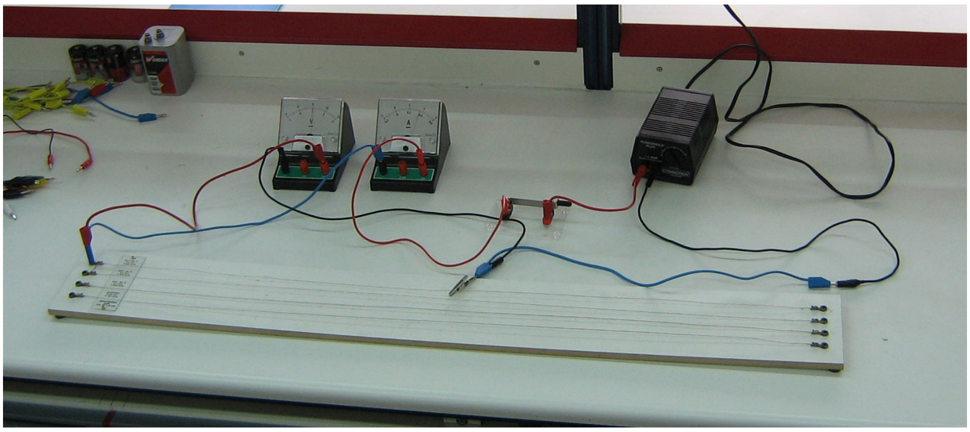
-Safety precautions:

None. Because of very low voltage.

Experimental procedure:

The switch and the ammeter are connected in succession with the resistance, whereas the voltmeter is connected in parallel with it. The circuit is connected with the power supply (DC) where its value can be changed.

1) measuring resistance for two different values of voltage by keeping material (p) and cross section (s) constant and record their values.
2) measuring the length (l) and the material (ρ) constant and record their values.
3) measuring the length (l) and the cross section (s) constant and record their values.



Data collection:

Length alteration Voltage supply ……. V				
	Length (m)	Voltage (V)	Intensity (A)	Resistance (Ohm)
1				
2				
3				

Cross section alteration Voltage supply …. V				
	Cross section m^2	Voltage (V)	Intensity (A)	Resistance (Ohm)
1				
2				
3				

Spesific resistance alteration Voltage supply … V				
	Material	Voltage (V)	Intensity (A)	Resistance (Ohm)
1				
2				
3				

Indicate the sources of errors and determining errors

Errors provoked by the experimenter are

- Reading out the indications on the instruments (voltmeter, ammeter, gradated scale)

Errors during measurements are

- Low precision of the indication of the instruments
- Imprecision of the indications
- Through the recorded indications of the length and the radius in relation with their real values.

Errors provoked by the method of calculation are

- Internal resistance of instruments (voltmeter, ammeter)
- Increase of temperature of the resistance
- Resistance of the conductors used for connection.
-

Interpreting the results

In table 1 (constant ρ and s), we notice that resistance is in proportion with the length of the conductor (l).
In table 2 (constant ρ and l), we notice that resistance is in inverse proportion with the area of its cross section (s).
In table 3 (constant l and s), we notice that resistance depends on its material (ρ)

Explanation and conclusions:

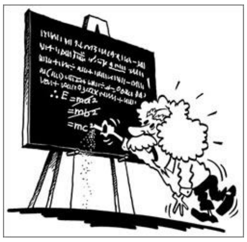
From the above mentioned experiment, we conclude that resistance (R) of a conductor, is its main characteristic which depends on 3 factors ρ, l, s. Its value is irrelevant to Voltage (V) which is in proportion with and the current (I) intensity which flows in it

References:

1. Physics experiments (Ioannis Bouroutis)
2. Physics experiments (P. Kokkotas, B. Karapanayiotidis, Ioannis Amaoutakis, Ioannis Karanikas, Ioannis Kourelis)« Grigoris » Editions
Students experiments in Physics, "Phywe" Edition

EXPERIMENT NR. 82 LORENTZ FORCE

CHAPTER: ELECTRICITY



PROPOSED BY: Comenius College Capelle aan den Ijssel; THE NETHERLANDS

Theoretical aspects:

The Lorentz force is a force on a wire or coil, carrying an electric current, and placed in a magnetic field. Well known applications, where Lorentz forces occur, are the electromotor and the loudspeaker.

For a straight wire, carrying a current and placed in a magnetic field, the Lorentz force follows the equation: $F_L = B \cdot I \cdot \ell$,

In which the following symbols are used:

F_L : *Lorentz force (sometimes called Laplace force) in Newtons*
B : *Magnetic induction in Teslas*
ℓ` : *Length of the wire within the induction field B in meters*
I : *Electric current in Amperes*

In this equation the straight wire has to be placed perpendicular to the fieldlines of the magnetic induction B. F_L is perpendicular to the directions of vectors B and I (the cross product of the B and I vectors). A memorizer to determine the direction of F_L is the left-hand-rule as shown in figure 1. (Catch B in the palm of the left hand, point the fingers in the direction of the electric current I and the thumb will show the direction of F_L.)

The aim of this experiment is to derive the equation $F_L = B \cdot I \cdot \ell$ from measurements of F_L, for different values of B, I, and ℓ.

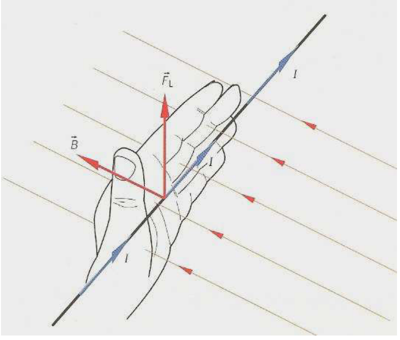


Fig 1

Materials, apparatus:

Power supply, DC, 0 - 12 V, 0 - 3 A
Straight conductors of different lengths
Ammeter
Magnet holder for 1 – 5 magnets
Electric balance
Power slide potentiometer
See fig. 2

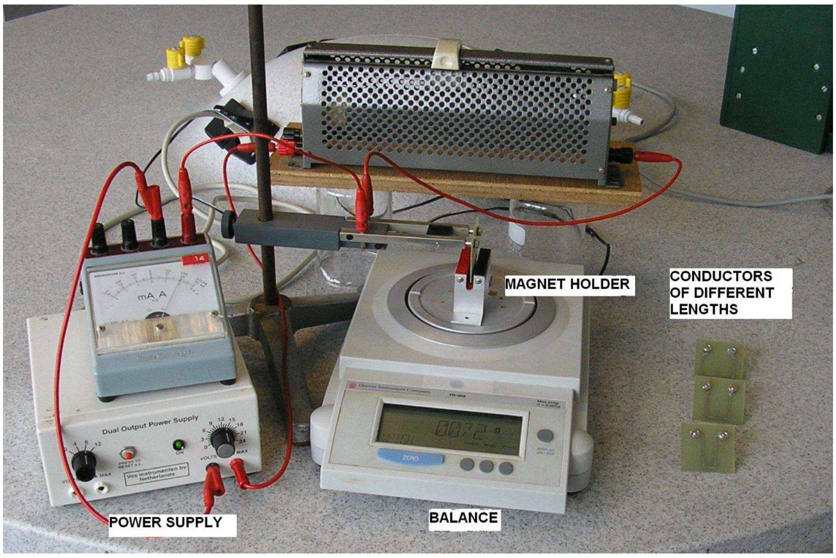


Fig 2

Experimental procedure:

