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

Professor R. Gronsky

Fall Semester 2000

ENGINEERING 45

MIDTERM #1

NAME:_____
(Please Print Clearly)

This is a *closed book* Exam. You must work independently, and no reference materials are permitted.

Please use only the pages given here, and write your answers in the spaces provided.

Question 1 Choose the *best* answer. (**2** points for each correct answer)

a The directional atomic bonds include

① ionic bonds.

② covalent bonds.

③ metallic bonds.

b Metallic bonding is generally NOT responsible for

① translucency.

② malleability.

③ ductility.

c The van der Walls bond is a

① primary bond in polymeric materials.

② dipole-dipole interaction.

③ charge-transfer fluctuation.

d The near-neighbor distances between anions and cations in a ceramic

① are established by a force balance.

② are established by a charge balance.

③ are established by the coordination number.

e Crystal structure is conventionally described using

① only one unit cell of the Bravais lattices.

② lattice and motif.

③ fcc, bcc, or hcp.

f During elastic deformation, a metal experiences

① necking.

② bond breaking.

③ bond stretching.

g Plastic deformation in metallic alloys is the result of

① necking.

② dislocation motion.

③ the uniaxial tensile test.

h Hardness is a measure of

① resistance to surface penetration.

② resistance to deformation in the elastic limit.

③ resistance to formation of circular indentations.

i Young's modulus characterizes what property of a material?
- ① slope.
- ② rigidity.
- ③ elasticity.

j Materials with the greatest toughness
- ① have the greatest ductility
- ② have the highest Young's modulus.
- ③ have a combination of strength and ductility.

k The percent elongation of a material at failure defines its
- ① fracture strength.
- ② tougness.
- ③ ductility.

l Structural engineering steels are sometimes found to be brittle
- ① at high values of strain
- ② at low ambient temperatures.
- ③ at moderate concentrations of carbon.

m Edge and screw dislocations differ in what way?
- ① magnitude of their Burgers vectors.
- ② line direction is straight (edge) or curved (screw).
- ③ angle between Burgers vector and line direction.

n Interstitial defects
- ① come from impurity atoms on lattice sites
- ② are usually associated with vacant lattice sites.
- ③ are found between lattice sites.

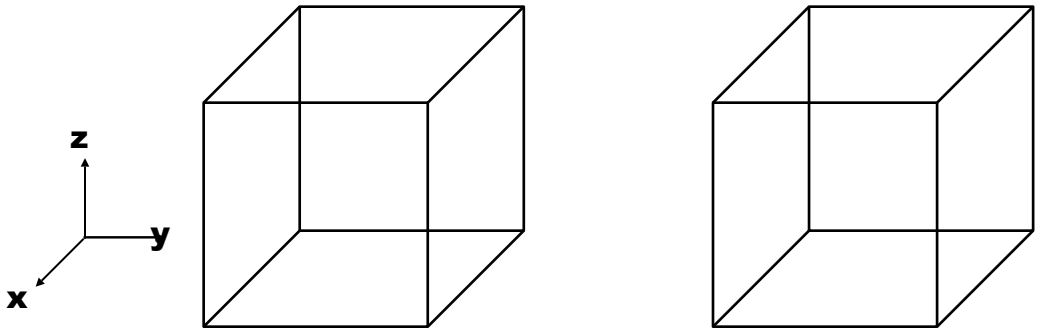
o Diffraction distinguishes fcc alloys from bcc alloys by
- ① the number of hkl peaks.
- ② the angular positions of the hkl peaks.
- ③ the shape of the hkl peaks.

Question 2 (**20** points)

A piezoelectric ceramic is suspected to have oxygen anions (O^{2-}) at locations

$\mathbf{0\frac{1}{2}\frac{1}{2}}$, $\mathbf{\frac{1}{2}0\frac{1}{2}}$, $\mathbf{\frac{1}{2}\frac{1}{2}0}$, barium cations (Ba^{2+}) at $\mathbf{000}$, and titanium cations (Ti^{4+}) at $\mathbf{\frac{1}{2}\frac{1}{2}\frac{1}{2}}$.

Draw and label the contents of a unit cell of this material (**5** points)



What is its chemical formula? (**5** points)

Chemical formula =

Specify and draw the Bravais lattice (**5** points) and motif (**5** points) that defines this structure.

