Heat capacity of the calorimeter (Item No.: P1044100)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physics	Age 16-19	Thermodynamics	Calorimetry	Heat capacity of the calorimeter

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

Additional Requirements:

- Butane burner, Labogaz 206 type 32178-00
- Butane cartridge C206, without valve 47535-00
- Matches

Experiment Variations:

- with lab thermometer with stem

Keywords:

Task and equipment

Information for teachers

Additional Information

The same quantities of hot and cold water are mixed. The hot water is always poured into a calorimeter containing cold water (room temperature). The measurements are repeated three times and the calorimeter's heat capacity is then calculated as the average value of the three measurements.

Remarks

1. For exact measurement use the pipette and plastic beaker.
2. The thermometer should already be in the hot water during heating. After the burner has be extinguished, stir before reading the temperature ϑ2.
3. To pour the hot water the universal clamp should be removed from the bosshead and used as a handle for the Erlenmeyer flask.
4. The highest temperature which occurs after the hot water is poured in is the mix temperature.

The sample measurements provided were made with a thermometer with 1 degree divisions and estimation to the nearest 0.5 °C. The results for Ccal vary by about 50 %.
If, e.g., an error of only 0.5 °C occurs in the determination of ϑ_m, its influence on the result has this order of magnitude due to the double subtraction in the formula. The given values for C_{cal} and m_w were therefore estimated to the nearest 0.5 °C.
If a thermometers with 1/10 degree divisions is available, this should be used to measure the temperature of the cold water and the mix temperature! A suitable thermometer is on the Material page.
If necessary, the temperature of the hot water should be limited so that the mix temperature does not exceed the measuring range of thermometer.

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Task and equipment

Task

How much heat does the calorimeter absorb?

Mix equal quantities of hot and cold water and determine the mix temperature each time.

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	2
5	Glass tube holder with tape measure clamp	05961-00	1
6	Ring with boss head, i. d. = 10 cm	37701-01	1
7	Universal clamp	37715-00	1
8	Wire gauze with ceramic, 160 x 160 mm	33287-01	1
9	Lid for student calorimeter	04404-01	1
10	Felt sheet, 100 x 100 mm	04404-20	2
11	Agitator rod	04404-10	1
12	Pipette with rubber bulb	64701-00	1
13	Graduated cylinder 100 ml, PP transparent	36629-01	1
14	Students thermometer,-10...+110°C, l = 180 mm	38005-02	1
15	Students thermometer, -10...+110°C, l = 230 mm	38005-10	1
16	Beaker, low form, plastic, 100 ml	36011-01	1
17	Glass beaker DURAN®, short, 250 ml	36013-00	1
18	Glass beaker DURAN®, short, 400 ml	36014-00	1
19	Erlenmeyer flask 100 ml, wide-neck SB 29	36428-00	1
Additional material:			
20	Butane burner, Labogaz 206 type	32178-00	1
21	Butane cartridge C206, without valve	47535-01	1
22	Matches		
As an alternative	(Additional Information on the Information for teachers page)		
	Lab thermometer with stem 50 mm, +15...+40 °C	38057-00	1

Set-up and procedure

Set-up

Attention!

1. The thermometer reading should be estimated to the nearest 0.5 °C.
2. During the heating of the water the support ring and the wire gauze become extremely hot! To transfer the hot water to another container the universal clamp should be removed from the bosshead and used as a handle for the Erlenmeyer flask.

Setup

- Set up the support stand according to the following pictures.

Fig. 1

Fig. 2

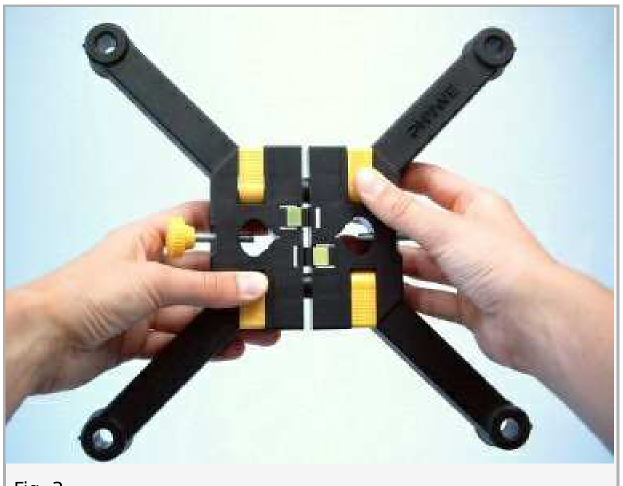

Fig. 3

Fig. 4


Fig. 5


Fig. 6


Fig. 7


Fig. 8

- Fix the short thermometer above the wire gauze using the glass tube holder.