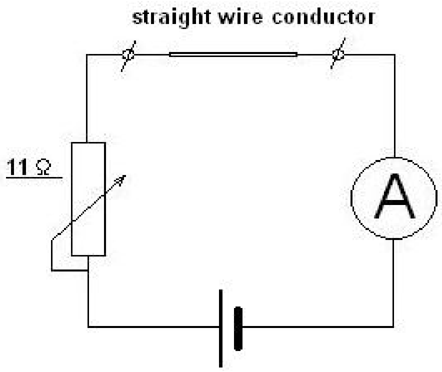


Fig 3

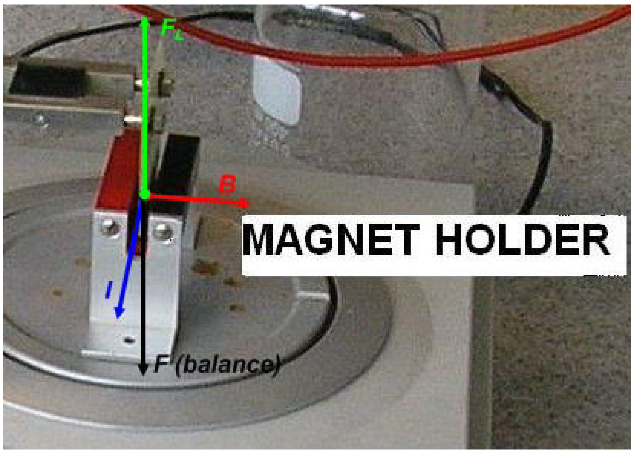


Fig 4

With the electric circuit as shown in fig 3, the current through the conductor can be set with the potentiometer. The conductor has to be placed exactly in the middle of the magnetic field. This causes a Lorentz force on the conductor in upward direction. At the same time an equal force on the magnets in the magnet holder will work in downward direction on the balance, according to the 3rd law of Newton. See fig 4. The balance shows different mass values when the current through the conductor is switched on or off. This difference, Δm, is caused by the Lorentz force. The Lorentz force can be calculated now by $F_L = \Delta m \cdot 9{,}81$. (m in kg !!).

Tasks:

Part A. The relation of F_L and B:

1. Use the conductor with length of 4,0 cm and set a current of 2,0 A.
2. B can be varied by placing different numbers of magnets in the magnet holder. Start with 1 magnet, read the mass values on the balance and calculate F_L .
3. Add 1 magnet (with the dotted north pole in the same direction) and repeat the measurement. Use Table 1 to fill in the results.
4. Repeat 3. until all 5 magnets are in place.

Part B. The relation of F_L and I:

5. Place 3 magnets in the holder, use a conductor of 4,0 cm.
6. Vary the electric current from 0 A until 2,5 A with steps of 0,5 A. Read the mass values as in part A and fill in Table 2.

Part C. The relation of F_L and ℓ:

7. Use 5 magnets and a current of 2,0 A.
8. Measure F_L for all the different conductors. Fill in Table 3.

Data collection:

Table 1

I = 2,0 A ; ℓ = 4,0 cm			
n (=number of magnets)	Δm (g)	F_L (N)	F_L / n (N)
0			
1			
2			
3			
4			
5			

Table 2

$n = 3$ magnets ; $\ell = 4{,}0$ cm			
I (A)	Δm (g)	F_L (N)	F_L / I (N/A)
0			
0,5			
1,0			
1,5			
2,0			
2,5			

Table 3

$n = 5$ magnets ; $I = 2$ A			
ℓ (cm)	Δm (g)	F_L (N)	F_L / ℓ (N/m)
0			
1			
2			
3			
4			

Interpreting the results

1. Calculate the values of F_L / n and fill in the last column of table 1, do the same for the values F_L / I (Table 2) and F_L / ℓ (Table 3)
2. Make graphs of the measurements:
   a. F_L versus the number of magnets n, as measured in part A.
   b. F_L versus the electric current **I**, as measured in part B.
   c. F_L versus the length ℓ, as measured in part C.

3. Conclusions:
   a. What is the relation between F_L and n?
   b. What does this mean for the relation of F_L and B?
   c. What is the relation between F_L and I?
   d. What is the relation between F_L and ℓ?
   e. Derive one formula from a, b and c.

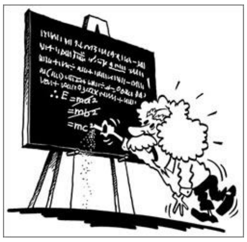
Explanation and conclusions:

Do your conclusions match with the equation $F_L = B \cdot I \cdot \ell$? If not, mention the sources of error.

References:

1. Natuurkunde Overal Havo NT3, ISBN 9789011044142
2. Wikipedia, http://en.wikipedia.org/wiki/Lorentz_force

EXPERIMENT NR. 83 COMPARED USE OF A RHEOSTAT AND A POTENTIOMETER



CHAPTER: Electricity

PROPOSED BY: General Gymnasium Vassiliadis Private School, Thessaloniki, GREECE.

Theoretical aspects:

In various electric circuits, there are times when the voltage change is necessary. It is during that time when the potentiometer is used. The potentiometer functions as a volume control in audio amplifiers, also used in television to control picture brightness, contrast and color response among other uses. (Figure 1)

However, when the current intensity changing value (I) is required, we use the rheostat. Rheostats are widely used, for such purposes, as controlling the speed of electric motors and diminishing lights (Figure 2)

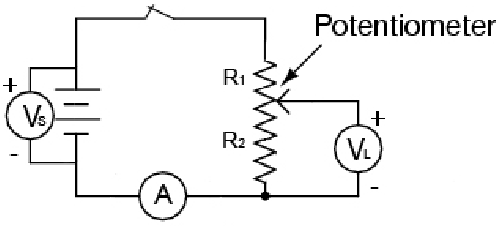


Figure 1

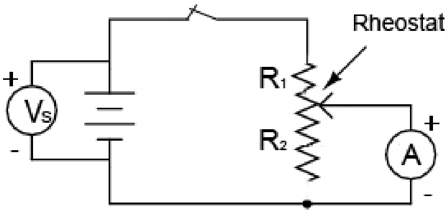


Figure 2

Materials, apparatus:

- cables
- a lamp
- two voltmeters
- one ammeter
- power supply DC (electric source DC)
- a potentiometer and a rheostat

Safety precautions:

While connecting the different parts of the electric circuit, we should bear in mind that it **MUST NOT** be joined with the voltage supply. Moreover, small voltage values should be used from 3 Volt to 9 Volt, if possible.

