Temperature of mixed liquids (Item No.: P1044000)

Curricular Relevance

Area of Expertise: Physics
Education Level: Age 14-16
Topic: Thermal physics
Subtopic: Heat energy, thermal capacity
Experiment: Temperature of mixed liquids

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Easy	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:

Keywords:

Task and equipment

Information for teachers

Additional Information

Different amounts of hot and cold water are mixed. The hot water is always poured into a calorimeter containing cold water (room temperature). This has the following advantage: the cold water defines the temperature of the calorimeter; and since the hot water is poured in, the mix temperature is the largest value which is found in every case.

The emergence of a mix temperature is first qualitatively explained. In the supplementary problem the equation for the mix temperature is given. The comparison of the calculated and measured values shows that the heat capacity of the calorimeter must still be considered.

Remarks

1. For exact measurement of quantities of water the pipette and the graduated cylinder should be used.
2. The thermometer should already be in the hot water when heating. After the burner has be extinguished, stir before reading the temperature ϑ_2.
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.
5. The thermometer reading should be estimated to the nearest 0.5 °C.

Supplementary problem

The equation for the mix temperature results from the energy balance, i.e.
heat release = heat absorption
$c \times m_2 \times (\vartheta_2 - \vartheta_m) = c \times m_1 \times (\vartheta_m - \vartheta_1)$

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Task and equipment

Task

What temperature results from the mixing of hot and cold water?

Mix different 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 = 600 mm, d = 10 mm	02037-00	1
3	Support rod, stainless steel, l = 250 mm, d = 10 mm	02031-00	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		

Set-up and procedure

Set-up

Attention!

1. During the heating of the water the support ring and the wire gauze become extremely hot!
2. To pour the hot water 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

