

Review Package #2

Percentage Composition, Empirical and Molecular Formulae:

1. Write the empirical formula for each of the following compounds.

- | | |
|-------------------|--------------------------------|
| a) P_4O_{10} | <u>P_2O_5</u> |
| b) Mg_2Cl_4 | <u>$MgCl_2$</u> |
| c) $Pb_2(CO_3)_4$ | <u>$Pb(CO_3)_2$</u> |
| d) N_2O_2 | <u>NO</u> |

2. Calculate the percentage composition by mass of each of the following compounds. a) CO_2 b) C_4H_8O

$$CO_2 \text{ MM} = 44.0 \text{ g/mol}$$

$$\%C = \frac{12.0 \text{ g/mol}}{44.0 \text{ g/mol}} \times 100\% = 27.3\%$$

$$\%O = \frac{32.0 \text{ g/mol}}{44.0 \text{ g/mol}} \times 100\% = 72.7\%$$

$$C_4H_8O \text{ MM} = 72.0 \text{ g/mol}$$

$$\%C = \frac{48.0 \text{ g/mol}}{72.0 \text{ g/mol}} \times 100\% = 66.7\%$$

$$\%O = \frac{16.0 \text{ g/mol}}{72.0 \text{ g/mol}} \times 100\% = 22.2\%$$

$$\%H = \frac{8.0 \text{ g/mol}}{72.0 \text{ g/mol}} \times 100\% = 11.1\%$$

3. Calculate the percentage composition of the bold species in each of the following compounds. a) $Cu(NO_3)_2$ b) $NaSCN \cdot 5H_2O$

$$Cu(NO_3)_2 \text{ MM} =$$

$$\%NO_3 = \frac{124.0 \text{ g/mol}}{187.6 \text{ g/mol}} \times 100\% = 66.12\%$$

$$NaSCN \cdot 5H_2O \text{ MM}$$

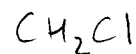
$$\%H_2O = \frac{90.0 \text{ g/mol}}{171.1 \text{ g/mol}} \times 100\% = 52.6\%$$

4. a) A compound has the following composition: 24.24% C, 4.04% H and 71.72% Cl. What is the empirical formula of the compound?

$$P_{mol}C = 24.24\% \times \frac{1 \text{ mol}}{12.0 \text{ g}} = 2.02 \text{ mol} \quad ; \quad 1 \text{ mol}$$

$$P_{mol}H = 4.04\% \times \frac{1 \text{ mol}}{1.0 \text{ g}} = 4.04 \text{ mol} \quad ; \quad 2 \text{ mol}$$

$$P_{mol}Cl = 71.72\% \times \frac{1 \text{ mol}}{35.5 \text{ g}} = 2.04 \text{ mol} \quad ; \quad 1 \text{ mol}$$



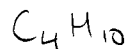
$$\text{MM} = 49.5 \text{ g/mol}$$

b) If the molecular mass of this compound is 99.5 g/mol, what is the molecular formula?

$$\frac{\text{molecular mass}}{\text{empirical mass}} = \frac{99.5 \text{ g/mol}}{49.5 \text{ g/mol}} = 2 \quad ; \quad C_2H_4Cl_2$$

5. The molar mass of a compound is 58 g/mol. What is the molecular formula of the compound if the empirical formula is C_2H_5 ?

$$\downarrow \text{MM} = 29.0 \text{ g/mol}$$



half of molar mass

Molarity Calculations:

1. If a 4.50g sample of solid NaOH is dissolved to make 0.500L of solution, what is the molarity of the solution?

$$\text{MM NaOH} = 40.0 \text{ g/mol}$$
$$P_{\text{mols NaOH}} = 4.50 \text{ g} \times \frac{1 \text{ mol}}{40.0 \text{ g}} = 0.1125 \text{ mol}$$
$$C = \frac{n}{V} = \frac{0.1125 \text{ mol}}{0.500 \text{ L}} = 0.225 \text{ M}$$

