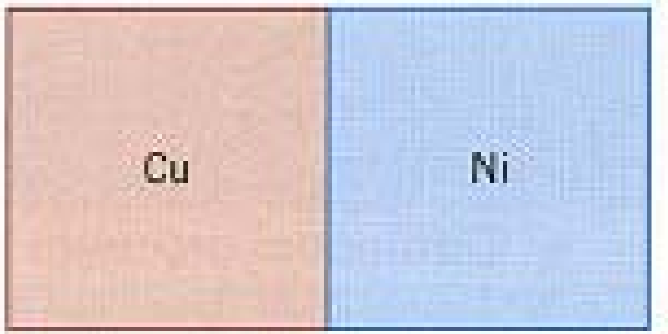
Structural metallic materials

3.1 Diffusion

diffusion: mass transport by atomic motion

Structural metallic materials

3.1 Diffusion



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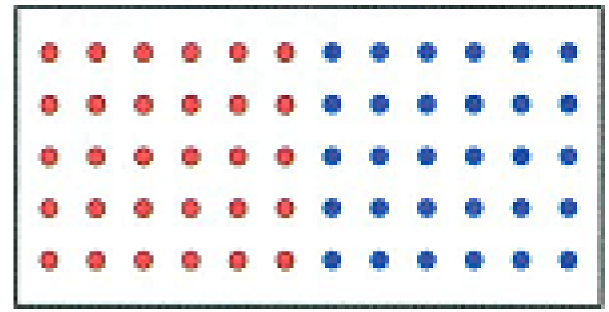

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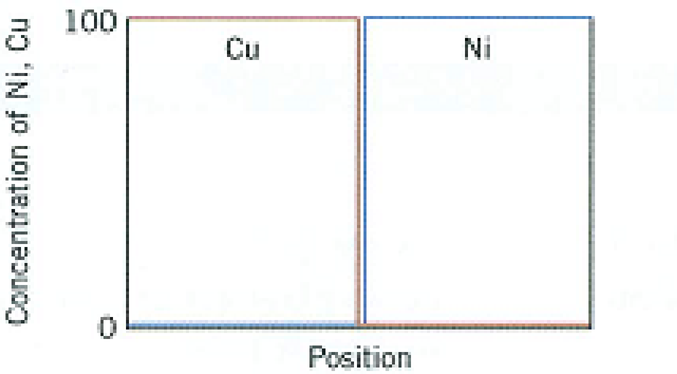

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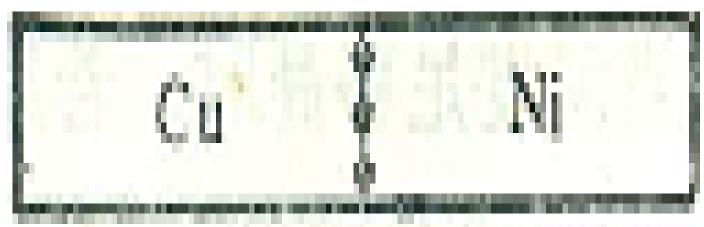
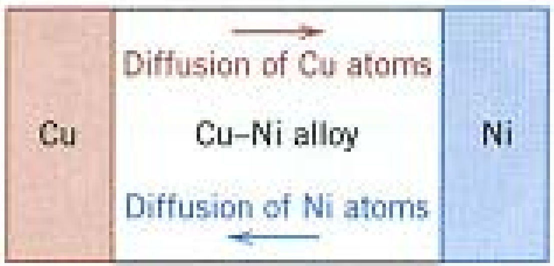


Structural metallic materials

3.1 Diffusion



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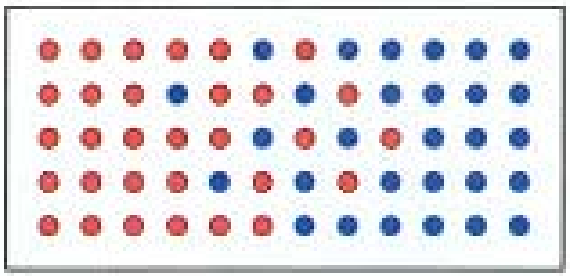
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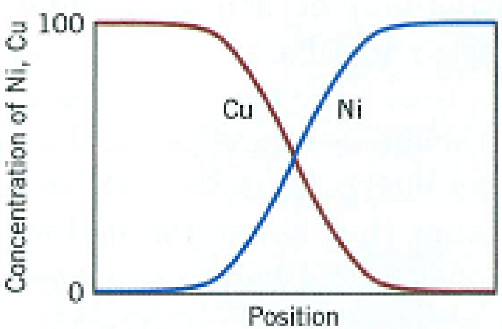

