

Chapter 5: Chemical Reactions and Equations

September 26, 2022

Chemistry Department, Cypress College

Class Announcements

Lecture Section

- All assignments have been graded
- 1.5 hrs Ch. 1 – 4 exam, questions are based on the lectures, homework, and worksheets
- Review Ch. 4 material and begin Ch.5 - Chem Reactions and Equations

Outline

Review: Mass Percent, Moles, and Molarity

Chemical Reactions

Signs of a Chemical Reaction

Writing and Balancing Chem Equations

Predicting Chemical Reactions

Classes of Reactions

Precipitation Rules

Elemental Composition of a Penny



- Penny has not been made of solid copper
- Mix of cheaper metal along with copper on the surface
- Made of 97.5% zinc and 2.5% copper

Different Types of Steel



- Steel is a metal alloy; mixture of different metals yield different physical properties
- Different types:
 - Carbon steel
 - Stainless steel
 - Alloy steel
 - Tool steel

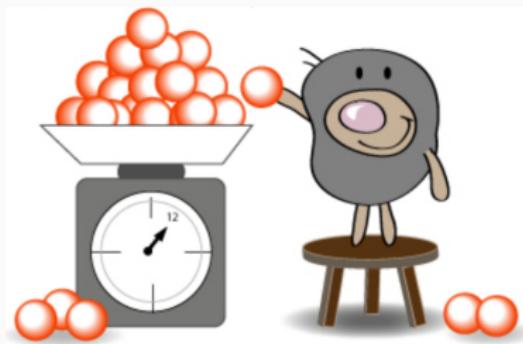
Mass Percent Composition

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

$$P_A = \frac{M_A}{M_{\text{Tot}}} \times 100\% \quad (1)$$

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

The Mole Concept

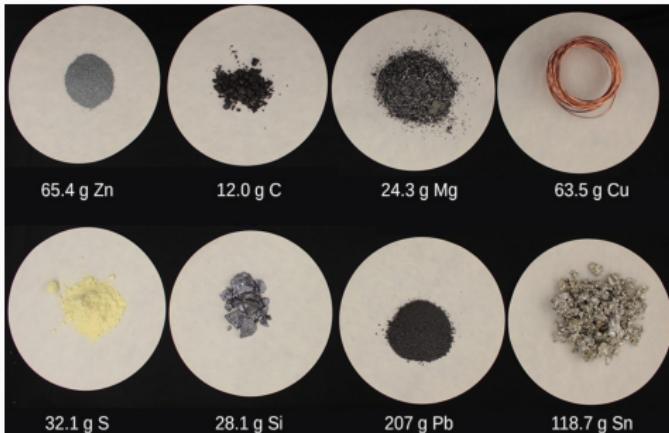


Q: What is a mole (mol)?

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

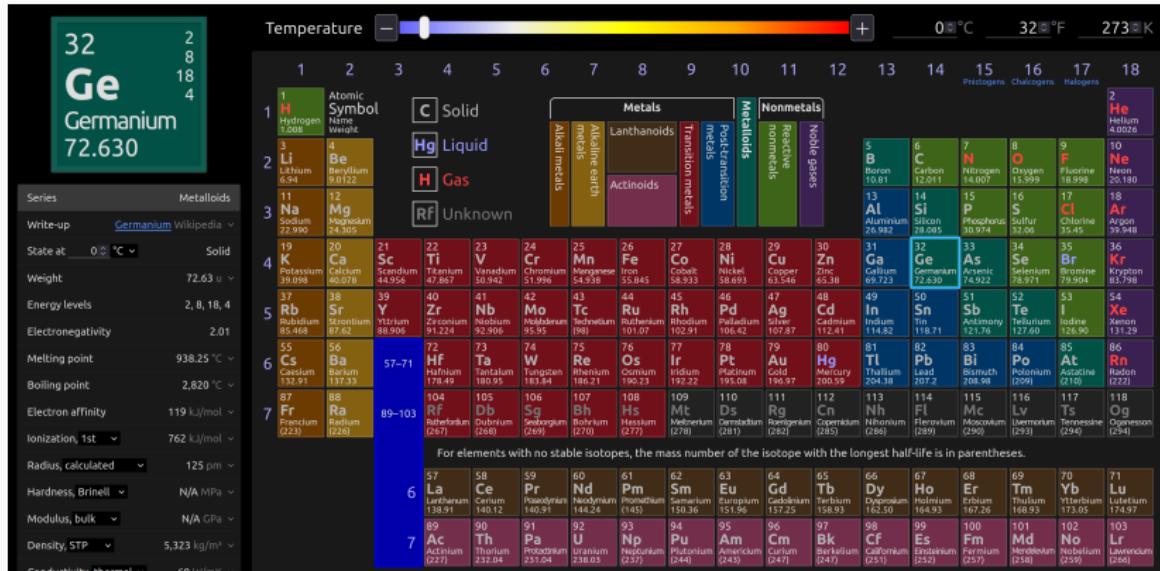
side note: Mole day is Oct. 23, between 6:02 a.m. and 6:02 p.m

