WJEC EDUQAS A-LEVEL PHYSICS · COMPONENT 2

PHYSICS



EXAM QUESTION PACK

2.3 D.C. CIRCUITS

SCORE	PERCENTAGE
/109	%

STEMUP

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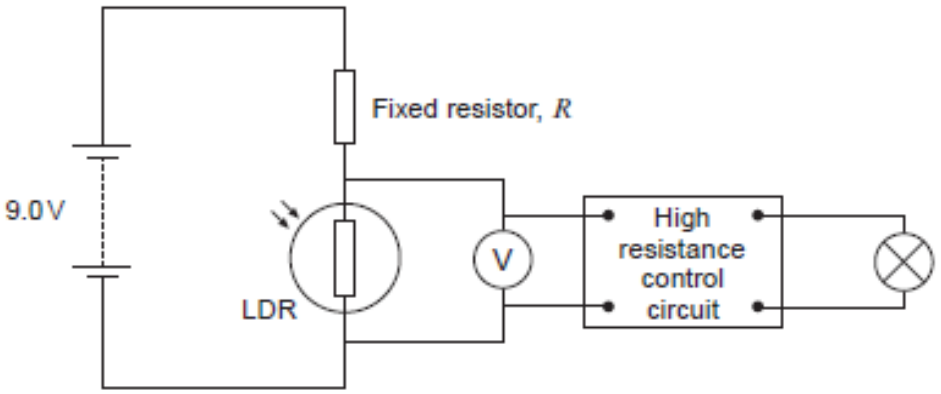
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#1

1. *(a)* An engineer investigates the use of a light dependent resistor (LDR) as a light sensor in a potential divider circuit. He designs the following sensing circuit to operate a 230 V lamp in the dark.



The control circuit draws a negligible current. During his research, the engineer determines the following facts:

The control circuit requires at least 4.0 V to activate.
The LDR the engineer intends to use has a resistance of 2.4 kΩ at the light intensity required to switch the lamp on.

(i) Explain how the current in the LDR changes as the light intensity decreases. [2]

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(ii) Determine a suitable value for the fixed resistor R, which would allow the lamp to be switched on. [3]

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(b) When installing the circuit, the engineer made the mistake of placing the lamp near to the LDR. The engineer noted that, when in the dark, the lamp kept turning on and off repeatedly rather than staying on. Explain why this was the case. [2]

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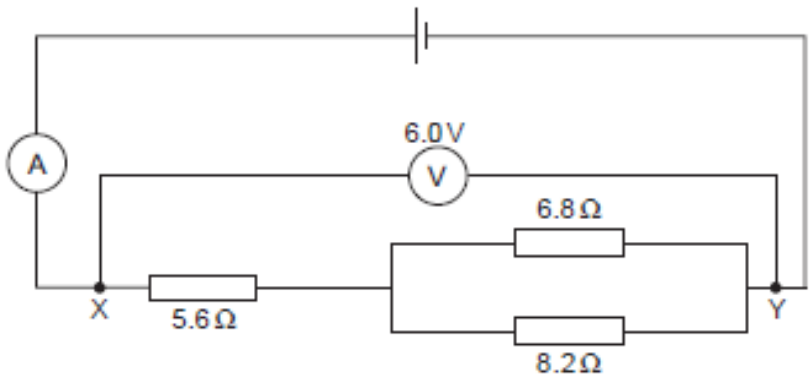
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Question taken from Eduqas examination paper 842102, June 2018

#2

2. A circuit is set up as shown.



(a) In the circuit shown, the potential difference between X and Y is 6.0 V. Explain what this statement means. [2]

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(b) (i) Determine the reading on the ammeter if it has an instrument resolution of ± 0.01 A. [4]

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(ii) Calculate the potential difference across the 8.2 Ω resistor. [2]

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(iii) Calculate the power dissipated in the parallel resistor combination. [2]

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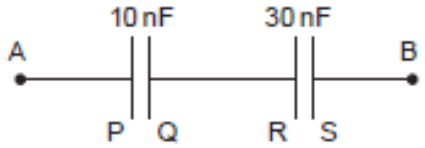
#3

6. *(a)* Define the *capacitance* of a capacitor. [1]

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(b) Two capacitors, initially uncharged, are arranged in series as shown. When a battery is connected across A and B, the charge on plate P is found to be +75 nC.



(i) Write down the charges on each of the plates Q, R and S. Give a reason for your answer to the charge on plate S. [3]

Charge on Q: .....

Charge on R: .....

Charge on S: .....

Reason:

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(ii) Calculate the pd across A and B. [2]

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(iii) A Physics student makes the following comment:

For capacitors in series, a capacitor of higher capacitance stores more energy than a capacitor of smaller capacitance.

