



UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA
SECOND SEMESTER EXAMINATIONS, MAY 2018

COURSE NO: MR 274
COURSE NAME: MATERIAL SCIENCE AND ENGINEERING
CLASS: MR II **TIME:** 3 HOURS

Name: _____ Index Number: _____

Answer All Questions

1. a) What are the Hume-Rothery conditions for **substitutional** and **interstitial** solid solution solubility **(5 marks)**
b) Draw a binary eutectic phase diagram and label all its essential parts. **(5 marks)**
c) Explain the following phase transformations **(2 marks each)**
 - i. Allotropy iii. Eutectoid
 - ii. Eutectic iv. Peritectic
 - iii. Eutectoid v. Peritectoid
d) The binary alloy of $\text{Al}_2\text{O}_3\text{-Cr}_2\text{O}_3$ has complete solid solubility. For an overall composition C_0 containing 73 wt% Cr_2O_3 , the liquid composition containing 57 wt% Cr_2O_3 and the solid composition having 82 wt% Cr_2O_3 are in thermal equilibrium. The melting point of Al_2O_3 is 2050 °C and the melting point of Cr_2O_3 is 2300 °C. Draw the phase diagram and determine the relative amounts of the solid and liquid phases. **(3 marks)**

2. a) Explain the two mechanisms of diffusion with the aid of sketches. **(6 marks)**
b) Distinguish between steady state and non-steady state diffusion. **(6 marks)**
c) Explain activation energy in terms of diffusion and list three factor that influences it. **(3 marks)**

d) The wear resistance of a steel gear is to be improved by hardening its surface. This is to be accomplished by increasing the carbon content within an outer surface layer as a result of carbon diffusion into the steel; the carbon is to be supplied from an external carbon-rich gaseous atmosphere at an elevated and constant temperature. The initial carbon content of

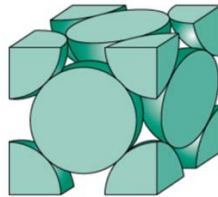
the steel is 0.20 wt%, whereas the surface concentration is to be maintained at 1.00 wt%. For this treatment to be effective, a carbon content of 0.60 wt% must be established at a position 0.75 mm below the surface. Specify an appropriate heat treatment in terms of temperature and time for temperatures 900 °C and 1050 °C. D_0 is $2.3 \times 10^{-5} \text{ m}^2/\text{s}$ and the activation energy is 148 KJ/mol. **(10 marks)**

3. a) Define the following terms **(8 marks)**

- i. Unit cell
- ii. Lattice
- iii. Coordination number
- iv. Atomic packing factor

b) List the seven crystal systems. **(7 marks)**

c) For the unit cell below show that the packing factor is 0.74. Where the cubic edge length is a and the radius of the sphere is r . **(6 marks)**



d) Copper has an atomic radius of 0.128 nm, an FCC crystal structure, and an atomic weight of 63.5 g/mol. Compute its theoretical density. **(4 marks)**

4. a) What is corrosion **(4 marks)**

b) Distinguish between Dry and Wet Corrosion **(6 marks)**

c) What is galvanic corrosion and list four (4) strategies to control it. **(11 marks)**

d) List four (4) corrosion monitoring methods. **(4 marks)**

Examiner: Dr S. N. Asare-Asher