U.G. 6th Semester Examination - 2022

PHYSICS

Course Code : BPHSDSHT4 [DSE-4]

Course Title : Nuclear & Particle Physics

Full Marks : 40 Time : 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 **ten** questions: 1×10=10

a) Two nuclei have Mass number ratio of 1:8. What is the ratio of its radii?

b) Differentiate between isotopes and isobars.

c) What is the main information does one get from the N vs. Z plot of nuclei?

d) Does neutron has an electric dipole moment?

e) Write down the relation between strangeness quantum number (S) and the electric charge of an elementary particle (Q).

f) If a radioactive substance is placed in a vacuum, what will be the effect on its rate of disintegration?

[Turn Over]

g) Name a conservation law which is violated in β-decay.

h) Under which condition a radioactive equilibrium is called as secular equilibrium?

i) What is the shape of a nucleus when its intrinsic quadrupole moment (Q_0) is negative?

j) Give an example of a pair of mirror nuclei.

k) What are the quark combination of π^0, Ω^-?

l) Explain the term 'dead time' of a GM Counter.

m) Predict the ground state spin and parity of ${}_{18}Ar^{41}$.

n) Can a nuclear force be dependent on the spin of the nuclei?

o) Name the process by which electrons are emitted from nucleus.

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

a) How do you get the information of charge distribution of a nucleus from its electric quadrupole moment?

b) Derive the Geiger law.

c) Why ${}^4_2He$ has no magnetic moment?

d) How nuclear fusion and nuclear fission can be explained from average Binding energy vs. Mass number plot?

e) A nucleus emits an α-particle followed by two β-particles. Show that the final nucleus is an isotope of the original one.

f) What do you mean by Q-value of a nuclear reaction?

g) Obtain an expression for the intensity of γ-rays during its passage through a material medium.

h) If a radioactive substance exhibits both α and β-activities, then show that the mean life time of the substance is $T = \frac{T_\alpha . T_\beta}{T_\alpha + T_\beta}$, where T_α and T_β are the partial half-lives of disintegration by α and β emissions respectively.

3. Answer any **two** questions: 5×2=10

a) i) Show that electron capture is possible, if the mass of the parent atom is greater than that of the daughter atom by at least the binding energy of the electron.

ii) Why in β^+ decay neutrino (ν_e) and in β^- decay anti-neutrino $(\bar{\nu}_e)$ are emitted? 3+2

b) Cite some evidences supporting shell structure of nucleus. Find the total angular momentum and parity for the ground state of ${}_{16}S^{33}$, using the shell model. 2+3

c) Explain, with diagram, the working principle of a cyclotron. Why synchrotons are used? 3+2

4. Answer any **one** question: 10×1=10

a) i) What are mass parabolas?

ii) For odd A, we get a single parabola for each A, but for even A, we get two parabolas for the same A–one is for even z (even-even nuclei) and other for odd z (odd-odd nuclei). Explain it.

iii) Which of the following reactions are possible?

A) $n \rightarrow p + e^- + \bar{\nu}_e$

B) $\pi^0 + n \rightarrow k^0 + \Sigma^0$

C) $p \rightarrow e^{+} + \gamma$

D) $\pi^{+} + n \rightarrow \pi^{-} + p$ 2+4+4

b) Explain briefly the quark model. Why the strangeness number has such a name? Show how the color hypothesis explains the stability of structure of baryons made of exactly same three quarks. Calculate the minimum energy required to be given to the neutron in order that the following nuclear reaction may occur:

$$ {}^{1}_{0}n + {}^{31}_{15}p \rightarrow {}^{31}_{14}Si + {}^{1}_{1}H $$

Given the masses (in amu)

$M\left({}^{1}_{0}n\right) = 1.008665$, $M\left({}^{31}_{15}P\right) = 30.973766$,

$M\left({}^{31}_{14}Si\right) = 30.975349$ and $M\left({}^{1}_{1}H\right) = 1.007825$.

4+1+2+3

c) Give Gamow's theory of α-decay. Hence derive the Geiger-Nuttall relation. 10

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