

# **Chapter 5: Chemical Reactions and Equations**

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September 26, 2022

Chemistry Department, Cypress College

# Class Announcements

## Lab Section

- Read the Exp 7: Water in Hydrates Lab
- Bunsen burner to heat the hydrate
- Temperature change is not required observation
- TIP: record all qualitative and quantitative observations

## 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

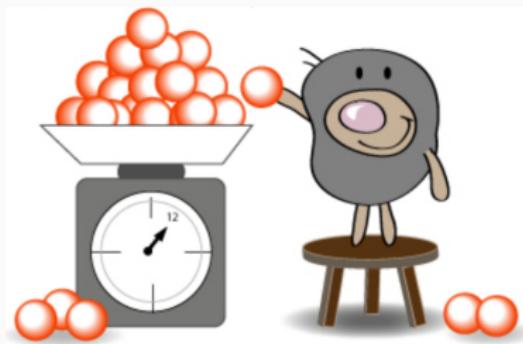
# Mass Percent Composition

**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  $M_{\text{Tot}}$  is the total mass,  $M_A$  is the mass and  $P_A$  is the percent composition for component  $A$

# The Mole Concept

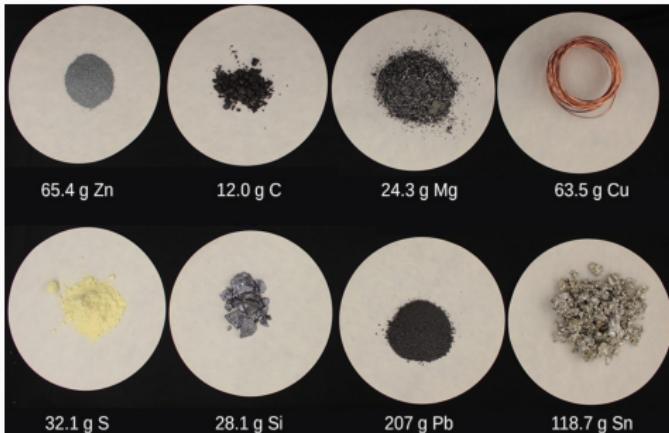


**Q:** What is a mole (mol)?

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

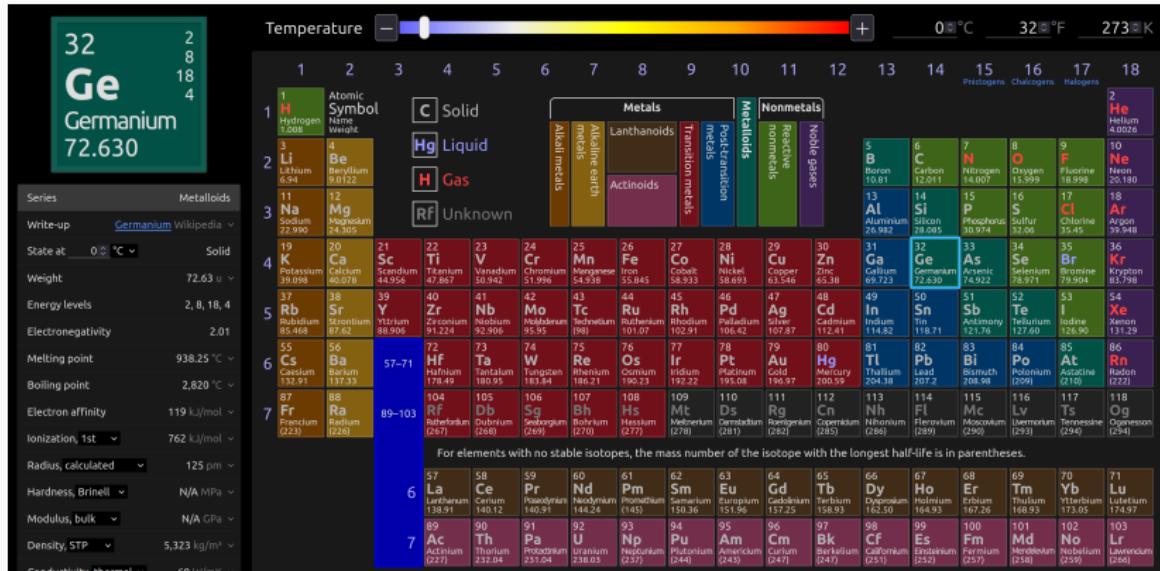
**side note:** Mole day is Oct. 23, between 6:02 a.m. and 6:02 p.m