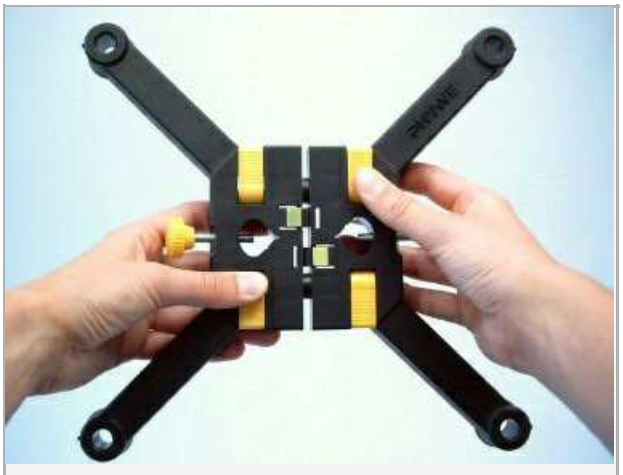
Fig. 3


Fig. 4


Fig. 5


Fig. 6


Fig. 7


Fig. 8

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

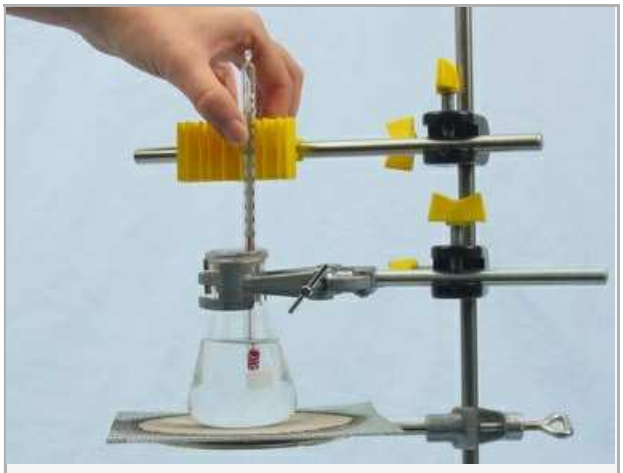
Fig. 9


Fig. 10

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

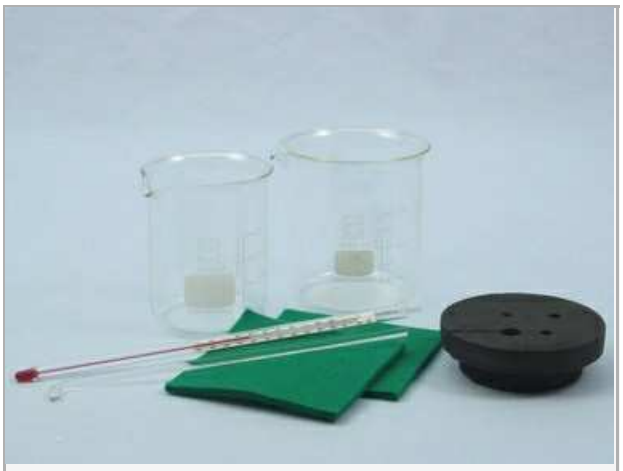
Fig. 11


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.

Fig. 14

Fig. 15

Procedure

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

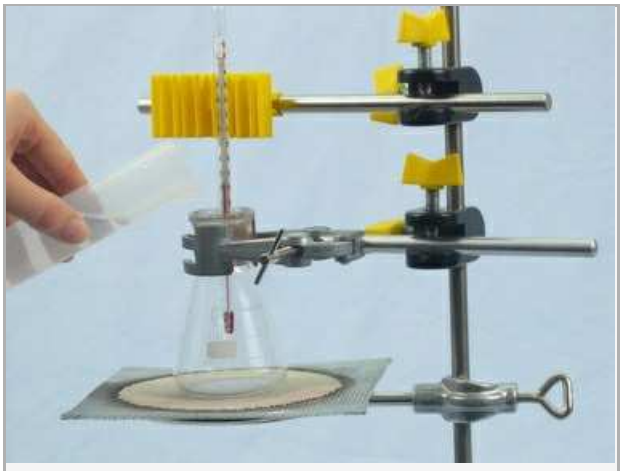

Fig. 16

- Heat the water in the Erlenmeyer flask to about 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 and record the values in Table 1 in the report.
- Pour the hot water in the calorimeter.

Fig. 18

- Stir and then read the highest temperature which appears (mixed temperature ϑ_m).
- Repeat the experiment with other quantities of water:
  50 ml cold and 100 ml hot water;
  100 ml cold and 50 ml hot water.

Report: Temperature of mixed liquids

Result - Table 1

1. Note the initial temperature of cold (ϑ_1) and hot (ϑ_2) water in the table as well as the temperature of the mixed liquids (ϑ_m).
2. Calculate the average values of ϑ_1 and ϑ_2; record them in the table.

cold water		hot water		mixture	average value
m_1 in g	ϑ_1 in °C	m_2 in g	ϑ_2 in °C	ϑ_m in °C	$(\vartheta_1 + \vartheta_2) / 2$ in °C
100	1 ±0	100	1 ±0	1 ±0	1 ±0
50	1 ±0	100	1 ±0	1 ±0	1 ±0
100	1 ±0	50	1 ±0	1 ±0	1 ±0

Evaluation - Question 1

Compare the mix temperatures with the average values.

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Evaluation - Question 2

Explain your result from the previous question!

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Evaluation - Supplementary problem 1

Calculate the mix temperature using the following equation and record the values in the table below:

$\vartheta_m = (m_1 \cdot \vartheta_1 + m_2 \cdot \vartheta_2) / (m_1 + m_2)$

cold water	hot water	calculated
m_1 in g	m_2 in g	ϑ_m in °C
100	100	$^{1}_{\pm 0}$
50	100	$^{1}_{\pm 0}$
100	50	$^{1}_{\pm 0}$

Robert-Bosch-Breite 10
D - 37079 Göttingen

Tel: +49 551 604 - 0
Fax: +49 551 604 - 107

info@phywe.de
www.phywe.com

Evaluation - Supplementary problem 2

How can the measured value's deviation from the calculated one be explained?

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