Module 2: What is a “Chemical Species”? Introduction to Chemical Nomenclature

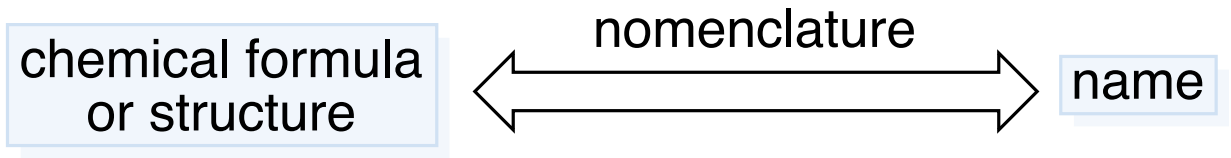
Fundamentals of Chemistry Open Course

Learning Objectives | Module 2

1. State and apply the laws of chemical combination.
2. State and apply the tenets of the modern atomic theory.
3. Visualize the subatomic particles that constitute the atom using a simple planetary model; count subatomic particles using atomic number (Z) and mass number (M).
4. Represent an atom or ion using an atomic symbol.
5. Represent the number ratios of atoms in a compound using a chemical formula.
6. Visualize and distinguish between submicroscopic models of molecular and ionic compounds.
7. Use the periodic table to efficiently find information about a chemical element.
8. Recognize key collections of elements on the periodic table.
9. Determine the name of a binary ionic compound from the chemical formula and *vice versa*.
10. Determine the name of a simple molecular compound from the chemical formula and *vice versa*.

Motivations for Chemical Nomenclature

- **Chemical nomenclature** refers to a system for assigning names to chemical substances.
- A robust nomenclature system enables the "conversion" of a chemical formula into a name and *vice versa*.



- Nomenclature reflects the way we think about chemical structure. The rules and conventions of nomenclature systems are not exactly arbitrary…
- For example, many chemical names are structured to list metallic components first and nonmetallic components second. This convention allows us to infer the distribution of charge in the structure:

"metal(lic) nonmetal(lic)"

Simple Ionic and Molecular Compounds

- Here, we will cover naming conventions for simple ionic and molecular compounds.

- **Binary ionic compounds** consist of one type of cation and one type of anion.
  - The ions may be monatomic or polyatomic; the cation is listed first and the anion second.
  - Examples: NaCl, $Ca(OH)_2$, NH_4Cl, $Pd(NO_3)_2$

- **Binary molecular (covalent) compounds** consist of two nonmetallic elements.
  - The “more metallic” element, further down and to the left on the periodic table, is generally listed first.
  - Examples: NO_2, CS_2, P_4O_{10}, NF_3

- For both classes of compounds, the elements may not be present in a 1:1 number ratio.

Naming Binary Ionic Compounds

- **Polyatomic ions** contain more than one type of atom; bonds *within* a polyatomic ion are covalent and the net charge may be positive (lack of electrons) or negative (excess of electrons).

Name	Formula	Name	Formula
acetate	$C_2H_3O_2^-$	hypochlorite	ClO^-
ammonium	NH_4^+	chlorite	ClO_2^-
carbonate	CO_3^{2-}	chlorate	ClO_3^-
cyanide	CN^-	perchlorate	ClO_4^-
hydrogen carbonate	HCO_3^-	chromate	CrO_4^{2-}
hydrogen phosphate	HPO_4^{2-}	dichromate	$Cr_2O_7^{2-}$
hydrogen sulfate	HSO_4^-	permanganate	MnO_4^-
hydroxide	OH^-		
nitrite | nitrate	NO_2^- | NO_3^-		
peroxide	O_2^{2-}		
phosphite | phosphate	PO_3^{3-} | PO_4^{3-}		
sulfite | sulfate	SO_3^{2-} | SO_4^{2-}		

Naming Binary Ionic Compounds

- Because ionic compounds are electrically neutral and ion names include information about charge, prefixes are *omitted* in names of binary ionic compounds.
- Ions with variable charge require a Roman numeral in parentheses after the name of the ion.

