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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 : 1×10=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

(ii) Nucleon is the term used for

(a) all the light nuclei

(b) hydrogen nuclei

(c) neurons

(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 : 2×5=10

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

(b) Obtain approximately the ratio of nuclear radii of $^{56}_{26}Fe$ and $^{238}_{92}U$. 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)*** 5×4=20

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

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

Given that the masses of $^{2}_{1}H$, $^{3}_{1}H$ and $^{1}_{1}H$ are 2·014102 amu, 3·016050 amu and 1·007825 amu respectively.

(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-Nuttal law ?

(f) What are quarks ? Give the qualitative description of the quark model.

4. Answer the following questions : ***(any four)*** 10×4=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 $B = 0{\cdot}15$ 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)*** 5×2=10

(i) Binding energy curve

(ii) Gamma ray interaction through matter

(iii) Three modes of beta decay

(iv) Rutherford scattering

(v) Fundamental forces of nature

(vi) Strange particles
