Name_____________________

ME 328 Exam #3
Winter 2003-04

Closed book, closed notes, no help from other students.
Show all work for full credit.
All justifications should use materials engineering principles.

Questions 1-3 (6 pts): Choose the best answer from a) - d) (answers can be used more than once).

a) grain size refinement
b) solid solution strengthening
c) strain hardening
d) none of these

_a_ 1. This type of strengthening relies on the fact that it is difficult for dislocations to move across grain boundaries.

_d_ 2. This strengthening mechanism can be accomplished by heating the metal to an elevated temperature for a prescribed length of time.

_c_ 3. Some manufacturing processes, such as cold rolling, result in a decrease in the ductility of the part as a result of this strengthening mechanism.

4. (4 pts) In an effort to do grain size refinement we heat a cold worked brass part (condition 1). We heat it for the prescribed time, but realize after cooling that the temperature was 50°C too high. We now have a part heated for the correct time but incorrect temp (condition 2). In an effort to fix this, we reheat that part using the correct time and the correct temperature (condition 3).

The part is/was strongest at condition	a) 1	b) 2	c) 3
The part is/was weakest at condition	a) 1	b) 2	c) 3

5. (4 pts) In the figure shown, we see that for iron, recrystallization temperature goes to infinity for cold work less than about 5%. Explain this phenomenon from a microstructural perspective. (Hint: the best answer will use phrases such as: lattice strain, driving force, internal energy, etc.)

There is little plastic strain and little elastic strain stored if CW < 5%. The lattice is not highly distorted. Hence the thermodynamic driving force behind the formation of new grains is insufficient to produce recrystallization.

6. (2 pts) Circle the most accurate statement about dislocations.
    a. As plastic deformation proceeds the dislocation density diminishes, making the material stronger.
    b. The dislocation is a point defect in crystals which accounts for the fact that their yield strength is less than atomic theory predicts.
    c. A dislocation moving through a crystal lattice produces an amount of slip that is proportional to the length of the dislocations path.
    d. The dislocation is a line defect in crystals whose motion through a crystal produces a fixed amount of slip.
    e. As plastic deformation proceeds, the dislocation density increases, thereby weakening the crystalline material.

7. (2 pts) Circle the letter of each true statement about solid solution strengthening.
    a. Solute atoms disturb the crystalline lattice which promotes the motion of dislocations.
    b. Solute atoms which are nearly the same size as the atoms in the crystal have a weaker strengthening effect.
    c. The effect of solute atom size on strength is given by $\sigma_{ys} = \sigma_o + k_y d^{1/2}$.
    d. Impurity atoms impede dislocation motion, strengthening the crystal.
    e. The extra size of the impurities increase grain size, making the crystalline material stronger.

8. (5 pts) Match the best word with each definition shown

_b_ Exhibiting different values of a property in different crystallographic directions.
_l_ The formation of a new set of strain-free grains within a previously cold-worked material.
_i_ A solid solution in which the solute atoms must be much smaller than the solvent atoms.
_m_ Plastic deformation as the result of dislocation motion.
_e_ The crystal structure that permits the easiest motion of dislocations, resulting in materials with high ductility.

a) alloy
b) anisotropic
c) body-centered cubic
d) crystalline
e) face-centered cubic
f) grain boundary
g) grain growth
h) hexagonal close-packed
i) interstitial solid solution
j) isotropic
k) recovery
l) recrystallization
m) slip
n) substitutional solid solution

9. a. (5 pts) A sheet of annealed pure copper is cold-worked from a thickness of 20 mm to a thickness of 12 mm, while maintaining constant width. What are the expected values of yield strength, (ultimate) tensile strength, and ductility after this process?

Yield strength____310 +- 10__(MPa)

Tensile strength ___350 +- 10_____(MPa)

Ductility ____5+-1______ % elongation

b. (3 pts) Is it possible to produce a copper sheet that has ultimate tensile strength in excess of 300 MPa while maintaining a ductility of at least 10% elongation? If so, describe how. If not, why not?

Find the CW between about 20 and about 28% produces an acceptable ductility and UTS