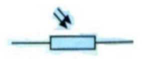
Mark scheme – Energy, Power, Resistance Circuits Symbols

Question			Answer/Indicative content	Marks	Guidance
1			**C**	1	**Examiner's Comments** This question was based on recognising circuit symbols. This was successfully answered by the vast majority of the candidates who opted for C because of the light-dependent resistor in the circuit. The popular distractor was A. The light-emitting diode in circuit A was often mistaken for a light-dependent resistor.
			Total	**1**	
2			B	1	**Examiner's Comments** The correct response is **B**. This question was correctly answered by around two thirds of candidates. There appeared to be various routes to the correct solution; many opted to work out a current in terms of *R*, but the more elegant working was in terms of simple ratios which demonstrated a good understanding of p.d. in a series circuit. Encouragingly, very few candidates opted for response **A**, which was a p.d. below that of the thermistor alone. It should be noted that a couple of candidates put a '7' in the answer box – as correct working had been shown by them, and leading to the correct numerical value this was credited by examiners. However, this cannot be guaranteed to occur in other cases and candidates are to be encouraged to put only the correct letter.
			Total	**1**	
3			D	1	
			Total	**1**	
4			the current (induced in the aerial) is alternating (5×10^8 times per second) (so the meter would register zero) / AW **or** the diode (half-)rectifies the current / changes the current (from a.c.) to d.c. / AW	B1	**Allow** 'a diode only lets current pass through in one direction' AW **Examiner's Comments** Allowing a mark for the diode only letting current pass in one direction enabled many candidates to score this mark. There was

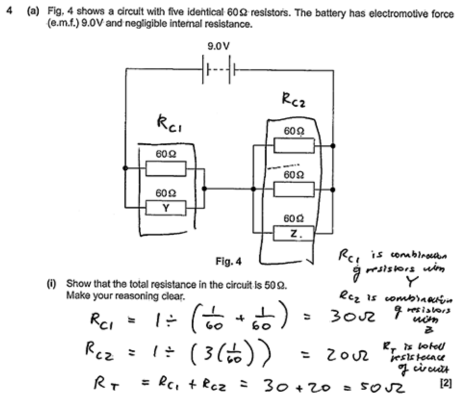
					little mention of alternating current among the responses.
			Total	**1**	
5			$\Sigma E = \Sigma V$ or $\Sigma E = \Sigma Ir$ $E = V + Ir \Rightarrow V = E - Ir$	C1 A1	
			Total	**2**	
6			Circuit with cell in series with an ammeter and variable resistor. A voltmeter is connected across the variable resistor / (terminals of the) cell	B1	**Allow** this B1 mark for a clearly drawn circuit with correct symbols for the cell, variable resistor, voltmeter and ammeter. **Allow** a battery symbol instead of symbol for a cell
			Measure current and p.d./voltage across variable resistor / cell	B1	**Allow** 'terminal p.d.' for p.d. across the cell **Allow** 'measure *I* and *V*' if the circuit is correct **Allow** 'measure voltmeter and ammeter readings' if the circuit is correct Possible ECF for incorrect symbol for variable resistor **Examiner's Comments** Candidates were familiar with this experiment and some gave answers using the bullet points as prompts. Although most candidates scored two or more marks, there were some missed opportunities. The most common error was the incorrect symbol for the variable resistor in the circuit. It was either a thermistor symbol or a hybrid. Some candidates also lost a mark for not clearly specifying the graph being plotted. Instead of *'Plot a graph of V against I and determine the gradient which is equal to the internal resistance*', examiners were faced with less robust statements such as '*Plot a graph and find the gradient*' or '*Use the data to draw a graph and use E = V +Ir to calculate r'.*
			Correct description of how to get multiple readings (of current or p.d) E.g. change the resistance of the variable resistor / use different value resistors, etc.	B1	
			($E = V + Ir$) Plot a graph of *V* against *I* and the gradient (of the graph / line) is equal to (−) *r* (AW)	B1	
			Total	**4**	
7			Any <u>three</u> from:	M1×3	**Note** that each of the M1 mark can be implied in a calculation **Note** 8.3.. (Ω) will score the **3.0** V and the

