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HIGHER

P2H Electricity: Higher Tier Practice

AQA 8463 · Calculator allowed · about 110 minutes

Total Marks

Name: ________________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 State the unit of electrical resistance and give its symbol. Include the name of the unit and the common symbol used in equations and on instruments.

(Total for Question 1 is 1 mark)

2 A small DC circuit supplies 12.0 V across a resistor and the current through it is 0.60 A. Use V = I x R to find the resistance.

(Total for Question 2 is 2 marks)

3 Two resistors, 8.0 ohm and 12.0 ohm, are connected in series across a 10.0 V battery. Calculate the total resistance and the current drawn from the battery.

(Total for Question 3 is 2 marks)

4 The circuit below shows a resistor R and a diode D connected to a 9.0 V supply. The diode conducts only in the forward direction and has an approximate forward voltage of 0.7 V when conducting.

Explain why the diode will conduct when the resistor is 100 ohm but will not conduct when the resistor is 100 kohm. Show calculations for the potential difference across the diode in each case and compare with the forward voltage.

(Total for Question 4 is 2 marks)

5 A heater coil draws a current of 4.5 A from a 230 V mains supply. Use two equations to calculate (a) the power dissipated by the coil, and (b) the energy supplied in 15 minutes. Give units in each answer.

(Total for Question 5 is 3 marks)

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6 A power supply provides 24 V across a resistor. The power dissipated by the resistor is 48 W.

Calculate the current through the resistor.

(Total for Question 6 is 2 marks)

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7 A phone power bank supplies a current of 1.2 A for 2.5 hours at an output voltage of 5.0 V. Calculate (a) the total charge passed, and (b) the energy delivered. Give units.

(Total for Question 7 is 3 marks)

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8 Three resistors, 30.0 ohm, 60.0 ohm and 120.0 ohm, are connected in parallel across a 12.0 V supply. Calculate the total resistance of the combination and the total current drawn from the supply.

(Total for Question 8 is 4 marks)

9 A potential divider is made from two resistors R1 and R2 connected in series across a 24.0 V source. R1 = 4.0 kohm and R2 = 2.0 kohm.

(a) Calculate the potential difference across R2. (b) A sensor is connected across R2 and draws an additional parallel resistance of 20.0 kohm across R2. Calculate the new potential difference across R2 with the sensor connected. State whether the sensor connection increases or decreases the PD across R2 and explain briefly.

(a) Calculate the potential difference across R2 when only R1 and R2 are present. **(2)**

....

(b) Calculate the new potential difference across R2 when a 20.0 kohm sensor is connected in parallel with R2, and say whether the PD increases or decreases. **(2)**

....

(Total for Question 9 is 4 marks)

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10 A battery has an emf of 12.0 V and internal resistance r. When connected to a 6.0 ohm external resistor, the terminal potential difference is 10.8 V.

(a) Calculate the current in the circuit. (b) Use your answer to calculate the internal resistance r of the battery. (c) Calculate the power dissipated inside the battery due to its internal resistance.

(a) Calculate the current in the circuit. **(1)**

....

(b) Calculate the internal resistance r of the battery. **(2)**

....

(c) Calculate the power dissipated inside the battery by its internal resistance. **(1)**

....

(Total for Question 10 is 4 marks)

11 Explain how changing the resistance in a step-up transformer primary winding circuit (while the primary is connected to an AC supply of fixed frequency and amplitude) would affect the current in the primary, the magnetic flux in the core and the voltage induced in the secondary. In your answer discuss the chain of cause and effect and state any assumptions you make about the transformer being ideal. You are assessing the relationship between supply, impedance and induced emf.

(Total for Question 11 is 6 marks)

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12 A circuit contains three resistors and a 12.0 V battery as shown: R1 = 10.0 ohm is in series with a parallel pair of R2 = 20.0 ohm and R3 = 30.0 ohm. Calculate (a) the total resistance of the circuit, and (b) the current through R1. (c) Calculate the current through R3.

(a) Calculate the total resistance of the circuit. **(2)**

....

(b) Calculate the current through R1. **(1)**

....

(c) Calculate the current through R3 (one branch of the parallel pair). **(1)**

....

(Total for Question 12 is 4 marks)

13 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 when warmed up. (b) Explain why the resistance of the filament changes as it warms, referring to the material properties of the filament and the effect on current.

(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. **(2)**

(Total for Question 13 is 4 marks)

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14 An electric motor is supplied from a 48.0 V DC supply and draws 12.0 A under load. The motor is rated at 90% electrical efficiency (electrical power in to mechanical power out). Calculate (a) the electrical input power, (b) the mechanical power output, and (c) the heat power lost inside the motor (in watts).

