UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Materials Science and Engineering

Professor R. Gronsky Fall Semester 2001

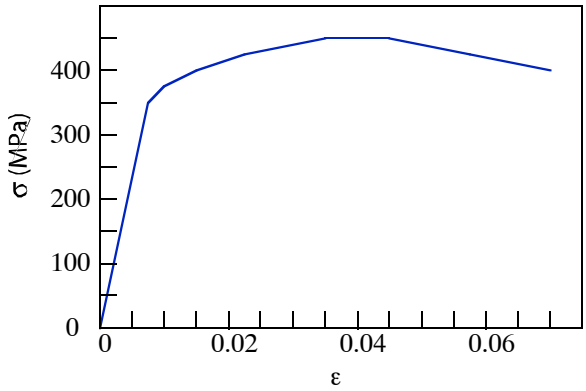
ENGINEERING 45

Midterm #1
Solutions

Question 1 The mechanical properties of materials are described in engineering terms using simple concepts and normalized parameters. Choose the *best* answers from those presented below for 2 points each.

a. The data at right could have been obtained from a
- ☒ uniaxial tensile test
- ☐ three-point bend test
- ☐ Brinell hardness test

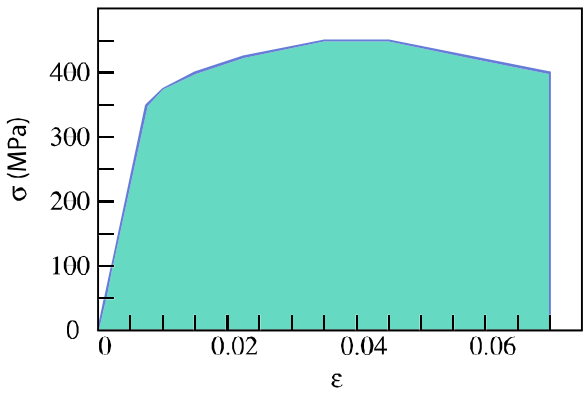
b. This data reveals that the sample had a yield strength of
- ☒ 350 MPa
- ☐ 400 MPa
- ☐ 450 MPa



c. Necking would have been observed in this sample when the stress reached
- ☐ 350 MPa
- ☐ 400 MPa
- ☒ 450 MPa

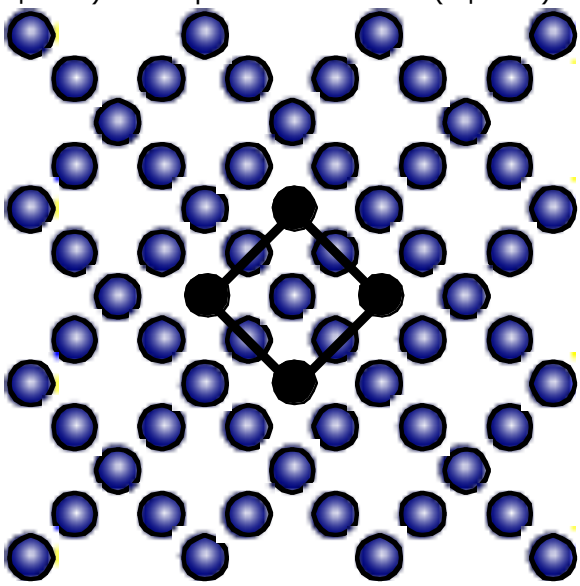
d. Dislocations began to move in this sample when the strain exceeded
- ☐ 0.0475
- ☐ 0.0375
- ☒ 0.0075

e. The construction at right represents
- ☐ percent elongation to failure
- ☒ estimate of toughness
- ☐ modulus of elasticity



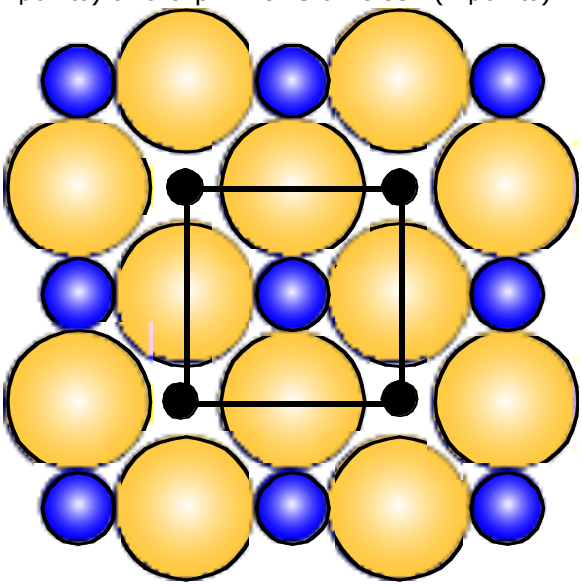
Question 2 A lattice is an array of points in space with identical environment. A primitive unit cell, also called "simple," is one that contains only a single lattice point.

a. Label the lattice (4 points) and a primitive unit cell (2 points).



