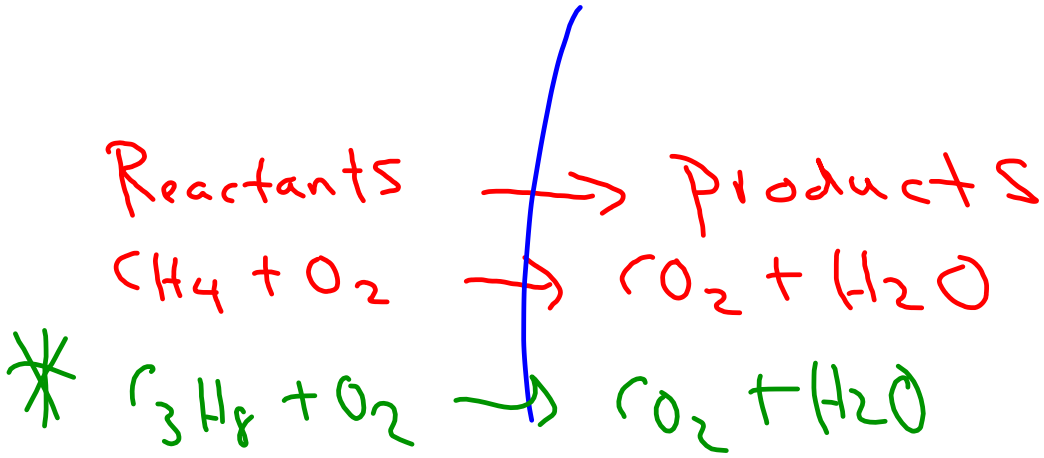
CHEMICAL EQUATIONS

- These show the rearrangement of atoms and/or ions that takes place as a result of a chemical change of reactants into products.
- Chemical equations are a shorthand method of representing what experimental evidence indicates happens in a chemical reaction.



BALANCING CHEMICAL EQUATIONS

Balancing chemical equations involves using experimental evidence from chemical reactions. The experimental evidence indicates that:

- Atoms are conserved
- Mass is conserved
- Energy is conserved

A chemical equation must:

- Represent the correct chemical formula and state for each reactant and product
- Show that atoms or ions are conserved:
- Total # of each kind of atom/ion in reactants = total # of each kind of atom/ion in products

General Steps:

1. Balance atoms by using *coefficients* (in front of chemical formulas) to indicate the number of formula units or molecules of each reactant and product required.
2. Generally, begin by balancing the atom of which there is the greatest number. Find the lowest common multiple of the number of reactant and product atoms.
3. Continue progressively to balance the rest of the atoms.

Example: Copper metal reacts with silver nitrate solution to produce silver and aqueous copper (II) nitrate.

solid → liquid → gas

Note: Subscripts (s), (l) and (g) are used to indicate solid, liquid or gas and (aq) indicates an aqueous solution (in water).

(aq) → a substance dissolve in water.

Step 1: Write the word equation

Copper metal + silver nitrate → silver + copper (II) nitrate

Step 2: Write the chemical formulas

Step 3: Count atoms of each type for reactants and products.

1 Cu 1 Cu
1 Ag 1 Ag
1 NO_3 2 NO_3

Note that NO_3 is treated as one complex ion.

Step 4: Balance the equation.

$Cu_{(s)} + 2AgNO_{3(aq)} \rightarrow 2Ag_{(s)} + Cu(NO_3)_{2(aq)}$

Note that balancing the nitrate ion affects the silver which must also be balanced.

Examples:

1. $2\ Mg_{(s)} + 1\ O_{2(g)} \rightarrow 2\ MgO_{(s)}$

2. $1\ Cu_{(s)} + 2\ AgNO_{3(aq)} \rightarrow 2\ Ag_{(s)} + 1\ Cu(NO_3)_{2(aq)}$

3. $1\ Pb(NO_3)_{2(aq)} + 2\ KI_{(aq)} \rightarrow 1\ PbI_{2(s)} + 2\ KNO_{3(aq)}$

