Lesson 3:
Atoms, Molecules, and Ions

Periodic Table

Layout of the periodic table

- Groups: columns
- Periods: rows

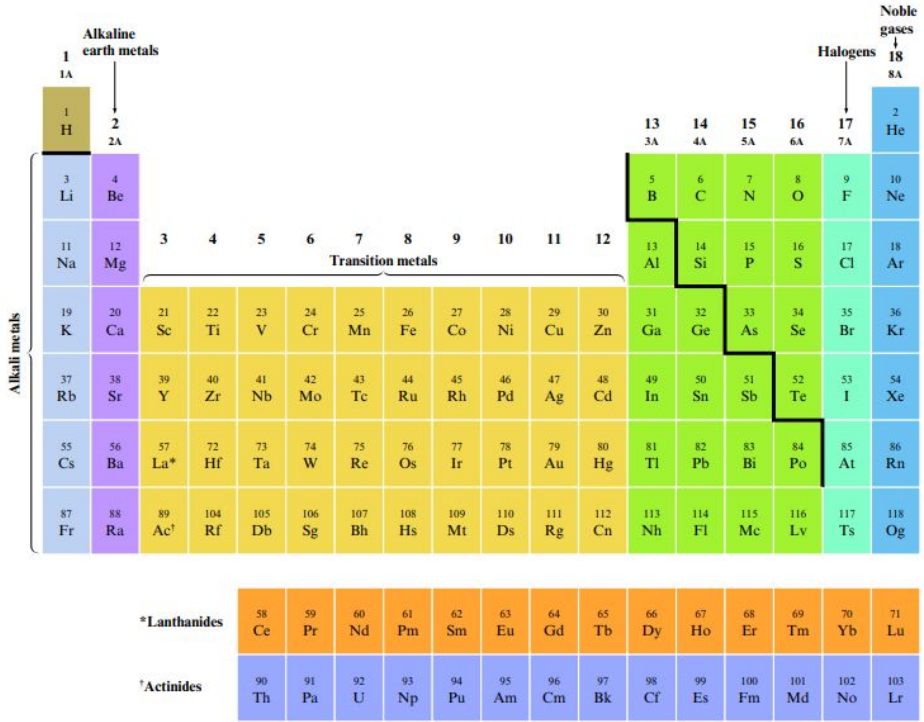
Group 1: alkali metals (except hydrogen)

