

Lab 7: Metathesis Reactions

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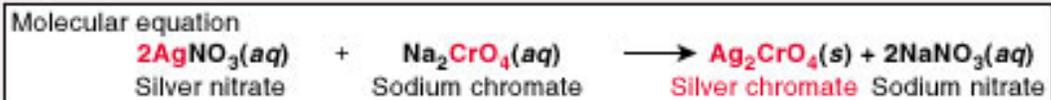
Lab Objectives

- Careful observation and detailed description of chemical reactions in solution
- Inferring from observation and from other information whether or not a reaction actually takes place
- Writing the reactions that take place in the shorthand language of chemistry: chemical equations (molecular, complete ionic, and net ionic)
- Physical Properties of Compounds

Types of Metathesis Reactions

- Precipitation reaction
- Neutralization reaction
- Gas formation reaction

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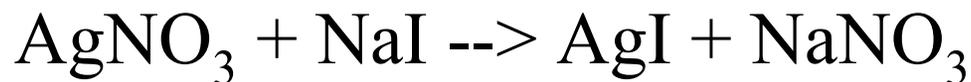
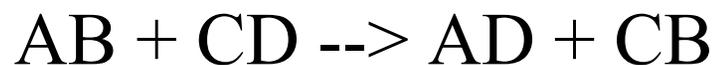
Why do ions exchange partners?

- Cations are always attracted to anions, but the hydration and hydrogen bonding keep the ions of electrolytes in solution.
- When two solutions are mixed, cations of one electrolyte meet anions of the other.
- If they form a more stable substance such as a solid or neutral molecules, exchange or metathesis reaction takes place. The new couples form a precipitation, gas, or neutral molecules.

Part A

Predicting the Products of Metathesis Reactions

- Products of metathesis ("double replacement") reactions are obtained by interchanging the ions produced by dissociation of the reactants.

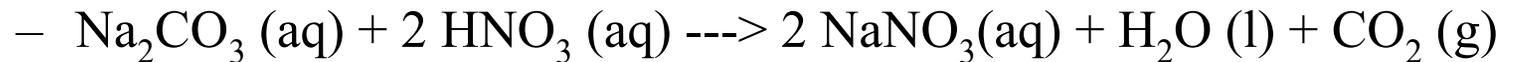


Observing Chemical Reactions

1. Precipitate Forms
2. Gas Formation
3. Color change
4. Change in density
5. Electrical Conductivity is altered
6. Different melting/boiling point
7. Temperature change during the reaction

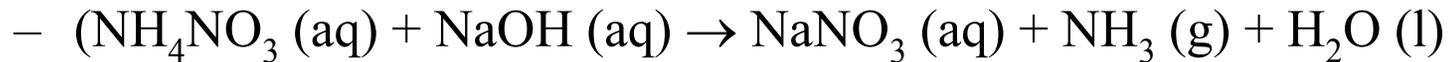
Salts that can form a gas as a product

- Carbonates



- Sulfides

- Ammonium Salts



- Cyanides

- Metal + Acid (hydrogen gas)

A precipitate forms:

- When mixing a pair of soluble reactants in solution, the sudden appearance of a solid that 'rains down' (precipitates) into the bottom of the container is a sign that a reaction has occurred. Sometimes the precipitate particles are too small to settle out; in this case, look for a cloudy solution.

Signs of Chemical Change

- Bubbles of gas appear.
- Gas-producing reactions run to completion when the gas can leave the reaction mixture.
- Gaseous products appear as bubbles only after the reaction mixture has become saturated with the gas. If there are no rough surfaces or dust particles to nucleate the bubbles, the reaction may produce a supersaturated gas solution.

Solubility

- The **solubility** of a substance is the maximum amount of a material (called the **solute**) that can be dissolved in given quantity of solvent at a given temperature. When a solute is dissolved in a solvent to give a homogeneous mixture, one has a solution.
- **Solubility** is generally expressed as the number of grams of solute in one liter of saturated solution. For example, 12 g/L at 25 °C.
- **Molar solubility** is the number of moles of solute in one liter of saturated solution. For example, 0.115 mol/L at 25 °C.

