BITS, Pilani – Dubai Campus

Knowledge Village, Dubai

II Year – II Semester 2003 – 2004

COMPREHENSIVE EXAMINATION

Course No. : ES UC242.
Course Title : Structure & Properties of Materials.
Date : 07.05.2004.

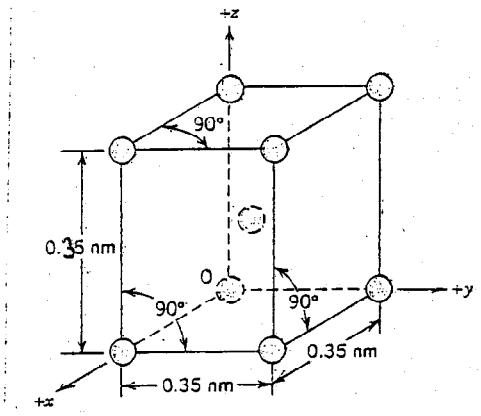
Time : 3 hours.
Max. Marks : 40
Weightage : 40 %

NOTE:

i. Answer all the Questions.
ii. Assume any missing data suitably.

Q1. Below is a unit cell for a hypothetical metal.

a. To which crystal system does this unit cell belong?
b. What would this crystal structure be called?
c. Draw the (110) plane and find the planar density.



[4 marks]

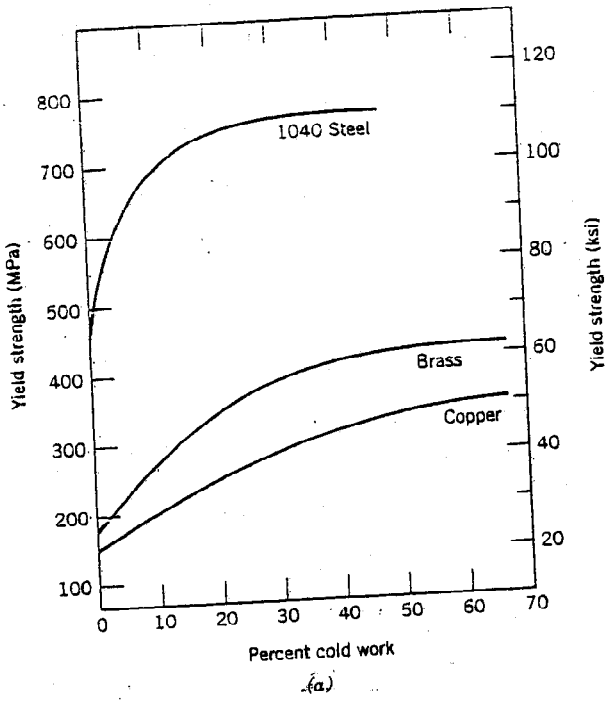
Q2. Gold forms a substitutional solid solution with silver. Compute the weight percent of gold that must be added to silver to yield an alloy that contains 5.5×10^{21} Au atoms per cm^3. The densities of pure Au and pure Ag are 19.32 and 10.49 g/cm^3 respectively.

(4 marks)

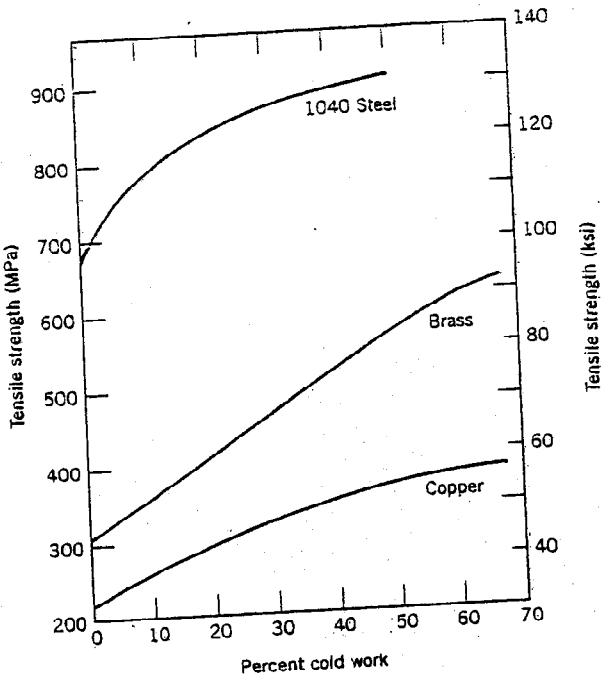
Q3. A sheet of BCC iron 1.2 mm thick was exposed to a carburizing gas atmosphere on one side and a decarburizing atmosphere on the other side at 730°C. After having reached steady state, the iron was quickly cooked to room temperature. The carbon concentrations at the two surfaces of the sheet were determined to be 0.013 and 0.0077 wt%. Compute the diffusion coefficient it the diffusion flux is 1.4×10^{-8} $kg / m^2\text{-}s$.

