Sr. No. of Question Paper	:	7763
Unique Paper Code	:	42227929
Name of the Course	:	B.Sc. (Prog.): DSE-3A J
Name of the Paper	:	Elements of Modern Physics
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 including question no. 1 which is compulsory.
3. All questions carry equal marks.
4. Use of non-programmable scientific calculators is allowed.

1. Attempt any five questions. 3 x 5=15

(a) X-rays of 0.1 nm are scattered from a target. Find the maximum kinetic energy of the recoil electrons.

(b) For a hydrogen like atom of nuclear charge +Ze, if 30.22 eV is the energy required to excite the electron from the second Bohr orbit to the third Bohr orbit, determine Z.

(c) A proton in a one-dimensional box has an energy of 450 keV in its first excited state. How wide is the box?

(d) Does the wave associate with a particle travel with it with the same speed? Explain.

(e) Write Schrodinger's time dependent equation in 1-dimension and show that the equation is linear.

(f) Write three properties of nuclear forces.

(g) The half-life period of a radioactive element A is same as the mean-life time of another radioactive element B. Which of the two will have a faster rate of decay if both have the same number of atoms initially?

2. (a) Enlist the features of photoelectric effect. Give an account of Einstein's explanation of these features in the light of quantum theory. 10

(b) If Davisson and Germer had used 100 volts to accelerate their electron beam ins
of 54 volts, at which scattering angle ϕ would they have found a peak in the distribu
of scattered electrons (the intensity)? [Given: d for Nickel = 0.091 nm, ϕ is the a
between the original direction of the electron beam and scattered direction] 5

3. (a) State the postulates of Bohr's theory of hydrogen atom. Obtain an expression for
energy of an electron in the n^{th} orbit of hydrogen atom in terms of the radius of the or
and absolute constants. 10

(b) A hydrogen atom originally at rest in the n = 3 state decays to the ground state wit
the emission of a photon. Calculate the wavelength of the emitted photon. Estimate th
energy E and magnitude p of the momentum of the emitted photon. 5

4. (a) State Heisenberg's uncertainty principle for position and momentum measurement.
Explain how the gamma ray thought experiment validates this principle. 1, 4

(b) An electron is confined to a box of length 1.05 nm. From the uncertainty principle,
estimate the minimum kinetic energy (in eV) of the electron. 5

(c) The wave function for a particle moving along the positive x-direction is given by

$$\psi(x,t) = Ae^{i(kx-\omega t)}$$

Using this obtain an expression for the momentum and kinetic energy operator in one
dimension. 5

5. (a) Explain how the double-slit experiment indicates that nature, at the microscopic scale,
can display dual behavior. 5

(b) Obtain the time dependent Schrodinger equation of a non-relativistic particle in 1-
dimension. 5

(c) For a wave function defined by

$$\psi(x,t) = C\tilde{\psi}(x,t)$$

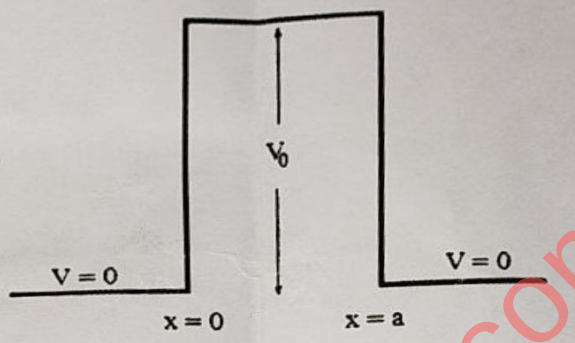
where C is a complex constant and $\tilde{\psi}(x,t)$ is a real function of x and t. Determine the
probability current density. What does the result signify? 5

6. Consider a one-dimensional rectangular potential barrier of constant height V_0 that
extends from x = 0 to x = a, defined by the following potential function V(x), such that

$V(x) = 0,$ $x < 0$ (region-I)

$= V_0,$ $0 < x < a$ (region-II)

$= 0,$ $x > a$ (region-III)



A particle of mass m and energy $E > V_0$ is incident from the left on the barrier at $x = 0$.

(i) Write the Schrodinger wave equation and its physically acceptable solution in the three regions.

(ii) Using these equations, obtain the reflection and transmission coefficients.

(iii) Explain quantum mechanical tunneling? 6, 6, 3

7. (a) Write the semi-empirical binding-energy formula for a nucleus of mass number A, containing Z-protons and N-neutrons and explain each term appearing in the expression. Schematically represent the variation of binding energy as a function of the mass number. 7, 3

(b) Show that an electron cannot be in the nucleus as a consequence of the uncertainty principle. 5

8. (a) What is beta decay? Discuss the neutrino hypothesis for the emission of beta particles from a nucleus. What is the energy released during β-decay. 10

(b) At a given instant there are 25 % undecayed radio-active nuclei in a sample. After 20 seconds, the number of undecayed nuclei reduces to 12.5 %. Determine the mean-life of the nuclei and the time in which the number of undecayed nuclei will further reduce to 6.25 % of the reduced number. 5