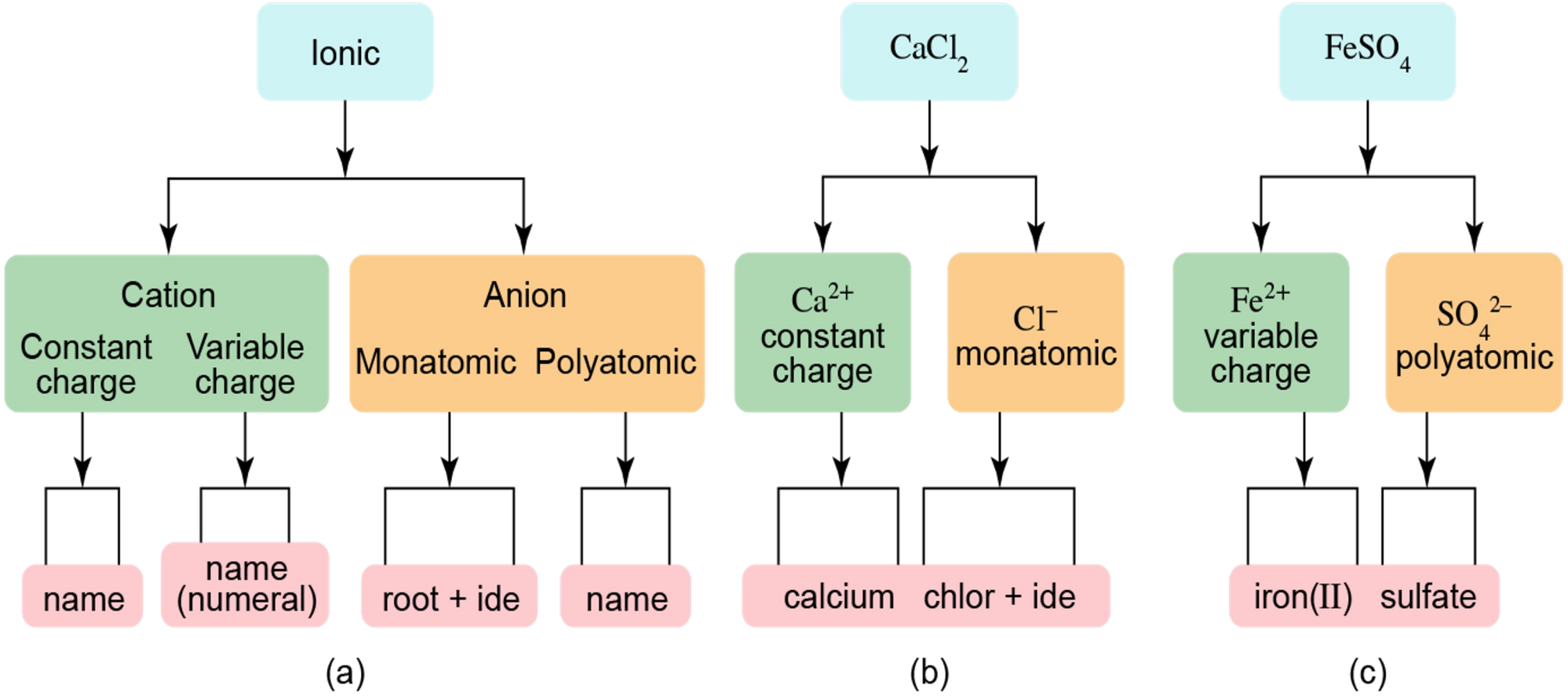


Figure. (a) A general scheme for naming binary ionic compounds and (b, c) two examples.

Naming Binary Molecular Compounds

- Molecular (covalent) compounds are composed of two or more *nonmetals*; **binary** covalent compounds contain only two elements.

1. List the first nonmetal with a prefix indicating the number of atoms of that type in the molecule.
2. After a space, list the second nonmetal with a similar prefix, replacing the ending of the element name with -ide.