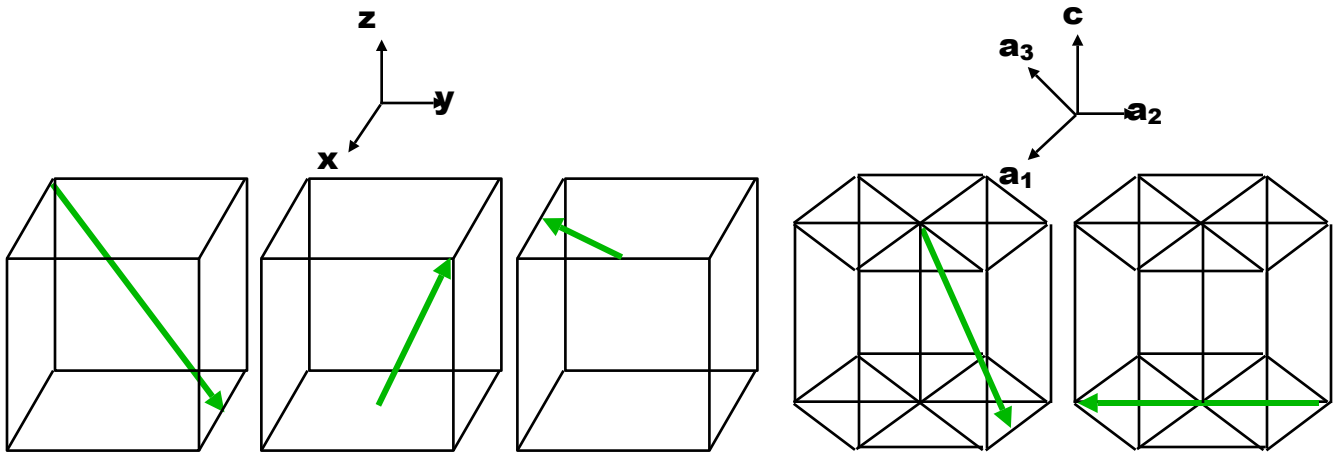
Bravais Lattice =

Motif =

Question 3: (**30** points)

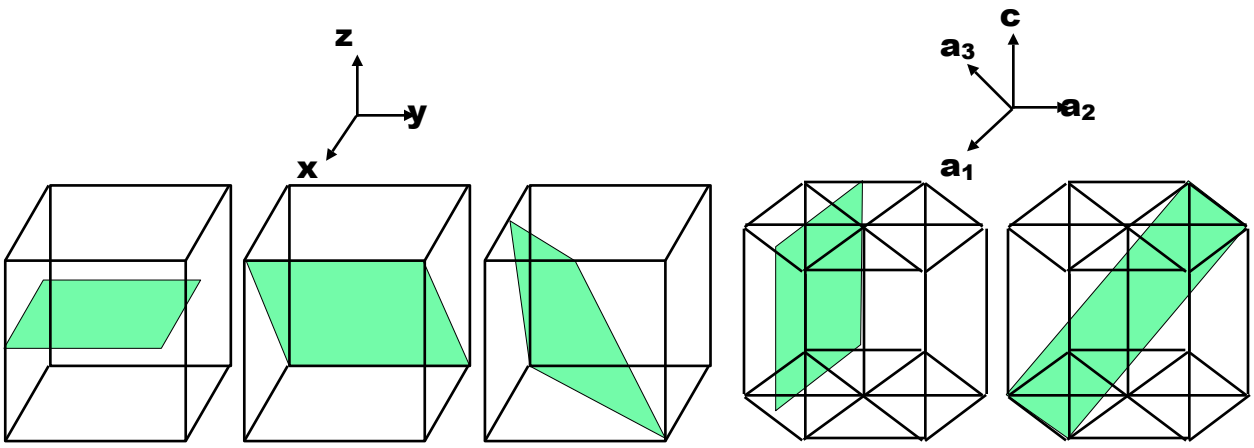
Identify each of the lattice *directions* and *planes* in the following figures relative to the coordinate axes shown. All intersections between the vectors and the unit cells occur at corners or midpoints of cell edges or face centers. Use appropriate Miller indices or Miller-Bravais notation and write answers in boxes provided.

Lattice Directions (**3** points each)



a ____ b ____ c ____ d ____ e ____

Lattice Planes (**3** points each)



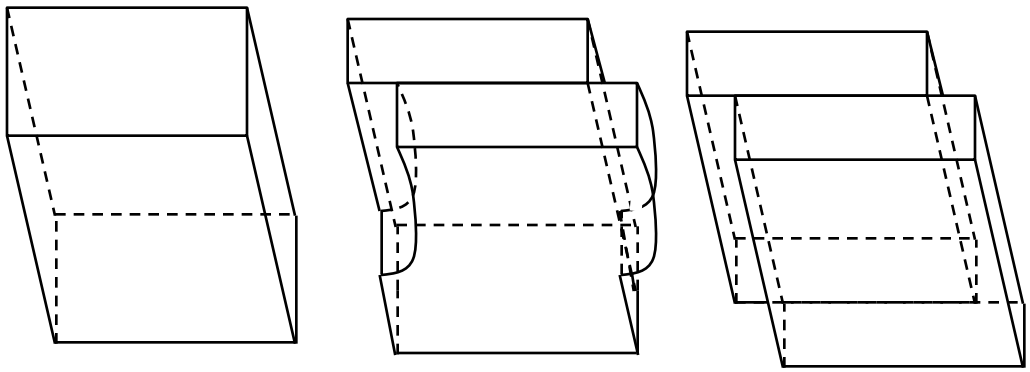
f ____ g ____ h ____ i ____ j ____

Question 4: (**20** points)

Consider the following schematics showing the deformation sequence of a crystal in response to an applied shear stress. In each case:

- label the direction of the shear load that caused the deformation (**1** point);
- draw the dislocation line and label ξ the dislocation line direction (**2** points);
- draw and label **b** the Burgers vector (**2** points);
- identify the slip plane by shading it in (**1** point);
- show with arrows the motion of the dislocation during continued slip (**2** points); and
- specify the type of dislocation (edge or screw) represented by your figure (**2** points).