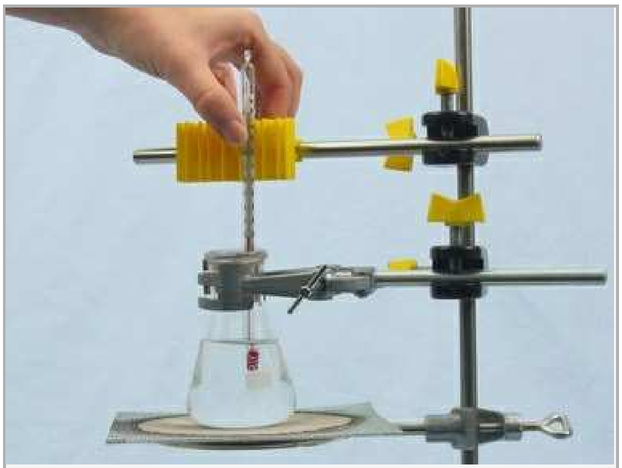

Fig. 9

Fig. 10

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

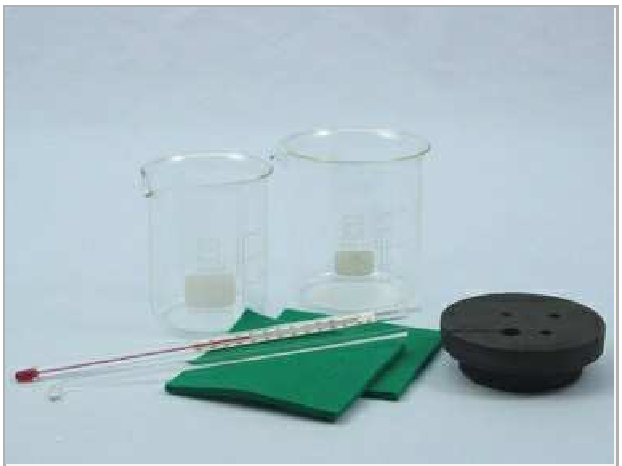

Fig. 11

Fig. 12

Fig. 13

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

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Fig. 14

Fig. 15

Procedure

- Pour 100 ml (100 g) of water in the Erlenmeyer flask (exact measurement using the graduated cylinder and pipette).

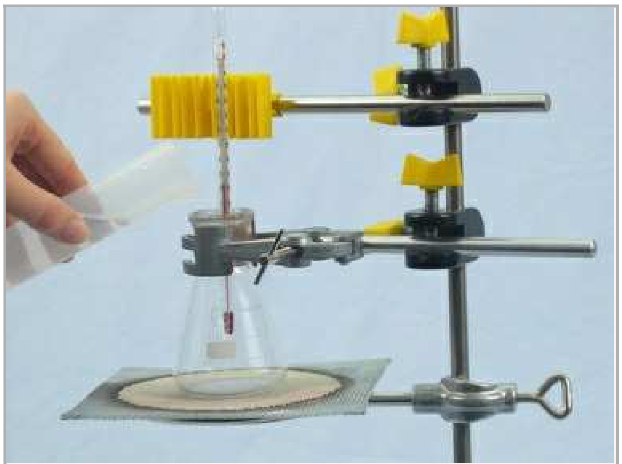

Fig. 16

- Heat the water in the Erlenmeyer flask to a temperature between 50 °C and 60 °C.
- Pour 100 ml (100 g) of cold water into the calorimeter (exact measurement using the graduated cylinder and pipette).

Fig. 17

- Turn off the burner.
- Measure the temperature of the cold water ϑ_1 and the hot water ϑ_2(stir!); record the values in Table 1 in the report.
- Pour the hot water in the calorimeter.

Fig. 18

- Stir and then record the highest temperature which appears (mix temperature ϑm).
- Repeat the experiment two more times.

Report: Heat capacity of the calorimeter

Result - Table 1

Record the measured values of the temperatures of cold (ϑ_1) and hot (ϑ_2) water and of the mixture (ϑ_m) for all 3 measurements in the table.

	Measurement 1	Mesurement 2	Measurement 3
ϑ_1 in °C	1 ±0	1 ±0	1 ±0
ϑ_2 in °C	1 ±0	1 ±0	1 ±0
ϑ_m in °C	1 ±0	1 ±0	1 ±0

Evaluation - Question 1

1. Calculate the differences $\vartheta_2 - \vartheta_m$ and $\vartheta_1 - \vartheta_m$; record the values in the table below.
2. Calculate the heat capacity C of the calorimeter according to the following formula:
   $C = c \cdot (m_2 \cdot (\vartheta_2 - \vartheta_m) / (\vartheta_m - \vartheta_1) - m_1)$,
   where c = 4.19 J/g°C is the specific heat capacity of water. Record the values in the table.

	Measurement 1	Measurement 2	Measurement 3
$\vartheta_2 - \vartheta_m$ in °C	1 ±0	1 ±0	1 ±0
$\vartheta_m - \vartheta_1$ in °C	1 ±0	1 ±0	1 ±0
C in J/°C	1 ±0	1 ±0	0 ±0

Evaluation - Question 2

Determine the heat capacity C as the average value of the three measurements:

C = ... J/°C.

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Evaluation - Supplementary problem 1

Instead of the heat capacity of the calorimeter the "water equivalent" is often given, i.e. the mass of water which would require just as much energy to heat as the calorimeter. Calculate the water mass which has the same heat capacity as your calorimeter.

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