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

S. No. of Question Paper : 7734

Unique Paper Code : 32225417 HC

Name of the Paper : **Nuclear and Particle Physics**

Name of the Course : **Generic Elective : Physics**

Semester : IV

Duration : 3 Hours Maximum Marks : 75

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

Attempy *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 end of the question paper.

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

(*a*) Why are β-decay disintegrations also called isobaric transformations ?

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

P.T.O.

(*c*) What are direct and compound nuclear reactions ?

(*d*) In what respects a particle is similar and dissimilar to its anti-particle ?

(*e*) Write down the law of radioactive disintegrations. Obtain an expression for the half-life of a radioactive material.

(*f*) Why is photoelectric effect not possible with free electrons ?

(*g*) Complete the following reactions :

$^{3}_{2}He + \ldots\ldots\ldots\ldots\ldots\ldots = ^{4}_{2}He + ^{1}_{0}n$

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

2. (*a*) Explain the Binding energy per nucleon *Vs* mass number curve. How can 'nuclear fission' and 'nuclear fusion' be accounted from the Binding Energy per nucleon *Vs*. mass number curve ? 5

(*b*) Find the binding energy of $^{56}_{26}Fe$ in MeV.

$m_p = 1.007825$ a.m.u., $m_n = 1.008665$ a.m.u. and $m_{Fe} = 55.934939$ a.m.u. Symbols have their usual meaning. 5

(*c*) The activity of a certain nuclide decreases to 15% of its original value in 10 days. Find its half-life. 5

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 speeds of alpha particles with energies 1 MeV and 1000 MeV. 5

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

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

(*b*) What are the magic numbers ? Write down the basic assumptions of shell model. 5

(*c*) Using the shell model, calculate the spin and parity of the following : 5

$^{15}_{8}O, ^{19}_{10}Ne$

5. (*a*) What is Compton effect ? Obtain an expression for the Compton shift. 10

(*b*) The threshold wavelength for photoelectric emission in platinum is 190 nm. Find the wavelength of light used in order to liberate an electron with a maximum kinetic energy of 1.1 eV. 5

6. (*a*) What are scintillation detectors ? What are the usage of photocathodes and dynodes in photomultiplier tubes ? 7

(*b*) What are the advantages of cyclic accelerators over linear accelerators ? 5

(*c*) A cyclotron oscillating frequency of 1 MHz is used to accelerate protons. If the radius of the dee is 60 cm, find the magnetic field. 3

7. (*a*) What is the importance of strangeness while analysing strong and electromagnetic interactions ? Write down the Gell-Mann-Nishijima formula and explain each term. 6

(*b*) What is meant by 'Isospin' ? Give the values of the isospin and the z-component (I_3) of isospin for :

(*i*) neutron

(*ii*) proton. 5

(*c*) State the conservation law violated or/and allowed in any *two* : 4

(*i*) $\pi^+ + n \rightarrow \Lambda^0 + K^+$

(*ii*) $\pi^+ + n \rightarrow K^0 + K^+$

(*iii*) $p + p \rightarrow K^+ + \Sigma^+$

(*iv*) $p + p \rightarrow p + p + p + \bar{p}$

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

Values of constants :

Mass of protons : 1.007825 u

Mass of neutrons : 1.008665 u

Mass of electrons : 0.00055 u

1 a.m.u = 1 u $= 1.66 \times 10^{-27}$ kg

$R_0 = 1.2$ fm

$\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

PHYSICAL CONSTANTS

$m_p = 1.007825$ u, $m_n = 1.008665$ u

$m_e = 0.00055$ u, $m_{He} = 2.0141$ u

1 amu $= 1.66 \times 10^{-27}$ kg, $R_0 = 1.2$ fm

$\epsilon_0 = 8.85 \times 10^{-12}$ F/m, $h = 6.6 \times 10^{-34}$ Js

$c = 3 \times 10^8$ m/s, 1 eV $= 1.6 \times 10^{-19}$ J

[This question paper contains 6 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 8093 J

Unique Paper Code : 32227504

Name of the Paper : Nuclear and Particle Physics

Name of the Course : **B.Sc. (Hons.) Physics : DSE-2**

Semester : V

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. Question No. **1** is compulsory.
3. **All** questions carry equal marks.
4. Use of Scientific Calculator is allowed.

