RULES OF INORGANIC NOMENCLATURE

INTRODUCTION

- How to name a compound from its formula.
- The interrelationship of names and formulas is very important to you.
- You will be required recognize both, in interpreting, preparing, and using these chemicals.

GENERAL TERMS

- There are several general terms we use that give us information about inorganic compounds.
- To describe the number of different elements in a compound we use the terms binary, ternary, and quaternary.
- A binary compound contains two different elements, such as NaCl.
- A ternary compound contains three different elements, such as H_2SO_4.
- A quaternary compound contains four different elements such as $NaHCO_3$.

Questions.

(1) CO_2 is a _____ compound because it contains _____ different elements.

(2) $Al(OH)_2Cl$ is a _____ compound because it contains _____ different elements.

(3) KNO_3 is a _____ compound because it contains _____ different elements.

Questions.

(1) CO_2 is a Binary compound because it contains two (C,O) different elements.

(2) $Al(OH)_2Cl$ is a Quaternary compound because it contains four (Al,O,H,Cl) different elements.

(3) KNO_3 is a Ternary compound because it contains three (K,N,O) different elements.

NUMBER PREFIXES

- We often use prefixes to denote the number of atoms of an element in a compound.
- For example, CO contains one oxygen atom and is named carbon monoxide.
- Mon or mono indicates one atom. Here is a list of the commonly used number prefixes.

Mono, mon	= one
Di	= two
Tri	= three
Tetra	= four
Penta	= five
Hexa	=six
Hepta	= seven
Octa	= eight
Nona	= nine
Deca	= ten

Examples

CO	Carbon monoxide
CO_2	Carbon dioxide
SO_3	Sulfur trioxide

Questions

(1) NCl3 is named nitrogen _____ chloride.

(2) SO2 is named sulfur _____ oxide.

(3) CF4 is names carbon _____ flouride.

Questions

(1) NCl_3 is named nitrogen Tri chloride.

(2) SO_2 is named sulfur Di oxide.

(3) CF_4 is names carbon Tetra flouride.

NAMING METALLIC CATIONS

- Many metallic elements have only one possible valence.
- The names for the cations formed by these metals are given the name of the element. For example, Na^{+1} is called sodium ion; Ca^{+2} is called calcium ion
- Other metallic elements, however, may have more than one valence.

- Since valence is a measure of combining power, these elements may form more than one compound with the same anion.
- Therefore, we must have some way to differentiate between the varying valences when we name them. There are two common methods for doing this.

a.

- The first method uses a root word from the name of the element (or the Latin name for the element) with a suffix to indicate the valence state.
- The suffix –ous indicates the lower valence; the suffix –ic indicates the higher valence.
- For example, Hg^{+1} is called mercurious ion, but Hg^{+2} is called mercuric ion.

Questions.

(a) Al+3 is called _____ion.

(b) Fe+2 is called ferr-- _____ ion.

(c) Fe+3 is called ferr--_____ ion.

(d) K+1 is called _____ ion.

(e) Cu+1 is called cupr- _____ ion.

(f) Cu+2 is called cupr- _____ ion.

(g) Ba+ is called _____ ion.

Questions.

(a) Al+3 is called Aluminum ion.

(b) Fe+2 is called ferrous ion.

(c) Fe+3 is called ferric ion.

(d) K+1 is called Potassium ion.

(e) Cu+1 is called cuprous ion.

(f) Cu+2 is called cupric ion.

(g) Ba+ is called Barium ion.

b.

- The second method for naming metallic cations uses the name of the element followed by a roman numeral in parentheses to indicate the valence. For example,
- Cu+1 is written as copper (I) and
- Cu+2 is written as copper (II).
- Remember, these methods for specifying valence need be used only when there is more than one valence possible.

(1) Questions.

(a) Fe+2 is written _____ ion.

(b) Fe+3 is written _____ ion.

(c) Mg+2 is wrjtten _____ ion.

(d) Hg+1 is written _____ ion.

(e) Ag+1 is written _____ ion.

(f) Pb+4 is written _____ ion.

(1) Questions.

(a) Fe+2 is written Iron (II) (ferrous) ion.

(b) Fe+3 is written Iron (III) (ferric) ion.

(c) Mg+2 is wrjtten Magnesium ion.

(d) Hg+1 is written Mercury (I) (mercurous) ion.

(e) Ag+1 is written Silver ion.

(f) Pb+4 is written Lead (IV) (plumbic) ion.

NAMING ANIONS

- There are generally two types of anions.
- Many anions are elemental; that is they are made of only one atom of one element.
- Others are composed of groups of atoms of one or more elements that pass through a reaction unchanged in most cases.
- This latter group of anions is called radicals.

a.

