1	**B is the correct answer as it is a *V-I* graph for a filament lamp** A is not the correct answer as it is not a *V-I* graph for a diode C is not the correct answer as it is not a *V-I* graph for an ohmic conductor D is not the correct answer as it is not a *V-I* graph for a thermistor	**(1)**

9	The only correct answer is **A** B is not correct because $W = VIt$ and area under graph = It C is not correct because $W = VIt$ and area under graph = It D is not correct because $W = VIt$ and area under graph = It	**1**

4	**The only correct answer is A** ***B** is not correct as it uses an incorrect expression.* ***C** is not correct as it uses an incorrect expression.* ***D** is not correct as it uses an incorrect expression.*	**(1)**

5	**A is the correct answer as $R = V/I$, and V is measured in JC^{-1} and I is measured in Cs^{-1}.** B is not the correct answer as the units of resistance are not JC^2s^{-1} C is not the correct answer as the units of resistance are not JC^{-1} s^{-1} D is not the correct answer as the units of resistance are not JCs	**(1)**

19(a)	A photon (incident on a surface) is absorbed by an atom / electron **Or** A photon (incident on a surface) collides with an atom / electron An electron gains energy and is emitted (from the surface)	**(1)** **(1)**	**2**

19(b)	(To cause the photoelectric effect) the energy (of a photon) must be greater than the work function (of the photocathode) **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)** **(1)**	**2**

19(c)	Use of 1 eV = 1.6×10^{-19} 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 **Or** Comparison of 2.85×10^{-19} J with 2.37×10^{-19} 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 x 10^{14} Hz with 4.29 x 10^{14} Hz Example calculation $E = 1.48 \text{ eV} \times 1.6 \times 10^{-19} \text{ J eV}^{-1} = 2.37 \times 10^{-19}$ J $f_{\text{threshold}} = \frac{2.37 \times 10^{-19} \text{ J}}{6.63 \times 10^{-34} \text{ Js}} = 3.57 \times 10^{14}$ Hz $\lambda_{\text{threshold}} = \frac{3 \times 10^{8} \text{ m s}^{-1}}{3.57 \times 10^{14} \text{ Hz}} = 840 \times 10^{-9}$ m 700 nm < 840 nm so all wavelengths of visible light can be detected	**(1)**	**4**

19(d)	Use of $E_k = ½ mv^2$	**(1)**	
	Use of $V = \frac{W}{Q}$	**(1)**	
	Final kinetic energy = 1.81×10^{-17} (J) Example calculation Initial $E_k = 0.5 \times 9.11 \times 10^{-31} \text{ kg} \times (1.35 \times 10^{6} \text{ m s}^{-1})^2 = 8.30 \times 10^{-19}$ J $W = 108 \text{ V} \times 1.6 \times 10^{-19} \text{ C} = 1.73 \times 10^{-17}$ J Final kinetic energy (= 1.73×10^{-17} J + 8.30×10^{-19} J) = 1.81×10^{-17} J	**(1)**	**3**

19(e)	**EITHER** Use of $V = IR$ to calculate current in circuit Calculates total p.d across resistors A to D Use of sum of e.m.f. = sum of p.d Internal resistance = 1.20 MΩ **OR** Calculates total p.d. across resistors A to D Uses ratio of resistance = ratio of p.d. Correct values substituted into ratio equation Internal resistance = 1.20 MΩ <u>Example calculation</u> $I = \frac{108\ \text{V}}{85 \times 10^3\ \Omega} = 1.27 \times 10^{-3}\ \text{A}$ $V = 1960 - 4 \times 108 = 1530\ \text{V}$ $r = \frac{1530\ \text{V}}{1.27 \times 10^{-3}\text{A}} = 1.20 \times 10^6\ \Omega$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**4**

Question Number	Answer	Mark
14 (a)	Use of e.m.f. = sum of p.d.s **(1)** Use of $V = IR$ **(1)** $r = 17\ 000\ (\Omega)$ **(1)** <u>Example of calculation</u> 1.79 V = 1.72 V + (4.20 μA × r) $r = 16\ 700\ (\Omega)$	**3**
14 (b)	Use of $P = IV$ with V=1.72 (V) **(1)** $P = 7.2 \times 10^{-6}$ W **(1)** <u>Example of calculation</u> $P = 4.20\ \mu\text{A} \times 1.72\ \text{V}$ $P = 7.2 \times 10^{-6}$ W	**2**
14 (c)	Resistance of voltmeter very large **Or** $R >> r$ **Or** internal resistance much less than resistance of voltmeter **(1)** (So) I very small [accept $I = 0$] **(1)** (So) Ir very small **Or** lost volts ≈ 0 **Or** $Ir << \mathcal{E}$ **(1)** (So) V (approximately) equal to e.m.f. **(1)**	**4**
	Total for question 14	**9**

11 (a)	The p.d. (across component) can be (reduced to) zero	**(1)**	**1**
11 (b)	Use of $R = \rho l/A$ Use of $A = \pi r^2$ Diameter = 1.8×10^{-4} m Example of calculation	**(1)** **(1)** **(1)**	**3**
	$24\ \Omega = 1.2 \times 10^{-6}\ \Omega\ \text{m} \times 0.5\ \text{m} \div A$ $A = 2.5 \times 10^{-8}\ \text{m}^2$ $r = \sqrt{(2.5 \times 10^{-8}\ \text{m}^2 \div \pi)} = 8.9 \times 10^{-5}\ \text{m}$ $d = 1.78 \times 10^{-4}\ \text{m}$		
11 (c)	Use of ratio lengths:voltages **Or** Use of ratio lengths:resistances **Or** See $I = 0.24$ (A) p.d. = 2.1 V Example of calculation $V = 12.0\ \text{V} \times 7.16\ \text{cm} / 40.0\ \text{cm} = 2.15\ \text{V}$	 **(1)** **(1)**	 **2**
	Total for question 11		**6**