Question Bank

Subject: Applied Physics II **Semester: II**

Unit IV

1. Wave Particle Duality

Marks

1 State and explain Heisenberg's uncertainty principle? Illustrate it by an experiment on diffraction at a single slit. [6]

2 Starting from the uncertainty principle for the position-momentum pair, derive the uncertainty principle for the Energy-time pair. [4]

3 Show that the phase velocity of a matter wave is c^2/v, where c is the speed of light and v is the velocity of the particle. [4]

4 Show that the group velocity of a matter wave is equal to the particle velocity. [6]

5 Explain how the concept of a de Broglie group wave is associated with the Heisenberg's uncertainty principle. [4]

6 With the help of a neat diagram, explain the phenomenon of diffraction of an electron from a single slit on the basis of Heisenberg's uncertainty principle. [6]

7 State the de Broglie hypothesis and derive the equation of de Broglie wavelength in terms of energy. [4]

8 Show that the wavelength associated with an electron, accelerated by a potential difference of V volts, is given by $h/\sqrt{2meV}$. [4]

9 What is the de Broglie wavelength of an electron at rest? Give reasons. [3]

Problems:

1 Calculate the de Broglie wavelength of (a)1 keV electron (b)1 keV proton and (c) 1KeV neutron. [4]

2 The wavelength of yellow spectral emission line of sodium is 5893A. At what kinetic energy would an electron have that wavelength as its de Broglie wavelength? [4]

3 An electron and a photon each have a wavelength of 2A. Calculate their (a) momenta and (b) their energies. [4]

4 What accelerating voltage would be required for the electrons of an electron microscope if the microscope is to have the same resolving power as could be obtained using 100 keV gamma rays? [4]

5 Imagine playing baseball in a universe (not ours) where the Planck constant is 0.60 Js. What would be the uncertainty in the position of a 0.50kg baseball that is moving at 20 m/s along an axis if the uncertainty in the speed is 1.0 m/s? [4]

6 Compare the uncertainties in the velocities of an electron and a proton confined in a 10A box. [4]

7 The position and momentum of a 1 keV electron are simultaneously determined. If its position is located to within 1A, what is the percentage of uncertainty in its momentum? [4]

8 Show that the uncertainty in the velocity of a particle is of the order of the particle velocity itself. [4]

9 An electron and a proton have the same kinetic energy. Which of them has the greater de Broglie wavelength? Why? [4]

10 If you double the kinetic energy of a particle, how does its de Broglie wavelength change? (b) What if you double the speed of the particle? [4]

11 The mass of an electron is 9.1×10^{-31} kg and that of a bullet is 10g. If both of them travel with a velocity of 10 m/s, calculate their de Broglie wavelengths. Why do we observe wave behavior for an electron but not for a bullet? [4]

2. Wave Equations

1 Derive the Schrodinger's time independent equation by setting up a wave equation and using the de Broglie wavelength. [6]

2 What is the physical significance of ψ and $|\psi|^2$. [4]

3 Derive an expression for the energy levels and the wave functions of a particle enclosed in an infinite potential well. [7]

4 What is normalization of a wave function? [4]

5 Draw ψ and $|\psi|^2$ for a particle in (a) a rigid box and (b) a non-rigid box. Explain the differences between the two. [4]

6 Write down the Schrodinger's equation in the different regions of a finite potential well. State the boundary conditions that the wave function must satisfy. [6]

7 Derive the Schrodinger's time dependent equation starting from the Schrodinger's time independent equation. [6]

8 What is tunneling effect? Describe the I-V characteristics of a tunnel diode on the basis of tunneling phenomenon in its energy bands. [6]

Problems:

1 An electron is trapped in a one-dimensional, infinitely deep potential energy well of width 1A.

- (a) What is the ground state energy? [3]
- (b) How much energy is required to transfer the electron from the ground state to the second excited state? If this energy is provided by a photon, what is its wavelength? [4]
- (c) Once the electron has been excited to the second excited state, what wavelengths of light can it emit by de-excitation? [4]

2 1) A ground state electron is trapped in the one-dimensional infinite potential well with width 1A.

