This question paper contains 4+4 printed pages]

Roll No.

S. No. of Question Paper : 6234

Unique Paper Code : 222604

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Name of the Paper : Nuclear and Particle Physics (PHHET-622)

Name of the Course : B.Sc. (Hons.) Physics

Semester : VI

Duration : 3 Hours

Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt only *Five* questions.

Question No. 1 is compulsory.

All questions carry equal marks.

1. Answer any *five* : 3×5=15

(a) Outline why it is so difficult to make nuclear reactors based on fusion.

(b) Compute the nuclear magneton. Is the magnetic moment of a neutron zero ?

(c) Two protons in a nucleus interact via the strong interaction. Are they also subject to the electromagnetic, weak and gravitational interactions ? Justify.

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(d) Why are lighter and heavier nuclei prone to fusion and fission respectively ?

(e) What is the origin of cosmic rays ?

(f) Compute the half-life and mean life of a radioactive element whose decay constant λ is 0.00231 per day.

(g) Show that the density of nuclear matter is independent of its mass number.

(h) Differentiate between an ionization chamber and a proportional counter.

2. (a) Define the Binding Energy (BE) of a nucleon. Draw the BE/nucleon *Vs.* the mass number curve. Indicate the stable and unstable regions due to fusion and fission. 2+2+

(b) Mention and relate the dependence of the various factors that contribute to the semiempirical BE formula based on this model.

(c) Calculate the nuclear density of $^{56}_{26}Fe$, Given $r_0 = 1.4 \times 10^{-15}$ m.

3. (a) What are the basic assumptions of Gamow's theory of alpha decay ? How did this theory account for the enormous variations of half-life of radioactive elements ? 2+3

(*b*) In a particular semiconductor device, electrons that are accelerated through a potential of 5 V attempt to tunnel through the barrier of width 0.8 nm and height 10 V. What fraction of the electrons is able to tunnel through the barrier if the potential is 0 V outside the barrier ?

5

(*c*) What led Pauli to propose a *Neutrino* to explain the observed beta decay spectrum ?

5

4. (*a*) Distinguish between compound and direct reactions. 5

(*b*) What is the principle of a chain reaction in fission ? What is the role of moderators in nuclear reactors ? 3+2

(*c*) Compare the energy released in the fission of 1 kg ^{239}Pu (energy released per event is 200 MeV) and the energy released in the fusion of 1 kg Deuterium with tritium $^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$. Given neutron mass = 1.008665 amu. 5

5. (*a*) Why are the following particle interactions forbidden :

(*i*) $\mu^- \rightarrow e^- + \gamma$

(*ii*) $\Lambda^0 \rightarrow \pi^+ + \pi^-$ and

(*iii*) $p + p \rightarrow p + p + n$ 2+2+

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(b) Define Isospin and strangeness quantum numbers. 2+2

(c) Plot the eight-fold way pattern for the Baryon Decuplet on the Isospin strangeness axes. 5

6. (a) What do you mean by the Q value of a nuclear reaction ? Calculate the Q value for $^{4}_{2}He + {}^{9}_{4}Be \rightarrow {}^{12}_{6}C + {}^{1}_{0}n$? Is it endoergic or exoergic ? 3+3+1

(b) If there are n scattering centers (nuclei) per unit volume, each of area sigma, in a thin target of thickness dT, find the ratio R of the area covered by scattering centres to the total area of the target. 4

(c) Find the minimum kinetic energy in the laboratory system a proton must have to react with $^{65}_{29}Cu$ to produce $^{65}_{30}Zn$ and a neutron. 4

7. (a) Deduce the expression for the final energy of an accelerated particle as it leaves a Cyclotron. 4

(b) Why does the cyclotron not work at every high energies ? What is the need for synchrotron or synchrocyclotron ? 6

(c) Calculate the frequency of the oscillating potential applied to a cyclotron to accelerate deuterons when magnetic inductance is 2.5 Weber/m^2, given mass of Deuteron is 3.34×10^{-27} kg. 3

(d) If you are required to accelerate the protons at a very high energy, will you prefer a linear accelerator or a cyclotron and why ? 2

5. (a) Draw a curve of ionization current Vs. applied voltage to indicate the regions of the operation of various detectors based on the principle of ionization. 6244

(b) Explain why quenching is needed in a Geiger Muller counter. How is this achieved ? 5

(c) Establish an expression for a secular equilibrium in a decay series. 5

Given masses of the following nuclei in amu

Deuterium = 2.014102

Tritium = 3.016050

Helium = 4.002603

Beryllium = 9.012182

Carbon = 12.00000

2200

[This question paper contains 2 printed pages.]

Sr. No. of Question Paper : 5791 F Your Roll No.....

Unique Paper Code : 222604

Name of the Paper : Nuclear and Particle Physics (PHHT-622)

Name of the Course : B.Sc. (Hons.) Physics

Semester : VI

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** questions in all.
3. Question No. **1** is compulsory.
4. **All** questions carry equal marks.

1. Answer any **five** : (3×5)

   (a) Compute the magnetic moment of a nucleon ?

