Specific heat of fusion of water (Item No.: P1044700)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physics	Age 14-16	Thermal physics	States of matter: Melting, boiling, evaporation	Specific heat of fusion of water

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
- Ice, crushed (hammer, ice cubes and cloth)

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional Information

Ice cubes are placed in warm water and the specific heat of fusion of water is determined from the mix temperature. In relation, the calculations carried out in the evaluation show which mix temperature would occur in an experiment with the same volume of water at 0 °C. The comparison of these calculations with the actually measured mix temperature shows very clearly the influence of the specific heat of fusion.

Remarks

1. The experiment can also be performed with water at room temperature (at least 20 °C). However, in warm water the ice cubes melt more rapidly. Additionally, the mix temperature then is higher and reading errors are not so noticeable in the following calculation (temperature difference not so small).
2. When reading the thermometer, the temperature should be estimated to the nearest 0.5 °C.

The attempted comparison of mixing experiment with ice and a mixing experiment with water at 0 °C is not simple to perform experimentally since the warm water in both cases should have the same initial temperature.

Information on Tasks

The formulas for the mix temperature can be derived from the following statement:
$Q_{out} = Q_{in}$.
For Question 2 that means
$c \cdot m_1 (\vartheta_1 - \vartheta_{mw}) = c \cdot m2 (\vartheta_{mw} - \vartheta 2)$.
For Question 4:
$c \cdot m_1 (\vartheta_1 - \vartheta_m) = c \cdot m2 (\vartheta_m - \vartheta 2) + q \cdot m_2$.
For the supplementary problem:
$(c \cdot m_1 + C) \cdot (\vartheta_1 - \vartheta_m) = c \cdot m2 (\vartheta_m - \vartheta 2) + q \cdot m_2$.

The literature value for the specific heat of fusion of water is: q = 334 J/g.

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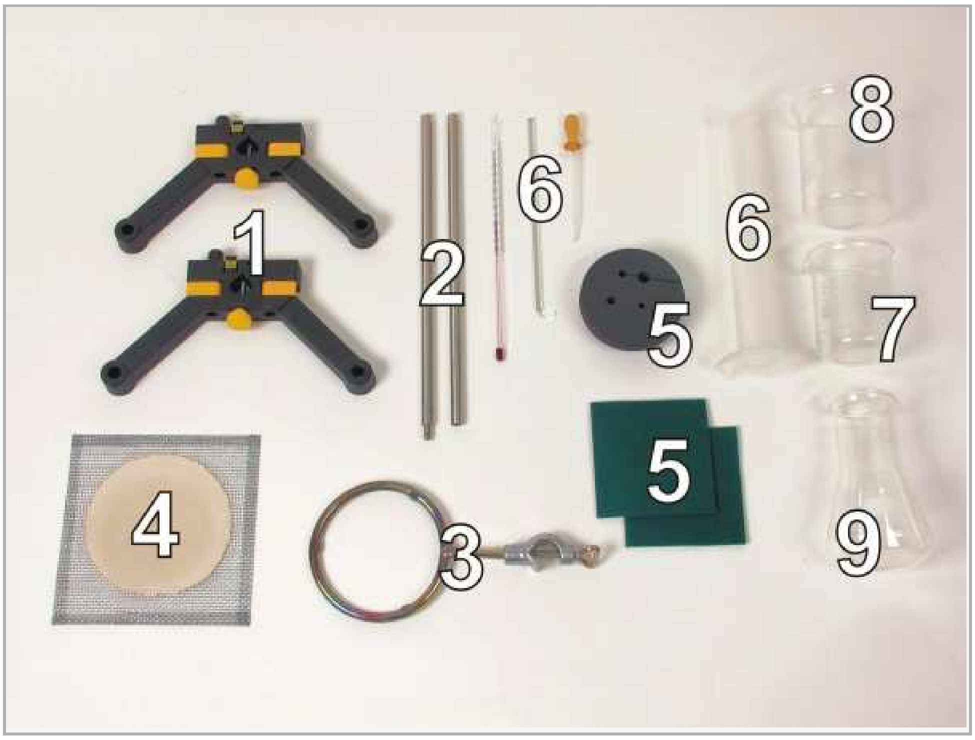
Task and equipment

Task

How much heat is needed to melt ice?

Add ice cubes to a measured quantity of warm water and determine the mix temperature.

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	Ring with boss head, i. d. = 10 cm	37701-01	1
4	Wire gauze with ceramic, 160 x 160 mm	33287-01	1
5	Lid for student calorimeter	04404-01	1
6	Felt sheet, 100 x 100 mm	04404-20	2
7	Agitator rod	04404-10	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	Glass beaker DURAN®, short, 250 ml	36013-00	1
12	Glass beaker DURAN®, short, 400 ml	36014-00	1
13	Erlenmeyer flask,wide neck,250ml	36134-00	1
Additional material:			
14	Butane burner, Labogaz 206 type	32178-00	1
15	Butane cartridge C206, without valve	47535-01	1
16	Matches		
17	Ice, crushed (ice cubes, hammer and cloth)		

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. When reading temperatures, the temperature should be estimated to the nearest 0.5 °C.