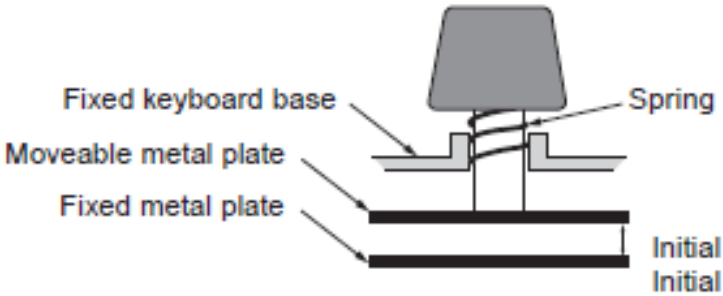
By considering this combination of capacitors, investigate whether or not the student is correct. [2]

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(c) Some computer keyboards work on the principle of varying capacitance. When a key is pressed, a spring is compressed and the separation of two parallel metal plates is decreased. The computer responds if the increase in capacitance of the plates is 0.20 pF or more.
The diagram shows how a single key is constructed.



Initial separation of plates = 5.2×10^{-3} m
Initial capacitance = 0.27 pF
Plate area = 1.6×10^{-4} m^2

The designers of a keyboard require that the increase in capacitance of 0.20 pF occurs when a force of 0.20 N is exerted on a key. Different springs are available, of spring constant 90 N m^{-1}, 120 N m^{-1} and 150 N m^{-1}. Determine which (if any) of these springs would be suitable in meeting the designer's requirements. The capacitor is filled with air. [4]

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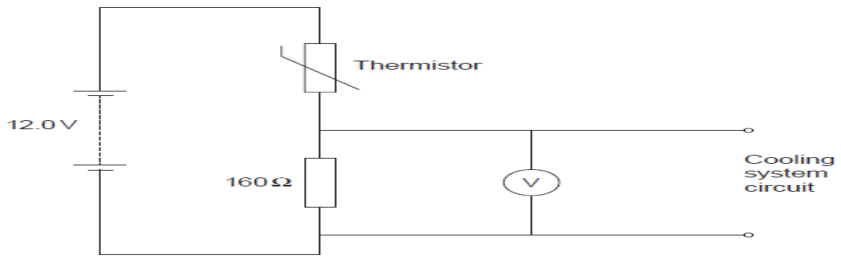
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Question taken from Eduqas examination paper 842102, June 2018

#4

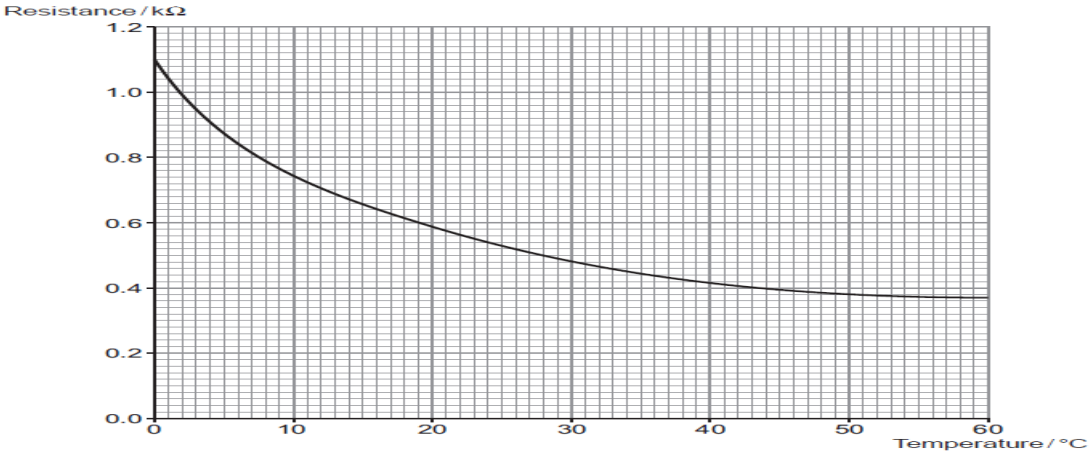
(a) Define the *potential difference* across two points in an electric circuit. [1]

(b) The diagram shows a possible control circuit for a cooling system. It consists of a battery of emf 12.0 V and negligible internal resistance connected in series with a thermistor and a 160 Ω fixed resistor. The voltmeter and cooling system circuit have very high resistances.



Calculate the resistance of the thermistor when the voltmeter reads 2.4 V. [3]

(c) The graph shows how resistance varies with temperature for this thermistor.



(i) The reading on the voltmeter increases when the temperature of the thermistor increases. Explain why this is the case. [2]

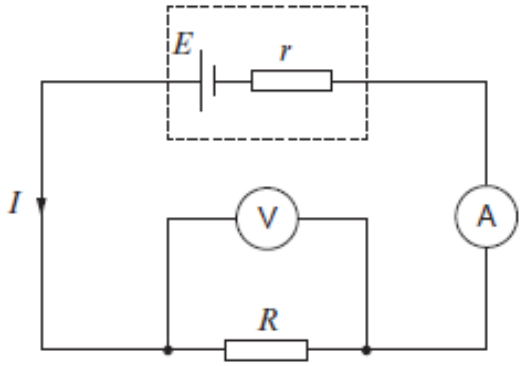
(ii) The cooling system can only be activated when the voltage across the 160 Ω resistor rises above 2.8 V. An engineer suggests that this thermistor and resistor combination is suitable to use in a car cooling system and should activate when the temperature reaches 30 °C. Check this claim. [4]

(d) The arrangement can also be used as a basis for a thermometer. By considering the shape of the graph on page 3 discuss whether this thermistor arrangement would be more effective at measuring changes in temperature between 0 °C and 10 °C or between 50 °C and 60 °C. [2]

Question taken from Eduqas examination paper 842102, June 2017

#5

1. The following circuit shows a cell of emf, E, and internal resistance, r, connected to a resistor of resistance, R.



(a) An equation which can be applied to the above circuit is:

$$V = E - Ir$$

Explain this equation in terms of energy. [4]

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(b) Two students, Kiera and Tom, set up a circuit using two identical cells in series, each with an emf of 1.5V, to power a small heating coil. The heating coil dissipates power at the rate of 1050mW and the pd across the coil is 2.5V.

