Chapter 4: Chemical Composition

Sept 14, 2022

Chemistry Department, Cypress College

Lecture and Lab Weekly Agenda

Lab Section

- Lab Safety Quiz
- Begin Exp 2 - Nomenclature

Lecture Section

- Go over homework assignment; present your work for 1pt EC
- Review Ch 3+8 - Chemical Compounds and Types of Bonding
- Finish up Ch 3 lect and worksheet
- Homework and quiz 3 released Fri, Sept 16 at 3pm
- Homework due Fri, Sept 23 at 11:59pm
- Quiz 3 due Mon, Sept 19 at 11:59pm
- **Heads up:** Exam 1 coming up Sept 26 in lecture and 1.5 hours exam

Outline

Review: Naming Compounds

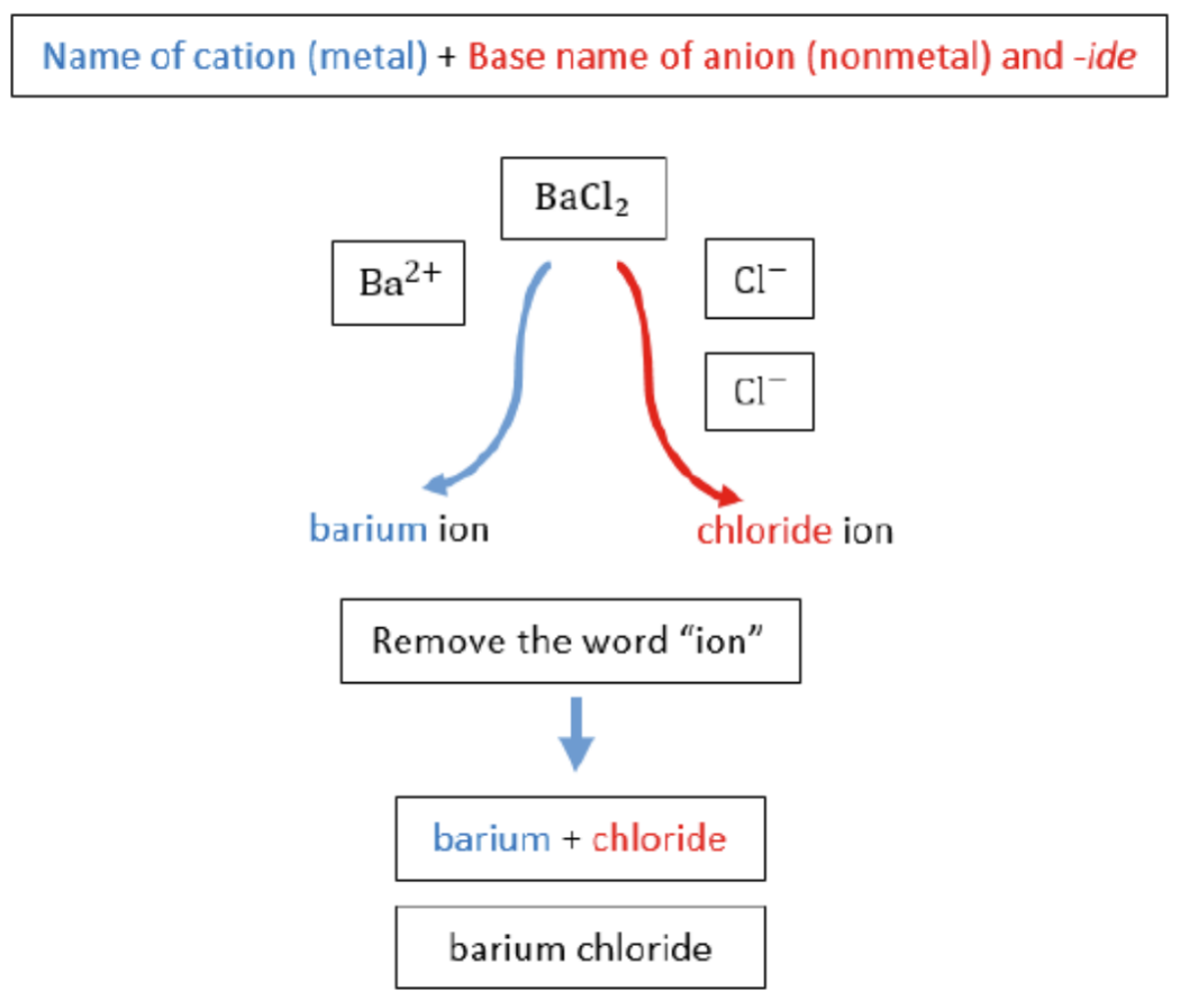
Percent Composition

The Mole Concept

Determining Empirical and Molecular Formulas

