Cp Chemistry C **Need to know Chapter 6 Chemical Reactions** Jaeger

Name _____ **Date** _____ **Period** _____

Objectives
Write balanced chemical equations and identify types of chemical reaction

Conservation of Matter

(recall from chapter2) Atoms are neither created nor destroyed, just rearranged
As reactants turn into products, bonds, holding atoms together, are broken and new bonds are formed.

Chemical Equations

In writing reactions, separate the reactants from the products by writing and arrow ($\rightarrow$), which means "yields, gives, reacts to, or produces" In a "word equation" words are used to describe all the reactants and products.

Better than word equations are **chemical equations,** using symbols instead of words. The following example is a "skeleton equation," which only shows the types of reactants and products, not how many are needed. It is not "balanced."

Example: Reactants $\rightarrow$ Products

Iron + oxygen $\rightarrow$ iron (III) oxide **Word Equation**

Chemical equation $Fe + O_2 \rightarrow Fe_2O_3$ **Skeleton Equation** (unbalanced equation)

$\mathbf{4}\ Fe + \mathbf{3}\ O_2 \rightarrow \mathbf{2}\ Fe_2O_3$ **Balanced Equation**

Symbol Used in Chemical Equations

Symbol	Explanation
+	Used to separate two reactants or two products
$\longrightarrow$	"Yields," separates reactants from products
$\rightleftharpoons$	Used in place of $\longrightarrow$ for reversible reactions
(*s*)	Designates a reactant or product in the solid state; placed after the formula
(*l*)	Designates a reactant or product in the liquid state; placed after the formula
(*g*)	Designates a reactant or product in the gaseous state; placed after the formula
(*aq*)	Designates an aqueous solution; the substance is dissolved in water; placed after the formula
$\xrightarrow{\Delta}$ $\xrightarrow{heat}$	Indicates that heat is supplied to the reaction
* $\xrightarrow{Pt}$	A formula written above or below the yield sign indicates its use as a catalyst (in this example, platinum)

*A **catalyst** is a substance that speeds up the rate of a reaction but is not used up in the reaction. Because its neither reactant nor product it is written above the arrow.

Energy

Noticeable amount of energy is often released or absorbed during a chemical reaction and is sometimes written in the equation along with the chemicals.

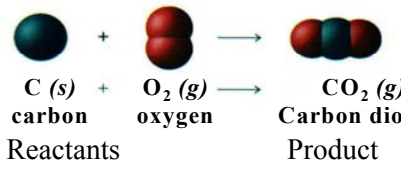
Exothermic: Energy is being released = energy written with the products

$CH_4\ (g) + 2\ O_2\ (g) \dashrightarrow CO_2\ (g) + 2\ H_2O\ (g) + energy$

Endothermic: **E**nergy is being absorbed = energy written with the reactants

$2\ H_2O\ (l) + energy \dashrightarrow 2H_2\ (g) + O_2\ (g)$

Balancing Equations



Balanced equation

2 oxygen	2 oxygen
1 carbon	1 carbon

A balanced equation gives the correct number of each reactant and product.

The number **before** the formula is called a **coefficient**.

Both sides of the equation need to contain the same number of each kind of atom. If there are 2 oxygen atoms on one side, there need to be 2 oxygen atoms on the other side.

Rules for Balancing Equations

1. Make a chart and write down all the elements that you have in your equation.
2. Write down and count the number of atoms of each element in the reactants and products.
3. Balance the elements one at a time by using **coefficients**.

   When no coefficient is written, it is assumed to be 1.

   It is best to begin the balancing operation with elements that appear only once on each side of the equation.

   Don't change the subscripts in a chemical formula and don't write anything inside a formula.
4. Make sure there are equal numbers of each element on both sides of the equation.
5. Finally, make sure all the coefficients are in the lowest possible ratio that balances.

Your Turn

Balance the following equations

a) H_2 *(g)* + O_2 *(g)* $\xrightarrow{Pt}$ H_2O *(l)*

b) Al *(s)* + O_2 *(g)* → Al_2O_3 *(s)*

c) Mg *(s)* + HCl → $MgCl_2$ *(s)* + H_2 *(g)*

d) Carbon and chlorine gas react to carbon tetrachloride.

Types of Chemical Reactions

There are **five basic types** of reactions:
Combination -, Decomposition -, Single-Replacement -, Double-Replacement -, and Combustion Reactions.

1. In a **synthesis reaction**, (or combination reaction) two or more substances combine to form a single substance

A + B + … → AB..

