BITS Pilani, Dubai Campus

II Year I Semester 2012-2013

Comprehensive Exam (Closed Book)

Course No. ME F213 **Course Title:** Materials science & Engineering

Date: 08-01-2013 **Max.Marks:** 80

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

Notes:

- **Answer PART A and PART B 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,
- $R = 8.62 \times 10^{-5}$ eV/atom-K, R = 8.31J/mol-K
- Electronegativity of Si = 1.8, C = 2.5, Ca = 1.0, F =4.0

PART A

1. a) Calculate the percent ionic character in SiC and CaF_2

   b) Sketch $(3\bar{1}1)$ plane and its intercepts

   c) If the atomic radius of lead is 0.175nm, calculate the volume of its unit cell in cubic meters. **[12 M]**

2. a) Calculate the energy for vacancy formation in silver, given that the equilibrium number of vacancies at 800°C is $3.6 \times 10^{23} m^{-3}$. The atomic weight and density (at 800 °C) for silver are, respectively, 107.9 g/mol and 9.5 g/cm^3.

   b) Compute the number of vacancies at 650 °C. (Assume the density of silver is the same at 650 °C and 800 °C.) **[10 M]**

3. For a steel alloy, it has been determined that a carburizing heat treatment of 15 hrs duration will raise the carbon content to 0.35 wt% C at a point 2.0 mm from the surface. Estimate the time needed to produce the same concentration at 6.0 mm from the surface in an identical steel at the same carburizing temperature. **[8 M]**

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4. Consider a single crystal of some hypothetical metal that has the FCC crystal structure and is oriented such that a tensile stress is applied along a $[\bar{1}02]$ direction. If slip occurs on a (111) plane and in a $[\bar{1}01]$ direction, compute the stress at which the crystal yields if its critical resolved shear stress is 3.42 MPa. **[10 M]**

PART

5. An electrochemical cell is constructed such that on one side a pure Zn electrode is in contact with a solution containing Zn^{2+} ions at a concentration of 10^{-2} M. The other cell half consists of a pure Pb electrode immersed in a solution of Pb^{2+} ions that has a concentration of 10^{-4} M. At what temperature will the potential between two electrodes be +0.568 V? (V^0_{Zn} = - 0.763 V, V^0_{Pb} = -0.126 V, F = 96,500 C/mol) **[8 M]**

6. A random poly (isobutylene – isoprene) copolymer has a weight – average molecular weight of 20, 000 g/mol and a weight average degree of polymerization of 3000. Compute the fraction of isobutylene and isoprene mers in this copolymer. The isobutylene mer has four carbon atoms and eight hydrogen atoms and isoprene mer has five carbon atoms and eight hydrogen atoms. (Atomic weight of C = 12.01 g/mol and atomic weight of H = 1.008 g/mol). **[8 M]**

7. A cylindrical specimen of steel having an original diameter of 12.8mm is tensile tested to fracture and found to have an engineering fracture strength of 460 MPa .If its cross sectional diameter at fracture is 10.7 mm determine a) the ductility in terms of percentage reduction in area and b) the true stress at fracture. **[8 M]**

8. A 45 wt % - 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 Mg_2Pb, having respective mass fractions of 0.65 and 0.35. Determine the composition of α phase and hence give the approximate temperature from which the alloy was quenched. (Draw on the phase diagram: figure 1) **[8 M]**

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9. Using the isothermal transformation diagram for a 1.13 wt% C steel alloy, determine the final microstructure (in terms of just the micro constituents present) of a small specimen that has been subjected to the following time- temperature treatments. In each case assume that the specimen begins at 920°C and that it has been held at this temperature long enough to have achieved a complete and homogeneous austentic structure. (Show the paths on the isothermal transformation diagram: figure 2)

a) Rapidly cool to 400 °C, hold for 500 sec, then quench to room temperature.

b) Rapidly cool to 650 °C, hold at this temperature for 3 s, rapidly cool to 400 °C, hold for 25 s, then quench to room temperature. **[8 M]**

