

Student Edition

# **Chemical Reactions**

OOPS! SOMEHOW WE FIND OURSELVES MAROONED ON A DESERT ISLAND. HOW ARE WE GOING TO SURVIVE? MAYBE WE CAN MAKE SOMETHING USEFUL OUT OF THE MATERIALS AT HAND...



 Reactions Topic#9		

Handouts: SW#1, SW#2, Acid Nomenclature, Activity series

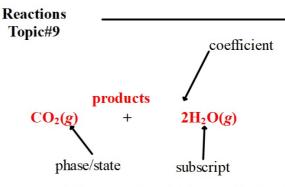
# $\frac{\text{Characteristics}}{\text{Parts of a Chemical Reaction}}$ $\frac{\text{reactants}}{\text{CH}_4(g)} + \frac{2O_2(g)}{\text{CH}_2(g)} \rightarrow$

### **Indicators of a Reaction**

- (1) heat absorbed/lost
- (2) color change
- (3) light
- (4) gas evolved
- (5) formation of a precipitate (solid)

### **Characteristics of a Chemical Reaction**

- (1) The equation must represent known facts.
- (2) Must contain correct formulas for reactants and products.
- (3) Conservation of mass must be obeyed.



# **Elements that Exist as Molecules**

- (1) H<sub>2</sub> (hydrogen)
- (2) N<sub>2</sub> (nitrogen)
- (3) O<sub>2</sub> (oxygen) (O<sub>3</sub> (ozone) (allotrope))
- (4) F<sub>2</sub> (fluorine)
- (5) Cl<sub>2</sub> (chlorine)
- (6) Br<sub>2</sub> (bromine)
- (7) I<sub>2</sub> (iodine)
- (8)  $S_8$  (sulfur)
- (9) P<sub>4</sub> (phosphorus)

Reactions Topic#9

# <u>Characteristics</u> <u>Common Symbols Used in Reactions</u>

- yields
- reversible (equilibrium)  $\leftrightarrow$
- solid (s)
- liquid (l)
- aqueous (solution with water as the solvent) (aq)
- **(g)**
- precipitate is formed (ppt)
- gas is evolved  $\uparrow$
- Δ
- $\rightarrow$  or  $\rightarrow$  heat is added to the reaction
- 2atm
- reactants are under 2 atm pressure
- pressure
  - reactants are under pressure
- 0°C
- temperature at which reaction occurred
- MnO<sub>2</sub>
- reaction is catalyzed (MnO<sub>2</sub> is the catalyst)


# **Characteristics**

Elemental reactants with subscripts and conservation of mass:

Phosphorus reacts with oxygen to produce diphosphorus pentoxides

$$P_{4} + 5O_{2} \longrightarrow 2P_{2}O_{5} \qquad \text{Lcn}(0*y) \text{ is } 10$$

$$P_{4(30.97)} O_{5(2(16))} \qquad 2(141.94)$$

$$123.88g \qquad 160g \qquad ?$$

$$283.88g = 283.88g \qquad \checkmark$$

Assign WS#1
2,
o: ow stick reaming gummi bear (glucose + KClO <sub>3</sub> )
)

	Reaction
Balancing	Topic#9

# Reactions Topic#9 Sample WS#1 - Balancing Chemical Equations

1. Balance the following chemical equations.

a. Fe + 
$$Cl_2 \rightarrow FeCl_3$$

b. 
$$FeBr_3 + H_2SO_4 \rightarrow Fe_2(SO_4)_3 + HBr$$

c. 
$$C_4H_6O_3$$
 +  $H_2O$   $\rightarrow$   $C_2H_4O_2$ 

# Balancing Combustion Reactions

- 1. Balance C
- 2. Balance H
- 3. Balance O
- 4. Remove denominator
- \*\*subscript of C becomes the coefficient of CO<sub>2</sub>, the subscript of H ÷ 2 is the coefficient of H<sub>2</sub>O. The coefficient of O<sub>2</sub> is the sum total of O's ÷ 2

Reactions Topic#9 **Balancing Balancing Combustion Reactions** 1. Balance C 2. Balance H e.  $(OYO) C_4H_{10}O + O_2$  $CO_2$  $H_2O$ 3. Balance O 4. Remove denominator \*\*subscript of C becomes the coefficient of  $CO_2$ , the subscript of  $H \div 2$  is the coefficient of  $H_2O$ . The coefficient of  $O_2$  is sum total of O's  $\div 2$ f. (OYO)  $H_2SiCl_2 +$  $H_2O$  $H_8Si_4O_4$ **HCl** +  $C_7H_6(NO_2)_3$ g. (OYO) C<sub>7</sub>H<sub>9</sub>  $HNO_3$  $H_2O$ h. (OYO)  $C_5H_8O_2$ HC1  $C_5H_{12}O_2$ NaC1 + NaH

