UNIT – V

CRYSTAL PHYSICS

PART-A: Two marks questions and answers

1.what is a Crystal? (or) What are crystalline materials? Give examples

Crystalline solids (or) Crystals are those in which the constituent atoms (or) molecules are arranged in an orderly fashion throughout in a three dimensional pattern. Example: Copper, Silver

2.What is an amorphous solid? Give example. (or) Non-Crystalline materials.

It is a type of solid, in which the atoms (or) molecules are not arranged in an orderly fashion. (ie) the same atomic groups are arranged more randomly. Example: Plastic, rubber

3. What is meant by Crystallography?

The study of the geometric form and other physical properties of crystalline solids, using x-rays (or) electron beam (or) neuron beam etc is termed as the science of crystallography.

4.What is a single crystal?

A crystal in which solid contains only one crystal. These single crystals are produced artificially from their vapor (or) Liquid State.

5.What is a poly crystal? Give example.

A crystal structure in which has an aggregate of many small crystals (or) grains separated by well defined grain boundaries. These crystals will have a sharp melting point. Examples:Diamond, Copper, Platinum, Silver, Polonium, Gold, Aluminum, Nickel, Cadmium, Iron etc.

6. What are the differences between crystalline and non-crystalline materials?

CRYSTALLINE MATERIAL	NON-CRYSTALLINE MATERIAL
They have definite and regular geometrical shapes which extend through the crystal.	They don't have definite geometrical shapes.
They are anisotropic	They are isotropic
They are most stable	They are less stable
Example: Nacl , Kcl	Example: Plastic, Glass, rubber

7. What is meant by crystallization and X-ray crystallography?

The phase change from Liquid (or) gas to solid is called Crystallization. The crystal structure gives the arrangement of atoms within a crystal. Determination of crystal structure with the help of X-ray is known as X-ray crystallography.

8. Define Lattice.

Lattice is defined as an array which are imaginarily kept points to represent the position of atoms in the crystal such that every lattice point has got the same environment as that of the other and hence one lattice point can not be distinguished from the other lattice point.

9. Define space lattice (or) crystal lattice (May 2003, June 2005)

A three dimensional collection of points in space are called space lattice (or) crystal lattice. The environment about any particular point is in every way the same.

10. Define lattice points

Lattice points denote the position of atoms (or) molecules in the crystal (or) The points in the space lattice are called lattice points.

11 .Define Basis (or) Motif

Basis (or) Motif is an unit assembly of atoms (or) molecules which are identified with respect to the position of lattice points, identical in composition arrangement and orientation.

12 What is meant by structure?

A crystal lattice refers to the geometry of a set of point in space, Where the crystal structure refers to the actual ordering (or) alignment of its constituent ions, atoms (or) molecules in the space. The crystal structure is formed by the addition of basis to every lattice point of the lattice. (ie) Space lattice + Basis (or) Mot if = Crystal structure

13. Define lattice planes?

A set of parallel and equally spaced planes in a space lattice, Which are formed with respect to the lattice points are called lattice planes.

14. Define unit cell.

The unit cell is defined as the smallest geometric figure, the translational repetition of which in all over the three dimensions gives the actual crystal structure.(OR) The unit cell may also be defined as the fundamental elementary pattern with minimum number of atoms, molecules (or) groups of molecules which represents the total characteristics of the crystal.

15. What is called as crystallographic axis?

The lines drawn parallel to the lines of intersection of any three faces of the unit cell which do not lie in the same place called crystallographic axis.

16. What is unit cell parameter (or) lattice parameters?

The three intercept quantities a, b and c are called the fundamental translational vectors (or) axial lengths (or) intercepts (a, b and c) and three inter facial angles are called unit cell parameter (or) lattice parameters.

17. What are primitives (or) Characteristic intercepts?

The intercepts a, b and c are nothing but the edge of the unit cell (ie the distance between two lattice points) which define the dimensions of an unit cell. These intercepts are known as its primitives (or) characteristic intercepts on the axis.

18. What is primitive cell (May 2003, Nov 2003)

A primitive cell is the simplest type of unit cell which contains only one lattice point per unit cell (contains lattice points at its corner only)Example :Simple Cubic (SC)

19. Which are called Non-Primitive cell.

If there are more than one lattice point in an unit cell, it is called a non-primitive cell. Example: BCC and FCC.

20. Name of the seven crystal system.

Triclinic, Mono clinic, Orthorhombic, Tetragonal, Hexagonal, Trigonal and Cubic.

21. What are Bravais lattices? (May 2004)

The 14 possible ways of arranging points in space lattice such that, all lattice points have exactly the same surroundings. These 14 lattice in seven crystal structure are called Brava is lattice.

22. What is known number of atoms per unit cell (or) effective number?

The total number of atoms present in (or) shared by an unit cell is known as number of atoms per unit cell.

23. Define atomic radius

Atomic radius is defined as half of the distance between any two nearest neighbor atoms which have direct contact with each other, in a crystal of a pure element. It is interns of cube edge ‘a’.

24. Define co-ordination number.

Co-ordination number is the number of nearest neighboring atoms to a particular atom. (Or) Co-ordination number is the number of nearest neighbors directly surrounding a given atom.

