2017
PHYSICS
Paper : 203

NUCLEAR PHYSICS - I

Full Marks: 80

Time: 3 hours

The figures in the margin indicate full marks for the questions

1. **Answer the following :** $1 \times 5 = 5$

(a) The spin and parity of the ground state of ${}^{25}_{12}\mathrm{Mg}$ is

(i) $\frac{5}{2}^-$ (ii) $\frac{5}{2}^+$ (iii) $\frac{1}{2}^-$ (iv) $\frac{1}{2}^+$

(b) Fill in the blanks

$^{34}\mathrm{Cl} \rightarrow {}^{34}\mathrm{S} + - + -$

(c) The strangeness of Ξ^- baryon is

(i) 3 (ii) -3 (iii) 2 (iv) -2

(d) GM counter is used for the measurement of energy of elementary particles.

(i) True (ii) False

(e) Which one of the following represents elastic scattering type nuclear reaction

P.T.O.

(i) X(x, y)Y (ii) X(x, y)X

(iii) X(x, x)X (iv) None of these

2. **Answer the following (Any five)** $2 \times 5 = 10$

(a) Write down the four properties of nuclear force.

(b) Why beta ray spectrum is continuous ? Explain.

(c) Write down the selection rules for first forbidden Gamow-Teller transition of beta decay.

(d) Why Coulomb correction is necessary in Fermi's theory of nuclear β decay ?

(e) What do you mean by strangeness quantum number. Write down Gell-Mann Nishijima formula and explain various terms in it.

(f) What do you mean by the absolute and intrinsic efficiency of a radiation detector.

(g) Mention two advantages of solid-state detector over gas-filled detector.

3. **Answer the following (Any five)** $5 \times 5 = 25$

(a) Electron scattering experiment is performed with ${}^{16}_{8}O$ nucleus. The first minimum of the diffraction like pattern is found to be at 45^0. Calculate the approximate radius of the ${}^{16}_{8}O$ nucleus using the above data. Given, hc = 1240 MeV fm, E = 420 MeV. 5

(b) What do you mean by nuclear spin ? Calculate the ground state spin and parity of ${}^{14}_{7}N$ using extreme single particle shell model. 1+4=5

(c) Obtain the condition for spontaneous symmetric fission for a nucleus using liquid drop model. Given, $a_c = 0.72$ MeV and $a_s = 16.8$ MeV. 5

(d) Consider the reaction,

$${}^{1}_{0}n + {}^{19}_{9}F \rightarrow {}^{19}_{8}O + {}^{1}_{1}H - 7.6342\text{ MeV}$$

Kinetic energy of the incident neutrons is 15 MeV, and protons are emitted at an angle of 90^0 with the direction of the incident neutrons. Calculate the kinetic energy of protons. Given, $m({}^{19}_{8}O) = 19.05862$ amu, $m({}^{1}_{0}n) = 1.0087$ amu, $m({}^{1}_{1}H) = 1.0073$ amu, and $m({}^{19}_{9}F) = 19.0457$ amu. 5

(e) Use the conservation of energy and momentum to show that threshold energy for an incoming projectile to initiate an endothermic reaction X(a, b)Y as measured in the laboratory frame is

$$E_{th} = -\left(\frac{M_X + m_a}{M_X}\right) Q$$

where, m_a is the mass of the incoming projectile and M_X is the mass of the target nucleus.

(f) Describe the three important mechanisms through which gamma rays interact with matter.

4. Answer the following (Any four) 10 x 4 = 40

(a) What do you mean by *magic numbers*. Write down the experimental evidences in support of nuclear shell model. Show that only three magic numbers are surfaced if one assume the underlying nuclear interaction as harmonic oscillator potential.

1+3+6=10

(b) Discuss Fermi's theory of beta decay and derive an expression to find the energy distribution of the emitted beta particles. What is Fermi factor ? 9+1=10

(c) Calculate the strength of np potential for deuteron using finite square well potential. Given, binding energy of deuteron = 2.225 MeV and nuclear interaction range, r_0 = 2.1 fm. Also calculate the normalized wave function of deuteron. 5+5=10

P.T.O.

(d) Discuss why neutrino detection is very difficult ? Discuss Cowan-Reines experiment for the experimental detection of neutrinos.

2+8=10

(e) Write a short note on classification of elementary particles. Apply necessary conservation laws, decide which of the following reactions are allowed. If allowed, indicate the process of interaction. 5+5=10

(i) $\pi^+ + n \rightarrow \Lambda^0 + K^+$
(ii) $p \rightarrow e^+ + \gamma$
(iii) $K^- + \Xi^0 \rightarrow \Omega^- + \pi^0$
(iv) $p + \gamma \rightarrow p + \pi^0$
(v) $K^0 \rightarrow \pi^+ + \pi^-$

(f) Explain the working principle of a NaI(Tl)-scintillation detector. Draw a typical gamma ray-spectrum using scintillation detector induced my mono-energetic gamma-rays and explain various features in view of the formation of various peaks. 5+5=10

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