Title: Water, contained in a clay jug, heat transfer

Topics: WATER, CONTAINED IN A CLAY JUG, HEAT TRANSFER	**Time**: : 90 minutes (2 lessons)	**Age**: 9 class 14-15 years old pupils

Differentiation:

- More able students are asked to depict in one graph temperature and humidity change dependence on time of the 1st jug; in another graph - of the 2nd jug. Explain these parameter changes.
- Discussion about temperature and air humidity importance for man and his environment with most able and talented students is carried out.
- Students who complete the work quickly are asked to work on the extension tasks provided.

Guidelines, ICT support etc.:

- Students are presented with a consistent workflow and with a list of equipment needed for this activity.
- As the results of this work among students are not known in advance, the possibility of discussion in groups arises. Analysis of results and discussion effective when the work is done in pairs or in groups of 3-5 students.

Equipment needed for this activity:

- 2 clay jugs;
- 2 lids to cover the jugs. Lids with the holes for inserting sensors;
- Hot water (about 70 ^{o}C);
- 2 temperature sensors (from -25 ^{o}C to 110 ^{o}C) or thermometres;
- 2 humidity sensors;
- Plastic bag;
- A lace for tying the plastic bag;
- Computerised teaching system (*Nova*5000, *Xplorer GLX* or other);
- Textbooks;
- Activity sheet.

Required knowledge:

- Concepts of temperature, energy, air humidity;
- $y = f(x)$ graph and its rate of change.

Health and Safety:

Safe handling of experimental tools and hot water.

Learning outcomes for this activity:

All

- Will be capable of characterising the temperature.
- Will be capable of describing evaporation process.
- According to instruction, will be able to arrange the appliances for work

Most

- Will be able to determine temperature as internal body energy measurement.
- Will be able to describe parametres, determining phase changes.
- Will be able to draw humidity and temperature changing graphs.
- From the graphs, will be able to explain heat transfer processes.

Some

- Will be able to find connection between heat metabolism, occuring in a clay jug and the one in a human body when it is sweating.
- Will be capable of defining air humidity importance to man and his environment.

Lesson description

Starter Activity

Pupils enter the classroom put away coats and bags.
Pupils are asked to recall from mathematics: to analyse expressed by graph relationship between two variables, to assess the rate of change of the process.

Hot water is poured into a metal and clay container and completely closed. After some time, the temperature in both containers is measured. Pupils are asked which vessel remained higher temperature? Why?

Pupils are asked to explain energy endurance law in case of various changes of physical energy.

Main Activity

Pupils begin work on **Water, contained in a clay jug, heat transfer** worksheet.
An explanation of practical is given.

Arrange the appliances so, as it is shown in the picture:

- Pour the same amount of water and of the same temperature into the jugs (almost 2/3 of the jug‘s capacity).
- Put 1 clay jug into a plastic bag.
- Insert temperature sensors into every lid hole.
- Put one humidity sensor into a plastic bag, the second one – leave near the 2nd jug.
- Tie the plastic bag, in which the jug is.

Fix the temperature changes in both jugs.
Fix the humidity changes in the environment and in the plastic bag for 10 min.
After10 min. take out the jug from the bag.
Observe humidity and temperature changes for 10–15 minutes more.
The changes can be observed even more, leaving *Nova5000* in action for several hours more.
Draw temperature $t = f(\tau)$ graphs.
Draw humidity $\rho = f(\tau)$ graphs.

Extension

More able pupils at this point may be asked to consider any issues with the design of the experiment or they could be asked to suggest improvements.

Work sheet activity

Pupils are asked to complete the activity work sheets individually. Pupils are asked to record results, to fill in temperature (t) and humidity (ρ) data tables, draw graphs $t = f(\tau)$ and $\rho = f(\tau)$ and from these graphs to define and put down temperature and humidity initial and final values and the changes of these values in the first and in the second jug.

More able pupils may be asked to depict in one graph temperature and humidity change dependence on time of the 1st jug; in another graph to depict temperature and humidity change dependence on time of the 2nd jug. Explain these parameter changes.

Extension activity

Pupils who complete the work quickly are asked to work on the extension tasks provided (**Water, contained in a clay jug, heat transfer research**).

