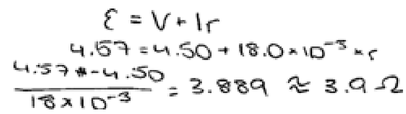
Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1			**D**	1	**<u>Examiner's Comments</u>** Candidates performed well on this question by correctly applying Kirchoff's current law that the current flowing into a junction must be equal to the current flowing out of it to give the correct answer D.
			Total	**1**	
2			**A**	1	**<u>Examiner's Comments</u>** This should have been a straightforward starting question for all the candidates in identifying the correct S.I. base unit but only some gave the correct response of A. The most common distractor was B.
			Total	**1**	
3			**C**	1	**<u>Examiner's Comments</u>** Overall, candidates performed well. They correctly determined that because the copper wire, **Q**, has an equal cross-sectional area to copper wire, **P**, that *n* (the number density of charge carriers) is the same for both wires. Most candidates determined that the resistance of **Q** would double in size due to the length of wire **Q** being twice as long, hence why the most common distractor was D.
			Total	**1**	
4	i		$V = \frac{Q}{4 \pi \varepsilon_0 r}$ $V = \frac{155}{(4\pi\ 8.85 \times 10^{-12} \times 2 \times 10^{3})}$ = 7.0×10^8 (V)	C1 A1	All values substituted correctly Correct answer to at least 2sf (6.97) **<u>Examiner's Comments</u>** Most candidates were able to correctly select the equation and evaluate the correct answer. Some chose the field strength equation or wrote the potential equation with a r^2.

					Some selected the wrong value of r, giving it as the radius of the cloud. As with Question 18(b)(iii) candidates are reminded that, in general, answers should be given to the lowest number of significant figures in the question, and that an answer of 7 × 10^{8} will incur the significant figure penalty (applied only once per paper).
		ii	Either (I =) 155 / 25 × 10^{-3} = (6200 A) n = 6200 / 1.6 × 10^{-19} = 3.88 x10^{22} n (in 1ms) = 3.88 × 10^{22} × 10^{-3} = 3.9 × 10^{19} Or (Charge flow) = 155/25 = (6.2 C ms^{-1}) n = 6.2 / 1.6 × 10^{-19} n = 3.9 × 10^{19}	C1 C1 A1 (C1) (C1) (A1)	**Ignore** units throughout although penalise any unit on answer line Correct evaluation to at least 2sf (3.88) Correct evaluation to at least 2sf (3.88) **<u>Examiner's Comments</u>** This question could be answered in several ways. Most candidates chose to calculate the current in amps and then converting back to ms at the end. Very few were confused by the need to give the answer in ms. This question polarised the candidates with the vast majority scoring 0 or 3; those who got part way to solving it generally ended up with the correct answer.
			Total	**5**	
5	a		Calculation in eV: $E_{\text{light photon}} = hc/\lambda$ =6.63 x 10^{-34} x 3.0 x 10^{8} / 510 x 10^{-9} = 3.90 x 10^{-19} (J) $E_{\text{light photon}}$ = 3.9 x 10^{-19} / 1.6 x 10^{-19} = 2.44 (eV) Number of photons = ($E_{\text{x-ray photon}}/E_{\text{light photon}}$) × efficiency = (32 000 / 2.44) x 0.15 = 1969	C1 C1 C1 A0	Calculation in J: $E_{\text{X-ray photon}}$ = 32 x10^{3} x1.6 x 10^{-19} = 5.12 x10^{-15} (J) $E_{\text{X-ray photon}}$ = 32 x10^{3} x1.6 x 10^{-19} = 5.12 x10^{-15} (J) Number of photons = ($E_{\text{x-ray photon}}/E_{\text{light photon}}$) × efficiency = (5.12 x$10^{-15}$ / 3.90 x 10^{-19}) x 0.15 = 1969 Answer to at least 3sf **Allow** use of 2.4eV for energy of light photon to give 2000 in either method

