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9702/52

May/June 2023

1 hour 15 minutes

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [].

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[Turn over

2

- 1 Two coils, P and Q, are placed close to each other, as shown in Fig. 1.1.

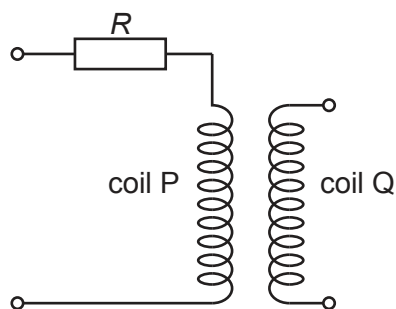


Fig. 1.1

A resistor of resistance R is connected in series with coil P.

A changing magnetic flux of frequency f in coil P causes an electromotive force (e.m.f.) E to be induced across the terminals of coil Q.

It is suggested that E is related to R by the relationship

$$E = 2\pi f M \left(\frac{V}{R + k} \right)$$

where V is the potential difference across the resistor and coil P, and k and M are constants.

Plan a laboratory experiment to test the relationship between E and R .

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for k and M .

In your plan you should include:

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

Diagram

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- 2 A student investigates how the volume of a gas varies with its temperature. Air is trapped in a transparent cylinder of diameter d with a movable piston as shown in Fig. 2.1.

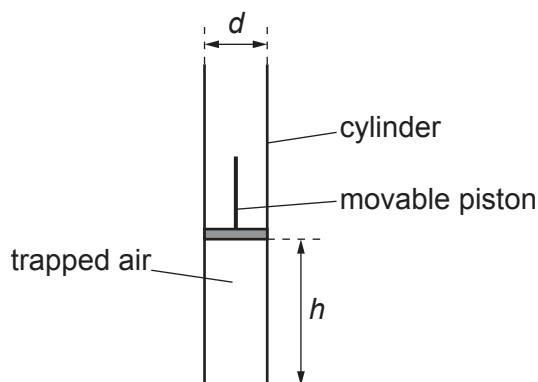


Fig. 2.1

The distance between the base of the cylinder and the bottom of the piston is h .

The trapped air is heated by placing the cylinder in water of temperature θ . The increase in temperature of the trapped air causes the piston to move. When the piston stops moving, the value of h is measured.

For each value of h , the volume V of the trapped air is calculated.

The experiment is repeated for different values of θ .

It is suggested that V and θ are related by the equation

$$pV = Yk(\theta + Z)$$

where k is the Boltzmann constant, p is the atmospheric pressure, and Y and Z are constants.

- (a) A graph is plotted of V on the y -axis against θ on the x -axis.

Determine expressions for the gradient and y -intercept.

gradient =

y -intercept =

[1]

(b) Values of θ and h are given in Table 2.1.

Table 2.1

$\theta / ^\circ\text{C}$	h / mm	$V / 10^{-5} \text{m}^3$
23	62.4 ± 0.1	
35	65.2 ± 0.1	
48	68.1 ± 0.1	
62	70.9 ± 0.1	
73	73.3 ± 0.1	
88	76.1 ± 0.1	

