TMT 4185 – Øving 3

4.2 Calculate the number of vacancies per cubic meter in gold at 900°C.The energy for vacancy formation is 0.98 eV/atom. Furthermore, the density and atomic weight for Au are 18.63 g/cm^3 (at 900°C) and 196.9 g/mol, respectively.

4.4 Below, atomic radius, crystal structure, electronegativity, and the most common valence are tabulated, for several elements; for those that are nonmetals, only atomic radii are indicated.

Element	***Atomic Radius (nm)***	***Crystal Structure***	***Electro-negativity***	***Valence***
Ni	0.1246	FCC	1.8	+2
C	0.071			
H	0.046			
O	0.060			
Ag	0.1445	FCC	1.9	+1
Al	0.1431	FCC	1.5	+3
Co	0.1253	HCP	1.8	+2
Cr	0.1249	BCC	1.6	+3
Fe	0.1241	BCC	1.8	+2
Pt	0.1387	FCC	2.2	+2
Zn	0.1332	HCP	1.6	+2

Which of these elements would you expect to form the following with nickel:
(a) A substitutional solid solution having
complete solubility
(b) A substitutional solid solution of incomplete
solubility
(c) An interstitial solid solution

4.9 Calculate the composition, in weight percent, of an alloy that contains 105 kg of iron, 0.2 kg of carbon, and 1.0 kg of chromium.

4.10 What is the composition, in atom percent, of an alloy that contains 33 g copper and 47 g zinc?

4.27 For an FCC single crystal, would you expect the surface energy for a (100) plane to be greater or less than that for a (111) plane? Why? (*Note:* You may want to consult the solution to Problem 3.53 at the end of Chapter 3.)

4.29
(a) For a given material, would you expect the surface energy to be greater than, the same as, or less than the grain boundary energy? Why?
(b) The grain boundary energy of a small angle grain boundary is less than for a high angle one. Why is this so?

4.D1 Aluminum–lithium alloys have been developed by the aircraft industry to reduce the weight and improve the performance of its aircraft. A commercial aircraft skin material having a density of 2.47 g/cm^3 is desired. Compute the concentration of Li (in wt%) that is required.

5.7 A sheet of steel 2.5 mm thick has nitrogen atmospheres on both sides at 900°C and is permitted to achieve a steady-state diffusion condition. The diffusion coefficient for nitrogen in steel at this temperature is 1.2×10^{-10} m^2/s, and the diffusion flux is found to be 1.0×10^{-7} kg/m^2s. Also, it is known that the concentration of nitrogen in the steel at the high-pressure surface is 2 kg/m^3. How far into the sheet from this highpressure side will the concentration be 0.5 kg/m^3? Assume a linear concentration profile.

5.11 Determine the carburizing time necessary to achieve a carbon concentration of 0.30 wt% at a position 4 mm into an iron–carbon alloy that initially contains 0.10 wt% C.The surface concentration is to be maintained at 0.90 wt% C, and the treatment is to be conducted at 1000°C. Use the diffusion data for γ-Fe in Table 5.2.

Table 5.2 A Tabulation of Diffusion Data

Diffusing Species	*Host Metal*	$D_0(m^2/s)$	*Activation Energy Q_d* kJ/mol	*Activation Energy Q_d* eV/atom	*Calculated Values* T(°C)	*Calculated Values* $D(m^2/s)$
Fe	α-Fe (BCC)	2.8×10^{-4}	251	2.60	500 900	3.0×10^{-21} 1.8×10^{-15}
Fe	γ-Fe (FCC)	5.0×10^{-5}	284	2.94	900 1100	1.1×10^{-17} 7.8×10^{-16}
C	α-Fe	6.2×10^{-7}	80	0.83	500 900	2.4×10^{-12} 1.7×10^{-10}
C	γ-Fe	2.3×10^{-5}	148	1.53	900 1100	5.9×10^{-12} 5.3×10^{-11}
Cu	Cu	7.8×10^{-5}	211	2.19	500	4.2×10^{-19}
Zn	Cu	2.4×10^{-5}	189	1.96	500	4.0×10^{-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}

Source: E. A. Brandes and G. B. Brook (Editors), *Smithells Metals Reference Book,* 7th edition, Butterworth-Heinemann, Oxford, 1992.

5.27

(a) Calculate the diffusion coefficient for magnesium in aluminum at 450°C.

(b) What time will be required at 550°C to produce the same diffusion result (in terms of concentration at a specific point) as for 15 h at 450C?

Eksamensoppgave:
Oppgave 1
(*English version below*)
a)
Diffusjon i fast fase er en viktig prosess. Beskriv de to viktigste mekanismene man ser for seg for diffusjon i fast fase.

b)
En titanstav inneholder i utgangspunktet 0,0001 vekt% (= 0,0045 kg/m^3) nitrogen. Den ene enden av denne kvadratiske staven, med tverrsnittsareal på 100 cm^2, eksponeres til en nitrogenatmosfære ved 900°C. Dette resulterer i at det dannes et TiN belegg, der veksten av dette sjiktet er diffusjonsavhengig. Overfatekonsentrasjonen av nitrogen ved disse betingelser tilsvarer 0,1 vekt%. **Man har oppnådd et tilstrekkelig tykt belegg når konsentrasjonen ved l = 0,1 mm under overflaten er 0,01 vekt%.**

Diffusjonskoeffisienten for nitrogen i titan er oppgitt til å være 10^{-12} m^2/s ved denne temperaturen. Hvor lang tid må prøvestykket holdes ved disse betingelsene for å oppnå ønsket TiN sjikt?

Exercise 1
a)
Diffusion is an important process. Describe the two most important mechanisms for diffusions in solids.

b)
A titanium rod has a bulk composition of 0.0001 wt% (= 0.0045 kg/m^3) nitrogen. One end of this quadratic rod, with a cross-section area of 100 cm^2, is exposed to a nitrogen atmosphere at 900°C. As a result a thin TiN layer is formed, and the growth of this layer is controlled by diffusion. Under these conditions the surface concentration of nitrogen amounts to 0.1 wt%. **The thickness of the layer is sufficient when the concentration of nitrogen at l = 0.1 mm from the surface is 0.01 wt%.**

The diffusion coefficient of nitrogen in titanium at this temperature is 10−12 m^2/s. What is the required exposure time in order to reach the desired TiN layer?