Energy and Mains Electricity

Questions

Q1.

This question is about using the mains electricity supply.

(i) An electric kettle is used to boil some water.
The mains supply voltage is 230 V.
The power supplied to the kettle is 1.9 kW.

Calculate the current in the kettle.
Use the equation

$$I = \frac{P}{V}$$

(2)

current supplied to the kettle = ... A

(ii) A coffee machine takes 120 s to heat some water.

Mains supply voltage = 230 V
Current in this coffee machine = 7.4 A
Calculate the energy transferred to the coffee machine in 120 s.
Use an equation selected from the list of equations at the end of the paper.

(2)

energy transferred to coffee machine = ... J

(Total for question = 4 marks)

Q2.

(i) Figure 11 shows an electric kettle.

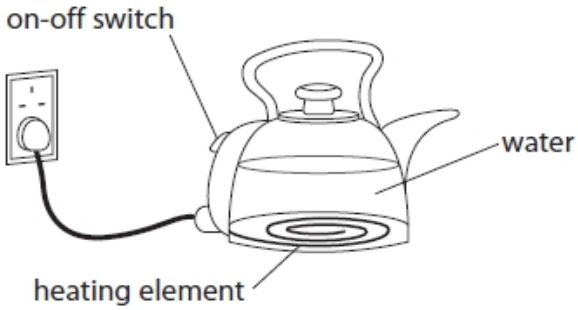

Figure 11

The kettle contains 1.5 kg of water.
The kettle is switched on.
Calculate the energy needed to raise the temperature of the water by 50 °C.
Specific heat capacity of water = 4200 J/kg °C
Use the equation

$$\Delta Q = m \times c \times \Delta\theta$$

(2)

energy needed = ... J

(ii) The amount of energy, *E*, needed to bring the water to boiling point is 670 000 J.

The kettle has a power of 3500 W.
Calculate the time, *t*, it takes to bring the water to boiling point.
Use the equation

$$P = \frac{E}{t}$$

(3)

time to bring the water to boiling point = ... s

(Total for question = 5 marks)

Q3.

A circuit is then set up with two resistors as shown in Figure 21.

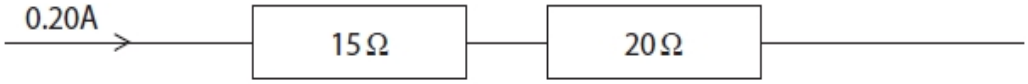

Figure 21

(i) Calculate the potential difference across the 15 Ω resistor.

(2)

potential difference = ... V

(ii) Calculate the total power dissipated when there is a current of 0.20 A in the two resistors.

Use the equation

$$P = I2 \times R$$

(2)

power produced ..... W

(Total for question = 4 marks)

Q4.

Figure 19 shows two electrical devices for heating water.

