TIME
Technologies in Modern Education

How Fast Does Water Evaporate from a Cup of Hot Tea?

How much water evaporates from a cup of hot tea in 100 seconds? How much can we slow down the cooling, when we prevent the evaporation?

What you need:

- sensitive balance connectable to a PC via USB or LabQuest

- a thermo cup (or a common cup)

- a plastic bag

- USB Go!Temp thermometer

- a kettle

- a stand

Tasks:

Preparation for measurement

1. Before the measurement, it is necessary to unlock the balance. Remove the metal plate off the balance, turn the red knob to the "unlocked" position and return the metal plate back in its original place.

2. Connect the balance to an electrical grid (so that the battery is not being "wasted") and switch the balance on.

3. Connect the balance and a thermometer via USB ports to your computer, open the Logger Lite software.

4. Set Durarion to 600 s and Sampling Rate to 1 Hz.

5. Fill the cup with tap water so that the water level is 1 - 2 cm below the edge and put it on the balance. If the mass of the cup with water exceeds the measuring range of the balance (600 g), pour some water out.

6. Use the stand to place the thermometer so that its tip is immersed 2 cm below the water level.

7. Boil the water in the kettle. Meanwhile, prepare the plastic bag. In the first phase of the experiment it will serve as a pot lid to prevent the evaporation – pierce a hole in the bag with the tip of the thermometer. After pouring hot water into the cup and starting the experiment, it will look something like the image above.

Performing measurements

1. Start the measurement. After 300 seconds, lift the bag gently and fasten it on the stand so that it does not prevent the evaporation of water from the cup any more. Do not stop the measurement. This manipulation with the bag will be shown on the graph of mass vs. time as an irregularity ("spike").

2. The measurement stops after 600 seconds (10 minutes). Store the measurement and look at the graphs.

Evaluation

1. How much water has evaporated in the first and in the second case?

2. How has the removal of the "lid" affected the cooling rate?

Notes for teachers

Which cup to use

The experiment can be performed with an ordinary cup, but the results are more convincing when you use a thermo cup, because the heat transfer by conduction through the walls of the cup is reduced and the part of the transferred heat used for evaporation is increased.

In which order to perform experiments

The cooling rate depends greatly on the temperature, the lower the difference between the temperature of water and the surroundings, the slower the temperature decrease. The temperature of spontaneously cooling water asymptotically approaches the room temperature; the temperature curve has a convex character.

Therefore, I recommend doing the experiments always in the same order, i.e. first without evaporation, then with evaporation. The curve thus has a concave character. It is obvious that the evaporation plays an important role in cooling. The reverse order might be a little less convincing.

Typical measurement results

The blue graph below shows the change of mass over time. In the first 5 minutes, the cup was covered with a plastic bag with a small hole for the thermometer. The mass decrease

was about 0.25 g per 100 s. When we remove the plastic bag (the removal is manifested by the spike in the graph), the rate of evaporation of water increases sharply to 1.35 g per 100 s.

It is interesting to compare the blue graph with the red one showing the temperature changes. When we removed the plastic bag, the cooling rate has increased abruptly. The graph has a concave character.