8			• Fig. 23.3 - p.d. split equally / (p.d. across each =) **3.0** (V) • Fig. 23.3 - current = **0.36** (A) (from the graph) • Fig. 23.4 - p.d. = **6.0** (V) (across each or combination) • Fig. 23.4 - current (= 2 × 0.50) = **1.0**(0) (A) 0.36 × 3 (= 1.08) is about 1.0 (A)	A1	**0.36** A marks **Note** 12 (Ω) will score the **6.0** V mark **Note** this mark is for showing that I_P is about 3 times I_S **<u>Examiner's Comments</u>** This question produced a range of marks, with most candidates securing 2 or more marks. For the lamps in series, it was important to recognise that the potential difference across each lamp is 3.0 V. From the *I-V* graph, this meant a current I_S of about 0.36 A. For the lamps in parallel, the current in each lamp was 0.50 A because the potential difference across each lamp was 6.0 V. This meant that the current I_P was twice the current in each lamp; 1.00 A. The current I_P is about 2.8 times greater than current I_S. This final step of the analysis was often omitted by most of the candidates. A significant number of candidates scored no marks here and about 10% of the candidates omitted this question altogether. **Misconception** The most common mistake made by candidates, across the ability spectrum, was to assume that each lamp had a constant resistance of 12 Ω in the series combination. A lamp is a non-ohmic component. At a potential difference of 3.0 V, the resistance of each lamp is about 8.3 Ω.
			Total	**4**	
8			*Please refer to point 10 of the marking instructions of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Typically, circuit including meters is correctly drawn on Fig. 4.2(b). Explanation of action of **both** circuits is correct. Presence of 100 Ω explained.	B1	**Indicative scientific points may include** **circuit diagram** 1. resistor and LED in series 2. ammeter in series and voltmeter in parallel with LED 3. correct symbols for LED, ammeter, voltmeter, etc.

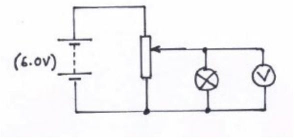
			There is a well−developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated. **Level 2 (3–4 marks)** Typically, circuit including meters is correctly drawn on Fig. 4.2(b). Action of only Fig. 4.2(b) circuit explained correctly. Purpose of 100 Ω stated but value not justified. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Typically, circuit including meters is correctly drawn on Fig. 4.2(a). No correct explanations **or** basic information on the action of circuit **or** presence of 100 Ω resistor. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear* **0 marks** No response or no response worthy of credit.		4. correct polarity of LED **action of circuit** 1. circuit completed on Fig. 4.2(b) 2. voltage across **AB** can be varied from 0 to 6 V 3. some justification; e.g. potential divider circuit 4. in Fig. 4.2(a) circuit voltage only varies from 6 to about 5.6 V as resistance can only be varied from 110 to 100 Ω (+ LED)/AW **presence of 100 Ω resistor** 1. the current in the circuit is limited by the resistor so ensures LED cannot burn out 2. at 6 V the potential divider across **AB** gives 2 V across LED as its resistance is about 50 Ω / AW
3			**Total**	**6**	
9		i	$V = \frac{1.1}{6.8 + 1.4 + 1.1} \times 6$ 0. 71 (V)	**C1** **A1**	**Allow** $I = \frac{6}{(6.8+1.4+1.1)\times 10^3} = 0.00065$ **Allow** 0.7 **Examiner's Comments** Candidates who use the potential divider equation invariably gained the correct answer of 0.71 V. Alternatively, some candidates correctly determined the current and then determined the voltmeter reading.
		ii	As temperature of thermistor increases, resistance of thermistor decreases Total resistance of circuit decreases or current increases Greater proportion of p.d. across <u>fixed resistor</u> or p.d. across <u>fixed resistor</u> increase Reading on the voltmeter will increase	**B1** **B1** **M1** **A1**	**Examiner's Comments** Candidates were expected to explain how the voltmeter reading would change as the temperature of the thermistor increased. Good answers used a step-by-step approach. Candidates needed to explain how the potential difference of across the fixed resistor would change. It was essential that clearly defined terms were used – often candidates referred to V_1, R_2, or p.d. and resistance without indicating explicitly the

