U.G. 6th Semester Examination - 2020

PHYSICS

Course Code : BPHSDSHT4

Course Title : Nuclear and 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

   i) What is mirror nuclei? Give an example.

   ii) Explain the nuclear magnetic moment.

   iii) Why stable nuclei have more neutrons than protons?

   iv) What do you mean by nuclear isomerism? Give an example.

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

vi) What is anti-particle? Give an example of a anti-particle which exist in nature.

vii) Mention two important applicatiosn of radioactivity.

viii) What is Cherenkov radiation?

ix) Explain the Fermi gas model.

x) Predict:

   a) the ground state spin

   b) parity of $^{27}_{13}\mathrm{Al}$

xi) What is nuclear transmutation?

xii) Define Q-value of a nuclear reaction.

xiii) Define Baryons and Mesons with an example each.

xiv) $^{236}_{94}\mathrm{Pu}$ will spontaneously decay by α-emission. Find the Q_α.

[Given $M_{Pu} = 236.046\mathrm{u}$; $M_U = 232.037\mathrm{u}$; $M_{He} = 4.0020\mathrm{u}$]

$$^{236}_{94}\mathrm{Pu} \rightarrow ^{232}_{92}\mathrm{U} + ^{4}_{2}\mathrm{He} + Q_\alpha$$

xv) What do you mean by internal conversion?

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

a) Calculate the binding energy of an α-particle $\left({}_{2}^{4}\mathrm{He}\right)$.

[Given $M_P = 1.007276u$; $M_n = 1.008665u$; $M_{He} = 4.002603u$]

b) Neutron is charge neutral particle. Does it have magnetic moment? If yes, explain it.

c) A radioactive source emits α and β particles with 1600 years and 400 years as respective half-life. After what time would the one-fourth of the material remain unchanged?

d) Write down the differences between the Shell model and Liquid drop model.

e) Write down the quark content of the following particles $\wedge, \Sigma^+, \pi^+$ and K^-.

f) Which of the reactions are possible?

i) $\pi^+ + n^0 \rightarrow \wedge^0 + K^+$

ii) $\pi^+ + n^0 \rightarrow K^0 + K^+$

g) Explain clearly the meaning of *isotopic spin* and *strangeness*.

h) What is Geiger-Nuttall law? What is the importance of this law?

Answer any **two** questions: 5×2=10

3. a) What is Geiger law? Derive the Geiger law. 1+2

b) ${}^{212}P_0$ emits an α-particle of 8.776 MeV energy. Calculate the disintegration energy that correspond to it. 2

4. Obtain Bethe-Wiezsacker semi-empirical mass formula. Clearly explaining the significances of the term involved. 5

5. a) Define the threshold energy of endoergic reaction and derive the expression for threshold energy. 1+2

b) Calculate the threshold energy for the nuclear reaction ${}^{14}N(n, \alpha)\,{}^{11}\beta$ in MeV.

[Given: $M_N = 14.007550u$; $M_n = 1.008987u$; $M_B = 11.012811u$; $M_{He} = 4.003879u$] 2

Answer any **one** question: 10×1=10

6. a) Describe in detail the working principle of a GM-counter. What is dead time and recovery time? How is quenching achieved in a GM-counter? 2+1+2

b) Explain the principle and operation of a scintillation counter. $2\frac{1}{2}$

c) What are the advantages of semiconductor detector over ionisation chamber? $2\frac{1}{2}$

7. a) What are the three forms of β-decay? Find out the condition of their occurance. 2+3

b) Explain the Kurie plot. Write down the selection rule for allowed β-transition. 2+1

c) What are the basic properties of neutrino? 2

8. a) Calculate the mass defect of the $^{108}_{47}Ag$ nucleus.

b) Consider a nuclear reaction in which an incident particle on mass m_i and kinetic energy t_i collides with a target particle of mass m_t at rest. After the reaction, an emitted particle of mass m_e and kinetic energy t_e leaves the residual nucleus of mass m_r and kinetic energy t_r. Find out the Q value of this reaction in terms of scattering angle in the nonrelativistic approximation.

c) Out of the two particles, which one is a lepton: ν_μ, k_o? 3+6+1

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