Answers to Problem Sheet 3

1. Consider the reaction below:

(a) The Br\(^+\) ion, Q, is attracted to the \(\pi\) electrons of the benzene ring.

(b) P is aromatic. The aromaticity is lost in R.

(c) R has a positive charge on carbon and so is a carbocation.

(d) See diagram.

(e) The reaction involves electrophilic attack on carbon resulting in substitution of \(H^+\) by \(Br^+\): the reaction is an electrophilic substitution.
2. The reaction involves *nucleophilic* attach on carbon leading to *substitution* of bromine by amine. It is a nucleophilic substitution reaction (S_N).

\[ \begin{array}{c}
\text{H}_3\text{C}^+ \text{N}^+ \text{H} \text{C}^+ \text{Br}^-
\end{array} \rightarrow \begin{array}{c}
\text{H}_3\text{C}^+ \text{N}^- \text{C}^+ \text{H} \text{H} \text{H} \text{Br}^-
\end{array} \]

| nucleophile | electrophile |

3. (a) \[ \text{H}_2 \text{C} = \text{H} + \text{Br}_2 \rightarrow \text{H}_2 \text{C} - \text{Br} \]

(b) \[ \text{H}_2 \text{C} = \text{H} + \text{HBr} \rightarrow \text{H}_2 \text{C} - \text{Br} \]

Markovnikov addition - H becomes attached to carbon with fewer alkyl groups attached.

(c) \[ \text{H}_2 \text{C} = \text{H} + \text{dilute H}_2\text{SO}_4 \rightarrow \text{H}_2 \text{C} \text{OH} \]

Markovnikov addition - H becomes attached to carbon with fewer alkyl groups attached.

(d) \[ \text{C}_5\text{H}_5 \text{+ H}_2 \rightarrow \text{C}_5\text{H}_{10} \]

(e) \[ \text{C}_6\text{H}_{12} \text{+ HCl} \rightarrow \text{C}_6\text{H}_{13}\text{Cl} \]

Markovnikov addition - H becomes attached to carbon with fewer alkyl groups attached.
Markovnikov addition twice - each time H becomes attached to carbon with fewer alkyl groups attached.

(g) 

4.

(a) 

(b) 

(c) 

(d)
5.
\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{C}^+ & \quad \text{CH}_3 \\
\text{H}_3\text{C} & \quad \text{C} & \quad \text{O}^\oplus \\
\text{H}_3\text{C} & \quad \text{S}^+ & \quad \text{CH}_3
\end{align*}
\]
(no charges - does not obey 'octet rule')

6. a.

\[
\begin{align*}
\text{H} & \quad \text{C} & \quad \text{H} \\
\text{H}_3\text{C} & \quad \text{C} & \quad \text{Br}^\ominus \\
\text{H}_3\text{C} & \quad \text{C} & \quad \text{Br}^\ominus
\end{align*}
\]

b.

\[
\begin{align*}
\text{Cl} & \quad \text{CH}_2 \\
\text{Cl} & \quad \text{H} \\
\text{Cl} & \quad \text{H}
\end{align*}
\]