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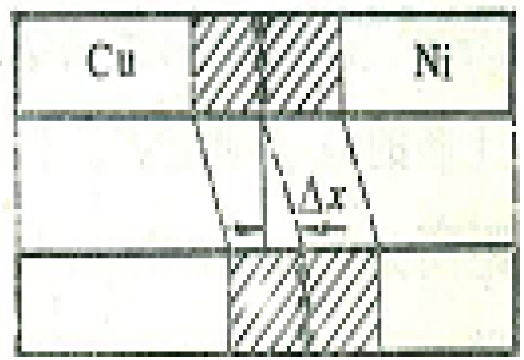
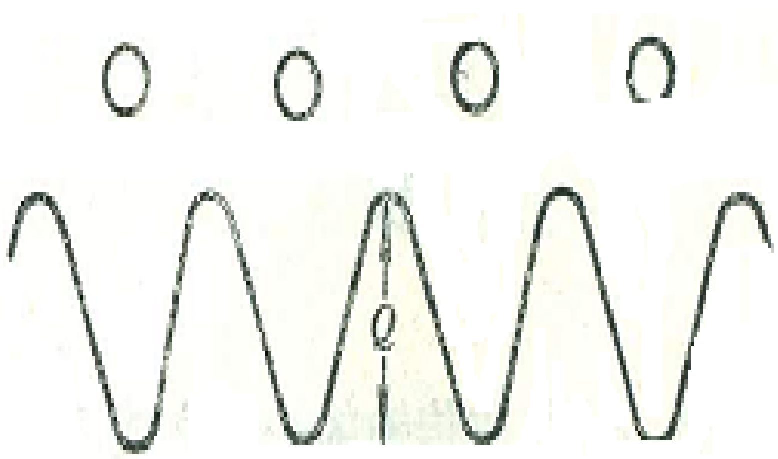
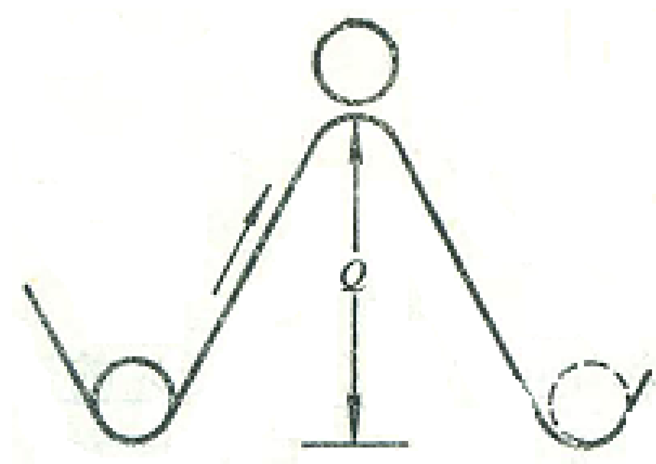


