Chemical Compounds

Chapter 3

Molecular Compounds

Molecular Formulas

exact number of atoms of each type in compound

example - H_2O

- inorganic compounds
  - contain no carbon

    examples - NH_3, H_2SO_4, P_2O_5
  - many are ionic
- organic compounds
  - contain carbon

    examples - C_2H_6, C_2H_6O, C_3H_8
  - generally molecular

Molecular Compounds

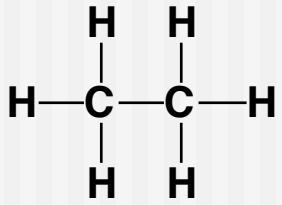
Molecular Formulas

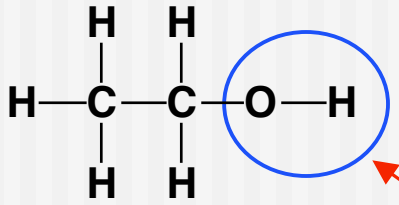
methods for writing formulas

- molecular formula

  C_2H_6 (ethane) C_2H_6O (ethanol)

- structural formula





Functional group
(hydroxide)

- condensed formula

  CH_3CH_3 CH_3CH_2OH

Naming Binary Inorganic Compounds

molecules containing atoms of only two elements

- element farthest left first

  HCl (*hydrogen* chloride)

- if same group - lowest first

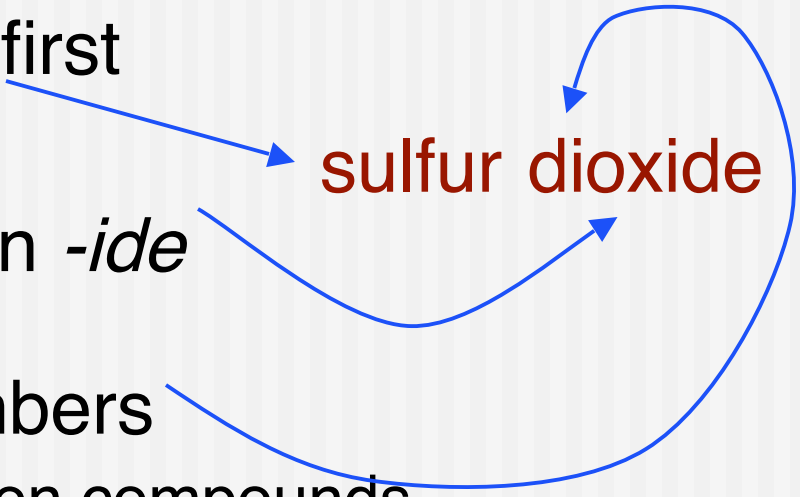
  SO_2

- second element ends in *-ide*

- Greek prefixes for numbers

  exception - binary hydrogen compounds

  example: H_2S - hydrogen sulfide



Naming Binary Inorganic Compounds

TABLE 3.2 Prefixes Used in Naming Chemical Compounds

Prefix	Number
Mono-	1
Di-	2
Tri-	3
Tetra-	4
Penta-	5
Hexa-	6
Hepta-	7
Octa-	8
Nona-	9
Deca-	10

Naming Binary Inorganic Compounds

compounds with common, nonsystematic names:

- H_2O water
- NH_3 ammonia
- N_2H_4 hydrazine
- NO nitric oxide
- N_2O nitrous oxide
- PH_3 phosphine

(text p. 82)

Hydrocarbons

- contain only C and H
- simplest type is alkanes
  - general formula - C_nH_{2n+2} (n = integer)
  - first 4 have common names - remaining systematic

