University of Alberta
Department of Chemical and Materials Engineering

Examiner: Dr. Stojan Djokić, P.Eng.

MAT E 201
Materials Science 1

Mid-Term Exam
MEC E 2 1
March 1, 2013 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		9
2		6
3		9
4		12
5		14
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.

Q 1 (9 marks)

A metal having and a cubic structure has density of 10.49 g/cm^3, atomic mass of 107.868 g/mol and lattice parameter a_o = 4.0862 Å

a) Determine if this metal has SC, BCC or FCC structure

b) Consider that this metal was deposited onto a ceramic substrate with surface area of 10 cm^2. If the deposited metal contains $2 \cdot 10^{18}$ atoms, determine the thickness (δ), considering that the metallic substrate is uniformly coated with the metallic film.

c) Calculate the mass of the deposited metal in mg.

Q 2 (6 marks)

Sketch the following in a cubic crystal structure:

a) Surfaces A(001), B(222). Use individual sketches to represent these planes.

b) Directions **A**[212], **B**[131]. Use individual sketches to represent these directions.

Q 3 (9 marks)

The lattice parameter of BCC molybdenum is 3.1468 Å and its density is 10.22 g/cm^3. Atomic mass of molybdenum is 95.94 g/mol. Calculate:

a) The fraction of lattice points that contains vacancies

b) The total number of vacancies in a cm^3 of Mo

c) If the value of number of vacancies obtained in part b) is correct for room temperature (25 °C), calculate the activation energy to produce ***one mole*** of vacancies in molybdenum.

Q4 (12 marks)

a) The melting point of Cu is 1085 °C and the melting point of Ni is 1455 °C. Ni-Cu system is known to display unlimited solubility. Sketch the phase diagram of Ni-Cu system and label the axes, melting points of Cu and Ni, 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) Melting point of H_2O is 0 °C at 101.3 kPa. Sketch the phase diagram for water. Label the axes and show solid, liquid and vapour phases.

Q5 (14 marks)

a) Give one typical example of eutectic phase diagram used in electronics applications

b) Give at least two examples of intermetallic compounds

c) Give at least two examples of ceramics used in electronics applications

d) Give at least two examples of glasses used in electronics applications

e) Give at least two examples of polymeric materials used as insulators of an electric field

f) Give at least one example of a ceramic material used in memory storage devices

g) Give at least one example of a polymer produced via addition polymerization and one produced via condensation polymerization.

FORMULA SHEET

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

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

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

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

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