(4 points) Number of atoms in the unit cell = 3 atoms

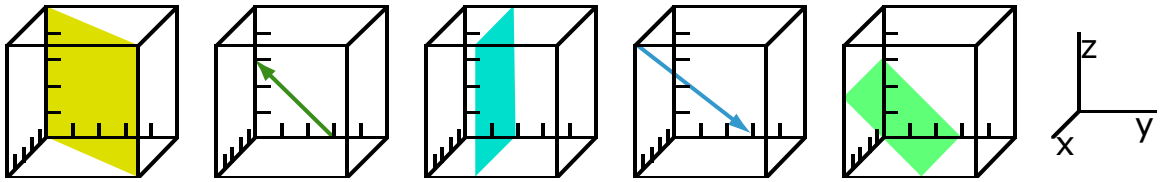
b. Label the lattice (4 points) and a primitive unit cell (2 points).



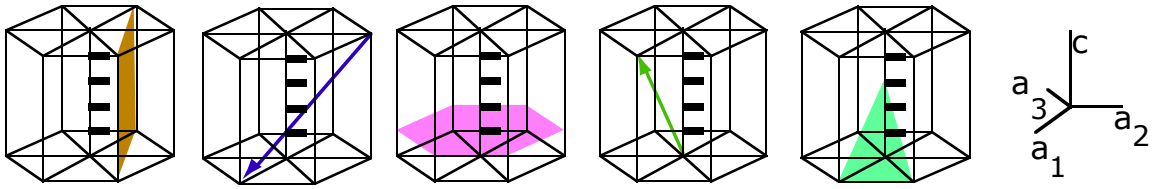
(4 points) Number of atoms in the unit cell = 3 atoms (1 small, 2 large)

Question 3 Identify the lattice directions and lattice planes shown in the sketches below for 3 points each. Note especially the scale markings and use them to precisely identify any fractional intercepts. Be sure that your answer satisfies the special requirement of the four-index Miller-Bravais notation that

$$h + k = -i.$$



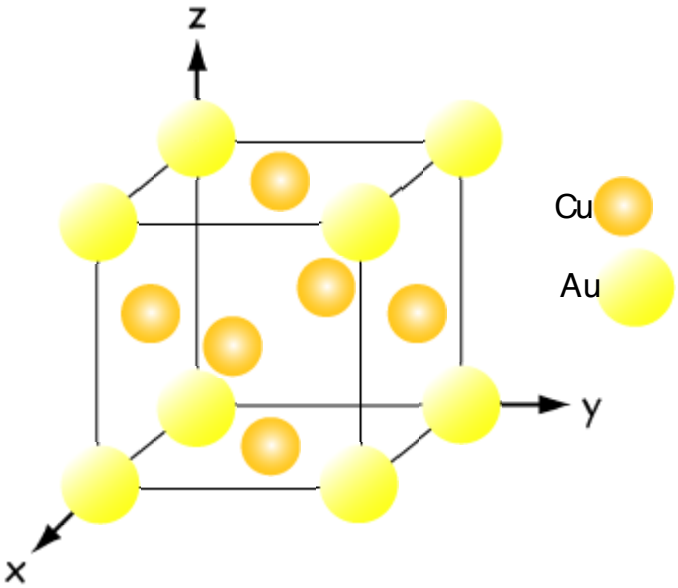
a. $(\bar{1}10)$ b. $[0\bar{1}1]$ c. (050) d. $[\bar{5}3\bar{5}]$ e. (055)



f. $(\bar{1}2\bar{1}0)$ g. $[1\bar{1}0\bar{1}]$ h. (0005) i. $[2\bar{1}\bar{1}3]$ j. $(30\bar{3}5)$

Question 4 An alloy of copper and gold forms a special "ordered" crystal structure known as $L1_2$ in the *Strukturbericht* notation. It has a cubic unit cell with Au atoms at the corners and Cu atoms at the face centers.

a. Draw and label the contents of the unit cell (5 points)



b. Show how to count all of the atoms in the unit cell and use your result to specify the chemical formula of this ordered alloy? (5 points)