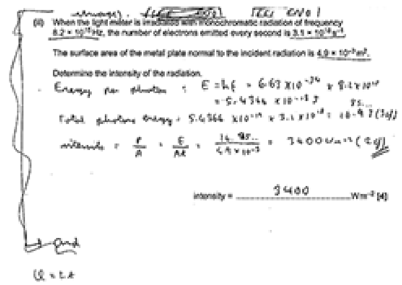
					Examiner's Comments Most candidates were able to correctly show that the number of light photons was close to 1970. There were a number of methods and units that could be used and the inclusion of the 15% factor could be done at several points. Examiners were aware of these various routes and gave credit to working at each point where appropriate. The conversion of the keV to joules and the conversion of nm seemed to cause no difficulties.
	b	i	(The work function is) the minimum energy required to release an electron (from the surface of a metal)	B1	**Allow** minimum work done for minimum energy Do **not allow** idea of energy needed to release multiple electrons Do **not allow** release of electron from atom Do **not allow** idea of ionisation energy **Examiner's Comments** This explanation requires some specific detail; that it is a *minimum* energy and that it is not being applied to an atom. Nearly two thirds of candidates gave an explanation clear enough for credit and most of those who missed out on the mark simply weren't detailed enough rather than being wholly wrong. Responses such as 'the minimum energy for the photoelectric effect to occur' are not quite detailed enough.
		ii	$\phi = 2.3 \times 1.6 \times 10^{-19}$ (= 3.68×10^{-19} J) KE_{max} = (3.90 − 3.68) × 10^{-19} = 2.2 × 10^{-20} (J)	C1 A1	Or ϕ = 2.44 - 2.3 (= 0.14 eV) KE_{max} = 0.14 × 1.6 × 10^{-19} = 2.2 × 10^{-20} (J) Answer to at least 2sf **Allow** use of 2.4 eV to give 1.6 × 10^{-20} (J) ecf light photon energy from (a) **Examiner's Comments** Most candidates were able to obtain at least 1 mark by correctly converting the work function into joules. As always, correct working is very helpful in obtaining the intermediate marks. Several arranged the equation

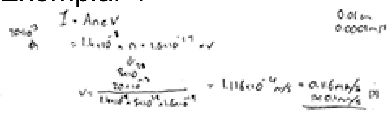
					incorrectly, by adding on the work function, but well over half of the candidates correctly evaluated the maximum kinetic energy.
		iii	$I\left(=\frac{Q}{t}\right)=\frac{12\times1969\times1.6\times10^{-19}}{60}$ $= 6.3 \times 10^{-17}$ (A)	C1 A1	**Allow** full credit for use of 2000 Answer to at least 2sf (6.30) **Allow** use of *N*= 2000 to give $I = 6.4 \times 10^{-17}$ (A) **Allow** ecf on *N* from (a) **<u>Examiner's Comments</u>** A little under half of the candidates were able to correctly calculate the current. Incorrect methods included missing out the factor of 12, or by dividing by 3600 instead of 60.
		iv	One from: One to one interaction between (light) photon and electron That there are no secondary electrons That the current is continuous / X-rays arrive at a constant rate within the minute (or 1 every 5s) All the electrons leave the photocathode	B1	**<u>Examiner's Comments</u>** The main expectation for this question was to appreciate the one-to-one relation between the photon and the electron, although other valid answers were given. Ideas about efficiency are a little too limited for credit, along with statements like 'there are exactly 2000 photons'. Information in the question has to be treated as correct in any case, so is not an assumption.
			Total	**9**	
6	a	i	Since the <u>current is zero</u>, the (terminal) p.d. / voltmeter reading is the e.m.f.	B1	no p.d. across *r* as *I* = 0 **<u>Examiner's Comments</u>** There were many vague answers given. Candidates needed to state the reading of 4.57 V occurs when the current was zero. An open switch was not good enough.
		ii	$\frac{1}{R}=\frac{1}{300}+\frac{1}{300}$ and $\frac{1}{R}=\frac{1}{300}+\frac{1}{300}+\frac{1}{300}$ (3.9 Ω)	M1 A0	**Allow** $4.57 = 4.50 + 18 \times 10^{-3} \times r$ and 3.88… **Allow** $4.57 = 18 \times 10^{-3} \times 250 + 18 \times 10^{-3} \times r$ and 3.88… **<u>Examiner's Comments</u>** This was another show question where the method needed to be clearly stated. High scoring

