Chemical Reactions: An Introduction

Objectives

- Learn the signals that show a chemical reaction has occurred.
- Learn to identify the characteristics of a chemical reaction and the information given by a chemical reaction.
- Learn to write a balanced equation for a chemical reaction.

Section 7.1: *Evidence for a Chemical Reaction*

TABLE 7.1

Some Clues That a Chemical Reaction Has Occurred

1. The color changes.
2. A solid forms.
3. Bubbles form.
4. Heat and/or a flame is produced, or heat is absorbed.

Section 7.2: Chemical Equations

All chemical reactions have two parts:

1) *Reactants* - the substances you start with (analogous to the ingredients needed to bake a cake).
2) *Products* - the substances you end up with (the cake).

- The reactants turn into the products.
- Reactants → Products

Section 7.2: Chemical Equations

- In a chemical reaction:
  - The way atoms are joined is changed.
  - Atoms aren't created or destroyed.
  - Can be described several ways.
- In a sentence:
  - Copper reacts with chlorine to form copper (II) chloride.
- In a word equation:
  - copper + chlorine → copper (II) chloride

In a chemical equation:

- $Cu^{2+} + Cl^{-} \longrightarrow CuCl_2$

Chemical Equations

Symbols used in equations:

- The arrow (→) separates the reactants from the products.
  - Read as "reacts to form"
- The plus sign is read as "and"
- (s) after the chemical formula - solid
- (g) after the chemical formula - gas
- (l) after the chemical formula – liquid
- (aq) after the chemical formula - dissolved in water, an *aq*ueous solution.

Chemical Equations

- More symbols used in equations:

  ↑ may be used after a product to indicate a gas (same as (g)).

  ↓ may be used after a product to indicate a solid (same as (s)).

Chemical Equations

Still more symbols used in equations:

-  indicates a reversible reaction (more on that later).
-  shows that heat is supplied to the reaction.
-  is used to indicate a catalyst used supplied, in this case, platinum.

What is a catalyst?

- A substance that speeds up a reaction without being changed by the reaction.
- Enzymes are biological or protein catalysts.

Chemical Equations

- Convert these to equations

1) Solid iron (III) sulfide reacts with gaseous hydrogen chloride to form iron (II) chloride solid and hydrogen sulfide gas.
2) Nitric acid dissolved in water reacts with solid sodium carbonate to form liquid water and carbon dioxide gas and sodium nitrate dissolved in water.

Chemical Equations

Now try the other way, put into words:

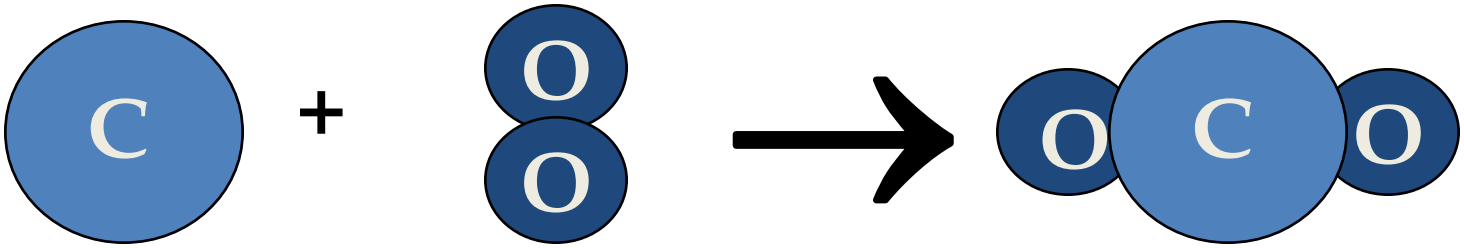
1) $Fe_{(g)} + O_{2(g)} \rightarrow Fe_2O_{3(s)}$
2) $Cu_{(s)} + AgNO_{3(aq)} \longrightarrow Ag_{(s)} + Cu(NO_3)_{2(aq)}$
3) $NO_{2(g)} \rightarrow N_{2(g)} + O_{2(g)}$

Section 7.3: Balancing Chemical Equations

Balanced Equations:

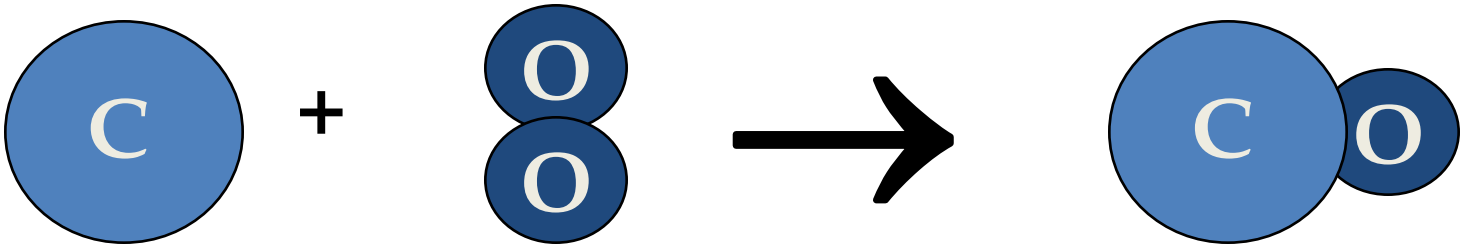
- Atoms can't be created or destroyed.
- All the atoms we start with, we must end up with.
- A balanced equation has the same number of each element on both sides of the equation.

