3.9 Physics Required Practicals and Uncertainties: 1-hour Pack

Total Marks

AQA 8464 · Calculator allowed · about 60 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Olivia investigates the current through a filament lamp for a range of potential differences, using a circuit with a variable resistor, an ammeter in series, and a voltmeter connected in parallel across the lamp.

Potential difference (V): 0	1.0	2.0	3.0	4.0
Current (A): 0	0.20	0.32	0.40	0.46

(a) State the name of the circuit component Olivia uses to vary the potential difference across the lamp. **(1)**

(b) Calculate the resistance of the filament lamp when the potential difference is 1.0 V. **(2)**

.....

(c) Calculate the resistance of the filament lamp when the potential difference is 4.0 V. **(2)**

.....

(d) Using your answers to (b) and (c), describe how the resistance of the filament lamp changes as the potential difference across it increases. **(2)**

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(e) Explain, in terms of energy and particles, why the resistance of the filament increases as the potential difference across it increases. **(3)**

(Total for Question 1 is 10 marks)

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2 Josh investigates the effect of insulation on the cooling rate of a beaker of hot water. Two identical beakers are each filled with the same volume of water at the same starting temperature; one is wrapped in a layer of insulating foam and the other is left unwrapped. Both are placed in the same room, and the temperature of the water in each is recorded every 30 seconds.

(a) Identify the independent variable and the dependent variable in this investigation. **(2)**

(b) State two variables, other than insulation, that must be kept the same for this to be a fair test. **(2)**

(c) After 300 s, the temperature of the insulated beaker has fallen from 80°C to 68°C, and the temperature of the uninsulated beaker has fallen from 80°C to 50°C. Calculate the mean rate of cooling, in °C per second, for each beaker. **(4)**

(d) State which beaker has the greater rate of cooling, and explain this in terms of energy transfer. **(2)**

(Total for Question 2 is 10 marks)

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3 Amara directs a ray of light from air into a rectangular glass block, and traces the path of the ray using pins (or a ray box) and a protractor. The angle of incidence in air is 40 degrees, and the angle of refraction inside the glass is measured as 25 degrees. The equation linking the refractive index of a material to these angles is: refractive index = sin(angle of incidence) / sin(angle of refraction) [Higher Tier only]

(a) State what happens to the speed and the wavelength of the light as it passes from air into the glass block. **(2)**

(b) Calculate the refractive index of the glass. [Higher Tier only] **(3)**

.....

(c) The critical angle of the glass can be found using: sin(critical angle) = 1 / refractive index. Calculate the critical angle of this glass. [Higher Tier only] **(3)**

.....

(d) State what happens to a ray of light travelling inside the glass block that strikes the glass-air boundary at an angle greater than the critical angle. **(1)**

(e) Describe how Amara ensures the angle of refraction is measured accurately, referring to the use of the normal. **(2)**

(Total for Question 3 is 11 marks)

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4 A student plots a graph of potential difference against current for a fixed length of wire at a constant temperature, obtaining a straight line through the origin.

(a) State what the gradient of this graph represents. **(1)**

(b) One point on the line is (current = 0.40 A, potential difference = 2.0 V). Calculate the resistance of the wire. **(2)**

.....

(c) This wire has a length of 50 cm and a resistance of 5.0 ohms. Assuming resistance is directly proportional to length (at the same temperature), calculate the resistance of a 125 cm length of the same wire. **(3)**

.....

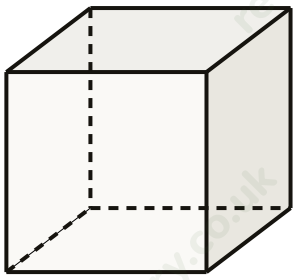
(d) Suggest two reasons why, in a real experiment, the resistance of a very long length of this wire might not be exactly proportional to its length. **(2)**

(Total for Question 4 is 8 marks)

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5 Priya measures the density of a metal cube. The cube has a side length of 2.00 cm, measured using vernier calipers, and a mass of 21.6 g, measured using a top-pan balance. The equation linking density, mass and volume is: density = mass / volume

Diagram NOT accurately drawn



2.00 cm

(a) State the equation linking the volume of a cube to its side length. **(1)**

(b) Calculate the volume of the cube, in cm^3. **(2)**

.....

(c) Calculate the density of the metal. **(2)**

.....

(d) Explain why using vernier calipers, rather than a millimetre ruler, to measure the side length improves the accuracy of the calculated density. **(2)**

(Total for Question 5 is 7 marks)

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Mark scheme · 3.9 Physics Required Practicals and Uncertainties: 1-hour Pack

Question 1

(a) variable resistor (rheostat), oe **B1**

(a) Answer: Variable resistor.

(b) 1.0 / 0.20, oe **M1**

(b) 5.0 ohms cao **A1**

(b) Answer: 5.0 ohms

(c) 4.0 / 0.46, oe **M1**

(c) 8.7 ohms (2 s.f.), awrt 8.7 **A1**

(c) Answer: 8.7 ohms

(d) resistance increases as potential difference (and current) increases, ft **B1**

(d) correctly quotes both values, e.g. from 5.0 ohms at 1.0 V to 8.7 ohms at 4.0 V, ft **B1**

(d) Answer: Resistance increases as potential difference increases, from 5.0 ohms at 1.0 V to 8.7 ohms at 4.0 V.