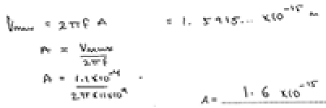
					candidates stated the circuit equation, substituted the data and evaluated answer before rounding it to 3.9 Ω. The majority of the candidates gained credit. **Exemplar 3**  The candidate has stated an equation, substituted in the data and evaluated the answer (3.889) which has then clearly been rounded to 3.9 Ω.
		iii	$\frac{1}{R}=\frac{1}{300}+\frac{1}{300}$ and $\frac{1}{R}=\frac{1}{300}+\frac{1}{300}+\frac{1}{300}$ 150 + 100 = 250 Ω OR $R=\frac{4.5(\text{V})}{18(\text{mA})}$ or $\frac{4.5}{0.018}$ = 250 Ω	M1	$R=\frac{300}{2}+\frac{300}{3}$ **Allow** $R=\frac{4.57(\text{V})}{18(\text{mA})}-3.9$ **<u>Examiner's Comments</u>** This question was well answered. There were two different routes for gaining credit. Candidates could either use the formulae for resistors in series and parallel or use the data given and use *R*=*V*/*I*.
	b	i	$(0.018^2 \times 3.9 \times 300 = 0.379)$ 0.38 (J)	A1	(0.018 × 0.07 × 300 = 0.378) **<u>Examiner's Comments</u>** Many candidates incorrectly calculated the total energy dissipated in the five 300 Ω resistors rather than *r*.
		ii	0.018 × 300 OR 5.4 (C) OR $Q=\frac{0.38}{0.07}=5.43$ $\left(N=\frac{5.43}{1.60\times10^{-19}}=\right)3.4\times10^{19}$	C1 A1	**Allow ecf** from (b)(i) For use of 24 J (calculating energy in circuit) $Q=\frac{24}{4.5}=$ 5.33 which gives 3.3×10^{19} **<u>Examiner's Comments</u>** This question required candidates to determine the total charge flow and then divide this by the change on one electron.

		iii	I_X = 0.009 A **and** I_Y = 0.006 A 1.5	C1 A1	**Allow** use of total current through 1st parallel combination = total current through second parallel combination and $I_X = I / 2$ **and** $I_Y = I / 3$ **Allow** $\frac{3}{2}$, 3:2 **Examiner's Comments** Candidates needed to understand how the current in X and Y would be different and relate this to the *I=Anev* equation.
	c	i	decreases	B1	**Examiner's Comments** Candidates generally found this question challenging. They needed to understand that removing a resistor from a parallel combination, increased the total resistance of the circuit so that the current decreased.
		ii	increases	B1	**Examiner's Comments** This question was very challenging. Since the current has decreased, there would be less 'lost volts' across r so the voltmeter reading would increase. May candidates thought incorrectly that the voltmeter reading would remain the same.
			Total	**10**	
7		i	intensity of radiation is proportional to the rate of incident photons (above threshold frequency) AW (increased) one-to-one interaction between photons and electrons AW current is the rate of flow of charge/current = charge flow/time (so proportional to rate of electron release)	B1 B1 B1	**Examiner's Comments** Candidates did not perform well on this question as 60% of candidates achieved no marks. A common response was to describe that greater intensity leads to more photoelectrons which was not given, and few made the important connection between intensity and 'rate of photons hitting the plate'. Also, many candidates did not apply the 1:1 correlation between photons and electrons in the photoelectric effect as they simple stated that more electrons were released without applying knowledge of the individual interaction between incident photons to the release of