2. How many grams of Na_2CO_3 would be required to produce 400.0mL of 0.600M Na_2CO_3 ?

$$\text{MM} = 106.0 \text{ g/mol}$$
$$P_{\text{g Na}_2\text{CO}_3} = 0.4000 \text{ L} \times \frac{0.600 \text{ mol}}{1 \text{ L}} \times \frac{106.0 \text{ g}}{\text{mol}} = 25.4 \text{ g Na}_2\text{CO}_3$$

3. If 75.7g of Magnesium chloride are mixed with sufficient water to make a 0.885M solution, what is the volume of the solution?

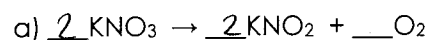
$$\text{MM} = 94.31 \text{ g/mol} \quad \text{MgCl}_2$$
$$P_{\text{V MgCl}_2} = 75.7 \text{ g} \times \frac{1 \text{ mol}}{94.31 \text{ g}} \times \frac{1 \text{ L}}{0.885 \text{ mol}} = 0.907 \text{ L MgCl}_2$$

4. How many mL of 16.4 M H_2SO_4 are needed to prepare 755mL of 0.25M H_2SO_4 ?

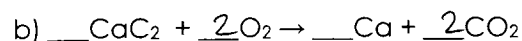
$$C_1 V_1 = C_2 V_2$$
$$C_1 = 16.4 \text{ M} \quad V_2 = 755 \text{ mL} \quad V_1 = V_2 \cdot \frac{C_2}{C_1} = 755 \text{ mL} \cdot \frac{0.25 \text{ M}}{16.4 \text{ M}} = 12 \text{ mL}$$
$$V_1 = ? \quad C_2 = 0.25 \text{ M}$$

Chemical Reactions and Equations:

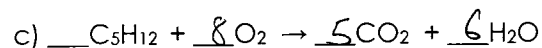
1. Balance and classify the following chemical reactions.



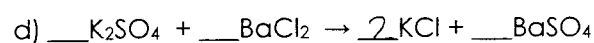
Type of Reaction
decomposition



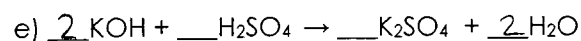
single replacement



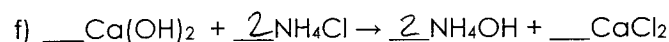
combustion



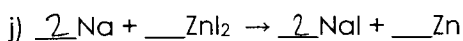
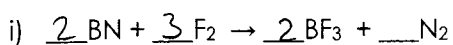
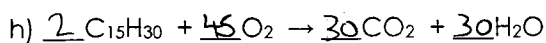
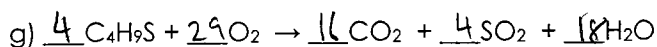
double replacement



double replacement (acid/base)



double replacement



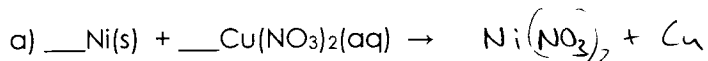
combustion

combustion

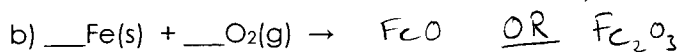
single replacement

single replacement

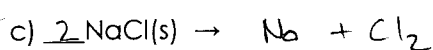
2. Classify, complete AND balance the following chemical equations. Type of Reaction