Plenary

Pupils are asked about the procedure carried out; they are asked to consider the reason for any odd results.
Pupils are asked to make a conclusion about temperature changes in both jugs, to explain differences, to make a conclusion about humidity changes near both jugs, to explain differences.
With the more gifted pupils, connection between heat metabolism occurring in a clay jug and the one in a human body when it is sweating is discussed about

WATER, CONTAINED IN A CLAY JUG, HEAT TRANSFER

Heat transfer through conductivity happens when the heat spreads from one attached body to another body or within the body itself. Substances which conduct the heat very well, are called heat conductors (e.g.: silver, copper, gold and other metals). Materials, within which the heat almost does not spread, are called heat insulators (e.g.: plastics, wood, glass, air and other). In antique times nomadic tribes, having lived in the hot and dry places, used to keep water in the clay jugs. Notwithstanding the heat of the environment, water used to remain cold. Clay is porous material, therefore water can permeate through it and evaporate.

The temperature of bodies is measured by various types of thermometers. The measurement rule is very simple: the thermometer for some time has to be attached to the body, so that the body and the thermometer temperature becomes equal, until *heat balance* settles. Then the thermometer readings do not change. When heating the body, between the thermometer and the body another heat balance forms, the thermometer shows another temperature. Thus, *temperature describes a heat balance condition of the bodies.* Speaking of heat condition, mixing the gases of different temperatures, the average kinetic energy of the disorderly, irregular movement of the molecules equalises, common temperature settles. It is believed that, *temperature is a measure of the average kinetic energy of the disorderly movement of particles.*

Liquid molecule speed at the same temperature is different. The molecules with the fastest speed overcome the other molecule attraction, fly out from the liquid, it is said, *liquid evaporates*. Having lost the molecules with the bigger kinetic energy, evaporating the liquid *chills.*

Having flown from the liquid, the molecules move disorderly, gather at the liquid surface. Some of them return back to the liquid, vapour *condenses*. In the closed dish the conditions can form – as many as liquid molecules fly out, that many vapour molecules during the same time return back into the liquid. Such vapour, which is in the dynamic balance with the liquid, is called *saturated vapour.*

The Earth is the only planet that we know of, on which there is a lot of surface water. In the atmosphere there is water vapour, which has influence on the processes, occurring on the surface of the Earth. The amount of water vapour in the atmosphere is called *air moisture,* which constantly changes. Moisture is important for vegetation, has influence on animals. The man's health depends on the air moisture. Air moisture affects the buildings, art works. It is important to keep suitable moisture in the living premises, especially preserving the fruit, vegetables, food products.

For good health relative humidity is necessary from 40% to 60%. In winter in the heated living premises relative humidity does not reach 20%. Very quickly mucous membranes of nose, throat, lungs become dry. In winter living premises may have to be moistened.

High temperature of the environment can raise the temperature of the human body. Though the skin feels the outer temperature change as well, however temperature controlling the centre, located in the interstitial brains, is sensitive only to blood temperature changes. When the body temperature is higher than normal, control centre sends the signals, which make the arterioles located on the skin surface widen, more warm blood flow into them, the skin gets red. Also, sweat glands are activated, which increase the amount of produced sweat. The sweat, having flown out onto the skin surface, evaporation process occurs. Vapour lessens the amount of heat on the skin surface, because water turning into vapour uses the heat for breaking off hydrogenous relation. Skin surface cools, cooling off the running blood. The temperature of the environment decreasing, control centre turns on heat saving mechanism. Then, the arterioles located on the skin surface shrink, and the deep ones, widen. In this way, a normal body temperature is saved.

Questions	Answers
1. What does the temperature describe? 2. What is temperature? 3. What is air humidity? 4. Equations are given: $y = 3x$; $y = 4x$. Draw $y = f(x)$ graphs and compare their rate of change.	

