BITS Pilani, Dubai Campus

II Year II Semester 2011-2012

Comprehensive Exam (Closed Book)

Course No. ES C242 **Course Title:** Structure and properties of materials

Date: 07-06-2012 **Max.Marks:** 80

Weightage: 40% **Duration:** 3 Hours

Notes:

- **Answer PART A PART B and PART C of the questions in separate answer books**
- Answer all the questions.
- Draw neat sketches wherever necessary.
- Make suitable assumptions if required and clearly state them
- Avagadro number = 6.023×10^{23} atoms/mol,
- R = 8.62×10^{-5} eV/atom-K, R = 8.31J/mol-K
- Atomic weight of carbon = 12 g/mol and Fluorine = 19 g/mol

PART A

1. The potential energy of a system of two atoms is given by the relation $U = -\frac{A}{r^2} + \frac{B}{r^{10}}$

   A stable molecule is formed with the release of 8eV energy when the interatomic distance is 2.8 A. Find the A and B. **[8M]**

2. Aluminum has FCC structure. Its density is 2700 kgm^{-3}. Find the unit cell dimensions and atomic diameter. Given the weight of Al = 26.98. **[6M]**

3. The mass numbers of the Sodium and Chlorine are 22.99 $gmol^{-1}$ and 35.45 $gmol^{-1}$ respectively. Their atomic radii are 0.102 nm and 0.181 nm respectively. Draw sodium chloride crystal structure by clearly mentioning the positions of Na^+ and Cl^- ions. Also, calculate its theoretical density. **[6M]**

4. Calculate the energy for vacancy formation in silver, given that the equilibrium number of vacancies at 800°C (1073K) is 3.6×10^{23} m^{-3}. The atomic weight and density (at 800°C) for silver are 107.9 g/mol and 9.5 g/cm^3, respectively. **[8M]**

5. Determine the position at which will a carbon concentration of 0.3 wt% is achieved with a carburizing time of 19.25 h into an iron-carbon alloy that initially contains 0.2 wt% C. The surface concentration is to be maintained at 0.9 wt% C, and the treatment is to be conducted at 1100°C. For diffusion of carbon in γ-Fe: D_0 = 2.3 x10^{-5} m2/s ; Q_d =148 kJ/mol, R = 8.31J/mol-K. **[12M]**

Table 6.1 Tabulation of Error Function Values

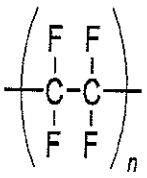
z	erf(z)	z	erf(z)	z	erf(z)
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999

PART B

6. a) Write the electrochemical reactions taking place during corrosion of Zn in HCl solution **[4M]**

   b) Define Galvanic and pitting corrosion **[4M]**

7. (a)The molecular weight data for a poly tetrafluro ethylene material are tabulated



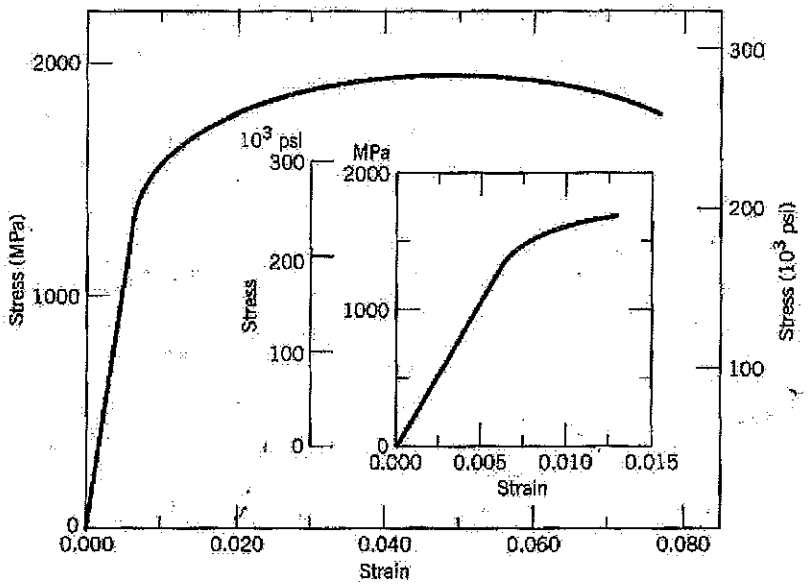
Molecular weight	X_i	W_i
10,000-20,000	0.03	0.01
20,000-30,000	0.09	0.04
30,000-40,000	0.15	0.11
40,000-50,000	0.25	0.23
50,000-60,000	0.22	0.24
60,000-70,000	0.14	0.18
70,000-80,000	0.08	0.12
80,000-90,000	0.04	0.07