Naming Binary Ionic Compounds

The metal cation is named first, followed by the nonmetal anion. The word ion is dropped from both parts.

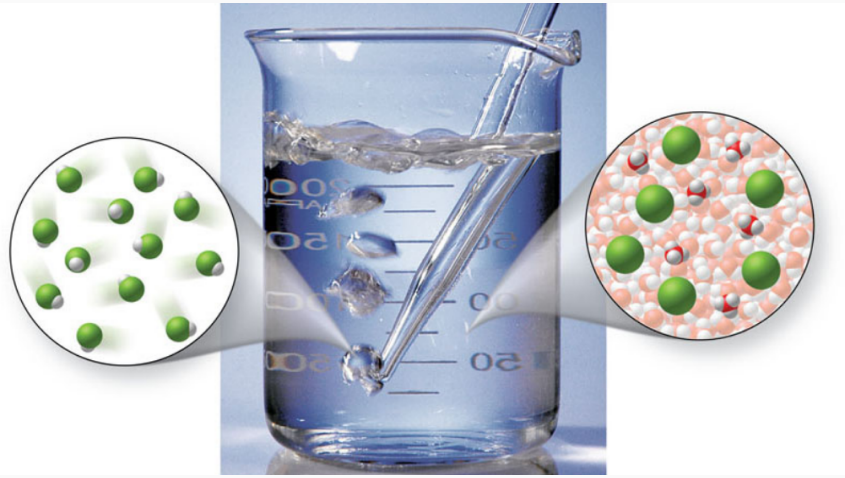


Naming Molecular Compounds

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

1. Use numerical prefix for the element (usually ignore the first when using "mono")
2. Add "-ide" to the second element

Naming Acids and Bases



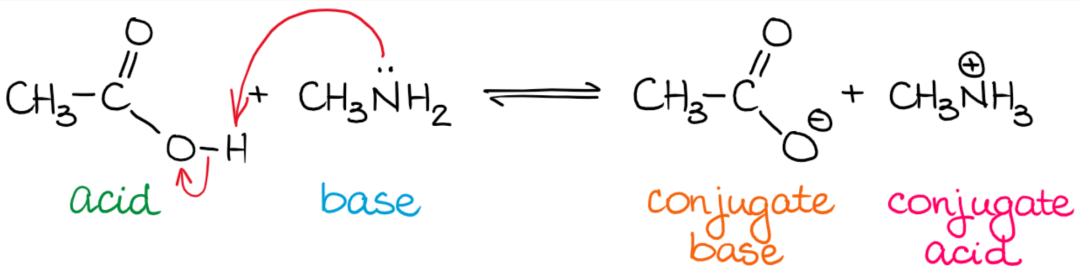
1. If anion ends in "-ide," add "hydro" before the root of the anion name followed by "-ic acid"
2. If anion ends in "-ate," use the root of the anion name followed by "-ic acid"
3. If anion ends in "-ite," use the root of the anion name followed by "-ous acid"