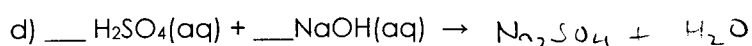
single replacement



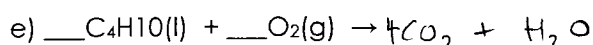
synthesis



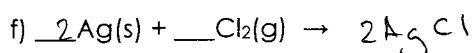
decomposition



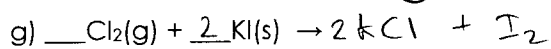
double replacement/neutralization



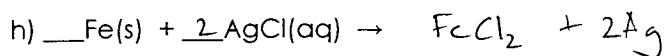
combustion



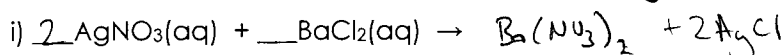
synthesis



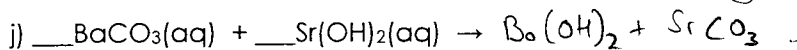
single replacement



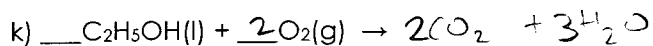
single replacement



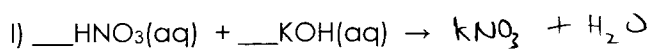
double replacement



double replacement



combustion



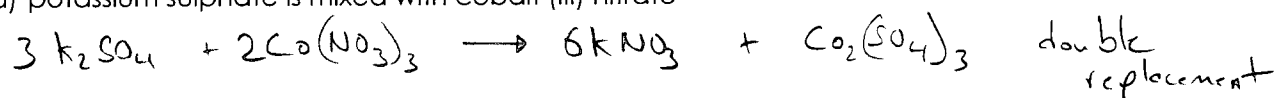
double replacement/neutralization

need to know what type of Fe

need to know what type of Fe

3. Write a balanced chemical equation for each of the following, and classify each as synthesis, decomposition, single replacement, double replacement, neutralization or combustion.

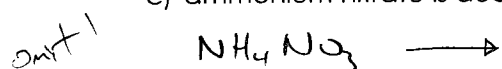
a) potassium sulphate is mixed with cobalt (III) nitrate



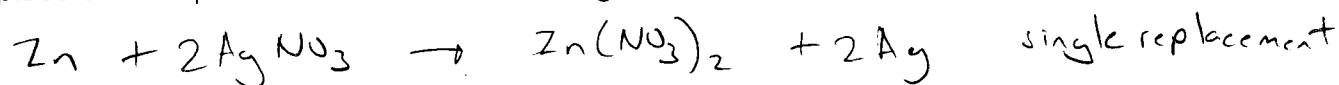
b) liquid propanol ($\text{C}_3\text{H}_7\text{OH}$) is burned in air



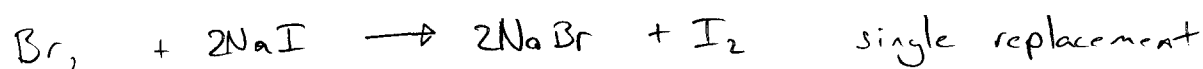
c) ammonium nitrate is decomposed into it's elements



d) a piece of zinc is placed in a test-tube containing a solution of silver nitrate



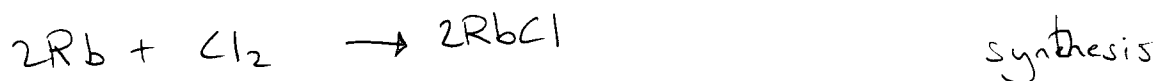
e) bromine reacts with sodium iodide



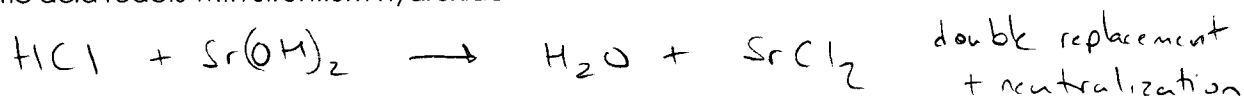
f) bromine reacts with aluminum



g) rubidium reacts with chlorine gas



h) hydrochloric acid reacts with strontium hydroxide



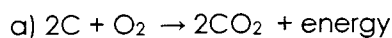
Energy of Reactions:

