Nomenclature Review

Before you can begin naming or writing formulae for chemicals, you need to be able to be able to tell the difference between the different three types of compounds we will be working with: ionic compounds, molecular compounds, and acids. The nomenclature of each of these has some similarities and some differences so you need to know which rules to apply. This review is intended to give you an overview of nomenclature, give you detailed examples of each, and give you practice.

Identifying the type of compound being named:

Ionic compounds

Ionic compounds are made up of positive ions (cations) and negative ions (anions) which are attracted to each other to combine to form neutral "formula units". This means that one way to identify an ionic compound is to look for cations and ions within the compound. Another way to say this is that all ionic compounds must contain a metal ion or the ammonium ion. Ionic compounds must also be neutral. In order for a compound to be classified as an ionic compound, it MUST satisfy the following criteria:

1) **the compound must contain a metal ion or the ammonium ion (NH_4^+)**
2) **the compound must be neutral (have an overall charge of 0)**

Examples of ionic compounds:	$Sr(ClO)_2$	NH_4NO_3	PbS_2	$NaOH$
explanation:	Sr^{2+} is a metal ion	NH_4^+ is present	Pb^{4+} is a metal ion	Na^+ is a metal ion
Examples of non-ionic compounds:	H_2O	CrO_4^{2-}	PO_4	$C_{11}H_{22}O_2$
explanation:	no metal or NH_4^+	not neutral	no metal or NH_4^+	no metal or NH_4^+

Molecular compounds

Molecular compounds are NOT made up from ions at all but instead are formed when two (or more) nonmetal elements share electrons. You can identify a molecular compound by either recognizing that there are no metals, or that all elements in the compound are nonmetals (these mean the exact same thing). Molecular compounds must also be neutral. In order for a compound to be classified as a molecular compound, it MUST satisfy the following criteria:

1) **the compound must contain only nonmetal elements (no ions!)**
2) **the compound must be neutral (have an overall charge of 0)**

Examples of molecular compounds:	CO_2	$C_8H_{10}N_4O_2$	N_3Cl_7	HBr
Examples of non-molecular compounds:	Fe_2O_3	PO_4^{3-}	NH_4NO_3	
explanation:	Fe^{3+} is metal ion	not neutral	NH_4^+ and NO_3^- are ions	

Acids

Acids are probably the most easily identifiable type of compound that we are going to deal with, especially when it comes to identifying by name since the word "acid" is in the name of most acids! The part of and acid that actually does the work is hydrogen and by convention the hydrogen is written first when writing the formula of an acid. Also, an acid isn't an acid unless it is in water which is indicated by putting (aq) after the compounds name (not just acids). In order for a compound to be classified as an acid, it MUST satisfy the following criteria:

1) **the compound formula must begin with at least one hydrogen**
2) **the compound formula must have a subscript (aq) after it**
3) **the compound must be neutral (have an overall charge of 0)**

Examples of acids:	$H_3PO_{4(aq)}$	$H_2CO_{3(aq)}$	$HC_2H_3O_{2(aq)}$	$HF_{(aq)}$
Examples of non-acids:	HI	$NaCl_{(aq)}$	$NH_{3(aq)}$	
explanation:	no (aq)	no H in front	no H in front	

Writing the name or formula for a compound:

Name to formula for MOLECULAR compounds

The nomenclature for molecular compounds is similar to ionic compounds in that you start with the first half and then move to the second half. It differs in a major way as well. Molecular compounds are NOT made up of ions so you will not have to worry about charges. What you will have to worry about is how many of each nonmetal make up the molecule you are dealing with. As long as you know the numeric prefixes you should not have much trouble with this.

Step 1: Write the symbol and the subscript for the first element

Step 2: Write the symbol and the subscript for the second element

That's it.

Example: tetranitrogen nonachloride

Step 1: $N_{\mathbf{4}}$ (tetra = 4, think tetris!!)

