Calorimetric temperature measurement with Cobra SMARTsense

Physics > Thermodynamics > Calorimetry

Difficulty level	Group size	Preparation time	Execution time
medium	2	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/61669418e473310003365dd6

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

PHYWE

General information

Application

PHYWE

Experiment setup

This experiment deals with the method of temperature determination via calometry.

Explicitly, the temperature of a hot metal body is determined by a mixing experiment.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Other information (1/4)

PHYWE

Previous knowledge

Students should be familiar with basic concepts of thermodynamics, such as temperature and the concept of energy transfer.

Scientific principle

In this experiment, heated metal samples are mixed with water in a calorimeter.

The temperature development of the system is then observed and statements are made about the initial temperature of the metal sample.

Other information (2/4)

PHYWE

Learning objective

Students will learn a method of temperature determination via calorimetry.

Tasks

Heat a metal block over a flame, then place it in a calorimeter with cold water and determine the mixture temperature that is reached. From this, calculate the initial temperature of the metal block.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Other information (3/4)

PHYWE

Notes on structure and implementation

- Because of the high temperatures, the suspension loop must be made of wire and not fishing line.
- The wire should be at least 40 cm long.
- When the metal block is immersed in the water, it hisses, as it becomes significantly hotter than 100 °C.
- The aluminium block could be damaged in the burner flame - please do not use it.

Other information (4/4)

PHYWE

Note on evaluation

- The temperatures of the two bodies should be about the same if they hung in the same place in the burner flame for the same amount of time.
- The temperature of the metal body depends on how high it hangs above the flame and for how long. For example, if the body hangs close above the flame for 5 min, a temperature of 700 °C is determined.
- Since this is a student experiment and the principle of temperature measurement is to be demonstrated, heating the body over the flame for 1 min is sufficient.
- The measurement errors also increase towards high temperatures.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Safety instructions

PHYWE

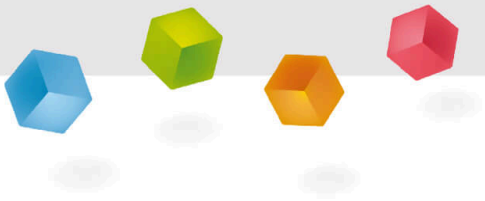
The general instructions for safe experimentation in science lessons apply to this experiment.

Attention!

1. the hanging wire should be 40 cm long so that the upper end does not get too hot.

The metal body becomes very hot! Make sure that it cannot fall down.

PHYWE



Student Information

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Motivation

PHYWE

Glowing coal

Calorimetry can be used to determine the temperature of a body that would be difficult to measure by other means, for example, because it is too hot for the available thermometers.

The heat content of the body can be calculated from the mixture temperature, which occurs in the calorimeter. If the heat capacity of the body is known, this yields the required temperature.

Another common application of the calorimeter is the determination of the calorific value of various materials such as wood, gas or coal.

Tasks (1/2)

PHYWE

For measurement with the **Cobra SMARTsense sensors** the **PHYWE measureAPP** is required. The app can be downloaded free of charge from the relevant app store (see below for QR codes). Before starting the app, please check that on your device (smartphone, tablet, desktop PC) **Bluetooth** is **activated**.

iOS

Android

Windows

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Tasks (2/2)

PHYWE

The experimental setup

How much heat can be stored in metals?

Heat a metal body over a flame, then place it in a calorimeter with cold water and determine the mixture temperature that is reached.

Calculate the initial temperature of the metal block.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - Temperature, - 40 ... 120 °C (Bluetooth)	12903-00	1
2	Support base, variable	02001-00	1
3	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	1
4	Universal clamp	37715-01	1
5	Boss head	02043-00	1
6	Metal bodies, set of 3	04406-00	1
7	Lid for student calorimeter	04404-01	1
8	Agitator rod	04404-10	1
9	Felt sheet, 100 x 100 mm	04404-20	2
10	Beaker, Borosilicate, low form, 250 ml	46054-00	1
11	Beaker, Borosilicate, low-form, 400 ml	46055-00	1
12	Beaker, 100 ml, plastic (PP)	36011-01	1
13	Pipette with rubber bulb	64701-00	1
14	Graduated cylinder 100 ml, PP transparent	36629-01	1
15	Iron wire, d = 0.5 mm, l = 50 m	06105-00	1
16	Butane burner, Labogaz 206 type	32178-00	1
17	Butane cartridge C206, without valve, 190 g	47535-01	1
18	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Set-up

PHYWE

Figure 1

1. Set up the tripod according to Fig. 1.

2. Pull a piece of wire 40 cm long through the brass body, bend it into a loop and hang it on the universal clamp.

3.Assemble a heat-insulating vessel (calorimeter) from two beakers (250 ml and 400 ml) and two felt plates.

4.Fill the calorimeter with 200 ml of water. Precise measurement with measuring cylinder and pipette from the plastic cup

5.Push the stirring rod from below through the corresponding hole in the lid and place the lid on the calorimeter.

