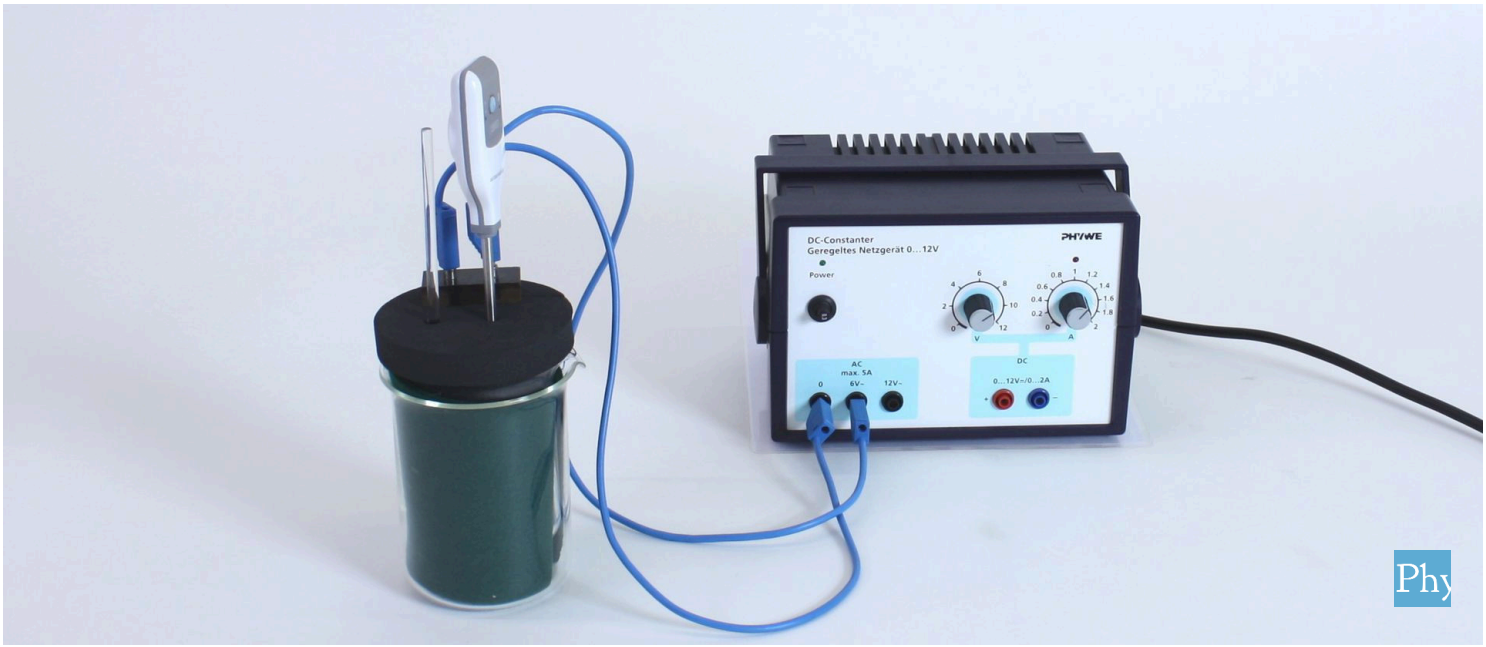
Heating of various liquids with Cobra SMARTsense



Physics > Thermodynamics > Heat energy, thermal capacity

Difficulty level	Group size	Preparation time	Execution time
hard	2	10 minutes	20 minutes

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Teacher information

Application

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Experiment setup

The dependence of the heat absorption of a liquid on its specific heat capacity is to be worked out here. Since absolute heat capacities depend on density, specific heat capacities differ with respect to volume, amount of substance or mass.

The specific heat capacities of gases and solids do not differ very much with respect to mass, but very much with respect to volume.

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Other teacher information (1/4)

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Prior knowledge

Students should be familiar with the basic concepts of thermodynamics and temperature.

Scientific Principle

In this experiment, different liquids are heated with constant energy and their temperature is observed via a heat sensor.

Based on this, statements are made about the behaviour of the temperature in connection with the observed substance.

Other teacher information (2/4)

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Learning objective

Students learn how the temperature change depends on the substance used.

