Expansion coefficient of liquids (Item No.: P1042600)

Curricular Relevance

Area of Expertise: Physics

Education Level: Age 14-16

Topic: Thermal physics

Subtopic: Thermal expansion of solids, liquids and gases

Experiment: Expansion coefficient of liquids

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
- Glycerol, 250 ml 30084-25
- Matches
- Felt-tip pen

Experiment Variations:

Keywords:

Task and equipment

Information for teachers

Additional Information

Using water as a model the expansion of a liquid is shown as a function of temperature. In the supplementary problem, the expansion coefficient is calculated at different temperatures. The expansion of water is not linear; its coefficient is not constant.

If you wish to demonstrate a liquid with a linear expansion coefficient, we recommend alcohol. However, it is very inflammable: be extremely careful when doing experiments with it!

Remark

After inserting the rubber stopper in the Erlenmeyer flask, there must be no air bubbles under it. In addition, no water may overflow since the measured initial volume is required for the calculations.

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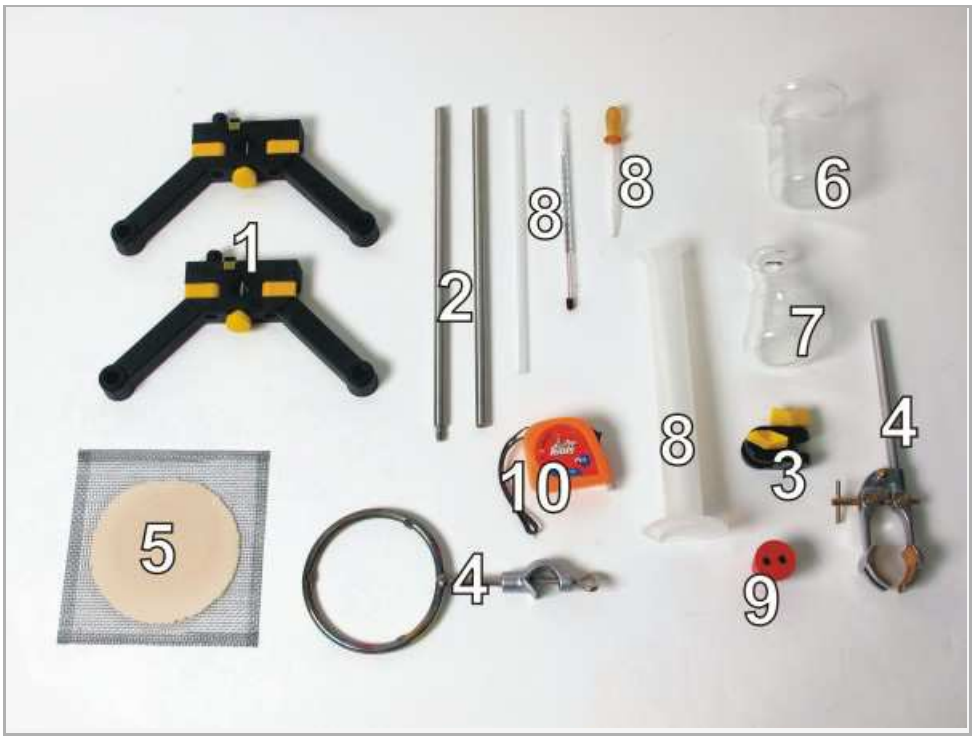
Task and equipment

Task

How much does the volume of water change during heating?

Heat a specific quantity of water and determine the change in its volume.

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
5	Universal clamp	37715-00	1
6	Wire gauze with ceramic, 160 x 160 mm	33287-01	1
7	Glass beaker DURAN®, short, 250 ml	36013-00	1
8	Erlenmeyer flask 100 ml, wide-neck SB 29	36428-00	1
9	Glass tubes,l.250 mm, pkg.of 10	36701-68	1 piece
10	Pipette with rubber bulb	64701-00	1
11	Students thermometer, -10...+110°C, l = 230 mm	38005-10	1
12	Graduated cylinder 100 ml, PP transparent	36629-01	1
13	Rubber stopper 26/32, 2 holes 7 mm	39258-02	1
14	Measuring tape, l = 2 m	09936-00	1
Additional material:			
15	Butane cartridge C206, without valve	47535-01	1
16	Butane burner, Labogaz 206 type	32178-00	1
17	Glycerol, 250 ml	30084-25	15 ml
18	Matches		
19	Felt-tip pen		1

Set-up and procedure

Set-up

Warning!

1. Always insert the thermometer or glass tubes in the rubber stoppers using glycerol.
2. During the heating of the water the support ring and the wire gauze become extremely hot!

