Unit - I

Crystallography

Two mark questions

1. What is a space lattice ?

It is an array of points in three dimensions in which every point has an identical surroundings.

2. What is a unit cell ?

It is the smallest volume of a solid from which the entire crystal structure can be constructed by repetition in three dimension.

3. Name the seven crystal systems.

i) Cubic
ii) Tetragonal
iii) Orthorhombic
iv) Monoclinic
v) Triclinic
vi) Rhombohedral
vii) Hexagonal

4. What is primitive cell ?

A primitive cell is the simplest type of unit cell which contains only one lattice point per unit cell.

5. Bismuth has $a=b=c=4.74\ \text{Å}$ and angles $\alpha=\beta=\gamma=60^\circ$. What is crystal structure ?

$$a=b=c=4.74\ \text{Å}$$

$$\alpha=\beta=\gamma=60^\circ$$

Since $a=b=c$ and $\alpha=\beta=\gamma\neq 90^\circ$

The crystal structure of Bismuth is trigonal (Rhombohedral)

6. What are Bravais lattices?

There are 14 possible types of space lattices out of the seven crystal systems. These 14 space lattices are called Bravais lattices.

7. Define coordination number?

It is the number of nearest neighbouring atoms that any atom has in the given crystal structure.

8. Define atomic radius?

The half of the distance between nearest neighbouring atoms in a crystal is known as atomic radius. The atomic radius is denoted by r and the cube edge 'a'.

9. Define Packing factor. What is its unit?

It is the ratio of volume of atoms in unit cell to the volume of the unit cell.

10. What are crystalline materials? Give example

Crystalline materials in which the atoms are arranged in an orderly fashion throughout in a three dimensional space. Example: copper, silver etc.

11. What is an amorphous solid? Give example

It is a type of solid in which the atoms are not arranged in an orderly fashion.

12. What is a crystal?

A crystal is a three dimensional solid composed of a periodic and regular arrangement of atoms.

13. What are lattice points?

The points in the space to represent position of atom or group of atoms of the crystal are called lattice points.

14. What is basis?

The crystal structure is formed by associating with every lattice point a unit assembly of atoms or molecules. This unit assembly is called the basis or pattern.

15. What is the relation between lattice constant 'a' and density ρ of the crystal?

$$\rho = \left(\frac{nM}{Na^3} \right)$$

where

n - Number of atoms in unit cell

M - atomic weight

N - Avagadro's number = 6.023×10^{26} mol^{-1}

16. What is mean by closely packed structure?

Closely packed structure has the highest packing factor of 0.74. Here the atoms are closely packed leaving a small space as vacant site in the crystal. Face centred cubic copper and hexagonal close packed magnesium are examples to this closely packed structure.

17. What is crystal defect?

The deviation from the regularity of arrangement of atoms is called crystal imperfection or crystal defect.

18. Mention various types of defects

i) Point defects (zero dimensional)

a) Impurity defect

i) Substitutional impurity defect

ii) Interstitial impurity defect

b) Vacancies

i) Frenkel defect

ii) Schottky defect

iii) Line defects (one dimensional)

a) Edge dislocation

b) Screw dislocation

iii) Surface defects (two dimensional)

a) Grain boundaries

b) Twin boundaries

c) Tilt boundaries

d) Stacking faults

e) Ferromagnetic domain walls

iv) Volume defects (three dimensional)

a) cavities or voids

b) Cracks and holes.

19. What is impurity defect? What are types of impurity defects?

A foreign substance added to a crystal is called impurity.

i) Substitution impurity defect

ii) Interstitial impurity defect.

20. What are vacancies?

Vacancies are empty atomic sites. Vacancies may occur as a result of imperfect packing during the original crystallization or they may arise from the thermal vibrations of atoms, at higher temperatures.

21. What is Frenkel defect ?

A vacancy associated with interstitial impurity is called Frenkel defect.

22. what is Schokky defect ?

If an atom is missing from its lattice site, the vacancy is called Schokky defect.

23. What is line defect ? what are its types ?

The defect along a line is called line defect. Types are

i) Edge dislocation

ii) Screw dislocation

24. What is burger's vector ?

The magnitude and the direction of the displacement due to edge dislocation are defined by a vector called Burger's vector.