(e) as potential difference (and current) increases, more energy is transferred electrically to the filament, so its temperature increases, oe **B1**

(e) at a higher temperature the (positive) ions in the filament vibrate with greater amplitude, oe **B1**

(e) this causes more frequent/greater collisions between the charge carriers (electrons) and the vibrating ions, which increases the resistance, oe **B1**

(e) Answer: More energy is transferred to the filament, raising its temperature. At a higher temperature the ions vibrate more, so charge carriers collide with them more often, increasing resistance.

Question 2

(a) independent variable: whether the beaker is insulated or not, oe **B1**

(a) dependent variable: temperature of the water (over time), oe **B1**

(a) Answer: Independent variable: whether the beaker has insulation. Dependent variable: the water temperature over time.

(b) volume of water in each beaker, oe **B1**

(b) starting temperature of the water, oe; allow the room/surrounding temperature, absence of draughts, or whether a lid is used **B1**

(b) Answer: For example, the volume of water in each beaker and the starting temperature of the water.

(c) insulated: change in temperature = 80 - 68 = 12°C, oe **M1**

(c) insulated rate = 12 / 300 = 0.04°C/s cao **A1**

(c) uninsulated: change in temperature = 80 - 50 = 30°C, oe **M1**

(c) uninsulated rate = 30 / 300 = 0.10°C/s cao **A1**

(c) Answer: Insulated: 0.04°C/s. Uninsulated: 0.10°C/s.

(d) the uninsulated beaker, ft from part (c) **B1**

(d) it loses thermal energy to the surroundings at a faster rate, because the insulation on the other beaker reduces the rate of energy transfer (by conduction/convection) to the surroundings, oe **B1**

(d) Answer: The uninsulated beaker cools faster; insulation reduces the rate at which thermal energy is transferred to the surroundings.

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Question 3

(a) the speed of the light decreases, oe **B1**

(a) the wavelength of the light decreases (the frequency stays the same), oe **B1**

(a) Answer: The speed decreases, and the wavelength decreases (the frequency stays the same).

(b) sin(40) / sin(25), oe **M1**

(b) = 0.643 / 0.423 (or equivalent decimals), oe **M1**

(b) 1.5 (2 s.f.) or 1.52 (3 s.f.), awrt 1.5 **A1**

(b) Answer: 1.5 (1.52 to 3 s.f.)

(c) uses the refractive index from part (b), ft **M1**

(c) sin(critical angle) = 1 / 1.52, oe **dM1**

(c) 41 degrees (2 s.f.), awrt 41, ft **A1**

(c) Answer: 41 degrees

(d) total internal reflection occurs (all the light is reflected back into the glass; none is refracted out), oe **B1**

(d) Answer: Total internal reflection occurs.

(e) draws the outline of the glass block, marks the point of entry and draws a normal line perpendicular to the block's surface at that point, oe **B1**

(e) traces the path of the ray (e.g. using pins, or marking crosses along the emerging ray), removes the block, and joins the marks to draw the refracted ray; the angle between this ray and the normal is then measured with a protractor, oe **B1**

(e) Answer: Draw the block's outline and a normal perpendicular to its surface at the point of entry; trace the ray's path with marks, remove the block, join the marks, and measure the angle to the normal with a protractor.

Question 4

(a) the resistance of the wire, oe **B1**

(a) Answer: The resistance of the wire.

(b) 2.0 / 0.40, oe **M1**

(b) 5.0 ohms cao **A1**

(b) Answer: 5.0 ohms

(c) scale factor = 125 / 50 (= 2.5), oe **M1**

(c) 5.0 * 2.5, ft from part (b) **M1**

(c) 12.5 ohms cao, ft **A1**

(c) Answer: 12.5 ohms

(d) a longer wire carrying the same current dissipates more total energy, so it may heat up more, increasing its resistance above the value predicted by simple proportionality, oe **B1**

(d) or: the wire's cross-sectional area/diameter may not be perfectly uniform along its whole length, oe (credit either valid reason once, both if two distinct reasons given) **B1**

(d) Answer: A longer wire may heat up more for the same current, increasing its resistance above the proportional prediction; or its cross-sectional area may not be perfectly uniform along its full length.

Question 5

(a) volume = (side length)^3, oe **B1**

(a) Answer: Volume = side length^3.

(b) 2.00^3, oe **M1**

(b) 8.00 cm^3 cao **A1**

(b) Answer: 8.00 cm^3

(c) density = 21.6 / 8.00, oe **M1**

(c) 2.70 g/cm^3 cao **A1**

(c) Answer: 2.70 g/cm^3

(d) vernier calipers have a smaller resolution than a millimetre ruler, so the length reading has a smaller absolute uncertainty, oe **B1**

(d) since volume depends on length cubed, a small percentage uncertainty in length gives a much larger percentage uncertainty in the calculated volume (and so density), so improving the length measurement improves the density calculation, oe **B1**

(d) Answer: Vernier calipers have a smaller resolution than a ruler, so the length has a smaller percentage uncertainty; because volume is length cubed, this uncertainty is magnified in the volume (and density) calculation, so a more precise length measurement gives a more accurate density.

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