1. Define ENDOTHERMIC and EXOTHERMIC reactions.

Endothermic: A chemical reaction that consumes/absorbs heat
 $\Delta H = +$

Exothermic: A chemical reaction that release heat
 $\Delta H = -$

2. Classify the following reactions as either endothermic or exothermic.



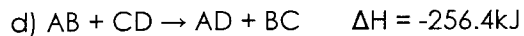
Exo



Endo



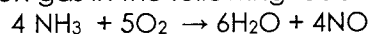
Exo



Exo

Stoichiometry:

1. Ammonia combines with oxygen gas in the following reaction:

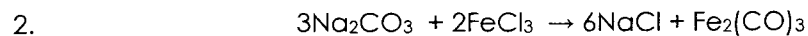


b) How many moles of NH_3 are needed to combine with 3.57 moles of O_2 gas?

$$? \text{ mol } NH_3 = 3.57 \text{ mol } O_2 \times \frac{4 NH_3}{5 O_2} = 2.86 \text{ mol } NH_3$$

c) If 1.5 grams of NO is produced in the above reaction, how many grams of NH_3 were reacted?

$$? \text{ g } NH_3 = 1.5 \text{ g } NO \times \frac{1 \text{ mol}}{30.0 \text{ g}} \times \frac{4 NH_3}{4 NO} \times \frac{17.0 \text{ g}}{1 \text{ mol}} = 0.85 \text{ g } NH_3$$



\nearrow $MM = 106.0$

a) How many grams of $NaCl$ will be produced from the reaction of 0.080 moles of Na_2CO_3 with excess $FeCl_3$?

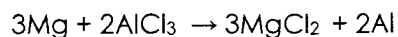
$$? \text{ g } NaCl = 0.080 \text{ mol } Na_2CO_3 \times \frac{1 \text{ mol}}{106.0 \text{ g}} \times \frac{6 NaCl}{3 Na_2CO_3} \times \frac{58.5 \text{ g}}{1 \text{ mol}} = 0.088 \text{ g } NaCl$$

b) How many grams of $FeCl_3$ would be needed to react with 4.2g of Na_2CO_3 ?

$$MM = 162.3 \text{ g/mol}$$

$$? \text{ g } FeCl_3 = 4.2 \text{ g} \times \frac{1 \text{ mol}}{106.0 \text{ g}} \times \frac{2 FeCl_3}{3 Na_2CO_3} \times \frac{162.3 \text{ g}}{1 \text{ mol}} = 4.3 \text{ g } FeCl_3$$

3.



a) How many grams of MgCl_2 would be formed if 50.0 mL of 0.200 M AlCl_3 is reacted with excess Mg?

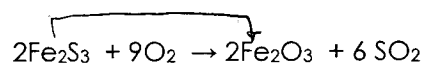
$$P_g \text{MgCl}_2 = 50.0 \text{ mL AlCl}_3 \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.200 \text{ mol}}{1 \text{ mol}} \times \frac{3 \text{ MgCl}_2}{2 \text{ AlCl}_3} \times \frac{943 \text{ g}}{1 \text{ mol}} = 1.41 \text{ g}$$

b) How many mL of 0.150 M AlCl_3 would be needed to react completely with 2.00 g of Mg?

$$P_V \text{AlCl}_3 = 2.00 \text{ g Mg} \times \frac{1 \text{ mol}}{24.3 \text{ g}} \times \frac{2 \text{ AlCl}_3}{3 \text{ Mg}} \times \frac{1 \text{ L}}{0.150 \text{ mol}} \times \frac{1000 \text{ mL}}{1 \text{ L}} = 366 \text{ mL}$$

Excess and Limiting Reagents/Percent Yield:

1.



