

BITS PILANI DUBAI CAMPUS

Knowledge Village, Dubai

II Semester 2006 - 07

Course No: ES UC242

Date: 29.05.07

Max Marks: 40

Course title: Structure and Properties of Materials

Comprehensive Examination

Duration: 3 Hours

Weightage: 40%

Values of Selected Constants:

Avogadro's number (N_A) = 6.023×10^{23} atoms/mol

Boltzmann's constant (k) = 1.38×10^{-23} J/atom-K

Gas constant (R) = 8.31 J/mol-K

Note:

- Answer Section A, Section B and Section C in separate answer books

SECTION A

Q1. Magnesium has electronegativity value of 1.2 and Mg^{2+} has ionic radius of 0.072 nm. Oxygen has electronegativity value of 3.5 and O^{2-} has ionic radius of 0.140 nm. What type of bonding will MgO form? Also suggest a suitable crystal structure for MgO. Justify your answers.

[1+3]

Q2. A single crystal of Aluminum has a tensile stress of 3.2 MPa applied along [001] direction. Find the resolved shear stress, τ_r , if the slip plane is (111) and slip direction is $[\bar{1}01]$. Draw suitable sketch to represent the planes and directions.

[4]

Q3. The diffusion coefficients of carbon in iron at two temperatures are given below:

T °C	D (m^2/s)
500	2.4×10^{-12}
900	1.7×10^{-10}

(a) Calculate the values of D_0 and the activation energy (Q_d).

(b) Also find the diffusion coefficient (D) at $1000^\circ C$.

[2+2+1]

SECTION B

Q4(a). A metal subjected to a tensile test has true strain of 0.23 at a true stress of 600 MPa . If the constant K is 900 MPa, calculate the true strain that results from the application of true stress of 700 MPa.

[2]

Q4(b) A series of reinforced steel wires are required for casting a pillar. It is estimated that load on each wire will be 14 kN. Determine the minimum required wire diameter if the working stress is 500 MPa for the steel.

[2]

Q5. A lead – tin alloy of composition 80 wt% Sn – 20% Pb and at 180 °C (Figure Q5), determine

- (a) the mass fractions of α and β phases.
- (b) the mass fractions of primary β and eutectic microconstituents.
- (c) the mass fraction of eutectic β .

[2+2+1]

Q6. Using isothermal transformation diagram for a 0.45 wt% C steel alloy (Figure Q6), determine the final microstructure (in terms of just the microconstituents present) of a small specimen that has been subjected to the following time-temperature treatments. In each case assume that the specimen begins at 845 °C, and that it has been held at this temperature long enough to have achieved a complete and homogeneous austenite structure.

- (a) rapidly cool to 700 °C, hold for 10 s, then quench to room temperature.
- (b) rapidly cool to 675 °C, hold at this temperature for 10 s, rapidly cool to 400 °C, hold at this temperature for 5 s, then quench to room temperature.
- (c) rapidly cool to 650 °C, hold at this temperature for 3 s, rapidly cool to 400 °C, hold for 1000 s, then quench to room temperature.

[1+2+2]

