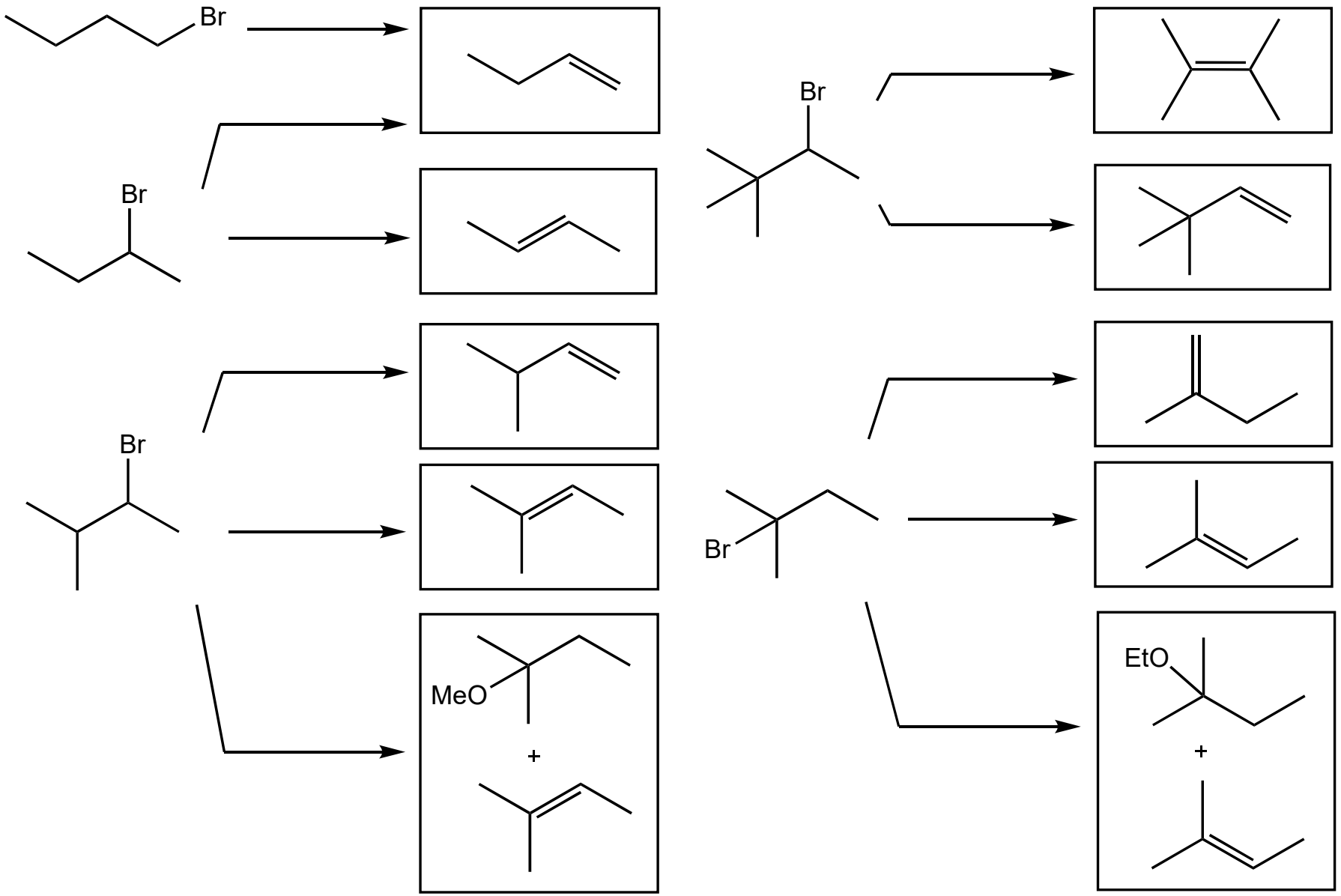
ALKENE ADDITION REACTIONS



Choose an appropriate base for each reaction, using any of the following: NaOH, NaOEt, NaOMe, tBuOK, or NaH