In a chemical reaction 6.92 g of Fe_2S_3 is combined with 4.54 g of oxygen gas.

a) Which reactant is the **LIMITING** reagent?

$$P_g \text{Fe}_2\text{O}_3 = 6.92 \text{ g Fe}_2\text{S}_3 \times \frac{1 \text{ mol}}{207.9 \text{ g}} \times \frac{2 \text{ Fe}_2\text{O}_3}{2 \text{ Fe}_2\text{S}_3} \times \frac{159.6 \text{ g}}{1 \text{ mol}} = 5.31 \text{ g Fe}_2\text{O}_3$$

Excess

$$P_g \text{Fe}_2\text{O}_3 = 4.54 \text{ g O}_2 \times \frac{1 \text{ mol}}{32.0 \text{ g}} \times \frac{2 \text{ Fe}_2\text{O}_3}{9 \text{ O}_2} \times \frac{159.6 \text{ g}}{1 \text{ mol}} = 5.03 \text{ g Fe}_2\text{O}_3$$

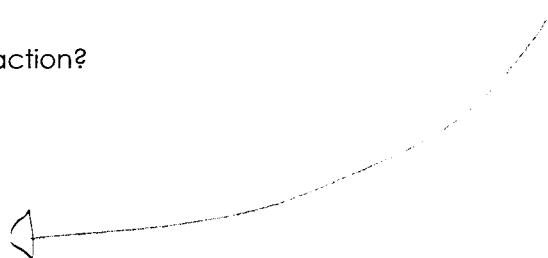
Limit

b) How many grams of the **EXCESS** reactant will be **left over** after the reaction is complete?

$$P_g \text{Fe}_2\text{S}_3 = 4.54 \text{ g O}_2 \times \frac{1 \text{ mol}}{32.0 \text{ g}} \times \frac{2 \text{ Fe}_2\text{S}_3}{9 \text{ O}_2} \times \frac{207.9 \text{ g}}{1 \text{ mol}} = 6.55 \text{ g Fe}_2\text{S}_3$$

$$\text{Excess} = 6.92 \text{ g} - 6.55 \text{ g} = 0.37 \text{ g}$$

c) How many grams of Fe_2O_3 can be formed in this reaction?



2. What mass of P_4 will be produced when 41.5g of $Ca_3(PO_4)_2$, 26.3g of SiO_2 , and 7.80g of C are reacted according to the following balanced equation?



$$P_g P_4 = 41.5g Ca_3(PO_4)_2 \times \frac{1 mol}{310.2g} \times \frac{1 P_4}{2 Ca_3(PO_4)_2} \times \frac{124.0g}{1 mol} = 8.29g$$

$$P_g P_4 = 26.3g SiO_2 \times \frac{1 mol}{60.1g} \times \frac{1 P_4}{6 SiO_2} \times \frac{124.0g}{1 mol} = 9.04g$$

$$P_g P_4 = 7.80g C \times \frac{1 mol}{12.0g} \times \frac{1 P_4}{10 C} \times \frac{124.0g}{1 mol} = \boxed{8.06g}$$

3. $4Al + 3O_2 \rightarrow 2Al_2O_3$

a) How many grams of aluminum oxide, Al_2O_3 , would be expected to form in the reaction of 15.0g Al with 18.43g of oxygen gas?

$$P_g Al_2O_3 = 15.0g Al \times \frac{1 mol}{27.0g} \times \frac{2 Al_2O_3}{4 Al} \times \frac{102.0g}{1 mol} = \boxed{28.3g}$$

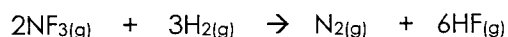
$$P_g Al_2O_3 = 18.43g O_2 \times \frac{1 mol}{32.0g} \times \frac{2 Al_2O_3}{3 O_2} \times \frac{102.0g}{1 mol} = 39.2g$$

b) If the actual yield of Al_2O_3 produced in the reaction was only 22.4g Al_2O_3 , what would the PERCENT YIELD of the reaction be?

$$\% \text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\% = \frac{22.4g}{28.3g} \times 100\% = \boxed{79.2\%}$$

Extra Stoich Problems:

1. Given the following balanced equation, answer the questions following it:



a) If 5.5 moles of H_2 are reacted, how many moles of NF_3 will be consumed?

$$? \text{ mol NF}_3 = 5.5 \text{ mol H}_2 \times \frac{2 \text{ NF}_3}{3 \text{ H}_2} = 3.7 \text{ mol NF}_3$$

Answer 3.7 mol NF₃

b) In order to produce 0.47 moles of HF, how many moles of NF_3 would be consumed?

$$? \text{ mol NF}_3 = 0.47 \text{ mol HF} \times \frac{2 \text{ NF}_3}{6 \text{ HF}} = 0.16 \text{ mol NF}_3$$

Answer 0.16 mol NF₃

c) If you needed to produce 180.6 g of N_2 , how many moles of H_2 would you need to start with?

