

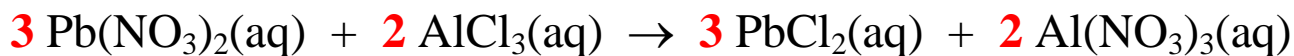
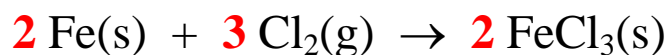
**4 • Chemical Equations and Stoichiometry****Station 1 – COMBUSTION EQUATIONS**

Write balanced equations for the complete combustion of the following fuels:

Fuel	Combustion Equation
$C_3H_8$	$C_3H_8 + 5 O_2 \rightarrow 3 CO_2 + 4 H_2O$
$C_6H_{14}$	$C_6H_{14} + \frac{19}{2} O_2 \rightarrow 6 CO_2 + 7 H_2O$
$CH_3OCH_3$	$CH_3OCH_3 + 3 O_2 \rightarrow 2 CO_2 + 3 H_2O$

**4 • Chemical Equations and Stoichiometry****Station 2 – BALANCING EQUATIONS**

Balance the following chemical equations:



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### Station 3 – PHASES

From the statement, decide whether each substance should be labeled with (s), (l), (g), or (aq):

Pure rubbing alcohol is $\text{C}_3\text{H}_7\text{OH}(l)$ .
Copper metal is $\text{Cu}(s)$ .
A solution of cupric chloride is $\text{CuCl}_2(aq)$ .
Melted iron is $\text{Fe}(l)$ .
Salt water is $\text{NaCl}(aq)$ .
Helium is $\text{He}(g)$ .
Dry ice is $\text{CO}_2(s)$ .
Steam is $\text{H}_2\text{O}(g)$ .

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### Station 4 – EMPIRICAL FORMULAS

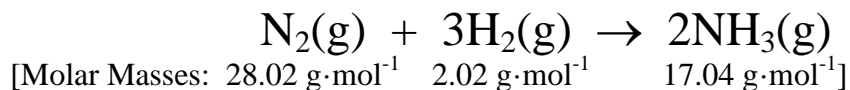
Determine the molecular formula given the following information:

Empirical Formula	Molecular Formula	Molar Mass
14 g/mol $\text{CH}_2$	$84/14 = 6$ $\text{C}_6\text{H}_{12}$	$84.18 \text{ g} \cdot \text{mol}^{-1}$
46 g/mol $\text{NO}_2$	$92/46 = 2$ $\text{N}_2\text{O}_4$	$92.02 \text{ g} \cdot \text{mol}^{-1}$
87 g/mol $\text{NaSO}_2$	$174/87 = 2$ $\text{Na}_2\text{S}_2\text{O}_4$	$174.14 \text{ g} \cdot \text{mol}^{-1}$
137 g/mol $\text{PCl}_3$	$\text{PCl}_3$	$137.32 \text{ g} \cdot \text{mol}^{-1}$

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### Station 5 – STOICHIOMETRY

Solve the following general stoichiometry problems: (Show work beautifully.)



Calculate the mass of ammonia, NH<sub>3</sub>, formed when 45.0 L N<sub>2</sub>(g) reacts with excess H<sub>2</sub>(g) at STP.

$$45.0 \text{ L N}_2 \times \frac{1 \text{ mole N}_2}{22.4 \text{ L N}_2} \times \frac{2 \text{ moles NH}_3}{1 \text{ mole N}_2} \times \frac{17.04 \text{ g NH}_3}{1 \text{ mole NH}_3} = \mathbf{68.5 \text{ g NH}_3}$$

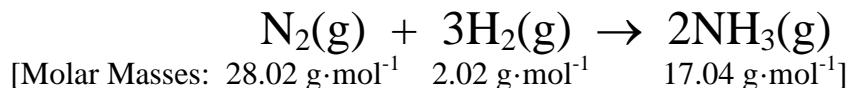
What mass of H<sub>2</sub> is needed to completely react with 10.0 grams of N<sub>2</sub>?

$$10.0 \text{ g N}_2 \times \frac{1 \text{ mole N}_2}{28.02 \text{ g N}_2} \times \frac{3 \text{ moles H}_2}{1 \text{ mole N}_2} \times \frac{2.02 \text{ g H}_2}{1 \text{ mole H}_2} = \mathbf{2.16 \text{ g H}_2}$$

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### Station 6 – LIMITING REACTANT PROBLEMS

Solve the following problem:



What mass of NH<sub>3</sub> is formed when 135.00 g N<sub>2</sub> reacts with 32.00 g H<sub>2</sub>?

