ME 254
MATERIALS ENGINEERING
1st Semester 1431/1432
3rd Mid-Term Exam
(1 hr)

Name: **No.:**

Question 1

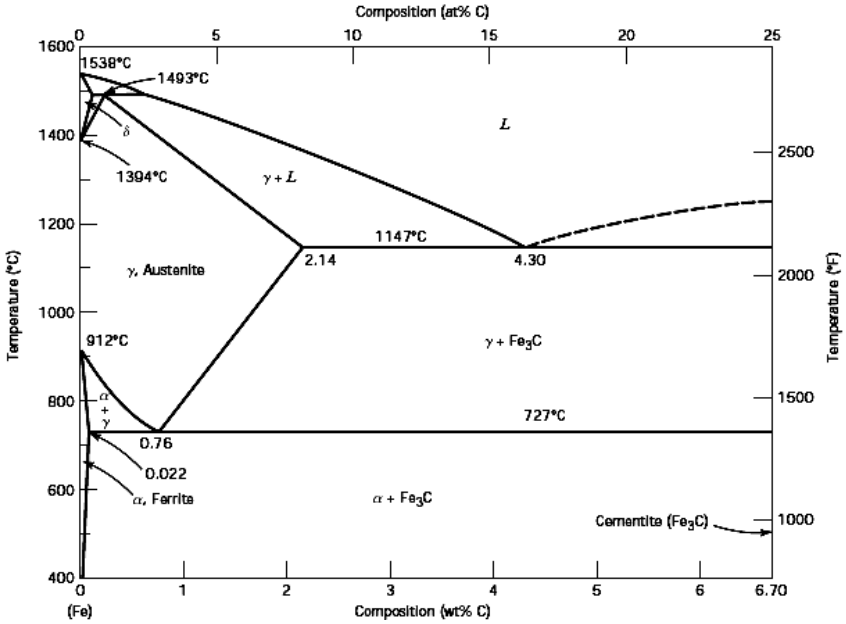
a) Answer the following:
1. Do all metals have the same slip system? Why or why not?
2. For each of edge, screw and mixed dislocations, cite the relationship between the direction of the applied shear stress and the direction of dislocation line motion.
3. Briefly cite differences between recovery and recrystallization processes.
4. Briefly explain why HCP metals are typically more brittle than FCC and BCC metals.

b) Sometimes cos ϕ cos λ in the equation of resolved shear stress is termed the *Schmid factor*. Determine the magnitude of the Schmid factor for an FCC single crystal oriented with its [120] direction parallel to the loading axis. Slip may occur on the (111) plane and in the $[01\bar{1}]$ direction.

Question 2

a) Schematically sketch simple isomorphous phase diagrams.
1. On these diagrams label the various phase regions.
2. Label liquidus, solidus, and solvus lines.

b) For a 99.65 wt% Fe–0.35 wt% C alloy at a temperature just below the eutectoid, determine the following:
1. The fractions of total ferrite and cementite phases.
2. The fractions of the proeutectoid ferrite and pearlite.
3. The fraction of eutectoid ferrite.



ME 254
MATERIALS ENGINEERING
1st Semester 1434/1435
3rd Mid-Term Exam
(2 hrs)

Name: **No.:**

Question 1 (7 marks)

a) Explain briefly two diffusion mechanisms. **(2 marks)**
b) Explain what is meant by diffusion flux. **(2 marks)**
c) A plate of iron is exposed to a carburizing (carbon-rich) atmosphere on one side and a decarburizing (carbon-deficient) atmosphere on the other side at (700 ºC). If a condition of steady state is achieved, calculate the diffusion flux of carbon through the plate if the concentrations of carbon at positions of 5 and 10 mm (5×10^{-3} and 10^{-2} m) beneath the carburizing surface are 1.2 and 0.8 kg/m3, respectively. Assume a diffusion coefficient of 3×10^{-11} m^2/s at this temperature. **(3 marks)**