A guide to solubility

- Most nitrates are soluble. So are alkali and ammonium halides.
- Most carbonates, phosphates, sulfites, sulfides, Ca(OH)_2 , and AgCl are some of the substances that are only sparingly soluble (less than 0.1 g per 100-mL water).

Additional Info

- For about 95% of all compounds, solubility in water increases with increasing temperature. Many compounds can have their solubility in water increased or decreased by the presence of another solute. Solubilities can be broken into four general classes:
 1. Soluble -
 2. Slightly soluble
 3. Sparingly soluble
 4. Insoluble

- Sparingly soluble materials have very low solubilities such as 0.5 g per liter or (much) lower.
- When discussing the solubility of one liquid in another, two additional terms are sometimes used:
 - 1. Immiscible** liquids are insoluble in each other. Oil and water is a typical example.
 - 2. Miscible** liquids form one homogeneous liquid phase regardless of the amount of either component present. A good example is methanol in water.

A color change occurs:

- Every compound absorbs a characteristic set of colors of light. This absorption spectrum is a chemical fingerprint for detecting the presence of that compound. When the compound is altered in a chemical reaction, the fingerprint will change—and so the color of the reacting mixture may change, as the reaction progresses.

The temperature changes:

- It takes energy to break chemical bonds.
- And energy is released when new chemical bonds form.
- When the reaction involves more bond-breaking than bond making, the energy required is often absorbed from the surroundings, making them cooler. (**ENDOTHERMIC**)
- When there is more bond-making than bond-breaking, the excess energy is released, making the surroundings hotter. (**EXOTHERMIC**)

Light is emitted:

- Sometimes energy is released by bond-forming reactions in the form of light. This occurs in most combustion reactions.
- Living things that glow in the dark- such as fireflies, fungi, and deep sea creatures- produce light without heat, using chemical reactions.

A change in volume occurs.

- Density is a characteristic of a compound.
- If new compounds are produced as other compounds are consumed in the reaction, the change in density can cause the reacting mixture to expand or contract as the reaction proceeds. Sometimes this volume change can be large and very rapid- and an explosion occurs.

A change in electrical conductivity occurs.

- Some reactions produce or consume ions (charged particles) in a solution. Changes in the character and concentrations of the ions will cause the reacting mixture's ability to conduct electricity to change.

A change in melting point or boiling point occurs.

- The melting or boiling point is characteristic of a compound; when the composition of a mixture changes, the melting point and boiling point also change.

Summary: Observing Chemical Reactions

1. Precipitate Forms
2. Gas Formation
3. Color change
4. Change in density
5. Electrical Conductivity is altered
6. Different melting/boiling point
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Part B: Solubility, Temperature and Crystallization

- Physical Properties
 - Color
 - Melting Point / Boiling Point
 - Density
 - Solubility
 - (Properties that do not change the compound or element)

Molarity

- The molarity is equal to the number of moles of solute divided by the volume of the solution measured in liters.
- What is the molarity of a solution containing 0.32 moles of NaCl in 3.4 liters?

Example

- What is the molarity of a solution made by dissolving 2.5 g of NaCl in enough water to make 125 ml of solution?

Solubility

- Substances that are solids at room temperature and pressure tend to become more soluble when the temperature rises.
- Heating a solution of a solid makes it easier for the particles of solid to move between the solution and the solid phase. The Second Law predicts that they will shift to the more disordered, more highly dispersed, and therefore, more probably solution state.

Crystal Shapes

- Needles
- Cubes
- Plates
- Prisms
- Hexagons

Note what the crystals look like at different temperatures.

Note

To avoid congestion at different reactions, you do not have to do the reactions in the order that they are given.

Part B can be completed before Part A.