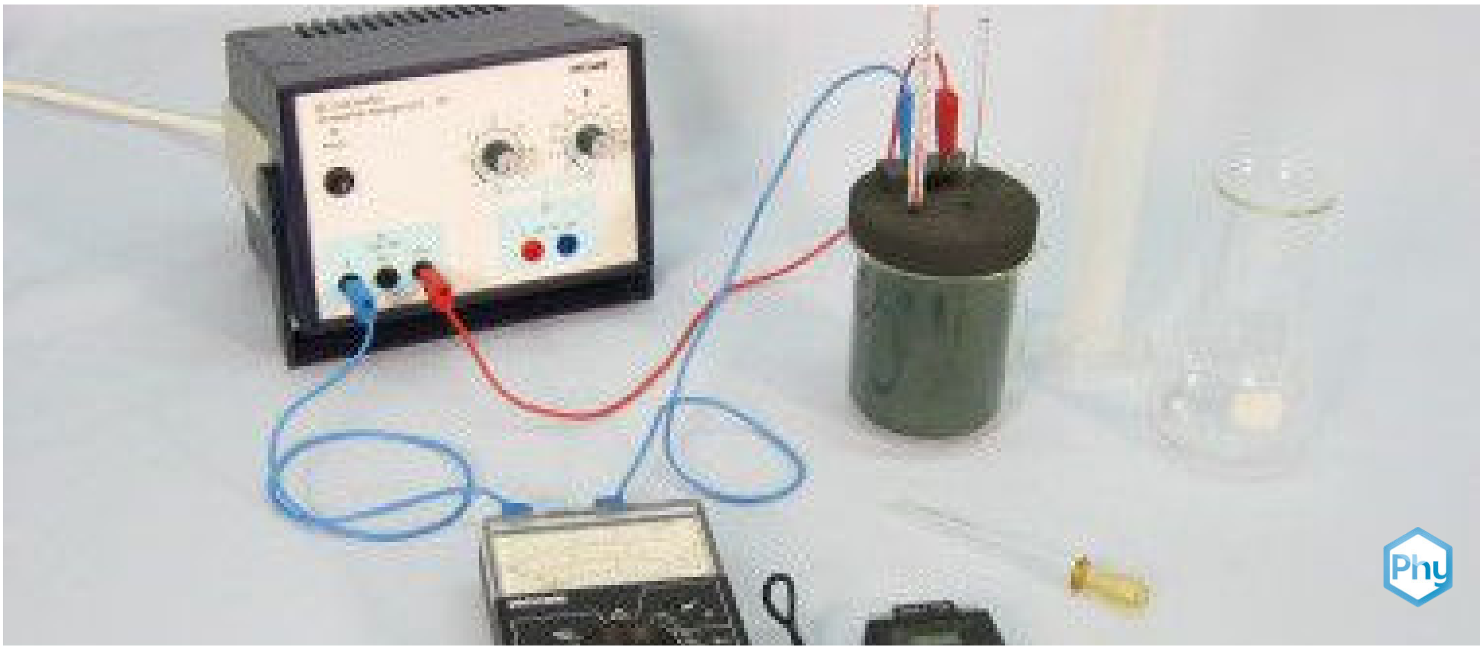
Specific heat capacity of water



P1043900

Physics → Thermodynamics → Heat energy, thermal capacity

Physics → Thermodynamics → Calorimetry

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

This content can also be found online at:

http://localhost:1337/c/6166945ce473310003365df4

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General information

Application

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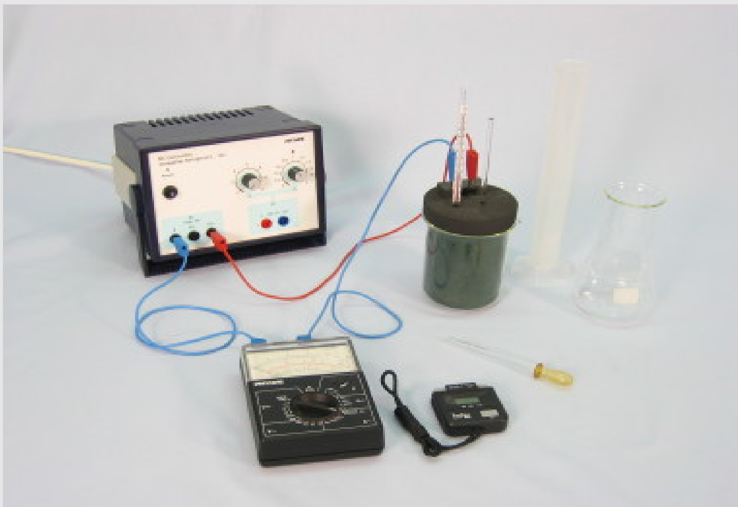

Experiment setup

The specific heat capacity c gives the proportionality factor between the heat supplied and the resulting temperature change of a body.

It is a material-dependent constant that can be used to directly compare how much heat a material can store.

In this experiment, students determine the specific heat capacity of water.

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Other teacher information (1/5)

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Previous knowledge

Students should be able to set up a simple circuit and take readings from a thermometer and a multimeter.

Scientific principle

A measured quantity of water is heated with a heating coil. The electrical heating power is determined. The specific heat capacity of water is calculated from the temperature increase and heating energy.

Other teacher information (2/5)

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Learning objective

With the help of this experiment, students learn how to determine the specific heat capacity.

Tasks

Heat 200 ml of water with a heating coil. Measure the temperature increase as a function of time and determine the power of the heating coil.

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Other teacher information (3/5)

Additional information

The specific heat capacity of water is calculated from the temperature increase and heating energy. This calculation is made in task 5 as the mean value of the individual measurements. This evaluation point can be skipped and the method of the additional task can be used instead. Here the specific heat capacity is determined from the graphical representation of the measured values. In addition, this value is corrected by taking into account the heat capacity of the calorimeter.

Notes

- The analogue multimeter (07028.01) has a special input socket for the 10 A measuring range.
- When a heating voltage of 12 V is switched on, the heating coil must be immersed in water, otherwise it will glow through.

Other teacher information (4/5)

Further hints

- The water in the calorimeter should be stirred regularly and intermediate values of 0.5°C should also be estimated when reading the thermometer.
- Determination of the power in the heating coil with 1 measuring instrument:
    - The student text suggests logging the specified output voltage of the power supply.
    - If the voltage at the heating coil is also to be measured, this must be done after the experiment has been carried out and with the heating coil connected (Fig. 1, other teacher information 5/5). The heating coil must be immersed in water! However, the value measured in this way does not correspond exactly to the voltage actually applied to the heating coil during the experiment, since the voltage drop at the ammeter is approx. 0.2 V.

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Other teacher information (5/5)

Further hints

- Determination of the power in the heating coil with 2 measuring instruments:
    - Current and voltage can be measured simultaneously. Due to the low resistance of the heating coil, the circuit shown in Fig. 2 should be used.

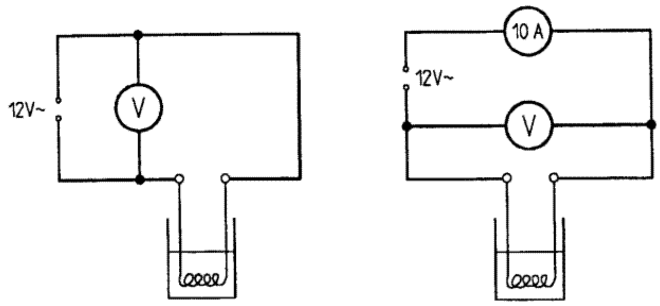

Fig. 1 Fig. 2

Safety instructions

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

The heating coil must be in the water when a voltage of 12 V is applied!

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Student Information

Motivation

When the sun sets in summer, the grass in the garden quickly becomes quite fresh, 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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Experiment setup

How much heat is needed to heat water?

Heat 200 ml of water with a heating coil. Measure the temperature increase as a function of time and determine the power of the heating coil.