Group 2: alkaline earth metals

Group 3-12: transition metals

Group 17: Halogens

Group 18: Noble gases



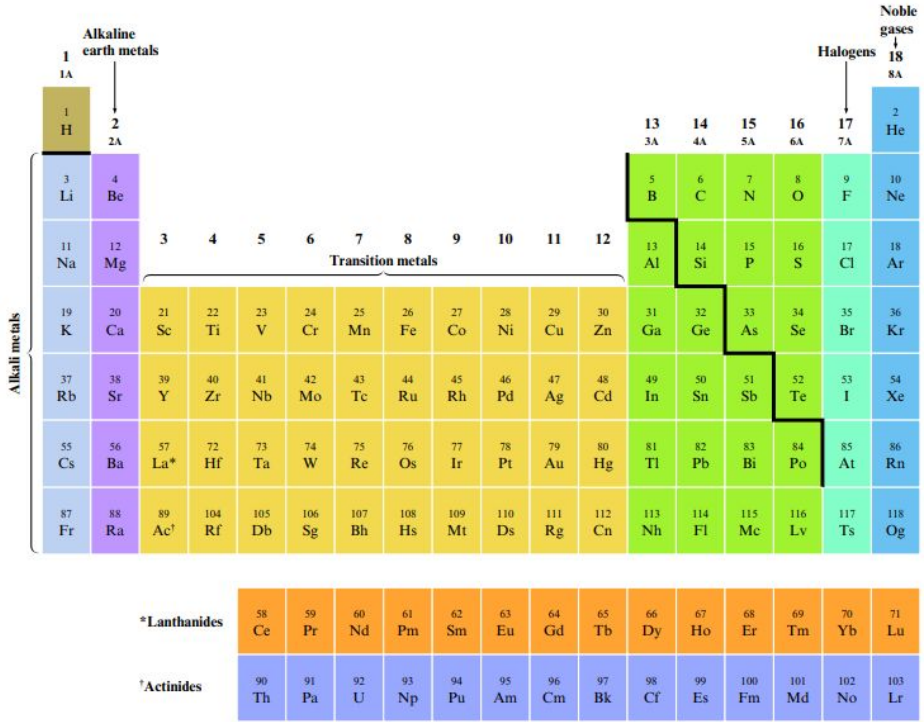
Periodic Table

Most of the elements in the periodic table are actually metals!

- Hydrogen and the elements to the right of the staircase are non metals

Properties

- Metals: good conductors of heat/electricity, malleable, ductile, lustrous
- Nonmetals: lack the properties of metals
  - Covalent bonds with other nonmetals
  - Ionic bonds with metals



Naming Binary Ionic Compounds

Type I:

- Cation named first, anion second
- Cation: element name (e.g., Na^+ is sodium)
- Anion: root name + "-ide" (e.g., Cl^- is chloride)
- Examples:
  - NaCl: Sodium chloride
  - CaS: Calcium sulfide

Type II:

- Cation charge specified with Roman numeral; e.g., Fe^{2+} is Iron(II)
- Examples:
  - $FeCl_2$: Iron(II) chloride
  - CuO: Copper(II) oxide

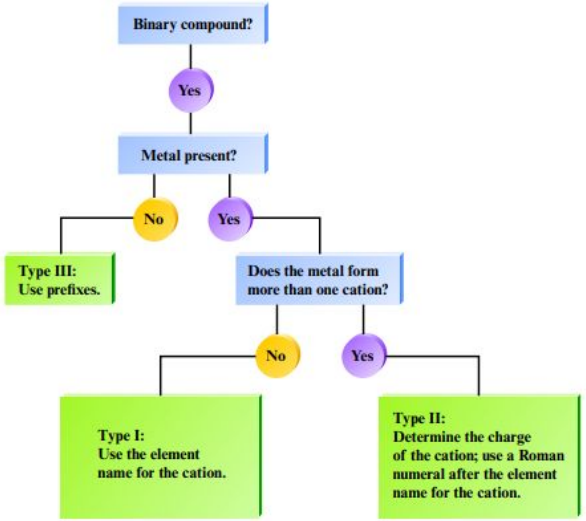
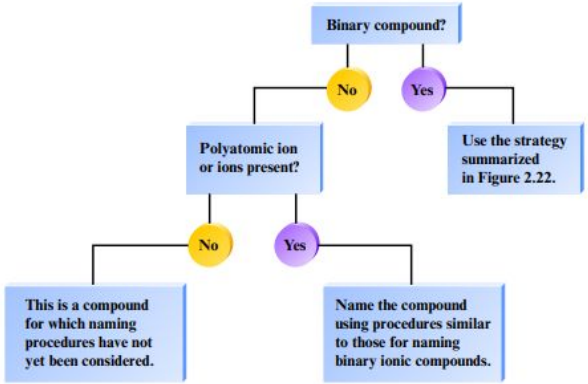


FIGURE **2.22** A flowchart for naming binary compounds.



