BITS, PILANI – DUBAI
Dubai International Academic City, Dubai
Second Semester 2008-2009
Comprehensive Examination

Course: ESC 242 Structure and Properties of Materials

Date: 02-06-09
Marks: 80 **Time: 3 hrs**
Weightage: 40%

1. **Answer Parts A, B, C and D in separate sheets.**
2. **Assume relevant data if required.**
3. **Answer all questions.**

PART – A

1.a Name the crystal structure for the following metals & calculate the Atomic Packing Factor for any one of these. [3 M]

i) Magnesium ii) Alpha Iron
iii) Copper iv) Aluminum

b Describe the Fick's second law of diffusion. [2 M]

2. A unit cell of hypothetical metal is shown in the Figure A-Q2. [5 M]

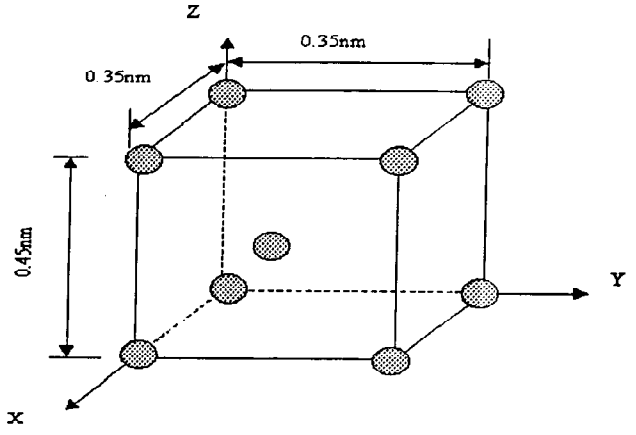


Figure A - Q2

a) To which crystal system does the unit cell belong?
b) What would this crystal structure be called?
c) Calculate the density of the material, given that atomic weight is 141 g/mol.

3. In a simple cubic crystal of lattice parameter 3 A°, a positive edge dislocation of 1 mm long climbs up by 1 μm. How many vacancies are lost or created? [5 M]

4. The vacancy migration energy in copper is 0.8 eV. The self-diffusion coefficient at 700 K & 100 K are 3.43×10^{-15} m^2/sec & 1.65×10^{-11} m^2/sec respectively. Determine the vacancy concentrations at these two temperatures. [5 M]

Boltzman constant K = 1.38×10^{-23} J/atom-K

Boltzman constant K= 5.62×10^{-5} eV/atom-K

Take Activation Energy = Energy required for formation of vacancy + Migration Energy

PART – B

1. The diffusivity of silver atoms in solid silver is 1.0×10^{-17} m^2/s at 500°C and 7.0×10^{-13} m^2/s at1000°C. Calculate the activation energy (joules per mole) for the diffusion of silver in silver in the temperature range 500°C to 1000°C. [5 M]

2. The yield strength of mild steel with an average grain size of 0.05 mm is 138 MPa. The yield stress of the same steel with a grain size of 0.007 mm is 276 MPa. What will be the average grain size of the same steel with a yield stress of 207 MPa? Assume the **Hall-Petch equation** is valid and that changes in the observed yield stress are due to changes in dislocation density. [5 M]

3. During a tensile test with a metal that obeys $\sigma = K \varepsilon^n$, the ultimate tensile strength (UTS) is found to be 340 MPa. The maximum load requires an elongation of 30%. From this limited information, find **K** and **n**. Hint: strain hardening exponent is equal to strain at UTS. [5 M]