Tasks

Heat 100 g and 100 ml of water and glycerol respectively with an electric heating coil and measure the temperature increase as a function of time.

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Other teacher information (3/4)

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Notes on structure and implementation

- A scale could also be used to measure the quantity used - however, the handling of the measuring cylinder is easier and sufficiently accurate here.
- Glycerol should not be thrown away, but collected after use and reused in subsequent experiments.
- Stirring is very important, especially with the more viscous glycerol - it is best to start stirring before the measurement begins.
- If a magnetic stirrer is available, it is recommended that it be used to ensure even heat distribution.
- Only the lower heating power at 6 V~ should be used so that measurement errors due to poor distribution of heat and insulation losses of the calorimeter do not play a major role.

Other teacher information (4/4)

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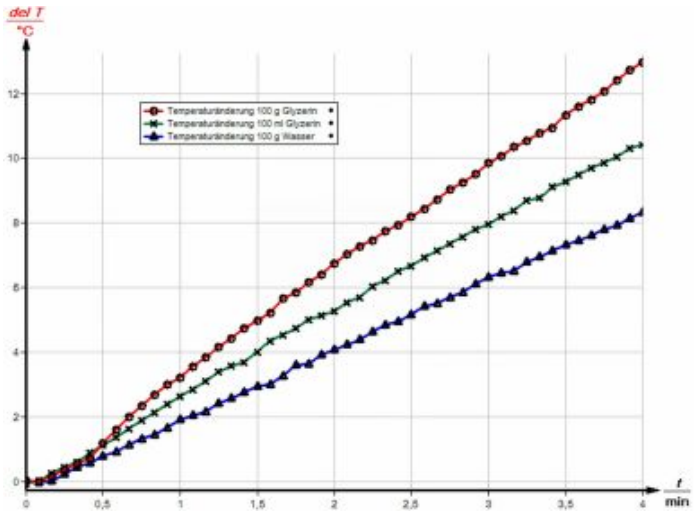
The adjacent figure represents a sample illustration of the interrelationships. Fluctuations in the measurement are due to uneven stirring. Red is the curve for glycerol (100 g), green glycerol (100 ml) and blue water (100 ml).



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Safety instructions

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

Attention!

The heating coil must be in the liquid before the power supply unit is switched on!

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Student Information

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Motivation

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Boiling water

Dinner is being prepared in the kitchen. There should be noodles and in the pan oil should be made warm for frying. Now it would be good to know whether the liquids heat up at the same time or which plate has to be turned on first, if the meal is to be ready at about the same time.

For this purpose, it can be investigated how the different liquids behave at the same heating power on the basis of water and glycerine.

Tasks

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The experimental setup

Are there differences when heating liquids?

Do different liquids take the same amount of time to heat up for a given heating?

Heat 100 g and 100 ml of water and glycerol respectively with an electric heating coil and measure the temperature increase as a function of time.

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Equipment

Position	Material	Item No.	Quantity
1	Cobra SMARTsense - Temperature, - 40 ... 120 °C (Bluetooth)	12903-00	1
2	Lid for student calorimeter	04404-01	1
3	Agitator rod	04404-10	1
4	Heating coil with sockets	04450-00	1
5	Felt sheet, 100 x 100 mm	04404-20	2
6	Beaker, 100 ml, plastic (PP)	36011-01	1
7	Beaker, Borosilicate, low form, 250 ml	46054-00	1
8	Beaker, Borosilicate, low-form, 400 ml	46055-00	1
9	Graduated cylinder 100 ml, PP transparent	36629-01	1
10	Pipette with rubber bulb	64701-00	1
11	Connecting cord, 32 A, 500 mm, blue	07361-04	2
12	PHYWE Power supply, 230 V, DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
13	Glycerol, 250 ml	30084-25	1
14	measureAPP - the free measurement software for all devices and operating systems	14581-61	1

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Set-up (1/3)

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The Cobra SMARTsense and measureAPP are required to measure oxygen levels. The app can be downloaded free of charge from the App Store - see below for QR codes. Check if Bluetooth is activated on your device (tablet, smartphone).

measureAPP für Android Betriebssysteme

measureAPP für iOS Betriebssysteme

measureAPP für Tablets / PCs mit Windows 10

Set-up (2/3)

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Figure 1

The experimental setup can be found in Fig. 1.