	Reactions	
Word/Formula Equations	 Topic#9	

- How to treat elements hydrogen, nitrogen, oxygen, fluorin, chlorine, bromine, iodine, phsophorus, and sulfur when the are a reactant or product.
- When writing the formula equation from a word equation, certain elements (above) need a subscript in their formula.
  - hydrogen or hydrogen gas is written as H<sub>2</sub>
  - nitrogen or nitrogen gas is written as N<sub>2</sub>
  - oxygen or oxygen gas written as O<sub>2</sub>
  - fluorine or fluorine gas written as F<sub>2</sub>
  - chlorine or chlorine gas written as Cl<sub>2</sub>
  - bromine or liquid bromine is written as Br<sub>2</sub>
  - iodine or solid iodine is written as I<sub>2</sub>
  - phosphorus or solid phosphorus is written as P<sub>4</sub>
  - sulfur or solid sulfur is written as  $S_8$

	Reactions	
Word/Formula Equations	Topic#9	

**Word Equation** - describes a reaction using sentence(s)

Formula equation - uses the formulas of the reactants and products to describe a reaction

# Reactions Topic#9 Sample WS#1 - Word/Formula Equations

2. Write the word and formula equations for the chemical reaction that occurs when solid <u>sodium oxide</u> is added to <u>water</u> at room temperature and forms <u>sodium hydroxide</u> (dissolves in the water). Include symbols for physical states in the formula equation. Then balance the formula equation to give a balanced equation.

charges: word equation:

balanced formula equation:

	Reactions	
Word/Formula Equations	Topic#9	
3. Translate the following chemical equ	ation into a sentence:	
$BaCl_2(aq) + Na_2CrO_4(aq) \rightarrow BaCl_2(aq)$	$O_4(s) + 2NaCl(aq)$	

### **Process for Writing Word/Formula Equations:**

(1) Write word equation.

(3) Balance

(2) Write formula equation.

(4) Count atoms to check for correct balancing.

### **Word/Formula Equations Practice**

4. Aluminum (III) sulfate and calcium hydroxide are used in a water-purification process. When added to water, they dissolve and react to produce two insoluble products, aluminum (III) hydroxide and calcium sulfate. These products settle out, taking suspended impurities with them. (flocculation of organic material)

charges:

word equation:

balanced formula equation:

Word/Formula Equations	Reactions Topic#9
Process for Writing Word/Formul (1) Write word equation. (2) Write formula equation.	a Equations:  (3) Balance  (4) Count atoms to check for correct balancing.
5. The reaction of zinc with a hydrogen gas. charges: word equation: balanced formula equation:	queous hydrochloric acid produces a solution of zinc (II) chloride and

	Reactions	
Word/Formula Equations	Topic#9	Assign WS#2
6. (OYO) Solid aluminum (III) carbide, A <sub>4</sub> O	$C_3$ , reacts with water to pro-	oduce methane gas (CH <sub>4</sub> ) and solid
aluminum (III) hydroxide. Write a charges: word equation:	balanced equation.	Per EB/1 start here 01/14/20
balanced formula equation:		
7. (OYO) Butane gas (C <sub>4</sub> H <sub>10</sub> ) is ignited in the charges: word equation:	e presence of oxygen gas p	roducing carbon dioxide and water.
balanced formula equation:		
		Balancing Combustion Reaction 1. Balance C 2. Balance H 3. Balance O 4. Remove denominator
**subscript of C becomes the coefficient of CO	<sub>2</sub> , the subscript of H $\div$ 2 is the	e coefficient of H <sub>2</sub> O. The coefficient

of  $O_2$  is the sum total of O's  $\div$  2

# Reactions Topic#9

# **Types of Reactions**

Intro

- o 5 basic types of general reactions
- o Synthesis (composition), decomposition, single-replacement (single displacement), double-replacement (double-displacement), and combustion

