RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FIFTH SEMESTER EXAMINATION, FEBRUARY 2022

THIRD YEAR [BATCH 2019-22]

Date : 26/02/2022 **PHYSICS (HONOURS)**

Time : 11 am – 1 pm **Paper : XI [CC11]** Full Marks : 50

Answer **any five** questions of the following: [5×10]

1. a) Find out an estimate of the minimum energy of a particle in a 1D infinite well by using the uncertainty principle.

   b) Show that the group velocity of the de-Broglie wave equals the velocity of the particle. What is its significance?

   c) Find out the de Broglie wavelength of an electron accelerated through a p.d. of 0.5 MeV. [3+4+3]

2. a) Prove that the time rate of change of the momentum of a particle equals the negative of the rate of change of the potential. What is the expectation value of an operator A in a state which is an eigenstate of A with the eigenvalue a.

   b) A system is in a state X=cY +dZ at t=0 , where Y and Z are the eigenstates of the energy operator with the eigenvalues E and F respectively. X,Y,Z are normalised. If the average energy be G find out the state at any time t. [4+1+5]

3. a) If two operators commute, they have a complete set of simultaneous eigenstates. Prove it assuming nondegeneracy.

   b) A particle is in a state B=A(x-a)(x+a) for |x|<a and zero elsewhe(a)re. Normalise the wavefunction and verify the uncertainty principle regarding the position and the momentum by finding out the uncertainty product for these variables. [4+6]

4. a) Find out the normalised eigenfunctions of a particle in a 1D infinite well with the boundaries at x=0 and x=l . Hence find out the probability of finding the particle between x=0 and x=l/2.

   b) Using the creation and annihilation operators of a 1D harmonic oscillator find out its ground state and the first excited states. [6+4]

5. a) Normalise the ground state wavefunction exp(-r/a) of a hydrogen atom.Hence find out the average value of the observables (1/r) and(r).

   b) Find out the commutator of (a)any two components of orbital angular momentum,(b) any one component and the square of the orbital angular momentum. Does the commutator behave identically if the orbital angular momentum be replaced by the total angular momentum (Spin+ orbital)? Explain.What do these results signify from the measurement of angular momentum? [4+6]

6. a) Explain strong field and weak field Zeeman splitting of the spectral lines. Define Stark effect.

   b) Explain how the spin-orbit coupling causes a splitting of the spectral lines. [7+3]

7. a) Find out using perturbation theory the first order change in the energy levels.

   b) For an infinite well potential the potential is shifted everywhere by a constant amount. Find out the change in the energy levels in the first order. Does this result agree with the exact result obtained without using the perturbation theory? (The boundaries are at x=0 and x=l. You can assume the wave function) [5+5]

8. a) Explain LS and JJ coupling. The quantum numbers of two electrons in a two-valence electron atom are n1=6,l1=3,s1=1/2 and n2=5,l2=1,s2=1/2. Assuming LS and JJ coupling find out the possible values of J.

   b) State Pauli's exclusion principle. What condition does it impose on the total web function(spin+orbital) of a system of two electrons? [7+3]

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