Purpose of the Mole



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

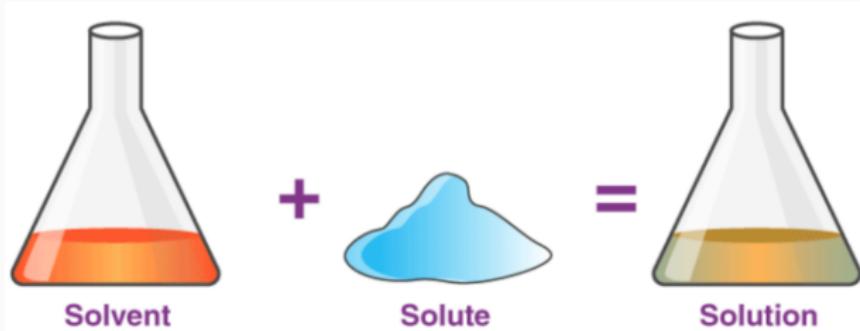
Periodic Table Revisited



Ge - 72.630 amu for 1 atom and the molar mass is 72.630 g/mol

$$1 \text{ amu} = 1.66054 \times 10^{-24} \text{ g}$$

Defn: Solvent and Solute



Solute - a substance (solid, liquid, or gas) dissolved in a solvent

Solvent - the material (liquid or gas) that dissolves the solute

Molarity - Concentration of Solution

Definition of Molarity

$$M = \frac{n_{\text{solute}}}{V} \quad (2)$$

where M is molarity, n_{solute} is the mols of solute, and V is volume in L

Q: What are the units for molarity M ?

Diluting Solutions



Dilution is the process that makes a solution less concentrated.
Example is lemonade tasting too sweet.

Q: For given concentrated solution at molarity M_1 and a given volume V_1 , does diluting the solution to a new concentration M_2 and volume V_2 change the amount of mols present?

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Chemistry is Everywhere!

CHEMICAL REACTIONS IN EVERYDAY LIFE



COMBUSTION



RUST



DIGESTION



PHOTOSYNTHESIS



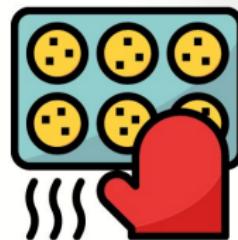
BATTERIES



FERMENTATION



WASHING



BAKING

SCIENCE NOTES.ORG

Defining a Chemical Reaction



- Reactants - chemicals that we start with (A and B)
- Products - chemicals that are formed after (C and D) a reaction

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Q: Based on Eqn 3, can the reaction go in the reverse e.g. C and D turning into A and B ? Why and why not?

Indications of a Chemical Reaction



- Change in color
- Production of light
- Formation of a solid e.g. precipitate
- Formation of a gas
- Absorption or release of heat

Writing and Balancing Chem Equations

Definitions:

Chemical equation - symbolic representation of a chemical reaction

Balanced equation - draws upon the conservation of mass; the mass of the reactants and the mass of products are equal

Writing and Balancing Chem Equations

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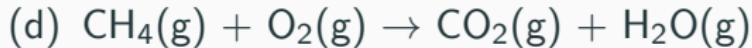
Chemical equation - symbolic representation of a chemical reaction

Balanced equation - draws upon the conservation of mass; the mass of the reactants and the mass of products are equal

Q: Are the moles of reactants and the moles of products the same?

Example: Balancing Chem Equation

Balance the following chemical equations:



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Classes of Reactions

Class	Reactants	Products	Example
Decomposition	1 compound	multiple	$CD \rightarrow C + D$
Combination	multiple	1 compound	$A + D \rightarrow AD$
Single-displacement	elem+comp	elem+comp	$A + CD \rightarrow C + AD$
Double-displacement	2 compounds	2 compounds	$AB + CD \rightarrow AD + BC$

Decomposition Reactions



- Breaks down compounds into simpler compounds and/or elements
- Often the breakdown involves the use of heat e.g. breaking the bonds

Examples of Decomposition Reactions

Oxides and Halides of Metals



Peroxides



Metal Carbonates



Cont. Examples of Decomposition Reactions

Oxoacids



Metal Hydrates

A number of compounds that contain water or components of water e.g. metal hydrates



Anhydrous compound - substances without any water contents

Example: Decomposition Reaction

A scientist needs cobalt(II) oxide to make cobalt glass. The available compounds are $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, CoCO_3 , CoS , and Co(OH)_2 . Which of these compounds can make the cobalt(II) oxide needed?

