3.5 Electricity: Test Pack

AQA 7408 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Quickfire: for each question, identify the one correct answer.

(a) Identify the correct SI unit for resistivity. **(1)**

- ☐ A) ohm
- ☐ B) ohm metre
- ☐ C) ohm per metre
- ☐ D) ohm metre squared

(b) Identify the equation that correctly defines electrical power P in terms of current I and potential difference V. **(1)**

- ☐ A) $P = I V$
- ☐ B) $P = I / V$
- ☐ C) $P = V / I$
- ☐ D) $P = I + V$

(c) Identify which statement correctly defines the volt. **(1)**

- ☐ A) the potential difference across a component when 1 coulomb of charge transfers 1 joule of energy
- ☐ B) the current in a component when 1 joule of energy is transferred per second
- ☐ C) the charge that flows in 1 second when the current is 1 ampere
- ☐ D) the resistance of a component that produces 1 watt of power per ampere

(d) Identify which component has a resistance that decreases as its temperature increases. **(1)**

- ☐ A) a resistor at constant current
- ☐ B) an NTC thermistor
- ☐ C) a filament lamp
- ☐ D) a length of copper wire carrying an increasing current

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(e) Identify the correct expression for the combined resistance R of two resistors R1 and R2 connected in parallel. **(1)**

- ☐ A) R = R1 + R2
- ☐ B) R = (R1 + R2) / (R1 R2)
- ☐ C) R = (R1 R2) / (R1 + R2)
- ☐ D) R = R1 - R2

(Total for Question 1 is 5 marks)

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2 A 3.0 kW electric kettle is connected to the UK 230 V mains supply.

(a) Calculate the current drawn by the kettle when it is operating normally. Use P = I V. **(2)**

(b) Calculate the energy transferred by the kettle in 4.0 minutes of continuous use. Use E = P t. **(2)**

(c) Electricity costs 28p per kilowatt-hour. Show that the cost of using the kettle for 4.0 minutes is about 5.6p. **(3)**

(d) State one advantage, in terms of energy cost, of only boiling the amount of water actually needed rather than filling the kettle completely. **(1)**

(Total for Question 2 is 8 marks)

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3 This is a quickfire question testing circuit relationships.

(a) State Kirchhoff's first law. **(1)**

(b) State the base SI unit of resistivity. **(1)**

(c) Define the volt in terms of energy transferred and charge. **(1)**

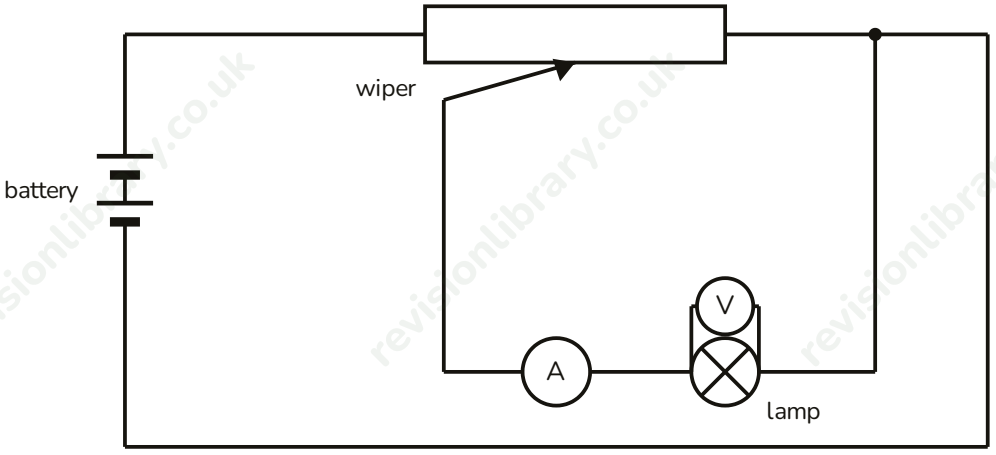
(d) State the equation linking power P, current I and resistance R. **(1)**

(Total for Question 3 is 4 marks)

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4 Practical investigation: a student investigates the I-V characteristic of a filament lamp using a circuit containing a variable resistor connected as a potential divider across the battery, with the lamp, an ammeter and a voltmeter connected appropriately to obtain a series of current and potential difference readings across the lamp.