You may also use the neutral versions of the above strong bases: H_2O, EtOH, MeOH, tBuOH. *(except H_2, which is an inert gas)*

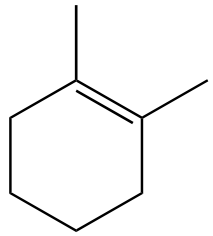


1. What is the **HDI** (or **DOU**)?

$$\textbf{DOU} = \frac{2C + 2 + N - H - X}{2} = \text{\# of pi bonds or rings}$$

What does this tell us about the **conformational isomers** of $C_6H_{10}O$?

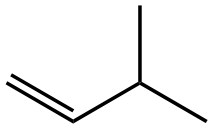
2. What determines the **stability** of an alkene?



H_2

Pd *or* Pt *or* Ni

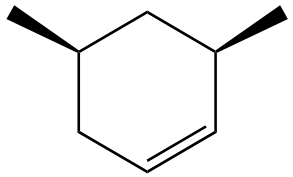
HYDROGENATION



1. O_3

2. DMS

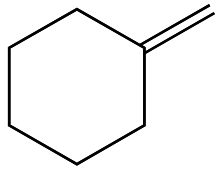
OZONOLYSIS



$HBr_{(dilute)}$

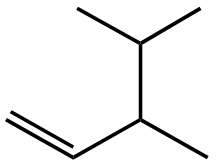
CH_2Cl_2

HYDROHALOGENATION



HBr

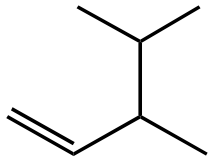
ROOR



H_2O

$[H_2SO_4]$

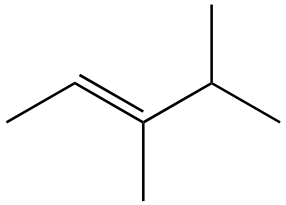
ACID-CATALYZED HYDRATION



$HOCH_3$

$[H^+]$

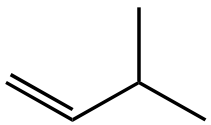
ACID-CATALYZED ETHER FORMATION



1. BH_3 - THF

2. H_2O_2, NaOH

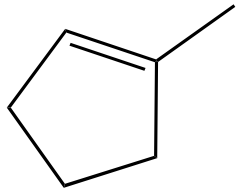
