SUBJECT: WATER PROPERTIES

For the students

Task 1.

a) Read the text:

A 14-year-old student got the first prize in a competition for scientific research carried out by students.

He asked 50 people to sign an appeal to the state government to forbid the use of the chemical compound "dihydrogen monoxide" because of the following dangerous characteristics it possesses:

– when big quantities of the substance get into the stomach, this causes ample perspiration and vomiting;

– if this substance gets into the respiratory system, this could cause choking and even death;

– when it is in a gaseous state, it has a strong burning effect on the skin;

– it is contained in great quantities in all disease-causing microorganisms, in cancer formations, etc.

The results from the survey that was carried out by the student were quite interesting:

The greatest part of the participants signed the appeal for forbidding the use if the substance; several had no opinion on the matter, and only 1 person figured out that it was all about the water.

A reader of the magazine which had published the survey of the student sent a witty letter to the editorial office:

"I'm amazed at the one-sided position of your respected magazine and I would like to bring back the balance by standing up for the dihydrogen monoxide: …"

b) You have 2 minutes to fill in the reader's text by pointing out as many as possible properties of the water which have a biological significance or practical application.

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c) You have 3 minutes to share your ideas with a partner, to listen to his/her ideas and discuss a joint text. You got 10 minutes to discuss all the texts of the dyads in the group and to together create an intellectual map with key words which point to the listed properties of water.

Note: You can find more information about the „dihydrogen monoxide" joke and for the discussions related to it here: http://www.dhmo.org

Task 2.

You and your group have 30 minutes to suggest ideas for simple experiments which illustrate some of the properties of the water reflected in the intellectual map.

Carry out the experiments using as many of the materials, vessels and chemical agents which you have at your disposal. One material or a vessel can be used more than once.

Note: If you are experiencing difficulties, you could use the "Did you know that…" cards for help.

For the teacher

Objectives (tasks):

• to increase the cognitive interests of the students towards the properties of the water by integrating three aspects of the knowledge about this substance – physical, chemical and biological – into one focus;

• to activate the reflective and creative thinking of the students by creating a problematic situation (a contradiction between available knowledge about the properties of the water and the need of a new structuring of this knowledge in the unfamiliar cognitive situation);

• to update the skills for experimental work by requiring planning an experiment and carrying out experiments with water;

• to update team work skills by requiring team work to resolve the problems.

Expected results:

• interest in the topic and achievement of satisfaction from the cooperation while solving the problems;

• updated and enriched knowledge for the properties of water;

• improved skills for carrying out of a constructive and a cognitive learning experiment;

• updated and improved intellectual, experimental and communicative skills.

Basic methods:

Think-Pair-Share+

Experiment

Necessary materials and chemical agents for one group:

Task 1.

• a work sheet (for each participant in the group)
• a sheet of paper, size A3
• a marker

Task 2.

• 2 test-tubes (a stand is not obligatory);
• 3 beaker glasses (capacity from 25, 50 and 100 ml);
• 2-3 transparent small plastic cups
• 3 glass tubes (length 10-15 cm, diameter 0.2, 0.5 and 1 cm; the sizes of the tubes could be different from these but the first should be very thin and the third should be quite wider than the first one);
• one full and one empty match box;
• a Petri dish;
• a paper clamp;
• a piece of elastic;
• a piece of caramelized sugar (length 2-3 cm, a few millimeters wide);
• a thin piece of soap (length 2-3 cm, a few millimeters wide);
• a cotton piece (band with length of 7-8 cm and 4-5 cm width);
• a glass pencil;
• a piece of paper cut in the shape of a star with at least 5-6 beams and folded as a closed flower (diameter of the unfolded star – 4cm at the most);
• a small glass stick;
• a small metal spoon;
• a small knife;
• 2 small spatulas or 2 small plastic spoons;
• a candle with approximate size of 4-5cm long and 1-2 cm wide;
• a cone-shaped flask (capacity from 100-150 ml);
• an alcohol thermometer (not obligatory);
• a fresh egg which has been dipped in a glass of vinegar for one night so that the shell is dissolved or a red-onion hull (the egg should be put in a plastic cup);
• 3-4 ice cubes;
• a sprinkle with distilled water (water – about 150 ml);
• 5-6 g sugar; 5-6 g NaCl; 5-6 g $CuSO_4.5H_2O$ and 5-6 g $CuSO_4$ (waterless); vegetable oil;
• 5-6 square or circular pieces of filter paper;
• a plastic cup for waste;
• a plastic bath with length of about 20 cm (for some of the experiments to be carried out in).
• envelopes containing cards with interesting facts and drawings (the information in these cards could be used as a way of pointing students to ideas for experiments)

