Name____Date____/____/____Period____

Solving for Molecular Formulas and Diatomic Molecules

Reminder that the empirical formula is the simplest form of a chemical formula. Empirical formula have the smallest possible whole-number ratio. To solve empirical formula, we needed to know the **percent composition** of each element in unknown chemical and follow the 5 steps to solve for the empirical formula.

Molecular formula is the same or a multiple of the empirical formula. The molecular formula can solve for by **knowing or solving for the empirical formula and knowing the molar mass of the molecular formula.** By knowing the empirical formula and the molar mass of the molecular formula, the mass can be compared and we can solve for the factor in which the molecular formula increases the empirical formula.

Example 1 The empirical formula for a compound is CH_4N. The molar mass of the compound (molecular) is 60.0 g/mol. Solve for the molecular formula. molecular

Step 1. Calculate the empirical formula mass for CH_4N.

1 carbon atoms x 12 mass of one mole carbon = 12
4 hydrogen atoms x 1 mass of one mole hydrogen = 4
1 nitrogen atoms x 14 mass of one mole nitrogen = 14

empirical formula mass of CH_4N is equal to 12 + 4 + 14 = 30 g/ mol CH_4N

Step 2. Divide the molar mass by the empirical mass to calculate the increase in factor.

$$\frac{molar\ mass}{empirical\ formula\ mass} = \frac{60}{30} = 2$$

Step 3. Multiply the empirical formula by the factor to solve for the molecular formula.

$$(CH_4N) \times 2 = C_2H_8N_2$$

BOOGIE BOARD Example 2 What is the molecular formula of a compound with the empirical formula CH_2O and a molar mass of 90.0 g/mol? **($C_3H_6O_3$)**

↑ molecular mass

CH_2O

C 1 x 12 = 12
H 2 x 1 = 2
O 1 x 16 = 16

30

factor = $\frac{90}{30}$ = 3

$(CH_2O) \times 3 = C_3H_6O_3$

HW# 1 What is the molecular formula of a compound with the empirical formula H_2PO_3 and a molar mass of 405 g/mol ? ($H_{10}P_5O_{15}$)

81 g/mol

factor = $\frac{405}{81}$ = 5 $(H_2PO_3) \times 5$

MOLECULAR = $H_{10}P_5O_{15}$

HW#2 Find the molecular formula of a compound with the empirical formula C_3H_3N and a molar mass of 212 g/mol. ($C_{12}H_{12}N_4$)

53

factor $\frac{212}{53}$ = 4 $(C_3H_3N) \times 4$

$C_{12}H_{12}N_4$

HW#3 What is the molecular formula of a compound with the empirical formula CClN and a molar mass of 61.5 g/mol ? **(CClN) * Reminder that a molecular formula can be the same as the empirical formula**

61.5

factor = $\frac{61.5}{61.5}$ = 1 $(CClN) \times 1$

CClN

Diatomic Molecules

Diatomic molecules are composed of only two atoms. The two atoms can either be the same or different. There are **seven diatomic molecules** that you need to memorize which exists as two atoms together because they are more stable together. These seven diatomic molecules are **hydrogen** gas, **nitrogen** gas, **oxygen** gas, **fluorine** gas, **chlorine** gas, **bromine** gas and **iodine** gas. Whenever these elements are mentioned as **"gases** "they exist as two atoms.

BrINClHOF BrINClHOF

Hydrogen gas = H_2

Nitrogen gas = N_2

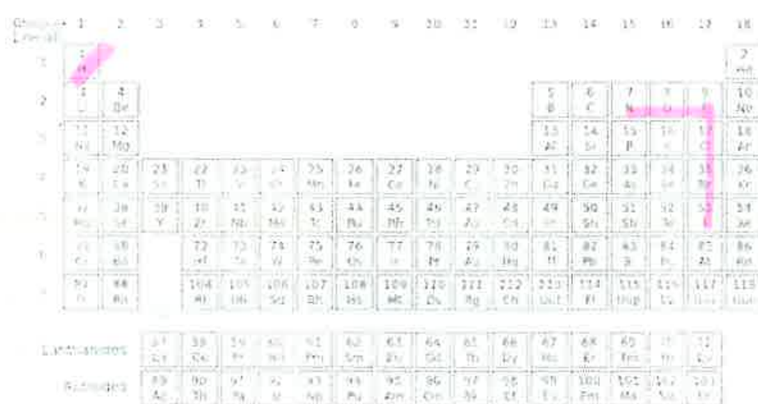
Oxygen gas = O_2

Fluorine gas = F_2

Chlorine gas = Cl_2

Bromine gas = Br_2

Iodine gas = I_2



HW#4 What is the mass of 2.00 moles of nitrogen gas? (56.0 g N_2)

