BACHELOR OF ENGINEERING (FTBE) EXAMINATION, 2017

(1st Year, 2nd Semester)

Food Technology & Bio-Chemical Engineering

Time - Three hours | PHYSICS II | Full Marks : 100

Answer any five questions (all carry equal marks) :

1. (a) Write down the time dependent Schrödinger equation for a particle of mass m in a one-dimensional potential well $V(x)$ given by,

$$V(x) = 0 \quad \text{for } 0 \le x \le a$$
$$= \infty \quad \text{otherwise.}$$

(b) Determine whether the following time dependent wave function satisfies the above mentioned equation,

$$\Psi(x,t) = \frac{1}{\sqrt{a}}\left[\sin\left(\frac{\pi x}{a}\right)e^{-iE_1 t/\hbar} + \sin\left(\frac{3\pi x}{a}\right)e^{-iE_3 t/\hbar}\right], \quad \text{for } 0 \le x \le a\,,$$
$$= 0\,, \quad \text{otherwise}\,,$$

where $E_n = (n^2\pi^2\hbar^2)/(2ma^2)$. Explain whether $\Psi(x,t)$ is an eigen-state of energy ?

(c) Find whether the probability density $\Psi^*(x,t)\cdot\Psi(x,t)$ is time dependent or independent.

(d) Find the expectation value of $\hat{H} = -\hbar^2/(2m)(\partial^2/\partial x^2)$. 2+(6+2)+4+6

2. (a) A particle of mass $m = 10^{-5}$ gm is moving with a velocity $v = 3 \times 10^5$cm/sec. What is the wavelength associated with this motion. ($h = 6.626 \times 10^{-34}$joule second).

(b) Write down the time dependent Schrodinger equation for a free particle of mass m (consider one space dimension).

(c) Using separation of variables, find the corresponding time independent Schrodinger equation.

(d) Considering the travelling wave solution for the time dependent wave function for a free particle, show that the relations $p = \hbar k$ and $E = \hbar\omega$ are satisfied. 5+2+7+6

3. Consider the following solution of a relevant time dependent Schrödinger equation,

$$\Psi_n(x,t) = A\cos\left(\frac{n\pi}{a}x\right)e^{-iE_nt/\hbar}, \qquad \text{for } -\frac{a}{2} \le x \le \frac{a}{2},$$
$$= 0 \qquad \text{otherwise}.$$

Where $E_n = (n^2\pi^2\hbar^2)/(2ma^2)$, for $n = 1, 2, 3, \ldots$.

(a) Find the normalisation constant A.

(b) Show that $\Psi_n(x,t)$ is a stationary state.

(c) For the particular case $n = 1$, i.e., for $\Psi_1(x,t)$, find the expectation values of position and momentum, $\langle\hat{x}\rangle$, $\langle\hat{p}\rangle$, where $\hat{p} = (h/i)(\partial/\partial x)$.

(d) For the same state, find $\langle\hat{x}^2\rangle$, $\langle\hat{p}^2\rangle$, and hence the root mean square deviations σ_x, σ_p. 4+2+(3+3)+(4+4)

4. (a) Briefly describe Young's double slit experiment with photons.

(b) Argue how, from the outcome of such experiment, the "strange nature of quanta" (wave-particle duality) can be explained.

(c) Describe the important physical observations in Photo-electric effect.

(d) Discuss how Albert Einstein introduced the idea of quantization in order to explain

5. (a) A fully charged capacitor is suddenly connected in parallel to an inductor of very low resistance (R). Show under what condition the charge on the capacitor will decay in an oscillatory manner.
(b) Obtain an expression for the frequency of oscillation.
(c) What happens when R=0?

14+4+2

6. (a) Mentioning the underlying physical laws, write the Maxwell's equations in free space (use SI units).
(b) Starting from Maxwell's equations, derive the wave equation for the electric field in free space.

6+14

7. (a) What are self and mutual inductances? What is their unit?
(b) Calculate the coefficient of self-inductance for a plane circular coil having 'n' no. of turns with a radius 'r' and carrying a constant current 'i'.
(c) A coil of certain radius has 600 turns and a self inductance of 360 mH. What will be the self-inductance of a second similar coil with 510 turns?

5+10+5

8. Write short notes on:
(a) Time constant in LR circuit
(b) Poynting theorem.

10+10