RAN-2103000205021003

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T.Y.B.Sc. (Sem.-V) Examination October - 2025

Physics : Paper-VIII (old Course) Atomic and Nuclear Physics

Time: 2 Hours] **[Total Marks: 50**

સૂચના : / Instructions
(1) ઉપરોક્ત દર્શાવેલ વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fill up strictly the above details on your answer book

Seat No.:

Student's Signature

Q.1. Answer in short as directed: **10**

(1) Name three quantum numbers that arises in solution of Schrodinger's equation for hydrogen atom.
(2) What are the possible values of magnetic quantum number m_l of an electron in p-state?
(3) Which quantum number figures orientation of electron orbit?
(4) State condition of allowed transition for an electron in terms of wave function.
(5) What is Bohr magneton?
(6) What is meant by anti-symmetric wave functions?
(7) What are magic numbers?
(8) What is electron capture?
(9) What is meant by disintegration energy of nucleus?
(10) A nucleus ${}^{A}_{Z}X$ disintegrate to ${}^{A'}_{Z'}Y$ through an α decay followed by a β^- decay then Z' = ---------- and A'= ----------

Q.2. (a) Attempt any one of the following: **07**

(1) From Schrodinger's equation of hydrogen atom in spherical polar coordinates, obtain three separate equations for each variable r, θ, and Ø
(2) Discuss radial part of the Schrodinger's equation and obtain formula for electron's angular momentum L = $\sqrt{l(l+1)}\,\hbar$.

(b) Attempt any one of the following: **03**

(1) The wave function of 1s electron of hydrogen atom is given by $\Psi(r,\theta,\varphi) = \frac{e^{-r/a}}{\sqrt{\pi}\,a^{3/2}}$. Verify that $\left\langle \frac{1}{r} \right\rangle = \frac{1}{a}$.
(2) Discuss uncertainty principal and space quantization of electron in hydrogen atom.

Q.3. (a) Attempt any one of the following: **07**

(1) What is Zeeman Effect? Explain normal Zeeman Effect with the help of vector atom model.
(2) Explain radiative transitions of hydrogen atom with the help of wave function and justify Bohr's assumption about it.

(b) Attempt any one of the following: **03**

(1) A beam of electrons enters a uniform magnetic field of 1.20T. Find the energy difference between electrons whose spins are parallel and antiparallel to the field. (Take $\mu_B = 5.79 \times 10^{-5}$ *eV/T* and $h = 6.625 \times 10^{-34}$ *J – S*)

(2) Discuss selection rules for allowed transitions.

Q.4. (a) Attempt any one of the following: **07**

(1) Derive the expression for the Weizsacker's semi-empirical mass formula of the nucleus

(2) Explain in detail about the volume energy term (B_1) and surface energy term (B_2) about the nucleus.

(b) Attempt any one of the following: **03**

(1) Calculate the total binding energy of $^{40}_{20}Ca$ in Mev. (Mass of the $^{40}_{20}Ca$ is 39.962591 amu, mass of proton and neutron are 1.007825 amu and 1.008665 amu respectively)

(2) Find the value of Coulomb energy term for $^{28}_{14}si$. Proportionality constant for Coulomb energy term is 0.7 MeV.

Q.5. (a) Attempt any one of the following: **07**

(1) What is radioactive decay? Explain Gamow theory of alpha decay.

(2) Explain β-decay. Derive necessary condition for spontaneous emission of β^- particle.

(b) Attempt any one of the following: **03**

(1) Write short note on Geiger-Nuttal law.

(2) The total energy liberated in the α-decay of $^{226}_{88}Ra$ is 4.87MeV. Find the kinetic energy of an α-particle and the recoil energy of the nucleus.