Birla Institute of Technology and Science, Pilani
Second Semester, 2016-17
CHE F243-Materials Science and Engineering

Mid Semester (Open Book) **10th March, 2017 (2-3:30PM)**
Max Time: 90 min **Total Max Marks:78**
Name: **ID:**

This question paper is divided into two sections; A & B. For the section A, use the question paper. Write answers of section B on the answer sheet. There is not time bound. Return Section A and B together, Don't tie.

SECTION A (40 Marks)

Q1: Fill in the Blanks with right word(s). No marks will be awarded if you write one right, one wrong, or leave one blank. [1x10]

a) Diffusion is _____ in the grain boundary compared to that _____ the grain.

b) Compared to atactic polymers, syndiotactic polymers show _____ strength and _____

c) Vulcanized rubber is _____ with sulphur cross-links. This crosslinking _____ strength of the material.

d) For microscope, depth of field _____ as the magnification _____.

e) For a single component system, the maximum no of phases that can _____ in equilibrium is _____.

f) As the inter planner distance _____ miller indices of planes _____.

g) Polyethylene has an _____crystal structure with _____ repeating C_2H_4 unit per unit cell at room temp.

h) The magnitude of an edge dislocation Burger vector in Pt should be _____.

i) Considering the annealing of a heavily cold worked brass sample, _____stage influences the tensile strength and brittleness _____ than that in the recrystallization stage.

j) A cored microstructure may produce in Ni-Cu binary alloy system if the maintained cooling rate is _____ than the _____ cooling rate.

Q2: Multiple choice: cross the right one only. Multiple cross awards zero marks. [1x10]

A. The migration of atoms in a pure material is called
a) Interstitial diffusion
b) Mixed diffusion
c) None of the above
d) Substitutional diffusion
e) Self-diffusion

B. Highest diffusion of CO is expected to occur in the polypropylene with
a) 20 % crystallinity
b) 30 % crystallinity
c) 40 % crystallinity
d) 50 % crystallinity
e) 60 % crystallinity

C. For the same diffusion time, the depth of diffusion penetration at 500 and 850 °C is in the ration of 1:6. The activation energy for diffusion is

a) 74 kJ/mol
b) 80 kJ/mol
c) 57 kJ/mol
d) 37 kJ/mol
e) 114 kJ/mol

D. The fraction of the octahedral voids filled by Al^{3+} ions in Al_2O_3 is

a) 0.87
b) 1
c) 0.43
d) 0.287
e) 0.667

The oxygen anions define a hexagonal close packed structure.

E. X-Ray diffraction study cannot be used to find

a) Phase composition
b) Crystallite size
c) Crystal strain
d) Elemental composition
e) Lattice parameters

F. Which of the following statements is true for binary iron–iron carbide system?

a) Ni addition increases eutectoid C wt% and temperature.
b) Mo addition decreases eutectoid C wt% and temperature
c) Ti addition decreases eutectoid C wt% and temperature
d) Si addition decreases eutectoid C wt% and temperature
e) Ni addition decreases eutectoid C wt% and temperature

G. Which of the following statements is true?

a) Burger vector motion is parallel to the direction of motion of the edge dislocation line.
b) Burger vector motion is perpendicular to the direction of the edge dislocation line
c) Burger vector motion is parallel to the direction of motion of the screw dislocation lines.
d) Burger vector motion is perpendicular to the applied stress for screw dislocation
e) Burger vector motion is perpendicular to the applied stress for edge dislocation

H. Which of the following statements is true for XRD spectrum?

a) The (111) plane cannot be observed, but (221) plane can for BCC structure
b) The (111) plane cannot be observed, but (222) plane can for FCC structure
c) The (111) plane cannot be observed, but (222) plane can for SC structure
d) Both (111) and (222) planes can be observed for FCC structure
e) Both (111) and (222) planes can be observed for BCC structure

I. Which of the following planes cannot be possible for a Hexagonal Bravais lattice?

a) $(11\bar{2}0)$
b) $(12\bar{2}0)$
c) $(21\bar{3}0)$
d) $(1\bar{1}00)$
e) $(2\bar{2}00)$

