

Chapter 5

Writing Balanced Chemical Equations Predicting Products of a Chemical Reaction.

Chemical Equations:

Evidence for a chemical reaction

Parts of a chemical equation: Reactants \rightarrow Products (\rightarrow , yields or produces. Catalyst on arrow)

Law of Conservation of mass: *Atoms are neither created nor destroyed*, only rearranged. Balance of atoms.

Ex. 3.0 g of Na + 2.1 g S = 5.1 g of Na₂S

*Phase Notation: solid (s), if product (\downarrow), (ppt.), precipitate

Liquid (l)

Gas (g), if product (\uparrow)

Dissolved in water (aq), aqueous

*Write one phase for each pure substance. Do not indicate it for each element in a compound

Endothermic (+ ΔH , heat is a reactant) and exothermic (- ΔH , heat is a product).

Coefficients used to balance atoms. Ex. "3 Al₂(SO₄)₃ bookkeeping

Example: Photosynthesis $6 \text{CO}_2(\text{g}) + 6 \text{O}_2(\text{g}) \text{-----} > \text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6 \text{H}_2\text{O}(\text{l})$

Show balance of reactants and product atoms as a bookkeeping table

Assignment: Write a balanced equation and structural (show atoms with balls) diagram equations for:

a.) 3 Cl₂, 2 Fe, 5 H₂O

b.) nitrogen and hydrogen make ammonia **Ex. on display screen**

c.) zinc and hydrochloric acid produces hydrogen gas and zinc chloride

d.) carbon reacts with oxygen to produce carbon dioxide

e.) sodium chloride is broken down into its elements

Guidelines for Balancing Chemical Equations by Inspection (Trial and Error):

1. Identify the reactants and products and write their correct chemical formulas. Write the unbalanced equation.
2. Balance most complex atoms first. Use coefficients only. Never change a formula's subscripts
3. Balance the polyatomic ions if they appear on both the reactant and product side.
4. Complete balancing of all other atoms. Usually H and O can be done last. They seem to balance themselves.
5. Reduce coefficients to simplest whole numbers

Describing Reactions and Predicting the Products of Chemical Reactions

5 Major Types of Chemical Reactions and Evidence of a Reaction:

1. Double Displacement Reactions (Metathesis): Chapter 7

2 compounds react by switching ions. Ionic charges do not change.

In general: $\text{AB} + \text{CD} \rightarrow \text{AD} + \text{BC}$

3 Types of evidence: Formation of a solid precipitate, Neutralization produces water, formation of a gas.

Prelude: Anionic salt, when placed in water, dissociates "breaks up" into ions. A positive cation and a negative anion. Ex's.

$\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^-$

$\text{K}_2\text{SO}_4 \rightarrow 2\text{K}^+ + \text{SO}_4^{2-}$

$\text{AlCl}_3 \rightarrow \text{Al}^{3+} + 3 \text{Cl}^-$

A. Precipitation Reaction: formation of a solid precipitate:

Introductory Discussion: (listen, don't worry about note taking.)

Pure water does not conduct an electric current. A *non-electrolyte*. **Demonstrate with conductivity apparatus.** When ionic substances are placed in water they dissociate and as free ions would conduct an electric current, *electrolytes*. Most ionic materials only contain two types of ions. **Ex. When ions of AgNO₃ are placed in solution they appear as (Ag⁺ and NO₃⁻). In a separate beaker ions of NaCl appear as Na⁺ and Cl⁻. If these 4 ions are mixed a solid precipitate is formed. What possible identity could the**

solid have? Rationalize with possibilities. Introduce Solubility Rules (P.183, Table 7.1 and back cover of textbook). Discuss **solubility rules handout** to distinguish soluble (disappears) Vs, Insoluble (remains undissolved) salts.

Write balanced equation with phase notation for reaction of silver nitrate and sodium chloride.

