U.G. 5th Semester Examination-2020

PHYSICS

[HONOURS]

Discipline Specific Elective (DSE)

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

(Nuclear and Particle Physics)

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 **ten** questions from the following: 2×10=20

a) Show that the energy equivalent of 1amu~ 931 MeV.

b) What are the magic numbers? Explain.

c) What are the importance of binding fraction curve?

d) What is internal conversion?

e) Distinguish compound nuclear reaction and direct reaction.

f) What are the experimental evidences that suggest the nuclear shell model?

g) What is Cerenkov radiation?

h) What is the basic principle of a linear accelerator?

i) Define exoergic and endoergic nuclear reaction.

j) Indicate the relative strength of the different types of interaction.

k) Write down the quark content of proton and neutron.

l) What are the Baryons?

m) What is Gamow window?

n) Why an electron cannot reside inside a nucleus?

o) Calculate the nuclear density and compare it with atomic density.

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

a) Explain the electric dipole and quadrupole moment of the nuclei. What are the shapes of nuclei for different values of electric quadrupole moment? What are the mirror nuclei? 2+2+1

b) What is neutrino? Explain qualitatively how the hypothesis of a neutrino solves the apparent breakdown of conservation of energy and momentum in β decay. What are the pair

production and pair annihilation? 1+2+2

c) An alternating potential difference of 50 kV maximum value is applied to the dees of radius 40 cm of a cyclotron by an oscillator. A deuteron of mass 2 amu acquires energy of 4 MeV in the cyclotron. Calculate the magnetic field strength, frequency of the oscillator and the number of revolutions which the deuteron has to make inside the cyclotron to gain the energy. Can electron be accelerated through a cyclotron? Explain. 4+1

d) Predict the ground state spin and parity of the following nuclei:

$_{13}Al^{27}$, $_{15}P^{30}$ and $_{7}N^{14}$ 2+2+1

e) i) Find the third component of isospin of Ξ^- in the following strong interaction:

$$\pi^+ + n \rightarrow \Xi^- + K^+ + K^-$$

ii) Identify the unknown particle in the reactions given below, using the conservation laws:

$$\mu^- + p \rightarrow n + ... \text{ and } \pi^- + p \rightarrow K^0 + ...$$

iii) Identify the type of reaction from the conservation laws:

$\Xi^- \rightarrow n + \pi^-$ (life-time ~ 1.6×10^{-10}s)

2+2+1

f) i) State Rutherford's nuclear model of atom. How will you estimate the nuclear size from the Rutherford's theory of scattering of α - particle?

ii) An α - particle of energy 5 MeV is scattered through 180^o by a fixed Uranium nucleus. Calculate the distance of closet approach. (1+2)+2

3. Answer any **two** questions from the following: 10×2=20

a) i) Derive an expression for the nuclear charge of the most stable nucleus for a given isobaric family using semi-empirical mass formula. Show, by way of computation, which nuclei you would expect to be more stable:

$_{3}Li^{7}$ or $_{3}Li^{8}$ and $_{4}Be^{9}$ or $_{4}Be^{10}$

ii) Explain nuclear fission from binding energy curve.

iii) Explain the behaviour of binding energy curve at smaller and larger values of mass number. (3+3)+2+2

b) Find an expression for the Q-value of a nuclear reaction. What is threshold energy? Obtain an expression for threshold energy of an endoergic nuclear reaction. Calculate the threshold energy for the nuclear reaction N^{14} (n, α) B^{11} in MeV. 3+1+3+3

c) Explain the difference between ionisation chamber, proportional counter and GM counter. How a GM counter operates? Explain the principle of action of a Scintillation counter.

3+3+4

d) i) A pion decays from rest to give a muon of 4.0 MeV energy, what is the kinetic energy of the accompanying neutrino? What is the mass of the neutrino in the process?

ii) Check if the following reactions are allowed or forbidden:

$p \rightarrow \pi^+ + \pi^- + e^-$ and $\pi^+ + n \rightarrow \Lambda^0 + K^+$

iii) Show that the nature of binding fraction curve is complementary to the nature of the packing fraction curve

iv) What is Geiger-Nuttal law? Explain.

(2+1)+2+3+2

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