

Mark Scheme

Q1.

Question Number	Answer	Mark
	The only correct answer is D ($V = 12 \times \frac{2}{6}$) A is not correct because $V = \left(\frac{E}{R+r}\right) \times r$ B is not correct because $V = \left(\frac{E}{R+r}\right) \times r$ C is not correct because $V = \left(\frac{E}{R+r}\right) \times r$	1

Q2.

Question Number	Answer	Mark
	D is the correct answer A is not the correct answer as these are the units of charge B is not the correct answer as these are the units of energy C is not the correct answer as these are the units of force	(1)

Q3.

Question Number	Answer	Mark
	D is the correct answer as the sum of e.m.f. = the sum of p.d. A is not the correct answer as this does not include the p.d. across R_2 B is not the correct answer as this does not include the p.d. across R_2 C is not the correct answer as this does not include the p.d. across R_1	(1)

Q4.

Question Number	Answer	Mark
	C is the correct answer as $\mathcal{E} = I(R + r)$ A is not the correct answer as this does not include the effect of r B is not the correct answer as this does not include the effect of R D is not the correct answer as the two resistances are subtracted instead of added.	(1)

Q5.

Question Number	Answer	Mark
	C is the correct answer A is not correct because the p.d. across r should be added to the p.d. across the $6\ \Omega$ resistor B is not correct because there is a potential difference across r D is not correct because the current in r is $\frac{1.2}{6}$ A	1

Q6.

Question Number	Answer	Mark
	The only correct answer is A - $\frac{10 \times (9 - 6)}{6}$ B is not correct because this is a potential difference squared divided by a resistance C is not correct because this gives a resistance divided by potential difference squared D is not correct because the answer is inverted	1

Q7.

Question Number	Answer	Mark
	A is the correct answer as this represents the current in the internal resistance multiplied by the p.d. across the internal resistance. B is not the correct answer as this is the power dissipated by the external resistance C is not the correct answer as this is the power dissipated by the whole circuit. D is not the correct answer as this equation combines the p.d. across the external resistance with the value for the internal resistance – as a result, it does not represent the power of any of the components in the circuit	(1)

Q8.

Question Number	Answer	Mark								
(a)	Uses ratio of resistances to p.d.s (1) $V = 1.2 \text{ V}$ (1) OR Use of $R = V/I$ (1) $V = 1.2 \text{ V}$ (1) <u>Example of calculation</u> $V = \left(\frac{55 \text{ k}\Omega}{12 \text{ k}\Omega + 55 \text{ k}\Omega} \right) \times 1.5 \text{ V} = 1.23 \text{ V}$	2								
(b)	1 mark for each correct reason (1)(1) 1 mark for each explanation (1)(1) <table><tr><th>Reason</th><th>Explanation</th></tr><tr><td>Cell has (internal) resistance</td><td>Terminal/cell p.d. is lower Or lost volts</td></tr><tr><td>Resistance in wires/connections</td><td>Wires/connections have p.d. across them too.</td></tr><tr><td>Voltmeter has a “low” resistance Or voltmeter draws current</td><td>Resistance of parallel combination would be less than 55 kΩ (so p.d. would be lower)</td></tr></table>	Reason	Explanation	Cell has (internal) resistance	Terminal/cell p.d. is lower Or lost volts	Resistance in wires/connections	Wires/connections have p.d. across them too.	Voltmeter has a “low” resistance Or voltmeter draws current	Resistance of parallel combination would be less than 55 k Ω (so p.d. would be lower)	4
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	Total for question	6								

Q9.

Question Number	Answer	Mark
(a)	Use of $R = \frac{\rho l}{A}$ (1) Use of cross-sectional area = width $\times$ thickness (1) Thickness of layer of carbon = $1.2 \times 10^{-5} \text{ m}$ (1) <u>Example of calculation</u> $8.8 \Omega = \frac{3.7 \times 10^{-5} \Omega \text{ m} \times 0.12 \text{ m}}{0.042 \text{ m} \times t}$ $t = 1.2 \times 10^{-5} \text{ m}$	3
(b)(i)	Use of $R = V/I$ to calculate I (1) Or ratio of resistances = ratio of p.d.s (1) Calculate p.d. across the internal resistance (see 0.1 V) (1) Or calculate whole circuit resistance (see 9.4 Ω) (1) $r = 0.63 \Omega$ (1) <u>Example of calculation</u> $I = \frac{1.4}{8.8} = 0.16 \text{ A}$ $r = \frac{0.1 \text{ V}}{0.16 \text{ A}} = 0.63 \Omega$	3
(b)(ii)	Reading on voltmeter = 0.35 V (1) <u>Example of calculation</u> $\frac{V}{1.4 \text{ V}} = \frac{3.0 \text{ cm}}{12.0 \text{ cm}}$ $V = 0.35 \text{ V}$	1
Total for question		7

