3.2 Electricity: Test Pack

Calculator allowed · about 55 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Electric current is a flow of charged particles. Answer the following recall items.

(a) State the unit of electrical current. **(1)**

(b) Give the direction conventional current is said to flow in a circuit. **(1)**

(c) State the charge on an electron (name and sign). **(1)**

(Total for Question 1 is 3 marks)

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2 A simple circuit contains a 1.5 V cell and a lamp. The lamp is connected with a switch and a single fixed resistor.

(a) Name the instrument used to measure current in a circuit. **(1)**

(b) Name the instrument used to measure potential difference (voltage). **(1)**

(Total for Question 2 is 2 marks)

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3 A circuit has two identical 1.5 V cells connected in series. State the total potential difference (voltage) supplied by the pair.

(Total for Question 3 is 1 mark)

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4 In an experiment to investigate the resistance of a wire, a student is told to keep the temperature of the wire constant. State one practical way the student could keep the wire at constant temperature and give one reason why this control is important.

(a) State one practical way to keep the wire at constant temperature during measurements. **(1)**

(b) Give one reason why keeping the temperature constant is important for resistance measurements. **(1)**

(Total for Question 4 is 2 marks)

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5 A 6.0 V battery supplies two identical lamps connected in parallel. Each lamp draws 0.50 A.

(a) Calculate the total current drawn from the battery. **(2)**

(b) State whether the potential difference across each lamp is the same as the battery voltage and give a short reason. **(1)**

(Total for Question 5 is 3 marks)

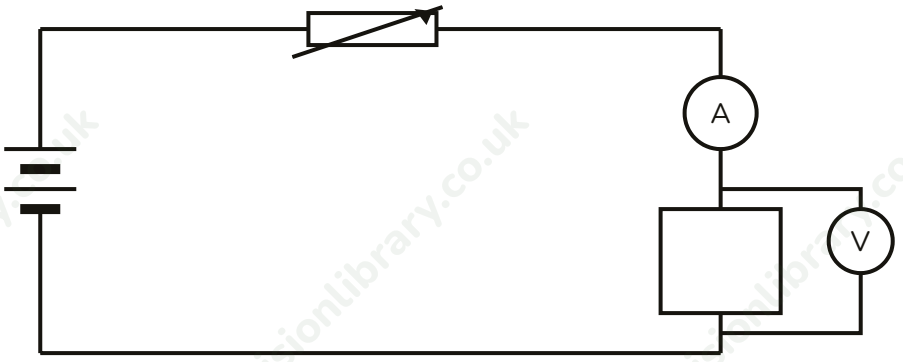
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6 Electrical power of 2.0 MW is transmitted along a cable of total resistance 5.0 ohm. Option A transmits this power using a current of 100 A. Option B transmits the same power using a current of 10 A (achieved by using a higher transmission voltage). Use the equation $P = I^2 \times R$ to show that the power wasted as heat in the cable is much greater for Option A than for Option B, and state why the National Grid transmits power at high voltage.

(Total for Question 6 is 6 marks)

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7 A student carries out the required practical to investigate the I-V characteristics of a resistor and a filament lamp. The circuit contains a low-voltage power supply, a variable resistor, an ammeter, a voltmeter and the component under test.



low-voltage power supply

component under test

(a) State the correct positions of the ammeter and the voltmeter in this circuit. **(2)**

(b) Describe the shape of the I-V graph obtained for a resistor at constant temperature. **(2)**

(c) The student then tests a filament lamp. Explain why the I-V graph for the filament lamp curves so that the current increases less rapidly as the potential difference increases. **(3)**

(Total for Question 7 is 7 marks)

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8 A kettle's heating element has resistance 20 ohm and carries a current of 11.5 A.

(a) Use the equation $P = I^2 \times R$ to calculate the power output of the heating element. **(3)**

(b) Use the equation $P = V^2 / R$, together with your answer to part (a), to show that this is consistent with a potential difference of about 230 V across the element. **(3)**

(Total for Question 8 is 6 marks)

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9 A filament lamp has a resistance of 15.0 ohm when cold. When connected to 6.0 V it draws a current of 0.30 A after warming up.

(a) Calculate the power dissipated when the lamp is warmed and draws 0.30 A at 6.0 V. **(2)**

(b) Explain why the resistance of the filament increases as it warms, referring to the material properties of the filament and the effect on current. **(2)**

(Total for Question 9 is 4 marks)

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10 A student investigates how the resistance of a wire depends on its length. The student measures resistance of the same wire material at lengths 0.20 m, 0.40 m, 0.60 m and 0.80 m and obtains resistances 0.50 ohm, 1.00 ohm, 1.50 ohm and 2.00 ohm respectively.

(a) State the relationship between resistance and length shown by the data. **(1)**

(b) Use the data to calculate the resistivity of the wire using the gradient method. Cross-sectional area = 0.50 mm^2. Show your working. **(2)**

(c) Suggest one practical improvement to reduce random error in the investigation. **(1)**

(Total for Question 10 is 4 marks)

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11 A resistor R and a diode D are connected in series to a 9.0 V supply, with the diode connected in the forward direction. The diode conducts only in the forward direction and has an approximate forward voltage of 0.7 V when conducting.

Explain why the diode conducts both when the resistor is 100 ohm and when it is 100 kohm, but the current is very different. Show calculations for the current in each case, taking the potential difference across the conducting diode to be its forward voltage.

