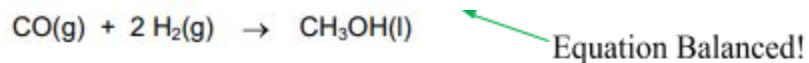


Researchers at Washington University in St. Louis determined the methods by which students acquire concepts as key predictors in their success in chemistry courses. A more abstract based concept building approach is suggested to leverage for greater overall performance and interpretation of chemistry concepts. The following demonstrates the approach from an abstract learning perspective vs. exemplary learning perspective.

The following question depicts the basic attributes of calculating limit reagent and theoretical yield:



Starting with 12.0 g H₂ and 74.5 g CO,

What mass of methanol can be obtained (in theory)?

$$\frac{12.0 \text{ g H}_2}{2.016 \text{ g/mol H}_2} = 5.952 \text{ mol H}_2 \quad \text{PRESENT initially}$$

$$\frac{74.5 \text{ g CO}}{28.0 \text{ g/mol CO}} = 2.661 \text{ mol CO} \quad \text{PRESENT initially}$$

$$2.661 \text{ mol CO reacted} \times \frac{1 \text{ mol CH}_3\text{OH made}}{1 \text{ mol CO reacted}} \times \frac{32.04 \text{ g}}{\text{mol CH}_3\text{OH}} = 85.258.. = \boxed{85.3 \text{ g CH}_3\text{OH}}$$

← Determine which of the reactants is the limiting reagent.

← Use the limiting reagent to calculate the product theoretical yield

In contrast, solving the next problem requires similar skills but requires one step further in abstract thinking, which is outlined in the box on the right:

A reaction container holds 5.77 g of P_4 and 5.77 g of O_2 . The following reaction occurs: $P_4 + O_2 \rightarrow P_4O_6$. If enough oxygen is available then the P_4O_6 reacts further: $P_4O_6 + O_2 \rightarrow P_4O_{10}$.

a. What is the limiting reagent for the formation of P_4O_{10} ?

Step 1: Data given

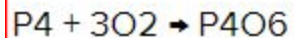
Mass of P_4 = 5.77 grams

Mass of O_2 = 5.77 grams

Molar mass of P_4 = 123.90 g/mol

Molar mass O_2 = 32.0 g/mol

Step 2: The balanced equation



Always make sure
reaction is balanced.

Things needed to be determined:

- Which is the limiting reagent to form P_4O_6
- Is there enough O_2 to further the cascade into the next reaction for P_4O_{10} reaction
- Which limits the P_4O_{10} reaction P_4O_6 or O_2 ?

Step 3: Calculate moles of P4

Moles P4 = mass P4 / molar mass P4

Moles P4 = 5.77 grams / 123.90 g/mol

Moles P4 = 0.0466 moles

Step 4: Calculate moles O2

Moles O2 = mass O2 / molar mass O2

Moles O2 = 5.77 grams / 32.0 g/mol

Moles O2 = 0.1803 moles

Determine the L.R. using
standard procedure

At Step 5 this point some abstract thinking skills
are needed that are not used in the previous
example problem.

Step 5: Calculate limiting reactant

P4 is the limiting reactant in this reaction. It will completely be consumed (0.0466 moles). O2 is in excess, there will react $3 \times 0.0466 = 0.1398$ moles

There will remain $0.1803 - 0.1398 = 0.0405$ moles O2

If one were to go by Example of the first problem above in green, it would not be clear the need to use the balance equation to stoichiometrically know how much O2 has reacted and now left to react with P4O6 in order to form P410.

Step 6: Calculate the amount of P4O6
For 1 mol P4 we'll have 1 mol P4O6
For 0.0466 moles P4 we'll have 0.0466 moles P4O6

Standard procedure using L.R. to determine P4O6

Step 7: The balanced equation
 $\text{P4O6} + 2\text{O2} \rightarrow \text{P4O10}$
We have 0.0466 moles P4O6 and 0.0405 moles O2

Using excess remaining O2 + P4O6 produced to determine the new L.R.

Step 8: Calculate the limiting reactant
For 1 mol P4O6 we need 2 moles O2 to produce 1 mol P4O10
O2 is the limiting reactant. It will completely be consumed (0.0405 moles)

b. What mass of P4O10 is produced?

P4O6 is in excess. There will react $0.0405/2 = 0.02025$ moles P4O10

Standard procedure to determine P4O10 produced

This is $0.02025 * 219.88 \text{ g/mol} = 5.79 \text{ grams P4O10}$