Definition(s) of an Acid

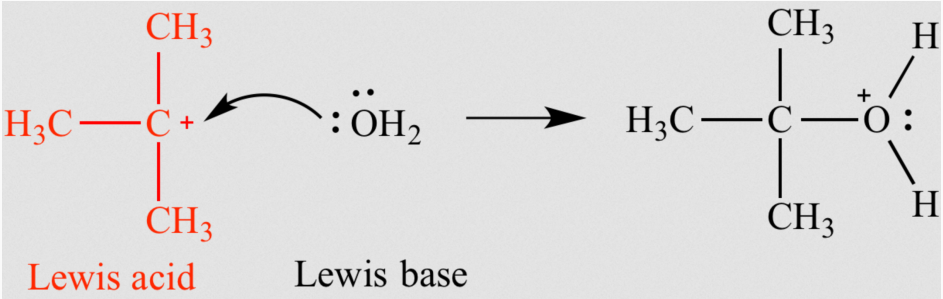
Arrhenius Acid - dissociation of acid in water to yield the ions

e.g. $HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

Brønsted Acid - any species that can donate a proton H^+



Lewis Acid - donation of a pair of electrons



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Percent Compsition

Main Takeaway: Convert the mass of each component to a percentage of the total mass

$$P_A = \frac{M_A}{M_{\text{Tot}}} \times 100\% \tag{1}$$

where M_{Tot} is the total mass, M_A is the mass and P_A is the percent composition for component A

Example Problem: Percent Composition

Magnetite, Fe_3O_4, is a mineral containing 72.4% iron. What mass of iron is present in an 837g sample of magnetite?

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$$(837\text{g magnetite})\frac{72.4\text{g iron}}{100\text{g magnetite}} = 606\text{g iron}$$

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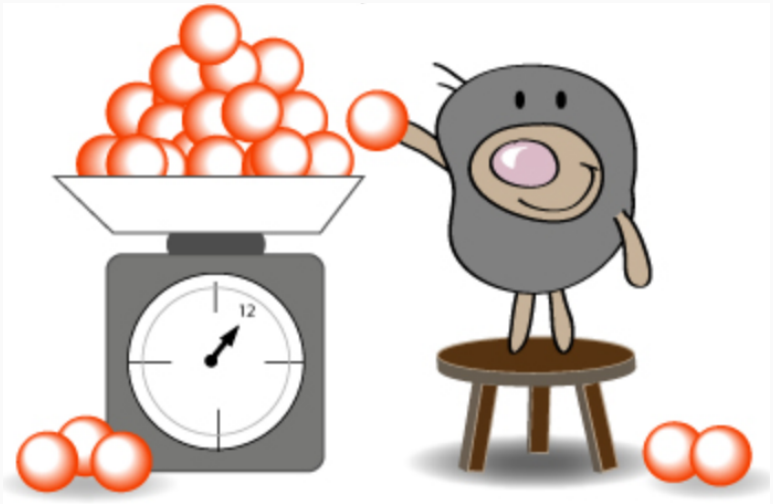
The Mole Concept

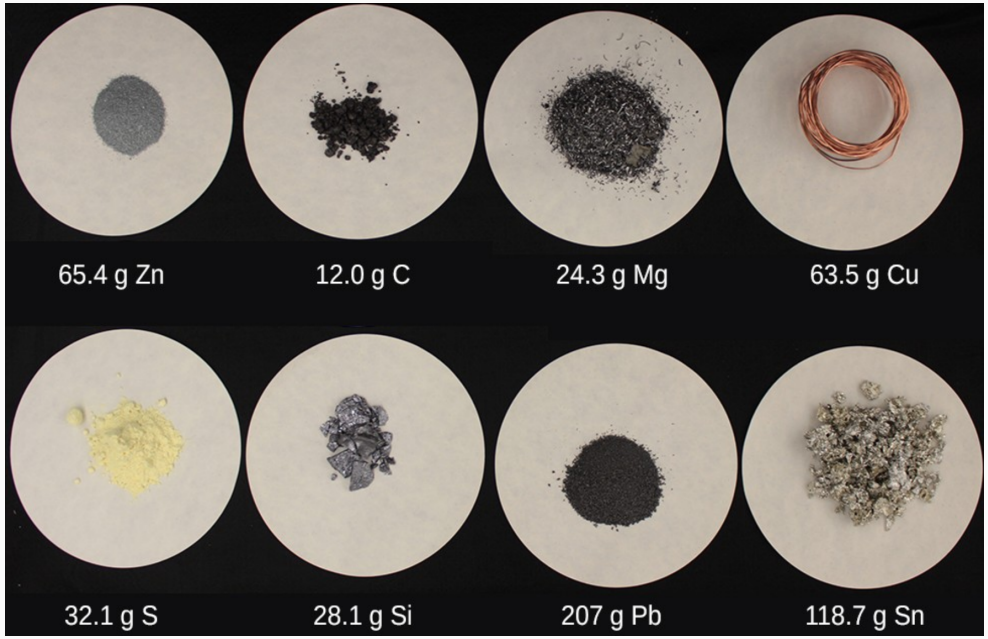


Q: What is a mole (mol)?