4. Derive the equation for critical resolved shear stress for slip in a single crystal. [5 M]

1. **PART – C**

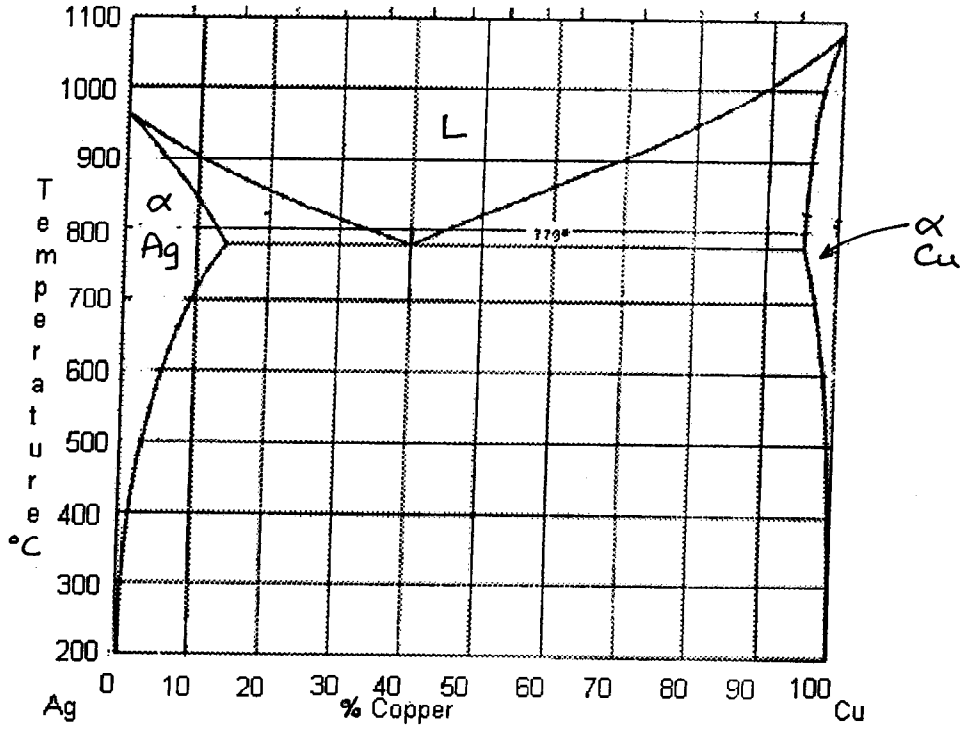


Figure C-Q1

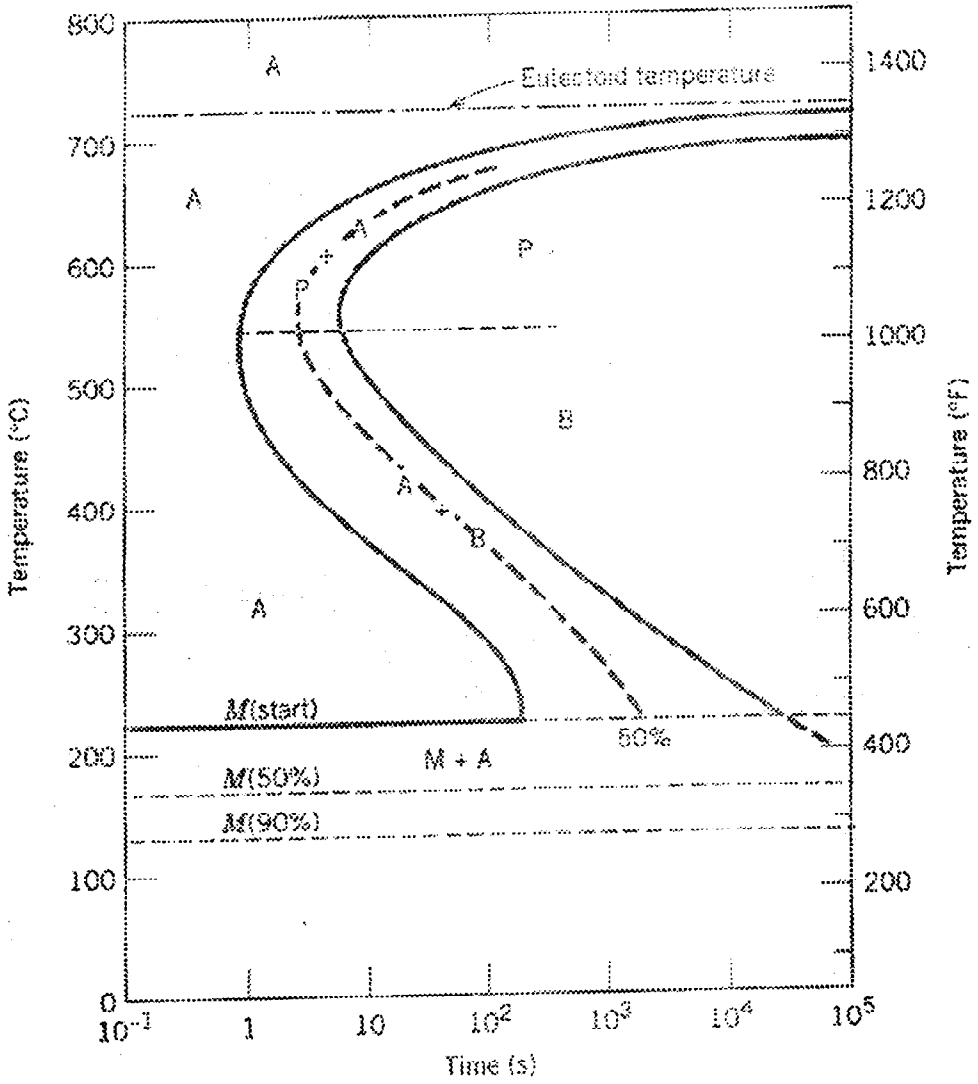
(i) For the following temperatures and compositions state all the phases present. [5 M]
(Refer Figure C-Q1)

(1) 20% Cu at 900 °C
(2) 5% Cu at 700 °C
(3) 80% Cu at 800 °C

(ii) For 70% Cu at 600 °C determine the relative amounts of all phases present.

2. Referring to Figure C-Q2, describe the microstructure of the final steel using the following cooling processes: [10 M]

a. from 750 °C rapidly cool to 650 °C, hold for 30 seconds, and rapidly cool to room temperature.
b. from 750 °C rapidly cool to room temperature.
c. from 750 °C rapidly cool to 500 °C, hold for 1000 seconds, and rapidly cool to room temperature.
d. from 750 °C rapidly cool to 400 °C, hold for 10 seconds, and rapidly cool to room temperature.
e. from 750 °C rapidly cool to 550 °C, hold for 3 seconds, and rapidly cool to room temperature.
f. from 750 °C rapidly cool to 550 °C, hold for 3 seconds, rapidly cool to 400 °C, hold for 300 seconds, and rapidly cool to room temperature.



