Heat: Temperature and heat experiments

These four subexperiments on temperature and heat based on Experimento | 10+ are designed to encourage learning through research in science class in the lower grades. The materials are editable and can be adapted individually to the learning group or supplemented with other interesting content from the media portal of the Siemens Stiftung (https://medienportal.siemens-stiftung.org).

The subexperiments are:

- 1. Water stores heat (1)
- 2. Water stores heat (2)
- 3. Heated water is mixed with water at room temperature
- 4. Does a metal spoon conduct heat?

1 Relevance to the curriculum

Topics related to heat (temperature, heat conduction) are found in nearly all curricula worldwide. These experiments deal with the following topics:

- Sun as the basis for life
- Temperature and heat
- Experimentation as a way to acquire scientific knowledge; measuring and recording temperatures in logs and on charts
- Heat transport (heat conduction)
- Principle of temperature equalization

2 General information

2.1 Structure of the worksheets

The experiments supplement the lesson, but are not sufficient on their own for working through the learning content. Each experiment has a worksheet that includes a list of the required apparatus and materials, illustrated instructions for preparing and conducting the experiment, and various assignments that can be completed.

The assignments are suggestions that can always be scaled down or expanded as needed. Note that in the list of apparatus and materials, items printed in *italics* must be provided separately. These items are not included in the photo.

2.2 Safety information

Observe the safety information, which is found in the teacher instructions for Experimento | 10+: A2 We store heat – From heat store to molten salt.

If the materials are used as described in the teacher instructions and the experimentation instructions, they pose no hazards.

2.3 Cleaning information

Please point out to your students that all objects that become dirty during the experiment must be clean and dry before being returned to the experimentation kit. Materials that cannot be used again can be disposed of in the trash or poured down the sink.

3 Information on the subexperiments

3.1 Subexperiment 1: Water stores heat (1) Subexperiment 2: Water stores heat (2)

3.1.1 Information for teachers

In these experiments, the students are taught that water is good at storing due to its heat (water has a high heat capacity). But without insulation, water continually releases this heat into the environment until its temperature has equalized with the ambient temperature.

The students will heat water, measure temperatures, enter the values in a table, and create charts. Due to the different ambient temperatures in the classrooms and the different distances between the test tube and the flame (subexperiments 1 and 2), the students' measured values will differ from the measured values indicated as the answer.

3.1.2 Skills

The students will ...

- measure the temperature using a thermometer.
- complete a value table and draw a time/temperature chart.
- know that heated water releases heat to the environment.

3.1.3 Variation, additional tasks

Subexperiment 1: Water stores heat (1)

- Open-ended task: The students can develop their own experiments using the apparatus and materials (for example, how hot can water become? When does the water in the test tube change?).
- The terms "boil" and "steam," for example, can be repeated while the water is being heated, which takes about five minutes. The experiment is also suitable for working on these terms (for example, what happens when I heat water? At what temperature does water boil?).

Subexperiment 2: Water stores heat (2)

- Assignment 2: Targeted questions and phrases can help slower students find the answers (for example, how did the temperature change after one minute? The temperature decreased by ... °C. How many °C did the temperature decrease within three minutes? After three minutes, the temperature decreased ... °C).
- Additional task for faster students: What would change if you conducted the experiment outdoors, in the summer, or in the winter? (different starting temperature, faster or slower temperature equalization)
- Additional task: The students heat other liquids (for example, oil, salt water) and compare the results with those of water.
- A modifiable assignment from Experimento | 10+: A2 subexperiment 2 "Water as an effective heat store" (also as worksheets for subject teaching in English) is available on the media portal of the Siemens Stiftung.

3.1.4 Answer

Subexperiment 1: Water stores heat (1)

Assignment 1

Enter the measured values in the table.

	Starting tempera- ture at 0 min	Temperature after 1 min	Temperature after 2 min	Temperature after 3 min
Temperature [°C] [degrees Celsius]	21.4	36.7	49.5	65.6

Assignment 2

Look at the water in the test tube. What do you observe?

Bubbles form. The water boils.

Assignment 4

Enter the values from your table on the chart.



Subexperiment 2: Water stores heat (2)

Assignment 1

Start the stopwatch and read the water's temperature after each minute. Enter it in the table.

	Starting tempera-	empera- Temperature after Temperature after		Temperature after
	ture at 0 min	1 min	2 min	3 min
Temperature [°C]	44.9	43.2	41.4	40.2
[degrees Celsius]				40.3

	Temperature after 4 min	Temperature after 5 min	Temperature after 6 min	Temperature after 7 min
Temperature [°C] [degrees Celsius]	38.9	37.8	36.7	35.8

Assignment 2

Look at the temperature values in the measurement table. What do you notice?

At the beginning, the temperature changes by approx. 2°C after one minute. After three minutes, the temperature decreases only by approx. 1°C.

