# 4. Electricity and magnetism

## 4.3 Electric circuits

## Paper 3 and 4

Answer Key

# Paper 3

Q1.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | (to) change / control current (in circuit / heater)<br>OR change / control p.d. voltage (across heater) | **B1** |
| (a)(ii) | (6.0 ÷ 1.5 =) 4 (cells) | **B1** |
| (a)(iii) | symbol for voltmeter seen or used | **B1** |
| | connected in parallel with heater | **B1** |
| (b) | (*E* =) 260 (J) | **A3** |
| | (*E* =) 1.6 × 40 × 4.0 | (C2) |
| | (*E* =) *I* × *t* × *V* OR *P* = *I* × *V* **AND** (*E* =) *P* × *t* | (C1) |

Q2.

| Question | Answer | Marks |
|---|---|---|
| (a) | any **two** from:<br>• switch<br>• ammeter<br>• variable resistor | **B2** |
| (b) | (power =) 2.4 (W) | **A3** |
| | (power =) 0.4(0) × 6(.0) | (C2) |
| | (power =) *I* × *V* | (C1) |
| (c) | lamp symbol drawn in parallel with lamp in circuit | **B1** |

Q3.

| Question | Answer | Marks |
|---|---|---|
| (a) | ammeter symbol correct | **B1** |
| | voltmeter symbol correct | **B1** |
| (b) | (*R* =) 5.7 (Ω) | **A3** |
| | (*R* =) 8(.0) ÷ 1.4 | (C2) |
| | *V* = *IR* in any form **OR** (*R* =) *V* ÷ *I* | (C1) |
| (c) | (*E* =) 340 (J) | **A3** |
| | (*E* =) 8(.0) × 1.4 × 30 | (C2) |
| | (*E* =) *V I t* | (C1) |

Q4.

| Question | Answer | Marks |
|---|---|---|
| (a) | **5 correct symbols for 3 marks**<br>**3 or 4 correct symbols for 2 marks**<br>**1 or 2 correct symbols for 1 mark**<br><br>any from:<br>• correct symbol for battery<br>• correct symbol for ammeter<br>• correct symbol for lamp<br>• correct symbol for fixed resistor<br>• correct symbol for switch. | **B3** |
| | all components drawn connected in a series circuit | **B1** |
| (b) | electrons | **B1** |
| (c) | 6(.0) (V) | **A3** |
| | 0.40 × 15 | C2 |
| | ($V$ =) $I \times R$ **OR** $R = V / I$ | C1 |

Q5.

| Question | Answer | Marks |
|---|---|---|
| (a) | ammeter, battery and test wire in complete series circuit | **B1** |
| | voltmeter in parallel with AB | **B1** |
| | correct circuit symbols for ammeter AND voltmeter | **B1** |
| (b) | 14 | **A3** |
| | 1.56 ÷ 0.112 | (C2) |
| | (R =) V ÷ I in any form OR V = I × R | (C1) |
| | Ω / ohm(s) | **B1** |

Q6.

| Question | Answer | Marks |
|---|---|---|
| (a) | correct symbol for battery | **B1** |
| | correct symbol for switch | **B1** |
| | correct symbol for lamp | **B1** |
| | all 3 components connected in series | **B1** |
| (b)(i) | 0.26 (A) | **B1** |
| (b)(ii) | 5.4 (Ω) | **A3** |
| | 1.4 ÷ 0.26 | **(C2)** |
| | V= IR or (R =) V/I | **(C1)** |

Q7.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | (electric) current | B1 |
| (a)(ii) | tick in third box $A_1$ is equal to $A_3$ | B1 |
| (b)(i) | resistors in parallel | B1 |
| | connected to battery AND correct circuit symbol for battery | B1 |
| (b)(ii) | same brightness / if one fails the rest are still lit / lamps can be switched off independently / same p.d. across owtte | B1 |
| (c)(i) | potential divider / potentiometer | B1 |
| (c)(ii) | dimmer / change light output / intensity | B1 |
| (c)(iii) | move the slider | B1 |
| | varies p.d. (across lamp) | B1 |