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Equipment

Position	Material	Item No.	Quantity
1	Lid for student calorimeter	04404-01	1
2	Agitator rod	04404-10	1
3	Heating coil with sockets	04450-00	1
4	Felt sheet, 100 x 100 mm	04404-20	2
5	Beaker, Borosilicate, low form, 250 ml	46054-00	1
6	Beaker, Borosilicate, low-form, 400 ml	46055-00	1
7	Erlenmeyer flask, borosilicate, wide neck, 250 ml	46152-00	1
8	Pipette with rubber bulb	64701-00	1
9	Graduated cylinder 100 ml, PP transparent	36629-01	1
10	Students thermometer, -10...+110°C, l = 230 mm	38005-10	1
11	Digital stopwatch, 24 h, 1/100 s and 1 s	24025-00	1
12	Digital multimeter, 600V AC/DC, 10A AC/DC, 20 MΩ, 200 µF, 20 kHz, −20°C… 760°C	07122-00	1
13	Connecting cord, 32 A, 500 mm, red	07361-01	1
14	Connecting cord, 32 A, 500 mm, blue	07361-04	2
15	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

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Structure (1/2)

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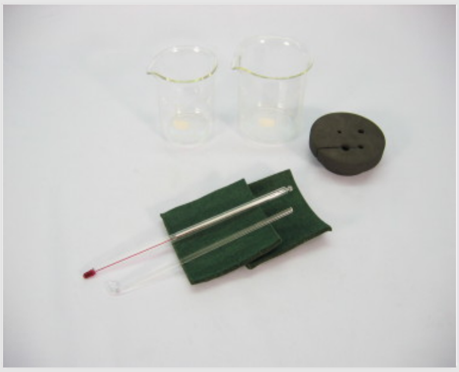
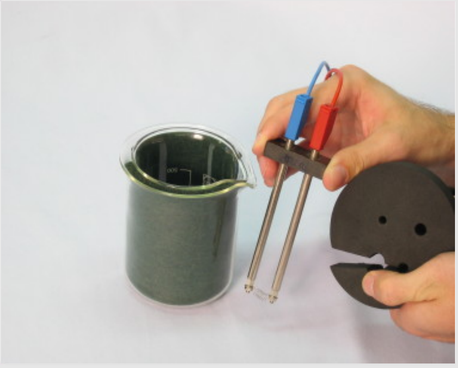
- Assemble a heat-insulating vessel (calorimeter) from two beakers (250 ml and 400 ml) and two felt plates.
- Carefully slide the heating coil into the slot in the calorimeter lid.





Structure (2/2)

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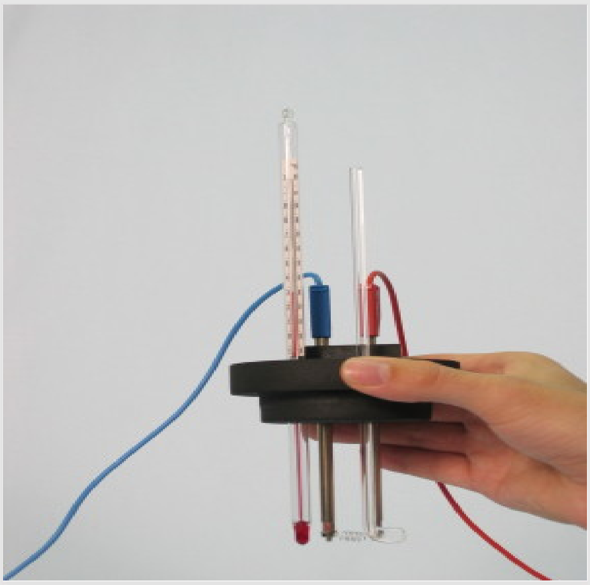

- Push the thermometer (d = 8 mm) and stirring rod (d = 5 mm) through the corresponding holes in the lid.
- Make sure that the power supply is still switched off.

