QK-5323

M. Sc. (Sem.-I) Examination, December-2023

PHYSICS

PAPER – PHY-1003

Quantum Mechanics-I

Time Allowed : **Three Hours**

Maximum Marks : **70**
Min. Marks : **28**

Note : This question paper contains two sections as under :

Section-A ***Max. Marks-20***

This section will have 10 questions, having 02 question from each unit with no internal choice. Answer in about 20 words. All questions carry equal marks. (10×02=20)

Section-B ***Max. Marks-50***

This section will have 10 questions, having 02 questions from each unit, one question to be attempted from each unit. Words limit approximately 400-500 words. Questions may have sub divisions. All questions will have equal marks. (10×05=50)

https://pyqpole.com

SECTION - A

1 (i) What do you mean by the Hilbert space in Quantum mechanics.

(ii) Show that the momentum operator $(\hat{p}_x)$ is self adjoint.

(iii) Draw the first four eigen functions for the Harmonic oscillator potential problem.

(iv) Find the validity condition of the WKB approximation.

(v) What is meant by the time evaluation quantum mechanical operator i.e. $\hat{U}(t_2, t_1)$?

(vi) Discuss the properties of the Pauli's spin matrices.

(vii) Write the energy of the stationary states of the NH_3 molecule for weak and strong field perturbations.

(viii) What do you understand by the quasi stationary states ?

(ix) What is the connection between compatible observation and constant of motions ?

(x) Give one example of irreduceble tensor operator of rank 1.

10×2=20

SECTION - B

UNIT - I

2 (a) Prove that a unitary transformation has the important property of maintaining the normalization of state vectors. **5**

(b) Show that the circular polarization states $|+>$ and $|->$ given by

$$R.|+> = \frac{1}{\sqrt{2}}[|x> + i|y>]$$

$$L|-> = \frac{1}{\sqrt{2}}[|x> - i|y>]$$

are orthogonal i.e. $<+|->=0$ to each other. **5**

OR

If $\hat{A}$, $\hat{B}$ and $\hat{C}$ are Hermitian operators, determine if the following combinations are Hermitian :

(a) $(\hat{A}+\hat{B})$ (b) $\frac{1}{2i}[\hat{A}.\hat{B}]$

(c) $(\hat{A}\hat{B}\hat{C} - \hat{C}\hat{B}\hat{A})$ (d) $(\hat{A}^2 + \hat{B}^2 + \hat{C}^2)$

(e) $(\hat{A} + i\hat{B})$

2×5=10

https://pyqlelo.com

UNIT - II

3 What is meant by the variational principle ? Using this method find the expression of the ground state energy of H-atom for the trial wave function

$$cp = A, e^{-\alpha r/a_0}$$

where symbols have their usual meanings.

5+5=10

OR

Write the Schrodinger equation in time independent form. Explain the energy quantization procedure for the harmonic potential using graphical method. **10**

UNIT - III

4 Explain the non-degenerate perturbation theory. Calculate the energy correction upto second order in case of linear harmonic oscillator problem for the perturbations given by

(a) $H' = \frac{1}{2} bx^2$

(b) $H' = Q \sum x$

5+5=10

OR

Consider the matrix

$$H = \begin{pmatrix} 1+\epsilon & \epsilon \\ \epsilon & -1+\epsilon \end{pmatrix},$$

Find the energy correction for non-degenerate and degenerate case(s).

5+5=10

UNIT - IV

5 A perturbation

$$\epsilon(t) = \epsilon_o \cos wt$$

is applied on a NH_3 molecule then find the probability of finding the system in the stationary states | I > and | II >. Also show that the probability conservation condition

$P_I(t) + P_{II}(t) = 1$ is satisfied.

10

OR

Find the expression of the Fermi Golden rule

$$R_{s_i} = \frac{2\pi}{x} \overline{\left| \left(H_1 \right)_{s_i} \right|^2} \rho(E_s)$$

in quantum mechanics. Show that it is a manifestation of the uncertainty principle.

10

https://pyqlelo.com

UNIT - V

6 Prove the following commutation relation

(a) $[J_2, J_+] = \hbar J_+$

(b) $[J_2, J_-] = -\hbar J_-$

(c) $[J_+, J_-] = 2\hbar J_2$

(d) $[J^2, J_2] = 0$

(e) $[J_x, J_y] = i\hbar J_2$

2×5=10

OR

State and prove the Wigner Eckhart theorem.
Also discuss its importance.

5+5=10

---

https://pyqlelo.com