Q8.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | (3.0 + 5.0 =) 8.0 (Ω) | B1 |
| (a)(ii) | 0.5(0) (A) | B1 |
| (b) | (current/reading) increases | B1 |
| | (because circuit) resistance decreases | B1 |
| | (circuit)resistance becomes less than 3(.0)Ω OR less than smallest resistor (value)<br>OR current/reading more than doubles | B1 |
| (c) | V= IR or (R =) V/I | C1 |
| | 6.0 ÷ 0.4 | C1 |
| | 15 (Ω) | A1 |

Q9.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | electron(s) | B1 |
| (a)(ii) | (component X is a) variable resistor | B1 |
| (a)(iii) | V= IR or (R =) V/I | C1 |
| | 5.5 ÷ 0.05 (0) | C1 |
| | 110 (Ω) | A1 |
| (b) | (current in circuit) increases | B1 |
| | (because) resistance of LDR decreases | B1 |

Q10.

| Question | Answer | Marks |
|---|---|---|
| (a) | any **three** from:<br>current in relay coil<br><br>produces magnetic field<br><br>relay / switch R is closed<br><br>heater connected to 120 V or switches on | **B3** |

Q11.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | thermistor | **B1** |
| (a)(ii) | correct symbol for ammeter drawn | **B1** |
| | correct symbol for voltmeter drawn | **B1** |
| | both meters correctly positioned in circuit | **B1** |
| (b)(i) | 12 (Ω) | **B1** |
| (b)(ii) | smaller (than A) | **B1** |

Q12.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | correct symbol for ammeter | **B1** |
| | correct symbol for voltmeter | **B1** |
| | ammeter in series and voltmeter in parallel with lamp | **B1** |
| (a)(ii) | (R =) V ÷ I OR $V = I \times R$ in any form | **C1** |
| | (R = ) 4.5 ÷ 0.25 | **C1** |
| | 18 ( Ω) | **A1** |
| (b)(i) | variable resistor | **B1** |
| (b)(ii) | (sliding contact moved to) change resistance (in circuit) | **B1** |
| | (and so) change current (in lamp) or p.d. (across lamp) | **B1** |

Q13.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | cell symbol correctly drawn | B1 |
| (a)(ii) | series | B1 |
| (a)(iii) | electrons | B1 |
| (b)(i) | any **two** from:<br>(both) lamps have correct / full potential difference<br>if one lamp fails the other lamp still lights<br>lamps can be switched (on/off)independently | B2 |
| (b)(ii) | V = IR or (I =) V √ R | C1 |
| | 3 √ 12 | C1 |
| | 0.25 (A) | A1 |

Q14.

| Question | Answer | Marks |
|---|---|---|
| (a) | (position) R | B1 |
| (b) | V = IR in any form | C1 |
| | (R =) 6.0 ÷ 0.5 OR 6.0 = 0.5 × R | C1 |
| | (R=) 12 | A1 |
| | Ω or ohms | B1 |
| (c) | both lamps have correct p.d. OR voltage (across them) | B1 |
| | if one lamp fails the other is still lit | B1 |

Q15.

| Question | Answer | Marks |
|---|---|---|
| (a) | thermistor | B1 |
| (b)(i) | low (brightness) OR off | M1 |
| | pd or voltage (across lamp) is zero or almost zero | A1 |
| (b)(ii) | (brightness / it) increases | B1 |
| | p.d. / voltage (across lamp) increases | B1 |
| (b)(iii) | lamp blows / fuses (when p.d. too high) | B1 |

Q16.

| Question | Answer | Marks |
|---|---|---|
| (a) | ammeter symbol | B1 |
| | ammeter in series (with power supply) | B1 |
| | voltmeter symbol | B1 |
| | voltmeter in parallel (with lamps/power supply) | B1 |
| | two lamps in parallel | B1 |
| (b) | (brightness) stays the same | B1 |
| | current (in working lamp) stays the same | B1 |

