Name of the Student:_____
Max. Marks : 18 Marks **Time : 18 Minutes**

Q1.

In the research into nuclear fusion one of the most promising reactions is between deuterons $\left({}_{1}^{2}H\right)$ and tritium nuclei $\left({}_{1}^{3}H\right)$ in a gaseous plasma. Although deuterons can be relatively easily extracted from sea water, tritium is difficult to produce. It can, however, be produced by bombarding lithium-6 $\left({}_{3}^{6}Li\right)$ with neutrons. The two reactions are summarised as:

$${}_{1}^{2}H + {}_{1}^{3}H \rightarrow {}_{2}^{4}He + {}_{0}^{1}n + \text{energy}$$

$${}_{3}^{6}Li + {}_{0}^{1}n \rightarrow {}_{1}^{3}H + {}_{2}^{4}He + \text{energy}$$

Masses of reactants:

${}_{0}^{1}n$ = 1.008665u

${}_{1}^{2}H$ = 2.013553u

${}_{1}^{3}H$ = 3.016049u

${}_{2}^{4}He$ = 4.002603u

${}_{3}^{6}Li$ = 6.015122u

1u is equivalent to 1.66×10^{-27} kg or 931 MeV

(a) (i) Explain why the atomic mass unit, u, may be quoted in kg or MeV.

_____

_____

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_____

(2)

(ii) Calculate the maximum amount of energy, in MeV, released when 1.0 kg of lithium-6 is bombarded by neutrons.

_____

_____

energy released _____ MeV

(5)

(iii) Suggest why the lithium-6 reaction could be thought to be self-sustaining once the deuteron-tritium reaction is underway.

(1)

(b) (i) In order to fuse, a deuteron and a tritium nucleus must approach one another to within approximately 1.5×10^{-15} m.
Calculate the minimum total initial kinetic energy that these nuclei must have.

minimum total kinetic energy of nuclei _____ J

(3)

(ii) Show that a temperature of approximately 4×10^{9} K would be sufficient to enable this fusion to occur in a gaseous plasma.

(3)

(iii) Explain in terms of the forces acting on nuclei why the deuteron-tritium mixture must be so hot in order to achieve the fusion reaction.

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(4)
(Total 18 marks)