Solution 5·6 Year 11
Answer 1

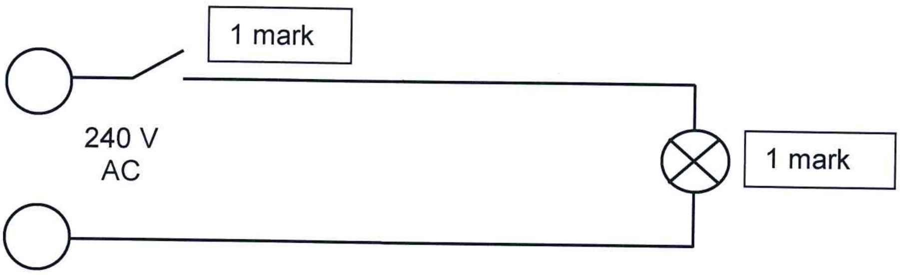
(14 marks)

Adam returns from Singapore with a lamp only to find that the plug on the lamp does not fit the power outlets in Australia. The lamp consists of a plug, a switch and a globe. The tag on the lamp says it is designed for a 110 V power supply. The Australian power supply voltage is 240 V.


Lamp


Lamp plug

(a) Using appropriate circuit symbols complete the circuit diagram for this lamp when connected to the 240V AC power supply. (3 marks)



The globe in the lamp is marked '110 V, 0.60 A'.

Description	Marks
Each component shown	1–2
Switch and globe in series	1
	Total 3

(b) What is the power rating of this globe when it is used in Singapore? (2 marks)

Description	Marks
$P = VI = 110 \times 0.6$	1
$= 66$ W	1
	Total 2

(c) What is the theoretical resistance of this globe under these conditions? (2 marks)

Description	Marks
$R = V/I = 110/0.6$	1
$= 183\ \Omega$	1
	Total 2

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Answer 1 continued

(d) Adam buys a plug suitable for Australian power outlets, cuts the Singaporean plug from the wires and connects the Australian plug. Assuming that he has wired it correctly, is the lamp now safe to use in Australia? Explain. (2 marks)

Description	Marks
No. If R is constant then higher V will draw more than double the current which will probably exceed the current rating of the wiring.	1–2
Or	
Yes. If R is increased, as in (e) below then current ($I = \frac{V}{R}$) will be less so wiring is safe.	1–2
	Total 2

(e) The original 110 V globe is changed to an Australian-made globe with a power rating of 75 W. What is the theoretical resistance of the new globe when it is connected to the Perth electricity supply? (3 marks)

Description	Marks
$R = \frac{V^2}{P}$	1
$= \frac{240^2}{75}$	1
$= 768\ \Omega$	1
	Total 3

(f) In (c) you were asked to calculate the theoretical resistance. This is because an operating globe is a non-ohmic conductor. Explain what is meant by the term 'non-ohmic conductor'. (2 marks)

Description	Marks
V not proportional to I – Does not obey Ohm's Law	1–2
	Total 2

Answer 2

(3 marks)

Many multi-outlet power boards are rated for a maximum current of 7.50 A. Why should we **not** connect a portable electric heater that is rated at 240 V, 2.4 kW to such a board? Explain, showing relevant calculations.

Description	Marks
Current drawn by heater $= \frac{P}{V} = \frac{2400}{240}$	1
$= 10$ A	1
This exceeds the safe design current of the power board.	1
	Total 3

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Answer 3

(4 marks)

A hair dryer was used for 10.0 minutes to dry a person's wet hair. When the hair dryer was connected to a 240 V supply, it drew a current of 4.80 A.

(a) How much charge passed through the coil of the hair dryer in this time? (2 marks)

(b) Calculate the power of the hair dryer. (2 marks)

Description	Marks
(a) q=It = 4.8H10H 60	1
= 2.88H10^3 Coulombs	1
(b) P=VI = 240H4.8	1
P= 1.15 kW	1
	Total 4

Answer4

(4 marks)

A calculator uses a 6.00 V battery and is rated at 0.500 W. Calculate the overall resistance of the electric circuit in the calculator. Give the appropriate units with your answer.

Description	Marks
$P = V^2/R$ therefore $R = V^2/P$	1
$= 6^2 / 0.5$	1
72.0	1
Ω	1
Total	**4**

Answer 5

(a) The article states that 70.0 MW of thermal (heat) power are converted into 25.0 MW of electrical power. Explain why there is a difference in the quantities. (2 marks)

Description	Marks
The missing energy is waste heat	1
It is released into the environment through the cooling towers or Energy conversions are not 100% efficient	1
Total	**2**

(b) The last paragraph states that the nuclear reactor can be used to replace an existing diesel-fuelled generator. In the diagram on page 30, circle the part of the power station that would be the same as for a diesel-fuelled power station. (1 mark)

Description	Marks
Circle around electrical section, can include cooling system, but not reactor.	1
Total	**1**

(c) Using the concept of neutron-induced fission, explain how the boron carbide is able to 'shut-down' the nuclear reactor. (2 marks)

Description	Marks
The boron carbide absorbs the neutrons	1
Therefore fewer neutrons available for fission events to occur	1
Total	**2**

(d) (i) Choose one point from the table or the article on page 30 that illustrates an advantage of using the HPM instead of a Fukushima-type of nuclear power station and explain why you believe it to be an advantage. (2 marks)

Description	Marks
Advantage, e.g. underground location	1
Related explanation, e.g. improved environmental isolation	1
Total	**2**

(ii) Although advances in nuclear reactors have made nuclear power safer and more easily managed, there are still some problems. Using information from the article, the table or your course work, choose one point that illustrates a problem of nuclear power stations and explain why you believe it to be a problem. (2 marks)

Description	Marks
Problem, e.g. storage or disposal of spent fuel	1
Related explanation, e.g. waste is both toxic and radioactive	1
Total	**2**

(e) Most power stations are able to provide electrical power at a potential difference of 1.10×10^4 V to local areas through a substation. Given an HPM produces 25.0 MW of electricity for a local area at 1.10×10^4 V, calculate the amount of current that is available. (3 marks)

Description	Marks
25.0 MW=25 000 000 W	1
I = 25 000 000/11 000	1
= 2.27×10^3 A	1
Total	**3**

(f) Over its 10 year operational life, the plant will convert the binding energy of nuclides through fission processes to produce a continuous output of 70.0 MW of thermal power.

(i) Calculate how many joules of energy the reactor would deliver over the 10 year period. (2 marks)

Description	Marks
$E = P \times t = 70\,000\,000 \times 10 \times 365 \times 24 \times 60 \times 60$	1
$= 2.21 \times 10^{16}$ J	1
Total	**2**

(ii) Using the calculated energy in (i) and the formula $E=mc^2$, determine the decrease in the mass of the nuclear reactor during this time. If you were unable to determine a value for energy in (i) use 2.00×10^{17} J. (3 marks)

Description		Marks
$E = mc^2 = 2.21 \times 10^{16}$	$E = mc^2 = 2 \times 10^{17}$	1
$m = 2.21 \times 10^{16}/(3 \times 10^8)^2$	$m = 2 \times 10^{17}/(3 \times 10^8)^2$	1
m = 0.245 kg	m = 2.22 kg	1
	Total	**3**