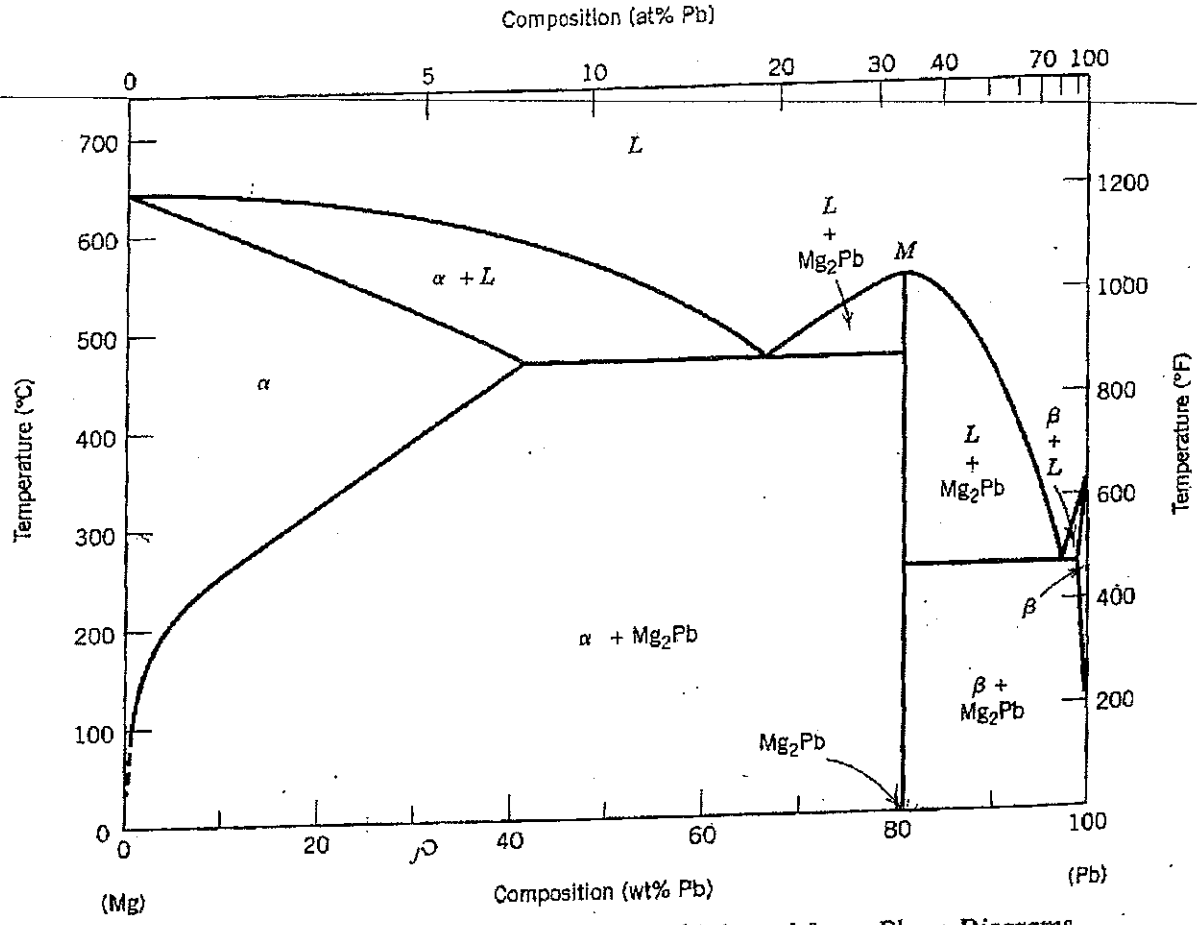

FIGURE 9.18 The magnesium–lead phase diagram. [Adapted from *Phase Diagrams of Binary Magnesium Alloys*, A. A. Nayeb-Hashemi and J. B. Clark (Editors), 1988. Reprinted by permission of ASM International, Materials Park, OH.]