[5 M]

Figure C-Q2

3. Compute the atomic packing factor for the ROCK SALT structure in which $r_C/r_A = 0.414$.

PART – D

Atomic weights data:
Carbon= 12.011; Hydrogen = 1.008; Sulfur = 32.06; Chlorine =35.45; Fluorine =19.00.

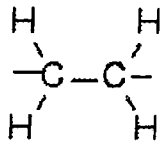
1. Name any two commercial alloys used in electrical applications. [2 M]

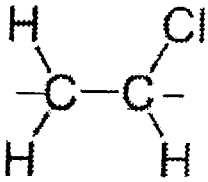
2. Mention any two methods of corrosion prevention. [2 M]

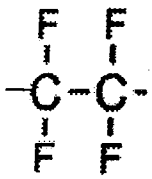
3. A polymer has a number average molecular weight of 21,150 g/mol and a weight average molecular weight of 23,200 g/mol. It s weight average degree of [8 M]

polymerization is 371. Which of the following polymers does this molecular weight data belong to? What is its number average degree of polymerization?

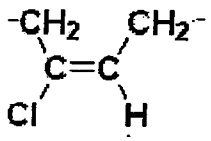
a. polyethylene b. polyvinylchloride c. polytetrafluoroethylene







4. Vulcanization of polychloroprene is obtained by adding 42 wt% of sulphur to it. How many sulphur atoms are there for each crosslink, if complete cross linking is achieved for polychloprene? [8 M]



polychloroprene

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Second Semester 2008-2009

TEST II (Open Book)

Course: ES C242 Structure and Properties of Materials

Note: 1.Answer all the questions

2. Prescribed text book and hand written class notes are allowed.

Date: 26-04-09 **Weightage: 20%**

Time: 50 min. **Marks : 40**

1. (a) Can the temperature be the driving force for steady state diffusion? If yes, justify your answer. If not, state the reason why? **[2M]**

(b) The steady-state diffusion flux through a metal plate is 8.7×10^{-9} kg/m^2 –s at a temperature of 1300^0 C and when the concentration gradient is -620 kg/m^4. Calculate the diffusion flux at 1050^0 C for the same concentration gradient and assume activation energy for diffusion as 183 kJ/mol. **[8M]**

2. (a) A cast iron tube is used to support a compressive load. E = 69 GPa and maximum allowable change in length is 0.025%. Determine

(i) the maximum normal stress in the tube and

(ii) the minimum wall thickness for a load of 7.2 kN if the outside diameter of the tube is 50mm. **[6M]**

(b) What will be the diameter of indentation for a material with a tensile strength of 2000 MPa when a 500 kg load and 10mm diameter brinell indenter are used? **[4M]**

3. (a) Comment on the statement "All the metals do not have same slip system". **[2 M]**

(b) A single crystal of copper is oriented such that a tensile stress is applied along The [100] direction. The critical resolved shear stress for copper is 0.5 MPa.

(i) Prove that slip will not take place in (111) [0 $\bar{1}$ 1] slip system. **[6M]**

(ii) What is the Schmid's factor for the above? **[2M]**

4. For Cu-Ni system the following data (Table 1) is available.

Table 1

Temperature °C	Melt composition (Wt % Ni)	Composition of solid first formed on cooling (Wt % Ni)
1100	3	10
1180	20	37
1260	40	57
1340	60	78
1410	80	87

Table 2

Temperature °C	Wt. % Ni.
1120	15
1200	55
1300	60

i) Draw the phase diagram with the available data and melting temperatures of the metals (Cu-1095°C, Ni and 1450°C). **USE GRAPH SHEET.** **[6M]**

ii) For the data in table 2 identify the phases present and the composition of Ni. **[4M]**

BITS, PILANI- DUBAI
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II Semester 2008-2009
T E S T I (Closed Book)

Class: II Year | Date:15.03.09
Course No.: ES C242 | Course title: Structure & Properties of Materials
Time duration: 50 min. | Marks: 50 | Weightage: 25%

- Answer all the Questions
- Assume relevant data, if essential.

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1. a. Why metals are good conductors of both heat and electricity? [2]

   b. Consider a hypothetical $X^+ - Y^-$ ion pair for which the equilibrium interionic spacing and bonding energy values are 0.36 nm and -6.54 eV respectively. If the value of n is 10, find the constants A and B [10]

2 a. Metallic iron changes from BCC to FCC at 910°C. The atomic radii of the iron atom in two structures are 0.1258 nm (BCC) and 0.1292 nm (FCC) respectively. Calculate the volume change in % during structural change. [8]

   b. The lattice constant of a unit cell of iron is 0.287 nm. Find the number of atoms/mm^2 of planes (110) and (111) if iron has BCC structure. [6]

3 a. Give an example of metals/alloys for the each of the following defects:
   i) Interstitial Defects
   ii) Substitutional Defects [2]

   b. Determine the number of vacancies needed for a BCC iron crystal to have a density of 7.87 g/cm^3.
   The lattice parameter of the iron is 2.866×10^{-8} cm.
   Use the following data:
   Avogadro Number = 6.02×10^{23} atoms/mol [10]
   Atomic weight of iron = 55.847 amu

4 a. Show all the point defects by means of free hand sketches, comparing with the pure crystal. [2]

   b. Calculate the composition weight percent of an alloy that contains 218 kg Titanium, 14.6 Kg Aluminium, and 9.7 Kg of Vanadium. Calculate the alloy atomic weight.(Atomic weight: Ti = 47.88 amu; Al = 26.98 amu; V = 50.94 amu). Find alloy atomic weight by converting composition in terms of atomic percentage. [10]