Naming Binary Ionic Compounds

Question 1: Name the following binary ionic compounds

a. KBr

b. MgO

Question 2: Write the formula for the following binary ionic compounds

a. Barium chloride

b. Aluminum oxide

Question 3: Identify whether the following compounds are Type I or Type II, and then name them

a. Fe_2O_3

b. $CuCl_2$

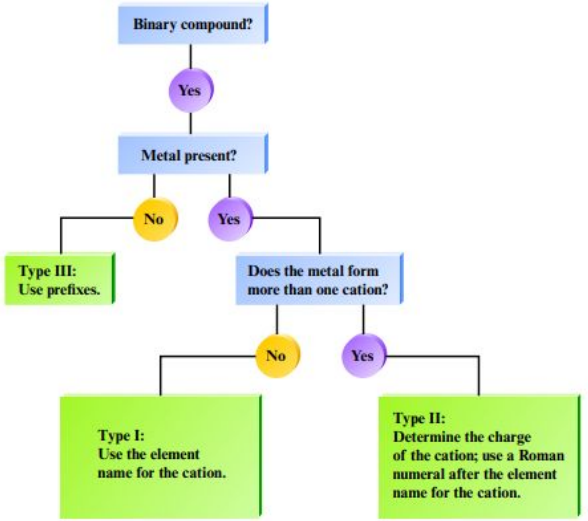
Naming Binary Ionic Compounds

Monatomic Cations: Na^{+}, Ca^{2+}, Al^{3+}, Fe^{2+}/Fe^{3+}

Monatomic Anions: Cl^{-}, O^{2-}, N^{3-}

Polyatomic Ions:

- NH_4^{+} (Ammonium)
- NO_3^{-} (Nitrate)
- SO_4^{2-} (Sulfate)
- Examples:
  - $NaNO_3$: Sodium nitrate
  - NH_4Cl: Ammonium chloride
  - $CaSO_4$: Calcium sulfate



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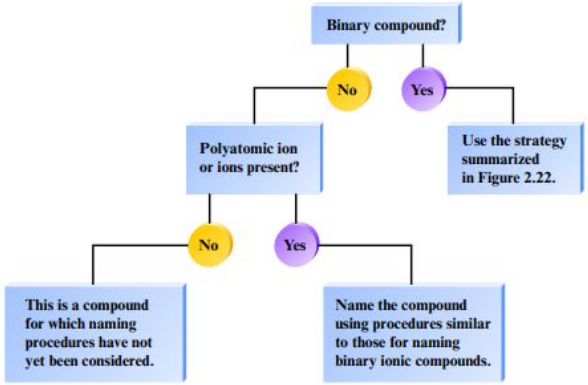


Polyatomic Ions - Full List

Acetate Ion: $C_2H_3O_2^-$

Carbonate Ion: CO_3^{2-}

Chlorate Ion: ClO_3^-

Chromate Ion: CrO_4^{2-}

Cyanide Ion: CN^-

Sulfate Ion: SO_4^{2-}

Hydroxide Ion: OH^-

Phosphate Ion: PO_4^{3-}

Nitrate Ion: NO_3^-

Ammonium Ion: NH_4^+

Permanganate Ion: MnO_4^-

Hydronium Ion: H_3O^+

Naming Binary Ionic Compounds

Question 1: Name the following compounds

a. $RbNO_3$

b. NH_4Cl

c. $CaSO_4$

Question 2: Write the formula for the following compounds

a. Ammonium sulfate

b. Calcium carbonate

Question 3: Identify the type of ion (monatomic or polyatomic) and provide its charge

a. NO_3^-

b. Fe_3^+

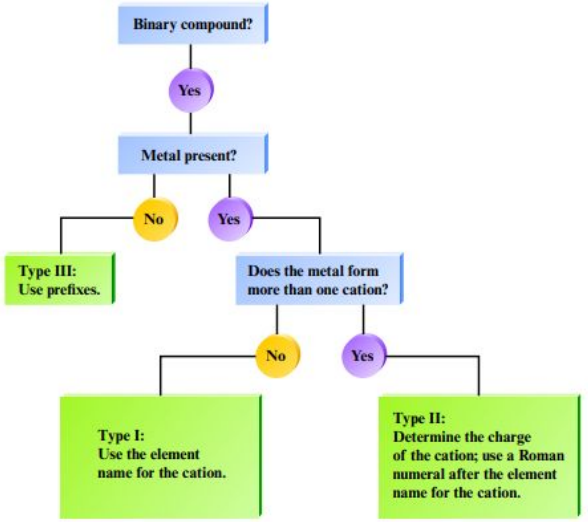
Naming Binary Covalent Compounds

1. First element full name
2. Second element as anion (-ide)
3. Prefixes denote number of atoms

- Examples:
  - CO: Carbon monoxide
  - SF_6: Sulfur hexafluoride

Prefixes:

