University of Alberta
Department of Chemical and Materials Engineering

Instructor: Dr. Stojan Djokić

MAT E 201
Materials Science 1

Mid-Term Exam

MEC 2 1

February 26, 2010 at 11:00 am

TIME ALLOWED 50 minutes

Student's Name____

Student's ID____

For Instructor's use only:

Question No.	Mark	Out of
1		10
2		10
3		10
4		10
5		10
T O T A L		50

Answer all the questions. Where appropriate show the work. Final result will not be accepted without showing the work. Where appropriate explain your answers as brief as possible. Where needed, equations and constants are provided. Books, notes and any additional papers are not allowed. If you need additional paper please ask Instructor. Only non-programmable calculators are permitted. Total marks: 50.

Dr. Stojan Djokić, University of Alberta, **MAT E 201 Mid- term Exam**, Feb. 26, 2010

Question 1 **(10 marks)**

Spherical silver particulates of 1 μm diameter in size were uniformly coated with palladium using an electroless deposition process. The laboratory results have found that the mass ratio of Ag : Pd was 70 : 30. Considering that the Ag particles were uniformly coated with Pd, determine:

a) Thickness of the palladium layer in μm. **(7 marks)**

b) Number of Pd atoms per one Pd coated Ag particle. **(3 marks)**

Question 2 **(10 marks)**

Show that the packing factor in a:
a) SC cell is 0.52
b) BCC cell is 0.68
c) FCC cell is 0.74
d) DCC cell is 0.34
e) HCP cell is 0.74

Question 3 **(10 marks)**

BCC iron has the lattice parameter of 0.2566 nm and the lattice parameter of FCC iron is 0.3589 nm. Considering that 80000 J/mol is required to produce a mole of vacancies in BCC iron and that 85000 J/mol is required to produce a mole of vacancies in FCC iron, calculate:

a) Concentration of vacancies in BCC iron per cm^3. **(2.5 marks)**
b) Concentration of vacancies in FCC iron per cm^3. **(2.5 marks)**
c) Determine the temperature in ^{o}C at which the ratio of vacancies in FCC iron and BCC iron ($n_{v(FCC)}/n_{v(BCC)}$) is equal 0.5 . **(5 marks)**

Question 4 **(10 marks)**

The diffusion coefficient of Mg^{2+} in MgO at 1380 °C is $2.2 \cdot 10^{-12}$ cm^2/s and $7.5 \cdot 10^{-11}$ cm^2/s at 1750 °C. Calculate:

a) The activation energy, **(8 marks)**
b) Constant D_o. **(2 marks)**

Question 5 **(10 marks)**

Schematically present the following:

a) Crystal showing:

i)	Vacancy	**(1 mark)**
ii)	Interstitial defect	**(1 mark)**
iii)	Schottky defect	**(1 mark)**
iv)	Twin boundary defect	**(1 mark)**

b) Unary phase diagram (Label the regions showing the solid, liquid and vapour) **(2 marks)**

c) Binary phase diagram (Label Liquidus, Solidus and Freezing Range) **(4 marks)**

FORMULA SHEET

Number of atoms $= \dfrac{\text{mass} \times N_A}{\text{Atomic Mass}}$

N_A= 6.023 x 10^{23} atoms/mol; R= 8.315 J/mol·K; ($\rho_{(Ag)}$ = 10.49 g/cm^3, A_r (Ag) = 107.868 g/mol; $\rho_{(Pd)}$ = 12.02 g/cm^3, A_r(Pd) = 106.4 g/mol)

$\rho = \dfrac{m}{V}$; $\text{PF} = \dfrac{\textit{Number of atoms per unit cell} \times V_{at}}{V_{uc}}$; $V = \dfrac{4}{3} r^3 \pi$

Volume of cubic cell= a_o^3
Volume of HCP cell = 0.866 $a_o^2 c_o$, c_o =1.633a_o

$D = D_0 \exp(-\dfrac{Q}{RT})$; $n_v = n \exp(-\dfrac{Q}{RT})$

Relations between the atomic radius and lattice parameters for various cells:

SC	$a_0 = 2r$
BCC	$a_0 = \dfrac{4r}{\sqrt{3}}$
FCC	$a_0 = \dfrac{4r}{\sqrt{2}}$
HCP	$a_0 = 2r$
DC	$a_0 = \dfrac{8r}{\sqrt{3}}$

First Fick's Law:

$$J = -D \frac{dc}{dx}$$

Second Fick's Law

$$\left(\frac{C_s - C_x}{C_s - C_0} \right) = erf \left(\frac{x}{2\sqrt{Dt}} \right)$$