Q17.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | correct symbols for: | |
| | ammeter | B1 |
| | voltmeter | B1 |
| | ammeter in series **OR** voltmeter in parallel | B1 |
| (a)(ii) | **Any five from:**<br>close switch<br>adjust / change variable resistor to give current in resistor / reading on ammeter<br>measure / record (pair of) readings on ammeter and voltmeter<br>description of any check for reliability<br>idea of adjusting variable resistor to give range of readings<br>plot a graph<br>suitable spacing of readings e.g. every 0.05A or 0.1 A<br>use of V= IR or R = V / I<br>repeat AND calculate average (value for R) | B4 |
| (b) | (circuit) resistance increases | B1 |
| | BUT (circuit) resistance doubles / becomes 40 Ω (award two marks as assumes previous (1st) marking point) | B1 |
| | (current) decreases | B1 |
| | BUT(current) halves / becomes 0.2 A (award two marks as assumes previous (3rd) marking point) | B1 |

Q18.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | top box (electrons) ticked | 1 |
| (a)(ii) | 12 + 6 seen or 18 (Ω) | 1 |
| (a)(iii) | (V =) I × R | 1 |
| | (V =) 0.50 × 18(.0) | 1 |
| | (V =) 9.0 (V) ecf from **(a)(ii)** | 1 |
| (b) | (reading/current) increases | 1 |
| | (because effective circuit) resistance decreases/resistors in parallel have less resistance | 1 |

Q19.

| Question | Answer | Mark |
|---|---|---|
| (a) | 12 (Ω) | **A3** |
| | 4.8 / 0.4 | (C2) |
| | $V = IR$ **OR** ($R =$ ) $V / I$ | (C1) |
| (b) | (lamp is) brighter **OR** (brightness) increases | **B1** |
| | resistance of wire and resistor in parallel is less than resistance of wire owtte<br>**OR** voltage across lamp / L increases | **B1** |
| | (so) current in lamp increases | **B1** |

Q20.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | increased | **B1** |
| | decreased | **B1** |
| (a)(ii) | the same | **B1** |
| (b) | correct voltmeter symbol | **B1** |
| | in parallel with battery | **B1** |
| (c) | R = V ÷ I in any form | **C1** |
| | 3(.0) ÷ 0.15 | **C1** |
| | 20 | **A1** |
| | Ω / ohms | **B1** |

# Paper 4

Q21.

| Question | Answer | Marks |
|---|---|---|
| (a) | work done by a unit charge passing through a component | **A2** |
| | (electrical) work done **AND** moving charge | C1 |
| (b) | (p.d. =) $E$ – reading on voltmeter **OR** subtract reading on voltmeter from $E$ | **B1** |
| (c)(i) | (intensity of light on LDR) increased<br>**AND**<br>(temperature of thermistor) decreased | **B1** |
| (c)(ii) | reading on voltmeter / it decreases | **B1** |
| | *Any **two** from:*<br>1 e.m.f. is constant<br>2 $R_{LDR}$ / $R_{thermistor}$ decreases **OR** $R_{LDR}$ is a smaller proportion of the total resistance<br>3 $V_{LDR}$ / $V_{thermistor}$ decreases **OR** $V_{LDR}$ is a smaller proportion of e.m.f.<br>4 $\frac{R1}{R2} = \frac{V1}{V2}$ | **B2** |

Q22.

| Question | Answer | Marks |
|---|---|---|
| (a) | (electrical) work done moving a unit charge around a (complete) circuit | **A2** |
| | work done **AND** moving a charge (in a circuit) | C1 |
| (b)(i) | correct symbols for five cells in series | **B1** |
| | correct symbols for variable resistor **AND** fixed resistor | **B1** |
| | cells, variable resistor and fixed resistor connected in series | **B1** |
| (b)(ii) | curve with negative gradient of decreasing magnitude from 0 Ω to 150 Ω **AND** does not reach the $x$-axis | **A2** |
| | curve / line with negative gradient from 0 Ω to 150 Ω | C1 |
| | $y$-axis labelled 0.25 where candidate's line meets the $y$-axis **OR** the mark on the $y$-axis labelled 0.25 | **A2** |
| | $R = V / I$ **OR** ($I_{max}$ =) $V / R$ **OR** 7.5 / 30 | C1 |