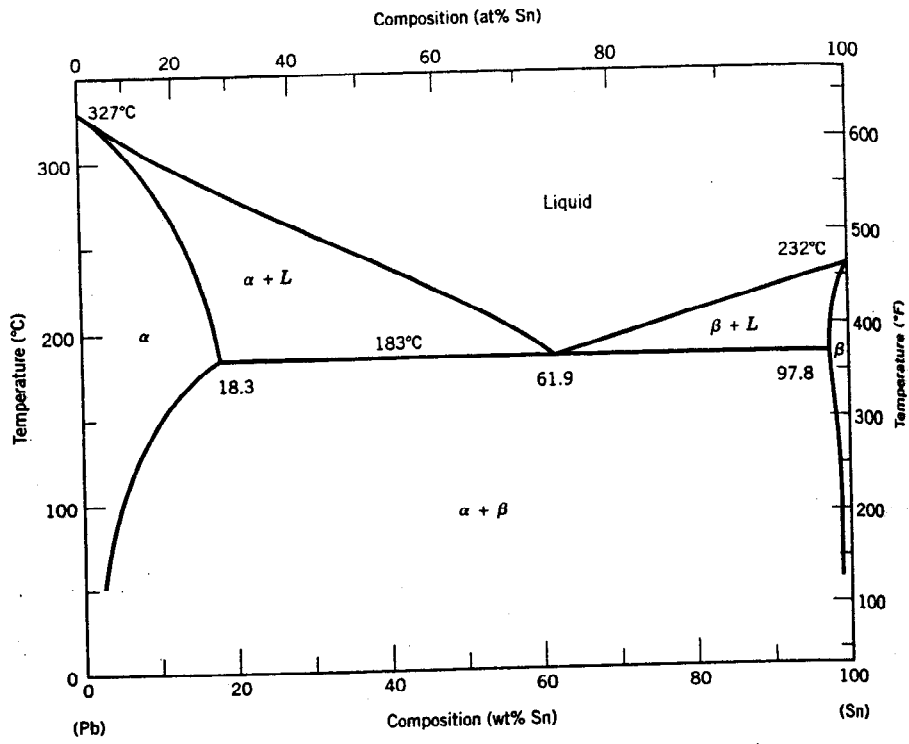


Figure Q5

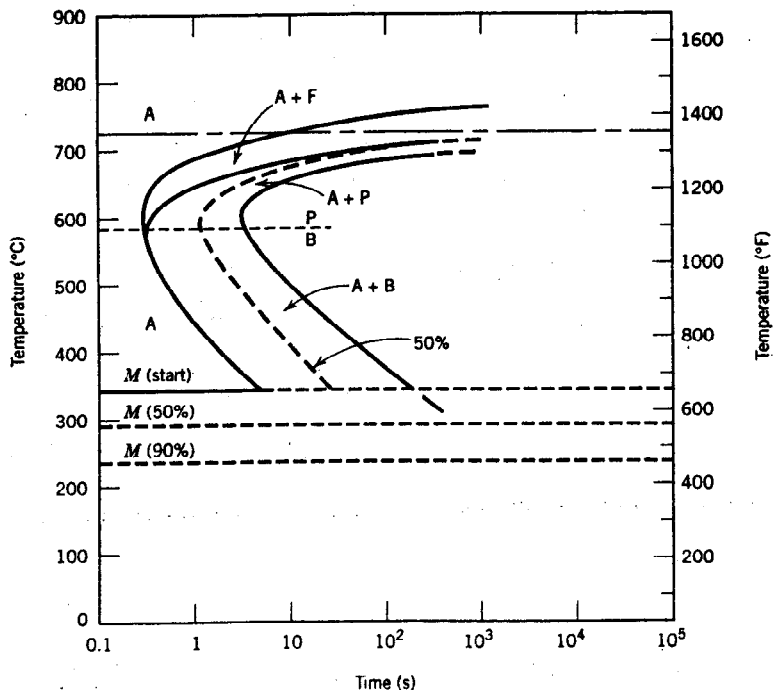


Figure Q6

SECTION C

Q7(a). Compute the mer molecular weight and weight - average molecular weight for a polystyrene for which the weight - average degree of polymerization is 25,000.

[2]

Q7(b). The tensile strength and number - average molecular weight for two polyethylene materials are as follows.

Tensile strength (MPa)	Number average molecular weight (g/mol)
85	12,700
150	28,500

Estimate the number - average molecular weight that is required to give a tensile strength of 195 MPa.

[3]

Q8(a). Briefly explain selective leaching.

[1]

Q8(b). Schematically show cathodic protection.

[1]

Q8(c). A thick sheet of area 625 cm^2 is exposed to air near the ocean. After one year period (1 year = 8760 hours) it was found to experience a weight loss of 500,000 milligram due to corrosion. Using the constant $K=87.6$, determine to what rate of corrosion, in millimeters per year (mm/yr), does this correspond? $\rho=7.9$ grams per cubic centimeter.

