

STRUCTURE OF SOLIDS

✓ 60 Cryst.

A 60

In solid, molecules are packed together which keep the shape in order. Molecular motion in solid particles is confined to a very small vibrations of the atoms around their fixed position (that makes them rigid and hard). Therefore, Solids have a fixed shape (that makes it difficult to change). Solids also have a definite volume (that is, they keep their size no matter how you try to change them).

Classification of Solids

- Amorphous solids and ✓ 52.2ans
- Crystalline solids

1. Amorphous solids:

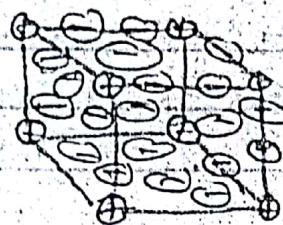
- These are substances whose constituents do not possess an orderly arrangement. ✓ 63 exes
- Literally, amorphous means "solid without form", the particles do not have a repeating lattice pattern. e.g. glass, gel, rubber and plastic. ✓ 14
- Amorphous solid do not have a definite melting point, instead melts gradually over a wide range of temperature, because their bonds do not break all at once, for instance candle wax, glass or plastic.
- Amorphous solid do not have regular planes of cleavage. When cut, the edge may be curved.

2. Crystalline solids:

These are made of an ordered array of atoms, ions or molecules. Example: When Copper is heated above its melting point and then slowly allowed to cool, its atoms arranged themselves in ordered 3 dimensional

array forming a crystalline solid.

Crystalline solids are substance which possess orderly arrangement of atoms, ions or molecules in a definite geometric pattern. e.g. NaCl.



network crystalline solid.

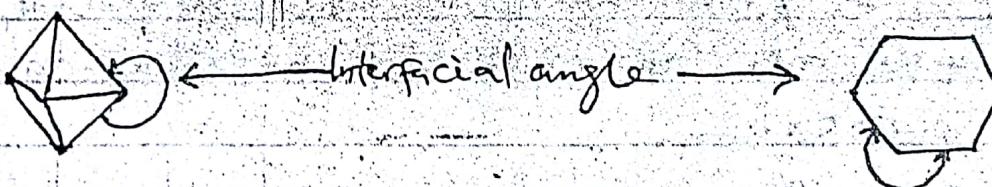
An ordered 3D (length, width x height)

Unit cell: Is the basic or small repeating unit of the arrangement of atoms, ions, or molecules in a crystalline solid. Test:

A crystal lattice is the 3D array of particle (atoms, ions or molecules) in a crystalline solid.

Characteristics of Crystalline Solids

1. Orderly arrangement ✓
2. Crystals are always bonded by plane faces
3. The faces of crystals always meet at some fixed angles.

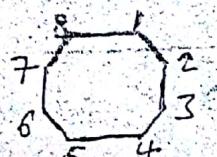
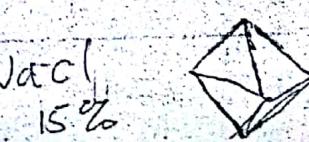


Crystals of the same substance may sometimes appear to be different from the outside, due to either different rate of growth by different faces or due to damage to the corner or edge. However, interfacial angle is always the same. Example NaCl grows from water solution as cubes but from 15% aqueous urea as an Octahedron.

NaCl



NaCl
in 15%



4. Crystalline solid exhibit anisotropy! These are properties which depend on the directions or angular orientation of crystals.

5. Transition from solid to liquid (melting point)
Crystalline solid is sharp and distinct.

6. Cyclic solids exhibit definite heat of fusion.

TYPES OF CRYSTALLINE SOLIDS

1. Ionic solids: Ionic compounds forms crystals that are composed of oppositely charged ions. A positively charged cation and a negatively charged anion. Because of the strong attraction b/w the two opposite charges, it takes a lot of energy to overcome ionic bonds. It means ionic solids have a very high melting points. Ionic solid are hard, brittle, and most of them dissolve in water forming free ions that conduct heat and electricity.

and MgO Melting point of $NaCl$ and MgO .

$NaCl = 801^\circ C$ What is responsible for the high melting point of $NaCl$ ($801^\circ C$) compared with ($80^\circ C$)

$MgO = 2852^\circ C$ ~~6900~~ due to high charge, or

The high melting point of MgO is due to the +2 charge, Mg^{2+} hence high the higher the charge, the greater the lattice energy, hence increase in melting point. Consequently, If the atomic radius increases, the lattice energy and melting point decreases. The melting point of $NaCl$ is small because of its +1 charge, Na^+ .

2. Molecular solids: These composed of covalently bonded molecules attracted to each other by weak attractive forces (Van der Waals forces). E.g. CO_2 , F_2 , I_2 , Cl_2 , Br_2 . Iodine (I_2) has higher melting point because it's solid.

Because covalent bonding involves sharing of

electrons, the shared electrons may spend more time in the electron cloud of the larger atom, causing weak or shifting polarity. This electrostatic attraction b/w poles (dipoles) is much weaker than ionic or covalent bonding, so molecular solids tends to be softer than ionic solid or crystals and have lower melting points. Most molecular solids are non-polar and will not dissolve in water but in non-polar solvent. They are non-conductive, e.g. HCl, ice, Cl₂.