Structural metallic materials





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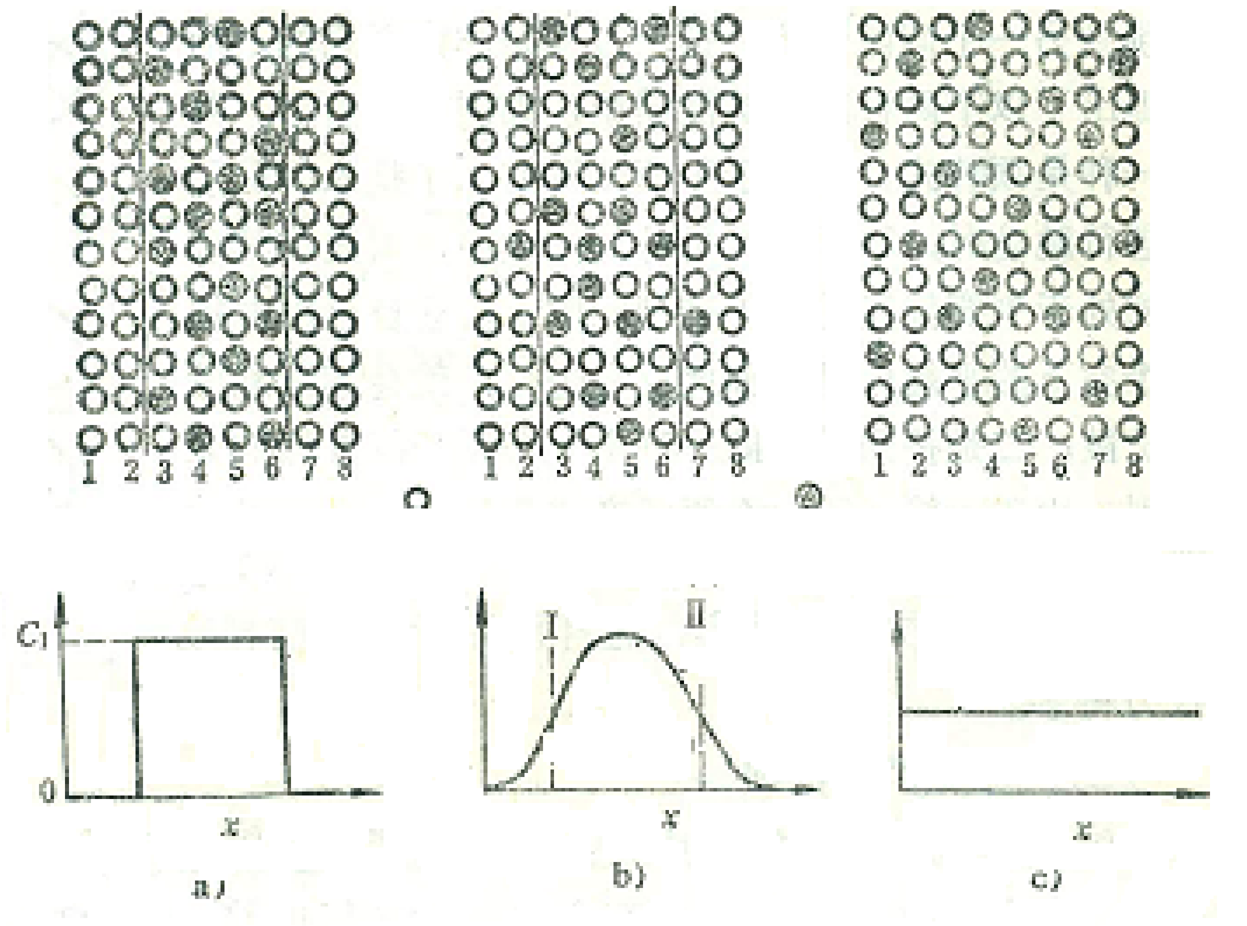
Structural metallic materials