$2 \text{ mol } N_2 \times \frac{28 \text{ g } N_2}{1 \text{ mol } N_2} = 56$

HW#5 How many molecules are there in 5.00 moles of chlorine gas? **(3.01×10^{24} molecules Cl_2)**

$5 \text{ mol } Cl_2 \times \frac{6.02 \times 10^{23} \text{ molecules } Cl_2}{1 \text{ mol } Cl_2} = 3.01$

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Writing Skeleton Equations and Extra Balancing Reactions Problems

Reminder of the Seven Diatomic Molecules

hydrogen	nitrogen	oxygen	fluorine	chlorine	bromine	iodine
H_2	N_2	O_2	F_2	Cl_2	Br_2	I_2

Section A *Write down the skeleton reactions and balance the reaction if needed.*

1. Carbon disulfide reacts with oxygen to yield carbon dioxide and sulfur dioxide.

$1\,CS_2 + 3\,O_2 \rightarrow 1\,CO_2 + 2\,SO_2$

2. Zinc sulfide reacts with oxygen to yield zinc oxide and sulfur dioxide.

$2\,Zn^{2+}S^{2-} + 3\,O_2 \rightarrow 2\,Zn^{2+}O^{2-} + 2\,SO_2$

3. Calcium hydride reacts with water to yield calcium hydroxide and hydrogen.

$Ca^{2+}H_2^{1-} + 2\,H_2O \rightarrow Ca^{2+}(OH)_2^{1-} + 2\,H_2$

4. Magnesium reacts with water to yield hydrogen and magnesium oxide.

$Mg + H_2O \rightarrow H_2 + Mg^{2+}O^{2-}$

5. Potassium chlorate decomposes to yield potassium chloride and oxygen.

$2\,K^{1+}ClO_3^{1-} \rightarrow 2\,K^{1+}Cl^{1-} + 3\,O_2$

Section B *Balance each reaction with coefficients.*

6. 2 H_2 + 1 O_2 → 2 H_2O

7. 1 $CaCO_3$ → 1 CaO + 1 CO_2

8. 1 Cl_2 + 2 LiBr → 2 LiCl + 1 Br_2

9. 1 $Ba(OH)_2$ + 1 H_2SO_4 → 1 $BaSO_4$ + 2 H_2O

10. 2 C_2H_6 + 7 O_2 → 4 CO_2 + 6 H_2O

11. _2_ H_2O_2 → _2_ H_2O + _1_ O_2

12. _4_ Fe + _3_ O_2 → _2_ Fe_2O_3

13. _1_ Cl_2 + _2_ NaBr → _2_ NaCl + _1_ Br_2

14. _1_ Zn + _1_ H_2SO_4 → _1_ $ZnSO_4$ + _1_ H_2

15. _1_ CH_4 + _2_ O_2 → _1_ CO_2 + _2_ H_2O

16. _1_ $Pb(NO_3)_2$ + _1_ K_2CrO_4 → _1_ $PbCrO_4$ + _2_ KNO_3

17. _2_ Ag + _1_ Cl_2 → _2_ AgCl

18. _6_ HCl + _1_ Fe_2O_3 → _2_ $FeCl_3$ + _3_ H_2O

19. _1_ $MgCO_3$ → _1_ MgO + _1_ CO_2

20. _2_ C_2H_6 + _7_ O_2 → _4_ CO_2 + _6_ H_2O

21. _2_ NaN_3 → _2_ Na + _3_ N_2

22. _2_ K + _2_ H_2O → _2_ KOH + _1_ H_2

Name ______________________________ Date____________ Period___

Introduction to the Mole

Review of TED Mole Video

In Chemistry we will begin analyzing the composition of matter and perform chemical calculations. In order to solve for these problems, we will be using a unit called a "mole".

When you hear the unit "pair" you think of 2. When you hear the unit "dozen" you think of 12. In today's lesson we will be using a new unit "mole" which represents 602 000 000 000 000 000 000 000 or using scientific notation 6.02×10^{23}. This number is also pronounced 602 sextillion.

Examples: 1 mole of apples is 6.02×10^{23} apples.

