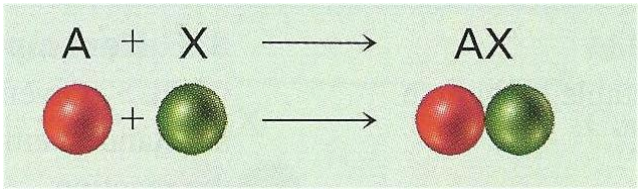
Types of Chemical Reactions

Knowledge of types useful for:
- Predicting products from starting materials
- Estimating starting materials from analyzed products
- Evaluating potential health/safety issues

Focus on type recognition (pattern recognition), NOT individual reactions

Combination or Synthesis Reactions



2 or more substances combine to form 1 single product

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

$Br_2 + PBr_3 \rightarrow PBr_5$

$MgO + CO_2 \rightarrow MgCO_3$

$6\ Li + N_2 \rightarrow 2\ Li_3N$

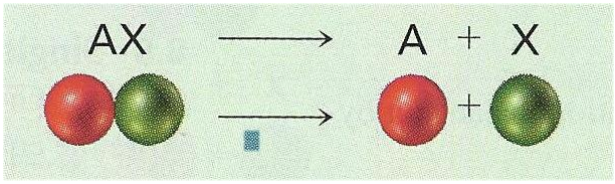
$N_2 + 3\ H_2 \rightarrow 2\ NH_3$

$CaO + H_2O \rightarrow Ca(OH)_2$

$2\ Al + 3\ Br_2 \rightarrow 2\ AlBr_3$

$4\ Fe + 3\ O_2 \rightarrow 2\ Fe_2O_3$

Decomposition Reactions



opposite of combination reaction
1 compound breaks down into simpler substances

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

$CaCO_3 \rightarrow CaO + CO_2$

$PCl_5 \rightarrow PCl_3 + Cl_2$

$2\ HgO \rightarrow 2\ Hg + O_2$

$2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$

$2\ Cl_2O_5 \rightarrow 2\ Cl_2 + 5\ O_2$

$2\ N_2O_5 \rightarrow O_2 + 4\ NO_2$

$2\ NaCl \rightarrow 2\ Na + Cl_2$

Burning or Complete Combustion

$C_xH_yO_z$ + O_2 ➔ CO_2 + H_2O

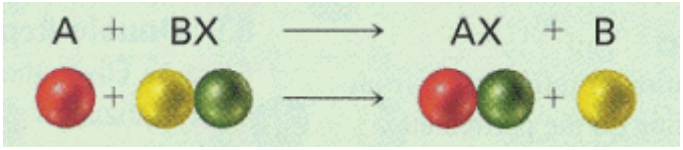
One reactant is organic (contains C & H; sometimes N & O)
Other reactant is always O_2

Products are always CO_2 + H_2O

$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$ (methane)
$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$ (propane)
$C_2H_5OH + 3\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$ (ethanol)
$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ (glucose)

Single Replacement (Displacement)

A + BX ➔ AX + B Or Y + BX ➔ BY + X



One free element replaces another element in a compound
Reactant & product side have different free element

metal replaces another metal

$Cu + 2\ AgNO_3 \rightarrow 2\ Ag + Cu(NO_3)_2$
$Fe + Cu(NO_3)_2 \rightarrow Cu + Fe(NO_3)_2$
$2\ Au(CN)_2\ (aq) + Zn\ (s) \rightarrow 2\ Au\ (s) + Zn(CN)_4\ (aq)$

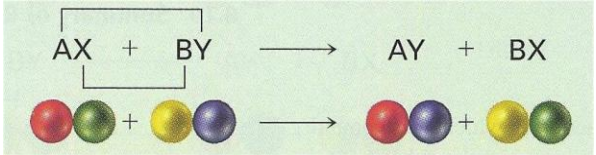
metal replaces hydrogen

$Mg + 2\ HCl \rightarrow MgCl_2 + H_2$
$Zn + 2\ HCl \rightarrow ZnCl_2 + H_2$

nonmetal replaces another nonmetal

$Cl_2 + 2\ NaBr \rightarrow 2\ NaCl + Br_2$
$Br_2 + 2\ KI \rightarrow 2\ KBr + I_2$

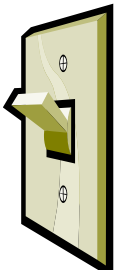
Double Replacement (Displacement) Reactions



(+) and (–) ions switch partners
(keep products electrically balanced)

Precipitation

$AgNO_3$ (aq) + NaCl (aq) ➔ AgCl (s) + $NaNO_3$ (aq)
$AgNO_3$ (aq) + KCl (aq) ➔ AgCl (s) + KNO_3 (aq)
2 $AgNO_3$ (aq) + $CaCl_2$ (aq) ➔ 2 AgCl (s) + $Ca(NO_3)_2$ (aq)
$CaCl_2$ (aq) + K_2SO_4 (aq) ➔ $CaSO_4$ (s) + 2 KCl (aq)
$BaCl_2$ (aq) + Na_2SO_4 (aq) ➔ $BaSO_4$ (s) + 2 KCl (aq)
Na_2CO_3 + $CaCl_2$ ➔ $CaCO_3$ (ppt) + 2 NaCl
$Pb(NO_3)_2$ + 2 KI ➔ PbI_2 + 2 KNO_3



Most double displacements result in precipitation

Neutralization Reactions
H^+ (Acid) combines with OH^- (Base) to form HOH (H_2O)

