Chapter 7 – Chemical Equations

- Chemical and Physical Reactions
- Chemical Equations
- Precipitation Reactions
- Acid/Base Reactions
- Redox Reactions (Combustion Reactions)
- Classifying Chemical Reactions by What They Do

Physical and Chemical Reactions

Physical Reaction: A change in the appearance of matter.

- Phase changes
 - Solid → Liquid Melting
 - Liquid → Solid Freezing
 - Liquid → Gas Vaporization
 - \circ Gas \rightarrow Liquid Condensation
 - Solid → Gas Sublimation
 - \circ Gas \rightarrow Solid Deposition
- Dissolving
- Rearranging (tearing, crumpling, ...)

Physical and Chemical Reactions

Chemical Reaction: The conversion of one or more substances into different substances.

Evidence of a Chemical Reaction

- The formation of a gas (when no heat is added)
- The formation of a solid
- Emission of light
- A temperature changes without supplying heat
- A color change
- a new odor is produced

Chemical Equations

Hints for Balancing Chemical Equations

• If an element occurs in only one compound on both sides of the equation, balance it first

Note: If there are more than one such element balance metals before nonmetals

• If an element occurs as a free element on either side of the chemical equation, balance it last

Chemical Equations

When aluminum is melted and heated with solid barium oxide, a vigorous reaction takes place, and elemental molten barium and solid aluminum oxide are formed. Write the balanced chemical equation for the reaction

Precipitation Reactions

Soluble Substance: A substance that dissolves to a significant extent in a specified solvent

Note: If no solvent is mentioned, the solvent is assumed to be water

Insoluble Substance: A substance that does not dissolve significantly in a specified substance

Note: A substance is considered insoluble if they do not dissolve to more than $\sim 0.1 \text{ M}$

Precipitation Reactions

Electrolyte: A substance that, in solution, is present as ions

Example: Ionic solids that are soluble in water and acids

Ionic solutions conduct electricity

Nonelectrolyte: A substance that does not form ions in solution

Example: Molecular compounds that are not acids

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Precipitation Reactions

| TABLE 7.2 Solubility Rules | | | |
|---|--|--|--|
| Compounds Containing the Following Ions Are Mostly Soluble | Exceptions | | |
| $Li^{+}, Na^{+}, K^{+}, NH_{4}^{+}$ | None | | |
| $NO_3^-, C_2H_3O_2^-$ | None | | |
| Cl ⁻ , Br ⁻ , I ⁻ | When any of these ions pairs with Ag^+ , Hg_2^{2+} , or Pb^{2+} , the compound is insoluble. | | |
| SO ₄ ²⁻ | When SO_4^{2-} pairs with Sr^{2+} , Ba^{2+} , Pb^{2+} , or Ca^{2+} , the compound is insoluble. | | |
| Compounds Containing the Following Ions Are Mostly Insoluble | Exceptions | | |
| OH ⁻ , S ²⁻ | When either of these ions pairs with Li^+ , Na^+ , K^+ , or NH_4^+ , the compound is soluble. | | |
| | When S^{2-} pairs with Ca^{2+} , Sr^{2+} , or Ba^{2+} , the compound is soluble. | | |
| | When OH ⁻ pairs with Ca ²⁺ , Sr ²⁺ , or Ba ²⁺ , the compound is slightly soluble.* | | |
| CO ₃ ²⁻ , PO ₄ ³⁻ | When either of these ions pairs with Li^+ , Na^+ , K^+ , or NH_4^+ , the compound is soluble. | | |

TABLE 7.2 Solubility Rules

*For many purposes these can be considered insoluble.

Precipitation Reactions

Step 1:

Determine if a chemical reaction takes place and write a balanced chemical reaction

Note: If no reaction takes place stop here.

Step 2:

Write the complete ion equation (shows all ions separately) **Step 3:**

Determine the Spectator ions (ions that do not participate in the reaction)

Step 4:

Write the net ionic equation (only species that participate in the reaction)

Precipitation Reactions

Applications of Precipitation Reactions

Make Compounds: Choose starting solutions that form a precipitate of the desired insoluble compound when they are mixed

Qualitative Analysis: Determine substances present in a sample.

Note: The formation of a precipitate is used to confirm the identity of certain ions

Quantitative Analysis: Determine the amount of each substance or element present

Note: This can be done by gravimetric analysis [the amount of substance present is determined by measurements of mass (i.e. measure the amount of precipitate)]

Acid/Base Reactions

Early Chemists' Definitions of Acids and Bases

Acids: A substance that has a sharp or sour taste

Example: Vinegars (contains acetic acid CH₃COOH)

Bases: A substance that had a soapy feeling

Note: Needed less hazardous ways of classifying acids and bases.

Acid/Base Reactions

Arrhenius Acids and Bases (1884)

Acid: A compound that contains hydrogen and reacts with water to form hydrogen ions

Example: HCl (acid) CH₄ (not an acid because it does not release H atoms in solution)

Base: A compound that produces hydroxide (OH⁻) ions in water

Example: NaOH (base)

Acid/Base Reactions

TABLE 7.3 Some Common Acids and Bases

| Acid | Formula | Base | Formula |
|-------------------|-------------------|---------------------|---------------------|
| hydrochloric acid | HCl | sodium hydroxide | NaOH |
| hydrobromic acid | HBr | lithium hydroxide | LiOH |
| nitric acid | HNO ₃ | potassium hydroxide | КОН |
| sulfuric acid | H_2SO_4 | calcium hydroxide | Ca(OH) ₂ |
| perchloric acid | HClO ₄ | barium hydroxide | Ba(OH) ₂ |
| acetic acid | $HC_2H_3O_2$ | | |

Redox Reactions

Oxidization Reduction Reactions

(Redox Reactions): Involves the transfer of electrons

Redox Reactions

Combustion: A reaction between a substance and O_2 Synthesis: A + B \rightarrow AB Decomposition: AB \rightarrow A + B

Note: A and B are a metal and a nonmetal.

Oxidation: A reaction in which an atom, ion, or molecule loses an electron

Reduction: A reaction in which an atom, ion, or molecule gains an electron

Summary

Precipitation Reaction

2 aqueous reactants form a solid product Acid/Base Reaction

2 aqueous reactants 1 with H^+ ion and 1 with OH^- ion form H_2O and a salt (ionic compound)

Redox reaction

Reactants or products are either O_2 or a metal and a nonmetal. Electrons are transferred during the reaction