1 mole of water bottles is 6.02×10^{23} water bottles.

As mentioned in the video, a mole is a big value.

Examples: A mole of basketball has more volume than the size of planet earth.

If you had a mole of dollars and spent one million dollars per second up until you were 100 years old, you would still have 99% of your money.

This value for the mole is also known as **Avogadro's number.** The value was discovered by the scientist Jean Perrin who was able to determine there were 6.02×10^{23} atoms of hydrogen in 1 mole of hydrogen in the mid-1800s. He decided to dedicate the number "6.02×10^{23}" to the scientist Lorenzo Avogadro who originally had the idea earlier but past away.

"Representative particle or unit" refers to the species present in a substance, usually atoms, ions, molecules or formula units. We must use the correct label to express a substance.

Refer to Table 10.1 on page 326.

1. Copper (Cu) and Nitrogen (N), the representative particle is "ATOM" which is used when there is exactly one element.
2. Nitrogen gas (N_2), Water (H_2O) and Sucrose ($C_{12}H_{22}O_{11}$), the representative particle is "MOLECULE" which is used for **covalent** compound between NONMETALS atom(s) or element(s).
3. Calcium ion (Ca^{2+}), the representative particle is "ION" which is used when an atom, molecule or ionic compound has a positive or negative ION.
4. Calcium fluoride (CaF_2), the representative particle is "FORMULA UNIT (F.U.)" which is used for **ionic** compounds between a METAL and NONMETAL.

Section A Determine which representative particle (atom, molecule, ion, formula unit) to use to express the following substances.

1. sodium chloride, NaCl answer: **formula unit**, ionic compound because sodium (Na) is a metal and chlorine (Cl) is a nonmetal
2. oxygen gas, O_2 answer: **molecule**, covalent compound between two nonmetals
3. hydroxide, OH^{1-} answer: **ion**, molecule with a charge
4. hydrogen, H answer: **atom**
5. carbon dioxide, CO_2 (NM, NM) molecule
6. lithium ion, Li^{1+} ion
7. magnesium fluoride, MgF_2 (M, NM) f.u.
8. helium, He atom

Section B Convert the number of moles (mol) to the correct representative particles or units.

1. How many atoms in 1.00 mol H? **(6.02 x 10^{23} atoms H)**

$$1.00 \text{ mol H} \left| \frac{6.02\times10^{23} \text{ atoms H}}{1 \text{ mol H}} \right. = \frac{(1.00)(6.02E23)}{1}$$

2. How many molecules in 2.00 x 10^5 mole H_2O? **(1.20 x 10^{29} molecules H_2O)**

$$2.00\times10^{5} \text{ mol } H_2O \left| \frac{6.02\times10^{23} \text{ molecules } H_2O}{1 \text{ mol } H_2O} \right.$$

3. How many formula units in 4.00 mol NaCl? **(2.41 x 10^{24} formula units or f.u. NaCl)**

$$4.00 \text{ mol NaCl} \left| \frac{6.02\times10^{23} \text{ f.u. NaCl}}{1 \text{ mol NaCl}} \right.$$

4. How many oranges are 3.00 mol oranges? **(1.81 x 10^{24} oranges)**

$$3.00 \text{ mol oranges} \left| \frac{6.02\times10^{23} \text{ oranges}}{1 \text{ mol orange}} \right.$$

Section C Convert the number of representative units to moles (mol).

1. How many moles are in 5.00 formula units (f.u.) of LiF? **(8.31 x 10^{-24} mol LiF)**

$$5.00 \text{ f.u. LiF} \left| \frac{1 \text{ mol}}{6.02\times10^{23} \text{ f.u. LiF}} \right.$$

2. How many moles are equal to 2.50 x 10^3 ions of Na^+? **(4.15 x 10^{-21} mol Na^+)**

$$2.50\times10^{3} \text{ ions } Na^+ \left| \frac{1 \text{ mol } Na^+}{6.02\times10^{23} \text{ ions } Na^+} \right.$$

3. How many moles are in 6.02 x 10^{23} atoms of Cu? **(1.00 mol Cu)**

$$6.02\times10^{23} \text{ atoms Cu} \left| \frac{1 \text{ mol Cu}}{6.02\times10^{23} \text{ atom Cu}} \right.$$

4. How many moles are in 15.0 of grapes? **(2.49 x 10^{-23} mol grapes)**

$$15.0 \text{ grapes} \left| \frac{1 \text{ mol grapes}}{6.02\times10^{23} \text{ grapes}} \right.$$

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Introduction to Molar Mass

The atomic mass on the periodic table is the average mass of all known isotopes of the element. This atomic mass is equal to the mass of one mole of the element as well. The atomic mass is the usually one value expressed in decimal however this value can be **rounded to the nearest whole number**. However there are **two exceptions**, the **mass of one mole of Chlorine (Cl) is 35.5** and will not be rounded and the **mass of one mole of Copper (Cu) is 63.5** and will not be rounded.

