1. [7 Points] Osmium (VIII) oxide, OsO₄, is a pale yellow solid with a melting point of 40 °C and a boiling point of 130 °C. It is an electrical insulator and is soluble in water. Based on these observations what do you think is the most appropriate classification of OsO₄?

   (a) metallic solid 
   (b) molecular solid 
   (c) ionic solid 
   (d) covalent-network solid 
   (e) polymeric solid 

2. [7 Points] For the 2D crystal structure shown below what is the lattice type and how many atoms are there per unit cell?

   (a) Lattice = rectangular, Atoms per unit cell = 2 A + 4 B + 2 C 
   (b) Lattice = centered rectangular, Atoms per unit cell = 2 A + 8 B + 2 C 
   (c) Lattice = square, Atoms per unit cell = 2 A + 8 B + 2 C 
   (d) Lattice = square, Atoms per unit cell = 1 A + 4 B + 1 C 
   (e) Lattice = square, Atoms per unit cell = 5 A + 12 B + 4 C 

3. [7 Points] Arrange the following metallic structures in order of increasing packing efficiency (the fraction of space in a crystal that is actually occupied by atoms).

   hexagonal close packed (hcp) metal  
   body centered cubic (bcc) metal  
   face centered cubic (fcc) metal  
   primitive cubic (pc) metal  

   (a) Lowest  pc < bcc < fcc < hcp  highest  
   (b) Lowest  pc < bcc < hcp < fcc  highest  
   (c) Lowest  pc < bcc < fcc = hcp  highest  
   (d) Lowest  fcc < bcc < pc < hcp  highest  
   (e) Lowest  fcc = hcp < bcc < pc  highest
4. [7 Points] Which of the following statements about interstitial alloys is false?

(a) Interstitial alloys have a variable composition
(b) Interstitial alloys are usually stronger but less ductile than substitutional alloys
(c) Interstitial alloys generally form when all of the atoms in the alloy have similar radii
(d) Steel is an example of an interstitial alloy
(e) Interstitial alloys are classified as homogeneous mixtures

5. [7 Points] Which property of metals cannot be adequately explained by the electron sea model, but can be explained by the molecular orbital model.

(a) Metals are malleable
(b) Metals are good conductors of electricity
(c) Metals are good conductors of heat
(d) On moving left to right across the periodic table the melting points of metallic elements first increase and then decrease
(e) Metals tend to form structures where the atoms are closely packed together

6. [7 Points] If you were to take the cesium chloride crystal structure and make all of the atoms the same (i.e. make all of the atoms cesium), what structure type would result?

a. Hexagonal close packed metal
b. Face centered cubic metal
c. Body centered cubic metal
d. Primitive cubic metal
e. Diamond structure

7. [7 Points] Rubidium iodide crystallizes with the same structure as sodium chloride (see below). Use the ionic radii and molar masses of Rb\(^{+}\) (1.66 Å, 85.47 g/mol) and I\(^{-}\) (2.06 Å, 126.90 g/mol) to estimate the density of RbI.

(a) 0.858 g/cm\(^3\)
(b) 2.06 g/cm\(^3\)
(c) 0.429 g/cm\(^3\)
(d) 5.68 g/cm\(^3\)
(e) 3.43 g/cm\(^3\)
8. [7 Points] Which of the following semiconductors would you expect to have the smallest band gap?

(a) Aluminum phosphide, AlP
(b) Cadmium telluride, CdTe
(c) Gallium arsenide, GaAs
(d) Indium antimonide, InSb
(e) Zinc sulfide, ZnS

9. [7 Points] One unit cell of the crystal structure of a cubic compound that forms between strontium, titanium and oxygen is shown below. What is the empirical formula of this compound?

a. SrTi$_8$O$_{12}$
b. SrTi$_2$O$_3$
c. Sr$_2$Ti$_2$O$_3$
d. SrTiO$_6$
e. SrTiO$_3$