Compute (i) the number – average molecular weight (ii) the weight-average molecular weight, and (iii) both the degree of polymerization **[8M]**

(b) Write the various factors that affect the resistivity of metals. Also show their relationship with **[4M]**

PART C

8. a) A bar of a steel alloy that exhibits the stress strain behavior shown in the figure is subjected to a tensile load .The specimen is 375mm long and of square cross section 5.5mm on a side.



i) Calculate the magnitude of the load necessary to produce an elongation of 2.25mm

ii) What will be the deformation after the load has been released?

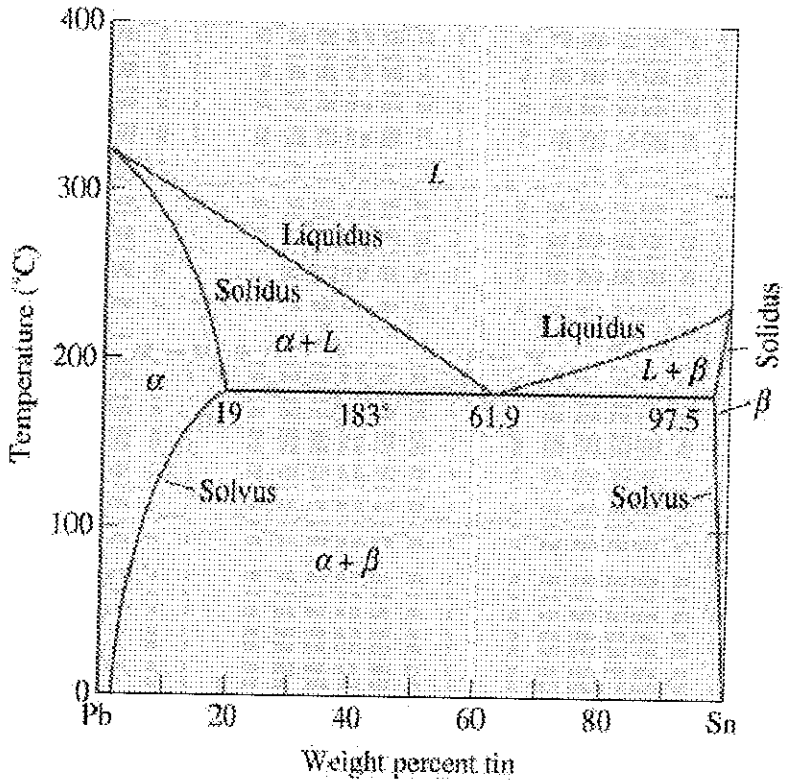
iii) In case if the steel alloy is considered as a cylindrical specimen of 8.5mm diameter and 80 mm length and it is pulled in tension, compute its elongation when a load of 65,250 N is applied. **[5M]**

b) A cylindrical specimen of a nickel alloy having an elastic modulus of 207 GPa and an original diameter of 10.2 mm will experience only elastic deformation when a tensile load of 8900 N is applied .Compute the maximum length of the specimen before deformation if the maximum allowable elongation is 0.25mm. **[3M]**

9. Using the isothermal transformation diagram for an iron-carbon alloy of eutectoid composition (figure is given), determine the final microstructure (in terms of micro constituents present & approximate percentages).
   (i) Cool rapidly to 160 °C, left for 20 min, then quench to room temperature
   (ii) Cool rapidly to 250 °C, hold for 100s, then quench to room temperature.
   (iii) Cool rapidly to 600 °C, hold for 10^5 s, then quench to room temperature
   (iv) Cool rapidly to 400 °C , hold for 200 s, then quench to room temperature.

[8M]

10. Consider a 50:50 Pb – Sn solder. For a temperature of 200°C, determine
    (i) the phases present,
    (ii) their compositions, and
    (iii) their relative amounts (expressed in weight percent). **[4M]**



Use the diagram given below for answering question number 9 and attach it with the Part C of the answer booklet .