Calculate:

(i) the internal resistance of each cell; [3]

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(ii) the energy dissipated in each cell in **one minute**. [2]

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(c) The students note that the cells get hot when the heater is switched on for long periods. Tom believes that adding an identical heating coil in parallel with the original would halve the energy dissipated in each cell. Kiera disagrees. She believes that the energy dissipated would increase by a factor of 3 if a coil is added in parallel. Investigate whether Kiera or Tom or neither of them is correct. [4]

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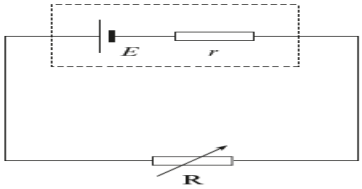
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Question taken from Eduqas examination paper 842102, June 2019

#6

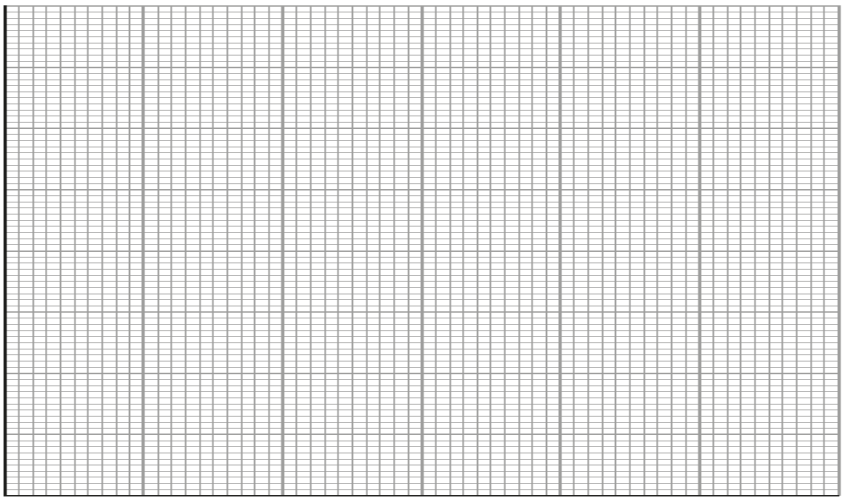
Abigail investigates how the power dissipated in a variable resistor varies as its resistance is altered. The diagram shows the circuit that Abigail uses (meters not shown). The variable resistor is connected to a battery of emf, E, and internal resistance, r.



Abigail obtains the following data as the resistance is varied from 0.5 Ω to 6.0 Ω.

Resistance, R / Ω	Power dissipated in R / W
0.5	2.5
1.0	3.3
2.0	3.8
3.0	3.8
4.0	3.7
5.0	3.6
6.0	3.5

(a) Plot a graph of power dissipated in R (on the y-axis) against resistance (on the x-axis) and draw a smooth curve through the data. [3]



(b) The emf of the battery is 6.0 V and the resistance, R, is now set at **4.5** Ω.

(i) State what is meant by an *emf* of 6.0 V. [2]

(ii) Calculate the current through the battery using data from your graph. [3]

(iii) Calculate the internal resistance, r, of the battery. [3]

(c) Abigail repeats the experiment but with a battery of the same emf but smaller internal resistance. Explain how the graph would change. [2]

Question taken from Eduqas examination paper 842002, June 2017

2. *(a)* (i) State what is meant by *electric current*. [1]

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(ii) Show that the unit of resistance, the ohm (Ω), can be expressed as: [2]

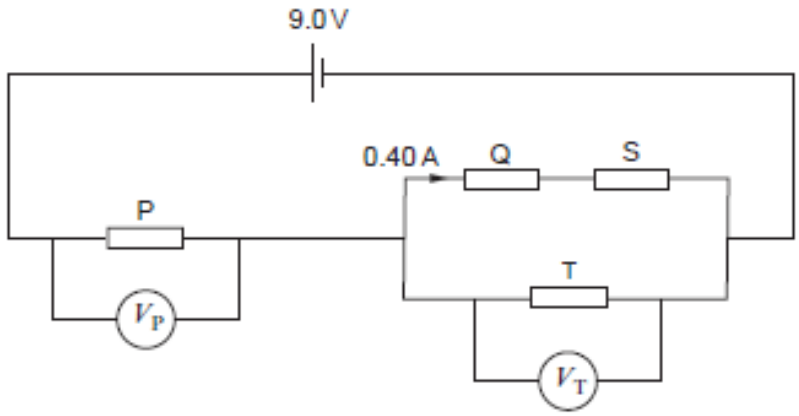
$$J\,s\,C^{-2}$$

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(b) The following circuit shows an arrangement of **identical resistors** labelled P, Q, S and T connected to a fixed pd of 9.0 V. V_P and V_T are the pds across P and T respectively. There is a current of 0.40 A in Q and S.



