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 26, 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		12
2		6
3		12
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.

Q 1 (12 marks)

It was reported in literature that from 1 g of gold 3 km long wire can be obtained by classical metallurgical methods. Using these classical metallurgical methods thin gold foils with a thickness of $1\cdot10^{-5}$ mm can be produced. Obtained gold foils have yellow color in the reflected light and a green color in the transmitted light. Atomic mass of gold is 197.2 g/mol and it density is 19.3 g/cm^3. Determine:

a) Diameter of 3 km long gold wire in μm
b) Surface area of $1\cdot10^{-5}$ mm thick gold foil in cm^2.
c) Number of atoms in 1 g of gold.

Q 2 (6 marks)

Sketch the following in a cubic crystal structure:

a) Surfaces A(333), B(222), C(111). Use individual sketches to represent these planes.
b) Directions A[321], B[123] C[323]. Use individual sketches to represent these directions.

Q 3 (12 marks)

The density of HCP titanium is 4.495 g/cm^3 and its lattice parameters are a_o=2.9503 Å and c_o=4.6831 Å. The atomic mass of titanium is 47.9 g/mol. Calculate:

a) The fraction of lattice points that contains vacancies.
b) Total number of vacancies in a cubic centimeter of Ti.
c) Activation energy to create 1 mol of vacancies at room temperature.

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

Which of the following systems would be expected to display unlimited solubility according to the Hume-Rothary's rules? a) Al-Mo; b) Mo-Ta; c) Ge-Si; d) Au-Ag. Explain your answers.

Q5 (15 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.

Dr. Stojan Djokić, University of Alberta, **MAT E 201 Mid- term Exam**, Oct. 26, 2012

FORMULA SHEET

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

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

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

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

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 = $0.866\, a_o^2 c_o$, $c_o = 1.633 a_o$

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

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