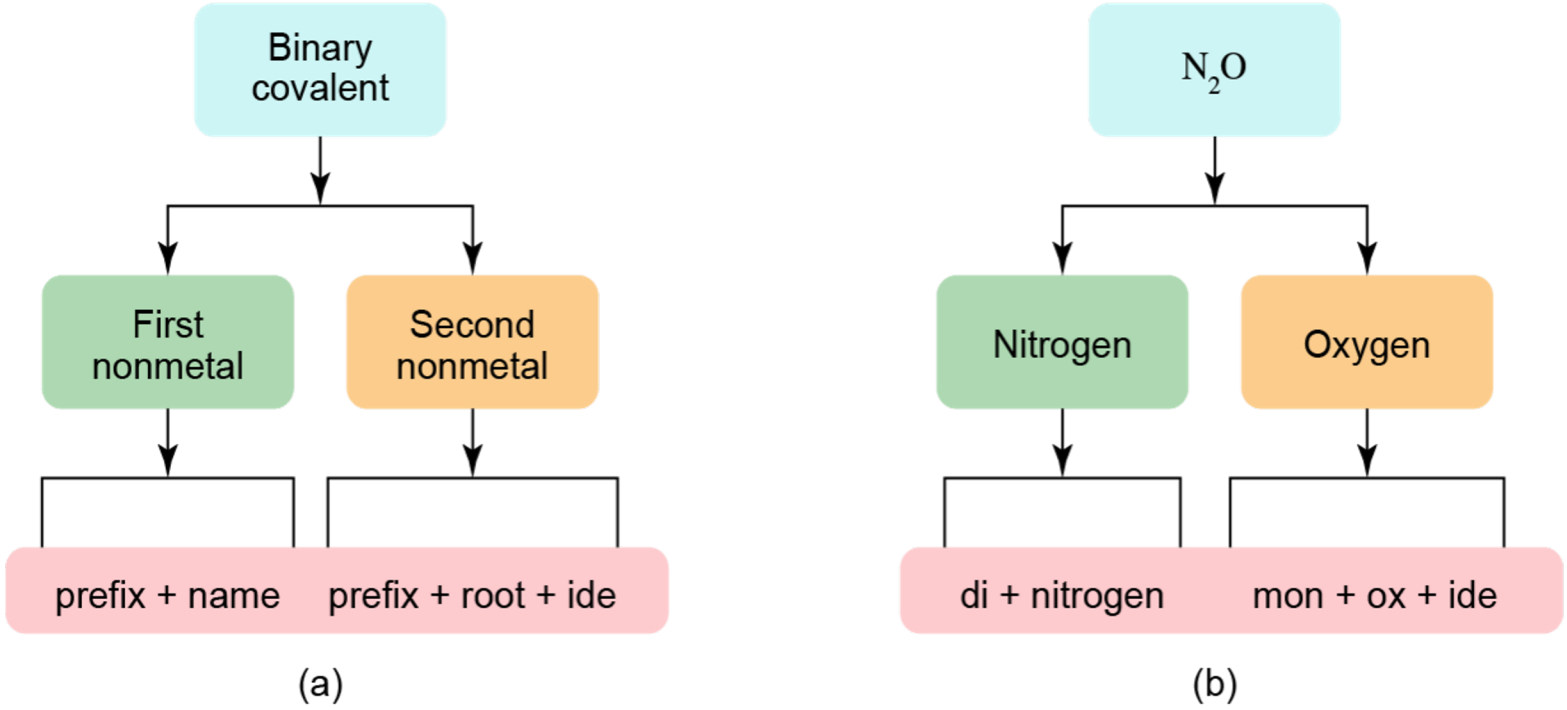


Figure. (a) A general scheme for naming binary covalent compounds and (b) an example.

Prefix	Number of Atoms per Molecule
mono	1
di	2
tri	3
tetra	4
penta	5
hexa	6
hepta	7
octa	8
nona	9
deca	10

Practice Problems

Example. Determine the names of each of the following compounds.

A. $Mg(ClO_4)_2$

B. $FeBr_3$

C. SO_2

D. N_2O_5

Practice Problems

Example. Determine chemical formula for each of the following compounds.

A. Calcium cyanide

B. Ruthenium(IV) oxide

C. Silicon dioxide

D. Diphosphorus trisulfide

Lingering Questions

- How do we name compounds with more complex structures? What kinds of naming conventions are needed?