Assignment 3

Enter the values from your table on the time/temperature chart. Round your measured values to whole numbers, for example, $30.7^{\circ}C \rightarrow 31^{\circ}C$.



Assignment 4

Fill in the missing words.

heat, heated, room temperature, increases, decreases

In the experiment water is <u>heated</u>. The water absorbs the <u>heat</u> of the flame. The water's temperature <u>increases</u>. If you put the test tube down, the temperature <u>decreases</u>. If you allow the water to sit long enough, it reaches <u>room temperature</u> again.

3.2 Subexperiment 3: Heated water is mixed with water at room temperature

3.2.1 Information for teachers

In the experiment, the students are given an understanding of the principle of heat equalization. They heat water and mix it with the same amount of water at room temperature. In principle, when the same amounts of the same substance are mixed, the ensuing temperature of the mixed substance lies almost exactly between the two starting temperatures. However, heat losses may occur during experimentation. For this reason, the mixed temperature may be higher or lower than expected.

Due to the different ambient temperatures in the classrooms and the different distances from the flame, the students' measured values will differ from the measured values indicated as the answer. The temperatures should be measured in teams of at least two students so that the measured values can be read and recorded by two separate students.

3.2.2 Skills

The students will ...

- measure the temperature using a thermometer.
- complete the values in a table.
- learn the basic law of heat transfer.

3.2.3 Variation, additional tasks

 Alternative to assignment 2: The students can describe the results of the experiment. Phrases can help slower students find the answers (for example, the heated water has a temperature of ... °C. The water at room temperature has a temperature of ... °C. After mixing, the water has a temperature of ... °C. The temperature is ... the first and the second temperature.). The students can also enter the temperatures (T1, T2, T1+2) on a straight line (0 – 60°C).

3.2.4 Answer

Assignment 1

Enter all measured values in the table.

	Unheated water	Heated water	Mixed water
Temperature [°C] [de- grees Celsius]	22.5	40	31

Assignment 2

How do you explain the temperature of the mixed water? Write down your guess.

The heated water mixed with the unheated water.

Assignment 4

True or false? Mark the correct answer with an X.

	True	False
A glass jar holds hot water. The same amount of cold water is added to	X	
it. The temperature changes.	Χ	
If you mix two liquids with different temperatures, the hotter liquid does		Y
not give off any heat.		~
You mix a little hot water in a lot of cold water. The mixed temperature		~
lies exactly in between.		^
If you place a heated iron nail in a test tube with cold water, the iron nail		~
does not give off heat.		^

3.3 Subexperiment 4: Does a metal spoon conduct heat?

3.3.1 Information for teachers

In the experiment, the students are given an understanding of the transfer of heat through heat conduction. The students heat a metal spoon on which two pieces of wax are positioned at different distances from the heat source (here, a tea light). The teacher must make these pieces of wax by chopping a tea light with a knife. At the beginning of the heating process, the spoon has different temperatures. The metal conducts the heat from the section with the higher temperature to the section with the lower temperature. The temperature difference is reduced.

Point out to the students that they must not touch the spoon again after heating the tip. Risk of burning!

Hot rinse water can be used to clean the wax from the spoon. The wax is completely removed in this way.

3.3.2 Skills

The students will ...

- know that metals conduct heat well.
- be able to describe the process of heat conduction.

3.3.3 Variation, additional tasks

- Assignment 2: Terms can help slower students find the answers (for example, melt, piece of wax, first, second, quickly, slowly).
- Additional task: The students can test other noncombustible materials for their heat conductivity (copper, glass).

3.3.4 Answer

Question 1

What will happen to the wax pieces when the tea light is lit? Write down your guess.

The first piece of wax melts because it is nearly directly over the flame. Nothing happens to the second piece of wax.

Assignment 1

Note your observations.

Both pieces of wax melted.

The first piece of wax melted very quickly. This process took some time for the second piece of wax.

Assignment 2

Try to explain what happened. Write down your guess.

The spoon conducted heat.

Assignment 4

Fill in the missing words using the following words: cold, heat up, higher, different, hot, temperature difference, lower, spoon, heat

I held a <u>spoon</u> over a tea light. The end of the spoon <u>heated up</u>. The spoon now has <u>different</u> temperatures. It is <u>hot</u> on the one side and <u>cold</u> on the other side. The <u>heat</u> flows from the section with the <u>higher</u> temperature to the section with the <u>lower</u> temperature. The <u>temperature difference</u> is reduced.

Assignment 5

Draw in a yellow flame. Color the section that heats up first red. Color the section that is still cold initially blue. Draw an arrow to show the direction of heat transfer.



Assignment 6

In the photos, a copper nail is being heated. In which photo is the experiment being conducted properly? Why?

Photo 1

The copper nail is being heated correctly in the second photo. The test tube clamp prevents burns.