1. Answer any **five** : (3×5=15)

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

(b) What is Pair production phenomenon?

(c) Differentiate between Proportional counter and Geiger Muller chamber.

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

(e) What is pairing effect? Why are even–even nuclei more stable as compared to even-odd and odd-odd nuclei?

(f) By how much the atomic mass of a parent nucleus exceed the atomic mass of a daughter when (i) an electron is emitted (ii) a positron is emitted and (iii) an electron is captured?

(g) Give any three characteristics of a nuclear force.

(h) Determine the minimum energy of an antineutrino to produce the reaction $\bar{\nu}+p\rightarrow n+e^{+}$.

2. (a) What are direct reactions? Explain deuteron pick up and stripping reaction. (8)

(b) Show that kinetic energy of an α-particle released in the decay of a nucleus with mass number A is given by

$$KE_{\alpha}=\frac{(A-4)Q}{A}$$

where Q is the Q -value of the reaction. (7)

3. (a) Starting from the density of states obtained from free Fermi gas confined within a volume; obtain the kinetic energy of the highest occupied orbit. (5)

(b) Compare the minimum energies required to remove a neutron from $^{41}_{20}Ca$, $^{42}_{20}Ca$ and $^{43}_{20}Ca$. (5)

(c) For the mirror nuclei $^{23}_{11}Na$ and $^{23}_{11}Mg$, calculate the coulomb coefficient a_c. Given $M[^{23}Mg]$ = 22.994124 amu and $M[^{23}Na]$ = 22.989768 amu. (5)

4. (a) What conservation laws were apparently being violated in the observed continuous β spectrum? How did it help Pauli in predicting the nature of the new particle? (3+2=5)

(b) State the assumptions of Gamow's Theory of Alpha Decay and derive an expression for decay constant of a radioactive nuclei using Gamow's Theory of Alpha Decay. (3+7=10)

5. (a) How does a heavy charged particle interact with matter? Differentiate between energy loss due to heavy ions and electrons in matter. (3+3=6)

(b) What is the working principle of a Betatron? (3)

(c) Linear absorption coefficient of Lead for 1 MeV γ rays is 0.75 per cm. Calculate thickness of lead required to reduce the intensity of γ rays to $\frac{1}{100}$. (6)

6. (a) Explain the procedure by which high potential of the order of MV is generated in a Tandem accelerator. Explain the purpose of using SF_6 gas in Tandem accelerator tank. (3+2=5)

(b) Define quenching in GM counters. An organic-quenched GM tube operates at 1000V and has a wire diameter of 0.2 mm. The radius of the cathode

is 2 cm and the tube has a guaranteed lifetime of 10^9 counts. What is the maximum radial field and how long will the counter last, if it is used on the average for 66 hours per week at 2000 counts per minute? (2+3=5)

(c) A cyclotron in which the flux density of 2 T is employed to accelerate protons. The radius of the cyclotron is 0.32 m. Calculate the frequency of the alternating field applied to Dees. Mass of proton $m_p = 1.6 \times 10^{-27}$ kg and charge $= 1.6 \times 10^{-19}$ C. (5)

7. (a) State the conversation principles preserved or violated in the following particle interactions :

(i) $\pi^- + p \rightarrow \Lambda^\circ + \pi^\circ$

(ii) $\pi^+ + p \rightarrow K^\circ + \Lambda^\circ$

(iii) $\Sigma^\circ \rightarrow \Lambda^\circ + \gamma$ (3×3=9)

(b) Distinguish between Baryons and Mesons. (3)

(c) What happens when electron and positron annihilate? (3)

(b) Discuss the principle of a linear accelerator.