					electrons. Many took the reverse view that greater current led to greater intensity or simply referred to the ammeter reading rather than referencing current. Exemplar 2  Because the more intense the radiation is, the more electrons released from the metal. Moreover As electrons have charge, this means when there are more electrons in the circuit, the current will increase, so the ammeter reading will increase. This exemplar demonstrates a typical response from candidates where a simple statement is made in relation to the intensity of electrons emitted and corresponding current reading on the ammeter. As in many similar responses the intensity of radiation is not linked to the ‘rate of incident photons’ resulting in a similar ‘rate of electron emission’ due to the 1:1 interaction between photons and electrons. Candidates were then required to link the rate of electron emission to the equation $\Delta Q = I\Delta t$ to conclude that current is equal to the rate of flow of charge and hence the ammeter reading is proportional to the intensity of the radiation.
		ii	$6.634 \times 10^{-34} \times 8.2 \times 10^{15} / 5.44 \times 10^{-18}$ J $5.44 \times 10^{-18} \times 3.1 \times 10^{18} / 16.9$ (W) $\text{intensity} = \frac{16.9}{4.9 \times 10^{-3}}$ 3.4×10^{3} W m^{-2}	C1 C1 C1 A1	**ALLOW** 3439(.48)W m^{-2} **<u>Examiner’s Comments</u>** Candidates did not perform well on this question as just over half of candidates scored 0 marks. Candidates had to select the equations $hf = \Delta E$ and $I = P/A$ from the Data, Formulae and Relationship booklet and then apply that the power was equal to the energy as the rate of emission of electrons was in a time of 1 second. Many candidates would select the correct equation $I = P/A$ but would then try and calculate power by using the equation $P = VI$ and $\Delta Q = I\Delta t$ by using the charge of an electron to calculate the current and using the battery e.m.f. of 3 V given in the circuit diagram. This demonstrated for a majority of candidates a lack of a

					confident understanding of the photoelectric effect that the energy of incident photons results in the release of electrons. Exemplar 3  (ii) When the light meter is irradiated with monochromatic radiation of frequency 8.2×10^{14} Hz, the number of electrons emitted every second is 3.1×10^{19} s^{-1}. The surface area of the metal plate normal to the incident radiation is 4.9×10^{-3} m^2. Determine the intensity of the radiation. intensity = 3400 Wm^{-2} [4] This response demonstrates the correct and clear selection and application of formulae to calculate the intensity of the incident radiation.
			Total	**7**	
8			C	1	**Examiner's Comments** Most candidates correctly answered this question as they determined that the oil drop had lost electrons (since the oil drop had gained a positive charge) and used the charge of an electron to give the correct answer C. The most common distractor was D.
			Total	**1**	
9			A	1	**Examiner's Comments** Only half of candidates gave the correct answer A by understanding and applying the equation *I* = *Anev.*
			Total	**1**	
10		i	$I_{max} = nAv_{max}e$ $v_{max} = \frac{20 \times 10^{-3}}{8 \times 10^{28} \times 1.6 \times 10^{-19} \times 1.4 \times 10^{-8}}$ $v_{max} = 1.1 \times 10^{-4}$ (ms^{-1})	B1 M1 A1	**Allow** v for v_{max} throughout **Allow** I for I_{max} **Allow** q or Q for e / a for A / V for v but **not** N for n Substitution must be shown in full

					Answer must be given initially to 2 or more sf (but may later be rounded to 1sf) **<u>Examiner's Comments</u>** Since the answer is given here and candidates are being asked to show where it comes from, it is important to show every stage in the working. The following steps were necessary to gain full marks: write down the correct formula substitute the given values <u>and</u> the values of any physical constants (such as *e*) work out the answer to more significant figures than given in the question Exemplar 1  The exemplar above shows the type of response that gained full marks.
		ii	$\omega = 2\pi f$ $A\ (= v_{max}/\omega) = \frac{1.1 \times 10^{-4}}{2\pi \times 11 \times 10^{9}}$ **or** $A\ (= v_{max}/\omega) = \frac{1.1 \times 10^{-4}}{6.9 \times 10^{10}}$ $A = 1.6 \times 10^{-15}$ (m)	C1 C1 A1	May be inferred from working $\omega = 2\pi \times 11 \times 10^{9} = 6.9 \times 10^{10}$ (rad s^{-1}) **Allow** use of $V_{max} = 1 \times 10^{-4}$ (m s^{-1}) **Allow** V_{max} from **(a)(i)** given to more than 2sf but **not ECF** from any value which does not round to 1×10^{-4} (ms^{-1}) **Allow** use of $v_{max} = 1 \times 10^{-4}$ (ms^{-1})[1] giving $A = 1.4 \times 10^{-15}$ (m) to 2sf or 1.45×10^{-15} (m) to 3sf Special case: **Allow** $A = 1 \times 10^{-15}$(m) to 1 sf if $v_{max} = 1 \times 10^{-4}$ (ms^{-1}) is used **<u>Examiner's Comments</u>** The formula sheet gives $v = \pm\omega(A^2 - x^2)^{½}$ as a starting point.

