Limiting and Excess Reagent Problems

Objective: Determine the quantity of product produced if given the quantity of two or more reactants.

Techniques and Definitions

Limiting Reagent: The reactant which is get's used up first. The product yield is based on the complete consumption of the limiting reagent.

Excess Reagent: The reactant which does not get completely consumed

Stoichiometric Proportions: The ratio of the stoichiometric coefficients of two chemical species. There are no excess reagents when two or more reactants are mixed in stoichiometric proportions.

Tips: Identify moles of all reactants present and divide by stoichiometric coefficients. The smallest value represents the limiting reagent, the larger value(s) represent the excess reagent. If all values are the same they are in stoichiometric proportions.

To Calculate moles of Excess reagent you subtract the amount used with the complete consumption of the limiting reagent from the initial moles of the excess reagent.

(in class)

Analine, ($C_6H_5NH_2$) can be formed from nitro benzene ($C_6H_5NO_2$) by the following equation:

$4C_6H_5NO_2 + 9Fe + 4H_2O \text{ ---> } 4C_6H_5NH_2 + 3\ Fe_3O_4$

(123.105) g/mol (55.845) g/mol (18.016) g/mol (93.121g/mol) g/mol (231.535) l g/mol

1) What is the minimum mass in grams of iron which would be required to consume 3.48 grams of nitrobenzene?

$$3.48g\, C_6H_5NO_2\left(\frac{mol\ C_6H_5NO_2}{123.105\, g}\right)\left(\frac{9\, mol\ Fe}{4mol\ C_6H_5NO_2}\right)\left(\frac{55.845g\ Fe}{mol}\right) = 3.55g\ Fe$$

2) What mass of iron would be left over if 5.00 g of iron reacted with 3.48 g nitrobenzene?

Step 1: Calculate mass of iron required to consume 3.48 g $C_6H_5NO_2$

$$3.48g\, C_6H_5NO_2 \left(\frac{mol\ C_6H_5NO_2}{123.105\, g}\right)\left(\frac{9\, mol\ Fe}{4 mol\ C_6H_5NO_2}\right)\left(\frac{55.845 g\ Fe}{mol}\right) = 3.55 g\ Fe$$

Step 1: Subtract that from the initial mass of iron

5.00g - 3.55g = 1.45g iron in excess

3) How many moles of analine would be formed if 3.78moles of iron and 5.69 moles of nitrobenzene were mixed in excess water?

$$\begin{array}{lll} 4C_6H_5NO_2 \quad + & 9Fe \quad + & 4H_2O \rightarrow 4C_6H_5NH_2 + 3Fe_3O_2 \\ nitrobenzene & iron & water \\ \left(\frac{5.69 mol}{4}\right) & \left(\frac{3.78 mol}{9}\right) & (excess) \\ 1.4225 & 0.42 & \end{array}$$

As $0.42 \langle 1.42$ iron is the limiting reagent

$$3.78 molFe\left(\frac{4 mol\ C_6H_5NH_2}{9\, mol\ Fe}\right) = 1.68 mole\, C_6H_5NH_2$$

4) How many grams of analine would be formed if 3.78 g of iron and 5.69 g of nitrobenzene were mixed in excess water?

$$\begin{array}{lll} 4C_6H_5NO_2 \quad + & 9Fe \quad + & 4H_2O \rightarrow 4C_6H_5NH_2 + 3Fe_3O_2 \\ nitrobenzene & iron & water \\ \left(\frac{5.69g\left(\frac{mol}{123.105g}\right)}{4}\right) & \left(\frac{3.78g\left(\frac{mol}{55.845g}\right)}{9}\right) & (excess) \\ 0.0116 & 0.0075 & \end{array}$$

As $0.007 \langle 0.012$ iron is the limiting reagent

$$3.78 gFe\left(\frac{mol\ Fe}{55.845 g}\right)\left(\frac{4 mol\ C_6H_5NH_2}{9\, mol\ Fe}\right)\left(\frac{93.121 g\, C_6H_5NH_2}{mol}\right) = 2.80 g\, C_6H_5NH_2$$

5) How many grams of analine would be formed if 32.78g of iron were mixed with 23.89g of nitrobenzene in excess water?

$$4C_6H_5NO_2 \quad + \quad 9Fe \quad + \quad 4H_2O \rightarrow 4C_6H_5NH_2 + 3Fe_3O_2$$

nitrobenzene *iron* *water*

$$\left(\frac{23.89g\left(\frac{mol}{123.105g}\right)}{4}\right) \qquad \left(\frac{32.78g\left(\frac{mol}{55.845g}\right)}{9}\right) \qquad (excess)$$

0.0485 0.065

As $0.065 \langle 0.049$ nitrobenzene is the limiting reagent

$$23.89gC_6H_5NO_2\left(\frac{mol\ C_6H_5NO_2}{123.105g}\right)\left(\frac{4mol\ C_6H_5NH_2}{4\,mol\,C_6H_5NO_2}\right)\left(\frac{93.121g\,C_6H_5NH_2}{mol}\right) = 18.07g\,C_6H_5NH_2$$