Q10.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	Use of $R = \frac{V}{I}$ to calculate I (1) Use of $V = IR$ with $V = 0.1V$ to calculate internal resistance (1) $r = 0.71 \Omega$ (1)	<u>Example of calculation</u> $I = \frac{1.4 V}{10 \Omega} = 0.14 A$ $r = \frac{0.1 V}{0.14 A} = 0.71 \Omega$	3
(b)	When going up a hill more work is done (by the bicycle motor / battery) (1) Or When going up a hill more power is required (from the bicycle motor / battery). (1) $P = IV$ so the current increases (1) Or $P = I^2R$ so the current increases (1) And the p.d. across the internal resistance increases (1) Energy transferred as thermal energy due to internal resistance increases (and battery gets hot) (1)	Accept energy for work done	4

Q11.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	6 J of energy is transferred to each coulomb of charge (by the battery) (1)	Accept: 6 V is the potential difference between the terminals of the battery if no current is drawn Terminal potential difference is 6 V (since internal resistance is negligible)	1

(b)(i)	p.d across $200\ \Omega$ resistor = $6.00 - 1.64$ (= 4.36 V) Use of $R = \frac{V}{I}$ Or Ratio of resistance = ratio of p.d. $I = 2\text{ (mA)}$	(1) (1) (1) <u>Example of calculation</u> $200\ \Omega = \frac{4.36\text{ V}}{I}$ $I = \frac{4.36\text{ V}}{200\ \Omega} = 2.18 \times 10^{-2}\text{ (A)}$	3
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(b)(ii)	EITHER Use of $R = \frac{V}{I}$ for resistance of parallel section Or Use of $R = \frac{V}{I}$ for resistance of total circuit and subtract $200\ \Omega$ (1) Use of resistors in parallel equation. (1) $R_X = 304\ \Omega$ (1) (Allow ecf from (b)(i)) OR Use of $R = \frac{V}{I}$ for current in $100\ \Omega$ resistor (1) Use of $I_{\text{tot}} = I_1 + I_2$ for current in resistor X (1) $R = 304\ \Omega$ (1) (Allow ecf from (b)(i))	Show that value gives $456\ \Omega$ (MP3 dependent on MP2 being awarded) <u>Example of calculation</u> $R_{\text{parallel}} = \frac{1.64\ \text{V}}{2.18 \times 10^{-2}\ \text{A}}$ $= 75.23\ \Omega$ show that value $= 82\ \Omega$ $\frac{1}{R_X} + \frac{1}{100\ \Omega} = \frac{1}{75.23\ \Omega}$ $R_X = 303.7\ \Omega$ OR $I = \frac{1.64\ \text{V}}{100\ \Omega} = 1.64 \times 10^{-2}\ \text{A}$ $2.18 \times 10^{-2}\ \text{A} - 1.64 \times 10^{-2}\ \text{A}$ $= 5.4 \times 10^{-3}\ \text{A}$ $R = \frac{1.64\ \text{V}}{5.4 \times 10^{-3}\ \text{A}} = 303.7\ \Omega$	3
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(b)(iii)	Use of $P = \frac{V^2}{R}$ Or use of $P = VI$ (1) Or use of $P = I^2R$ (1) $P = 2.70 \times 10^{-2} \text{ W}$ (Allow ecf from (b)(i) or (b)(ii) for I)	<u>Example of calculation</u> $P = \frac{(1.64 \text{ V})^2}{100 \Omega}$ $P = 2.70 \times 10^{-2} \text{ W}$	2
(c)	The resistance of the parallel combination would increase (1) So the ratio / share of parallel combination resistance to other resistance increases and so does the voltmeter reading, so student is correct (1)		2

Q12.

Question Number	Answer	Mark
(a)	Energy (supplied) to/per unit charge Or Work done (supplied) to/per unit charge Or The work done moving unit charge around the whole circuit (1)	1

