Question	Answers	Extra information	Mark	AO / Specification reference
01.1	the potential difference of the mains electricity in the UK is: about 230 V the frequency of mains electricity in the UK is: 50 Hz the mains supply in the UK produces a current that is: alternating		1 1 1	AO1 4.2.3.1
01.2	earth **or** neutral earth; neutral in any order live; neutral in any order		1 2 2	AO1 4.2.3.1
01.3	if the casing on an appliance becomes live, the earth wire conducts the current safely to earth	do not accept 'for safety' do not accept 'to protect the user'	1	AO1 4.2.3.1
02.1	power = potential difference × current **or** P = I x V = 6 V × 1.5 A (= 9 W)		1 1	AO1 AO2 4.2.4.1
02.2	power = $\frac{\text{energy}}{\text{time}}$		1	AO1 4.1.1.4
02.3	$9 = \frac{\text{energy}}{30}$ energy = 9 × 30 = 270 (J)	accept 270 with no working for three marks	1 1 1	AO2 4.2.4.2
02.4	both devices transfer the same amount of energy		1	AO2 4.2.4.2

Question	Answers	Extra information	Mark	AO / Specification reference
03.1	a fault can be caused by the live wire touching the case of the fan the earth wire is connected to the case providing a (low resistance) path to 'earth' so the current flows through the earth wire and not through the person touching the case a large current flows, so the fuse melts so the current stops flowing		1 1 1 1 1	AO1 AO2 4.2.3.2
03.2	make the case of the fan out of plastic/non-conducting material if the live wire touches the case the current will not travel through the case to the person		1 1	AO1 AO2 4.2.3.2
03.3	power = potential difference × current = 230 × 4.5 = 1035 W = 1000 W (to two significant figures)	accept 1000 W with no working for two marks	1 1	AO1 AO2 4.2.4.1

Question	Answers	Extra information	Mark	AO / Specification reference
03.4	power = current^2 × resistance energy = power × time energy = current^2 × resistance × time 5.4 = 5^2 × resistance × 0.63 resistance = $\frac{5.4}{(5^2 \times 0.63)}$ = 0.3428 = 0.34 Ω (to two significant figures) **or** $P = \frac{E}{t}$ and $P = I^2 \times R$ $\left(P = \frac{5.4}{0.63}\right)$ = 8.57 W $\left(R = \frac{P}{I^2}\right) = \frac{8.57}{5}$ = = 0.3428 R = 0.34 Ω (to two significant figures)		1 1 1 1 **or** 1 1 1 1	AO1 AO2 4.2.4.1
04.1	a transformer changes the potential difference/steps a potential difference up or down		1	AO1 4.2.4.3
04.2	**Level 3:** Detailed explanation of why the National Grid uses a higher potential difference. Calculations of the current in each wire and of power loss in each wire		5-6	AO3 4.2.4.3
	Level 2: Explanation of why the National Grid uses a higher potential difference. Calculation of the current in each wire or an attempt at calculation of power loss in each wire		3-4	

Question	Answers	Extra information	Mark	AO / Specification reference
	Level 1: Explanation of why the National Grid uses a higher potential difference. Calculation of the current in each wire or an attempt at calculation of power loss in each wire.		1-2	
	No relevant comment.		0	
	Indicative content: • transmitting power at a higher potential difference means that the current is smaller • the wires have a resistance, so they will get hot • so there is less energy transferred to the thermal store of the surroundings • at a power of 80×10^6 W and a potential difference of 400 000V, the current in the wire is: current = $\frac{\text{power}}{\text{potential difference}} = \frac{80 \times 10^6}{400000}$ = 200 A ○ power loss is: $P = I^2 \times R = 200^2 \times 4 = 1.6 \times 10^5$ W • at a power of 80×10^6 W and a potential difference of 4000 V the current in the wire is: current = $\frac{\text{power}}{\text{potential difference}} = \frac{80 \times 10^6}{4000}$ = 20000 A power loss is: $P = I^2 \times R = (20\,000)^2 \times 4 = 1.6 \times 10^9$ W			
05.1	power = current × potential difference	accept symbol equation $P = V \times I$	1	AO1 4.1.1.4

Question	Answers	Extra information	Mark	AO / Specification reference
05.2	potential difference of the mains = 230 V power = 2 kW = 2000 W 2000 = current × 230 current = $\frac{2000}{230}$ = 8.69 A = 8.7 A (to two significant figures)	accept 8.2 with no working for the four calculation marks	1 1 1 1 1 1	AO1 AO2 4.2.4.2
05.3	potential difference = current × resistance	accept V = IR	1	AO1 4.2.1.3
05.4	230 = 8.69 × resistance resistance = $\frac{230}{8.69}$ = 26.47 Ω = 26 Ω (to two significant figures) **or** power = current^2 × resistance 2000 = $(8.69)^2$ × resistance resistance = $\frac{2000}{(8.69)^2}$ = 26.48 Ω = 26 Ω (to two significant figures)	allow 26.4 = 26 Ω if 8.7A used allow 26.4 = 26 Ω if 8.7A used	1 1 1 1 **or** 1 1 1 1	AO2 4.2.1.3 4.2.4.1