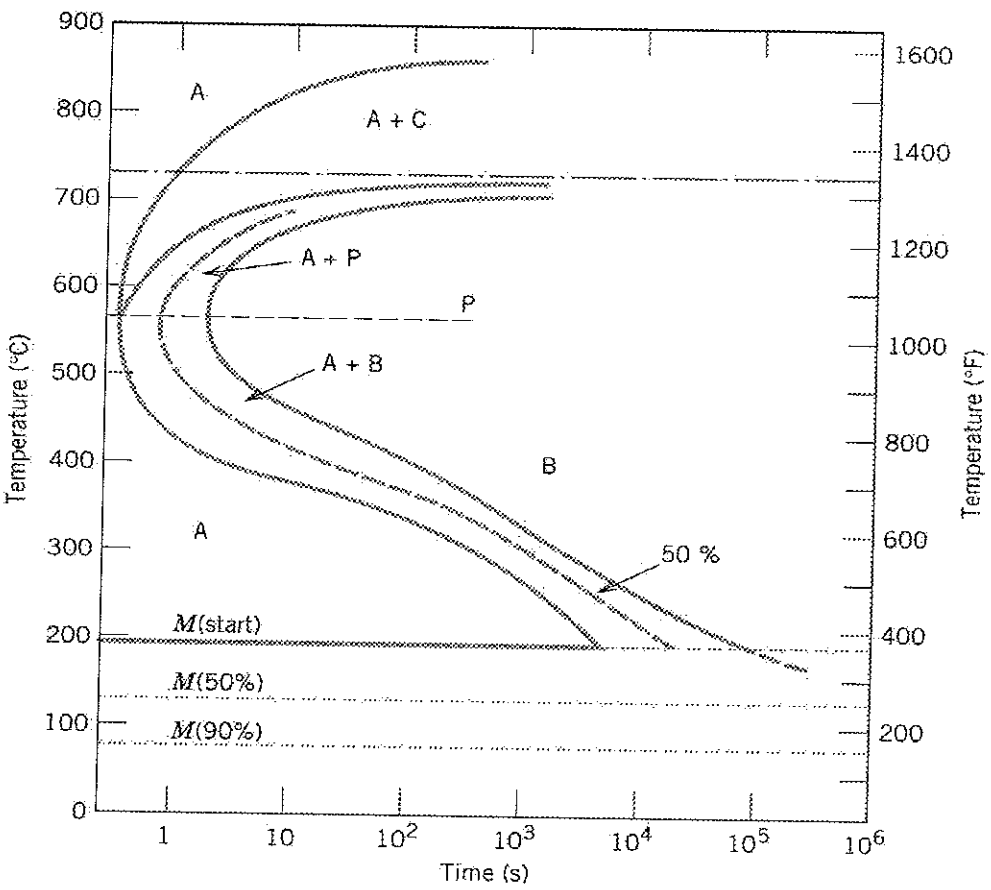


FIGURE 10.28 Isothermal transformation diagram for a 1.13 wt% C iron–carbon alloy: A, austenite; B, bainite; C, proeutectoid cementite; M, martensite; P, pearlite. [Adapted from H. Boyer (Editor), *Atlas of Isothermal Transformation and Cooling Transformation Diagrams*, American Society for Metals, 1977, p. 33.]

BITS Pilani, Dubai Campus

II Year II Semester 2011-2012

Test No. 2 (Open Book)

Course No. ES C242 **Course Title:** Structure and properties of materials

Date: 26-04-2012 **Max.Marks:** 40

Weightage: 20% **Duration:** 50 min

Notes:

- Answer all the questions.
- Draw neat sketches wherever necessary.
- Make suitable assumptions if required and clearly state them

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1. A tensile stress of 5 kPa is applied parallel to the [432] direction of a cubic crystal. Find the shear stress on the (111) plane in the [011] direction. Show the diagram having the plane and the directions clearly. **[7 Marks]**

2. The yield strength of a polycrystalline material increases from 120 MNm^{-2} to 220 MNm^{-2} on decreasing the grain diameter from 0.004 mm to 0.01 mm. Calculate the yield stress for a grain diameter of 0.0159 mm. **[8 Marks]**

3. A 5.0 cm long circular rod (with diameter of 1.28 cm) of a test material annealed, is loaded to failure in tension. [YS = 950 Mpa, UTS = 1000 MPa and for the specified gauge length , there is a 15% elongation for a 5 cm gauge]
   i)What is the load necessary to break the sample ?
   ii)If 75% of the total elongation was uniform prior to onset of localized deformation ,compute the true stress at the point of incipient necking.
   iii) What is the reduction in area at necking? **[10 Marks]**