Hydrocarbons

TABLE 3.4 The First Ten Alkane Hydrocarbons, C_nH_{2n+2}

Molecular Formula	Name	Boiling Point (°C)	Physical State at Room Temperature
CH_4	Methane	−161.6	Gas
C_2H_6	Ethane	−88.6	Gas
C_3H_8	Propane	−42.1	Gas
C_4H_{10}	Butane	−0.5	Gas
C_5H_{12}	Pentane	36.1	Liquid
C_6H_{14}	Hexane	68.7	Liquid
C_7H_{16}	Heptane	98.4	Liquid
C_8H_{18}	Octane	125.7	Liquid
C_9H_{20}	Nonane	150.8	Liquid
$C_{10}H_{22}$	Decane	174.0	Liquid

Ions and Ionic Compounds

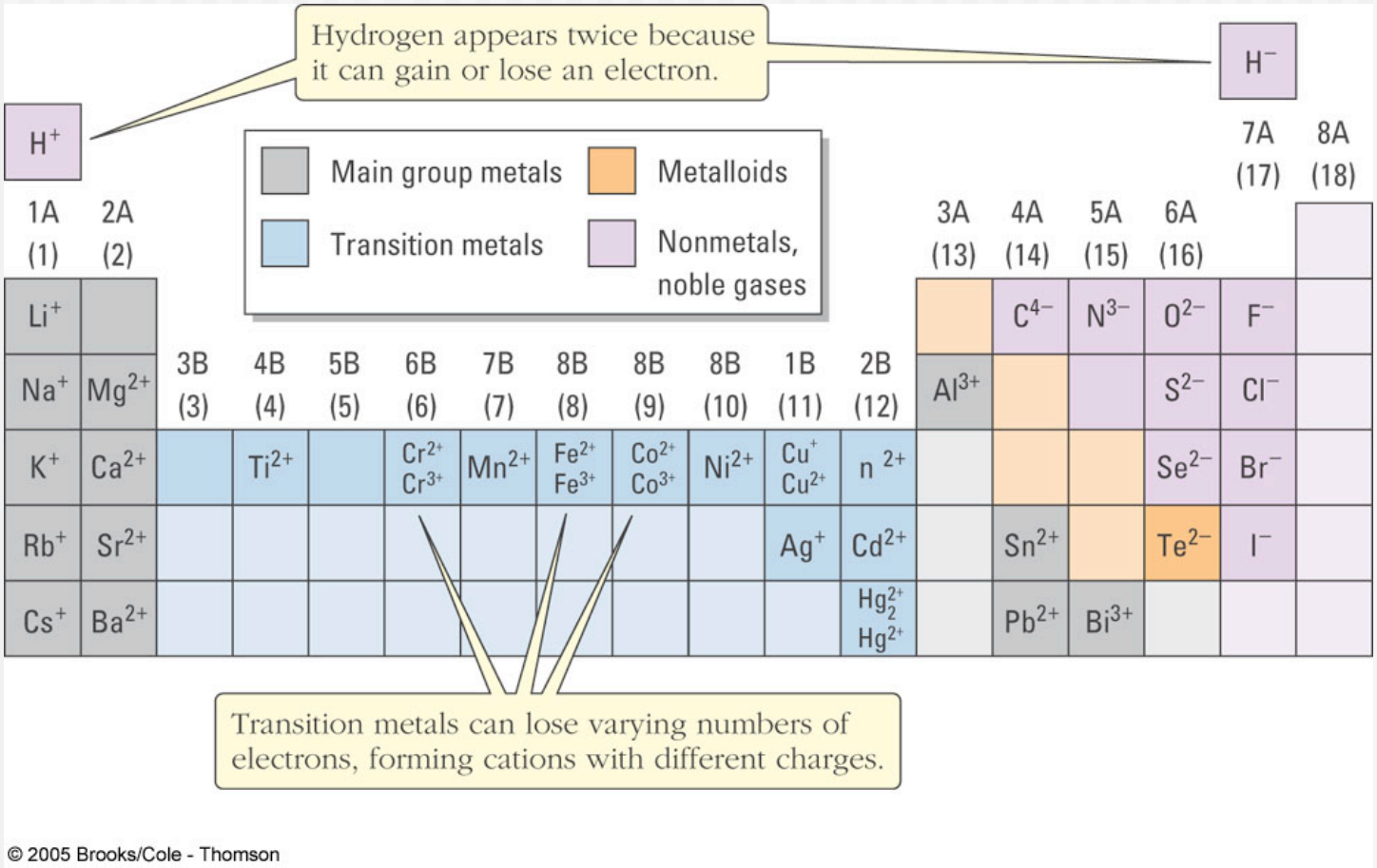
ionic compound - composed of positive and negative ions

