895.

Problem 55.53 (RHK)

Suppose we had a quantity of N deuterons (^{2}H *nuclei*). (a) *We have to find which one of the following procedures for fusing these N nuclei releases more energy, and how much more*. (A) $N/2$ *fusion reactions of the type* $^2\mathrm{H} + {}^2\mathrm{H} \rightarrow {}^3\mathrm{H} + {}^1\mathrm{H} \quad (Q = +4.03\ \mathrm{MeV})$, *or* (B) $N/3$ *fusion reactions of the type* $^2\mathrm{H} + {}^3\mathrm{H} \rightarrow {}^4\mathrm{He} + \mathrm{n} \quad (Q = +17.59\ \mathrm{MeV})$, *using* $N/3$ *nuclei of* ^{3}H *that are first made in* $N/3$ *reactions of the type* A. (b) *We have to list the ultimate product nuclei resulting from the two procedures and the quantity of each*.

Solution:

(a)

In $N/2$ fusion reactions of the type (A)

$^2\mathrm{H} + {}^2\mathrm{H} \rightarrow {}^3\mathrm{H} + {}^1\mathrm{H} \quad (Q = +4.03\ \mathrm{MeV})$

the total energy released will be

$= \frac{4.03N}{2}$ MeV $= 2.015N$ MeV.

We consider next the process of type (B). In $N/3$ reactions of the type A the energy released will be

$= \frac{4.03N}{3}$ MeV $= 1.343N$ MeV,

and $2N/3$ deuteron nuclei $^2\mathrm{H}$ would have fused and $N/3$ nuclei of $^3\mathrm{H}$ would have formed. These $N/3$ nuclei of $^3\mathrm{H}$ fuse with the remaining $N/3$ nuclei of $^2\mathrm{H}$ by the process

$^2\mathrm{H} + {}^3\mathrm{H} \rightarrow {}^4\mathrm{He} + \mathrm{n} \quad (Q = +17.59 \text{ MeV})$,

and released additional energy

$= \frac{17.59N}{3}$ MeV $= 5.863N$ MeV.

Thus the total energy released in the fusion of N deuteron, $^2\mathrm{H}$, nuclei would be

$= (1.343N + 5.863N)$ MeV $= 7.206N$ MeV.

We note that when N nuclei $^2\mathrm{H}$ fuse with the process (B) , excess energy of amount $5.191N$ MeV would be released.

(b)

The ultimate products of fusion process of the type (A) will be $N/2$ nuclei of $^{3}\mathrm{H}$, and $N/2$ protons.

And, the ultimate products of fusion process of the type (B) will be $N/3$ nuclei of $^{4}\mathrm{He}$, and $N/3$ protons and neutrons each.