Experimental procedure:

POTENTIOMETER

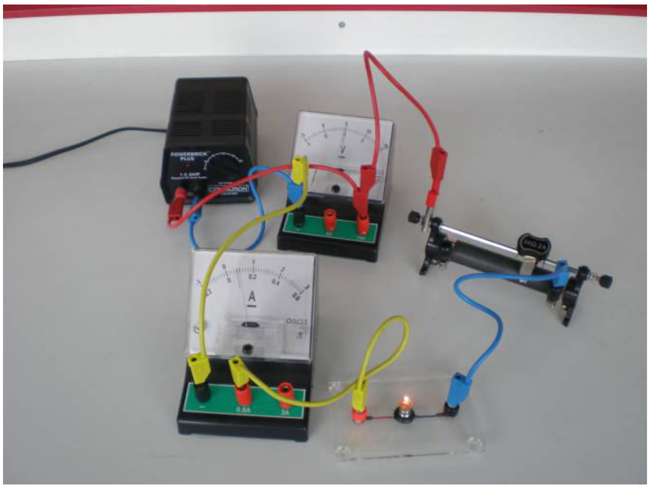
While connecting the lamp to the edges B and C of the circuit, we join the lamp with the voltmeter in parallel. In turn, the system voltmeter-lamp is connected to the edges of the potentiometer as indicated in picture 1. Next, we connect the source of continuous current, through the ammeter and the switch, with the potentiometer. At the edges of the source, a second voltmeter is joined. By supplying the circuit with power, the lamp turns on, and records various indications into the two voltmeters and the ammeter (Table 1) regarding the different positions of the driver.

RHEOSTAT

We join the lamp to the points D and E of the circuit and then in sequence we connect the ammeter. The system is connected to the rheostat as indicated in picture 2. Then, we join the source (DC), through the switch, with the circuit we have created. By moving the driver we record the indications of the ammeter and the voltmeter (Table 2) regarding the different positions of the driver.

Images of the apparatus or how it is conducted

1



Data collection:

POTENTIOMETER				
Experimental values				
	position of the driver	V_S	V_L	A
1				
2				
3				
4				

Table 1

RHEOSTAT			
Experimental values			
	position of the driver	V_S	A
1			
2			
3			
4			

Table 2

Indicate the sources of errors and determining errors

Errors caused by the experimenter are

- Reading out the indications on the instruments (voltmeter, ammeter)

Errors during measurements are

- Low precision of the indication of the instruments
- Imprecision of the indications
- Through the recorded values of the resistance being used in relation with their real values which can be measured with a multimeter with quite good precision.

Errors caused by the method of calculation are

- Internal resistance of instruments (voltmeter, ammeter)
- Increase of temperature of the lamp resistance
- Resistance of the cables used for connection.

Interpreting the results

In table 1, we notice that the voltage at the edges of the switch is in proportion with the length of the resistance (R_2)

In table 2, we notice that the electric intensity, which flows through the switch, is in inverse proportion with the length of the resistance (R_1)

Explanation and conclusions:

In the potentiometer, the voltage V_L is different to the voltage of the supply source V_S and almost equal to $V_L= (R_2/R_1+R_2)V_S$ where $R_1+R_2=$ constant. In the rheostat, the intensity (I) required is almost equal to $I=V_S/R_1$.

Due to the fact that the resistance R_2 with the potentiometer and the resistance R_1 with the rheostat are in proportion to their length in the experiment, we conclude that by changing the position of the driver, the values of V and I change as well.

References:

1. https://en.wikipedia.org/wiki/Potentiometer#Rheostat
2. www.allaboutcircuits.com
3. The Columbia encyclopaedia (sixth edition)

EXPERIMENT NR. 92 MEASURE OF TEMPERATURE

CHAPTER : Physique, Physics, Thermics, concept of temperature

PROPOSED BY: L.P. «La Closerie», Saint Quai Portrieux, FRANCE

Theoretical aspects:

Manufacturing of a thermometer using the property of liquids to expand when heated.

Various approaches:

The problem is to find the good liquid. Mercury is ideal but the pupils are not authorized any more to handle it. Water is difficult to implement because the level is difficult to measure when it approaches 100°C and too much evaporates at that tempetature. Measures are also difficult at 0°C when water tends to freeze. Coloured alcohol remains a good choice as it is cheap and does not solidify at 0°C, still it cannot be used at 100°C, it is thus necessary to use a secondary thermometer …

Materials:

- Coloured alcohol,
- Thermometer,
- Melting ice,
- Thermoscope, which can be replaced by a balloon closed by a stopper itself crossed by a small fine tube.

Precautions:

No particular precautions.

Experimental procedure, individual tasks:

Place the thermoscope in a container with melting ice. After stabilization, note the position of the alcohol level. Then place the thermoscope in a container with water at approximately 60°C. Also place a thermometer in that container. After stabilization, note the level of the liquid in the tube and the temperature T indicated by the thermometer.
Mark the two references on a sheet of paper and divide the interval corresponding into T equal spaces.
Place this graduation on the thermoscope respecting the initial marks

Possible sources of mistakes:

1) The fine part of the thermoscope is not at the same temperature as the balloon.
2) It is not easy to note finely the levels on the tube.
4) The division of the interval T is difficults.
5) This method is a little more precise and faster than with the balloon unit/stopper/tube but it requires to fill the thermoscopes beforehand which is long and difficult for the students

EXPERIMENT NR. 94 DENSITY MEASUREMENT OF LIQUIDS AND SOLIDS

CHAPTER: Thermodynamics

PROPOSED: General Gymnasium Vassiliadis Private School; Thessaloniki, GREECE.

Theoretical aspects:

To figure out if a material has a higher or lower density from another, we have to calculate the masses of two equal volumes of these materials. This way, we get the definition for density: Density is the mass of a volume unit of an object.
In order to calculate this we use the equation: d=m/v.
Where m is the mass of an object and v is its volume. The units of density that are usually used are kg/m3 and g/cm3.

Different approaches:

The density of liquids can be measured by using a device called densitometer.

Materials, apparatus:

- volumetric cylinder
- weighing scale
- water/ olive oil/ plasticine

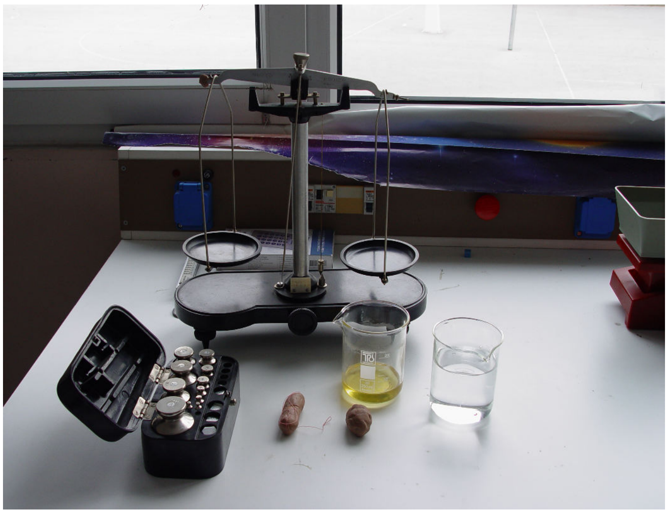
Safety precautions:

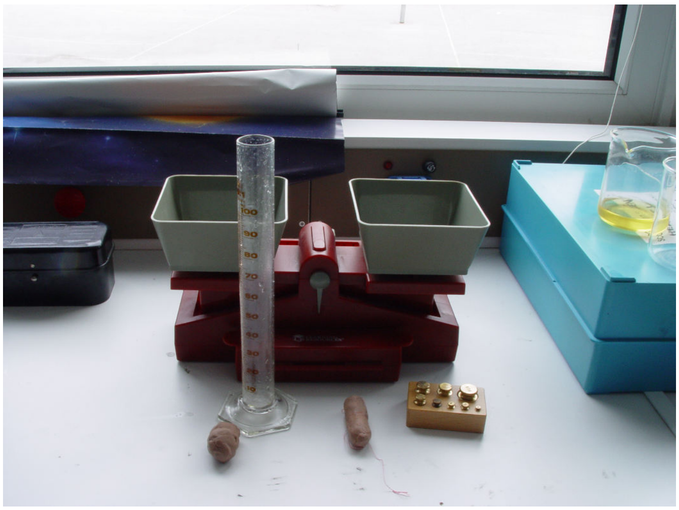
None.

