11-10-2017

Mid Semester Examination II – Monsoon 2017
IIIT-Hyderabad
Subject: Science I (ISC201)

Full Marks: 35 **Time: 90 min**

Use of non-programmable scientific calculators is allowed

1 (a) Compare space quantization diagrams of the Bohr-Sommerfield orbits with the azimuthal quantum number k = 3 and k = 4. (Note: You need to specify the respective orientation angles in the diagrams). 3M

(b) Draw Sommerfeld elliptic orbits for n=1, 2 and 3 for the elements H and He^+. 3M

(c) Discuss the characteristics of a well-behaved wavefunction. 2M

2 (a) Obtain the Schröedinger equation from the plane wave equation. 3M

(b) Does the curvature of a wavefuction depend on the sign of the wavefunction and relative values of the total energy and potential energy of a quantum system? Justify your answer using schematic diagrams. 2M

(c) Construct operators for the momentum and kinetic energy of a quantum system. 2M

3 (a) Discuss the formation of a chemical bond between two hydrogen atoms to form a H_2 molecule in terms of the symmetry and antisymmetry wavefunctions. 3M

(b) Consider a quantum system with two electrons (labelled as 1 and 2). If a and b are the two allowed states for these electrons, write possible wavefunctions of the system. Among the possible wavefunctions, identify the wavefunction that obeys the Pauli's exclusion principle. 2M

(c) The azimuthal wave function for the hydrogen atom is $\psi(\phi)=Ae^{im_l\phi}$. Show that the value of normalization constant A is $\frac{1}{\sqrt{2\pi}}$ over all angles 0 to 2π. 2M

4 (a) Find the expectation values of the operators p_x and p_x^2 for a quantum particle with a wavefunction $\sqrt{\frac{2}{L}}\sin\frac{\pi x}{L}$ in the range 0 to L. 3M

(b) Write a short note on Born-Oppenheimer approximation. 2M

(c) Write the Hamiltonian for a hydrogen molecule. 2M

5 (a) Show that for a given orthonormal function, the expectation value of the Hamiltonian is greater than or equal to the exact ground state energy. 3M

(b) Describe the procedure of obtaining a trail wavefunction using the molecular orbital theory. 4M