Step 2: $N_4Cl_{\mathbf{9}}$ (nona = 9, kinda looks like nine)

Example: hexaarsenic octaphosphide

Step 1: $As_{\mathbf{6}}$ (hexa = 6, hexagon)

Step 2: $As_6P_{\mathbf{8}}$ (octa = 8, octopus)

You try:

1) chlorine pentoxide
2) pentasulfur tetrabromide
3) diphosphorous hexaiodide
4) carbon dioxide
5) dixenon decafluoride

Formula to name for MOLECULAR compounds

This is pretty much the reverse of above.

Step 1: Write the prefix and name for the element (make no changes to the name of the element)

Step 2: Write the prefix and name for the second element (change the end of the name of the element to –ide)

The prefix "mono" is optional

Example: O_2F

Step 1: dioxygen

Step 2: dioxygen monofluor**ide**

Example: P_3S_7

Step 1: triphosphorous

Step 2: triphosphorous heptasulf**ide**

You try:

1) Br_6Cl_9
2) I_4Cl_5
3) CO
4) S_8O_6
5) HCl

Name to formula for ACIDS

Acid nomenclature is based solely upon the name of the anion that is paired up with the hydrogen. Because of this it will be impossible for you to name acids without knowing the names of anions. Each of the 3 different anion endings ("ide", "ite", and "ate") have a different relation with the name of the corresponding acid.

acid name	anion name
hydro*stem*ic acid	*stem*ide
*stem*ous acid	*stem*ite
*stem*ic acid	*stem*ate

The easiest way to remember these relationships is that if the acid name starts with hydro, then the anion is monoatomic (like Cl^- or S^{2-}). After that, remember the phrase "I ate something icky at the White House"

Step 1: Write the symbol for the anion based on the above relationships

Step 2: Balance the anion charge by adding hydrogen(s) in front and add (aq) to the end. (the anion charge = # of hydrogens needed)

Example: **hydro**fluoric acid
Step 1: The acid name starts with a **hydro**, so the anion ends with an **–ide**. That means that it is $\mathbf{F}^-$
Step 2: The acid is $H\mathbf{F}_{(aq)}$

Example: carbon**ic** acid
Step 1: The acid name end with **–ic** acid (without a hydro), so the anion ends with an **–ate**. That means that it is $\mathbf{CO_3}^{-2}$
Step 2: The acid is $H_2\mathbf{CO_3}_{(aq)}$

You try:
1) perchloric acid
2) hydrosulfuric acid
3) hypoiodous acid
4) sulfuric acid
5) chlorous acid

Formula to name for ACIDS

Again, this is pretty much the opposite of the name to formula rules.

Step 1: Name the anion based on the above relationships

Step 2: Change the ending of the anion name (add the prefix "hydro" if the anion ends with "ide") and add the word acid

Example: $\mathbf{HClO_{4(aq)}}$
The anion is ClO_4^- which is the perchlor**ate** anion, so third relationship applies
Ending is changed to **–ic,** so this is **perchloric acid**

Example: $\mathbf{H_2SO_{3(aq)}}$
The anion is SO_3^{-2} which is the sulf**ite** anion, so second relationship applies
Ending is changed to **–ous**, so this is **sulfurous acid**

Example: $\mathbf{HCN_{(aq)}}$
The anion is CN^- which is the cyan**ide** anion, so first relationship applies
hydro is put out front and the ending is changed to **–ic**, so this is **hydrocyanic acid**

Try these:
1) $H_2CO_{3(aq)}$
2) $HIO_{2(aq)}$
3) $HBr_{(aq)}$
4) $HMnO_{4(aq)}$
5) $HNO_{3(aq)}$

Name to formula for IONIC compounds

Once you have identified a compound as an ionic compound, you need to be able to write the formula from the name. This is done by following 3 simple (once you have practiced) steps.

Step 1: Write the symbol for each ion.