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Procedure (1/2)

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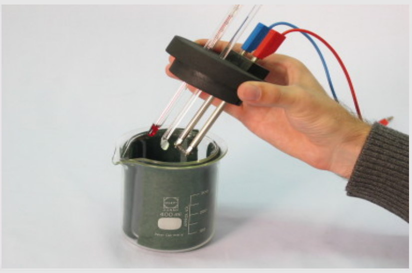
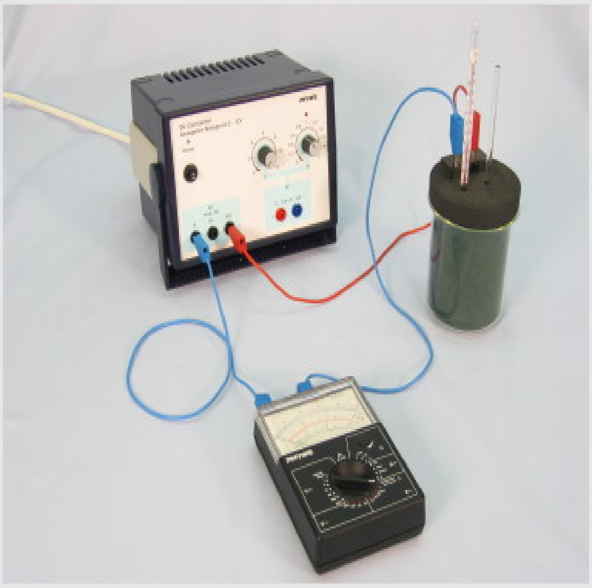
- Fill the Erlenmeyer flask with water.
- Measure 200 ml of this with the measuring cylinder (accurate measurement with the pipette), fill the water into the calorimeter and record the amount of water (see figure above).
- Place the lid with heating coil, thermometer and stirring rod on the calorimeter (see figure below).
- Set the measuring instrument to the measuring range 10 A.



Procedure (2/2)

- Connect the heating coil to the AC output 12 V of the power supply unit (still off!) using the connecting cables, as shown in the illustrations.
- Measure the initial temperature T_0 of the water and enter them in Table 1 in the protocol.
- Switch on the power supply and the stopwatch at the same time.
- Measure the water temperature every minute for 10 minutes. Stir regularly in between and enter the measured values in Table 1. Measure the current in the heating circuit during heating.
- Switch the power supply off again at the end of the measurement series.



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Report

Task 1

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Enter your measured values in the fields.

Water quantity	V in ml	Current	I A
Initial temperature	T_0 in °C	Voltage	U in V

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Task 2

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Enter the measured values for the water temperature T in the table.

t in min	T in °C	t in min	T in °C	t in min	T in °C
1		5		9	
2		6		10	
3		7			
4		8			

Task 3

PHYWE

- Determine the mass of the water $m = \rho \cdot V$ (ρ = density)
- Calculate the electrical power of the heating coil $P = U \cdot I$.

m in g	P in W

- Calculate the temperature increase $\Delta T = T - T_0$ and enter them in the table on the next page.
- Calculate the electrical heating energy $Q = P \cdot t$. It is like the heat added to the water.

  Note: Convert heating time to seconds and the unit of energy is 1 Ws = 1 J.
- Also known:

  "The greater the mass of water heated, the greater the energy required to do so."

  Man therefore forms the quotient $c = Q/(m \cdot \Delta T)$. This quantity is called the specific heat capacity.

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Task 4

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t in min	ΔT in °C	Q in J	c in J/(g·°C)
1			
2			
3			
4			
5			

t in min	ΔT in °C	Q in J	c in J/(g·°C)
6			
7			
8			
9			
10			

Task 5

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Calculate the mean value of the specific heat capacity from the previous table.

c_{mittel} in J/(g·°C)

What is the relationship between heating energy and temperature increase?

- They are directly proportional.
- They're not connected.
- They are antiproportional.

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Additional tasks

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Determine the specific heat capacity of water from the slope of the straight line.

Discuss with your classmates:

1. What systematic error does the experimental design contain?
2. What is its influence on the result of the spec. heat capacity of water?

Slide	Score / Total
Slide 22: Untitled: Single Choice Set	0/1

Total 0/1

Solutions Repeat Export text

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