Question 2 (10 marks)

a) Do all metals have the same slip system? Why or why not? **(2 marks)**
b) Explain by drawing the steps of annealing, (recovery, recrystallization and grain growth) and its importance. **(3 marks)**
c) Briefly explain why HCP metals are typically more brittle than FCC and BCC metals. **(2 marks)**
d) Sometimes cos ϕ cos λ in the equation of resolved shear stress is termed the *Schmid factor*. Determine the magnitude of the Schmid factor for an FCC single crystal oriented with its [120] direction parallel to the loading axis. Slip may occur on the (111) plane and in the $[01\bar{1}]$ direction. **(3 marks)**

Question 3 (10 marks)

a) Explain briefly the strengthening mechanisms in metals. **(3 marks)**
b) Name the two most common hardness-testing techniques; note two differences between them. **(2 marks)**
c) In normal motion, the compressive load exerted on the hip joint is 2.5 times body weight.
   1. Calculate the corresponding stress (MPa) on an artificial hip implant with cross sectional area of 5.64 cm^2 in a patient weighing 800 N.
   2. Calculate the corresponding strain if the implant is made of Ti-6Al-4V alloy which has an elastic modulus of 124 GPa.
   3. What is the shear modulus of the alloy? The Poisson's ratio is 0.35. **(5 marks)**

Question 4 (9 marks)

(a) The Ni-Cu phase diagram is given below:
1- Draw the cooling curve for an alloy of Ni- 20 wt. % Cu. What are the liquidus and solidus temperature of this alloy?

2- For the alloy of Ni- 40 wt. % Cu, at 1300 ^{o}C:

- Find the equilibrium phases and their chemical composition.
- The weight fraction of the present phases.
- Draw the microstructure of this alloy at 1200 ^{o}C.

Chose the correct answer, (4 marks)

1. The ratio of relative contraction to the expansion strain or transverse strain to the axial strain is called----------
   a. shear modulus b. modulus of resilience c. poisson's ratio
2. Resilience is the ------- energy absorbed in the tension test.
   a. Elastic b. Plastic c. Total
3. During plastic deformation dislocation density……..
   a. Increases b. decreases c. does not change
4. Eutectic composition alloys have ……..melting temperature compared to their parent metals.
   a. less b. higher c. same
5. The ability of the metal to plastically deform depends on the ability of the……..
   a. Dislocation to move b. restricting or hindering dislocation c. grain boundary to slid
6. The strain fields that are exist around dislocations is.....
   a. Strain rate b. plain strain c. lattice strain.
7. Iron is allotropic it goes from ---------- when heated up to 910 ^{o}C.
   a. BCC→ FCC b. FCC→ HCP C. FCC→BCC
8. Diffusion is the phenomenon of material transport by----------
   a. dislocation motions b. atomic motions c. slipping

