C $\frac{6.30}{.969} = 6.5 \times 2$ | O $\frac{.969}{.969} = 1 \times 2$ | H $\frac{8.71}{.969} = 8.99 \times 2$

$C_{13}O_2H_{18}$

Unit 3: Stoichiometry Quiz Study Guide

1. Determine the empirical and molecular formulas of Ibuprofen, a headache remedy, contains 75.69% C, 8.80% H, and 15.51% O by mass, and has a molar mass of 206 g/mol.

   a. What is its empirical formula?

$75.69\text{ g C} \times \frac{1\text{ mol C}}{12.01\text{ g}} = 6.30\text{ mol C}$

$8.80\text{ g H} \times \frac{1\text{ mol H}}{1.01\text{ g}} = 8.71\text{ mol H}$

$15.51\text{ g O} \times \frac{1\text{ mol O}}{15.99\text{ g}} = .969\text{ mol O}$

   b. What is Ibuprofen's molecular formula?

$(12.01 \times 13) + (15.99 \times 2) + (1.01 \times 18) = 206.29\text{ g/mol}$

$C_{13}O_2H_{18}$ or $C_{13}H_{18}O_2$

2a. Determine the empirical formula of Styrene, a compound substance used to make Styrofoam® cups and insulation, contains 92.26% C and 7.74% H by mass and has a molar mass of 104 g/mol.

$92.26\text{ g C} \times \frac{1\text{ mol C}}{12.01\text{ g}} = 7.68\text{ mol C}$ $\quad \frac{7.68}{7.66} = 1.00$

$7.74\text{ g H} \times \frac{1\text{ mol H}}{1.01\text{ g}} = 7.66\text{ mol C}$ $\quad \frac{7.66}{7.66} = 1.00$

CH

   b. What is styrene's molecular formula?

$(12.01 \times 1) + (1.01 \times 1) = 13.02$ g/mol for Empirical Formula

$\frac{104}{13.02} = 7.98 \rightarrow 8$

C_8H_8

3. Aluminum hydroxide reacts with sulfuric acid as follows:

$$2\,Al(OH)_3(s) + 3\,H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 6\,H_2O(l)$$

   a. Which reagent is the limiting reactant when 0.470 mol $Al(OH)_3$ and 0.470 mol H_2SO_4 are allowed to react?

$.470\text{ mol } Al(OH)_3 \times \frac{3\text{ mol } H_2SO_4}{2\text{ mol } Al(OH)_3} = .705\text{ mol } H_2SO_4$ ← not enough

$.470\text{ mol } H_2SO_4 \times \frac{2\text{ mol } Al(OH)_3}{3\text{ mol } H_2SO_4} = .313\text{ mol } Al(OH)_3$ ← Have used

H_2SO_4

   b. How many moles of $Al_2(SO_4)_3$ can form under these conditions?

$.470\text{ mol } H_2SO_4 \times \frac{1\text{ mol } Al_2(SO_4)_3}{3\text{ mol } H_2SO_4} = 0.157\text{ mol } Al_2(SO_4)_3$

   c. How many moles of the excess reactant remain after the completion of the reaction?

$.470\text{ mol } Al(OH)_3 - .313\text{ mol } Al(OH)_3 = 0.157\text{ mol } Al(OH)_3$ left over

4. One of the steps in the commercial process for converting ammonia to nitric acid is the conversion of NH_3 to NO.

$$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$$

a. What are the coefficients for the reaction above?

4, 5, 4, 6

b. In a certain experiment (experiment A), 1.94 g of NH_3 reacts with 2.41 g of O_2. Which is the limiting reactant?

not enough

$$1.94\text{ g } NH_3 \times \frac{1\text{ mol } NH_3}{17.03\text{ g } NH_3} \times \frac{5\text{ mol } O_2}{4\text{ mol } NH_3} \times \frac{32\text{ g } O_2}{1\text{ mol } O_2} = 4.56\text{ g } O_2$$

$$2.41\text{ g } O_2 \times \frac{1\text{ mol } O_2}{32\text{ g } O_2} \times \frac{4\text{ mol } NH_3}{5\text{ mol } O_2} \times \frac{17.03\text{ g } NH_3}{1\text{ mol } NH_3} = 1.03\text{ g } NH_3$$

have used

O_2

c. How many grams of NO and of H_2O form in experiment A?

