THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

UNIVERSITY EXAMINATIONS

FINAL EXAMINATION FOR SEMESTER II, 2007

FEBRUARY 11, 2008

ME 232 – PROPERTIES ENGINEERING MATERIALS I

QUESTION PAPER

Read the following instructions carefully before you start writing:

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1. ***This question paper has two printed pages including this cover***
2. ***This examination is Closed Book***
3. ***Time allowed is THREE (3) Hours***
4. ***Answer ANY FIVE QUESTIONS, with AT LEAST TWO from each Section***
5. ***All Questions carry equal marks***
6. ***Hand in Sections A and B SEPARATELY***

SECTION A (Answer at least two questions from this Section.)

Question 1: Graph paper will be provided for Q1(b).

(a) Two hypothetical metals *A* and *B* have melting points of 600°C and 850°C, respectively. Assuming all lines are straight, sketch the likely binary phase diagram for each of the following sets of assumptions. In each case label only the major features clearly. Interpretation of the diagrams and use of graph paper in *Q*1(a) is not required. Lines may all be assumed straight.

(i) The metals form an intermetallic compound with the formula AB_2. [06 marks]

(ii) Both metals are partially soluble in one another in the solid state and a eutectic occurs. [03 marks]

(iii) Both metals are partially soluble in one another in the solid state and a peritectic reaction occurs. [03 marks]

(b) Two hypothetical metals *A* and *B*, whose melting points are 700°C and 500°C, respectively, are miscible in all proportions in the liquid state and are partially soluble in one another in the solid state, the maximum solutions being 15%*B* and 5%*A* by weight. The solubilities are 5%*B* and 2%*A*, respectively at 0°C. The two metals form a compound A_2B which melts at 750°C and in which neither metal is soluble. The atomic weights of *A* and *B* are 30 and 50, respectively. Eutectics are formed at 20% and 75% by weight of *B* and at temperatures 450°C and 320°C, respectively.

Construct and fully label the equilibrium diagram of the two metals, assuming that all the lines on it are straight. [08 marks]

Question 2

(a) Distinguish in detail between an interstitial and substitutional solid solution. What part does the ration of the atomic radii play in determining the type and range of solid solution? What other factors are involved? Illustrate your answer with suitable sketches. [10 marks]

(b) Copper and nickel form a continuous solid solution at all compositions, whereas copper and silver form two solid solutions of limited solubility. Explain this in detail in terms of atomic radii? Use sketches to illustrate your answers. [10 marks]

Question 3

(a) Explain the mechanism of rust formation beneath a drop of water on a steel surface. [08 marks]

(b) Compare and contrast the principles involved in cathodic protection and anodic protection against corrosion. Describe a pourbaix diagram, and explain how it is used to show the conditions under which each protection method applies. [12 marks]

Question 4

(a) (i) Describe the influence of ionic and covalent bonds on the mechanical properties of crystals. [08 marks]

(ii) In a cubic structure, what are the angles between (111) and (122)? [04 marks]

(b) From the information given in Table *Q*4, calculate the density of rhenium. [08 marks]

Table Q4: Atomic Data for Rhenium

Element	Symbol	Structure	Atomic mass (kg)	Lattice constant (nm)	
				a	*c*
Rhenium	Re	cph	3.09174×10^{-25}	0.2760	0.4458

SECTION B (Answer at least two questions from this Section.)

Question 5

Describe in detail the following:

(a) Glass formers [05 marks]
(b) Intermediates [05 marks]
(c) Alumina [05 marks]
(d) Zirconia [05 marks]

Question 6

(a) Sketch the Iron-Carbon phase diagram indicating on it all the relevant temperatures and phases. [10 marks]

(b) Describe the expected reactions in the Iron-Carbon phase diagram and the temperatures at which they occur. [05 marks]

(c) Define all the phases indicated on the above diagram. [05 marks]

Question 7

(a) From the point of view of composition and structure, describe in detail four main groups into which ceramics may be classified. [10 marks]

(b) Discuss the following heat treatment methods of steel
   (i) Recrystallisation annealing [05 marks]
   (ii) Stress-relief annealing [05 marks]

Question 8

Discuss in detail the following:

(a) Phenolics [05 marks]
(b) Glass-fibre reinforced plastics [05 marks]
(c) Polystyrene [05 marks]
(d) PTFE [05 marks]

END OF ME 232 EXAMINATION
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