Chemical Compounds Notes

1. When elements form compounds, changes occur in the arrangement of electrons.
    a. Atoms want to have a complete valence shell like the noble gases.
    b. They achieve this by sharing or transferring electrons.
    c. We will learn about two main types of compounds:
        i. In ionic compounds electrons are transferred between metals and nonmetals.
        ii. In molecular compounds electrons are shared between nonmetals. (These are also called covalent compounds.)
2. Metals and nonmetals combine to form ionic compounds by transferring electrons.
    a. The metal atoms lose electrons to form positive ions, and the nonmetal atoms gain those electrons to form negative ions.
    b. The opposite charges cause the two ions to be attracted to each other. The attraction is called an ionic bond.
    c. The result is a compound that is electrically neutral. The sum of the charges on the positive ions equals the sum of the charges on the negative ions.
        i. *E.g.*, aluminum chloride ($AlCl_3$). The ionic charge of the aluminum ion is 3+ and the ionic charge of each chloride ion is 1–. Since the compound has one Al3+ ion and three Cl– ions, the total ionic charge is zero.
    d. The positive and negative ions attract each other to make a stable compound.

3. Writing formulas for ionic compounds.
    a. A chemical formula shows us which elements are in the compound and how many of each atom.
    b. Crisscross Rule:
        i. Write the ionic charges above the symbols.
        ii. Crisscross the numbers, by using the charge on each ion as a subscript for the other ion.
        iii. Reduce the subscripts to the lowest numbers possible.
    c. *E.g.*, what is the formula for the ionic compound formed by aluminum and sulfur? Al has a charge of 3+ and S has a charge of 2- so the formula is Al_2S_3.
    d. *E.g.*, what is the formula for the ionic compound formed by nickel and oxygen?
        i. Follow the same steps as in the previous example.
        ii. Nickel has a charge of 2+ and O has a charge of 2- so the formula is Ni_2O_2.
            1. Always reduce the subscripts to the lowest ratio. In this case we can divide them both by 2 to make the formula NiO.
4. Naming Ionic Compounds
    a. Use the name of the metal first, then the name of the nonmetal.
    b. The name of the nonmetal changes to “ide.”
        i. *E.g.*, the compound formed by calcium and iodine is called calcium iodide. The compound formed by aluminum and sulfur is called aluminum sulfide.

5. Names and formulas for atoms containing polyvalent metals
    a. A polyvalent metal is one that can form more than one kind of ion.
    b. These compounds are named in the same way as other ionic compounds, except that a Roman numeral is added in round brackets after the metal to indicate its ionic charge.
        i. *E.g.*, CuCl is called copper(I) chloride because the ionic charge on the copper is 1+. $CuCl_2$ is called copper(II) chloride because the ionic charge on the copper is 2+.

6. Writing Formulas for Polyatomic Compounds

a. Some ions contain more than one atom.
b. To name them, write the symbols of the metal and of the polyatomic group then use the crisscross rule.
    i. *E.g.*, Write the formula for the compound formed by sodium and sulfate. The charge on the sodium ion is 1+ and the charge on the sulfate ion is 2-. The formula is Na_2SO_4.
        1. We cannot reduce the subscripts to $NaSO_2$ in this case because the sulfate ion (SO_4) is a group.
    ii. *E.g.*, What is the formula of lead(IV) carbonate? The Roman numeral tells you the charge on the lead ion is 4+ and the charge on carbonate is 2-. Using the crisscross rule, we get the formula $Pb_2(CO_3)_4$, which we reduce to $Pb(CO_3)_2$. We have to put parentheses around CO_3 to show there are 3 of that ion in the compound.

7. Naming Polyatomic Compounds
    a. Compounds containing polyatomic ions are fairly easy to name.
        i. Write the name of the metal first and then the name of the polyatomic ion.
        ii. The positive part of the compound is always written first in both the formula and the name.
            1. *E.g.*, the compound formed by a potassium ion (K+) and a carbonate ion (CO_3 2–) has the formula K_2CO_3 and its name is potassium carbonate.
            2. *E.g.*, Ammonium (NH_4 +) and nitrate (NO_3 –) combine to form ammonium nitrate (NH_4NO_3).

8. Writing formulas for molecular compounds
    a. The number of electrons that a nonmetal needs to share to become stable is a clue to the number of covalent bonds it can form. The combining power (**valency)** of a nonmetal is a measure of the number of covalent bonds that it will need to form a stable molecule.
        i. *E.g.*, carbon has four electrons in its outer (or valence) orbit. Carbon could have eight electrons in the outer orbit by sharing electrons with other atoms. If carbon shared one of its outer orbit electrons with each of four different hydrogen atoms it would form CH_4 (methane). Notice that each hydrogen atom also gains a full outer orbit by sharing one electron with the carbon atom.
    b. Write the symbols for each atom and their valency. Crisscross the valencies to produce subscripts.
        i. *E.g.*, How would you write the formula for a compound formed between carbon and sulfur? The valency of carbon is 4 and the valency is sulfur is 2 so the formula is C_2S_4. Remember we have to reduce the subscripts to CS_2.

9. Naming molecular compounds
    a. Common names have been used for centuries for water (H_2O); ammonia (NH_3), which is used in many cleaning products; hydrogen peroxide (H_2O_2), used in antiseptic solutions; and methane (CH_4), found in natural gas. Less common substances follow rules for naming.
    b. The names of molecular compounds often contain prefixes to indicate the number of atoms in the compound. For example, the gas that you exhale is carbon dioxide (CO_2), while the poisonous combination of carbon and oxygen that can be formed in automobile engines is carbon monoxide (CO).
    c. When there is only one atom of the first element in the molecular compound, the prefix “mono” is not necessary.
    d. The most common prefixes are mon(o) – 1; di – 2; tri – 3; tetra – 4; penta - 5