(Total for Question 11 is 2 marks)

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Mark scheme · 3.2 Electricity: Test Pack

Question 1

(a) ampere or amp or A cao **B1**

(a) Answer: A (ampere)

(b) from the positive terminal to the negative terminal of the power supply, oe **B1**

(b) Answer: From the positive terminal to the negative terminal

(c) negative (electron has negative charge) cao **B1**

(c) Answer: Negative charge

Question 2

(a) ammeter cao **B1**

(a) Answer: Ammeter

(b) voltmeter cao **B1**

(b) Answer: Voltmeter

Question 3

3.0 V cao **B1**

Answer: 3.0 V

Question 4

(a) use short measurement times and allow the wire to cool between readings or keep ambient temperature constant (e.g. perform in a draught-free room), oe **B1**

(a) Answer: Use short measurement times and allow the wire to cool between readings or carry out the experiment in a draught-free room to keep temperature constant.

(b) temperature affects resistance of the wire so changes in temperature would change the resistance and affect the results, oe **B1**

(b) Answer: Because temperature affects the resistance, and any temperature change would change the resistance and make the results unreliable.

Question 5

(a) adds currents: Itot = 0.50 + 0.50 **M1**

(a) 1.0 A cao **A1**

(a) Answer: 1.0 A

(b) yes, because in parallel each component is connected across the battery so has the same potential difference as the battery, oe **B1**

(b) Answer: Yes. In parallel each lamp is connected across the battery so each has the same potential difference as the battery.

Question 6

substitutes for Option A: $P = 100^2 \times 5.0$ **M1**

P(A) = 50000 W (50 kW) **A1**

substitutes for Option B: $P = 10^2 \times 5.0$ **M1**

P(B) = 500 W (0.5 kW) **A1**

correct comparison: Option A wastes 100 times more power than Option B **A1**

therefore transmitting at high voltage (low current) minimises energy wasted as heat, so the National Grid uses high voltage **B1**

Answer: P(A) = 50000 W, P(B) = 500 W; Option A wastes 100 times more power, so high-voltage (low-current) transmission is used to minimise losses.

Question 7

(a) ammeter connected in series with the component under test **B1**

(a) voltmeter connected in parallel across the component under test **B1**

(a) Answer: Ammeter in series with the component; voltmeter in parallel across the component.

(b) a straight line **B1**

(b) through the origin, showing current is directly proportional to potential difference **B1**

(b) Answer: A straight line through the origin (current directly proportional to potential difference).

(c) as potential difference increases, current increases and the filament heats up **B1**

(c) resistance of the filament increases with temperature **B1**

(c) higher resistance means a smaller increase in current for a given increase in p.d., so the graph gradient decreases oe **B1**

(c) Answer: The filament heats up as current increases, its resistance rises, so the current increases less for each extra volt, curving the graph.

Question 8

(a) substitutes: $P = 11.5^2 \times 20$ **M1**

(a) P = 2645 (awrt 2600-2650 if given in W, or the equivalent in kW, e.g. 2.6 or 2.65) **A1**

(a) correct unit for the value given: W (or kW) **B1**

(a) Answer: 2645 W (approx. 2.6 kW)

(b) rearranges to $V = \sqrt{P \times R}$ **M1**

(b) substitutes (using ft power from a): $V = \sqrt{2645 \times 20}$ **M1**

(b) $V = \sqrt{52900}$ = 230 V cso, consistent with the stated value **A1**

(b) Answer: 230 V (shown)

Question 9

(a) substitutes P = V x I = 6.0 x 0.30 **M1**

(a) P = 1.80 W cao **A1**

(a) Answer: 1.80 W

(b) states that heating increases lattice vibrations in the metal filament, scattering electrons more **M1**

(b) leads to more frequent collisions between the electrons and the vibrating metal ions (the number of charge carriers is unchanged) so resistance increases; links to lower current for a given PD or requires larger PD for same current, oe **A1**

(b) Answer: Heating increases the metal lattice vibrations which scatter electrons more, reducing their mobility and so increasing resistance.

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Question 10

(a) resistance is directly proportional to length (doubling length doubles resistance) cao **B1**

(a) Answer: Resistance is directly proportional to length.

(b) uses R = ρ L / A and computes ρ from gradient: gradient = delta R / delta L = 0.50 / 0.20 = 2.5 ohm m^{-1} then ρ = gradient x A **M1**

(b) A = 0.50 mm^2 = 0.50 x 10^{-6} m^2, ρ = 2.5 x 0.50e-6 = 1.25 x 10^{-6} ohm m cao **A1**

(b) Answer: 1.25e-6 ohm m

(c) any one of: take repeated measurements and average; use more precise instruments (digital multimeter) to measure resistance; ensure good contact and use four-terminal sensing to reduce lead resistance, oe **B1**

(c) Answer: Take repeated measurements and average them to reduce random error.

Question 11

for R = 100 ohm: the supply (9.0 V) is greater than the forward voltage (0.7 V), so the diode conducts; the PD across the resistor is 9.0 - 0.7 = 8.3 V, so I = 8.3/100 = 0.083 A **M1**

for 100 kohm: the diode still conducts (9.0 V is still greater than 0.7 V), the PD across the resistor is still 8.3 V, so I = 8.3/100000 = 8.3e-05 A, a much smaller current, cao **A1**

Answer: With 100 ohm: the diode conducts with about 0.7 V across it, so the resistor has 9.0 - 0.7 = 8.3 V and the current is 8.3/100 = 0.083 A. With 100 kohm: the diode still conducts, because 9.0 V is greater than its 0.7 V forward voltage, so the resistor still has 8.3 V and the current is 8.3/100000 = 8.3e-05 A. Only the size of the current changes.

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