HYDROBORATION-OXIDATION



1. $Hg(OAc)_2$, H_2O

2. $NaBH_4$

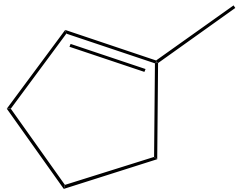
EPOXIDATION & *ANTI*-DIHYROXYLATION



RCO_3H

H_3O^+

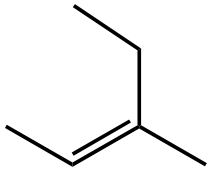
FORMATION OF ETHER via EPOXIDE



RCO_3H

$HOEt, [H^+]$

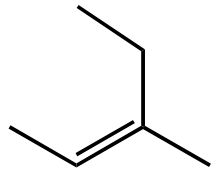
HALOGENATION



Br_2

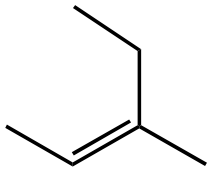
CH_2Cl_2

HALOHYDRIN FORMATION



Br_2

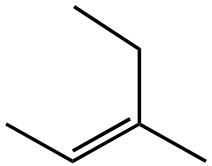
H_2O



$KMnO_4$, NaOH

cold

***SYN* – DIHYROXYLATION**



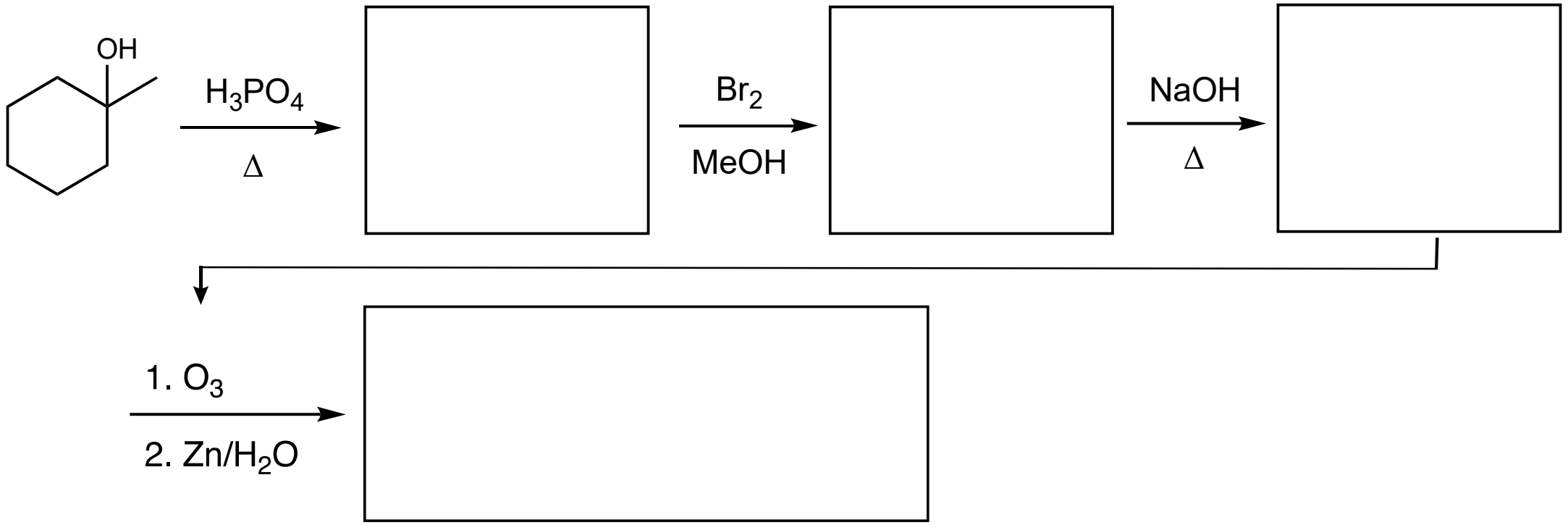
1. OsO_4

2. $NaHSO_3$, H_2O

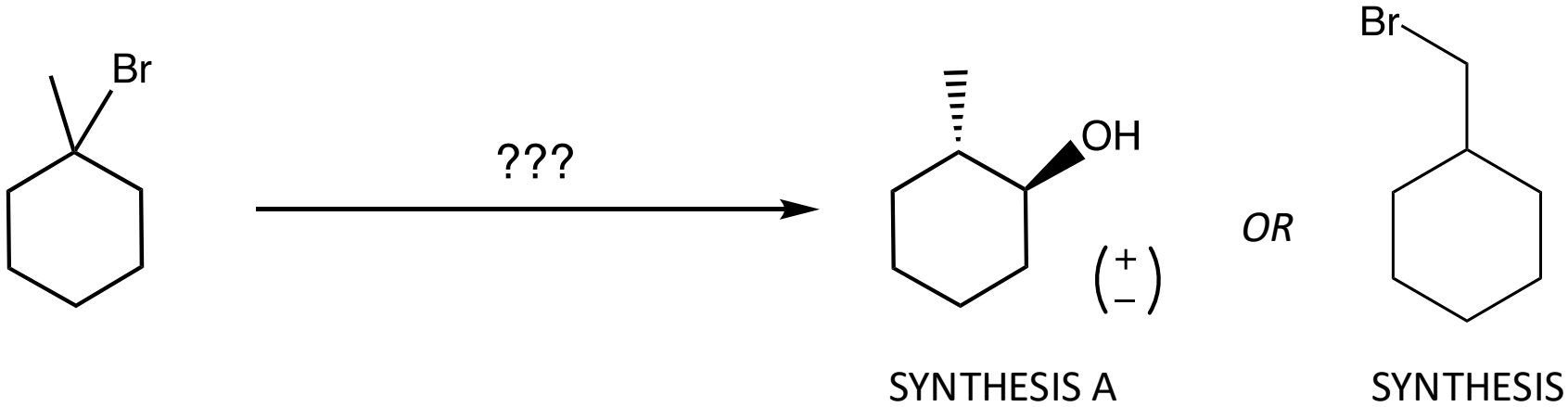
***SYN* – DIHYROXYLATION**

PUT IT ALL TOGETHER. Give the major product(s) formed in the first reaction. Provide reasonable synthesis strategies for the two reactions in #2. Each synthesis requires more than one step.

1.



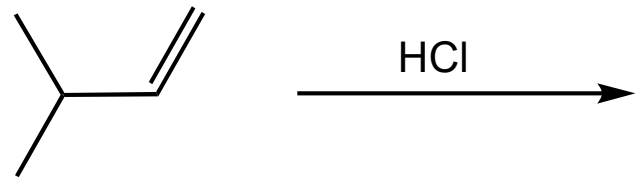
2.



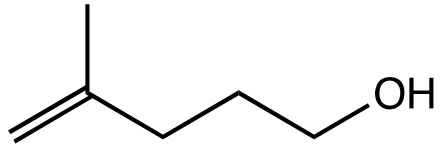
SYNTHESIS A

SYNTHESIS B

Give the major product(s) formed in each reaction.

