Chapter 5·6 Exam Q Year 11

Question 1

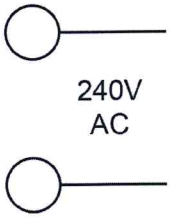
(14 marks)

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'.

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

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

(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)

(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)

(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)

Question 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.

Question 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)

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Question 4

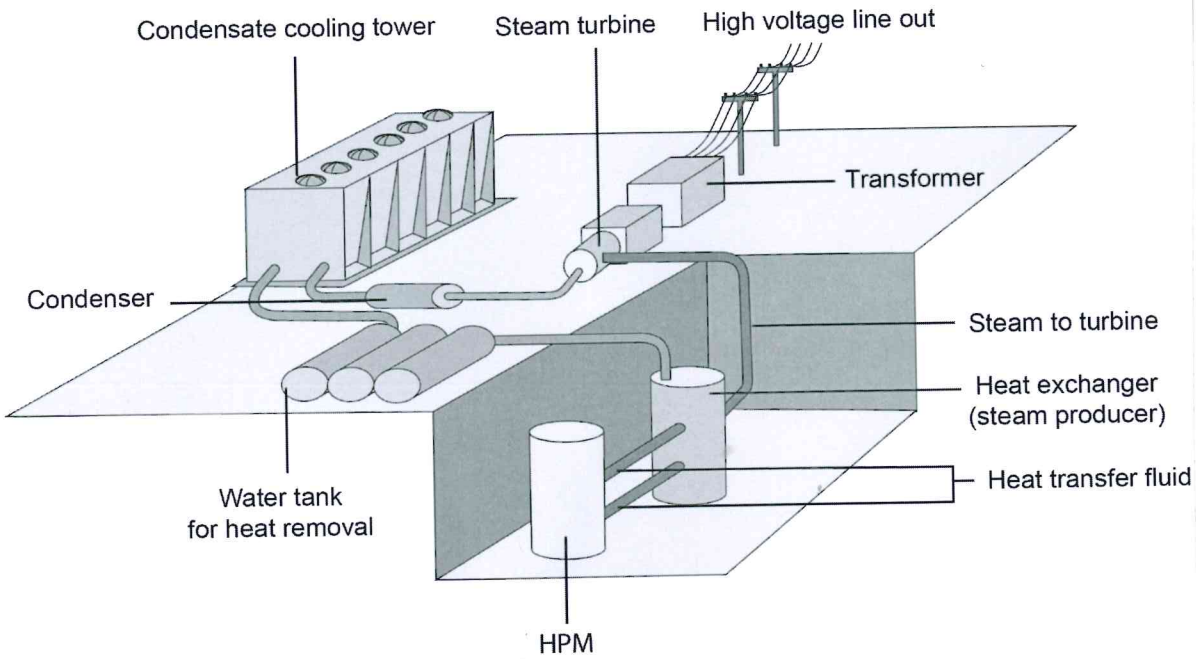
(4 marks)

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.

Question 5

(17 Marks)

Hyperion Power Generation Inc. is developing a next generation nuclear reactor called the Hyperion Power Module (HPM). It is a liquid metal-cooled small modular nuclear reactor that employs boron carbide (B_4C) control rods to control the reaction. Fuelled by uranium nitride, the HPM has an output of 70.0 megawatts (MW) of thermal power, which is converted to 25.0 MW of electrical power for a 10-year lifetime, without refuelling.



The HPM produces 25.0 MW of electricity that could power remote mining, oil and gas operations, large government complexes or remote and island communities. A smaller nuclear reactor such as this is more appropriately sized for smaller generation requirements, and can directly replace existing diesel-fuelled generators. It requires no upgrading of existing small electricity distribution systems. The HPM was designed so that it will provide safe and reliable power that is always available and emits no greenhouse gases. It will be manufactured in a factory, transported to the installation site completely sealed, and after its useful life has been reached, replaced with an entirely new power module.

(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)

(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)

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Question 5 continued

(c) The safety control system includes three independent shut down systems in the core: a shutdown rod system composed of six boron carbide rods, a control rod system comprising 12 boron carbide rods and a reserve shutdown system consisting of a central cavity into which boron carbide balls may be inserted. Each of the three systems can independently take the core to long-term cold shutdown. The rod shutdown and the ball shutdown systems perform this safety function automatically and instantaneously when triggered.

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

(d) Following the tsunami and nuclear incident near Fukushima, Japan in March 2011, there has been worldwide concern for the prevention of similar events in the future. The technology has improved over time and some differences between the Fukushima and Hyperion Power Module nuclear reactors are listed in the table below.

	Fukushima reactor	HPM reactor	Improvement
Design era	1950s–1960s	2000s–2010s	Incorporates 50 years of reactor operating experience
Coolant	Water (boils at 100°C)	Pb-Bi Metal (boils at >1700°C)	Coolant is highly unlikely to ever evaporate
Containment	Aboveground structure	Underground silo	Better environmental isolation
Decay heat removal	Active, electric power needed	Passively safe for more than 14 days	Less susceptible in accident scenarios
Size	Large	Small	Simplified earthquake resistance

(i) Choose one point from the table or the article 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)

(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)

(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 that 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)

(f) Over its 10.0 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 10.0 year period. (2 marks)

(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)