South Pasadena • AP Chemistry **Answers** Name _____

Period ___ Date ___/___/___

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	$\mathbf{C_3H_8 + 5\,O_2 \rightarrow 3\,CO_2 + 4\,H_2O}$
C_6H_{14}	$\mathbf{C_6H_{14} + {}^{19}/_{2}\,O_2 \rightarrow 6\,CO_2 + 7\,H_2O}$
CH_3OCH_3	$\mathbf{CH_3OCH_3 + 3\,O_2 \rightarrow 2\,CO_2 + 3\,H_2O}$

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Station 2 – BALANCING EQUATIONS

Balance the following chemical equations:

$\mathbf{2}\ KClO_3(s) \rightarrow \mathbf{2}\ KCl(s) + \mathbf{3}\ O_2(g)$
$\mathbf{2}\ Fe(s) + \mathbf{3}\ Cl_2(g) \rightarrow \mathbf{2}\ FeCl_3(s)$
$\mathbf{3}\ Pb(NO_3)_2(aq) + \mathbf{2}\ AlCl_3(aq) \rightarrow \mathbf{3}\ PbCl_2(aq) + \mathbf{2}\ Al(NO_3)_3(aq)$

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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 C_3H_7OH(***l***).
Copper metal is Cu(***s***).
A solution of cupric chloride is $CuCl_2$(***aq***).
Melted iron is Fe(***l***).
Salt water is NaCl(***aq***).
Helium is He(***g***).
Dry ice is CO_2(***s***).
Steam is H_2O(***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 CH_2	84/14 = 6 **C_6H_{12}**	84.18 g·mol^{-1}
46 g/mol NO_2	92/46 = 2 **N_2O_4**	92.02 g·mol^{-1}
87 g/mol $NaSO_2$	174/87 = 2 **$Na_2S_2O_4$**	174.14 g·mol^{-1}
137 g/mol PCl_3	**PCl_3**	137.32 g·mol^{-1}

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Station 5 – STOICHIOMETRY

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

$$\underset{[\text{Molar Masses: } 28.02\ \text{g·mol}^{-1}}{N_2(g)} + \underset{2.02\ \text{g·mol}^{-1}}{3H_2(g)} \rightarrow \underset{17.04\ \text{g·mol}^{-1}]}{2NH_3(g)}$$

Calculate the mass of ammonia, NH_3, formed when 45.0 L $N_2(g)$ reacts with excess $H_2(g)$ at STP.

$$45.0\ \text{L } N_2 \times \frac{1\ \text{mole } N_2}{22.4\ \text{L } N_2} \times \frac{2\ \text{moles } NH_3}{1\ \text{mole } N_2} \times \frac{17.04\ \text{g } NH_3}{1\ \text{mole } NH_3} = \mathbf{68.5\ g\ NH_3}$$

What mass of H_2 is needed to completely react with 10.0 grams of N_2?

$$10.0\ \text{g } N_2 \times \frac{1\ \text{mole } N_2}{28.02\ \text{g } N_2} \times \frac{3\ \text{moles } H_2}{1\ \text{mole } N_2} \times \frac{2.02\ \text{g } H_2}{1\ \text{mole } H_2} = \mathbf{2.16\ g\ H_2}$$

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Station 6 – LIMITING REACTANT PROBLEMS

Solve the following problem:

$$\underset{[\text{Molar Masses: } 28.02\ \text{g·mol}^{-1}}{N_2(g)} + \underset{2.02\ \text{g·mol}^{-1}}{3H_2(g)} \rightarrow \underset{17.04\ \text{g·mol}^{-1}]}{2NH_3(g)}$$

What mass of NH_3 is formed when 135.00 g N_2 reacts with 32.00 g H_2?

$$\mathbf{135.00\ g\ N_2} \times \frac{1\ \text{mole } N_2}{28.02\ \text{g } N_2} \times \frac{2\ \text{moles } NH_3}{1\ \text{mole } N_2} \times \frac{17.04\ \text{g } NH_3}{1\ \text{mole } NH_3} = \mathbf{164.2\ g\ NH_3}\ \textbf{Answer}$$

$$32.00\ \text{g } H_2 \times \frac{1\ \text{mole } H_2}{2.02\ \text{g } H_2} \times \frac{2\ \text{moles } NH_3}{3\ \text{mole } H_2} \times \frac{17.04\ \text{g } NH_3}{1\ \text{mole } NH_3} = \mathbf{179.96\ g\ NH_3}$$

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Station 7 – LABORATORY PROBLEM

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

$$\mathbf{3}\ X + \mathbf{2}\ Y \rightarrow Z + \text{heat}$$

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
60	**40**	**35.0°C**
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: $Zn(s) + 2HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$

When 25.00 grams of Zn metal reacted with excess HCl 7.50 L $H_2(g)$ was collected at STP.

The **theoretical yield** of $H_2(g)$ for this reaction is: (show work)

$$25.00\ \text{g Zn} \times \frac{1\ \text{mole Zn}}{65.38\ \text{g Zn}} \times \frac{1\ \text{mole H}_2}{1\ \text{mole Zn}} \times \frac{22.4\ \text{L H}_2}{1\ \text{mole H}_2} = \mathbf{8.565\ L\ H_2}$$

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_2 and 7.72 g H_2O are formed.

What is the **empirical formula** of the compound? ___**CH_3**___ **mass = 15 g/mol**

$$12.57\text{ g } CO_2 \times \frac{1\text{ mole } CO_2}{44.01\text{ g } CO_2} \times \frac{1\text{ moles C}}{1\text{ mole } CO_2} = \mathbf{0.2856\text{ moles C}} \qquad \frac{0.2856\text{ moles}}{0.2856\text{ moles}} = \mathbf{1}$$

$$7.72\text{ g } H_2O \times \frac{1\text{ mole } H_2O}{18.02\text{ g } H_2O} \times \frac{2\text{ moles H}}{1\text{ mole } H_2O} = \mathbf{0.8568\text{ moles H}} \qquad \frac{0.8568\text{ moles}}{0.2856\text{ moles}} = \mathbf{3}$$

The molar mass of the compound is found to be about 30 $g \cdot mol^{-1}$. **30/15 = 2**

The **molecular formula** for the compound is ____**C_2H_6**____