Specific heat capacity of solid bodies (Item No.: P1044200)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physik	Klasse 10-13	Thermodynamik	Kalorimetrie	Spezifische Wärmekapazität fester Körper

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

Additional Requirements:

- Matches
- Scissors

Experiment Variations:

- with lab thermometer with stem

Keywords:

Task and equipment

Information for teachers

Additional Information

Three metal bodies having the same mass are heated in boiling water and then successively placed in a calorimeter. Even from just the measured mix temperatures it is possible to make qualitative conclusions as to the size of the storage ability (heat capacity) of the metals. The specific heat capacity of solid bodies is calculated from the released heat.

Remarks

1. The metal bodies should not touch the bottom of the beaker being heated since it could be hotter than 100 °C.
2. Heating all the metal bodies at one time has the advantage that no additional waiting times are required for the bodies to reach 100 °C.
3. When reading the thermometer, estimate the values to the nearest 0.5 °C.
4. The maximum value which occurs is to be considered as the mix temperature.

For this experiment we recommend a thermometer with 1/10-degree divisions since very small temperature differences must be evaluated. A suitable thermometer is on the Material page.

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Task and equipment

Task

How much heat can be stored in solid bodies?

Heat metal bodies in boiling water to 100 °C, immerse them in cold water and measure 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	Boss head	02043-00	1
4	Ring with boss head, i. d. = 10 cm	37701-01	1
4	Universal clamp	37715-00	1
5	Wire gauze with ceramic, 160 x 160 mm	33287-01	1
6	Lid for student calorimeter	04404-01	1
6	Felt sheet, 100 x 100 mm	04404-20	2
6	Fishing line, l. 20m	02089-00	1
7	Students thermometer, -10...+110°C, l = 230 mm	38005-10	1
7	Graduated cylinder 100 ml, PP transparent	36629-01	1
7	Pipette with rubber bulb	64701-00	1
7	Agitator rod	04404-10	1
8	Beaker, low form, plastic, 100 ml	36011-01	1
8	Glass beaker DURAN®, short, 400 ml	36014-00	1
9	Glass beaker DURAN®, short, 250 ml	36013-00	1
10	Erlenmeyer flask,wide neck,250ml	36134-00	1
11	Metal bodies, set of 3	04406-00	1
	Butane burner, Labogaz 206 type	32178-00	1
	Butane cartridge C206, without valve	47535-01	1
	Boiling beads, 200 g	36937-20	1
Additional material			
	Matches		
	Scissors		1
As an alternative	(Additional information for teachers)		
	Lab thermometer with stem 50 mm, +15...+40 °C	38057-00	1

Set-up and procedure

Set-up

Attention!

1. During heating of the water the support ring and the wire gauze become extremely hot!
2. The thermometer reading must be estimated to the nearest 0.5 °C.

Setup

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

Fig. 1

Fig. 2

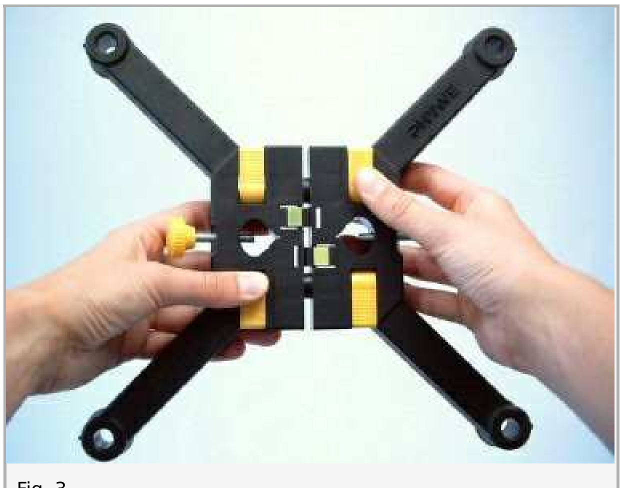

Fig. 3


Fig. 4a


Fig. 4b


Fig. 5


Fig. 6


Fig. 7

- Pour at least 250 ml of water into the Erlenmeyer flask and drop two beads into it.

Fig. 8

Fig. 9

- Thread a 40 cm long piece of fish line through each of the metal bodies and knot the ends of each together to form a loop.

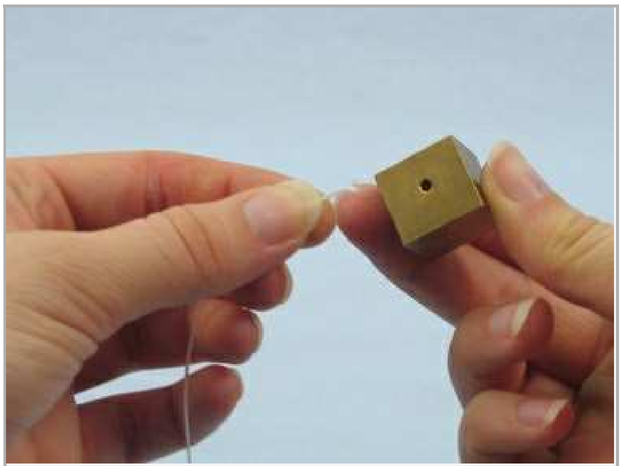

Fig. 10

- Hang all the metal bodies on the universal clamp. They should not touch the bottom of the Erlenmeyer flask and must be individually removable.


