This question paper contains **4** printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : **1603**

Unique Paper Code : **222604** **C**

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**

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

Attempt any *Five* questions.

Question No. **1** is compulsory.

All questions carry equal marks.

1. Answer any *five* : 3×5

   (*a*) Determine the ratio of the nuclear radii of $^{4}_{2}H$ and $^{238}_{92}U$.

   (*b*) Define nuclear cross-section. In what unit it is measured ?

   (*c*) What factors make a fusion reaction difficult to achieve ?

   (*d*) A positive pion collides with a proton and two protons plus another particle are created. What is the other particle ?

   (*e*) What is the Q value of the reaction $^{4}_{2}He + ^{14}_{7}N \rightarrow ^{17}_{8}O + ^{1}_{1}H$?

   (*f*) Why do stable nuclei usually have more neutrons than protons ?

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(*g*) Why does the cross-section for neutron induced reaction increase with decreasing neutron energy ?

(*h*) Differentiate between cloud chamber and bubble chamber.

2. (*a*) What are the salient features of the shell model and liquid drop model ? 4+4

(*b*) Briefly outline the findings of the Meson theory of nuclear forces. 4

(*c*) Compute the density of a typical nucleus and find the resultant mass if we could manufacture a nucleus with radius of 1 cm. Given $r_0 = 1.2 \times 10^{-15}$ m. 3

3. (*a*) Why are only α particles emitted by radioactive nuclei, while protons and neutrons are not ? 2

(*b*) Show that kinetic energy of alpha particle released in a decay of a nucleus of mass number A is given as $KE\alpha = (A-4)\ Q/A$. Q is the Q value of the reaction. 3

(*c*) What is the successive disintegration of radioactive atoms ? Define secular and transient equilibrium. 4+3+3

4. (*a*) Consider a nucleus at rest, which then spontaneously splits into two fragments, of masses m_1 and m_2. Show that the fraction of the total kinetic energy that is carried by fragment m_1 is $m_2/(m_1 + m_2)$ assuming relativistic corrections can be ignored. 4

(*b*) Establish the relation between the total kinetic energy of the lab system and that of the centre of mass system for nuclear reactions. 6

(*c*) What are the primary and secondary cosmic rays ? What is the energy range of the ultra-high-energy cosmic rays ? 2+2+1

5. (*a*) Classify the fundamental forces based on their strengths, range and reaction rate. 5

(*b*) Distinguish between Baryons and Mesons with examples. 2+2

(*c*) State the conservation principles preserved or violated in the following particle interactions : 2+2+2

(*i*) $\gamma + n \rightarrow \pi^- + p$

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

(*iii*) $e^- + e^+ \rightarrow \mu^- + \pi^+$.

6. (*a*) What is the working principle of a cyclotron ? What are its limitations in the relativistic region ? How can they be overcome in a synchro-cyclotron ? 4+4+4

(*b*) A cyclotron in which the density is 1.4 weber/m^2 is employed to accelerate protons. How rapidly should the electric field between the dees be reversed ? Mass of the proton is 1.67×10^{-27} kg and the charge is 1.6×10^{-19} C. 3

7. (*a*) What is the working principle of an ionization chamber ? How can it be operated as a proportional counter ? 3+3

(*b*) An electron and a proton of identical energy encounter the same potential barrier. For which is the probability of transmission greatest, and why ? 4

(*c*) Two copper coducting wires are separated by an insulating oxide layer (CuO).Modeling the oxide layer as a square barrier of height 10 V, estimate the transmission coefficient for penetration by 7 eV electrons if the layer thickness is 5 nm. Given mass of the electron m_e = 0.51 Me V and $h = 6.6 \times 10^{-34}$ Js. 5

P.T.O.

8. (*a*) Define the critical mass for a fission reaction and give the Lawson criterion for a fusion reaction. 3+3

(*b*) What conservation laws were apparently being violated in the observed continuous beta spectrum ? How did it help Pauli in predicting the nature of a new particle ? 3+2

(*c*) Compute the average lifetime of a radioactive nucleus. 4

Given Masses of the following nuclei in amu :

Hydrogen = 1.007825

Helium = 4.002603

Nitrogen = 14.003074

Oxygen 17 = 16.999131.