A2 Storing heat – From heat store to molten salt

1 Water as a heat store – Not only the tea gets cold

Heat is often produced and not used. But what if we wanted to store heat ….

1.1 Apparatus and materials

- 1 digital thermometer
- 1 lighter or matches
- 1 plant clip (as test tube holder)
- 1 syringe (conical tip), 5 ml (as pipette)
- 1 tea light
- 1 test tube, glass, 13 cm
- 1 test tube clamp, wooden
- 1 watch
- Water

Attention: After you have completed the experiment, return the materials or dispose of them properly as instructed by your teacher.

1.2 Safety information

The materials may be used only as instructed by your teacher or as described in the experimentation instructions.
For this experiment, be aware of the following risks:

- Take care when working with a flame that you don't burn yourself or start a fire.
- Be careful not to scald yourself when handling hot water.

1.3 Conducting the experiment

- Use the syringe to transfer 3 ml of water into the test tube.
- Carefully insert the thermometer into the test tube so that the probe is submerged in the water.
- Secure the test tube in the wooden test tube clamp, light the tea light, and heat the water to about 45°C.

Fig. 1: Heating the water.

- Using the plant clip, set aside the test tube.
- Read the display and record the value in a table based on the following template (the second line will be needed in the next experiment):

Fig. 2: Measuring the cooling process for an uninsulated test tube.

	Starting temperature	After 3 min.	After 6 min.	After 9 min.	After 12 min.
Water in test tube					
Water in insulated test tube					

- Repeat the measurement every 3 minutes for a total of 4 times.
- Transfer the measured values to a graph (x-axis = time, y-axis = temperature) so that you can see how the temperature has dropped.

1.4 Observation

Summarize your observations in one or two sentences.

1.5 Analysis

a) Describe the variations in the graph you made.
b) Think about what caused the temperature to drop.

1.6 Questions

a) How would the results differ if the experiment were conducted outdoors, in the summer, in the winter?
b) What could you do to keep the water hot longer? What possibilities and devices can you think of?
c) Can you think of an example of the principle of storing solar heat during the summer that is already being applied on a large scale for heating in the winter?

2 Water as an effective heat store – Water can stay hot longer if …

Heat is often produced and not used. But what if we were able to store it for a longer period of time, such as saving heat from the summer and using it in the winter ….

2.1 Apparatus and materials

- 1 digital thermometer
- 1 lighter or matches
- 1 plant clip (as test tube holder)
- 1 syringe (conical tip), 5 ml (as pipette)
- 1 tea light
- 1 test tube, glass
- 1 test tube clamp, wooden
- Various materials to insulate the test tube
- 1 watch
- Water

Attention: After you have completed the experiment, return the materials or dispose of them properly as instructed by your teacher.

2.2 Safety information

The materials may be used only as instructed by your teacher or as described in the experimentation instructions.
For this experiment, be aware of the following risks:

- Take care when working with a flame that you don't burn yourself or start a fire.
- Be careful not to scald yourself when handling hot water.

2.3 Conducting the experiment

Fig. 3: Measuring the cooling process for a test tube insulated with a paper towel.

- Use the syringe to transfer 3 ml of water into the test tube.
- Secure the test tube in the wooden test tube clamp, light the tea light, and heat the water.
- Make sure the temperature is approximately the same as for the first experiment.
- Wrap the test tube in the insulation material you've selected and set it aside using the plant clip.
- Coordinate with the other groups as to who is using what insulating material.
- Insert the thermometer in the test tube so that the probe is submerged in the water.
- Read the display and record the value in the table from the first measurement.
- Repeat the measurement every 3 minutes for a total of 4 times.
- Transfer the measurements to the same graph in which you entered the first measurements.

2.4 Observation

Summarize your observations in one or two sentences, and also record them in a table (based on the template below).

Insulation	Temperature drop after 12 min.
None	°C
Material 1 (e.g., woolen cloth)	°C
Material 2 (e.g., aluminum foil)	°C

2.5 Analysis

a) How much did the temperature drop compared to the measurements you took in a non-insulated test tube?
b) Compare the variations in your graph. Is the assumption correct that this time the water cooled more slowly?
c) Which material provided the best insulation? Compare your results with those of the other groups.
d) Create a shared table or graph for recording the results for the materials used by all the groups.

2.6 Questions

a) Can you imagine how insulation works? Come up with an explanation and discuss it with your partner.
b) Do you have a theory about why some materials provide better insulation than others?

3 Heat for cold fingers – Is the heat pack a heat store?

Heat is often produced and not used, sometimes in large quantities. It should be possible to store very large amounts of heat in a very small store over very long periods of time ….

3.1 Apparatus and materials

- 1 digital thermometer
- Insulating surface, e.g., corrugated cardboard, styrofoam
- 1 heat pack (with molten salt)
- 2 rubber bands

3.2 Safety information

The materials may be used only as instructed by your teacher or as described in the experimentation instructions.