Question	Answers	Extra information	Mark	AO / Specification reference
05.5	energy transferred by kettle = power × time	accept E = Pt	1	AO1 4.2.4.2
05.6	E = 2000 × 2 × 60 = 240 000 J for toaster: 240 000 = 1200 × time time = $\frac{240000}{1200}$ = 200 seconds = 3 minutes 20 seconds.		1 1 1 1 1 1	
05.7	yes they both transfer energy from a chemical/nuclear energy store (in the power station) to the thermal energy store (of the surroundings) by an electric current	no marks for 'yes'	 1 1	AO1 AO2 4.2.4.2
06.1	2000 W means 2000 joules of energy are transferred per second/unit time		1	AO1 4.2.4.2
06.2	230 V means 230 joules of energy are transferred by each coulomb of charge (that flows in the circuit)		1	AO1 4.2.4.2
06.3	energy = power × time	accept symbol equation E = P × t	1	AO1 4.2.4.2
06.4	E = 2000 x 5 x 60 = 600 000 J	accept 600 000 with no working for two marks	1 1	AO2 4.2.4.2

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO / Specification reference</th></tr>
<tr><td>06.5</td><td>energy = charge × potential difference</td><td>accept symbol equation E = Q × V</td><td>1</td><td>AO1
4.2.4.2</td></tr>
<tr><td>06.6</td><td>600 000 = charge × 230
charge = $\frac{600000}{230}$
= 2608.7 C</td><td>accept 2609 with no working for three marks</td><td>1
1</td><td>AO2
4.2.4.2</td></tr>
<tr><td>07.1</td><td><table><tr><th>Metal rod</th><th>Time for nail to fall off in s</th><th>Time for nail to fall off in s</th><th>Time for nail to fall off in s</th><th>Mean time for nail to fall off in s</th></tr><tr><td>1</td><td></td><td></td><td></td><td></td></tr></table></td><td>evidence of metal rod as independent variable in the first column
evidence of repeat readings
evidence of calculation of mean</td><td>1
1
1</td><td>AO2
AO3
4.1.3</td></tr>
<tr><td>07.2</td><td>two from:
distance of a nail from end of rod
Bunsen burner, type/air hole position/position on rod
amount of wax on nail
size/material/mass of nail
initial temperature of nail</td><td>one mark for each correct point up to a maximum of two marks</td><td>2</td><td>AO3
4.1.2.1</td></tr>
<tr><td>07.3</td><td>the control variables are difficult to control
leading to a big uncertainty in the data produced</td><td></td><td>1
1</td><td>AO3
4.1.2.1</td></tr>
<tr><td>07.4</td><td>use a different method for working out when the end of the rod has gotten hot e.g., thermal paint, temperature sensor attached to rod</td><td></td><td>1</td><td>AO3
4.1.2.1</td></tr>
</table>

Question	Answers	Extra information	Mark	AO / Specification reference
08.1	230 V for all appliances this is the potential difference of the mains		1 1	AO1 4.2.3.1 4.2.4.1
08.2	thermal (energy store)		1	AO1 4.2.3.1 4.2.4.1
08.3	iron→ hairdryer → toaster The current is proportional to the power if the potential difference is constant **or** $I = \frac{P}{V}$		1 1	AO2 4.2.4.1
08.4	$2000 = 8.7^2 \times$ resistance resistance = $\frac{2000}{8.7^2}$ = 26.4 = 26 Ω (to two significant figures)		1 1 1 1	AO2 4.2.4.1
09.1	the energy from the Sun will not run out (in the immediate future)		1	AO1 4.1.3
09.2	4×10^{26} W		1	AO2 4.2.4.2
09.3	energy per year = power × time $= 500 \times 3.1\times10^{7}$ $= 1.55\times10^{10}$ J		1 1	AO2 4.2.4.2

Question	Answers	Extra information	Mark	AO / Specification reference
09.4	area needed = $\frac{7\times10^{18}}{1.55\times10^{10}}$ = 4.5×10^{8} m^2		1 1	AO2 4.1.3
10.1	($E_e = 0.5ke^2$) = $0.5 \times 500 \times 0.01^2$ = 0.025 J	accept 0.025 (J) with no working	1 1	AO2 4.1.1.2
10.2	at the top of the first bounce there is more energy in the gravitational potential energy store at the top of the second bounce the energy has been transferred to a gravitational potential energy store and the thermal energy store of the surroundings there is less energy in the gravitational potential energy store, so the second bounce is not so high		1 1 1	AO1 AO2 4.1.1.1 4.1.1.2
10.3	energy is transferred by forces/mechanically and by heating		1 1	AO1 AO2 4.1.1.1
11.1	the National Grid		1	AO1 4.2.4.3
11.2	both transformers change the potential difference the transformer near the power station/transformer 1 is a step-up transformer/increases the potential difference the transformer near the house/transformer 2 is a step-down transformer/decreases the potential difference		1 1 1	AO1 4.2.4.3

