Thermal Equilibrium with SMARTsense (Item No.: P1042269)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 14-16
Topic: Thermal physics
Subtopic: Measurement of temperature
Experiment: Thermal Equilibrium with SMARTsense

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Easy	10 Minutes	10 Minutes	2 Students

Additional Requirements:

- mobile device

Experiment Variations:

Keywords:

Heating, Temperature difference

Task and equipment

Information for teachers

When two bodies of different temperature have contact with each other, then temperature equalization takes place until both bodies have the same temperature (thermal equilibrium). The students should measure the temperature behaviour over time and thereby find that the change in temperature is greater the bigger the temperature difference is.

Notes on set-up and procedure

The water in the vessels is not stirred in this experiment. This is not necessary for a qualitative observation of the temperature behaviour. Temperature equalization is quicker when the water is stirred (see question 9.).

Caution!
The support ring and the wire gauze get very hot when the water is heated up! Hold the glass beaker at the upper rim when you pick it up to pour out hot water. Take care! Do not let the sensor cables touch the wire gauze!

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Set-up

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Task and equipment

Task

Application

Why do tea or coffee get cold on standing, but never hot? And why are ice cubes melting after taking them out of the freezer?

Kaffee kühlt durch Verdunstung ab.

Schmelzende Eiswürfel.

Task

Can a temperature difference be permanent?

Watch the water temperatures when a vessel containing cold water is dipped into a hot water bath.

Equipment

Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	1
3	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	1
4	Boss head	02043-00	1
5	Glass tube holder with tape measure clamp	05961-00	1
6	Ring with boss head, i. d. = 10 cm	37701-01	1
7	Wire gauze with ceramic, 160 x 160 mm	33287-01	1
8	Beaker, low, BORO 3.3, 250 ml	46054-00	1
9	Beaker, low, BORO 3.3, 400 ml	46055-00	1
10	Erlenmeyer flask 100 ml, wide-neck SB 29	36428-00	1
11	Butane burner, Labogaz 206 type	32178-00	1
12	Butane cartridge C206, without valve, 190 g	47535-01	1
13	SMARTsense temperature sensor -40...120°C	12903-00	2
Additional material:			
	Tablet with measure-App		1

Set-up and procedure

Set-up

Fig. 1: Set-up.

- Set the stand up as shown in Fig. 1.
- Fill 100 ml of cold water into the Erlenmeyer flask, then place the flask in the empty 400 ml glass beaker.
- Fix both temperature sensors in the glass tube holder. Adjust them so that one dips into the water in the Erlenmeyer flask and the other dips into the glass beaker to the same depth but does not touch the Erlenmeyer flask.

Procedure

Caution!
The support ring and the wire gauze get very hot when the water is heated up! Hold the glass beaker at the upper rim when you pick it up to pour out hot water. Take care! Do not let the sensor cables touch the wire gauze!

- Switch both temperature sensors on and connect them via "Measure" > "Sensor" in measureAPP with the tablet. The sensors will start blinking green if the connection works. Make sure that both temperature measuring channels are activated.
- The preset sampling rate is suitable for this experiment.
- Fill about 160 ml of water into the 250 ml glass beaker and heat it up to just below boiling, i.e. to about 80 °C. You can alternatively make the 160 ml of hot water available from a kettle.
- Pour hot water into the 400 ml glass beaker to the side of the Erlenmeyer flask until the beaker has about the same level as the water in the Erlenmeyer flask.
- Check that both temperature sensors dip into water.
- Start measured value recording in measureApp . Measure for about 8 minutes. For timing you can use the stoppwatch of the measureApp.
- After 8 minutes stopp the measurement , save and open it for further analysis under "my measurements".

