NOTES OF THE CHAPTER NUCLEI

Nucleus

The entire positive charge and nearly the entire mass of atom is concentrated in a very small space called the nucleus of an atom.

The nucleus consists of protons and neutrons. They are called nucleons.

Terms Related to Nucleus

(i) **Atomic Number** The number of protons in the nucleus of an atom of the element is called atomic number (Z) of the element.
(ii) **Mass Number** The total number of protons and neutrons present inside the nucleus of an atom of the element is called mass number (A) of the element.
(iii) **Nuclear Size** The radius of the nucleus $R \propto A^{1/3}$
$\Rightarrow R = R_o A^{1/3}$
where, $R_o = 1.1 * 10^{-15}$ m is an empirical constant.
(iv) **Nuclear Density** Nuclear density is independent of mass number and therefore same for all nuclei.
ρ = mass of nucleus / volume of nucleus $\Rightarrow \rho = 3m / 4\pi R^3_o$
where, m = average mass of a nucleon.

(v) **Atomic Mass Unit** It is defined as 1 / 12th the mass of carbon nucleus.
It is abbreviated as arnu and often denoted by u. Thus

1 amu = $1.992678 * 10^{-26} / 12$ kg
= $1.6 * 10^{-27}$ kg = 931 Me V

Isotopes

The atoms of an element having same atomic number but different mass numbers. are called isotopes.

e.g., $_1H^1$, $_1H^2$, $_1H^3$ are isotopes of hydrogen.

Isobars

The atoms of different elements having same mass numbers but different atomic numbers, are called isobars.

e.g., $_1H^3$, $_2He^3$ and $_{10}Na^{22}$, $_{10}Ne^{22}$ are isobars.

Isotones

The atoms of different elements having different atomic numbers and different mass numbers but having same number of neutrons, are called isotones.

e.g., $_1H^3$, $_2He^4$ and $_6C^{14}$, $_8O^{16}$ are isobars.

Isomers

Atoms having the same mass number and the same atomic number but different radioactive properties are called isomers,

Nuclear Force

The force acting inside the nucleus or acting between nucleons is called nuclear force.

Nuclear forces are the strongest forces in nature.

- It is a very short range attractive force.
- It is non-central. non-conservative force.
- It is neither gravitational nor electrostatic force.
- It is independent of charge.
- It is 100 times that of electrostatic force and 10^{38} times that of gravitational force.

According to the Yukawa, the nuclear force acts between the nucleon due to continuous exchange of meson particles.

Mass Defect

The difference between the sum of masses of all nucleons (M) mass of the nucleus (m) is called mass defect.

Mass Defect (Δm) = M – m = $[Zm_p + (A – Z)m_n – m_n]$

Nuclear Binding Energy

The minimum energy required to separate the nucleons up to an infinite distance from the nucleus, is called nuclear binding energy.

Nuclear binding energy per nucleon = Nuclear binding energy / Total number of nucleons

Binding energy, $E_b = [Zm_p + (A – Z) m_n – m_N]c^2$

Packing Fraction (P)

p = (Exact nuclear mass) – (Mass number) / Mass number

= M – A / M

The larger the value of packing friction. greater is the stability of the nucleus.

[The nuclei containing even number of protons and even number of neutrons are **most stable.**

The nuclei containing odd number of protons and odd number of neutrons are **most instable.]**

Radioactivity

The phenomena of disintegration of heavy elements into comparatively lighter elements by the emission of radiations is called radioactivity. This phenomena was discovered by Henry Becquerel in 1896.

Radiations Emitted by a Radioactive Element

Three types of radiations emitted by radioactive elements

(i) α-rays

(ii) β-rays

(iii) γ – rays

α-rays consists of α-particles, which are doubly ionised helium ion.

β-rays are consist of fast moving electrons.

γ – rays are electromagnetic rays.

