Nomenclature and the Periodic Table

To name compounds and to determine molecular formulae from names a knowledge of the periodic table is helpful.

Atomic Number = number of protons Mass Number = number of protons + number of neutrons Number of Electrons = number of protons (in a neutral element)

- The periodic table is arranged by grouping together elements that react similarly.
- How the elements react is determined by the arrangement of their electrons; the number of electrons an element has is determined by the atomic number of the element.

Achieving a Noble Gas Electron Configuration

For reasons we will discuss later, elements react until the element achieves an electron configuration of a noble gas.

Elements can achieve a noble gas electron configuration using three methods.

1. An element can give up electrons to achieve the electron configuration of the next lowest noble gas.

2. An element can attract additional electrons to achieve the electron configuration of the next highest noble gas.

3. Two (or more elements) can share electrons so that each attains the electron configuration of the nearest noble gas.

τŢ																	
1 1 A	+2											+3	?	-3 ↓	-2 	-1 ↓	18 8A
1 H	2 2A											13 34	14 4A	15 5A	16 6A	17 74	^z He
8	4											5	6	7	8	9	10
Li	Ве											_B_	С	N	0	F	Ne
11	12											13	14	15	16	17	18
Na	Mg	3	4	5	6	7	8	9	10	11	12	A1	Si	Ρ	S	C1	An
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
К	Са	Sc	Ti	V	Cr	Mn	Fe	Со	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	48	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Τc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te		Xe
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	La*	Hf	Та	W	Re	Os	Ir	Pt	Au	Нg	Τl	Pb	Bi	Po	At	Rn
87	88	89	104	105	106	107	108	109	110	111							
Fr	Ra	Ac†	Unq	Unp	Unh	Uns	Uno	Une	Uun	Uuu							

	58			
*Lanthanides	Ce			
+101130000000	90			
Actinides	T1-			

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59	60	61	62	63	64	65	66	67	68	69	70	71
Pr	Nd	Ρm	Sm	Eu	Gd	Tb	Dy	Но	Er	Tm	Yb	L
91	92	93	94	95	96	97	98	99	100	101	102	103
Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	L

Na, and Mg lose e⁻'s to attain the configuration of Ne. F, and O gain e⁻'s to attain the configuration of Ne.

Sodium and chlorine can combine. Sodium simply gives up an electron to chlorine to form Na⁺ (which has as many e⁻'s as Ne) and Cl⁻ (which also has the same number of e⁻'s as Ne).

What does an element like C do? Will carbon gain 4 e's or lose 4 e's?

It will do neither. Carbon will share electrons so that it approaches the electron configuration of a noble gas.

Carbon and chlorine can combine to form a compound. Carbon would like to gain (or lose) 4 e⁻'s to resemble Ne, or He. Gaining or losing 4 e⁻'s is quite unlikely. Chlorine would like to gain an electron. Chlorine and carbon reach an agreement in which they share the e⁻'s. They share the e⁻'s through chemical bonds.

1 chlorine uses one of Carbon's electrons to achieve a noble gas electron configuration, but it cannot take the electron away from carbon. So the electron is part of as bond which contains 1 electron from carbon and 1 electron from chlorine. Now, chlorine has 18 electrons (it "owns" 16 and shares two), and carbon has 7 electrons (it owns 5 and shares 2). The carbon still needs additional electrons to resemble Ne so it bonds with a 2nd, 3rd, and 4th chlorine. Finally, carbon has 10 electrons (it "owns" 2 and shares 8 with 4 chlorine atoms).

We have the basis for predicting how elements can combine.

How will Na and O combine? Na₂O

N and Cl? NCl3

How do we name simple binary compounds?

There are two sets of rules; one set of rules for ionic compounds, and another set of rules for covalent compounds. Acids are named based on the names of the ions involved.

I. Ionic Compounds

Binary Ionic Compounds Type I cations Type II cations

Polyatomic Ions with Type I cations Type II cations

II. Binary Covalent Compounds

III. Acids

So the first step is determining if the compound is ionic, covalent, or an acid.

I. Name ionic compounds

A. Naming compounds with type I cations—type I cations are cations that have one possible charge.

All the elements in the first period form type I cations. A few of the elements in groups 3 though 13 form only one cation; therefore a few of them are type I cations—Ag⁺, Cd²⁺, Zn²⁺, Al³⁺.

The cation is named first.

If the cation is a "simple" cation ("simple" ion is made from only one element.) the cations is named after the element.

If the cation is a polyatomic cation (a polyatomic ion is made from two or more covalently bonded elements.) you use the name that you have *memorized* (however since we only talk about one polyatomic cation this should not prove to be difficult NH_4^+ is the ammonium ion).

The anion is named second.

- If the anion is a simple ion it takes its name from the root name of the element , and *-ide* is added.
- If the anion is a polyatomic anion you use the name that you have *memorized*.

