1. (6 pts. each) Predict the products of the following reactions, include the relative yields for each of the products (ignore stereochemistry). The following numbers might be useful: 5:3:8:1, 1600:82:1.

a. \[ \text{Cl}_2 \xrightarrow{h\nu} \]

b. \[ \text{Br}_2 \xrightarrow{h\nu} \]

2. A chemist needs to make a primary alkyl halide from 2-methylpropane.
   a. (8 pts.) Should the chemist use Cl\(_2\) or Br\(_2\)? Explain.

   b. (4 pts.) Draw 2-methylpropane.

   c. (4 pts.) Draw the primary alkyl halide formed in this reaction.
3. Both toluene and methylcyclohexane undergo radical substitution reactions with Br₂.
   a. (8 pts.) Draw the most likely products for each of the reactions.

   ![Toluene](image)

   b. (6 pts.) Explain why toluene reacts more quickly than methylcyclohexane.

4. (2 pts. each) Identify whether the following alkyl halides react via an S_N1 and/or an S_N2 mechanism.
   a.  
   ![Image of alkyl halide](image)
   b.  
   ![Image of alkyl halide](image)
   c.  
   ![Image of alkyl halide](image)
   d.  
   ![Image of alkyl halide](image)

5. a. (4 pts.) To encourage a reaction to proceed via an S_N2 the solvent should be protic or aprotic, explain.
   
   b. (4 pts.) Provide an example of a protic solvent.

6. (8 pts.) Draw a mechanism that explains how the product forms in the following reaction.
   
   ![Reaction mechanism](image)
7. a. (4 pts.) Identify the molecule with the best leaving group.
   b. (4 pts.) Identify the molecule with the worst leaving group.

   \[
   \text{OH} \quad \text{SH} \quad \text{Br} \quad \text{I}
   \]

8. a. (6 pts.) In lab, you performed the following reaction. If you had started with \( R \)-2-bromobutane, what would the configuration of the product be? Explain your response.

   \[
   \begin{array}{c}
   \text{Br} \quad \text{CH}_3\text{CH}_2\text{OH} \quad \text{OCH}_2\text{CH}_3 \\
   \text{(R)}
   \end{array}
   \]

   b. (6 pts.) In lab, you performed the following reaction. If you had started with \( R \)-2-bromobutane, what would the configuration of the product be? Explain your response.

   \[
   \begin{array}{c}
   \text{Br} \quad \text{Nal} \quad \text{acetone} \quad \text{I} \\
   \text{(R)}
   \end{array}
   \]

9. (8 pts.) In lab, you performed the following reaction.

   \[
   \begin{array}{c}
   \text{OH} \quad \text{HCl} \quad \text{HBr} \quad 0.5 \quad \text{Cl} \quad + \quad 0.5 \quad \text{Br} \quad + \quad \text{H}_2\text{O}
   \end{array}
   \]

   Under these conditions, bromide is a better nucleophile than chloride. Explain then, why the product is a 50:50 mixture of the two alkyl halides.