Nomenclature Basics

Chemistry 129

Chemical nomenclature is an essential skill that you will need throughout your chemistry life. Summarized below are the basic rules you should learn for naming chemical compounds. While much of this will NOT be covered in lecture, YOU MUST LEARN THESE RULES. You are responsible for all the common ions, acids and bases listed on the Common Nomenclature handout. If you are stuck, see me for help.

Ionic Nomenclature Basics

An ionic compound is a neutral species formed between a cation (positive ion) and an anion (negative ion). Because the overall species is neutral, the positive charge of the cation(s) must be balanced by the negative charge of the anion(s). This in turn dictates the relative number of cations and anions present in the compound.

e.g. Salt formed between Na\(^+\) and O\(^2-\):

The salt needs two 1+ cations for every one 2- anion to be neutral.

∴ The formula unit or empirical formula for this salt is Na\(_2\)O.

Naming an ionic compound is fairly straightforward. The cation is named first and the anion is named second. Charge balance is an implicit assumption when naming all ionic compounds.

Naming Simple Monatomic Ionic Compounds: Ions with one charge state

Simple monatomic ionic compounds are the easiest to name. The cations are metals with only one common charge state and the anions are non-metals with only one common charge state. The cation keeps the name of the metal and the anion keeps the root name of the non-metal while adopting the suffix –ide.

e.g. Ag\(_2\)S cation: Ag\(^+\) Silver ➔ Silver ➚ Silver Sulfide

anion: S\(^2-\) Sulf ➔ Sulfide ➚ Silver Sulfide

Naming More Complex Monatomic Ionic Compounds: Ions with multiple charge states

Many transition metals can form more than one monatomic ion. There are two general approaches to naming compounds with these cations.

• Systematic: By far the most straightforward of the two methods. The charge of the cation is represented by Roman numerals in parenthesis.

e.g. FeBr\(_3\) cation: Fe\(^{3+}\) Iron ➔ Iron (III) ➚ Iron(III) Bromide

anion: Br\(^-\) Brom ➔ Bromide ➚ Bromide

• Common Names: Mastering common cation names will require work. There are some systematic aspects of common cation name. The suffix –ous refers species with the lower charge while the suffix –ic refers to the species with the higher charge.

e.g. Fe\(^{3+}\) vs Fe\(^{2+}\) Iron (III) Ferric Cu\(^{2+}\) Copper (II) Cupric

Fe\(^{2+}\) Iron (II) Ferrous Cu\(^+\) Copper (I) Cuprous

You need to become bilingual, comfortable with both systematic and common names. Because charge balance is implied, we can write a name from an empirical formula.

e.g. Cu\(_2\)O cation: Cu\(^2+\) Since there are two Cu\(^2+\) ions for every one O\(^2-\) ion, ? ➔ 1+

anion: O\(^2-\)

Naming Polyatomic Ionic Compounds: Compounds with molecular ions

Polyatomic ions are charged species that contain more than one atom in a covalent network. You are expected to know the common polyatomic ions included in the Common Nomenclature handout. I suggest you make flash cards, as there are quite a few to absorb. Naming salts with these ions is relatively easy if you have the common polyatomic names down.

e.g. The salt formed between aluminum and SO\(_4\)\(^{2-}\) (sulfate)
cation: Al\(^{3+}\) aluminum ➔ Aluminum Sulfate; Empirical Formula: Al\(_2\)(SO\(_4\))\(_3\)

anion: SO\(_4\)\(^{2-}\) sulfate ➔ Note: Because the polyatomic ions are covalently bound species, they are in effect a fixed unit. Thus we use parenthesis and write Al\(_2\)(SO\(_4\))\(_3\) and not Al\(_2\)S\(_3\)O\(_{12}\).
**Oxoanions**

Most of the polyatomic ions we will see in this class are oxoanions. An oxoanion usually contains a non-metal bonded to one or more oxygen atoms. An oxoanion family will have a common non-metal bound to differing number of oxygen atoms. Within an oxoanion family there are two naming conventions:

- If there are two oxoanions in the family, the ion with more oxygens takes the nonmetal root name with an -ate suffix and the ion with fewer oxygens takes the nonmetal root name with an -ite suffix.  
  
