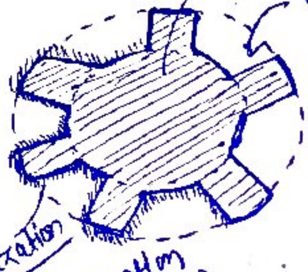
~~[illegible]~~

Diffusion

Low carbon steel.



wear resistance on the surfac...
↓
→ Higher hardness
→ Higher C ↑↓
(more Fe_3C)

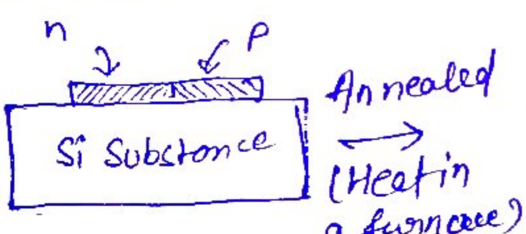
→ Higher C ↓es machineability

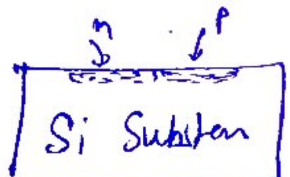
carburization
↓
carbon concentration in steel surface can be increased by carburization treatment.

→ Heat the low carbon-aceous atmosphere. (packing in C powder or hydrocarbon gases).

→ This is possible bcoz of diffusion.

→ pn-Junction (example).



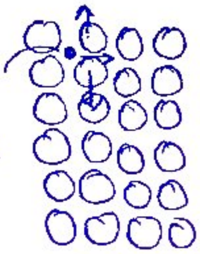


Two Kinds of diffusion

1. Interstitial Diffusion

(Diffusion of Solute in an interstitial solid solution).

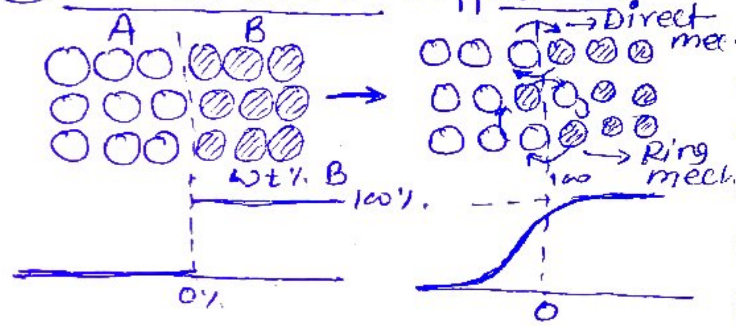
Inter-stitial Solute

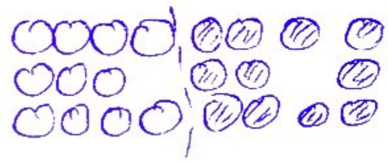


During atomic jump from one site to neighbouring site the surrounding atom have to displaced.

→ Interstitial atoms jumps from one interstitial site to a neighbouring interstitial position.

② Substitutional Diffusion :-





Vacancy mechanism.

→ Direct / Ring / Vacancy mechanism. are made.

Note: Interstitial diffusion is generally faster than Substitutional diffusion.

↑ Energy

$$[D] = \frac{[j]}{\left[\frac{\partial c}{dx}\right]} = \frac{kg\, m^{-2} s^{-1}}{\left(\frac{kg/m^3}{m}\right)}$$

$$= m^2 s^{-1}$$

$$= [M^2 T^{-1}]$$

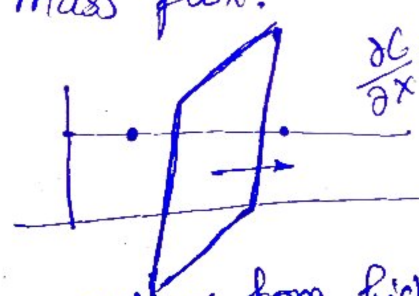
Ficks' First Law of Diffusion

	Heat Flow	charge Flow	mass flow
1. Flux	Heat flux $q\,(J m^{-2} s^{-1})$	Charge flux j (current density)	mass flux (j)
2. gradient	Temp. grad $\frac{\partial T}{\partial x}$	Electric Potential grad $\frac{dv}{dx}$	concentration gradient $\left(\frac{dc}{dx}\right)$
3. Law	Fourier's Law $q = -K\left(\frac{dT}{dx}\right)$	Ohm's Law $j = -\sigma \frac{dv}{dx}$	Ficks $j = -D\cdot\left(\frac{dc}{dx}\right)$
4. Material Property	Thermal conductivity (K) $(W m^{-1} K^{-1})$	Electrical conduction σ (	Diffusivity or Diffusion coefficient)
5. Year	1807	1827	1855.

$$\boxed{\mathring{j} = -D\frac{\partial c}{\partial x}}$$

$\mathring{j}$ = mass flux.