[When an α – particle is emitted by a nucleus its atomic number decreases by 2 and mass number decreases by 4.

$${}_{Z}X^{A} \xrightarrow{\alpha\text{-particle}} {}_{Z-2}Y^{A-4}$$

When a β -particle is emitted by a nucleus its atomic number is Increases by one and mass number remains unchanged.

$${}_{Z}X^{A} \xrightarrow{\beta\text{-particle}} {}_{Z+1}Y^{A}$$

When a γ – particle is emitted by a nucleus its atomic number and mass number remain unchanged

Radioactive Decay law

The rate of disintegration of radioactive atoms at any instant is directly proportional to the number of radioactive atoms present in the sample at that instant.

Rate of disintegration $(- dN / dt) \propto N$

$- dN / dt = \lambda N$

where λ is the decay constant.

The number of atoms present undecayed in the sample at any instant $N = N_o e^{-\lambda t}$
where, N_o is number of atoms at time t = 0 and N is number of atoms at time t.

Half-life of a Radioactive Element

The time is which the half number of atoms present initially in any sample decays, is called half-life (T) of that radioactive element.

Relation between half-life and disintegration constant is given by

$T = \log^{2}_{e} / \lambda = 0.6931 / \lambda$

Average Life or Mean Life(τ)
Average life or mean life (τ) of a radioactive element is the ratio of total life time of all the atoms and total number of atoms present initially in the sample.

Relation between average life and decay constant τ = 1 / λ

Relation between half-life and average life τ = 1.44 T

The number of atoms left undecayed after n half-lifes is given by

$N = N_o (1 / 2)^n = N_o (1 / 2)^{t/T}$
where, n = t / T, here t = total time.

Activity of a Radioactive Element
The activity of a radioactive element is equal to its rate of disintegration.

Activity R = (– dN / dt)

Activity of the sample after time t,

$R = R_o e^{-\lambda t}$
Its SI unit is Becquerel (Bq).

Its other units are Curie and Rutherford.

1 Curie = $3.7 * 10^{10}$ decay/s
1 Rutherford = 10^6 decay/s
Nuclear Fission
The process of the splitting of a heavy nucleus into two or more lighter nuclei is called nuclear fission.

When a slow moving neutron strikes with a uranium nucleus ($_{92}U^{235}$), it splits into $_{56}Ba^{141}$ and $_{36}Kr^{92}$ along with three neutrons and a lot of energy.

$$_{92}U^{235} + {}_0n^1 \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} = 3\,{}_0n^1 + \text{energy}$$

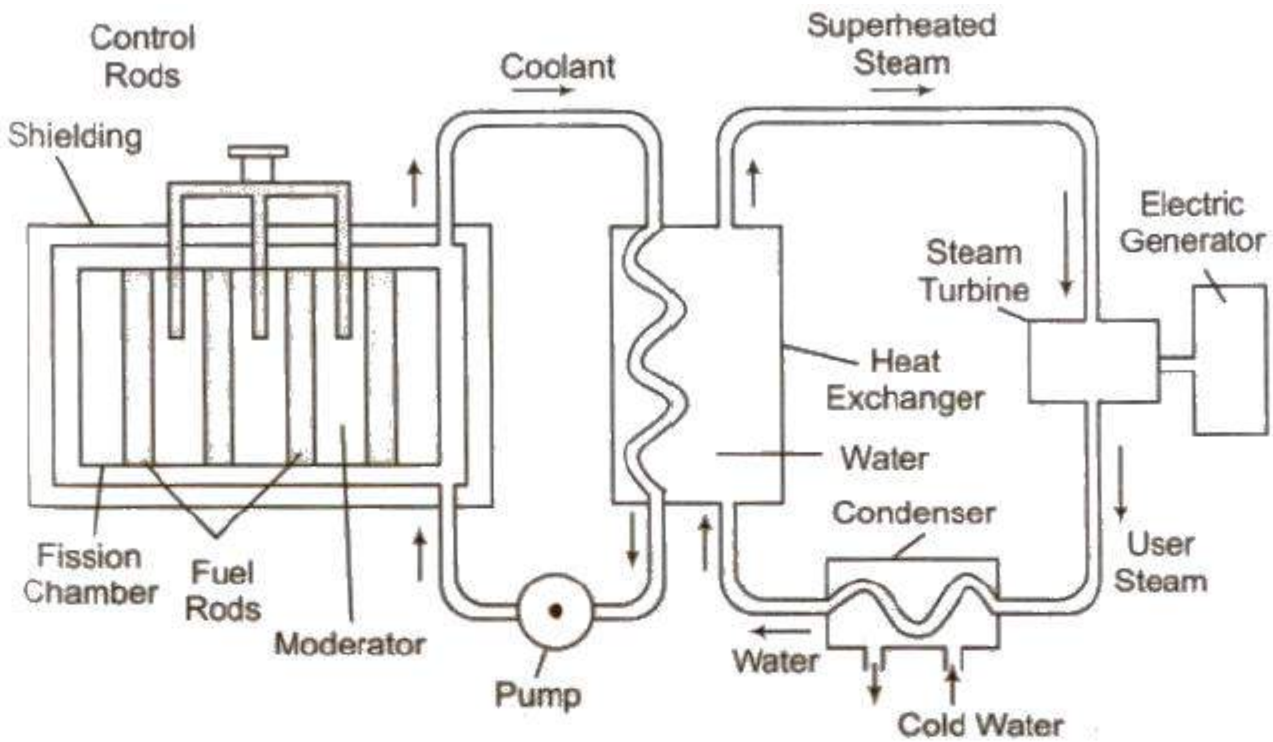
Nuclear Chain Reaction
If the particle starting the nuclear fission reaction is produced as a product and further take part in the nuclear fission reaction, then a chain of fission reaction started, which is called nuclear chain reaction.

