2022

5th Semester Examination

PHYSICS (Honours)

Paper : DSE 2-T

[CBCS]

Full Marks : 60 Time : Three Hours

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

[Nuclear and Particle Physics]

Group - A

Answer any *ten* of the following questions : 10×2=20

1. (a) Calculate binding fraction for ^{16}O. Given M (^1H) = 1.007825 u, M(^1n) = 1.008655 u, M(^{16}O) = 15.994915 u, and 1 u = 931.5 MeV.

   (b) A 5 MV Van de Graaff generator is equipped to accelerate protons, deuterons and α-particles. What are the maximum energies of the various particles available from the accelerator?

   (c) Show that the mass difference of two mirror nuclei of odd A and with N and Z differing by one unit is given by : $M_a - M_a = a_c A^{\frac{1}{3}}$.

P.T.O.

B.Sc./5th Sem (H)/PHS/22(CBCS)

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   (c) Show that the mass difference of two mirror nuclei of odd A and with N and Z differing by one unit is given by : $M_P - M_n + a_c A^{\frac{2}{3}}$.

P.T.O.

(d) Predict the state of energy level of unpaired odd nucleon and spins and parities of the following nuclei from the single particle shell model of $^{33}_{16}S$.

(e) The masses of the different nuclei taking part in $^{7}Li_{3}(p,n)^{A}Y_{Z}$ reaction in u are follows : $M(^{7}Li_{3})$ = 7.01822, $M(^{1}Li_{1})$ = 1.00814, $M(^{7}n_{0})$ = 1.00898 and mass of the product nucleus = 7.01915. Calculate the Q-value of this reaction in MeV.

(f) What is exoergic reaction? Give an example.

(g) What do you mean by 'dead time' and 'recovery time' of a GM counter?

(h) What are the predictions of nuclear shell model?

(i) Write down Bohr's independence hypothesis on compound nuclear reaction mechanism.

(j) A cyclotron has a magnetic field of 1.5 Wb/m^2. The extraction radius is 0.5m. Calculate the frequency of RF oscillator necessary for accelerating deuterons.

(k) Using Gell-Mann-Nishijima relation, show that strangeness quantum number of Σ-particles is –1.

(l) Explain parity violation in weak interaction or in Beta decay.

(m) State with reasons whether the following reactions are allowed or forbidden.

(i) $e^- + e^+ \rightarrow \mu^+ + \pi^-$ (ii) $p + \mu^- \rightarrow n + \gamma_\mu$

(n) What are Lepton and Baryon quantum numbers?

(o) A π^+ meson of rest mass 273 m_e decays from rest to emit a μ^+ meson of rest mass 207 m_e with an average kinetic energy 4.2 MeV and a μ-neutrino. Calculate the energy of the μ-neutrino.

Group - B

Answer any ***four*** of the following questions : 5×4=20

2. What is scintillation detector? Write down the uses and limitations of the detector. 1+2+2

3. Derive an expression for the Coulomb energy of a nucleus ${}^{A}X_{Z}$ in terms of A and Z. Give any two achievements of liquid drop model. 3+2

4. Find the density of ${}^{12}C_6$ nucleus. Comment on the following properties of ${}^{208}Pb_{82}$ nucleus (i) Charge (ii) Spin (iii) Size. 2+1+1+1

5. (a) What are the different modes of radioactive decays? 2

   (b) Explain internal conversion process. 3

6. (a) Find the lowest values of the kinetic energy of an electron and a proton causing the emergence of Cherenkov's radiation in a medium with refractive index n = 1.60. 3

   (b) Calculate Compton shift in wavelength when scattering angle is 180°. 2

P.T.O.

7. What are colour quarks? Why was it necessary to introduce an additional property designated as colour to quarks and antiquarks? 2+3

Group - C

Answer any *two* of the following questions : 10×2=20

8. (a) What is meant by isospin? Give the value of the isospin and the z component of the isospin for (i) pions and (ii) nucleons. 3

(b) For heavy α-emitters show that the kinetic energy of α-particle is nearly equal to α-disintegration energy. 2

(c) Write down Nordheim's rules to determine the ground-state spin-parity of an odd-odd nuclei. Find the grond-state spin-party of ^{42}K nucleus. 3+2

9. (a) Why are the most stable nuclei found in the region near A = 60? Find the energy release, if two ^{2}H nuclei fuse together to form ^{4}He nucleus. The binding energy per nucleon of *H* and *He* is 1.1 MeV and 7.0 MeV respectively. 2+3

(b) What are magic number? What is the evidence for shell structure of the nucleus? Sketching the main assumption, explain the shell model of the nucleus. 1+2=2

10. (a) Discuss the energy spectrum curve from β-decay of a radioactive nuclide. Show that the law of

conservation of energy and momentum are not obeyed in β-decay. 4+2

(b) The beam of a fixed frequency cyclotron has a maximum radius of 1 m. The magnetic field induction is 1.5 tesla. Find the energy of α-particles accelerated by the accelerator. 4

11. (a) Show that the Q-value of nuclear reaction is :

$$Q = K_y\left(1+\frac{m_y}{M_y}\right) - K_x\left(1-\frac{m_x}{M_y}\right) - \frac{2}{M_y}\sqrt{m_x m_y k_x k_y}\cos\theta$$

where, m_x : mass of incident particle, m_y : mass of product particle, M_x : mass of target nucleus, M_y : mass of product nucleus. Other symbols have usual meanings. 5

(b) Explain the difference between ionization chamber, proportional counter and Geiger Muller Counter. 3

(c) Write down and explain the semi-empirical mass formula. 2