Experimental procedure:

First, we weigh the volumetric cylinder on the scale. Then, we fill the volumetric cylinder with water and we keep record of its volume. We weigh the volumetric cylinder which is filled with water and we calculate the mass of the water by subtracting the mass of the volumetric cylinder from the total mass. So, we get the density of water from the equation: d=m/v.
We repeat the same procedure with the oil.
Following that, we weigh a piece of plasticine and we measure the volume of the plasticine. We put water inside the volumetric cylinder and we write down its volume. Then, we put the plasticine in it, being careful not to spill any water and we write down the new volume. From the final value we subtract the initial one and we get the volume of the plasticine.
So, we get the density of plasticine from the equation: d=m/v.

Images of the apparatus or how it is conducted





Data collection:

Materials	Mass	Volume	Density
Volumetric cylinder			
Water			
Oil			
Plasticine			

Indicate the sources of errors and determining errors

The minor deviations that may appear on the experimental values and the real values lie on the possibility of a potential error that may occur while measuring the mass using the scale.

Explanation and conclusions:

From the experimental results we get the conclusion that the density of a material is proportional to its mass and inverse to its volume.

References:

1. Laboratory manual (Antoniou Nikolaos, Dimitriadis Panagiotis, Papamixalis Konstantinos, Papatsimpa Lambrini).

EXPERIMENT NR. 95 DETERMINING THE SUPERFICIAL TENSION COEFFICIENT (THE DROP METHOD)

CHAPTER: MOLECULAR PHYSICS

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU", Şimleu Silvaniei, ROMANIA

Theoretical aspects:

On the free surface of the liquid are acting, superficial tension forces, that have like effect shredding of the free surface of the liquid.

The drops of liquid take a spherical form, because for a given volume, the spherical surface is minimal.

From the superficial tension force F = σ * l , where σ*l is the length of the shape of the sphere, equal with the length of the equatorial circle, that is deduced by the coefficient of superficial tension : σ

$$\sigma = \frac{F}{l} = \frac{F}{2\pi r}$$

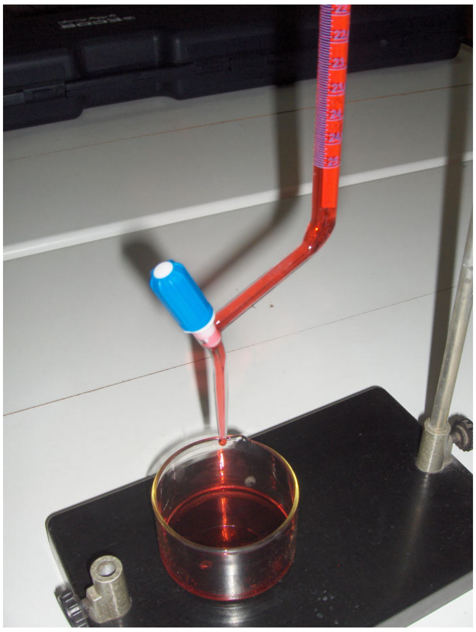
For measuring of the superficial tension force the drops method it's used.

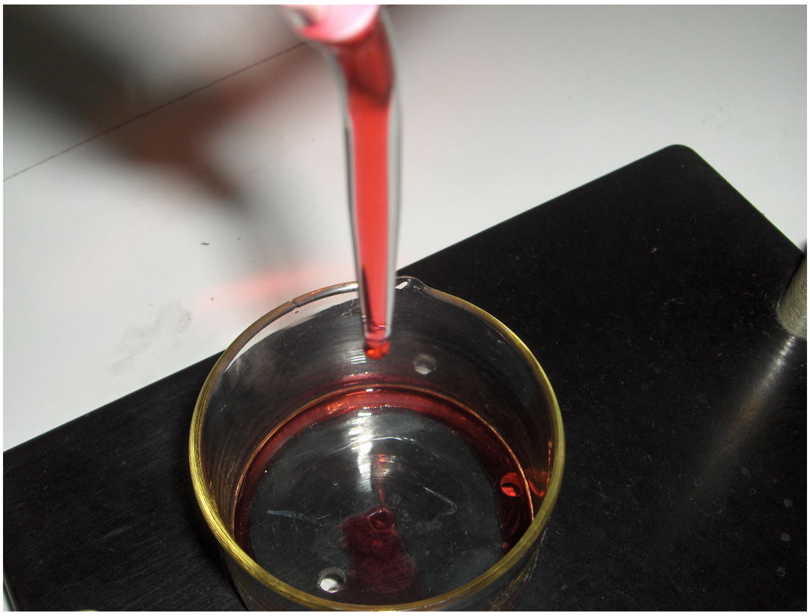
Materials, apparatus:

- burette;
- colored liquid;
- glass;

Safety precautions:

The students are made aware that they must obey the general protection rules applicable when using chemical glassware and different substances. In general the method is used for harmless substances like colored water.





Experimental procedure:

- the diameter of the burette it's measured with the liner (D)
- the drops of liquid are numbered from a volume of 1-2 ml liquid from the burette (N)
- the condition of hatching from the drop it's imposed

$$G_1=F_\sigma$$

- the superficial tension coefficient it is calculated:

$$G_1=\frac{\rho V g}{N}$$

$$F_\sigma=\sigma 2\pi r=\sigma\pi D$$

$$\sigma=\frac{\rho V g}{\pi N D}$$

Data collection:

Nr. det.	D (m)	V (m^3)	N	ρ (kg/m^3)	σ (N/m)	σ med.
1.						
2.						
3.						

Indicate the sources of errors

Errors due to the experimenter:

- errors in reading the divisions of the burette
- errors in measuring the diameter of the burette
- g is approximated

Interpreting the results

The results are very close to the values founded in different charts.

Explanation and conclusions:

The method used is called the *stalagnometric method*.