Balancing Chemical Equations



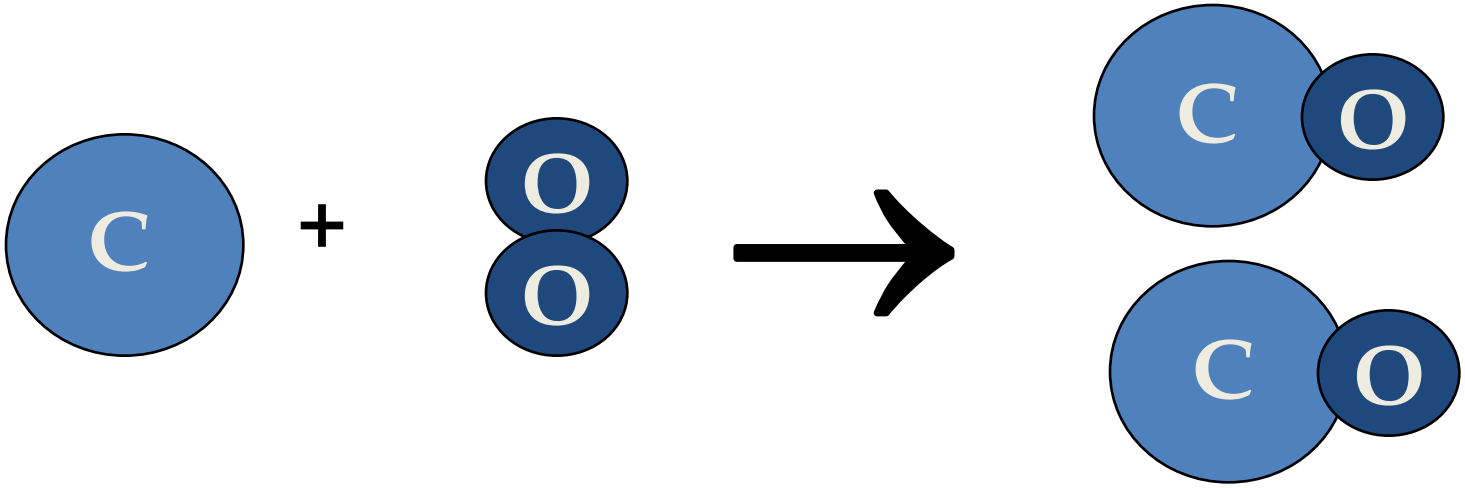
- $C + O_2 \rightarrow CO_2$
- This equation is already balanced
- What if it isn't already?

Balancing Chemical Equations



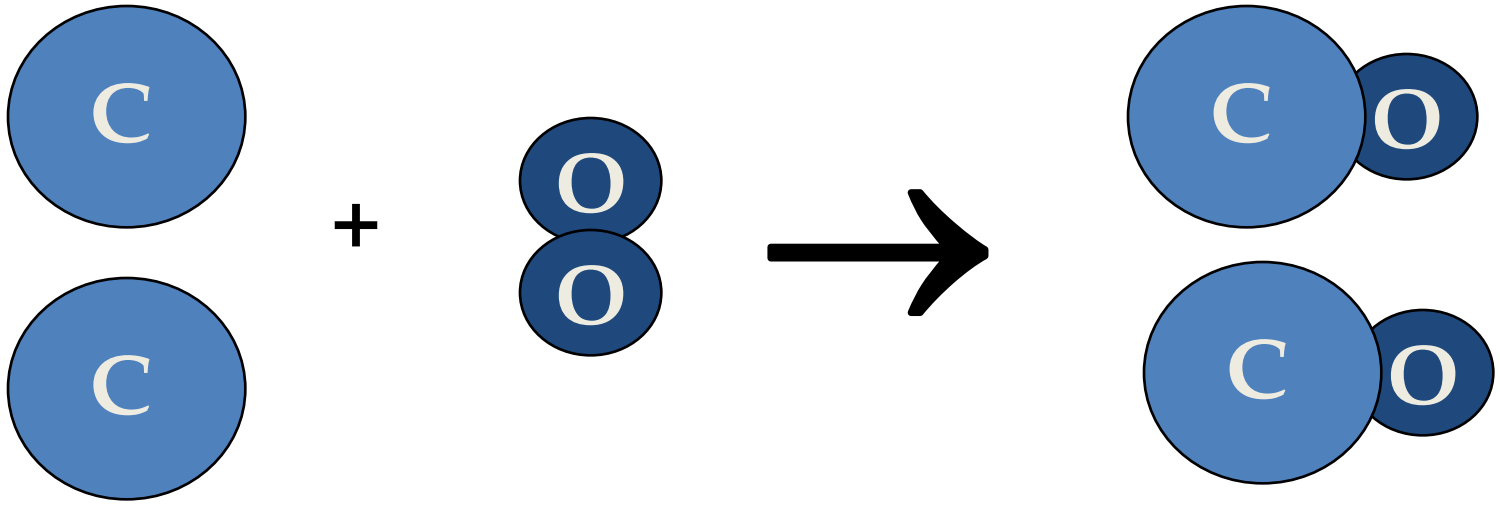
- $C + O_2 \rightarrow CO$
  - Reactants = 1 carbon atom + 2 oxygens
  - Products = 1 carbon atom + 1 oxygen
- We need one more oxygen in the products.
- Can't change the formula, because it describes what the compound is.

