Exercise - IV (TOUGH SUBJECTIVE PROBLEMS)

1. The kinetic energy of an α - particle which flies out of the nucleus of a Ra^{226} atom in radioactive disintegration is 4.78 MeV. Find the total energy evolved during the escape of the α-particle.

2. A small bottle contains powdered beryllium Be & gaseous radon which is used as a source of α-particles. Neutrons are produced when α - particles of the radon react with beryllium. The yield of this reaction is (1/4000) i.e. only one α-particle out of 4000 induces the reaction. Find the amount of radon (Rn^{222}) originally introduced into the source, if it produces 1.2×10^6 neutrons per second after 7.6 days. [$T_{1/2}$ of R_n = 3.8 days]

3. When thermal neutrons (negligible kinetic energy) are used to induce the reaction ;
$^{10}_{5}B + ^{1}_{0}H \rightarrow ^{7}_{3}Li + ^{4}_{2}He$. α – particles are emitted with an energy of 1.83 MeV.
Given the masses of boron neutron & He^4 as 10.01167, 1.00894 & 4.00386 u respectively. What is the mass of $^{7}_{3}Li$? Assume that particles are free to move after the collision.

4. Show that in a nuclear reaction where the outgoing particle is scattered at an angle of 90° with the direction of the bombarding particle, the Q-value is expressed as

$$Q = K_P\left(1+\frac{m_P}{M_O}\right) - K_1\left(1+\frac{m_1}{M_O}\right)$$

Where, I = incoming particle, P = product nucleus, T = target nucleus, O = outgoing particle.

5. A body of mass m_0 is placed on a smooth horizontal surface. The mass of the body is decreasing exponentially with disintegration constant λ. Assuming that the mass is ejected backward with a relative velocity u. Initially the body was at rest. Find the velocity of body after time t.

6. A radionuclide with disintegration constant λ is produced in a reactor at a constant rate α nuclei per sec. During each decay energy E_0 is released. 20% of this energy is utilised in increasing the temperature of water. Find the increase in temperature of m mass of water in time t. Specific heat of water is S. Assume that there is no loss of energy through water surface.

7. U^{238} and U^{235} occur in nature in an atomic ratio 140 : 1. Assuming that at the time of earth's formation the two isotopes were present in equal amounts. Calculate the age of the earth.
(Half life of u^{238} = 4.5×10^9 yrs & that of U^{235} = 7.13×10^8 yrs)

8. An experiment is done to determine the half-life of radioactive substance that emits one β-particle for each decay process. Measurement show that an average of 8.4 β are emitted each second by 2.5 mg of the substance. The atomic weight of the substance is 230. Find the half life of the substance.

9. A wooden piece of great antiquity weight 50 gm and shows C^{14} activity of 320 disintegrations per minute. Estimate the length of the time which has elapsed since this wood was part of living tree, assuming that living plants show a C^{14} activity of 12 disintegrations per minute per gm. The half life of C^{14} is 5730 yrs.

10. The element Curium $^{248}_{96}Cm$ has a mean life of 10^{13} seconds. Its primary decay modes are spontaneous fission and α decay, the former with a probability of 8% and the latter with a probability of 92%. Each fission releases 200 MeV of energy. The masses involved in α decay are as follows :
$^{248}_{96}Cm$ = 248.0.072220 u, $^{248}_{96}Pu$ = 244.064100 u & $^{4}_{2}He$ = 4.002603 u.
Calculate the power output from a sample of 10^{20} Cm atoms. (1 u = 931 MeV/c^2)

11. A small quantity of solution containing ^{24}Na radionuclide (half life 15 hours) of activity 1.0 microcurie is injected into the blood of a person. A sample of the blood of volume 1 cm^3 taken after 5 hours shows an activity of 296 disintegrations per mimute. Deterimine the total volume of blood in the body of the person. Assume that the radioactive solution mixes uniformly in the blood of the person.
(1 Curie = 3.7×10^{10} disintegrations per second)

12. At a given instant there are 25% undecayed radio–active nuclei in a sample. After 10 sec the number of undecayed nuclei remains to 12.5%. Calculate :
(i) mean – life of the nuclei and
(ii) The time in which the number undecayed nuclear will further reduce to 6.25% of the reduced number.