Ref:EX/ET/PH/T/2B/126/2017

Bachelor of Electronics & Telecommunication Engineering Examination – 2017

(1st Year, 2nd Semester)

Physics – IIB

Time:3 hours Full Marks: 100

Answer any *five* questions

1 a) What are Newton's rings? Obtain the conditions for bright and dark fringes in case of Newton's ring experiment. Why are the fringes circular?

b) Using Newton's ring how you can determine (i) wavelength of an unknown monochromatic light; (ii) refractive index of an unknown liquid.

c) In a Newton ring experiment the diameter of the 15^{th} ring was found to be 0.59 cm and that of the 5^{th} ring was 0.336 cm. If the radius of the plano-convex lens is 100 cm, calculate the wavelength of the light used. (8+8+4)

2 a) Write the conditions for sustained interference of light. Do you think energy conservation principle is valid in interference? If yes, explain how?

b) Describe Young's experiment and derive expressions for (i) intensity at a point in the screen and also for (ii) fringe width. Mention the conditions for observing distinct and larger fringe width.

c) A light source emits light of two wavelengths 4300 Å and 5100 Å. The source is used in a double slit experiment. The distance between the source and the screen is 1.5 m and the distance between the slits is 0.025 mm. Calculate the separation between the third order bright fringes due to these two wavelengths. (5+10+5)

3. (a) What is a plane transmission grating? What are replica grating?

Obtain the conditions for observing the maxima and minima in a grating spectrum.

(b) Discuss how you can use a grating for determining the wavelength of an unknown light. What are the differences between a grating spectrum and prism spectrum?

(c) Explain the term dispersive power of a grating. On what parameters does it depend?

(d) Calculate the possible order of spectra with a plane transmission grating having 18,000 lines per inch when light of wavelength 4500 Å is used. (8 + 4 + 4+ 4)

[Turn over

(4)

(a) What do you mean by the term 'square integrability' of a quantum mechanical wave function.

(b) Consider $|\psi(t)>$ is a state vector of a system. Let the position and momentum space wave function be $\psi(x,t)$ and $\phi(p,t)$ respectively. Write down the expression connecting $\psi(x,t)$ and $\phi(p.t)$.

(c) Consider a thermal neutron at room temperature. What is the ratio of a particle's compton and De-Broglie wavelength.

(d) State Ehrenfest's theorem and prove any one of the following :
(i) $\frac{d}{dt} < \hat{x} > = \frac{<\hat{P}_x>}{m}$
(ii) $\frac{d}{dt} < \hat{P}_x > = < F_x >$

(e) Show that if Ψ be an eigenfunction of an operator $\hat{A}$ with a eigenvalue λ then it also an eigenfunction of $e^{\hat{A}}$ with eigenvalue e^{λ}.

(f) Evaluate $[\hat{x}, \sin \hat{p_x}]$. [2+2+4+5+3+4]

(5)

(a) What is tunneling? A rectangular potential barrier of height V_0 extends from $x=0$ to $x=a$. Prove that for a particle of energy $E < V_0$, the transmission coefficient through the barrier is given by $T = [1 + \frac{V_0^2}{4E(V_0-E)} \sinh^2 \beta a]$ where $\beta^2 = \frac{2m}{\hbar^2}(V_0 - E)$.

(b) Experimental data indicate that the highest energy of an electron (β- particle) emitted from a radioactive substance doesnot exceed 4Mev . If size of a nucleus is $\sim 10^{-15} m$ then show that electrons can not reside within the nucleus.

(c) Calculate the normalisation constant for a wave function given by $\psi(x) = A \exp{(-\frac{\sigma^2 x^2}{2})} \exp{(ikx)}$ .Also determine the probability density ρ and the probability current density J.

[(1+8)+5+6]

(6)

(a) The potential energy of a harmonic oscillator of mass m is $V(x) = \frac{1}{2} m\omega^2 x^2$ where ω is the angular frequency.

(i) Write the time independent Schrodinger equation for a simple harmonic oscillator.

(ii) The eigenfunction of the Hermitian operator for the ground state is $\psi_0 = ((\frac{\alpha}{\pi})^{1/4} \exp(-\frac{\alpha x^2}{2})$ where $\alpha = \frac{m\omega}{\hbar}$. Calculate the energy eigenvalue in the ground state

(iii) Show that the existance of zero point energy of a linear harmonic oscillator is consistent with Heisenberg uncertainty principle.

(iv) Also find the average Kinetic energy and potential energy in the ground state.

(v) Further prove that it satisfy minimum uncertainty relation $< \delta x >< \delta p > \sim \frac{\hbar}{2}$

[1+4+4+6+5]