(a) (**10** points)



Type of dislocation = _____

(b) (**10** points)

(Corrupted file)

Type of dislocation = _____

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

Professor R. Gronsky

Fall Semester 2001

ENGINEERING 45

Midterm #1

NAME:_____
(Please Print Clearly)

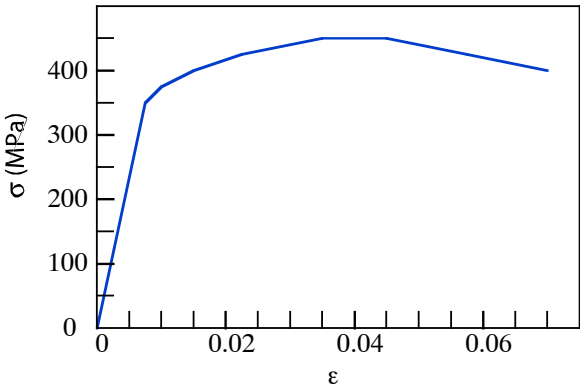
This is a *closed book* Exam. You must work independently, and no reference materials are permitted.

Please use only the pages given here, and write your answers in the spaces provided.

 NAME:_____

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

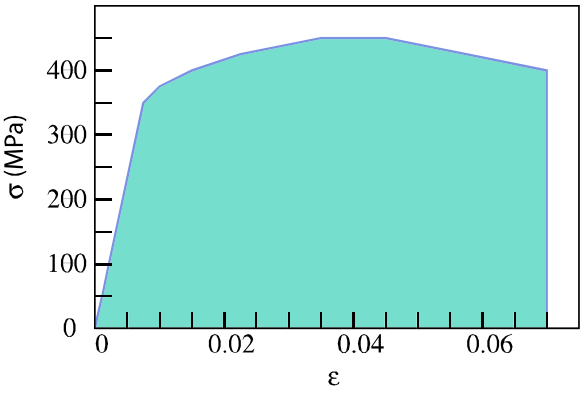


b. This data reveals that the sample had a yield strength of
   350 MPa
   400 MPa
   450 MPa

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

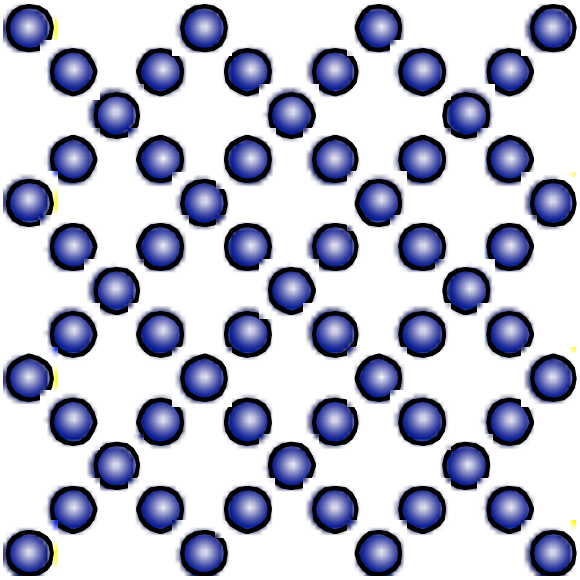
d. Dislocations began to move in this sample when the strain exceeded
   0.0475
   0.0375
   0.0075

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



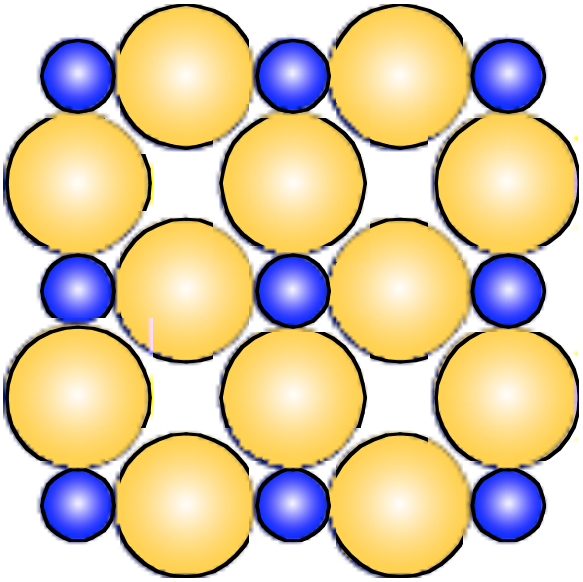
Question 2 A lattice is an array of points in space with identical environment. A primitive unit cell, also called "simple," is one that contains only a single lattice point.