The mass of one mole of an element or substance is known as **molar mass**. You can say, "The mass of one mole of hydrogen is 1 gram per mole" or you can say, "The molar mass of hydrogen is 1 gram per mole".

To calculate the mass of one mole of an element or substance, you will always use a periodic table to look up the molar mass values. You are not expected to memorize these values.

Chalk Activity: In the chalk activity we measured the mass of the chalk before and after we wrote our name on the butcher paper. We can calculate the mass of the chalk required to write your name by subtracting the two masses.

Question 1 Calculate the mass of the chalk used to write your name.

mass before: 5 g

mass after: 2g

Mass of chalk used to write name: (mass before- mass after): 3g

Question 2 Chalk also known as calcium carbonate is a simple substance that has a chemical formula of $CaCO_3$. Calculate the molar mass (or the mass of one mole) of $CaCO_3$.

Step 1 Determine how many atoms of each element you have in $CaCO_3$.

Answer: 1 calcium, 1 carbon and 3 oxygens

Step 2 Look up the molar mass of each element on the periodic table

Answer: The molar mass of Ca is 40 g/mol.
The molar mass of C is 12 g/mol.
The molar mass of oxygen is 16 g/mol.

Step 3 Multiply each molar mass by the number of atoms present and add all the masses together to get the total mass or molar mass of $CaCO_3$.

Answer: 1 calcium mol x 40 g/mol = 40 g/mol
1 carbon mol x 12 g/mol = 12 g/mol
3 oxygen mol x 16 g/mol = 48 g/mol
The molar mass of $CaCO_3$ = 40 + 12 + 48 = 100 g/mol.

Question 3 Calculate the moles of chalk used to write your name by converting the mass from question 1. **Hint:** Used the molar mass or conversion factor that we just solve for in step 2. We know for every one mole of $CaCO_3$ is equal 100 g. This can be expressed as (1 mol $CaCO_3$/ 100 g $CaCO_3$) or (100 g $CaCO_3$/ 1 mol $CaCO_3$).

$$3\,g\,CaCO_3 \times \frac{1\ mol\ CaCO_3}{100\ g\ CaCO_3} = 0.03$$

Section A Calculate the molar mass for each substance.

$Mg(NO_3)_2$ **(148 g /mol)**

mol x g/mol = g

1 Mg mol x 24 g/mol 24 g
2 N mol x 14 g 28
6 O x 16 g 96

The molar mass of $Mg(NO_3)_2$ is 24 + 28 + 96 = 148 g /mol

148 g/mol

2. NaOH **(40 g/mol)**

Na 1 x 23 = 23
O 1 x 16 = 16
H 1 x 1 = 1
40

3. $Ca(OH)_2$ **(74 g /mol)**

Ca 1 x 40 = 40
O 2 x 16 = 32
H 2 x 1 = 2
74

4. Fe_2O_3 **(160 g/mol)**

Fe 2 x 56 = 112
O 3 x 16 = 48
> 160

Section B Calculate the number of moles from each of the following mass of each substance.
You must first calculate the molar mass to use as a conversion factor.

5. 4.75 g of NaOH **(1.19×10^{-1} mol NaOH)**

Answer: The molar mass of NaOH was solve in section A to be 40 g/mol.

4.75 g NaOH | 1 mol NaOH / g NaOH =

6. 39 g of LiF **(1.5×10^{0} mol LiF)**

39 g LiF | 1 mol LiF / 26 g LiF

7. 168 g of HCl **(4.60×10^{0} mol HCl)**

168 g HCl | 1 mol HCl / 36.5 g HCl

USE PERIODIC TABLE

Section C Calculate the mass from each of the following moles of each substance. You first must calculate the molar mass to use as a conversion factor.

