

3. Chlorine gas can be produced in the laboratory by adding concentrated hydrochloric acid to manganese(IV) oxide in the following reaction: $MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O$

a. Calculate the mass of MnO_2 needed to produce 25.0g of $MnCl_2$

$$25g Cl_2 \times \frac{1 mol Cl_2}{70.90g} \times \frac{1 mol MnO_2}{1 mol MnCl_2} \times \frac{86.94g}{1 mol} = 17.27g MnO_2$$

b. What mass of H_2O is produced when 0.091g of $MnCl_2$ is generated?

$$.091g MnCl_2 \times \frac{1 mol MnCl_2}{125.84g} \times \frac{2 mol H_2O}{1 mol MnCl_2} \times \frac{18.02g}{1 mol H_2O} = 0.026g H_2O$$

Part 5: Volume Stoichiometry- Write out the conversion factor needed to solve the following problems:

1. If an excess of nitrogen gas reacts with 25.0 L of hydrogen gas at STP, according to the reaction below, how many L of ammonia will be produced? $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

$$25L H_2 \times \frac{2L NH_3}{3L H_2} = 16.67L NH_3$$

2. What volume of oxygen gas would react with 35.0 L of hydrogen gas at STP, according to the equation below?

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

$$35L H_2 \times \frac{1L O_2}{2L H_2} = 17.5L O_2$$

Part 6: Limiting Reagents: Write out the conversion factor needed to solve the following problems:

1. Use the following equation for the oxidation of aluminum in the following problems. $4Al + 3O_2 \rightarrow 2Al_2O_3$

a.) Which reactant is limiting if 0.32 mol Al and 0.26 mol O_2 are available?

$$.32 mol Al \times \frac{2 mol Al_2O_3}{4 mol Al} = .16 mol Al_2O_3$$

$$.26 mol O_2 \times \frac{2 mol Al_2O_3}{3 mol O_2} = .17 mol Al_2O_3$$

$\therefore Al$ is LR

b.) How many moles of Al_2O_3 are formed from the reaction of 6.38×10^{-3} mol of O_2 and 9.15×10^{-3} mol of Al?

$$6.38 \times 10^{-3} mol O_2 \times \frac{2 mol Al_2O_3}{3 mol O_2} = .00425 mol Al_2O_3$$

$$9.15 \times 10^{-3} mol Al \times \frac{2 mol Al_2O_3}{4 mol Al} = .004575 mol Al_2O_3$$

c.) If 3.17g of Al and 2.55g of O_2 are available, which reactant is limiting?

$$3.17g Al \times \frac{1 mol Al}{26.982g} \times \frac{2 mol Al_2O_3}{4 mol Al} = .0587 mol Al_2O_3$$

$$2.55g O_2 \times \frac{1 mol O_2}{32g} \times \frac{2 mol Al_2O_3}{3 mol O_2} = .0531 mol Al_2O_3$$

$\therefore O_2$ is LR

2. A reaction such as the one shown here is often used to demonstrate a single replacement reaction.



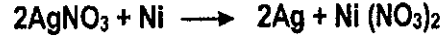
If you place 0.092 mol of iron filings in a solution containing 0.158 mol of $CuSO_4$, what is the limiting reactant? How many moles of Cu will be formed?

$$.092 mol Fe \times \frac{3 mol Cu}{2 mol Fe} = .138 mol Cu$$

$$.158 mol CuSO_4 \times \frac{3 mol Cu}{3 mol CuSO_4} = .158 mol Cu$$

$\therefore Fe$ is LR

3. Nickel replaces silver from silver nitrate in solution according to the following equation:



a.) If you have 22.9g of Ni and 112g of $AgNO_3$, which reactant is in excess?

$$22.9g Ni \times \frac{1 mol Ni}{58.693g} \times \frac{1 mol Ni(NO_3)_2}{1 mol Ni} = .39 mol Ni(NO_3)_2$$

$$112g AgNO_3 \times \frac{1 mol AgNO_3}{169.88g} \times \frac{1 mol}{2 mol} = .33 mol AgNO_3$$

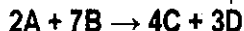
$\therefore AgNO_3$ is LR

b.) What mass of nickel (II) nitrate would be produced given the quantities above?

$$.33 mol Ni(NO_3)_2 \times \frac{182.713g}{1 mol} = 60.3g Ni(NO_3)_2$$

Part 7: Percent Yield: : Write out the conversion factor needed to solve the following problems:

1. Assume the following hypothetical reaction takes place.



Calculate the percentage yield in each of the cases:

a. The reaction of 0.0251 mol of A produces 0.0349 mol of C

$$0.0251 \text{ mol A} \times \frac{4 \text{ mol C}}{2 \text{ mol A}} = 0.0502 \text{ mol C} \quad \text{theoretical}$$
$$\% \text{ yield} = \frac{0.0349}{0.0502} \times 100 = 69.5\%$$

b. The reaction of 1.19 mol of A produces 1.41 mol of D

$$1.19 \text{ mol A} \times \frac{3 \text{ mol D}}{2 \text{ mol A}} = 1.785 \text{ mol D} \quad \text{theoretical}$$
$$\% \text{ yield} = \frac{1.41}{1.785} \times 100 = 78.99\%$$

c. The reaction of 189 mol of B produces 39 mol of D

$$189 \text{ mol B} \times \frac{3 \text{ mol D}}{7 \text{ mol B}} = 81 \text{ mol D} \quad \text{theoretical}$$
$$\% \text{ yield} = \frac{39}{81} \times 100 = 48.15\%$$

d. The reaction of 3500 mol of B produces 1700 mol of C

$$3500 \text{ mol B} \times \frac{4 \text{ mol C}}{7 \text{ mol B}} = 2000 \text{ mol C} \quad \text{theoretical}$$
$$\% \text{ yield} = \frac{1700}{2000} \times 100 = 85\%$$

2. Elemental Phosphorous can be produced by heating calcium phosphate from rocks with silica from sand and carbon in the form of coke. The following reaction takes place: $\text{Ca}_3(\text{PO}_4)_2 + 3\text{SiO}_2 + 5\text{C} \rightarrow 3\text{CaSiO}_3 + 2\text{P} + 5\text{CO}$

a. If 57 mol of $\text{Ca}_3(\text{PO}_4)_2$ is used and 101 mol of CaSiO_3 is obtained what is the percentage yield?

$$57 \text{ mol Ca}_3(\text{PO}_4)_2 \times \frac{3 \text{ mol CaSiO}_3}{1 \text{ mol Ca}_3(\text{PO}_4)_2} = 171 \text{ mol CaSiO}_3 \quad \text{theoretical}$$
$$\% \text{ yield} = \frac{101}{171} \times 100 = 59\%$$

b. Determine the percentage yield obtained if 1280 mol of carbon is consumed and 622 mol of CaSiO_3 is produced.

$$1280 \text{ mol C} \times \frac{3 \text{ mol CaSiO}_3}{5 \text{ mol C}} = 768 \text{ mol CaSiO}_3 \quad \text{theoretical}$$

$$\% \text{ yield} = \frac{622}{768} \times 100 = 80.99\%$$