(4 marks)

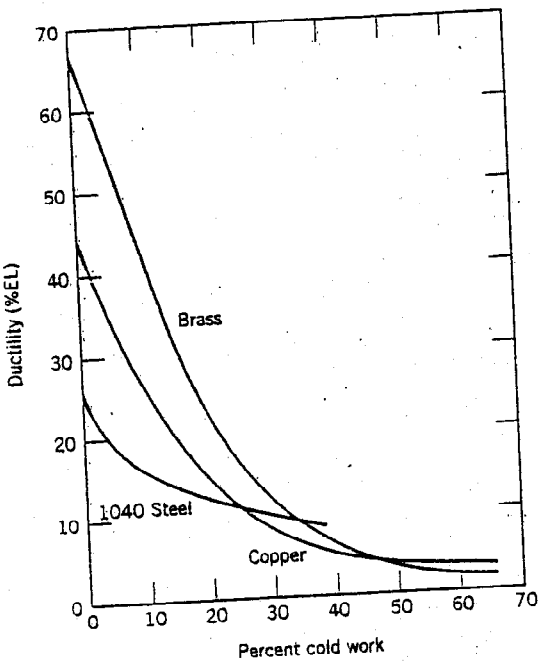
Q4. A cylindrical rod of 1040 steel originally 15.2 mm in diameter is to be cold worked by drawing; the circular cross section will be maintained during deformation. A cold worked tensile strength in excess of 840 MPa and a ductility of atleast 12% EL are desired. Furthermore, the final diameter must be 10 mm. Explain how this may be accomplished. (4 marks)



(a)



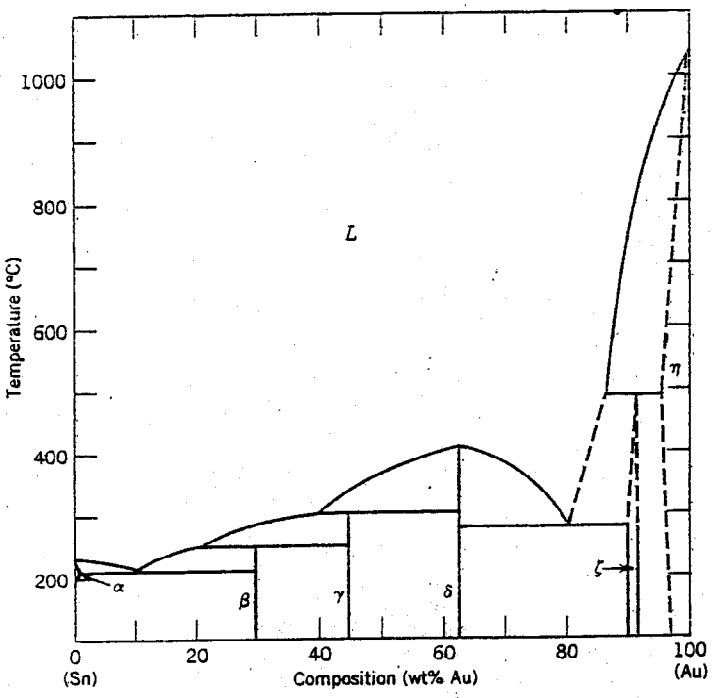
(b)



(c)

95. Following figure is the tin-gold phase diagram, for which only single-phase regions are labeled. Specify temperature-composition points at which all eutectic, eutectoid and peritectic reactions occur. Also for each, write the reactions upon cooling.

(4 marks)



96. Using the isothermal transformation diagram for an iron carbon alloy of eutectoid composition (figure Q6), specify the nature of the final microstructure (in terms of micro constituents present and approximate percentages of each) of a small specimen subjected to the following time-temperature treatments. In each case assume that the specimen begins at 750°C and that it has been held at this temperature long enough to have achieved a complete and homogeneous austenitic structure.

a. Cool rapidly to 700°C, hold for 10^4 s, then quench to room temperature.
b. Rapidly cool to 600°C, hold for 4 s, rapidly cool to 450°C, hold for 10s, then quench to room temperature.
c. Cool rapidly to 400°C, hold for 200 s, then quench to room temperature.
d. Rapidly cool to 575°C, hold for 20 s, rapidly cool to 350°C, hold for 100 s, then quench to room temperature.

