CHAPTER 4

Diffusion

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Diffusion Phenomena

If a droplet of *ink* is placed without stirring at the bottom of a bottle filled with water, the colour will slowly spread through the bottle.

***At first*, it will be concentrated near the bottom. *After some time*, it will penetrate upwards a few centimeters. *With time pass*, the solution will be coloured homogeneously. The process responsible for the movement of the colored material is called *diffusion*.**

***Diffusion is caused by the motion of atoms or molecules that leads to complete mixing*.**

***In gases*, diffusion progresses at a rate of centimeters per second;**
***in liquids*, its rate is typically fractions of millimeters per second;**
***in solids*, diffusion is a fairly slow process and the rate of diffusion decreases strongly with decreasing temperature: *near the melting temperature* of a metal a typical rate is about *one micrometer per second*; *near half of the melting temperature* it is only of the *order of nanometers per second*.**

Diffusion Definition

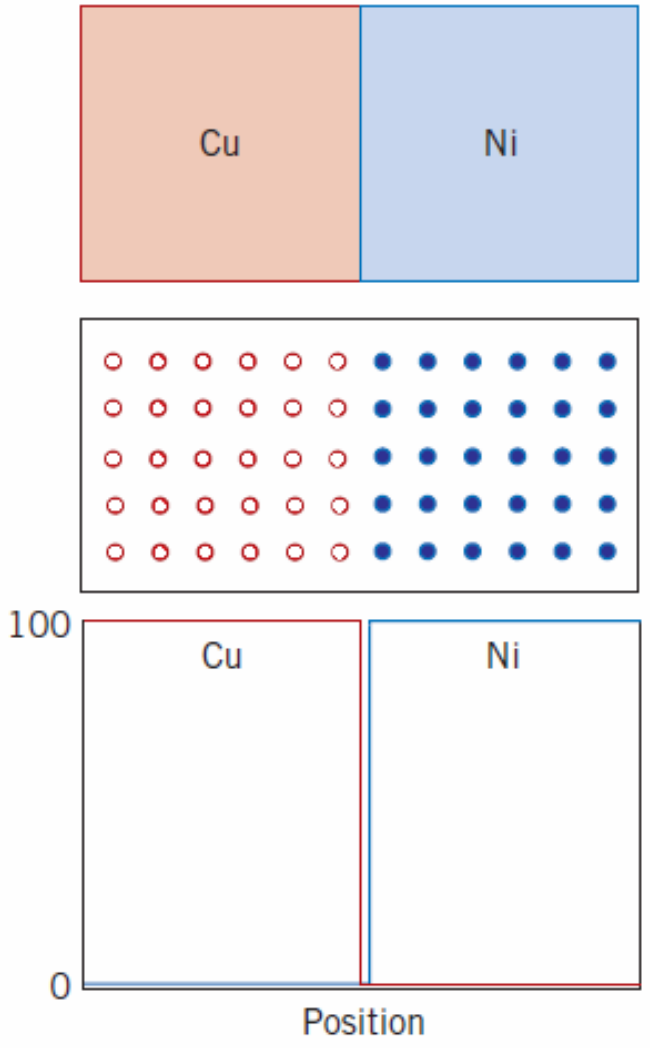
Diffusion is *the transport of matter (material) from one point to another by motion of atoms or molecules*.

Importance of Diffusion

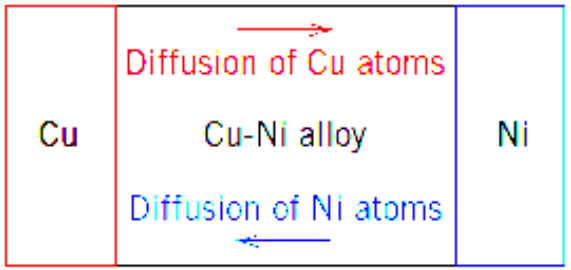
Diffusion in solids and liquid solid is fundamental in the art and science of materials as *diffusion is playing the major role in alloying, thermal processing, Phase transformation, recrystallisation, and thermal oxidation*.

Diffusion Phenomena

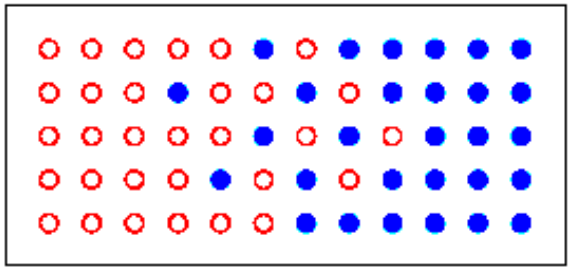
Suppose joining bars of two different metals together so that there is *close contact between the two faces*. This is illustrated for copper and nickel in the given figure, which includes schematic representations of atom positions and composition across the interface.



