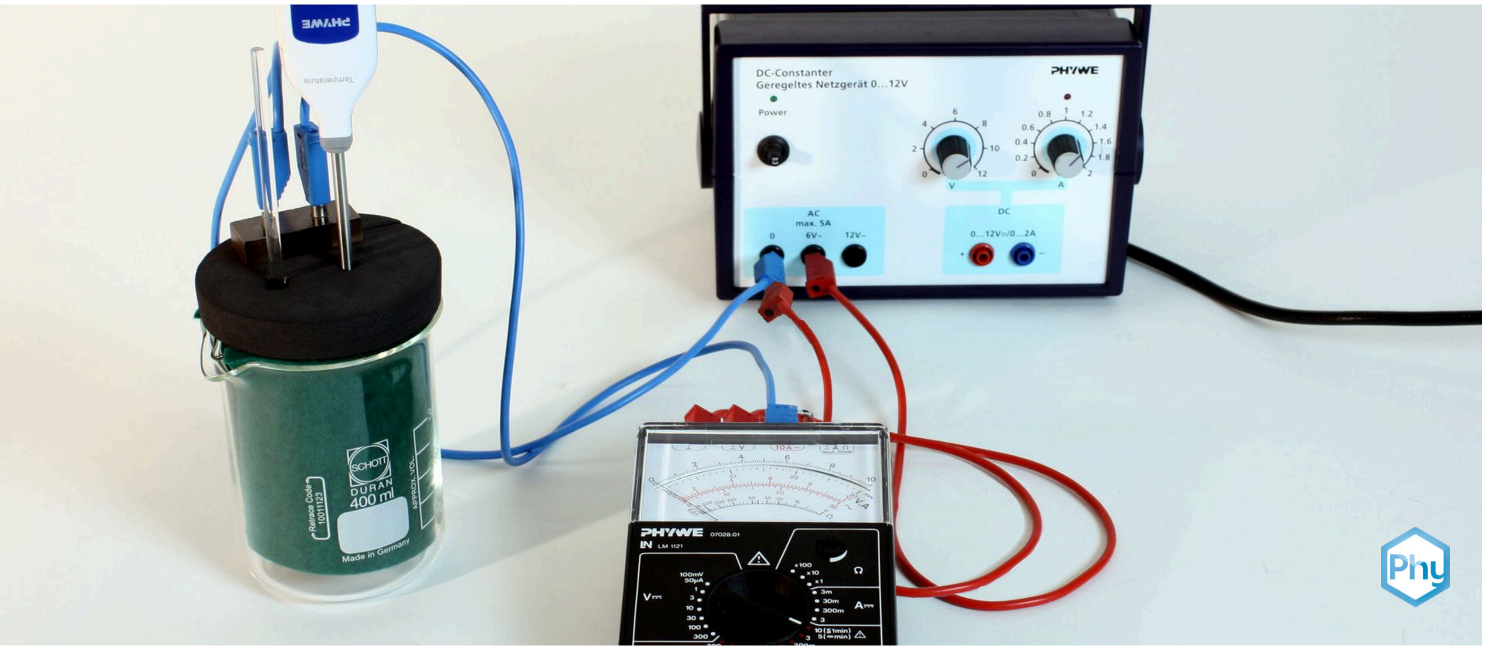
Specific heat capacity of water with Cobra SMARTsense