Q23.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | correct voltmeter symbol connected across LDR | **B1** |
| (a)(ii)1 | (resistance) increases | **B1** |
| (a)(ii)2 | (p.d.) increases because resistance of parallel combination of LDR and LED increases | **B1** |
| | greater proportion of (total) p.d. across LDR / LED / parallel combination of LDR and LED | **B1** |

| | | |
|---|---|---|
| (b) | 960 Ω | **A3** |
| | current in each bulb = 0.25 **OR** $R = V / I$ **OR** ($R$ =) $V / I$ | C1 |
| | resistance = 240 / 0.25 **OR** 1 / 480 = 1 / $R$ + 1 / $R$ | C1 |

Q24.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | 0 (A) | **B1** |
| (a)(ii) | ($I$ = 12 / 2 =) 6.0 A | **A2** |
| | ($I$ =) $V / R$ in any form | C1 |
| (a)(iii) | ($I$ = 12 / 5 =) 2.4 A | **A2** |
| | ($R_s = R_1 + R_2$ = 2 + 3 =) 5 (Ω) | C1 |
| (b) | ($R_p$ = 6 / 5 =) 1.2 Ω | **A3** |
| | $1 / R_p = 1 / R_1 + 1 / R_2$ OR ($R_p$ =) $R_1 R_2 / (R_1 + R_2)$ | C1 |
| | $1 / R_p = 1 / 2 + 1 / 3$ OR ($R_p$ =) $2 \times 3 / (2 + 3)$ | C1 |

Q25.

| Question | Answer | Marks |
|---|---|---|
| (a) | 7.5 V | **B1** |
| (b)(i) | $1 / R_p = 1 / R_1 + 1 / R_2$ OR ($R_p$ =) $R_1 R_2 / (R_1 + R_2)$ in any form | **C1** |
| | ($R_p$ =) 1.2 (Ω) | **C1** |
| | 3.2 Ω | **A1** |
| (b)(ii) | (V =) IR in any form | **C1** |
| | 4.1 V | **A1** |

Q26.

| Question | Answer | Marks |
|---|---|---|
| (a) |  **and** between P and Q | **B1** |
| (b) | 1.5 V **c.a.o.** | **B1** |
| (c)(i) | 1600 Ω | **A3** |
| | ($V_{800\,\Omega}$ =) 4.0 (V) | **C1** |
| | ($I$ =) $V$ / $R$ in any form or 4.0 / 800 or 0.0050 (A) **or** ($R$ =) $V$ / $I$ or 8.0 / 0.0050 | **C1** |
| | **OR**<br>1600 Ω | **(A3)** |
| | ($V_{800\,\Omega}$ =) 4.0 (V) | **(C1)** |
| | ($R_{Th}$ =) $R_{800\,\Omega} \times V_{Th} / V_{800\,\Omega}$ in any form **or** ($R_{Th}$ =) 800 × 8.0 / 4.0 in any form | **(C1)** |
| | **OR**<br>1600 Ω | **(A3)** |
| | $\frac{12}{800+R_{Th}}$ **or** $\frac{8.0}{R_{Th}}$ **or** $\frac{R_{Th}}{800+R_{Th}}$ | **(C1)** |
| | $\frac{12}{800+R_{Th}} = \frac{8.0}{R_{Th}}$ in any form | **(C1)** |

| | | |
|---|---|---|
| (c)(ii) | larger proportion of the e.m.f. (across thermistor) **or** smaller voltage across 800 Ω | **B1** |
| | temperature (of thermistor) is smaller / has decreased | **B1** |
| | resistance of thermistor / circuit is large(r) | **B1** |

Q27.

