Molecular and Ionic Compound Structure and Properties
2.1 Types of Chemical Bonds
2.3 Structure of Ionic Solids
2.4 Structure of Metals and Alloys
Worksheet Key

1) Which compound from each set is covalent? Explain.
   a. **CO** or LiF
   b. ZnS or **SO_2**
   c. **BF_3** or Fe_2O_3
   Covalent compounds are composed of non-metals.

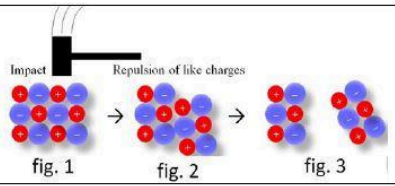
2) Which bond from each set is most covalent? Explain.
   a. **Cl – Cl** or Al – F
   The electronegativity difference between like elements is zero.
   b. **N – O** or C – O
   c. Ca – O or **N – O**
   The smaller the electronegativity difference between two atoms, the more covalent the bond. This is because electrons are more evenly shared.

3) Which bond from each set is most ionic? Explain.
   a. Al – O or **Na – O**
   b. **K – Cl** or Zn – Cl
   c. **Fr – F** or B – F
   The greater the electronegativity difference between two atoms, the more ionic the bond.

4) Which compound from each set in most ionic? Explain.
   a. Al_2O_3 or **NaCl**
   b. **KCl** or FeO
   The greater the electronegativity difference between two atoms, the more ionic the bonds. The more ionic the bonds, the more ionic the compound.

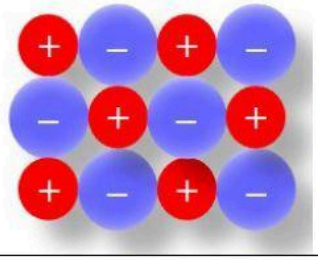
5) Which is the most polar bond in each set? Explain.
   a. **C – F** or C – O
   b. P – O or **P – F**
   c. As – S or **As – F**
   The greater the electronegativity difference, the more polar the bond.

6) Are ionic solids malleable? Justify your answer. Create a visual representation to assist with your justification.

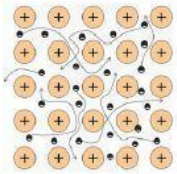


Ionic solids are not malleable. Ions are lined up in a repetitive 3D pattern. When an ionic solid is hit with a hammer (fig. 1), one plane will slide along an adjacent plane (fig. 2). When this happens, ions with like charges move closer to one another, which will result in forces of repulsion between the planes (fig. 2). These repulsive forces can cause the solid to cleave along that plane (fig. 3). For this reason, ionic solids are considered to be brittle, and not malleable.

7) Create a visual representation of a particulate model of a ionic solid in two dimensions. In any ionic solid, cations and anions are always arranged so that Coulombic forces of attraction between oppositely charged ions are maximized and repulsive forces between like charged ions are minimized. Keep the periodic trends for the relative sizes on anions and cations in mind.

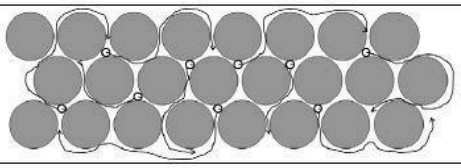


8) Create a visual representation of a metallic solid that can be used to explain the electron sea model of metallic bonding. Use that representation to help you explain the factors that make metals good conductors of heat and electricity?

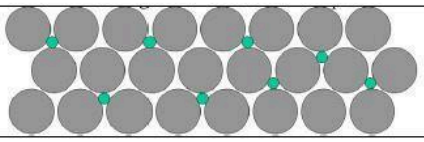


The electron sea model accounts for the properties of metals. The free movement of valence electrons allows metals to conduct electricity. Electron movement also enables metals to conduct heat rapidly. If you heat one end of metal bar, you will transfer heat to the electrons in that area. These energized electrons will move to the other end of the bar, carrying the heat with them.

9) The following questions pertain to a pure sample of iron and a sample of steel.
   a. Create an illustration of pure iron which shows the iron atoms and provides a visual representation of the electron sea model.



   b. Create a representation of steel that shows the iron and carbon atoms.



c. In what way have some of the bonds changed when this alloy was formed?

Pure iron only has metallic bonds, which lack direction. In steel carbon forms strong directional bonds with the neighboring iron atoms.

d. What type of alloy is steel?

Steel is an interstitial alloy.

e. Identify four properties that change when carbon is added to pure iron in order to make steel?

When carbon is added to pure iron, the metal becomes more rigid, less malleable, and less ductile. The density of steel is also greater than the density if pure iron.

f. Explain how carbon changes the properties outlined in part e.

Carbon atoms from strong directional bonds with neighboring iron atoms, and pure iron lacks directional bonds. This is why steel is much more rigid, less malleable, and less ductile than pure iron. The density of steel is much higher than that of pure iron, because the interstitial carbon atoms do not increase the overall volume or expand the lattice of iron by very much.

10) A 1.0 mole pure sample of molten tin is dissolved in a 5.0 mole pure sample of molten copper. The solution is set aside to cool and solidifies. The atomic radius of tin is 140 pm and the atomic radius of copper is 128 pm.
    a. Identify the type of alloy that is formed. Justify your answer.

A substitutional alloy is formed. Since the atomic radii of the two elements are similar, tin will substitute for copper.

b. Identify the solvent in this solution. Justify your answer.

There are 5.0 moles of copper and 1.0 moles of tin in the solution. Since copper is more plentiful, it is the solvent.

11) The macroscopic properties of a pure sample of an unknown solid were examined in order to determine the type of bonding between particles. The solid is very hard. When it is broken, the fragments form similar three dimensional shapes. When dissolved in water the resulting solution conducts electricity. Make a prediction about the type of bonding in this compound. Justify your answer.

The properties of this solid indicate that it is held together by ionic bonds. The unit cells in ionic solids repeat in a regular 3D patterns and these solids tend to cleave along planes, which would give the fragments similar 3D shapes. The angles that the planes cleave along will be the same. When dissolved in water, ionic compounds dissociate into individual ions, which are charged particles that are free to move. For this reason, ionic compounds are able to conduct electricity when dissolved in polar solvents.

12) The macroscopic properties of a pure sample of an unknown solid were examined in order to determine the type of bonding within the particles. The solid is soft and can be cut with a knife. It starts melting at 35°C. It does not dissolve in water – instead it floats on the surface. Make a prediction about the type of bonding in this compound. Justify your answer.

The properties of this solid indicate that it is composed of molecules. Individual molecules are held together with covalent bonds. Molecular solids tend to be relatively soft, have low melting points and low boiling points. Some molecular solids dissolve in water and some do not.

13) The macroscopic properties of a pure sample of an unknown solid was examined in order to determine the type of bonding between the particles. When hit with a hammer, it dents. When cleaned with steel wool it becomes very shinny. The solid conducts electricity but does not dissolve in water. Make a prediction about the type of bonding in this compound. Justify your answer.

The properties of this solid indicate that it is a metal and the atoms are held together by metallic bonds. Metallic bonds are not directional, so they tend to be malleable. Malleable materials will dent when they are hit with a hammer. The outer surfaces of metals will oxidize in the presence of oxygen gas. If the oxidized surface is cleaned off, metals are shinny. Metals conduct electricity in the solid state.