CHAPTER 12

SURFACE CHEMISTRY

12.1 INTRODUCTION

It is that branch of chemistry, which deals with the interaction (ملاپ) **of a certain substance at the surface of a solid substance.** When a solid surface is exposed (ظاہر کرنا) to a gas or a liquid, the molecules from the gas or a solution phase concentrate (مرتکز ہوتے ہیں) at the surface of solid. We can also say that molecules of gas are accumulated (اکٹھے ہوتے ہیں) on the surface of the solid.

"This phenomenon of accumulation (جمع ہونے کا عمل) ***of the molecules of a gas or a liquid at a solid surface is called adsorption."***

12.1.1 Adsorbate And Adsorbent:

That substance which concentrates upon the surface of a solid is called adsorbate (جذب ہونے والا) ***and the solid is called adsorbent*** (جذب کرنے والا).

Examples:

(i) **Methylene blue is on organic dye.** When finally divided charcoal (پسا ہوا چارکول) is stirred into the dilute solution of methylene blue, then the molecules of dye are adsorbed by the particles of charcoal. The process of adsorption is noted by the effect, that intensity (شدت) of the colour of solution decreases.

(ii) It has also been observed (مشاہدہ کرنا) that the pressure of the gases like SO_2, Cl_2 and NH_3 are decreased, when powdered charcoal is placed in the vessels of these gases. Actually, the molecules of these gases concentrate (مرتکز ہوتے ہیں) on the charcoal surface and we say that gas has been adsorbed on the surface of charcoal.

12.1.2 Difference Between Adsorption And Absorption:

As we have discussed above, that in **case of adsorption the concentration is present on the surface of solid** (ٹھوس کی سطح پر). In the case of **absorption, the outer substance penetrates** (اندر تک چلا جاتا ہے) **into the body of absorbent.** Anyhow, absorption and adsorption take place side by side. For this purpose, a new term has been introduced which is called sorption. This phenomenon includes both adsorption and absorption.

12.1.3 Why Absorption Takes Place?

The atoms and molecules of solid substance present in the bulk (ذخیرے کے اندر) of a solid are satisfied (کی تسلی ہوتی ہے) due to surrounding atoms and molecules. Their valencies are fulfilled. The atoms and molecules at the surface of solid are unbalanced (غیر متوازن). There are residual (بچی ہوئی) attractive

forces (کشش کی قوتیں) on the solid surface. These residual forces are responsible to hold the molecules of adsorbate.

12.1.4 Types Of Adsorption:

When a gas is adsorped on the surface of a solid, then two types of adsorptions can be thought of

(a) Physical (طبعی) adsorption (b) Chemical (کیمیائی) adsorption

(i) Physical Adsorption

"It is that type of adsorption, which is due to presence of Van der Waal's attractive forces between the gas molecules and the solid surface." The adsorption of H_2 and O_2 on the surface of charcoal is physical adsorption. This is also called Van der Waal's adsorption.

(ii) Chemical Adsorption

"When the molecules of a gas are held by the solid substance by chemical bonds, then it is called chemical adsorption." It is also called chemisorption.

Hydrogen is chemisorbed on nickel. Hydrogen has physical adsorption on nickel and the after dissociation (ٹوٹنے کے بعد) of H_2 it gets chemisorption on the surface of nickel. It means that process of adsorption is a combination of two types of adsorptions i.e. physical and chemical.

12.1.5 Difference Of Physical And Chemical Adsorption:

When the gases are adsorbed on the solid surface then, there can be physical or chemical adsorption. These two types of adsorptions differ in many respects. Let us discuss some of them.

(i) Surface Area:

The extent (حد) of adsorption depends upon surface area (سطحی رقبہ). Greater the surface area of adsorbent, greater the amount of the gas adsorbed. If nickel and platinum metals are finally divided (باریک پسی ہوئی), then they adsorb the hydrogen gas to greater extent just like charcoal and silica gel.

(ii) Nature of Gas:

Greater the critical temperature of gas, greater the possibility (امکانات) of adsorption. Critical temperature of SO_2 is 157°C and 1 g of activated charcoal adsorbs 380 cm^3 of SO_2. But adsorption of CH_4 and H_2 is less.

(iii) Heat of Adsorption:

It is the amount of heat evolved when 1g mole of a gas is adsorbed on the solid surface. This heat of adsorption is less for physical adsorption and is in the range of 5 kcal mol^{-1}. It varies from 20 – 100 kcal mol^{-1} for chemisorption.

(iv) Reversible Process:

The gas which is adsorbed on the solid surface, can be desorbed under reverse conditions of temperature and pressure. Anyhow, **chemisorption** is not a reversible process because a compound is produced upon the surface of the solid.

(v) Effect of Temperature:

Low temperature favours (حق میں ہوتا ہے) the physical adsorption while chemisorption generally increases with temperature. For example, nitrogen shows physical adsorption on the surface of iron at 190°C, but at 900°C chemisorption takes place to form nitride.

12.2.8 Applications Of Adsorptions:

The phenomenon of adsorption of gases by solids and of solute particles has many applications on industrial scale (صنعتی معیار پر) and in the laboratories as well. We are going to discuss some of them.

(1) Removal Of Coloured Matter From The Solutions:

When substances are prepared in the laboratory or on industrial scale, then they develop the colour due to the impurities. Animal charcoal is used to remove the coloured impurities. The coloured solutions of cane sugar (گنے سے بنائی ہوئی چینی) can be decolourized (بے رنگ کرنا) by animal charcoal or activated charcoal.

(2) Chromatographic Analysis:

The process of chromatography (کروميٹوگرافی) involves the principle of selective (چننے کا عمل) adsorption. This is done by dissolving the mixture in a suitable solvent (مناسب سالونٹ). This solution is poured through a tube which contains the adsorbent. The commonly used adsorbent is alumina.

Some of the components of the mixture which are easily adsorbed on alumina remain in the upper part of the tube. The other parts of the mixutres are adsorbed one after the other depending upon its adsorption co-efficients. The mixture of gases can be separated by selective adsorption of the gases by liquid. This process is called gas chromatography.

(3) **Heterogeneous Catalysis:**

As we will discuss in the next part of this chapter, that the solid catalysts (ٹھوس عمل انگیز اشیاء) adsorb the molecule of the gases, which have to react upon the surface. In this way, they do the reaction at the surface and complete the reaction.

(4) **Production Of High Vacuum:**

Suppose we have partially evacuated (جس کا تھوڑا سا حصہ خالی ہو) vessel. It is connected to a container of the activated charcoal which is cooled with the liquid air. The molecules of the gas are adsorbed by the charcoal. This process is used in high vacuum equipment (زیادہ خلا پیدا کرنے والا آلہ) as Dewar flask for the storage of liquid air or liquid hydrogen. We can also use silca gel as an adsorbent.

(5) **Froth Floatation Process:**

During the metallurgy of the metals, the ore is crushed (پیس ڈالنا) to a fine powder and it is suspended in water. It is agitated (زور سے ہلانا) with pine oil (ایسا تیل جو دیار چیڑ وغیرہ کے درختوں سے ملے) in the presence of water containing a detergent (مُنظف کار). This detergent acts as a foaming agent (جھاگ بنانے والا). Air is bubbled into the mixture. The air bubbles are stabilized (قائم ہونا) by the detergents. The adsorbed mineral particles are wetted with oil and rise to the surface. The silica and other earthy matter is wetted by water and settles down at the bottom. This method is best applicable for the low grade sulphide ores as PbS, ZnS and CuS.