

Total number of printed pages-8

3 (Sem-5/CBCS) PHY HE 5

2023

**PHYSICS**

(Honours Elective)

Paper : PHY-HE-5056

**(Nuclear and Particle Physics)**

Full Marks : 80

Time : Three hours

***The figures in the margin indicate full marks for the questions.***

1. Answer the following questions :  $1 \times 10 = 10$ 
  - (i) Two nuclei with same value of  $A$ , but  $N$  and  $Z$  values are interchanged are called
    - (a) isotopes
    - (b) isobars
    - (c) isomers
    - (d) mirror nuclei

Contd.

- (ii) An isotope without any neutron
- Tritium
  - Deuterium
  - Protium
  - None of the above
- (iii) Nuclear force is
- short range and charge dependent
  - long range and charge dependent
  - short range and charge independent
  - long range and charge independent
- (iv) Which term in the semi-empirical mass formula assigns a direct proportionality to the mass number ?
- Volume energy term
  - Surface energy term
  - Coulomb energy term
  - Asymmetry energy term
- (v) The particle emitted in  $\beta$ -decay together with electron
- Photon
  - Neutron

- Antineutrino
  - Meson
- (vi) The nuclear process in which one or more particle may be liberated when the target nucleus absorbs  $\gamma$ -ray is called
- Fission reaction
  - Nuclear fusion
  - Radioactive decay
  - Photo disintegration
- (vii) Change in wavelength of photon in Compton effect depends on
- frequency of incident photon
  - mass of recoil electron
  - angle of recoil electron
  - angle of scattering of photon
- (viii) The sum of the dead time and recovering time of a GM counter is called
- Sensitive time
  - Ionizing time
  - Resolving time
  - Peak-up time

(ix) Neutrinos are a subset of which of the following categories

- (a) Photons
- (b) Leptons
- (c) Mesons
- (d) Baryons

(x) According to quark model, a proton consists of quarks represented as

- (a) uud
- (b) udd
- (c) bud
- (d) cud

2. Answer the following questions :  $2 \times 5 = 10$

- (a) Show that nuclear density does not depend upon mass number  $A$ .
- (b) What are magic numbers ? Give one example of doubly magic nucleus.
- (c) What is pair production ? Calculate the minimum energy of a photon to produce electron-positron pair.
- (d) Complete the following reactions
  - (i)  $?(n, p)_{11}\text{Na}^{24}$
  - (ii)  ${}_3\text{Li}^7(p, ?) {}_4\text{Be}^7$

(e) What are the values of baryon number ( $B$ ), lepton number ( $L$ ) and strangeness ( $S$ ) of electron and positron.

3. Answer the following questions : **(any four)**  
 $5 \times 4 = 20$

- (a) Define binding energy of a nucleus. Draw a curve showing the binding energy per nucleon as a function of the mass number of nuclei.
- (b) What is  $\beta$ -decay ? Write on three forms of  $\beta$ -decay.
- (c) Briefly explain the construction and working principle of semi-conductor detector.
- (d) The pole pieces of a cyclotron is  $1.2m$  in diameter and provide a magnetic field of  $1.6 \text{Wb}/m^2$ . What will be the energy of protons in such a machine ? (Mass of proton =  $1.67 \times 10^{-27} \text{kg}$  and charge =  $1.6 \times 10^{-19} \text{C}$ )
- (e) Calculate the binding energy of the  ${}_{27}^{59}\text{Co}_{32}$  nucleus using semi-empirical mass formula.
- (f) Compare the stopping power of  $4 \text{MeV}$  protons and  $8 \text{MeV}$  deuterons in a given medium.

4. Answer the following : **(any four)**  $10 \times 4 = 40$

(a) (i) Derive the Bethe-Bloch formula for the energy loss of a heavy charged particle passing through matter.

(ii) In a Compton scattering experiment, the incident gamma ray is scattered through  $60^\circ$ . Find the wavelength of the incident radiation if the wavelength of the scattered gamma ray is  $0.250 \text{ \AA}$ .

$$8+2=10$$

(b) (i) Give salient features of nuclear shell model and point out its successes and failures.

(ii) Write the characteristics of nuclear force.

$$7+3=10$$

(c) (i) What is a particle accelerator ?

(ii) Write the principle, construction and working of a LINAC.

(iii) Write *one* advantage and *one* disadvantage of LINAC.

$$1+7+2=10$$

(d) (i) What are the necessities of a particle accelerator ?

(ii) What is the role of electric and magnetic fields in an accelerator ?

(iii) Write briefly on accelerator facilities available in India.

$$2+2+6=10$$

(e) (i) What are elementary particles ?

(ii) Classify the fundamental forces of nature highlighting their relative strength, mediator particles and characteristic time.

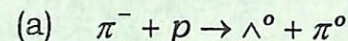
(iii) How elementary particles are classified according to types of interactions ?

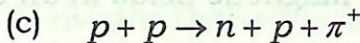
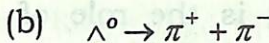
$$2+4+4=10$$

(f) (i) What do you understand by strangeness ? Find the strangeness no. of the following particles

$$\Sigma^+, p, \Omega^-$$

(ii) Based on the conservation of charge, lepton no., baryon no. and strangeness, state whether the following reactions are possible or not :





1+3+6=10

(g) Write short notes on : (any two)

5×2=10

(i) Neutron interaction with matter

(ii) Photo-electric effect

(iii) Concept of quark model

(iv) Rutherford scattering

(v) Cherenkov radiation

(vi) Construction of photomultiplier tube

(h) Define

(i) half life

(ii) disintegration constant, and

(iii) mean life of a radioactive substance.

Obtain the relation between them.

2+2+2+4=10

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