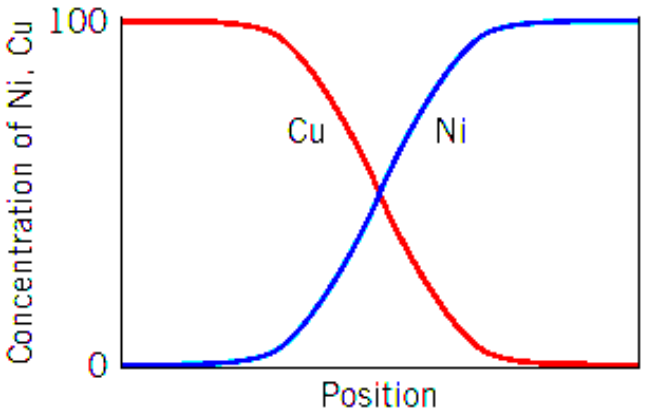
This couple is heated for an extended period at an elevated temperature below the melting temperature, **and cooled to room temperature.**



Schematic representations of atom positions and composition across the interface are given in the figure.



Chemical analysis reveals that pure copper and nickel at the two extremities of the couple, separated by an alloyed region.

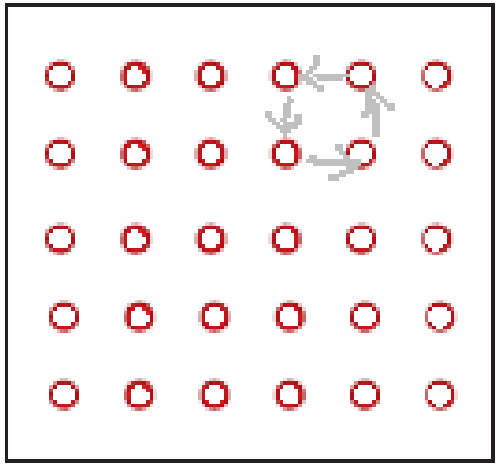


This result indicates that copper atoms have migrated or diffused into the nickel, and that nickel has diffused into copper.

This process, whereby atoms of one metal diffuse into another, is termed *interdiffusion*, or impurity diffusion.

Diffusion also occurs for pure metals, but all atoms exchanging positions are of the same type; this is termed self-diffusion.

Of course, subject *self-diffusion* is not normally to observation by noting compositional changes.



Diffusion Mechanism

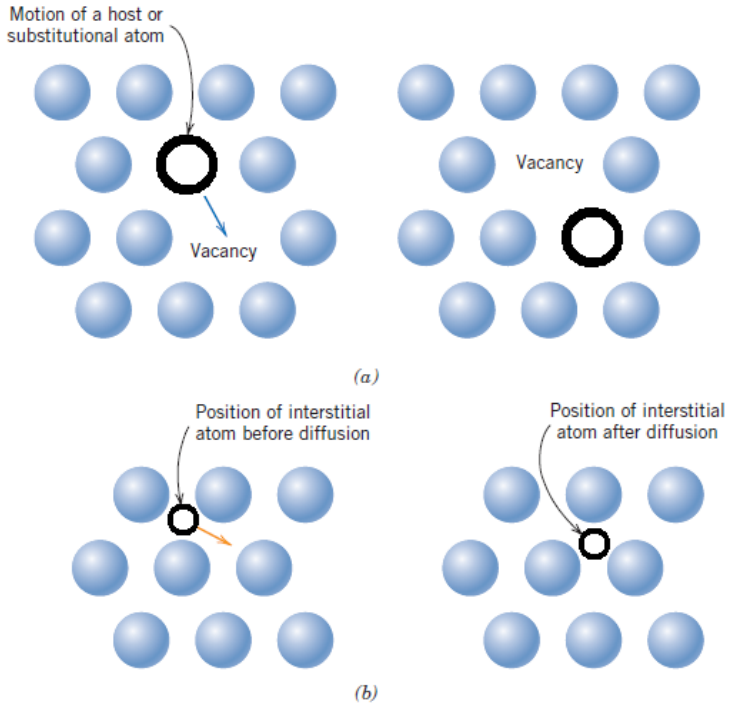
There are two *dominate* for metallic diffusion:

Vacancy Diffusion

One mechanism involves the interchange of an atom from a normal lattice position to an adjacent vacant lattice site or vacancy. Of course, this process necessitates the presence of vacancies.

Interstitial Diffusion

This type of diffusion involves atoms that migrate from an interstitial position to a neighboring one that is empty. This mechanism is found for *interdiffusion* of impurities such as *hydrogen, carbon, nitrogen, and oxygen*, which have atoms that are small enough to fit into the interstitial positions.