Question Number	Answer	Mark																																								
* a	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. <table><tr><th>IC points</th><th>IC mark</th><th>Max linkage mark</th><th>Max final mark</th></tr><tr><td>6</td><td>4</td><td>2</td><td>6</td></tr><tr><td>5</td><td>3</td><td>2</td><td>5</td></tr><tr><td>4</td><td>3</td><td>1</td><td>4</td></tr><tr><td>3</td><td>2</td><td>1</td><td>3</td></tr><tr><td>2</td><td>2</td><td>0</td><td>2</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td></tr></table> The following table shows how the marks should be awarded for structure and lines of reasoning. <table><tr><th></th><th>Number of marks awarded for structure of answer and sustained line of reasoning</th></tr><tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr></table> Indicative content • Current is the rate of flow of charge • Current is the same at all points in a series circuit Or current in C = current in cell. • total current going into a junction = total current out of junction Or current in C/cell = current in A + current in B Or current splits (equally) between A and B • p.d. is energy transferred per unit charge • p.d. is shared between components in series Or p.d. across C + p.d. across A = e.m.f. of cell Or p.d. across C + p.d. across B = e.m.f. of cell Or p.d. across C + p.d. across A/B combination = e.m.f. of cell • p.d. is the same across components in parallel Or p.d. across A is the same as that across B	IC points	IC mark	Max linkage mark	Max final mark	6	4	2	6	5	3	2	5	4	3	1	4	3	2	1	3	2	2	0	2	1	1	0	1	0	0	0	0		Number of marks awarded for structure of answer and sustained line of reasoning	Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0	
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bi	Use of resistors in parallel formula (1) Use of resistors in series formula (1) Total resistance = 18.8Ω (1) (Allow MP1 for use of $R^2 / 2R$) <u>Example of calculation</u> For parallel section, $\frac{1}{R_p} = \frac{1}{12.5\Omega} + \frac{1}{12.5\Omega}$ so $R_p = 6.25\Omega$ $R_{total} = 6.25\Omega + 12.5\Omega = 18.75\Omega$.	3
bii	Equation for sum of p.d. = sum of e.m.f. seen e.g. $\mathcal{E} = IR + Ir$ (1) Rearranged to make r the subject of the formula e.g. $r = \frac{\mathcal{E}}{I} - R$ (1) Ammeter labelled anywhere on series part of circuit (1) Or Terminal p.d. calculated using IR (1) Subtract from $\mathcal{E}$ and divide by ammeter reading (1) Ammeter labelled anywhere on series part of circuit (1) Or $\mathcal{E}$ divided by ammeter reading (1) Subtract answer for (b)(i) from this value (1) Ammeter labelled anywhere on series part of circuit (1)	3
	Total for question	12

Q14.

Question Number	Answer	Mark
(a)	A <u>photon</u> (incident on a surface) is <u>absorbed</u> by an atom / electron (1) Or A <u>photon</u> (incident on a surface) collides with an atom / electron An electron gains energy and is emitted (from the surface) (1)	2
(b)	(To cause the photoelectric effect) the energy (of a photon) must be greater than the work function (of the photocathode) (1) Or (to cause the photoelectric effect) the frequency (of a photon) must be greater than the threshold frequency (of the photocathode) Photon energy is proportional to frequency, so photons below a certain frequency / energy cannot cause the photoelectric effect (1)	2
(c)	Use of $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$ (1) Use of $E = hf$ (1) Use of $v = f\lambda$ (1) Comparison of 840 nm with 700 nm and conclusion all wavelengths of visible light can be detected (1) Or Comparison of $2.85 \times 10^{-19} \text{ J}$ with $2.37 \times 10^{-19} \text{ J}$ and conclusion all wavelengths of visible light can be detected Or Comparison of 1.78 eV with 1.48 eV and conclusion all wavelengths of visible light can be detected Or Comparison of $3.57 \times 10^{14} \text{ Hz}$ with $4.29 \times 10^{14} \text{ Hz}$ <u>Example calculation</u> $E = 1.48 \text{ eV} \times 1.6 \times 10^{-19} \text{ J eV}^{-1} = 2.37 \times 10^{-19} \text{ J}$ $f_{\text{threshold}} = \frac{2.37 \times 10^{-19} \text{ J}}{6.63 \times 10^{-34} \text{ Js}} = 3.57 \times 10^{14} \text{ Hz}$ $\lambda_{\text{threshold}} = \frac{3 \times 10^8 \text{ m s}^{-1}}{3.57 \times 10^{14} \text{ Hz}} = 840 \times 10^{-9} \text{ m}$ 700 nm < 840 nm so all wavelengths of visible light can be detected	4

(d)	Use of $E_k = \frac{1}{2} mv^2$ (1) Use of $V = \frac{W}{Q}$ (1) Final kinetic energy = 1.81×10^{-17} (J) (1) <u>Example calculation</u> Initial $E_k = 0.5 \times 9.11 \times 10^{-31} \text{ kg} \times (1.35 \times 10^6 \text{ m s}^{-1})^2 = 8.30 \times 10^{-19} \text{ J}$ $W = 108 \text{ V} \times 1.6 \times 10^{-19} \text{ C} = 1.73 \times 10^{-17} \text{ J}$ Final kinetic energy ($= 1.73 \times 10^{-17} \text{ J} + 8.30 \times 10^{-19} \text{ J}$) = $1.81 \times 10^{-17} \text{ J}$	3
(e)	EITHER Use of $V = IR$ to calculate current in circuit (1) Calculates total p.d across resistors A to D (1) Use of sum of e.m.f. = sum of p.d (1) Internal resistance = $1.20 \text{ M}\Omega$ (1) OR Calculates total p.d. across resistors A to D (1) Uses ratio of resistance = ratio of p.d. (1) Correct values substituted into ratio equation (1) Internal resistance = $1.20 \text{ M}\Omega$ (1) <u>Example calculation</u> $I = \frac{108 \text{ V}}{85 \times 10^3 \Omega} = 1.27 \times 10^{-3} \text{ A}$ $V = 1960 - 4 \times 108 = 1530 \text{ V}$ $r = \frac{1530 \text{ V}}{1.27 \times 10^{-3} \text{ A}} = 1.20 \times 10^6 \Omega$	4
Total for question		15