Guiding Question revisited

How are chemical equations used to calculate reacting ratios?

In this chapter we have used chemical equations to:

- ☐ Deduce the mole ratio of reactants and products from their coefficients in the balanced equation.
- ☐ Determine masses, volumes and concentrations of reactants and products involved in chemical reactions.
  - When dealing with masses, mole ratios can be converted to a reacting ratio by mass using $m = nM$.
  - For gases, Avogadro's law can be applied to mole ratios to determine a reacting ratio by volume. At STP, we can also convert between moles and volume using $n = \frac{V}{V_m}$ where V_m is the molar volume of a gas (provided in the data booklet).
  - The volumetric analysis of solutions, often carried out using a titration, requires the use of $n = cV$ to calculate the number of moles of one reactant before using the mole ratio to determine the number of moles of the other reactant and then its concentration.
- ☐ Identify the reactant that will be used up first in a reaction, the limiting reactant, by comparing the mole ratio from the balanced equation to the mole ratio in the quantities being reacted. The reactant not fully used is said to be in excess. As the limiting reactant determines the amount of product being formed, we can use it to calculate the expected amount of product, known as the theoretical yield.
- ☐ Quantify the efficiency of a chemical process using percentage yield and atom economy.
  - Percentage yield is calculated from the ratio of experimental yield to theoretical yield using the formula:

$$\text{percentage yield} = \frac{\text{experimental yield}}{\text{theoretical yield}} \times 100$$

  - Atom economy takes into account the amount of waste produced in a reaction by comparing the molar mass of the target product to the molar mass of the reactants used. This formula can be found in the data booklet:

$$\%\ \text{atom economy} = \frac{\text{molar mass of desired product}}{\text{molar mass or all reactants}} \times 100$$