Chapter 4 – Nomenclature

1) The Periodic Table – Review from Chapter 3
The elements are arranged in rows and columns on the Periodic Table according to similarities in their properties. We are going to talk about the development of the modern Periodic Table when we begin working on Chapter 11, but there are important features that you need to understand now in order to be able to think about formulas and names.

   a) Period – A row of elements in the Periodic Table.

   b) Group – A column of elements in the Periodic Table. Each group is designated by a number-letter combination (first column on left is IA or 1).

   c) Representative Elements – The Group A (IA, IIA, IIIA, IVA, VA, VIA, VIIA) elements are known as the representative elements. On the Periodic Table in the room these are groups 1,2 and 13 through 18.

   d) Metals – are elements that have a high luster when clean and a high electrical conductivity. They are ductile (can be drawn into a wire) and malleable (can be beaten into thin sheets). Most of the elements are metals.

   e) Transition Metals – The Group B elements (the elements in the middle of the Periodic Table - groups 3 through 12 - and those listed at the bottom of the table, that is the Transition and Inner Transition elements).

   f) Nonmetals – are elements that are non lustrous and are poor conductors of electricity.

   g) "Semi metals" or Metalloids – are elements with the properties of both metals and nonmetals. (They are semiconductors of electricity.)

2) Atoms and Ions

   a) Ions are atoms or groups of atoms that have a positive or negative charge. An ion is formed when an atom or group of atoms gains or loses electrons.

   b) Cation – Any atom or group of atoms with a positive charge. Atoms of metallic elements tend to form positive ions (cations) by losing one or more electrons.

      Example – How many electrons does one atom of the following contain?
      1) K^{+1} 2) Ba^{+2} 3) Fe^{+3}

   c) Anion – Any atom or group of atoms with a negative charge. Atoms of nonmetallic elements tend to form negative ions by gaining one or more electrons. The names of the anions that are formed from the nonmetals differ from that of the neutral nonmetal. The suffix **-ide** is added to the name of the nonmetal when it is an anion. (Example: Cl^{-1} is called **chloride** instead of chlorine.)

Example – How many electrons does one atom of the following contain and what is the name of each of the ions?

1) I^{-1} 2) S^{-2} 3) N^{-3}

3) Compounds are pure substances that differ from elements because they contain more than one kind of atom. Compounds are formed when atoms of two or more different elements combine chemically. In any compound, the elements are always present in the same proportion by mass (Law of Definite Proportions).

a) Molecules – A neutral group of atoms that act as a unit. In many compounds the atoms are bound together in molecules.

b) Molecular Compounds – Compounds that are composed of molecules.
   1) They tend to have relatively low melting and boiling points. (That is, most are either gases or liquids at room temperature.)

   2) Most are composed of two or more nonmetallic elements.

c) Ionic Compounds – are composed of positive and negative ions. These compounds do not exist in any unit or group (do not exist as molecules). Ionic compounds are electrically neutral although they are composed of ions.
   1) Most ionic compounds are crystalline solids at room temperature.

   2) They are usually formed from at least a metallic and a nonmetallic element.

   3) They usually have high melting and boiling points.

4) Chemical Formulas show the kinds and numbers of atoms in the smallest representative unit of the substance.

a) A Molecular Formula shows the number and kinds of atoms present in a molecule of the compound.

Example – Give the molecular formula of butane if it contains 4 carbon atoms and 10 hydrogen atoms.

Example – Give the molecular formula of carbon dioxide if it contains 1 carbon atom and 2 oxygen atoms.

b) A Formula Unit is the lowest whole-number ratio of ions in an ionic compound.

Example – Give the simplest formula unit for calcium chloride if it contains one Ca^{+2} ion for each two Cl^{-1} ions.

Example – Give the simplest formula unit for ferric bromide if it contains 1 iron atom and 3 bromine atoms.

c) When atoms occur in a group and the group is ionic (either lost or gained electrons), the group is called a polyatomic ion. Most common polyatomic ions are listed in Table 4.4 in your book.

YOU NEED TO MEMORIZE TABLE 4.4 if you have not begun so yet!!