(a) Calculate the electrical input power. **(1)**

....

(b) Calculate the mechanical power output given 90% efficiency. **(2)**

....

(c) Calculate the heat power lost inside the motor. **(2)**

....

(Total for Question 14 is 5 marks)

15 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 indicated by these results. (b) Use the data to calculate the resistivity of the wire if its cross-sectional area is 0.50 mm^2. Show your working. (c) Suggest two practical improvements to reduce random error in the investigation.

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

(b) Calculate the resistivity of the wire using the gradient method from the data. **(2)**
Cross-sectional area = 0.50 mm^2.

....

(c) Suggest two practical improvements to reduce random error in the investigation. **(1)**

(Total for Question 15 is 4 marks)

Mark scheme · P2H Electricity: Higher Tier Practice

Question 1

- **B1** ohm and symbol ohm or ω not required; accept the word ohm and symbol written as ohm (oe)
- **Answer: ohm (symbol: ohm)**

Question 2

- **M1** rearranges and substitutes R = V / I with 12.0 / 0.60
- **A1** 20 ohm cao
- **Answer: 20 ohm**

Question 3

- **M1** adds resistances: R_total = 8.0 + 12.0 = 20.0 ohm
- **A1** current = 10.0 / 20.0 = 0.50 A cao
- **Answer: Total resistance 20.0 ohm; current 0.50 A**

Question 4

- **M1** calculates PD across resistor and compares with supply to find PD across diode for R = 100 ohm: I = (9.0 - 0.7)/100 = 0.083 A or shows resulting PD across diode is about 0.7 V enabling conduction
- **A1** for 100 kohm calculates I = (9.0 - 0.7)/100000 = 8.3e-05 A and shows PD across diode would be less than 0.7 V so diode does not reach forward threshold cao
- **Answer: With 100 ohm: current = (9.0 - 0.7)/100 = 0.083 A so diode can reach forward PD about 0.7 V and it conducts. With 100 kohm: current = (9.0 - 0.7)/100000 = 8.3e-05 A so PD across diode is less than 0.7 V and it does not conduct.**

Question 5

- **M1** substitutes P = V x I: P = 230 x 4.5
- **A1** P = 1035 W cao
- **A1** E = P x t = 1035 x (15 x 60) = 1035 x 900 = 931500 J cao
- **Answer: Power 1035 W; energy 931500 J**

Question 6

- **M1** uses P = V x I and substitutes I = P / V = 48 / 24
- **A1** I = 2.0 A cao
- **Answer: 2.0 A**

Question 7

- **M1** converts time to seconds and computes charge: t = 2.5 x 3600 = 9000 s; Q = I x t = 1.2 x 9000
- **A1** Q = 10800 C cao
- **A1** energy E = V x Q = 5.0 x 10800 = 54000 J cao
- **Answer: Charge 10800 C; energy 54000 J**

Question 8

- **M1** calculates reciprocals: 1/R_total = 1/30 + 1/60 + 1/120 = 0.033333 + 0.016667 + 0.008333
- **M1** sums reciprocals and inverts: 1/R_total = 0.058333 so R_total = 17.142857 ohm
- **A1** R_total = 17.14 ohm (to 3 s.f.) cao
- **A1** I_total = V / R_total = 12.0 / 17.142857 = 0.700 A (0.700 to 3 s.f.) cao
- **Answer: Total resistance 17.14 ohm; total current 0.700 A**

Question 9

- (a) **M1** finds total resistance and divides to get PD: R_total = 4.0 + 2.0 = 6.0 kohm so I = 24.0 / 6000
- (a) **A1** V_{R2} = I x R2 = (24.0 / 6000) x 2000 = 8.0 V cao
- **(a) Answer: 8.0 V**
- (b) **M1** calculates parallel combination: R2_parallel = 1 / (1/2000 + 1/20000) = 1818.18 ohm approx
- (b) **A1** new V_{R2} = 24.0 x (1818.18 / (4000 + 1818.18)) = 24 x (1818.18 / 5818.18) = 7.50 V (3 s.f.) cao
- **(b) Answer: 7.50 V; the PD decreases (from 8.0 V to 7.50 V) because the parallel sensor reduces the effective R2**

