Roll No. Total No. of Pages : 02

Total No. of Questions : 09

M.Sc.(Physics) (2015 to 2017) (Sem.–2)

QUANTUM MECHANICS

Subject Code : MPH-201

Paper ID : [A2815]

Time : 3 Hrs. Max. Marks : 100

INSTRUCTION TO CANDIDATES :

1. Attempt any FIVE questions in ALL, including compulsory Question No.9
2. Each question carries TWENTY marks.

1. a) Explain Heisenberg uncertainty principle and Using this principle calculate the binding energy of an electron in hydrogen atom. (12)

   b) Derive time-dependent Schrodinger wave equation for a particle subjected to a force. (8)

2. a) The position of an electron moving with a velocity of 10^6 m/s is located with an accuracy of 10^{-4} cms. Calculate :

   i. The minimum uncertainity in the momentum of electron.

   ii. The fractional uncertainly in the momentum. (6)

   b) What ratio of E/V_0 is necessary for scattering from a one dimensional step potential so that the transmission probability is 50%. (14)

3. a) For Pauli's matrices, prove that (i) $\sigma_x\sigma_y\sigma_z = i$, (ii) $[\sigma_x, \sigma_y] = 2i\sigma_z$ (4+4)

   b) If the eigen values of J^2 and J_z are given by $J^2|\lambda m\rangle = \lambda|\lambda m\rangle$ and $J_z|\lambda m\rangle = m|\lambda m\rangle$, show that $\lambda \geq m^2$ (12)

4. a) Evaluate the Clebsh-Gordan coefficients for a system having j_i =1/2 and j_2 =1/2. (7)

   b) What is the ground state energy and wave function for two identical particles in the potential?

   $V(x) = \infty$ for x<0and x>0, for 0< x< a. if the two particles are (i) bosons and (ii) fermions? (3+3=6)

   c) The valence electron in the first excited state of an atom has the electronic configuration $3s^1 3p^1$.

   i. Under L-S coupling what values of L and S are possible? (2)

   ii. Write the spatial part of their wave functions using single particle functions $\Psi_s(r)$ and $\Psi_{as}(r)$. (2)

   iii. Out of the levels, which will have the lowest energy and why? (3)

5. Discuss time independent perturbation theory and obtain the expressions for the first order correction & second order correction to Energy and Eigen function. (20)

6. a) Prove that parity operator is Hermitian and unitary. (6)

   b) Prove that the fundamental commutation relation [x,px] = ih remains unchanged uner unitary transformation. (6)

   c) Write a short note on the concept of space inversion and time reversal. (4+4=8)

7. a) Write a short note on Fermi golden Rule. (4)

   b) Evaluate the scattering amplitude in the Born approximation for scattering by the Yukawa potential

$$V(r) = V0\frac{\exp(-\alpha r)}{r}$$, where V_0 and α are constants.

   Also show that σ (θ) peaks in the forward direction ($\theta = 0$) except at zero energy and decreases monotonically as θ varies from 0 to Π. (8)

   c) In the Born approximation, calculate the scattering amplitude for scattering from the square well potential $V(r) = -V_0$ for $0 < r < r_0$ and $V(r) = 0$ for $r > r_0$. (8)

8. a) Starting from the Klein-Gordan equation, obtain the equation of continuity. (8)

   b) Show that the Dirac matrices α_x, α_y, α_z and β anticommute in pairs and their squares are unity. (12)

9. **Answer briefly :**

   a) Define inner product and outer product in dual space.

   b) Show that a unitary operator remains unitary under a unitary transformation.

   c) What is optical theorem?

   d) Define particle exchange operator and show that its eigen values are ± 1.

   e) Define differential scattering cross-section.

   f) Write down the eigenvalues of S_x & S_y operators.

   g) What is the formula for the first Born Approximation for scattering amplitude?

   h) Write down the selection rules for transitions between different states (8×2.5=20)