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

2. Carefully slide the heating coil into the slot in the calorimeter lid.

3. Push the stirring rod from below through the corresponding hole in the lid.

4. Make sure that the power supply is still switched off.

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Set-up (3/3)

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Notice:

In this experiment, 100 g and 100 ml of each of the different liquids are to be heated. The density of the liquids can be assumed to be known. With the following table you can determine the necessary volume:

Liquid	Density	Mass	Volume
Water	1,00 g/ml	100 g	100 ml
Glycerin	1.26 g/ml	100 g	79.4 ml

In the case of water, therefore, only one measurement is to be made, because in the case of water the volume 100 ml corresponds exactly to the mass 100 g.

Procedure (1/3)

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1.Turn on your Cobra SMARTsense Temperature Sensor. Open the measure\ app and select the temperature sensor. app and select the temperature sensor.

2.Fill the plastic cup with water.

3.Place the lid with heating coil and stirring rod on the calorimeter and insert the temperature sensor through the remaining hole in the lid so that it is immersed in the water but does not touch the bottom.

4.Connect the heating coil with the connecting leads to the AC voltage output 6 V~ (power supply unit off!).

5.Stir and wait until the temperature reading remains constant.

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Procedure (2/3)

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6.Then set the temperature to 0 by selecting the setting "Set to zero". In this experiment you are not interested in the absolute temperatures but only in the temperature difference to the start temperature.

7.Simultaneously start the measurement recording in the app and switch on the power supply unit.

8.During the measurement, stir the liquid in the calorimeter carefully so that the heat is distributed evenly. Start stirring immediately after starting the measurement.

9.Stop the measurement after about 250 s and save it for further evaluation.

10. Switch off the power supply again!

Procedure (3/3)

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11. Repeat the experiment with 100 g corresponding to 79.4 ml glycerol and also with 100 ml glycerol, which you can measure in the same way as the water before.

12. Before adding the glycerine, rinse the beaker in cold water and dry the beaker, measuring cylinder and plastic cup.

13. Call up your measurement again. Transfer every 10th value to the measurement table in the log (up to 200 s) to better compare the graphs. The curves should all be approximately linear with different slopes.

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Report

Task 1 (1/3)

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Enter your measured values for the temperature difference T in $^{\circ}C$ on this table.

Time t on s	Water (100 ml)	Glycerin (100 g / 79.4 ml)	Glycerin (100 ml)
10			
20			
30			
40			
50			
60			

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Task 1 (2/3)

Time t on s	Water (100 ml)	Glycerin (100 g / 79.4 ml)	Glycerin (100 ml)
70			
80			
90			
100			
110			
120			
130			

Task 1 (3/3)

Time t on s	Water (100 ml)	Glycerin (100 g / 79.4 ml)	Glycerin (100 ml)
70			
80			
90			
100			
110			
120			
130			

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Task 2

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Compare the temperature increases after 4 minutes with each other. What do you find?

- The temperatures of the two amounts of glycerol are the same but warmer than those of the water.
- The temperatures of all three observed liquids are exactly identical.
- Although all temperatures increase linearly, the individual liquids are nevertheless differently warm. The smaller amount of glycerine is the warmest, followed by the larger amount of glycerine and the water heats up the least.
- The water is warmer than the larger amount of glycerin, which in turn is warmer than the smaller amount of glycerin.

Task 3

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Drag the words into the correct boxes!

The _____ C describes the energy required to heat one kilogram of a substance by one _____. This is a _____. If you want to find the energy required to heat a given _____ of a substance, divide heat capacity C by its _____ m and obtains the specific heat capacity c.

substance constant
heat capacity
amount
mass
Kelvin

Check

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Task 4

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The temperature of 100 g of glycerine is different from the temperature of 100 ml of glycerine. This phenomenon is explained by the fact that 100 g of glycerine and 100 ml of glycerine have two different masses.

Thus their specific heat capacities differ and from the mass smaller sample heats up faster.

○ True ○ Incorrect

Check

Slide	Score / Total
Slide 22: Temperature change	0/1
Slide 23: Heat capacity	0/5
Slide 24: Stir	0/1
Total	**0/7**

Solutions Repeat Export text

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