Physics	Thermodynamics	Heat energy, thermal capacity

Applied Science	Engineering	Renewable Energy	Basic Principles

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/61249dfbf2f5510003a25d41

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Teacher information

Application

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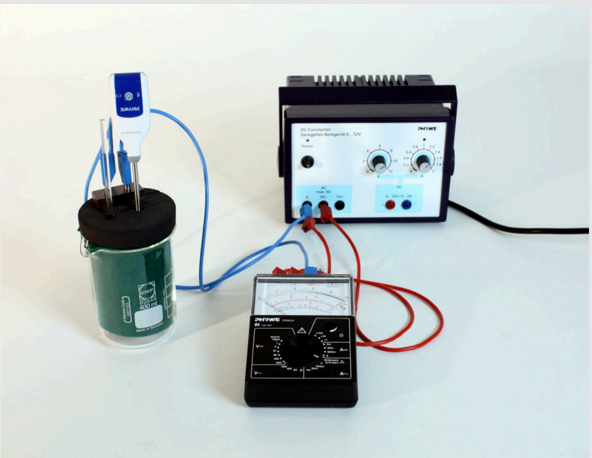

Experiment setup

In this experiment, students use a calorimeter to determine the specific heat capacity of water.

The concept of heat quantity and the concept of a systematic error are established.

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Other teacher information (1/3)

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Prior knowledge

It is assumed that the heat absorption of a substance is proportional to its quantity and independent of the temperature.

In addition, the electrical power is completely converted into heat and the relationship between electrical energy and heat quantity is known.

Scientific Principle

In this experiment, water is heated and its temperature development is observed.

In addition, the amperage used for heating is I and the tension U and a correlation is established between all recorded variables.

Other teacher information (2/3)

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Learning objective

Students learn how the temperature of water behaves during a heating process.

Tasks

Heat 200 ml of water with an electric heating coil.

Measure the temperature increase as a function of time.

Determine the electrical power of the heating coil and thus the amount of heat absorbed by the water per degree increase in temperature.

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Other teacher information (3/3)

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Notes on structure and implementation

- Only the lower heating power at 6 V~ should be used so that measurement errors due to poor distribution of heat and insulation losses of the calorimeter do not play a major role.
- Large temperature differences lead to large measuring errors here - it is recommended that all parts and the water are at (uniform) room temperature.

Safety instructions

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The general instructions for safe experimentation in science lessons to be applied to this experiment.

Attention!

The heating coil must be in water when it is connected to the power supply unit!

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Student Information

Motivation


Boiling water

When the sun sets in summer, the grass in the garden quickly becomes quite chilly, whereas it is still pleasantly warm on the terrace close to the house. This is due to the different ability of materials to absorb thermal energy.

This property is called specific heat capacity. The specific heat capacity can also be used to find out how much energy is needed to heat water, for example.

In this experiment you have to determine how much energy is needed to heat water by a certain temperature change.

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Tasks

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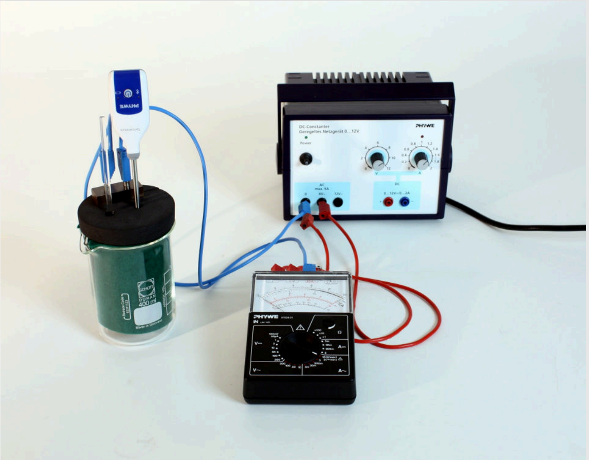

The experimental setup

How are heat quantity, heat capacity and temperature change related?

Heat 200 ml of water with an electric heating coil. Measure the temperature increase as a function of time.

