University of Alberta
Department of Chemical and Materials Engineering

Dr. Stojan Djokić, Adjunct Professor

MAT E201
Materials Science I
Example Mid-Term Exam

TIME ALLOWED 50 minutes

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.

SAMPLE QUESTIONS

Question 1 If a mass of thin copper film plated onto Si-substrate is 5.35×10^{-2} g and its surface is10 cm^2, determine:

a) Total number of Cu atoms
b) Moles of Cu per unit surface area
c) Thickness of Cu film in μm

A_r(Cu) = 63.54 g/mol, $N_A = 6.023 \times 10^{23}$ atoms/mol, ρ(Cu)=8.93 g/cm^3.

Question 2 Show that the number of lattice points per unit cell in the cubic crystal systems is as follows:

a) Simple cubic (SC) 1 atom/u.c.; Body centered cubic (BCC) 2 atoms/u.c. and Face centered cubic (FCC) 4 atoms/u.c.
b) Assume that a pure metal changes its structure from a simple-cubic (SC) to a face-centered-cubic (FCC) and then to a body-centered-cubic (BCC). If the relations between the atomic radius (r) and lattice parameter (a_o) are given by the equations: $a_o = 2r$ (for SC), $a_o = 4\frac{r}{\sqrt{2}}$ (for FCC) and $a_o = 4\frac{r}{\sqrt{3}}$ (for BCC), calculate:
    i) The theoretical volume change accompanying a polymorphic transformation in a pure metal from the SC to FCC
    ii) The theoretical volume change accompanying a polymorphic transformation in a pure metal from the BCC to FCC.

Question 3 Suppose the following point defects are introduced in discussed materials. What other changes must be necessary to maintain a charge balance. Explain and name for each case the type of defect.

a) Be^{2+} ions substitute for Al in Al_2O_3
b) Al^{3+} ions substitute for Ba in $BaTiO_3$
c) Li^{+} ions substitute for Ca in $CaSO_4$
d) Ni^{2+} ions replace K in KCl

Question 4 Determine the Miller indices for directions and planes given in the following figures:
a)
b)

Question 5 Consider the impurity diffusion of gallium into a silicon wafer with no previous gallium present in it at temperature 1100 ^{o}C for 3 hours. If the surface concentration of gallium atoms after the completion of the diffusion process is 10^{18} aoms/cm^3, determine the depth (x) below the surface at which the concentration of gallium is 10^{16} atoms/cm^3. Diffusion coefficient of gallium into silicon at 1100 ^{o}C is D = 7.0×10^{-13} cm^2. ($\frac{c_s - c_x}{c_s - c_o} = \text{erf}\left(\frac{x}{2\sqrt{Dt}}\right)$).

Question 6 Name the five systems that involve three separate phases in binary phase diagrams

a) Give examples of ceramic materials used in:
    i) the recording media
    ii) capacitors
    iii) electro-optical applications
b) Briefly define a glass material
c) Which polymers have a lower level of crystallinity:
    i) linear
    ii) branched
d) What are thermosetting polymers? List some examples.