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



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

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

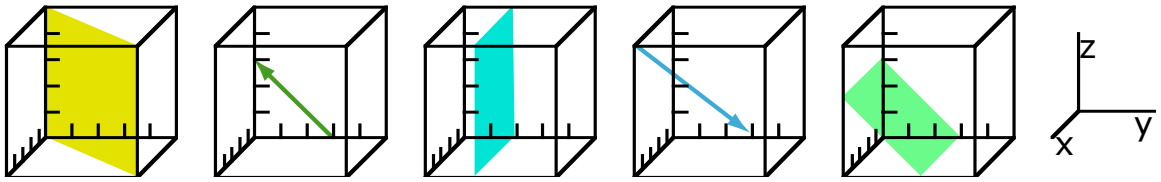


(4 points) Number of atoms in the unit cell =

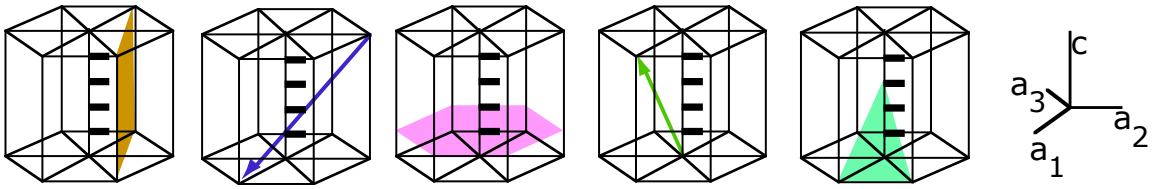
 NAME:_____

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

$$h + k = -i.$$

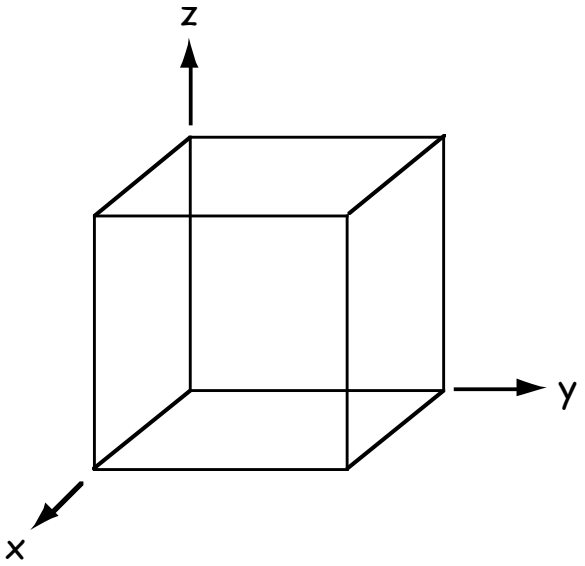


a. b. c. d. e.



f. g. h. i. j.

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.



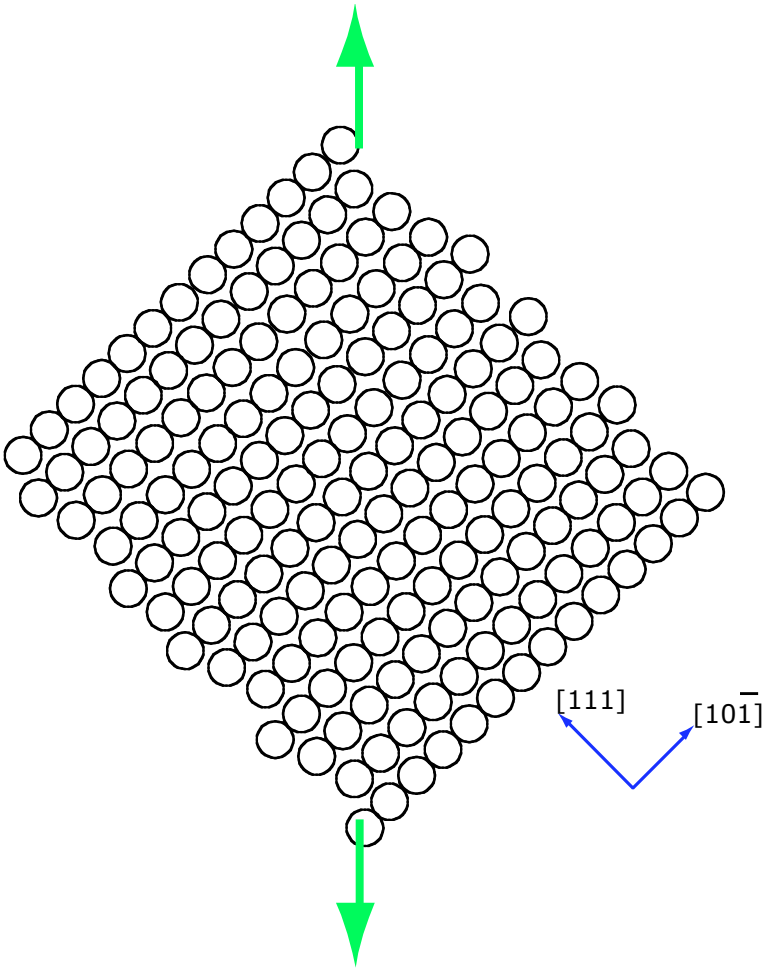
a. Draw and label the contents of the unit cell (5 points)

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)

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

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.



UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Materials Science & Engineering
Professor R. Gronsky Fall Semester, 2005

Engineering 45 Midterm 01

Name:
(Please print)

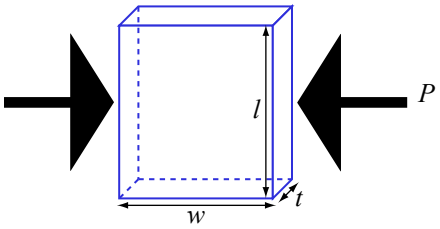
INSTRUCTIONS

LATTICE seating..... Please be seated with *occupied* seats to your front and back, *vacant* seats to your left and right.
CLOSED BOOK format..... All you need are writing instruments and a straightedge. Please store all books, reference materials, calculators, PDAs, cell phones (OFF), and iPods.
NO DISRUPTION rule..... Questions cause too much of a disturbance to others in the room. Instead of asking questions, write any concerns or alternative interpretations in your answers.
PROFESSIONAL protocol... Engineers do not cheat on the job and they certainly don't cheat on exams.

Do not open until "START" is announced.

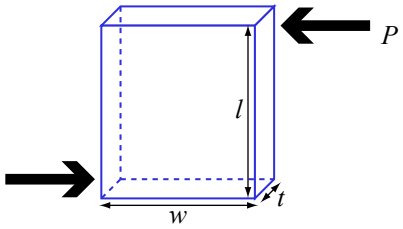
1. Mechanical Properties (20 points)
Mark ☒ the ballot box corresponding to the best answer.
Two (**+2**) points for correct answers, **-1** if wrong, **0** if blank.

(**a**) The compressive stress induced in the volume element shown below is defined by which expression?



☐ $\sigma = P / (w \times t)$
☐ $\sigma = P / (l \times w)$
☐ $\sigma = P / (l \times t)$

(**b**) The shear stress induced in the volume element shown below is defined by which expression?



☐ $\sigma = P / (w \times t)$
☐ $\sigma = P / (l \times w)$
☐ $\sigma = P / (l \times t)$

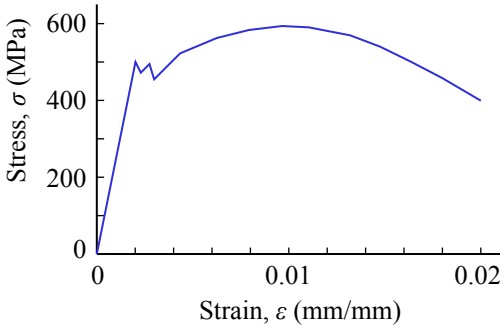
(**c**) In order to convert the data from a load *vs* elongation plot to a stress *vs* strain plot, the following information is essential.
☐ the cross-sectional area of the sample
☐ the yield strength of the sample
☐ the geometry of the sample

(**d**) Elastic deformation is_____?
☐ linear
☐ recoverable
☐ time-dependent

(**e**) The gage length of a metallic alloy sample used in the standard uniaxial tensile test
☐ has the smallest cross-sectional area
☐ establishes the initial length of the sample
☐ calibrates the sample's elongation to failure

(**f**) "True" stress differs from "engineering" stress
☐ in the way tensile test data is collected
☐ in the way tensile test data is reported
☐ in the way tensile test data represents the actual sample

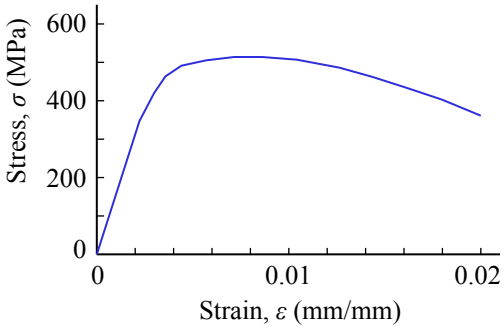
(**g**) The following data from a uniaxial tensile test of a low carbon steel sample indicates that



☐ it has a lower yield point of 450 MPa
☐ it has an 0.2% offset yield point of 450 MPA
☐ it fractured at precisely 0.02% offset

(**h**) For the same steel sample as above, an observer in the room would have observed necking in the sample
☐ just before the sample fractured at 400 MPa
☐ just when the sample yielded at 500 MPa
☐ just as the stress exceeded 600 MPa

(**i**) An aluminum alloy produced the following stress-strain plot during a uniaxial tensile test. Its yield strength is



