B. N. BANDODKAR COLLEGE OF SCIENCE, THANE

USPH 403

Duration: 2 Hrs. 30 min **Total Marks: 75**

N.B.: 1) *All questions are compulsory.*

2) *Figures on the right indicate full marks.*

3) *Non – programmable calculators are allowed.*

Q.1) (A) Attempt any **TWO**

1) Explain the structural hierarchy of the universe. (8)

2) Explain Hubble's law. Hence derive the expression for relation between fractional shift and Hubble's constant. (8)

3) Explain Photoelectric effect and work function. Derive the expression for K.E. of electron in photoelectric effect. (8)

4) Derive an expression for phase velocity and group velocity by considering a group of two waves having same amplitude A and differ by angular frequency $\Delta\omega$ and wave number Δk. (8)

(B) Attempt any **ONE.**

1) Calculate the apparent magnitude of the sun, given that its luminosity $L_{\odot} = 4\times10^{33}\, ergs^{-1}$ and its distance from the earth is $1.5\times10^{8}\, km$. (4)

Given: zero point magnitude $= 2.48\times10^{-5}\, erg/cm^2 s$

2) An electron has a de Broglie wavelength of 2 pico meter. Find its K.E. (4)

Given : $h = 6.62\times10^{-34}\, Js$, $m_e = 9.1\times10^{-31}\, Kg$

Q.2) (A) Attempt any **TWO**

1) Assuming the one dimensional simple harmonic undamped wave equation, y = A sin (ω t ± k x), obtain a second order partial differential classical wave equation. (8)

2) Write the Schrodinger's time dependent equation for a function V as a function of x alone and hence derive the Schrodinger's time independent equation (STIE). (8)

3) What is a wave function? Using a suitable expression for the wave function, derive Schrodinger's time dependent equation. (8)

4) $\Psi(x) = e^{\frac{-m\,\omega^2}{\hbar^2}x^2}$ represents the state of an oscillator of angular frequency ω. Normalize the wave function and find the expectation values of momentum. (8)

(B) Attempt any **ONE.**

1) Explain Max Born's interpretation of the wave function. (4)

2) Find the expectation value of a particle's position if the Eigen function describing the particle is given by (4)

P. T. O.

$\Psi = 12\, x^2$; $0 < x < 1$

$= 0$; elsewhere

Q.3) (A) Attempt any **TWO**

1) Set up the Schrödinger equation for a free particle. Solve the equation to obtain the solution. Find the expectation value of the momentum and comment on it. **(8)**
2) A particle is incident from the left on a potential step: **(8)**

   $V(x) = V_o$ for $x \geq 0$

   $= 0$ for $x \leq 0$

   Set up the Schrödinger equation and write down the solutions. Consider the case of $E < V_o$ and show that there is definite probability of the particle penetrating the classically forbidden region.
3) Consider a particle trapped in a one-dimensional rigid box and show that its energy is quantized. Draw the energy level diagram and comment on it. **(8)**
4) Set up the Schrödinger equation for one dimensional finite square well potential given by: **(8)**

   $V(x) = 0$ for $0 \leq x \leq L$

   $= V_0$ for $x \leq 0$ and $x \geq L$

   Solve it to obtain two classes of energy Eigen functions.

(B) Attempt any **ONE**.

1) Distinguish between bound states and free states. **(4)**
2) Show that the expectation value of the momentum of a particle in a one dimensional box is zero. **(4)**

Q.4) Attempt any **THREE**.

1) Write a note on radiation background. **(5)**
2) Explain Heisenberg's uncertainty principle. **(5)**
3) An Eigen function of the operator $\frac{d^2}{dx^2}$ is e^{-4x}. Find the corresponding Eigen value. **(5)**
4) State the conditions for a well behaved wave function. **(5)**
5) Estimate the zero point energy for a neutron in a nucleus by treating it as if it were in an infinite square well of width equal to nuclear diameter of 10^{-14} m. **(5)**

   Given: mass of neutron: 1.67×10^{-27} Kg.

   h : 6.62×10^{-34} Js.
6) An α -particle having energy 10 MeV approaches a potential barrier of height 50 MeV and width 10^{-15} m. Determine the transmission coefficient. **(5)**

   Given: mass of α -particle $= 6.68 \times 10^{-27}$ kg.

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