A: A mole is measurement of a substance and relates to Avogadro's number (6.022×10^{23})

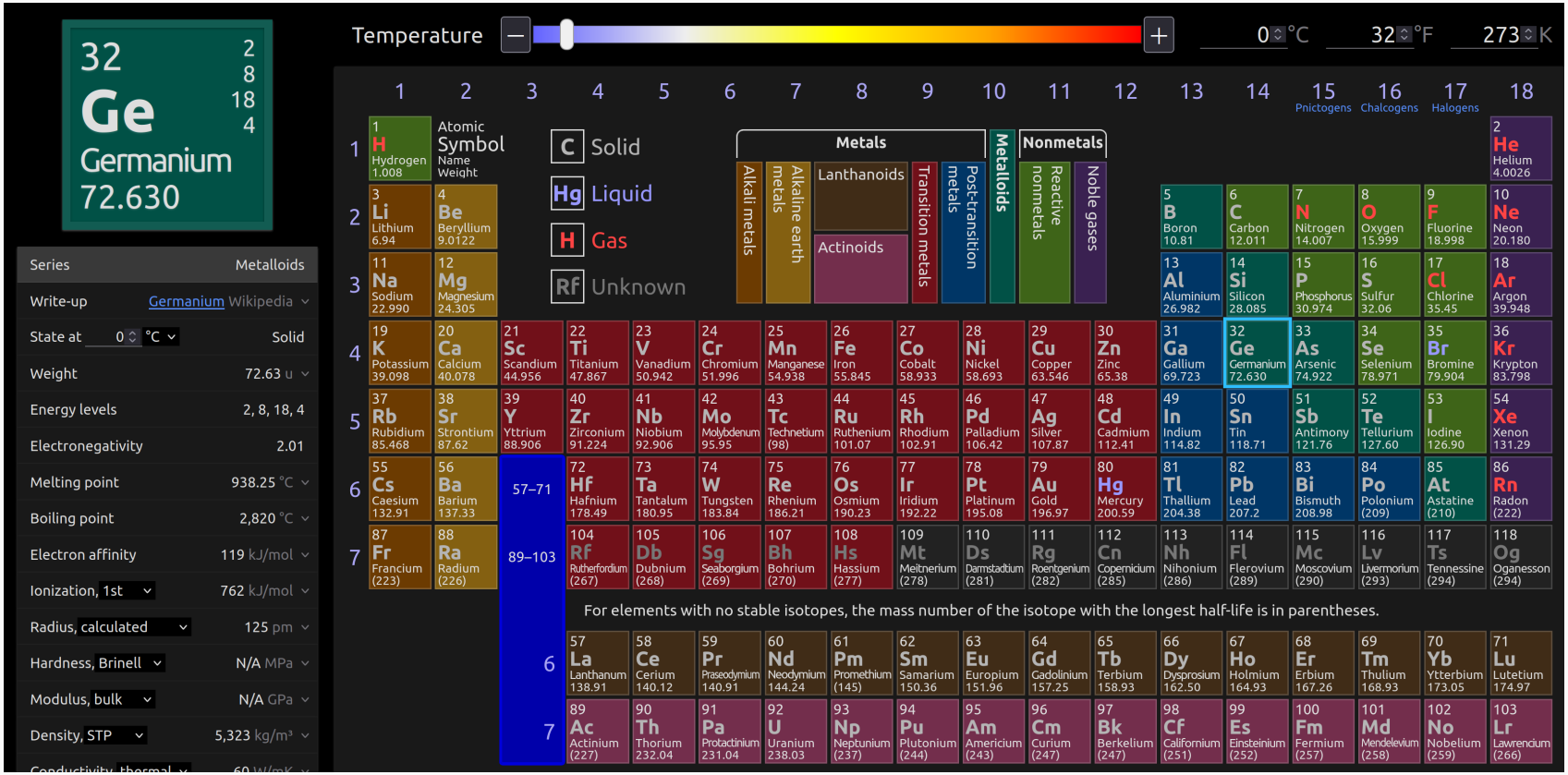
side note: Mole day is Oct. 23, between 6:02 a.m. and 6:02 p.m

