A Level · OCR · Physics

48 mins 5 questions

Structured Questions

Experimental Design

Experimental Design / Control Variables / Refining of Experimental Design / Investigative Approaches & Methods / Using Practical Equipment & Materials / Appropriate Units for Measurements

Medium (3 questions)	/24
Hard (2 questions)	/24
Total Marks	**/48**

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Medium Questions

1 A resistance wire is coiled around a thermistor. The coil of wire will warm the thermistor.

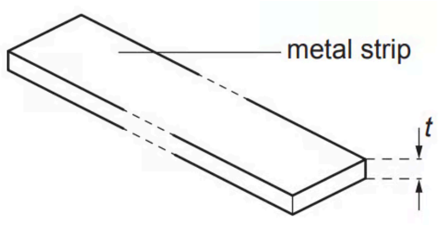
It is suggested that the relationship between the power P dissipated in the coiled wire and the stable resistance R of the thermistor is given by the expression $P = kR^n$, where k and n are constants.

Describe how an experiment can be conducted to assess the validity of this expression and how the data collected can be analysed to determine k and n.

Use the space below for a circuit diagram.

(6 marks)

2 (a) A metal strip has thickness *t*, as shown below.



Five measurements of the thickness *t* at different positions along the length of the strip are shown below.

1.86mm	1.88mm	1.85mm	1.89mm	1.88mm

Determine the percentage uncertainty in the thickness *t*.

percentage uncertainty = ... %

....

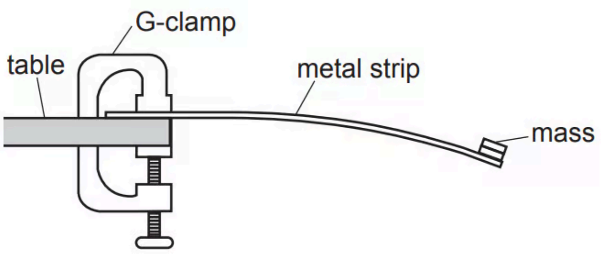
....

....

(3 marks)

(b) A student wants to determine the Young modulus *E* of the metal of the strip in **(a)**.

The student clamps the metal strip to the edge of a table using a G-clamp. A mass is **permanently** fixed to the end of the strip as shown.



The mass oscillates freely when it is moved away from its equilibrium position and then released.

The Young modulus *E* of the metal can be determined using the equation

$$E = \frac{16\,\pi^2 m L^3}{w t^3 T^2}$$

where *m* is the mass fixed to the end of the strip, *L* is the length of the strip from the end of the table to the centre of the mass, *w* is the width of the strip, *t* is the thickness of the strip, and *T* is the period of oscillations.

Describe how an experiment may be safely conducted, and how the data can be analysed to determine an accurate value for *E*.

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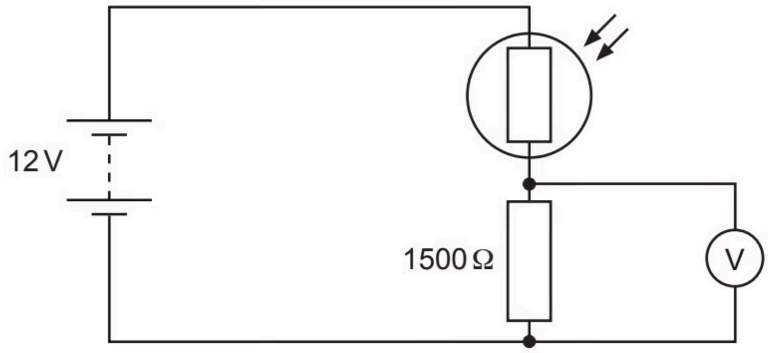
(6 marks)

3 (a) This question is about a light-dependent resistor (LDR).

A student connects a potential divider circuit as shown below. It contains an LDR.



The fixed resistor has resistance 1500 Ω. The battery has electromotive force (e.m.f.) 12 V and negligible internal resistance. The voltmeter has extremely high resistance.

i) When the LDR is covered, its resistance is 3000 Ω.

Calculate the voltmeter reading.

voltmeter reading = ... V**[2]**

ii) When fully illuminated, the resistance of the LDR is 100 Ω.

Show that the voltmeter reading **changes** by more than 7 V.

[1]

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....

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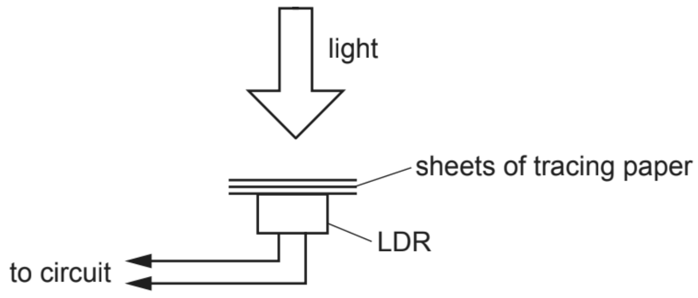
(3 marks)

(b) The current in an LDR depends on the intensity of light incident on it.