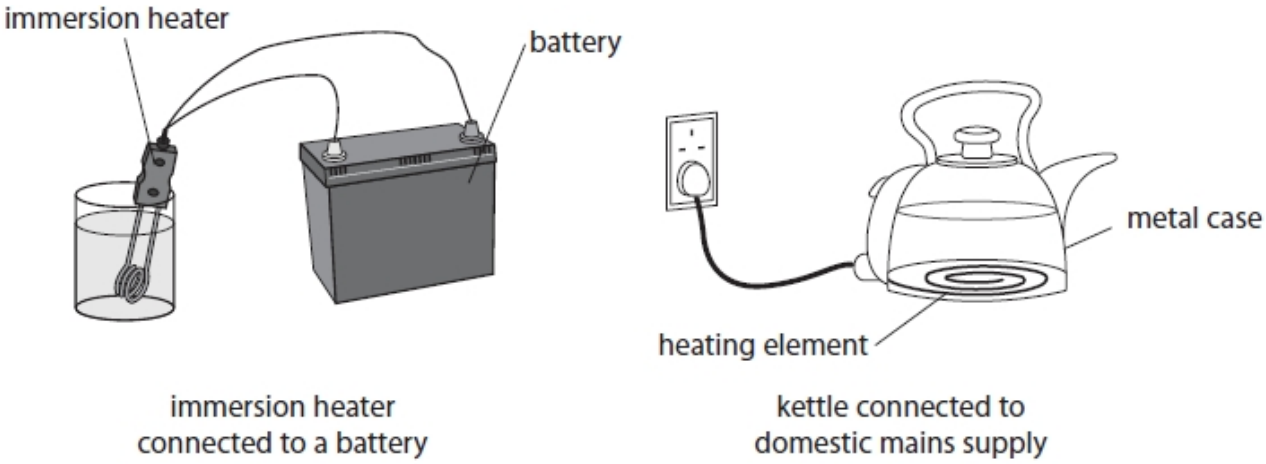

Figure 19

(i) The current in the element of the immersion heater is 14 A.

The power of the immersion heater is 130 W.
Calculate the resistance of the immersion heater.
Give your answer to two significant figures.

(3)

resistance of immersion heater = ... Ω

(ii) The current in the heating element of the kettle is 8.3 A.

State two differences between the movement of charge in the heating element of the kettle and the movement of charge in the immersion heater.

(2)

1 .....

.....

2 .....

.....

(Total for question = 5 marks)

Q5.

A lamp is connected to a potential difference of 0.24 V.

The current in the lamp is 0.12 A.

(i) Calculate the power of the lamp.
Use the equation
$P = I \times V$

(2)

power of the lamp = ... W

(ii) The potential difference is changed to 0.30 V.

The current in the lamp is now 0.13 A.
The lamp is switched on for 35 s.
Calculate the energy that is transferred in this time.
Select an equation from the list of equations at the end of this paper.

(2)

energy transferred = ... J

(iii) The current in the lamp stays at 0.13 A.

Calculate the charge that flows through the lamp in 35 s.
Use the equation
$Q = I \times t$

(2)

charge = ... C

(Total for question = 6 marks)

Q6.

A technician investigates different electrical devices that are used in a car.

The technician connects a device to the 12 V car battery.

The technician measures the current in the circuit and the potential difference (voltage) across the device.

Figure 17 shows the car battery and the device that is being tested.

Figure 17

(i) Draw on Figure 17 to show how the circuit should be completed so that the current in the circuit and voltage across the device can be measured.

(2)

(ii) The technician tests a headlamp.

The current in the headlamp is 4.8 A when connected to the 12 V battery.
Calculate the power supplied to the headlamp.

(2)

power = ... W

(iii) The technician tests an interior light.

The current in the interior light is 600 mA when connected to the 12 V battery.
Calculate the energy transferred to the interior light in 7 minutes.
Use an equation selected from the list of equations at the end of the paper.

(2)

energy transferred = ... J

(Total for question = 6 marks)

Q7.

Figure 4 shows the inside of a mains plug.

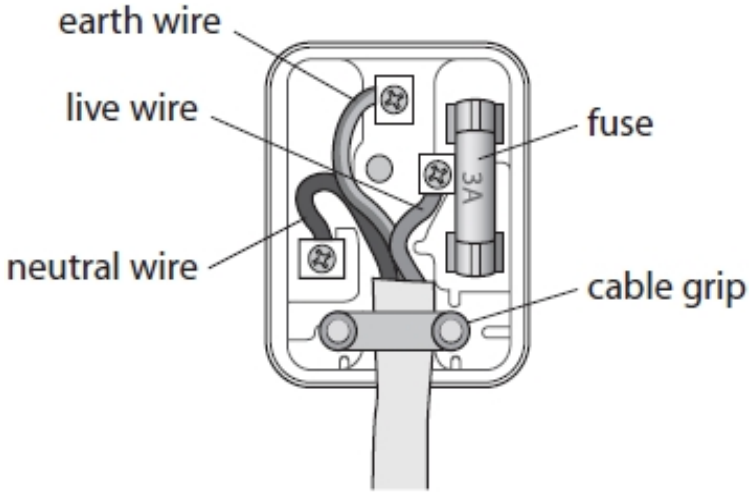

Figure 4

The mains plug has three safety features.

