CHE F243
Materials Science and Engineering

II Semester 2012-13 **Mid sem (Closed Book)**
Max Time: 90 min **Total Max Marks:90**

This question paper is divided in two sections A & B. Write answers on two different answer sheets and mark on the top of answer sheet section A or B.

SECTION A

Q1: True or false? [0.5 point each]

A. As the miller indices of planes increase interplanner spacing increase
B. At room temperature polystyrene will deform less than polyethylene under a constant force.
C. Diffusivity increase in polymer as the % of crystallinity decrease.
D. For optical microscope, working distance increases with the numerical aperture.
E. X-ray diffraction occurs when atoms of a parallel plane family d_{hkl} in a crystal can produce destructive interference of the scattered rays at specific angles.
F. The closed pack stacking sequence for a defect free FCC crystal can be expressed as ABCABCABBABBABC
G. It is possible to determine the angle between two grains, if the burger vector of the crystal and the spacing between the dislocations are known.
H. Diffusion is faster in a single crystal materials compared to a polycrystalline material.
I. Compared to isotactic polymers, atactic polymers crystallize easily.
J. Considering the annealing of a heavily cold worked brass sample, recrystallization influences the mechanical properties less than the grain growth stage.

Q2: Multiple choice: cross the right one(s) [1 point each].

1. In a BCC unit cell one atom is in contact of following number of the identical atoms
    a) Ten
    b) Eight
    c) Twelve
    d) None of the above
2. The volume of atoms in a selected unit cell divided by the volume of the unit cell is known as
    a) Volume ratio of the unit cell
    b) Volume density of the unit cell
    c) Planer density of the unit cell
    d) Atomic packing factor of the unit cell
3. Vacancies are
    a) Planner defects
    b) Volume defects
    c) Line defects

d) Point defects

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

5. Poisson's ratio refers to
   a) Modulus of rigidity to modulus of elasticity
   b) Longitudinal strain to lateral strain
   c) Engineering strain to true strain
   d) Lateral strain to longitudinal strain

6. Crosslinks between the chains in an elastomer have the effect of
   a) Reducing the elastic modulus
   b) Preventing softening on heating
   c) Increasing crystallinity
   d) Preventing diffusion of gas molecules

7. Like optical microscope in TEM lenses are used for
   a) Magnifying the image
   b) Magnifying the image and confining the incoming beam
   c) Increasing resolution
   d) Decreasing working distance

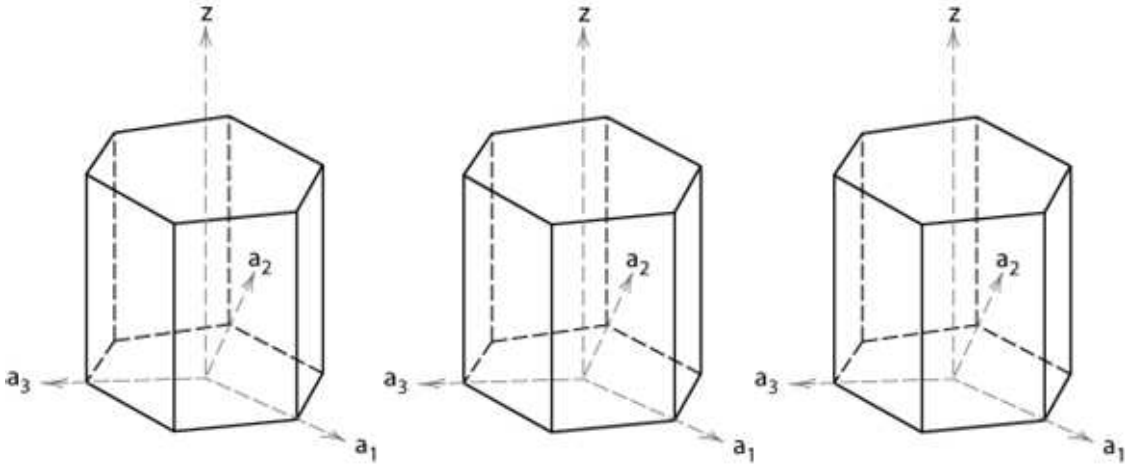
8. A bar of length l is considered to be semi-infinite when
   a) $l>10dt$
   b) $l> 10(dt)^{1/2}$
   c) $l< 10(dt)^{1/2}$
   d) $l=10dt$

where d is the diffusivity of a material through the bar and t is the time for diffusion.

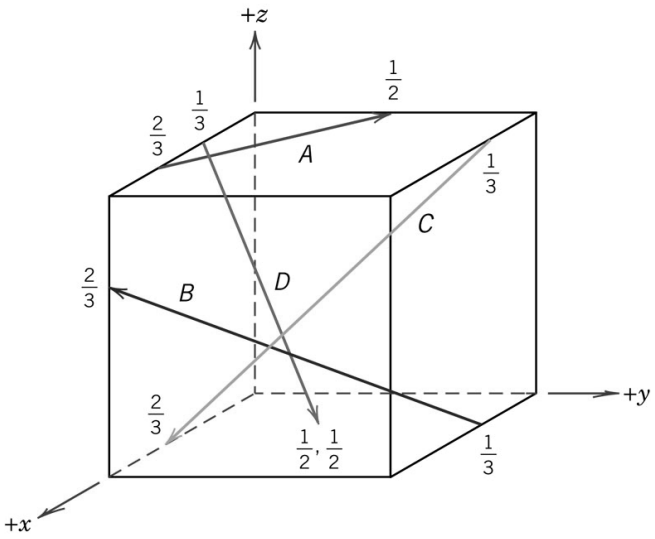
9. Polycrystalline materials are stronger than the single crystal materials, because
   a) Grain boundaries prevent dislocations to move.
   b) Slip planes and directions don't change from one grain to another.
   c) Resolved shear stress doesn't vary from one grain to another.
   d) None of the above is true.