Schematic representations of (*a*) vacancy diffusion and (*b*) interstitial diffusion.

In most metal alloys, *interstitial diffusion occurs much more rapidly than* diffusion by the vacancy mode, since the interstitial atoms are smaller and there are more empty interstitial positions than vacancies.

Factors that Influence Diffusion

Temperature:

Diffusion rate increases very rapidly with increasing temperature.

Diffusion mechanism:

Interstitial is usually faster than vacancy.

Diffusing and host species:

The rate of the diffusion is depending on the diffusing species as well as the host material.

Microstructure:

diffusion faster in polycrystalline vs. single crystal materials because of the accelerated diffusion along grain boundaries and dislocation.

Home Work Chapter 3 & 4

Problem 1

The given figures indicate the following:

(1) self interstitial
(2) Vacancy diffusion method
(3) edge dislocation
(4) FCC crystal structure
(5) substitutional impurity
(6) vacancy defect
(7) Interstitial diffusion method
(8) screw dislocation
(9) Stacking faults imperfection
(10) interstitial impurity

It is required to put the corresponding correct number below each figure:

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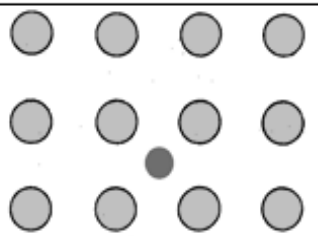	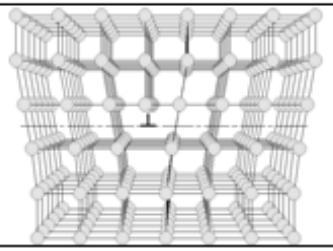	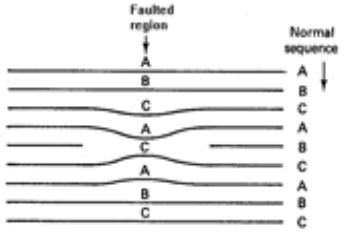
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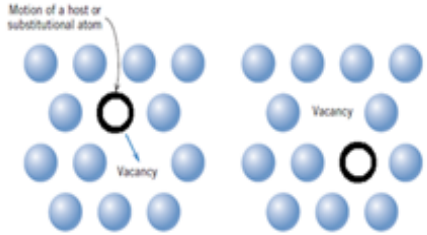	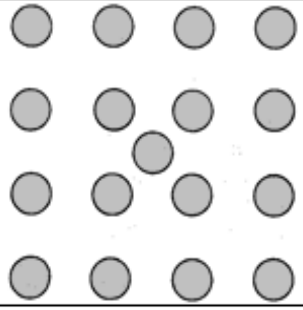	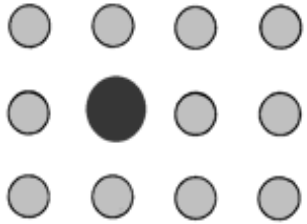
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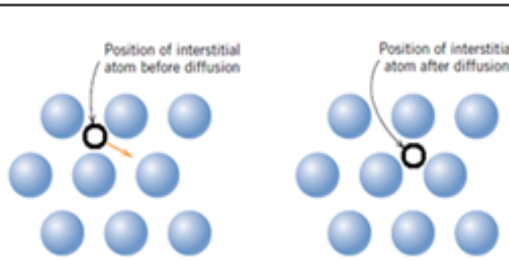	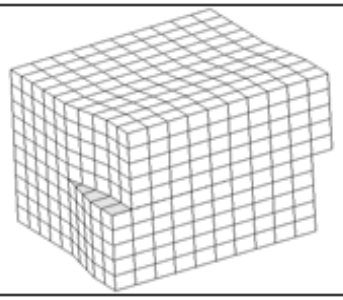	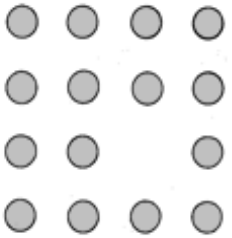
(.....)	(.....)	(.....)

Problem 2

Put sign √ for correct answer and sign X in wrong answer

- (……) Diffusion is caused by the motion of atoms or molecules that leads to complete mixing
- (……) The rate 0f diffusion in solid is very fast compare to liquid and gases
- (……) Diffusion is the transport of matter (material) from one point to another by motion of atoms or molecules
- (……) When all atoms exchanging positions are not of the same type; this is termed self-diffusion.
- (……) Diffusion rate increases very rapidly with increasing temperature
- (……) Term *dislocation* is used to refer to the line defects imperfections in crystalline structure