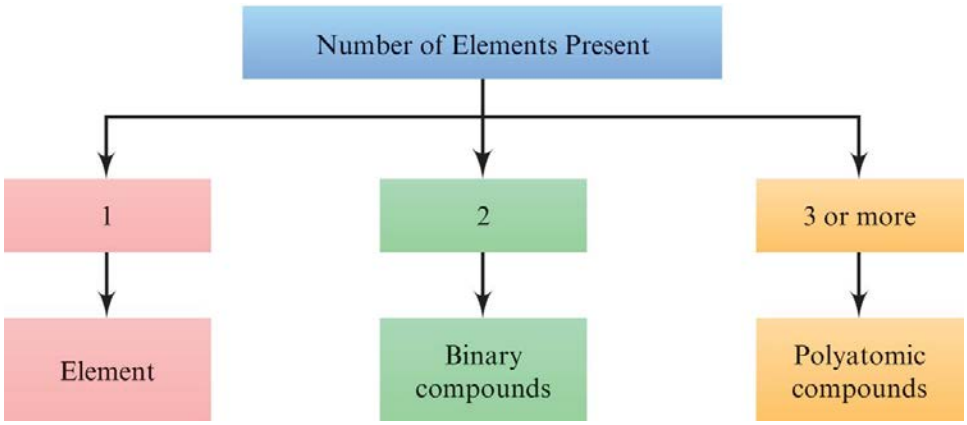
Chapter 6: Nomenclature of Inorganic Compounds

6.1 Common and Systematic Names

- There are far too many known chemical compounds (50 million) to refer to all of them by common names.
  - Some common names are so well established we use them:
    - H_2O water
    - NH_3 ammonia
    - O_3 ozone
    - CH_4 methane (a systematic organic compound name)
  - We will use the IUPAC system to name other compounds.

- More effort will be applied to writing name when given chemical formula.
  - Most students find that writing the formula from the name is easier!

- A good place to start is to count the number of elements in the formula.



6.2 Elements and Ions

- Atoms form monatomic ions by gaining or losing electrons.
  - Metals lose electrons to form cations, and
  - Nonmetals gain electrons to form anions.

- Among the Representative elements (Groups 1-2 and 13-18), ions of elements in the same group have the same charge.
  - Transition metal ions often exhibit more than one charge.

- Note the trends in the ionic charges of the Representative elements in the following table.

1 1A	2 2A	3	4	5	6	7	8	9	10	11	12	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
H^+																	
Li^+	Be^{2+}													N^{3-}	O^{2-}	F^-	
Na^+	Mg^{2+}											Al^{3+}		P^{3-}	S^{2-}	Cl^-	
K^+	Ca^{2+}				Cr^{2+} Cr^{3+}		Fe^{2+} Fe^{3+}			Cu^+ Cu^{2+}	Zn^{2+}					Br^-	
Rb^+	Sr^{2+}			Transition metals						Ag^+	Cd^{2+}					I^-	
Cs^+	Ba^{2+}																

- Simple or monatomic cations and anions are formed from a single element.
  - Cations formed form metal atoms are named their parent metal atoms:

Atom		Ion	
K	potassium	K^+	potassium ion
Mg	magnesium	Mg^{2+}	magnesium ion
Al	aluminum	Al^{3+}	aluminum ion

  - Anions formed from nonmetal atoms are named by changing the ending of the nonmetal element name to '*ide*'.

TABLE 6.2 | Examples of Elements Forming Anions

Symbol	Element	Stem	Anion name
Br	bromine	brom	bromide
Cl	chlorine	chlor	chloride
F	fluorine	fluor	fluoride
H	hydrogen	hydr	hydride
I	iodine	iod	iodide
N	nitrogen	nitr	nitride
O	oxygen	ox	oxide
P	phosphorus	phosph	phosphide
S	sulfur	sulf	sulfide

NOTE: When writing a chemical formula or a compound name, the cation always comes first, followed by the anion.

6.3 Writing Formulas from Names of Ionic Compounds

- A chemical compound must have a net charge of zero.
  - Sum of the positive charges cancels sum of the negative charges.

- We can determine the number of each ion to use in the formula by finding the least common multiple (LCM) of the two charges.
  - Divide LCM by the |charge| to find the subscript of the ion in the formula.

Rules for Writing Formulas for Ionic Compounds

1. Write the formula for the metal ion followed by the formula for the nonmetal ion.
2. Combine the smallest numbers of each ion needed to give the charge sum equal to zero.
3. Write the formula for the compound as the symbol for the metal and nonmetal, each followed by a subscript of the number determined in 2.

Name of compound	Ions	Least common multiple	Sum of charges on ions	Formula
Sodium bromide	Na^+, Br^-	1	$(+1)+(-1)=0$	NaBr
Potassium sulfide	K^+, S^{2-}	2	$2(+1)+(-2)=0$	K_2S
Zinc sulfate	Zn^{2+}, SO_4^{2-}	2	$(+2)+(-2)=0$	$ZnSO_4$
Ammonium phosphate	NH_4^+, PO_4^{3-}	3	$3(+1)+(-3)=0$	$(NH_4)_3PO_4$
Aluminum chromate	Al^{3+}, CrO_4^{2-}	6	$2(+3)+3(-2)=0$	$Al_2(CrO_4)_3$

- When the ionic charges are equal in magnitude but opposite in charge, no subscripts are used (both subscripts are 1).