Nuclear chain reaction are of two types

(i) Controlled chain reaction

(ii) Uncontrolled chain reaction

Nuclear Reactor
The main parts of a nuclear reactor are following



(i) **Fuel** Fissionable materials like $_{92}U^{235}$, $_{92}U^{238}$, $_{94}U^{239}$ are used as fuel.
(ii) **Moderator** Heavy water, graphite and beryllium oxide are used to slower down fast moving neutrons.
(iii) **Coolant** The cold water, liquid oxygen, etc. are used to remove heat generated in the fission process.
(iv) **Control rods** Cadmium or boron rods are good absorber of neutrons and therefore used to control the fission reaction.
Atom bomb working is based on uncontrolled chain reaction.

Nuclear Fusion
The process of combining of two lighter nuclei to form one heavy nucleus, is called nuclear fusion.

Three deuteron nuclei ($_1H^2$) fuse, 21.6 MeV is energy released and nucleus of helium ($_2He^4$) is formed.

$$_1H^2 + {}_1H^2 + {}_1H^2 \longrightarrow {}_2He^4 + {}_1H^1 + {}_0n^1 + 21.6\,\text{MeV}$$

In this process, a large amount of energy is released.

Nuclear fusion takes place at very high temperature approximately about 10^7 K and at very high pressure 10^6 atmosphere.
Hydrogen bomb is based on nuclear fusion.

The source of Sun's energy is the nuclear fusion taking place at sun.

Thermonuclear Energy

The energy released during nuclear fusion is known as thermonuclear energy. Protons are needed for fusion while neutrons are needed for fission process.

NCERT EXEMPLAR QUESTIONS

1. Suppose we consider a large number of containers each containing initially 10000 atoms of a radioactive material with a half life of 1 year. After 1 year,
(a) all the containers will have 5000 atoms of the material.
(b) all the containers will contain the same number of atoms of the material but that number will only be approximately 5000.
(c) the containers will in general have different numbers of the atoms of the material but their average will be close to 5000.
(d) none of the containers can have more than 5000 atoms.

2. The gravitational force between a H-atom and another particle of mass m will be given by Newton's law:
$F = G\frac{M.m}{r^2}$, where r is in km and
(a) $M = m_{proton} + m_{electron}$.
(b) $M = m_{proton} + m_{electron} - (B/c_2)$ (B = 13.6 eV).
(c) M is not related to the mass of the hydrogen atom.
(d) $M = m_{proton} + m_{electron} - (|V|/c^2)$ (|V| = magnitude of the potential energy of electron in the H-atom).