Rheostat used as potential divider



(a) Describe how the student could use the potential divider arrangement to obtain a full set of I-V readings for the lamp, including readings for both directions of current through the lamp. **(4)**

(b) Two of the student's readings are: at V = 2.0 V, I = 0.40 A; at V = 6.0 V, I = 0.60 A. Calculate the resistance of the lamp at each of these two pd values, and state how the resistance of the lamp changes between them. **(3)**

(c) Explain, in terms of the filament, why the resistance of the lamp increases as the current through it increases. **(2)**

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(d) The student then investigates the I-V characteristic of a silicon diode using the same method. Explain why a protective resistor should be included in series with the diode, and suggest one other precaution the student should take. **(3)**

(Total for Question 4 is 12 marks)

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5 A cell of EMF 9.0 V and negligible internal resistance is connected to a resistor R1 = 15 ohm in series with a parallel combination of R2 = 20 ohm and R3 = 30 ohm.

(a) Calculate the combined resistance of R2 and R3 in parallel. **(2)**

(b) Calculate the total resistance of the circuit. **(1)**

(c) Calculate the total current supplied by the cell. **(2)**

(d) Calculate the current through R2. **(2)**

(Total for Question 5 is 7 marks)

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6 A cell has EMF 4.5 V and internal resistance 1.5 ohm and is connected to a variable external resistor R.

(a) Show that the power P delivered to the external resistor R is given by $P = E^2 R / (R + r)^2$, where E is the EMF and r is the internal resistance. **(2)**

(b) Calculate the power delivered to R when R = 1.5 ohm (equal to the internal resistance). **(3)**

(c) Without further calculation, state and explain how the power delivered to R would compare with your answer to (b) if R were changed to 0.50 ohm or to 4.5 ohm. **(2)**

(Total for Question 6 is 7 marks)

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Mark scheme · 3.5 Electricity: Test Pack

Question 1

(a) correct option identified: B, cao **B1**

(a) Answer: B (ohm metre)

(b) correct option identified: A, cao **B1**

(b) Answer: A (P = I V)

(c) correct option identified: A, cao **B1**

(c) Answer: A

(d) correct option identified: B, cao **B1**

(d) Answer: B (NTC thermistor)

(e) correct option identified: C, cao **B1**

(e) Answer: C

Question 2

(a) correct rearrangement I = P/V and substitution **M1**

(a) 13.0 A, awrt, cao **A1**

(a) Answer: 13.0 A

(b) convert time to seconds (240 s) and substitute into E = Pt **M1**

(b) 7.2 x 10^5 J (720 kJ), cao **A1**

(b) Answer: 7.2 x 10^5 J (720 kJ)

(c) energy in kWh = power (kW) x time (h) = 3.0 x (4.0/60) **M1**

(c) = 0.20 kWh **M1**

(c) cso: cost = 0.20 x 28 = 5.6p **A1**

(c) Answer: 5.6p (shown)

(d) less water means less energy is needed to heat it, so less energy is transferred/wasted and the cost is lower, oe **B1**

(d) Answer: Boiling less water needs less energy, so the cost of heating it is lower.

Question 3

(a) the sum of currents entering a junction equals the sum of currents leaving the junction oe **B1**

(a) Answer: The sum of currents entering a junction equals the sum of currents leaving it.