Figure: 1

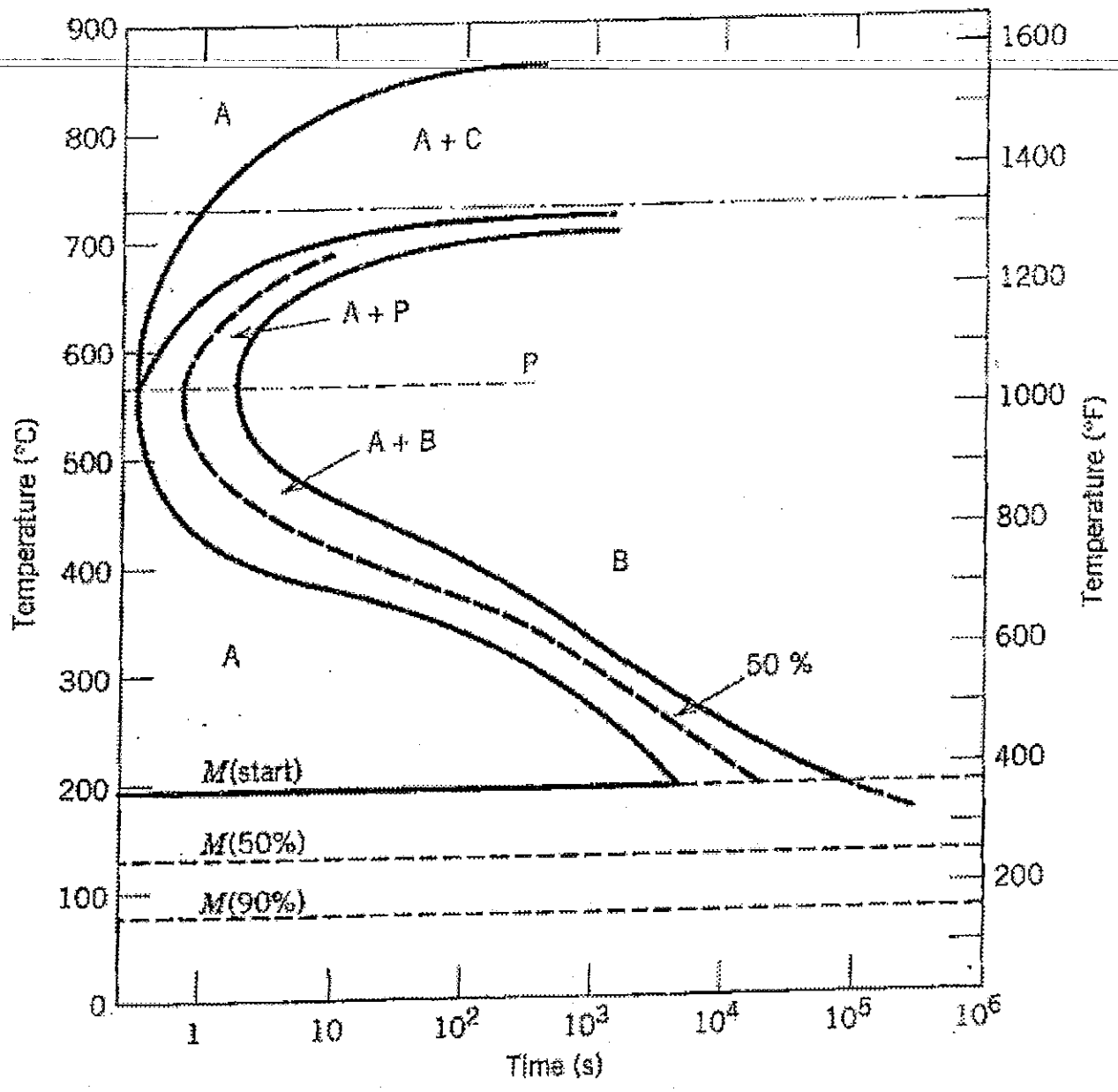
900
800
700
600
500
400
300
200
100
0
1600
1400
1200
1000
800
600
400
200
A
A + C
A + P
P
A + B
B
A
50 %
M(start)
M(50%)
M(90%)
1
10
10²
10³
10⁴
10⁵
10⁶
Time (s)
Temperature (°C)
Temperature (°F)

Figure: 2

BITS Pilani, Dubai Campus

II Year I Semester 2012-2013

Test No.2 (Open Book)

Course No. ME F213 **Course Title:** Materials Science and Engineering

Date: 13-12-2012 **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. Cite the phases that are present and the phase compositions for the following alloys:
   (a) 90 wt% Zn-10 wt% Cu at 400°C (750°F)
   (b) 2.12 kg Zn and 1.88 kg Cu at 500°C (930°F) **[15 M]**