Examples:

Fe *(s)* + S*(s)* → FeS *(s)*	iron (II) sulfide
SO_2 *(g)* + H_2O *(l)* → H_2SO_3 *(aq)*	sulfurous acid
CaO*(s)* + H_2O *(l)* → $Ca(OH)_2$ *(aq)*	calcium hydroxide

Reactants: Generally two elements (or two compounds, where at least one compound is a molecular compound).
Probable Products: A single compound

2. In a **decomposition reaction**, a single compound is broken down into two or more products

AB.. → A + B + ...

Example:
$CaCO_3$ *(s)* → CaO *(s)* + CO2 (*g)* *("opposite of combination reaction)*
Explosion of dynamite is a powerful decomposition reaction

Reactants: Generally a single binary or ternary compound
Probable Products: Two elements (from a binary compound), or two or more elements and/or compounds (for ternary compound).

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3. In a **single-replacement reaction**, one element replaces a second element in a compound

AB + C → CB + A

Example:
Mg *(s)* + 2 $AgNO_3$ *(aq)* → $Mg(NO_3)_2$ *(aq)* + 2 Ag *(s)*

but Mg *(s)* + 2 $LiNO_3$ *(aq)* → no reaction

If one metal will actually displace another metal from a compound, can be determined by the relative reactivity of two metals. The activity series of metals lists metals in order of decreasing reactivity. A nonmetal can also displace another nonmetal (usually halogens) reactivity decreases down group 7A.

** Metals from Li to Na will replace H from acids and water; from Mg to Pb they replace H from acids only*

Reactants: An element and a compound. One element replaces a second element in a compound The element that is displaced must be less reactive than the element that is displacing it.
Probable Products: A different element and a new compound.

Activity Series of Metals

Decreasing reactivity ↓

Name	Symbol
Lithium	Li
Potassium	K
Calcium	Ca
Sodium	Na
Magnesium	Mg
Aluminum	Al
Zinc	Zn
Iron	Fe
Lead	Pb
(Hydrogen)	(H)*
Copper	Cu
Mercury	Hg
Silver	Ag

4. **Double-replacement reactions** involve an exchange of positive ions between two reacting compounds

AB + CD → AD + CB

Examples:

$NaS\ (aq) + Cd(NO_3)_2\ (aq) \rightarrow CdS\ (s) + 2\ NaNO_3\ (aq)$

$NaCN\ (aq) + H_2SO_4\ (aq) \rightarrow 2\ HCN\ (g) + Na_2SO_4\ (aq)$

$Ca(OH)_2\ (aq) + 2HCl\ (aq) \rightarrow CaCl_2\ (aq) + 2\ H_2O\ (l)$

Reactants: Generally a reaction between two ionic compounds.

Probable Products: Two new ionic compounds. Reaction is driven by formation of a precipitate, gaseous product, or water.

5. In a **combustion reaction** an element or compound reacts with oxygen, usually releasing energy in form of heat or light.

$C_xH_y + O_2 \rightarrow CO_2 + H_2O$ (not balanced)

Examples:

$2\ C_2H_6(g) + 7\ O_2(g) \rightarrow 4\ CO_2(g) + 6\ H_2O(g)$

$2\ CH_3OH(l) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 4\ H_2O(g)$

$C\ (s) + O_2\ (g) \rightarrow CO_2(g)$

Reactants: Oxygen and a compound of C, H, (O)

Probable Products: **CO_2** and **H_2O (**complete combustion). Without sufficient oxygen, carbon monoxide and carbon (soot) may also be formed (incomplete combustion).

Remember Chapter 5 Chemical Formulas ???

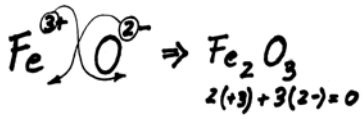
To write equations you must know how to **write formulas of given compound names** and vice versa.

1. Complete the table of ionic charges of elements from different groups of the periodic table

1A	2A	3A	4A	5A	6A	7A	0	B groups
		+3						

Once you know the charges, use the criss-cross method to find the subscripts and check for lowest whole number ratio for ionic compounds. Roman numerals in the name indicate the charge of the cation (metal ion).

Example: Iron (III) oxide



2. What are the formulas for

a) Calcium bromide b) nickel (II) chloride c) sodium sulfide

d) Cobalt (II) iodide e) Lithium nitride f) Potassium oxide

3. The criss-cross method does **not** work for molecular compounds; often there is more than one combination possible when you combine 2 nonmetals. Binary inorganic **molecular** compounds (all nonmetals) have prefixes to indicate the number of atoms of each element. Example: N_2O dinitrogen monoxide.

What is the name of N_2O_3

What is the formula of carbon tetrachloride