Question 10

- (a) **B1** I = V_terminal / R = 10.8 / 6.0 = 1.80 A cao
- **(a) Answer: 1.80 A**
- (b) **M1** uses emf = V_terminal + I r and substitutes r = (emf - V_terminal) / I = (12.0 - 10.8) / 1.80
- (b) **A1** r = 0.667 ohm (0.67 ohm to 2 s.f.) cao
- **(b) Answer: 0.667 ohm**
- (c) **B1** P_internal = I^2 r = $(1.80)^2$ x 0.666666... = 3.24 x 0.666666... = 2.16 W cao
- **(c) Answer: 2.16 W**

Question 11

- **Level 3** (5-6): Detailed explanation linking resistance change to primary current, primary magnetising flux and then to secondary induced voltage; states ideal transformer assumption; uses correct terms such as impedance, magnetising current, flux, and Faraday's law; gives a clear causal chain and conclusion.
- **Level 2** (3-4): Partial explanation that links a change in resistance to a change in current and mentions an effect on flux or induced voltage, but with limited causal detail or missing the ideal transformer assumption.
- **Level 1** (0-2): Simple statements such as 'higher resistance gives lower current' without linking to flux or induced voltage, or statements that are irrelevant or incorrect.
- **Indicative content:**
  - Assume ideal transformer means negligible losses and primary current produces flux in core.
  - Increasing primary circuit resistance reduces the primary current (I = V / Z), so magnetising current falls.
  - Reduced magnetising current produces reduced magnetic flux in the core (flux is proportional to magnetising current).
  - Faraday's law: induced emf in secondary is proportional to rate of change of flux; lower flux gives lower induced emf and therefore lower secondary voltage amplitude.
  - If resistance increases greatly the primary current becomes small and secondary voltage falls significantly; lowering resistance increases primary current, increasing flux and secondary induced voltage, until core saturation or non-ideal effects occur.
  - State any assumptions: frequency constant, supply amplitude constant, negligible winding resistance and leakage flux for ideal behaviour.

Question 12

- (a) **M1** calculates parallel R2 and R3: 1/Rp = 1/20 + 1/30 = 0.05 + 0.033333 = 0.083333; Rp = 12.0 ohm
- (a) **A1** R_total = R1 + Rp = 10.0 + 12.0 = 22.0 ohm cao
- **(a) Answer: 22.0 ohm**
- (b) **B1** I_total = V / R_total = 12.0 / 22.0 = 0.545 A (0.545 to 3 s.f.) cao
- **(b) Answer: 0.545 A**
- (c) **B1** V across parallel pair = I_total x Rp = 0.54545 x 12.0 = 6.545 V so I_{R3} = V / R3 = 6.545 / 30.0 = 0.218 A (0.218 to 3 s.f.) cao
- **(c) Answer: 0.218 A**

Question 13

- (a) **M1** substitutes $P = V \times I = 6.0 \times 0.30$
- (a) **A1** $P = 1.80$ W cao
- **(a) Answer: 1.80 W**
- (b) **M1** states that heating increases lattice vibrations in the metal filament, scattering electrons more
- (b) **A1** leads to fewer charge carriers able to move freely so resistance increases; links to lower current for a given PD or requires larger PD for same current, oe
- **(b) Answer: Heating increases the metal lattice vibrations which scatter electrons more, reducing their mobility and so increasing resistance.**

Question 14

- (a) **B1** $P_{in} = V \times I = 48.0 \times 12.0 = 576$ W cao
- **(a) Answer: 576 W**
- (b) **M1** uses efficiency = P_{out} / P_{in} and substitutes $P_{out} = 0.90 \times 576$
- (b) **A1** $P_{out} = 518.4$ W (518 W to 3 s.f. acceptable) cao
- **(b) Answer: 518.4 W**
- (c) **M1** calculates heat lost as difference: $P\_loss = P_{in} - P_{out}$
- (c) **A1** P_loss = 576 - 518.4 = 57.6 W cao
- **(c) Answer: 57.6 W**

Question 15

- (a) **B1** resistance is directly proportional to length (doubling length doubles resistance) cao
- **(a) Answer: Resistance is directly proportional to length.**
- (b) **M1** uses $R = \rho L / A$ and computes ρ from gradient: gradient = delta R / delta L = 0.50 / 0.20 = 2.5 ohm m^{-1} then ρ = gradient x A
- (b) **A1** $A = 0.50\ mm^2 = 0.50 \times 10^{-6}\ m^2$, ρ = 2.5 x 0.50e-6 = 1.25×10^{-6} ohm m cao
- **(b) Answer: 1.25e-6 ohm m**
- (c) **B1** 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
- **(c) Answer: Repeat measurements and average; use a more precise digital meter or four-terminal sensing to reduce lead/contact resistance.**