# 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

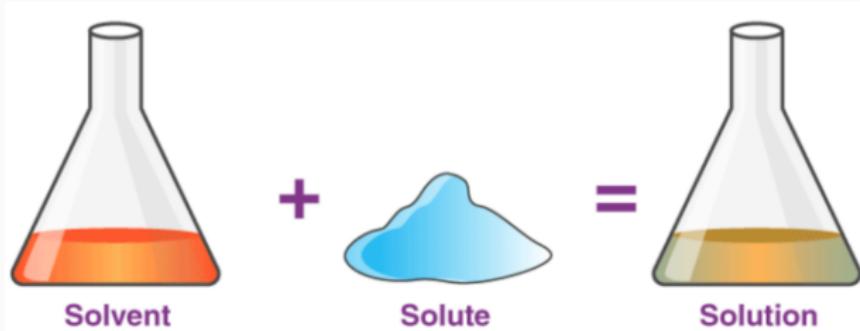
# Periodic Table Revisited



**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,  $n_{\text{solute}}$  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



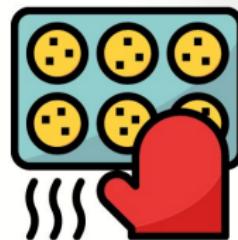
BATTERIES



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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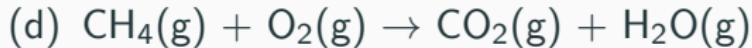
Chemical equation - symbolic representation of a chemical reaction

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

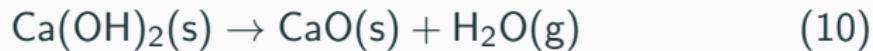


## Metal Carbonates



## 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  $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ ,  $\text{CoCO}_3$ ,  $\text{CoS}$ , and  $\text{Co(OH)}_2$ . 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 Fe<sub>2</sub>O<sub>3</sub>**



**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 water
Aluminium	Reacts with water
Zinc	Reacts with water
Manganese	Reacts with water
Chromium	Reacts with water
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

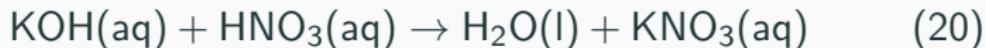
## Double-Displacement Reaction

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 ( $\text{Li}^+$ , $\text{Na}^+$ , $\text{K}^+$ , $\text{Rb}^+$ , $\text{Cs}^+$ ), $\text{NH}_4^+$	No Exceptions
$\text{NO}_3^-$ , $\text{ClO}_4^-$ , $\text{CH}_3\text{COO}^-$ , $\text{ClO}_3^-$	No Exceptions
$\text{Cl}^-$ , $\text{Br}^-$ , $\text{I}^-$	Halides of $\text{Ag}^+$ , $\text{Hg}_2^{2+}$ , $\text{Pb}^{2+}$
$\text{SO}_4^{2-}$	Sulfates of $\text{Sr}^{2+}$ , $\text{Ba}^{2+}$ , $\text{Hg}_2^{2+}$ , $\text{Pb}^{2+}$
Some Insoluble Compounds	
$\text{S}^{2-}$	Sulfides of Group 1A cations, $\text{NH}_4^+$ , $\text{Ca}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Ba}^{2+}$
$\text{CO}_3^{2-}$	Carbonates of Group 1A cations and $\text{NH}_4^+$
$\text{OH}^-$	Hydroxides of Group 1A cations, $\text{NH}_4^+$ , $\text{Ca}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Ba}^{2+}$
$\text{PO}_4^{3-}$	Phosphates of Group 1A cations and $\text{NH}_4^+$

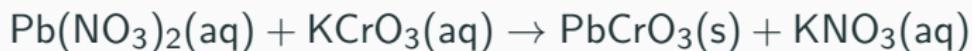
## Practice: Precipitation Reaction

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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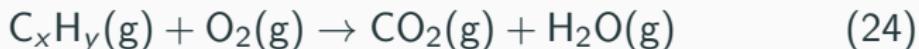


# Combustion Reactions

## Hydrocarbon Combustion (Majority)



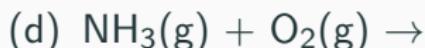
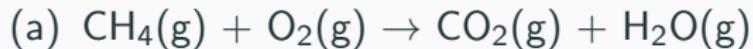
Reactions with  $O_2(g)$  leading to large heat released. Example above is the burning of hydrocarbon ( $C_xH_y$ ) and follows



## 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