Setup

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


Fig. 1


Fig. 2

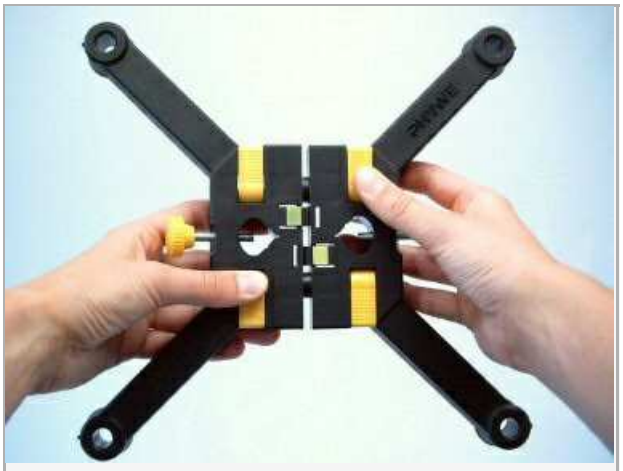


Fig. 3


Fig. 4


Fig. 5


Fig. 6


Fig. 7

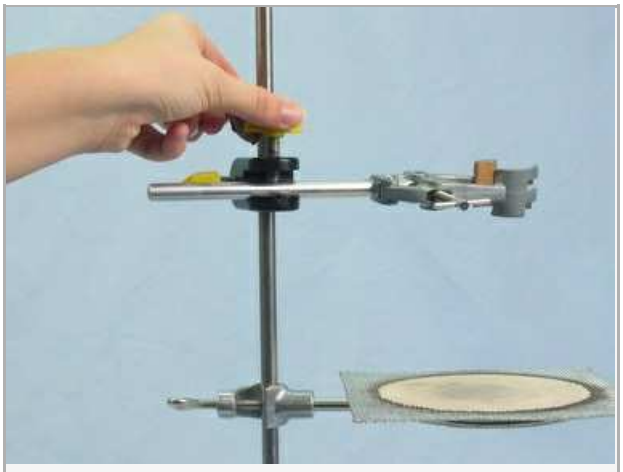


Fig. 8

- Insert the thermometer in the 2-hole rubber stopper so that the entire immersion stem juts out of the stopper.
- Insert the long glass tube into the stopper so that its lower end is even with the bottom of the stopper.

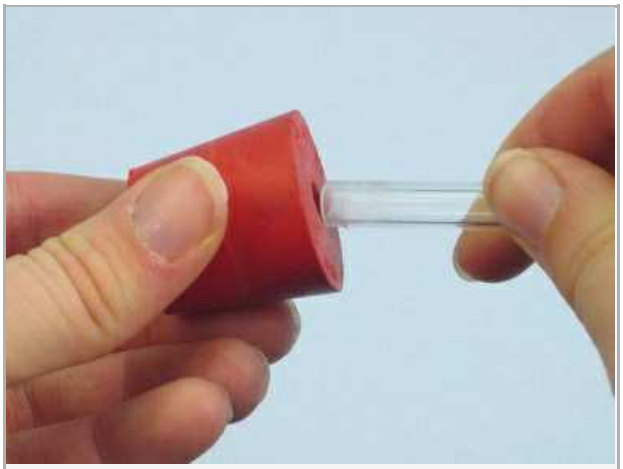


Fig. 9

Procedure

- Fill the Erlenmeyer flask with a measured quantity of cold water (graduated cylinder!) so that the water is about 0.5 cm below its rim; record this volume V_0 in the table in the report.

Fig. 10

- Insert the stopper in the Erlenmeyer flask so that no water overflows. There must not be any air bubbles under the stopper!

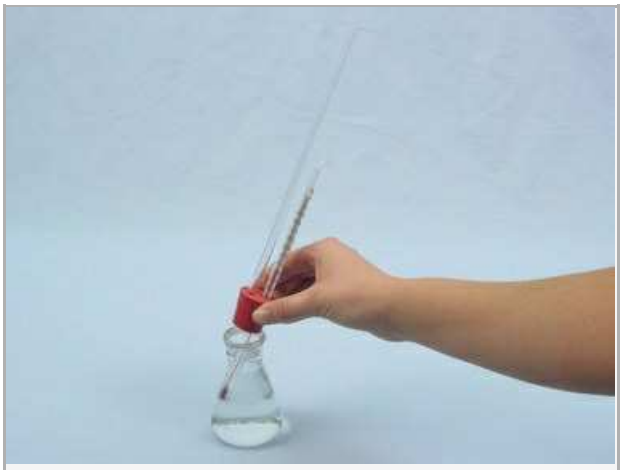


Fig. 11

- Mark the water level in the glass tube.

Fig. 12

- Place the Erlenmeyer flask into the 250 ml beaker and clamp it into position with the universal clamp so that it extends as deep as possible into the beaker.
- Fill the beaker completely with water.