5) Ionic Charges of the Elements – In order to write chemical equations, we need to know the types of ions (ionic charges of the elements) that atoms tend to form. For the representative elements (those on Group A), the ionic charges can easily be determined using the Periodic Table.

a) The metals in Groups IA, IIA, and IIIA lose electrons when they form ions. The ionic charge is positive and numerically equal to the Group number.

Example – What is the charge of the ion formed by the following elements?

1) Li 2) Ba 3) Al

b) The numerical charge of an ion of a Group A nonmetal (VA, VIA, VIIA) is determined by subtracting the group number from 8. The sign of the charge is minus because nonmetals gain electrons and form anions.

Example – What is the charge of the ion formed by the following elements?

1) N 2) S 3) Br

c) The elements in the two remaining representative groups, IVA and 0, do not commonly form ions.

d) Unlike the Group A elements, many of the transition metals have more than one common ionic charge. (Iron, for example, forms ions with a charge of +2 and +3). There is no simple way to determine the charges of the ions formed by the transition metals, but one of the ions that (almost) all of them have is the +2 ion. Since many of the transition metals form more than one ion, the ions must be given special names. There are two ways of doing this:

1) An older, less preferred method of naming these ions uses a root word and suffixes. The classical name of the element is used as the root word. An -ous ending is used for the ion with the lower charge and an -ic ending is used for the ion with the higher charge. (Example: Fe^{+2} is ferrous and Fe^{+3} is ferric.)

The preferred method is called the Stock system or systematic system. A Roman numeral in parenthesis is used after the name of the element to indicate the

numerical value of the charge. (Example: Fe^{+2} is named iron(II) and Fe^{+3} is named iron(III).)

Example – Name the two ions formed by tin (Sn^{+2} and Sn^{+4}) using both systems.

Why do we learn the older method? Because a lot of chemicals are still named this way so we need to know what it means when we see it in print or read a label.

e) A few transition metals form ions with only one ionic charge. The names of these cations will not have a Roman numeral. (Example: Zn^{+2} is named zinc or zinc ion.)

Examples –

1) Write the symbol for each of the following ions:

a) iodide b) mercury(II) c) barium d) stannic e) silver

2) Name the following ions:
a) Cu^{+2} b) O^{-2} c) Li^{+1}

6) Sec 4.1 – Naming Compounds That Contain a Metal and a Non-Metal

a) Binary Compounds are composed of two elements. The components of a binary ionic compound are a cation formed from a metal and an anion formed from a nonmetal.

b) Ionic compounds are electrically neutral. In writing the formula for an ionic compound, we must exactly balance the positive charge of the cation by the negative charge of the anion.

c) There are two kinds of binary ionic compounds – **Type I** and **Type II** compounds.

1) Type I ionic compounds are those made from metals that can only form one possible ion and an anion made from one of the simple non-metals. The names depend upon the ions involved.

2) Type II ionic compounds are those made from metals that can form more than one possible ion and an anion made from one of the simple non-metals. The names take into consideration how the metal is named.

3) Binary ionic compounds are named by writing the name of the cation followed by the name of the anion (-ide ending).

Examples – Write formulas for compounds composed of these pairs of ions.

1) Li^{+1} and S^{-2} b) Sn^{+4} and O^{-2} c) H^{+1} and Cl^{-1} d) Mg^{+2} and N^{-3}

Examples – Write names for these binary compounds.

1) AlI_3 2) FeO 3) Cu_2S 4) $CaBr_2$

(The "crisscross" or "cross-over" system can always be used for writing formulas from the compound names and the ions used.)

(One can also "uncross" the formulas to be able to name the compounds, including determining the charges of the metal ions.)

7) Sec 4.2 – Binary Molecular Compounds are composed of two nonmetallic elements.

a) Two characteristics of binary molecular compounds affect how they are named. First, because they are composed of molecules, the ionic charges are not used in writing the formulas for these compounds. Second, when two nonmetallic elements combine, they often do so in more than one way. (Example: CO and CO_2)

b) Prefixes are used to show how many atoms of each element are present in each molecule of a binary molecular compound. The prefix is normally omitted if there is just a single atom of the first element in the name.