References:

1 Manual de Fizica, cls. a XI-a, N. Gherbanovschi, editura Niculescu, 2004
2 Manual de Fizica cls. a XI-a O. Rusu , editura ALL, 2004

EXPERMENT NR. 104 DETERMINING THE SPECIFIC HEAT CAPACITY OF A MATERIAL

CHAPTER: THERMODINAMICS

PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU" ; Şimleu Silvaniei, ROMANIA

Theoretical aspects:

In a calorimeter that contains a quantity m_l of water, initially at the temperature t_1, is introduced a solid object with the mass m_2 and the temperature $t_2>t_1$. The object will give up heat to the water and the calorimeter, respecting the calorimetric equation:

$m_2c_x(t_2-\theta)=(k+m_1c_1)(\theta-t_1)$; $c_x=(k+m_1c_1)(\theta-t_1)/m_2(t_2-\theta)$ (1)

where k is the heat capacity of the calorimeter.

Materials, apparatus:

Calorimeter and accessories (thermometer with divisions of 1/10 ˚C), electronic balance, vessel with water to heat the solid object, heat source, the object that is under study, water, stirring stick (wand)

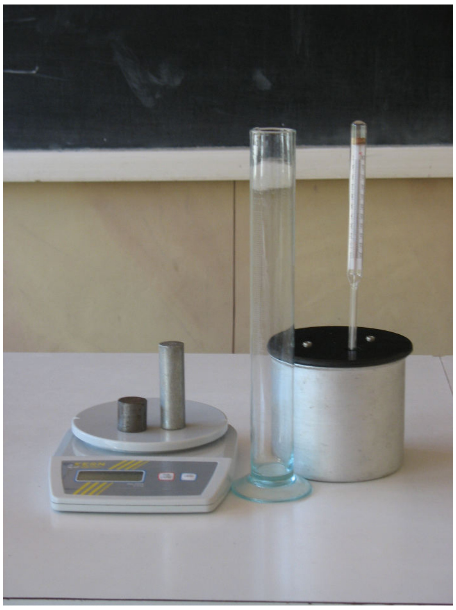
Safety precautions:

There is no need for safety precautions.

Experimental procedure:

The change of heat is produced between the water, the calorimeter and the solid object that is studied.
We measure the balance temperature θ and we calculate the specific heat capacity c_x.

Images of the apparatus or how it is conducted



Individual tasks:

We measure the weight of the calorimeter m and we determine its heat capacity $k=mc_{Al}$ (c_{Al}=895 J/KgK).
We weight the object that is studied and we write down the results in the table.
We measure a quantity m_l of water and we introduce it in the calorimeter. After the system is balanced, we measure the balance temperature of the water and calorimeter t_l and we write it in the table.
We submerge the object in the vessel in which it will be heated, and we measure it.
We introduce the heated object in the calorimeter and we observe the increase of the temperature until the temperature stops rising. At this moment the system is balanced, and the balance temperature is measured and wrote down in the table.
We determine the specific heat of the body using the formula obtained at the first point(1).
We repeat the experience several times.

Data collection:

Nr. det	m (g)	m_l (g)	t_l (grade Celsius)	t_2 (grade Celsius)	Θ (grade Celsius)	c_x (J/Kg grad)	$c_{average}$ (J/g Kgrad)
1							
2							
3							

Indicate the sources of errors

Errors done by the experimenter

- the subjective determination of the balance temperature.
- errors in reading the temperatures
- approximated calculation

Errors due to the imprecision of the apparatus:

- the low precision of the thermometer.
- the imprecision of electronic balance

Errors due to the imprecision of the method

- we have neglected the heat changes between the calorimeter and the environment.

Interpreting the results

The method is not very precise because the calorimeter is not perfectly insulated but also because of the subjectivity when determining the thermal balance.

References:

1. Panaitoiu, L., Chelu, I., *Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972
2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995
3. http://www.olimpiade.ro
4. http://www.didactic.ro

EXPERIMENT NR. 105 HEAT CAPACITY OF A CALORIMETER

CHAPTER:THERMODYNAMICS

PROPOSED BY: Comenius College, Capelle aan den Ijssel, THE NETHERLANDS

Theoretical aspects:

The aim of this experiment is to determinate the heat capacity of a calorimeter with accessories and the specific heat of water.

The used formulas are:
$Q = C_{cal} \cdot \Delta T$
Q : absorbed thermal energy (J)
C_{cal} : heat capacity of the calorimeter (J / K or J / ^{0}C)
ΔT: increase of the temperature (K or ^{0}C)

C (m kg of a substance) = $c_{substance} \cdot m$
c : specific heat of a substance (J/kg.K or J/kg.^{0}C)
m : mass (kg)

$Q = P \cdot \Delta t$
Q : thermal energy, produced by a heater (J)
P : power of the heater (W)
Δt : time of heat production by the heater (s)

Materials, apparatus:

See fig 1:

- A calorimeter, thermometer, stirring stick
- A balance
- A stopwatch

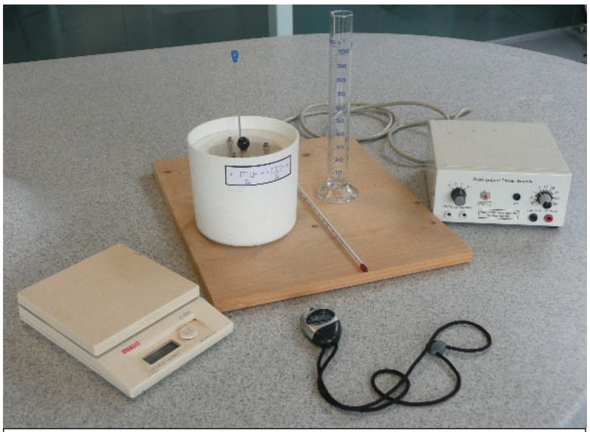


fig 1

Safety precautions:

Do not switch the heater on if the calorimeter is empty.

Experimental procedure:

At first the calorimeter is heated with 150 g water, secondly with 250 g during 6,0 minutes. The heat capacity of the calorimeter and the specific heat of water will be calculated from the difference in temperature increase between the two measurements.

Individual tasks:

1, Fill the calorimeter with 150 g water. Measure the temperature. During 6,0 minutes the water is heated. The temperature must be read every 60 seconds. Therefore switch the heater every 60 seconds off and stir the water. Measure the temperature (in 0,1 ^{0}C) as soon the temperature remains stable. Fill in table 1, column 2.

2. Repeat this measurement series with 250 g water in the calorimeter. Fill in table 1, column 3.

3. Read the power of the heater (in Watt). See fig 2. Fill in table 1.

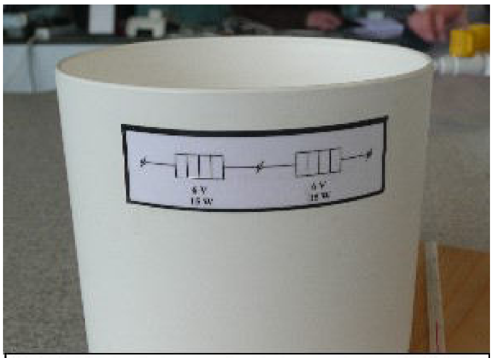


fig 2

Data collection:

Table 1

P = W			
t (s)	T_1 (^{0}C)	T_2 (^{0}C)	Q_{heater} (J)
0			0,0
60			
120			
180			
240			
300			
360			

Interpreting the results

1. Calculate the thermal energy Q (in J) produced by the heater. Fill in table 1 (column 4).
2. Make a diagram with Q (J) horizontal and T_1 (^{0}C) and T_2 (^{0}C) vertical. Draw the two curves in one diagram.
3. Calculate the inclination $\Delta Q/\Delta T$ of both curves. The heat capacity of the calorimeter with 150 g water $C_1 = \Delta Q/\Delta T_1$, and the heat capacity with 250 g water $C_2 = \Delta Q/\Delta T_2$.
4. Then $C_2 - C_1$ will be the heat capacity of 100 g water
   → the specific heat c_{water} (in J/kg.^{0}C) = $10 \cdot (C_2 - C_1)$.
5. The heat capacity of the calorimeter can be calculated with:
   $C_{cal} = (C_1 - c_{water} \cdot 0{,}15)$,
   or with
   $C_{cal} = (C_2 - c_{water} \cdot 0{,}25)$

EXPERIMENT NR. 106 FUNDAMENTAL EQUATION OF CALORIMETRY Q=M·C·ΔΘ

CHAPTER: Thermodynamics

PROPOSED: General Gymnasium Vassiliadis Private School; Thessaloniki, GREECE.