$\frac{\partial c}{\partial x} \equiv -ve$



mass flows from high concentration to low concentration region

- Diffusivity is highly temp. dependent.
- $D = D_0 \exp\left(-\frac{Q}{RT}\right)$

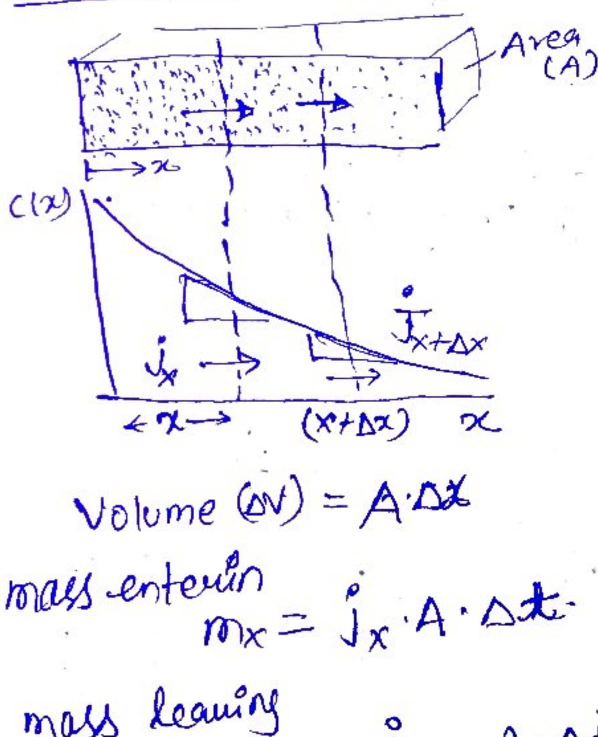
D_0 = pre exponential Factor

R = Gas constant

Q = Activation Energy.

T = Abs. Temp.

Fick's Second Law



Volume (ΔV) = $A \cdot \Delta x$

mass entering
$m_x = \mathring{j}_x \cdot A \cdot \Delta t$

mass leaving
$m_{x+\Delta x} = \mathring{j}_{x+\Delta x} \cdot A \cdot \Delta t$

mass accumulation

$$\Delta m = (\mathring{j}_x - \mathring{j}_{x+\Delta x}) A \cdot \Delta t$$

$$= -(\Delta \mathring{j}) \cdot A \cdot \Delta t$$

Concentration change in ΔV in time Δt.

$$\Delta C = \left(\frac{\Delta m}{\Delta V}\right)$$

$$= \frac{-\Delta \mathring{j} \cdot \cancel{A} \cdot \Delta t}{\cancel{A} \cdot \Delta x}$$

$$= -\frac{\Delta \mathring{j}}{\Delta x} \cdot \Delta t$$

$$\frac{\Delta C}{\Delta t} = -\frac{\Delta \mathring{j}}{\Delta x}$$

take limit.

$$\lim_{\Delta t \to 0} \left(\frac{\Delta C}{\Delta t}\right) = -\lim_{\Delta x \to 0} \frac{\Delta \mathring{j}}{\Delta x}$$

$$\boxed{\frac{\partial C}{\partial t} = -\frac{\partial \mathring{j}}{\partial x}}$$ I^{st} form

We can obtain another form of II^{nd} law. by replacing $\mathring{j}$ using Ficks' 1^{st} law.

$$\mathring{j} = -D \cdot \frac{\partial C}{\partial x}$$

$$\frac{\partial C}{\partial t} = -\frac{\partial}{\partial x}\left(-D \cdot \frac{\partial C}{\partial x}\right)$$

$$\boxed{\frac{\partial C}{\partial t} = D\left(\frac{\partial^2 C}{\partial x^2}\right)}$$ Ficks' II^{nd} Law 2^{nd} form

Assume D is indepent of x.