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

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

S. No. of Question Paper : **958**

Unique Paper Code : **222604** **E**

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 *Five* questions in all. Question No. **1** is compulsory.

Use of log tables, trigonometric tables and scientific calculator is allowed.

Values of constants are given at the and of the question paper.

1. Attempt any *five* of the following : 5×3

(*a*) By what process is $^{15}_{8}O$ likely to decay ? Write the reaction.

(*b*) What is 'Q' value of a reaction ? What do positive and negative Q values indicate ?

(*c*) Why is $^{14}_{6}C$ radioactive while $^{12}_{6}C$ is not ?

(*d*) What is meant by 'saturation' of nuclear forces ?

(*e*) What is meant by a (*d*, *p*) reaction ? Is it more likely to occur by direct reaction or compound nucleus formation ?

(*f*) In what respects is an antiparticle similar to and dissimilar from a particle ?

(*g*) What are 'cosmic rays' ? What is their probable origin ?

(*h*) Complete the following nuclear reactions :

$^{6}_{3}Li + \ldots\ldots\ldots\ldots \rightarrow {}^{7}_{4}Be + {}^{1}_{0}n$

$^{35}_{17}Cl + \ldots\ldots\ldots\ldots \rightarrow {}^{32}_{16}S + {}^{4}_{2}He$

P.T.O.

2. (*a*) How can 'nuclear fission' and 'nuclear fusion' be accounted for by the 'Binding Energy per nucleon' *Vs.* 'Atomic mass no.' graph. What is the difference between 'spontaneous fission' and 'induced fission' ? What is it difficult to make nuclear fusion occur in the laboratory while it occurs so easily in stars ? 2+2+2

(*b*) Find the energy needed to remove a neutron from $^{4}_{2}\mathrm{He}$. Also. find the energy needed to remove a proton from $^{4}_{2}\mathrm{He}$. Compare the two and comment. Atomic masses are given as follows :

$$\mathrm{M}\left[^{4}_{2}\mathrm{He}\right] = 4.002603\ \mathrm{u},\quad \mathrm{M}\left[^{3}_{2}\mathrm{He}\right] = 3.016029\ \mathrm{u} \text{ and } \mathrm{M}\left[^{3}_{1}\mathrm{He}\right] = 3.016050\ \mathrm{u}.$$

2+2+1

(*c*) The atomic ratio between the uranium isotopes $^{238}_{92}\mathrm{U}$ and $^{234}_{92}\mathrm{U}$ in a mineral sample is found to be 1.8×10^{4}. The half-life of $^{234}_{92}\mathrm{U}$ is 2.5×10^{5} years. Find the half life of $^{238}_{92}\mathrm{U}$. 4

3. (*a*) What is 'Geiger-Nuttal Law' ? In some alpha spectra, instead of one discrete line, several closely spaced discrete lines are observed. Why ? 3+2

(*b*) Find the maximum height of the potential barrier encountered by an alpha particle if $^{238}_{92}\mathrm{U}$ nucleus has to undergo alpha decay. The radius of the residual nucleus is 9.3×10^{-15} m. 5

(*c*) Destinguish between compound nucleus reaction and direct reaction with example. 5

4. (*a*) How do the 'asymmetry' and 'pairing energy' terms arise in the semi-empirical mass formula ? 5

(*b*) What is the 'Meson Theory of nuclear forces' ? Estimate the mass of a π-meson from the 'uncertainty principle'. Assume that the speed of the π-meson is nearly equal to *c*. 2+3

(*c*) $^{23}_{12}Mg$ undergoes positron emission. Express the decay process by an equation. Calculate the end-point energy of the positrons emitted. The atomic masses are given as follows :

$M\left[^{23}_{12}Mg\right] = 22.994127$ u, $M\left[^{23}_{11}Na\right] = 22.989770$ u, $M[_{+}e] = 0.00055$ u. 2+3

5. (*a*) What is cross-section of a neclear reaction ? What are the factors that it depends on ? 2+2+1

(*b*) Derive an expression for the 'mean free path' of a particle entering a medium. The cross-section for interaction of a neutrino with matter is 10^{-47} m^2. Find the mean free path of neutrinos in solid iron. The density of iron is 7.8×10^3 kg/m^3 and average atomic mass is 55.9 u. Express the answer in light years. 3+2

(*c*) The Q-value for the reaction $^{14}N(\alpha, p)^{17}O$ is equal to –1.20 MeV. Find the minimum kinetic energy that the alpha particle must have in the laboratory frame for this reaction to occur. 5

6. (*a*) What is the working principle of a Betatron ? What are its limitations ? 4+2

(*b*) The maximum magnetic induction in a betatron is 0.5T. If the radius of the ring is 0.8 m and the frequency of variation of the magnetic field is 50 Hz, determine the average energy gained by the electrons per turn. Assume that the magnetic flux 'ϕ' linking the orbit, varies with time 't' as $\phi = \phi_0 \sin \omega t$, where '$\omega$' is the angular frequency, and the electrons are accelerated during the first quarter of the cycle. 5

(*c*) Which accelerator is better for accelerating alpha particle ? Justify. 4

7. (*a*) What is working principle of a 'GM counter'. Give *one* of its drawback. 4+1

(*b*) Compare the working principle of Wilson's Cloud Chamber and Bubble Chamber. 2+2

(*c*) Distinguish between the 'fundamental interactions' on the basis of their strength and range. Name the 'exchange particle' involved in each case. 6

8. (*a*) What is meant by 'isospin' ? Give the values of the isospin and the *z*-component of the isospin for (*i*) pions and (*ii*) nucleons. 3+1+1

(*b*) Which of the following reactions can occur ? State the conservation laws violated or/ and followed in each case : 5

(*i*) $n \rightarrow p + e^- + \nu_e$

(*ii*) $p + p \rightarrow p + \Lambda^0 + \Sigma^+$

(*iii*) $\pi^0 \rightarrow \gamma + \gamma$

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

(*v*) $e^+ + e^- \rightarrow \gamma$

(*c*) Schematically show the Baryon decuplet based on the eight fold way. 5

Values of constants :

Mass of proton : 1.007825 u

Mass of neutron = 1.008665 u

Mass of an electron = 0.00055 u

1 amu = 1 u = 1.66×10^{-27} kg

$R_0 = 1.2$ fm

$\epsilon_0 = 8.85 \times 10^{-12}$ F/m