Heating various liquids

P1043800

Physics	Thermodynamics	Heat energy, thermal capacity

Difficulty level	Group size	Preparation time	Execution time
easy	-	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/61dc1631a2474d0003e0908f

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Teacher information

Application

fig. 1 setup

Different liquids can also be heated at different rates. The reason for this is the different heat capacity of the liquids.

In this experiment, water and glycerol are compared in this respect. The students recognize that glycerin can be heated more quickly. In the additional tasks, they conclude that water has a greater specific heat capacity.

These considerations are applied in cooking, for example, when milk, water or oil are brought to a boil.

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

Other teacher information (1/4)

Prior

Students should be able to set up a simple circuit and read the temperature on a thermometer.

For the additional tasks, it is necessary that the students already know the concept of heat capacity.

Principle

Water and glycerin are each heated in a calorimeter. The students realize that glycerol heats up faster than water and that not all liquids can be heated equally well.

Other teacher information (2/4)

Learning

Students should learn that the rate of temperature rise under the same conditions is different for different liquids.

Tasks

Heat 100g each of water and glycerin with a heating coil and measure the temperature increase as a function of time.

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

Other teacher information (3/4)

PHYWE

Additional information

In the test series, the masses of the liquids and the heating power are the same, so that the spec. heat capacities, although not absolute, can be given in relation to the water. The liquids are heated with a heating coil to ensure that all test series are carried out with the same heating power. If a butane burner with a constant flame were used as the heater, this condition would only be insufficiently fulfilled, since the temperatures of, for example, the stand ring, wire mesh base and beaker also have an influence on the measurement result.

Notes on the tasks

Additional task: The heating of liquids is given by the formula $Q = c \cdot m \cdot \Delta T$. The mass $m$and the heating power are constant in both test series. In order to obtain a comparison of the spec. heat capacities, therefore, after the heating time (heat input) for a certain temperature increase ΔT asked.

Other teacher information (4/4)

PHYWE

Notes

1. So that 100 g of each liquid can be easily measured with a graduated cylinder, the density and the volume corresponding to 100 g are indicated.
2. Glycerin should not be poured away, but collected after use and reused in subsequent experiments.
3. The liquids are heated with a heating voltage of only 6 V, as slow heating provides better results. In addition, the liquid in the calorimeter should be stirred regularly.
4. When reading the thermometer, intermediate values of 0.5 °C should also be estimated
5. Since glycerin is strongly hygroscopic, the water content of the glycerol used may be high. The determined spec. heat capacity therefore deviates from the value for pure glycerol. $C_{Gl} = 2,4 J/(g \cdot {}^{\circ}C) = 0,57 \cdot c_W$

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 education apply to this experiment.

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

fig. 2 boiling water

When cooking, various liquids often need to be heated. For example, water for a tea or milk for a hot chocolate. In the event that both beverages are required and are to be served at the same time, it is relevant to know whether both liquids can be heated at the same rate.

In this experiment, you will learn whether water or glycerin can be heated faster and what this depends on.

Tasks

PHYWE

fig. 3 setup

Are there differences when heating liquids?

Heat 100 g each of water and glycerin with a heating coil and measure the temperature increase as a function of time.

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

Equipment

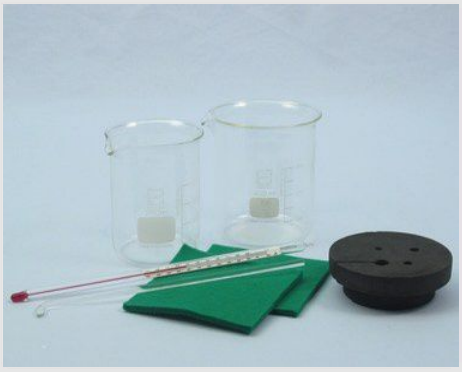
Position	Material	Item No.	Quantity
1	Lid for student calorimeter	04404-01	1
2	Agitator rod	04404-10	1
3	Heating coil with sockets	04450-00	1
4	Felt sheet, 100 x 100 mm	04404-20	2
5	Beaker, 100 ml, plastic (PP)	36011-01	1
6	Beaker, Borosilicate, low form, 250 ml	46054-00	1
7	Beaker, Borosilicate, low-form, 400 ml	46055-00	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	Digital stopwatch, 24 h, 1/100 s and 1 s	24025-00	1
12	Connecting cord, 32 A, 500 mm, blue	07361-04	2
13	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
14	Glycerol, 250 ml	30084-25	1

