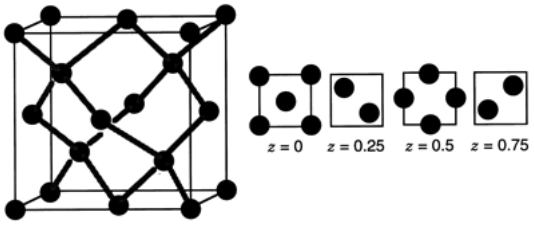
Worksheet 6: Solid State Basics

Other questions: 11.97, 11.99, 11.101, 11.103, 11.105, 11.111, 11.113

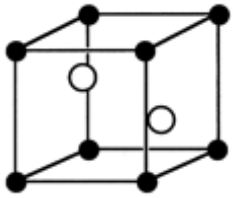
1. Shown in the figure below is the unit cell structure for one form of C, the diamond structure. Also shown is the corresponding z-diagram for this unit cell. Using this z-diagram, determine the contribution of atoms to each z-layer, and from this, determine the net number of atoms contained within one unit cell.



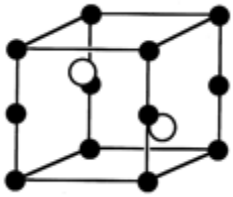
The diamond structure.

2. For each of the following pictures of unit cells for ionic compounds, draw corresponding z-diagrams. For all of these, determine the correct ionic formula for the compound.

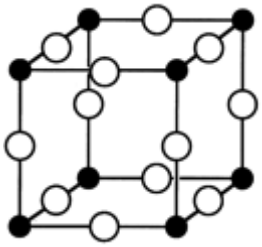
a. Key: ● Cd ○ I



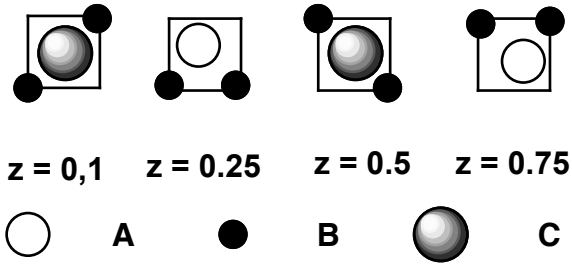
b. Key: ● Ni ○ As

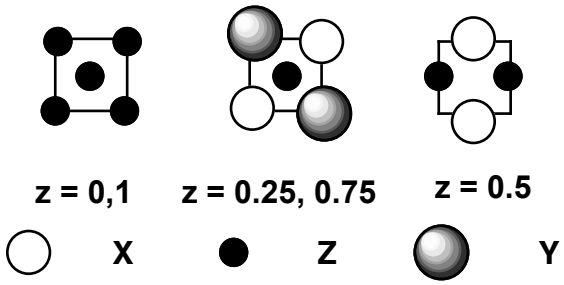


c. Key: ● Re ○ O

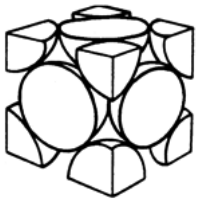


3. Find the simplest formula for the following unit cell structures:





4. Europium is one of the lanthanide elements used in television screens. Europium crystallizes in a body-centered structure with a unit cell edge of 240.6 pm. Calculate the radius of a europium atom.
5. Calculate the edge length of the fcc unit cell of NaCl on the basis of the average radii of Cl^- (181 pm) and Na^+ (98 pm) assuming that the corner Cl^- ions and the Na^+ along the edges touch.
6. Lithium chloride crystallizes with the same structure as NaCl except that the chloride anions touch along the face diagonal of the unit cell. If the unit cell edge is 513 pm, what is the radius of the chloride anion?
7. Silver, Ag, crystallizes in the unit cell structure shown below.



a. Identify this unit cell type
b. How many net atoms are contained in one unit cell of this type?
c. If Ag has a density of 10.5 g/cm^3, what is the radius of an Ag atom in pm?

8. Complete the table provided by calculating the missing data.

	Atom	**Radius (pm)**	**Density (g/cm^3)**	**Type of Unit Cell**	**% Packing Efficiency**
a.	$_{25}$Mn		7.23	bcc	
b.	$_{79}$Au		19.3	fcc	
c.	$_{45}$Rh	135			74 %
d.	$_{56}$Ba	218			68 %

9. Copper metal has a density of 8.95 g/cm^3. If the edge length of a copper unit cell is 361 pm, is the copper unit cell simple cubic, body-centered cubic or face-centered cubic?
10. The unit cell of ReO_3 consists of a cube with rhenium atoms at the corners and an oxygen atom on each of the 12 edges. The atoms touch along the edge of the unit cell. The radii of Re and O atoms in ReO_3 are 137 and 74 pm, respectively. Calculate the density of ReO_3.
11. Rank the following ionic compounds in order of increasing magnitude of the lattice energy: KBr, $SrBr_2$ and CsBr.
12. Draw an energy level diagram that illustrates the Born Haber Cycle for KCl. Calculate the lattice energy of potassium chloride from the following data:
    First ionization energy of K = 425 kJ/mole
    Electron affinity for Cl = -349 kJ/mole
    energy to vaporize K = 89 kJ/mole
    Cl_2 bond energy = 240 kJ/mole
    energy for the formation of KCl = -438 kJ/mole
13. Draw an energy level diagram that illustrates the Born Haber Cycle for $CdBr_2$. Use this cycle to calculate the lattice energy for $CdBr_2$.

Enthalpy of formation of $CdBr_2$	-308 kJ
1st Ionization energy of Cd	867 kJ
2nd Ionization energy of Cd	1630 kJ
Sublimation of Cd	102 kJ
Heat of vaporization for Br_2	18 kJ (Bromine's standard state is Br_2 (liquid))
Bond energy of Br_2	186 kJ
Electron affinity of Br	-322 kJ

Key:

1. 8 atoms
2. CdI_2, NiAs, ReO_3
3. ABC, X_2YZ_5
4. 104.2 pm
5. 558 pm
6. 181 pm
7. a. fcc b. 4 c. 144 pm
8. a. 127 pm, 68% b. 144 pm, 74% c. 12.3 g/cm^3, fcc d. 3.57 g/cm^3, bcc
9. fcc
10. 5.18 g/cm^3
11. CsBr, KBr, $SrBr_2$
12. -723 kJ
13. -2467 kJ