(c) A cyclotron with dees of radius 90 cm is subjected to a transverse magnetic field of 0.8 Tesla. Calculate the energy to which a deuteron of mass 3.34×10^{-27} kg can be accelerated.

6. (a) Sketch the Baryon Octet based on the quark model and assign the required quantum numbers. 6,5,4

(b) When does a nucleus undergo gamma decay ? State the differences between internal conversion and photo-electric effect.

7. (a) State *four* characteristics of nuclear forces. 8,7

(b) The radius of Ge is found to be twice the radius of $^{9}_{4}$Be. Using this information, determine the number of nucleons in Ge.

(c) Find the threshold wavelength of gamma rays needed to produce a proton anti-proton pair. 5,5,5

Useful data :

$M(^{1}_{1}H) = 1.007825u$, Mass of neutron $= 1.008665u$

$M(^{2}_{1}H) = 2.014102u$, $M(^{4}_{2}He) = 4.002603u$

This question paper contains 4 printed pages]

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

S. No. of Question Paper : **8520**

Unique Paper Code : **32227504** **HC**

Name of the Paper : **Nuclear and Particle Physics**

Name of the Course : **Physics : DSE**

Semester : **V**

Duration : **3 Hours** Maximum Marks : **75**

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

Five questions have to be attempted.

Question No. 1 is compulsory.

Attempt any *four* from the remaining set of questions.

Use of Scientific Calculator is permitted.

1. Attempt any *five* (5) questions :

(a) Represent graphically the variation of average binding energy per nucleon with the mass number A. Indicate the stabel and unstable regions due to fusion and fission.

(b) Calculate the binding energy per nucleon for $^{98}_{42}$Mo.

(c) In a fission reaction of Uranium, each reaction releases 200 MeV of energy. Calculate the number of fissions per second in a 150 MW (mega Watt) reactor.

(*d*) State *two* differences between internal conversion and beta decay.

(*e*) What is the Q value of a nuclear reaction ? Find the Q value for the following reaction.

$_2He^4 + {}_7N^{14} \rightarrow {}_8O^{17} + {}_1H^1$

(*f*) Define "dead time" in GM counter. 5×3=15

2. (*a*) What are direct reactions ? Explain deuteron pick up and stripping reaction.

(*b*) Consider a nucleus with $A = 237$. Use the semi-empirical mass formula to find Z for the most stable isobar for this A. Do not derive the semi-empirical formula.

(*c*) Estimate the typical range of the nuclear force if it is assumed that the nucleon-nucleon interaction arises due to the exchange of particles with mass $m = 782.7\ MeV/c^2$. 5,5,5

3. (*a*) What is the Geiger Nutall rule ? Represent it graphically.

(*b*) Calculate the threshold velocity of electrons to produce Cerenkov radiation in a medium of refractive index 1.52.

(*c*) ${}^A_Z X_N \rightarrow {}^{A-4}_{Z-2}X'_{N-2} + {}^4_2He$ represents the spontaneous emission of an alpha particle. If the parent nucleus is at rest, derive the expression for the kinetic energy of the alpha particle $T_\alpha = \frac{Q}{\left(1+\frac{m_\alpha}{m'_x}\right)}$. Use non-relativistic kinematics. Q, m_α, m'_x are the disintegration energy, mass of the emitted alpha particle and the mass of the daughter nucleus respectively. 5,5,5

4. (*a*) Alpha particles of energy 6 MeV pass through an ionization chamber at the rate of 20 per second. Assuming all the energy is used in producing ion pairs, calculate the current produced if 34 eV is required to produce an ion pair.

(*b*) Determine the ratio of the heights of the Coulomb barrier for ${}^{16}_8O$ as seen by a proton and an alpha particle. 7,8

5. (*a*) Indicate, with an explanation, whether the following reactions proceed through the strong, electromagnetic or weak interactions, or whether they do not occur.