B. Neutralization Reaction: Formation of water

Acids and bases neutralize to form salt and water. Acid + Base → Ionic Salt and Water

Both are electrolytes. Net ionic: $H^+ + OH^- \rightarrow H_2O$

| | Acids | Bases |
|-----------|--|--|
| Taste | Sour | Bitter |
| Arrhenius | Produces H^+ (proton) in solution | Produces OH^- (hydroxide ions) in solution |
| Ex. | HCl, HNO_3 , H_2SO_4 , see ion sheet | NaOH, KOH, NH_3 , $Ba(OH)_2$ |
| Litmus | Red | Blue |
| pH | Below 7 | Above 7 |

Ex. Reaction of hydrochloric acid and potassium hydroxide, with phase notation

Ex. Reaction of sulfuric acid and sodium hydroxide, with phase notation

C. Formation of a gas.. Gas escapes as bubbles

Ex. Decomposition of carbonates: $PbCO_{3(s)} \rightarrow PbO_{(s)} + CO_{2(g)}$

Ex. “Volcano”; $HC_2H_3O_{2(aq)} + NaHCO_{3(s)} \rightarrow NaC_2H_3O_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

Describing Reactions and Predicting the Products of Chemical Reactions

Major Types of Chemical Reactions and Evidence of a Reaction:

B. Oxidation-Reduction Reactions (Transfer of electrons. Oxidation numbers change) Chapter 8

- Recall that metals lose e^- (cation) and non-metals gain e^- (anion).
- “OIL” “RIG”
- Thermite
- Clues; Metal and Non-metal to produce an ionic compound, rusting, fuel burning, thermite!
- Review of periodic table: major trends of ions

| Column I | Column II | Column III | Column VI | Column VII |
|-----------------|------------------|------------------|------------------|-----------------|
| Lose 1 electron | Lose 2 electrons | Lose 3 electrons | Gain 2 electrons | Gain 1 electron |
| +1 cation | +2 cation | +3 cation | -2 anion | -1 anion |
| | | | | |

2. **Synthesis (Combination):** 2 pure elements or small compounds that create a larger compound on the product side.
Ex. $2 Na_{(s)} + Cl_{2(g)} \rightarrow 2 NaCl_{(s)}$, Uncharged neutral atoms develop a charge in compound.
Demo: Write for burning of magnesium ribbon with phase notation: $Mg_{(s)} + O_{2(g)} \rightarrow MgO_{(s)}$
3. **Decomposition (Analysis):** A compound (never an element) is broken down into simpler substances, usually accomplished with heat or electric current.
Ex. $2 HgO_{(s)} \rightarrow 2 Hg_{(l)} + O_{2(g)}$
Demo: Write for decomposition by heating of $KClO_3$. $2 KClO_{3(s)} \rightarrow 2 KCl_{(s)} + 3 O_{2(g)}$
4. **Combustion:** Involve oxygen and produce heat so rapidly that a flame results.
Ex. $CH_{4(g)} + 2 O_{2(g)} \rightarrow CO_{2(g)} + 2 H_2O_{(g)}$
Demo: Gummy Bear into the hot KCl / O_2 from decomposition.
 $C_6H_{12}O_{6(s)} + 6 O_{2(g)} \rightarrow 6 CO_{2(g)} + 6 H_2O_{(g)}$
5. **Single Displacement Reaction:** Element and compound combine. The element replaces the similar type of ion in the compound. $A + BC \rightarrow AC + B$, A and B are metals.

Activity Series

Ex. $Zn_{(s)} + 2 HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$ With metal element as reactant

Ex. $F_{2(g)} + KCl_{(aq)} \rightarrow KF_{(aq)} + Cl_{2(g)}$ With non-metal element as reactant

Demo: Write for Cu wire in solution of silver nitrate. $Cu_{(s)} + AgNO_{3(aq)} \rightarrow Cu(NO_3)_2 + Ag_{(s)}$