**Synthesis** (2 become 1)

$$A + X \rightarrow AX$$
 metal + nonmetal  $\rightarrow$  ionic compound

$$X + Y \rightarrow XY$$
 nonmetal + nonmetal  $\rightarrow$  molecular compound

$$C + C \rightarrow BC$$
 compound + compound  $\rightarrow$  new compound

$$A + B \rightarrow$$
 no reaction  $metal + metal \rightarrow NR$ 

$$X + Y \rightarrow XY$$
  $X + Y \rightarrow XY$   $C + C \rightarrow BC$  (bigger compound)  $2Na + Cl_2 \rightarrow 2NaCl$   $S_8 + 8O_2 \rightarrow 8SO_2$   $CO_2 + CaO \rightarrow CaCO_3$ 

Reactions
Tonic#9

# **Types of Reactions**

**Decomposition** (1 becomes 2 or more)

$$AX \rightarrow A + X$$
 ionic compound  $\rightarrow$  metal + nonmetal  $XY \rightarrow X + Y$  molecular compound  $\rightarrow$  nonmetal + nonmetal  $BC \rightarrow C + C$  compound  $\rightarrow$  compound + compound  $XY \rightarrow X + Y$   $YY \rightarrow X +$ 

BC (bigger compound) 
$$\rightarrow$$
 C + C  
 $H_2CO_3 \rightarrow H_2O + CO_2$ 

Reactions Topic#9

# **Types of Reactions**

# **Single-Replacement Reactions (Single-Displacement)**

```
SR(c) A
                                BX
                                                              AX
                                                                                  В
         metal_1 +
                          metal<sub>2</sub>-nonmetal
                                                        metal<sub>1</sub>-nonmetal +
                                                                                 metal<sub>2</sub>
         metal
                          ionic compound
                                                        ionic compound +
                                                                                 metal
                          Zn(s) + CuCl_2(aq) \rightarrow ZnCl_2(aq) + Cu(s)
           Y
                                BX
                                                              BY
                                                                           +
                                                                                   X
SR(a)
       nonmetal_1 +
                          metal-nonmetal<sub>2</sub>
                                                        metal-nonmetal<sub>1</sub> + nonmetal<sub>2</sub>
                          ionic compound
                                                        ionic compound + nonmetal
       nonmetal +
```

$$\mathbf{F}_2(g) + \mathbf{M}\mathbf{g}\mathbf{Cl}_2(aq) \rightarrow \mathbf{M}\mathbf{g}\mathbf{F}_2(aq) + \mathbf{Cl}_2(g)$$

	Reactions
Types of Reactions	Topic#9

# **Double-replacement reactions (DR)**

$$AX + BY \rightarrow AY + BX$$
 $cation_1$ -anion<sub>1</sub> +  $cation_2$ -anion<sub>2</sub>  $\rightarrow$   $cation_1$ -anion<sub>2</sub> +  $cation_2$ -anion<sub>1</sub>

ionic compound + ionic compound ionic compound + ionic compound

 $AgNO_3(aq) + KCl(aq) \rightarrow AgCl(s) + KNO_3(aq)$ 

# Combustion (C)

 $C_xH_y + O_2 \rightarrow CO_2 + H_2O$  (water and carbon dioxide are the only products, period!)

	Reactions	
Types of Reactions	Topic#9	Assign WS#4
Reactions Sample WS#2 - Balancing/	Types of Chemical Equ	uation Practice Problems
Balance/Classify the following equations	s. Type	(C, S, D, SR(a), SR(c), or DR)
$(1)$ N <sub>2</sub> $(g)$ +H <sub>2</sub> $(g)$ $\rightarrow$ NH <sub>3</sub> $(g)$	)	
$(2) \underline{\qquad} \operatorname{Li}(s) + \underline{\qquad} \operatorname{H}_2\operatorname{O}(l) \to \underline{\qquad} \operatorname{LiOH}(s)$	$(aq) + \underline{\hspace{1cm}} H_2(g)$	
$(3) \underline{\hspace{1cm}} NaNO_3(s) \rightarrow \underline{\hspace{1cm}} NaNO_2(s) + \underline{\hspace{1cm}}$	$_{\mathrm{O}_{2}}\!(g)$	
$(4)$ C <sub>4</sub> H <sub>10</sub> ( $l$ ) +O <sub>2</sub> ( $g$ ) $\rightarrow$ CO <sub>2</sub>	$(g) + \underline{\hspace{1cm}} H_2O(g)$	
$(5) \underline{\qquad} NH_4Cl(s) \rightarrow \underline{\qquad} NH_3(g) + \underline{\qquad} H$	ICl(g)	
(6) (OYO) $\_$ BaO(s) + $\_$ H <sub>2</sub> O( $l$ ) $\rightarrow$	$\underline{\hspace{1cm}}$ Ba(OH) <sub>2</sub> ( $aq$ )	·
(7) (OYO) $\_$ AgNO <sub>3</sub> ( $aq$ ) + $\_$ NaCl( $aq$ )	$aq) \rightarrow \underline{\hspace{1cm}} AgCl(s) + \underline{\hspace{1cm}}$	NaNO <sub>3</sub> (aq)
(8) (OYO) $\underline{\hspace{1cm}} F_2(g) + \underline{\hspace{1cm}} HCl(g) \rightarrow \underline{\hspace{1cm}}$	$\text{Cl}_2(g) + \text{HF}(g)$	

