Study of Diffusion of Solids in Liquids

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Abstract: **Solids Diffusion Diffusion is the movement of atoms in a medium in a specific direction. It can occur in a solid, liquid, or gas. It can happen even when there is no external force. Many solid-state phenomena, as well as the kinetics of microstructural changes during metallurgical processing and applications, rely on diffusion processes. Phase transformations are a common example: Nucleation is the first step. Recrystallization is the second step. 3. The process of oxidation. 4. Creep. Sintering is the fifth step. Ionic conductivity is the sixth property. Intermixing in thin-film devices. 8. Diffusion has direct technological applications such as solid electrolytes for advanced battery and fuel cell applications. 9. Manufacturing of semiconductor chips and microcircuits. Carburization is used to harden the surface of steels. Diffusion Types: (i) Self Diffusion: This is the transition of a thermally excited atom from one site of a crystal lattice to another site or interstice. (ii) Inter Diffusion: This can be seen in binary metal alloys like the (Cu-Ni) system. (iii) Volume Diffusion: This type of diffusion occurs as a result of atomic movement in bulk materials. (iv) Grain Boundary Diffusion: This type of diffusion results solely from atomic movement along grain boundaries. (v) Surface Diffusion: This type of diffusion is caused by atomic movement along a phase's surface. In this paper, we will look at the Study of Solid Diffusion in Liquids.**

Keywords: **Diffusion, Solids, Liquids, Solid-State Phenomena, Oxidation, Sintering, Solid Electrolytes, Self-Diffusion, Inter Diffusion, Volume Diffusion, Grain Boundary Diffusion.**

Introduction:

When two substances come into contact with each other, they intermix; this is known as diffusion. This property of diffusion occurs very quickly in gases and to a lesser extent in liquids, whereas solids do not exhibit this process of diffusion with each other. However, in the case of solids, we can see that solids diffuse into liquids at a very slow rate. When a solid is exposed to an excess of a solvent in which it is soluble, some of the solid dissolves. This process is known as dissolution of a solid in liquid, and it occurred due to the diffusion of solid particles into liquid. [1]

Diffusion is the chemical process by which molecules from a material move from a high concentration area (where there are many molecules) to a low concentration area (where there are few molecules). This occurs as a result of otherwise random movement. Diffusion usually occurs in a gas, but it can also occur in a liquid. When two liquids are mixed in a transparent container, diffusion can be observed. It describes the continuous motion of particles in all liquids and gases. These particles collide as they move in all directions. Diffusion is also known as the process by which molecules intermingle as a result of their random kinetic energy. The diffusion process is repeated until a homogeneous solution is achieved. Solute diffusion into solvent is, in fact, a bilateral process. [2]

Characteristics are as follows:

- Solute molecules move upward into the solvent;
- solvent molecules move downward into the solution.

This continuous mixing of solute and solvent molecules results in the formation of a solution of uniform concentration. Diffusion can thus be defined as "the tendency to equalise concentration in all parts of the solution that is responsible for solute diffusion."As a result, diffusion of any solute can occur when two solutions of unequal concentrations are kept in the same vessel or in contact.

Diffusion occurs very quickly in gases and to a lesser extent in liquids, whereas solids do not exhibit this process of diffusion with each other. However, in the case of solids, we can see that solids diffuse into liquids at a very slow rate. When a solid is exposed to an excess of a solvent in which it is soluble, some of the solid dissolves. This process is known as dissolution of a solid in liquid, and it occurred due to the diffusion of solid particles into liquid. Because of collisions between solute and solvent molecules, solute molecules are in constant random motion. [3]

When a solid is exposed to an excess of a solvent in which it is soluble, some of the solid dissolves. We know that this process is known as dissolution of solid particles into liquid, and it occurs as a result of solid particle diffusion into the liquid. Diffusion is also defined as the movement of particles in a given volume of fluid (either liquid or gas) from a high concentration area to a low concentration area along a concentration gradient.

As a result, solid-liquid diffusion simply refers to the movement of solid molecules into the liquid medium along a concentration gradient. [4]

Diffusion In Solid:

Individual atom diffusion is random. If there is a concentration gradient (high concentration to low concentration), the overall atomic movement is directional rather than random. WE can study solid diffusion in two ways: the type of diffusion and the mechanism of diffusion.