25. what are twin boundaries ?

If the atomic arrangement on one side of the boundary is the mirror image of the arrangement on the other side the defect is called twin boundaries.

26. What is stacking faults ?

This defect arises due to defect in the stacking of atomic planes. In some cases a part certain atomic plane will be missing where as in some other cases a portion of extra atomic plane is present, changing the sequence of arrangement of atoms.

Unit - II

Electrical and Magnetic Properties of Materials

Two mark questions

1. Give the Assumptions (or) postulates of classical free electron theory.

   i) Electrons move freely like molecule in a gas

   ii) The free electrons move in a uniform - potential field due to the ions fixed in the lattice.

   iii) In the absence of electric field ($E = 0$), the free electrons move in random directions and collide with each other.

   iv) During collision no loss of energy is observes Since the collisions are elastic.

   v) when the presence of electric field ($E \neq 0$) the free electrons are accelerated in the direction opposite to the direction of applied electric field.

   vi) Since the electrons are assumed to be perfect gas, they obey the laws of classical theory of gases

2. Define mean free path

   The average distance travelled by a free electron between any two successive collisions in the presence of an applied field is known as mean free path

$$\lambda = v_d \times \tau_c$$

3. Define relaxation time of an electron

The average time taken by a free electron to reach its equilibrium state from its disturbed state due to application of an external electrical field is called relaxation time.

4. Define drift velocity of electron. How is it different from the thermal velocity of an electron

The average velocity acquired by a free electron in a particular direction after a steady state is reached on the application of an electrical field is called drift velocity. It is denoted as v_d and its value is very small.

The thermal velocity is random in nature and its value is very high.

5. Define mobility of electrons

The magnitude of the drift velocity acquired by the electrons per unit electric field is defined as the mobility of electrons (μ)

$$\mu = \frac{v_d}{E}$$

$v_d \longrightarrow$ Drift velocity of electrons

$E \longrightarrow$ Electrical field

6. Define electrical conductivity. What is its unit

The amount of electrical charges (q) conducted per unit time(t) across unit area (A) of the conductor for unit applied electrical field (E) is defined as electrical conductivity

$$\sigma = \frac{q}{t A E}$$

Its unit is $ohm^{-1}\ m^{-1}$ or $mho\ m^{-1}$

7. Define Fermi distribution function

The Probability F(E) of an electron occupancy for a given energy level at temperature T is known as Fermi distribution function. It is given by

$$F(E) = \frac{1}{1 + e^{(E - E_F)/kT}}$$

$E_f \rightarrow$ Fermi level, $k \rightarrow$ Boltzmann's Constant

$T \rightarrow$ Absolute temperature, $E \rightarrow$ Energy of the level

8. Define Fermi level and Fermi energy with its importance.

Fermi level: It is the energy level at finite temperature above 0K in which the probability of the electron occupation is 1/2 and it is also the level of maximum energy of the filled states at 0K

Fermi energy: It is the energy of the state at which the probability of the electron occupation is 1/2 at any temperature above 0K. It is also the maximum energy of filled states at 0K.

Importance: Fermi level and Fermi energy determine the probability of an electron occupation for a given energy level at a given temperature.

9. Define density of states. What is its use?

It is defined as the number of available electron states per unit volume in an energy interval E and E+dE. It is denoted by Z(E).

It is used to determine Fermi energy at any temperature

10 What is electron theory of solids?

The electrons in the outermost orbit of the atoms

10 which constitute the solids determine its electrical properties. The electron theory of solids explains the structure and properties of solids through their electronic structure.

11. What is a periodic potential.

When an electron moves through a solid, its potential energy varies periodically with the periodicity equal to period of space lattice 'a'. This is called periodic potential.

12 on the basis of spin how the materials are classified as para, ferro, antiferro and ferrimagnetic

- Paramagnetic materials have few unpaired electron spins of equal magnitudes.
- Ferro magnetic materials have many unpaired electron spins with equal magnitudes.
- Anti ferro magnetic materials have equal magnitude of spins but in antiparallel manner.
- Ferrimagnetic materials have spins in antiparallel manner but with unequal magnitudes.