- (a) What is the probability that the electron can be detected in the left one-third of the well ($0 < x < L/3$)? [4]
- (b) What is the probability that the electron can be detected in the middle one-third of the well ($L/3 < x < 2L/3$)? [4]

3 What must be the width of an infinite potential well if an electron trapped in the state for n=3 to have energy of 4.7eV? [4]

4 An electron is trapped in a rigid box in the n=17state. How many points of (a) zero probability and (b) maximum probability does its matter wave have? [3]

5 A proton and an electron are trapped in the ground state of identical rigid boxes. At the centre of the well, is the probability density for the proton greater than, less than or equal to that of the electron? Give reason. [3]

6 If a nucleus is approximated by a one-dimensional infinite potential well with width L = 1.4×10^{-14} m then what is the ground state energy of (a) an electron and (b) a proton confined to the nucleus? [4]

7 An electron in a rigid box 2.5 A wide is in the ground state. How much energy must it absorb if it is to jump to the state with n = 4? [4]

8 The lowest possible energy for a certain particle trapped in a rigid box is 1 eV. (a) What are the next two higher energies the particle can have? (b) If the particle is an electron, how wide is the box? [3] each

9 Consider a potential energy barrier whose height is 6 eV and whose thickness is 7 A. What is the energy of an incident electron whose transmission coefficient is 0.001? [4]

10 Rank the following pairs of quantum states for an electron states for a particle confined to an infinite well according to the energy difference between the states, greatest first: (a) n=3 to n=1, (b) n=5 to n=4 and (c) n=4 to n=3. Give reasons. [4]

11 Three infinite wells with width L, 2L and 3L have an electron each in their n=10 state. Rank the wells, with reasons, according to (a) number of maxima for the probability density of the electron and (b) the energy of the electron, greatest first. [4]

12 By what factor should the width of an infinite potential well be reduced to decrease the ground state energy of the trapped particle to half? [3]

13 An electron, trapped in a finite potential well, is in its ground state. Are (a) its de Broglie wavelength, (b) the magnitude of its momentum and (c) its energy greater than, the same as, or less than they would be if the potential well were infinite? Give reasons for each briefly. [6]

Unit V:

3. Laser:

1 .Define the terms: i) Stimulated absorption
ii) Spontaneous emission
iii) Stimulated emission
iv) Pumping
v) Meta-stable state
vi) Population inversion [1]
vii) Active medium. each

2 Explain the terms: i) Stimulated absorption
ii) Population inversion [2]
iii) Pumping each

3 Distinguish between Spontaneous emission & Stimulated emission. [4]

4 What are lasers? State the properties of lasers. [4]

5 What are properties of lasers? Explain any one. [4]

6 What is population inversion? How it is achieved by optical pumping? [4]

7 What is population inversion? Why it is necessary for lasing? [4]

8 What is Meta-stable state? What role do such states play in the operation of lasers? [4]

9 What do you understand by a negative temperature state? How can it be achieved? [4]

10 Explain the operation of Ruby laser with neat labeled diagram. [6]

11 Explain how lasing action is achieved in a semiconductor laser? [6]

12 With the help of energy band diagram explain working of semiconductor laser. [6]

13 Explain construction & working of He-Ne laser. [6]

14 Explain any one application of laser. [4]

15 Explain in brief – i) Spatial coherence
ii) Temporal coherence [4]

16 What is holography? Explain Recording & Reconstruction of a Hologram. [6]

4. Superconductivity:

1 What are superconductors? Define critical temperature. [2]

2 What is the significance of critical temperature, critical magnetic field for superconductors? [4]

3 Explain the following terms : i) Zero Electrical resistance
ii) Persistent current. [6]

4 Explain the isotope effect & its significance [6]

5 Explain the Meissner effect. [6]

6 Explain the Meissner effect. What important property of superconductors it explain? [6]

7 Explain the perfect diamagnetism in superconductors. [6]

8 Distinguish between Type I & Type II superconductors. [6]

9 Explain Type I & Type II superconductors with examples. [6]

10 What is superconductivity? Explain the BCS theory of Superconductors. [6]

11 Explain DC * AC Josephson effect. [6]

12 Explain the use of superconductors in electromagnets & transmission lines. [4]

Unit VI:

5. Semiconductor Physics:

1 Describe in brief the formation of energy bands in solids. [4]

2 What is Fermi energy? Show the location of Fermi energy levels in intrinsic and extrinsic semiconductors. [6]

3 Classify the elements as conductors, insulators and semiconductors on the basis of band theory of solids. [6]

4 What is Fermi function? Show that the Fermi level lies at the centre of the energy gap in an intrinsic semiconductor. [6]

5 Explain why a potential difference develops across an open circuited P -N Junction. [2]

6 Explain the terms valance band, conduction band and forbidden energy gap. [3]

7 What are transistors? Explain the working of PNP / NPN transistor. [6]

8 Give the energy band picture of P-N junction diodes and explain the effect of biasing on the band picture. [6]

9 Discuss the working of NPN transistors. Explain with respect to the energy band diagram. [6]

10 “P-N junction is a unidirectional device”. Explain. [2]