Theoretical aspects:

We already know that when we heat a material, its temperature rises (Δθ). This rise is proportional to the mass (m) of the material, as well as to the specific heat of the material (c), which is its particular feature. The equation that relates these quantities is the fundamental equation of calorimetry.

Materials, apparatus:

- 3 volumetric cylinders
- 1 electric Hob
- 1 thermometer
- 1 scale with articulated arms
- 1 stirrer
- water
- Oil
- Antithermic gloves
- Antithermic cloth
- Absorbent paper

Safety precautions:

During the heating procedure of the materials, when touching the devices we should **ALWAYS** wear antithermic gloves, to avoid burnings. Also, we should be cautious so that the liquids that are heated do not reach boiling point.

Experimental procedure:

When the amount of heat_which is emitted per second from the source of heat is constant, the amount of heat is proportional to the time of its emission. Such a source of heat is the electric hob. This way, we can measure the heat which is transmitted to the heated material by the time (Δt) that lasts its heating procedure. To verify the equation Q=m·c·Δθ we have three different experiments.

Experiment 1 Relationship **(Q-Δθ)**

We put 200gr of water in a boiling vessel and we put this vessel on the heating source which has been regulated so as the heat flow is low. When the thermometer that we have put in the water reaches a temperature indication of 30°C .We put the chronometer in use and we fill in the first line of the table (1) with the time and temperature measurements and its changes. We stop recording the indications when the temperature reaches 90°C and simultaneously we cut off the heat rate of flow.

Experiment **2** Relationship **(Q-m)**

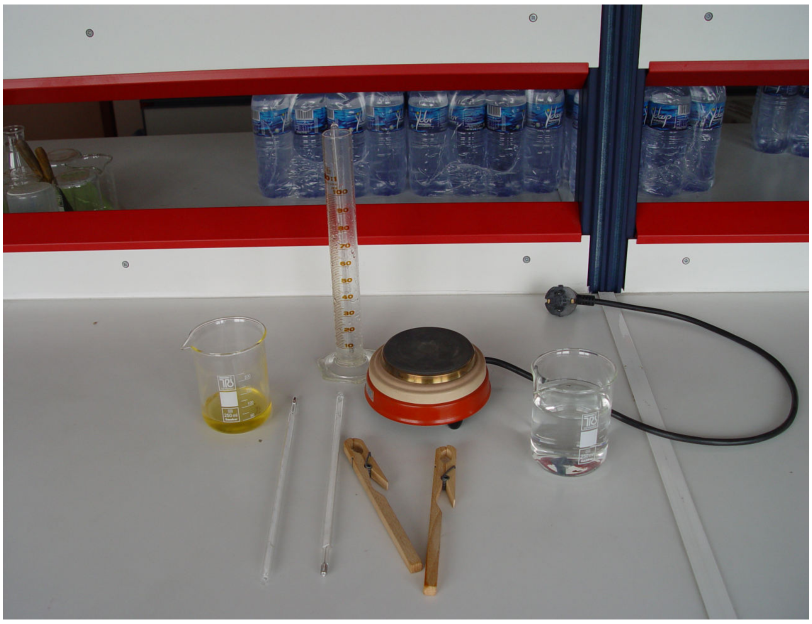
In three identical volumetric cylinders (which we call K1, K2, K3) we put 100gr of water in K1, 200 gr in K2 and 300gr.

We put K1 on a heated electric hob. Using the chronometer we measure the time needed to change the temperature of water from 20°C to 40° ($\Delta\theta=20°$).We repeat the same procedure for cylinders K2 and K3. We complete table 2 with these measurements.

Experiment **3** Relationship **(Q-c)**

In two identical volumetric cylinders, we put 100gr of water in the first one and 100gr in the second.We put the first one with the water on the heated electric hob. Using the chronometer we measure the time needed to change the temperature of water from 30°C to 60° ($\Delta\theta=30°$).We repeat the same procedure for the oil cylinder. We complete table 3 with these measurements.

Images of the apparatus or how it is conducted



Data collection:

Relationship **(Q-Δθ)**		
t (min)	θ (^{0}C)	Δθ (^{0}C)

Relationship **(Q-m)**	
m (g)	t (min)

Relationship **(Q-c)**	
Material	t (min)
Water	
Oil	

Indicate the sources of errors and determining errors

The errors that occur during the measurements are:

- false reading of the indications on the chronometer, thermometer
- low sensitivity of the scale measuring the mass of materials

Errors on the method of calculation

- Loss of heat in the environment
- part of the heat is absorbed by the volumetric cylinders

Interpreting the results

In table (1) we notice that heat (Q) is proportional to the change of temperature (Δθ). In table (2), we notice that the heat (Q) is proportional to the mass of the material (m).
In table (3), we notice that the heat (Q) is dependent on specific heat (C) of each material.

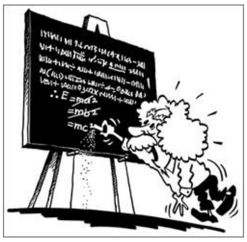
Explanation and conclusions:

From the above experimental procedures we draw the conclusion that the change in temperature of a material is proportional to the quantity of heat (Q) which was given, and is inverse to the mass(m) and the specific heat (C)

References:

1. Laboratory manual (Antoniou Nikolaos, Dimitriadis Panagiotis, Papamixalis Constantinos, Papatsimpa Lambrini).

EXPERIMENT NR. 108 SIMULATION OF RADIOACTIVE DECAY



CHAPTER: ATOMIC AND NUCLEAR PHYSICS

PROPOSED BY: Comenius College
Capelle a/d IJssel, THE NETHERLANDS

Theoretical aspects:

Radioactive decay is a random process. Every instable atom has a 50% chance to decay within the so called half-life $t_{1/2}$. In that case emission of α, β or γ radiation occurs. Different radioactive isotopes differ much in half-life: ^{14}C, for example, has a half-life of 5730 years, ^{123}I has 13,3 hours, and ^{218}Rn only $1{,}9 \cdot 10^{-3}$ s. The radiation of a radioactive source can damage structures, like the DNA in human cells. This causes illness. Radiation, on the other hand, can also be used to diagnose or treat of diseases.
The symbol to indicate radioactive material is shown in fig 1.