☐ 400 MPa
☐ 450 MPa
☐ 500 MPa

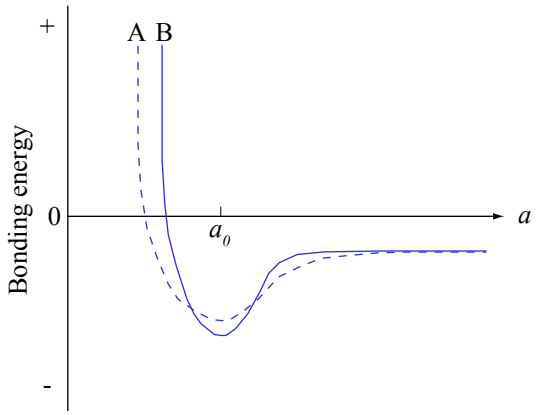
(**j**) Comparing the above plots from a steel sample and an Al alloy sample, it can be concluded that
☐ the Al alloy has greater elastic recovery after fracture
☐ the Al alloy has a larger elastic modulus
☐ the Al alloy deforms more before it fails

2. Bonding (20 points)
Mark ☒ the ballot box corresponding to the best answer.
Two (+**2**) points for correct answers, **-1** if wrong, **0** if blank.

(**a**) "Primary" bonds are formed
☐ by the transfer of primary electrons
☐ primarily between individual atoms or ions
☐ during primary chemical reactions

(**b**) "Secondary" bonds are so-named because
☐ they require secondary electrons to complete the charge transfer necessary for bonding
☐ they occur between groups of atoms after primary bonding has occurred
☐ they result in secondary reactions with reduced efficiency relative to primary bonds

(**c**) Consider the following bonding energy curves for two alloys, A and B.



☐ A has a higher tensile strength than B
☐ A has a lower elastic modulus than B
☐ A has a smaller lattice constant than B

(**d**) The "octet rule" predicts that Group IV elements
☐ form bonds with four near neighbors
☐ have eight bonding electrons
☐ reside in octahedral sites

(**e**) When compared with materials that form ionic bonds, metallic alloys
☐ melt at higher temperatures
☐ exhibit greater bond directionality
☐ have higher coordination numbers

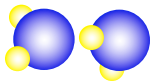
(**f**) During the formation of covalent bonds, a bonding model called "hybridization" explains why
☐ some bonds show both covalent and metallic character
☐ carbon has more than one isotope
☐ silicon atoms are tetrahedrally coordinated

(**g**) The metallic bonding model explains ductility on the basis of
☐ lack of bonding electrons, yielding weaker bonds
☐ excess of mobile electrons, causing fluid bonds
☐ lack of bond directionality

(**h**) The basis for the van der Waals interaction that causes molecular bonding is
☐ mutual charge symmetry
☐ induced electric dipoles
☐ distortion in electron orbitals

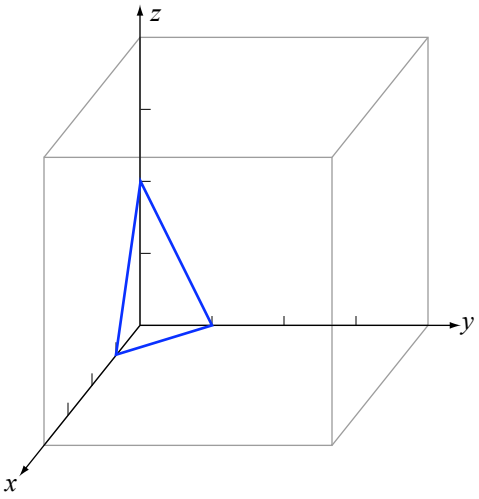
(**i**) One explanation for why graphite powder acts so well as a "solid lubricant" is
☐ carbon atoms in graphite are covalently bonded within planar layers but have weaker secondary bonds between layers
☐ finely-powdered carbon has many unsatisfied bonds at the particle surfaces, which act as a "sea of electrons" to cause lubrication
☐ when crushed into a fine powder, graphite establishes a "polar" distribution of charge, leading to Coulombic repulsion between powder particles

(**j**) The following schematic shows two water molecules in a "bonded" configuration due to

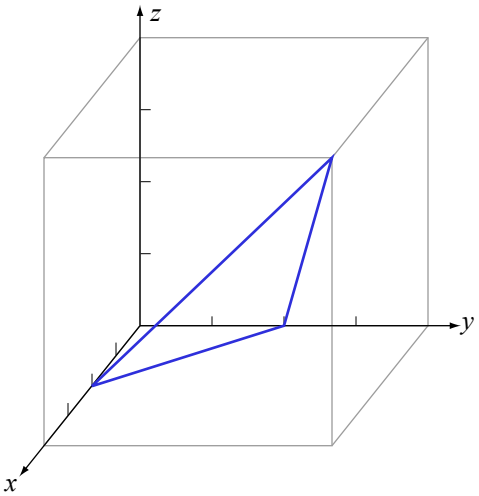


☐ 109.5° covalent bond angles
☐ a functional hydrogen bridge
☐ the ideal radius ratio, $0 < r/R < 0.155$