Prefixes Used: mono (1), di (2), tri (3), tetra (4), penta (5), hexa (6)

Examples

1) Name these compounds:
   1) CBr_4 b) N_2O_5 c) BCl_3

2) Write formulas for these compounds:
   a) nitrogen dioxide b) carbon tetrachloride c) diphosphorus trioxide

8) Binary Molecular Formulas and Names – These are really very simple in that both are "what you see is what you get."

9) Sec 4.4 – Polyatomic Ions are tightly bound groups of atoms that behave as a unit and carry a charge. (Example is the sulfate ion is SO_4^{-2}.) You need to memorize the names of the common polyatomic ions listed in Table 4.4.

a) Observe that the names of most polyatomic ions end in -ite or -ate. Notice the relationship between the ate/ite ion pairs. The -ite ending will always indicate one less oxygen than the -ate. The charge on each ion pair is the same.

Example: Sulfate (SO_4^{-2}), sulfite (SO_3^{-2})

b) There are three common polyatomic ions that do not end in -ate or -ite. The ammonium ion (NH_4^{+1}) is the one common polyatomic ion that is positively charged.

The two anions that end in -ide are the cyanide ion (CN^{-1}) and the hydroxide ion (OH^{-1}).

c) A polyatomic ion whose formula begins with H (hydrogen) can be viewed as a hydrogen ion (H^{+1}) combined with another polyatomic ion. (Example: HCO_3^{-1} is a combination of H^{+1} and CO_3^{-2}. The name of the ion is **hydrogen carbonate** and its "common" name is **bicarbonate**.)

10) Naming Ternary Ionic Compounds

a) Ternary Compounds contain atoms of three different elements. Ionic compounds with polyatomic ions are often ternary ionic compounds.

b) The procedure for writing the formula of a ternary ionic compound is the same as that for binary ionic compounds. Whenever more than a single polyatomic ion is needed to balance a formula, parentheses must be used.

Examples

1) Write formulas for these compounds:
   a) barium sulfate b) tin(IV) chlorite c) aluminum hydrogen carbonate

2) Write names for these compounds:
   a) $Mg_3(PO_4)_2$ b) Li_2CrO_4 c) $Cu(HSO_4)_2$

11) Sec 4.5 – Acids are a group of compounds that are given special treatment in naming. Acids are compounds that give off hydrogen ions (protons) when dissolved in water.

a) The formulas for acids are of a general form HX, where X is a monatomic or polyatomic ion.

b) When the anion (X) ends in -ide, the acid name begins with the prefix hydro-. The stem of the ion has the suffix -ic and it is followed by the word acid. (Example: HCl is named as hydrochloric acid when it is a water solution.)

When these acids are not in water they are just named as compounds of the anion. (Example: HCl is named now as hydrogen chloride.)

c) When the anion (X) ends in -ite, the acid name is the stem of the anion followed with the suffix -ous, followed by the word acid. (Example: H_2SO_3 is named as sulfurous acid.)

d) When the anion (X) ends in -ate, the acid name is the stem of the anion followed with

the suffix -ic, followed by the word acid. (Example: HNO_3 is named as nitric acid.)

HCl —> chloride —> --chlor- ---
$HClO_2$ —> chlorite —> chlor- ---
$HClO_3$ —> chlorate —> chlor- ---

Examples

1) Name these compounds:
   a) HF b) H_2SO_4 c) HNO_3

2) Write formulas for the following acids:
   a) chromic acid b) hydrobromic acid c) chlorous acid

12) Writing Formulas from Names – It is important for all that we will be doing from now on that you can write formulas from names and, of course, also names from formulas.

Review:

Sodium Sulfide	Na_2S
Stannous Phosphate	$Sn_3(PO_4)_2$
Carbonic Acid (carbonate)	H_2CO_3
Calcium Iodide	CaI_2
iron(II) oxide	Fe_2O_3
Sodium Sulfate	Na_2SO_4
Copper(II) nitrate	$Cu(NO_3)_2$
Carbon Tetrachloride	CCl_4
Diphosphorus Pentoxide	P_2O_5