- The names of the elemental anions are made by adding the ––ide suffix to the root of the element's name.
- Thus anions formed by chlorine (Cl^{-1}) are called chloride ion; anions formed by oxygen (O^{-2}) are called oxide ion.

(1) Questions.

(a) Br^{-1} is called Bromide ion.

(b) S^{-2} is called Sulfide ion.

(c) H^{-1} is called Hydride ion.

(d) N^{-3} is called Nitride ion.

b.

- The most common type of anionic radicals consists of a central atom covalently bonded to a number of atoms of oxygen.

- Monovalent anionic radicals (Valence = −1) normally contain three oxygen atoms; radicals with negative valences greater than one normally contain four oxygen atoms.
- The names for these normal types of radicals are formed from the root for the name of the central atom plus the suffix −ate.

- Thus, ClO_3^{-1} is named chlorate and SO_4^{-2} is named sulfate.
- It is important to note that these generalizations have exceptions.
- The best way to remember the names and formulas for the radicals is to memorize the common ones.

(1)

- Sometimes a central atom may be bonded to a different number of oxygen atoms than normal; in other words, a series of radicals may be formed with the same central atom.
- Different suffixes and prefixes are used to name these different radicals.
- When there is one less oxygen atom than normal, the suffix –ite is used. The name for ClO_2^{-1} is chlorite; SO_3^{-2} is called sulfite.

(2)

- Occasionally, there are other radicals in a series. This is especially true of the halides (fluoride, chloride, bromide, and iodide ions).

- If there are two less oxygen atoms than usual, the –ite suffix is used with the prefix hypo–.
  For example, ClO^{-1} is called hypochlorite.
- If there is one more oxygen atom than normal, the –ate suffix is used in combination with the prefix per–, so ClO_4^{-1} is named perchlorate.

(3) A chart summarizing the use of the prefixes and the series of radicals formed by chlorine as examples follows:

PREFIX	SUFFIX	NAME OF ION	RADICAL
hypo-	--ite	hypochlorite	ClO^{-1}
	--ite	chlorite	ClO_2^{-1}
	--ate	chlorate	ClO_3^{-1}
per-	--ate	perchlorate	ClO_4^{-1}

Questions.

1 IO_3^{-1} is called _____ ion.

2 IO_2^{-1} is called _____ ion.

3 IO_4^{-1} is called _____ ion.

4 PO_4^{-3} is called _____ ion.

5 PO_3^{-3} is called _____ ion.

6 NO_3^{-1} is called _____ ion.

7 CO_3^{-2} is called _____ ion.

Answers.

1 Iodate. 2 Iodite. 3 Periodate.
4 Phosphate. 5 Phosphite.
6. Nitrate. 7 Carbonate.

NAMING SALTS

- A salt is an ionic compound containing some cation other than hydrogen and some anion other than hydroxide and oxide.
- Since the compound must be electrically neutral, the total positive valence (from all of the cations) must equal the total negative valence (from all the anions).
- This gives us a method for determining the valence of any particular ion in the formula.
- The names for salts are made by writing the name of the cation followed by the name of the anion.

- For example, $CaCl_2$ has calcium as the cation and chloride as the anion, so the compound is called calcium chloride.
- $FeSO_4$ has sulfate as the anion, but we need to know whether the ion is ferrous ion or ferric ion.
- Since we know the total negative valence (from sulfate) is −2, the total positive valence (for iron) must be +2; therefore, it is ferrous ion.
- The compound is ferrous sulfate.

Questions.

(1) KBr is _____ .
(2) Mg(NO3)2 is _____ .
(3) BaSO4 is _____ .
(4) BiOCl is _____ .
(5) HgCl2 is _____ .
(6) CuSO4 is _____ .
(7) Al(OH)2Cl is _____ .
(8) NaHCO3 is _____ .
(9) PbSO4 is _____.
(10) KBrO3 is _____ .

Answers.

(1) Potassium bromide.

(2) Magnesium nitrate.

(3) Barium sulfate.

(4) Bismuth oxychloride.

(5) Mercuric chloride (mercury (II) chloride).

(6) Cupric sulfate (copper (II) sulfate).

(7) Aluminum dihydroxychloride.

(8) Sodium bicarbonate (sodium hydrogen carbonate).

(9) Plumbous sulfate (lead (II) sulfate).

(10) Potassium bromate.

NAMING BINARY ACIDS

- All acids have hydrogen as the only cation. Binary acids are those acids that are composed of only two elements; that is, they consist of hydrogen in combination with some elemental anion.
- Usually the anion is a halide (F, Cl, Br, I), but binary acids with other anions also occur.

a. The names for the binary acids are formed by using the prefix hydro–, the root name for the anion, and the suffix –ic , followed by the word “acid.” For example, HCl is called hydrochloric acid.

b. An exception to this rule hydrocyanic acid which has the formula HCN. Although this is a ternary acid, the cyanide radical (CN^{-1}) is usually treated like a halide ion when naming its compounds.

c. The binary acids are really covalent compounds which act as acids only when they are in solution, especially in water. When you know that one of the binary acids is by itself, you can properly name it in a similar manner to the salts; thus, HCl as a pure gas would be called hydrogen chloride.