25. Define Atomic packing factor (or) Packing density (or) density of packing.

Atomic packing factor is defined as the ratio between the volume occupied by the total number of atoms per unit cell (v) to the total volume of the unit cell (V).

APF=Volume occupied by the total number of atoms per unit cell(v)

Total volume of the unit cell(V)

26. Name the crystal structure of the following (Dec 2003)

(a).Gold – FCC (b) Germanium –Diamond cubic

(c).Barium – BBC (d) Zinc – HCP

27.Bismuth has a=b=c=4.74AU and angle α=β= γ =60ºwhat is its crystal structure?

Ans : a=b=c=4.74AU α=β=r=60º

Bismuth is Trigonal (or) Rhombohedral

28. State the condition imposed on the coll parameter for systems having the largest number of bravais lattices the least number of nearest neighbors,

(i) Crystal with least number of nearest neighbours is simple (six neighbours)

(ii)crystal system with largest number of bravais lattice is orthorhombic (4bravaais lattices).

29. Give the ration between the density of the crystal and the lattice constant the relation is

$$\rho = \frac{nA}{Na^3}$$

Where 'n' is the number of atoms per unit cell , N is the Avogadro number , 'A' is the atomic weight and 'a' is the lattice constant.

30. Define inter – atomic distance and inter planer distance.

Inter atomic distance: The distance between any two atoms is called inter atomic distance.Inter planar distance: The distance between any two planer is called inter – planar distance.

31. Name some crystal growth methods

a. Solid Growth - Solid-to-Solid phase transformation

b. Liquid Growth - Liquid to Solid phase transformation

c. Vapour Growth - Vapour to Solid phase transformation

32. What are solution growth methods

1. High temperature solution growth
2. Low temperature solution growth

33. Define Bridgman crystal growth method

Bridgman method under high pressure of inert gas allows to grow single crystals of highly volatile substances, what are for example II-VI compounds. The main advantage of vertical Bridgman crystal growth process among other crystal growth techniques is its simplicity.

34. State Czochralski method of crystal growth

Czochralski method is one of the most popular and widely used industrial methods for growing single crystals of semiconductor and dielectric materials, as well as synthetic crystals of gems. Technological features of the process are determined by the requirements to the geometrical parameters, structure, morphology and physico-chemical properties of single crystals.

PART-B

1. Explain the various types of crystal system with a neat sketch and example.
2. (i) Explain the following terms (a) Space Lattice (b)Basis (c)Unit cell

(ii) Define the terms atomic radius and coordination number, packing factor and calculate the above for SC, BCC and FCC structures.

3.(i)Define packing factor and obtain the packing factor for the Hexagonal closed packing factor.

(ii) Show that for a cubic structure the interplanar distance'd' in terms of miller indices and the cell edge 'a' is given by $d = \sqrt{\frac{a^2}{h^2 + k^2 + l^2}}$

4.(i) Describe the structure of HCP crystal (ii) Calculate the axial ratio (c/a) and atomic packing factor for HCP structure.

5. Define atomic packing factor, calculate packing factor for (a) SC (b) BCC (c) FCC (d) HCP (c) Diamond unit cells.

6. Describe the Structure for (1)Nacl (2) Zns (3) Graphite (4)Diamond

What are Miller indices and Cscl. Sketch two successive (110) planes, show that for a Cubic Lattice and distance between two successive plane (hkl) is given by $d = \sqrt{\frac{a^2}{h^2 + k^2 + l^2}}$

Problems to solve

1. Copper has FCC structure and its atomic radius is 1.273 A° ,find the lattice parameter and the density of copper.
   (i) Atomic weight of copper =63.5gm (ii) Avogadro's number = 6.023×10^{26} atoms/Kilomole.

2 .α-iron of atomic weight 55.85 solidifies into BCC structure and has a density of 7860 kgm^{-3} .Calculate the radius of an atom.

3. Copper crystalline in the FCC structure. The Density and atomic weight of copper are 8960 kg/m^3 and 63.54 respectively. Calculate its lattice constant.

4. Calculate the value of d-spacing for (`100) planes in a rock salt crystal of $a = 2.814A^{\bullet}$.

5. Calculate the interplanar distance for (321) plane in simple cubic lattice with interatomic spacing equal to 4,12 $A^{\bullet}$.

6. Calculate the inter-planar spacing for (101) and (221) planes in a simple cubic lattice whose lattice is 0.42nm.

7. Calculate inter planar spacing (1 0 1) in a simple cubic crystal whose lattice constant is 0.42nm.

8. Iron has BCC structure with atomic radius 0.123A˚. Find the lattice constant and also the volume of the unit cell.

9. The lattice constant of a metal with cubic lattice is 2.88A˚. The density of metal is 7200Kg/m^3. Calculate the number of unit cell present in 1 Kg of the metal.

10. Calculate the lattice constant and distance between two adjacent atom form Potassium bromide crystals (FCC lattice) having the density and molecular weight of 2700Kg/m^2 and 119 gram respectively.

11. Magnesium has HCP structure. The radradius of atom is 0.1605 nm. Calculate the volume of the unit cell of Magnesium.