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

Structure (1/2)

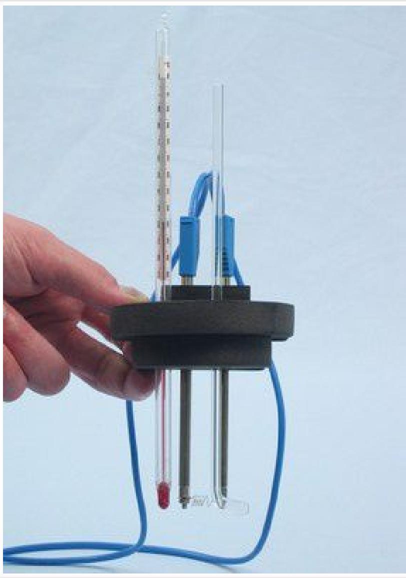
PHYWE

- Assemble a heat-insulating vessel (calorimeter) from two beakers (250 ml and 400 ml) and two felt plates.
- Carefully slide the heating coil into the slot in the calorimeter lid.



Structure (2/2)

PHYWE



- Push the thermometer (d = 8 mm) and stirring rod (d = 5 mm) through the corresponding holes in the lid.
- Make sure that the power supply is still switched off.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

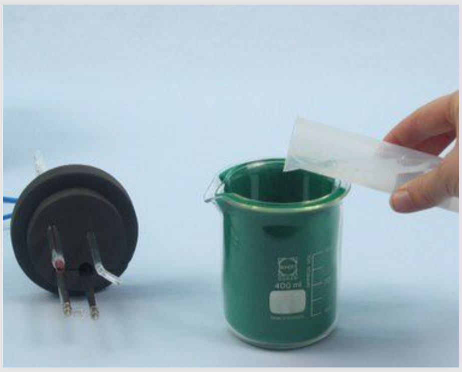
Tel.: 0551 604 - 0
Fax: 0551 604 - 107

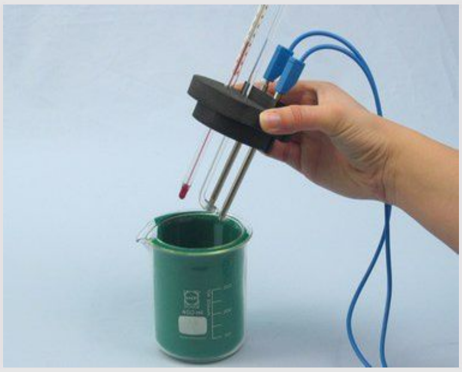
info@phywe.de
www.phywe.de

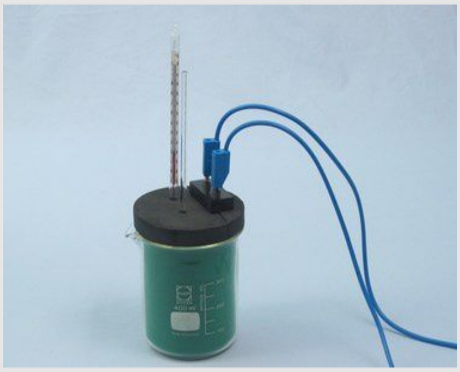
Procedure (1/2)

PHYWE

Fill the plastic beaker with water. Measure 100 ml of water in the measuring cylinder (exact measurement with the aid of the pipette) and fill it into the calorimeter. Place the lid with heating coil, thermometer and stirring rod on the calorimeter.







Procedure (2/2)

fig. 11 power supply with heating coil

- Connect the heating coil with the connecting leads to the 6 V AC output (power supply unit off!).
- Measure the initial temperature of the water and record it in Table 1 in the log at time t= 0 min on.
- Switch on the power supply and the stopwatch at the same time.
- Measure the water temperature after 1, 2, 3, 4 and 5 min. Stir carefully before reading and record the readings in Table 1.
- Switch the power supply unit off again.
- Repeat the experiment with 100 g (79.4 ml) glycerin. Rinse the calorimeter in cold water and dry it out.

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

PHYWE

Report

Task 1

PHYWE

Enter your readings for the temperature of water and glycerin in the table.