- Criss-cross the numbers of the charges (**not** the signs!!) so that the charge number of each ion becomes the subscript of the other.
  - Check for possible simplification of the subscripts.

Write formulas for compounds containing the following ions:

K^+ and F^-

Mg^{2+} and N^{3-}

Ba^{2+} and O^{2-}

Ca^{2+} and Br^-

Na^+ and S^{2-}

As^{5+} and CO_3^{2-}

6.4 Naming Binary Compounds

- Binary compounds contain only two different elements.
- We divide binary compounds into three types to simplify naming.
  - Compounds containing a metal forming only one type of cation.
    - These are representative metals, and a few transition metals.
  - Compounds containing a metal that can form two or more cations.
    - These are mainly transition metals.
    - The charge must be included in the name.
  - Compounds containing two nonmetals.
    - Prefixes are used in the name to indicate the subscripts.

Compounds containing a metal forming only one type of cation

(1) Write the name of the metal cation (followed by a space).

(2) Write the name of the anion.

Note that we do not include any subscript information in the name since the number of each ion in the formula can be determined using charge cancellation (sum of all charges = 0).

Compounds containing a metal that can form two or more types of cations

(1) Once you have identified the metal as one that can form cations with different charges, inspect the formula to determine the charge on the metal in this compound.

Use the anion charge (which will not vary) and the numbers of cations and anions in the formula to find the cation charge.

(2) Write the name of the metal cation immediately followed by the parenthesized charge in Roman numerals, then add a space.

(3) Write the name of the anion.

Note that we do not include any subscript information in the name since the number of each ion in the formula can be determined using charge cancellation (sum of all charges = 0).

Some metals are named using a traditional (non-systematic) scheme that may still be used today.

Alternative (old) names for some transition metal ions	
Cr^{2+} = chromous	Cr^{3+} = chromic
Fe^{2+} = ferrous	Fe^{3+} = ferric
Co^{2+} = cobaltous	Co^{3+} = cobaltic
Cu^{+} = cuprous	Cu^{2+} = cupric
Sn^{2+} = stannous	Sn^{4+} = stannic
Hg_2^{2+} = mercurous	Hg^{2+} = mercuric
Pb^{2+} = plumbous	Pb^{4+} = plumbic

Compounds containing two nonmetals

- The book gives this list of nonmetals and tells you that the nonmetal coming first in the list should come first in both the formula and the name:

  Si, B, P, H, C, S, I, Br, N, Cl, O, F

  - However, you will always be given the name or formula of the compound, so there is no need to memorize this list!

(1) Pay attention to the subscripts in the formula; they will appear as prefixes in the name.

(2) Write the name for the first element using a prefix if there is more than one atom of the element (followed by a space).

(3) Write the anion name of the second element. Use a prefix to indicate the number of atoms of the second element.

Numeric Prefixes

1 = mono	6 = hexa
2 = di	7 = hepta
3 = tri	8 = octa
4 = tetra	9 = nona
5 = penta	10 = deca

6.5 Naming Compound Containing Polyatomic Ions

- A polyatomic ion is an ion that contains two or more elements.
  - You need to learn and recognize the polyatomic ions listed on the memorization sheet.
  - Polyatomic ions are treated as a unit and never broken down into ions of their elements when naming compounds.
    - SO_4^{2-} is named as sulfate, **not** sulfide oxide.

(1) Write the name of the cation.

(2) Write the name of the anion.

6.6 Acids

- Acids are the class of compounds whose aqueous solutions are acidic! (Because they donate a H^+ ion to water.)

  - We recognize acids because their formulas are almost always written starting with H followed by an anion formula, and their names end in 'acid.'
    - Exceptions: H_2O = water, H_2O_2 = hydrogen peroxide

  - Acid nomenclature relies on separating the compound into cation (H^+) and anion (monatomic or polyatomic).
    BUT
    Acids are molecular compounds that generate ions when they react with water; we say that acids 'ionize.' More later…

- Binary Acids contain H^+ and a monatomic anion; named as follows:
  hydro + <root of the anion name> + *ic acid*
  The root or stem is not always consistently formed!

  HCl

  H_2S

  - Names acids whose polyatomic anion ends in –ide are written this way.

    HCN

- Oxy-acids contain H^+ and a polyatomic anion whose name ends in *–ate* or *–ite*. An oxy-acid name depends on the ending of the anion: the ending is changed to give the name of the acid.

  - If the anion name ends in *–ite*, change the ending to *–ous* and add the word '*acid*.' 'Hydrogen' does <u>not</u> appear in the name.

    H_2SO_3

    HNO_3

  - If the anion name ends in *–ate*, change the ending to *–ic* and add the word '*acid*.' 'Hydrogen' does <u>not</u> appear in the name.

    H_2CO_3

    H_2SO_4

    - Note that some variations will be learned, like 'sulfate' and 'sulfuric.'

- Acetic acid

- You might find the text's flow diagrams for naming compounds helpful.