Setup

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

Fig. 1

Fig. 2

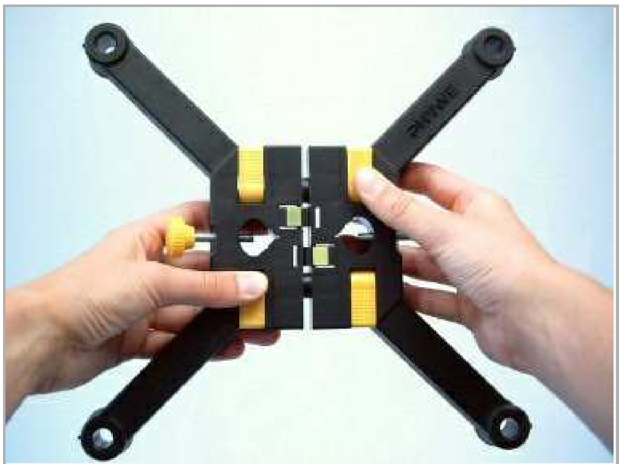


Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

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

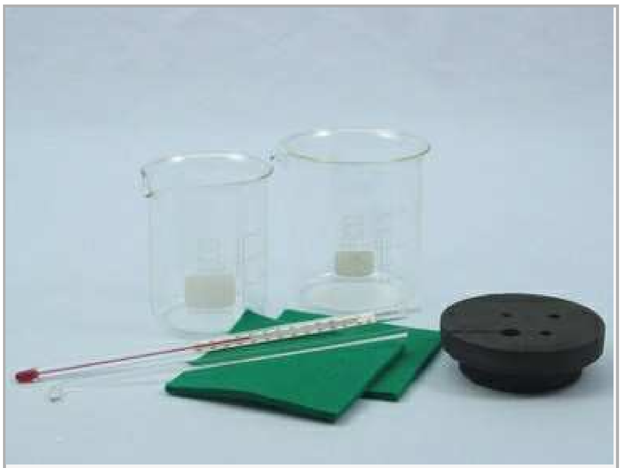


Fig. 9


Fig. 10

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


Fig. 11


Fig. 12

- Crush some large ice cubes with a hammer into pieces about 1 cm^3 in size. In doing so, you should wrap the ice cubes in a cloth so that the small pieces do not scatter.


Fig. 13


Fig. 14

- Leave the crushed ice on the cloth to dry.

Procedure

- Pour about 200 ml of water in the Erlenmeyer flask and heat it to about 35 °C.


Fig. 15

- Pour 150 ml of the warm water into the calorimeter (exact measurement with graduated cylinder and pipette).

Fig. 16

- Stir the water for about 1 min.
- Then, measure the water temperature ϑ_1 in the calorimeter and record the value in the table in the report.
- Place the (dried!) ice cubes into the calorimeter.

Fig. 17

- Put the lid on the calorimeter; rotate the agitator rod until all the ice has melted; measure the mix temperature ϑ_m and note its value in the report.
- Measure the final volume V_2 of the water in the calorimeter by pouring it back into the graduated cylinder (report).

Report: Specific heat of fusion of water

Result - Table 1

Note your measured values in the table.

Initial volume of water V_1 in ml	1 ±0
Initial water temperature ϑ_1 in °C	1 ±0
mix temperature ϑ_m in °C	1 ±0
Final volume of water V_2 in ml	1 ±0
Temperature of the ice ϑ_2 in °C	0

Evaluation - Question 1

Using the density of water (ρ = 1.0 g/ml) calculate the masses in the experiment.

1. Mass of the warm water $m_1 = \rho \cdot V_1 =$ .... g.
2. Mass of the ice $m_2 = \rho \cdot (V_2 - V_1) =$ .... g.

Evaluation - Question 2

Calculate how high the mix temperature would be if you were to use cold water with mass m_2 at a temperature ϑ_2 = 0 °C instead of ice.

$\vartheta_{mw} = (m_1 \cdot \vartheta_1 + m_2 \cdot \vartheta_2)/(m_1 + m_2) =$ .... °C.

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Evaluation - Question 3

Explain why there is a difference between the mix temperature calculated in Question 2 and that which was measured in the experiment.

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Evaluation - Question 4

From the measured mix temperature ϑ_m calculate the specific heat of fusion of water q. This quantity specifies how much heat is required to melt 1 g of water.

$q = (c_1 \cdot m_1(\vartheta_1\text{-}\vartheta_2) - c \cdot m_2\ (\vartheta_m\text{-}\vartheta_2))/m_2 =$ .... J/g,

where c = 4.19 J/g°C (specific heat capacity of water).

Evaluation - Supplementary problem 1

How large is the specific heat of fusion when the heat capacity of the calorimeter C = 80 J/°C is included in the calculation?

$q = (\ (c{\cdot}m_1+C)\ {\cdot}(\vartheta_1\text{-}\vartheta_2) - c{\cdot}m_2\ (\vartheta_m\text{-}\vartheta_2)\ )/m_2 =$ .... J/g.