**3 A Chemical Synthesis - an introduction**

The design of a chemical synthesis is affected by a number of factors. Often, the process is commercially driven; therefore, the object is to produce the chemical as efficiently and cheaply as possible, without compromising on safety or environmental factors. In most cases, synthesis involves more than one step, and there may be more than one possible pathway or reaction mechanism. There are many factors to consider when deciding on the appropriate procedure; for example, other possible products, availability and cost of reactants, and the conditions required for the reaction.

In a multistep reaction, each step will have its own reactants, products and activation energy. These will affect the speed of the reaction and the chemicals available for the next step. Along the pathway; the products of one step may be used as reactants for another step. Therefore, these products are used up during the process. These chemicals are known as intermediates. An energy profile diagram can be used to represent the stages of the reaction (Figure 20.2.1).

**FIGURE 20.2.1** Energy profile diagram for a multistep reaction. In Figure 20.2.1:

* A is a reactant
* B and C are intermediates
* D is a product.

When we perform reactions in chemistry, it is often assumed that all the reactants will react to form the products. In reality, this rarely happens. The yield of a reaction refers to the amount of product actually produced from the reactants. A reaction with a high yield will produce a large amount of product from the reactants.

In industry, it is desirable to make as much of the product as possible. To facilitate this, the conditions would be managed so that the position of an equilibrium lies as far to the right as possible. This means that at equilibrium, there will be a much higher proportion of products than reactants, and also, that a high proportion of the reactants have *become* products. The conditions required will vary depending on the reaction; however, there are some common features.

* The **removal** of the product: by decreasing the concentration of a product the forward reaction will be favoured, shifting equilibrium to the right.
* **Recycling** of reactants that have not been used: by recycling the unused reactants, there is less wastage and the concentration of a reactant is increased. This favours the forward reaction, shifting equilibrium to the right.
* Conducting the reaction at an appropriate **temperature**: the temperature chosen should favour the forward reaction so that equilibrium lies as far to the right as possible. At the same time, the effect on the rate of the reaction and the cost of heating should be considered.
* Choosing a suitable **pressure** for a system including gases: the pressure of a gaseous system will affect the position of equilibrium; therefore, the pressure used should favour the forward reaction so that equilibrium lies as far to the right as possible. However, the effect on the rate of the reaction, cost and safety should also be considered.
* A **catalyst** is often used to increase the rate of production of the product. While this does not increase the yield directly, it will mean that the product is produced in a shorter time. It might also mean that the reaction can occur at a sufficiently productive rate at a lower temperature. In this case, if the reaction is exothermic, the lower temperature will also result in a higher yield.

**Questions** – Most of the text above is an introduction and a guide to understanding – except for the last 5 points. You should know and understand how these five factors influence synthesis reactions

1. Which of the five factors above are specific to equilibrium reactions… list them
2. Explain how pressure can be used to influence the position of a gaseous equilibrium synthesis reaction.
3. Explain how increasing the temperature to increase the rate of the reaction, may effect exothermic equilibriums differently to endothermic equilibriums.