2. Find the total time required for 95% transformation of austenite to pearlite. Given

Fraction transformed	Time (s)
0.2	12.6
0.8	28.2

[15 M]

3. Using the isothermal transformation diagram for an iron-carbon alloy of eutectoid composition given below, specify the nature of the final microstructure (in terms of micro constituents present and approximate percentages of each) of a small specimen that has been subjected to the following time-temperature treatments. In each case assume that the specimen begins at 760°C and that it has been held at this temperature long enough to have achieved a complete and homogenous austenitic structure.
   a) Cool rapidly to 550 °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 10 s, then quench to room temperature. **[10 M]**

Q1) Use the following phase diagram. Mark the answer and attach with the answer booklet.

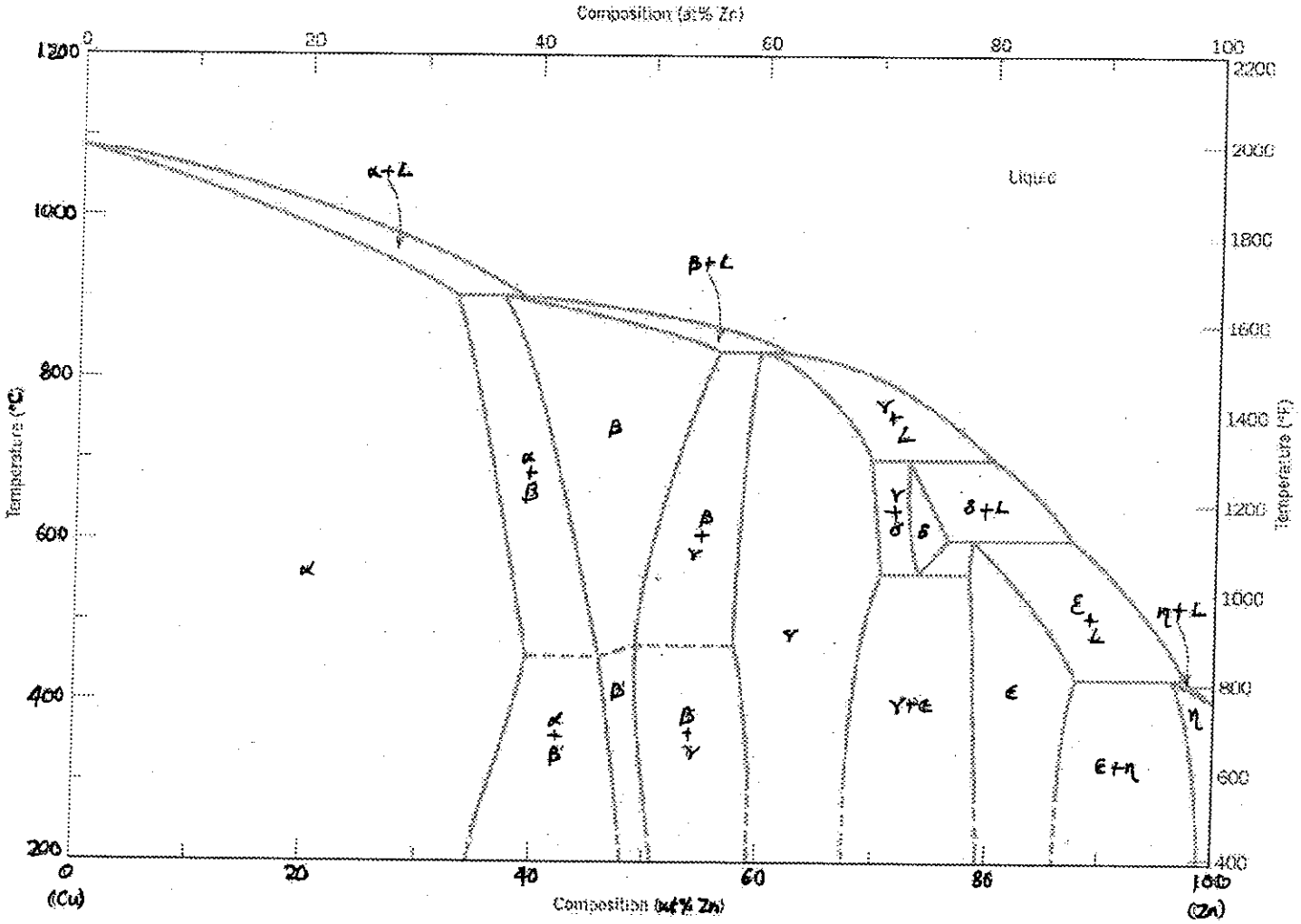

Figure 9.19 The copper–zinc phase diagram. [Adapted from *Binary Alloy Phase Diagrams*, 2nd edition, Vol. 2, T. B. Massalski (Editor-in-Chief), 1990. Reprinted by permission of ASM International, Materials Park, OH.]