3. When a nucleus in an atom undergoes a radioactive decay, the electronic energy levels of the atom
(a) do not change for any type of radioactivity .
(b) change for α and β radioactivity but not for γ-radioactivity.
(c) change for α-radioactivity but not for others.
(d) change for β-radioactivity but not for others.

4. M_x and M_y denote the atomic masses of the parent and the daughter nuclei respectively in a radioactive decay. The Q-value for a β^- decay is Q_1 and that for a β^+ decay is Q_2. If m_e denotes the mass of an electron, then which of the following statements is correct?
(a) $Q_1 = (M_x - M_y) c^2$ and $Q_2 = (M_x - M_y) - 2m_e))c^2$
(b) $Q_1 = (M_x - M_y) c^2$ and $Q_2 = (M_x - M_y))c^2$
(c) $Q_1 = (M_x - M_y - 2me) c^2$ and $Q_2 = (M_x - M_y) + 2 m_e)c^2$
(d) $Q_1 = (M_x - M_y + 2me) c^2$ and $Q_2 = (M_x - M_y) + 2 m_e)c^2$

5. Tritium is an isotope of hydrogen whose nucleus Triton contains 2 neutrons and 1 proton. Free neutrons decay into p + e + v . If one of the neutrons in Triton decays, it would transform into He^3 nucleus. This does not happen. This is because
(a) Triton energy is less than that of a He^3 nucleus.
(b) the electron created in the beta decay process cannot remain in the nucleus.
(c) both the neutrons in triton have to decay simultaneously resulting in a nucleus with 3

protons, which is not a He3 nucleus.
(d) because free neutrons decay due to external perturbations which is absent in a triton nucleus.

6. Heavy stable nucle have more neutrons than protons. This is because of the fact that
(a) neutrons are heavier than protons.
(b) electrostatic force between protons are repulsive.
(c) neutrons decay into protons through beta decay.
(d) nuclear forces between neutrons are weaker than that between protons.

7. In a nuclear reactor, moderators slow down the neutrons which come out in a fission process. The moderator used have light nuclei. Heavy nuclei will not serve the purpose because
(a) they will break up.
(b) elastic collision of neutrons with heavy nuclei will not slow them down.
(c) the net weight of the reactor would be unbearably high.
(d) substances with heavy nuclei do not occur in liquid or gaseous state at room temperature.

Multiple Choice Questions (MCQ II)

8. Fusion processes, like combining two deuterons to form a He nucleus are impossible at ordinary temperatures and pressure.
The reasons for this can be traced to the fact:
(a) nuclear forces have short range.
(b) nuclei are positively charged.
(c) the original nuclei must be completely ionized before fusion can take place.
(d) the original nuclei must first break up before combining with each other.

9. Samples of two radioactive nuclides A and B are taken. λ_A and λ_B are the disintegration constants of A and B respectively. In which of the following cases, the two samples can simultaneously have the same decay rate at any time?
(a) Initial rate of decay of A is twice the initial rate of decay of B and $\lambda_A = \lambda_B$.
(b) Initial rate of decay of A is twice the initial rate of decay of B and $\lambda_A > \lambda_B$.
(c) Initial rate of decay of B is twice the initial rate of decay of A and $\lambda_A > \lambda_B$.
(d) Initial rate of decay of B is same as the rate of decay of A at t = 2h and $\lambda_B < \lambda_A$.

10. The variation of decay rate of two radioactive samples A and B with time is shown in Fig. 13.1.

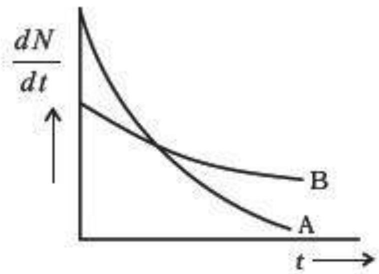


Fig. 13.1

Which of the following statements are true?

