Unit 7 Part 4: Types of Chemical Reactions

1. **Synthesis** Reactions

$A + B \rightarrow AB$

- Also called combination reactions
- Two elements, or compounds combine to make one compound.
- We can predict the product if the reactants are two elements.

Example: 3 Mg (s) + 1 N_2 (g) → 1 Mg_3N_2

Now you try: 4 Al (s) + 3 O_2 (g) → 2 Al_2O_3

2. **Decomposition** Reactions

$AB \rightarrow A + B$

- Decompose = break down
- One compound (reactant) decomposes into two or more elements or compounds.
- Usually requires energy
- We can predict the products if the reactants break apart into two elements.

Example: 2 H_2O (g) → 2 H_2 + O_2

Now you try: 2 NaCl (s) → 2 Na + Cl_2

3. **Single Replacement**

$A + BC \rightarrow AC + B$ (must know this charge)

- Also referred to as single displacement
- One element replaces another
- Reactants must be an element and a compound
- Products will be a different element and a different compound
- We can predict the products if we know the charge on the cation in the compound being formed:

Example: ___ $Cu(NO_3)_2(aq)$ + 2 Ag(s) → Cu + 2 $AgNO_3$

Now you try: ___ Zn(s) + ___ $Pb(Cl)_2(aq)$ → Pb + $ZnCl_2$

Uh Oh! Not every Single Replacement Reaction Occurs!!!!

How to check if a single replacement reaction will occur:

1. Is the single element reactant higher than the corresponding element in the reactant compound?
   - Yes → The reaction occurs!
   - No → No reaction (No rxn)

Activity Series of Metals

Increasing Activity ↑

Metal	Half Reaction	E°_{ox} (V)
Lithium	$Li(s) \rightarrow Li^+(aq) + e^-$	+3.05
Rubidium	$Rb(s) \rightarrow Rb^+(aq) + e^-$	+2.93
Potassium	$K(s) \rightarrow K^+(aq) + e^-$	+2.92
Barium	$Ba(s) \rightarrow Ba^{2+}(aq) + 2e^-$	+2.90
Calcium	$Ca(s) \rightarrow Ca^{2+}(aq) + 2e^-$	+2.87
Sodium	$Na(s) \rightarrow Na^+(aq) + e^-$	+2.71
Magnesium	$Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$	+2.37
Aluminum	$Al(s) \rightarrow Al^{3+}(aq) + 3e^-$	+1.66
Manganese	$Mn(s) \rightarrow Mn^{2+}(aq) + 2e^-$	+1.18
Zinc	$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$	+0.76
Chromium	$Cr(s) \rightarrow Cr^{3+}(aq) + 3e^-$	+0.74
Iron	$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$	+0.44
Cobalt	$Co(s) \rightarrow Co^{2+}(aq) + 2e^-$	+0.28
Nickel	$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^-$	+0.25
Tin	$Sn(s) \rightarrow Sn^{2+}(aq) + 2e^-$	+0.14
Lead	$Pb(s) \rightarrow Pb^{2+}(aq) + 2e^-$	+0.13
(Hydrogen)	$H_2(g) \rightarrow 2H^+(aq) + 2e^-$	0.00
Copper	$Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$	−0.34
Silver	$Ag(s) \rightarrow Ag^+(aq) + e^-$	−0.80
Mercury	$Hg(l) \rightarrow Hg^{2+}(aq) + 2e^-$	−0.85
Platinum	$Pt(s) \rightarrow Pt^{2+}(aq) + 2e^-$	−1.20
Gold	$Au(s) \rightarrow Au^{3+}(aq) + 3e^-$	−1.50

Activity Series of Nonmetals

Increasing Activity ↑

Nonmetal	Half Reaction	E°_{red} (V)
Fluorine	$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87
Chlorine	$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
Bromine	$Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$	+1.07
Iodine	$I_2(s) + 2e^- \rightarrow 2I^-(aq)$	+0.53
(Hydrogen)	$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00

Examples:

1. *Can iron replace manganese in a single replacement reaction?* No *Why/ why not?*
   Iron is lower than activity, so it cannot replace higher activity manganese.
2. *Can bromine replace fluorine in a single replacement reaction?* No *Why/ why not?*
   Bromine is lower in activity.
3. *What do you notice about the location of metals commonly used to make jewelry (such as silver, gold, platinum and copper)? Why would that make sense for metals people wear?*
   Low activity - you don't want your jewelry to always be reacting with everything

Practice Makes Perfect!

Use the appropriate activity series to determine if the following reaction will occur. If the reaction will occur, write the products and balance the equation. If the reaction will not occur, write *No Reaction (NR)*.