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II Year I Semester 2012-2013

Test No.1 (Closed Book)

Course No. ME F213 **Course Title:** Materials Science and Engineering

Date: 21-10-2012 **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

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1. Iron and Vanadium both have a bcc crystal structure and V forms a substitutional solid solution for concentrations upto approximately 20% V at room temperature. Compute the unit cell edge length for a 90 wt% Fe – 10 wt% V alloy.
   (Given: r_{Fe} = 0.124nm, r_V = 0.132 nm, ρ_{Fe} = 7.87 g/cm^3, ρ_V = 6.10 g/cm^3, A_V = 50.94 g/mol, A_{Fe} =55.85 g/mol and N_A = 6.023x 10^{23} atoms/mol). **[10 M]**

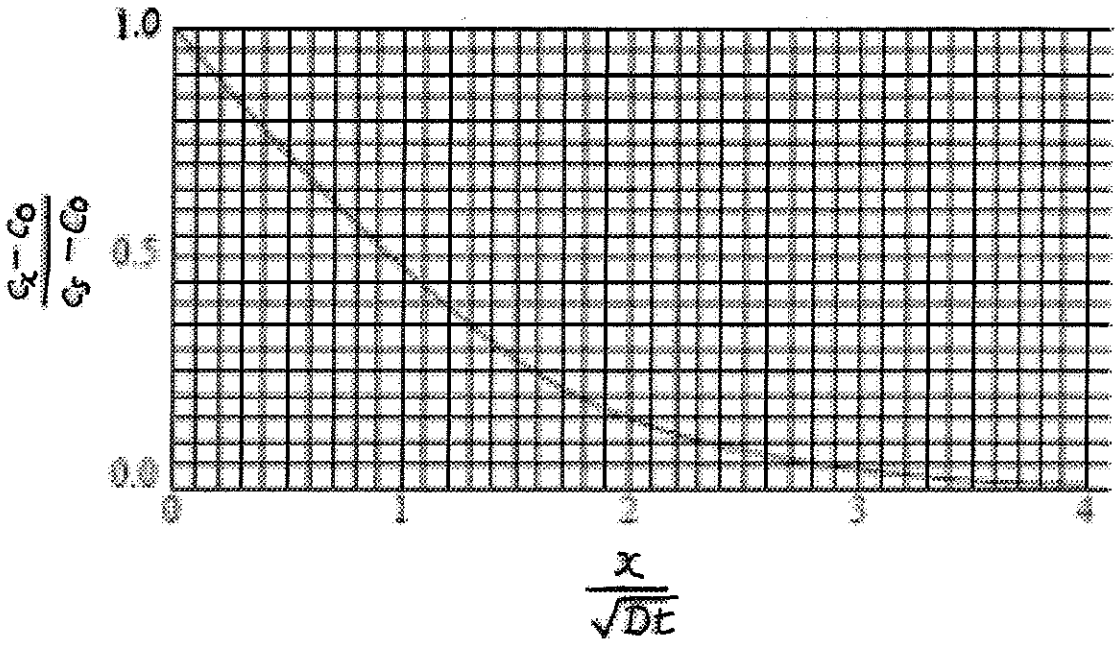
2. Calculate the energy for vacancy formation in Aluminium, given that the equilibrium number of vacancies at 500° C is 7.57x 10^{23}m^{-3} . The atomic weight and density for Aluminium are 26.98 g/mol and 2.62 g/cm^3 respectively and k = 8.62 x 10^{-5} eV /atom-k. **[10 M]**

3. Determine the composition, in atom percent of an alloy that consists of 97 wt% Aluminium and 3 wt% copper. (Given: A_{Cu} = 63.55 g/mol, A_{Al} = 26.98 g/mol) **[10 M]**