(a) Decay constant of A is greater than that of B, hence A always decays faster than B.
(b) Decay constant of B is greater than that of A but its decay rate is always smaller than that of A.
(c) Decay constant of A is greater than that of B but it does not always decay faster than B.
(d) Decay constant of B is smaller than that of A but still its decay rate becomes equal to that of A at a later instant.

Very Short Answer Type Questions

11. He_2^3 and He_1^3 nuclei have the same mass number. Do they have the same binding energy?
12. Draw a graph showing the variation of decay rate with number of active nuclei.
13. Which sample, A or B shown in Fig. 13.2 has shorter mean-life?

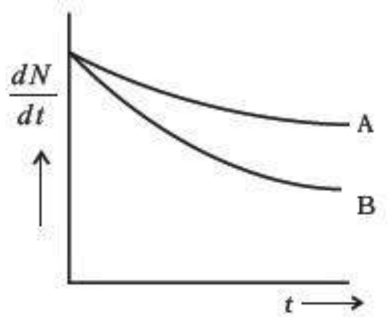


Fig. 13.2

14. Which one of the following cannot emit radiation and why? Excited nucleus, excited electron.
15. In pair annihilation, an electron and a positron destroy each other to produce gamma radiation. How is the momentum conserved?

Short Answer Type Questions

16. Why do stable nuclei never have more protons than neutrons?
17. Consider a radioactive nucleus A which decays to a stable nucleus C through the following sequence:

A → B → C
Here B is an intermediate nuclei which is also radioactive. Considering that there are N_0 atoms of A initially, plot the graph showing the variation of number of atoms of A and B versus time.

18. A piece of wood from the ruins of an ancient building was found to have a ^{14}C activity of 12 disintegrations per minute per gram of its carbon content. The ^{14}C activity of the living wood is 16 disintegrations per minute per gram. How long ago did the tree, from which the wooden sample came, die? Given half-life of ^{14}C is 5760 years.
19. Are the nucleons fundamental particles, or do they consist of still smaller parts? One way to find out is to probe a nucleon just as Rutherford probed an atom. What should be the kinetic energy of an electron for it to be able to probe a nucleon? Assume the diameter of a nucleon to be approximately 10^{-15} m.
20. A nuclide 1 is said to be the mirror isobar of nuclide 2 if $Z_1 = N_2$ and $Z_2 = N_1$.
(a) What nuclide is a mirror isobar of $^{23}_{11}Na$?
(b) Which nuclide out of the two mirror isobars have greater binding energy and why?

Long Answer Type Questions

21. Sometimes a radioactive nucleus decays into a nucleus which itself is radioactive. An example is :

$$^{38}\text{Sulphur} \xrightarrow[=2.48\text{h}]{\text{half-life}} {}^{38}\text{Cl} \xrightarrow[=0.62\text{h}]{\text{half-life}} {}^{38}\text{Ar (stable)}$$

Assume that we start with 1000 ^{38}S nuclei at time t = 0. The number of 38Cl is of count zero at t = 0 and will again be zero at t = ∞ . At what value of t, would the number of counts be a maximum?
22. Deuteron is a bound state of a neutron and a proton with a binding energy B = 2.2 MeV. A γ -ray of energy E is aimed at a deuteron nucleus to try to break it into a (neutron + proton) such that the n and p move in the direction of the incident γ-ray.
If E = B, show that this cannot happen. Hence calculate how much bigger than B must E be for such a process to happen.
23. The deuteron is bound by nuclear forces just as H-atom is made up of p and e bound by electrostatic forces. If we consider the force between neutron and proton in deuteron as given in the form of a Coulomb potential but with an effective chargee′ :

$$F = \frac{1}{4\pi\varepsilon_0}\frac{e'^2}{r}$$

estimate the value of (e’/e) given that the binding energy of a deuteron is 2.2 MeV.
24. Before the neutrino hypothesis, the beta decay process was throught to be the transition,
n → p + e
If this was true, show that if the neutron was at rest, the proton and electron would emerge with fixed energies and calculate them.Experimentally, the electron energy was found to have alarge range.
25. The activity R of an unknown radioactive nuclide is measured at hourly intervals. The results found are tabulated as follows:

t (h)	0	1	2	3	4
R (MBq)	100	35.36	12.51	4.42	1.56

(i) Plot the graph of R versus t and calculate half-life from the graph.