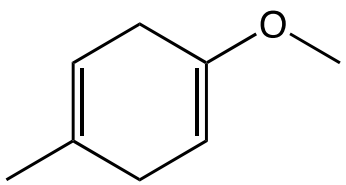


HCl



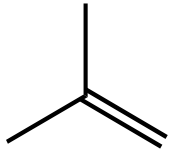
OH

$[H^+]$



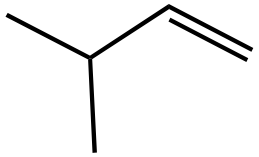
O

xs HCl



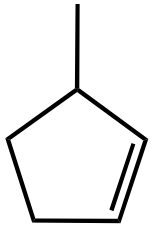
$[H_2SO_4]$

MeOH

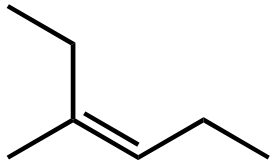


HBr

H_2O_2

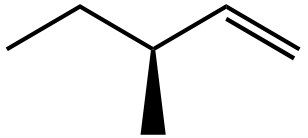


H_3O^+



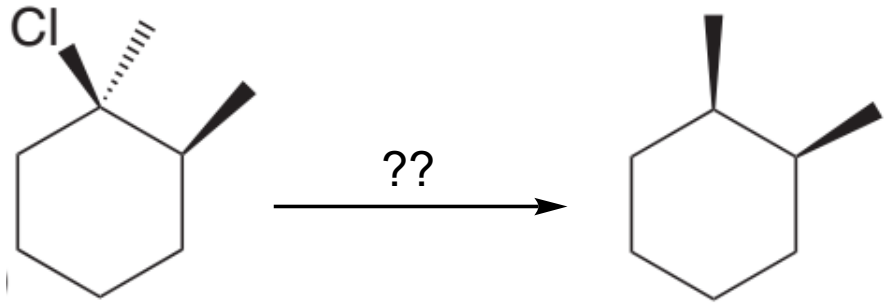
H_2O

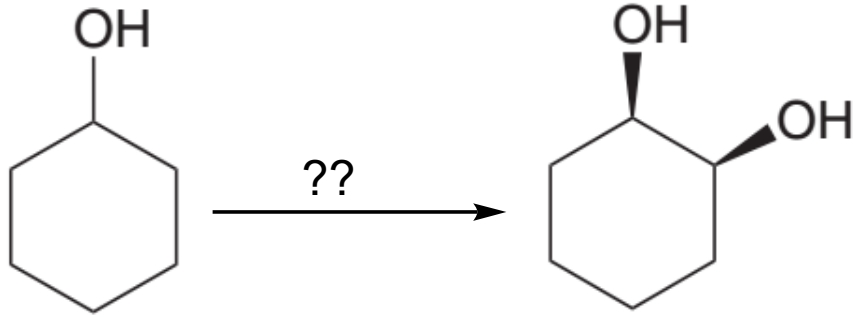
$[H^+]$



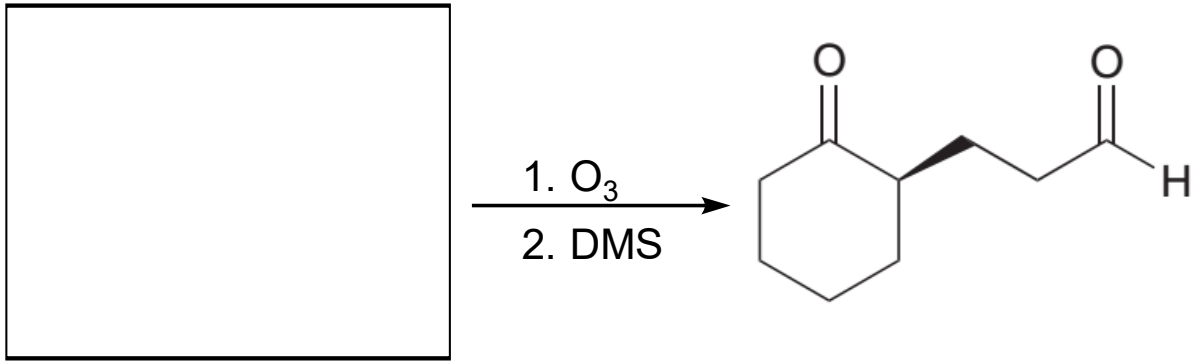
1. $Hg(OAc)_2$, HCN
2. $NaBH_4$

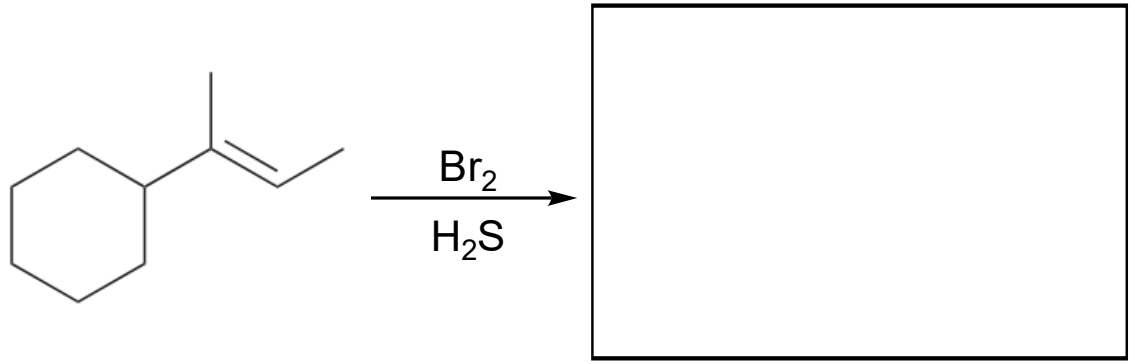
List the appropriate reactants to form the following products.





Draw the reactant and/or product for each reaction below.

