Worksheet – Organic Redox Reactions

Certain organic compounds can undergo redox reactions. Oxidation state changes occur at the reactive carbon in the compound.

1. Assign oxidation states to the highlighted carbons in the three compounds shown below. (Hint: H is usually 1+ and O is usually 2-).

\[ \text{ethanol} \quad 1^\circ \text{alcohol} \]
\[ \text{ethanal} \quad \text{aldehyde} \]
\[ \text{ethanoic acid} \quad \text{carboxylic acid} \]

Oxidizing agents will lead to an increase in the oxidation state of some organic compounds by removing H or adding O. Reducing agent will decrease the oxidation state by removing O or adding H.

The figure below is a summary of the common redox reactions and the reagents which bring them about.

Permanganate and chromate are the strongest oxidizing agents. They will oxidize 1° alcohols completely, to carboxylic acids, and 2° alcohols to ketones. PCC is a weaker oxidizing agent which will oxidize 1° alcohols to aldehydes, and 2° alcohols to ketones.

The reducing agents are also selective. LiAlH₄ is the strongest reducing agent. It will reduce carboxylic acids, aldehydes, and ketones to alcohols. NaBH₄ and H₂/Pt will reduce aldehydes and ketones, but not carboxylic acids. H₂/Pt will also add across C=C bonds (hydrogenation).
2. Identify the reactants (1°, 2°, 3° alcohol, aldehyde, etc) then draw and identify the organic product of each reaction.

a. \[\text{aldehyde} + \text{PCC} \rightarrow \text{no reaction, 1° alcohol}\]

b. \[\text{2° alcohol} + \text{MnO}_4^- \rightarrow \text{ketone}\]

c. \[\text{3° alcohol} + \text{CrO}_4^{2-} \rightarrow \text{no reaction}\]

d. \[\text{1° alcohol} + \text{PCC} \rightarrow \text{aldehyde}\]

3. Identify the reactants then draw and identify the organic product of each reaction.

a. \[\text{aldehyde} + \text{LiAlH}_4 \rightarrow \text{1° alcohol}\]

b. \[\text{carboxylic acid} + \text{NaBH}_4 \rightarrow \text{no reaction}\]

c. \[\text{ketone + alcohol} \rightarrow \text{2° alcohol, alkane}\]

d. \[\text{alcohol + LiAlH}_4 \rightarrow \text{no reaction}\]
4. An organic compound has the empirical formula $C_4H_{10}O$. Upon oxidation with $\text{MnO}_4^-$, it is converted to a compound with the formula $C_4H_8O$. Draw the structure of possible reactants and products.

5. Draw the organic products of the following reactions.
Additional problems:

6. What reagents and experimental conditions will convert 1-propanol to:

   a. propanal
   \[
   \text{CH}_3\text{OH} \xrightarrow{\text{PCC}} \text{CH}_3\text{O}
   \]

   b. propanoic acid
   \[
   \text{CH}_3\text{OH} \xrightarrow{\text{MnO}_4^-} \text{CH}_3\text{O}
   \]

   c. 1-propene
   \[
   \text{CH}_3\text{OH} \xrightarrow{\text{H}^+/\text{H}_2\text{O}} \text{CH}_3\text{O}
   \]

   d. 2-propanol
   \[
   \text{CH}_3\text{OH} \xrightarrow{\text{H}^+/\text{H}_2\text{O}} \text{CH}_3\text{O}
   \]

   e. 2-bromopropane
   \[
   \text{CH}_3\text{OH} \xrightarrow{\text{H}^+/\text{H}_2\text{O}} \text{CH}_3\text{O} + \text{HBr}
   \]

   f. propanone
   \[
   \text{CH}_3\text{OH} \xrightarrow{\text{H}^+/\text{H}_2\text{O}} \text{CH}_3\text{O}
   \]

7. Show how to convert the following compounds:

   a. \[
   \text{CH}_3\text{CH(OH)CH}_3 \xrightarrow{\text{H}^+/\text{H}_2\text{O}} \text{CH}_3\text{C} = \text{CH}_3
   \]

   b. \[
   \text{CH}_3\text{C} = \text{CH}_3 \xrightarrow{\text{H}^+/\text{H}_2\text{O}} \text{CH}_3\text{C} = \text{CH}_3
   \]
b. \[ \text{CH}_3 \text{OH} \xrightarrow{\text{H}^+ / \text{H}_2\text{O}} \text{CH}_3 \text{OH} \]

c. \[ \text{CH}_3 \text{OH} \xrightarrow{\text{MnO}_4^-} \text{CH}_3 \text{C} = \text{O} \]

d. \[ \text{OH} \xrightarrow{\text{H}^+ / \text{H}_2\text{O}} + \text{HCl} \rightarrow \text{CH}_3 \text{Cl} \]

e. \[ \text{OH} \xrightarrow{\text{H}^+ / \text{H}_2\text{O}} \]

\[ \text{OH} \xrightarrow{\text{H}_2/\text{Pt}} \]