Procedure(1/4)

PHYWE

1.Turn on your Cobra SMARTsense temperature sensor. Open the measure\ app app and lect the temperature sensor.

2.Set the sampling rate to 1 Hz.

3.Put the temperature sensor through a hole in the lid of the calorimeter so that it is immersed in the water but does not touch the bottom.

4.Start the measured value recording in measureApp , emperature measured value is then recorded every second.

5.Hang the brass body about 5 cm above the flame of the burner and heat it for one minute.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Procedure (2/4)

PHYWE

6.Meanwhile, stir in the calorimeter - the temperature reading should become constant.

7.Put the brass body into the calorimeter, which you immediately close again.

8.Stir the water in the calorimeter carefully so that the heat is distributed evenly.

9.Stop the measurement when the temperature drops slowly, after 100 s at the latest. Then save the measurement. The measurement can be opened and analyzed at any time under "my measurements".

10. Repeat the experiment in the same way with the iron body.

Procedure (3/4)

PHYWE

12. The following statements now apply:

- All metal bodies have the same mass m_{Metall} = 60 g.
- The mass of water in the calorimeter for each experiment is m_{Metall} = 200 g.
- The specific heat capacities are:

c_{Wasser} = 4.2 J/(g ·°C).

c_{Messing} = 0.39 J/(g ·°C).

c_{Eisen} = 0.45 J/(g ·°C).

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Procedure (4/4)

PHYWE

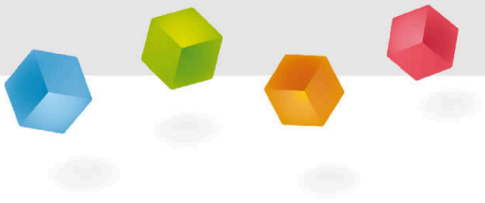
- Assume that the calorimeter has a heat capacity corresponding to a water value of 20 g

  oder C = 84 J/°C has
- After transferring a metal body into the calorimeter, the temperatures of the water in the calorimeter and the metal body equalize to the common temperature $\vartheta_{\mathrm{Kal},\,2}$ on.

13. In the measureApp, select the "Measure" tool with the , to set the initial temperature in the calorimeter $\vartheta_{\mathrm{Kal},\,1}$ and the mixture temperature in the calorimeter $\vartheta_{\mathrm{Kal},\,2}$ for all three measurement curves. Complete the table in the log in task 1.

14. Calculate the temperature differences of the temperature of the calorimeters $\Delta\vartheta_{\mathrm{Kal}} = \vartheta_{\mathrm{Kal},\,1} - \vartheta_{\mathrm{Kal},\,2}$ and complete the table.

PHYWE



Report

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 1

PHYWE

Enter your readings in this table.

Brass	$\vartheta_{\mathrm{Kal},\,1}$ / °C		$\vartheta_{\mathrm{Kal},\,2}$ / °C		$\Delta\vartheta_{\mathrm{Kal}}$ / °C	
Iron	$\vartheta_{\mathrm{Kal},\,1}$ / °C		$\vartheta_{\mathrm{Kal},\,2}$ / °C		$\Delta\vartheta_{\mathrm{Kal}}$ / °C	

Task 2

PHYWE

Calculate the amount of heat ΔQusing the formula:

$\Delta Q=C_{\text{Kal}}\cdot\Delta\vartheta_{\text{Kal}}$

Brass	ΔQ / J	
Iron	ΔQ / J	

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 3

PHYWE

Calculate the initial temperature of the metal block $\vartheta_{\mathrm{Metall,\,1}}$ using the formula:

$\vartheta_{ ext{metal, 1}}=\frac{\delta Q}{c_{ ext{metal}}\cdot m_{ ext{metal}}+\vartheta_{ ext{cal, 2 }}}$

Brass	$\vartheta_{\mathrm{Metall,\,1}}$ / J	
Iron	$\vartheta_{\mathrm{Metall,\,1}}$ / J	

Task 4

PHYWE

The physical quantity T of temperature describes the average velocity of the particles of a substance. Its unit is K for Kelvin.

○ True ○ False

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Task 5

PHYWE

Drag the words into the correct boxes!

Particles [ ] energy [ ] temperature* of a system is usually homogeneously distributed.

. So if a fast particle meets a slower particle, it will always give up energy, so that it has less energy afterwards. Since this happens continuously until all particles have the same energy on average, the

strive for the state of least

Check

Task 6

PHYWE

On which physical quantities does the specific heat capacity c of an object depend?

- ☐ Air pressure ρ
- ☐ Outdoor temperature T
- ☐ Mass m
- ☐ Heat capacity C

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Slide	Score / Total
Slide 22: Temperature	0/1
Slide 23: Particles and energy	0/2
Slide 24: Heat capacity	0/2

Total 0 / 5

Solutions | Repeat | Export text

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de