1. (27) 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) \[ \text{HOO}^{-} + \text{H}_3\text{C}^\text{O}\text{B(OCH}_3\text{)}_2 \rightarrow \]

b) \[ \text{BF}_4^{-} + \text{NH}_2 \rightarrow \]

c) \[ \text{PhC} = \text{NH} + \text{H}_2\text{O}^+ \rightarrow \]

d) \[ \text{H}_3\text{C}^\text{O}^\text{SO}_2\text{CF}_3 + \text{O} \rightarrow \]

e) \[ \text{Et}_3\text{P} + \text{O} \rightarrow \]

f) \[ \text{Br} + \text{KOC(CH}_3\text{)}_3 \rightarrow \]

g) \[ \text{D}_2\text{H}^\text{NH}_2 + \text{Ph}^\text{SOBr} \rightarrow \]
2. (5) Draw in the missing charges (if any) on the appropriate atoms in each of the following.

a) \( \text{N}^\text{+} = \text{N} = \text{N} = ^\text{CH}_3 \)  

b) \( \text{C} = \text{S} = \text{CH}_2 = \text{CH}_3 \)

3. (3) Circle the alkene below that reacts faster with HBr.

\[
\begin{align*}
\text{O}_2\text{N} & \quad \text{Me}_2\text{N} \\
\end{align*}
\]

4. (4) In each of the molecules shown below, draw an arrow to the atom which would react with a Grignard reagent (RMgBr).

a) \( \text{O} - \text{D} \)  

b) \( \text{H}_3\text{COCO} - \text{CH}_2\text{OCH}_3 \)

5. (8) Draw two other significant resonance forms for each of the following species.

a) \( \text{H}_2\text{C} = \text{C} - \text{H}_2\text{C} = \text{H}_2\text{C}^\text{+} \)

b) \( \text{CO} - \text{O} = \text{C} - \text{H}_2\text{O}^\text{+} \)

6. (6) In each of the following molecules, circle the hydrogen atom that will be most acidic. \textit{Note:} you may have to draw in the hydrogen.

a) \( \text{Br} - \text{C} - \text{C} - \text{H}_2\text{Br} \)  

b) \( \text{O} - \text{CH}_3 \)  

c) \( \text{N}^\text{+} - \text{O} - \text{H}_2\text{C} - \text{C} - \text{H}_2\text{C} \)
7. (6) In each of the following, circle the atom which is the most likely source of electrons.

a) ![Ammonia molecule]

b) ![N-Methylpiperidine molecule]

c) ![Alkenylamine molecule]

8. (5) In each of the following pairs, circle the compound which will react more readily with the reagent indicated. You need not explain why.

a) ![Phenol and phenyl N,N-dimethylamine with MeMgBr]

b) ![Formaldehyde and acetyl chloride with NaBH₄]

9. (13.5) State whether each of the following is a nucleophile / base or an electrophile.

a) LDA

b) H₃O⁺

c) Br₂

d) SCl₂

e) B(OCH₃)₃

f) NaCNBH₃

g) SnCl₄

h) HONH₂

10. (7.5) Using the list of numbers given below, assign approximate pKa values to the circled H's in each of the following molecules.

   pKa  5  10  15  20  35

   a) ![Water molecule]

   b) ![Dimethyl ether molecule]

   c) ![Dimethyl malonate molecule]

   d) ![Tartaric acid molecule]

   e) ![Dimethylamine molecule]
11. (6) In each of the following, circle the atom which is the most likely acceptor of electrons.

a) 
\[ \text{N} - \text{O} - \text{O} - \]

b) 
\[ \text{N}^+ - \text{N} - \]

c) 
\[ \text{C} = \text{N} - \]

12. (5) 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) 
\[ \text{S}^\ominus \text{ or } \text{O}^\ominus \]

b) 
\[ \text{Ph} = \cdot \] \text{ or } \[ \text{= C} - \cdot \]

13. (4) Clearly, suggest a reason why reaction 1 works well but reaction 2 does not.

\[ \begin{align*}
\text{Reaction 1:} & \quad \text{PyCl} + \text{CH}_3\text{O}^- \to \text{PyOMe} \\
\text{Reaction 2:} & \quad \text{PyCl} + \text{CH}_3\text{O}^- \to \text{PyOMe}
\end{align*} \]