(b) ohm metre (ohm m) cao **B1**

(b) Answer: ohm metre (ohm m)

(c) one volt is the potential difference across a component when one joule of energy is transferred per coulomb of charge that passes through it oe **B1**

(c) Answer: One volt is the potential difference when one joule of energy is transferred per coulomb of charge passing through a component.

(d) P = I^2 R cao **B1**

(d) Answer: P = I^2 R

Question 4

(a) moving the wiper of the potential divider varies the pd applied to the lamp smoothly from zero up to the supply value, oe **B1**

(a) at each setting, record the ammeter reading (current) and the voltmeter reading (pd across the lamp) **B1**

(a) reverse the connections to the lamp (or swap the battery terminals) to obtain readings with current in the opposite direction **B1**

(a) repeat each reading (or take readings at closely spaced intervals) and/or allow the lamp to cool between readings to improve reliability **B1**

(a) Answer: Vary the pd smoothly using the potential divider, recording I and V at each setting; reverse the lamp connections to obtain negative pd/current readings; repeat readings for reliability.

(b) R = V/I at 2.0 V: R = 5.0 ohm, cao **B1**

(b) R = V/I at 6.0 V: R = 10.0 ohm, cao **B1**

(b) correctly states resistance increases as the pd/current increases, oe **B1**

(b) Answer: 5.0 ohm at 2.0 V; 10.0 ohm at 6.0 V; resistance increases as pd (and current) increase.

(c) as current increases, the temperature of the filament increases **B1**

(c) the (lattice) ions vibrate with greater amplitude, so drifting electrons collide with them more frequently, increasing resistance, oe **B1**

(c) Answer: Higher current heats the filament; the hotter lattice ions vibrate more, causing more frequent collisions with drifting electrons, which increases resistance.

(d) once forward biased beyond its threshold voltage, the diode's resistance becomes very small, so current would rise very rapidly for a small increase in pd **B1**

(d) a protective resistor limits the current, preventing damage to the diode (or exceeding the range of the ammeter), oe **B1**

(d) precaution: avoid leaving a large forward current flowing for long periods, to prevent the diode overheating (or use a low-voltage supply), oe **B1**

(d) Answer: A protective resistor limits the rapidly rising current once the diode conducts, preventing damage; the student should also avoid prolonged large currents that could overheat the diode.

Question 5

(a) use 1/R23 = 1/20 + 1/30, or R23 = (20 x 30)/(20+30) **M1**

(a) R23 = 12 ohm cao **A1**

(a) Answer: 12 ohm

(b) R(total) = 15 + 12 = 27 ohm cao **B1**

(b) Answer: 27 ohm

(c) I = V/R(total) = 9.0/27 **M1**

(c) I = 0.33 A cao **A1**

(c) Answer: 0.33 A

(d) pd across parallel section = I(total) x R23 = 0.333 x 12 = 4.0 V, then I(R2) = 4.0/20 **M1**

(d) I(R2) = 0.20 A cao **A1**

(d) Answer: 0.20 A

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Question 6

(a) current in the circuit is $I = E/(R+r)$; power delivered to R is $P = I^2 R$ **M1**

(a) substituting gives $P = [E/(R+r)]^2 \times R = E^2 R / (R+r)^2$ **A1**

(a) Answer: $P = E^2 R / (R + r)^2$

(b) substitute $P = 4.5^2 \times 1.5 / (1.5+1.5)^2$ **M1**

(b) carry out the calculation: 20.25 x 1.5 / 9.0 **M1**

(b) P = 3.4 W cao **A1**

(b) Answer: 3.4 W

(c) the power delivered would be lower for both R = 0.50 ohm and R = 4.5 ohm **B1**

(c) because maximum power is delivered to the external resistor when R equals the internal resistance r (here r = 1.5 ohm); any R above or below this value gives less power transferred to R oe **B1**

(c) Answer: The power would be lower in both cases, since maximum power transfer to R occurs when R = r (here 1.5 ohm); values of R above or below 1.5 ohm both deliver less power to the external resistor.

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