| Question | Answer | Marks |
|---|---|---|
| (a)(i) | recognisable ammeter in gap AB AND straight lines in CD AND EF | B1 |
| (a)(ii) | recognisable voltmeter across 4 Ω | B1 |
| | correct voltmeter symbol used | B1 |
| (a)(iii) | $V = IR$ in any form or ($V =$) $IR$ words, symbols or numbers | C1 |
| | ($V_{2\Omega} = 2 \times 2.5 =$) 5 V | C1 |
| | ($I_{4\Omega} = 5 \div 4 =$) 1.3 A<br>must be clear that $I$ refers to 4 Ω<br>OR calculates $R_p = 1.33\ \Omega$ OR $4 \div 3\ \Omega$ | C1 |
| | ($I_{6\Omega} = 2.5 + 1.3 =$) 3.8 A<br>OR ($I_{6\Omega} = 5 \div 1.33 =$) 3.8 A | A1 |
| | Alternative route for first 3 mps | |
| | $I$ proportional to $1 \div R$ OR $I_{2\Omega} \times R_{2\Omega} = I_{4\Omega} \times R_{4\Omega}$ | C1 |
| | $I_{4\Omega} = I_{2\Omega} \div 2$ | C1 |
| | ($I_{4\Omega} = I_{2\Omega} \div 2 = 2.5 \div 2 =$) 1.3 A | C1 |
| | Alternative route by potential divider | |
| | $V = IR$ in any form or ($V =$) $IR$ words, symbols or numbers | C1 |
| | ($V_{2\Omega} = 2 \times 2.5 =$) 5 V | C1 |
| | $V_T = 7.33 \times 5 \div 1.33$ (= 27.51 V) | C1 |
| | ($I_{6\Omega} = 27.51 \div 7.33 =$) 3.8 A | A1 |

| | | |
|---|---|---|
| (b) | any sort of triangle symbol pointing to left in EF | B1 |
| | a wire in CD | B1 |

Q28.

| Question | Answer | Marks |
|---|---|---|
| (a) | any **two** from:<br>• (potential divider) splits / shares / divides the e.m.f. / voltage / potential difference / p.d. (of a power source / in a circuit)<br>• (e.m.f. is) split between (two) resistors / components (connected in series to power source)<br>• (potential divider shares e.m.f.) in proportion to the resistances (of the resistors / components) | B2 |
| (b)(i) | (e.m.f. =) 15 V | B1 |
| (b)(ii) | (resistance =) 60 Ω | A3 |
| | ($R_{\text{II}} =$) $R_2R_3 / (R_2 + R_3)$ **OR** ($R_{\text{II}} =$) $40 \times 40 / (40 + 40)$ **OR** ($R_{\text{II}} =$) 1600 / 80<br>**OR** $1 / R_{\text{II}} = 1 / R_2 + 1 / R_3$ **OR** $1 / R_{\text{II}} = 1 / 40 + 1 / 40$ **OR** ($R_{\text{II}} =$) $(1 / 40 + 1 / 40)^{-1}$ **OR** ($R_{\text{II}} =$) 20 (Ω) | C1 |
| | (resistance =) 40 + (candidate's value for combined resistance of $R_2$ and $R_3$) | C1 |

| | | |
|---|---|---|
| (c) | (reading =) 10 V | A2 |
| | emf shared in same proportion as resistance<br>**OR** e.g. $R_1 / R_{\text{II}} = V_1 / V_{\text{II}}$<br>**OR** (reading =) $15 \times 40 / 60$ **OR** (reading =) $0.25 \times 40$ | C1 |

Q29.

| | | |
|---|---|---|
| (c)(i) | 2.0 V | **A1** |
| (c)(ii) | (ratio of p.d. across $R_2 : R_3$ =) 1 : 2 | **B1** |
| (c)(iii)1. | current is zero in $R_1$ **AND** diode is in wrong direction (to allow current) owtte | **B1** |
| (c)(iii)2. | (ratio of p.d. across $R_2 : R_3$ =) 1 : 1 | **B1** |

Q30.