Determine the electrical power of the heating coil and thus the amount of heat absorbed by the water per degree increase in temperature.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - Temperature, - 40 ... 120 °C (Bluetooth)	12903-00	1
2	Lid for student calorimeter	04404-01	1
3	Agitator rod	04404-10	1
4	Heating coil with sockets	04450-00	1
5	Felt sheet, 100 x 100 mm	04404-20	2
6	Erlenmeyer flask, borosilicate, wide neck, 250 ml	46152-00	1
7	Beaker, Borosilicate, low form, 250 ml	46054-00	1
8	Beaker, Borosilicate, low-form, 400 ml	46055-00	1
9	Graduated cylinder 100 ml, PP transparent	36629-01	1
10	Pipette with rubber bulb	64701-00	1
11	Connecting cord, 32 A, 500 mm, blue	07361-04	2
12	Connecting cord, 32 A, 500 mm, red	07361-01	2
13	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
14	Digital multimeter, 600V AC/DC, 10A AC/DC, 20 MΩ, 200 µF, 20 kHz, −20°C… 760°C	07122-00	1
15	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Set-up (1/3)

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For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check that on your device (smartphone, tablet, desktop PC) **Bluetooth** is **activated**.

iOS

Android

Windows

Set-up (2/3)

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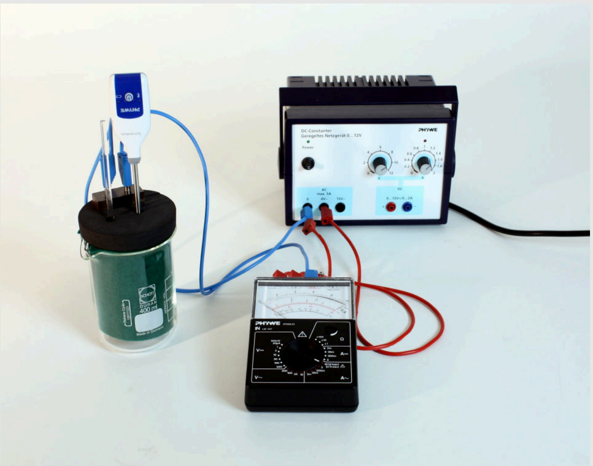

Figure 1

The experimental setup can be found in Fig. 1.

1. Fill the Erlenmeyer flask with water (storage vessel at room temperature).

2. Assemble a heat-insulating vessel (calorimeter) from two beakers (250 ml and 400 ml) and two sheets of felt, lining the larger beaker with the felt and then inserting the smaller one.

3. Carefully slide the heating coil into the slot in the calorimeter lid.

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Set-up (3/3)

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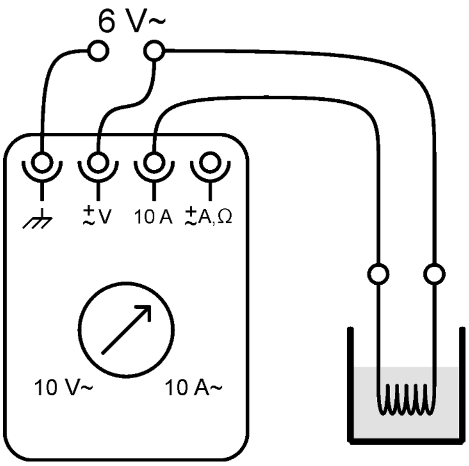

Circuit diagram of the structure

4.Carefully slide the heating coil into the slot in the calorimeter lid.

5.Push the stirring rod from below through the corresponding hole in the lid.

6.Make sure that the power supply is still switched off.

Procedure (1/3)

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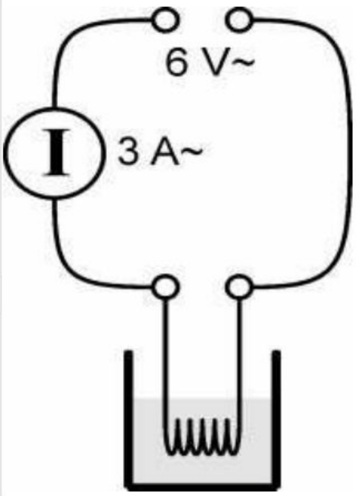

Figure 2

1.Turn on your Cobra SMARTsense temperature sensor. Open the measure\ app app and select the temperature sensor.