11 Write a note on solar cell. [6]

12 Derive the expression for conductivity in an intrinsic and extrinsic semiconductor. [6]

13 Explain the working of a P-N junction diode under forward and reverse bias on the basis of energy level diagram. [6]

14 Discuss application of a solar cell. [4]

15 Write a note on the construction and characteristics of a solar cell. [6]

16 Explain Hall Effect and Hall coefficient. [6]

17 Explain the process that takes place in and around the depletion layer. [2]

18 Explain the working of a solar cell. Give the significance of the cell parameters I_{sc}, V_{oc} and fill factor. [6]

19 Derive an expression for conductivity in a metal. [6]

Problems:

1 The mobilities of carriers in intrinsic germanium sample at room temperature are μ_n = 3600cm^2 /volt –sec and μ_p = 1700cm^2 /volt-sec. If the density of electrons is same as holes and is equal to 2.5x 10^{13} per cm^3, calculate the conductivity. (Ans. 2.12 mho/m) [4]

2 Calculate the number of acceptors to be added to a germanium sample to obtain the resistivity p= 10 ohm-cm. Given, μ = 1700cm^2 /volt-sec. (Ans. 3.676x10^{14} per cm^3) [4]

3 At room temperature the conductivity of a silicon crystal is 5x 10^{-4} mho/cm. If the electron and hole mobilities are 0.14 m^2/ volt-sec and 0.05 m^2/ volt-sec, determine the density of carriers. (Ans. 1.64 x 10^{16} /m^3) [4]

4 The specific density of tungsten is 18.8 g/cm3 and its atomic wt. is 184.0. Assume that there are two free electrons per atom. Calculate the concentration of free electrons. Av. No. = 6.025 x 10^{23} /g mole. (Ans. 2.5 x10^{23} / cm^3) [4]

5 Compute the conductivity of copper for which μ_e = 34.8 cm^2 volt-sec and d= 8.9gm/cm3. Assume that there is one free electron per atom. Av. No. = 6.025 x 10^{23} /g mole. At wt. of Cu = 63.5. If an electric field is applied across such a copper bar with an intensity of 10 V/cm, find the average velocity of free electrons. (Ans. 47.02 x 10^{-4} mho/cm, 348 cm/sec.) [4]

6 The resistance of copper wire of diameter 1.03 mm is 6.51 ohm per 300 m. The concentration of free electrons in copper is 8.4 x10^{28} /m^3. if the current is 2A, find the (a) mobility, (b) drift velocity, (c) conductivity.
(Ans. 0.413 m^2 /volt-sec, 0.286 x 10^{-20} m/sec, 55.5 x 10^8 mho/m) [4]

7 Calculate the energy gap in silicon if it is given that it is transparent to radiation of wavelength greater than 11000 A^0 (Ans. 1013 eV) [4]

8 An N- type semiconductor is ti has a resistivity of 10 ohm – cm. Calculate the number of donor atoms which must be added to achieve this.
Given: $\mu_e = 500\ cm^2 / volt\text{-}sec$. (Ans 12.5x 10^{23}) [4]

6. Physics of Nano-particles:

1 Define Nanotechnology. [1]
2 What is the significance of size of particles in the nano-domain? [2]
3 Discuss the mechanical & electrical properties of nano-materials. [6]
4 Discuss the optical & magnetic properties of nano-materials. [6]
5 Give a brief account of the properties of nano-materials**.** [7]
6 Give a brief description of different methods of synthesis of nano-materials. [3]
7 What are the advantages of synthesizing nano-materials by chemical methods? [3]
8 Define colloids and nano-materials with reference to colloids. Give examples of colloids. [3]
9 Explain briefly the theory of colloids. [3]
10 Explain briefly how colloids are synthesized by the chemical route. [3]
11 Explain with the help of Lamer diagram the nucleation and growth of nano-particles. [3]
12 What is “Ostwald ripening” of nano-particles? [1]
13 How are metal nano-particles synthesized by the colloidal route? [2]
14 Discuss the following applications of nanotechnology**.**

(i) Electronics (ii) Energy (iii) Space & defense [6]

15 Discuss the following applications of nanotechnology**.**

(i) Automobiles (ii) Medical (iii) Nanotechnology & Environment [7]

16 Give a brief account of the applications of Nanotechnology**.** [7]