CHEM1405 Worksheet 11 – Answers to Critical Thinking Questions

The worksheets are available in the tutorials and form an integral part of the learning outcomes and experience for this unit.

Model 1: Nucleophilic Substitution

1. A new bond is forming between this C atom and the attacking O atom, using the lone pair on this O atom. At the same time, the bond between this C atom and the Cl is breaking. The attack from the O atom inverts the configuration at the C atom.

2. See below.

3. S = substitution, N = nucleophilic, “1” = unimolecular (key or rate determining step involves 1 molecule) and “2” = bimolecular (key or rate determining step involves 2 molecules).

4. $S_N2$ is disfavoured if the C atom being attacked is very crowded. In the first example, the C being attacked is a primary carbon (attached to 2H and 1C) so $S_N2$ is possible. In the second example, the carbon being attacked is a tertiary carbon (attached to 3C) and so is more crowded. $S_N2$ is less likely.

$S_N1$ is favoured when the positive charge in the intermediate can be stabilised. In the first example, the positive charge would be on a primary carbon so would be unstable and difficult to form so $S_N1$ is unlikely. In the second example, the positive charge will be on a tertiary carbon so will be more stable and $S_N1$ is possible.

Overall: the primary alkyl halide reacts via $S_N2$ and the second alkyl halide reacts via $S_N1$.

Model 2: Carboxylic Acid Derivatives

1. See below. The base, B, could be solvent or $\text{H}_2\text{NCH}_3$.
2. Addition of an amine:

3. An alcohol (with its alkyl group corresponding, as shown above, to the \(-\text{OR'}\) group in the ester.

4. Simple \(\text{H}^+\) transfer reactions occur:

5. Step 1: \(\text{CH}_3\text{OH}\) is added and \(\text{H}_2\text{O}\) is removed. The acid and alcohol combine to make an ester in the condensation reaction.

   Step 2: \(\text{H}_2\text{O}\) is added and \(\text{CH}_3\text{OH}\) is removed in this hydrolysis reaction.

6. See below.
7. An acid chloride is more reactive to nucleophiles like water than an amide.