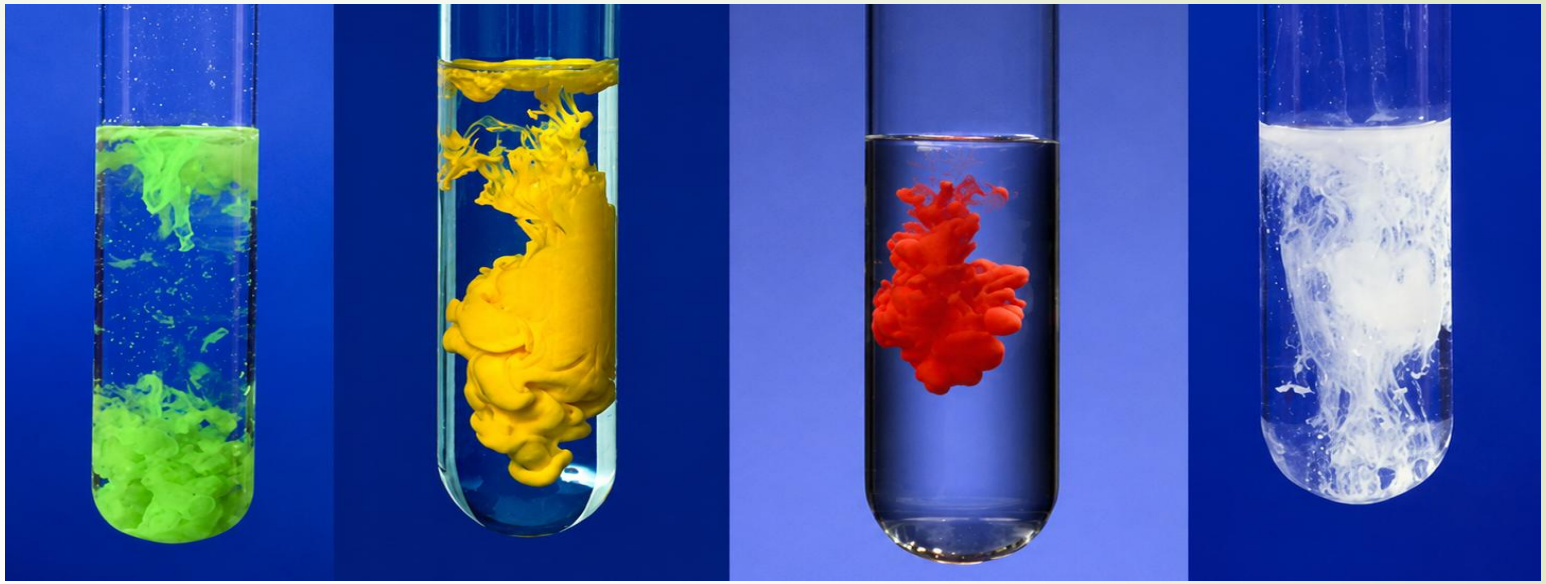
Auburn Mountainview
Karl Steffin, 2006
7/29/2026



Precipitation Chemistry

By end of this unit I can…

- A.1 Predict the products of a precipitation reaction.
- B.1 Create and/or evaluate models of precipitation reactions.
- C.1 Create and/or evaluate models that represent the concentration of a solution.
- C.2 Perform calculations relating to the molarity of volume of that solution.
- D.1 Predict the amount of solid produced in a precipitation reaction using gravimetric analysis based on the concentrations of the starting solutions.
- D.2 Evaluate the results of a gravimetric analysis.

Writing Equations: Phase States

States of Matter:

$X_{(g)}$: Gas $X_{(l)}$: Liquid $X_{(s)}$: Solid

$X_{(aq)}$: Aqueous (dissolved in water)

Diatomic Element: Molecule comprised of only one type of element (H_2, O_2, N_2, F_2, Cl_2, I_2, Br_2, At_2, P_4, S_8)

Types of Reactions (I)

- Synthesis (Direct Combination)

$$A + B \rightarrow C$$

- Two or more reactants that combine to form a more complex product.