8. 4.5 moles of KOH. **(2.5 x 10^2 g KOH)**

$$\frac{4.5 \text{ mol KOH}}{} \left| \frac{56 \text{ g KOH}}{1 \text{ mol KOH}} \right. =$$

9. 2.3 moles NaCl. **(1.3 x 10^2 g NaCl)**

$$\frac{2.3 \text{ mol NaCl}}{} \left| \frac{58.5 \text{ g NaCl}}{1 \text{ mol NaCl}} \right.$$

10. 0.25 moles of NaOH. **(1.0 x 10^1 g NaOH)**

$$\frac{0.25 \text{ mol NaOH}}{} \left| \frac{40 \text{ g NaCl}}{1 \text{ mol NaOH}} \right.$$

11. 0.5 mol KCl. **(4 x 10^1 g KCl)**

$$\frac{0.5 \text{ mol KCl}}{} \left| \frac{74.5 \text{ g KCl}}{1 \text{ mol KCl}} \right.$$

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Introduction to Stoichiometry

Notes to convert MOLS to MOLS

Directions: Solve each of the following problem. Show all work and units.

1. Given the balanced equation, determine the following mole to mole ratio also known as **molar ratio.**

$$\mathbf{2}\ C_4H_{10} + \mathbf{13}\ O_2 \rightarrow \mathbf{8}\ CO_2 + \mathbf{10}\ H_2O$$

a. C_4H_{10} / O_2 $\frac{2}{13}$

b. O_2 / CO_2 $\frac{13}{8}$

c. O_2 / H_2O $\frac{13}{10}$

d. C_4H_{10} / CO_2 $\frac{2}{8}$

e. C_4H_{10} / H_2O $\frac{2}{10}$

2. $2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$

How many moles of oxygen are made if 12.0 moles of potassium chlorate react? **(18.0 mol O_2)**

$$12 \text{ mol } KClO_3 \times \frac{3 \text{ mol } O_2}{2 \text{ mol } KClO_3} = \frac{12(3)}{2} = 18$$

3. $2\ K + Cl_2 \rightarrow 2\ KCl$ (2.5 g, A; g KCl, B)

3a. How many grams of potassium chloride are produce from 2.50 grams of potassium? **(4.74 g KCl)**

Cl 35.5
Cu 63.5

$$2.5 \text{ g } K \times \frac{1 \text{ mol } K}{39 \text{ g } K} \times \frac{2 \text{ mol } KCl}{2 \text{ mol } K} \times \frac{74.5 \text{ g } KCl}{1 \text{ mol } KCl}$$

3b. How many grams of potassium chloride are produced from 1.00 g of chlorine? **(2.11 KCl)**

$$1.00 \text{ g } Cl_2 \times \frac{1 \text{ mol } Cl_2}{71 \text{ g } Cl_2} \times \frac{2 \text{ mol } KCl}{1 \text{ mol } Cl_2} \times \frac{74.5 \text{ g } KCl}{2 \text{ mol } KCl}$$

4. $2\ FePO_4 + 3\ Na_2SO_4 \rightarrow Fe_2(SO_4)_3 + 2\ Na_3PO_4$

25.0 g of iron(III) phosphate react with excess sodium sulfate, how many grams of iron(III) sulfate can be made? **(33.1 g $Fe_2(SO_4)_3$)**

$$25\ g\ FePO_4 \times \frac{1\ mol\ FePO_4}{151\ g\ FePO_4} \times \frac{1\ mol\ Fe_2(SO_4)_3}{2\ mol\ FePO_4} \times \frac{400\ g\ Fe_2(SO_4)_3}{1\ mol\ Fe_2(SO_4)_3}$$

5. $Na_2O + H_2O \rightarrow 2\ NaOH$

5a. What mass of sodium hydroxide is made from 1.20×10^2 g of sodium oxide? **(155 g NaOH)**

$$1.20 \times 10^2\ g\ Na_2O \times \frac{1\ mol\ Na_2O}{60\ g\ Na_2O} \times \frac{2\ mol\ NaOH}{1\ mol\ Na_2O} \times \frac{40\ g\ NaOH}{1\ mol\ NaOH}$$

5b. How many grams of sodium oxide are required to produce 1.60×10^2 grams of sodium hydroxide? **(124 g Na_2O)**

$$1.60 \times 10^2\ g\ NaOH \times \frac{1\ mol\ NaOH}{40\ g\ NaOH} \times \frac{1\ mol\ Na_2O}{2\ mol\ NaOH} \times \frac{62\ g\ Na_2O}{1\ mol\ Na_2O}$$