One of these safety features has been ticked in the table.

Put two more ticks in the table to show the other two safety features.

(2)

part of plug	safety feature
cable grip	✓
earth wire	
fuse	
live wire	
neutral wire	

(Total for question = 2 marks)

Q8.

A long piece of wire is made into a coil as shown in Figure 22.

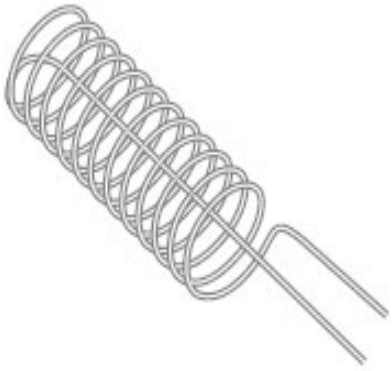

Figure 22

The coil is connected to a low voltage power supply.

Describe how this coil could be used instead of the Bunsen burner in Figure 20.

(2)

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(Total for question = 2 marks)

Q9.

A resistor is connected to a power supply.

The potential difference across the resistor is 6.0 V.

(i) Which of these corresponds to a potential difference of 6.0 V?

(1)

- ☒ A 6.0 joules per ohm
- ☒ B 6.0 amps per coulomb
- ☒ C 6.0 joules per coulomb
- ☒ D 6.0 amps per ohm

(ii) The resistor remains connected for a period of time.

The current in the resistor is 200 mA.
A total charge of 42 C flows through the resistor.
Calculate, in minutes, the time taken for this amount of charge to flow through the resistor.

(3)

time = ... minutes

(iii) Calculate the total energy transferred by the 6.0 V power supply when a charge of 42 C flows through the resistor.

(2)

energy = ... J

(Total for question = 6 marks)

Q10.

* Figure 18 shows a battery connected to a filament lamp.

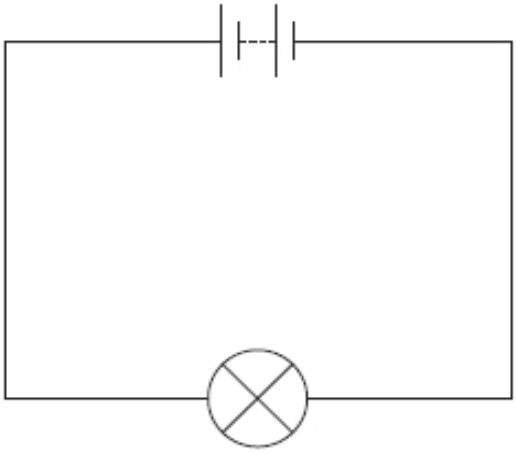

Figure 18

Explain, in terms of the movement of charged particles, how energy is transferred from the battery, through the lamp, to the surroundings.

(6)

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(Total for question = 6 marks)

Q11.

* Figure 20 shows the three-pin plug used to connect the kettle to the mains.

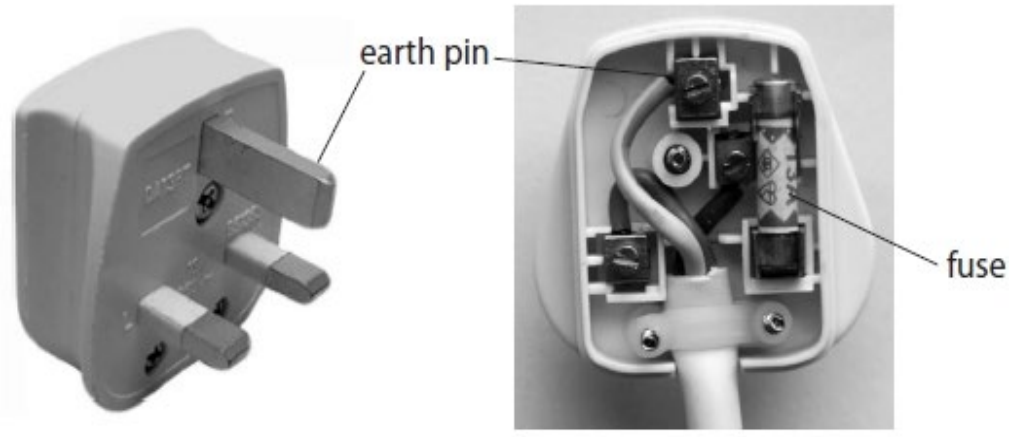

Figure 20

A fault occurs in the kettle causing the live wire to touch the metal case of the kettle.