$$2.41\text{ g } O_2 \times \frac{1\text{ mol } O_2}{32\text{ g } O_2} \times \frac{4\text{ mol NO}}{5\text{ mol } O_2} \times \frac{30\text{ g NO}}{1\text{ mol NO}} = 1.81\text{ g NO}$$

$$2.41\text{ g } O_2 \times \frac{1\text{ mol } O_2}{32\text{ g } O_2} \times \frac{6\text{ mol } H_2O}{5\text{ mol } O_2} \times \frac{18.0\text{ g } H_2O}{1\text{ mol } H_2O} = 1.63\text{ g } H_2O$$

d. In experiment B, 2.51 g of NH_3 reacts with 4.67 g of O_2, which is the limiting reactant? SHOW YOUR WORK

not enough

$$2.51\text{ g } NH_3 \times \frac{1\text{ mol } NH_3}{17.03\text{ g } NH_3} \times \frac{5\text{ mol } O_2}{4\text{ mol } NH_3} \times \frac{32\text{ g}}{1\text{ mol } O_2} = 5.89\text{ g } O_2$$

$$4.67\text{ g } O_2 \times \frac{1\text{ mol } O_2}{32\text{ g } O_2} \times \frac{4\text{ mol } NH_3}{5\text{ mol } O_2} \times \frac{17.03\text{ g } NH_3}{1\text{ mol } NH_3} = 1.99\text{ g } NH_3$$

have used

O_2

e. In experiment B, how many grams of the *excess reactant* remain after the limiting reactant is completely consumed? SHOW WORK.

$$2.51\text{ g } NH_3 - 1.99\text{ g } NH_3 = 0.52\text{ g } NH_3$$

f. What is the theoretical yield of experiment B? SHOW YOUR WORK.

$$4.67\text{ g } O_2 \times \frac{1\text{ mol } O_2}{32\text{ g } O_2} \times \frac{4\text{ mol NO}}{5\text{ mol } O_2} \times \frac{30\text{ g NO}}{1\text{ mol NO}} = 3.50\text{ g NO}$$

$$4.67\text{ g } O_2 \times \frac{1\text{ mol } O_2}{32\text{ g } O_2} \times \frac{6\text{ mol } H_2O}{5\text{ mol } O_2} \times \frac{18.01\text{ g } H_2O}{1\text{ mol } H_2O} = 3.15\text{ g } H_2O$$

g. Assume that your target was to achieve at least 95% yield in experiment B. How many grams would this be? SHOW YOUR WORK

$NO = 3.50 \times .95 = 3.33\text{ g NO}$

$H_2O = 3.15 \times .95 = 2.99\text{ g } H_2O$

AP Chemistry 2016-17

Unit 3: Stoichiometry (2017-18 MULTIPLE CHOICE QUIZ WILL NOT USE A CALCULATOR)

Multiple Choice Questions – 10 questions

1. Based on the following molecular formulas, which compound has 64.6% carbon by mass?

(A) C_7H_6O
(B) $C_8H_8O_3$
(C) $C_7H_{14}O_2$
(D) CH_2O

2. Cadaverine, a foul-smelling substance produced by bacteria as it decays flesh, contains 58.77% C, 13.81% H, 27.42% N by mass; its molar mass is 102.2 g/mol. What is the molecular formula of cadaverine?

(A) $C_5H_{14}N_2$
(B) $C_5H_2N_{14}$
(C) $C_{14}H_2N_5$
(D) $C_2H_{14}N_5$

3. Caffeine contains 49.48% C, 5.19% H, and 28.85% N, and 16.48% O by mass and has a molar mass of 194 g/mol. What is the molecular formula of caffeine?