4. A 45 wt% Pb – 55 wt% Mg alloy is rapidly quenched to room temperature from an elevated temperature in such a way that the high temperature microstructure is preserved. This microstructure is found to consist of the α phase and Mg2Pb, having respective mass fractions of 0.65 and 0.35.

   i) Draw the tie line and clearly mark the required values in the given phase diagram. Determine the approximate temperature from which the alloy is quenched. **Attach the phase diagram sheet with the answer booklet.**

   [12 Marks]

   ii) At point 'A' in the phase diagram, find the number of degrees of freedom.

   [3 Marks]

Use this phase diagram for Q4. Attach it with answer sheet

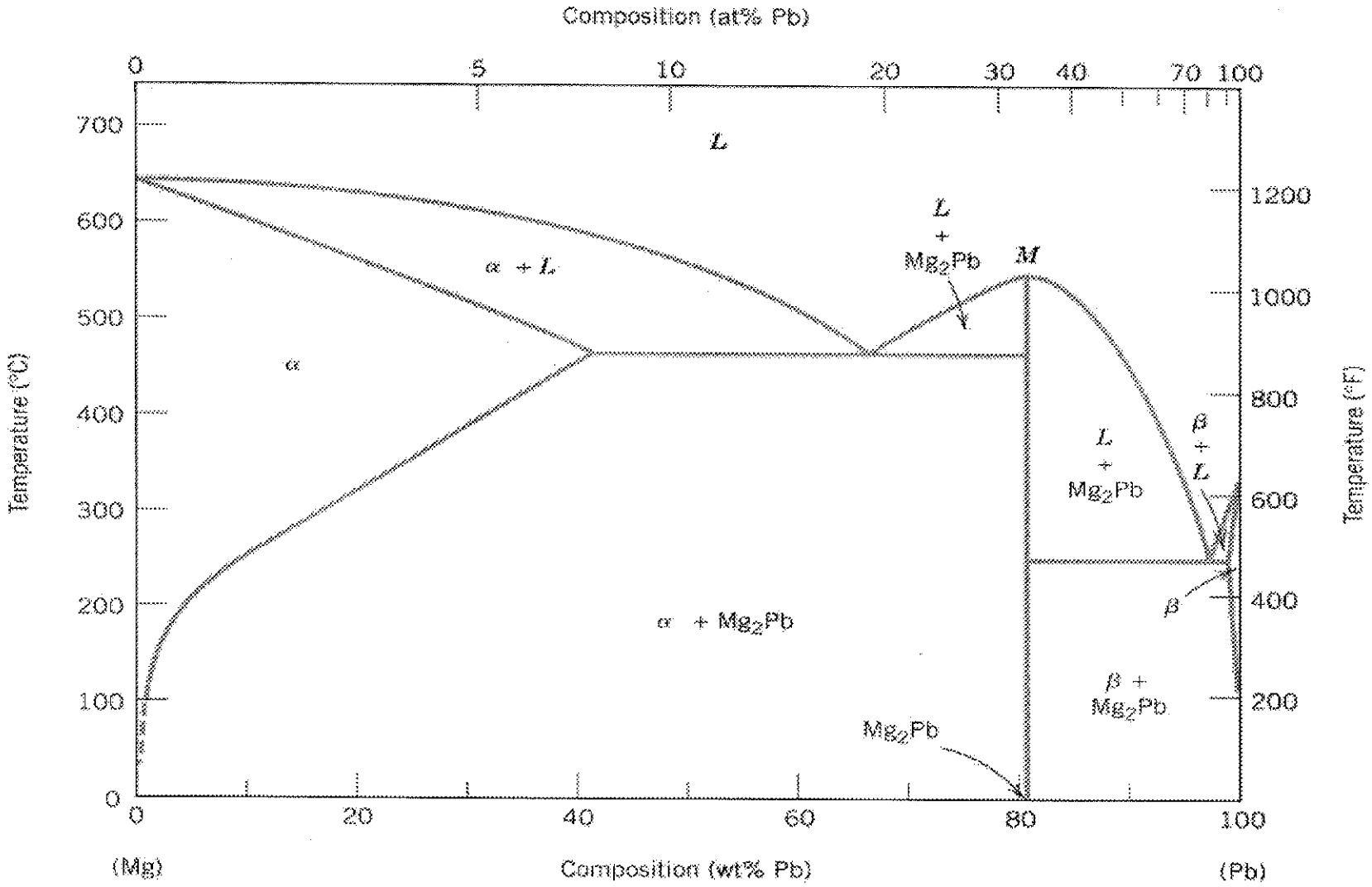

FIGURE 9.18 The magnesium–lead phase diagram. [Adapted from *Phase Diagrams of Binary Magnesium Alloys*, A. A. Nayeb-Hashemi and J. B. Clark (Editors), 1988. Reprinted by permission of ASM International, Materials Park, OH.]

BITS Pilani, Dubai Campus

II Year II Semester 2011-2012

Test No.1 (Closed Book)

Course No. ES C242 **Course Title:** Structure and properties of materials

Date: 11-03-2012 **Max.Marks:** 50

Weightage: 25% **Duration:** 50 min

Notes:

- Answer all the questions.
- Draw neat sketches wherever necessary.
- Make suitable assumptions if required and clearly state them