4. A 5 mm thick sheet of palladium with a cross – sectional area of 0.2m^2 is used as a steady state diffusional membrane for purifying hydrogen. If the hydrogen concentration on the high– pressure (impure gas) side of the sheet is 0.3 kg/m^3 and the diffusion coefficient for hydrogen in palladium is 1.0 x 10^{-8} m^2/s, calculate the mass of hydrogen being purified per hour. **[10 M]**

(PTO)

5. Determine the carburizing time necessary to achieve a carbon concentration of 0.6 wt% at a position 1 mm into an iron-carbon alloy that initially contains 0.2 wt% C. The surface concentration is to be maintained at 1.0 wt% C, and the treatment is to be conducted at 1000°C, using the following plot. For diffusion of carbon in γ - Fe: $D_0 = 2.0 \times 10^{-5}\ m^2/s$; $Q_d = 142$ kJ / mol, $R = 8.314$ J/mol-K **[10 M]**



A

BITS PILANI, DUBAI CAMPUS

2nd Year, FIRST SEMESTER 2012 – 2013

QUIZ - 2

Course code: **ME F213** Date: **7.11.12**
Course Title: **Materials Science and Engineering** Maximum Marks :**14**
Duration: **20 minutes** Weightage: **7%**

Name _____

ID No: _____ **Section** _____

1. A cylindrical specimen of a titanium alloy having an elastic modulus of **E** and an original diameter of d_o will experience only elastic deformation when a tensile load of **F** is applied. Compute the maximum length l_o of the specimen before deformation if the maximum allowable elongation is Δl **[2 M]**

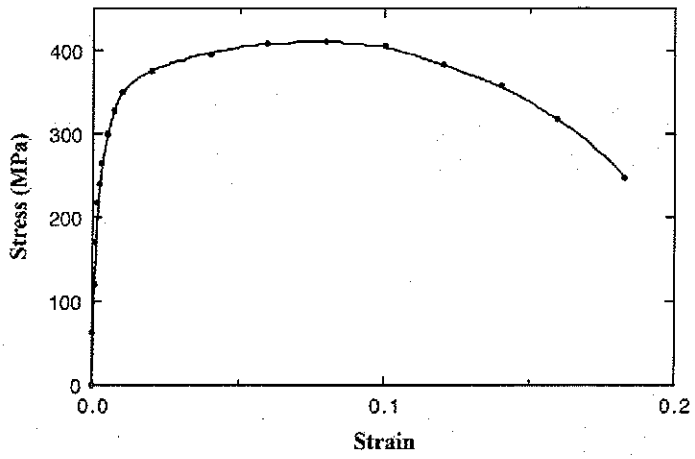
   Ans

2. Consider a cylindrical specimen of some hypothetical metal alloy that has a diameter of 8.0 m. A tensile force of 1000 N (225 lb_f) produces an elastic reduction in diameter of 2.8×10^{-4} mm. Compute the transverse strain for this alloy, given that Poisson's ratio is 0.30. **[2 M]**