Purpose of the Mole



- Gives a consistent method to convert between atoms/molecules and grams
- Convenient way to preform calculations
- View the mole (mol) as a unit conversion type approach

Reminder: Periodic Table



Example: Determine the mol of each element within a compound.

H_2O

$C_6H_{12}O_6$

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$C_6H_{12}O_6$ - 6 mols C, 12 mols H, 6 mols O

Concept: Determine the molar masses

Example: Mole Connection to Chemical Rxn

$Zn(s) + 2\ HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

Q: What are the mols of each reagent required to run this reaction? And how much mol of each product is produced?

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$Zn(s) + 2\ HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

Q: What are the mols of each reagent required to run this reaction? And how much mol of each product is produced?

2 mol Zn(s) and 2 mol HCl(aq) (reagents) produce 1 mol $ZnCl_2$(aq) and 1 mol H_2(g)

Example: Combine Percent Composition and the Mole

Determine the mass percent of each element in $Al_2(SO_4)_3$.

$$\% \text{ mass of Al} =$$

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Determine the mass percent of each element in $Al_2(SO_4)_3$.

$$\begin{aligned}\%\text{ mass of Al} &= \frac{n \times \text{molar mass Al}}{n \times \text{molar mass of } Al_2(SO_4)_3} \times 100\% \\ &= \frac{2 \times 26.98\text{g}}{342.14\text{g}} \\ &= 15.77\%\end{aligned}$$

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Determine the mass percent of each element in $Al_2(SO_4)_3$.

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\%\text{ mass of Al} &= \frac{n \times \text{molar mass Al}}{n \times \text{molar mass of } Al_2(SO_4)_3} \times 100\% \\
&= \frac{2 \times 26.98\text{g}}{342.14\text{g}} \\
&= 15.77\%
\end{aligned}$$

$$\begin{aligned}
\%\text{ mass of S} &= \frac{n \times \text{molar mass S}}{n \times \text{molar mass of } Al_2(SO_4)_3} \times 100\% \\
&= \frac{3 \times 32.06\text{g}}{342.14\text{g}} \\
&= 28.11\%
\end{aligned}$$

$$\begin{aligned}
\%\text{ mass of O} &= \frac{n \times \text{molar mass O}}{n \times \text{molar mass of } Al_2(SO_4)_3} \times 100\% \\
&= \frac{12 \times 16.00\text{g}}{342.14\text{g}} \\
&= 56.12\%
\end{aligned}$$

Practice: Determine Mass from Moles

A friend heats water in a copper kettle and makes a cup of tea. The friend adds 0.0120 mol of table sugar (sucrose, $C_{12}H_{22}O_{11}$). What mass of sugar has he added?

Practice: Number of Molecules from Mass

A substance named Agorca M5640 is used for concentrating extracted copper ore. Its molecular formula is $C_{16}H_{25}NO_2$. If you have a 150.0 g sample of Agorca M5640, how many molecules do you have?

Defn: Empirical and Molecular Formulas

Empirical Formula - the simplest ratios of atoms in a compound; lowest possible ratio

Molecular Formula - a factor of the empirical formula

Approach for Empirical/Molecular Problems

- Convert all elemental masses to mols
- Determine the lowest possible ratio
- Round to the nearest integer for each element and that number is the empirical formula
- For molecular formula, use the given experimental molar mass and divide by the molar mass of empirical formula. Multiply the empirical formula by that ratio.

Practice: Empirical Formula from Percent Composition

Determine the empirical formula for the mineral chalcocite, which has the percent composition 79.8% Cu and 20.2% S.