10. Elastic modulus, E for a material depends on the
   a) Magnitude of the applied tensile force
   b) Rate of the deformation
   c) Interatomic distance
   d) Interatomic potential energy

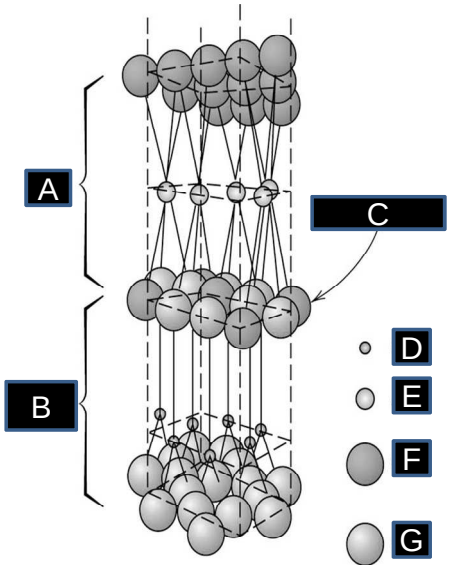
Q3: Draw the planes $(10\bar{1}0)$, $(\bar{1}101)$ and $(\bar{2}112)$ in the hexagonal unit cells below [3]



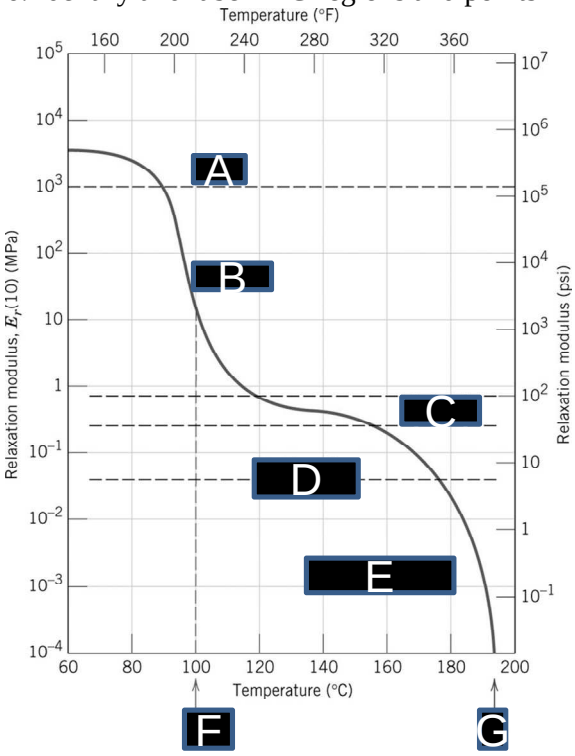
Q4: Determine the Miller indices of the directions in the unit cell below [4]



Q5: Identify the following structure. What is the name of this mineral? Label A-G accordingly. [4.5]



6: Identify and label A-G regions and points in the following diagram. [3.5]



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SECTION B

Q1: Calculate the radius of largest interstitial void in γ iron lattice. The atomic radius of γ iron atom is 0.129 nm. Show the position of these voids in a unit cell diagram and mention the corresponding coordinates. [8]

Q2: For BCC crystal (110), (211), and (321) are the possible slip planes with the common slip direction $[\bar{1}11]$. If a stress of 13.7 MPa is applied in the [001] direction of a single crystal, slip will occur in which of these planes first? Why? [10]

Q3: What kind of structure would you expect for potassium chloride; sodium chloride, cesium chloride, zinc blend, perovskite, fluoride? Why? Ionic radius of Cl^- is 0.181 nm and K^+ is 0.138 nm. Based on your answer determine the followings for the structure. [10]

1. The lattice parameter
2. The density
3. The packing factor

Q4: The results of an X-ray diffraction (λ= 0.07107 nm) produce peaks at the 2θ angels of 20.20, 28.72, 35.36, 41.07, 46.19, 50.9, 55.28, and 59.42. Determine the crystal structure, the indices of the planes producing the peaks, and the lattice parameters of the material. Find the planar density of the plane corresponding to the 6th peak. [12]

Q5: Consider a diffusion couple set up between pure W and W-1 at% Th alloy. After several minutes of exposure at 2000°C, a transition zone of 0.1 mm thickness is established. What is the flux of Th atoms at this time if the diffusion due to (a) volume diffusion, (b) grain boundary diffusion, and (c) surface diffusion? W is a BCC structure with lattice parameter 0.3165 nm. For surface, grain boundary, and volume the pre-exponential factor is 0.47×10^{-3}, 0.74×10^{-3} , and 1×10^{-3} m^2/s respectively and activation energy is 277950, 376750, and 502300 J/mol, respectively for the same. [10]

Q6: If there are twice as many H atoms as C atoms in the polyethylene chain, how many C and H are in each unit cell of crystalline polyethylene? The density of polyethylene is about 0.9972 Mg/m^3. Lattice parameters are 0.741 nm, 0.494 nm, and 0.255 nm. [5]

Q7: Calculate the theoretical volume change accompanying a polymorphic transformation in a pure metal from FCC to BCC. Consider the hard-sphere atomic model and there is no change of atomic volume before and after transformation. [5]