					The maximum velocity of the electrons has been given in (i) as 0.1 mm s^{-1}. The electrons are moving in simple harmonic motion, and so their maximum velocity occurs as they pass equilibrium i.e. when $x = 0$. This simplifies the formula to $v_{MAX} = \omega A$. Equal marks were given for using either the given value for v_{MAX} of 0.1 mm s^{-1} or the candidate's own value from (a)(i). **Exemplar 2**  The exemplar above shows the type of response that gained full marks.
		iii	($a_{max} = \omega^2 A$ and $v_{max} = \omega A$) $a_{max} = 2\pi f V_{max}$ Since V_{max} is constant, $a_{max} \propto f$	M1 A1	**Allow** $a_{max} = \omega v_{max}$ **Allow** a for a_{max} and V for V_{max} **<u>Examiner's Comments</u>** This was a difficult question; hard to visualise and involving some challenging algebra. Most candidates did not notice that the question specified the <u>maximum</u> acceleration of a free electron. Therefore the most common response was that $a = (2\pi f)^2 x$, showing that $a \propto f^2$. This gained no marks. Other candidates went further and said that the maximum acceleration occurs when $x = A$. This means that $a_{MAX} = (2\pi f)^2 A$ and so $a_{MAX} \propto f^2$, since A is constant. However, the amplitude A of the oscillation is itself dependent on the frequency. If the maximum current remains constant then the maximum velocity v_{MAX} of the electron must also remain constant. In (a)(ii), we used the fact that $v_{MAX} = 2\pi fA$, so fA must remain constant. $a_{MAX} = (2\pi f)^2 A = (2\pi)^2 fA - f$ = constant × f. So we conclude that $a_{MAX} \propto f$.

					An easy way to see this algebraically is: $a_{MAX} = (2\pi f)^2 A$ and $v_{MAX} = 2\pi f A$ Therefore $a_{MAX} = (2\pi f)\ v_{MAX}$ v_{MAX} remains constant and so $a_{MAX} \propto f$
			Total	**8**	
11		i	f (= $1/T$) = 1 / (40 × 10^{-3}) f = 25 (Hz)	B1 B1	**Allow** $f = 1/T$ **and** $T = 40 \times 10^{-3}$ (s) **<u>Examiner's Comments</u>** It is important to show how the information from the graph has been used to calculate the frequency. The correct answer did not score full marks unless some working had been shown.
		ii	**EITHER** Calculation of Q_o / e time constant (read from graph) = 14 (ms) **OR** Use of $Q = Q_0 e^{-t/CR}$ time constant = 14 (ms)	C1 A1 (C1) (A1)	**Allow** any initial value of charge e.g. 8.0 / e = 2.9 (μC) **or** 37% × 8.0 = 3.0 (μC) **Allow** 14±1 (ms) e.g. $2.0 = 8.0e^{-0.02/CR}$ gives CR = 0.02 / ln4 Using the decay equation may incur two POT errors **<u>Examiner's Comments</u>** The question specifies using the discharging section of the graph. Some candidates tried to use the charging section, but this proved more difficult. Using the definition of the time constant, we need to find how long it takes for the charge to fall from any initial value to 37% (1/e) of that value. Many candidates chose 8μC for their initial value, but this is not vital. 37% of 8μC is 2.9μC. The charge is 8μC at 20ms and 2.9μC at 34ms, so the time taken is 34 − 20 = 14ms. A common alternative approach was to insert values from the graph into the

