University of Alberta
Department of Chemical and Materials Engineering

Lecturer: Dr. Stojan Djokić, P.Eng.

MAT E 201
Materials Science 1

Mid-Term Exam
MEC 2 1
March 2, 2012 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**, Mar.2, 2012

Question 1 **(10 marks)**

The atomic relative mass of silver is 107.868 g/mol and its density is 10.49 g/cm^3. The lattice parameter of FCC silver, as found by the XRD analysis is 4.09 Å. Using the above data determine:

a) The Avogadro's number with three decimal places **(7 marks)**

b) If the true value of the Avogadro's number is $6.023 \cdot 10^{23}$ atoms/mol, determine the error of your calculations in %. **(3 marks)**

Question 2 **(10 marks)**

Two samples of iron were analyzed by the x – ray diffraction (XRD). The XRD analysis found that the sample A had a lattice parameter $2.866 \cdot 10^{-8}$ cm, and that sample B had a lattice parameter $3.589 \cdot 10^{-8}$ cm.

a) Determine the number of atoms per unit cell for each A and B samples. **(7 marks)**

b) What are the structures of samples A and B, simple cubic (SC), body centered cubic (BCC) or face centered cubic (FCC)? **(3 marks)**

Question 3 **(10 marks)**

FCC aluminium has a lattice parameter of $4.04958 \cdot 10^{-8}$ cm and contains one vacancy per 200 unit cells. Calculate:

a) Number of vacancies per cm^3. **(2 marks)**

b) Activation energy to produce a mol of vacancies at 25 °C. **(3 marks)**

c) The real [redacted] density of aluminum **(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 in kJ/mol **(8 marks)**

b) Constant D_o in cm^2/s. **(2 marks)**

Question 5 **(10 marks)**

Sketch 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

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

$N_A = 6.023 \times 10^{23}$ atoms/mol; R= 8.315 J/mol·K; ($\rho_{(Ag)} = 10.49$ g/cm^3, A_r(Ag) = 107.868 g/mol; $\rho_{(Al)} = 2.699$ g/cm^3, A_r(Al) = 26.981 g/mol), $\rho_{(Fe)} = 7.87$ g/cm^3 A_r(Fe)= 55.847 g/mol)

$$\rho = \frac{m}{V}\ ;\ PF = \frac{Number\ of\ atoms\ per\ unit\ cell \times V_{at}}{V_{uc}};\quad V = \frac{4}{3}r^3\pi \qquad \rho = \frac{N_{at/uc} \cdot A_r}{V_{uc} \cdot N_A}$$

Volume of cubic cell= a_o^3

Volume of HCP cell = $0.866\ a_o^2 c_o$, $\quad c_o = 1.633 a_o$

$$D = D_O \exp(-\frac{Q}{RT});\qquad n_v = n\exp(-\frac{Q}{RT})$$

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

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

First Fick's Law: $\quad J = -D\frac{dc}{dx}$

Second Fick's Law $\quad \left(\frac{C_s - C_x}{C_s - C_0}\right) = erf\left(\frac{x}{2\sqrt{Dt}}\right)$