- typically metal with non-metal
  - metal loses electrons to form cation
  - non-metal gains electrons to form anion

    example - NaCl (formed from Na^+ and Cl^-)

Ionic Charges

determine charges of monatomic ions from Periodic Table



Ionic Compounds

formed from a cation(s) and an anion(s)

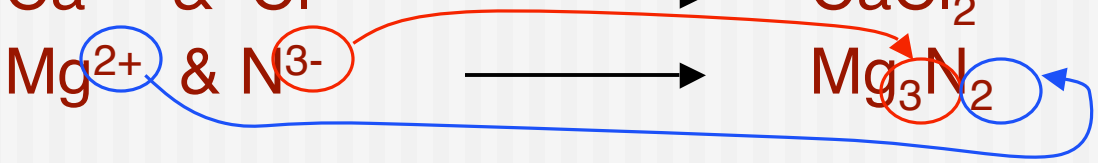
- overall charge on formula is neutral

  examples:

  Na^+ & Cl^- ⟶ $NaCl$

  Ca^{2+} & Cl^- ⟶ $CaCl_2$

  Mg^{2+} & N^{3-} ⟶ Mg_3N_2



- "empirical" formulas only
- write formula: cation then anion

Naming Ionic Compounds
Cations

- Cations from metals
  - same name as metal

    Na^+ sodium ion Ca^{2+} calcium ion

- Same metal, differing charges
  - use Roman numeral to distinguish
  - usually transition metals

    Fe^{2+} iron(II) ion Fe^{3+} iron(III) ion

- Cations from non-metals
  - names end in *-ium*

    NH_3 ammonia NH_4^+ ammonium

Naming Ionic Compounds
Anions

- Monatomic
  - drop ending, add *-ide*

    H^- hydride ion O^{2-} oxide ion

- Polyatomic
  - oxoanions (if only 2 possible - *e.g. N, S, P*)
    - larger # of O atoms - suffix *-ate*

      NO_3^- nitrate ion SO_4^{2-} sulfate ion
    - smaller # of O atoms - suffix *-ite*

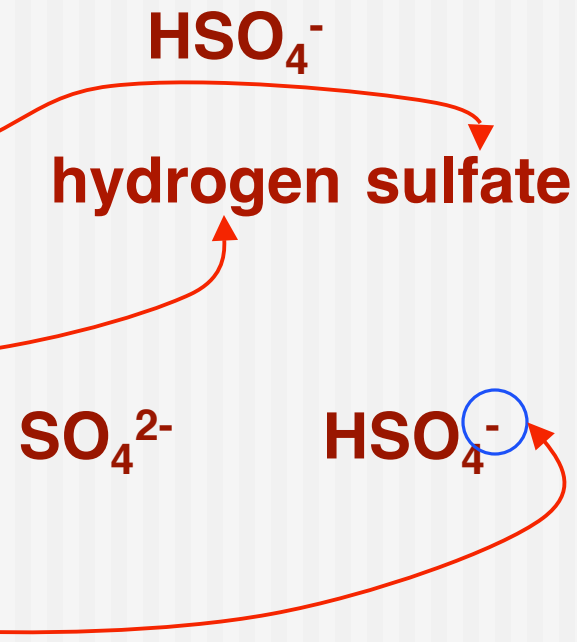
      NO_2^- nitrite ion SO_3^{2-} sulfite ion

Naming Ionic Compounds
Anions (cont'd)