					equation $Q = Q_0 e^{-t/CR}$ This gave the same result, but sometimes resulted in a POT error because of the need to give the answer in milliseconds.
		iii	tangent drawn to graph <u>at steepest part of curve</u> maximum current in range 5.0×10^{-4} to 7.0×10^{-4} (A)	M1 A1	Judge by eye, no daylight between curve and tangent **Allow** a negative answer **Allow** answer to 1sf **<u>Examiner's Comments</u>** Many candidates lost marks here because they did not realise that, to calculate the *maximum* current in the resistor, they had to draw the steepest possible tangent to the graph.
		iv	vertical axis labelled as current with the correct unit **and** at least one positive and one negative scale marking **and** scale should allow for their maximum current to be plotted exponential decay of current in each section sign of current alternates at 20, 40, 60 and 80 ms	B1 M1 A1	For example *I* / mA, *I* (mA), *I* /10^{-4} A, current in mA etc All scale markings shown must be correct **Allow** any curve with a decreasing gradient in each section **Ignore** value of minimum current but **not** zero **Ignore** sign of current for this marking point All curves should start at the correct maximum current value. However, If **B1** mark has not been scored, **allow** any value of maximum current as long as it remains consistent across all four sections **<u>Examiner's Comments</u>** Since $I = \Delta Q/\Delta t$, the graph of *I* against *t* can be found from the gradient of the graph of Q against *t.* The gradient is positive from 0 − 20 ms and negative from 20 − 40ms; this represents the current flowing one way around the circuit while the capacitor charges and then the opposite way while it discharges. Since the gradient is never zero, the value of the current is never zero either.

					Tasks that caused problems in 6(b)(iv) • drawing an exponential decay, particularly in the negative section of the graph (most drew a sinusoidal curve). • converting the maximum current into mA or μA. • labelling the vertical axis and drawing on a sensible scale. **Assessment for learning** Centres should consider providing more practice in drawing graphs without the aid of graph-plotting software.
			Total	**9**	
12	a		Allows only those gamma rays / waves / photons travelling along axis (of the collimator) to get through (and reach scintillator)	B1	**Allow** less fuzzy / clear image **Allow** all the gamma rays / waves / photons are parallel / in the same direction (to each other) **Allow** <u>absorbs</u> those gamma rays / waves / photons not parallel (to the axis of collimator) **Allow** so the photons are travelling perpendicular to the scintillator **Do not allow** the gamma rays are travelling vertically, unless it is clear the collimator is also vertical **<u>Examiner's Comments</u>** This question was well answered by around half of the candidates who appreciated that the long, narrow collimator would allow only gamma rays which were parallel to each other to be received by the scintillator. This can be expressed in a number of ways and marks were given to candidates who were able to state this using alternative descriptions. A common confusion appeared between using the terms perpendicular and parallel, with some candidates incorrectly stating that the collimator

					allowed photons perpendicular to the tubes to pass. Essentially, the collimator allows for a clearer image to form and so this is an acceptable response.
	b		Turn gamma (photons) into (many photons of) light	B1	**Ignore** reference to rays / waves **Ignore** reference to flash **<u>Examiner's Comments</u>** Around half of the candidates were able to correctly explain that the gamma photons produced visible light in the scintillator. Several candidates thought that the scintillator produced electrons or a voltage when the gamma photons were incident on it instead. Many candidates gave the extra correct information that many visible photons are produced from one gamma photon, although this was not a required detail on this occasion.
	c		number of electrons = $\frac{0.32 \times 10^{-6} \times 1.2 \times 10^{-9}}{e}$ number of electrons = 2400	C1 A1	**Ignore** any POT error for C1 mark **<u>Examiner's Comments</u>** This calculation was done well by a large majority of candidates. There were few errors in the unit prefixes, with the most common one being 1.2 ns as 1.2 × 10^{-12} s. A small number of candidates calculated the charge correctly, but then took it no further to determine the number of electrons.
	d		Any sensible <u>diagnostic</u> suggestion, e.g. <u>detection</u> of cancer / scans of (named) organ / scans of tissue / bone scans / observing functionality of (named) organ	B1	**Not** medical <u>treatment</u> e.g. radiotherapy **Not** body scan **Ignore** PET scanner **Do not allow** CAT scan **<u>Examiner's Comments</u>** The key word here was "diagnostic" and responses were expected to state any reasonable diagnostic use of a gamma camera and a wide variety of responses were given and accepted. Common responses included checking for brain tumours and observing kidney failure. Although a gamma camera may be used in a PET scanner, this alone was not