					meaning of V_1, R_2, or explaining which p.d. or resistance was being referred to.
			Total	**6**	
10		i		**B1**	two arrows needed **not** across resistor; allow a surrounding circle with arrows outside circle
		ii	**1** from graph 3.0 (kΩ) I = 4.0 / 3.0 = 1.33 × 10^{-3} A **or** R = 2.0 / 4.0 × 3.0 × 10^3 R = (6.0 − 4.0) / 1.33 × 10^{-3} = 1.5 × 10^3 (Ω) **2** at 2.4 V R_{LDR} = 1.0 kΩ giving 2.5 (W m^{-2})	**B1** **C1** **A1** **M1** **A1**	**allow** 3.1 ± 0.1 (kΩ) **accept** 1.3 mA; **accept** potential divider argument **allow** 1.5 kΩ; **special case:** using 2.4 V in place of 4.0 V gives R = 4.5 kΩ; give 1 mark out of 2 **ecf (b)(ii); allow** potential divider or I = 2.4 mA; **for special case:** R_{LDR} = 9.0 kΩ ; give 1 mark out of 2 allow 2.4 to 2.6 W m^{-2} **N.B. remember to record a mark out of 5 here** **Examiner's Comments** More than half of the candidates knew the correct circuit symbol for an LDR. The most common error was to draw an LED. More candidates used a potential divider approach to solve the problem than calculated the current in the circuit; many gaining full marks. Those who misread the question and reversed the voltages required to switch the lamp on and off were given some credit for their answers.
			Total	**6**	
11		i	Arrow in anticlockwise direction	B1	**Allow** this mark for correct direction shown on diagram either on or off connecting wires **<u>Examiner's Comments</u>** This question required the candidates to appreciate that the sum of the emfs will lead to an anticlockwise conventional current. This question was answered well by the majority of candidates, however a number put two directions on, one from each cell. ? **Misconception** The unusual setting out of the circuit meant that some candidates were unsure whether parts of the circuit were in series or parallel.

					This could have been overcome by following the circuit or even by redrawing it.
		ii	(E =) 4.5 – 2.4 **or** (R_T =) 0.80 + 0.50 + 1.2 4.5 – 2.4 = I × (0.80 + 0.50 + 1.2) I = 0.84 (A)	C1 C1 A1	E = 2.1 (V); R_T = 2.5 (Ω) Treat missing 1.2 resistance as TE **Allow** 2 marks for 2.8 (A); E = 6.9 V used **Examiner's Comments** This calculation required the candidate to set out the whole circuit in one. Around one third did not score any marks on this question as they attempted to treat each cell individually and then produce some form of average. Other common misunderstandings included treating the 0.5 ohm and 0.8 ohm resistors as if they were in parallel, and adding the emfs.
		iii	($I = Anev$) 0.84 = π × (2.3 × 10^{-4})^2 × 4.2 × 10^{28} × 1.60 × 10^{-19} × v v = 7.5 × 10^{-4} (m s^{-1})	C1 A1	Possible ECF from **(ii)** Note answer is 2.5 × 10^{-3} (m s^{-1}) for I = 2.76 (A) **Allow** 1 mark for 1.9 × 10^{-4}; diameter used as radius **Examiner's Comments** This question was well done by a large number of candidates, many of whom scored full marks by correctly following through with their value of current from the previous part. Few candidates used the diameter instead of the radius when determining the cross sectional area, and for the most part the setting out of the calculation meant that credit could be given even if arithmetic errors occurred later.
		iv	Sensible suggestion, e.g. use a water bath / fan / only switch on when taking readings Need to lower the temperature / reduce resistance of **R**	M1 A1	**Allow** keep the surroundings cold **Allow** to keep the temperature / resistance constant **OR allow** increase in temperature increases resistance **Examiner's Comments** Candidates were expected to provide any method of cooling the circuit, or preventing it heating in the first place. A wide variety of solutions were given and as long it is viable, it was credited.