[3]

Q9. Estimate the electrical resistivity of copper containing 1.75 at% Ni at 100°C . The values of ' ρ_0 ' and ' a ' for pure copper are $1.58 \times 10^{-8} \Omega\text{-m}$ and $6.5 \times 10^{-11} \Omega\text{-m}^\circ \text{C}$ respectively. Assume the value of composition independent constant A for nickel as an impurity in copper as $1.18 \times 10^{-6} \Omega\text{-m}$.

[3]

BITS PILANI DUBAI CAMPUS
Knowledge Village, Dubai
II Semester 2006-07

Course No: ES UC242
 Date: 25.03.07
 Max Marks: 20

Course title: Structure and Properties of Materials
 Test 1-Regular
 Duration: 50 Min
 Weightage: 20%

Values of Selected Constants:

Avogadro's number (N_A) = 6.023×10^{23} atoms/mol
 Boltzmann's constant (k) = 1.38×10^{-23} J/atom-K
 Gas constant (R) = 8.31 J/mol-K

Q1 (a). Tungsten has a BCC structure with atomic radius 0.137 nm. Find its planar density for (100) and (110) planes. [4]

Q1 (b). Which of these two planes would be a possible slip plane? Why? [1]

Q2. Below, atomic radius, crystal structure, electronegativity and the most common valence are tabulated, for some elements; for those that are nonmetals, only atomic radii are indicated.

Element	Atomic radius (nm)	Crystal structure	Electronegativity	Valence
Cu	0.1278	FCC	1.9	+2
C	0.071			
H	0.046			
O	0.060			
Ag	0.1445	FCC	1.9	+1
Al	0.1431	FCC	1.5	+3
Ni	0.1246	FCC	1.8	+2
Pd	0.1376	FCC	2.2	+2
Pt	0.1387	FCC	2.2	+2

Which of these elements would you expect to form the following with copper.

- (a) A substitutional solid solution having complete solubility
- (b) A substitutional solid solution of incomplete solubility
- (c) An interstitial solid solution

[4]

Q3. A sheet of iron 2.5 mm thick has nitrogen atmospheres on both sides at 1100 °C and is permitted to achieve a steady state diffusion condition. The diffusion coefficient for nitrogen in iron at this temperature is 5.5×10^{-11} m²/s, and the diffusion flux is found to be 0.9×10^{-7} kg/m²s. It is also known that concentration of nitrogen in iron at the high pressure surface is 3.5 kg/m³. How far into the sheet from this high pressure side will the concentration be 1.5 kg/m³? Assume linear concentration profile. [5]

Q4. Consider zinc – copper alloy that initially has uniform zinc concentration of 0.20 wt%. The concentration of zinc at the surface is suddenly brought to and maintained at 1.10 wt% and after 50 hrs the concentration of zinc is 0.78 wt% at a position 3 mm below the surface.

- (a) Find the diffusion coefficient for zinc in copper
- (b) Determine the temperature at which the treatment was carried out.

Take D_0 and Q_d for the diffusion of zinc in copper as 2.4×10^{-5} m²/s and 189 kJ/mol respectively. The error function values are listed in Table Q4. [4+2]

Table Q4 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

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Knowledge Village, Dubai
II Semester 2006-07



Course No: ES UC242
Date: 14.03.07
Max Marks: 10

Course title: Structure and Properties of Materials
Quiz 1-Regular
Duration: 30 Min
Weightage: 10%

Answer sheet

Name of the student:

ID No.:

Section:

Instructor Name:

Tick ✓ for correct answer. Do not overwrite.

Que No.	(a)	(b)	(c)	(d)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

For official use only:

Marks obtained

= _____

Signature of Examiner

Request for Recheck:

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Knowledge Village, Dubai
II Semester 2006-07

A

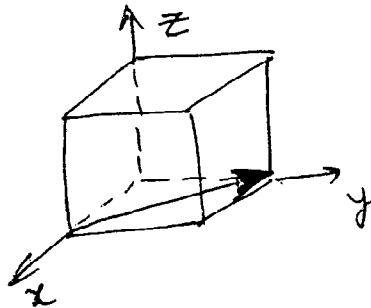
Course No: ES UC242
Date: 14.03.07
Max Marks: 10