					acceptable as it does not explain the diagnostic use. Candidate should be encouraged to write in a clear sentence structure as simple responses such as “cancer” cannot be given marks.
			Total	**5**	
13			**B**	1	**Examiner’s Comments** The vast majority of candidates were able to correctly recall the correct charge carriers in the resistor and the electrolyte. **A** proved to be the most common distractor, possibly as the others contained “protons”.
			Total	**1**	
14		i	p.d across wire = 14.4 − 12.0 = (2.4 V) resistance of wire $\frac{2.4}{3.0}$ (= 0.80Ω) $0.80 = \frac{\rho \times 25.0}{0.54 \times 10^{-6}}$ ρ = 1.7 xd7; 10^{-8} (Ω m)	C1 C1 C1 A1	**ECF** R = 2.8Ω (V = 8.4 V) to give ρ = 6.0 × 10^{-8} (Ω m) for 3 marks **Examiner’s Comments** Candidates did not perform well on this question as they did not understand what the question was asking candidates to calculate. The skill and understanding with this question were to first determine that the p.d. was shared across the two lamps and the metal wire which most candidates did not do and apply it to calculate a value of resistance of the metal wire. Candidates were able to select and carry out a correct calculation using $R = \rho L/A$ which demonstrated that they understood a value for resistance was required for the calculation but many used an incorrect value of R. Many candidates would calculate the resistance of the metal wire as R = 6.0 V / 3.0 A = 2 Ω (the resistance of one of the lamps) and would also not correctly convert the cross-sectional area into m^2. **Misconception**

					Candidates did not fully read the question that the resistivity of the metal wire **only** was to be calculated and that to calculate the resistivity correctly they had to determine the p.d. across the metal wire (p.d. across the wire = 14.4 V – (2 × 6.0 V)). Conversion error as candidates did not convert mm^2 to m^2 for the cross-sectional area.
		ii	($I = Anev$) $3.0 = 0.54 \times 10^{-6} \times 1.60 \times 10^{-19} \times 8.5 \times 10^{28} \times v$ $v = 4.1 \times 10^{-4}$ ($m\ s^{-1}$)	C1 A1	Do not penalise the same **POT** error in 0.54 mm^2 from **(c)(i)** again **<u>Examiner's Comments</u>** Most candidates were given at least 1 mark with half the candidates correctly calculating the drift velocity using the formula $I = Anev$. Less successful responses did not select the correct formula and some candidates had an incorrect or absent conversion of the cross-sectional area to m^2.
			Total	**6**	
15			D	1	**<u>Examiner's Comments</u>** This question was generally answered well with candidates giving the correct answer D by selecting and applying the equation $W = VQ$ and that the charge of one electron is 1.60×10^{-19} C.
			Total	**1**	
16			C	1	**<u>Examiner's Comments</u>** This question was generally answered well but candidates had to use the charge of an electron to calculate the total charge of the electrons flowing in the wire. If candidates missed this step in their working, they weren't able to access the correct value for the current.
			Total	**1**	

17			A	1	**Examiner's Comments** This question assessed candidates understanding of Kirchhoff's two laws with most candidates applying their knowledge that current and potential difference were used in the laws. This meant that most candidates answered A correctly but C was a common distractor.
			Total	**1**	
18			$p = \sqrt{2 \times 9.11 \times 10^{-31} \times 1.6 \times 10^{-19} \times 1800}$ OR 5.24×10^{-46} OR $\lambda = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.11 \times 10^{-31} \times 1.6 \times 10^{-19} \times 1800}}$ or 2.9×10^{-11} (m) 2.3×10^{-23} (kg ms^{-1})	C1 A1	**Examiner's Comments** This question was generally well answered. Many candidates realised that the denominator was momentum. Other candidates calculated the wavelength and then calculated the momentum. Some candidates omitted the 1800 V. A significant number of candidates omitted the question, presumably based on the perceived difficulty of the question. To assist candidates in the examination it may help if they write the numerical values beside each quantity. **Assessment for learning** When dealing with questions with powers of ten, write the equation down, then substitute the numbers including the powers of ten. It is worth calculating intermediate values and writing these down before calculating the final answer.
			Total	**2**	