					Misconception Some candidates gave perfectly viable solutions, but these involved changes to the circuit, which was not allowed in the question. It is very important to make sure than any response does fit what is being asked.
			Total	**8**	
12	a	i	$\frac{1}{R} = \frac{1}{60} + \frac{1}{60}$ or $\frac{1}{R} = \frac{1}{60} + \frac{1}{60} + \frac{1}{60}$ or $R = \frac{60}{n}$ or $R = \frac{60 \times 60}{60+60}$ 30 Ω + 20 Ω = 50 Ω	M1 A1	**<u>Examiner's Comments</u>** This question was generally answered well although, a number of candidates did not take due care when writing the mathematical expressions. **Exemplar 6**  4 (a) Fig. 4 shows a circuit with five identical 60 Ω resistors. The battery has electromotive force (e.m.f.) 9.0 V and negligible internal resistance. Fig. 4 (i) Show that the total resistance in the circuit is 50 Ω. Make your reasoning clear. $R_{C1} = 1 \div \left(\frac{1}{60} + \frac{1}{60}\right) = 30\Omega$ $R_{C2} = 1 \div \left(3\left(\frac{1}{60}\right)\right) = 20\Omega$ $R_T = R_{C1} + R_{C2} = 30 + 20 = 50\Omega$ R_{C1} is combination of resistors with Y R_{C2} is combination of resistors with Z R_T is total resistance of circuit [2] The candidate's response is logically structured showing the effective resistance of the two combinations of resistors and then clearly showing the adding of the two effective resistances together. This answer gained both marks.
		ii	$\frac{30}{50} \times 9$ or $I = \frac{9}{50} = 0.18$ A 5.4 V	C1 A1	**<u>Examiner's Comments</u>** For this question, many candidates incorrectly stated that the potential difference was 4.5 V. Other candidates tried determining the current but did not make clear their working. The simplest solution was to use the potential divider relationship.

		iii	$\left(I = \frac{5.4}{60} =\right)$ 0.090 A (0.09 x 120 =) 11 C or coulomb	C1 A1 B1	**Allow ECF** from **(ii)** **Allow** 10.8 **Note** 0.18 C scores two marks provided 0.09 A is seen **Note** 21.6 C scores one mark (for the correct unit) **Examiner's Comments** The majority of the candidates gained a mark for the unit of charge on this question. A common incorrect answer was 21.6 C where candidates had used the total current in the circuit rather than the current of 0.09 A in resistor Y. Some candidates did not change the time in minutes to a time in seconds.
		iv	(11 x 5.4 or 0.09 x 5.4 x 120)= 59 or 58 (J)	A1	**Note** 58(.3) if 10.8 C used **Allow ECF** from **(ii)** and/or **(iii)** **Not** 60 **Examiner's Comments** Candidates who multiplied the charge by the potential difference easily gained the mark in this question. Other candidates who used different methods often made mistakes.
	b		I = *nAve* or *v α I* larger current through **Y** than **Z** ORA drift velocity in **Y** is 1.5 times drift velocity in **Z** ORA	B1 B1 B1	**Allow** any correct rearrangement of $I = nAve$ **Allow** I_Y = 0.090 A and I_Z = 0.060 A OR I_Y / I_Z = 1.5 ORA **Examiner's Comments** In this question, many candidates correctly quoted the equation and stated that the mean drift velocity was directly proportional to the current. The majority of the candidates realised that there was a larger current in resistor Y than resistor Z; however, few candidates realised that the current was 1.5 times larger and therefore the mean drift velocity was 1.5 times larger.
			Total	**11**	

13		i	Correct circuit with a battery, potential divider, lamp and voltmeter. 	B1	
		i	Correct symbols used for all components.	B1	**Allow**: A cell symbol for a battery
		ii	Description: The temperature of the filament increases. (AW)	B1	
		ii	The resistance of the lamp increases	M1	
		ii	from a non-zero value of resistance.	A1	**Allow** 'when cold the resistance is small'
		ii	Explanation: Resistance increases because electrons/charge carriers make frequent collisions with ions. (AW)	B1	
		iii	($P = VI$) current in **X** is 3 times the current in **Y** Or area of **X** is 4 times smaller than area of **Y**	C1	**Allow** other correct methods.
		iii	$I = Anev$ and ratio = $\frac{3}{0.25}$	C1	
		iii	ratio = 12	A1	
			Total	**9**	