Fig. 11


Fig. 12

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

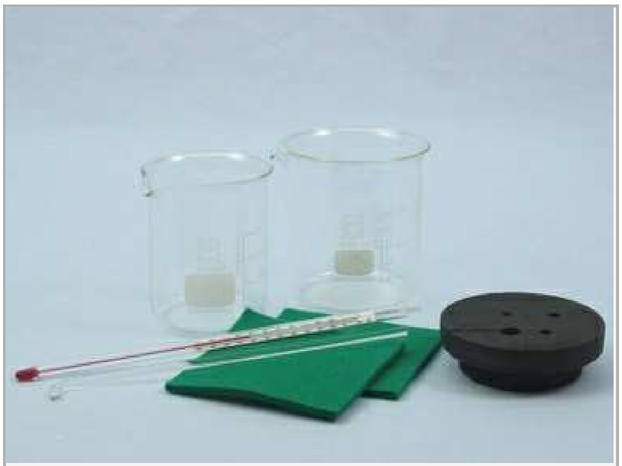
Fig. 13


Fig. 14

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

Fig. 15

Fig. 16

- Pour 100 ml of water into the calorimeter (exact measurement with graduated cylinder and pipette).

Fig. 17

Procedure

- Bring the water in the Erlenmeyer flask to a boil.
- Measure the temperature of the cold water ϑ_1 in the calorimeter and record it in the report.
- When the water boils, reduce the size of the flame slightly.
- Take one of the metal bodies out of the boiling water and transfer it rapidly to the calorimeter.

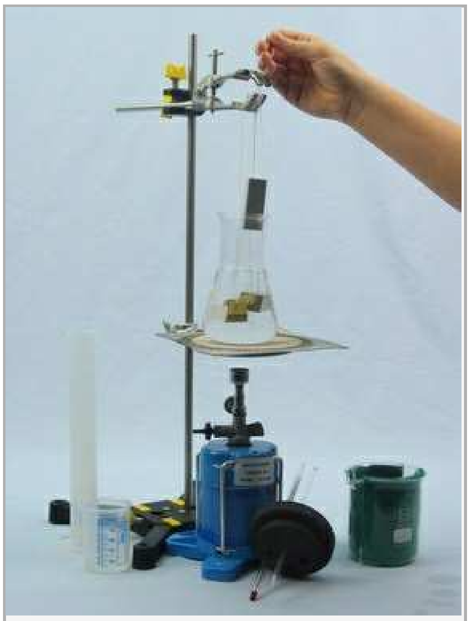

Fig. 18

Fig. 19

- Stir and measure the mix temperature ϑ_m and add the value to the table in the report.
- Rinse the calorimeter with cold water, dry it and repeat the experiment with each of the other metal bodies.

Report: Specific heat capacity of solid bodies

Result – Table 1

Note down the temperature of the cold water ϑ_1 in the calorimeter and the mix temperature ϑ_m with metal body inside of the calorimeter in the table below.

	ϑ_1 in °C	ϑ_m in °C
Iron	1 ±0	1 ±0
Aluminium	1 ±0	1 ±0
Brass	1 ±0	1 ±0

Evaluation – Question 1

Which metal can store more heat? Give reasons for your answer.

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Evaluation – Question 2

1. Calculate the heat Q absorbed by the cold water in each case; record the values in following table 2 (specific heat capacity of water c_W = 4.19 J/g°C, mass of the water in the calorimeter m_1 = 100 g).
   $Q = c_W \times m_1 (\vartheta_m - \vartheta_1)$
2. Calculate the specific heat capacity c of iron, aluminium and brass; record the values in table.
   $c = Q / (m_0 \times (\vartheta_0 - \vartheta_m))$,
   (mass of each metal body m_0 = 60 g, temperature of each metal body in the hot water ϑ_0 = 100 °C)
3. Compare your values for the specific heat capacity of water with the values from the scientific literature given in the following table.

	Measurement		values from the scientific literature
	Q in J	*c* in J / (g °C)	*c* in J / (g °C)
Iron	1 ±0	1 ±0	
	1 ±0	1 ±0	
Brass	1 ±0	1 ±0	

Evaluation – Question 3

Identify several possible sources of error for deviations of the calculated and the literature value:

Evaluation – Additional Task 1

Calculate the specific heat capacity c of iron, aluminium and brass taking the heat capacity of the calorimeter (C = 80 J/g°C) into consideration:

$Q = (c_W\, m_1 + C) \times (\vartheta_m - \vartheta_1)$,

$c = Q / (m_0 \times (\vartheta_0 - \vartheta_m))$

by using the values m_0 = 60 g and ϑ_0 = 100 °C for all metal bodies in hot water and m_1 = 100 g for the mass of the water in calorimeter for each experiment.

	Q in J	c in (J / g°C)
Iron	1 ±0	1 ±0
Aluminium	1 ±0	1 ±0
Brass	1 ±0	1 ±0