(1) Questions.

(a) HBr is called _____ .

(b) HI is called _____ .

(c) H_2S is called _____ .

(d) HF gas is called _____ .

NAMING TERNARY ACIDS

a.

- The ternary acids generally are made of hydrogen ion combined with one of the radicals that contain oxygen.
- For this reason, they are often referred to as “oxyacids.”

b.

- When naming the ternary acids, the suffixes on the names of the radicals are changed and followed by the word "acid" to show the presence of the hydrogen.
- Radicals ending in –ate change their suffix to –ic; radicals ending in –ite change their suffix to –ous.
- The prefixes, if there are any, are not changed.
- Occasionally, an extra syllable is added in the middle of the name for pronunciation purposes--these do not follow any pattern and must be learned.

- Here are some examples of naming ternary acids from the radicals:

RADICAL	NAME OF RADICAL	ACID	NAME OF ACID
SO_4^{-2}	Sulfate	H_2SO_4	Sulfuric acid
SO_3^{-2}	Sulfite	H_2SO_3	Sulfurous acid
ClO^{-1}	Hypochlorite	HClO	Hypochlorous acid

Questions.

(a) HNO_3 is called _____ .

(b) HNO_2 is called _____ .

(c) $HClO_4$ is called _____ .

(d) H_2CO_3 is called _____ .

(e) H_3PO_3 is called _____ .

(f) H_3PO_4 is called _____ .

NAMING BASES

a.

- The most common bases are those included by the Classical Theory of Acids and Bases; that is, they are hydroxyl ion (OH^{-1}) donors.
- Thus most of the bases a composed of the hydroxyl radical combined with a metallic cation.

b.

- The names for these bases are made by writing the name of the cation followed by "hydroxide”
- It is not normally necessary to use number prefixes because the valence of the cation tells us the number of hydroxyl radicals in each molecule.
- This method of naming bases is very similar to the method used for naming salts, except that the anion is always hydroxide.
- For example, NaOH is called sodium hydroxide and $Ca(OH)_2$ is called calcium hydroxide.

Questions.

(a) KOH is called _____ .

(b) $Mg(OH)_2$ is called _____ .

(c) $Fe(OH)_2$ is called _____ .

(d) $Al(OH)_3$ is called _____ .

(e) $Fe(OH)_3$ is called _____ .

NAMING COVALENT INORGANIC COMPOUNDS

- There are a number of inorganic compounds that are bonded into molecules by covalent bonds.
- Most of these are the oxides, sulfides, and halides of the nonmetallic elements.

a.

- Generally, these compounds are named by writing the name of the central atom (usually the first one in the formula) followed by the name of the anion formed by the other element.
- Number prefixes are used when necessary to avoid confusion between different compounds formed by the same elements.

Here are some examples

COMPOUND	NAME OF COMPOUND
H_2S gas	Hydrogen sulfide
CO	Carbon monoxide
CO_2	Carbon dioxide

b.

- There are two very important exceptions.
- These are water (H2O) and ammonia (NH3).
- Both of these have common names, which are firmly established in the nomenclature, property of these two compounds which makes them different from almost all others is the ability to readily accept a proton (coordinate covalent bond with a hydrogen cation) to form cations.

- Thus water becomes hydronium ion (H_3O^{+1});
  ammonia becomes ammonium ion (NH_4^{+1}) very easily in the right conditions.

Questions.

(a) SO_2 is called _____ .

(b) SO_3 is called _____ .

(c) CCl_4 is called _____ .

(d) NI_3 is called _____ .

(e) CS_2 is called _____ .

(f) NH_3 is called _____ .

(g) NH_4^{+1} is called _____ .

(h) NH_4Cl is called ____ .

WATERS OF HYDRATION

- Many times when a substance crystallizes into a solid, molecules of water are included in the crystal.
- These molecules of water combine with the substance in a fixed ratio, similar to the fixed ratios between the atoms in a molecule.
- Whenever weighing or doing calculations based on compounds that have waters of hydration, the amount of water in the crystals must be taken into consideration

a.

- When writing formulas for these compounds, the waters of hydration are shown by placing a dot (or dash) after the formula for the compound, followed by the formula for water with a coefficient to indicate the number of waters of hydration.
- For example, cupric sulfate forms crystals that contain five molecules of water for each molecule of cupric sulfate--its formula is written $CuSO_4 \cdot 5H_2O$.

b.