In this experiment, we assume a decayed atom to be stable, which, in reality, is not always true. The decay of a radio-active source may be simulated by playing dice. Each throw is comparable with an instable atom. After throwing the die, it can be "odd" (1, 3 or 5) or "even" (2, 4 or 6). "Even" means: the atom has decayed.

Fig 1

Materials:

Dice.

Fig 2

Experimental procedure and tasks:

1. Half-life1: Throw 100 times, using one or more dice. Each throw represents one instable atom. Fill in the table the numbers of atoms that are decayed and not-decayed.
2. Next period: Throw the dice as many times as the number of atoms that did not decay in the previous period. Fill in the table.

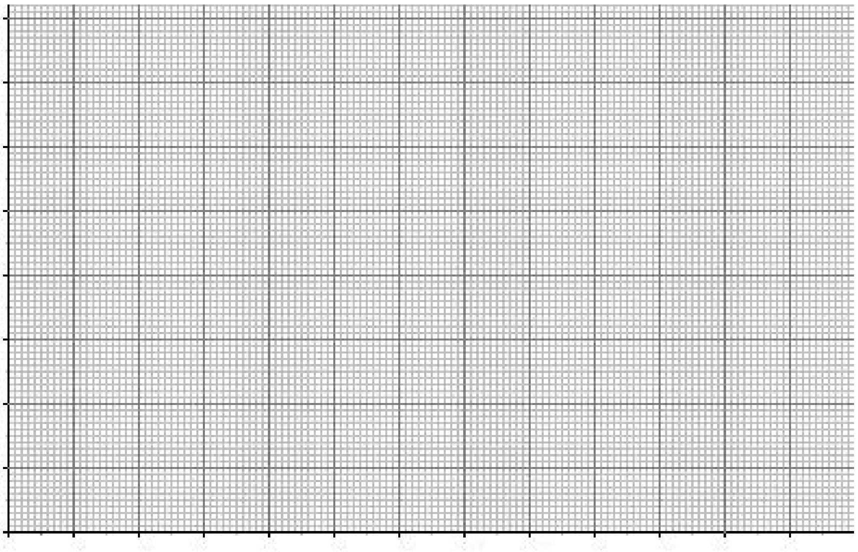
3. Repeat task 2 until all atoms are decayed.

Data collection:

Period	# Decayed	# Not decayed	% decayed in this period	% decayed since the beginning of period 1
1				
2				
3				
4				
5				
6				
7				
8				
9				

Interpreting the results

1. What is the meaning of the result "odd" after a throw?
2. Make a graph. Place the periods on the horizontal axis, against the number of instable atoms at the beginning of each period on the vertical axis.
3. Can you predict if a chosen atom will decay or not in a period?
4. Can you predict the shape of the graph?
5. In case atoms have a smaller chance to decay, how do you adapt the simulation?



References:

1. Natuurkunde Overal havo NG/NT1, ISBN 9011040961
2. http://en.wikipedia.org/wiki/Radioactive_decay

EXPERIMENT NR. 112 THE DETERMINATION OF THE LENGTH OF THE DETERGENT MOLECULE

CHAPTER: MOLECULAR PHYSICS

PROPOSED BY: COLEGIUL NATIONAL "SIMION BĂRNUŢIU" Şimleu Silvaniei, ROMANIA

Theoretical aspects:

Starting with a detergent solution of concentration 20%, we will dilute it till 0, 05 %. At this concentration, at the fall of one drop on the surface of the water, the molecules will form a monomolecular spot, considered circular.

Different approaches:

Knowing the volume of one drop of diluted solution and its concentration, we can determine the volume of detergent in one drop.

$c/100 = V_{detergent} / V_{drop} \Rightarrow V_{detergent} = c\, V_{drop} / 100.$

Because of the monomolecular layer and because the molecules are considered cubes, the thickness of the spot represents the length of the detergent molecule. Knowing the volume of detergent and the surface of the spot, the length is easy to calculate.

$V_{detergent} = l\, S$, where $S = \pi D^2/4$ and D is the diameter.

$\Rightarrow l = V_{detergent}/S \quad \Rightarrow \quad l = 4c\, V_{drop} / 100\, \pi D^2$, c is the concentration of the solution.

Materials, apparatus:

2 vessels filled with a known volume of water, detergent of 20% concentration, gradated syringe, measuring rule, pepper.

Safety precautions:

There is no need for safety precautions.

Experimental procedure:

To obtain results, as accurate as possible, is recommended to wash very well the vessels before you repeat the experiment. Also, the pepper must be spread evenly all over the surface of the water in order to see better the formed spot. For a circular spot it is better to use chalk dust instead of pepper, but the spot is not so visible (picture from the right)

Images of the apparatus or how it is conducted

Individual tasks:

Using the graded syringe, we pour the exact amount of detergent solution in one vessel in order to obtain the more diluted solution. With the same syringe, we count how many drops of 0,05% solution are in 1 ml. We do this operation several times to obtain a more accurate number, and therefore, a more accurate volume of one drop. We spread evenly the pepper all over the surface of the water, and we let fall only one drop of solution. With the measuring rule we determine the diameter of the spot.

Data collection:

Number of determination	D (cm)	l (nm)	$l_{avearge}$ (nm)	Δl (nm)	$\Delta l_{average}$ (nm)	$\varepsilon_{average}$ (nm)

$l=4c\ V_{drop}/\ 100\ \pi D^2$

$l_{avearge}=\ (l_1+\ l_2+\ l_3+......+\ l_n)/\ n$, where n is the total number of determinations, and l_n is the obtained value.

$\Delta l=|\ l_{avearge}-\ l\ |$, Δl is the absolute error

$\varepsilon_{average}=\ \Delta l_{average}/\ l_{avearge}$, ε is the relative error

Indicate the sources of errors

The sources of errors are:

- The molecules do not form an exactly monomolecular layer
- The molecules are not cubes and they are not all the same length.
- The obtained spot is not exactly circular
- The measuring rule cannot be brought very close to the spot, and therefore the measured diameter is not very accurate.
- The volume of the drops varies
- The concentration is not exactly of 0, 05% because the syringe is not completely emptied.

The errors are calculated in the table above

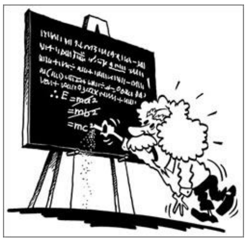
Interpreting the results

The experiment presented here is not very accurate due to the many approximations needed in order to make this experiment practical. It is more important for the particular method in which is determined the length of the detergent molecules.