Solution:

• *Fluid water is colorless and transparent, it refracts and reflects light.*

Experiment 1.

a) In a glass, pour some water and put a small spoon or a small glass tube. The effect observed shows that the glass of water is a cylindrical lens. Because of the refraction of light this lens increases the size of the objects horizontally but does not change them vertically.

b) Pour some water in a glass and put a piece of paper behind it; the piece of paper should have a word written on it (for example, "water"). The words which can be seen from the glass of water are significantly wider and thicker in comparison to the words written on the dry piece of paper. If the paper with the text is pulled away from the glass, the images of the words start changing in a surprising way.

c) Fill in a beaker glass with water and put the burning candle in front of the glass at a distance of 5-6 cm; behind the glass, put a sheet of paper in a vertical position as if it is a screen. By moving the sheet of paper, try to find the distance at which the image of the flame is most clear.

Did you know that…

• *The density of the water increases when the temperature decreases to 3,98 ^{o}C, and then it decreases.*

Experiment 2.

In a cup (a transparent plastic cup or a beaker glass), pour some water and put 1-2 ice cubes. Mark the water level with a glass pencil. Make a suggestion about what the level of the water will be after the ice has melted. Measure the level of the water after some time has passed.

Did you know that…

• *The heat capacity of fluid water is greater than that of ice and of water vapour, and in the 0-100 ^{0}C interval, the heat capacity changes a little.*

Experiment 3.

a) Pour water in an empty match box. The bottom of the box is put above the flame of a lit candle. The paper does not catch on fire although it's dry on the outside.

b) A small band of filter paper is dipped into water and then put into the flame of a candle. The paper does not catch on fire until it has dried out.

Did you know that…

• *Fluid water has high surface tension. From all other liquids, only mercury has a higher surface tension.*

Experiment 4.

a) Pour water in a Petri dish. Take a paper clamp and put it gently on a small piece of paper. When the paper gets moistened and falls on the bottom, the clamp stays on the surface.

b) Pour vegetable oil in a Petri dish. Use a pipette to drop a few drops of water over the oil.

Did you know that…

• *Some substances decrease the surface tension of water, and others increase its surface tension*.

Experiment 5.

Pour water in both parts of a Petri dish. Put two matches in each part at a distance of about 1-2 cm from one another. Put a very thin piece of soap between the matches in one part of the Petri dish, and in between the matches in the other part, put a thin piece of caramelized sugar. In the first part you can observe a slight setting apart of the matches, and in the second – they get closer to one another.

• *Fluid water has the ability to "stick" to various materials and to moist them.*

Thanks to its high surface tension and its ability to moist things, water can go up in vertical channels to a height greater than the height allowed by the power of weight. This quality is called *capillarity*.

Experiment 6.

a) Two small glass tubes with different diameters are put into a glass of water. A difference between the heights of the water pillars in the tubes can be observed in comparison to the surface of the water in the glass. The thinner the tube, the higher the water pillar.

b) Water is poured in a Petri dish. Put the paper figure folded in the shape of a flower on the surface of the water. The "flower" gradually unfolds.

c) A 25-milliliter glass is put on a match box. An empty 50-milliliter glass is put right next to it on the counter. Pour water in the smaller glass until half its capacity has been filled. Then, dip one of the ends of a cotton band or bandage. The other end of the band is put in the empty glass so that the band touches the walls of the second glass. The water moves from the smaller glass into the larger one.

• *Water is a good dissolver. The dissolving of the different substances is accompanied with a thermal effect.*

Experiment 7.

Put some **$CuSO_4.10H_2O$** (taken on the edge of the spoon) in a test-tube and then pour some water and stir the test-tube. A negative thermal effect is observed by pressing your fingers to its walls (at the bottom end of the test-tube).

