# Specific heat capacity of water (Item No.: P1043900)

## Curricular Relevance

| Area of Expertise: | Education Level: | Topic: | Subtopic: | Experiment: |
|---|---|---|---|---|
| Physik | Klasse 10-13 | Thermodynamik | Kalorimetrie | Spezifische Wärmekapazität von Wasser |

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

**Additional Requirements:**

**Experiment Variations:**

**Keywords:**

## Task and equipment

## Information for teachers

## Additional Information

A measured quantity of water is heated with a heating coil. The electrical heat output is determined. From the temperature increase and the heat energy, the specific heat capacity of water is calculated. This calculation is performed under point 6 of "Evaluation", i.e. determination of the average value of the individual measurements. Optionally, this evaluation point can be skipped and the method in the supplementary problem can be used instead.
In the supplementary problem the specific heat capacity is determined from a plot of the measured values. Additionally, this value is corrected by accounting for the heat capacity of the calorimeter.

## Remarks

1. The multi-range meter, analogue (07028-01) has a special input jack for the 10 A measuring range.
2. Before the 12 V heating voltage is applied, the heating coil must be immersed in water; otherwise, it will burn out.
3. The water in the calorimeter must be regularly stirred.
4. The thermometer reading should be estimated to the nearest 0.5 °C.
5. Determination of the heating coil's output:

   With one meter:

   In the student's text we recommend recording the power supply's output voltage.If the voltage at the heating coil is also measured, this must be done after completing the experiment and with connected heating coil. The heating coil must be immersed in water during the measurement! The thus-measured value does not exactly correspond to the voltage applied to the heating coil during the experiment since the voltage drop at the meter is about 0.2 V. (Fig. 1)

   With 2 meters:

   Current and voltage can be simultaneously measured. Due to the small resistance of the heating coil, this should be done using the circuit shown in the figure 2.

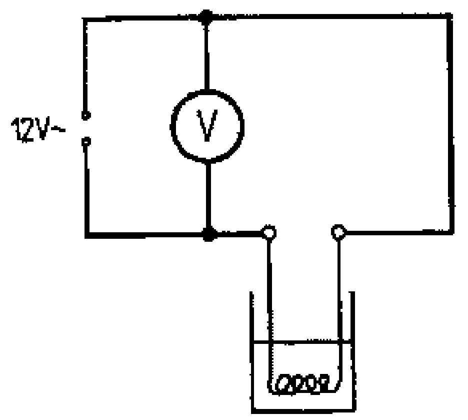

Fig. 1

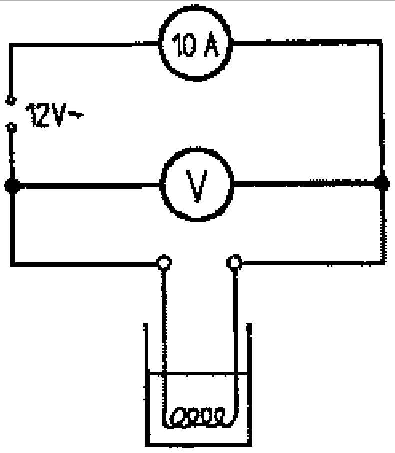

Fig. 2

# Specific heat capacity of water (Item No.: P1043900)

## Task and equipment

### Task

### How much heat is needed to raise water's temperature?

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

## Equipment


| Position No. | Material | Order No. | Quantity |
|---|---|---|---|
| 1 | Lid for student calorimeter | 04404-01 | 1 |
| 1 | Felt sheet, 100 x 100 mm | 04404-20 | 2 |
| 1 | Stop watch 4 | 03078-00 | 1 |
| 2 | Agitator rod | 04404-10 | 1 |
| 2 | Heating coil with sockets | 04450-00 | 1 |
| 2 | Pipette with rubber bulb | 64701-00 | 1 |
| 2 | Graduated cylinder 100 ml, PP transparent | 36629-01 | 1 |
| 2 | Students thermometer, -10...+110°C, l = 230 mm | 38005-10 | 1 |
| 3 | Glass beaker DURAN®, short, 250 ml | 36013-00 | 1 |
| 4 | Glass beaker DURAN®, short, 400 ml | 36014-00 | 1 |
| 5 | Erlenmeyer flask,wide neck,250ml | 36134-00 | 1 |
| 6 | Connecting cord, 32 A, 500 mm, red | 07361-01 | 1 |
| 6 | Connecting cord, 32 A, 500 mm, blue | 07361-04 | 2 |
| | PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A | 13505-93 | 1 |
| | Multi-range meter, analogue | 07028-01 | 1 |

# Set-up and procedure

## Set-up

## Attention!

Before the 12 V heating voltage is applied, the heating coil must be immersed in water; otherwise, it will burn out.

## Setup

- Assemble a thermally insulated vessel (calorimeter) using two beakers (250 ml and 400 ml) and two felt sheets.

Fig. 1

Fig. 2

- Insert the heating coil carefully through the slit in the calorimeter's lid.

Fig. 3

- Insert the thermometer (d = 8 mm) and agitator rod (d = 5 mm) through the corresponding holes in the lid.