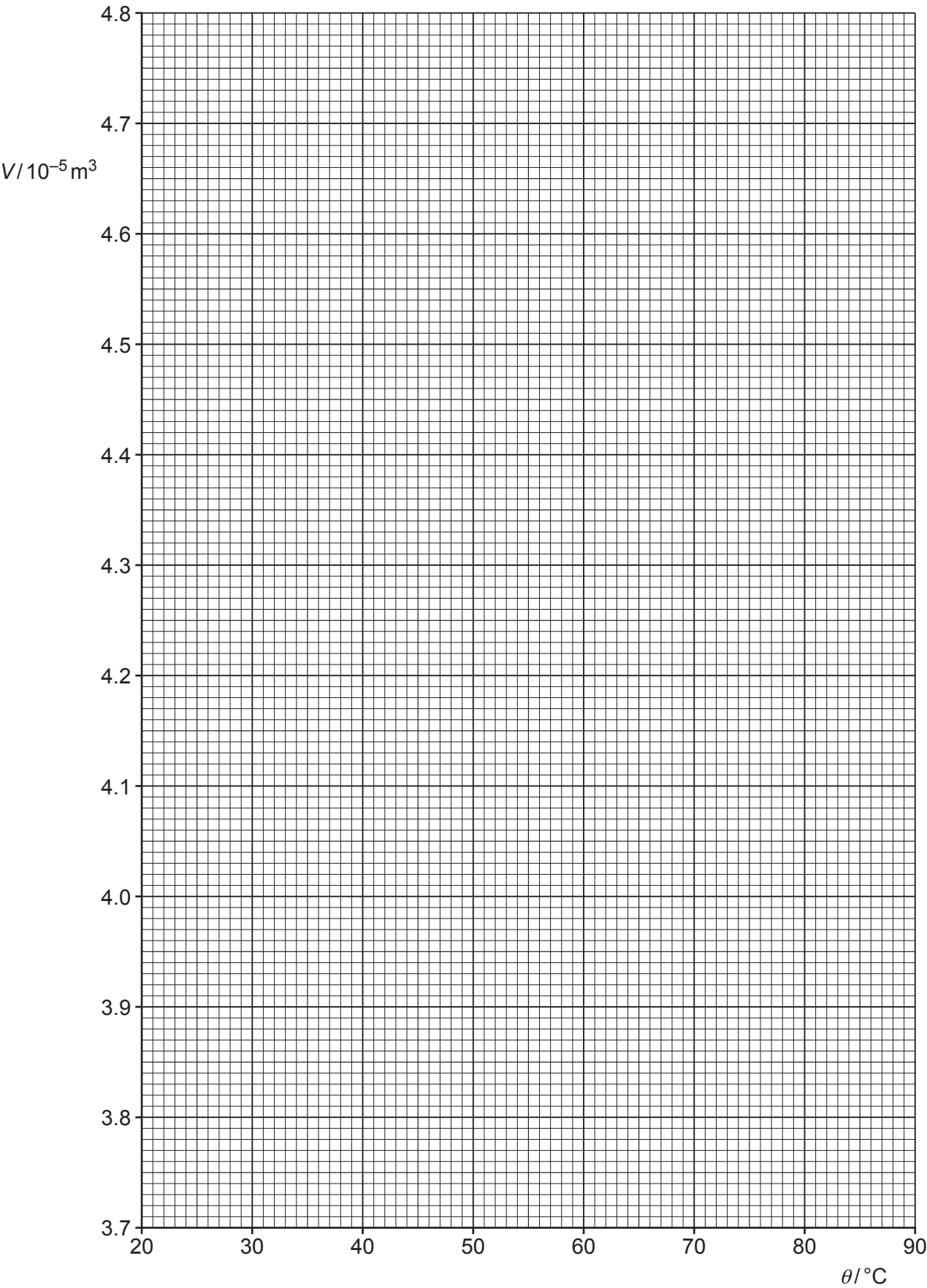
The value of d is $(27.9 \pm 0.1) \text{mm}$.
The volume V is calculated using the relationship

$$V = \frac{\pi d^2 h}{4}.$$

Calculate and record values of $V / 10^{-5} \text{m}^3$ in Table 2.1.
Include the absolute uncertainties in V . [2]

- (c) (i) Plot a graph of $V / 10^{-5} \text{m}^3$ against $\theta / ^\circ\text{C}$. Include error bars for V . [2]
- (ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Label both lines. [2]
- (iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient = [2]



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- (iv) Determine the y -intercept of the line of best fit. Include the absolute uncertainty in your answer.

y -intercept = [2]

- (d) (i) Using your answers to (a), (c)(iii) and (c)(iv), determine the values of Y and Z . Include appropriate units.

Data: $p = (1.01 \pm 0.01) \times 10^5 \text{ Pa}$
 $k = 1.38 \times 10^{-23} \text{ J K}^{-1}$

$Y = \dots\dots\dots$

$Z = \dots\dots\dots$ [2]

- (ii) Determine the percentage uncertainty in Y .

percentage uncertainty in $Y = \dots\dots\dots\%$ [1]

- (e) The experiment is repeated. Determine the temperature θ that gives a value of h of 60.0 mm.

$\theta = \dots\dots\dots^\circ\text{C}$ [1]

[Total: 15]