   Ans

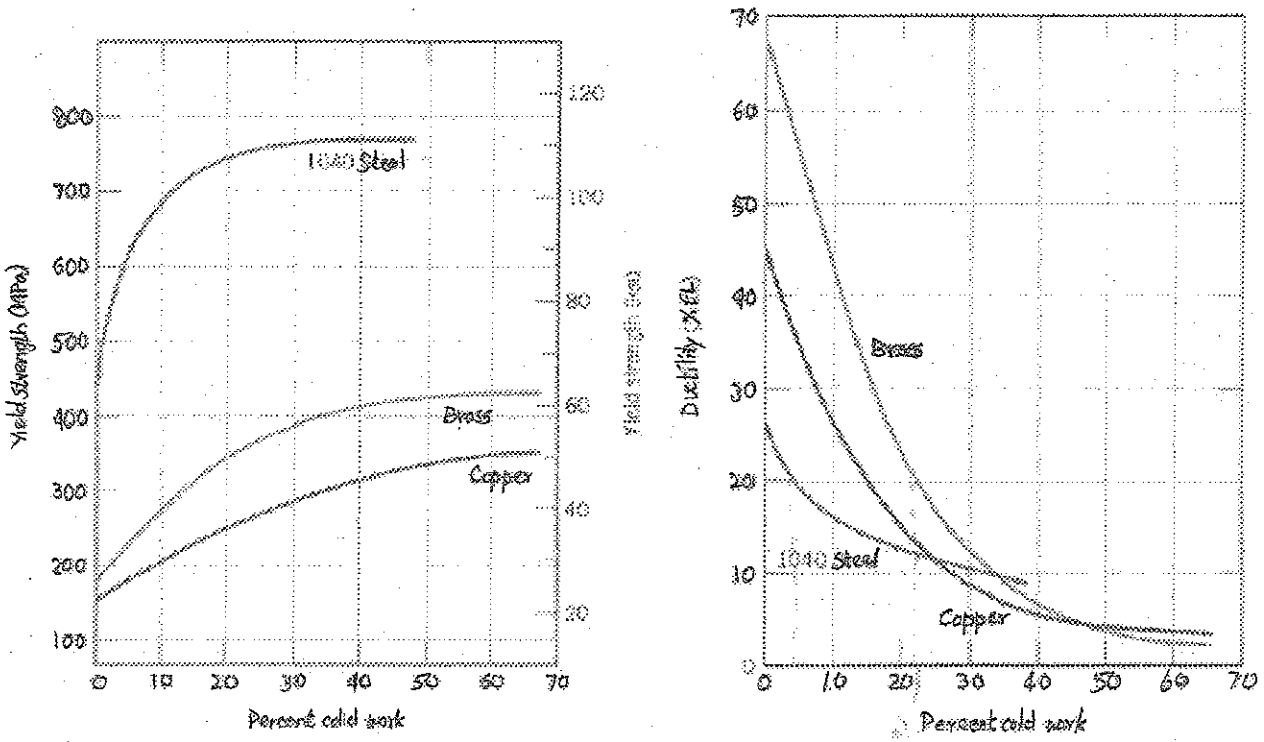
(PTO)

3. The stress-strain curve of a specimen is given below. Determine the tensile strength **[1 M]**



Ans.

4. It is necessary to select a metal alloy for an application that requires a yield strength of at least 310 MPa while maintaining a minimum ductility (%EL) of 28%. If the metal may be cold worked, decide which of the following are the candidates. **[1 M]**



Ans.

5. The critical resolved shear stress for copper is 0.48MPa. Determine the maximum possible yield strength for a single crystal of copper pulled in tension. **[2 M]**

Ans

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6. What is a slip system? **[1 M]**

Ans

7. Name three methods by which metals can be strengthened after plastic deformormation has set in. **[2 M]**

Ans

8. The lower yield point for an iron that has an average grain diameter of $5x\ 10^{-2}$ mm is 135MPa.At a grain diameter of $8x10^{-3}$ mm , the yield point increases to 260 MPa. At what grain diameter will the lower yield point be 205MPa. **[3 M]**

Ans

A

BITS PILANI, DUBAI CAMPUS

2nd Year, FIRST SEMESTER 2012 – 2013

QUIZ - 1

Course code: **ME F213** Date: **3.10.12**
Course Title: **Materials Science and Engineering** Maximum Marks :**16**
Duration: **20 minutes** Weightage: **8%**

Name _____

ID No: _____ **Section** _____

Note: 1. Answer ALL questions,
2. $\epsilon_o = 8.85 \times 10^{-12}$ F/m and $e = 1.6 \times 10^{-19}$ C

1. The force of attraction between a K^+ and an O^{2-} ion the centers of which are separated by a distance of 1.5 nm. [3 M]

   a) 1.05 x10 $^{-10}$ N

   b) 2.05 x10 $^{-10}$ N

   c) 3.05 x10 $^{-10}$ N

   d) 4.05 x10 $^{-10}$ N

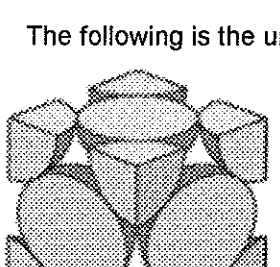
2. The electron negativities of the ions **Mg^+ and O^-** are 1.2 and 3.5 respectively. The percent ionic character is [2 M]
   a) 47%,
   b) 65.1%,
   c) 73.4%,
   d) 17%