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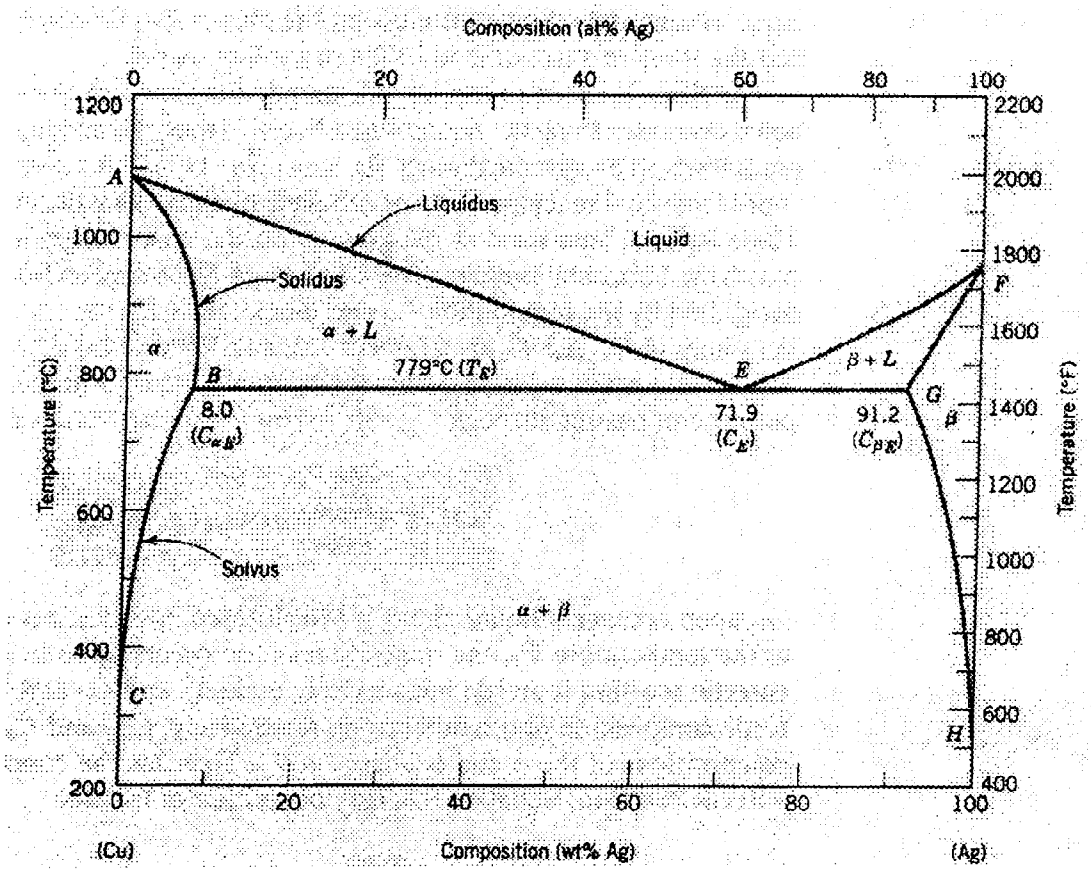
II Semester 2008 – 2009
ES C242– Structure and Properties of Materials
Quiz 3 – Sec 7

Q1. A copper-silver alloy of composition 40 at% Ag-60 at% Cu is slowly heated from a temperature of 650°C.

a. At what temperature does the first liquid phase form?
b. What is the composition of this liquid phase?
c. At what temperature does complete melting of the alloy occur?
d. What is the composition of the last solid remaining prior to complete melting?
e. Write the eutectic reaction for this phase diagram.

(5 marks)



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BITS, Pilani – Dubai
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II Semester 2008 – 2009
ES C242– Structure and Properties of Materials
Quiz 2 – Sec 7

Q1. The purification of hydrogen gas can take place by diffusion through a palladium sheet. Compute the number of kilograms of hydrogen that pass through a 5 mm thick sheet of palladium per hour having an area of 2000 cm^2 at 500°C, if the diffusion coefficient of 10^{-8} m^2/s is used. The concentrations at steady state at the high and low pressure sides of the plate are 2.4 and 0.6 kilograms of hydrogen per cubic meter of palladium. (5 marks)

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II Semester 2008 – 2009
ES C242– Structure and Properties of Materials
Quiz 1 – Sec 7

Q1. Find the equilibrium spacing r_0 and bonding energy E_0 for Cs-F ion pair, given

$E_A = -1.357 / r$

$E_R = 8.43 \times 10^{-6} / r^8$ (5 marks)

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II Semester 2008 – 2009
ES C242– Structure and Properties of Materials
Quiz 3 – Sec 6

Q1. Molecular weight data for a polymer is given below. Find the following:

a. number-average molecular weight
b. weight-average molecular weight
c. number-average degree of polymerization
d. weight average degree of polymerization (5 marks)

Molecular weight Range (g/mol)	x_i	w_i
8,000 – 16,000	0.05	0.02
16,000 – 24,000	0.16	0.10
24,000 – 32,000	0.24	0.20
32,000 – 40,000	0.28	0.30
40,000 – 48,000	0.20	0.27
48,000 – 56,000	0.07	0.11