- Compounds that contain waters of hydration are called hydrates. (If all the water has been removed by drying, they are called anhydrous.)
- When writing the names for these compounds, the number of waters of hydration is indicated by using number prefixes.
- Thus, the name for CuSO4.5H2O is cupric sulfate pentahydrate.
- Another number prefix seen occasionally in the names of hydrates is hemi-, which means one-half (1/2).

Questions.

(a) $AlCl_3.6H_2O$ is called _____ .

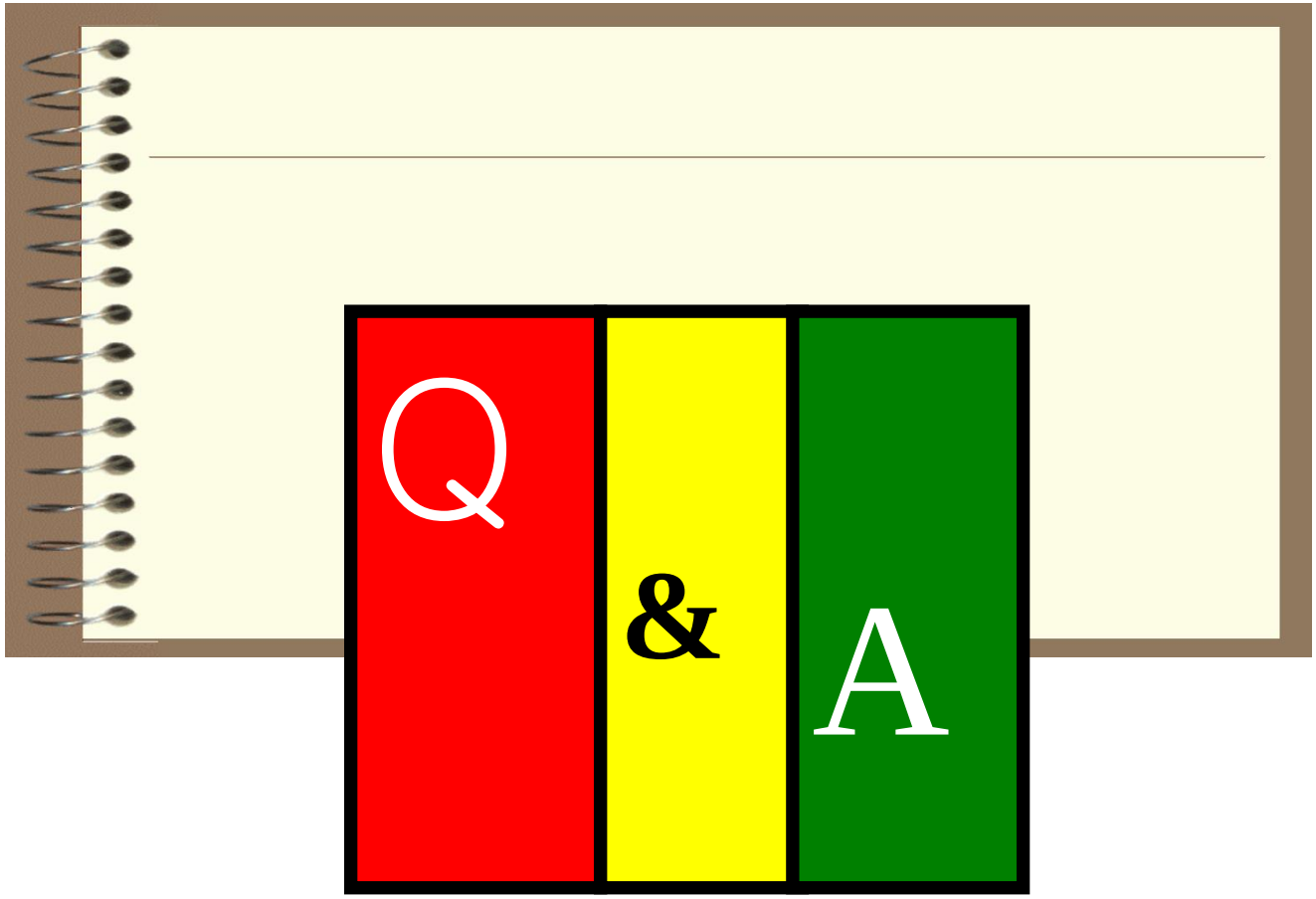
(b) $Mg_3(PO_4)_2.5H_2O$ is called _____ .

(c) $Na_2HPO_4.7H_2O$ is called _____ .

(d) $FeSO_4.7H_2O$ is called _____ .

(e) $Na_2CO_3.1OH_2O$ is called _____ .

(f) $CaSO_4.1/2H_2O$ is called _____ .



Thanks.