	Water	Glycerin
t in min	T in °C	T in °C
0		
1		
2		

	Water	Glycerin
t in min	T in °C	T in °C
3		
4		
5		

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

task 3

PHYWE

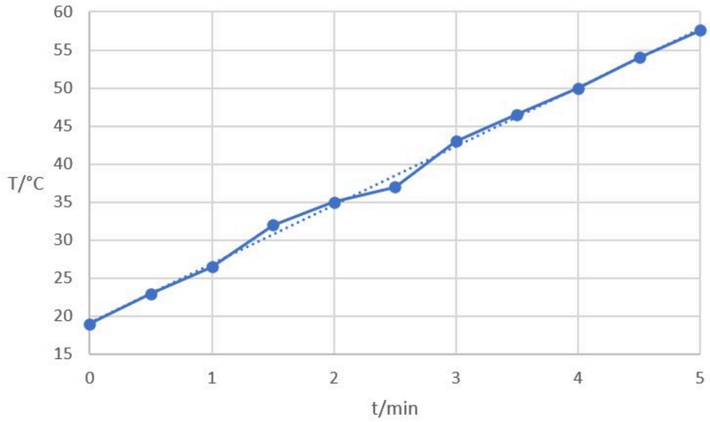


fig. 12 exemplary shows for example the temperature curve for a volume of 100 ml water over a period of 5 minutes

Task 2

PHYWE

Calculate the temperature increase for both liquids ΔT (i.e. the temperature difference to the respective initial temperature) and enter them into the table. Then enter these values in a ΔT-t-diagram with t on the x-axis.

	Water	Glycerin		Water	Glycerin
t in min	ΔT in °C	ΔT in °C	t in min	ΔT in °C	ΔT in °C
0			3		
1			4		
2			5		

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

Additional task 1/2

PHYWE

Heat is supplied to a liquid through the heating coil. The greater the heating time, the greater the heat supply.

1. From the diagram in task 2, read the heating time for both liquids $t$required for a temperature increase of 5 °C and enter the values in the table.
2. This difference in heating time (heat input) is indicated by the term "specific heat capacity" of a liquid. Calculate the ratio of the heating time for glycerine to the heating time for water and enter this value in the table. This gives you a comparison of the specific heat capacities of the liquids.

	t in min	Ratio		t in min	Ratio
Water			Glycerin		

Additional task 2/2

PHYWE

The ratio of heating times is equal to the ratio of specific heat capacities:

$$\frac{t_{Glycerin}}{t_{Water}} = \frac{C_{Glycerin}}{C_{Water}}$$

Here $t_{Glycerol}$ and t_{Water} are the heating times for glycerol and water, respectively, and $C_{Glycerol}$ and C_{Water} are the specific heat capacities for glycerol and water, respectively.

You can research or obtain the specific heat capacities for glycerol and water from reliable sources and then calculate the ratio. After you can enter the value into the table to get the comparison of the specific heat capacities of the liquids.

Please note that the specific heat capacities can be temperature dependent and can be affected by various factors, so the values may vary slightly.

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

Task 3

PHYWE

Compare the heating time and temperature increase of the two liquids. What do you find?

- [ ] The liquids heat up at different rates.
- [ ] The liquids heat up at the same rate.
- [ ] No correlation can be found between heating time and temperature increase.
- [ ] For both fluids, the temperature increase is proportional to the heating time.
- [ ] For both fluids, the temperature increase is antiproportional to the heating time.

Check

Task 4

PHYWE

Compare the temperature increases after 5 min with each other. What do you find?

- Water has warmed up much more than glycerin after 5 min.
- Water and glycerin have warmed up the same amount.
- Water has warmed up more than glycerin after 5 min.
- Water warmed up much less than glycerin after 5 min.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Additional task 2

PHYWE

Drag the words into the correct boxes!

It can be concluded: ______ has a greater specific heat capacity than ______

As an example of the application of the specific heat capacity in nature: the water in a swimming lake ______ only slowly during the day. In the evening, when the air ______, ______ is often warmer than ______.

- the water in the lake
- water
- cools down
- heats
- glycerol.
- the air

Check

Slide	Score / Total
Slide 22: Comparison heating time and temperature increase	0/2
Slide 23: Comparison of temperature increase after 5 min.	0/1
Slide 24: Comparison heat capacity and application	0/6

Total 0 / 9

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