1. Write a curved-arrow mechanism for the following reaction. Make sure to show lone pairs of electrons and charges as is appropriate.

\[ \text{Br} \quad \text{HBr} \quad \rightarrow \quad \text{Br} \]

2. Write a curved-arrow mechanism for the following reaction. Make sure to show lone pairs of electrons and charges as is appropriate.

\[ \text{H}_2\text{O} \quad \text{H}_{2}\text{O} \quad \rightarrow \quad \text{H} \]
3. Show how you would prepare tritium (³H) labeled (radioactive!) cyclohexane starting with cyclohexane, tritium oxide (T₂O) and any inorganic reagents that you require.

![cyclohexane and tritium labelled cyclohexane](image)

4. Write the products that form in the boxes. Clearly indicate the stereochemistry of the products, if relevant. If no reaction occurs, indicate this.

![reaction diagram](image)
5. Write the missing reactant(s), reagent(s), or product(s) in the box. If no reaction occurs write NR.

\[
\begin{align*}
\text{Li} & + \text{EtOH} & \xrightarrow{\text{Mg}} & \text{MgCl} \\
& & & \\
\text{CH}_3 & & \xrightarrow{\text{NaOMe}} & \text{MeOH} \\
& & & \\
\text{EtOH} & & \xrightarrow{\text{NaOEt}} & \\
\end{align*}
\]

6. Threonine (III and IV), like all amino acids, is both an acid and a base. The pK\textsubscript{a} of the carboxylic acid group in III (below) is 3.5, and the pK\textsubscript{a} of the ammonium ion in IV is 8.5.

\[
\begin{align*}
\text{III} & \xrightarrow{K_{eq}} & \text{IV} \\
\end{align*}
\]

a. What is \(K_{eq}\) for the internal acid-base reaction shown?

b. What is the \(\Delta G^\circ\) for this process?
7. In the formation of Grignard reagents from magnesium and alkyl halides, the most frequent side reactions are dimerization and disproportionation, as in the following example:

\[ \text{Cl} \xrightarrow{\text{Mg}} \text{MgCl} + \text{C}_2 \text{H}_4 + \text{C}_6 \text{H}_{12} + \text{C}_6 \text{H}_{12} \]

Propose a mechanism for these side reactions.

(Hint: Two of the products form by a type of reaction called a radical disproportionation.)

8. 

a. Generation of Grignard reagents with any sort of leaving group at the \( \beta \)-position is not possible. For example, reaction of 1-bromo-2-methoxyethane with magnesium generates ethylene and a magnesium alkoxide salt. Propose a reasonable mechanism for this reaction.

\[ \text{Br} - \text{OMe} + \text{Mg} \rightarrow \text{C}_2 \text{H}_4 + \text{MeOMgBr} \]

b. Propose a reasonable mechanism for the Freund reaction, shown below, in which treatment of an open-chain 1,3-dihaloalkane with zinc dust generates a cyclopropane.

\[ \text{Br} - \text{Br} + \text{Zn} \rightarrow \text{C}_3 \text{H}_6 + \text{ZnBr}_2 \]