Solving Limited Reactant Problems Using Mole Ratio Methods

A reaction in a chemical equation is always located on the left side of the equation while the product is located on the right side of the equation. The reactant in shortest supply is called the limiting reactant, because it limits the amount of product that can form. To solve limited reactant problems, follow these steps:

1. Balance the equation
2. All information must be in moles (It may be necessary to convert grams of reactant and/or product into moles.)
3. Once you have all the reactant information in moles divide moles of each reactant by the respective coefficient in the balanced equation, and the lowest number obtained is the limiting reactant.
4. Once you have identified the limiting reactant, determine amount of product formed in moles or grams depending on what question has been asked.

Problem 1 C_2H_4 (g) + H_2O (g) → C_2H_5OH (l)

What is the maximum amount of C_2H_5OH that can be produced when 1 kg of C_2H_4 reacts with .010 kg of steam (H_2O)?

<u>Step 1</u> Equation is balanced.

<u>Step 2</u> Convert C_2H_4 and H_2O into moles.

1 mole C_2H_4 = 28g 1 mole H_2O = 18 g

1 kg C_2H_4 = 1000g C_2H_4

$$1000\text{g } C_2H_4 \times \frac{1 \text{ mole } C_2H_4}{28\text{g } C_2H_4} = 35.7 \text{ moles } C_2H_4$$

$$.010 \cancel{\text{kg } H_2O} \times \frac{1000 \cancel{\text{g } H_2O}}{1 \cancel{\text{kg } H_2O}} \times \frac{1 \text{ mole } H_2O}{18 \cancel{\text{g } H_2O}} = .555 \text{ moles } H_2O$$

<u>Step 3</u>

$$\frac{35.7 \text{ moles } C_2H_4}{1 \text{ coefficient } C_2H_4} = 35.7$$

$$\frac{.555 \text{ moles } H_2O}{1 \text{ coefficient } H_2O} = .555 \text{ (limited reactant)}$$

<u>Step 4</u> 1 mole C_2H_5OH = 46g

$$.555 \cancel{\text{moles } C_2H_5OH} \times \frac{46\text{g } C_2H_5OH}{1 \cancel{\text{mole } C_2H_5OH}} = 25.53\text{g } C_2H_5OH$$

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Problem #2

Given the balanced equation: $C_4H_4 + 5\ O_2 \rightarrow 4\ CO_2 + 2\ H_2O$

If 0.3618 moles of C_4H_4 are allowed to react with 1.818 moles of O_2, and this is the only reaction, what is the maximum quantity of carbon dioxide that could be produced?

Step 1 Equation is balanced.
Step 2 Reactants are already converted to moles.
Step 3 Now let's review each reactant with below equation

$\frac{.3618 \text{ moles } C_4H_4}{1 \text{ coefficient } C_4H_4} = .3618$ (limited reactant)

$\frac{1.818 \text{ moles } O_2}{5 \text{ coefficient } O_2} = .3636$

Step 4 Determine the amount of CO_2 that can be produced from C_4H_4 (limiting reactant).

4 moles of CO_2 is produced by 1 mole of C_4H_4 in the reaction.

$$.3618\ \cancel{\text{moles } C_4H_4} \times \frac{4 \text{ moles } CO_2}{1\ \cancel{\text{mole of } C_4H_4}} = 1.4472 \text{ moles } CO_2$$

Problem #2, Alternate solution

Another way to solve this problem is to estimate the amount of product that each quantity of reactant will produce.

In problem #2, the solution is:

1 mole of C_4H_4 will produce 4 moles of CO_2 (limited reactant)

$$\therefore\ .3618 \text{ moles } C_4H_4 \times \frac{4 \text{ moles } CO_2}{1 \text{ mole } C_4H_4} = 1.4472 \text{ moles } CO_2$$

5 moles O_2 will produce 4 moles CO_2

$$\therefore\ 1.818 \text{ moles } O_2 \times \frac{4 \text{ moles } CO_2}{5 \text{ moles } O_2} = 1.45 \text{ moles } CO_2$$

The reactant that produces the least amount of product identified is the limiting reactant.