(i) Show that $V_P = 1.5\ V_T$. [2]

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(ii) Hence or otherwise show that the values given in the diagram are consistent with the resistance of each resistor being 4.5 Ω. [3]

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(c) Show that the total energy dissipated per second in the whole circuit is 15 times more than the energy dissipated per second in resistor Q. [3]

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(d) Resistor T is now removed from the circuit. Explain the effect this will have on the ratio calculated in part *(c)*. [3]

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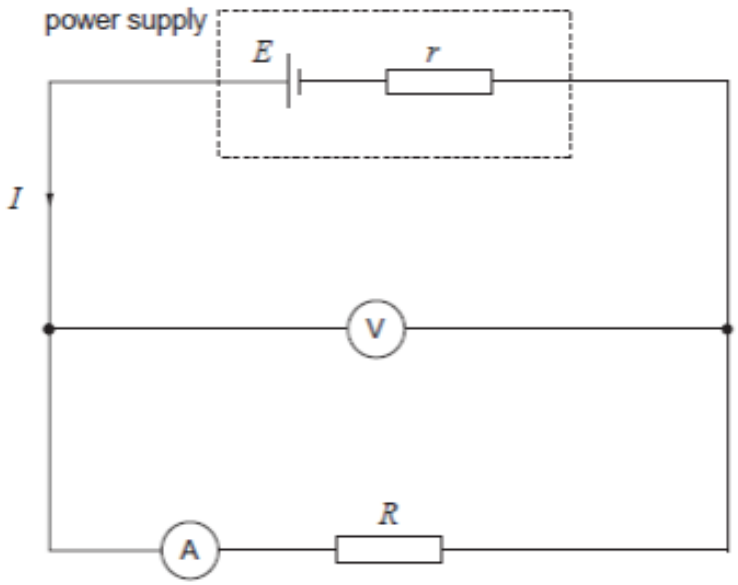
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Question taken from Eduqas examination paper 842102, June 2018

#8

5. Zhang Li sets up the following circuit and uses a spreadsheet to analyse her data as the load resistance, R, is varied.



	A	C	D	E	F
1					
2	Emf, E	Load resistance, R	Current, I	pd across R, V	Internal resistance, r
3	V	Ω	A	V	Ω
4	1.5	1.4	0.94	1.32	0.19
5	1.5	3.3	0.43	1.42	0.19
6	1.5	4.7	0.31	1.46	0.13
7	1.5	5.6	0.26	1.46	.....
8	1.5	8.0	0.19	1.49	0.17

(a) Zhang Li uses 3 resistors of values 3.3Ω, 4.7Ω and 5.6Ω, to create various load resistance values. Show clearly how the value in cell C4 (column C and row 4) is obtained. [3]

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(b) (i) Zhang Li uses the spreadsheet formula = $\frac{A4 - E4}{D4}$ to determine the internal resistance in cell F4. Explain in terms of energy why this is a valid method. [6]

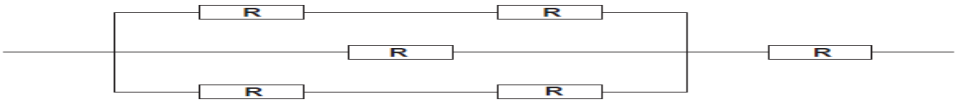
(ii) Determine the internal resistance value for cell F7. [2]

(iii) Zhang Li can choose between 4.7Ω resistors with power ratings of 0.25W or 0.50W. Justify, numerically, which resistor power rating she should use in the circuit. [3]

Question taken from Eduqas examination paper 842002, June 2019

#9

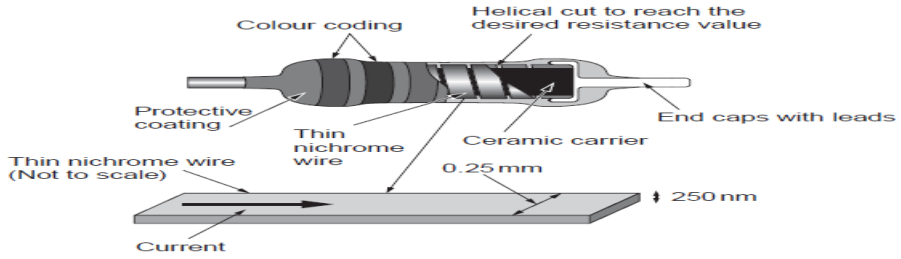
(a) The resistor network shown consists of six identical resistors, each of value **R Ω**.



(i) Determine, **in terms of R**, the total resistance of the network. [3]

(ii) **Draw a circle** around the resistor which dissipates the greatest power when a pd is applied across the arrangement. Explain your answer. [2]

(b) The alloy nichrome is commonly used to make 'Metal Film Resistors'. A cross-section through such a resistor is shown. The value of the resistor is determined by the length of the nichrome wire used in it.