Question	Answers	Extra information	Mark	AO / Specification reference
11.3	(the energy is transferred at a high potential difference so) the current is small so the energy/power/heat lost is small		1 1	AO1 4.2.4.3
12.1	power = potential difference × current 9000 = 230 × current oven current = $\frac{9000}{230}$ = 39 A		1 1 1	AO1 AO2 4.2.4.1
12.2	power = potential difference × current 2000 = 230 × current toaster current = $\frac{2000}{230}$ = 8.7 A difference between oven and toaster = $\frac{39}{8.7}$ = 4.48 the current in the oven is over 4 times bigger		1 1 1 1	AO1 AO2 AO3 4.2.4.1
12.3	the current is very large, so the heating effect is very big the wire needs to be thicker so that there is less resistance and so less heating in the wire/the wire does not melt		1 1	AO2 4.2.4.1

Question	Answers	Extra information	Mark	AO / Specification reference
12.4	there is an earth wire connected to the casing of an appliance through which current flows if the casing becomes live/connected to the live wire		1 1	AO1 AO2 4.2.3.2
13.1	as the light intensity increases, the resistance decreases at a decreasing rate		1 1	AO2 4.2.1.4
13.2	the resistance of B also decreases with increased light intensity but after light intensity reaches 30 lux, resistance of B is constant whereas the resistance of A continues to go down		1 1 1	AO3 4.2.1.4
13.3	when the light level is 13 lux, the resistance of A is about 40 kΩ **either**: the total resistance = $(40\times10^3) + (100\times10^3) = 140\times10^3\ \Omega$ current in circuit = $\frac{V}{R} = \frac{6}{140\times10^8}$ = $4.28\text{x}10^{-5}$ A so potential difference across the light dependent resistor $V = IR = (4.28\times10^{-5}) \times (40\times10^3) = 1.7$ V so the potential difference across the resistor $V_{out} = 6 - 1.7 = 4.3$ V **or**: $V = \left(\frac{40\times10^8}{\left[100\times10^8+40\times10^8\right]}\right)\times6$ = 1.7 V so the potential difference across the resistor $V_{out} = 6 - 1.7 = 4.3$ V		1 **either** 1 1 1 **or** 1 1 1	AO1 A02 4.2.1.3 4.2.1.4 4.2.2

Question	Answers	Extra information	Mark	AO / Specification reference
13.4	light dependent resistor A for light dependent resistor B, the lowest value of the resistance of light dependent resistor B is 40 kΩ so the lowest potential difference across the light dependent resistor is 1.7 V so the maximum potential difference of V_{out} is 4.3 V (because they add up to 6 V) to get a potential difference that is higher than 5 V, you need the potential difference across the light dependent resistor to be lower (than 1 V) so you need a light dependent resistor that has a resistance that can go lower than 40 kΩ		1 1 1 1 1 1	AO1 AO2 4.2.2 4.2.1.4
14	**Level 3**: Calculations of power generated in **each** bulb in **each** circuit. The link between power and brightness is explicit and the statement about brightness is correct.	synoptic question involving ideas from the previous chapter	5-6	AO1 AO2 4.2.2 4.2.4.1
	Level 2: Calculations of currents in circuits and a comment linking current and resistance to power. Statements about brightness that follow from previous reasoning.		3-4	
	Level 1: Recognition that power depends on current and potential difference/resistance. A general statement that bulbs are brighter in parallel/less bright in series		1-2	
	No relevant comment.		0	

Question	Answers	Extra information	Mark	AO / Specification reference
	Indicative content: • the brightness of the bulb depends on the power generated in it, $P = I^2R$ • in series, the current through each bulb is the same ○ current = $\frac{\text{potential difference}}{\text{total resistance}} = \frac{12}{15}$ = 0.8 A ○ the 10 Ω lamp will have a power of $0.8^2 \times 10$ = 6.4 W ○ the 5 Ω lamp will have a power of $0.8^2 \times 5$ = 3.2 W ○ the 10 Ω lamp will be brighter. • in parallel the potential difference across each bulb is the same, 12 V ○ current through the 5 Ω lamp = $\frac{\text{potential difference}}{\text{total resistance}} = \frac{12}{5}$ = 2.4 A ○ current through the 10 Ω lamp will be 1.2 A (as the resistance is double, current will be half) ○ the 10 Ω lamp will have a power of $1.2^2 \times 10$ = 14.4 W ○ the 5 Ω lamp will have a power of $2.4^2 \times 5$ = 28.8 W ○ the 5 Ω lamp will be brighter			