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II Semester 2008 – 2009
ES C242– Structure and Properties of Materials
Quiz 2 – Sec 6

Q1. The activation energy for diffusion of copper in silver is 193 kJ/mol. Calculate the diffusion coefficient at 1200 K given that D at 1000 K is 10^{-14} m^2/s. (5 marks)

ıe: _____

) No.: _____

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II Semester 2008 – 2009
ES C242– Structure and Properties of Materials
Quiz 1 – Sec 6

Q1. Show each of following planes in separate cubic unit cells without violating the unit cell geometry.

a. (101)
b. (011)
c. (3$\bar{1}$1)
d. (020)
e. (213)

(5 marks)

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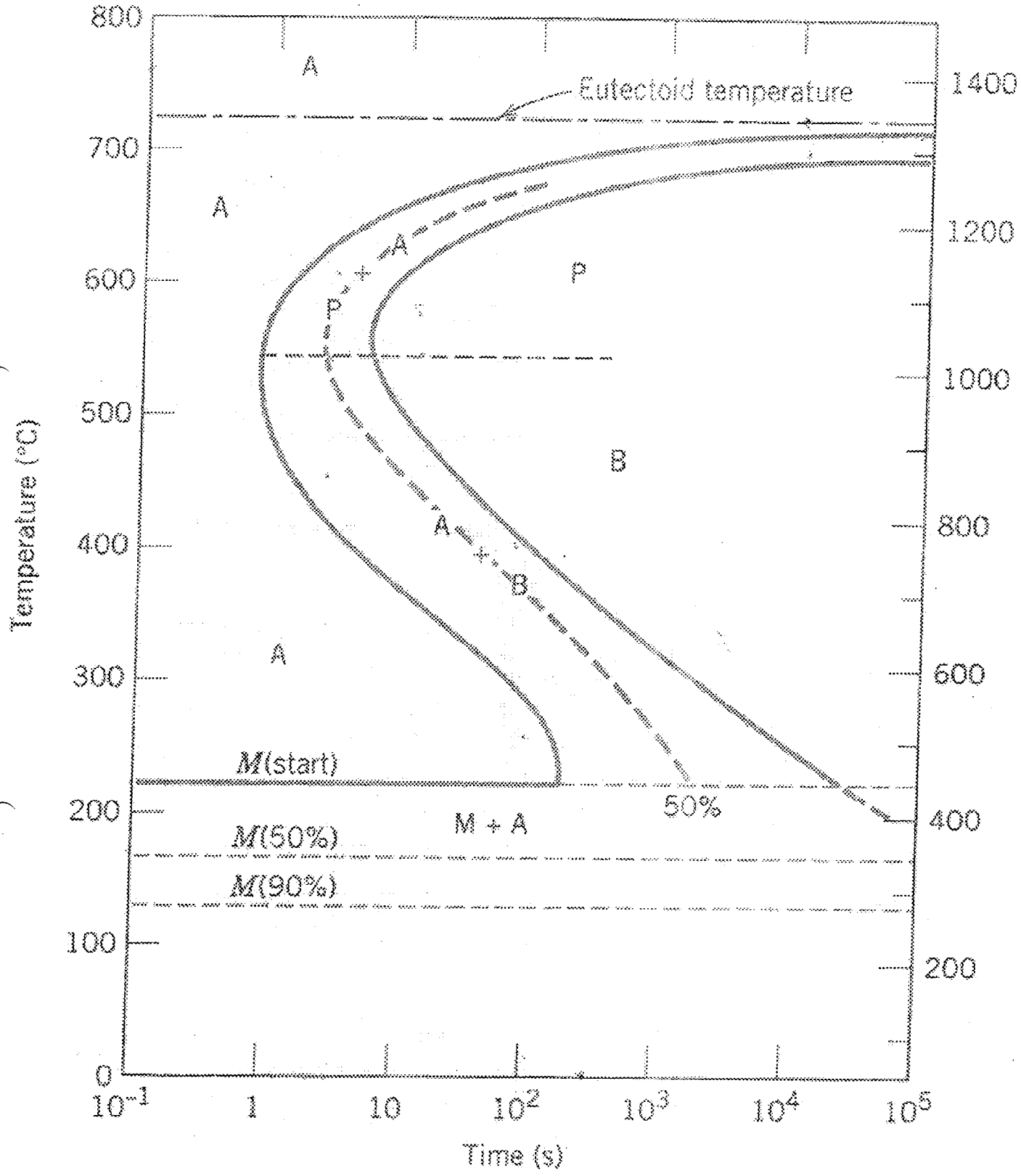
II Semester 2008 – 2009
ES C242– Structure and Properties of Materials
Quiz 3 – Sec 5