(ii) Plot the graph of (R/R_0) versus t and obtain the value of half-life from the graph.

26. Nuclei with magic no. of proton Z = 2, 8, 20, 28, 50, 52 and magic no. of neutrons N = 2, 8, 20, 28, 50, 82 and 126 are found to be very stable.

(i) Verify this by calculating the proton separation energy S_p for ^{120}Sn (Z = 50) and ^{121}Sb = (Z = 51).

The proton separation energy for a nuclide is the minimum energy required to separate the least tightly bound proton from a nucleus of that nuclide. It is given by $S_p = (M_{Z-1, N} + M_H - M_{Z,N}) c^2$.

Given ^{119}In = 118.9058u, ^{120}Sn = 119.902199u, ^{121}Sb = 120.903824u, ^{1}H = 1.0078252u.

(ii) What does the existence of magic number indicate?

Answers to Multiple Choice Questions

1 (c)

2 (b)

3 (b)

4 (a)

5 (a)

6 (b)

7 (b)

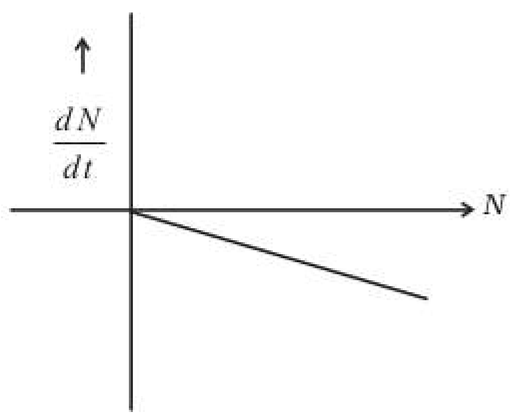
8 (a), (b)

9 (b), (d)

10 (c), (d)

11 No, the binding energy of H_1^3 is greater.

12



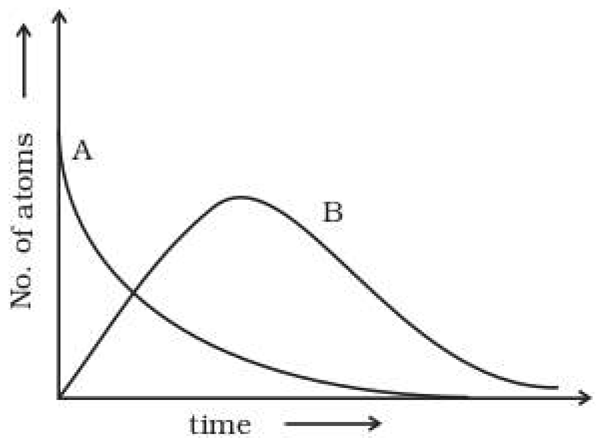
13 B has shorter mean life as λ is greater for B.

14 Excited electron because energy of electronic energy levels is in the range of eV, only not in MeV. as γ-radiation has energy in MeV.

15 2γ photons are produced which move in opposite directions to conserve momentum.

16 Protons are positively charged and repel one another electrically. This repulsion becomes so great in nuclei with more than 10 protons or so, that an excess of neutrons which produce only attractive forces, is required for stability.

17



At $t = 0$, $N_A = N_O$ while $N_B = 0$. As time increases, N_A falls off exponentially, the number of atoms of B increases, becomes maximum and finally decays to zero at ∞ (following exponential decay law).