- Polyatomic *(cont'd)*
  - oxoanions (if more than two possible - *e.g. Cl, Br, I*)
    - largest # of O atoms - prefix *per-* + suffix *-ate*
      ClO_4^- perchlorate ion IO_4^- periodate ion
    - next largest # of O atoms - suffix *-ate*
      ClO_3^- chlorate ion IO_3^- iodate ion
    - third largest # of O atoms - suffix *-ite*
      ClO_2^- chlorite ion IO_2^- iodite ion
    - smallest # of O atoms - prefix *hypo-* + suffix *-ite*
      ClO^- hypochlorite ion IO^- hypoiodite ion

Naming Ionic Compounds
Anions (cont'd)

- Polyatomic *(cont'd)*
  - oxoanions with hydrogen
    - name oxoanion portion according to rules
    - place "hydrogen" in front of oxoanion name
    - notice that the charge on the anion has increased (become more positive) by the same amount as the number of H^+ ions added



Naming Ionic Compounds
Anions (cont'd)

- Polyatomic anions with nonstandard names

CH_3COO^-	acetate ion
CN^-	cyanide ion
$C_2O_4^{2-}$	oxalate ion
OH^-	hydroxide ion
O_2^{2-}	peroxide ion
O_2^-	superoxide ion
MnO_4^-	permanganate ion
CrO_4^{2-}	chromate ion
$Cr_2O_7^{2-}$	dichromate ion

Naming Ionic Compounds

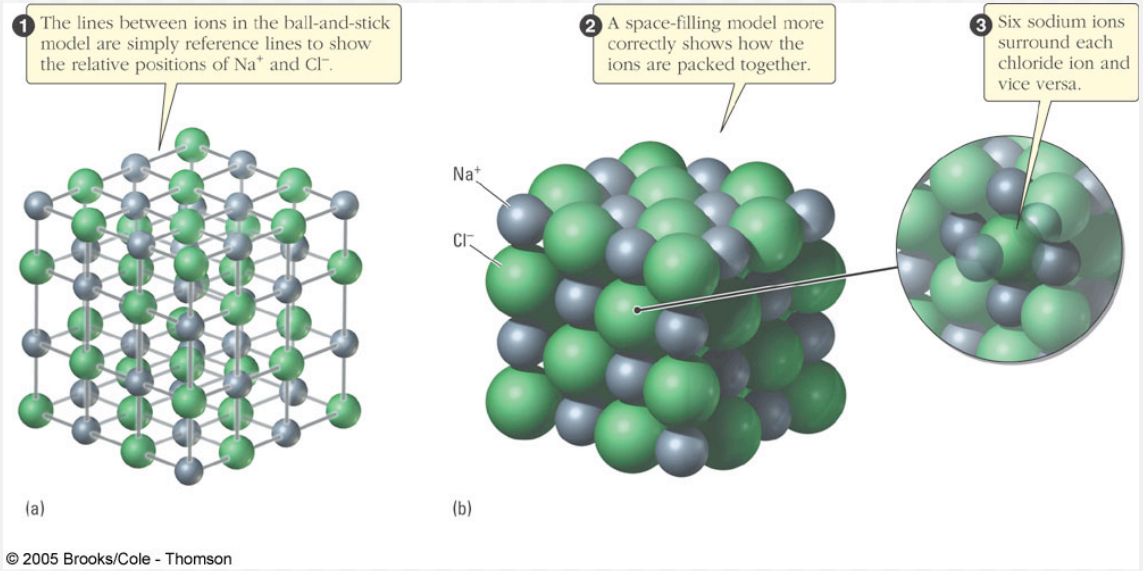
- Cation then anion

  examples:

$CaCl_2$	calcium chloride
$MgSO_4$	magnesum sulfate
$(NH_4)_2CO_3$	ammonium carbonate

Properties of Ionic Compounds

- metal + nonmetal
- crystalline
- hard, brittle
- high melting points
- high boiling points
- electrolytes