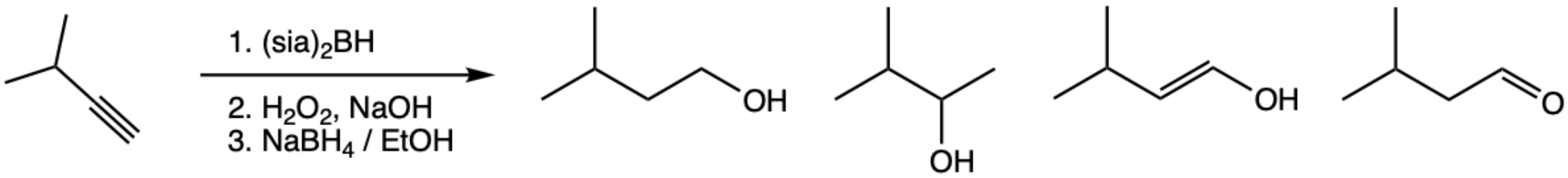




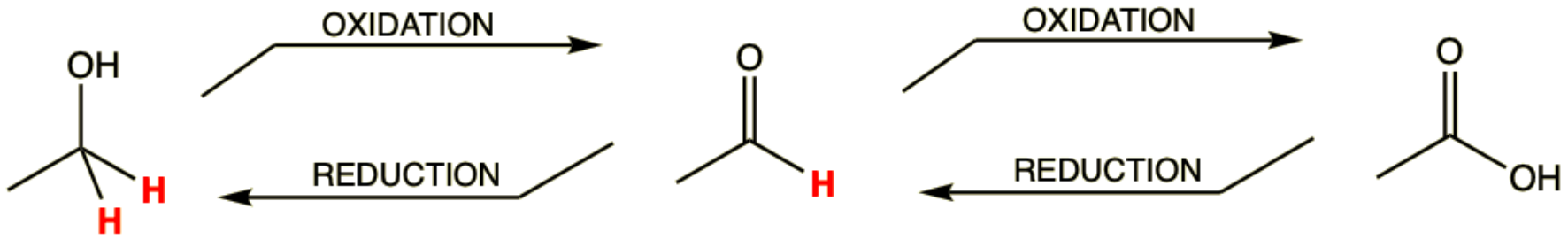
REDUCING AGENTS for ALKENES & Others

	H_2 / Pd, Pt, or Ni (*High Temp & Pressure*)	$NaBH_4$ / EtOH, MeOH, or H_2O	1. $LiAlH_4$ / 2. H_2O
REAGENTS			
REDUCTION TARGETS	a) alkenes, alkynes b) ketones, aldehydes c) esters, carboxylic acids	a) alkenes, alkynes b) ketones, aldehydes c) esters, carboxylic acids	a) alkenes, alkynes b) ketones, aldehydes c) esters, carboxylic acids

Circle the final product based on the given reaction sequence.



OXIDIZING AGENTS for ALKENES & Others



PRIMARY

Has _____ proton(s).
Undergoes _____ oxidation(s).

SECONDARY

Has _____ proton(s).
Undergoes _____ oxidation(s).