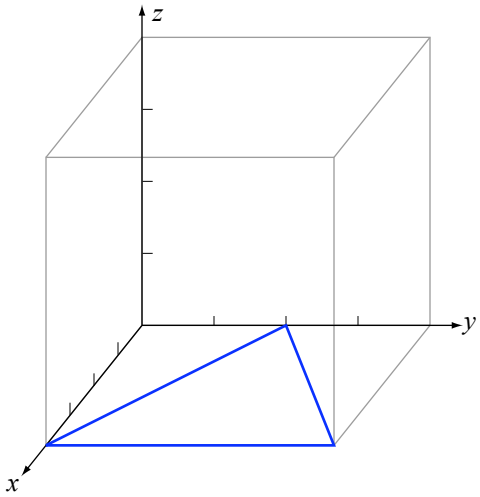
3. Lattice Planes (20 points)
The triangles drawn here are sections of planes through cubic and hexagonal lattices. Identify the relevant planes by their Miller indices or Miller-Bravais indices.
Four (**4**) points for *correct answers in the boxes* provided.



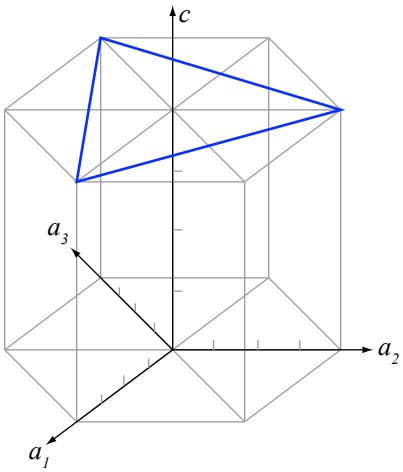
(a)



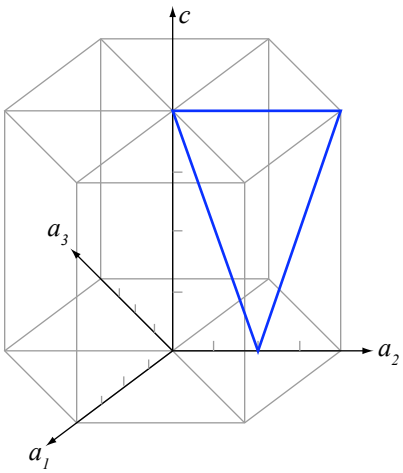
(b)



(c)

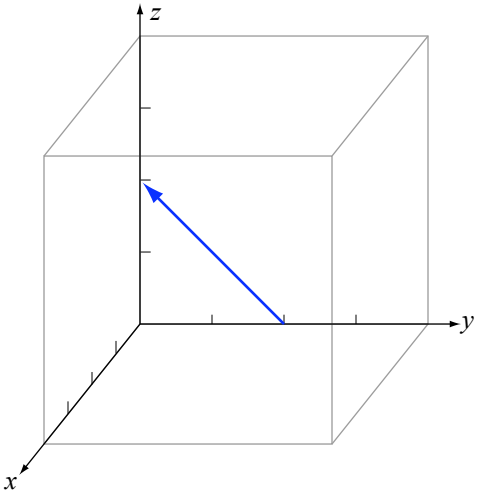


(d)

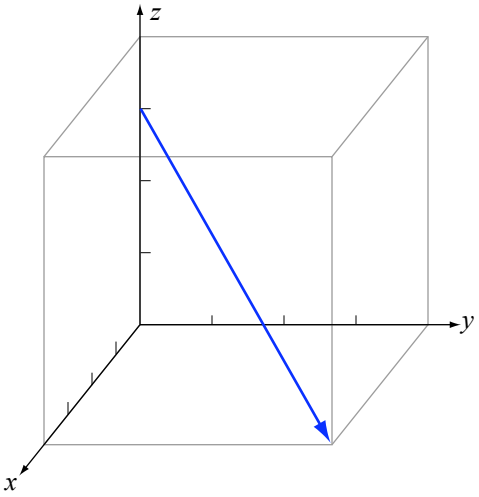


(e)

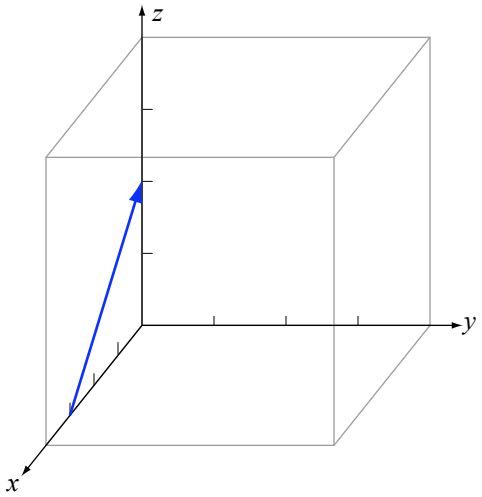
4. Lattice Directions (20 points)
Identify the following directions through both cubic and hexagonal lattices using the appropriate Miller index or Miller-Bravais index notation.
Four (**4**) points for *correct answers in the boxes* provided.