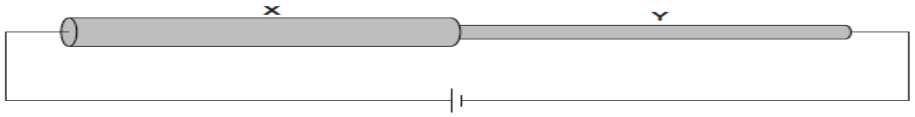
The wire used in such a resistor has a rectangular cross-section as shown. Determine the length of nichrome wire required to make a 2.0 kΩ resistor.
[Resistivity of nichrome = 1.20×10^{-6} Ω m] [2]

(c) The current I through a wire is related to the drift velocity, v, of free electrons through the wire by the equation:

$$I = nAve$$

(i) State the meaning of n. [1]

(ii) Two pieces of nichrome wire, **X** and **Y**, are joined end to end and connected to a battery as shown. The wires are of the same length but the diameter of **X** is **double** that of **Y**.



The table below shows the ratios of the values of n, I and v in the two wires. Write in the table the value of each ratio, giving an explanation for each of your answers. *Space is provided for calculations.* [3]

Ratio	Value	Explanation
$\frac{n_X}{n_Y}$		
$\frac{I_X}{I_Y}$		
$\frac{v_X}{v_Y}$		

(iii) Wire **Y** is replaced with another wire **Z** of the same cross-sectional area as **Y** but double the length and made of a material with resistivity half that of **X**. Calculate the ratio:

$$\frac{\text{Power dissipated in wire Z}}{\text{Power dissipated in wire X}}$$

[3]

Question taken from Eduqas examination paper 842102, June 2017

Marking Scheme

#1

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*	(i)	Resistance of LDR / circuit increases [as light intensity decreases] (1) [Hence] current decreases (1)	2			2		2
		(ii)	**Either:** Current in LDR $= \frac{4.0}{2.4 \times 10^{3}} = [1.67 \times 10^{-3}\ \text{A}]$ (1) $R = \frac{5.0(1)}{1.67 \times 10^{-3}}$ R = 3.0 kΩ (1) **Alternative:** $4.0 = \frac{2.4 \times 10^{3} \times 9.0}{(2.4 \times 10^{3} + R)}$ (1) [substitution into potential divider equation] Correct algebra (1) R = 3.0 kΩ (1) **Alternative:** $\frac{4}{5}(1) = \frac{2.4}{(1)R}$ R = 3.0 kΩ (1)	1	1 1		3	2	3
	(b)		Light from lamp will decrease [LDR resistance and hence] V across lamp low so lamp not activated (1) Hence reason for on/off, e.g. lamp off → LDR in dark → V_{out} high → lamp on		2		2		2
			Question 1 total	**3**	**4**	**0**	**7**	**2**	**7**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*		There are 6 J of energy/work done (converted from electrical to other forms) (1) Per coulomb of charge between X and Y (1)	2			2		
	(b)	(i)	Attempt to use equation to determine resistors in parallel (1) Resistance of parallel combination = 3.7[2] Ω (1) Total circuit resistance = 9.3 Ω ecf on parallel (1) Current = $\frac{V}{R}$ = 0.64 A [accept 0.65 A] answer to 2 d.p. (1)	1	1 1 1		4	3	
		(ii)	Apply ecf from part (b) (i) PD across parallel = 0.65 × 3.7 ecf OR pd across 5.6 Ω = 0.65 × 5.6 = 3.6 V (1) Answer = 2.4 V (1)		2		2	1	
		(iii)	Substitute values into $P = I^2R$ [$P = 0.65^2 \times 3.7$] (1) P = 1.54 W – ecf (1)	1	1		2	2	
			Question 2 total	**4**	**6**	**0**	**10**	**6**	**0**