Evaluation

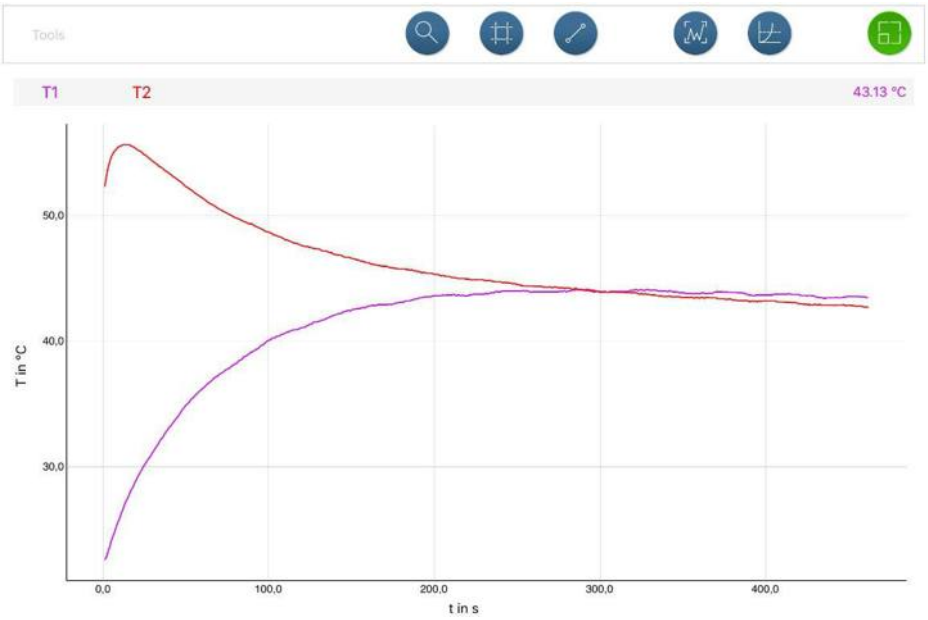

Fig. 2: Behaviour of the two temperatures with time.

Report: Thermal equilibrium with SMARTsense

Evaluation - Question 1 (1 point)

Describe the behaviour of the two temperatures.

Score is granted based on the occurrence of the following keywords: -

The hot water temperature decreases and the cold water temperature increases, until the temperature of the outside water is as low as that of the inside water. Both temperatures then decrease. The temperatures first approach each other and then the outer temperature decreases quicker than the inside temperature.

Scoring Mode:

Evaluation - Question 2 (1 point)

When the temperature of a substance changes, then the heat content of it also changes. From where to where does the heat content flow?

Score is granted based on the occurrence of the following keywords: -

An amount of heat flows from the vessel containing hot water to the vessel containing cold water, from hot to cold. Heat first flows from the outer vessel into the inner vessel as well as outside to the surroundings. Then heat flows from the inside vessel to the outer vessel and from there to the surroundings.

Scoring Mode:

Evaluation - Question 3 (1 point)

Does the temperature always change at the same speed?

Score is granted based on the occurrence of the following keywords: -

No, the temperature change per unit time is greater at the start.

Scoring Mode:

Evaluation - Question 4 (1 point)

The bigger the temperature difference, the greater the change in temperature.

Evaluation - Question 5 (1 point)

What happens to the water temperatures after some time? Will there finally be a difference between them?

Score is granted based on the occurrence of the following keywords: -

Finally, both temperatures will cool to ambient temperature and both will be the same.

Scoring Mode:

Additional question 1 (1 point)

What can you learn about sudden jumps in temperature from the answer to question 1.? Under which conditions would it surprise you if they occurred?

Score is granted based on the occurrence of the following keywords: -

Sudden jumps in temperature would be surprising when there is no source of heat. Temperatures only change steadily and in the direction of temperature equalization.

Scoring Mode:

Additional question 2 (1 point)

Describe the temperature behaviour using the terms “heat“ and “inner energy“.

Score is granted based on the occurrence of the following keywords: -

Heat passes from hot water with a high inner energy (high temperature) to cold water with a low inner energy (low temperature), never the other way round. The bigger the temperature difference, the greater the amount of heat that flows.

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Additional question 3 (1 point)

Would the temperature behaviour that was measured have been different if the water in one or both of the vessels had been stirred during measurement? What is the speed of the temperature change therefore also dependent on?

Score is granted based on the occurrence of the following keywords: -

Stirring would accelerate heat transmission and so also the temperature change, because no temperature stratification could form at the glass surface. The speed of the temperature change also depends on how easily heat can pass from one vessel to the next.

Scoring Mode: