Model questions (Quantum mechanics)

1. Explain the de-Broglie's hypothesis. Give the de-Broglie wave equation.
2. Why is the wave nature of matter not apparent for macroscopic particles?
3. Define phase velocity and group velocity.
4. Derive an expression for group velocity using superposition principle.
5. Establish a relation between phase velocity and group velocity in dispersive media.
6. Show that the group velocity of wave is equal to the velocity of the particle.
7. State and explain Heisenberg's uncertainty principle. Give its different relations.
8. Using Heisenberg's uncertainty principle, show that an electron cannot confine within the nucleus.
9. What is Max Born's interpretation of a wave function?
10. What is meant by normalization of a wave function?
11. What are the characteristics of a wave function?
12. What are quantum mechanical operators? What is the need for operators in quantum mechanics? Give the QM operators of momentum, Kinetic energy and Total energy.
13. What are expectation values? Give in brief the method of evaluation of expectation value of a parameter.
14. Starting from classical wave equation, set up time independent one dimensional Schrodinger wave equation.
15. Solve Schrödinger wave equation for a particle in one-dimensional infinite potential well of width L to obtain energy Eigen values and Eigen functions.
16. With the help of neat sketches, discuss the wave functions and probability density distribution curves for first two allowed energy states of a particle confined in one dimensional infinite potential well.

Problems for practice

1. Calculate the de-Broglie wavelengths of a photon, an electron and a proton, each having an energy of 50 eV.
2. Compare the de-Broglie wavelength of an electron and a proton if they have i) the same speed and ii) the same kinetic energy.
3. An electron has a speed of 1.6×10^5 m/s and it can be determined to an accuracy of 0.05%. Calculate the uncertainty in its position.
4. An electron and a photon have the same energy. The wavelength of photon is 10 times that of electron. Calculate the value of energy.
5. The mass of a particle is $0.5 MeV/c^2$ and its energy is 100 eV. If the velocity of the particle can be determined to a precision of 1%, what is the uncertainty in determining its position?
6. An electron is in the ground state in an infinite potential well of width 5Å. Calculate the excitation energy required to raise the electron to the third excited state.
7. A particle is confined to an infinite potential well of width 'L'. Calculate the probability of finding the particle for the following cases:
   (i) between x= 0 and x=L/2 in the ground state,
   (ii) between x=0 and x=L/3 in the first excited state
   (iii) between x=0.45 L and x=0.75 L in the second excited state.