HCl + NaOH ➔ NaCl + HOH
H_2SO_4 + 2 NaOH ➔ Na_2SO_4 + 2 H_2O
$Ca(OH)_2$ + 2 HNO_3 ➔ $Ca(NO_3)_2$ + 2 H_2O
$Ca(OH)_2$ + H_3PO_4 ➔ $Ca_3(PO_4)_2$ + H_2O
$Co(OH)_3$ + HNO_3 ➔ $Co(NO_3)_3$ + H_2O
$Al(OH)_3$ + $H(C_2H_3O_2)$ ➔ $Al(C_2H_3O_2)_3$ + H_2O

Salt = product of acid & base

Product breakdown to a gas

Na_2CO_3 +2 HCl ➔ NaCl + H_2CO_3 ↘ H_2O + CO_2

Other Common Breakdown Products

H_2SO_3 ➔ H_2O + SO_2
NH_4OH ➔ NH_3 + H_2O

Exercise:

Give the type of reaction for each:

C_2H_5OH (l) + 3 O_2 (g) ➔ 2 CO_2 (g) + 3 H_2O (g)
P_4 (s) + 6 Br_2 (l) ➔ 4 PBr_3 (l)
HNO_3 (aq) + KOH (aq) ➔ H_2O (l) + KNO_3 (aq)
Cd (s) + 2 $AgNO_3$ (aq) ➔ $Cd(NO_3)_2$ (aq) + 2 Ag (s)
$BaCl_2$ (aq) + K_2CrO_4 (aq) ➔ $BaCrO_4$ (s) + 2 KCl (aq)
NH_4Cl (s) ➔ NH_3 (g) + HCl (g)

Give the type of reaction for:

C_2H_5OH (l) + 3 O_2 (g) ➔ 2 CO_2 (g) + 3 H_2O (g)

Characteristics:
Organic + Oxygen Reactants
CO_2 & Water Products

Combustion

Give the type of reaction for:

P_4 (s) + 6 Br_2 (l) ➔ 4 PBr_3 (l)

Characteristics:
2 Reactants
1 Product

Combination

Give the type of reaction for:

HNO_3 (aq) + KOH (aq) ➔ H_2O (l) + KNO_3 (aq)

Characteristics:
Acid & Base Reactants
Water & Salt Product
Ions "switch" Places

Double Displacement
Neutralization

Give the type of reaction for:

Cd (s) + 2 $AgNO_3$ (aq) ➔ $Cd(NO_3)_2$ (aq) + 2 Ag (s)

Characteristics:
Cd, Free element, Replaces Ag
Reactant & Product Side Have Different Free Element

Single Replacement: Metal for Metal

Give the type of reaction for:

$BaCl_2$ (aq) + K_2CrO_4 (aq) ➔ $BaCrO_4$ (s) + 2 KCl (aq)

Characteristics:
Ions switch Places
Precipitate Formed

Double Replacement: Precipitation

Give the type of reaction for:
NH_4Cl (s) ➔ NH_3 (g) + HCl (g)

Characteristics:
1 Reactant
2 Products

Decomposition

Exercise Summary:

C_2H_5OH (l) + 3 O_2 (g) ➔ 2 CO_2 (g) + 3 H_2O (g) (Combustion)

P_4 (s) + 6 Br_2 (l) ➔ 4 PBr_3 (l) (Combination)

HNO_3 (aq) + KOH ➔ H_2O (l) + KNO_3 (aq) (Double Displacement)

Cd (s) + 2 $AgNO_3$ (aq) ➔ $Cd(NO_3)_2$ (aq) + 2 Ag (s) (Single Displacement)

$BaCl_2$ (aq) + K_2CrO_4 (aq) ➔ $BaCrO_4$ (s) + 2 KCl (aq) (Double Displacement)

NH_4Cl (s) ➔ NH_3 (g) + HCl (g) (Decomposition)

Summary of Reaction Types

Combination (Synthesis)
A + X ➔ AX

Decomposition
AX ➔ A + X

Burning or Complete Combustion
$C_xH_yO_z$ + O_2 ➔ CO_2 + H_20

Single Replacement (Displacement)
A + BX ➔ AX + B Or Y + BX ® BY + X

Double Replacement (Displacement)
A^+X^- + B^+Y^- ➔ A^+Y^- + B^+X^-

Neutralization
Acid + Base ➔ Salt + Water

Summary of Types of Reactions and Equations

Reactants	Reaction Type	Equation Type	Products
Any combination of elements and compounds that form one product	Combination	A + X ⟶ AX	One compound
One compound	Decomposition	AX ⟶ A + X	Any combination of elements and compounds
Element + ionic compound or acid	Single-replacement	A + BX ⟶ AX + B	Element + ionic compound
Solutions of two compounds, each with positive and negative ions	Double-replacement	AX + BY ⟶ AY + BX	Two new compounds, which may be a solid, water, an acid, or an aqueous ionic compound

For
A + B ➔ C + D

Best to
Think Patterns
Rather than memorize reactions
(Too many reactions to memorize them all)

Assignment

Start Taking Unit 6 Practice Test
Blackboard only records highest score
Take until multiple 100's have been scored (questions are variable)
(Gives sense of test exam format and content)

The Practice Quiz is very similar to the Unit Exam
Success on Unit exam is directly related to practice exam experiences

At this point:
Elements & polyatomic ions should be memorized