3.3 Conducting the experiment

- Examine the heat pack closely and describe it, especially its contents.
- Fold the heat pack and secure it with rubber bands.
- Now insert the probe of the thermometer into the fold so that the tip is in firm contact with the heat pack.
- Carefully bend the metal disk that’s inside the heat pack against its curved direction just far enough until you can hear or feel a snap. Observe the immediate change.
- Place the heat pack and thermometer on an insulating surface.
- Record the temperature and repeat after a few minutes.

You can repeat this experiment, but in this case the heat pack must be regenerated. The teacher boils the heat pack in water until the contents have returned to a liquid state. Once the heat pack has cooled to room temperature, it can be reused.

Fig. 4: Thermometer inserted into in the folded heat pack.

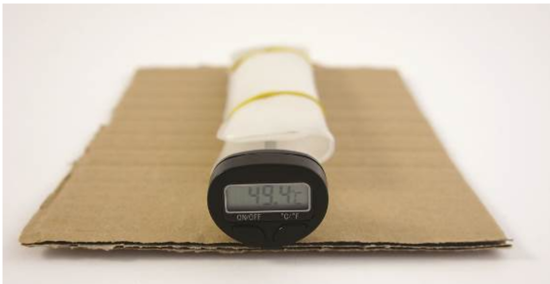

Fig. 5: Measuring the cooling process of the activated heat pack on an insulating surface (shown: cardboard).

3.4 Observation

Write down a summary of your observations. Does the temperature remain fairly constant over a longer period of time or does it steadily drop?

3.5 Analysis

a) Describe the most important changes in the heat pack after you bend the metal disk. State your conclusion in the form of a sentence, e.g., “I observed that … and felt that ….”
b) Try to establish a context: “It is assumed that … causes ….”
c) Compare your theories with those of your classmates. Agree on a statement.
d) Compare the highest heat pack temperatures measured by the individual groups.
e) Can you explain the results? Formulate a theory.

3.6 Questions

When comparing the measured values, you must have noticed that your values were usually below 58°C. Can you explain why your values were never higher than 58°C? Would it even be possible?

4 How the heat pack stores heat – A salt that changes between solid and liquid states

Some salts can obviously store a lot of heat, but how exactly do they do this?

4.1 Apparatus and materials

- 1 digital thermometer
- 1 glass rod
- 1 lighter or matches
- 1 pair of safety goggles per student
- 1 plant clip (test tube holder)
- Salt from inside the hardened heat pack
- 1 tea light
- 1 teaspoon
- 1 test tube, glass, 13 cm
- 1 test tube clamp, wooden

4.2 Safety information

The materials may be used only as instructed by your teacher or as described in the experimentation instructions.
For this experiment, be aware of the following risks:

- Take care when working with a flame that you don't burn yourself or start a fire.
- Although the salt is harmless, be careful that you don't get it in your eyes while it's hot (wear safety goggles)!

4.3 Conducting the experiment

- Put on your safety goggles.
- For this experiment, you need a little salt from inside a heat pack.
  Your teacher will supply the salt.
- Transfer approx. 1 cm of salt to the test tube. You can do this more accurately and cleanly using the handle of the teaspoon.
- Light the tea light, grasp the test tube with the clamp, and hold the test tube over the flame.
- Observe what happens. As soon as you notice a change, insert the thermometer in the test tube so that it touches the mixture.
- Record the temperature that you measured.
- Continue heating until the salt is completely liquefied.
- Remove the thermometer from the test tube.
- Using the plant clip, carefully set aside the test tube and let it cool.
- When the test tube no longer feels warm to the touch, insert the glass rod and gently scrape it against the sides. What happens?

- Remove the glass rod and insert the thermometer. Record the results.
- You can repeat this experiment. However, the salt may not melt completely the second time. In this case, add a drop of water.

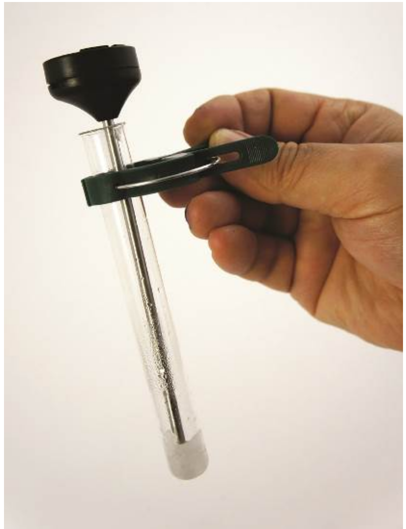

Fig. 6: Measuring the temperature of the hardened salt.

- Disposal and cleanup: You can dissolve the salt in water and throw it away. The teacher will tell you where. Then rinse out the test tubes and rinse the glass rod with water.

4.4 Observation

Write down a summary of your observations. Describe the changes that took place inside the test tube when you heated it.

4.5 Analysis

a) At what temperature did melting begin?
b) What was the temperature after you scraped the sides of the cooled test tube? Compare this with the previous experiment.
c) Compare your theories from the previous experiment with the results of this experiment. Do they match?

4.6 Questions

a) When the heat pack is placed in boiling water, it is said to be regenerated or “recharged.” What do you think that means?
b) Can you imagine how this “charging” takes place in systems that store large amounts of heat?