is the residual nucleus and b is the outgoing particle.

$$a + X \rightarrow Y + b$$
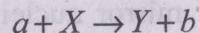
Draw the appropriate vector diagram of the above reaction in the centre of mass frame and laboratory frame.

ii) Let m_a, m_x, m_y, and m_b, are the masses of corresponding particles in the above reaction. Give an expression of Q value of the above reaction. What is the significance of Q?

iii) A nucleus (X) undergoes α-decay by emitting two groups of α-particles of different energies accompanying by γ radiation. Represent this process in the energy level diagram.

iv) What is the typical energy of the electron emitted in the β disintegration? How such an electron loses energy while passing through a medium?   2+2+3+3

e) Briefly explain the principle of ionization chamber with proper diagram. Calculate the ionic mobility of an ion in the ionization chamber.   5+5

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U.G. 5th Semester Examination-2025

PHYSICS

[HONOURS]

Discipline Specific Elective (DSE)

Course Code : PHY-H-DSE-T-02

(Nuclear and Particle Physics)

[CBCS]

Full Marks : 60   Time : $2\frac{1}{2}$ Hours

The figures in the right-hand margin indicate marks. Candidates are required to give their answers in their own words as far as practicable.

1. Answer any **five** questions :   2×5=10

a) Using the extreme single shell model, calculate the ground state spin parity of $_8^{17}O$.

b) A radioactive substance decays to $\frac{1}{32}$ th of its initial activity in 25 days. Calculate its halt life.

c) Justify that nuclear mass density is independent of mass number.

d) Distinguish between a Cyclotron and Synchrotron.

e) What do you mean by mirror nuclei ? Explain with proper example.

f) What are primary and secondary cosmic rays?

g) Using baryon number and strangeness number conservation laws, find which of the following reactions is allowed :

i) $\pi^- + p \rightarrow \wedge^0 + K^0$

ii) $\pi^- + p \rightarrow \wedge^0 + \pi^0$

h) Why is the Scintillation detector efficient than the GM counter for the detection of Gamma ray?

2. Answer any **four** questions: 5×4=20

a) Why the nucleus is considered as a liquid drop? What are the merits and demerits of the liquid drop model?

b) Derive Bethe-Block formula for Energy loss due to ionization. 5

c) Define the 'Binding energy of a nucleus'. Graphically show the variation of Binding Energy per nucleon with mass number A. Explain the constancy of Binding Energy per nucleon for a wide region of A.

d) Justify that nuclear density is independent of mass number. What do the peaks on the binding energy curve at lower mass number signify? 2+3

e) Determine the most stable nuclei among the members of isobaric family from the binding energy formula.

f) Draw the binding energy per nucleon versus the mass number curve and explain. 5

3. Answer any **three** questions: 10×3=30

a) Explain the primordial nucleosynthesis phenomenon. Discuss different particle nuclear interaction in primordial nucleosynthesis. How heavier elements were formed in nucleosynthesis? What is Gamow Window? 2+3+3+2

b) i) Explain clearly what is the energy conservation problem in β-decay phenomenon. How was it solved?

ii) What are mirror nuclei? Give an example. Find out the mass difference between two mirror nuclei in terms of their mass by using the semi-empirical mass formula.

iii) Using a Schematic Circuit diagram explain the working principle of a semiconductor detector for detecting nuclear radiation. What are the main advantages of semiconductor detector amongst all types of radiation detector? 2+(1+3)+(2+2)

c) i) What is cyclotron frequency? For a cyclotron operating at an extraction radius R = 0.4 m, and a magnetic field of B = 1.5 T = 1.5×10⁴ G, find the frequency of the alternating source needed to accelerate protons.

ii) What is a Synchrotron? What is the difference between cyclotron and synchrotron?

iii) Name the places in India where the following Accelerator facility are available:

a) Tandem accelerator

b) Linear accelerator

c) Cyclotron

d) Synchrotrons. (2+3)+(1+2)+2

d) i) Consider the following reaction where X is the nucleus at rest, a is the projectile, Y