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:

$$CO(g) + 2\,H_2(g) \rightarrow CH_3OH(l)$$

Equation Balanced!

Starting with 12.0 g H_2 and 74.5 g CO,

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

Determine which of the reactants is the limiting reagent.

$$\frac{12.0\text{ g }H_2}{2.016\text{ g/mol }H_2} = 5.9\underline{5}2\text{ mol }H_2 \quad \textbf{PRESENT initially}$$

$$\frac{74.5\text{ g CO}}{28.0\text{ g/mol CO}} = 2.6\underline{6}1\text{ mol CO} \quad \textbf{PRESENT initially}$$

Use the limiting reagent to calculate the product theoretical yield

$$2.6\underline{6}1\text{ mol CO reacted} \times \frac{1\text{ mol }CH_3OH\text{ made}}{1\text{ mol CO reacted}} \times \frac{32.04\text{ g}}{\text{mol }CH_3OH} = 85.\underline{2}58.. = \boxed{85.3\text{ g }CH_3OH}$$

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 P4O10?

Step 1: Data given

Mass of P4 = 5.77 grams

Mass of O2 = 5.77 grams

Molar mass of P4 = 123.90 g/mol

Molar mass O2 = 32.0 g/mol

Things needed to be determined:

- Which is the limiting reagent to form P4O6
- Is there enough O2 to further the cascade into the next reaction for P4O10 reaction
- Which limits the P4O10 reaction P4O6 or O2?

Step 2: The balanced equation

P4 + 3O2 → P4O6

Always make sure reaction is balanced.

Step 3: Calculate moles of P_4

Moles P_4 = mass P_4 / molar mass P_4

Moles P_4 = 5.77 grams / 123.90 g/mol

Moles P_4 = 0.0466 moles

Step 4: Calculate moles O_2

Moles O_2 = mass O_2 / molar mass O_2

Moles O_2 = 5.77 grams / 32.0 g/mol

Moles O_2 = 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

P_4 is the limiting reactant in this reaction. It will completely be consumed (0.0466 moles). O_2 is in excess, there will react 3*0.0466 = 0.1398 moles

There will remain 0.1803 - 0.1398 = 0.0405 moles O_2

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 stoichiometricly know how much O_2 has reacted and now left to react with P_4O_6 in order to form $P_4 1 0$.

Step 6: Calculate the amount of P_4O_6

For 1 mol P_4 we'll have 1 mol P_4O_6

For 0.0466 moles P_4 we'll have 0.0466 moles P_4O_6

Standard procedure using L.R. to determine P_4O_6

Step 7: The balanced equatio

$P_4O_6 + 2O_2 \rightarrow P_4O_{10}$

We have 0.0466 moles P_4O_6 and 0.0405 moles O_2

Step 8: Calculate the limiting reactant

For 1 mol P_4O_6 we need 2 moles O_2 to produce 1 mol P_4O_{10}

O_2 is the limiting reactant. It will completely be consumed (0.0405 moles)

Using excess remaining O_2 + P_4O_6 produced to determine the new L.R.

b. What mass of P_4O_{10} is produced?

P_4O_6 is in excess. There will react 0.0405/2 = 0.02025 moles P_4O_{10}

This is 0.02635 * 219.88 g/mol = 5.79 grams P_4O_{10}

Standard procedure to determine P_4O_{10} produced