- Avogadro number = 6.023×10^{23} atoms/mol.

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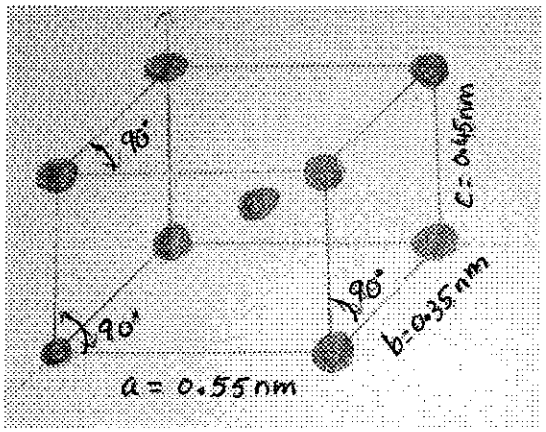
1. Calculate the percentage ionic character of CaO. [$X_{Ca} = 1$, $X_O = 3.5$]. **[4 marks]**

2. The potential energy (E_N) of two atoms forming a covalent bond a distance r apart is given by

   $$E_N = -A / r^m + B / r^n$$

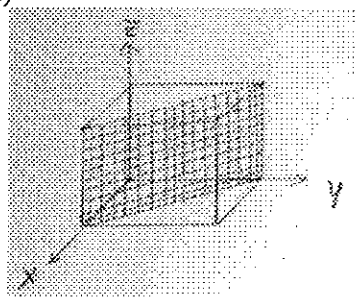
   Where m=2 and n=10. Determine the constants A and B if the two atoms form a stable molecule at $r_o = 0.3$ nm and $E_N(r_o) = -4$ eV. **[6 marks]**

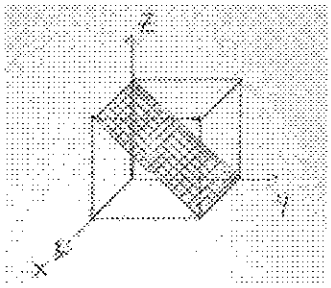
3. For the given unit cell **[2+2+3 marks]**
   a) find the crystal system to which it belongs
   b) Name the crystal structure to which it belongs
   c) Calculate the density of the material if its atomic weight is 250g/mol



4. i)Find the miller indices of the following planes **[4+4 marks]**

a) b)





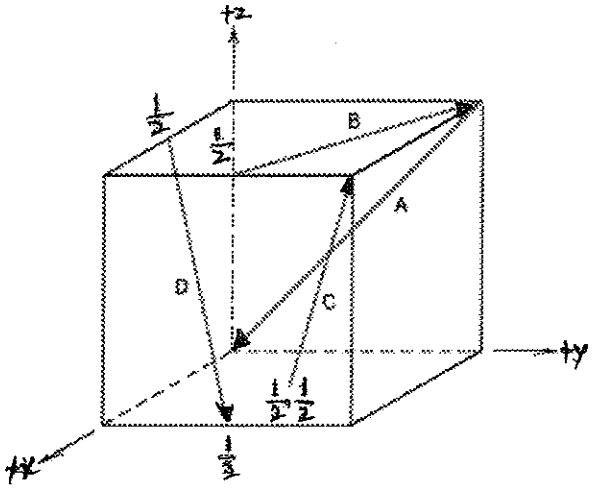
ii) Sketch within a cubic unit cell the following planes

a) $(\bar{3}\bar{1}2)$ b) $(\bar{1}\bar{1}\bar{1})$

5. a) Draw and List the lattice point positions for the corners of the unit cell in the base centered orthorhombic lattice.
   b) Compare planar densities for the (100), (110), and (111) planes for FCC.