13 What is curie constant? or what is curie law?

It is found that susceptibility (χ) is inversely proportional to the temperature (T)

$$\chi \propto 1/T$$

$$\chi = C/T$$

where C is constant and it is known as curie constant. This relation is known as curie law.

14. State Curie-Weiss law and its importance.

Curie-Weiss law is given by

$$\chi_x = \frac{C}{T-\theta}$$

$C \rightarrow$ Curie constant

$T \rightarrow$ Absolute temperature

$\theta \rightarrow$ Curie temperature.

Importance :

It determines the susceptibility of the magnetic materials in terms of temperatures.

If the temperature is greater than curie temperature, a ferromagnetic material becomes paramagnetic material

15. What is ferromagnetism?

Certain materials like Iron (Fe), Cobalt (Co), Nickel (Ni) and certain alloys exhibit spontaneous magnetization (ie) they have a small amount of magnetisation even in the absence of an external magnetic field. This phenomenon is known as ferromagnetism.

16. What is saturation magnetisation?

The maximum magnetisation in a ferromagnet when all the atomic magnetic moments are aligned is called saturation magnetization.

17. Mention application of GMR

The main application of GMR is magnetic field sensors, which are used to read data in hard disk drives, biosensors, micro electro mechanical systems and other devices.

GMR multilayer structures are also used in magnetoresistive random-access memory as cell that store one bit of information.

Unit - III

Semiconductors and Transport Physics

Two mark questions

1. What are elemental semiconductors? Give some important elemental semiconductors.

Elemental semiconductors are made from single element of the fourth group elements of the periodic table.

Example : Germanium and silicon

2. What are the properties of semiconductors?

- They are formed by covalent bond
- They have empty conduction band
- They have almost filled valence band
- These materials have comparatively narrow energy gap.

3. What are compound semiconductors? Give some important compound semiconductors?

Semiconductors which are formed by combining third and fifth group elements or second and sixth group elements in the periodic table are called compound semiconductors.

Examples

III & IV - Groupelements - Gallium phosphide
Gallium Arsenide

II & VI - Group elements - Magnesium oxide
zinc oxide.

4. What are the differences between elemental Semi Conductors and compound semiconductors?

S.No	Elemental Semiconductors	Compound Semiconductors
1.	They are made of single element. Ex: Ge, Si	They are made of compounds Ex; GaAs, MgO
2.	Heat is produced during recombination	The photons are emitted during recombination.
3.	They are used for the manufacture of diodes and transistors.	They are used for making LED's, Laser diodes and IC's.

5. Define Hall effect and Hall Voltage

When a conductor carrying a current (I) is placed in a transverse magnetic field (B), a potential difference is produced inside the conductor in a direction normal to the directions of the current and magnetic field.

This phenomenon is known as Hall effect and the generated voltage is called Hall-Voltage.

6. What is a Semiconductor?

Semiconductor is a special class of material which behaves like an insulator at 0K and acts as conductor at temperature other than 0K. Its resistivity lies in between a conductor and an insulator.

7. What is an intrinsic Semiconductor?

Semiconductor in an extremely pure form (without impurities) is known as intrinsic Semiconductor.

8. What is an extrinsic Semiconductor?

A semiconducking material in which impurity atoms added to the material to modify its conductivity is known as extrinsic Semiconductor or impurity Semiconductor.

9. What is n-type Semiconductor ?

When a small amount of pentavalent impurity is added to a pure Semiconductor, it becomes extrinsic or impurity Semiconductor, and it is known as n-type Semiconductor.

10. What is a p-type Semiconductor ?

When a small amount of trivalent impurity is added to a pure semiconductor, it becomes extrinsic Semiconductor or impure Semiconductor and it is called p-type Semiconductor.

11. What is mean by doping and doping agent ?

The technique of adding impurities to a pure Semiconductor is known as doping and the added impurity is called doping agent.

12. What is mean by donor energy level ?

A pentavalent impurity when doped with an intrinsic Semiconductor donates one electron which Produces an energy level called donor energy level.

