RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College under University of Calcutta)

B.A./B.SC. FIFTH SEMESTER EXAMINATION, DECEMBER 2012

THIRD YEAR

Date : 19/12/2012 **PHYSICS (Honours)**

Time : 11 am – 1 pm Paper : V Full Marks : 50

[Use separate Answer Book for each group]

Group – C

(*Answer **any three** questions*)

1. a) Using Heisenberg's uncertainty principle, show that a proton can stay inside a nucleus. [2]
   b) What is ultraviolet catastrophe in black body radiation? Explain briefly how this problem was avoided in Planck's formula. [2+3]
   c) Davisson and Germer studied the electron diffraction with a nickel crystal for which the interatomic distance was found to be 0·91Å using X-rays. When the electrons with kinetic energy of 54eV were scattered, the principal maximum occurred at $\theta = 65°$. Sow that this experiment verified the deBroglie relation. [3]

2. a) Write down Schroedinger's time dependent equation. What are stationary states? [1+2]
   b) A normalized wave function is $\psi(x) = (c/(\pi)^{1/2})^{1/2} \exp(-c^2x^2)\exp(ikx)$
   Obtain the probability density and the probability current density in this case. [2+2]
   c) Consider an infinite square well of width 2a (–a to +a). The wave function of a particle trapped in such a well is found to be $\psi = C\cos\left(\frac{\pi x}{2a}\right) + \sin\left(\frac{3\pi x}{a}\right) + \frac{1}{4}\cos\left(\frac{3\pi x}{2a}\right)$ inside the well and $\psi = 0$ outside the well [3]

3. a) What are the properties of a wave function? [2]
   b) Define a hermitian operator. Show that a hermitian operator has only real eigenvalues. [1+2]
   c) Evaluate the following commutator brackets : $[x, p_x]$ and $[x, L_x]$ [2+3]

4. a) What do you mean by bound and unbound states? Give suitable examples. [2+1]
   b) Consider two wave functions : $\psi_1 = Ae^{-\alpha x^2/2}$, $\psi_2 = Bxe^{\frac{-\alpha x^2}{2}}$ with $\alpha = \sqrt{\frac{m\omega}{\hbar}}$
      i) Show that they are eigen functions of the Hamiltonian operator of one dimensional harmonic oscillator. Which one of them has higher energy eigen value? Explain physically.
      ii) Is $\psi_1 + \psi_2$ an eigen function of parity operator? Explain. [(1½+1½+1+1)+2]

5. a) Find out the transmission and the reflection coefficient for a scattering problem in one dimension in a potential $V(x) = 0$ for $x < 0$,
   $= V_0$ for $x > 0$
   with energy $E > V_0$. [6]
   b) The ground state wave function a hydrogen atom problem is, $\psi_{10} = \frac{1}{2\pi} a^{-\frac{3}{2}} e^{-\frac{r}{a}}$; where a is the Bohr radius. Find out the position of the electron corresponding to maximum probability and the probability of the electron remaining between r = a and r = 2a. (You need not evaluate the integral). [4]

Group – D

(*Answer **any two** questions*)

6. a) What are the L, S, J quantum numbers of the state of an atom? Find out different states of L – S coupling scheme for two electron atom when $\ell_1 = 3$, $\ell_2 = 1$. What are doublet structure in the atomic spectra? [7]

   b) What is Lande's g-factor? State its importance in atomic spectra. Calculate the g-factor of $2p_{\frac{3}{2}}$ state. [3]

7. a) Obtain the rotational energy levels of a diatomic molecule. What is the selection rule for transition between rotational energy levels? Show the various energy levels and spectral lines in a diagram. [6]

   b) What are Einstein's A and B coefficients? Obtain a relation between them. [4]

8. a) State and explain Pauli's exclusion principle? Calculate the maximum number of electrons in a particular shell. [4]

   b) A laser beam of wave length 660 nm has coherence time 6×10^{-5} s. Calculate the order of magnitude of its coherence length and spectral width. [2]

   c) Explain briefly the theory of Raman effect. Why are Stoke's lines brighter than the anti-Stoke's lines? [4]