

2017

PHYSICS

Paper : 203

## NUCLEAR PHYSICS - I

Full Marks: 80

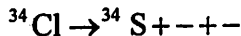
Time: 3 hours

The figures in the margin indicate full marks for the questions

1. Answer the following : 1 x 5 = 5(a) The spin and parity of the ground state of  ${}_{12}^{25}\text{Mg}$  is

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

(b) Fill in the blanks

(c) The strangeness of  $\Xi^-$  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

- (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 x 5 = 10

- Write down the four properties of nuclear force.
- Why beta ray spectrum is continuous? Explain.
- Write down the selection rules for first forbidden Gamow-Teller transition of beta decay.
- Why Coulomb correction is necessary in Fermi's theory of nuclear  $\beta$  decay?
- What do you mean by strangeness quantum number. Write down Gell-Mann Nishijima formula and explain various terms in it.
- What do you mean by the absolute and intrinsic efficiency of a radiation detector.
- Mention two advantages of solid-state detector over gas-filled detector.

3. Answer the following (Any five) 5x5 = 25

- Electron scattering experiment is performed with  $^{16}_8\text{O}$  nucleus. The first minimum of the diffraction like pattern is found to be at

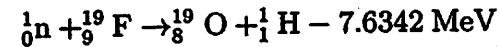
45°. Calculate the approximate radius of the  $^{16}_8\text{O}$  nucleus using the above data. Given,  $hc = 1240 \text{ MeV fm}$ ,  $E = 420 \text{ MeV}$ . 5

- What do you mean by nuclear spin? Calculate the ground state spin and parity of  $^{14}_7\text{N}$  using extreme single particle shell model.

$$1+4=5$$

- Obtain the condition for spontaneous symmetric fission for a nucleus using liquid drop model. Given,  $a_c = 0.72 \text{ MeV}$  and  $a_s = 16.8 \text{ MeV}$ . 5

- Consider the reaction,



Kinetic energy of the incident neutrons is 15 MeV, and protons are emitted at an angle of  $90^\circ$  with the direction of the incident neutrons. Calculate the kinetic energy of protons. Given,

$$m(^{19}_8\text{O}) = 19.05862 \text{ amu}, m(^1_0\text{n}) = 1.0087 \text{ amu}, m(^1_1\text{H}) = 1.0073 \text{ amu}, \text{ and } m(^{19}_9\text{F}) = 19.0457 \text{ amu}. \quad 5$$

- 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.

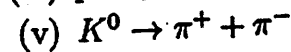
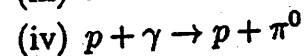
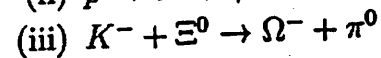
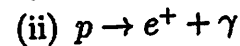
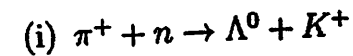
5+5=10

(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



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

5+5=10

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