Ex: $Pb_{(s)} + O_{2(g)} \rightarrow PbO_{2(s)}$

Lead reacts with Diatomic Oxygen to form Lead (IV) Oxide. (Basic oxidation reaction.)

Types of Reactions (II)

- Decomposition:

$$A \rightarrow B + C$$

  - A reactant that breaks down to form two or more products.

Ex: $KClO_{3(s)} \xrightarrow{\Delta} KClO_{(s)} + O_{2(g)}$

When heated Potassium Chlorate decomposes into Potassium Hypochlorite and Oxygen Gas. (Thermolytic)

Types of Reactions (III)

- (Single) Replacement:

$$A + BX \rightarrow AX + B$$

  - The more active element takes the place of another like element.

Ex: $Fe_{(s)} + CuSO_{4(aq)} \rightarrow FeSO_{4(aq)} + Cu_{(s)}$

Iron and Copper (II) Sulfate will form Iron (II) Sulfate and Copper Dendrites. (Basic replacement reaction.)

Types of Reactions (IV)

- (Ionic) Double-Replacement:

$$AX + BY \rightarrow AY + BX$$

  - When two compounds interact in an aqueous solution to form a precipitate, gas, or water/non-ionized substance.

Precipitation Reaction: $NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow NaNO_{3(aq)} + AgCl_{(s)}$

Gas Forming Reaction: $2HCl_{(aq)} + FeS_{(aq)} \rightarrow FeCl_{2(aq)} + H_2S_{(g)}$

Neutralization Reaction: $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

Solubility Rules

- Ionic Bonds not in the presence of water are solid.
- Predicting precipitate depend on the ions.
  - Formula Sheet: Soluble = (aq), Insoluble = (s)
  - If both products are (aq) then the reaction does not happen.
- Predicting water (l) requires an Acid (HX) reacting with a Base (YOH).
- Predicting a gas requires an unstable product to be formed first.
  - Carbonic or Sulfurous Acid, Ammonium Hydroxide, Hydrogen Sulfide.

$$NaHCO_3 + CH_3COOH \rightarrow NaCH_3COO + H_2CO_3$$

$$H_2CO_3 \rightarrow H_2O + CO_2$$

Net Equations/Spectator Ions

- Spectator ions are ions that don't participate in the reaction (they stay aqueous).
  - Look at this reaction:

$$NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow NaNO_{3(aq)} + AgCl_{(s)}$$

  - Notice the Na^+ and NO_3^- parts are always aqueous.
  - They just go along for the ride… (Spectators).
- You can rewrite the equation in Net Ionic Form.

$$Cl^-_{(aq)} + Ag^+_{(aq)} \rightarrow AgCl_{(s)}$$

Spectator Ions/Net Equations

- What is the Net Equation for the following?

$$Mg(ClO_3)_2 + K_2O \rightarrow KClO_3 + MgO$$

- First Balance and then add Phase States

$$Mg(ClO_3)_{2(aq)} + K_2O_{(aq)} \rightarrow 2KClO_{3(aq)} + MgO_{(s)}$$

- Highlight the non (aq) and its reactant parts.

$$Mg(ClO_3)_{2(aq)} + K_2O_{(aq)} \rightarrow 2KClO_{3(aq)} + MgO_{(s)}$$

- Rewrite: If the ion is separated add the correct charge back.