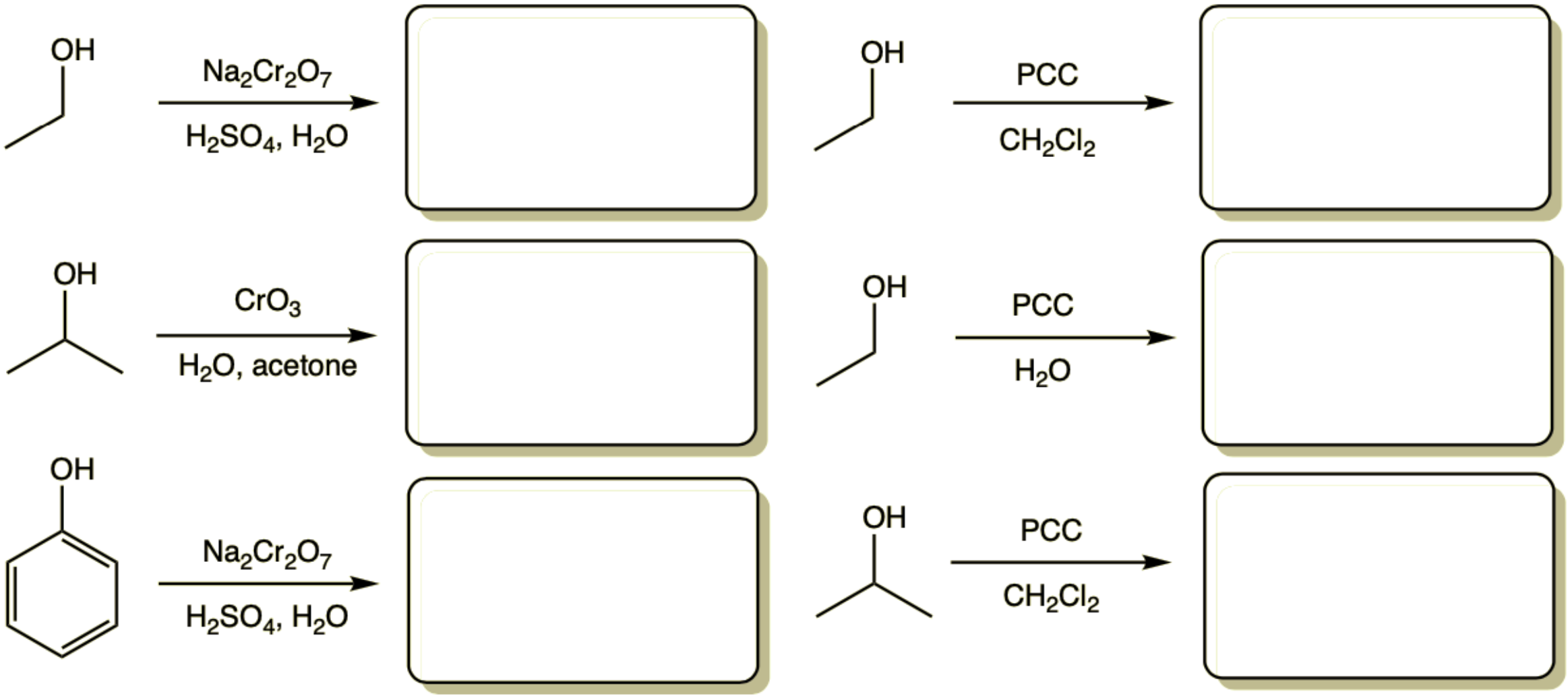
TERTIARY

Has _____ proton(s).
Undergoes _____ oxidation(s).