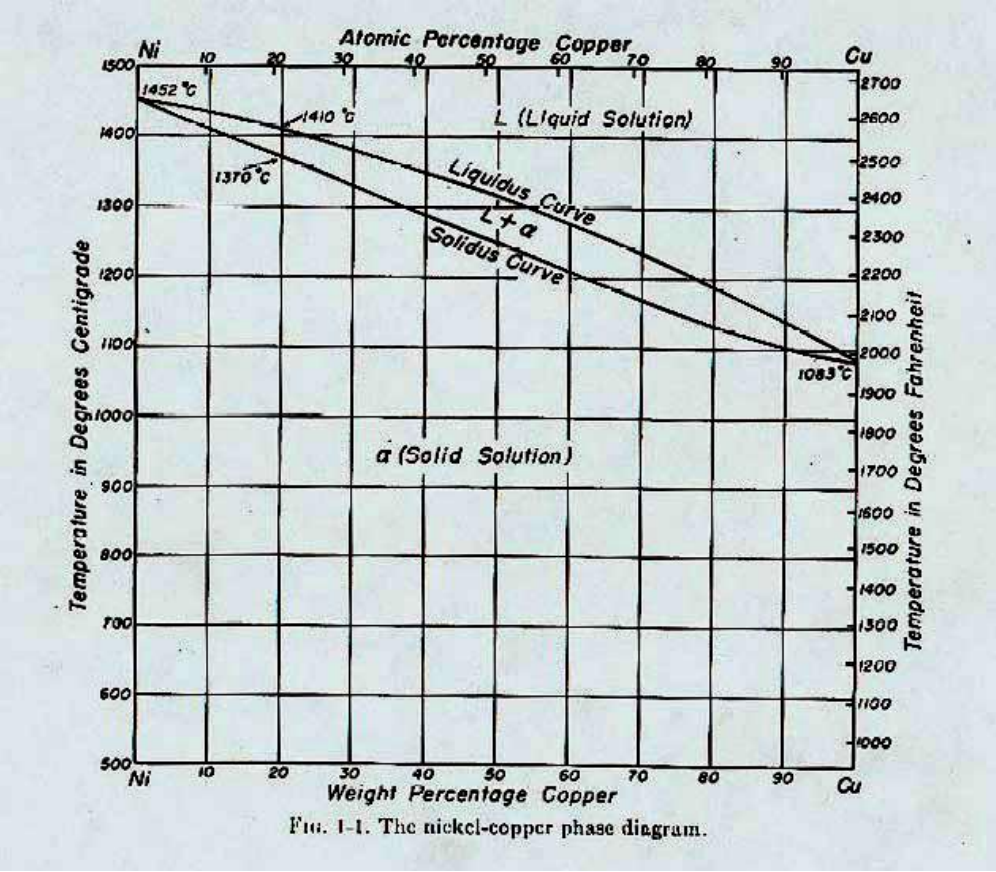


Fig. 1-1. The nickel-copper phase diagram.

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2nd Mid-Term Exam
(1.5 hrs)

Name: **No.:**

Question 1

(a)

1. Briefly explain the difference between self-diffusion and interdiffusion.
2. Compare interstitial and vacancy atomic mechanisms for diffusion.

(b) **Chose the correct answer**

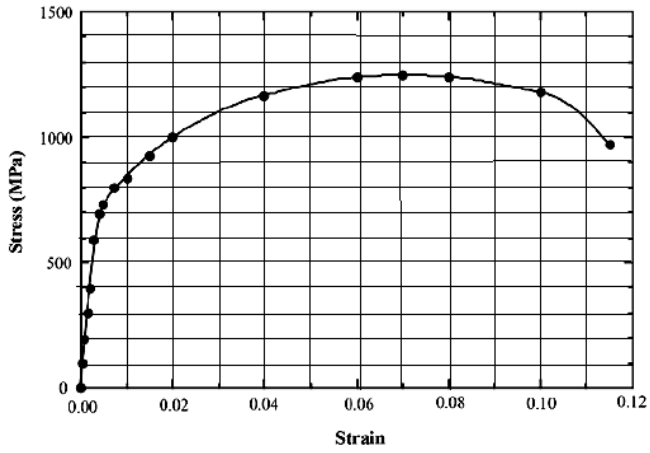
9. Ductility is the ---------strain sustained up to failure
   a. Maximum b. Minimum c. Medium
10. Resilience is the ------- energy absorbed
    a. Elastic b. Plastic c. Total
11. Plastic deformation in metals normally happens by -------.
    a. dislocation slip b. Point defects c. grain boundary sliding
12. During plastic deformation dislocation density……..
    a. increase b. decrease c. do not change
13. Recovery of the cold worked metals …….. their mechanical properties.
    a. increases b. decreases c. does not change
14. During strain hardening in tension test, uniform tue strain is…….. strain hardening exponent n.
    a. Equal to b. less than c. greater than