Percent Composition

composition of any compound expressed by

- # atoms of each type per molecule or formula unit
- mass of each element in a mole of compound

  % by mass of each element in compound *(part/whole) x 100%*

  example: $C_{12}H_{22}O_{11}$ 342.299 g/mol

$$\%C = \frac{12(12.011\ g/mol)}{342.299\ g/mol} \times 100\% = 42.107\%$$

$$\%H = \frac{22(1.0079\ g/mol)}{342.299\ g/mol} \times 100\% = 6.4779\%$$

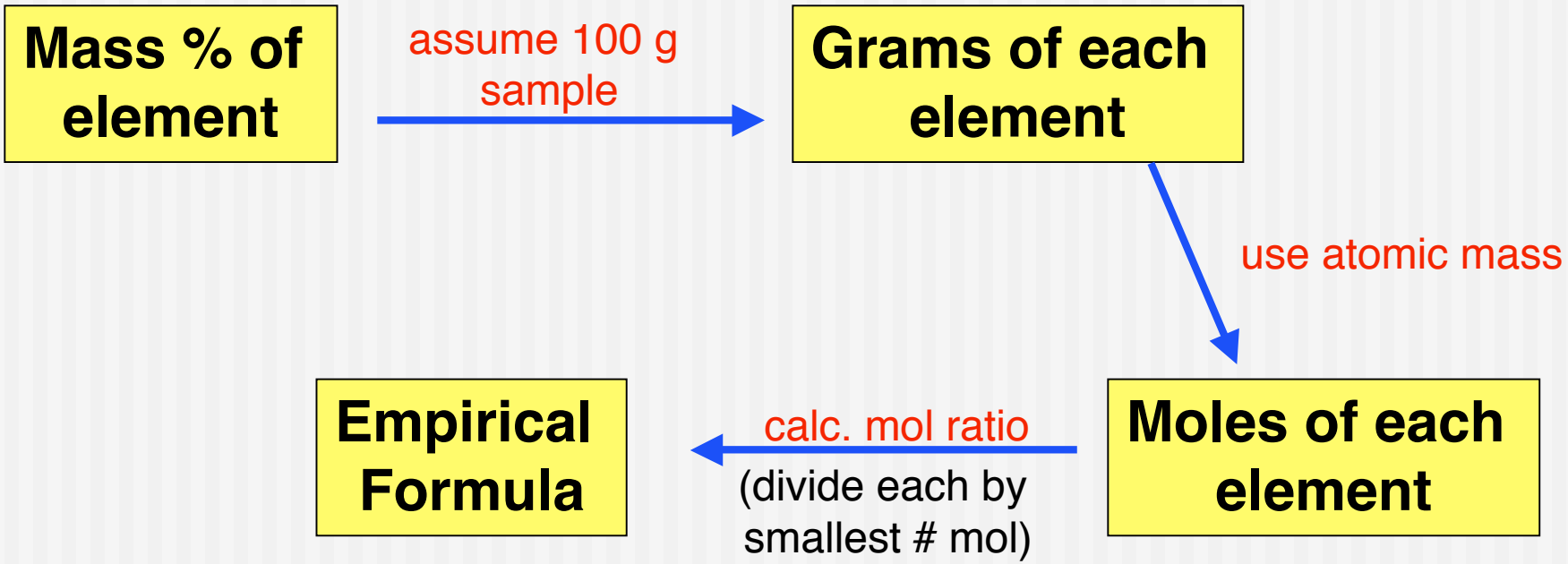
$$\%O = \frac{11(15.9994\ g/mol)}{342.299\ g/mol} \times 100\% = 51.4151\%$$

Empirical Formulas

ratio of mol of each element gives subscripts

H_2O - empirical formula for water

2 atoms H + 1 atom O OR 2 mol H + 1 mol O



Molecular Formula

need:

- empirical formula
- molar mass of molecular formula