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*		capacitance = $\frac{\text{charge (on either plate)}}{\text{pd (between the plates)}}$ Accept charge per unit pd / voltage [between plates] (1) Accept $C = \frac{Q}{V}$ if Q and V defined	1			1		
	(b)	(i)	Q = - 75 nC, R = + 75 nC, S = - 75 nC All numerical values stated as 75 [nC] (1) Correct signs and unit, i.e. nC (1) One of: (1) • Capacitors in series carry equal charges when joined to common pd • Conservation of charge applies for series circuit [hence if +75 μC moves from A to plate P, the same moves from Q → R etc] • Opposite charge to P (accept R), since connected to negative potential [Accept: battery transfers electrons from P to Q]	3			3		
		(ii)	Total capacitance = 7.5 nF (1) $V = \frac{75 \times 10^{-9}}{7.5 \times 10^{-9}}$ **(ecf on total C)** V = 10 V (1) **Alternative:** Application and substitution into $\frac{Q}{C_1} + \frac{Q}{C_2}$ i.e. $\frac{75 \times 10^{-9}}{30 \times 10^{-9}} + \frac{75 \times 10^{-9}}{10 \times 10^{-9}}$ (1) V = 10 V (1)		2		2	2	
		(iii)	**Either:** Q same on both capacitors (1) $\frac{1}{2}\frac{Q^2}{C}$ is bigger on smaller capacitor (1) (Award 2 marks for correct numerical analysis) **Or:** $V \propto \frac{1}{C}$ so V bigger across smaller capacitor (1) ½ CV^2 bigger across smaller capacitor (V^2 factor) (1) (Award 2 marks for correct numerical analysis) **Or** Q same on both capacitors and $V \propto \frac{1}{C}$ so V bigger across smaller capacitor (1) ½ QV is bigger on smaller capacitor (1) (Award 2 marks for correct numerical analysis			2	2		
	(c)		New C = 0.47 pF (1) New $d = 3.0 \times 10^{-3}$ m (1) $\Delta d = 5.2 \times 10^{-3} - 3.0 \times 10^{-3} = 2.2 \times 10^{-3}$ m (1) (**ecf** from new d) Application of $F = k\Delta d$ ecf k = 91 N m^{-1} so spring of k = 90 N m^{-1} suitable [conclusion consistent with value of F](1) **Alternative 'Trial and Error' :** Application of $x = \frac{F}{k}$ for each spring constant, showing that for: k = 120 N m^{-1}, $x = 1.67 \times 10^{-3}$ m k = 150 N m^{-1}, $x = 1.33 \times 10^{-3}$ m k = 90 N m^{-1}, x = 2.22 x 10^{-3} m (All required for1) New C = 0.47 pF (1) Application of $C = \frac{\varepsilon_0 A}{d}$ for each value of x above to show that, for $x = 2.22 \times 10^{-3}$ m, $C = 0.475 \times 10^{-12}$ F, so k = 90 N m^{-1} suitable. (1)			4	4	3	
			Question 6 total	**4**	**2**	**6**	**12**	**5**	**0**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		Electrical energy (or work) transferred [to other forms] per unit [accept coulomb] of charge [passing between the two points]	1			1		
	(b)		**Either:** I in circuit = $\frac{2.4}{160}$ (1) [= 15.0 mA] $R_{Thermistor} = \frac{(12.0-2.4)(1)}{15.0 \times 10^{-3}}$ [**ecf** on I] = 640 [Ω] (1) **Or:** $R_T = \frac{9.6(1)}{2.4} \times 160$ (1) **or** $2.4 = \frac{12 \times 160}{160 + R_T}$ (2) = 640 [Ω] (1)	1	1 1		3	3	
	(c)	(i)	[Resistance of thermistor decreases as temp increases] pd across thermistor decreases (1) So pd across fixed resistor increases **because**: **Either** - ratio of pds across potential divider changes **Or** - total pd must = 12.0 V (or equivalent) (1) **Alternative:** [Resistance of thermistor decreases as temp increases] so circuit current increases (1) So pd across fixed resistor increases **because** $V = IR$ and R is constant or $V \propto I$ (1)		2		2		
		(ii)	At 30 °C, $R_{thermistor}$ = 480 Ω from graph (1) $V_{cooling\ system} = \frac{160}{(480+160)} \times 12.0$ (1) [**ecf** on $R_{Thermistor}$] = 3.0 [V] (1) **Alternative:** $2.8 = \frac{160}{(R_{Thermistor}+160)} \times 12.0$ (1) $R_{Thermistor}$ = 526 [Ω] (1) Corresponds to 25 °C from graph (1) **Alternative:** $I_R = \frac{2.8}{160} = 0.0175$ [A] (1) $R_T = \frac{9.2}{0.0175} = 526$ [Ω] (1) Corresponds to 25 °C from graph (1) **Alternative:** $I_R = \frac{2.8}{160} = 0.0175$ [A] (1) At 30 °C, $R_{thermistor}$ = 480 Ω from graph (1) $I_T = \frac{9.2}{480} = 0.0192$ [A] (1) **Alternative:** At 30 °C, $R_{thermistor}$ = 480 Ω from graph (1) $I = \frac{V}{R} = \frac{12}{(480+160)} = 0.01875$ [A] (1) $V = IR = 0.01875 \times 160 = 3$ [V] (1) **Final mark for all methods - Valid conclusion consistent with answer:** i.e. Claim incorrect - system activated at $\theta < 30$ °C (1)			4	4	3	
	(d)		More effective at 0 °C – 10 °C (no mark) Because: Steeper gradient / larger change in resistance (1) Greater sensitivity in this range / greater [fractional] change in R per °C change in temperature or over the same temperature range) (1)			2	2		2
			Question total	**2**	**4**	**6**	**12**	**6**	**2**