(4 marks)

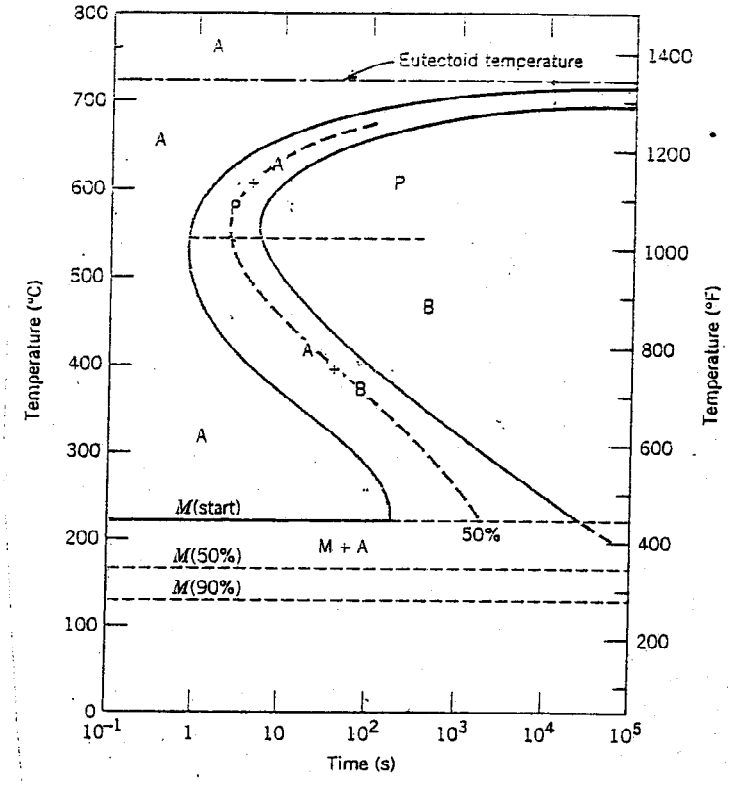


fig. 96.

97. Molecular weight data for a polypropylene material are tabulated below. Compute the following:

a. Number average molecular weight
b. Weight average molecular weight
c. Number average degree of polymerization
d. Weight average degree of polymerization.

(4 marks)

Molecular weight range (g/mol)	x_i	w_i
8000 – 16000	0.05	0.02
16000 – 24000	0.16	0.10
24000 – 32000	0.24	0.20
32000 – 40000	0.28	0.30
40000 – 48000	0.20	0.27
48000 – 56000	0.07	0.11

Q8. Briefly explain how each of the following influences the tensile or yield strength of a semi-crystalline polymer:

a. Molecular weight
b. Degree of crystallinity
c. Deformation by drawing
d. Annealing of an undeformed material.

(4 marks)

Q9. On the basis of ionic radii given in the table what crystal structure would you predict for NiO? Justify your answer.

(4 marks)

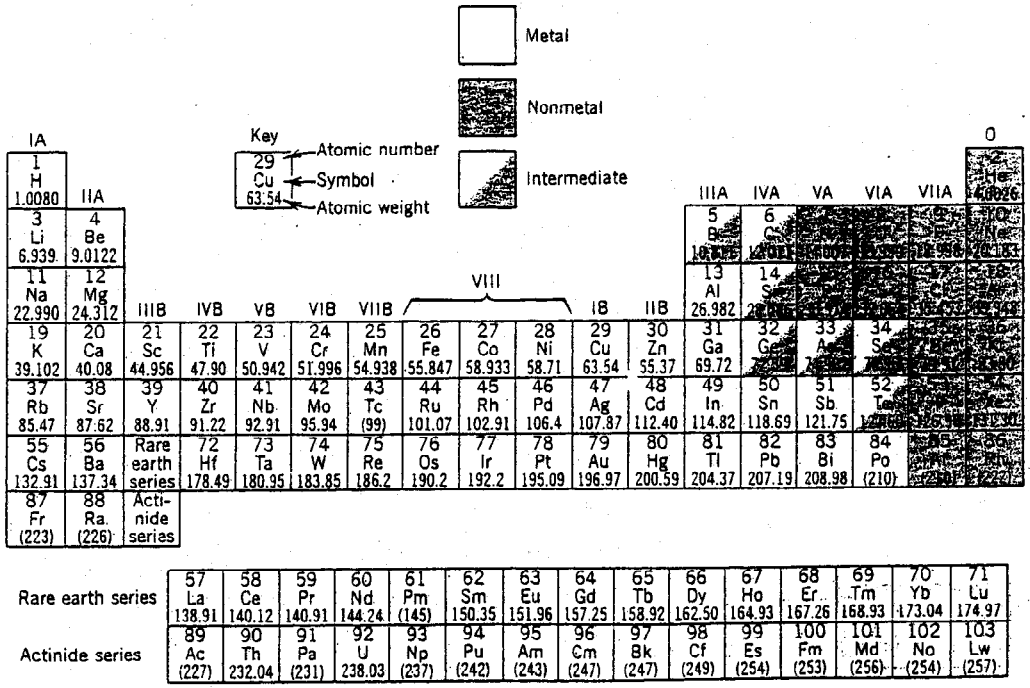
Cation	Ionic Radius (nm)	Anion	Ionic Radius (nm)
Al^{3+}	0.053	Br^-	0.196
Ba^{2+}	0.136	Cl^-	0.181
Ca^{2+}	0.100	F^-	0.133
Cs^+	0.170	I^-	0.220
Fe^{2+}	0.077	O^{2-}	0.140
Fe^{3+}	0.069	S^{2-}	0.184
K^+	0.138		
Mg^{2+}	0.072		
Mn^{2+}	0.067		
Na^+	0.102		
Ni^{2+}	0.069		
Si^{4+}	0.040		
Ti^{4+}	0.061		