- Mono- (1), Di- (2), Tri- (3)
- Tetra- (4), Penta- (5), Hexa- (6)



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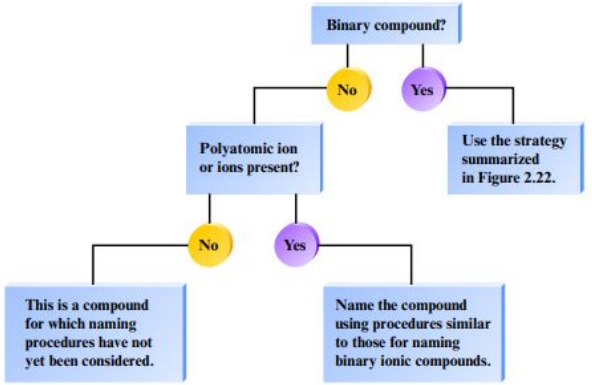


Naming Binary Covalent Compounds

Question 1: Name the following binary covalent compounds

a. CO_2

b. N_2O_5

Question 2: Write the formula for the following binary covalent compounds

a. Dinitrogen trioxide

b. Phosphorus pentachloride

Question 3: Identify the prefix and the number of atoms it represents

a. Tetra-

b. Hexa-

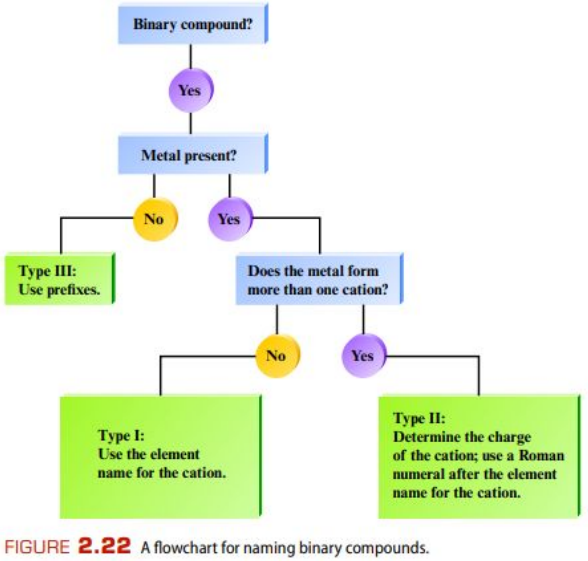
Naming Acids

Without Oxygen:

- Hydro- + anion root + -ic acid
- Example:
  - HCl: Hydrochloric acid

With Oxygen:

- Anion ends in -ate: root + -ic acid
- Anion ends in -ite: root + -ous acid
- Examples:
  - H_2SO_4: Sulfuric acid
  - H_2SO_3: Sulfurous acid



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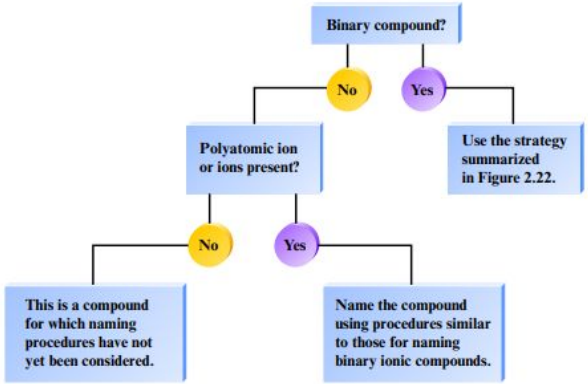