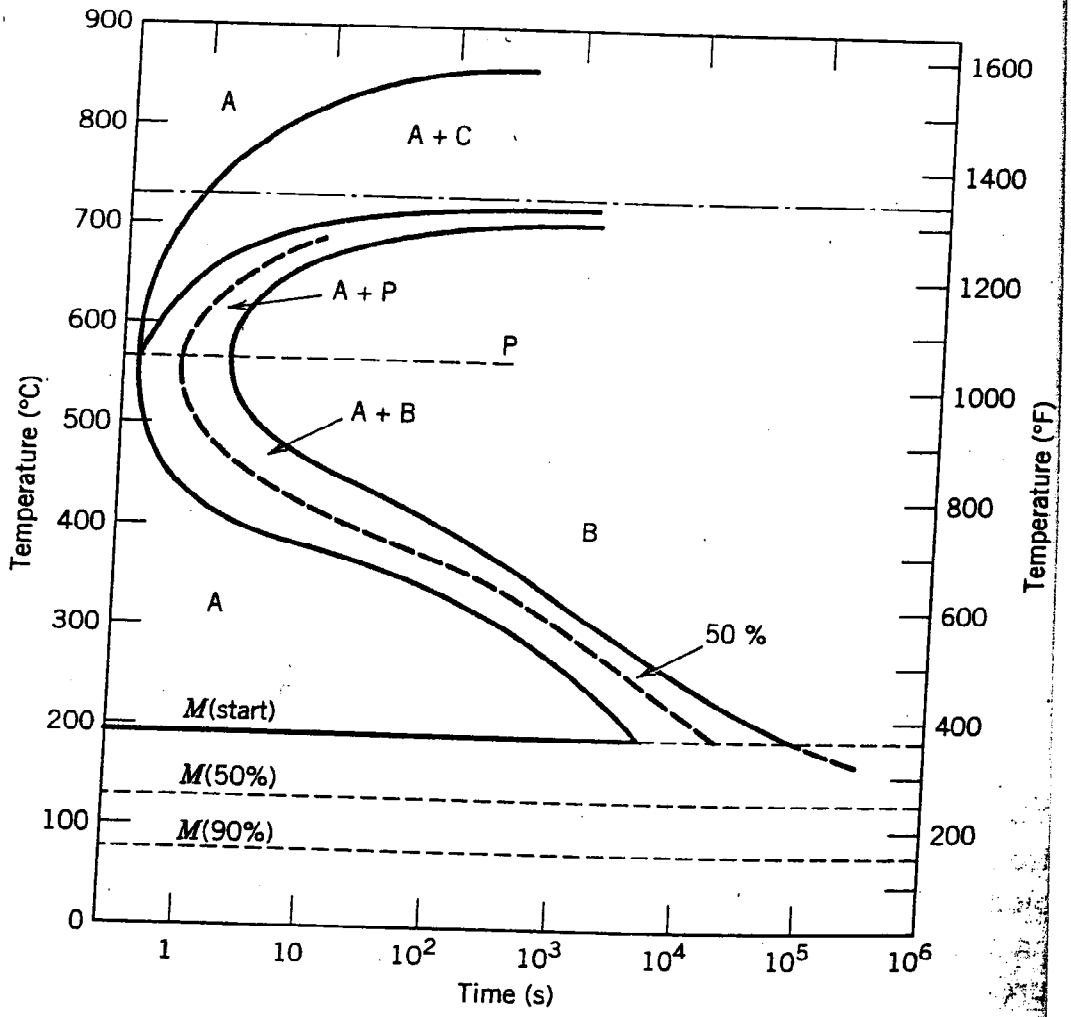
Q1. Sketch and label time-temperature paths to produce the following microstructures for eutectoid composition of carbon in iron-carbon alloy. (3 marks)

a. 50% fine pearlite, 25% bainite, 25% martensite
b. 40% bainite, 60% martensite
c. 50% martensite, 50% austenite

Q2. Sketch and label time - temperature paths to produce the following microstructures for a 1.13 wt% of carbon in iron-carbon alloy. (2 marks)

d. Cementite, fine pearlite
e. 50% bainite, 50% martensite


800
700
600
500
400
300
200
100
0
1400
1200
1000
800
600
400
200
A
Eutectoid temperature
A
P
A + P
A
B
A + B
A
M(start)
50%
M + A
M(50%)
M(90%)
Temperature (°C)
Temperature (°F)
10^{-1}
1
10
10^2
10^3
10^4
10^5
Time (s)


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%)
Temperature (°C)
Temperature (°F)
1
10
10^2
10^3
10^4
10^5
10^6
Time (s)

Name: _____

ID No.: _____

BITS, Pilani – Dubai
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II Semester 2008 – 2009
ES C242– Structure and Properties of Materials
Quiz-2-section 5

Q1. For a steel alloy it has been determined that a carburizing heat treatment of 10 hour duration will raise the carbon concentration to 0.45 wt% at a point 2.5 mm from surface. Estimate the time necessary to achieve the same concentration at a 5 mm position for identical steel and at the same carburizing temperature. (5 marks)

Name: _____

ID No: _____

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II Semester 2008 – 2009
ES C242– Structure and Properties of Materials
Quiz 1 – Sec 5

Q1. Find the linear density and planar density for [110] direction and (110) plane for BCC. (5 marks)

BITS, PILANI – DUBAI Sec. 4

Second Semester 2008-2009

ESC 242 Structure and Properties of materials **Quiz 3**

Name: **ID No.:** **Date:** _____

1. How will you obtain the following **from a stress-strain diagram**?
   a) elastic modulus b) 0.2% yield strength c) the tensile strength
   d) ductility e) toughness f) resilience g) elastic strain
   h) plastic strain i) fracture stress k) proportional limit

Use diagram and necessary relations.