Course title: Structure and Properties of Materials
Quiz 1-Regular
Duration: 30 Min
Weightage: 10%

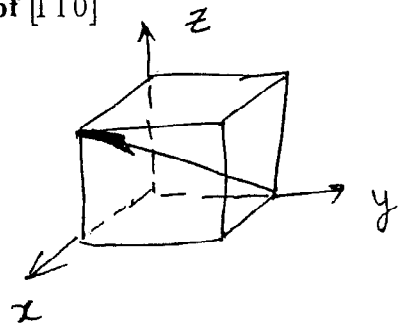
- Answer all the questions in the separate answer sheet provided.

- Repulsive and attractive forces depend on
(a) interatomic distance (b) intermolecular distance
(c) number of atoms (d) number of molecules
- Ionic materials are
(a) hard and brittle (b) tough and ductile
(c) soft and ductile (d) soft and brittle
- The type of bond for MgO is [electronegativity for Mg=1.2, O=3.5]
(a) metallic (b) covalent
(c) van der Waals (d) ionic
- If the electronegativities of Fe is 1.8 and O is 3.5, the then % ionic character of FeO is
(a) 50.4 % (b) 51.4 %
(c) 52.4 % (d) 49.4 %
- The crystal structure of Aluminum is
(a) SCC (b) FCC
(c) BCC (d) HCP
- Which of the following shows the crystal direction of $[1\bar{1}0]$

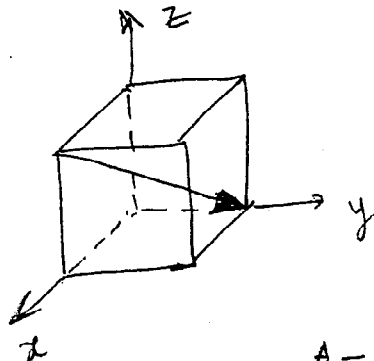
(a)



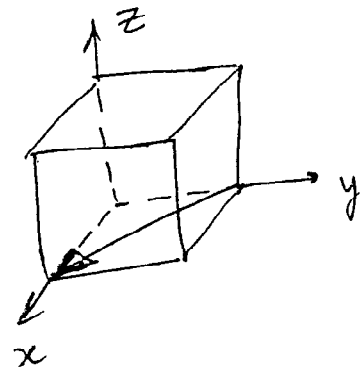
(b)



(c)



(d)



7. The Miller index for the crystallographic plane shown in the Fig. Q7 is
- (a) $(00\bar{1})$ (b) $(\bar{1}00)$
 (c) $(\bar{1}01)$ (d) $(11\bar{1})$

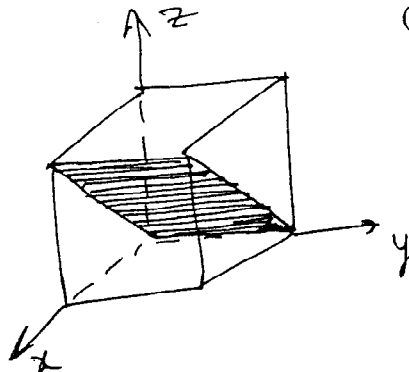


Fig. Q7

8. A hypothetical material 'X' has atomic weight of 207.2 g/mol and density of 11.35 g/cm^3 and atomic radius of 0.175 nm. The crystal structure for the material is _____. $N_A = \text{Avogadro's number } (6.023 \times 10^{23} \text{ atoms/mol})$
- (a) SCC (b) BCC
 (c) FCC (d) None of the above
9. If the atomic weight of Cu is 63.55 g/mol and that of Pt is 195.08 g/mol, then the composition in wt% of an alloy that contains 7 at% Cu and 93 at% Pt is _____
- (a) 81.2 wt% Pt and 18.8 wt% Cu (b) 98.3 wt% Pt and 1.7 wt% Cu
 (c) 85.7 wt% Pt and 14.5 wt% Cu (d) 97.6 wt% Pt and 2.4 wt% Cu
10. Atomic vibration is
- (a) line defect (b) interfacial defect
 (c) Frenkel defect (d) Schottky defect