A student decides to alter the intensity of light incident on an LDR by using sheets of tracing paper and a light source.

The diagram below shows part of an arrangement suggested by the student.



It is suggested that the current I in the LDR is given by the expression

$$I = ke^{-nx}$$

where x is the **total** thickness of the sheets of tracing paper, and k and n are constants.

Describe how the student could carry out an experiment to verify the validity of this expression and determine k and n. Include in your answer

- a circuit diagram
- a possible table for the results, including the headings
- the graph plotted to determine k and n
- any precautions taken to improve the quality of the results.

(6 marks)

Hard Questions

1 (a) A group of students are conducting an experiment in the laboratory to determine the value of absolute zero by heating a fixed mass of gas. The volume of the gas is kept constant. Fig. 17.1 shows the arrangement used by the students.

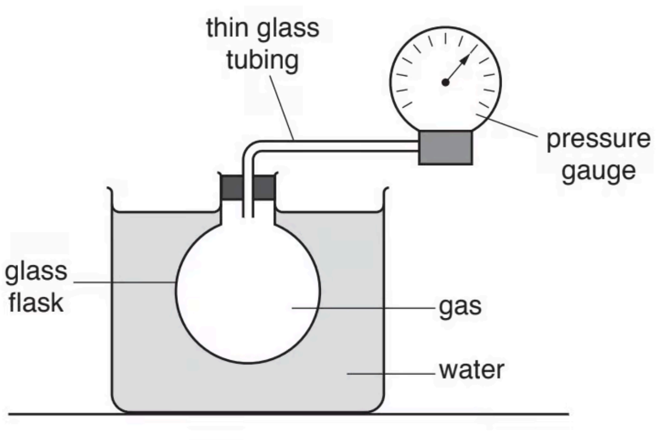


Fig. 17.1

The gas is heated using a water bath. The temperature θ of the water is increased from 5 °C to 70 °C. The temperature of the water bath is assumed to be the same as the temperature of the gas. The pressure p of the gas is measured using a pressure gauge.

The results from the students are shown in a table.

θ / °C	p / kPa
5 ± 1	224 ± 3
13 ± 1	231 ± 3
22 ± 1	238 ± 3
35 ± 1	248 ± 3
44 ± 1	
53 ± 1	262 ± 3
62 ± 1	269 ± 3
70 ± 1	276 ± 3

Describe and explain how the students may have made accurate measurements of the temperature θ.

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(2 marks)

(b) Fig. 17.2 shows the pressure gauge. Measurements of p can be made using the kPa scale or the psi (pounds per square inch) scale. The students used the psi scale to measure pressure and then converted the reading to pressure in kPa.

Fig. 17.2

i) Suggest why it was sensible to use the psi scale to measure p.

[1]

ii) The students made a reading of p of 37.0 ± 0.5 psi when θ was 44 ± 1°C.

Convert this value of p from psi to kPa. Complete the table for the missing value of p.

Include the absolute uncertainty in p.

1 pound of force = 4.448 N

1 inch = 0.0254 m

[2]

(3 marks)

(c) Fig. 17.3 shows the graph of p against θ.

