*1. (25.5) Show the first complete step of the arrow-pushing mechanism for each of the following. Additionally, show the consequence of your arrows for parts a) through d) only.

a) \[
\text{PhCO}_2\text{Na}^\ominus + \text{CH}_3\text{CH}_2\text{Br} \quad \rightarrow
\]

b) \[
\text{PhCO}_2\text{H} + \text{LiOH} \quad \rightarrow
\]

c) \[
\text{C}_5\text{H}_8\text{O}_2\text{H} + \text{Li}^\ominus \quad \rightarrow
\]

d) \[
\text{Me}_2\text{NH} \quad \rightarrow
\]

e) \[
\text{CF}_3\text{CO}_2\text{H} + \text{O}_2\text{C}_2\text{O} \quad \rightarrow
\]

f) \[
\text{NCH}_3\text{CH}_3\text{Br} + \text{ONa} \quad \rightarrow
\]

g) \[
\text{C}_6\text{H}_6\text{O} + \text{Me}\text{CH}_2\text{MgBr} \quad \rightarrow
\]
*2. (7.5) Draw in the missing charges (if any) on the appropriate atoms in each of the following.

a) \( \text{N}=\text{N}=\text{C} \quad \text{b) N}\equiv\text{C} \quad \text{c) S}\}

\[ \begin{array}{c}
\text{c) S}\}
\end{array} \]

*3. (17.5) Complete each of the following acid-base reactions and, using your knowledge of pKa values, indicate which side of the reaction will be favored.

a) \( \text{OK} + \text{CH}_3\text{CO}_2\text{H} \rightarrow \)

b) \( \text{O} \quad \text{Li}^+ \quad \text{N} \quad \text{N} \rightarrow \)

c) \( \text{BuLi} + \text{C} \rightarrow \)

d) \( \text{O} \quad \text{KO}^+\text{Bu} \rightarrow \)

d) \( \text{O} \quad \text{KO}^+\text{Bu} \rightarrow \)

*4. (9) Circle the better nucleophile and put a square around the better leaving group in each of the following pairs. You do not need to explain your answers.

a) \( \text{O} \quad \text{NO}_2 \quad \text{and} \quad \text{O} \quad \text{OCH}_3 \)

b) \( \text{N(CH}_3)_2 \quad \text{and} \quad \text{N}=\text{C(CH}_3)_2 \)
c) MeO\textsubscript{3}CHOMe and MeO\textsubscript{2}C\textsubscript{2}CHOMe

*5. (10) Draw all significant resonance forms for each of the following species.

a)

\begin{center}
\begin{tikzpicture}
  \draw (0,0) -- (1,0) -- (1,1) -- (0,1) -- cycle;
  \draw (0.5,0.5) circle (0.15); % N nucleus
\end{tikzpicture}
\end{center}

b)

\begin{center}
\begin{tikzpicture}
  \draw (0,0) -- (1,0) -- (1,1) -- (0,1) -- cycle;
  \draw (0.5,0.5) circle (0.1); % O nucleus
\end{tikzpicture}
\end{center}

*6. (12.5) For each reaction shown below, explain briefly but clearly why the reaction occurs as shown. You need not show arrow-pushing.

a)

\begin{center}
\begin{tikzpicture}
  \draw (0,0) -- (1,0) -- (1,1) -- (0,1) -- cycle;
  \draw (0.5,0.5) circle (0.15); % N nucleus
\end{tikzpicture}
\end{center}

\text{Br\textsubscript{2}}

\begin{center}
\begin{tikzpicture}
  \draw (0,0) -- (1,0) -- (1,1) -- (0,1) -- cycle;
  \draw (0.5,0.5) circle (0.15); % N nucleus
  \draw (0.75,0.75) -- (0.5,0.5) -- (0.75,0.25);
  \draw (0.5,0.5) -- (0.5,0.75); % Br attachment
\end{tikzpicture}
\end{center}

\text{even though the whole molecule is aromatic, reaction occurs only where shown. Explain.}

b)

\begin{center}
\begin{tikzpicture}
  \draw (0,0) -- (1,0) -- (1,1) -- (0,1) -- cycle;
  \draw (0.5,0.5) circle (0.15); % C nucleus
\end{tikzpicture}
\end{center}

\text{Nucleophiles attack the site indicated by the arrow even though the greatest}^{\text{+}} \text{ is at the site marked by the *. Explain.}
*7. (6) In each of the following molecules, circle the hydrogen atom that will be most acidic. Note: you may have to draw in the hydrogen.

a)  
\[
\begin{array}{c}
\text{CH}_3 \\
\text{CH}_2 \\
\end{array}
\]

b)  
\[
\begin{array}{c}
\text{NH}_2 \\
\text{O} \\
\end{array}
\]

c)  
\[
\begin{array}{c}
\text{O} \\
\text{O} \\
\end{array}
\]

*8. (6) In each of the following, circle the atom which is the most likely source of electrons.

a)  
\[
\begin{array}{c}
\text{N} \\
\text{N} \\
\end{array}
\]

b)  
\[
\begin{array}{c}
\text{N} \\
\text{N} \\
\end{array}
\]

c)  
\[
\begin{array}{c}
\text{O} \\
\text{O} \\
\end{array}
\]

*9. (6) In each of the following, circle the atom which is the most likely acceptor of electrons.

a)  
\[
\begin{array}{c}
\text{S} \\
\end{array}
\]

b)  
\[
\begin{array}{c}
\text{N}^+ \\
\end{array}
\]

c)  
\[
\begin{array}{c}
\text{B} \\
\end{array}
\]

\[
\begin{array}{c}
\text{O} \\
\end{array}
\]

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