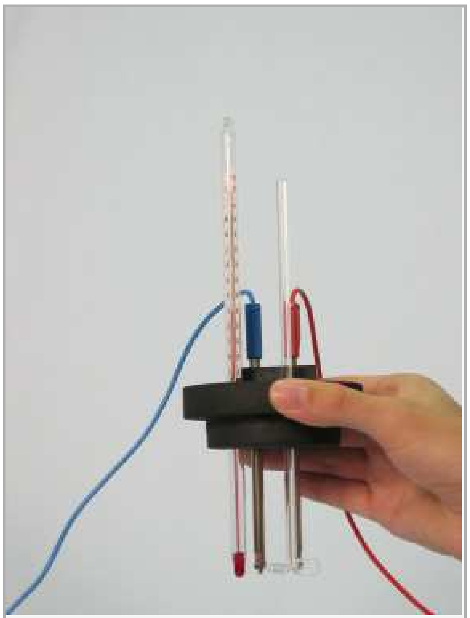

Fig. 4

- Be sure that the power supply is still turned off.

## Procedure

- Fill the Erlenmeyer flask with water.
- First, measure 200 ml of water with the graduated cylinder (exact measurement with the pipette) and then pour the water in the calorimeter. Record the quantity of water in the report.

Fig. 5

- Place the lid with heating coil, thermometer and agitator rod onto the calorimeter.

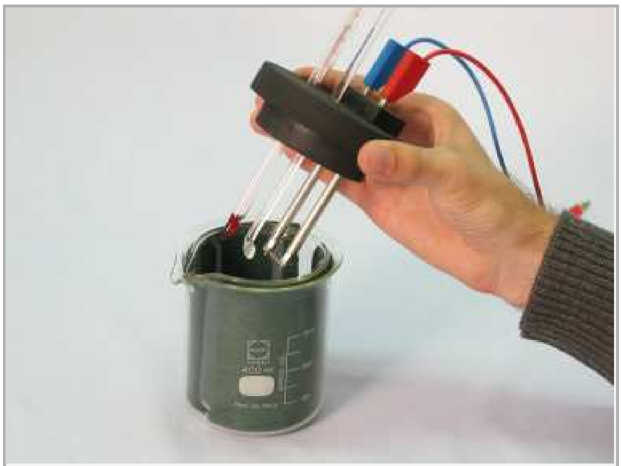

Fig. 6

Fig. 7

- Set the measuring range of the multi-range meter to 10 A.
- Connect the heating coil to the 12 V AC outlet on the power supply (still turned off!) with the connecting cords as shown.

Fig. 8

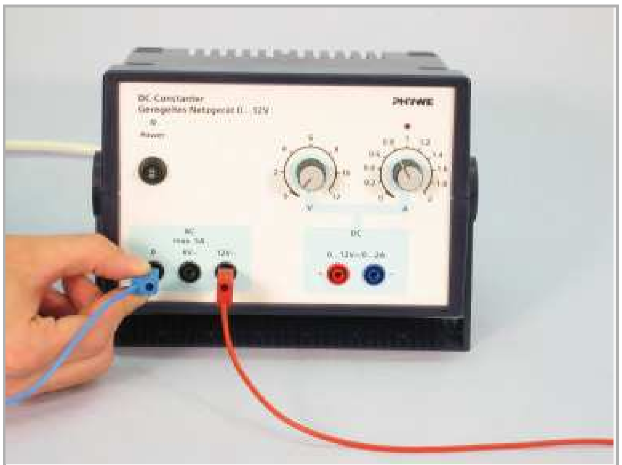

Fig. 9

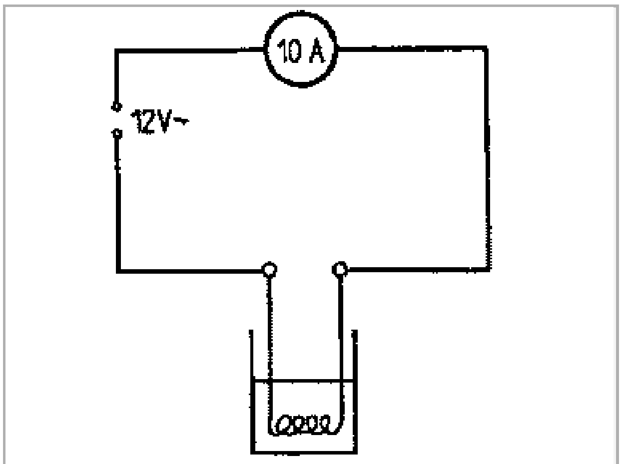


Fig. 10

Fig. 11

- Measure the initial temperature $\vartheta_0$ of the water and record it in the blank above table 1 in the report.
- Turn on the power supply and start the stop watch simultaneously.
- Determine the water temperature for 10 min at 1 min intervals. Stir at regular intervals; and record the measured values in table 1 (report).
- During the heating process, measure and record the current in the report.
- Turn off the power supply at the end of the experiment.