(A) $C_4H_5N_2O$
(B) $C_8H_{10}N_4O_2$
(C) $C_8H_{10}N_2O_2$
(D) $C_4H_5N_2O_2$

4. The complete combustion of octane, C_8H_{18}, the main component of gasoline, proceeds as follows.

$$2\ C_8H_{18}(l) + 25\ O_2(g) \rightarrow 16\ CO_2(g) + 18\ H_2O(g)$$

How many moles of O_2 are needed to burn 2.35 mol of C_8H_{18}?

(A) 31.8 mol
(B) 26.5 mol
(C) 28.3 mol
(D) 29.4 mol

5. Detonation of nitroglycerin proceeds as follows:

$$4\ C_3H_5N_3O_9(l) \rightarrow 12\ CO_2(g) + 6\ N_2(g) + O_2(g) + 10\ H_2O(g)$$

If a sample containing 1.98 mL of nitroglycerine (density = 1.592 g/mL) is detonated, how many total moles of gas are produced?

(A) 0.101 mol
(B) 0.01 mol
(C) 0.202 mol
(D) 0.02 mol

6. Automotive air bags inflate when sodium azide, NaN_3, rapidly decomposes to its component elements.

$$2\ NaN_3(s) \rightarrow 2\ Na(s) + 3\ N_2(g)$$

How many grams of NaN_3 are required to form 17.0 g of nitrogen gas?

(A) 17.8 g
(B) 29.4 g
(C) 26.3 g
(D) 53.1 g

Refer to the following information when answering #7 and #8

One of the steps in the commercial process for converting ammonia to nitric acid is the conversion of NH_3 to NO

$$4\ NH_3(g) + 5\ O_2(g) \rightarrow 4\ NO(g) + 6\ H_2O(g)$$

In a certain experiment, 1.72 g of NH_3 reacts with 2.43 g of O_2.

7. Which is the limiting reactant?

(A) O_2
(B) NH_3
(C) NO
(D) H_2O

8. How many grams of the *excess reactant* remain after the limiting reactant is completely consumed?

(A) 0.86
(B) 0.69
(C) 0.45
(D) 0.21

Refer to the following information when answering #9 and #10

When ethane (C_2H_6) reacts with chlorine (Cl_2) the main product is C_2H_5Cl, but other products containing Cl (chlorine), such as $C_2H_4Cl_2$, are also obtained in small quantities. The formation of these other products reduces the yield of C_2H_5Cl. In a certain experiment 125 g of C_2H_6 reacts with 255 g of Cl_2.