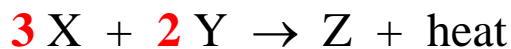
$$\mathbf{135.00 \text{ g N}_2} \times \frac{1 \text{ mole N}_2}{28.02 \text{ g N}_2} \times \frac{2 \text{ moles NH}_3}{1 \text{ mole N}_2} \times \frac{17.04 \text{ g NH}_3}{1 \text{ mole NH}_3} = \mathbf{164.2 \text{ g NH}_3 \text{ Answer}}$$

$$32.00 \text{ g H}_2 \times \frac{1 \text{ mole H}_2}{2.02 \text{ g H}_2} \times \frac{2 \text{ moles NH}_3}{3 \text{ mole H}_2} \times \frac{17.04 \text{ g NH}_3}{1 \text{ mole NH}_3} = \mathbf{179.96 \text{ g NH}_3}$$

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### Station 7 – LABORATORY PROBLEM

Using the following data, determine the best ratio of the chemical reaction:



Various mixtures of X and Y were mixed. A thermometer was used to record the temperature of the mixture. The **highest temperature reached** for each mixture was recorded in the table below.

Circle the mixture in the data table that released the **most** heat.

Determine the **stoichiometric ratio** for X and Y (write in the coefficients in the equation above).

Volume X (mL)	Volume Y (mL)	Max Temp Measured (°C)
0	100	20.0°C
20	80	25.0°C
40	60	30.0°C
<b>60</b>	<b>40</b>	<b>35.0°C</b>
80	20	27.5°C
100	0	20.0°C

In the mixture of 20 mL X and 80 mL Y, **X** was the limiting reactant.

*20 mL of X will use up only about 14 mL of Y.*

*X limits how much reaction occurs and how much heat is released.*

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### Station 8 – PERCENT YIELD

Solve the following problem:

Hydrogen gas was generated according to the equation:  $\text{Zn(s)} + 2\text{HCl(aq)} \rightarrow \text{H}_2\text{(g)} + \text{ZnCl}_2\text{(aq)}$

When 25.00 grams of Zn metal reacted with excess HCl 7.50 L  $\text{H}_2\text{(g)}$  was collected at STP.

The **theoretical yield** of  $\text{H}_2\text{(g)}$  for this reaction is: (show work)

$$25.00 \text{ g Zn} \times \frac{1 \text{ mole Zn}}{65.38 \text{ g Zn}} \times \frac{1 \text{ mole H}_2}{1 \text{ mole Zn}} \times \frac{22.4 \text{ L H}_2}{1 \text{ mole H}_2} = \mathbf{8.565 \text{ L H}_2}$$

The **percentage yield** for this reaction is: (show set-up)

$$\frac{7.50 \text{ L H}_2}{8.565 \text{ L H}_2} \times 100 = \mathbf{87.6 \%}$$

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### Station 9 – CHEMICAL ANALYSIS

*Solve the following problem:*

A compound composed of carbon and hydrogen is analyzed by combustion.

When a 4.297 g sample of the compound is burned, 12.57 g CO<sub>2</sub> and 7.72 g H<sub>2</sub>O are formed.

What is the **empirical formula** of the compound? CH<sub>3</sub>      **mass = 15 g/mol**

$$12.57 \text{ g CO}_2 \times \frac{1 \text{ mole CO}_2}{44.01 \text{ g CO}_2} \times \frac{1 \text{ moles C}}{1 \text{ mole CO}_2} = \mathbf{0.2856 \text{ moles C}} \quad \frac{0.2856 \text{ moles}}{0.2856 \text{ moles}} = \mathbf{1}$$

$$7.72 \text{ g H}_2\text{O} \times \frac{1 \text{ mole H}_2\text{O}}{18.02 \text{ g H}_2\text{O}} \times \frac{2 \text{ moles H}}{1 \text{ mole H}_2\text{O}} = \mathbf{0.8568 \text{ moles H}} \quad \frac{0.8568 \text{ moles}}{0.2856 \text{ moles}} = \mathbf{3}$$

The molar mass of the compound is found to be about 30 g·mol<sup>-1</sup>. **30/15 = 2**

The **molecular formula** for the compound is C<sub>2</sub>H<sub>6</sub>