

# ME 253 MATERIALS ENGINEERING

2<sup>nd</sup> Semester 1426/27

Final exam

7/5/1427



## Question 1 (10 points)

- Describe briefly the covalent bond. Give an example.
- Calculate the atomic packing factor of BCC unit cell.
- Gold has an FCC crystal structure and an atomic radius of 0.144 nm. Calculate the density of gold in  $\text{kg/m}^3$ .  $A_{\text{Au}} = 196.97 \text{ g/mol}$ .
- Calculate the linear atomic density (atoms/m) in  $[110]$  direction and the planar atomic density (atoms/ $\text{m}^2$ ) in the  $(111)$  plane in the copper crystal lattice. Copper is FCC and has a lattice constant of 0.361 nm.

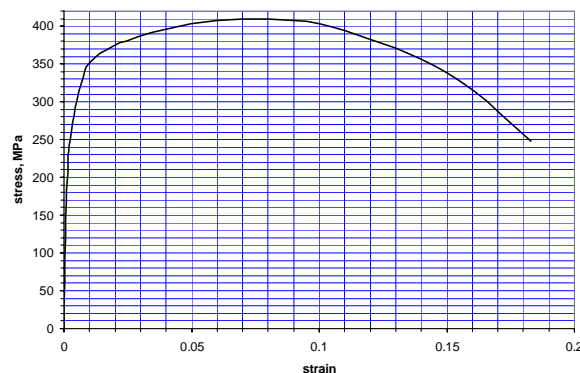
## Question 2 (8 points)

- Calculate the number of vacancies per  $\text{m}^3$  in Al at  $650^\circ\text{C}$ . Given that the energy for vacancy of formation is 0.7 eV/atom, density of Al is  $2.7 \text{ g/cm}^3$  and its atomic weight is 26.98 g/mol. Boltzmann's constant is  $8.62 \times 10^{-5} \text{ eV/K}$ .
- State the types of defects in crystal structures.
- The slip systems in FCC metals is  $\{111\} \langle 1\bar{1}0 \rangle$ . Sketch the  $(111)$  plane in a unit cell and show the possible slip directions.

## Question 3 (12 points)

A specimen of ductile cast iron having a rectangular cross section of dimensions  $4.8 \text{ mm} \times 15.9 \text{ mm}$  is deformed in tension. Using the stress-strain diagram shown, answer the following (show your work on the stress – strain diagram supplied in the extra sheet):

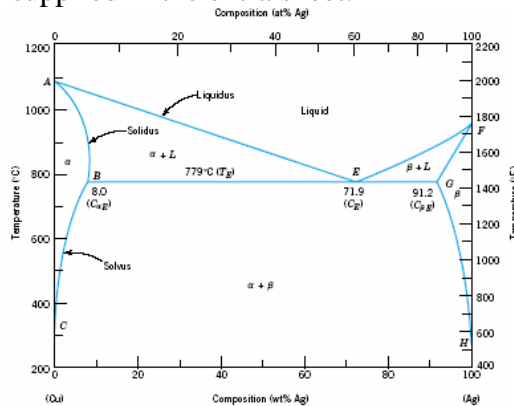
- Compute the modulus of elasticity
- Yield strength at a strain offset of 0.002
- Determine the tensile strength of this alloy
- What is the ductility, in percent elongation
- Compute the modulus of resilience
- Determine the lateral strain at a load of 10 kN given that the Poisson's ratio,  $\nu$  is 0.3
- Determine the true stress and true strain at a load of 24.5 kN
- Using the results obtained in case (g), compute the strain hardening exponent,  $n$  given that the constant  $K$  is 660 MPa