Step 2: Find the LCM of the two charges and use it to determine how many cations and how many anions you need in the formula.

$$\frac{\text{LCM}}{\text{charge of cation}} = \text{\# of cations} \qquad \frac{\text{LCM}}{\text{charge of anion}} = \text{\# of anions}$$

Step 3: Write the formula for the compound:

Remember: Parentheses are NOT used for monatomic ions or for single polyatomic ion, only if there are more than one polyatomic ions in the formula. Also remember that you do NOT write the charges in the final formula

Example: ammonium carbonate

Step 1: ammonium = NH_4^{+1} carbonate = CO_3^{2-}

Step 2: LCM of **1** and **2** is **2**. $\frac{2}{1} = 2$ cations → $(NH_4)_2$ $\frac{2}{2} = 1$ anion → CO_3

Step 3: $(NH_4)_2CO_3$

Note: There are two ammonium ions needed, so the NH_4 MUST be in parentheses with the number of cations on the outside of the parentheses. There is only a single carbonate needed, so there must NOT be parentheses.

Example: calcium phosphide

Step 1: calcium = Ca^{+2} phosphide = P^{3-}

Step 2: LCM of **2** and **3** is **6**. $\frac{6}{2} = 3$ cations → Ca_3 $\frac{6}{3} = 2$ anions → P_2

Step 3: Ca_3P_2

Note: There are no polyatomic ions here, so there will not be any parentheses in the formula. There will NEVER be parentheses unless there is a polyatomic ion present.

Example: bismuth (V) arsenate

Step 1: bismuth (V) = Bi^{5+} arsenate = AsO_4^{3-}

Step 2: LCM of **5** and **3** is **15**. $\frac{15}{5} = 3$ cations → Bi_3 $\frac{15}{3} = 5$ anions → $(AsO_4)_5$

Step 3: $Bi_3(AsO_4)_5$

Example: titanium (IV) sulfite

Step 1: titanium (IV) = Ti^{4+} sulfite = SO_3^{2-}

Step 2: LCM of **4** and **2** is **4**. $\frac{4}{4} = 1$ cation → Ti $\frac{4}{2} = 2$ anions → $(SO_3)_2$

Step 3: $Ti(SO_3)_2$

You try:

1) manganese (IV) selenide
2) copper (II) phosphate
3) rubidium oxide
4) calcium perbromate
5) nickel (III) sulfide
6) ammonium hydrogen carbonate

Formula to name for IONIC compounds

Writing the name of an ionic compound when given the formula is not as bad as it might appear, especially if there is not a VOS present. Wait, VOS? What is that? These are the metals within the red box you saw in class which can take on multiple charges when they form ions. Because they can take on multiple charges, you need to be able to tell which charge they have in a given compound and this is done by putting a roman numeral representing the charge in the name of the ion. For example Cr^{2+} is called the chromium (II) ion, Cr^{3+} is called the chromium (III) ion and Cr^{6+} would be called the chromium (VI) ion. You do NOT need to memorize all of the ions that each VOS metal can take, but you DO need to know which elements are VOS and which aren't and you need to be able to name them

There are only 2 steps for converting an ionic formula to an ionic name:

Step 1: Name the cation.

Step 1a: If the cation is a VOS metal you need to include the roman numeral for the charge in the cation name.

Step 2: Add the name of the anion.

It is **step 1a** that seems to cause the problems, but with a little practice it really isn't that bad. Because the total positive charge and the total negative charge must be equal to each other (why?) we can figure out the cation charge using the following method:

$$\text{roman numeral} = \textbf{charge of cation} = \frac{(\textbf{\# of anions})\bullet(\textbf{charge of anion})}{(\textbf{\# of cations})}$$

This equation itself is not hard to use, the hard part is figuring out what to plug into it. The **# of anions** and the **# of cations** come from the subscript values in the formula. Sadly, the only way to identify the **charges of the anions** is to memorize them.

Example: $Cr_2(SO_3)_3$

Step 1: chromium ( ) (Cr is a VOS so we need to go through step 1a)

Step 1a: The subscript 3 outside the parentheses tell us that there are 3 SO_3^{2-} in the compound. The subscript **2** after the Cr tells us that there are **2** Cr in the compound.

$$\frac{(3)\bullet(-2)}{(2)} = 3 \rightarrow \text{chromium (III)}$$

Step 2: **chromium (III) sulfite**

Example: $AlPO_4$

Step 1: aluminum (Al is NOT a VOS so no roman numerals)

Step 2: **aluminum phosphate**

Example: $Mn(CO_3)_2$

Step 1: manganese ( ) (Mn is a VOS so we need to go through step 1a)