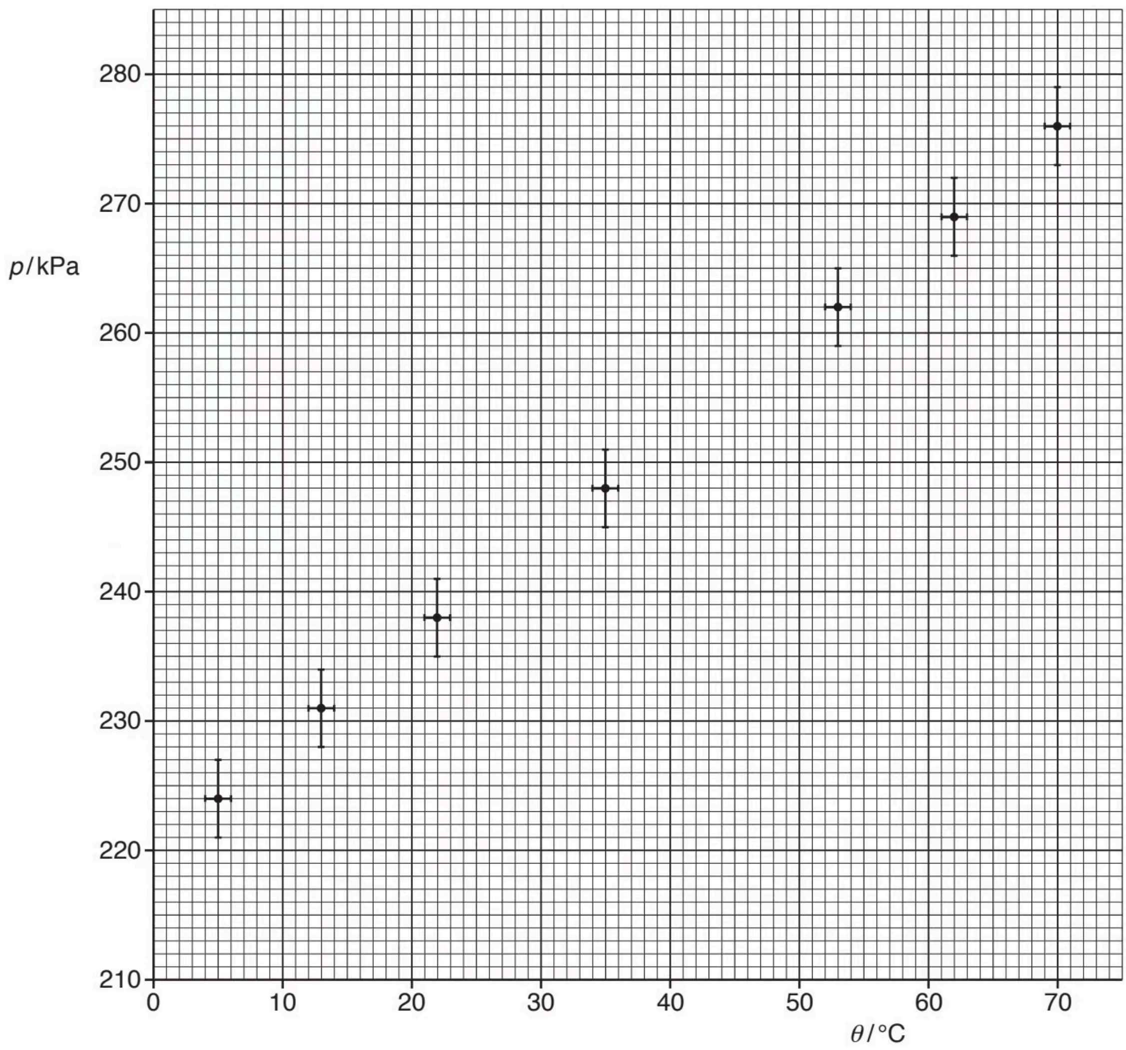


Fig. 17.3

i) Plot the missing data point and the error bars on Fig. 17.3.

[1]

*ii) Explain what is meant by absolute zero. Describe how Fig. 17.3 can be used to determine the value of absolute zero.

Determine the value of absolute zero. You may assume that the gas behaves as an ideal gas.

[6]

(7 marks)

(d) Describe, without doing any calculations, how you could use Fig. 17.3 to determine the actual uncertainty in the value of absolute zero in **(c)(ii)**.

(2 marks)

(e) The experiment is repeated as the water bath quickly cools from 70 °C to 5 °C. Absolute zero was found to be −390 °C.

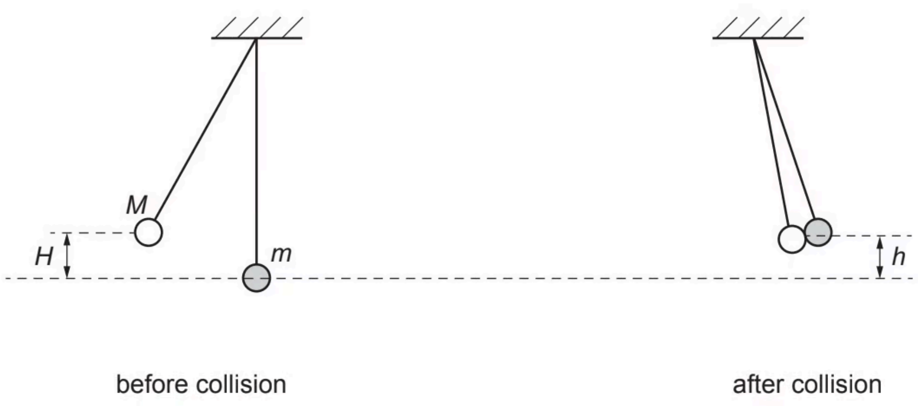
Compare this value with your value from **(c)(ii)** and explain why the values may differ. Describe an experimental approach that could be taken to avoid systematic error in the determination of absolute zero.

(4 marks)

2 A student makes a pendulum using a length of string with a ball of adhesive putty which acts as a bob. The mass of this bob is *M*.

A similar second pendulum is constructed with the same length of string but with a bob of a smaller mass. The mass of this bob is *m*.

The arrangement of the pendulums is shown below.



The bob of mass *M* is pulled back to a vertical height of *H* from its rest position. It is released and collides with the bob of mass *m*. The two bobs then stick together and reach a maximum vertical height *h* from the rest position.

The height *h* is given by the equation $h = \left(\frac{M}{M+m}\right)^2 H$

Describe how to perform an experiment to test the validity of this equation and how the data can be analysed.

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(6 marks)