Kafrelsheikh University
Faculty of Engineering
Mechanical Engineering Department
Subject: Metallurgy (MDP1104) Year: 1st Mech.

Date: 12 January 2017
Time allowed: 3 Hours
Full Marks: 75 Marks
Final Exam: 2 pages

Question 1: (10 Marks)

(a) Fill in the spaces the correct answer :   (5 Marks)

1. .... investigates the relationships that exist between the structure and properties of materials.

2. How many atoms are there in a mole of a substance?   Answer: ....

3. .... is one such type of defect involves a cation-vacancy and a cation-interstitial pair.

4. Diffusion occurs in pure metals, where all atoms exchanging positions are of the same type; this is termed ....

5. A .... may be defined as a homogeneous portion of a system that has uniform physical and chemical characteristics.

(b) Choose the right answer :   (5 Marks)

1. What type(s) of electron subshell(s) does an M shell contain?

☐ A. s   ☐ B. p   ☐ C. d   ☐ D. f

☐ E. s and p   ☐ F. s, p and d   ☐ G. All of the above

2. What is the predominant type of bonding for ceramic materials?

☐ A. Ionic   ☐ B. Covalent   ☐ C. Metallic

☐ D. Secondary   ☐ E. Both A and B   ☐ F. Both A and C

3. The drawing below represents the unit cell for which crystal structure?

☐ A. Simple cubic   ☐ B. Face-centered cubic

☐ C. Body-centered cubic   ☐ D. Hexagonal close-packed

4. Two metal specimens, A and B, have ASTM grain size numbers of 3 and 8, respectively. Which specimen has the larger grain size?

☐ Grain size of A > Grain size of B   ☐ Grain size of A < Grain size of B

5. As temperature decreases, the fraction of the total number of atoms that are capable of diffusive motion

☐ Increases   ☐ Decreases   ☐ Remains constant
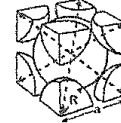
Question 2: (25 Marks)

(a) Would you expect Al_2O_3 or aluminum to have the higher coefficient of thermal expansion? Explain. (5 Marks)

(b) Compare between the SCC, BCC, FCC and HCP unit cells?   (6 Marks)

(c) A metal having a cubic structure has a density of 2.6 g/cm³, an atomic weight of 87.62 g/mol, and a lattice parameter of 6.0849 Å. One atom is associated with each lattice point. Examine whether the metal has a BCC or FCC crystal structure. (Avogadro's number = $6.02*10^{23}$ atoms/mol). (6 Marks)

(d) Sketch the following planes and directions within a cubic unit cell.   (8 Marks)

i) $[2\,0\,\bar{1}]$ ii) $(2\,0\,\bar{1})$

Question 3: (25 Marks)

(a) Discuss briefly the different types of point defects? *(5 Marks)*

(b) Calculate the energy for vacancy formation in silver, given that the equilibrium number of vacancies at 1073 °K is $3.6*10^{23}$ atom/m^3. The atomic weight and density at 1073 °K for silver are, respectively, 107.9 g/mol and 9.5 g/cm^3. (Note: $k = 8.62*10^{-5}$ eV/atom-°K) *(6 Marks)*

(c) Cite two reasons why interstitial diffusion is normally more rapid than vacancy diffusion, then illustrate your answer with schematic diagrams for both diffusion mechanisms? *(4 Marks)*

(d) The diffusion coefficients for carbon in γ-iron are $5.9*10^{-12}$ m^2/s and $5.3*10^{-11}$ m^2/s given at 900 °C and 1100 °C respectively. Determine the values of D_0 and the activation energy Q_d, then determine the approximate time at 1000 °C that will produce the same diffusion result (in terms of concentration of C at some specific point in γ-iron) as a 10 hours heat treatment at 900 °C. (Note: the gas constant $R = 8.31$ J/mol. °K) *(10 Marks)*

Question 4: (15 Marks)

(a) Phase diagram gives answer to three important questions, what are these questions? *(3 Marks)*

(b) Use the given lead - tin (Sn-Pb) phase diagram shown in figure to answer the following for an alloy contain 70 wt% Pb - 30 wt% Sn : *(12 Marks)*

    (i) The liquidus temperature, solidus temperature, freezing range and cooling curve

    (ii) What are the phases present and the phase compositions for this alloy at 200 °C.