When it comes to diffusion, it is further classified into two types: inter-diffusion and self-diffusion. It can also be divided into two parts based on the mechanism of diffusion: substitutional diffusion and interstitial diffusion. [5]

In liquids, molecular diffusion occurs through molecule jumps from one position to another; this occurs when the molecule's energy is high enough to rupture bonds with neighbouring molecules, allowing the molecule to move. On average, the jump does not exceed an intermolecular spacing, and because this is much smaller in a liquid than in a gas, the diffusion is much lower. Because a liquid is nearly incompressible, the diffusion rate is pressure independent. Temperature increases intermolecular spacings as well as the velocity of vibrations and jumps of molecules, enhancing diffusion. [6]

Review of Literature:

It is a hybrid model that models extracellular diffusion as a hindered space and intracellular diffusion as a restricted cylinder using diffusion tensors. Zhang et al. (2011) have also extended this method. [7]

Objectives:

- Particle size: As particle size increases, the rate of diffusion decreases.
- Temperature: As the temperature rises, the kinetic energy of the particles rises, increasing particle speed and thus the rate of diffusion.
- Particle mass: As particle mass increases, the rate of diffusion decreases.

Research Methodology:

This study's overall design was exploratory. As a result of this diffusion, people adopt a new idea, behaviour, or product as part of a social system. Adoption occurs when a person does something different than they did previously (for example, purchasing or using a new product, learning and performing a new behaviour, etc.). Adoption requires that the person perceive the idea, behaviour, or product as novel or innovative. Diffusion is only possible through this. Adoption of a new idea, behaviour, or product (i.e., "innovation") does not occur simultaneously in a social system; rather, it is a process in which some people are more likely than others to adopt the innovation. Researchers discovered that people who adopt an innovation early have distinct characteristics from those who adopt it later. When promoting an innovation to a specific population, it is critical to understand the characteristics of that population that will aid or hinder adoption of the innovation. [8]

Result and Discussion:

Diffusion:

The term "diffusion" is derived from the Latin word "diffundere," which means "to spread out." Diffusion is the movement or process by which particles spread from a region of higher concentration to a region of lower concentration. It occasionally moves from a lower concentration to a higher concentration.

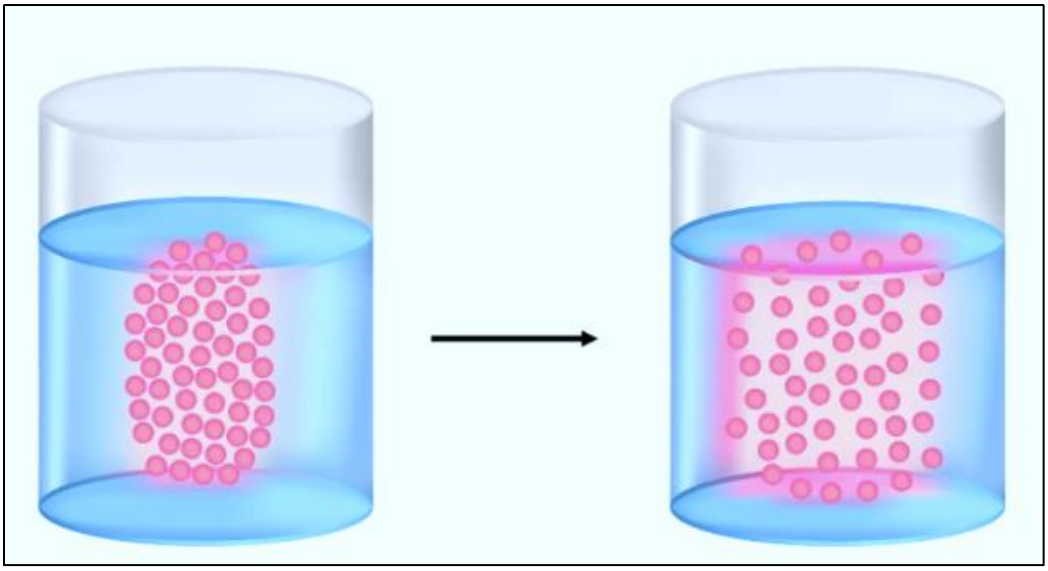

Figure 1: Diffusion Is Similar to Osmosis

Solids, liquids, and gases all undergo diffusion. Diffusion occurs more frequently in gases than in solids.

Consider how the smell spreads through the air. This is due to diffusion.

Let's look at diffusion in solids, liquids, and gases now.