[3+3 marks]

6. Determine the indices for the directions shown in the following cubic unit cell:



[4 marks]

7. The ionic radii of Na^+ ion and Cl^- ion are 0.102 nm and 0.181 nm respectively. The atomic masses of Sodium and Chlorine are 22.99 $gmol^{-1}$ and 35.45 $gmol^{-1}$ respectively. Draw the NaCl crystal structure and hence calculate its ceramic density. **[10 marks]**

8. Prove that for the coordination number 4, the minimum value of radii ratio, $(\frac{r_c}{r_a})$ is 0.225. **[5 marks]**

A

BITS PILANI, DUBAI CAMPUS

2nd Year, SECOND SEMESTER 2011 – 2012

QUIZ - 2

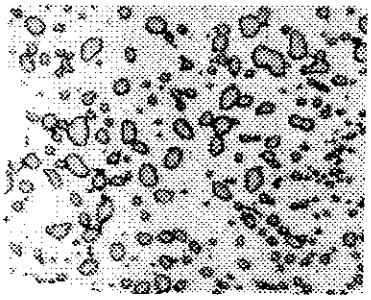
Course code: **ES C242** Date: **21.5.12**
Course Title: **Structure and Properties of Materials** Maximum Marks :**14**
Duration: **20 minutes** Weightage: **7%**

Name _____

ID No: _____ **Program:** _____ **Section** _____

1. Identify the following microstructures **[2 M]**

a) b)



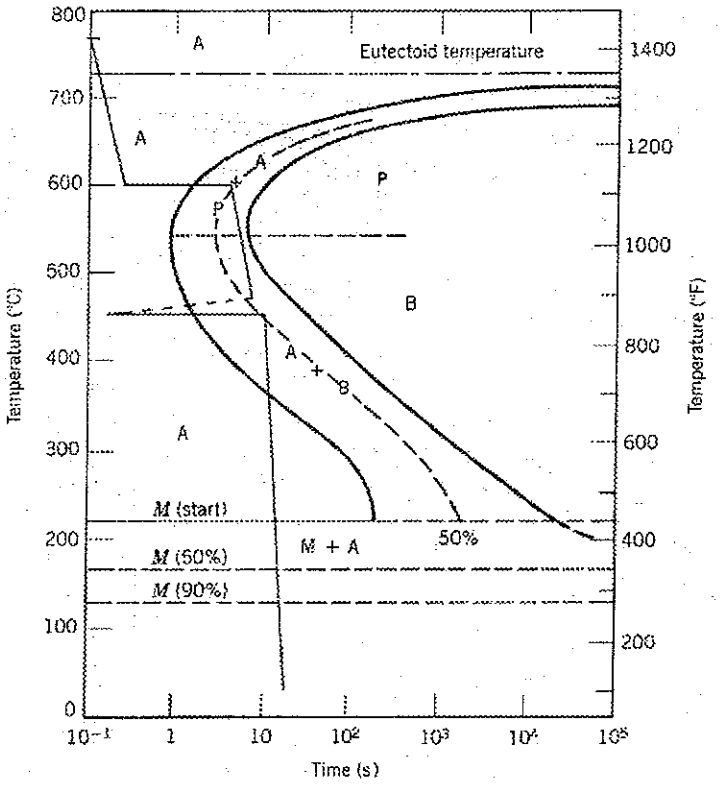
Ans. **a)**

b)

2. Find the rate of transformation in a particular reaction if it takes 37.23 seconds for 50% completion at some temperature. **[2 M]**

Ans.

3. In the following isothermal transformation diagram specify the nature of the final microstructure in terms of microconstituents present and approximate percentages of each **[2 M]**



Ans.

