U.G. 5th Semester Examination-2024

PHYSICS

[HONOURS]

Discipline Specific Elective (DSE)

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

(Nuclear & Particle Physics)

[New Syllabus]

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.

GROUP–A

1. Answer any **ten** questions: $2\times10=20$

a) Distinguish between a cyclotron and a betatron.

b) Explain that only α-particle is emitted by radioactive nuclei but not proton or neutron.

c) Write down the selection rules for β-transition.

d) It is observed that 3.67×10^{10} α-particles are emitted per sec. per gm of ^{226}Ra. Calculate the half-life of ^{226}Ra.

e) Radioactivity is a statistical phenomenon – explain it.

f) What do you mean by radioactive equilibrium? Write down the condition of secular equilibrium.

g) Define the mean life (τ) of a radioactive element. Show that the mean life (τ) of a radioactive element is equal to the inverse of its decay constant (λ).

h) Write down the characteristics of nuclear force.

i) Find the parities of the following two functions:
(i) $\psi(x) = \tan(\pi x/a)$ (ii) $\psi(x) = \cos(\pi x/a)$.

j) Explain the Mössbauer effect.

k) What is pick-up reaction? Give an example.

l) What is weak interaction paradox of single particle shell model? How was the paradox solved?

m) Write down the quark structure of Δ^{++}, Σ^{-}, K^{+} and Λ^{0}.

n) Explain the soft and hard components of cosmic rays.

o) Explain Fermi gas and degenerate gas.

GROUP–B

2. Answer any **four** questions : $5\times4=20$

a) Define the packing fraction (f). Derive the relation between packing fraction and atomic mass M(Z,A). Draw the packing fraction versus atomic number(A) curve and explain. 1+2+2

b) Write down charge and baryon numbers of all quarks. Using conservation of charge, spin and strangeness find which of the following reactions are allowed:

i. $K^- + p^+ \rightarrow \Xi^0 + K^0$
ii. $K^- + p^+ \rightarrow K^0 + n^0$
iii. $\Pi^- + p^+ \rightarrow \Sigma^0 + n^0$

2+3

c) Explain the Cerenkov radiation. Describe the construction and action of Cerenkov counter.

2+3

d) Write down at least five conservation laws of nuclear reactions $X(x,y)Y$ and explain them $(X + x \rightarrow Y + y)$.

5

e) Calculate the *disintegration energy* for orbital electron capture: ${}_{z}^{A}X + {}_{-1}^{0}e \rightarrow {}_{z-1}^{A}Y$. Explain the Pauli's neutrino hypothesis and write down the neutrino's properties.

2+3

f) Calculate the time in which the activity of a sample of thorium reduces to 90% of its original value. Assume the half-life of thorium to be 1.4×10^{10} years.

5

GROUP–C

3. Answer any **two** questions : $10\times2=20$

a) Write down at least three successes and limitations of shell model. Obtain an expression for the binding energy and mass formula of a nucleus in the ground state. For even A, there are two mass-parabola curve – explain it.

3+5+2

b) Explain the internal conversion phenomenon of γ-decay. A beam of monoenergetic γ-rays is incident on an Al-sheet of thickness 10 cm. The sheet reduces the intensity of the beam to 21% of its original value. Calculate the linear and mass absorption coefficients (given density of Al is 2700 $kg.m^{-3}$). Draw and explain the Kurie plot. 2+5+3

c) Explain the longitude effect and east-west asymmetry in the context of cosmic rays. Draw the Y-I_3 diagram for baryon decuplet for $J^P = 3/2^+$ and explain it. $\left(2\frac{1}{2}+2\frac{1}{2}\right)+5$

d) i) Assuming the collision to be elastic, show by using the Q-equation that the kinetic energy K_X of the target particle is given by

$$K_X = 4K_x \frac{m_x M_X}{(m_x + M_X)^2} \cos^2\theta.$$

ii) What is quenching of a G.M. counter? Explain the self-quenching of G.M. counter. Write down the two characteristics of G.M. counter.

5+(1+2+2)