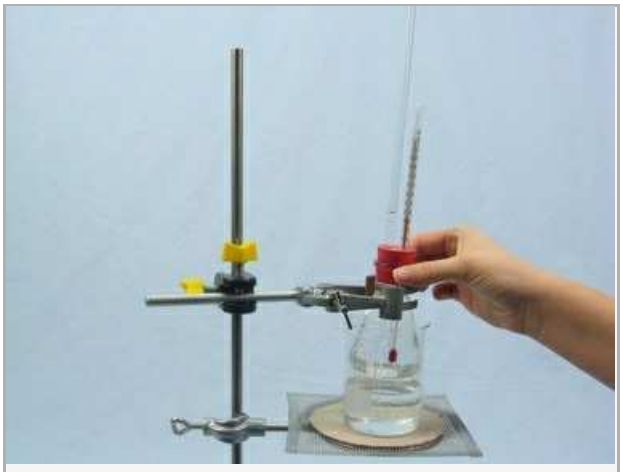


Fig. 13

- Record the initial temperature of the water θ0 in the table in the report.
- Heat the water with a small flame. At 20 °C, 30 °C, etc. record the change in the water level Δ*l* in the table, too.

Report: Expansion coefficient of liquids

Result - Observation 1

The initial volume V_0 is ..... ml.

Result - Observation 2

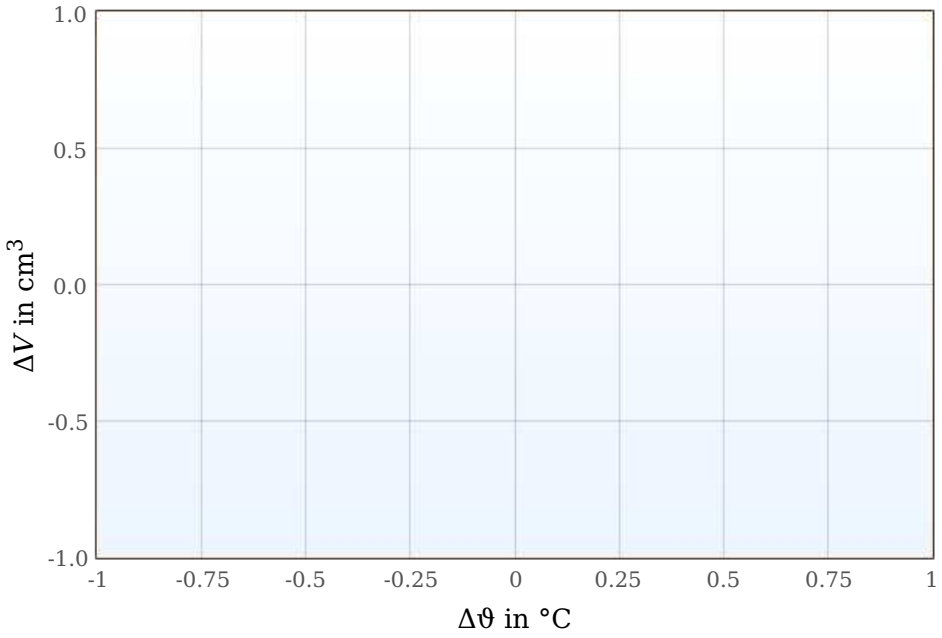
The initial temperature ϑ_0 is ..... °C.

Result - Table 1

1. Note the measured values in the table.
2. Calculate each temperature difference $\Delta\vartheta$ with reference to the initial temperature ϑ_0. $\Delta\vartheta = \vartheta - \vartheta_0$.
3. The inner diameter of the glass tube is d = 0.5 cm. From the change in height Δl calculate each change in volume. $\Delta V = (d/2)^2 \times \pi \times \Delta l$

ϑ in °C	Δl in cm	$\Delta\vartheta$ in °C	ΔV in cm^3
25	1 ±0	1 ±0	1 ±0
30	1 ±0	1 ±0	1 ±0
35	1 ±0	1 ±0	1 ±0
40	1 ±0	1 ±0	1 ±0
45	1 ±0	1 ±0	1 ±0
50	1 ±0	1 ±0	1 ±0
55	1 ±0	1 ±0	1 ±0
60	1 ±0	1 ±0	1 ±0
65	1 ±0	1 ±0	1 ±0
70	1 ±0	1 ±0	1 ±0

Number1



Evaluation - Question 1

Watch the chart to table 1. Describe the correlation between Δ*V* and Δϑ. Is it linear?

.....

.....

.....

.....

Evaluation - Question 2

How large would the volume changes be if the initial volume V_0 was only half as large?

Evaluation - Question 3

Consider the thermometer. Is the correlation between expansion and temperature linear for the liquid (alcohol) in its column?

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Evaluation - Supplementary problem 1

A measure for the expansion is the expansion coefficient γ. The quotient of volume increase and temperature increase is formed and referred to the initial volume V_0.

$\Delta V = \gamma \times V_0 \times \Delta\vartheta$

$\gamma = \Delta V / \Delta\vartheta = 1/V_0$

1. Calculate the expansion coefficient for water at the initial temperature ϑ_0 using the value at 30 °C:
   $\gamma =$ ..... $\cdot 10^{-3}(°C)^{-1}$.
2. Calculate the expansion coefficient of water at 50 °C. Use the values at 50 °C and 60 °C for your calculations. (Attention: How large is V_0 now?)
   $\gamma =$ ..... $\cdot 10^{-3}(°C)^{-1}$.

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