Q10. a. What is Matthiessen's rule?

b. Compute the voltage at 25°C of an electrochemical cell consisting of pure cadmium immersed in a 2.2×10^{-3} M solution of Cd^{2+} ions, and pure iron in a 0.44 M solution of Fe^{2+} ions.

(4 marks)

Periodic Table of the Elements



Some Constants!

1. Avogadro number = 6.023×10^{23} atoms/mole

2. Faraday constant = 96500 c/mol

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II Year – II Semester 2003 – 2004

TEST – II (OPEN BOOK)

Course No. : ES UC242.
Course Title : Structure & Properties of Materials.
Date : 18.04.2004.

Duration : 50 min.
Max. Marks : 20
Weightage : 20 %

NOTE:

i. Answer all the Questions.
ii. Only the prescribed textbook is allowed for the open book test.
iii. Assume any missing data suitably.

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1. a. What is case hardening of steel?
   b. What type of diffusion mechanism takes place during the case hardening of steel gear?
   c. What are the host and solute atoms for the above?
   d. What do you understand by the terms "ductility" and "brittleness"?
   e. How are materials classified as ductile and brittle in terms of % elongation?

   (4 marks)

2. The diffusivity of aluminum in copper is 2.6×10^{-17} m^2/s at 500°C and 1.6×10^{-12} m^2/s at 1000°C. Determine the values of D_o and Q_d for this diffusion couple. What is the diffusivity at 750°C?

   (3 marks)

3. A brass rod is required to have a diameter of 5.0 mm, an ultimate tensile strength of more than 420 MPa and a 50 mm elongation of more than 18%. The rod is to be drawn from 9.0 mm diameter stock that had been previously annealed. Specify the final processing steps for making the 5.0 mm rod.

   (4 marks)

4. Sterling silver is heated slowly from room temperature to 1000°C.
   a. Draw the phase diagram.
   b. What phases will be present as heating progresses?
   c. Show the microstructure at salient points.

   (5 marks)

5. A 65 wt% Ni – 35 wt% Cu alloy is heated to a temperature within the $\alpha + L$ phase region. If the composition of the α phase is 70 wt% Ni, determine
   a. Temperature of the alloy.
   b. Composition of the liquid phase.
   c. Mass fractions of both the phases.

   (4 marks)

BITS, Pilani – Dubai Campus

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II Year –/I Semester 2003 – 2004

TEST – I

Course No. : ES UC242.
Course Title : Structure & Properties of Materials.
Date : 29.02.2004.

Duration : 50 min.
Max. Marks : 20
Weightage : 20 %

NOTE:
Answer all the Questions.

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1. "Melting temperature is extremely low for Ar compared to H_2O".
   a. Is the above statement correct?
   b. Give reasons for your answer.
   c. What is the melting temperature of Ar and H_2O?

   (3 marks)

2. a. Show the unit cell for a pervoskite crystal structure of $BaTiO_3$.
   b. List the point coordinates for all the Ti and O ions for the above unit cell.

   (5 marks)

3. In a unit cell show the following: $(0\bar{1}\bar{1})$ and $[1\bar{1}0]$

   (4 marks)

4. Explain the Schottky defect with a neat diagram. In which type of ceramics is this found?

   (3 marks)

5. Calculate the energy for vacancy formation in silver given that the equilibrium number of vacancies at 800°C is 0.025×10^{28} m^{-3}. The atomic weight and density at 800°C for silver are 0.108 Kg/mol and 9.5 g/cm^3 respectively.

   (5 marks)