3. Network Covalent Solids:

In this case, there are no individual molecules. The atoms are covalently bonded in a continuous network resulting in huge crystals, e.g. Diamond. Network solids have similar properties to ionic solids but like ionic solid, they do not dissolve in water nor conduct electricity, e.g. Diamond.

4. Metallic Solids:

They are opaque metals that are both malleable and ductile. Malleable means they are soft and can be shaped or pressed into thin sheets while ductile means they can be pulled into wires.

In metallic bond, the valence electrons are not donated or shared as they are in ionic or covalent bonding; rather the electron clouds of adjacent atoms overlap so that electrons become delocalized. The electrons move with relative freedom from one atom to another throughout the crystal. They have high melting point, conduct heat and electricity.

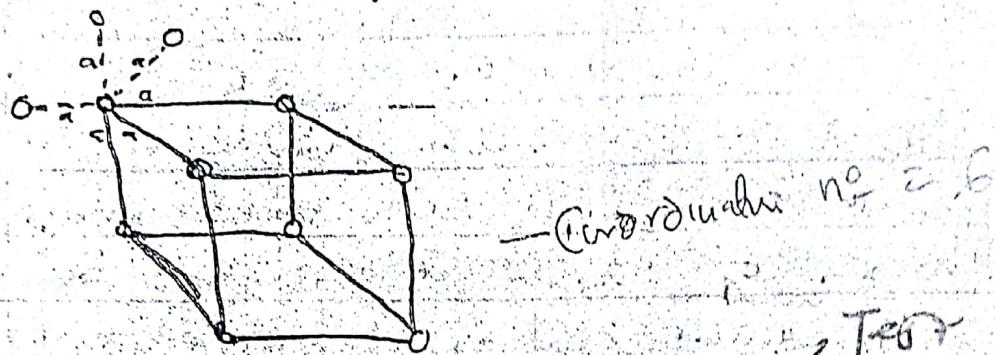
An alloy? is a solid mixture of metallic element with another substance. e.g. Bronze is an alloy of Copper and Tin (Tin), it is lighter while pure metal is heavy.

STRUCTURE OF METALS

Metals consist of spherical atoms ^{arranged} that are ~~giving~~ in BCC lattice. There are only four types of structures that are needed to show the arrangement of atoms in almost all metals. These arrangements for packing spheres are called closest packing.

1. Simple Cubic Structure:

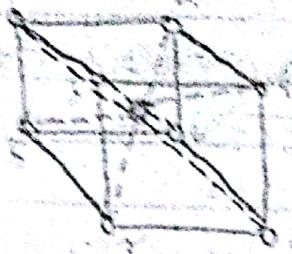
This shows how spherical atoms are packed, one atom on each corner of the cube.



In this case, each atom is surrounded by only six other atoms, hence the coordination number is six (6) and even when the atoms are touching each other, there is a great deal of free space. When cubes are stacked, there are eight corners to each cube, as shown above. Therefore, because eight (8) cubes share a common corner, only $1/8$ of each atom belongs in any cube. The total occupancy of the cube is $8 \times (1/8) = 1$ and there is one atom per unit cell, as shown above. Not all metals have this structure.

2. Body Centred Cubic Structure (B.C.C)

This contains one atom in the centre of a cubic cell that also has one atom on each corner of the cube. That is touching the centre atom. Here, there are two atoms per unit cell.



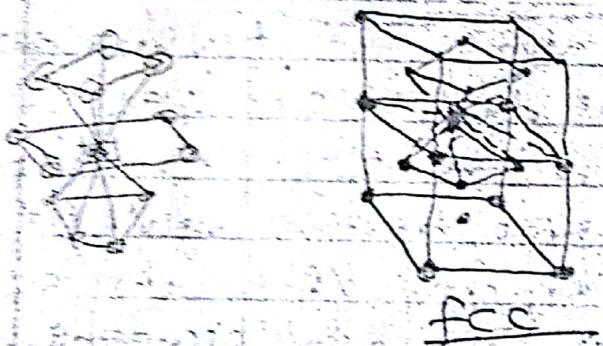
8 nearest
neighbors

Coordination no. = 8

In body centred cubic structure, each atom is surrounded by eight (8) nearest neighbours. Several metals are found to have the bcc structure. Therefore, it has a coordination number of eight (8).

3. Face centred Cubic (FCC):

This arrangement is possible, if we find the ratio of atomic size is 1/3 which allows a coordination number of 12; and it has one atom on each corner of the cube and one atom on each of the six (6) faces of the cube.



Coordination no. = 12

(4) Hexagonal closest packing (HCP): This has a coordination number of 12, if we examine the environment around the atom, we shall discover that there are six others arranged around it in a hexagonal pattern. It shows that six atoms touch the one in the centre just as they touch each other. In addition to the six atoms in the same layer, each atom is also surrounded by atoms that are contained in the layers above and below it; three atoms from each of those layers make contact with the atom that resides in the centre of the hexagon.