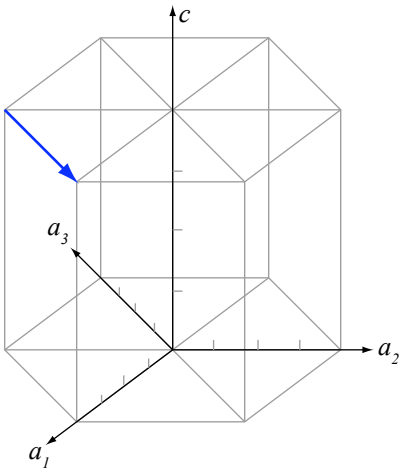
(a)



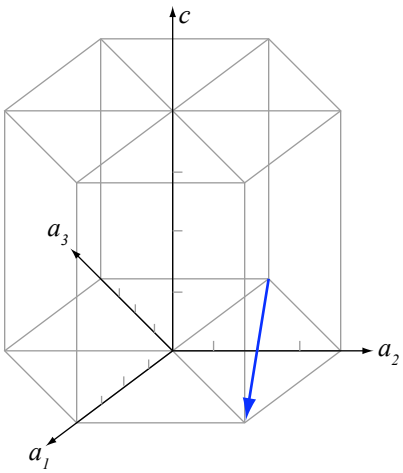
(b)



(c)



(d)

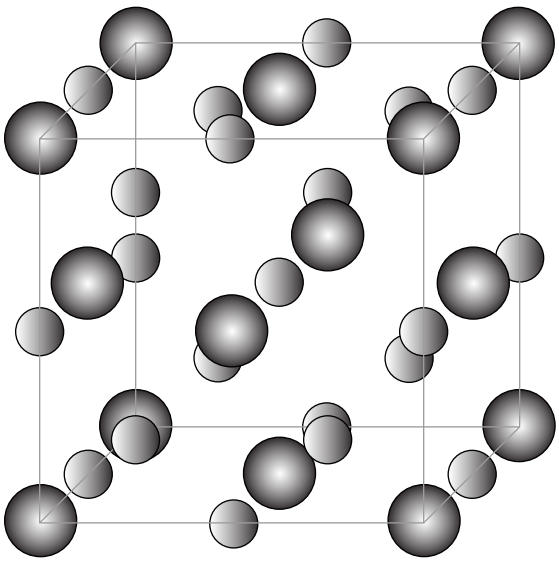


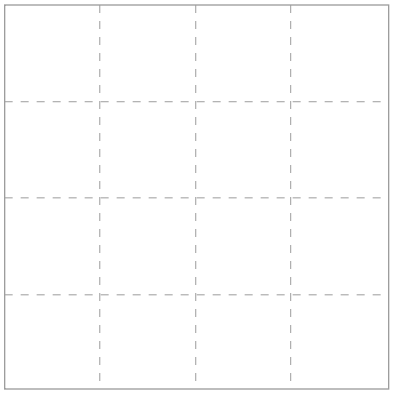
(e)

5. Crystal Structure (20 points)

An alloy of nickel and tin adopts a number of different structures, one of which is cubic, designated by the *Strukturbericht* symbol DO_3, where the first index *D* is reserved for the more "complicated" crystal structures. In this case, the larger Sn atoms are located at all face-centered-cubic lattice sites, and the smaller Ni atoms are found in all of the tetrahedral interstices and all of the octahedral interstices. A perspective sketch of the positions is shown below on the left.

(**a**) On the grid provided to the right, draw a cube-axis projection of the structure, and label the "elevation" of each atom from the bottom plane (elevation "0") to the top plane (elevation "1"). [*Hint*: On this scheme, for example, the side faces would be occupied by a single Sn atom at elevation "½."] (**5** points)





r_{Ni} = 0.125 nm

r_{Sn} = 0.158 nm

(**b**) How many Sn atoms are there in this unit cell? Ans: [ ] (**2** points)
(Show how you "count" the atoms occupying the lattice points in the unit cell)

How many Ni atoms are there in this unit cell? Ans: [ ] (**2** points)
(Show how you "count" the atoms occupying the interstitial sites in the unit cell)

Now write the "chemical formula" with the stoichiometry of the Ni-Sn alloy shown here. Ans: [ ] (**1** point)

(**c**) Using your evaluation above, specify both a Bravais lattice and motif that fully describes this $D0_3$ crystal structure.

Lattice: [ ] (**5** points) Motif: [ ] (**5** points)

Worksheet

No points will be given or deducted for work shown here. Please enter answers in the spaces provided.

DO NOT WRITE BELOW THIS LINE

Problem #	Possible Points	Your Score
1	20	
2	20	
3	20	
4	20	
5	20	
Total	100	