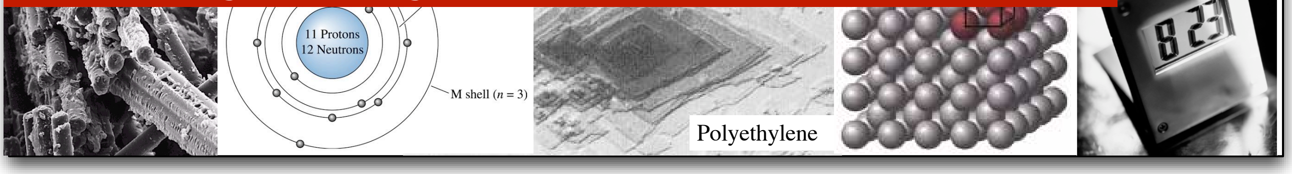
Spring 2006 **Engineering Material**



Final Exam

Tuesday, June 6, 2006

Duration: 3 hours

Open Book Exam

Write clearly your derivations and answers on the answer sheet

Name:

ID#:

Problem I [20 Pts]

1. Explain why a thermoplastic polymer with high crystallinity is desirable for conditions of exposure to high temperatures

2. When nylon reinforcing cord was first used in rubber tires, the tires developed "flat spots: as the vehicle remained stationary overnight. What accounts for this phenomenon, and why is the return to the round shape more rapid in the summer that in the winter

3. Explain the following effects with respect to the glass transition temperature Tg
(a) an increase in pressure on the polymer increases its glass transition temperature
(b)The ration Tg/Tm increases as the percentage of crystallinity decreases in a copolymer

4. Explain why a high degree of crystallinity may be difficult to achieve in brached polymers, in atactic polymers and in copolymers

5. Name three mechanisms of plastic deformation.

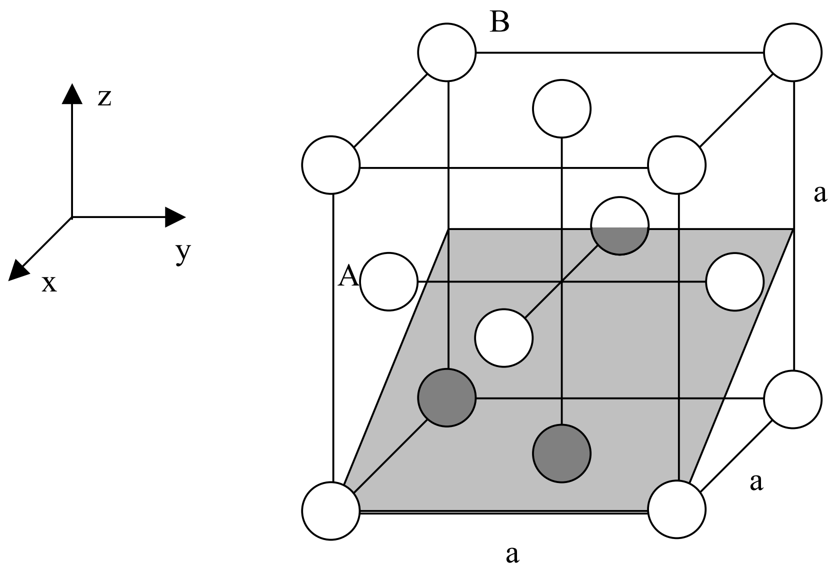
6. Name four main mechanisms of strengthening for metals.

7. What is recrystallisation? Is it possible to use the phenomenon of recrystallisation for the benefit of strengthening a metal? If yes, explain why.

8. Discuss the mechanical properties of ceramics and explain the brittleness of ionically bonded ceramics.

Problem II [15 Pts]

Shown below is a face-centred cubic unit cell.



(a) Write down the miller indices of the shaded plane according to the atomic co-ordinate system given. (2 points)

(b) Mark ALL <111> directions in this unit cell and label them with their indices. (4 points)

(c) Calculate the atomic packing factor of this structure (show your calculation procedure). (4 points)

(d) Pure iron undergoes an allotropic phase transformation from fcc (austenite) to bcc (ferrite) on cooling at 912°C. Calculate the percent change in atomic size accompanying this transformation, assuming that the volume change is zero. (5 points)

Problem III [20 Pts]

(a) Explain phases of austenite and ferrite in terms of their structures and chemical make- ups. What is pearlite?

(b) What are the solubility limits of carbon in the austenite and ferrite?

(c) Where do carbon atoms reside inside austenite (name(s) of the position(s))?

- Use a graphical presentation to illustrate the position(s) (illustrate only one if more than one).
- How many of these positions are there in one unit cell?
- If all these positions are occupied by carbon atoms, what would be the solubility limit, in terms of weight percentage (show your calculation)?
- If this value (the value calculated right above) is drastically different from that read from the phase diagram, offer your brief explanation.

(d) Calculate the density of pure Fe at room temperature, assuming an atomic radius of Fe of 0.124 nm.

(e) What would you call a Fe-0.4%C alloy (in engineering terms)? What phases will it contain when cooled from molten state to (i) 1000 °C, (ii) 730 °C, and (iii) 600 °C (you do not need to determine the portions of each phase)?

(f) Determine the weight percentages of pro-eutectoid ferrite and pearlite in this alloy at room temperature.

Problem IV [15 Pts]

A cylindrical piece of steel 25 mm in diameter is to be quenched in moderately agitated oil. Surface and center hardnesses should b at least 55 and 50 HRC, respectively. Which of the following alloys will satisfy these requirements 1040, 5140, 4340, 4140 and 8640? Justify your choices

11.D8 A one-inch diameter steel specimen is to be quenched in moderately agitated oil. We are to decide which of five different steels will have surface and center hardnesses of at least 55 and 50 HRC, respectively.

In moderately agitated oil, the equivalent distances from the quenched end for a one-inch diameter bar for surface and center positions are 3 mm (1/8 in.) and 8 mm (11/32 in.), respectively [Figure 11.16(b)]. The hardnesses at these two positions for the alloys cited (as determined using Figure 11.13) are given below.

Alloy	Surface Hardness (HRC)	Center Hardness (HRC)
1040	50	30
5140	55	47
4340	57	57
4140	56	54
8640	56	52.5

Thus, alloys 4340, 4140, and 8640 will satisfy the criteria for both surface and center hardnesses.

Problem V [10 Pts]

A solder manufacturer wishes to make a batch of solder having the eutectic composition. On hand is a supply of 250 kd of electrical solder scrap containing 60 wt% Sn-40wt% Pb, and 1250 kg of plumbing solder scrap containing 60wt%Pb -40wt%Sn. If all o the scrap is to be melted, how much pure Sn should be added to achieve the desired Sn composition.

Problem VI [20 Pts]

Iron Titanate, $FeTiO_3$ forms in the ilmenite crystal structure that consists of an HCP arrangement of O^{2-}

a. What type of interstitial site will the Fe^{2+} ions occupy, explain.

b. Which type of interstitial site will the Ti^{4+} ions occupy, explain

c. What fraction of the total tetrahedral sites will be occupied

d. What fraction of the total octahedral sites will be occupied