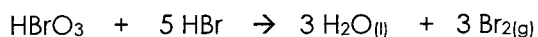
$$? \text{ mol H}_2 = 180.6 \text{ g N}_2 \times \frac{1 \text{ mol}}{28.0 \text{ g}} \times \frac{3 \text{ H}_2}{1 \text{ N}_2} = 19.35 \text{ mol}$$

Answer 19.4 mol H₂

d) If you completely react 17.04 g of NF_3 , what mass of HF will be produced?

$$? \text{ g HF} = 17.04 \text{ g NF}_3 \times \frac{1 \text{ mol}}{71.0 \text{ g}} \times \frac{6 \text{ HF}}{2 \text{ NF}_3} \times \frac{20.0 \text{ g}}{1 \text{ mol}} = \text{Answer } \underline{14.4 \text{ g HF}}$$

2. Given the following balanced equation, answer the questions following it:



a) If 3.56 moles of HBr are reacted, how many Litres of Br₂ will be formed at STP?

$$P_{\text{L Br}_2} = 3.56 \text{ mol HBr} \times \frac{3 \text{ Br}_2}{5 \text{ HBr}} \times \frac{22.4 \text{ L}}{1 \text{ mol}} = 47.8 \text{ L}$$

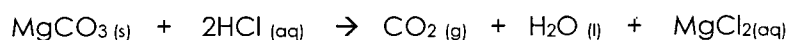
Answer 47.8 L Br₂

b) In order to produce 3.311×10^{24} molecules of Br₂, what mass of HBr is needed?

$$P_{\text{g HBr}} = 3.311 \times 10^{24} \text{ molec} \times \frac{1 \text{ mol}}{6.02 \times 10^{23} \text{ molec}} \times \frac{5 \text{ HBr}}{3 \text{ Br}_2} \times \frac{80.9 \text{ g}}{1 \text{ mol}} = 742 \text{ g}$$

Answer 742 g HBr

3. Given the following balanced chemical equation, answer the question below it.



a) What mass of MgCO₃ will react completely with 15.0 mL of 1.5 M HCl?

$$P_{\text{g MgCO}_3} = 15.0 \text{ mL HCl} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1.5 \text{ mol}}{1 \text{ L}} \times \frac{1 \text{ MgCO}_3}{2 \text{ HCl}} \times \frac{84.3 \text{ g}}{1 \text{ mol}} = 0.948 \text{ g}$$

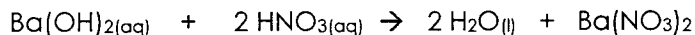
Answer 0.948 g MgCO₃

b) Calculate the volume of 2.0 M HCl which would be needed to react completely with 37.935 grams of magnesium carbonate.

$$P_{\text{L HCl}} = 37.935 \text{ g MgCO}_3 \times \frac{1 \text{ mol}}{84.3 \text{ g}} \times \frac{2 \text{ HCl}}{1 \text{ MgCO}_3} \times \frac{1 \text{ L}}{2.0 \text{ mol}} = 0.45 \text{ L}$$

Answer 0.45 L HCl

4. Given the following balanced equation, answer the questions below it.



a) In a titration, 18.20 mL of 0.300 M $\text{Ba}(\text{OH})_2$ is required to react completely with a 25.0 mL sample of a solution of HNO_3 . Find the $[\text{HNO}_3]$.

