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4 SEM TDC PHY M 2

2018

(May)

PHYSICS

(Major)

Course : 402

(Quantum Mechanics)

Full Marks : 60
Pass Marks : 24/18

Time : 3 hours

The figures in the margin indicate full marks for the questions

1. Choose the correct answer : 1×6=6

(a) The expression for the de Broglie wavelength for a particle of mass m moving with velocity which is comparable with the velocity of light is

(i) $\lambda = \dfrac{h}{\sqrt{2m_0 k}}$

(ii) $\lambda = \dfrac{h\sqrt{1 - v_2 / c_2}}{m_0 v}$

(iii) $\lambda = \dfrac{hc}{\sqrt{k + 2m_0 c^2}}$

(iv) $\lambda = \dfrac{-hc}{2m_0 v}$

(b) The ratio of the de Broglie wavelength to the Compton wavelength of a particle is

(i) $\sqrt{\left(\frac{c}{v}\right)^2 + 1}$

(ii) $\sqrt{\left(\frac{c}{v}\right)^2 - 1}$

(iii) $\frac{1}{2}\sqrt{\left(\frac{c}{v}\right)^2 + 1}$

(iv) $\frac{1}{2}\sqrt{\left(\frac{c}{v}\right)^2 - 1}$

(c) The uncertainty principle of Heisenberg is direct consequence of

(i) Compton effect

(ii) photoelectric effect

(iii) de Broglie hypothesis

(iv) Schrödinger wave function

(Continued

(d) The relation between transition probability per unit time (A_{ik}) and the mean life time (τ) of the atom in the excited state is

(i) $A_{ik} + \tau = 1$

(ii) $A_{ik} - \tau = 1$

(iii) $A_{ik} = \frac{1}{\tau}$

(iv) $A_{ik} = \sqrt{\frac{1}{\tau}}$

(e) "In quantum mechanics, the expectation or average values of observables behave in the same manner as the observables themselves do in the classical mechanics." The statement is related with

(i) Frank-Hertz theory

(ii) Planck's quantum theory

(iii) Ehrenfest's theorem

(iv) Bohr's complementarity principle

(Turn Over)

(f) The reflection coefficient R for a step barrier for the case $E > V_0$ is given by

(i) $R = \left[\dfrac{1-\sqrt{1-V_0/E}}{1+\sqrt{1-V_0/E}}\right]^2$

(ii) $R = \left[\dfrac{1-\sqrt{1-V_0/2E}}{1+\sqrt{1-V_0/2E}}\right]^2$

(iii) $R = \left[\dfrac{1+\sqrt{1-V_0/2E}}{1-\sqrt{1-V_0/2E}}\right]^2$

(iv) $R = \left[\dfrac{1-\sqrt{1-E/V_0}}{1+\sqrt{1-E/V_0}}\right]^2$

2. (a) Explain photoelectric effect.

(b) Derive the de Broglie relation for a photon from the principle of mass energy equivalence.

(c) Describe Davisson-Germer experiment for accurate determination of de Broglie wavelength of a free electron.

(Continued

3. (a) Explain the terms phase velocity and group velocity. Show that group velocity is found to be equal to the particle velocity and phase velocity is half the particle velocity. 2+3=5

(b) State and prove Heisenberg's uncertainty principle. 3

4. (a) Give a physical interpretation of the wave function. What is the importance of normalizing the wave function? 2+2=4

(b) Derive the time independent Schrödinger wave equation for a particle. 4

5. (a) A particle of mass m and total energy E moves from a region of constant potential V_1 to a region of constant potential V_2. Derive expressions for the reflection and transmission coefficients, when $E > V_1$ or V_2. 3+3=6

(b) Consider one-dimensional infinite potential well-defined as

$V(x) = 0, \quad 0 < x < a$

$V(x) = \infty, \quad 0 < x, \quad x > a$

Calculate ground-state energy equation. 6

(Turn Over)

6. *(a)* Define an operator. Give the properties of a linear operator. 2+2=4

(b) What are eigenfunctions and eigenvalues? Show that all the operators do not give real values after operation on a function. 2+3=5

(c) Define the expectation value of a dynamical quantity. Write down the expectation values of the energy and momentum of a particle. 2+2+2=6

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