Naming Acids

General Rules:

- Base Name: Standard form of the ion (e.g., sulfate: SO_4^{2-})
- One More Oxygen: Prefix "per-" and suffix "-ate" (e.g., perchlorate: ClO_4^-)
- One Less Oxygen: Suffix "-ite" (e.g., chlorite: ClO_2^-)
- Two Less Oxygens: Prefix "hypo-" and suffix "-ite" (e.g., hypochlorite: ClO^-)

Adding Hydrogen:

- Bi-/Hydrogen Prefix: When a hydrogen is added (e.g., bicarbonate: HCO_3^-)

Naming Acids

Question 1: Name the following acids

a. HCl (without oxygen)

b. $HClO_4$ (with oxygen)

Question 2: Write the formula for the following acids

a. Chloric acid

b. Hypochlorous acid

Question 3: Based on the rules, name the following compounds

a. H_2SO_4

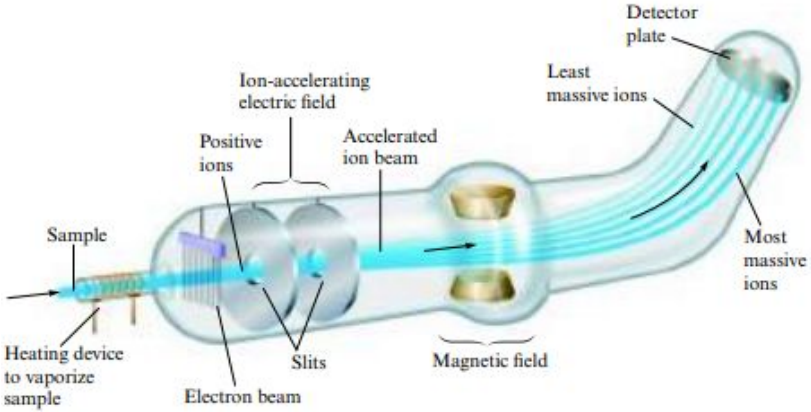
b. $HClO_2$

c. HCO_3

Atomic Masses

Mass spectrometer used to determine accurate atomic masses

- Atoms/molecules converted to positive ions
- Ions accelerated and deflected by magnetic field
- Deflection depends on ion mass; less massive ions deflected more



Example: ^{12}C vs ^{13}C ratio

The Mole

The mole (mol) is the unit for counting atoms, based on the number of atoms in exactly 12 g of ^{12}C

Avogadro's Number: 6.022×10^{23} (number of atoms in 12 g of ^{12}C)

⇒ units of a substance

Analogy:

- 1 mole of eggs = 6.022×10^{23} eggs
- 1 mole of atoms/molecules is manageable for reactions

TABLE 3.1 | **Comparison of 1-Mole Samples of Various Elements**

Element	Number of Atoms Present	Mass of Sample (g)
Aluminum	6.022×10^{23}	26.98
Copper	6.022×10^{23}	63.55
Iron	6.022×10^{23}	55.85
Sulfur	6.022×10^{23}	32.07
Iodine	6.022×10^{23}	126.9
Mercury	6.022×10^{23}	200.6

Molar Mass

Molar mass: is the mass in grams of 1 mole of the compound

Example: Methane (CH_4)

- Mass of 1 mole of carbon: 12.01 g
- Mass of 4 moles of hydrogen: 4×1.0084g
- Molar mass of methane: 12.01 + 4(1.0084g) = 16.04 g

Molar Mass

Question 1: How many atoms are there in 10.0g of Al? (1 mol of Al is 26.98 g)

Question 2: How many moles are there in 5.00×10^{20} atoms of Co?

Molar Mass

Question 1: Isopentyl acetate ($C_7H_{14}O_2$) is the compound responsible for the scent of bananas. Bees release about 1 µg this compound when they sting. How many molecules of isopentyl acetate are released in a typical bee sting? How many atoms of carbon are present?