#### Question 4 (10 points)

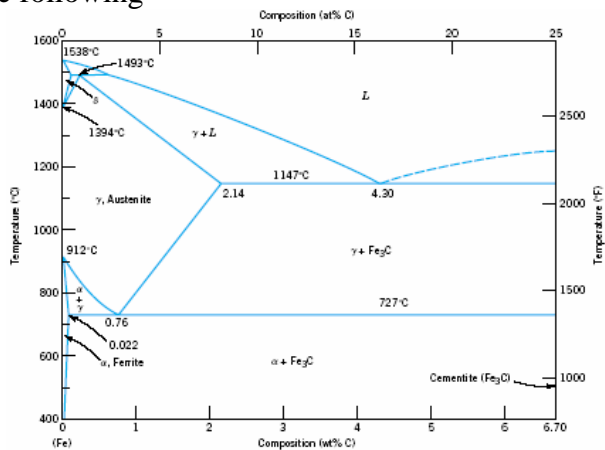
a) For an alloy containing 20 wt% Ag is cooled from 1200 C where it is entirely liquid, determine the following, showing your work on the phase diagram supplied in the extra sheet.

- I. At 900 C determine what are the phases present, weight fraction of each phase, and sketch the microstructure.
- II. At 700 C determine what are the phases present, weight fraction of each phase, and sketch the microstructure.



b) Using the iron carbon phase diagram shown, do the following

- I. Write the eutectic reaction showing the chemical composition of phases.
- II. Write the eutectoid reaction showing the chemical composition of phases.
- III. Sketch the microstructure at room temperature for a hypoeutectoid (0.4 wt% C), eutectoid (0.76 wt% C) and hyper eutectoid (1.0 wt% C) steel alloy.