In the second test-tube, add some **$CuSO_4$** (taken on the edge of the spoon) and then add some water and stir the test-tube. After stirring the test-tube, a positive thermal effect can be observed through pressing your fingers to its walls (at the bottom end of the test-tube). The thermal effect can be also established by using an alcohol thermometer.

Attention: If the experiments are carried out by young students, $Na_2SO_4.10H_2O$ and Na_2SO_4 should be used because the Cu^{2+} ions are toxic.

Did you know that…

• *Water solutions, regardless of their composition, can participate in the process of osmosis*.

Experiment 8.

a) Take a part of the soft cover of an egg which has been previously freed from its shell by staying in vinegar for one night. The soft cover will be used as a semi-permeable barrier. A glass tube is closed from one side with this egg cover by using a cicrle elastic band. In the glass tube, 3-4 ml of concentrated sugar or salt solution is then poured. The level of the solution is marked with a glass pencil. The glass tube is put into the mouth of the a cone-shaped flask which has been filled with water beforehand.

The experiment can also be carried out by pouring water into the glass tube, and concentrated solution into the cone-shaped flask.
b) The experiment with putting a whole egg in a glass with distilled water or in a glass with a concentrated solution would take more time (at least an hour). That is why this variant could be suggested as an idea for an experiment to be done at home.

Did you know that…

Note: Other experiments could be added or some of the abovementioned could be replaced.

1. Did you know that…

The English physicist Stephen Gray is one of the first scientists who worked on the idea for using an instrument while studying micro-objects by using materials different than glass for making microscope lenses. In 1696 he published an article, describing an instrument called the "Water Microscope".

S. Gray used a water drop as a lens for his microscope. Later on he also used fish-glue, as Hooke and Borellus had suggested. In 1837 Brewster created lenses out of various organic liquids (for example, amber, varnish, copal, and Canada balsam, also called Canada turpentine), all of which created high-quality, but unfortunately quite fragile lenses.

◄ The Gray Water Microscope
The figure is published with the permission of
Dr. Steven Ruzin – Curator of the U.C. Berkeley Golub Microscope Collection

For more information and illustrations, you visit:
http://golubcollection.berkeley.edu/17th/138.html
http://golubcollection.berkeley.edu/17th/138/imaging.html
http://golubcollection.berkeley.edu/17th/138/focus.html

2 Did you know that…

Fluid water has a greater thickness than this of ice, for example:
Ice (0 ^{o}C) ρ = 0,917 g/cm^3;
Water (20 ^{o}C) ρ = 0,998 g/cm^3.
Under atmospheric pressure, the freezing of water is accompanied by increasing of the volume of the system with about 9-10 %, and the melting of ice is correspondingly accompanied with a decreasing of the volume.

3. Did you know that…

• Among the liquids existing in Nature, water has the greatest thermal capacity. That is why it is used as a heat carrier in electric power stations as well as in nuclear power stations.

In the form of ice it is used for cooling in the system of public catering establishments and medicine. In fire-fighting, water is used not only as a coolant but also as an ingredient in the foam serving to isolate the fire from access to air.

• Because of the great thermal capacity, the comparatively high temperatures of melting and boiling, as well as thanks to the dependence of its thickness on temperature, water is an important regulator of the climate on Earth.

You could find some interesting ideas for home experiments here:
http://www.youtube.com/watch?v=qeDZQ9-gsjY&feature=related

4. Did you know that…

Some small insects called "*water striders*" cannot sink when they touch the water surface. They are able to stay above the surface because they weigh too little, that is why their legs cannot penetrate the surface of the water. Also, there is a genus of lizards, Basiliscus, which can move on the surface of water despite their weight. The Basiliscus can run at a velocity of 1.5 meters per second for approximately 4.5 meters before starting to sink and has to start swimming. Flaps between their toes help support their body, creating a larger surface and a pocket of air which prevents them from sinking. They can also sustain themselves on all four legs while "water-walking" to increase the time they stay above the surface by moving further 1.3 meters.