Structural metallic materials

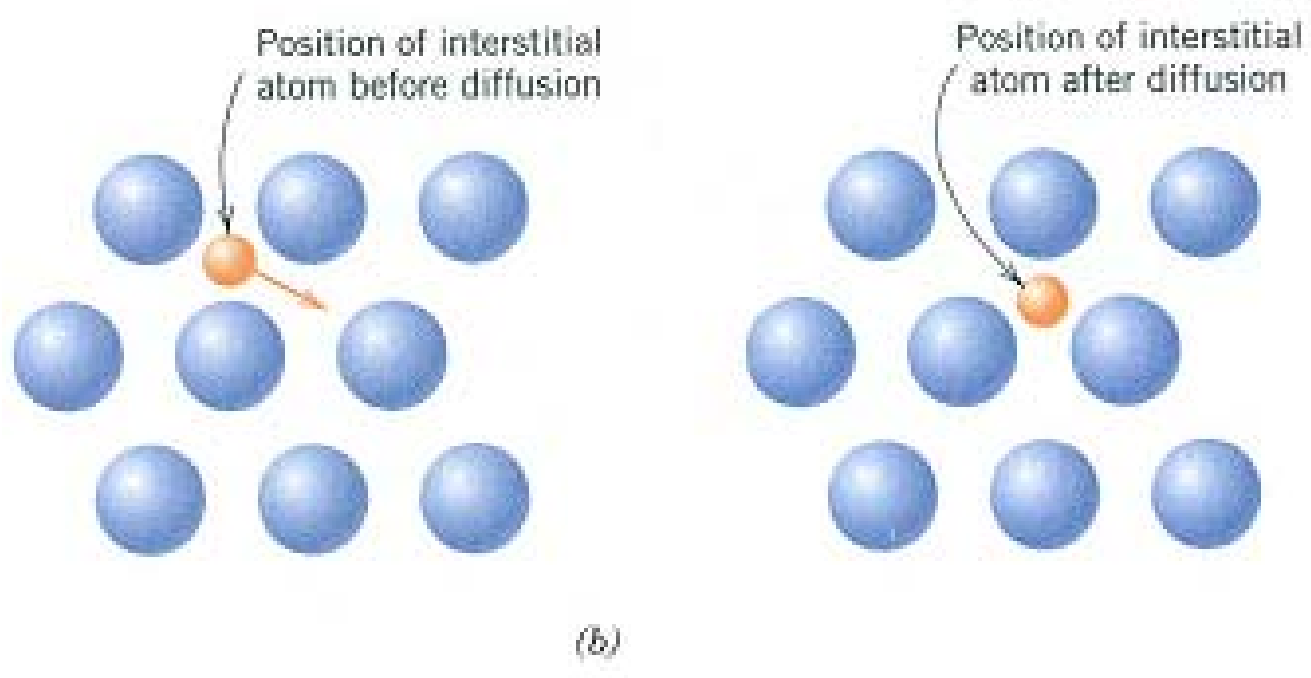
Interdiffusion : diffusion of atoms of one metal into another metal (impurity diffusion)

Self-diffusion: Atomic migration in pure metals

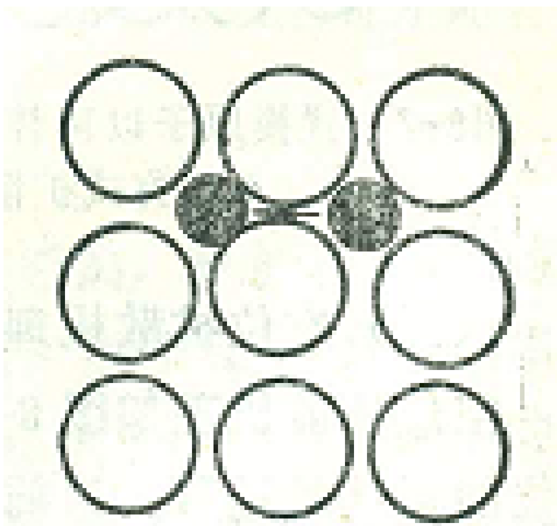
Structural metallic materials

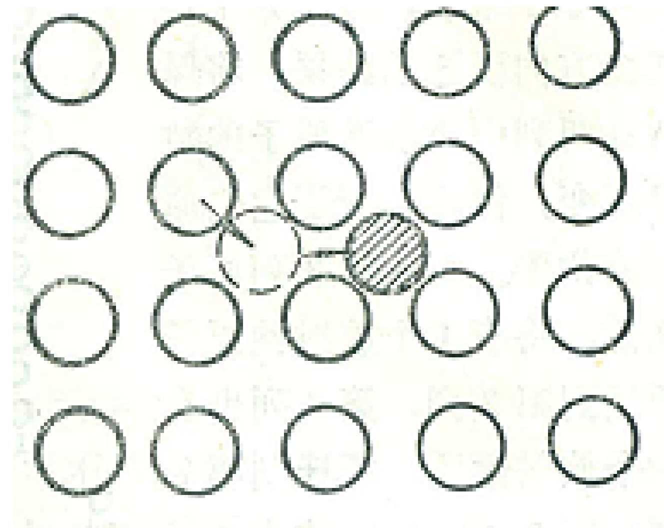
3.1.1 Diffusion Mechanisms

interstitial diffusion: A diffusion mechanism where by atomic motion is from interstitial site to Interstitial site.



