**Exercises for Part A:**

1. Construct a mechanism for the following reaction.

![ChemActivity 31 Nucleophilic Addition to a Carbonyl 283](image)

What could you do to push the reaction toward a high yield of hemiacetal?

2. The reagent Sodium Borohydride (NaBH₄) reacts exactly the way you would expect H⁻ to react (H⁻ is a very strong nucleophile). Given this, predict the product that results when butanal is treated with NaBH₄ followed by dilute HCl.

What reagents could you use to convert this alcohol back to butanal. Hint: this reaction is NOT reversible. Review your reaction sheet labeled oxidation of alcohols.

4. Most strong nucleophiles will react with any aldehyde (and most ketones). Strong nucleophiles we have discussed in this class include:

- Grignard and Lithium reagents (essentially alkane anions, R₃C⁻)
- The conjugate base of a terminal alkyne (RCC⁻)
- Hydride ion, H⁻ (produced by LiAlH₄ or NaBH₄)
- Hydroxide ion, HO⁻ (NaOH or KOH)
- Cyanide ion, NC⁻ (NaCN or KCN)
- Thiolate ion, RS⁻ (e.g. NaSCH₃)

Draw the product of a reaction between cyclohexanone and a representative from each category of nucleophiles above.
5. Construct mechanisms for the following reaction.

\[
\text{H}_3\text{C} = \text{C} = \text{H} \quad \text{aldehyde} \quad \text{K}^+ \quad \text{potassium cyanide} \quad \text{HCl} \quad \text{H}_3\text{C} - \text{C} = \text{N}^\oplus \quad \text{cyanohydrin} \\
\text{(dangerous stuff: less than 1g will kill you)}
\]

6. Formation of a cyanohydrin can also be accomplished using HCN (cyanide gas). Construct a reasonable mechanism for this reaction. Hint: the first step is protonation of the carbonyl oxygen.

\[
\text{H}_3\text{C} = \text{C} = \text{H} \quad \text{aldehyde} \quad \text{H} = \text{C} = \text{N}^\oplus \quad \text{hydrogen cyanide} \quad \text{acts first as an acid} \quad \text{H}_3\text{C} - \text{C} = \text{N}^\oplus \quad \text{cyanohydrin}
\]

7. Show the mechanism by which the following hemi-acetal can be converted into an aldehyde, and draw the resulting aldehyde.
Exercises for Part B

11. Most nucleophiles will react with an acid chloride, even a relatively weak nucleophile such as water (see part a, below). Each of these acid-chloride reactions takes place in at least TWO STEPS!
   a) Use curved arrows to show the mechanism of the following reaction.

   ![Reaction Mechanism](image)

   acid chloride  \[\text{HOH} \rightleftharpoons \text{ROH} + \text{HCl} \text{ carboxylic acid}\]

   b) Use curved arrows to construct a mechanism for the following reaction.

   ![Reaction Mechanism](image)

   acid chloride  \[\text{RNH}_2 \rightleftharpoons \text{RCONH}_2 + \text{NH}_3 \text{ amide} \text{ ammonium salt}\]

   (Rxn requires twice as much amine as acid chloride!)

   c) Construct an explanation for why you need twice as much amine as acid chloride in the reaction in part b. (Hint: an amine is a good base.)

   d) Draw the most likely products of the following reaction.

   ![Reaction Mechanism](image)

   acid chloride  \[\text{ROH} \rightleftharpoons \text{RCH}_2\text{OH} \text{ alcohol}\]