1. _____$MgCl_2(aq)$ + _____$Zn(s)$ → NR

2. Solid aluminum is placed in water vapor.

$2Al(s) + 3H_2O(g) \rightarrow 3H_2 + Al_2O_3$

2. _$I_2(g)$ + _____$KF(g)$ → NR

3. Solid magnesium metal is added to aqueous cobalt (II) nitrate.

$Mg_{(s)} + Co(NO_3)_2(aq) \rightarrow Mg(NO_3)_2 + Co$

4. Liquid bromine is added to an aqueous solution of potassium iodide.

$Br_2(\ell) + 2KI(aq) \rightarrow 2KBr + I_2$

4. **Double Replacement**

- Two things replace each other.
- Reactants must be two compounds ~~or~~ ~~_____~~.

AB + CD → AD + CB

- Usually in an aqueous solution
- Two types of DR reactions: precipitate & acid/base
- We can always predict the products of a DR reaction:

Example: ____$Cu(NO_3)_2(aq)$ + ____$Ag_2CO_3(aq)$ → $2AgNO_3 + CuCO_3$

Now you try: ____$Pb(ClO_3)_2(aq)$ + ____$Na_2SO_4(aq)$ → $PbSO_4 + 2NaClO_3$

5. **Combustion**

- A reaction in which a compound (often carbon) reacts with oxygen gas and usually produces carbon dioxide and water vapor.

$CH_4 + O_2 \rightarrow CO_2 + H_2O$

- We can always predict the products of a combustion reaction:

Example: ____$C_6H_{12}(g)$ + 9 $O_2(g)$ → $6CO_2(g) + 6H_2O(g)$

Now you try: 2 $C_8H_{18}(g)$ + 25 $O_2(g)$ → $16CO_2(g) + 18H_2O(g)$

How to recognize each type of reaction

1. Look at the **reactants**:
   - element + element = synthesis
   - compound = decomposition
   - element + compound = single replacement
   - compound + compound = double replacement
   - C_xH_y or $C_xH_yO_z$ + O_2 = combustion
2. Look at the **products**: CO_2 + H_2O = combustion

Practice Makes Perfect!

Directions: Balance the following equations by placing coefficients in the blanks. Classify the reaction.

		Type of Reaction:
1.	___ $Zn(s)$ + 2 $HCl(aq)$ → ___ $ZnCl_2(aq)$ + ___ $H_2(g)$	single replacement
2.	___ $C_3H_8(g)$ + 5 $O_2(g)$ → 3 $CO_2(g)$ + 4 $H_2O(g)$	combustion
3.	2 $KClO_3(s)$ → 2 $KCl(s)$ + 3 $O_2(g)$	decomposition
4.	___ $BaCl_2(aq)$ + 2 $KIO_3(aq)$ → ___ $Ba(IO_3)_2(s)$ + 2 $KCl(aq)$	double replacement
5.	3 $Fe(s)$ + 4 $H_2O(g)$ → ___ $Fe_3O_4(s)$ + 4 $H_2(g)$	single replacement
6.	4 $Fe(s)$ + 3 $O_2(g)$ → 2 $Fe_2O_3(s)$	synthesis
7.	4 $C(s)$ + 6 $H_2(g)$ + ___ $O_2(g)$ → 2 $C_2H_6O(s)$	synthesis
8.	19 $O_2(g)$ + 2 $C_6H_{14}(g)$ → 14 $H_2O(g)$ + 12 $CO_2(g)$	combustion
9.	2 $HNO_3(aq)$ + ___ $Mg(OH)_2(aq)$ → 2 $H_2O(l)$ + ___ $Mg(NO_3)_2(aq)$	double replacement

H(OH)

Practice Predicting Products!

Directions:

1. Determine type: single replacement (SR), double replacement (DR), synthesis (S), decomposition (D), or combustion (C)

2. Predict the products and write the correct chemical formula for each product. (Don't worry about states of matter!)

3. Balance each reaction using the correct coefficients.

Type?

DR 1. $2\ AgNO_3 + \_\_\_\ CaCl_2 \rightarrow 2AgCl + Ca(NO_3)_2$

S 2. $2\ Al + 3\ Cl_2 \rightarrow 2AlCl_3$

C 3. $\_\_\_\ C_2H_4 + 3\ O_2 \rightarrow 2CO_2 + 2H_2O$

SR 4. $\_\_\_\ Ba + \_\_\_\ MgI_2 \rightarrow BaI_2 + Mg$

DR 5. $\_\_\_\ NaOH + \_\_\_\ HCl \rightarrow NaCl + H(OH)$

SR 6. $3\ Na + \_\_\_\ FeBr_3 \rightarrow 3NaBr + Fe$

DR 7. $\_\_\_\ PbSO_4 + 2\ AgNO_3 \rightarrow Pb(NO_3)_2 + Ag_2SO_4$

DR 8. $2\ KMnO_4 + \_\_\_\ ZnCl_2 \rightarrow 2KCl + Zn(MnO_4)_2$

C 9. $7\ O_2 + \_\_\_\ C_5H_{12}O_2 \rightarrow 5CO_2 + 6H_2O$

D 10. $\_\_\_\ H_2O_2 \rightarrow H_2 + O_2$