4. Determine the potential of a galvanic cell of cadmium (potential of -0.403 V) and nickel (potential of -0.250V). Write the corresponding chemical reaction. **[2M]**

5. Explain the term – cathodic protection [**1M**]

6. A steel cube of 4 x 2 x 1/8 inches when placed in an acid solution for one week loses 90 mg. Calculate the rate of corrosion in mpy. Assume the density of steel as7.87 gcc^{-1}. [**3M**]

7. Write the Avrami equation and explain the terms involved. [**2M**]

B

BITS PILANI, DUBAI CAMPUS

2nd Year, SECOND SEMESTER 2011 – 2012

QUIZ - 1

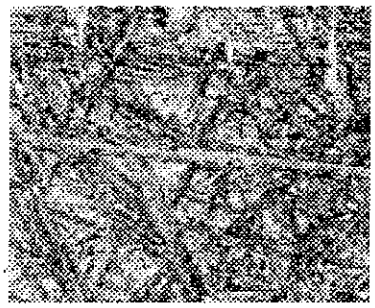
Course code: **ES C242** Date: **2.4.12**
Course Title: **Structure and Properties of Materials** Maximum Marks :**16**
Duration: **20 minutes** Weightage: **8%**

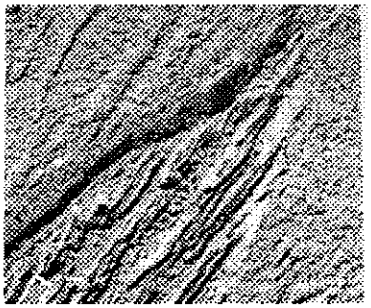
Name _____

ID No: _____ **Program:** _____ **Section** _____

1. Identify the following microstructures. **[2 M]**

a) b)



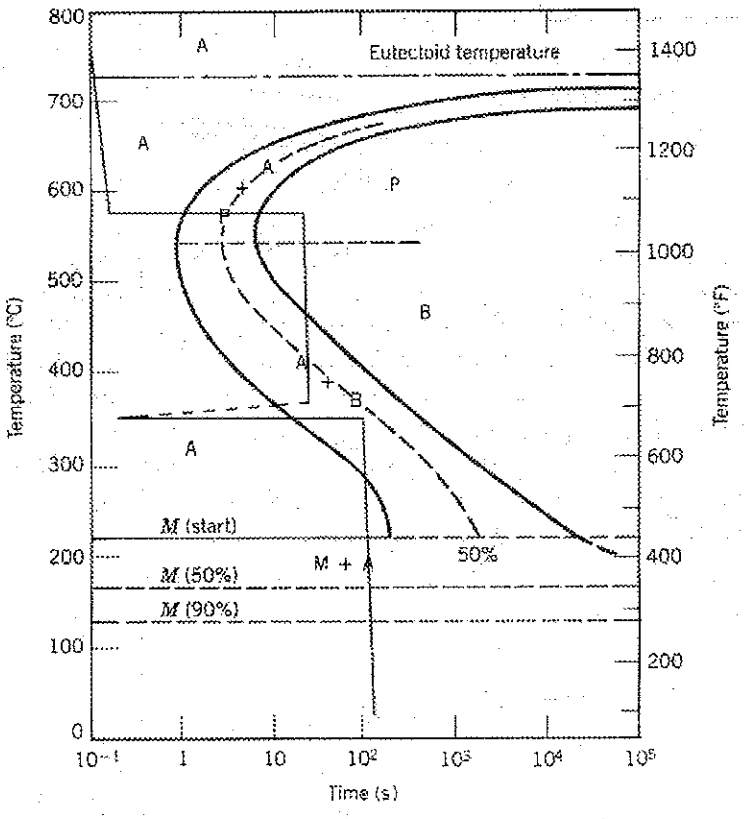


Ans. a) **b)**

2. Find the rate of transformation in a particular reaction if it takes 114.2 minutes for 50% completion at some temperature. **[2 M]**

Ans.

3. In the following isothermal transformation diagram specify the nature of the final microstructure in terms of microconstituents present and approximate percentages of each **[2 M]**



Ans.

4. Determine the potential of a galvanic cell of copper (potential of +0.34 V) and aluminium (potential of -1.66V). Write the corresponding chemical reaction. [**2M**]

5. Explain the term – selective leaching **[1M]**

6. Write the Avrami equation and explain the terms involved. **[2M]**

7. A steel cube of 4 x 2 x 1/8 inches is placed in an acid solution for one week, and loses 90 mg. Calculate the rate of corrosion in mpy. Assume the density of steel as7.87 gcc^{-1}. **[3M]**