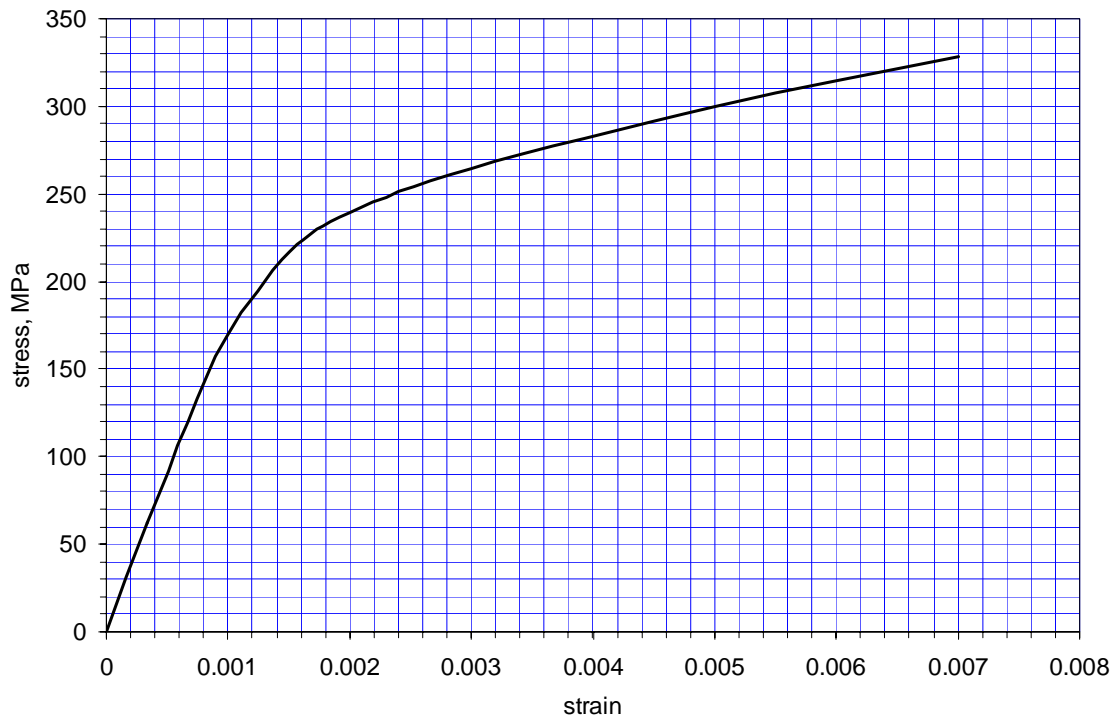
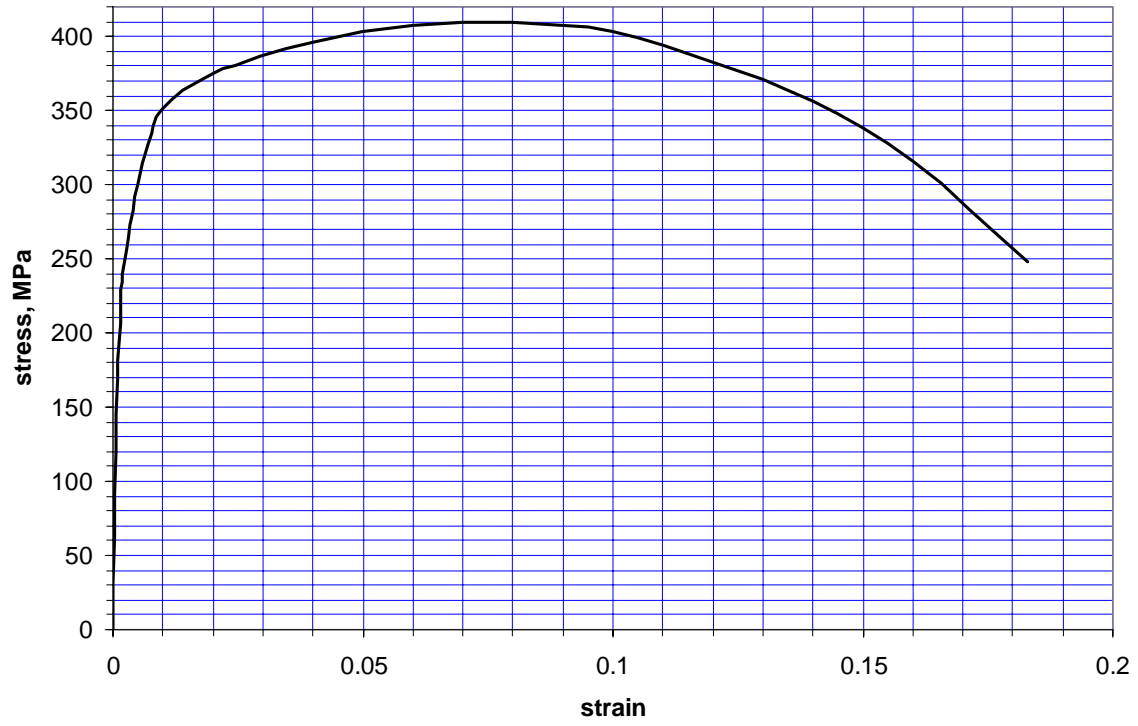


#### Question 5 ( 5points)

1. A crystal that has no defects (free of dislocations) would be ..... a crystal that contain defects.  
a. softer than                      b. stronger than                      c. as strong as
2. Pearlite is composed of .....  
a. one phase                      b. two phases                      c. three phases
3. Face center cubic crystal structure has slip systems of the family { ... } planes < ... > directions.  
a. {111} <110>                      b. {110} <111>                      c. {211} <111>
4. HCP metals are considered ... .. in room temperature deformation  
a. brittle                      b. ductile                      c. as ductile as fcc metals.
5. During plastic deformation dislocation density.....  
a. increase                      b. decrease                      c. do not change
6. Plastic deformation is due to  
a. resolved shear stress                      b. normal stress                      c. bending stress.
7. Ionic bonded materials have .....melting temperatures.  
a. high                      b. low                      c. extremely low
8. Pure iron has ..... allotropic (polymorphism) forms.  
a. one                      b. two                      c. three
9. Eutectic composition alloys have .....melting temperature compared to their parent metals.  
a. less                      b. higher                      c. same
10. All strengthening mechanisms ..... dislocation motion  
a. depend on impeding                      b. depend on facilitating                      c. has nothing to do with

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### Question (3)



## Question (4)