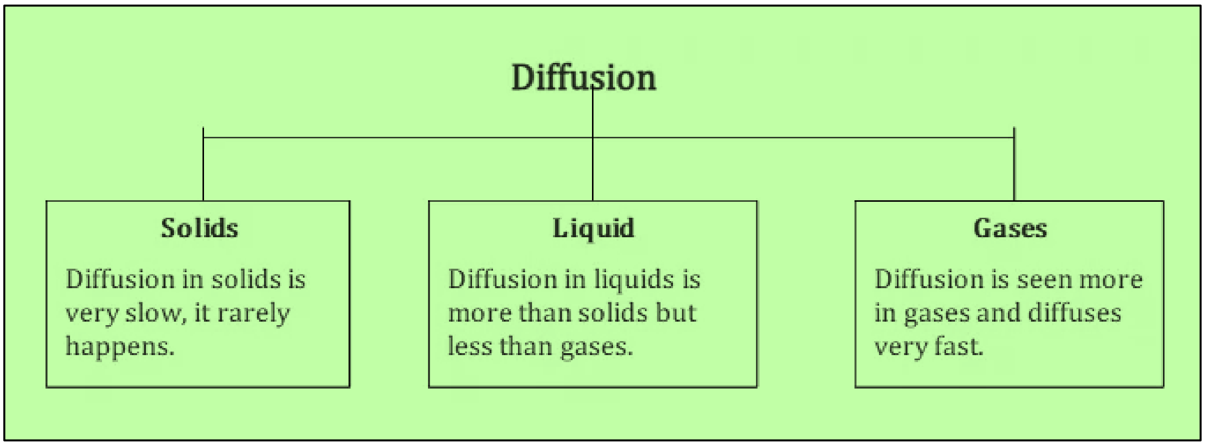

Figure 2: Diffusion Is Seen in Solids, Liquids and Gases

The movement of particles from one region to another in order to achieve equilibrium is referred to as diffusion.

Diffusion is one of the properties of matter that is affected by particle movement.

Diffusion in solids:

Diffusion in solids is very slow and uncommon because the particles do not move freely within the substance.

Diffusion in liquids:

Liquids diffuse slower than gases but faster than solids. This is because the particles in liquids move freely, allowing for easy diffusion.

The movement of the particles in the substance will also affect diffusion.

Example:

Take a glass of water and a blue ink bottle.

Pour in the blue ink into the water.

Blue will now be evenly distributed throughout the water on its own.

This is due to the colour and water diffusing together. [9]

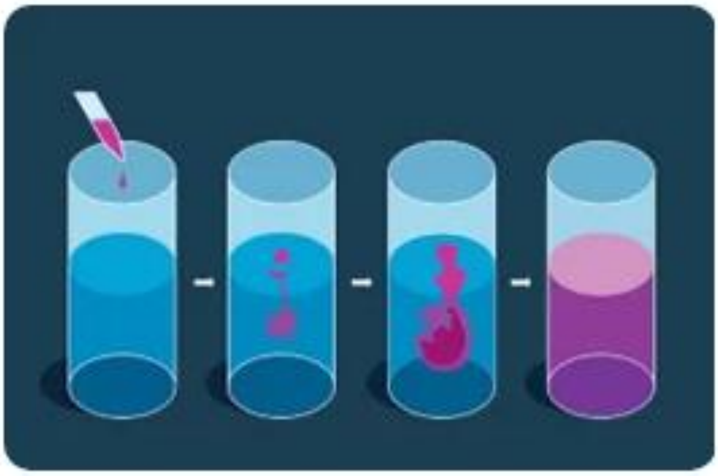

Figure 3: Diffusion in liquids

While the meal is being prepared in the kitchen, people sitting in the drawing room may smell it. Food vapour reaches us and gives us the fragrance of food due to diffusion in the air. A burning incense stick can be detected from a distance. Because of the heat, the incense inside an incense stick vaporises. The incense stick's vapour interacts with the air and finds its way to us.

