University of Alberta
Department of Chemical and Materials Engineering

Lecturer: Dr. Stojan Djokić

MAT E 201
Materials Science 1

Mid-Term Exam
MEC 2 1
March 4, 2011 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**, March 4, 2011

Question 1 **(10 marks)**

Spherical copper particulates with a diameter of 1μm were uniformly coated with silver. If the mass ratio ($m_{Cu} : m_{Ag}$) is 80 : 20, calculate:

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

b) Number of silver atoms per one Ag coated Cu particle. **(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)**

BCC lithium has a lattice parameter of $3.5089 \cdot 10^{-8}$ 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 and theoretical density of lithium **(5 marks)**

Question 4 **(10 marks)**

Given are the following perovskite crystal structures (ABO_3): a) $CaTiO_3$, b) $ZnTiO_3$ and c) $BaZrO_3$. Considering that all systems meet the electronegativity criterion, determine which of these compounds will have 100 % solid solubility when added to $BaTiO_3$, which also has the perovskite structure.

Atom	Valence	Atomic Radius (Å)
Ba	+2	2.176
Ca	+2	1.976
Zn	+2	1.332
Ti	+4	1.475
Zr	+4	1.616

Question 5 **(10 marks)**

Sketch the following:

a) Crystal showing:

i) Vacancy **(1 mark)**

ii) Interstitial defect **(1 mark)**

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

c) Cooling curve (Label Liquidus, Solidus and Freezing Range) **(4 marks)**

Give at least two examples of each:

i) Oxide ceramic materials **(1 mark)**

ii) Non-oxide ceramic materials **(1 mark)**

FORMULA SHEET

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

N_A= 6.023 x 10^{23} atoms/mol; R= 8.314 J/mol·K;
($\rho_{(Ag)}$ = 10.49 g/cm^3; A_r (Ag) = 107.868 g/mol; $\rho_{(Cu)}$ = 8.93 g/cm^3; A_r(Cu) = 63.54 g/mol;
$\rho_{(Fe)}$ = 7.87 g/cm^3, A_r(Fe) = 55.847 g/mol)

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

$$\rho = \frac{N_{at./u.c.} A_r}{V_{u.c.} N_A}$$

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

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

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:

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

Second Fick's Law

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