Explain how the safety features of the plug operate when this fault occurs.

(6)

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(Total for question = 6 marks)

Q12.

This question is about using the mains electricity supply.

Figure 10 shows the inside of a mains plug.
The neutral wire is labelled.

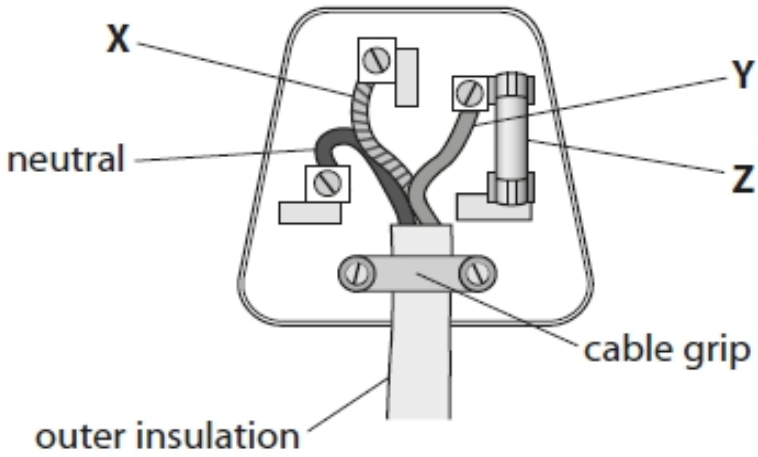


Figure 10

(i) State the name of wire X and the name of wire Y.

(2)

wire X .....

wire Y .....

(ii) State the name of component Z .

(1)

component Z .....

(Total for question = 3 marks)

Q13.

A student investigates resistors connected in series in an electrical circuit.

The student has

- a 3.0 V battery
- a 22 Ω resistor
- a resistor marked X.The student does not know the value of the resistor marked X.

The student decides to measure the potential difference (voltage) across resistor X.

Figure 15 shows the circuit that the student connected.

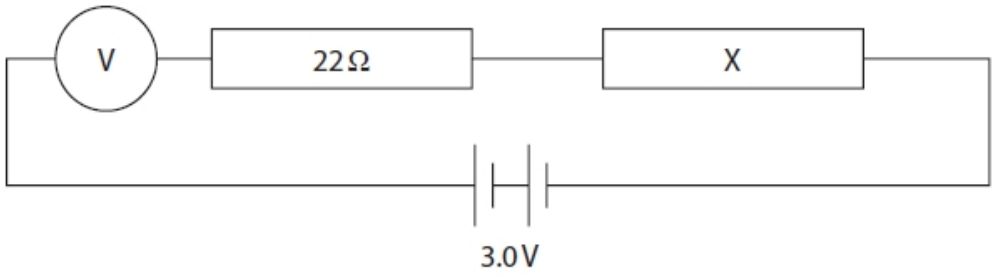


Figure 15

The circuit is connected incorrectly.

The student corrects the mistake.

The voltage across resistor X is 2.1 V.

The circuit is connected to a 3 V battery.

(i) State the value of the voltage across the 22 Ω resistor.

(1)

voltage across 22 Ω resistor = ... V

(ii) The current in resistor X is 0.041 A.

The voltage across resistor X is 2.1 V.
Show that the resistance of resistor X must be about 50 ohms.
Use the equation

$$V = I \times R$$

(2)

(iii) Calculate the power in resistor X when the voltage across X is 2.1 V and the current in resistor X is 0.041 A.

(2)

power = ... W

(iv) Calculate the overall resistance of the 22 ohm resistor and resistor X.

(2)

overall resistance = ... Ω

(v) The current in the circuit is 0.041 A.