13. What is mean by acceptor energy level ?

A trivalent impurity when doped with an intrinsic semiconductor accepts one electron which Produces an energy called acceptor energy level.

14. Mention the uses of Compound Semiconductor.

They are used as photovoltaic materials, photoconductive cell, laser materials and for making LED.

15. Define drift velocity

When an electrical field is applied in a Semiconducting material, the free charge carriers such

as free electrons and holes attain drift velocity v_d.

The drift velocity attained by the carriers is proportional to the electrical field strength E.

$$v_d \propto E$$

$$v_d = \mu E \longrightarrow (1)$$

μ – proportionality constant and known as the mobility of the charge carrier.

16. Define drift current.

The electric current produced due to the motion of charge carriers under the influence of an external electric field is known as drift current.

17. Define diffusion current

The non-uniform distribution of charge carriers creates the regions of uneven concentrations in the semiconductor.

The charge carriers move from the regions of higher concentration to the regions of lower concentration. This process is known as diffusion. The current is known as diffusion current.

18. What is a Hall device?

The device which uses the hall effect for its application is known as Hall device.

19. What are different types of Hall devices?

a) Gauss meter

b) Electronic Multiplier

c) Electronic Wattmeter.

20. What is a schottky diode?

It is a junction formed between a metal and n-type semiconductor

When the metal has a higher work function than that of **n-type** semiconductor then the junction formed is called schottky diode.

21. what is ohmic contact?

An ohmic contact is a type of metal semiconductor junction. It is formed by a contact of a metal with a heavily doped semiconductor.

When the semiconductor has a higher work function than that of metal, then the junction formed is called the ohmic junction.

22. What are the uses of ohmic contacts?

The use of ohmic contacts is to connect one semiconductor device to another, an IC, or to connect an IC to its external terminals.

Unit - IV

Optical properties of Materials

Two mark questions

(1) What are optical materials ?

The materials which are sensitive to light are known as optical materials. These optical materials exhibit a variety of optical properties.

(2) What are the type of optical materials ?

i) Transparent

ii) Translucent

iii) opaque

(3) Define scattering of light.

It is a process by which the intensity of the wave attenuates as it travels through a medium.

(4) Define carrier generation and recombination

The carrier generation is the process where by electrons and holes are created.

The recombination is the process where by electrons and holes are annihilated,

(5) What are types of carrier generations ?

i) Photogeneration

ii) Phonon generation

iii) Impact ionization

(6) What are types of recombination process ?

a) Radiative Recombination

b) Shockley - Read Hall Recombination

c) Auger Recombination.

(7) What is Solar cell ?

It is a P-N junction diode which converts solar energy (light energy) into electrical energy.

(8) What is LED ?

It is a p-n junction diode which emits light when it is forward biased.

(9) What is the basic principle behold LED ?

The injection of electrons into p-region from n-region makes a direct transition from the conduction band to valence band. Then, the electrons recombine with holes and emits photons of energy Eg.

The forbidden gap energy is given by

$$E_g = h\nu$$

(10) What is an organic light emitting diodes ?

Organic light emitting diodes are solid state devices made up of thin films of organic molecules that produce light with the application of electricity.

(11) What is a laser diode ?

It is a specially fabricated p-n junction diode. This diode emits laser light when it is forward-biased.

(12) What is Franz-Keldysh effect ?

The change in absorption in a semiconductor in the presence of a strong electric field is called Franz-Keldysh effect.

Since the energy of photon $h\nu$ is less than energy gap there is no absorption of photon in the absence of electric field. But in the presence of a strong electric field bending of bands occurs and the tunneling probability of photon

absorbed electron from valence band to conduction band increases. Thus due to application of the field absorption changes.

(13) What is Stark effect?

The change in atomic energy upon the application of an electric field is called the Stark effect. The electric field affects the higher order, or outer orbits of electrons and splitting of energy states occurs. This reduces the band gap.

(14) What is mean by electro absorption?

Both Franz-Keldysh and Stark effects results in absorption of photons with energies smaller than the band gap with application of an electric field. This phenomenon is known as electro absorption.