#5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)		*V*- Energy (per coulomb or unit charge) used in external resistor/circuit [1] *E*- Energy (per coulomb/unit charge) transferred by source [or from chemical energy or from other forms] or used in **whole** circuit [1] *Ir* – energy (per coulomb/unit charge) wasted/lost in source or due to internal resistance [1] Use of 'per coulomb' or 'unit charge' at least once [1]	4			4		
	(b)	(i)	Circuit current $= \frac{1050 \times 10^{-3}}{2.5} = 0.42$ [A] [1] Total internal resistance $= \frac{0.5}{0.42} = 1.2$ [Ω] ecf on *I* [1] $r_{cell} = 0.6$ [Ω] [1]		3		3	2	
		(ii)	Substitution into I^2rt i.e. $(0.42)^2 \times 0.6 \times 60$ (**ecf** on *I*, *r*) [1] **Alternative:** Substitution into $\frac{V^2t}{r}$ i.e. $\frac{(0.25)^2 \times 60}{0.6}$ (**ecf** on *V*, *r*) **Alternative:** Substitution into IVt i.e. $0.42 \times 0.25 \times 60$ (**ecf** on *I*, *V*) Energy dissipated = 6.3 [J] [N.B. Alternative → 6.4 J] [1]	1	1		2	1	
	(c)		**Either**: Total resistance of coils in parallel = 2.975 [Ω] [1] and total circuit resistance = 4.175 [Ω] ecf [1] New current in circuit $= \frac{3}{4.175} = 0.72$ [A] [1] **For the 4th mark:** Rate of energy dissipation in each cell $= (0.72)^2 \times 0.6 = 0.31$ [W] so Kiera correct (or ratio calculated to be approx. 3) **Or** Energy dissipated in each cell in one minute $= (0.72)^2 \times 0.6 \times 60 = 18.6$ [J] so Kiera correct (or ratio calculated to be approx. 3) [1] **Alternative:** Total resistance of coils in parallel = 2.975 [Ω] [1] and total circuit resistance = 4.175 [Ω] ecf [1] New current = 0.72 [A] and pd drop across internal resistance = $0.72 \times 1.2 = 0.86$ [V] [1] Rate of energy dissipation in each cell **For the 4th mark:** $= \frac{(0.43)^2}{0.6} = 0.31$ [W] so Kiera correct (or ratio calculated to be approx. 3) **Or** Energy dissipated in each cell in one minute $= \frac{(0.43)^2 \times 60}{0.6} = 18.6$ [J] so Kiera correct (or ratio calculated to be approx. 3) [1]			4	4		
			Question 1 total	**5**	**4**	**4**	**13**	**3**	**0**

#6

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		Label axis with units and suitable scale (1) Plot all points correctly ± ½ small square division (1) Draw a smooth curve with maximum between 2.3 and 2.6 Ω **no** straight lines present (no requirement to extend back to the origin) (1)	1	1 1		3	3	3
	(b)	(i)	6.0 [J] of [chemical] energy transferred/converted/work done to electrical [potential] energy (1) Per unit charge [or coulomb] [flowing through the cell/battery] (1)	2			2		2
		(ii)	Using $P = I^2R$ (1) Data point from graph when R = 4.5 Ω, P = 3.64 W (1) Need 2 dp and within ± ½ small square Calculation of current correctly i.e. = 0.90 [A] (1)	1	1 1		3	3	3
		(iii)	Using $E = V + Ir$ (1) Substituting correct values 6 = 0.90 × 4.5 + 0.90r **ecf** (1) Internal resistance = 2.2 [Ω] (1)	1	1 1		3	3	3
	(c)		Power is higher/greater/larger (1) Total resistance of circuit is less for all values of R (1) Accept peak of graph shifts to left			2	2		2
			Question total	**5**	**6**	**2**	**13**	**9**	**13**

#7

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)	(i)	Rate of charge flow Accept $I = \frac{\Delta Q}{\Delta t}$ only if ΔQ and Δt defined [accept Q and t]	1			1		
		(ii)	J C^{-1} and C s^{-1} as units of V and I respectively clearly shown (1) Correct division seen i.e. $\frac{JC^{-1}}{Cs^{-1}}$ seen (1) Or from alternative correct expression, e.g. $R = \frac{V^2}{P}$ Or equivalent in terms of quantities.	1	1		2	1	
	(b)	(i)	I through R_P = 1.2 A and I through R_T = 0.8 A (1) $\frac{V_P}{V_T} = \frac{1.2R_P}{0.8R_T}$ (=1.5) seen (1) Or Parallel combination calculated as $\frac{2}{3}R$ (1) Potential divider: $\frac{R}{R+\frac{2}{3}R} \times 9 = 1.5$ (1)		2		2	1	
		(ii)	$2.5V_T = 9.0$ or $\frac{5V_P}{3} = 9.0$ (1) V_T = 3.6 V or V_P = 5.4 V (1) Award 2 marks for either V_P or V_T calculated correctly. $R_T = \frac{3.6}{0.8} = 4.5\ \Omega$ or $R_P = \frac{5.4}{1.2} = 4.5\ \Omega$ or $\frac{1.8}{0.4} = 4.5\ \Omega$(1) **Alternative:** Total circuit $R = \frac{9.0}{1.2} = 7.5\ \Omega$ (1) Parallel and series combination shown to be = $\frac{5R}{3}$(1) $\frac{5R}{3}$ = 7.5 and R = 4.5 Ω (1) **Alternative:** Understanding that $V_P + V_T = 9$ (1) $1.2R_P + 0.8R_T = 9$ (1) (award 2 marks for this only) $R_P = R_T = R$ and $R = \frac{9}{2} = 4.5\ \Omega$ clearly shown (1) Accept reverse argument.		3		3	3	
	(c)		P (circuit) = 10.8 W (1) (either $\frac{81}{7.5}$ or $(1.2)^2 \times 7.5$ or 1.2×9) P in $R_Q = (0.4)^2 \times 4.5 = 0.72$ W (1) $\frac{10.8}{0.72} = 15$ seen (1) **Alternative:** $P_S = P_Q$ since $I_S = I_Q$ $P_T = 4 \times P_Q$ since $I_T = 2 \times I_Q$ $P_P = 9 \times P_Q$ since $I_P = 3 \times I_Q$ Hence total circuit power = $P_Q + P_Q + 4P_Q + 9P_Q$ $= 15P_Q$ Award (1) for correct individual power analysis Award (1) for correct reason linked to currents Award (1) for showing correct total P		3		3	2	
	(d)		Circuit resistance increases, leading to total current decreasing. Power dissipated in circuit decreases (1) V across R_Q has increased (from 1.8 V to 3.0 V), so P_Q increases / I through R_Q has increased (from 0.4 A to 0.67 A) so P_Q increases (1) Hence ratio decreases (1) [only award from correct explanation] Accept numerical explanation: e.g. Circuit resistance is now 13.5 Ω and circuit current = 0.67 A (1) circuit power shown to be 6 W and P_Q shown to be 2 W (1) Hence ratio decreases or is now 3 (1) **Alternative:** With T removed, I through all remaining resistors is the same or V across each is the same (1) Use of VI or I^2R or V^2/R or power / energy dissipated in all three resistors equal (1) So total $P = 3 \times P_Q$ or which is less than $15P_Q$(1)		3		3		
			Question 2 total	**2**	**12**	**0**	**14**	**7**	**0**