9. Assuming that C_2H_6 and Cl_2 react only to form C_2H_5Cl and HCl, what is the theoretical yield of C_2H_5Cl?

(A) 145 g
(B) 249 g
(C) 326 g
(D) 232 g

10. What is the percent yield of C_2H_5Cl if the reaction produced 178 g of C_2H_5Cl?

(A) 110%
(B) 81%
(C) 92%
(D) 76.7%

AP Chemistry 2016-17

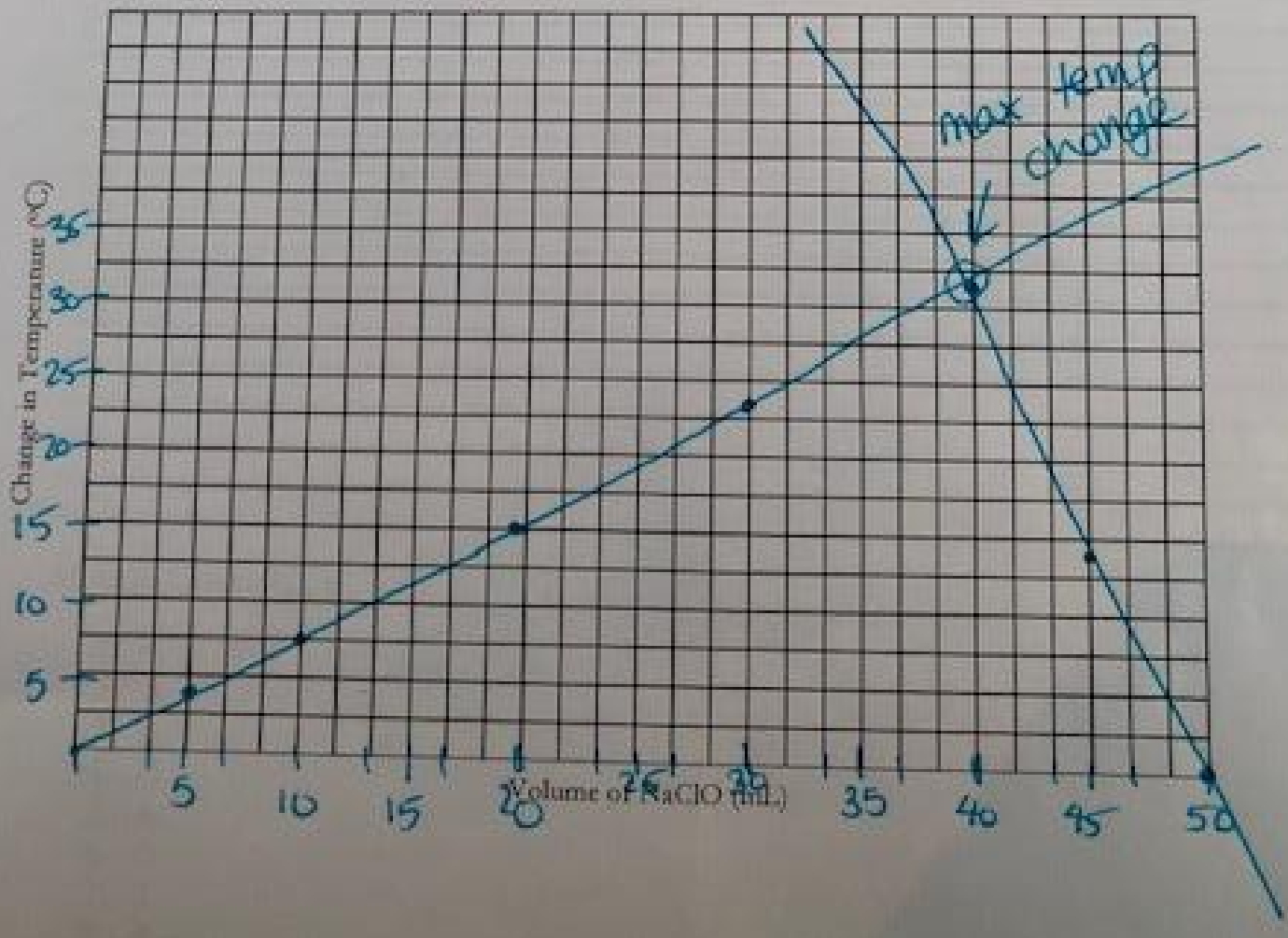
Unit 3: Stoichiometry
Free Response

Directions: Answer the following in the space below the questions. Make sure your answers are clearly labeled for each part. For example, if you are writing an answer to part b, make sure you have "b" or "part b" labeling that answer.

Below is data from an experiment when two solutions of the same concentration (same number of moles per volume) were mixed. The initial temperature was 26 °C

Ratio of NaClO to $Na_2S_2O_3$ (mL)	Temperature of Mixed Solution (°C) after 2 Min:	Change in Temperature
50 : 0	26 °C	0
45 : 5	40.5 °C	14.5
40: 10	58.0 °C	32
30 : 20	49.2 °C	23.2
20 : 30	41.0 °C	15
10 : 40	34.0 °C	8
5 : 45	30.2°C	4.2

Graph the data. Use best-fit line to determine the maximum temperature change from the reaction. Label this point on the graph.



A) What is meant by the term *limiting reactant*?
B) Why is it necessary to keep the total volume the same in an experiment like this?
C) What is the mole ratio of this reaction, based on the data provided? Be sure to cite the data and refer to it when making your argument.
D) At which ratios was NaClO the limiting reactant? At which ratios was NaClO the excess reactant?

See your lab and online resources

Mutliple Choice KEY

1. C
2. A
3. B
4. D
5. A
6. C
7. A