NaCl, MgCl₂, AlCl₃, NaNO₃, BaSO₄, (NH₄)₂SO₃

B. Naming compound with type II cations—type II cations are capable of having several charges.

If the cation is not from group 1 or 2, or is not Ag^+, Cd^{2+}, Zn^{2+} , or Al^{3+} then assume the cation is a type II cation.

The **cation** is named **first** and the charge of the cation is expressed as a roman numeral.

Occasionally suffixes, *-ic* and *-ous*, are used; however, we will not be using them. *-ic* is for the higher charge, *-ous* is for the lower charged cation. For example ferric is Fe^{3+} and ferrous is Fe^{2+} .

- If the cation is a "simple" cation the cation is named after the element.
- If the cation is a polyatomic you use the name that you have *memorized*. However, since we only talk about one polyatomic type II cation this should not prove to be difficult. Hg_2^{2+} is mercury (I).

The **anion** is named **second**.

- If the anion is a simple ion it takes its name from the root name of the element , and *-ide* is added.
- If the anion is a polyatomic anion you use the name that you have *memorized*.

Fe₃O₂, CrCl₃, MnO, Cu(NO₃)₂, Hg₂Cl₂

II. Naming covalent compounds.

A. The more positive element is named first.

- **B**. The more negative element is named as though it were an anion.
- **C**. Prefixes are used to denote the number of each of the elements involved. (The prefix *mono* is not used with the first element.)

III. Naming acids

- A. If the acid does not contain an oxygen then *hydro* + (anion root) + *ic acid.*
- **B**. If the acid contains an oxygen determine the name of the polyatomic anion. If the anion ends in *-ite* then the ending *ous* is used. If the anion ends in *-ate* then the ending *-ic* is used. Of course, there are exceptions...if the name of the acid sounds weird using the anion name, then the element name is used instead.

e.g. H₂SO₄ is based on sulfate

cross out the ate and add -ic and you would have sulfic acid....

sounds bad so use sulfur instead....sulfuric acid

e.g. H₃PO₄ is based on phosphate cross out *-ate* and add *-ic* and you would have posphic acid

sounds bad so use phosphorous instead....phosphoric acid

unfortunately the only way to remember this is to remember which acid are named differently.

To be able to name compounds you have to

(•) be able to identify a compound as

Ionic

Covalent

Acid

- Ionic compounds are made from a metal and a nonmetal.
- Covalent compounds are made from two non-metals.
- •Acids are made from H⁺ and an anion. The anion may or may not be polyatomic.

hint: if there are more the two elements listed at least one of them is a polyatomic ion

Covalent and acid are straight forward (see the rules), but once you have identified that a compound is ionic you have to (•), determine if the cation is a type I or a type II cation.

All the cations made from Group 1 and 2 elements can only have a single charge.

As far as we are concerned, four the transition metals are type I, Al^{3+} (Al is not actually a transition metal), Ag^+ , Zn^{2+} , Cd^{2+} all of the remaining transition metals are all type II.

Type I cations are easy, but once you have identified that a compound contains a type II cation you must (•) determine the charge on the cation.

All compounds will be neutral so the cations charge must equal the anions charge.

 $FeCl_{3}$, the 3 Cl's are each -1 for a total of -3; therefore the Fe must be +3.

The name is "iron (III) chloride"

$Cu(NO_3)_2$, each nitrate is -1 for a total of -2; therefore the Cu must be +2.

The name is copper(II) nitrate.

To determine the formula from the name you have to (•) identify a compound as

Ionic Covalent Acid

Covalent is the easiest. Simply write the element with the appropriate subscript which corresponds with the prefix.

Carbon tetraiodide is CI₄. Determining that carbon tetraiodide is a covalent compound is simple.

Carbon is a non-metal, and iodide is a non-metal; therefore, carbon and iodide form a covalent compound.

(hint: For our purposes, only covalent compounds use prefixes; therefore, the presence of a prefix means the compound must be covalent.)

An acid is also easy, add as many protons (H+) as needed to cancel the charge of the anion.

Hydrochloric acid is based on the chloride anion, Cl-. So, the formula is HCl.

Phosphoric acid is based on the phosphate ion, $PO_{4^{3-}}$. So, the formula is H_3PO_4

Formulae of ionic compounds

Actually, determining the formula of a Type II cation is easier than determining the formula of compound made from a Type I cation.

The charges of the cations and the anions must be known to determine the formula of the compound.

iron(III) oxide

Step 1 determine the charge of the cation. Type I . Check the periodic table. Type II . The name of a Type II cation contains the charge!

iron(III) means Fe³⁺.

Step 2 Determine the charge of the anion. Polyatomic anion . Remember the charge. Monoatomic anion . Check the periodic table.

Oxide is O²⁻. Step 3 Combine ions so that the charges cancel.

 $\begin{array}{l} 2 \ (Fe^{3+}) = +6 \\ 3 \ (O^{2-}) = -6 \\ Fe_2O_3 \end{array}$

magnesium chloride

Mg is Mg²⁺ Cl is Cl⁻ MgCl₂