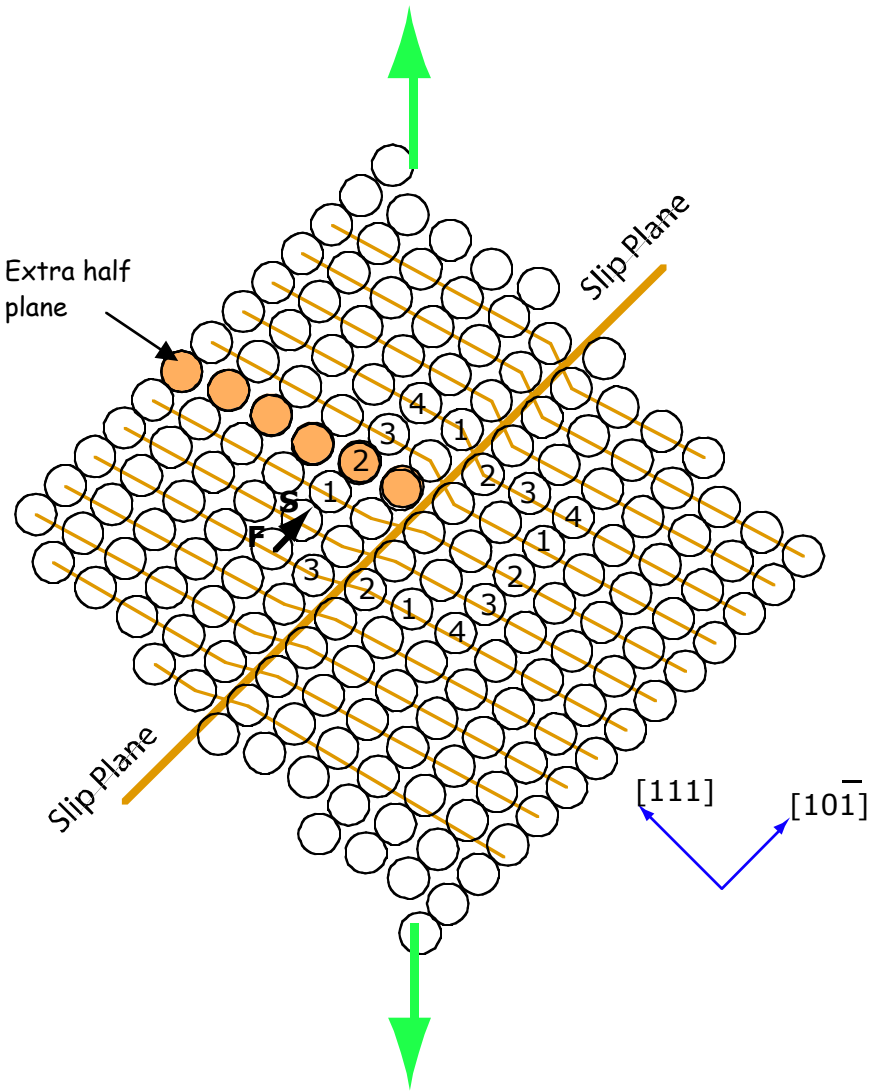
Au at corners = 8 x 1/8 = 1 Au atom in unit cell
Cu at face centers = 6 x 1/2 = 3 Cu atoms in unit cell
Ratio = 3 Cu for every 1 Au
Chemical formula = **Cu_3Au**

c. Now specify a Bravais lattice (5 points) AND a motif (5 points) that appropriately describe this ordered $L1_2$ crystal structure.

Bravais lattice = SIMPLE CUBIC
Motif = 1 Au atom at 0,0,0 and
3 Cu atoms at 1/2, 1/2, 0; 1/2, 0, 1/2; and 0, 1/2, 1/2

Question 5 Consider the following schematic of the atomic arrangements in an fcc crystal (lattice constant = *a*) that has been subjected to an external load of sufficient magnitude to exceed the critical resolved shear stress for motion of dislocations on the slip plane pictured here.
Find the *edge dislocation* in the fcc crystal illustrated below...

a. Locate and label the extra half plane (5 points).
b. Locate and label the slip plane (5 points).
c. Trace an FSRH Burgers circuit and draw in the Burgers vector (5 points).
d. Now specify the Burgers vector's magnitude and direction with respect to the fcc crystalline coordinate system indicated here (5 points). Remember that **b** is a lattice vector representing the shortest lattice translation.



Burgers vector: $\vec{b} = \frac{a}{2}\left[10\bar{1}\right]$.

Note that this is exactly one interatomic spacing along the close-packed direction of slip shown above.