References:

1. Panaitoiu, L.,Chelu, I.,*Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972
2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995
3. http://www.olimpiade.ro
4. http://www.didactic.ro

EXPERIMENT NR. 113 DETERMINING THE DENSITY OF AN OBJECT WITH AN IRREGULAR SHAPE



CHAPTER: MECHANICS

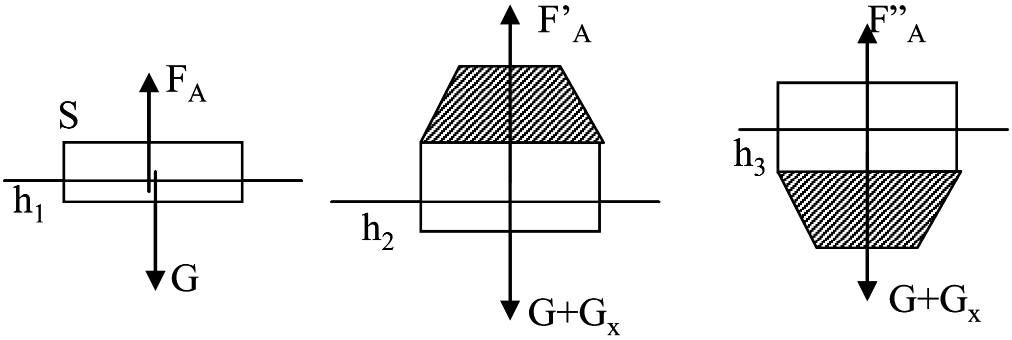
PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU" ; Şimleu Silvaniei, ROMANIA

Theoretical aspects:

The task is to determine the density of an object with irregular shape using a regular shaped object (a sealed box) that can assure the buoyancy of both objects tied together. The next cases have to be analyzed:

- the floating of the box
- the floating of the two objects tied up, the box under the object that is studied
- the floating of the two objects tied up, the box above the object that is studied

Using the balance equations in each case, the density of the object studied



$G = F_A \Rightarrow\ m = \rho_a S h_1$, where m is the mass of the regular shaped object

$G + G_x = F'_A$; $mg + m_x g = \rho_a S h_2 g$; $\rho_a S h_1 + m_x = \rho_a S h_2 g$; $m_x = \rho_a S(h_2 - h_1)$, where m_x is the mass of the irregular shaped object

$G + G_x = F''_A$; $mg + m_x g = \rho_a S h_3 g + \rho_a V_x g$; $\rho_a S h_1 + \rho_a S(h_2 - h_1) = \rho_a S h_3 + \rho_a V_x$; $V_x = S(h_2 - h_3)$, where V_x *is the volume of the irregular shaped object*

$$\rho_x = \rho_a \frac{h_2 - h_1}{h_2 - h_3}$$, where ρ_x is the density unknown

Different approaches:

Try to find another way to solve this problem.

Materials, apparatus:

An irregular shaped object, a cylindrical box, connection elements (elastic wires), a deep water vessel, a measuring rule, pencil.

Safety precautions:

There is no need for special precaution measures.

Individual tasks:

First, we submerge in water only the box. With the pencil, we mark on the box the level of the water. With the measuring rule we determine h_1, the level of the water.
We tie the two objects together. We submerge them, first with the box under the object studied, the last one remaining in the air. We mark with the pencil the level of the water and with the measuring rule we determine h_2.
We repeat the process, but this time the box is over the object. We determine h_3.
The chart below is filled with the obtained data.

Data collection:

Nr crt	h_1 (cm)	h_2 (cm)	h_3 (cm)	ρ_x (kg/m^3)	$\rho_{x\ average}$ (kg/m^3)	$\Delta\rho_x$ (kg/m^3)	$\Delta\rho_{x\ average}$ (kg/m^3)	$\varepsilon_{average}$ (kg/m^3)

Indicate the sources of errors and determining errors

Errors due to the experimenter:
- imprecision in marking the level of the water

Errors due to the imprecision of the apparatus:
- the imprecision of the measuring rule

Errors due to the imprecision of the method:
- the water is considered pure
- we have neglected the mass and volume of the connection elements

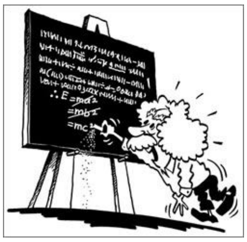
Interpreting the results

Though the physic principles on which this method relies on are very simple, it allows us to determine quite accurately the density of the irregularly shaped object.

References:

1. Panaitoiu, L., Chelu, I.,*Lucrari experimentale de fizica pentru liceu,* Ed Didactica si Pedagogica, Bucuresti,1972
2. Corega, C., Marinciuc, M., Andreica, *Probleme si lucrari practice de fizica,* Ed Studium, Cuj-Napoca, 1995
3. http://www.olimpiade.ro
4. http://www.didactic.ro

EXEPERIMENT NR. 114 DETERMINING THE ATMOSPHERIC PRESSURE



CHAPTER: LAWS OF GASES

PROPOSED BY: COLEGIUL TEHNIC "IULIU MANIU"; Şimleu Silvaniei, ROMANIA

Theoretical aspects:

A bottle with a very small hole is filled partially with water. Knowing the air volume in the bottle, we turn it upside down. We wait until the water stops pouring. The air inside the bottle passes through an isothermal transformation. Knowing the quantity of water that poured until the system reached a balance, we can determine the atmospheric pressure p_0 as follows::

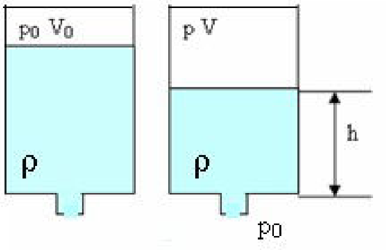
[p

$p_0V_0=pV$ (isotherm transformation);

$p_0 - p= \rho gh$;

$p_0= \rho ghV/ V-V_0$

$p_0= \rho gh(V_0+\Delta V)/ \Delta V$



Different approaches:

Try considering the transformation of the gas as adiabatic. Compare the results. Can you consider the transformation to be a polytrophic one?

Materials, apparatus:

Bottle completely filled with water, 100 ml beaker, measuring glass, measuring ruler.

Safety measures:

There is no need for special precautions.

Experimental:

Do not hurry and do not shake the bottle. Let the water pour by itself. Watch carefully the moment when the water column has balanced.

Images and apparatus

Modus operandi:

The bottle is completely filled with water. We pour 100 ml of water from the bottle in one glass. Now the air volume in the bottle is exactly V_0 =100 ml. We put on the perforated cap, we turn the bottle upside down. The water pours in the measuring glass until a balance is reached. In this moment we measure the level h of the water in the bottle using the measuring rule. Next we measure the water volume in the measuring glass (ΔV). The chart below is filled with the obtained data and then we calculate the value of the atmospheric pressure.

Consider the water density to be 1000 Kg/m^3 and the gravitational constant to be 9.81 m/s^2

Data collection:

Nr crt	h(cm)	ΔV(cm^3)	p_0(Pa)	$p_{0\ average}$(Pa)

Sources of errors:

Errors due to the experimenter:

- the subjective determination of the moment when the system is balanced

Errors due to the precision of the apparatus:

- low precision of the measuring glass
- low precision of the measuring rule

Errors due to the method:

- the transformation of the gas is not perfectly isotherm
- the omission of the Laplace pressure and the superficial effects at the perforation of the cap

Interpreting the results:

The results confirm that the transformation is not perfectly isotherm. This is way the method is not very accurate.

Explanations and conclusions:

Repeating the experience, considering the atmospheric pressure known, the polytrophic constant of air can be determined. The result will be somewhere between 1 and γ=1,4 , closer to one 1 than to the adiabatic constant.

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