   (b) Explain why heavy nuclei are unstable ?

   (c) What is the mass of a sample of $^{14}_{6}C\left(T_{\frac{1}{2}} = 5570 \text{ years}\right)$ that has an activity of 5 Ci ?

   (d) Determine the energy required to remove the least tightly bound neutron from $^{17}_{8}O$.

   (e) Explain the compound nucleus hypothesis. What is the main characteristic of a compound nucleus ?

   (f) Explain the effect of galactic magnetic field on incoming cosmic rays.

   (g) Which conservation laws are violated in the reaction $p \rightarrow \pi^+ + e^+ + e^-$?

2. (a) A certain radioactive material a, having decay constant λ_a decays into a material b having decay constant λ_b, which is also radioactive. Show that the amount of material b remaining after a time t is given by the expression

$$N_b = N_{b0}e^{-\lambda_b t} + \frac{\lambda_a N_{a0}}{\lambda_b - \lambda_a}\left(e^{-\lambda_a t} - e^{-\lambda_b t}\right),$$

5

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where N_{b0} and N_{a0} represent the initial number of atoms of the two kinds. (10)

(b) If it is assumed that $N_{b0} = 0$, find the time at which the number of atoms of b (N_b) is maximum. (5)

3. (a) Explain the Geiger-Nuttal law in terms of the range and energy of α particles. Describe the special features of α particle spectra. (8)

(b) Describe the various processes through which γ decay takes place. Explain nuclear isomerisrn. (7)

4. (a) What do you understand by the Q- value of a reaction ? Calculate the Q-value for the reaction ${}^{16}_{8}O + {}^{1}_{0}n \rightarrow {}^{13}_{6}C + {}^{4}_{2}He$ and determine whether the reaction is exoergic or endoergic. (7)

(b) What is the working principle of scientification detector ? What are its advantages ? (8)

5. (a) Briefly discuss the liquid drop model of the nucleus and obtain the semi-empirical mass formula. (10)

(b) What do you understand by the magic numbers ? Discuss stability of a nucleus in terms of magic numbers. (5)

6. (a) Describe the principle and working of an ionization chamber for detecting charged particles. (7)

(b) Explain the principle, construction and working of linear accelerator. (8)

7. (a) Classify elementary particles on the basis of thar interactions and quantum numbers e.q. spin, charge, isospin, laptor and baryon number. (10)

(b) Find the charge number, baryon number and strangeness of a particle described by the quark structure (u,u,s). Identify the particle. (5)

(Given mass of ${}^{16}_{8}O$ = 15.994915, mass of ${}^{13}_{6}C$ = 13.003354, mass of n = 1.008665 and mass of α = 4.002603, mass of ${}^{17}_{8}O$ = 16.999133 in amu, Planck's constant h = 6.625×10^{-34} Js)

This question paper contains 2 printed pages.

Your Roll No. .....

Sl. No. of Ques. Paper	: 5117
Unique Paper Code	: 222663
Name of Paper	: Physics VI— Solid State and Nuclear Physics (PHPT-606)
Name of Course	: B.Sc. Physical Sciences
Semester	: VI
Duration :	: 3 hours
Maximum Marks	: 75

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(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any five questions. All questions carry equal marks.

1. (a) Define reciprocal lattice vectors. Discuss their properties and physical significance. 7
   (b) Distinguish between diamagnetic, paramagnetic, and ferromagnetic materials. 8

2. (a) Explain Bragg's law for X-ray Diffraction. Also describe powder method of X-ray diffraction with diagram. 10
   (b) Electrons are accelerated to 344 volts and are reflected from a crystal. The first reflection maximum occurs when glancing angle is 60° Determine the spacing of the planes.
   Planck's constant= 6.6×10^{-34} js
   Charge on electron= 1.6×10^{-19} c
   Mass of the electron= 9.1×10^{-31} kg 5

3. (a) What is Hall Effect. Discuss its significance. 5
   (b) Obtain the Clausius- Mossotti relation between polarizability and dielectric constant of a solid. 10

4. (a) What is superconductivity. Explain Meissner effect. What are Type-1 and Type-2 superconductors. 5
   (b) Discuss how Kronig-Penny Model explains the energy band structure of solids. 10

5. (a) What is Binding energy. Give graph of variation of binding energy per nucleon vs atomic mass number and identify the regions suitable for nuclear fission and fusion reactions. 10
   (b) Calculate the binding energy per nucleon of $_2He^4$. Given mass of $_2He^4$ nucleus is 4.002634u, mass of hydrogen atom= 1.007825 u and mass of neutron=1.008665u, mass of proton=1.007276u. 5

P.T.O

6. (a) What is the difference between direct and compound nucleus formations. Explain with examples. 6

(b) Explain beta particle spectrum (β) in β-decay and hence the concept of neutrino. 8

7. (a) Complete the following reactions.