6. $6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$

A human needs about 120. grams of glucose per day. How many grams of carbon dioxide are used by plants to produce this amount of glucose? **(176 g CO_2)**

$$120\ g\ C_6H_{12}O_6 \times \frac{1\ mol\ C_6H_{12}O_6}{180\ g\ C_6H_{12}O_6} \times \frac{6\ mol\ CO_2}{1\ mol\ C_6H_{12}O_6} \times \frac{44\ g\ CO_2}{1\ mol\ CO_2}$$

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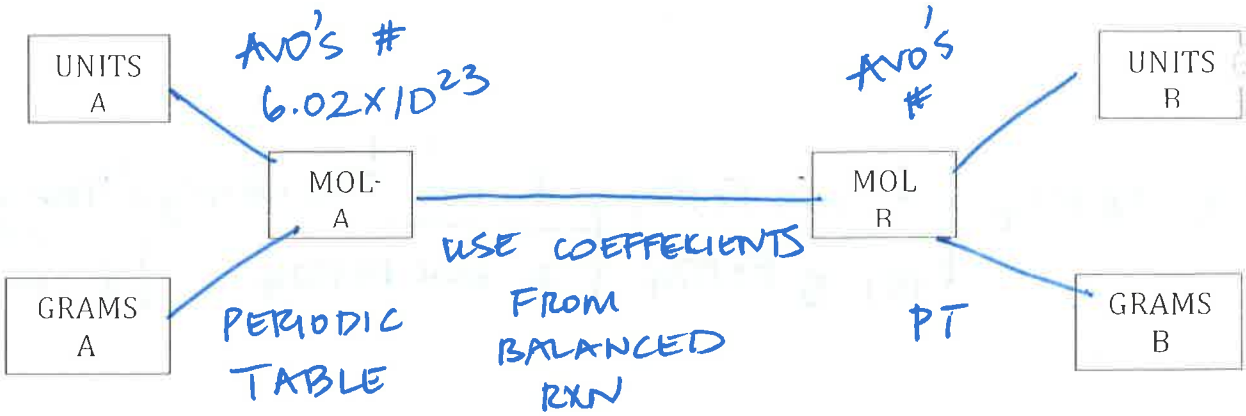
Stoichiometry Continued



Directions: Solve each of the following problem. Show all work and units. Round answer to proper sig figs.

1. $2\ H_2O\ (l) \rightarrow 2\ H_2\ (g) + O_2\ (g)$

How many molecules of oxygen are produced when 29.2 g of water are decomposed by electroloysis according to this balance equation? **(4.88×10^{23} molecules O_2)**

$$29.2\ g\ H_2O \times \frac{1\ mol\ H_2O}{18\ g\ H_2O} \times \frac{1\ mol\ O_2}{2\ mol\ H_2O} \times \frac{6.02\times10^{23}\ molecules\ O_2}{1\ mol\ O_2}$$

2. $2\ KClO_3\ (s) \rightarrow 2\ KCl\ (s) + 3\ O_2\ (g)$

How many molecules of oxygen are produced by the decomposition of 6.54 g of potassium chlorate ($KClO_3$) ? **(4.82×10^{22} molecules O_2)**

$$6.54\ g\ KClO_3 \times \frac{1\ mol\ KClO_3}{122.5\ g\ KClO_3} \times \frac{3\ mol\ O_2}{2\ mol\ KClO_3} \times \frac{6.02\times10^{23}\ molecules\ O_2}{1\ mol\ O_2}$$

3. $3\ NO_2\ (g) + H_2O\ (l) \rightarrow 2\ HNO_3\ (aq) + NO\ (g)$

How many grams of nitrogen dioxide must react with water to produce 5.00×10^{22} molecules of nitrogen monoxide? **(12.0 grams NO_2)**

$$5.00\times10^{22}\ molecules\ NO \times \frac{1\ mol\ NO}{6.02\times10^{23}\ molecules\ NO} \times \frac{3\ mol\ NO_2}{1\ mol\ NO} \times \frac{46\ g\ NO_2}{1\ mol\ NO_2}$$

4. $CO_2 (g) + 2 H_2 (g) \rightarrow CH_4O (g)$

a. How many molecules of hydrogen are need to produce 25.0 g of CH_4O? **(9.41 x 10^{23} molecules H_2)**

25.0 g CH_4O	1 mol CH_4O	2 mol H_2	6.02×10^{23} molecules H_2
	32 g CH_4O	1 mol CH_4O	1 mol H_2