The voltage across the battery is 3.0 V.
Calculate the energy transferred in 2 minutes.
Use the equation

$$E = I \times V \times t$$

(2)

energy = ... J

(Total for question = 9 marks)

Mark Scheme – Energy and Mains Electricity

Q1.

Question number	Answer	Additional guidance	Mark
i	substitution (1) $(I = \frac{P}{V}) = \frac{1.9 \text{ (x } 10^3\text{)}}{230}$ (1) evaluation (1) 8.3 (A)	 8.3 / 8.26 (A) award full marks for correct answer without working award one mark for 8.26×10^{-3} / 0.0083	**(2)** **AO2**

Question number	Answer	Additional guidance	Mark
ii	choice and substitution (1) $E = I \times V \times t$ = 7.4 x 230 x 120 evaluation (1) 200000 (J)	 accept 204000 / 204240 award full marks for correct answer without working award 1 mark for 3400 / 3404 (J) (using 2 minutes as time)	**(2)** **AO2**

Q2.

Question Number	Answer	Additional guidance	Mark
(i)	substitution (1) $(\Delta Q) = 1.5 \times 4200 \times 50$ evaluation (1) 320 000 (J)	 accept 315 000 (J) 310 000 (J) award full marks for the correct answer without working 320 000 000 315 000 000 310 000 000 score 1 mark (mass in grams)	**(2)**

Question Number	Answer	Additional guidance	Mark
(ii)	substitution (1) $3500 = \frac{670\,000}{t}$ rearrangement (1) $(t=) \frac{670\,000}{3500}$ evaluation (1) 190(s)	accept substitution and rearrangement in either order accept any answer that round to 190(s) power of ten error award 2 marks maximum award full marks for the correct answer without working	**(3)**

Q3.

Question number	Answer	Additional guidance	Mark
(i)	recall and substitution (1) V = 0.20 x 15 evaluation (1) 3 (V)	 7(V) gains 1 mark (use of 15 + 20) award full marks for the correct answer without working	(2)

Question number	Answer	Additional guidance	Mark
(ii)	addition and substitution (1) (P=) 0.20^2 x 35 evaluation (1) 1.4 (W)	 award full marks for the correct answer without working	(2)

Q4.

Question Number	Answer	Additional guidance	Mark
(i)	recall and substitution into $P = I^2 \times R$ (1) $130 = 14^2 \times R$ rearrangement (1) $R = \frac{130}{14^2}$ evaluation to **2 sig fig** (1) (R =) 0.66 (Ω)	substitution and rearrangement may be in either order alternative route: $V\ (= \frac{P}{I}) = \frac{130}{14}$ OR 9.3 V (1) $R\ (= \frac{V}{I}) = \frac{9.3}{14}$ (1) award full marks for the correct answer without working award 2 marks for 0.663.. or 0.67	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	**rate** of flow of charge in the immersion heater is greater than in the kettle / heating element (1) the direction of the flow of charge in the kettle / heating element keeps changing (whereas it remains in the same direction in the immersion heater) (1)	accept reverse arguments more charge per second in the immersion heater allow (in this context) faster (rate of) flow in immersion heater 14 coulombs per sec in immersion heater and 8.3 coulombs per sec in kettle / heating element flows both ways in the kettle / heating element (one way in the heater) simply referring to alternating current and direct current is not enough	(2)

Q5.

Question Number:	Answer	Additional guidance	Mark
(i)	substitution (1) (P)= 0.12 x 0.24 evaluation (1) 0.029 (W)	 accept 0.03 (W), 0.0288(W) 0.028 (W) power of ten error is awarded 1 mark award full marks for the correct answer without working	**(2)** AO 2 1

Question Number:	Answer	Additional guidance	Mark
(ii)	chooses /uses (1) E= V x I x t evaluation (1) 1.4 (J)	E =0.3 x0.13 x35 accept an answer that rounds to 1.4 (J) e.g. 1.365(J) a maximum of 1 mark is awarded in the case of a power of ten error award full marks for the correct answer without working	**(2)** AO 2 1