18 $t = \frac{1}{\lambda}\ln\frac{R_0}{R}$

$$= \frac{5760}{0.693}\ln\frac{16}{12} = \frac{5760}{0.693}\ln\frac{4}{3}$$

$$= \frac{5760}{0.693}\times 2.303\log\frac{4}{3} = \qquad 2391.12 \text{ years.}$$

19 To resolve two objects separated by distance *d*, the wavelength λ of the proving signal must be less than *d*. Therefore, to detect separate parts inside a nucleon, the electron must have a wavelength less than 10^{-15} m.

$$\lambda = \frac{h}{p} \text{ and } K \approx pc \Rightarrow K \approx pc = \frac{hc}{\lambda}$$

$$= \frac{6.63\times 10^{34}\times 3\times 10^{8}}{1.6\times 10^{-19}\times 10^{-15}}\text{eV}$$

$= 10^9$ eV. = 1 GeV.

20 (a) $^{23}_{11}\text{Na} : Z_1 = 11,\ N_1 = 12$

$\therefore$ Mirror isobar of $^{23}_{11}\text{Na} = {}^{23}_{12}\text{Mg}$.

(b) Since $Z_2 > Z_1$, Mg has greater binding energy than Na.

21 $^{38}S \xrightarrow[2.48\text{ h}]{} {}^{38}Cl \xrightarrow[0.62\text{ h}]{} {}^{38}Ar$

At time t, Let ^{38}S have $N_1(t)$ active nuclei and ^{38}Cl have $N_2(t)$ active nuclei.

$$\frac{dN_1}{dt} = -\lambda_1 N_1 = \text{rate of formation of } Cl^{38}. \text{Also}$$

$$\frac{dN_2}{dt} = -\lambda_1 N_2 + \lambda_1 N_1$$

But $N_1 = N_0 e^{-\lambda_1 t}$

$$\frac{dN_2}{dt} = -\lambda_1 N_0 e^{-\lambda_1 t} - \lambda_2 N_2$$

Multiplying by $e^{\lambda_2 t} dt$ and rearranging

$$e^{\lambda_2 t} dN_2 + \lambda_2 N_2 e^{\lambda_2 t} dt = \lambda_1 N_0 e^{(\lambda_2 - \lambda_1)t} dt$$

Integrating both sides.

$$N_2 e^{\lambda_2 t} = \frac{N_0 \lambda_1}{\lambda_2 - \lambda_1} e^{(\lambda_2 - \lambda_1)t} + C$$

Since at $t = 0$, $N_2 = 0$, $C = -\frac{N_0 \lambda_1}{\lambda_2 - \lambda_1}$

$$\therefore N_2 e^{\lambda_2 t} = \frac{N_0 \lambda_1}{\lambda_2 - \lambda_1} (e^{(\lambda_2 - \lambda_1)t} - 1)$$

$$N_2 = \frac{N_0 \lambda_1}{\lambda_2 - \lambda_1} (e^{-\lambda_1 t} - e^{-\lambda_2 t})$$

For maximum count, $\frac{dN_2}{dt} = 0$

On solving, $t = \left(\ln \frac{\lambda_1}{\lambda_2} \right) / (\lambda_1 - \lambda_2)$

$$= \ln \frac{2.48}{0.62} / (2.48 - 0.62)$$

$$= \frac{\ln 4}{1.86} = \frac{2.303 \log 4}{1.86}$$

$= 0.745$ s.

22 From conservation of energy

$$E - B = K_n + K_p = \frac{{p_n}^2}{2m} + \frac{{p_p}^2}{2m} \qquad (1)$$

From conservation of momentum

$$p_n + p_p = \frac{E}{c} \qquad (2)$$

If $E = B$, the first equation gives $p_n = p_p = 0$ and hence the second equation cannot be satisfied, and the process cannot take place.

For the process to take place, Let $E = B + \lambda$, where λ would be $<<B$.