More information and pictures are available at:
http://www.fcps.edu/islandcreekes/ecology/common_water_strider.htm
http://sites.google.com/site/kuscarji/vrste-kuscarjev/corytophanidae
http://news.nationalgeographic.com/news/2004/11/1116_041116_jesus_lizard.html
http://www.youtube.com/watch?v=45yabrnryXk

7. Did you know that…

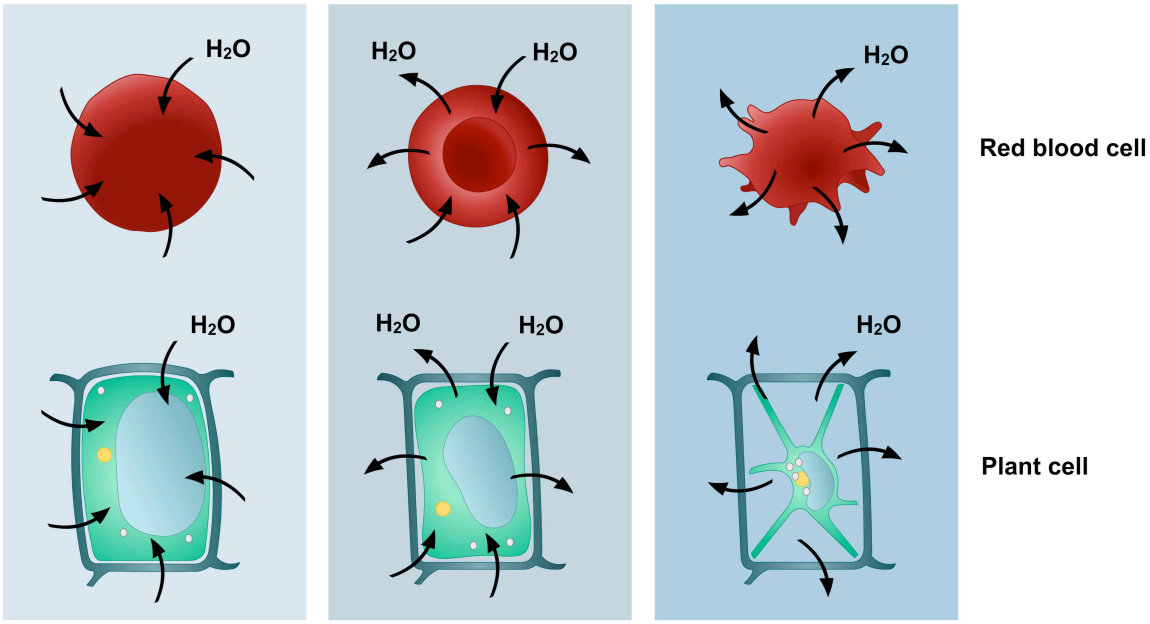
In Nature, $CuSO_4 \cdot 5H_2O$ is found only in the form of a mineral – chalcanthite (meaning "*flowers of copper*"). Due to its ready solubility, chalcanthite is more common in arid regions.

Chalcanthite is a representative of a group of substances called crystal-hydrates. In their crystals, the ions are surrounded by a certain number of water molecules, that is, their ions are hydrated. That is why the solving of crystal hydrates in water is always accompanied with heat absorbing.

8. Did you know that…

Water is the main ingredient of the biological liquids inside and outside of the cell. It participates in the constant metabolism between these liquids. Its molecules go freely through the biologic membranes in both directions. When, due to some reason, the concentration of the inner-cell or outer-cell liquid changes, water molecules pass through the biologic membrane from the solution with a lower concentration of substances that have been solved to the solution with a higher concentration until the concentrations of both solutions become the same on both sides of the membrane.

(The process of the movement of the molecules of the solvent through a semipermeable membrane is called osmosis).



You can find an illustration of the process of osmosis and an explanation of it if you follow the link:
http://www.youtube.com/watch?v=AYNwynwaALo&feature=related

Ideas for interesting home experiments can be found here:
http://www.youtube.com/watch?v=i0epq8J_K5k&feature=related
http://www.youtube.com/watch?v=0c8acUE9Itw&feature=related
http://www.youtube.com/watch?v=9QCxTf0QfTo&feature=related