RKK

II yr Dec '4'

BITS, PILANI – DUBAI

Second Semester 2008-2009

ESC 242 Structure and Properties of materials **Quiz 2**

Name: **ID No.:** **Date:**

1. Consider the gear carburizing of a gear of 0.2%C steel at 927 deg.C. Calculate the time in minutes necessary to increase the carbon content to 0.40% at 0.5 mm below the surface. Assume that the carbon content at the surface is 0.90%. The diffusivity is 1.28×10^{-11} m^2/s. [8]
2. State the *expressions* for Fick's first law and second law [2]

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

BITS, PILANI – DUBAI

Second Semester 2008-2009 II yr dec '09

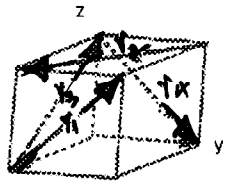
ESC 242 Structure and Properties of materials **Quiz 1**

Name: **ID No.:** **Date:**

1. Calculate the theoretical density for FCC Aluminium if the atomic radius is 0.254nm and the atomic weight is 26.98 g/mol.

2. Calculate the activation energy required for vacancy creation in the following conditions: Temperature: 500deg.C, Material: copper, Atomic weight = 63.5 g/mol, Density at 500 deg.C=8.4 g/cc; No. of vacancies=1.5×10^{22} /m^3

3. Obtain the miller indices for the following four directions in a cubic crystal system:



4. Derive the burger's vector for FCC crystal structure. (in terms of y)

Sec. 3

BITS, PILANI – DUBAI Sec. 3

Second Semester 2008-2009

ESC 242 Structure and Properties of materials **Quiz 3**

Name: **ID No.:** **Date:**

1. How will you obtain the following **from a stress-strain diagram**?

a) elastic modulus b) 0.2% yield strength c) the tensile strength
d) ductility e) toughness f) resilience g) elastic strain
h) plastic strain i) fracture stress k) proportional limit

Use diagrams and necessary relations.

PKR

II yr sec 'B'.

BITS, PILANI – DUBAI

Second Semester 2008-2009

ESC 242 Structure and Properties of materials **Quiz 2**

Name: **ID No.:** **Date:**

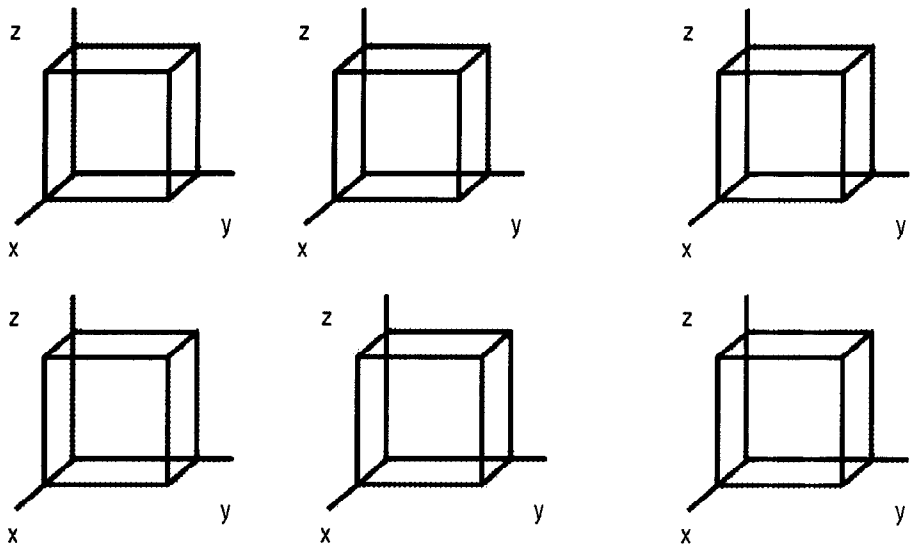
1. The diffusivity of silver atoms in solid silver is 1.0 $x10^{-17}m^2/s$ at 500 °C and 7.0 $x10^{-13}m^2/s$ at 1000°.C. Calculate the activation energy (J/mol) and pre exponential for the diffusion of Ag in the temperature range in the temperature range 500 to 1000°C. [8]

2. List the boundary conditions applied for diffusion based on Fick's second law. [2]

BITS, PILANI – DUBAI
Second Semester 2008-2009 II yr. Sec 3

ESC 242 Structure and Properties of materials **Quiz1**
Name: **ID No.:** **Date:**

1. Show the following in the cubic crystal system below: (1 1 0), (1 $\bar{1}$ 0), (1/2, 0, 1) and [1 1 1], [1 1 0], [$\bar{1}$ 0 $\bar{1}$]



2. Obtain the planar density for 100 planes for FCC structure and SC structure in terms of 'r'

3. Determine the number of vacancies needed for a BCC iron crystal to have a density of 7.86 g/cm^3. The lattice parameter of the iron is 2.866×10^{-8} cm. A = 55.847 g/mol

BITS, PILANI-DUBAI, INTERNATIONAL ACADEMIC CITY, DUBAI Sec 2

SECOND SEMESTER 2008-2009

ES UC 242 Structure Properties & Materials

QUIZ-3

MAX MARKS: 10 DURATION: 15 MINUTES WEIGHTAGE: 5%

NAME OF STUDENT: _____ I.D:_____

NOTES: i) Change of answer & overwriting is not permitted.
ii) If any one found in signal nodding or any form of cheating, his copy will be marked by # and forwarded to examination committee for further action.
iv) Answer in brief with suitable diagrams, each question carry one Mark.