(i) $_{92}U^{238} \rightarrow {}_{90}Th^{234} + ??$

(ii) $_{90}Th^{234} \rightarrow {}_{91}Pa^{234} + ?? + ??$

(iii) $_{11}Na^{22} \rightarrow {}_{10}Ne^{22} + ?? + ??$

(iv) $_{4}Be^{7} + ?? \rightarrow {}_{3}Li^{7} + ??$

(b) Explain liquid drop model of a nucleus. 4 11

8. (a) How many types of fundamental interactions are there between elementary particles. Name them and explain these interactions. 9

(b) Write short note on (i) quarks (ii) Nuclear Fusion 6

400

This question paper contains 4 printed pages.

Your Roll No. .....

S. No. of Paper	: 764	I
Unique Paper Code	: 32227504	
Name of the Paper	: **Nuclear and Particle Physics**	
Name of the Course	: **B.Sc. (H) Physics : DSE-2**	
Semester	: **V**	
Duration	: **3 hours**	
Maximum Marks	: **75**	

(Write your Roll No. on the top immediately on receipt of this question paper.)

*Attempt **five** questions in all. Question No. **1** is compulsory. Attempt any **four** questions from the remaining set of questions. Use of scientific calculator is permitted.*

1. Attempt any *five* questions:

(a) Calculate the Fermi energy, Fermi momentum and the well depth of a nucleus with $N = Z = A/2$.

(b) What isospin value is expected from an even mass nuclide (Z, N) ?

(c) Why do unstable nuclei emit alpha particles and not protons or neutrons?

(d) Define separation energy for neutrons.

(e) Give the Lepton and Baryon numbers for electrons, protons, neutrons and positrons.

(f) What is meant by the saturation of nuclear forces?

$3 \times 5 = 15$

P. T. O.

2. (a) Find the most stable isobar for A = 57 using the liquid drop model. Assume the constants as a_1 = 14 MeV, a_2 = = 13 MeV, a_3 = 0.59 MeV, a_4 = 19 MeV, a_5 = $(\pm, 0)$ 33.5 MeV where a_1 is the volume constant, a_2 is the surface energy constant, a_3, a_4, a_5 are respectively coulombic, asymmetric and pairing constants. Do not derive the semi-empirical mass formula.

(b) Thermal neutrons are captured by $^{10}B_5$ to form $^{11}B_5$ which decays by α-particle emission to $^{7}_{3}Li$. Calculate:

(i) The Q value of the decay in MeV.

(ii) The kinetic energy of the α-particles in MeV. 8,7

3. (a) Determine the applied voltage required to operate a proportional counter with a maximum radial field of 10^6 Vm^{-1}. The radius of the wire and tube are respectively 0.003 cm and 1 cm.

(b) The alpha particles emitted in the decay of $^{219}_{86}Ru$ have energies 6.82 MeV, 6.55 MeV and 6.43 MeV. Determine the energies of gamma rays emitted by the daughter nuclei.

(c) Give three characteristics of nuclear forces. 5,5,5

4. (a) In an absorption experiment with 1.14 MeV γ radiation from $^{65}_{30}Zn$, it is found that the intensity of radiation is reduced to 2% when it passes through 25 cm of aluminium. Determine the mass absorption coefficient of aluminium for this radiation. Density of aluminium is 2700 kg/m^3 and $M(^{26}_{13}Al) = 26.9815$.

(b) Calculate the binding energy per nucleon for $^{56}_{26}Fe$ and compare this with the value of the proton separation energy. Given $M(^{56}_{26}Fe)$=55.934939 u, $M(^{55}_{25}Mn)$= 54.938046 u .

(c) Find the height of the Coulomb barrier between an alpha particle and daughter nucleus $^{A}_{Z}D$, assuming that the nuclear potential has a sharp edge at a radius of $1.4\ A^{1/3}$ fm. 5,5,5

5. (a) Using the quark model draw the Baryon octet. State the quantum number of all the particles in the octet.

(b) Give the principle of a linear accelerator.

(c) A cyclotron, in which the transverse magnetic flux density is 1.5 weber/m^2, is used to accelerate protons. Determine the frequency of the source. 7,4,4

6. (a) What are the advantages of a GM counter over the ionization chamber for radiation detection?

(b) Give *two* differences between direct and compound nuclear reactions.

(c) Indicate giving reasons if the following reactions proceed through the weak, strong or electromagnetic interactions or they do not occur:

(i) $\pi^0 \rightarrow \gamma + \gamma$

(iii) $e^+ + e^- \rightarrow \mu^+ + \mu^-$ 5,5,5

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7. (a) What is Cerenkov radiation? Calculate the threshold velocity for electrons to produce this radiation when it travels through a medium of refractive index 1.6.

(b) Alpha particles and deuterons are accelerated under identical conditions in a cyclotron. The extracted beam of these particles is passed through an absorber. What is the ratio of the range of alpha particle to the range of the deuteron?

(c) Using the uncertainty principle, estimate the energy required for a proton to be a part of the nucleus.

5,5,5

USEFUL DATA:

$M(^{11}_{5}B) = 11.0119305$ u ; $M(^{1}_{1}H) = 1.007825$ u ; Mass of a neutron = 1.008665 u; $M(^{7}_{3}Li) = 7.016004$ u; $M(^{4}_{2}He) = 4.002603$ u.