Organic Chemistry: Synthesis of Alcohol and Haloalkane

To synthesize the final products from the starting materials using a minimum of 2 reaction steps, it is essential to choose the appropriate reagents and reaction conditions.

Problem (a): Starting Material – Alkyne, Final Product – Alcohol

Step 1: Hydrogenation (Partial) to Alkene
Reagents: Lindlar's Catalyst, H_2
Intermediate Product: Alkene (Ethene)

$$HC{\equiv}CH \xrightarrow{\text{Lindlar's Cat., } H_2} H_2C{=}CH_2$$

Explanation: Using Lindlar's catalyst with hydrogen gas partially hydrogenates the alkyne to a cis-alkene.

Step 2: Hydroboration-Oxidation to Alcohol
Reagents: 1) BH_3, THF 2) H_2O_2, NaOH
Final Product: Alcohol (Ethanol)

$$H_2C{=}CH_2 \xrightarrow{1)\ BH_3,\ THF;\ 2)\ H_2O_2,\ NaOH} H_3C{-}CH_2OH$$

Explanation: The hydroboration-oxidation process converts the alkene to an alcohol. Borane (BH_3) adds across the double bond to form a trialkylborane intermediate, which is then oxidized by hydrogen peroxide in basic medium to yield the alcohol.

Problem (b): Starting Material – Aldehyde, Final Product – Haloalkane

Step 1: Reduction to Primary Alcohol
Reagents: $NaBH_4$, MeOH (Methanol)
Intermediate Product: Ethanol

$$HCH{=}O \xrightarrow{NaBH_4,\ MeOH} CH_3CH_2OH$$

Explanation: Sodium borohydride ($NaBH_4$) is a reducing agent that converts the aldehyde to a primary alcohol.

Step 2: Halogenation with PBr_3
Reagents: PBr_3
Final Product: Ethyl Bromide (Bromoethane)

$$CH_3CH_2OH \xrightarrow{PBr_3} CH_3CH_2Br$$

Explanation: Phosphorus tribromide (PBr_3) converts the primary alcohol to an alkyl bromide via the formation of a trialkyl phosphate intermediate that reacts with bromide ion.

Summary of Reactions

Problem (a):
1. $HC{\equiv}CH \xrightarrow{\text{Lindlar's Cat., } H_2} H_2C{=}CH_2$
2. $H_2C{=}CH_2 \xrightarrow{1)\ BH_3,\ THF;\ 2)\ H_2O_2,\ NaOH} H_3C{-}CH_2OH$

Problem (b):
1. $HCH{=}O \xrightarrow{NaBH_4,\ MeOH} CH_3CH_2OH$
2. $CH_3CH_2OH \xrightarrow{PBr_3} CH_3CH_2Br$

Each step uses specific reagents and reaction conditions to convert the starting material to the desired product through intermediate compounds. This synthesis approach ensures the correct formation of the final products with the least number of reaction steps.