4. $2\ NH_{3(g)} \rightarrow 1\ N_{2(g)} + 3\ H_{2(g)}$

5. $1\ CH_{4(g)} + 2\ O_{2(g)} \rightarrow 1\ CO_{2(g)} + 2\ H_2O_{(g)}$

Examples: Balance the following equations:

6. $4\ Fe_{(s)} + 3\ O_{2(g)} \rightarrow 2\ Fe_2O_{3(s)}$

7. $2\ Na_{(s)} + 1\ Cl_{2(g)} \rightarrow 2\ NaCl_{(s)}$

8. $2\ AsCl_{3(aq)} + 3\ H_2S_{(aq)} \rightarrow 1\ As_2S_{3(s)} + 6\ HCl_{(aq)}$

9. $1\ H_2SO_{4(aq)} + 2\ NaHCO_{3(s)} \rightarrow 1\ Na_2SO_{4(aq)} + 2\ CO_{2(g)} + 2\ H_2O_{(l)}$

10. $1\ C_3H_{8(g)} + 5\ O_{2(g)} \rightarrow 3\ CO_{2(g)} + 4\ H_2O_{(g)}$

WRITING BALANCED CHEMICAL EQUATIONS

To write a balanced chemical equation from a statement or word equation:

E = Element

- write the chemical formulas for all reactants and products involved (including states)

C = Compound

- Follow the steps outlined above for balancing equations

Types of RXN

E + E → C Formation

C → E + E, etc decomp

E + C → E + C Single displacement

C + C → C + C Double displacement

$C_xH_y + O_2 \Rightarrow CO_2 + H_2O$ combustion

Examples

Translate each of the following statements into word equations, then balanced chemical equations. Remember that ***The "HONorable Halogens" are all diatomic.*** $H_2, O_2, N_2, Cl_2, F_2, Br_2, I_2$

1. Hydrogen and chlorine react to produce hydrochloric gas.

Word Equation: Hydrogen + chlorine → hydrochloric acid

Chemical Equation: $H_{2(g)} + Cl_{2(g)} \rightarrow 2HCl_{(g)}$

2. Solid potassium and aqueous magnesium chloride react to produce solid magnesium and aqueous potassium chloride.

Word Equation: potassium + magnesium chloride → magnesium + potassium chloride

Chemical Equation:

$K_{(s)} + Mg^{2+}Cl^- \rightarrow Mg_{(s)} + K^+Cl^-$

$2K_{(s)} + MgCl_{2(aq)} \rightarrow Mg_{(s)} + 2KCl_{(aq)}$

3. Solid aluminum combines with oxygen gas to produce solid aluminum oxide.

Word Equation:

Aluminum + oxygen → Aluminum oxide

$Al^{3+}O^{2-}$

Chemical Equation:

$4Al_{(s)} + 3O_{2(g)} \rightarrow 2Al_2O_{3(s)}$

molten (l)

4. Hydrogen peroxide decomposes (breaks down) into water and oxygen gas.

Word Equation: Hydrogen peroxide → water + oxygen

Chemical Equation:

$2H_2O_{2(l)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$

4-H 2-O 2-O 4-H 4-O

5. Zinc reacts with hydrochloric acid to produce zinc chloride solution and hydrogen gas.

Word. Equation: zinc + hydrochloric → zinc chloride + hydrogen

Chemical Equation:

$Zn^{2+}Cl^-$

$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$

6. The combustion (burning) of ethyne gas, $C_2H_{2(g)}$ in the presence of oxyge gas produces carbon dioxide gas and water vapor.

Word Equation: ethyne + oxygen → carbon dioxide + water

Chemical Equation:

$2C_2H_{2(g)} + 5O_{2(g)} \rightarrow 4CO_{2(g)} + 2H_2O_{(g)}$

8 - 0 2 - 0

10 - 0

Types of RXN E → Element. C → Compound

1) Formation
E + E → C

2) Decomposition
C → E + E, etc

3) Single Replacement
E + C → E + C
different

4) Double Replacement
C + C → C + C
different

5) combustion
$C_xH_y + O_2 \rightarrow CO_2 + H_2O$
different number
never change

Incomplete combustion
$C_xH_y + O_2 \rightarrow C + CO + CO_2 + H_2O$
never change