RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, JUNE 2022

SECOND YEAR [BATCH 2020-23]

Date : 25/06/2022 **PHYSICS (HONOURS)**

Time : 11 am – 1 pm **Paper : X [CC10]** Full Marks : 50

Answer **any five** questions: [5×10]

1. a) State the assumptions of liquid drop model. Using liquid drop model explain why the binding energy per nucleon decreases for mass number, A>56 ?

   b) Consider a particle of energy E approaching a potential barrier of height V_0 for $0 < x < L$, where $E > V_0$. The potential elsewhere is zero. Find the probability of particles being reflected or transmitted. [(3+2)+5]

2. a) Consider an experiment in which a beam of electrons is directed at a plate containing two slits, labelled ***A*** and ***B.*** Beyond the plate is a screen equipped with an array of detectors which enables one to determine where the electrons hit the screen. For each of the following cases draw a rough graph of the relative number of incident electrons as a function of position along the screen and give a brief explanation.

   (i) Slit ***A*** open, slit ***B*** closed.

   (ii) Slit ***B*** open, slit ***A*** closed.

   (iii) Both slits open.

   (iv) The Stern-Gerlach apparatus is attached to the slits in such a manner that only electrons with s, = ħ/2 can pass through ***A*** and only electrons with s, = -ħ/2 can pass through ***B.***

   (v) What is the effect of making the beam intensity so low that only one electron is passing through the apparatus at any time?

   b) What is Copenhagen interpretation of quantum theory?

   c) The masses (amu) of the mirror nuclei $^{27}Al_{13}$ and $^{27}Si_{14}$ are 26.981539 and 26.986704 respectively. Determine the Coulomb's coefficient in the semi empirical mass formula. [5+2+3]

3. a) What is a wave packet? State its properties.

   b) Formulate a wave description of particle motion in sinusoidal form.

   c) State the advantages of He-Ne LASER over Ruby Laser.

   Find the ratio of population of the two states of He-Ne Laser that produce light of the wavelength 6328 A^0 at 27 ^OC. [(1+1)+3+(3+2)]

4. a) State the properties of valid wave functions.

   b) Particle is described by the wavefunction,

   $\psi = 0$; $x < 0$

   $= \sqrt{2}e^{-x/L}$; $x \geq 0$

   where L = 1 nm. Calculate the probability of finding the particle in the region $x \geq 1$ nm.

   c) Determine the most stable isobar with mass number A = 64. [3+(4+1)+2]

5. a) State Ehrenfest's theorem. Show that $\frac{d<x>}{dt} = \frac{<p_x>}{m}$.

   b) A radioactive substance of half life 100 days which emits β-particles of average energy 5×10^{-7} ergs is used to drive a thermoelectric cell. Assuming the cell to have an efficiency 10%, calculate the amount (in gram-molecules) of radioactive substance required to generate 5W of electricity.

   c) Describe population inversion in four-level Laser [(1+4)+3+2]

6. a) Show that the wave-function $\psi 0(x) = A\exp(-x^2/2a^2)$ with energy $E = \hbar\omega/2$ (where A and a are constants) is a solution for all values of x to the one-dimensional time-independent Schrodinger equation for the simple harmonic oscillator (SHO) potential $V(x) = m\omega^2x^2/2$.Determine the expectation value $< p_x >$ of the momentum in state ψ_1.

   b) Explain each term in six-factor formula of a chain reaction in nuclear reactor. [(3+1)+6]

7. a) $^{7}_{4}$Be undergoes electron capture and decays to $^{7}_{3}$Li. Investigate if it can decay by the competitive decay mode of β^+ emission. Take masses $^{7}_{4}$Be = 7.016929 amu, $^{7}_{3}$Li = 7.016004 amu.

   b) What do you mean by collapse of the wavefunction. Prove that commutating observables possess a complete set of common eigenfunctions assuming self adjoint operator A has non-degenerated eigenvalues.

   c) If the binding energies of the mirror nuclei $^{41}Sc_{21}$ and $^{41}Ca_{20}$ are 343.143V and

   350.420MeV respectively, estimate the radii of the two nuclei by using the semi empirical mass formula [$e^2/4\pi\varepsilon_0$ = 1.44MeV fm] [2+(1+4)+3]

8. a) Explain how fusion takes place in Sun although the estimated energy value to overcome the Coulomb repulsion is higher than the temperature of the Sun. Write the solar PP-III chain reaction.

   b) Show that electron–positron pair cannot be created by an isolated photon.

   c) How Pauli resolved the enigma of the missing energy of beta decay? [(2+3)+3+2]

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