Structural metallic materials





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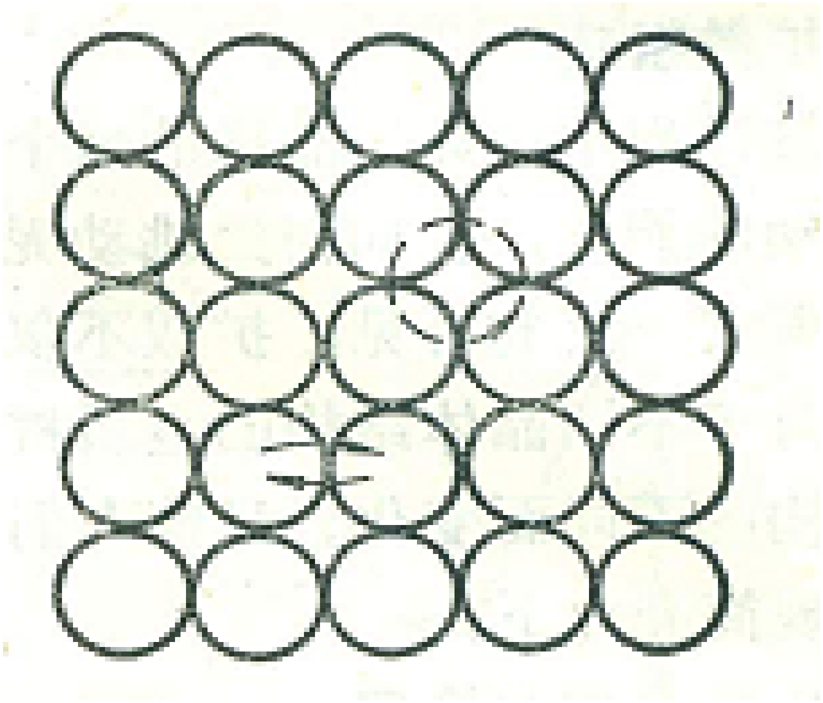
Structural metallic materials

exchange diffusion



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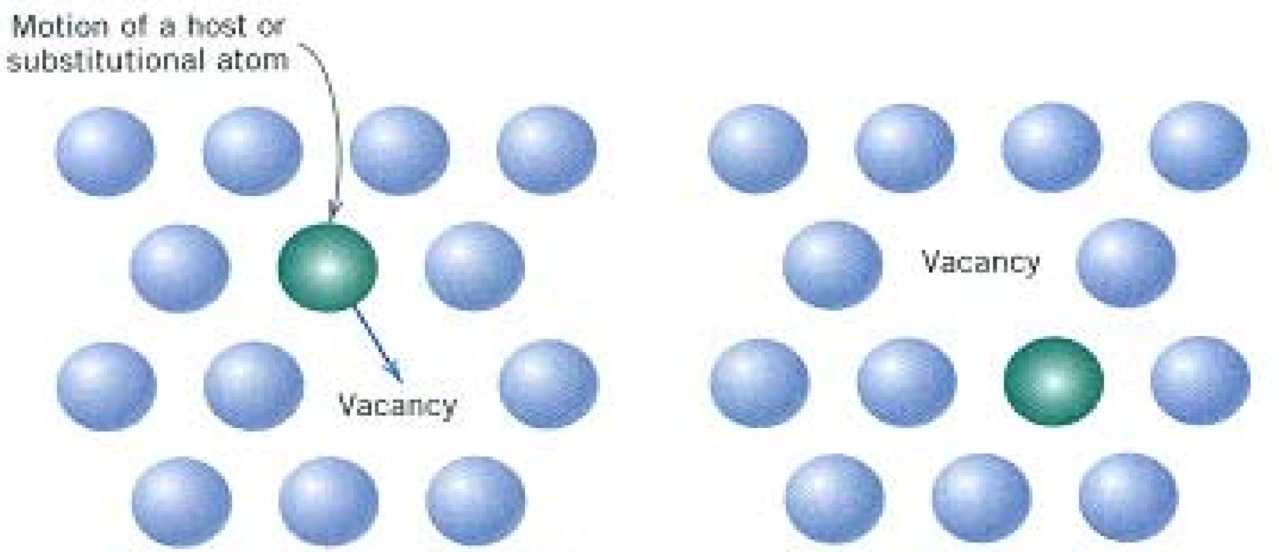
Structural metallic materials

3.1.1 Diffusion Mechanisms

Vacancy: a normally occupied lattice site from

Vacancy Diffusion: the diffusion mechanism wherein net atomic migration is from a lattice site to an adjacent vacancy



(a)

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Structural metallic materials