2.Set the sampling rate to 1 Hz. and go to the graph window.

3.Measure 200 ml of water from the Erlenmeyer flask in the measuring cylinder (exact measurement with the aid of the pipette) and fill it into the calorimeter. Record the amount of water.

4.Connect the heating coil and the multimeter with the connecting leads to the 6 V~ AC output (power supply unit off!), as shown in Fig. 2. Select the measuring range 3 A~.

5.Stir and wait until the temperature reading remains constant.

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Procedure (2/3)

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6.Simultaneously start the recording of measured values in the measureApp and switch on the power supply unit. A temperature reading is recorded every second.

7.During the measurement, stir the water in the calorimeter carefully so that the heat is distributed evenly. Start stirring immediately after starting the measurement.

8.End the measurement with after 350 s and save it.

Procedure (3/3)

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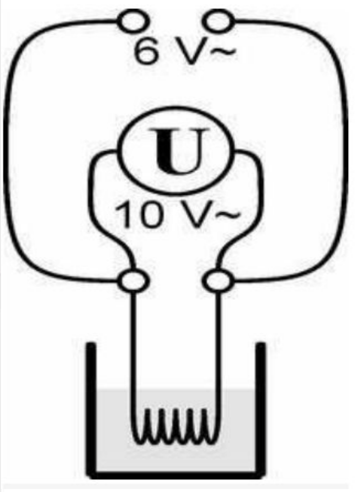

Figure 3

9.Connect the heating coil and the multimeter with the connecting leads to the AC output 6 V~ as shown in Fig. 3, select measuring range 10 V~.

10. Switch on the power supply unit and log the voltage. Switch the power supply unit off again!

11. In the app, select the regression line and pass it through the back part of the curve. The slope of the curve is the temperature change rate with the unit °C/s.

It is required for further evaluation in the log.

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Report

Task 1

Enter your readings in this table.

physical quantity	Measured value
Mass of the water m_W on g	
Electrical voltage U on V	
Electrical scattering strength I on A	
Termperature change rate in $\frac{^\circ C}{s}$	

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Task 2

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How large is the heat quantity ΔQ with the unit J (joules) that the water absorbs every second?

- The absorbed heat capacity corresponds to a constant amount of 756 kJ per second, regardless of the voltage and current with which the heating coil is operated.
- The amount of heat absorbed corresponds to the energy that the heating coil emits per second. This is called its electrical power P and is calculated from $P = U \cdot I$.
- The amount of heat absorbed is equal to the square of the energy emitted by the heating coil per second. It is therefore true that $\Delta Q = \frac{J^2}{s}$.
- The amount of heat absorbed per second corresponds to the amount of heat capacity C of the water.

Task 3

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Based on tasks 1 and 2, fill in the table and calculate the specific heat capacity $c = \Delta Q / \Delta \theta$ of water.

physical quantity	Measured value
electrical power P on J/s	
Heat quantity $\Delta\ Q$	
Temperature change $\Delta\theta$ on $^\circ C$	
specific heat capacity c on $J/(g \cdot {}^\circ C)$	

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Task 4

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Drag the words into the correct gaps

There is what is called a systematic ______ in this experiment. This is an unavoidable problem with the ______ which affects the results.
In this case, it is the ______ of the calorimeter which affects the ______.
Since perfect ______ never exist, one must be aware of such limitations in the implementation of experiments in science.

- temperature change
- experimental setup
- conditions
- heat capacity
- error

Check

Task 5

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The greater the heat capacity of a substance, the smaller the amount of heat required to heat the substance by 1 °C.

- True
- Incorrect

Check

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Slide	Score / Total
Slide 19: Heat quantity	0/1
Slide 21: Calorimeter	0/5
Slide 22: Stir	0/1

Total 0/7

Solutions Repeat Export text

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