Question Number:	Answer	Additional guidance	Mark
(iii)	substitution (1) (Q)=0.13 x 35 evaluation (1) 4.6 (C)	 accept an answer that rounds to 4.6 e.g. 4.55 or in this context allow 4.5 power of ten error is awarded 1 mark award full marks for the correct answer without working	**(2)** AO 2 1

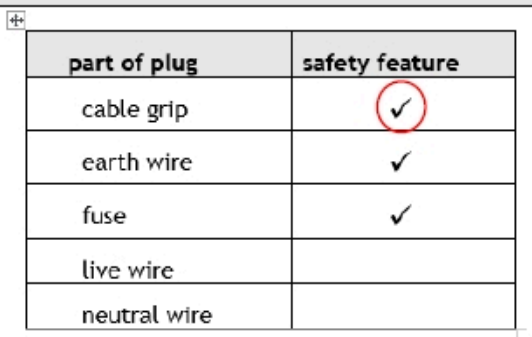
Q6.

Question number	Answer	Additional guidance	Mark
(i)	voltmeter connected in parallel with device (1) ammeter connected in series with device (1)	voltmeter connected in parallel with battery may be in top or bottom of circuit and could be inside or outside the voltmeter connections	(2) AO1

Question number	Answer	Additional guidance	Mark
(ii)	recall and substitution (1) (power =) 12 x 4.8 evaluation (1) (power =) 58 (W)	voltmeter connected in parallel with battery allow values that round to 58 e.g. 57.6 award full marks for the correct answer without working	(2) AO2

Question number	Answer	Additional guidance	Mark
(iii)	substitution (1) (power =) 12 x 600(/1000) x 7 (x60) evaluation (1) (energy =) 3000 (J)	allow values that round to 3000 e.g 3024 allow 1 mark for any other values of 3(.024) to any power of ten. if no other marks scored then award 1 mark for answers of 50,400 or 50.4 (substitution mark) award full marks for the correct answer without working.	(2) AO2

Q7.

Question number	Answer	Additional guidance	Mark
		Note that the tick next to cable grip is already in the grid more than two additional ticks deduct one mark for each incorrect tick.	**(2)**

Q8.

Question number	Answer	Additional guidance	Mark
	a description including two from: put the coil in the water (1) (electric) current in the wire/coil (1) thermal energy transferred (in the wire) (1)	 allow electricity for electric current heat(energy) in wire / temperature of wire increases/ produces heat/ gives energy/ to heat the water	**(2)**

Q9.

Question Number:	Answer	Mark
(i)	C 6.0 joules per coulomb **The only correct answer is C** ***A** is not correct because 1 volt is 1 joule per coulomb* ***B** is not correct because 1 volt is 1 joule per coulomb* ***D** is not correct because 1 volt is 1 joule per coulomb*	**(1)** AO 1 1

Question Number:	Answer	Additional Guidance	Mark
(ii)	recall and substitution (1) $42 = \frac{200 \times t}{(1000)}$ rearrangement (1) $t = \frac{42\ (\times 1000)}{200\ (\times 60)}$ evaluation (1) (t =) 3.5 (minutes)	accept substitution and rearrangement in either order 2.1 to any power of 10 or 3.5 to any power of 10 scores 2 marks 3 minutes 30 seconds award full marks for correct answer without working	**(3)** AO 1 1 AO 2 1

Question Number:	Answer	Additional Guidance	Mark
(iii)	recall and substitution (1) (E =) 42 x 6.0 evaluation (1) (energy =) 250 (J)	(using E = VIt) (E =) 6.0 x 200 (x 10^{-3}) x 2.10 (x 10^{2}) accept 252 (J) award full marks for correct answer without working	**(2)** AO 1 1 AO 2 1

Q10.