3. Repeatable entity of a crystal structure is known as _____ [1 M]

4. A family of planes is represented by _____ [1 M]

5. Define Tetragonal crystal system. [1 M]

6. The following is the unit cell of Aluminum with atomic diameter 0.286 nm.



Its unit cell volume is [3 M]

a) 6.62×10^{29} cm^3 ,

b) 66.2×10^{-29} cm^3 ,

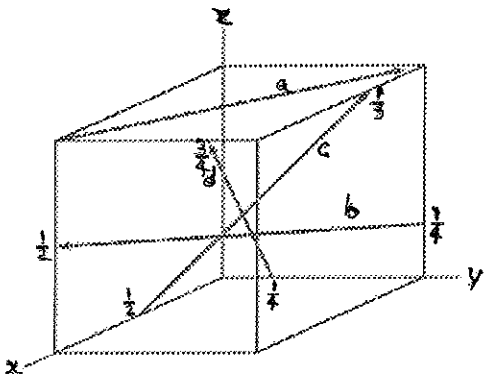
c) 66.2×10^{29}, cm^3

d) 6.62×10^{-29} cm^3

7. Volume fraction of atoms in cell _____ [1 M]

8. Sketch $(1\bar{3}\ 1)$ and $(11\bar{2})$ planes [2 M]

9. What are the indices of the directions shown in the unit cubes [2 M]



a)

b)

c)

d)

B

BITS PILANI, DUBAI CAMPUS

2nd Year, FIRST SEMESTER 2012 – 2013

QUIZ - 1

Course code: **ME F213** Date: **3.10.12**
Course Title: **Materials Science and Engineering** Maximum Marks :**16**
Duration: **20 minutes** Weightage: **8%**

Name _____

ID No: _____ **Section** _____

Note: 1. Answer ALL questions,
2. $\epsilon_o = 8.85 \times 10^{-12}$ F/m and $e = 1.6 \times 10^{-19}$ C

1. Volume fraction of atoms in cell _____ [1 M]

2. The electron negativities of the ions **Mg^+ and O^-** are 1.2 and 3.5 respectively. The percent ionic character is [2 M]
   a) 47%,
   b) 65.1%,
   c) 73.4%,
   d) 17%

3. Define Tetragonal crystal system. [1 M]

4. The force of attraction between a K^+ and an O^{2-} ion the centers of which are separated by a distance of 1.5 nm. [3 M]

   a) 1.05×10^{-10} N

   b) 2.05×10^{-10} N

   c) 3.05×10^{-10} N

   d) 4.05×10^{-10} N

5. Repeatable entity of a crystal structure is known as _____ [1 M]

6. A family of planes is represented by _____ [1 M]

7. Sketch $(1\bar{3}\ 1)$ and $(11\bar{2})$ planes [2 M]

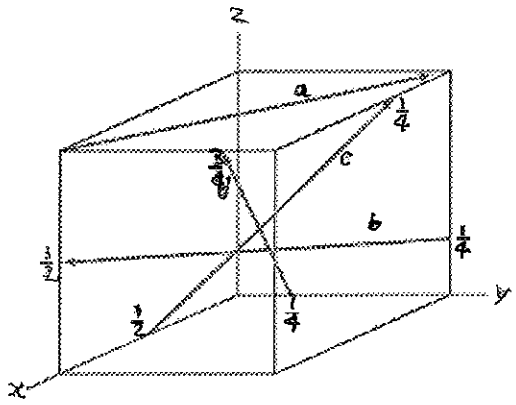
8. What are the indices of the directions shown in the unit cubes [2 M]

a)

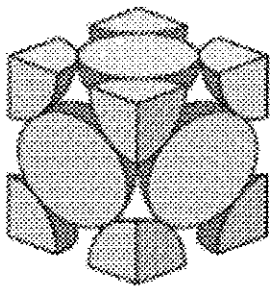
b)

c)

d)



9. The following is the unit cell of Aluminum with atomic diameter 0.286 nm.



Its unit cell volume is [3 M]

a) 6.62×10^{29} cm^3 ,

b) 66.2×10^{-29} cm^3 ,

c) 66.2×10^{29}, cm^3

d) 6.62×10^{-29} cm^3