(15) What is mean by quantum confined Stark effect?

In quantum well structure, with the application of an electric field, the electron and hole wave functions are seperated and pushed towards opposite sides of the well. The reduced overlap results in corresponding reduction in absorption. This results in a shift of the absorption spectrum to longer wavelength (red shift). This shift is known as the quantum confined Stark effect.

(16) What is electro optic effect?

Changing the refractive index and other optical characteristics of a medium by the application of electric field is called electro-optic effect.

(17) What are Pockel's effect and Kerr effect?

Due to electro optic effect the refractive index of a material changes with applied field as

$$\Delta\left[\frac{1}{n^2}\right] = rE + PE^2$$

where r is the linear electro optic coefficient. P is the quadratic electro optic coefficient. The linear variation of the refractive index is called Pockels effect and quadratic variation is called Kerr effect.

Unit : V

Nano electronic Devices

Two mark questions

1. Define nano materials.

Nanophase materials are newly developed materials with grain particle size at the nanometre range ($10^{-9}m$), in the order of 1-100 nm.

2. Define density of states.

It is defined as the number of available electron states per unit volume in an energy interval E and E+dE. It is denoted by Z(E)

3. Define Fermi energy.

It is defined as the highest energy level occupied by the electron at 0K in metal.

4. what is a quantum confinement?

It is a process of reduction of the size of the solid such that the energy levels inside become discrete.

5. What is quantum structure?

When a bulk material is reduced in its size, atleast one of its dimension, in the order of few nanometres, then the structure is known as quantum structure.

6. Define Zener - Bloch oscillation

It denotes the oscillation of a particle confined in a periodic potential when a constant force is acting on it.

7. What is resonant tunneling?

The transmission probability of the double symmetric barrier is maximum and hence the tunneling current reaches peak value when energy of electron wave is equal to quantised energy state of the well. This phenomenon is known as resonance tunneling.

8. What is single electron phenomena?

Present day, transistors require 10,000 electrons. Rather than moving many electrons through transistors it may very well be practical and necessary to move electrons one at a time. This is known as single electron phenomena.

9. Define Coulomb - Blockade effect.

The charging effect which blocks the injection or rejection of a single charge into or from a quantum dot is called coulomb blockade effect.

10. What is the condition for Coulomb Blockade effect?

If two or more charges near one another, they exert coulomb forces upon each other. If two charges are the same kind the force is repulsive. Therefore the condition for observing coulomb blockade effects is expressed as

$$We = \frac{e^2}{2C} >> KT$$

C - capacitance of the quantum dot

T - temperature of the system

W_c - charging energy and this energy needed to add one negatively charged electron to the dot.

11. what is single electron tunneling?

The quantization of charge can dominate and tunneling of single electrons across leaky capacitors carries the current. This is called single electron tunneling.

12. What is a single Electron Transistor?

SET is three terminal switching devices which can transfer electrons from source to drain one by one.

13. What is mesoscopic structure?

The structures which have a size between the macroscopic world and the microscopic or atomic one are called mesoscopic structure.

14. What is conductance fluctuation?

conductance fluctuations in quantum physics is a phenomenon exhibited in electrical transport experiment in a mesoscopic system.

15. What is quantum interference effect?

It states that much like waves in classical physics, any two or more quantum states can be added together (superposed) and the result will be another valid quantum state.

16. What are magnetic semiconductors?

The semiconducting materials which exhibit both ferromagnetism and useful semiconductor properties are known as magnetic semiconductors.

17. What is spintronics?

The spin of the electron can be used rather than its charge to create a remarkable new generation of spintronic devices. These are smaller more versatile and more robust than those currently making up silicon chips and circuit elements.

18. what is a carbon nano tube?

The carbon nanotubes are the wires of pure carbon like rolled sheets of graphite or like soda straws.

19. What are the types of carbon nano tube structure?

3 types, i) Armchair structure

ii) Zig-Zag structure

iii) chiral structure

20 How carbon nano tubes are classified?

Carbon nano tubes are classified as

i) Single-walled (SWNTs)

ii) Multi-walled (MWNTs)