4b. How many molecules of carbon dioxide are needed to produce 25.0 g of CH_4O? **(4.70 x 10^{23} molecules CO_2)**

25.0 g CH_4O	1 mol CH_4O	1 mol CO_2	6.02×10^{23} molecules CO_2
	32 g CH_4O	1 mol CH_4O	1 mol CO_2

5. $2 C_2H_2 (g) + 5 O_2 (g) \rightarrow 4 CO_2 (g) + 2 H_2O (g)$

a. How many grams of CO_2 and H_2O are produced when 52.0 g C_2H_2 burn in oxygen? **(176 g CO_2, 36.0 g H_2O)**

52.0 g C_2H_2	1 mol C_2H_2	4 mol CO_2	44 g CO_2
	26 g C_2H_2	2 mol C_2H_2	1 mol CO_2

52.0 g C_2H_2	1 mol C_2H_2	2 mol H_2O	18 g H_2O
	26 g C_2H_2	2 mol C_2H_2	1 mol H_2O

5b. How many moles of H_2O are produced when 64.0 g C_2H_2 burn in oxygen? **(2.46 mol H_2O)**

64.0 g C_2H_2	1 mol C_2H_2	2 mol H_2O	
	26 g C_2H_2	2 mol C_2H_2	~~mol H_2O~~

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Worksheet 8.3 Limiting Reagent and Excess Reagent

Notes:

Balanced Reaction to make S'mores is given below.

$$2\ Gc + 1\ M + 4\ Cp \rightarrow 1\ Sm$$

(a) If you have 12 graham crackers and 12 chocolate pieces, how many S'mores can you **THEORETICALLY** make? (Calculate how many S'mores can be formed from 12 Gc and 12 Cp.

12 Gc | 1 Sm / 2 Gc = 6 Sm   12 Cp | 1 Sm / 4 Cp = 3 Sm

(b) A reactant that is left over is said to be in **excess** and those that are used up limit the amount of product that can be made and are thus called **limiting reactants**. The maximum number of S'mores you could make is called the **theoretical yield**. Identify the limiting reagent and excess reagent.

Limiting Reagent: 12 Cp   Excess Regent: 12 Gc HAVE AVAILABLE

(c) Calculate the amount of excess reagent remaining.

① START WITH LIMITING

12 Cp | 2 Gc / 4 Cp = 24/4 = 6 Gc USE

12 − 6 = 6
AVAIL USE LEFT OVER

For each problem:

(a) Calculate the **theoretical yield** of GRAMS of product formed from each given reactant.

(b) Determine the **limiting reagent and excess reagent**

(c) Calculate the GRAMS of **excess reagent** remaining

1. **$2\ Al + 3\ Cl_2 \rightarrow 2\ AlCl_3$ 3.6 mol Al & 5.3 mol Cl_2**

1a.

AVAILABLE
3.6 mol Al | 2 mol $AlCl_3$ / 2 mol Al = 3.6 mol $AlCl_3$
EXCESS   AVAILABLE

5.3 mol Cl_2 | 2 mol $AlCl_3$ / 3 mol Cl_2 = 3.53 mol $AlCl_3$
LIMIT   LEAST

1b. Limiting Reagent: Cl_2 Excess Reagent: Al

1c.

① START W/ LIMITING → EXCESS

5.3 mol Cl_2 | 2 mol Al / 3 mol Cl_2 = 3.53 mol ~~Cl_2~~ Al   3.6 − 3.53 = .07
USE   left over

2. $2\ H_2 + O_2 \rightarrow 2\ H_2O$ 6.4 mol H_2 & 108.8g O_2

2a.

$$6.4\ \text{mol}\ H_2 \left| \frac{2\ \text{mol}\ H_2O}{2\ \text{mol}\ H_2} \right| \frac{18\ g\ H_2O}{1\ \text{mol}\ H_2O} = 115.2\ g\ H_2O$$

$$108.8\ g\ O_2 \left| \frac{1\ \text{mol}\ O_2}{32\ g\ O_2} \right| \frac{2\ \text{mol}\ H_2O}{1\ \text{mol}\ O_2} \left| \frac{18\ g\ H_2O}{1\ \text{mol}\ H_2O} \right. = 122.4\ g\ H_2O$$