Then : substituting for p_n from Equation (2) into Equation (1),

$$\lambda = \frac{1}{2m}(p_p^2 + p_n^2) = \frac{1}{2m}\left(p_p^2 + \left(p_p - E/c\right)^2\right)$$

$$\therefore 2p_p^2 - \frac{2E}{c}p_p + \left(\frac{E^2}{c^2} - 2m\lambda\right) = 0$$

$$\therefore p_p = \frac{2E/c \pm \sqrt{4E^2/c^2 - 8\left(\frac{E^2}{c^2} - 2m\lambda\right)}}{4}$$

Since the determinant must be positive for p_p to be real :

$$\frac{4E^2}{c^2} - 8\left(\frac{E^2}{c^2} - 2m\lambda\right) = 0$$

$$918\left(\frac{e'}{e}\right)^4 = \frac{2.2\text{MeV}}{13.6\text{eV}}$$

$$\Rightarrow \frac{e'}{e} \approx 11.$$

24 Before β decay, neutron is at rest. Hence $E_n = m_n c^2$, $p_n = 0$

After β decay, from conservation of momentum:

$$\mathbf{p}_n = \mathbf{p}_p + \mathbf{p}_e$$

Or $\mathbf{p}_p + \mathbf{p}_e = 0 \Rightarrow |\mathbf{p}_p| = |\mathbf{p}_e| = p$

Also, $E_p = (m_p{}^2 c^4 + p_p{}^2 c^2)^{\frac{1}{2}}$,

$$E_e = (m_e{}^2 c^4 + p_e{}^2 c^2)^{\frac{1}{2}} = (m_e{}^2 c^4 + p_p c^2)^{\frac{1}{2}}$$

From conservation of energy:

$$(m_p{}^2 c^4 + p^2 c^2)^{\frac{1}{2}} + (m_e{}^2 c^4 + p^2 c^2)^{\frac{1}{2}} = m_n c^2$$

$$m_p c^2 \approx 936\text{MeV}, m_n c^2 \approx 938\text{MeV}, m_e c^2 = 0.51\text{MeV}$$

Since the energy difference between n and p is small, pc will be small, $pc << m_p c^2$, while pc may be greater than $m_e c^2$.

$$\Rightarrow m_p c^2 + \frac{p^2 c^2}{2m_p{}^2 c^4} \simeq m_n c^2 - pc$$

To first order $pc \simeq m_n c^2 - m_p c^2 = 938\text{MeV} - 936\text{MeV} = 2\text{MeV}$

This gives the momentum.

Then,

$$E_p = (m_p{}^2 c^4 + p^2 c^2)^{\frac{1}{2}} = \sqrt{936^2 + 2^2} \simeq 936\text{MeV}$$

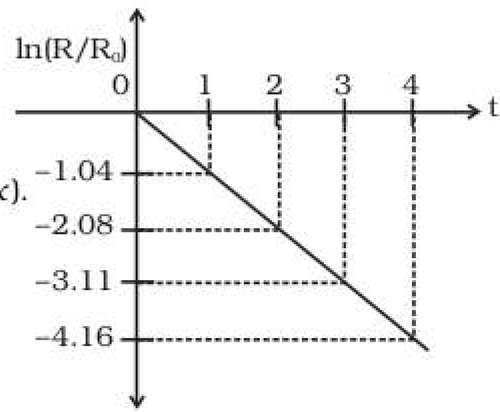
$$E_e = (m_e{}^2 c^4 + p^2 c^2)^{\frac{1}{2}} = \sqrt{(0.51)^2 + 2^2} \simeq 2.06\text{MeV}$$

25 (i) $t_{1/2}$ = 40 min (approx).

(ii) Slope of graph = –λ

$$\text{So } \lambda = -\left(\frac{-4.16+3.11}{1}\right) = 1.05\text{h}$$

$$\text{So } t_{1/2} = \frac{0.693}{1.05} = 0.66\text{h} = 39.6\,\text{min}\, or\, 40\,\text{min}(approx).$$



26 (i) $S_{pSn} = (M_{119,70} + M_H - M_{120,70})c^2$

$= (118.9058 + 1.0078252 - 119.902199)c^2$

$= 0.0114362\ c^2$

$S_{pSb} = (M_{120,70} + M_H - M_{121,70})c^2$

$= (119.902199 + 1.0078252 - 120.903822)c_2$

$= 0.0059912\ c^2$

Since $S_{pSn} > S_{pSb}$, Sn nucleus is more stable than Sb nucleus.

(ii) It indicates shell structure of nucleus similar to the shell structure of an atom. This also explains the peaks in BE/nucleon curve.