☐ ADSORPTION

The phenomenon of adsorption also known as surface phenomenon has been known in one form or the other since 1773 when Scheele discovered the uptake of gases by charcoal. Fontana (1777) described some similar experiments. Lowitz (1785) found that charcoal could take up colouring matter from solutions as well. However, systematic investigations and rationalisation of the theory have taken place only in the present century. The term adsorption was first used by Kayser (1881) at the suggestion of du Bois Reymond.

In the study of surface tension we have seen that the surface of the liquid is in a state of strain on account of unbalanced or residual forces. The same is true for the surface of a solid. As a result of these residual forces, the surface of a solid (or a liquid) tends to attract and retain other molecules when it is brought in contact with a gas or a solution. As these molecules remain only at the surface and do not go deeper into the bulk of the solid or liquid, their concentration is more at the surface than in the bulk. ***The phenomenon of higher concentration of any molecular species at the surface than in the bulk of a solid or liquid is known as adsorption.*** As a result of adsorption, *there is a decrease of residual surface forces and, therefore, that of surface energy.*

[I] Adsorbate and Adsorbent

The solid that takes up gas, vapour or solute from a solution is known as ***adsorbent***, while the gas or the solute which is held to the surface of the solid is called ***adsorbate.***

Since colloids have very small dimensions, they have very high surface area per unit mass; hence they are good adsorbents. Other adsorbents are charcoal, silica gel, clay, etc. Sometimes, the union between adsorbent and adsorbate is so firm that the product lies intermediately between a mixture and a compound. This compound is then termed as ***adsorption compound.***

[II] Adsorption and Absorption

Adsorption should be clearly distinguished from absorption. In absorption, the substance is not only retained on the surface, but passes through the surface to become uniformly distributed throughout the body of a solid or a liquid. On the contrary, in adsorption, the substance is only retained on the surface, but does not pass through the surface of a solid or liquid.

Thus, water is absorbed by a sponge or water vapour is absorbed by anhydrous $CaCl_2$, whereas acetic acid in solution and various gases like inert gases are adsorbed by charcoal. Water is adsorbd by silica gel also.

It is, therefore, clear that during adsorption the concentration of the adsorbate increases only at the surface of the adsorbent, whereas in absorption the increase in concentration is uniform

throughout the body of the absorbing sustance. The process in which the phenomenon of adsorption and absorption take place simultaneously is known as **sorption**, as suggested by McBain.

It is often difficult to distinguish between adsorption and absorption. When, for example, hydrogen is taken up by charcoal, it first condenses on the surface of the latter; this is adsorption. But as time progresses, the hydrogen slowly diffuses into the interior of the charcoal with the formation of a true solid solution; this is absorption. In all such cases of solutions, adsorption must of necessity precede dissolution. Graham (1866) did not distinguish between these two stages and termed the general adsorption of gases by solids as **occlusion.**

It is, however, easy to conclude that adsorption is a very fast process, whereas absorption is a slow one.

[III] Sorption and Occlusion

In several examples, the initial rapid adsorption is followed by a slow process of absorption of the substance into the interior of the solid. In such cases, the effects of adsorption cannot be distinguished from those of absorption. So, two new forms have been introduced.

Sorption : It is a process in which both adsorption and absorption take place simultaneously, as suggested by McBain (1909), *e.g.*,

(i) When hydrogen is taken up by charcoal, it first condenses on its surface. This is adsorption. After sometime, the hydrogen diffuses slowly into the interior of the charcoal forming a true solid solution. This is absorption. So, charcoal has absorbed as well as adsorbed hydrogen gas.

(ii) The direct dye-stuffs taken up by cotton fibres are also in the absorbed as well as in the adsorbed state.

(iii) The uptake of gases by zeolites is also an example of sorption.

Occlusion : According to Graham (1886) who introduced the term occlusion said that it has a significance similar to sorption. However, occlusion is restricted to the sorption of gases by metals only.