#8

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
5	(a)	(i)	All resistors connected in parallel (1) Using $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$ [or equiv] (1) R_{total} = 1.44 [Ω] (1)	1	1 1		3	2	3
	(b)	(i)	(A4/emf) is the energy generated in the cell (1) per coloumb (1) Loss of energy in circuit in the load resistor (E4) (1) $E - V$ is the energy is lost in internal resistance (1) Energy is conserved (1) Re-arrange gives $r=\frac{E-V}{I}$ (1)	1 1	1 1 1 1		6	1	
		(ii)	Substituting values in $\frac{\text{A7-E7}}{\text{D7}}$ (1) r = 0.15 [Ω] (1)	1	1		2	2	
		(iii)	Using $P = I^2R$ (1) P = 0.45 [W] (1) 0.50 W – has to be greater than the power dissipated (need reason) (1)	1	1 1		3	1	
			Question 5 total	**5**	**9**	**0**	**14**	**6**	**3**

#9

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	For Left Hand Combination: $\frac{1}{R_{parallel}}=\frac{1}{2R}+\frac{1}{R}+\frac{1}{2R}$ (RHS seen in any correct form e.g. $\frac{4}{2R}$)(1) $=\frac{R}{2}$ (1) Total $R=\frac{R}{2}+R$ or $\frac{3R}{2}$ seen (1) **Alternative solutions possible** e.g. Sum of top and bottom branch = R (1) Then parallel branch = $\frac{R}{2}$ (1) Total $R=\frac{R}{2}+R$ (1)		3		3	3	
		(ii)	Right hand resistor circled (1) Greatest current / greatest voltage (1)		2		2		
	(b)		Correct substitution into $l=\frac{RA}{\rho}$ i.e. $\frac{2.0\times10^{3}\times250\times10^{-9}\times0.25\times10^{-3}}{1.20\times10^{-6}}$ (1) l = 0.10 [m] (1) (**ecf** on slip in powers of 10)	1	1		2	2	
	(c)	(i)	n- free electron density. Accept- number of free electrons per unit volume or per m^3 (or equivalent)	1			1		
		(ii)	<table><tr><th>Ratio</th><th>Value</th><th>Explanation</th></tr><tr><td>$\frac{n_X}{n_Y}$</td><td>1</td><td>Wires made of the same material</td></tr><tr><td>$\frac{I_X}{I_Y}$</td><td>1</td><td>Wires in series</td></tr><tr><td>$\frac{v_X}{v_Y}$</td><td>0.25</td><td>Correct explanation based on $A_Xv_X = A_Yv_Y$ e.g $(d)^2v_x = \left(\frac{d}{2}\right)^2 v_y$</td></tr></table> Award 1 mark for each correct row	1 1	1		3		
		(iii)	$R=\frac{\rho l}{A}$ substituted into $P=I^2R$ i.e. $P=\frac{I^2\rho l}{A}$ (1) $P_x=\frac{I^2\rho_x l_x}{A_x}$ and $P_z=\frac{I^2\rho_z l_z}{A_z}$ (or equivalent) - can award 1st mark from one of these expressions $A_x = 4A_z$ and $l_x=\frac{l_z}{2}$ and $\rho_x = 2\rho_z$ to show: (1) $\frac{P_z}{P_x}$ = 4 (1)		3		3	3	
			Question total	**4**	**10**	**0**	**14**	**8**	**0**