Practice Question Set For A-Level
Subject : Physics
Paper-2 Topic: Thermal Physics

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Name of the Student:_____
Max. Marks : 21 Marks **Time : 21 Minutes**

Q1.

In a nuclear reactor the mean energy produced by each uranium-235 nucleus that undergoes induced fission is 3.0×10^{-11} J. In one pressurised water reactor, PWR, the fuel rods in the reactor contain 2.0×10^{4} kg of uranium-235 and 40% of the energy produced per second is converted to 500 MW of electrical output power. It is assumed that all the energy produced in the reactor core is removed by pressurised water in the coolant system. The pressure of the water is approximately 150 times greater than normal atmospheric pressure. The water enters the reactor at a temperature of 275 °C ad leaves at a temperature of 315 °C. Under the operational conditions of the reactor the mean density of water in the coolant circuit is 730 kg m^{-3} and the specific heat capacity of water is approximately 5000 J kg^{-1} K^{-1}.

normal atmospheric pressure = 1.0×10^{5} Pa
molar mass of uranium-235 = 0.235 kg

(a) The equation below gives one induced fission reaction that takes place in a reactor.

$$^{235}_{92}\mathrm{U} + {}^{1}_{0}\mathrm{X} \Rightarrow {}^{n}_{56}\mathrm{Br} + {}^{90}_{p}\mathrm{Kr} + 2{}^{1}_{0}\mathrm{X}$$

(i) State the name of the particle represented by **X**.

_____

(1)

(ii) State the proton and nucleon numbers represented by *p* and *n*.

p _____

n _____

(2)

(b) (i) Calculate the number of fission reactions that occur in the reactor each second.

number of fission reactions per second _____

(2)

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(ii) The reactor fuel rods contain 2.0×10^4 kg of uranium-235. Assume that all this uranium-235 could be used.
Calculate the maximum time, in years, for which the reactor could operate.

time _____ years

(4)

(iii) Suggest why it is not possible to use all the uranium-235 in the reactor fuel rods.

_____

_____

_____

_____

(2)

(c) Calculate the force exerted by the pressurised water on each square centimetre of the wall of the reactor.

force _____ N

(2)

(d) Calculate, in $m^3\ s^{-1}$, the flow rate of the water through the PWR reactor.
You will need to use data from the passage at the beginning of the question.

flow rate _____ $m^3\ s^{-1}$

(4)

(e) In a PWR the cooling water also acts as the moderator in the reactor and boron rods are used to control the power output. Describe the physical processes that take place in the moderator and control rods.

_____

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(4)

(Total 21 marks)

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