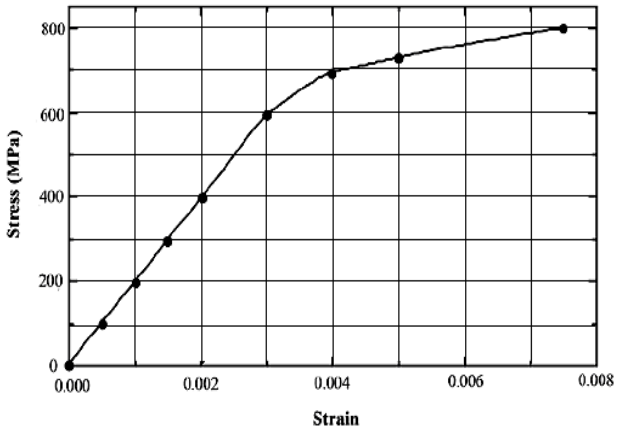
(c) A sheet of steel 1.5 mm thick has nitrogen on both sides at 1200 °C and achieved steady state diffusion. The diffusion coefficient of nitrogen in steel at this temperature is 6×10^{-11} m^2/s, and the diffusion flux is found to be 1.2×10^{-7} kg/m^2-s. The concentration of nitrogen at the high pressure surface is 4.0 kg/m^3. How far into the sheet from this high pressure side will the concentration be 2.0 kg/m^3.

Question 2

A cylindrical specimen of a stainless steel having a diameter of 12.8 mm and a gauge length of 50.8 mm is pulled in tension. Use the stress–strain curve shown in Fig. 3 to determine the following:

a) Compute the modulus of elasticity.
b) Determine the yield strength at a strain offset of 0.002.
c) Determine the tensile strength of this alloy.
d) What is the approximate ductility, in percent elongation?
e) Compute the modulus of resilience.
f) Determine the lateral strain at a load of 10 kN given that the Poisson's ratio, *v* is 0.3.
g) Determine the true stress and true strain at a load of 12.5 kN
h) Using the results obtained in case (g), compute the strain hardening exponent, *n* given that the constant *K* is 660MPa


1500
1000
500
0
Stress (MPa)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
Strain


800
600
400
200
0
Stress (MPa)
0.000
0.002
0.004
0.006
0.008
Strain

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Name: **No.:**

Question 1

(d)

3. Briefly explain the difference between self-diffusion and interdiffusion.
4. Compare interstitial and vacancy atomic mechanisms for diffusion.

(e) **Chose the correct answer**

15. Ductility is the ---------strain sustained up to failure
    a. Maximum b. Minimum c. Medium
16. Resilience is the ------- energy absorbed
    a. Elastic b. Plastic c. Total
17. Plastic deformation in metals normally happens by -------.
    a. dislocation slip b. Point defects c. grain boundary sliding
18. During plastic deformation dislocation density……..
    a. increase b. decrease c. do not change
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k) Determine the tensile strength of this alloy.
l) What is the approximate ductility, in percent elongation?
m) Compute the modulus of resilience.
n) Determine the lateral strain at a load of 10 kN given that the Poisson's ratio, *v* is 0.3.
o) Determine the true stress and true strain at a load of 12.5 kN
p) Using the results obtained in case (g), compute the strain hardening exponent, *n* given that the constant *K* is 660MPa

Question 3

a. Consider the simple cubic crystal structure which has a cubic unit cell with atoms positions at each of the eight corners. The atoms touch one another along the edges. The slip system for this crystal

structure is (100) [010]. A single crystal is stressed in tension along the [110] direction and yielded at a stress level of 13 MPa. Calculate the critical resolved shear stress.

b. Discuss three strengthening mechanisms in metals.
c. How can ductility lost during cold working be restored.

Question 4

For the Cu-Ni solid solution phase diagram, and for an alloy having a composition of 50wt%Ni – 50 wt% Cu, calculate the following:

a) Name the phases present on the diagram.
b) At 1270 C what are the phases present and weight fraction of each phase.
c) At what temperature does solidification starts, and what is the chemical composition of the first solid phase to form.
d) At what temperature does solidification ends, and what is the chemical composition of the last liquid prior to complete solidification.