Question Number	Answer	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • the batteries store energy as chemical energy • the energy is transferred to electrons to make them flow/move • the current is a flow of electrons • the electrons flow through the metal/filament • the electrons collide with the ions in the lattice • the collisions make the ions vibrate more • the increased vibrations makes the lattice/filament hotter • the heat energy is dissipated to the surroundings • the ions give out/emit light	**(6)**

Descriptor
• No rewardable material.
• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Level	Mark	Additional Guidance	General additional guidance – the decision within levels Eg - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance unlinked statements	Possible candidate responses Particles move through the wire Batteries store energy Lamp gives off heat
Level 2	3–4	Additional guidance Limited explanation **linking** facts about particles OR **linking** facts about energy transfers	Possible candidate responses Electrons move through the wire/lamp OR The particles moving in the wire are electrons OR Particles collide in the wire OR Chemical energy (stored) in battery OR Energy dissipated / {released as light or thermal} energy in surroundings OR Energy is transferred electrically (from battery to lamp)

Q11.

Question Number	Answer	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. AO1(6 marks) AO1 Earth • earth wire connected to metal case • metal case is a conductor • (when live touches case) resistance between live and earth is very low • (very) large current to earth through (low resistance) earth wire • case is kept at same potential as earth • so cannot get a shock if (earthed) person touches metal case Fuse • made of thin wire • fuse connected between live pin and wire to kettle • temperature of wire depends on current in it • when the current is (very) large, the temperature of the wire increases beyond melting point of wire • fuse (wire) breaks • disconnects mains supply to kettle • prevents damage to house wiring • (now) there is no possibility of live wire in kettle being at mains voltage	**(6)**

Descriptor
• No rewardable material.
• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Summary for guidance			
Level	**Mark**	**Additional Guidance**	**General additional guidance – the decision within levels** e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance isolated facts about either fuse or earth	Possible candidate responses The fuse blows when there is a fault. The earth stops you from getting shock
Level 2	3–4	Additional guidance facts about fuse and earth that are linked to provide an explanation of the operation of either the fuse or the earth. OR a well-developed explanation of the operation of fuse or earth	Possible candidate responses The earth wire is connected to the (metal) case of the kettle. The wire in fuse melts when current becomes too big. OR A large current flows through the wires in the kettle. The wire in the fuse heats up and melts. This disconnects the kettle from the mains supply.
Level 3	5–6	Additional guidance explanation of the operation of both the fuse and the earth one explanation may be more developed than the other but both fuse and earth must be explained.	Possible candidate responses A large current flows through the wires in the kettle. The wire in the fuse heats up and melts. The earth wire keeps (exposed) metal parts at earth potential and prevents shocks

Q12.

Question number	Answer	Additional guidance	Mark
i	Wire X .....earth.....(1) Wire Y .....live..... (1)	accept 'life'	(2) AO1

Question number	Answer	Additional guidance	Mark
ii	Component Z ....fuse..... (1)		(1) AO1

Q13.

Question number	Answer	Additional guidance	Mark
(i)	0.9 (v)	0.90 ignore units ignore calculations	(1)

Question number	Answer	Additional guidance	Mark
(ii)	substitution (1) $R = \frac{2.1}{0.041}$ evaluation (1) R = 51(.2) (Ω) (which is approx. 50 (Ω))	allow (V) = 0.041 x 50 V = 2.05 (v) (which is approx. 2.1) allow R = 51(.2) (Ω) with no working for 2 marks	(2)

Question number	Answer	Additional guidance	Mark
(iii)	recall and substitution (1) (P) = 2.1 x 0.041 evaluation (1) (P =) 0.086 (W)	 allow any value that rounds to 0.086; e.g. 0.0861 (W) 0.09 (W) award full marks for the correct answer without working allow POT error for 1 mark	(2)

Question number	Answer	Additional guidance	Mark
(iv)	recall that effective resistance = sum of individual resistances (1) (resistance =) 50 + 22 evaluation (1) 72 (Ω)	 51 + 22 73 (Ω) award full marks for the correct answer without working	(2)

Question number	Answer	Additional guidance	Mark
(v)	substitution (1) (E =) 3.0 x 0.041 x 2 (x60) evaluation (1) 15 (J)	 accept values that round to 15; e.g. 14.76 award full marks for the correct answer without working award 1 mark for answer of 0.246 (J) or 0.25 (J) without working	(2)