| Question | Answer | Marks |
|---|---|---|
| (a) | both relate to energy per unit charge | **B1** |
| (b) | e.m.f. applies to the whole circuit / source **or** p.d. to one (or more) component **or** energy conversion to electrical for e.m.f. **or** from electrical for p.d. | **B1** |
| (c)(i) | 4.8 V | **B1** |
| (c)(ii) | 20 Ω | **A3** |
| | $1 / R_T = 1 / R_1 + 1 / R_2$ **or** ($R_T$ =) $R_1 R_2 / (R_1 + R_2)$ **or** $1 / R_T = 1 / 24 + 1 / 12$ **or** $1 / R_T = 3 / 24$ **or** ($R_T$ =) $24 \times 12 / (24 + 12)$ | C1 |
| | 8.0 (Ω) | C1 |
| (c)(iii) | 2.9 V | **A2** |
| | $V = ER / R_T$ in any form **or** $4.8 \times 12 / 20$ **or** $I = E / R$ in any form **or** 0.24 seen | C1 |

Q31.

| Question | Answer | Marks |
|---|---|---|
| (a) | $Q / t$ **or** (rate of) flow of (electric) charge / electrons | **B1** |
| (b) | (current in the 450 Ω resistor =) $I_2 - I_1$ | **B1** |
| (c) | ($V_{450\,\Omega}$ =) $IR$ **or** $0.012 \times 450$ **or** 5.4 (V) **or** 9.0 – 5.4 **or** 3.6 (V) seen | **C1** |
| | ($I$ =) $3.6 / 800$ **or** 0.0045 (A) | **C1** |
| | ($P$ =) $VI$ **or** $3.6 \times 0.0045$ **or** $3.6^2 / 800$ | **C1** |
| | $1.6 \times 10^{-2}$ W **or** 16 mW | **A1** |
| (d) | resistance (of LDR) decreases | **B1** |
| | current (in circuit) increases **or** resistance of parallel pair decreases | **C1** |
| | p.d. across 800 Ω resistor increases **and** p.d. across 450 Ω resistor decreases **or** resistance of parallel pair a smaller fraction of total resistance **and** p.d. across 450 Ω resistor decreases | **A1** |

Q32.

| Question | Answer | Marks |
|---|---|---|
| (a) | (related to) energy supplied in driving charge in a circuit / conductor **or** property of source / battery / cell / power supply | **B1** |
| | energy supplied per / to unit charge **or** energy transferred to electrical energy **or** from other form of energy **or** energy in driving charge around a complete circuit | **B1** |
| (b)(i) | ($I = V \div R = 240 \div 30 =$) 8.0 A | **B1** |
| (b)(ii) | ($P =$) $VI$ **or** $240 \times 8.0$ | **C1** |
| | 1900 W | **A1** |
| (b)(iii)1 | half (the size) | **B1** |
| | (equal voltage / p.d. / e.m.f. and) resistance is twice the size **or** $I$ and $R$ are inversely proportional | **B1** |
| (b)(iii)2 | (fuse rating =) 13 A / 14 A / 15 A / 16 A / 17 A / 18 A / 19 A | **B1** |
| | total current is 12.1 A | **B1** |

Q33.

| Question | Answer | Marks |
|---|---|---|
| (a) | thermistor **c.a.o.** | **B1** |
| (b)(i) | $V_X = V_{30}$ | **B1** |
| (b)(ii) | $V_X = E - V_{20}$ in any form | **B1** |
| (c)(i) | $1/R_1 + 1/R_2 = 1/R_{tot}$ **OR** ($R_{tot} =$) $R_1 R_2 / (R_1 + R_2)$ **OR** $1/15 + 1/30 = 1/R_{tot}$ **OR** $(15 \times 30) / (15 + 30)$ | **C1** |
| | 10 (Ω) **OR** 10 + 20 | **C1** |
| | 30 Ω | **A1** |
| (c)(ii) | $I = V / R$ in any form **OR** ($I =$) $V / R$ **OR** 6.0 / 30 | **C1** |
| | 0.20 A | **A1** |
| (d) | resistance <u>of</u> <u>X</u> decreases | **B1** |
| | ammeter reading / it increases **and** (total) resistance (of circuit) decreases / more voltage across 20 Ω resistor | **B1** |