	React	ions				
Single Replacement Reactions - Activity Series Topic#9				Assign WS#5		
	Metal Ac	tivity S	Series <i>Ha</i>	ndout		s Student sheet
Li>Rb>K>Ba>Ca>Na >	Mg>Al>Mn>Zn>Cr>Fe	>			-	> Ag>Pt>At
cold H <sub>2</sub> O, acids, oxygen	steam, acids, oxygen	aci	ds, oxygen		oxygen	unreactive
	Nonmetal Act	•	eries			
D & G L WG//2 A	$F_2>Cl_2>1$					
Reactions Sample WS#2 - A	as Par er					
2. Using the activity series, pre- balance the equation.		$BX \rightarrow AX$	X + B			the products and
a. $\operatorname{Mn}(s) + \operatorname{H}_2\operatorname{O}(l) \rightarrow $		A vs B	(IIA>B, the	n a rea	action occurs.)	
b. $\operatorname{Sn}(s) + \operatorname{FeCl}_3(aq) \rightarrow$			_			A1> $A1^{3+}$
			_			$Z_{n} -> Z_{n}^{2+}$
c. $Ag(s) + NaCl(aq) \rightarrow $						$Cd> Cd^{2+}$
	<b>→</b>					$Ag - > Ag^{1+}$
e. $Fe(s) + H_2O(l) \stackrel{\triangle}{\longrightarrow} $						$Sn> Sn^{2+}$
f. $Cl_2 + NaI \rightarrow$						$Fe> Fe^{3+}$
g. $Cl_2 + NaF \rightarrow $						
h. Identify the element the	at replaces hydrogen from a	acids bu	it cannot rep	lace t	in from its co	mpounds.
i. According to the activit	ty series, what is the most ac	ctive tra	ansition meta	al?		
E	•			_		

# **Predicting Products.**

- 1. Identify type of reaction (Use A, B, X, and Y)
  - a. two products for a decomposition
  - b. one product for a sythesis
  - c. two products for a single replacement
  - d. two products for a double replacement
- 2. Write the names of the products
- 3. Write the formula equation
- 4. Balance equation

# Topic#9 Unique Reactions

Reactions

Carbonates decompose into the metal oxide plus carbon dioxide  $Na_2CO_3(s) \rightarrow Na_2O(s) + CO_2(g)$ Metal hydroxides decompose into metal oxides and water

Metal hydroxides decompose into metal oxides and water  $2NaOH \rightarrow Na_2O + H_2O$ 

# **Reactions Sample WS#3 - Predicting Products**

Synthesis with one product

1. potassium plus fluorine  $\rightarrow$ 

Decomposition with two products

2. zinc (II) carbonate  $\xrightarrow{\text{heated }\Delta}$ 

# **Predicting Products.**

Reactions Topic#9

3. sodium bromide plus silver (I) nitrate  $\rightarrow$ 

silver(1) bromide

SR(c) with two products  $A^{\circ} + B^{\circ}(X_{2}) \longrightarrow AW_{2} +$ 

4. strontium plus lead (II) chlorate  $\rightarrow$ 

5r + Pb(c103) -D Sr (c103) +

96

**Predicting Products.** 

Reactions Topic#9

SR(a) with two products

$$x^{\circ} + A V_{3} \longrightarrow A X_{3} + Y$$

5. fluorine plus iron (III) bromide  $\rightarrow$  iron (III) fluoride  $\rightarrow$  bromine

 $3 F_{2} + 2 Fe Br_{3} \longrightarrow 2 Fe F_{3} \longrightarrow 3 Br_{2}$ 

LCM - G

Combustion with two products, CO<sub>2</sub> and H<sub>2</sub>O

6. nonane 
$$(C_9H_{20})$$
 plus oxygen gas  $\rightarrow$  water + carbon dioxide  $C_9H_{20} + |40_2| \rightarrow 10 H_20 + 9 CO_2$ 

$$10 + 18 = 28/2 = 14$$

Reactions	
Topic#9	

# **END**