B. E. ELECTRONICS TELE-COMMUNICATION ENGINEERING EXAMINATION, 2019

(1st Year, 2nd Semester , Old)

PHYSICS IIB

Time : Three hours | Full Marks : 100

Answer any five questions (5×5=25).

All parts of a question must be written in a single place.

1. (a)Derive an expression for the intensity in a grating. What do you mean by absent spectra in a grating? Discuss the conditions for absent spectra.
(b)What is the highest order of spectrum which may be seen with sodium light of wavelength $5000A^o$ by means of a grating with 3000 lines per cm?
(c)What is a zone plate? Show that a zone plate acts as a converging lens. How does it differ from a convex lens? [(4+4+4)+(2+4+2)]

2. (a)What is Compton Effect? What is its significance? Write down energy and momentum balance equations?
(b)Explain de-Broglie's wave. Calculate the de Broglie wavelength associated with an electron subjected to a potential difference of 1KV.
(c)Consider a thermal neutron at room temperature. What is the ratio of a particle's compton and De-Broglie wavelength.
(d)State and explain Heisenberg's uncertainty principle. If size of a nucleus is around 10^{-15} m then show that electrons can not reside within the nucleus. Note that highest energy of an emitted electron from a radioactive decay does not exceed 4Mev. [6+4+4+(2+4)]

3. (a)Derive an expression for energy of radiation when an electron jumps from one orbit to another in a hydrogen like atom using Bohr's theory. Identify the different spectral lines.
(b) Explain the origin of continuous and characteristic X-ray spectra. What is meant by K_α line?
(c) Determine the relation between probability density and the probability current density. [(5+5)+5+5]

4. (a) Solve the Schrödinger equation for 1-dimensional potential well defined by

$$V(x) = 0 \qquad 0 \leq x \leq L$$
$$= \infty \qquad x < 0 \;\&\; x > L$$

Find out the energy eigen states at different energy levels. Further plot the eigen functions on the different energy levels. So that they are orthogonal to each other.

(b) Consider the Gaussian wave packet

$$\Psi(x) = A \exp\,(ikx - \frac{x^2}{2d^2})$$

Normalize the wave function.

Further show that $< (\Delta x)^2 >< (\Delta p)^2 >= \frac{\hbar^2}{4}$ [(5+3+2)+(2+4+4)]

5. (a) Show that for a potential $V(-x) = V(x)$, the wave function must have a definite parity.
(b) Give the eigen operator and eigen value of $\hat{L_z}$.
(c) Show that $[L_x, L_y] = i\hbar L_z$.
(d) Prove that parity operator is of eigen value ± 1.
(e) Evaluate $[x, \cos p_x]$. [4+4+4+4+4]

6. (a) What is transmission coefficient ? 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) The ground state wave function of hydrogen atom is given by $\psi_0 = \sqrt{\frac{1}{\pi(a_0)^3}}\exp\,(-\frac{r}{a_0})$
(c) Calculate the radial probability function for the ground state of hydrogen atom and plot it.
(d) Show that the most probable distance of the electron from the nucleus in the ground state of hydrogen atom is equal to the Bohr's radius.
(e) Find the expectation value of the potential energy of the above electron. [(1+8)+(3+2)+3+3]

7 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.
(a) Write the time independent Schrodinger equation for a simple harmonic oscillator.
(b) 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.
(c) Show that the existance of zero point energy of a linear harmonic oscillator is consistent with Heisenberg uncertainty principle.
(d) Also find the average Kinetic energy and potential energy in the ground state.
(e) Further prove that it satisfy minimum uncertainty relation $< \delta x >< \delta p > \sim \frac{\hbar}{2}$ [1+4+4+6+5]

8. (a) Explain the interference in a thin transparent film of refractive index μ due to reflected light. Why an extended source of light is used in such experiment?

(b) In a Newton's ring experiment the diameter of the 15th dark ring was found to be 0.590 cm and that of the 5th ring was 0.336 cm. If the radius of the plano-convex lens is 100 cm, calculate the wavelength of the light used.

(c) A 10 μm transparent plate when placed in the path of one of the interfering beams of a double slit experiment [λ= 5800 Å], the central fringe shifts by a distance equal to ten fringes. Calculate refractive index, μ of the plate. [(8+2)+5+5]