$$Mg^{2+}_{(aq)} + O^{2-}_{(aq)} \rightarrow MgO_{(s)}$$

Spectator Ions/Net Equations

- **What is the Net Equation for the following?**

$$SnI_4 + Pb(NO_3)_2 \rightarrow Sn(NO_3)_4 + PbI_2$$

$$SnI_{4(aq)} + 2Pb(NO_3)_{2\,(aq)} \rightarrow Sn(NO_3)_{4\,(aq)} + 2PbI_{2(s)}$$

$$SnI_{4(aq)} + 2Pb(NO_3)_{2\,(aq)} \rightarrow Sn(NO_3)_{4\,(aq)} + 2PbI_{2(s)}$$

$$\boxed{4I^{1-}_{(aq)} + 2Pb^{2+}_{(aq)} \rightarrow 2PbI_{2(s)}}$$

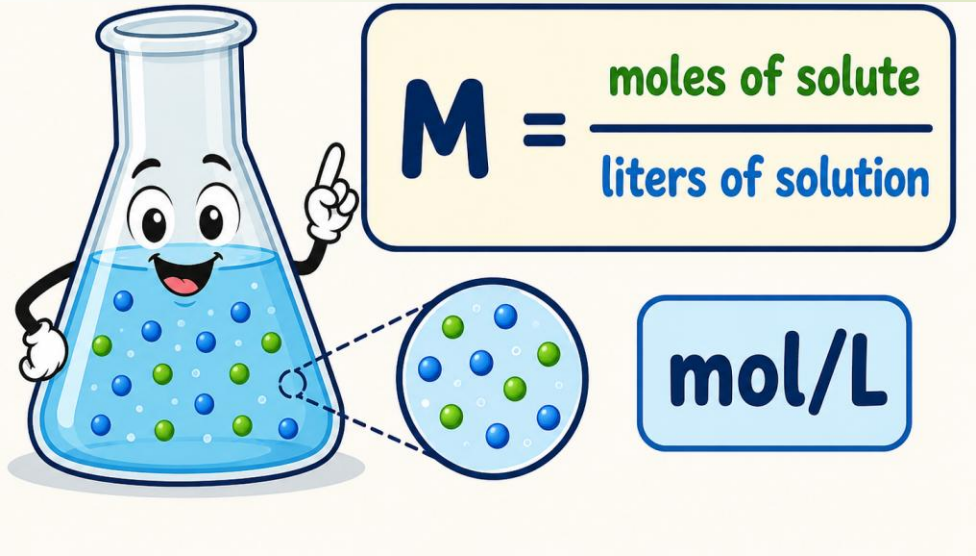
Special Redox Reaction

- Combustion
  - Hydrocarbons ($C_xH_{y\ or\ (2x+2)}$) reaction to O_2 (burning) will produce CO_2 and water vapor.

$$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$$

Molarity

- Molarity ($\mathcal{M}$): A unit of concentration for solutions.
  - Equal to # moles solute (n) per 1-L of solvent.
- The higher the $\mathcal{M}$, the stronger the solute in the solvent (normally water).
  - 12- $\mathcal{M}$ H_2SO_4 is the strongest concentration you can find, very dangerous.
  - Experiments normally use 1- $\mathcal{M}$ or less.



Molarity Example I

- What is the molarity of a solution formed by mixing 100.0-g of H_2SO_4 with enough water to make 100.0-mL?

$$M = \frac{n}{V}$$

$$100 - g\, x \frac{1 - mol}{98.1 - g} = 1.019 - mol$$

M =

V = .1-L

n = 1.019-mol

$$M = \frac{1.019 - mol}{.1 - L}$$

$$\boxed{M = 10.19 - Molar}$$

Molarity Example II

- How many milliliters of water are needed to make a 4.50-$\mathcal{M}$ solution with 52.0-g of table salt?

$$M = \frac{\mathrm{n}}{\mathrm{V}}$$

$$52 - g\ x \frac{1 - mol}{58.5 - g} = .889 - \mathrm{mol}$$

M = 4.5-Molar

V=

n = .889-mol

$$4.5 - \frac{mol}{L} = \frac{.89 - \mathrm{mol}}{\mathrm{V}}$$

$$V = .1975 - \mathrm{L}\ x \frac{m}{\frac{1}{1000}}$$

$$\boxed{V = 198 - \mathrm{mL}}$$

Gravimetric Analysis

- A method in which the mass of a solid product is used to calculate how much of a substance was originally present.
  - Analyte: The substance being measured.
  - Precipitate: An insoluble solid formed during a reaction.
  - Filtration: Separating a solid from a liquid.

