1. Provide the product for the following reaction of this cyclic ether with excess HX. Draw the stepwise mechanism for the following transformation and determine which mechanisms these undergo. Remember that SN1 occurs kinetically faster than SN2.

\[
\text{O} \quad \xrightarrow{H} \quad \text{I} \quad \xrightarrow{H} \quad \text{H}_{2}O
\]

2. The following ether can, in principle, be synthesized by two different combinations of alkylhalide and metal alkoxide. Show both combinations that produce the ether and propose by which mechanisms the reactions go. Note that the combination that provides the SN2 mechanism is called the Williamson ether synthesis and the SN1 mechanism will lead to more elimination than substitution. Draw the elimination product for the mechanism that undergoes SN1/E2.

This combination will undergo possibly SN1. As such, there is a possibility that the reaction will have some E2 product as well.

This combination will go SN2 with no doubt. This combination is called the Williamson Ether Synthesis.
3. Provide correct organic product(s) and the mechanism for the following reactions. If stereochemistry pertains, ensure it is clearly demonstrated. If there is more than one product, then circle the major product. If no reaction occurs, place an X or NR in the box clearly.

4. Provide products for the following reactions or syntheses.

   a. mCPBA
      OR
      RCO₃H
      \[ \text{Br} \quad + \quad \text{O} \quad + \quad \text{O} \]

   b. 
      excess HBr
      \[ \text{Br} \quad \text{Br} \quad (+ \text{H}_2\text{O}) \]

   c. 
      1. NBS/Hn
      2. NaH
      3. BH₃(THF)
      4. NaOH/H₂O₂
      5. PBr₃
      
      1. Halogenate at most substituted carbon
      2. (small base gives most subst'd alkene)
      3./4. hydroboration places --OH at least substituted carbon
      5. SN₂ reaction with inversion

   +E
d. 

1. SOCl₂, pyridine
2. NaH
3. Br₂/H₂O
4. NaH
5. HBr

Mechanism?

H₃CO
1. HCl

Mechanism?

Cl
2. HI

Mechanism?

HOCH₃

CH₃I

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5. Propose a series of steps to bring about the following transformations. These reactions cannot be brought about in just one step, so you will need to propose a multi-step synthesis.

a. 

\[ \text{Br}_2, \text{CCl}_4 \rightarrow \text{Br} \rightarrow 2 \text{NaNH}_2 \rightarrow 1. \text{LDA} \rightarrow 2. \text{CH}_3\text{X} \]

b. 

\[ \text{Br}_2, \text{light, heat} \rightarrow \text{Br} \rightarrow \text{KO}^1\text{Bu} \rightarrow 1. \text{BH}_3(\text{THF}) \rightarrow 2. \text{NaOH, H}_2\text{O}_2 \]

c. 

\[ \text{HX} \rightarrow \text{Br}_2, \text{CH}_3\text{OH} \rightarrow 1. \text{NaH} \rightarrow 2. \text{CH}_3\text{X} \rightarrow \text{Br}_2, \text{H}_2\text{O} \rightarrow \text{OCH}_3 \]
6. Provide viable mechanisms for the following reaction.

\[
\text{CH}_3\text{OH} + \text{H}_2\text{SO}_4 \rightarrow \text{O} + \text{CH}_3\text{OH}^+ + \text{H}_2\text{O}
\]

7. **Reactions.** Provide reagents or products in the spaces provided. If there are multiple steps needed, then indicate with a 1./2. as appropriate.

   **A**  
Pd, H\textsubscript{2}, high pressure

   **B**  
HBr

   **C**  
1. OsO\textsubscript{4}  2. NaHSO\textsubscript{3}

   **D**  
RCO\textsubscript{2}H

   **E**  
strong base like NaH

   **F**  
Br\textsubscript{2}, H\textsubscript{2}O

   **G**  
Br\textsubscript{2}, CCl\textsubscript{4}

   **H**  
1.) BH\textsubscript{3}(THF)  2.) NaOH, H\textsubscript{2}O\textsubscript{2}

   **I**  
H\textsubscript{2}SO\textsubscript{4}, H\textsubscript{2}O