  e.g. the Sulfur Oxoanion family
  
  \[ \text{SO}_3^{2-} \text{ sulfur} \leftrightarrow \text{sulfite} \]
  
  \[ \text{SO}_4^{2-} \text{ sulfur} \leftrightarrow \text{sulfate} \]

- If there are four oxoanions in the family, the ion with the most oxygen atoms has the prefix per-, the nonmetal root and the suffix -ate. Ion with one fewer oxygen has just the root and the suffix -ate. Ion with two fewer oxygens has just the root and the suffix -ite. Ion with fewest oxygens has the prefix hypo-, the root, and suffix -ite. For example Cl forms four oxoanions:

  e.g. the Chlorine Oxoanion family
  
  \[ \text{ClO}_4^{-} \text{ chlorine} \leftrightarrow \text{perchlorate} \]
  
  \[ \text{ClO}_3^{-} \text{ chlorine} \leftrightarrow \text{chlorate} \]
  
  \[ \text{ClO}_2^{-} \text{ chlorine} \leftrightarrow \text{chlorite} \]
  
  \[ \text{ClO}^{-} \text{ chlorine} \leftrightarrow \text{hypochlorite} \]

**Naming Hydrated Ionic Compounds**

Hydrated ionic compound have a specific number of water molecules within the formula unit. When naming a hydrate one uses a Greek numerical prefix (mono- di- etc.) followed by hydrate to indicate the how many water molecules are associate with the salt.

  e.g. \( \text{MgSO}_4 \cdot 7\text{H}_2\text{O} \)

  cation: magnesium \( \rightleftharpoons \)
  
  anion: sulfate \( \rightleftharpoons \)
  
  seven waters \( \rightleftharpoons \)
  
  magnesium sulfate heptahydrated

**Acid Nomenclature Basics**

Acids are an important class of compounds that generate hydrogen ions (H\(^+\)) in solution. When naming acids we treat them like a salt with the charge of the anion balanced by an appropriate number of H\(^+\) “cations.” There are two classes of acids we will consider.

**Naming Binary Acids**

A binary acid is a single non-metal atom bound to hydrogen. To name these compounds you attach the prefix hydro- and the suffix –ic to the non-metal root and then add the word acid.

  e.g. HCl  nonmetal: chlorine \( \rightleftharpoons \) hydrochloric acid

**Naming Oxoacids**

Oxoacids are formed between hydrogen ions and oxoanions. Their names are similar to those for the corresponding oxoanion, except for the suffixes. If your anion has the -ate suffix, the corresponding acid has an -ic suffix. If your anion has the -ite suffix, the corresponding acid has an -ous suffix. You keep any prefixes to the anions like hypo- and per-. So for example:

  e.g. HClO\(_4\)  Oxoacid: \( \text{ClO}_4^{-} \) perchlorate \( \rightleftharpoons \) perchloric acid

**Covalent Nomenclature Basics**

Covalent compounds are formed between two or more non-metals. We will only touch on nomenclature rules for these compounds, as this is a very broad subject and there are oodles of commonly used exceptions. We will focus on covalent species with only two different elements. Naming these compounds is very similar to naming ionic species. One element, typically the first in the molecular formula is treated like the cation and keeps its name. The second element is treated like a anion and keeps it’s the root of its name but adds the suffix –ide. (Do not infer that either of the species is charged! In a covalent compound bonds are formed when electrons are shared.) Greek numerical prefixes are used to indicate the number of each species present. By convention, no prefix is added to the cation-like element if only one atom of this element is present.

  e.g. CO  cation-like: carbon (1) \( \rightleftharpoons \) carbon
  
  anion-like: oxygen (1) \( \rightleftharpoons \) monoxide
  
  name: carbon monoxide
  
  CO\(_2\)  cation-like: carbon (1) \( \rightleftharpoons \) carbon
  
  anion-like: oxygen (2) \( \rightleftharpoons \) dioxide
  
  name: carbon dioxide
  
  N\(_2\)O\(_4\)  cation-like: nitrogen (2) \( \rightleftharpoons \) dinitrogen
  
  anion-like: oxygen (4) \( \rightleftharpoons \) tetraoxide
  
  name: dinitrogen tetraoxide