Step 1a: The subscript 2 outside the parentheses tell us that there are 2 CO_3^{2-} in the compound. The missing subscript after the Mn tells us that there is **1** Mn in the compound.

$$\frac{(2)\bullet(-2)}{(1)} = 4 \rightarrow \text{manganese (IV)}$$

Step 2: **manganese (IV) carbonate**

Example: $Ca(OH)_2$ (Ca is NOT a VOS so no roman numerals)

Step 1: calcium

Step 2: **calcium hydroxide**

Example: K_2O (K is NOT a VOS so no roman numerals)

Step 1: potassium

Step 2: **potassium oxide**

Example: $CuClO_3$

Step 1: copper ( ) (Cu is a VOS so we need to go through step 1a)

Step 1a: There is one ClO_3^{-1} in the compound. You can tell because the ClO_3 is not in parentheses. Don't get confused by the subscript 3 at the end. It is part of the ClO_3^{-1} polyatomic ion and does NOT indicate how many ClO_3^- ions there are. There is also a single Cu in the compound for the same reason.

$$\frac{(1)\bullet(-1)}{(1)} = 1 \rightarrow \text{copper (I)}$$

Step 2: **copper (I) chlorate**

Example: $Zn(C_2H_3O_2)_2$ (Zn is NOT a VOS so no roman numerals)

Step 1: zinc

Step 2: **zinc acetate**

Example: $Sn_3(PO_3)_4$

Step 1: tin ( ) (Sn is a VOS so we need to go through step 1a)

Step 1a: The subscript **4** outside the parentheses tell us that there are **4** PO_3^{3-} in the compound. The subscript **3** after the Sn tells us that there are **3** Sn in the compound.

$$\frac{(4)\bullet(-3)}{(3)} = 4 \rightarrow \text{tin (IV)}$$

Step 2: **tin (IV) phosphite**

Try these:

1) $Fe_2(CrO_4)_3$
2) $Bi_3(AsO_4)_5$
3) Ag_2CO_3
4) $Sr(NO_2)_2$
5) $NiPO_3$
6) Li_2S
7) $Al_2(SO_4)_3$
8) $CuClO_2$
9) $Cr(BrO_4)_3$
10) $Be(IO)_2$

Rules Page

Identifying the type of compound being named:

Ionic compounds

1) the compound must contain a metal ion or the ammonium ion (NH_4^+)
2) the compound must be neutral (have an overall charge of 0)

Molecular compounds

1) the compound must contain only nonmetal elements (no ions!)
2) the compound must be neutral (have an overall charge of 0)

Acids

1) the compound formula must begin with at least one hydrogen
2) the compound formula must have a subscript (aq) after it
3) the compound must be neutral (have an overall charge of 0)

Writing the name or formula for a compound:

Name to formula for MOLECULAR compounds

1):Write the symbol and the subscript for the first element
2):Write the symbol and the subscript for the second element

Formula to name for MOLECULAR compounds

1): Write the prefix and name for the element (make no changes to the name of the element)
2): Write the prefix and name for the second element (change the end of the name of the element to –ide)

Name to formula for ACIDS

acid name	anion name
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1): Write the symbol for the anion based on the above relationships
2): Balance the anion charge by adding hydrogen(s) in front and add (aq) to the end. (the anion charge = # of hydrogens needed)

Formula to name for ACIDS

1): Name the anion based on the above relationships
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Name to formula for IONIC compounds

1): Write the symbol for each ion.
2): Find the LCM of the two charges and use it to determine how many cations and how many anions you need in the formula.

$$\frac{\text{LCM}}{\text{charge of cation}} = \text{\# of cations} \qquad \frac{\text{LCM}}{\text{charge of anion}} = \text{\# of anions}$$

3): Write the formula for the compound:

Formula to name for IONIC compounds

1): Name the cation.
   1a): If the cation is a VOS metal you need to include the roman numeral for the charge in the cation name.
2): Add the name of the anion.

$$\text{roman numeral} = \textbf{charge of cation} = \frac{(\textbf{\# of anions}) \bullet (\textbf{charge of anion})}{(\textbf{\# of cations})}$$