AVAILABLE

2b. Limiting Reagent: H_2 Excess Reagent: O_2

2c. START LIMIT → EXCESS

$$6.4\ \text{mol}\ H_2 \left| \frac{1\ \text{mol}\ O_2}{2\ \text{mol}\ H_2} \right| \frac{32\ g\ O_2}{1\ \text{mol}\ O_2} = 102.4\ g\ O_2$$

USE

$$108.8\ g - 102.4\ g = 6.4\ g$$

LEFT

3. $2\ P_2O_5 + 6\ H_2O \rightarrow 4\ H_3PO_4$ 68.13 g P_2O_5 & 1.52 mol H_2O

3a.

$$68.13\ g\ P_2O_5 \left| \frac{1\ \text{mol}\ P_2O_5}{142\ g\ P_2O_5} \right| \frac{4\ \text{mol}\ H_3PO_4}{2\ \text{mol}\ P_2O_5} \left| \frac{98\ g\ H_3PO_4}{1\ \text{mol}\ H_3PO_4} \right. = 94.03\ g\ H_3PO_4$$

$$1.52\ \text{mol}\ H_2O \left| \frac{4\ \text{mol}\ H_3PO_4}{6\ \text{mol}\ H_2O} \right| \frac{98\ g\ H_3PO_4}{1\ \text{mol}\ H_3PO_4} = 99.31\ g\ H_3PO_4$$

AVAILABLE

3b. Limiting Reagent: P_2O_5 Excess Reagent: H_2O

3c. START LIMIT → EXCESS

$$68.13\ g\ P_2O_5 \left| \frac{1\ \text{mol}\ P_2O_5}{142\ g\ P_2O_5} \right| \frac{6\ \text{mol}\ H_2O}{2\ \text{mol}\ P_2O_5} \left| \frac{18\ g\ H_2O}{1\ \text{mol}\ H_2O} \right. = 25.91\ g\ H_2O$$

USE

$$1.52\ \text{mol}\ H_2O \left| \frac{18\ g\ H_2O}{1\ \text{mol}\ H_2O} \right. = 27.36\ g\ H_2O$$

AVAILABLE

$$27.36\ g - 25.91\ g = 1.45\ g$$

LEFT

4. $4\ P + 5\ O_2 \rightarrow 2\ P_2O_5$ 449.07 g P & 114 g O_2

4a.

$$\frac{449.07\ g\ P}{} \left|\ \frac{1\ mol\ P}{31\ g\ P}\ \right|\ \frac{2\ mol\ P_2O_5}{4\ mol\ P}\ \left|\ \frac{142\ g\ P_2O_5}{1\ mol\ P_2O_5} = 1028.52\ g\ P_2O_5\right.$$

AVAILABLE

$$114\ g\ O_2 \left|\ \frac{1\ mol\ O_2}{32\ g\ O_2}\ \right|\ \frac{2\ mol\ P_2O_5}{5\ mol\ O_2}\ \left|\ \frac{142\ g\ P_2O_5}{1\ mol\ P_2O_5} = 202.35\ g\ P_2O_5\right.$$

4b. Limiting Reagent: O_2 Excess Reagent: P

4c.

START LIMIT → EXCESS

$$114\ g\ O_2 \left|\ \frac{1\ mol\ O_2}{32\ g\ O_2}\ \right|\ \frac{4\ mol\ P}{5\ mol\ O_2}\ \left|\ \frac{31\ g\ P}{1\ mol\ P} = 88.35\ g\ P\right.$$

USE

449.07 g − 88.35 g = 360.72 g LEFT

5. $N_2 + 3\ H_2 \rightarrow 2\ NH_3$ 1.00 g N_2 1.00 g H_2

5a.

will do in class

5b. Limiting Reagent: Excess Reagent:

5c.

WILL DO IN CLASS

6. $Mg + 2\ HCl \rightarrow MgCl_2 + H_2$ 1.00g Mg 1.00g HCl

6a

6b. Limiting Reagent

Excess Reagent

6c

7. $3\ AgNO_3 + Na_3PO_4 \rightarrow Ag_3PO_4 + 3\ NaNO_3$ 1.00g $AgNO_3$ 1.00 g Na_3PO_4

7a

7b. Limiting Reagent

Excess Reagent

7c

1. SOLVE % ERROR = $\frac{(A - E)}{A}$ X 100 %

2. SOLVE FOR EMPIRICAL FORMULA

3. NOMENCLATURE

4. By Mae Chemical configuration

5. Isotope Calculations

6. SIG FIGS

+ − LOWEST COMMON PLACE VALUE

X ÷ LEAST SIG FIG