University of Alberta
Department of Chemical and Materials Engineering

Examiner: Dr. Stojan Djokić

MAT E 201
Materials Science 1

Mid-Term Exam
ETLE-1017
October 28, 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		5
5		15
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**, Oct. 28, 2011

Q 1 (10 marks)

a) Determine the diameter of spherical nickel particles in micrometers (μm) if each particle contains $1.8 \cdot 10^{14}$ Ni atoms.

b) These nickel particles were further coated with silver. If the thickness of Ag layer is 0.1 μm, determine the ratio of number of Ni atoms (n_{Ni}) to the number of Ag atoms (n_{Ag}) per one particle (n_{Ni}/n_{Ag} = ?)

Q 2 (10 marks)

Gallium has an orthorhombic structure with a_o=0.45258 nm, b_o=0.45186 nm and c_o=0.76570 nm. The atomic radius of Ga is 0.1218 nm , its density is 5.904 g/cm^3 and atomic mass is 69.72 g/mol. Determine:

a) The number of atoms in each unit cell

b) Packing factor

Q 3 (10 marks)

BCC lithium has a lattice parameter of $3.5089 \cdot 10^{-8}$ cm and contains $1.157 \cdot 10^{20}$ vacancies per cm^3. Determine:

a) The activation energy required to create these vacancies in lithium at 25°C.

b) The density of lithium if there is one vacancy per 200 unit cells. (A_r(Li)=6.94 g/mol)

Q 4 (5 marks)

The following data are given:

Element	Crystal Structure	Atomic Radius (Å)	Valence
Ag	FCC	1.445	+1
Al	FCC	1.432	+3
Mo	BCC	1.363	+4
Ta	BCC	1.43	+5
Ge	DC	1.225	+4
Si	DC	1.176	+4
Au	FCC	1.442	+1

Based on Hume-Rothary's conditions which of the following systems would be expected to display unlimited solubility: a) Ag-Al; b) Mo-Ta; c) Ge-Si; d) Au-Ag. Explain your answer.

Q5 (15 marks)

a) Sketch the binary phase diagram and label the axes, the liquidus, the solidus and the freezing range

b) Sketch the cooling curve and label the axes, local solidification time and the total solidification time

c) Sketch the unary phase diagram. Label the axes and show solid, liquid and vapour phases.

d) Give at least 3 examples of oxide ceramic materials

e) Give at least one example of ceramic materials used in:

i) magnetic applications

ii) electronics applications

iii) optical applications

FORMULA SHEET

Number of atoms $= \dfrac{\text{mass} \times N_A}{\text{Atomic Mass}}$; ρ(Ni)=8.902 g/cm^3; A_r(Ni) =58.71 g/mol

ρ(Ag)=10.49 g/cm^3; A_r(Ag)= 107.868 g/mol; A_r(Li)=6.94.2 g/mol

N_A= 6.023 x 10^{23} atoms/mol; R= 8.314 J/mol·K

$$\rho = \frac{m}{V} \qquad PF = \frac{Number\ of\ atoms\ per\ unit\ cell \times V_{at}}{V_{uc}};$$

$$V = \frac{4}{3} r^3 \pi \qquad V = \frac{d^2 \pi}{4} l$$

Volume of orthorhombic cell = $a_o b_o c_o$

$\rho = \dfrac{nA_r}{V_{uc} N_A}$; Volume of cubic cell= a_o^3; Volume of HCP cell = 0.866 $a_o^2 c_o$, c_o =1.633a_o

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

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

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

First Fick's Law: $J = -D\dfrac{dc}{dx}$; Second Fick's Law: $\left(\dfrac{C_s - C_x}{C_s - C_0}\right) = erf\left(\dfrac{x}{2\sqrt{Dt}}\right)$