When sugar is introduced to water, it is combined due to diffusion. Sugar particles collide with water particles due to their constant movement. Allowing gas to diffuse through water produces carbonated drinks. When we open the cap of a carbonated drink bottle, we hear a hissing sound caused by dispersed gas escaping from the water. Aquatic animals use dissolved oxygen in the water to breathe. Aquatic plants generate food underwater due to the dissolved carbon dioxide in water. These gases dissolved in water due to diffusion. [10]

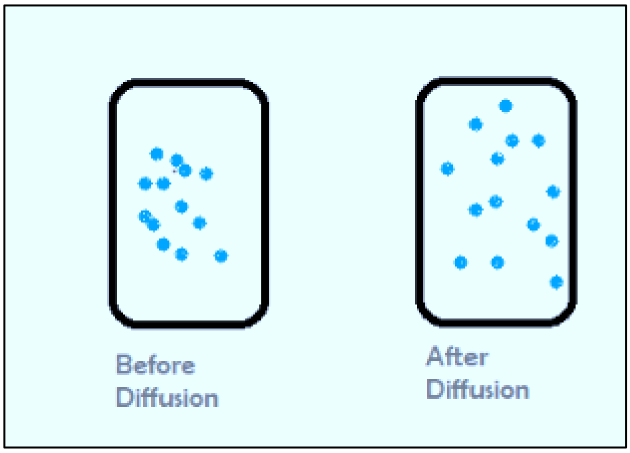

Figure 4: Gases to Dissolve in Water

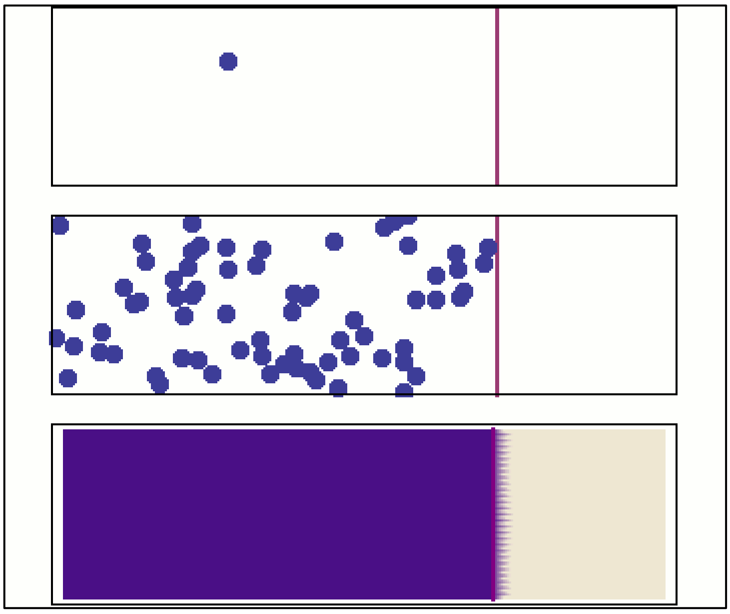

Figure 5: Diffusion from a microscopic and b macroscopic point of view

Diffusion at the microscopic and macroscopic levels. Initially, there are no solute molecules on the right side of a barrier (purple line). When the barrier is removed, the solute diffuses throughout the container. [11] Top: A single molecule moves erratically. Middle: As the number of molecules increases, there is a statistical trend that the solute fills the container more uniformly. Bottom line: With a large number of solute molecules, all randomness is eliminated: The solute appears to move deterministically and smoothly from high-concentration areas to low-concentration areas. There is no microscopic force pushing molecules to the right, but one appears in the bottom panel. This apparent force is referred to as an entropic force. [12]

Effect Of Temperature on The Rate of Diffusion of Solids in Liquids:

Requirements:

Copper sulphate crystals, a 200ml beaker, a watch glass, a wire gauge, a burner, a tripod stand, a thermometer and a stop watch are all included.

Procedure:

Ø Take 5g of copper sulphate each in three beakers. Ø Pour 100ml of distilled water slowly in one of the beakers. Ø Cover this beaker with a watch glass. Ø Pour 100ml of cold water in a second beaker slowly. Ø Place a third beaker containing 100ml of water on a tripod stand for heating. Ø Observe the diffusion process which begins in all the beakers. Ø Record the time taken for the dissolution of copper sulphate in all the three cases.

Table 1: Temperature on The Rate of Diffusion of Solids in Liquids [13]

S.No.	Temperature of water	Time Taken in Minutes
1.	25 ^{0}C	15 Min.
2.	10 ^{0}C	20 Min.
3.	70 ^{0}C	10 Min.

Conclusion:

Fill three beakers with 5g of copper sulphate each. Slowly pour 100ml of distilled water into one of the beakers. Put a watch glass over this beaker. Slowly pour 100ml of cold water into a second beaker. Place a third beaker with 100ml of water on a tripod stand to heat. Examine the diffusion process that begins in all of the beakers. Record the time it takes for copper sulphate to dissolve in each of the three cases.

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