Balancing Chemical Equations



- Must be used to make another *CO*
- But where did the other *C* come from?

Balancing Chemical Equations



- Must have started with two C
- $2\ C + O_2 \rightarrow 2\ CO$

Balancing Chemical Equations

Rules for balancing:

1. Write the unbalanced equation; the correct formulas for all the reactants and products (know the diatomic gases).
2. Count the number of atoms of each type appearing on both sides.
3. Balance the elements one at a time by adding coefficients (Hint: start with the most complicated molecule).
4. Check to make sure it is balanced. Be sure to indicate states.

Balancing Chemical Equations

Never:

- Change a subscript to balance an equation.
- If you change the formula you are describing a different reaction.
- H_2O is a different compound than H_2O_2
- Never put a coefficient in the middle of a formula
- 2 NaCl is okay, Na2Cl is not.

Example

$$H_2 + O_2 \rightarrow H_2O$$

Make a table to keep track of where you are at

Example

$$H_2 + O_2 \rightarrow H_2O$$

R		P
2	H	2
2	O	1

Need twice as much O in the product

Example

$$H_2 + O_2 \rightarrow 2\,H_2O$$

R		P
2	H	2
2	O	1

Changes the *O*

Example

$$H_2 + O_2 \rightarrow 2\,H_2O$$

	R		P
2	H	2	
2	O	~~1~~	2

Also changes the H

Example

$$H_2 + O_2 \rightarrow 2\,H_2O$$

	R		P
2	H	~~2~~	4
2	O	~~1~~	2

Need twice as much H in the reactant

Example

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

	R		P	
2	H	~~2~~		4
2	O	~~1~~		2

Recount

Example

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

R		P	
4	H	4	
2	O	2	

The equation is balanced, has the same number of each kind of atom on both sides

~~Example~~

$$2\,H_2 + O_2 \rightarrow 2\,H_2O$$

	R		P
4	~~2~~	H	~~2~~ 4
2		O	~~1~~ 2

This is the answer

Not this

Examples

- $Na_{(s)} + H_2O_{(l)} \rightarrow H_{2(g)} + NaOH_{(aq)}$
- $AgNO_{3(aq)} + Cu_{(s)} \rightarrow Cu(NO_3)_{2(aq)} + Ag_{(s)}$
- $Fe_2O_{3(s)} + HNO_{3(aq)} \rightarrow Fe(NO_3)_{3(aq)} + H_2O_{(l)}$

Examples

- $Li_{(s)} + Cl_{2(g)} \rightarrow LiCl_{(s)}$
- $NO_{(g)} + H_{2(g)} \rightarrow N_{2(g)} + H_2O_{(l)}$
- $Mg_{(s)} + N_{2(g)} \rightarrow Mg_3N_{2(s)}$
- $P_{(s)} + O_{2(g)} \rightarrow P_4O_{10(s)}$
- $Na_{(s)} + H_2O_{(l)} \rightarrow H_{2(g)} + NaOH_{(aq)}$
- $CH_{4(g)} + O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(l)}$
- $B_2O_{3(s)} + H_2O_{(l)} \rightarrow B(OH)_{3(aq)}$
- $AgNO_{3(aq)} + Cu_{(s)} \rightarrow Cu(NO_3)_{2(aq)} + Ag_{(s)}$
- $Fe_2O_{3(s)} + HNO_{3(aq)} \rightarrow Fe(NO_3)_{3(aq)} + H_2O_{(l)}$