(*i*) $\tau^+ \rightarrow \mu^+ + \gamma$

(*ii*) $p \rightarrow \pi^+ + e^+$

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

P.T.O.

(*b*) In a linear accelerator protons are accelerated from 0.75 MeV to 100 MeV. The applied AC source has a frequency of 200 mega Hz. Determine the length of the first cylindrical electrode.

(*c*) Mention any *two* features of a direct nuclear reaction. 5,5,5

7. (*a*) Sketch the meson Octet based on the quark model and assign the required quantum numbers.

(*b*) Determine if it is energetically possible for $^{64}_{29}Cu$ to undergo β^+ decay and transform into $^{64}_{28}Ni$.

Mass of positron = 0.5 MeV/c^2 with c as the velocity of light. 8,7

Useful Data :

$M(^1_1H)$=1.007825 u ; Mass of a neutron = 1.008665u

$M(^{64}_{29}Cu)$=63.929766 u ; $M(^{64}_{28}Ni)$=63.927968 u

$M(^2_1H)$=2.014102 u ; $M(^4_2He)$ = 4.002603 u

This question paper contains 4 printed pages]

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

S. No. of Question Paper : 8381

Unique Paper Code : 32227504 HC

Name of the Paper : Nuclear and Particle Physics

Name of the Course : Physics DSE

Semester : V

Duration : 3 Hours Maximum Marks : 75

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

Five questions have to be attempted

Question No. 1 is compulsory.

Attempt any *four* from the remaining set of questions.

Use of Scientific Calculator is permitted.

1. Attempt any *five* (5) questions :

(*a*) Calculate the isospin of a deuteron.

(*b*) Draw the N-Z curve for the known nuclei and give reason for the deviation from the symmetric line.

(*c*) Find the value of the total angular momentum quantum number J corresponding to the ground state of $^{27}_{13}Al$.

(*d*) What are (*a*) Hadrons (*b*) Leptons ? Give 2 examples each.

(*e*) Define Q value of a nuclear reaction ?

(*f*) Compare the order of the energy of the photons emitted in nuclear and atomic transitions. 5×3=15

2. (*a*) Give any *four* salient features of the shell model.

(*b*) $_{14}Si^{27}$ and $_{13}Al^{27}$ are "mirror nuclei", their ground states are identical except for change. If their mass difference is 6MeV, estimate their radius. (Neglect the proton – neutron mass difference) 8,7

3. (*a*) State *three* advantages of a semi-conductor detector over the gas ionization chamber detector.

(*b*) A Geiger Muller counter has an efficiency of 95%. If the counter reads 960 counts per minute, determine the number of charged particles that are actually incident per minute.

(*c*) Give any *four* characteristics of nuclear forces. 5,5,5

4. (*a*) A photon of energy 1.02 MeV is scattered through 90° by a free electron. Calculate the energy transferred to the recoiling electron and the energy of the scattered photon.

(*b*) Using the semi-empirical mass formula find the most stable isobar for a given A. Do not derive the semi-empirical formula. 7,8

5. (*a*) A radioactive nucleus decays by emitting alpha particles with energies 7.68 MeV, 8.28 MeV, 9.07 MeV and 10.51MeV. Draw a diagram showing the energy levels of the daughter nucleus.

(*b*) A 5 MeV alpha particle approaches a gold nucleus ($^{197}_{79}Au$) with an impact parameter of 2.6×10^{-13} m. Determine the angle through which it will be scattered. Density of gold is 1.93×10^4 kg/m^3.

(*c*) How much energy must a gamma ray photon possess to produce a 10 MeV proton -anti-proton pair ? 5,5,5

6. (*a*) Indicate giving reasons if the following reactions proceed through the strong, electromagnetic or weak interactions or they do not occur.

(*i*) $\pi^- + p \rightarrow \pi^0 + n$

(*ii*) $\tau^+ \rightarrow \mu^+ + \gamma$

P.T.O.