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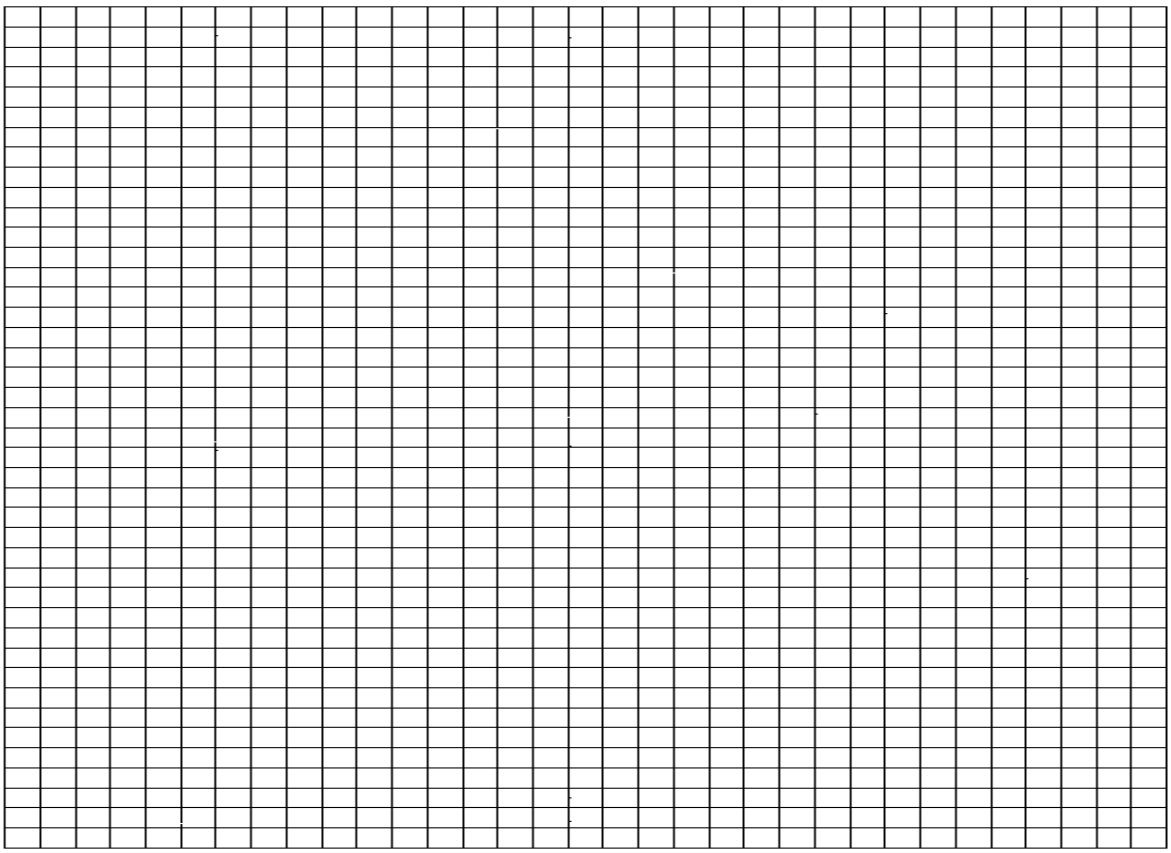
Answer sheet

Enter the data in the table

Temperature and humidity transfer

The time of the experiment τ (min)	1st jug Temperature, t (^{0}C)	2nd jug Temperature, t (^{0}C)	Humidity, near the 1st jug ρ (%)	Humidity, near the 2nd jug ρ (%)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
Taking out the1st jug from the plastic bag				
The time of the experiment τ (min)	1st jug Temperature, t (^{0}C)	2nd jug Temperature, t (^{0}C)	Humidity, near the 1st jug ρ (%)	Humidity, near the 2nd jug ρ (%)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

From the data in the table, draw the graphs of temperature transfer in the first and in the second jugs $t = f(\tau)$:



From the graphs, define temperature initial and final values and the changes of these values:

- 1st jug is in the plastic bag:

t_1=
t_2=
Δt =

- 1st jug is taken out from the plastic bag:

t_3=
t_4=
Δt =

- 2nd jug is in the room (in first two minutes):

