The Solid State

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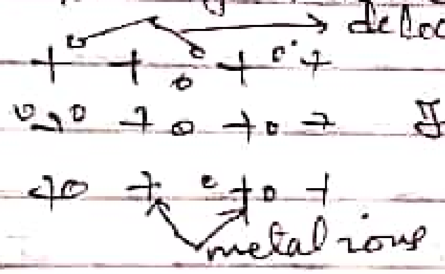
Three states of matter are solid, liquid and gas. Amongst them liquid and gases are called fluid because of their ability to flow. But solid cannot flow. The reason for that is particles in solid are not free to move in available space. There are strong intermolecular force of attraction in between the particle in solid. The constituents particles in solid have fixed position and can only oscillate about their mean position. This gives the rigidity to the solid and hence a fixed shape also. So, solid state of matter possesses fixed mass, volume, shape and rigidity. Solids are classified on the basis of constituent particle. Due to their specific arrangements, it shows wide range of properties and hence varied applications like as superconductors, magnetic materials, polymers etc.

General Characteristics of Solid State

In nature the particular state of matter is governed by two

Charged anions. The ions may either be monatomic or polyatomic. Generally ionic crystals form from a combination of Group 1 or 2 and Group 16 and 17 non metals, Ionic crystals are hard and brittle and have high melting points. Ionic compounds do not conduct electricity as solids but do conduct when molten or in aqueous sol.

(2) Metallic Crystal:— Metallic crystals consists of metal cations surrounded by a "sea" of valence electrons



These electrons are referred as delocalised electrons, do not belong to any one atom. but are capable of moving through the entire crystal. As a result metals are good conductors of electricity.

(3) Covalent crystals:— A covalent network crystal consists of atoms at the lattice points of the crystal with each atom being covalently bonded to its nearest neighbour atoms. The covalently bonded network is three dimensional and contains a very large nos. of atoms. Network solids are hard

opposing forces at given set of temperature and pressure. These forces are intermolecular force of attraction and thermal energy. If intermolecular force of ~~energy~~ attraction is high as compared to thermal energy, particles remains in closest position and hence very less movement in particles observed. In this case solid state is the preferred state of matter.

Forms of solids:-

There are two main categories of solids: Crystalline and amorphous. Crystalline solids are well ordered at the atomic level and amorphous solids are disordered.

Crystalline substances can be described by the types of particles in them and the types of chemical bonding that takes place between the particles.

There are four types of crystals

1) ionic (2) metallic (3) Covalent (4) molecular.

(1) Ionic Crystals :- The ionic crystal structure consists of alternating +vely charged cations and -vely

and brittle with extremely high melting and boiling points. Being composed of atoms rather than ions, they do not conduct electricity in any state.

4) Molecular Crystals:- Molecular Crystals typically consist of molecules at the lattice point of the crystal, held together by relatively weak inter-molecular forces. The intermolecular forces may be dispersion forces in the case of non-polar crystals or dipole-dipole forces in the case polar crystals. Some molecular crystals such as ice, have molecules held together by hydrogen bond. When one of the noble gases is cooled and solidified the lattice points are individual atoms rather than molecules. In all cases the intermolecular forces holding the particles together are far weaker than either ionic or Covalent bonds. As a result the melting and boiling points of molecular crystals are much lower. Lacking ions or free electrons molecular crystals are poor electrical conductors

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(18th lecture)

Relation between Kp, Kc and Kx

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Equilibrium constant Representation	Expressed in terms of	Expressed as
Kc	concentration of reactant and Products	$\frac{[C]^c[D]^d}{[A]^a[B]^b}$
Kp	Partial pressure of reactants and Products (only for substances which are in gaseous state	$\frac{P_C^c P_D^d}{P_A^a P_B^b}$
Kx	Mole fraction of reactants and Products	$\frac{[X_C]^c[X_D]^d}{[X_A]^A[X_B]^b}$

$$K_p = K_c(RT)^{\Delta n_g}$$

$$K_x = K_p(RT)^{\Delta n_g}$$

Δn_g = moles of gases products

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $K_c = \frac{[NO_2]^2}{[N_2O_4]}$

$2NO_2(g) \rightleftharpoons N_2O_4(g)$ $K_c = \frac{[N_2O_4]}{[NO_2]^2}$

$K_c = \frac{1}{K_c}$

(3) If the equation having equilibrium constant K is divided by 2, the equilibrium constant for the new equation is the square root of K.

$\frac{1}{2}A + \frac{1}{2}B \rightleftharpoons \frac{1}{2}C + \frac{1}{2}D$

$K_{halfed} = \frac{[C]^{1/2}[D]^{1/2}}{[A]^{1/2}[B]^{1/2}} = \sqrt{K_{initial}}$

(4) If the equation having equilibrium constant is multiplied by 2, the equilibrium constant for the new equation is a square of equilibrium constant

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$ $K_c = \frac{[NO_2]^2}{[N_2O_4]}$

$2N_2O_4(g) = 4NO_2(g)$ $K_c = \frac{[NO_2]^4}{[N_2O_4]^2}$

(5) If the equation having equilibrium constant is written in 2 steps then

− moles of gaseous reactants

K_c = Equilibrium constant expressed in terms of the concentration of the reactants / products.

K_p = Constant in terms of the partial pressures of the substances.

K_x = expressed in terms of the mole fraction.

Properties of Equilibrium constant :→

1) The value of the equilibrium constant for a particular reaction is always constant depending only upon the temperature of the reaction and is independent of the concentration of the reactant at which we start or the directions from which the equilibrium is approached.

$$CH_3COOH_{(l)} + C_2H_5OH_{(l)} \rightleftharpoons CH_3COOC_2H_{5(l)} + H_2O_{(l)}$$

$$K_c = \frac{[CH_3COOC_2H_5][H_2O]^{(l)}}{[CH_3COOH]^{(l)}[C_2H_5OH]^{(l)}}$$

(2) If the reaction is reversed, the value of equilibrium constant is reversed.

equilibrium constant $K = K_1 \times K_2$

$$2NO_2(g) \rightleftharpoons NO(g) + NO_3(g) \quad K_{c_1} = \frac{[NO][NO_3]}{[NO_2]^2}$$

$$NO_3(g) + CO(g) \rightleftharpoons NO_2(g) + CO_2(g)$$

$$NO_2(g) + CO(g) \rightleftharpoons NO(g) + CO_2(g)$$

$$K_{c_2} = \frac{[NO_2][CO_2]}{[NO_3][CO]}$$

$$K_{c_3} = \frac{[NO][CO_2]}{[NO_2][CO]}$$

(c) The value of equilibrium constant is not affected by the addition of a catalyst. –
This is because the catalyst increases the speed of forward reaction and backward reaction to same extent.

X——X.