J. Which of the following phase transformations cannot be considered as an allotropic transformation?

a) Fe (BCC) ↔ Fe (FCC)
b) Sn (BCT) ↔ Sn (DC)
c) Ice ↔ Water
d) Diamond ↔ Graphite
e) Ozone (O_3) ↔ Oxygen (O_2)

Q3: Conceptual/Short Questions. Answer to the point & with logic. Concept is only important.[4x5]

a) Show the graphical trend of hardness vs. isothermal heating time (0 to 10^4 hr) for 2014 Al alloy at 120, 150 and 260 °C, respectively. Explain the graphical trends.

b) Calculate atomic packing factor and density for CsCl

c) Can this following equation be considered to be true for heterogeneous nucleation? Why? Or why not? Provide explanation with proper equations only

$$0 \le \Delta G^*_{het} \le \Delta G^*_{\text{hom}o}$$

d) Consider that you are substituting 0.01 mole % of ZrO_2 by CaO. Write the appropriate defect reaction for the substitution of ZrO_2 by CaO using the Kroger-Vink notation. What will happen to the conductivity of ZrO_2? Increase or decrease? Why? Explain with proper logic.

e) In the following table mention four causes for strain hardening of metals, corresponding strategies for strengthening metals, and how these strategies work. Answer to the point. Unnecessary writing will deduct marks

No	**Causes for strain hardening of metal**	**Strategies for strengthening metal.**	**How the strategy works (1-2 sentences only)**
1			
2			
3			
4			

Birla Institute of Technology and Science, Pilani
Second Semester, 2016-17
CHE F243-Materials Science and Engineering

Mid Semester (Open Book) **10th March, 2017 (2-3:30PM)**
Max Time: 90 min **Total Max Marks:78**

This question paper is divided into two sections; A & B. For the section A, use the question paper. Write answers of section B on the answer sheet. There is not time bound. Return Section A and B together, Don't tie.

SECTION B (38 Marks)

- The concept is only important, not the final answer. Therefore, show all calculations starting from the scratch
- Box the final and intermediate answers. Mention unit.
- Don't skip any mathematical steps-otherwise you will lose marks
- You can use the data given in your text book only. Refer (fig no, table no etc.) the data you are using.

Q1:

a) Draw a diamond structure and number all Cs starts from one. The position of the Cs should be clear and distinguishable. May use different colors to make it clear. **[1]**

b) Write down the coordinate positions of all Cs in diamond structure against their numbers. **[3]**

c) Compute theoretical density of diamond using the coordinate positions and simple geometry. No trigonometric (angle related) consideration will be allowed. Simplest approach will get more marks. **[6]**

Q2: A single crystal of a metal that has the BCC crystal structure is oriented such that a tensile stress is applied in the [010] direction. If the magnitude of this stress is 2.75 MPa, then

a) Compute the resolved shear stress in the $[\bar{1}11]$ direction on each of the (110) and (101) planes. **[6]**

b) Which slip system(s) is (are) most favorably oriented to deform? Why? **[2]**

Q3: Consider the solidification of pure MgO via homogeneous nucleation. Values for the latent heat of fusion and surface free energy are 260 kJ/kg and 0.232 J/m^2, respectively. Use the degree of supercooling value as 100 °C and melting temperature as 2850 °C.

a) Calculate the critical radius and the activation free energy **[5]**

b) Calculate the maximum number of atoms found in a nucleus of critical size **[5]**

Q4: Device such as transistors are made by doping semiconductors. The diffusion coefficient of P in Si is 6.5×10^{-13} cm^2/s at a temperature of 1100 °C. Assume the source provides a surface concentration of 10^{20} atoms/cm^3 and the diffusion time is 1 hr. Si wafer is pure Si.

a) Calculate the depth at which the concentration of P will be 10^{18} atoms/cm^3. **[5]**

b) Clearly state the necessary assumptions (point wise) you must consider in order to solve this problem. **[5]**

END