Q.1 What is ferrite?

Q.2 What is cementite?

Q.3 What is Ledeburite?

Q.4 What is Hyper Eutectoid Steel?

Q.5 What is Hypo Eutectoid steel?

Q.6 What is Eutectoid Steel?

Q.7 What is Pearlite?

Q.8 What is austenite?

Q.9 Calculate the amount of ferrite & cementite in the Pearlite?
(Answer the question Back Side of this paper)

Q10. Calculate the amount of ferrite & Cementite in Ledeburite?
(Answer the question Back Side of this paper)

Sec-2

BITS, PILANI-DUBAI, INTERNATIONAL ACADEMIC CITY, DUBAI
SECOND SEMESTER 2008-2009
ES UC 242 Structure Properties & Materials
QUIZ-2

MAX MARKS: 10 DURATION: 15 MINUTES WEIGHTAGE: 5%

NAME OF STUDENT: _____ I.D:_____

NOTES: i) Change of answer & overwriting is not permitted.
ii) If any one found in signal nodding or any form of cheating, his copy will be marked by # and forwarded to examination committee for further action.

Q.1 Define Modulus of elasticity.

Q.2 Write the formula for measuring the ductility.

Q.3 Show the toughness of material with the help of stress strain curve.
(Use the back space of paper)

Q.4 Define the true stress.

Q.5 Define the hardness.

Q.6 Which material shows the shape the cup & cone after fracture?

Q.7 Write the relation between modulus of elasticity, modulus of rigidity & Poisson ratio?

Q.8 Among Fatigue, impact, tension, compression which tests is assumed most important in material testing?

Q.9 Draw the stress strain curve for mild steel & mark the important points.
(Use the back space of paper)

Q10. Draw the stress strain curve for Cast Iron & mark the important points.
(Use the back space of paper)

Sec. 2

BITS, PILANI-DUBAI, INTERNATIONAL ACADEMIC CITY, DUBAI
SECOND SEMESTER 2008-2009
ES UC 242 Structure Properties & Materials
QUIZ-1

MAX MARKS: 10 DURATION: 15 MINUTES WEIGHTAGE: 10%

NAME OF STUDENT: _____ I.D:_____

NOTES: i) Change of answer & overwriting is not permitted.
ii) If any one found in signal nodding or any form of cheating, his copy will be marked by # and forwarded to examination committee for further action.
iii) For rough work use the back side of question paper.
iv) Each question carry one Marks.

Q.1 Approximate number of materials which have been developed till now are_____.

Q.2 Ceramics are the compound between_____.

Q.3 Can we use the semiconductors as biomaterials yes or no ?_____

Q.4 MEMS are abbreviated for _____.

Q.5 Example of a material developed by Nanotechnology is _____.

Q.6 Physical & chemical Properties of solids are based on_____electrons.

Q.7 Methane (CH_4) molecules have _____ bonding.

Q.8 Atomic packing factor for FCC crystal structure is _____.

Q.9 If a triclinic crystal structure has axial length are a, b & c then the relation between them is _____.

Q10. Number of atoms in (111) plane of lead FCC structure for lattice constant a=4.93 ^{0}A are _____

Sec. T

Name: _____

ID NO: _____

BITS, PILANI – DUBAI
DUBAI INTERNATIONAL ACADEMIC CITY, DUBAI
ES C242 Structure & Properties of Materials
II SEMESTER 2008-2009

QUIZ III

Max. Marks: 10 **Duration: 15 Min.**
Weightage: 5% **Date: 27-04-09**

QUESTION

The stress at which plastic deformation begins for a bronze specimen of length 75 mm is 350 MPa and its modulus of elasticity is 107 GPa.
(a) What is the maximum load that may be applied to the specimen with a cross sectional area of 120 mm^2 without plastic deformation?
(b)Calculate the true stress and true strain
(c) Find the true strain at a true stress of 500 MPa if the constant in the true stress-true strain equation is 1040 MPa. **[10M]**

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ES C242 Structure & Properties of Materials
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Q U I Z I I

Max. Marks: 10 **Duration: 15 Min.**
Weightage: 5% **Date: 23-03-09**

- **Answer all questions.**
- **Marks are shown in brackets against each question.**

Question 1
Draw the free hand sketches of BCC and FCC crystal structures. **[2M]**

Question 2
Draw the free hand sketch c point defects, comparing with pure crystal. **[2M]**

Question 3
Explain briefly Burgers vector. [2M]

Question 4
How do you calculate vacancies in a crystal? [2M]

Question 5
Define atomic packing factor and find its value for a gold crystal. [2M]

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Q U I Z I

Max. Marks: 10 **Duration: 15 Min.**
Weightage: 5% **Date:19-02-09**

- **Answer all questions.**
- **Marks are shown in brackets against each question.**

Question 1
What are the characteristics of ionic bonding? **[2M]**

Question 2
Draw the free hand sketch of bonding, showing the sharing of electrons. **[2M]**

Question 3
Explain briefly secondary bonding. **[2M]**

Question 4
What is the relation between bonding force and bonding energy? **[2M]**

Question 5
What is the relation used for finding ionic character? **[2M]**