# Report: Specific heat capacity of water

## Result – Observations 1

1. Quantity of water: $V$ = .................................. ml
2. Initial temperature: $\vartheta_0$ = .................................. °C
3. Current: $I$ = .................................. A
4. Voltage: $U$ = .................................. V

## Result – Table 1

Enter measured values for temperature of water $\vartheta$ in the table.

| $t$ in min | $\vartheta$ in °C |
|---|---|
| 1 | 1 ±0 |
| 2 | 1 ±0 |
| 3 | 1 ±0 |
| 4 | 1 ±0 |
| 5 | 1 ±0 |
| 6 | 1 ±0 |
| 7 | 1 ±0 |
| 8 | 1 ±0 |
| 9 | 1 ±0 |
| 10 | 1 ±0 |

## Evaluation – Question 1

1. Determine the mass of the water $m = \rho$ x $V$ = .................................. g. (Density $\rho$ = 1 g/ml)
2. Calculate the electrical output of the heating coil $P = U$ x $I$ = .................................. W.

## Evaluation – Question 2

1. Calculate the temperature increase $\Delta\vartheta = \vartheta - \vartheta_0$ and record it in table 2 below.
2. Calculate the electrical heat energy $Q = P \cdot t$. Is it as large as the heat added to the water? Attention!
   - Convert the heating time to seconds!
   - For the energy units, 1 Ws = 1 J.
3. In addition, the following is known:
   "The larger the mass of the water to be heated, the greater the required energy."
   For this reason, the following quotient is formed: $c = Q / (m \cdot \Delta\vartheta)$. This quantity is termed the specific heat capacity.
   Complete table 2 below.

| $t$ in min | $\Delta\vartheta$ in °C | $Q$ in J | $c$ in J/(g °C) |
|---|---|---|---|
| 1 | 1 ±0 | 1 ±0 | 1 ±0 |
| 2 | 1 ±0 | 1 ±0 | 1 ±0 |
| 3 | 1 ±0 | 1 ±0 | 1 ±0 |
| 4 | 1 ±0 | 1 ±0 | 1 ±0 |
| 5 | 1 ±0 | 1 ±0 | 1 ±0 |
| 6 | 1 ±0 | 1 ±0 | 1 ±0 |
| 7 | 1 ±0 | 1 ±0 | 1 ±0 |
| 8 | 1 ±0 | 1 ±0 | 1 ±0 |
| 9 | 1 ±0 | 1 ±0 | 1 ±0 |
| 10 | 1 ±0 | 1 ±0 | 1 ±0 |


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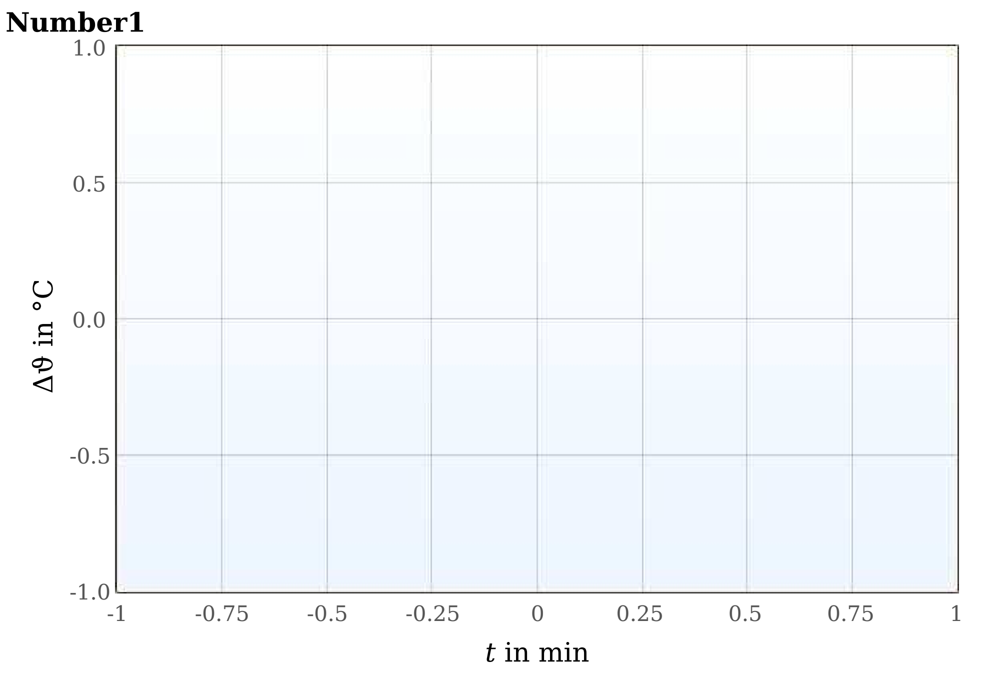


## Evaluation – Question 3

Calculate the average value of c (the specific heat capacity of water) from the values of table 2.

$c$ = ................................. J/(g °C).

## Evaluation – Question 4

What is the correlation between heat energy and temperature increase?

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## Evaluation – Additional Task 1

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

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## Evaluation – Additional Task 2

What is the methodological error contained in the experimental procedure? What is its influence on the resulting specific heat capacity of water?

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