$$P_{\text{mol HNO}_3} = 18.20 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.300 \text{ mol}}{\text{L}} \times \frac{2 \text{ HNO}_3}{1 \text{ Ba}(\text{OH})_2} = 0.01092 \text{ mol HNO}_3$$

$$C = \frac{n}{V} = \frac{0.01092 \text{ mol HNO}_3}{0.0250 \text{ L}} = 0.437 \text{ M}$$

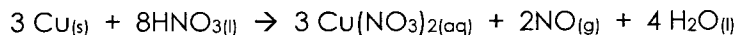
Answer 0.437 M HNO_3

b) In a titration, 11.06 mL of 0.200 M HNO_3 is required to react completely with a sample of 0.250 M $\text{Ba}(\text{OH})_2$. Find the volume of the $\text{Ba}(\text{OH})_2$ sample.

$$P_{V \text{ Ba}(\text{OH})_2} = 11.06 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{0.200 \text{ mol}}{\text{L}} \times \frac{1 \text{ Ba}(\text{OH})_2}{2 \text{ HNO}_3} \times \frac{1 \text{ L}}{0.250 \text{ mol}} = 0.00884 \text{ L} = 8.84 \text{ mL}$$

Answer 8.84 mL

5. Given the following balanced equation, answer the questions below it.



a) If 317.5 grams of Cu are placed into 756.0 grams of HNO_3 , determine which reactant is in excess.

$$P_{\text{g NO}} = 317.5 \text{ g Cu} \times \frac{1 \text{ mol}}{63.6 \text{ g}} \times \frac{2 \text{ NO}}{3 \text{ Cu}} \times \frac{30.0 \text{ g NO}}{1 \text{ mol}} = 99.8 \text{ g} \text{ --- Excess!}$$

$$P_{\text{g NO}} = 756.0 \text{ g HNO}_3 \times \frac{1 \text{ mol}}{63.0 \text{ g}} \times \frac{2 \text{ NO}}{8 \text{ HNO}_3} \times \frac{30.0 \text{ g NO}}{1 \text{ mol}} = 90.0 \text{ g}$$

Answer 90.0g

b) If the reaction in (a) is carried out, what mass of NO will be formed?

Answer 90.0g

6. Given the balanced equation: $2\text{BN} + 3\text{F}_2 \rightarrow 2\text{BF}_3 + \text{N}_2$,

When 161.2 grams of BN are added to an excess of F_2 , a reaction occurs in which 326.118 grams of BF_3 are formed.

a) Calculate the theoretical yield of BF_3 in grams.

$$\text{P.g BF}_3 = 161.2\text{g BN} \times \frac{1\text{mol}}{24.8\text{g}} \times \frac{2\text{BF}_3}{2\text{BN}} \times \frac{67.8\text{g}}{1\text{mol}} = 440.7\text{g}$$

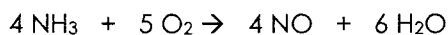
Answer 441g BF_3

b) Calculate the percentage yield of BF_3 .

$$\% \text{ yield} = \frac{\text{Actual yield}}{\text{theo yield}} \times 100\%$$
$$= \frac{326.118\text{g}}{440.7\text{g}} \times 100\% = 74.0\%$$

Answer 74.0%

7. When reacting NH_3 with O_2 according to the reaction:



Using 163.2 grams of NH_3 with an excess of O_2 produces a 67% yield of NO .

a) Calculate the theoretical yield of NO in grams.

$$\text{P.g NO} = 163.2\text{g} \times \frac{1\text{mol}}{17.0\text{g}} \times \frac{4\text{NO}}{4\text{NH}_3} \times \frac{30.0\text{g}}{1\text{mol}} = 288\text{g NO}$$

Answer 288g NO

b) Calculate the actual yield of NO in grams.

$$\text{actual yield} = \frac{\% \text{ yield}}{100\%} \times \text{theo yield}$$
$$= \frac{67\%}{100\%} \times 288\text{g}$$
$$= 192.96\text{g}$$

Answer 193g NO

