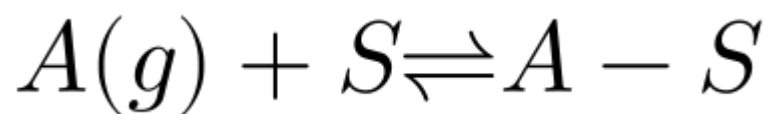


Gas-Solid Adsorption

Gas-solid adsorption refers to the adsorption of a gas on the surface of a solid. It is one of the most important types of adsorption in heterogeneous reactions because many reactions occur when gaseous molecules become attached to the surface of a solid and subsequently react there. The solid provides a number of surface sites at which gas molecules can be adsorbed.

When a gas is brought into contact with a solid surface, some of its molecules strike the surface and may remain attached to it. At the same time, adsorbed molecules may leave the surface and return to the gas phase. Thus, adsorption of a gas on a solid is generally a dynamic process.

The process can be represented by



Here A is a gas molecule, S is a vacant surface site, and $A - S$ represents an adsorbed molecule. The number of molecules present on the surface depends upon the pressure of the gas, temperature, nature of the solid, and strength of interaction between the gas and the surface.

| Surface Coverage

It is useful to describe gas-solid adsorption in terms of the fraction of the surface occupied by adsorbed molecules. This fraction is called the **surface coverage** and is represented by θ . If all

available surface sites are vacant, $\theta = 0$. When every available site is occupied,

$$\theta = 1.$$

Thus, the fraction of vacant sites is $1 - \theta$. If the adsorption process requires one vacant site for each gas molecule, the number of molecules that can be adsorbed depends directly upon the number of vacant sites available on the surface.

| Adsorption Equilibrium

For a gas in contact with a solid, adsorption and desorption occur simultaneously. Initially, when the surface is clean, the rate of adsorption is high because a large number of vacant sites are available. As the pressure is maintained and the surface becomes progressively occupied, the rate of adsorption

decreases. The rate of desorption, on the other hand, increases as the number of adsorbed molecules increases.

At equilibrium, the two rates become equal:

$$\text{Rate of adsorption} = \text{Rate of desorption}$$

The amount of gas present on the surface then remains constant, although adsorption and desorption continue microscopically. This is called dynamic adsorption equilibrium.

| Effect of Pressure

At a fixed temperature, increasing the pressure of a gas generally increases the amount adsorbed. At low pressure, many surface sites are vacant, so an increase in pressure produces a relatively large increase in adsorption. As the pressure becomes higher, an increasing fraction of the surface becomes occupied.

When the available surface sites are nearly completely occupied, the surface approaches saturation. Further increase in pressure then produces only a small increase in the amount adsorbed. The exact relationship between pressure and the amount adsorbed depends upon the nature of the adsorption process and the surface.

| Effect of Temperature

Gas-solid adsorption is generally accompanied by the evolution of heat. Consequently, physical adsorption usually decreases with increasing temperature. At a higher temperature, adsorbed molecules possess greater thermal energy and can escape from the surface more readily.

Chemisorption may behave differently because the formation of a chemical bond between the gas molecule and the surface can require activation energy. In such cases, an increase in temperature may initially increase chemisorption. At still higher temperatures, desorption may become predominant.

| Adsorption Isotherm

The relationship between the amount of gas adsorbed by a solid and the equilibrium pressure of the gas at a constant temperature is called an **adsorption isotherm**. It is usually expressed by plotting the amount adsorbed against the equilibrium pressure while keeping the temperature constant.

Adsorption isotherms are useful because they provide information about the interaction between the gas and the solid surface and about the manner in which the available surface sites become occupied as pressure increases.

For an idealized surface containing a fixed number of equivalent adsorption sites, the amount

adsorbed increases with pressure and approaches a limiting value when the surface becomes saturated. The mathematical treatment of such ideal gas-solid adsorption leads to the Langmuir adsorption equation.

The Langmuir treatment is based on the assumptions that the surface contains a fixed number of equivalent sites, each site can hold one adsorbed molecule, adsorption occurs as a monolayer, and there is no interaction between adsorbed molecules. The adsorption and desorption processes are treated as dynamic equilibrium processes.

These assumptions describe an idealized surface. Real solid surfaces are generally more complicated because they contain sites of different energies and may also show interactions between neighbouring adsorbed molecules. Such deviations from ideal behaviour are considered under **non-ideal adsorption**.