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3 (Sem-5/CBCS) PHY HE 5

2024

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. Choose the correct answer: $1 \times 10 = 10$

(i) What is the force that binds protons and neutrons in a nucleus ?

- (a) Gravitational force
- (b) Electromagnetic force
- (c) Strong nuclear force
- (d) Weak nuclear force

Contd.

(ii) Nucleon is the term used for

- (a) all the light nuclei
- (b) hydrogen nuclei
- (c) neutrons
- (d) protons and neutrons

(iii) Which combination of radioactive emissions will not change the mass number of radioactive nuclei ?

- (a) Alpha and beta decays
- (b) Alpha and gamma decays
- (c) Alpha, beta and gamma decays
- (d) Beta and gamma decays

(iv) A high energy gamma ray may materialize into

- (a) a meson
- (b) an electron and a proton
- (c) a proton and a neutron
- (d) an electron and a positron

(v) Fission of a nucleus is achieved by bombarding it with

(a) Electrons

(b) Protons

(c) Neutrons

(d) X-rays

(vi) Which of the following is not a gas-filled type detector?

(a) Proportional counter

(b) G-M Counter

(c) Semiconductor detector

(d) Ionization Chamber

(vii) Cyclotrons maintain particles in a circular path by use of

(a) Radio frequency waves

(b) Magnetic fields

(c) Electric fields

(d) None of the above

(viii) What is the bottom quark also called ?

- (a) Charm quark
- (b) Bubble quark
- (c) Bilou quark
- (d) Beauty quark

(ix) Particles that cannot participate in the strong interaction are

- (a) Kaons
- (b) Baryons
- (c) Leptons
- (d) Pions

(x) Which of the following is not composed of quarks ?

- (a) Muons
- (b) Neutrons
- (c) Pions
- (d) Protons

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

(a) What is the energy equivalent of 1 amu ?

- (b) Obtain approximately the ratio of nuclear radii of ${}^{56}_{26}\text{Fe}$ and ${}^{238}_{92}\text{U}$. What is the approximate ratio of their nuclear densities ?
- (c) What is the momentum of a photon of energy 1 MeV ?
- (d) What are the disadvantages of linear accelerators ?
- (e) Write down the quark content of protons, neutrons and pions.

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

(a) How many α and β particles are emitted in the disintegration of ${}^{232}_{90}\text{Th}$ to the end product ${}^{208}_{82}\text{Pb}$?

(b) Two deuterons ${}^2_1\text{H}$ fuse to form a triton ${}^3_1\text{H}$ and a proton. How much energy is released ? The reaction is ${}^2_1\text{H} + {}^2_1\text{H} = {}^3_1\text{H} + {}^1_1\text{H}$.

Given that the masses of ${}^2_1\text{H}$, ${}^3_1\text{H}$ and ${}^1_1\text{H}$ are 2.014102 amu, 3.016050 amu and 1.007825 amu respectively.

Contd.

- (c) Write about the independent particle model. What are the limitations of the shell model ?
- (d) Discuss the neutrino hypothesis in beta decay.
- (e) What is the range of alpha particles ? What is Geiger-Nuttall law ?
- (f) What are quarks ? Give the qualitative description of the quark model.
4. Answer the following questions : **(any four)**
 $10 \times 4 = 40$
- (a) What is nuclear force ? Write the characteristics of nuclear force. Define mass defect and nuclear binding energy.
 $2 + 6 + 2 = 10$
- (b) Explain the postulates of the liquid drop model. Give a simple derivation of semi-empirical mass formula. $2 + 8 = 10$
- (c) What is the Q value of a nuclear reaction ? Define reaction cross-section. What are exothermic and endothermic reactions ? What are the conservation laws in nuclear reactions ?
 $1 + 2 + 2 + 5 = 10$

(d) Write *two* differences among alpha, beta and gamma rays. Discuss the theory of alpha decay. $3+7=10$

(e) (i) Describe in detail the principle, construction and working of a cyclotron.

(ii) Calculate the frequency of a proton cyclotron, if the magnetic field $B = 0.15$ tesla. $2+3+3+2=10$

(f) What is a scintillator detector ? What are the requirements for a good scintillator material ? Give the construction of a photomultiplier tube. $1+4+5=10$

(g) What are elementary particles ? How are they classified ? What are the baryon number and lepton number of a proton ? $2+6+2=10$

(h) Write short notes on : **(any two)** $5 \times 2 = 10$

(i) Binding energy curve

(ii) Gamma ray interaction through matter

Contd.

- (iii) Three modes of beta decay
 - (iv) Rutherford scattering
 - (v) Fundamental forces of nature
 - (vi) Strange particles
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