3	**D is the correct answer** (Total resistance in series is 10Ω and 2.5Ω in parallel) A is not the correct answer as the two resistances are the wrong way around B is not the correct answer as this assumes the formulae for series and parallel resistors are the same C is not the correct answer as this assumes the formulae for series and parallel resistors are the same	**(1)**

2	**The only correct answer is C** A is not correct because this is the resistance if all the resistors were in parallel B is not correct because this is the resistance for a different arrangement of the resistors D is not correct because this is the resistance if all the resistors were in series	**1**

9	**A is the correct answer** B is not the correct answer as it appears in neither of the definitions C is not the correct answer as it only appears in the definition for current D is not the correct answer as it only appears in the definition for p.d.	**(1)**

2	**C 5.00C** (25×10^{-3}A $\times$ 200s)	**1**
	Incorrect answers: A 1.25×10^{-4} C is (25×10^{-3} A / 200s) B 1.25×10^{-1} C is (25 A / 200s) D 5.00×10^{3} C is (25 A $\times$ 200s)	

1	**C is the correct answer as the resistance of both listed components decreases as the applied potential difference increases.** A is not the correct answer as the resistance of an ohmic conductor remains constant when the applied potential difference increases. B is not the correct answer as the resistance of a filament lamp increases when the applied potential difference increases. D is not the correct answer as the resistance of a filament lamp increases when the applied potential difference increases.	**(1)**

7	**A is the correct answer** (Reading on V_1 decreases, readings on V_2 and A increase) B is not the correct answer as the decreased resistance of the thermistor will lead to a greater share of the p.d. across the fixed resistor C is not the correct answer as the meter readings show what would happen if the temperature decreased D is not the correct answer as none of the three meter readings would change in the ways stated	**(1)**

2	**D is the correct answer** A is not correct because the potential difference should not be halved and 3.3 V should be subtracted from 10 V B is not correct because the potential difference across R_1 is not the same as that across the voltmeter C is not correct because the potential difference should not be halved	**1**

4	**The only correct answer is D** A is not correct because this is an incorrect expression B is not correct because this is an incorrect expression C is not correct because this is an incorrect expression	**1**

13(b)	Calculates p.d. across fixed resistor as 1.497V Difference between 1.50 and 1.497 is less than 0.01V **OR** Calculates p.d across the LDR as 0.003 V 0.003 < 0.01V **OR** As resistance of the LDR decreases, the voltmeter reading increases p.d. across the LDR becomes less than 0.01 V **OR** Ratio of resistor resistance to LDR resistance becomes very high p.d. across the LDR becomes less than 0.01 V (Do not allow MP1 for use of V = IR with current value calculated in (a)) (3rd or 4th methods – allow "there is hardly any p.d. across the LDR") (For all MP, allow "resolution of the voltmeter" for "0.01V") (For MP1 via 3rd method, allow "p.d. across (fixed) resistor increases" for "the voltmeter reading increases")	(1) (1) (1) (1) (1) (1) (1) (1)	**2**
	Total for Question 13		**4**

Question Number	Answer		Mark
19(a)	Measure current and (corresponding) p.d. for a range of values	(1)	
	Reverse the supply **or** the polarity of diode	(1)	
	Voltmeter and ammeter correctly connected in the circuit	(1)	
	Means of varying p.d. across LED	(1)	**4**
19(b)(i)	Use $R = \frac{V}{I}$ with I in the range of 210 to 225 (mA)	(1)	
	R = 8.9 Ω to 9.5 Ω	(1)	**2**
	Example of Calculation: $R = \frac{2.0\ \text{V}}{0.215\ \text{A}} = 9.3\ \Omega$		
19(b)(ii)	Infinite **Or** very large	(1)	**1**
19(c)(i)	(in forward bias) the resistance (of LED or circuit) could be very/too low	(1)	**1**
19(c)(ii)	Use of $Q=It$ **and** $Q=ne$	(1)	
	Use of 95%	(1)	
	Use of graph at their value for I to determine V_{LED}	(1)	
	Use of $V=IR$ with $V_R=V- V_{LED}$	(1)	
	$R = 14.1\ \Omega$	(1)	**5**
	Example of Calculation: $I = \frac{1.6\times10^{18}\ \text{s}^{-1}}{0.95} \times 1.6 \times 10^{-19}\text{C} = 0.27\ \text{A}$ $R = \frac{6.0\ \text{V} - 2.2\ \text{V}}{0.27\ \text{A}} = 14.1\ \Omega$		
19(c)(iii)	Use of $V = \frac{W}{Q}$ with Q = 1.6 x 10^{-19} (C)	(1)	
	Use of 77%	(1)	
	$E = 2.2 \times 10^{-19}$ J	(1)	**3**
	Example of Calculation: $W = 1.8\ \text{V} \times 1.6 \times 10^{-19}\text{C} \times 0.77 = 2.2 \times 10^{-19}\ \text{J}$		
	Total for question 19		**16**

Question Number	Answer	Mark
*17(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 structure and lines of reasoning.	

	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 throughc	2
Answer is partially structured with some linkages and lines c reasoning	1
Answer has no linkages between points and is unstructured	0

Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning

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

Indicative content

IC1 Photons (of ultraviolet light)

IC2 cause (photo)electrons to be emitted

IC3 from (the surface of) the magnesium / ribbon

IC4 as the (photon) energy is greater than the work function of magnesium
Or as the frequency of the ultraviolet light is greater than the threshold frequency of magnesium

IC5 The electrons are attracted to the positively charged gauze (and create the current).

IC6 When the polarity is reversed the current is zero because the electrons no longer have enough kinetic energy to move across the gap
Or When the polarity is reversed the current is zero because the work function of copper is larger than the photon energy
Or When the polarity is reversed the current is zero because the threshold frequency of copper is larger than the frequency of ultraviolet light

6

Question Number	Answer		Mark
12(a)	$\varepsilon = 1.50$ V (accept answers in the range 1.48 V to 1.52 V)	**(1)**	
	Attempt to calculate gradient of graph to find r	**(1)**	
	$r = 0.75\ \Omega$ (accept answers in the range 0.72 Ω to 0.78 Ω)	**(1)**	**3**
12(b)	Gradient is doubled	**(1)**	
	y-intercept is doubled	**(1)**	**2**
	(If no other marks scored, allow "new graph has steeper gradient **and** y-intercept has a greater value" for 1 mark)		
	(If no other marks scored, allow new values for ε and r, consistent with their answers to (a))		
	Total for question 12		**5**