3.1.2 Diffusion conditions

- Temperature
- Time
- Solution
- Motivation

Structural metallic materials

3.1.3 Factors that influence diffusion

- temperature
- crystal structure
- Solid solution style
- Crystal defect
- chemical constituents

Structural metallic materials

3.1.3 Factors that influence diffusion

$$D = D_0 \exp\left(-\frac{Q_d}{RT}\right)$$

D_0 = a temperature-independent preexponential (m^2/s)

Q_d = the **activation energy** for diffusion (J/mol or eV/atom)

R = the gas constant, 8.31 J/mol·K or 8.62×10^{-5} eV/atom·K

T = absolute temperature (K)

Structural metallic materials

3.1.3 Diffusion coefficient

Using the data in following Table,
compute the diffusion coefficient for magnesium In aluminum at 550℃

A Tabulation of Diffusion Data

Diffusing Species	Host Metal	D_0 (m^2/s)	Activation Energy Kj/mol	Activation Energy ev/atom	Calculated Value T(℃)	Calculated Value D(m^2/s)
Fe	α-Fe (BCC)	2.8×10^{-4}	251	2.60	500	3.0×10^{-21}
					900	1.8×10^{-15}
Fe	γ-Fe(FCC)	5.0×10^{-5}	284	2.94	900	1.1×10^{-17}
					1100	7.8×10^{-16}
C	α-Fe	6.2×10^{-7}	80	0.83	500	2.4×10^{-12}
					900	1.7×10^{-16}
C	γ-Fe	2.3×10^{-5}	148	1.53	900	2.4×10^{-12}
					1100	1.7×10^{-11}
Cu	Cu	7.8×10^{-5}	211	2.19	500	5.9×10^{-19}
Zn	Cu	2.4×10^{-5}	189	1.96	500	5.3×10^{-18}
Al	Al	2.3×10^{-4}	144	1.49	500	4.2×10^{-14}
Cu	Al	6.5×10^{-5}	136	1.41	500	4.1×10^{-14}
Mg	Al	1.2×10^{-4}	131	1.35	500	1.9×10^{-13}
Cu	Ni	2.7×10^{-5}	256	2.65	500	1.3×10^{-22}

Structural metallic materials

3.1.3 Factors that influence diffusion

Solution

This diffusion coefficient may be determined by applying Equation5.8;the values of D and Q_d from Table 5.2 are $1.2\times10^4 m^2/s$ and 131KJ/mol,respectively. Thus,

$$D = (1.2\times10^{-4}\ m^2/s)\exp\left[-\frac{(131{,}000J/mol)}{(8.31J/mol.K)(550+273k)}\right]$$

$$= 5.8\times10^{-13}\ m^2/s$$

Structural metallic materials

SUMMARY

Introduction

- Solid-state diffusion is a means of mass transport within solid materials by stepwise atomic motion
- The term interdiffusion refers to the migration of impurity atoms; for host atoms, the term self-diffusion is used

diffusion mechanisms

- Two mechanisms for diffusion are possible; vacancy and interstitial.

✓ vacancy diffusion occurs via the exchange of an atom residing on a normal lattice site with an adjacent vacancy.

✓ for interstitial diffusion, an atom migrates from one interstitial position to an empty adjacent one.

- For a given host metal, interstitial atomic species generally diffuse more rapidly.

Structural metallic materials

SUMMARY

Factors that influence diffusion

- The magnitude of the diffusion coefficient is indicative of the rate of atomic motion and depends on both host and diffusing species as well as on temperature
- The diffusion coefficient is a function of temperature

Structural metallic materials

QUESTION

Using the data in following Table,

1、compute the diffusion coefficient for C In γ-Fe at 927℃and 1027℃.

2、compute the diffusion coefficient for Fe In α-Fe and γ-Fe at 912℃.

3、compute the diffusion coefficient for Ni In γ-Fe at 927 ℃.

基 体	扩 散 元 素	$D_0/(10^{-5} m^2 \cdot s^{-1})$	$Q/(10^3 J \cdot mol^{-1})$
γ-Fe	Fe（自扩散）	1.8	270
	C	2.0	140
	Ni	4.4	283
	Mn	5.7	277
α-Fe	Fe（自扩散）	19	239
	C	0.20	84
Al	Cu	0.84	136
Cu	Zn	2.1	171
Ag	Ag（晶内）	7.2	180
	Ag（晶界）	1.4	90

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