by the fusion are also forced to remain inside the plasma. Their kinetic energy is lost into the plasma itself contributing further rise in temperature. Again the lasers are operated in pulses of short duration.

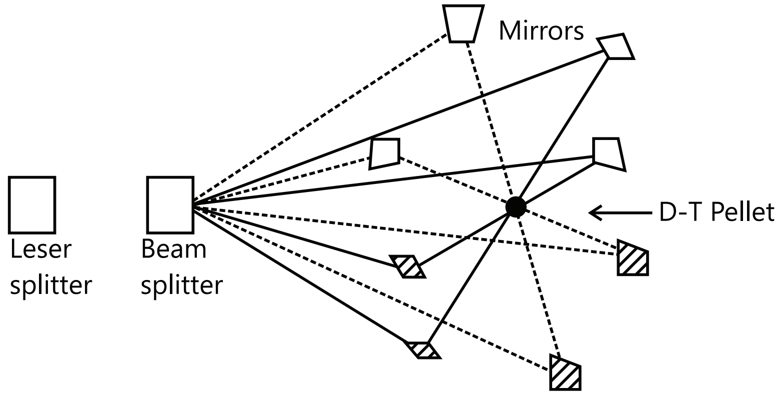

Figure 25.12

The research in fusion energy is going on. Fusion is the definite and ultimate answer to our energy problems. The 'fuel' used for fusion on earth is deuterium which is available in natural water (0.03%). And with oceans as the almost unlimited source of water, we can be sure of fuel supply for thousands of years. Secondly, fusion reactions are neat and clean. Radioactive radiation accompanying fission reactors will not be there with fusion reactors.

11.5 Nuclear Holocaust

Nuclear holocaust refers to a possible nearly complete annihilation of human civilization by nuclear warfare. Under such a scenario, all or most of the Earth is made uninhabitable by nuclear weapons in future word wars.

PROBLEM-SOLVING TACTICS

1. Problems from this section do not need any mathematically difficult involvement. One only needs to focus on exponential functions and its properties.

2. Questions related to energy can easily be solved by thinking.

3. For e.g. consider energy as money and think of it in terms of loss and gain, But overall total money is conserved i.e. total energy is conserved; only it is exchanged. One must not be worried with the relation $E = mc^2$ at this stage and just consider mass and energy as equivalent. So, if more clearly stated this equivalent quantity is conserved in every process.

4. Mostly, questions related to basic understanding of Nuclear force are asked rather than which involve complicated calculations.

5. Statistics must always be kept in mind while solving a problem of radioactive decay.

FORMULAE SHEET

1. After n half-lives

(a) Number of nuclei left $= N_0\left(\frac{1}{2}\right)^n$

(b) Fraction of nuclei left $= \left(\frac{1}{2}\right)^n$ and

(c) Percentage of nuclei left $= 100\left(\frac{1}{2}\right)^2$

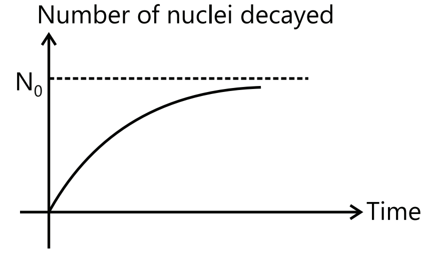

Figure 25.13

2. Number of nuclei decayed after time $t = N_0 - N$

$= N_0 - N_0 e^{-\lambda t} = N_0(1 - e^{-\lambda t})$

The corresponding graph is as shown in Fig. 25.13.

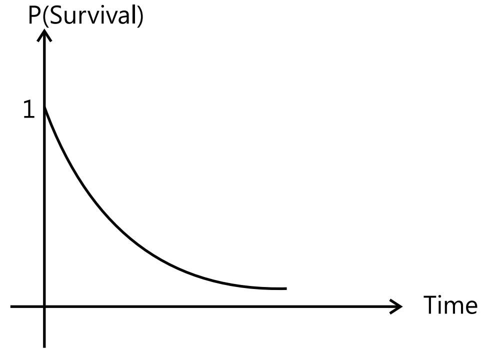

Figure 25.14

3. Probability of a nucleus for survival of time t,

$$P(\text{survival}) = \frac{N}{N_0} = \frac{N_0 e^{-\lambda t}}{N_0} = e^{-\lambda t}$$

The corresponding graph is shown in Fig. 25.14.

4. Probability of a nucleus to disintegrate in time t is,

$P(\text{disintergration}) = 1 - P(\text{survival}) = 1 - e^{-\lambda t}$

The corresponding graph is as shown.

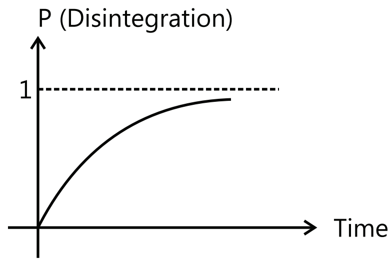

Figure 25.15

5. Half-life and mean life are related to each other by the relation, $t_{1/2} = 0.693 t_{av}$ or $t_{av} = 1.44 t_{1/2}$

6. As we said in point number (2), number of nuclei decayed in time t are $N_0(1 - e^{-\lambda t})$. This expression involves power of e. So to avoid it we can use, $\Delta N = \lambda N \Delta t$ where, ΔN are the number of nuclei decayed in time Δt, at the instant when total number of nuclei are N. But this can be applied only when $\Delta t << t_{1/2}$.

7. In same interval of time, equal percentage (or fraction) of nuclei are decayed (or left un decayed).

1. $R = R_0 A^{1/3}$

2. $\Delta E_{be} = \sum(mc^2) - Mc^2$ (binding energy)

3. $\Delta E_{ben} = \frac{\Delta E_{be}}{A}$ (binding energy per nucleon.)

4. $\frac{dN}{N} = -\lambda dt$

5. $N = N_0 e^{-\lambda t}$ (radioactive delay),

6. $\tau = \frac{1}{\lambda}$

7. $T_{1/2} = \frac{\ln 2}{\lambda} = \tau \ln 2.$

Solved Examples

JEE Main/Boards

Example 1: Sun radiates energy in all direction. The average energy received at earth is 1.4 kW/m^2. The average distance between the earth and the sun is 1.5×10^{11} m. If this energy is released by conversion of mass into energy, then the mass lost per day by sun is approximately (use 1 day = 86400 sec)

Sol: The sun produces energy by fusion reaction of hydrogen atoms. The loss in mass of sun is calculated using $\Delta m = \frac{\Delta E}{c^2}$ where ΔE is the amount of energy released during the day.

The sun radiates energy in all directions in a sphere. At a distance R, the energy received per unit area per second is 1.4 KJ (given). Therefore the energy released in area $4\pi R^2$ per sec is $1400 \times 4\pi R^2$ J the energy released per day = $1400 \times 4\pi R^2 \times 86400$ J

Where $R = 1.5 \times 10^{11}$m, thus

$\Delta E = 1400 \times 4 \times 3.14 \times (1.5 \times 10^{11})^2 \times 86400$