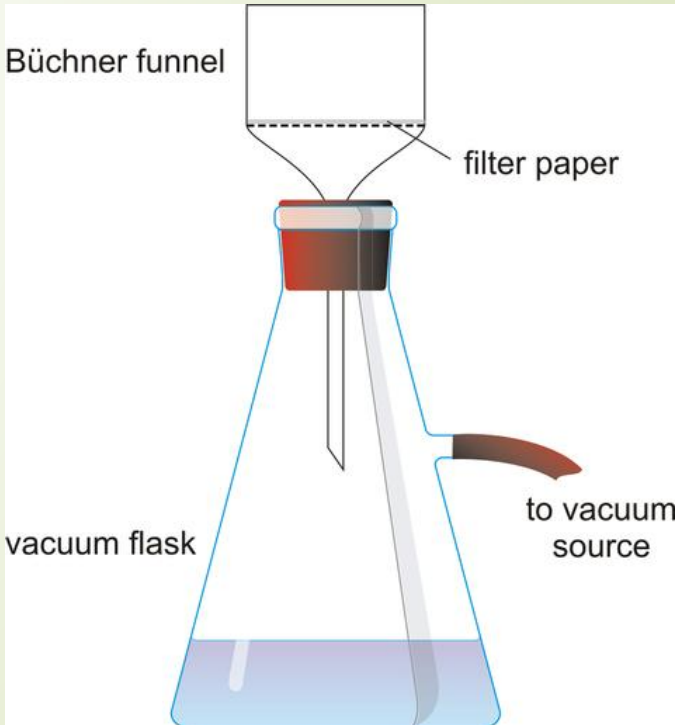
Gravimetric Analysis: Process

1. **Dissolve the sample:** Place the sample in water so its particles can react.
2. **Form a precipitate:** Add a chemical that reacts with the analyte to create an insoluble solid.
3. **Filter the mixture:** Separate the precipitate from the liquid.
4. **Wash the precipitate:** Rinse it with a small amount of distilled water to remove dissolved impurities.
5. **Dry the precipitate:** Remove all water so that only the solid is weighed.
6. **Weigh the precipitate:** Subtract the mass of the filter paper or container.
7. **Use stoichiometry:** Calculate the amount of the original substance from the mass of the precipitate.

Gravimetric Analysis: Example

- Water has dissolved Cl^- ions. Silver Nitrate is added to produce Silver Chloride: $Ag^+ + Cl^- \rightarrow AgCl$.
- The following data was collected after filtering and drying:
  - Mass of filter paper: 1.20-g
  - Mass of filter paper and Silver Chloride: 2.635-g
- Starting at Step 6: M_{AgCl}= 2.635-g-1.20-g= 1.435-g

$$1.435 - g\ AgCl \cdot \frac{1 - mol}{143.32 - g} = .01001 - mol\ AgCl$$



Gravimetric Analysis: Example

$$Ag^+ + Cl^- \rightarrow AgCl$$

- Step 7: $$.01001 - mol\ AgCl \cdot \frac{1 - Cl^-}{1 - AgCl} \cdot \frac{35.45 - g}{1 - mol} = .3549 - g\ Cl^-$$

.355-g Cl^-

- This requires technical skill to remove error:
  - Not a thorough reaction (collisions, limiting reactants)
  - Precipitate not thoroughly rinsed (Sodium Impurities remain)
  - Precipitate not dried (water adds mass)
  - Precipitate lost (spilled or not collected in filter)
- Percent yield?