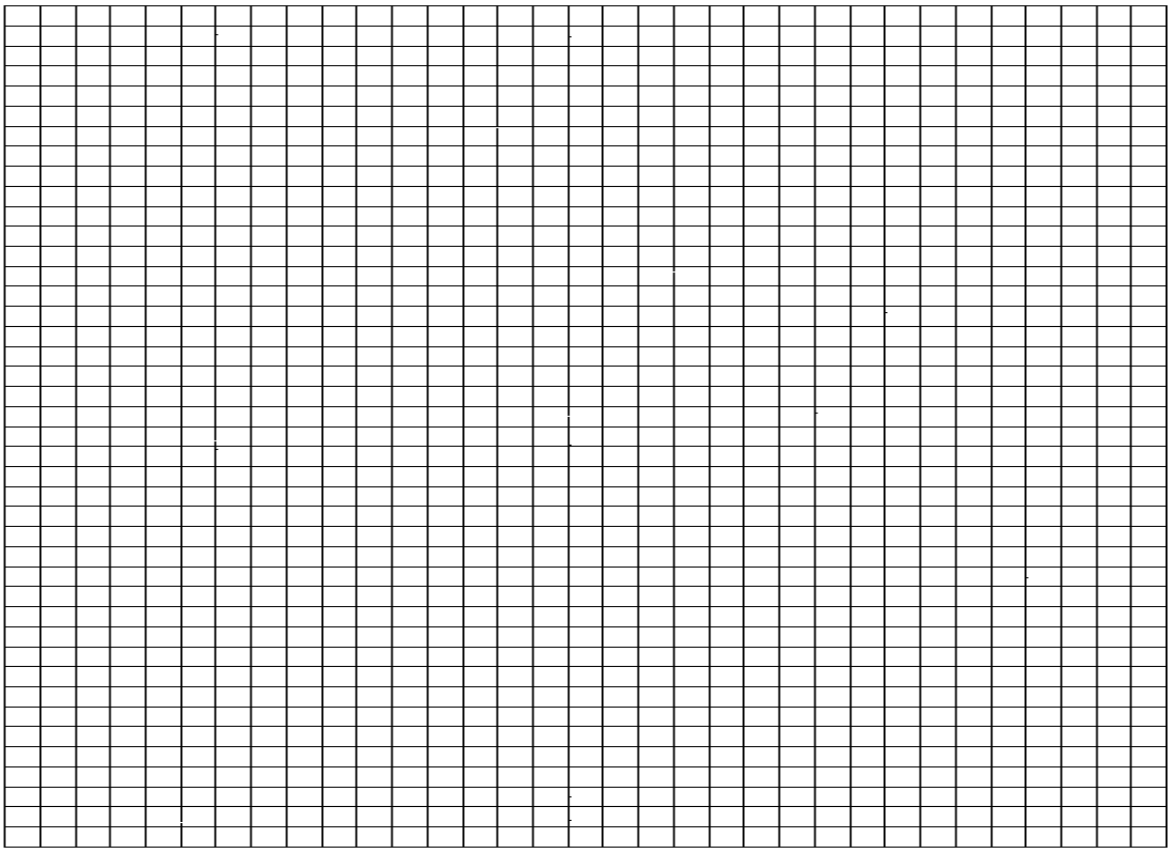
t_1=
t_2=
Δt =

- 2nd jug is in the room (in last two minutes):

t_3=
t_4=
Δt =

From the data in the table, draw the graphs of humidity transfer near the first and the second jugs

ρ = f (τ):



From the graphs, define the initial and final values of humidity and the changes of these values, when humidity sensor is:

- 1st jug in the plastic bag:

ρ_1 =
ρ_2 =
$\Delta\rho$ =

- After taking out the 1st jug from the plastic bag:

ρ_3 =
ρ_4 =
$\Delta\rho$ =

- Near the 2nd jug in the room:

ρ_1 =
ρ_2 =
$\Delta\rho$ =

Answer the questions and explain why:

- Compare the temperature changes:
  - ✓ 1st jug is in the plastic bag and 1st jug is taken out from the plastic bag

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- ✓ 2nd jug is in the room in first two minutes and in last two minutes

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- Compare the temperature changes in both jugs:
  - ✓ Whether they are the same?

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- ✓ Explain the differences.

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Conclusion:

- Make a conclusion about the plastic bag's influence on:
  - ✓ Humidity inside the bag .....

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- ✓ Water temperature change in the jug .....

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- Make a conclusion about heat transfer in the jugs:

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Water cooling speed

The thermometer is placed into a bowl with hot water and every 2 minutes water temperature is measured. The data of the experiment are given in the table.

Time, min.	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28
Temperature, ^{o}C	100	88	80	74	68	64	60	58	56	54	52	50	48	47	46

- Draw the graph of cooling water temperature dependence on time.

- Calculate water cooling speed:

  0 – 4 min. Cooling speed =

  4 – 8 min. Cooling speed =

  8 – 12 min. Cooling speed =

  12 – 16 min. Cooling speed =

  16 – 20 min. Cooling speed =

  20 – 24 min. Cooling speed =

  24 – 28 min. Cooling speed =

  28 – 30 min. Cooling speed =

- When did the water cool faster and why?