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Combination Reaction



- When two substances react to produce a single compound
- Elements react to form compounds
- Compounds can combine to form another compound
- Element react with another compound to form another substance

Summary of Combination Reactions

Metal and Nonmetal



Nonmetal and Nonmetal



Element and Compound



Compound and Compound



Practice: Combination Reaction

When pure calcium metal is exposed to the oxygen in air, white coating appears on the surface. Predict the product and write a complete, balanced equation.

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Single-Displacement Reaction

A single element displaces another element within a compound

Aluminum displacing Fe₂O₃



Metal displaces a hydrogen in water



Recall the alkali earth metals and alkaline earth metals are highly reactive species

Metal Reactivity

Metals	Reactivity
Potassium	Reacts with water
Sodium	Reacts with water
Lithium	Reacts with water
Barium	Reacts with water
Strontium	Reacts with water
Calcium	Reacts with water
Magnesium	Reacts with Acids
Aluminium	Reacts with Acids
Zinc	Reacts with Acids
Manganese	Reacts with Acids
Chromium	Reacts with Acids
Iron	Reacts with Acids
Cadmium	Reacts with Acids
Cobalt	Reacts with Acids
Nickel	Reacts with Acids
Tin	Reacts with Acids
Lead	Reacts with Acids
Hydrogen	Included for Comparison
Antimony	Included for Comparison
Bismuth	Included for Comparison
Copper	Highly Unreactive
Mercury	Highly Unreactive
Silver	Highly Unreactive
Gold	Highly Unreactive
Platinum	Highly Unreactive

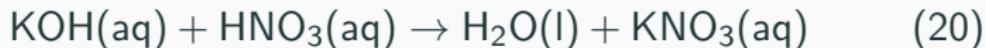
Double-Displacement Reaction

A reaction where elements/polyatomic ions within compounds switch places

Precipitation Reaction



Acid-Base Reaction



Memorize: Precipitation Rules

Solubility Rules for Common Ionic Compounds in Water	
Some Soluble Compounds	Exceptions
Group IA cations (Li^+ , Na^+ , K^+ , Rb^+ , Cs^+), NH_4^+	No Exceptions
NO_3^- , ClO_4^- , CH_3COO^- , ClO_3^-	No Exceptions
Cl^- , Br^- , I^-	Halides of Ag^+ , Hg_2^{2+} , Pb^{2+}
SO_4^{2-}	Sulfates of Sr^{2+} , Ba^{2+} , Hg_2^{2+} , Pb^{2+}
Some Insoluble Compounds	
S^{2-}	Sulfides of Group 1A cations, NH_4^+ , Ca^{2+} , Sr^{2+} , Ba^{2+}
CO_3^{2-}	Carbonates of Group 1A cations and NH_4^+
OH^-	Hydroxides of Group 1A cations, NH_4^+ , Ca^{2+} , Sr^{2+} , Ba^{2+}
PO_4^{3-}	Phosphates of Group 1A cations and NH_4^+

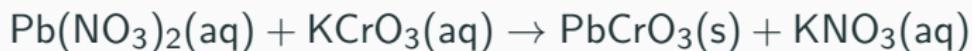
Practice: Precipitation Reaction

Suppose lead(II) nitrate and potassium chromate solutions are mixed. A yellow precipitate begins to appear, identify the precipitate and write a balanced equation for the reaction carried out.



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Practice: Addt'l Precipitation Reaction

Mixing solutions of cadmium(II) nitrate and sodium sulfide lead to an orange precipitate. Identify the precipitate and write the balanced equation carried out.

Acid-Base Reaction

Neutralizes the acidity/basicity of the solution



where HA is the acid and B is the base. An example is the mixture of $\text{Ca}(\text{OH})_2$ and HCl



Example: Antacids

Upset stomachs are often treated with an acid that is a suspension of magnesium hydroxide in water. Stomach acid is hydrochloric acid. Write a balanced equation for the reaction between magnesium hydroxide and stomach acid

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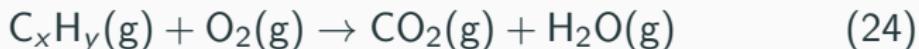


Combustion Reactions

Hydrocarbon Combustion (Majority)



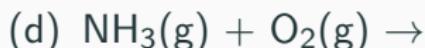
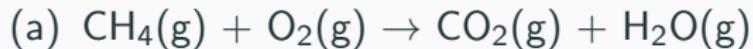
Reactions with $O_2(g)$ leading to large heat released. Example above is the burning of hydrocarbon (C_xH_y) and follows



Strategy to Balance Hydrocarbon Combustion

1. Balance carbon and hydrogen on the product side
2. Balance the oxygen on the reactant side

Practice: Balancing Hydrocarbon Combustion



Combustion Reactions

Metal Combustion



Iron Combustion Video Link

Practice: Combustion Reactions

Complete and balance the following combustion reactions

