4.4.2016

DOON UNIVERSITY, DEHRADUN

Mid Semester Examination, Second Semester, 2015-16

School of Physical Sciences

2-Years MSc Program

Course: PHC-452: Quantum Mechanics II

Time Allowed: 2 Hours *Maximum Marks: 30*

Note: Attempt All Questions from Sections A, B, C.

SECTION: A *(Marks: 1 X 4 = 4)*

1. With increasing quantum number, the energy difference between successive levels
   (A) Increases (B) Decreases (C) Remain the same (D) None of the above
2. The lowest possible energy for a particle in a potential box is 2 *e*V. The next highest energy the particle can have is
   (A) 4 *e*V (B) 8 *e*V (C) 16 *e*V (D) 32 *e*V
3. The existence of zero point energy for a linear harmonic oscillator is a consequence of
   (A) Pauli exclusion principle (B) Special theory of relativity
   (C) Matter waves (D) Uncertainty principle
4. The degree of degeneracy of the energy level $\frac{38\hbar^2\pi^2}{2ma^2}$ of the particle in a cubical potential box of side a is
   (A) 6 (B) 9 (C) 3 (D) 12

SECTION: B *(Marks: 4 X 4 = 16)*

5. Consider a charged particle q in a one dimensional harmonic oscillator potential of frequency ω. Suppose we turn on a weak electric field (E), so that the potential energy is shifted by an amount $H' = -qEx$. Calculate first and second order correction in energy levels.
6. Prove that the selection rules for orbital quantum number l and magnetic orbital quantum number m for one electron atom is $\Delta l = \pm 1$ and $\Delta m = 0, \pm 1$.
7. Write down the exact energies and wave functions of the ground states for the infinite cubic potential well $V(x,y,z) = \begin{cases} 0 & \text{if } 0 < x < L, 0 < y < L, 0 < z < L, \\ \infty & \text{otherwise} \end{cases}$

   Now add the following perturbation to the infinite cubic well

   $$Hp = V_0 L^3 \delta(x - L/4)\delta(y - 3L/4)\delta(z - L/4)$$

   Using the first order perturbation theory, calculate the energy of the ground state.
8. Find ground state energy for one dimensional harmonic oscillator using the variational principle.

SECTION: C *(Marks: 5 X 2 = 10)*

9. Use the variational method to calculate the ground state energy of *He* atom.
10. State the WKB approximation and show that the probability of finding a particle at any point is inversely proportional to its momentum. Prove that the transmission probability of a scattering particle from rectangular barrier with a bumpy top is

    $$T \cong e^{-2\gamma}, \text{ with } \gamma \equiv \frac{1}{\hbar}\int_0^a |p(x)|\, dx.$$