Oxidizing Agents

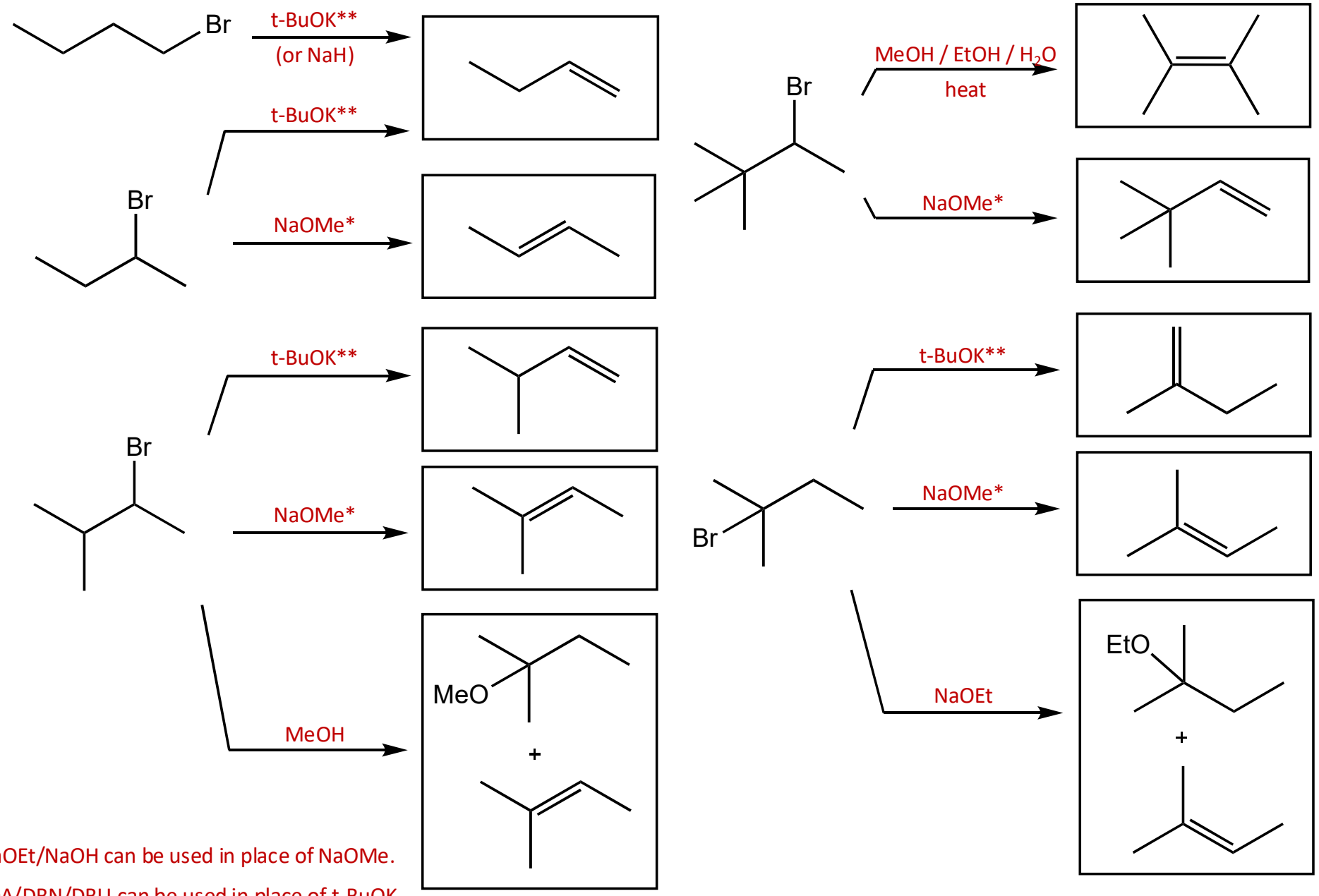
JONES Reagent Structure:

PCC Reagent Structure:


OH
$Na_2Cr_2O_7$
H_2SO_4, H_2O
OH
PCC
CH_2Cl_2
OH
CrO_3
H_2O, acetone
OH
PCC
H_2O
OH
$Na_2Cr_2O_7$
H_2SO_4, H_2O
OH
PCC
CH_2Cl_2

ANSWER KEY

Choose an appropriate base and draw the mechanism for each reaction.



*NaOEt/NaOH can be used in place of NaOMe.

**LDA/DBN/DBU can be used in place of t-BuOK

What are the two methods we know for the formation of alkenes from alcohols?

<u>Acid-Cat. Dehydration</u>

- TsOH
- H_2SO_4

<u>Phosphorus Oxychloride</u>

- $POCl_3$, pyr. (excess)

1. What is the **HDI** (or **DOU**)?

$$\textbf{DOU} = \frac{2C + 2 + N - H - X}{2} = \text{\# of pi bonds or rings}$$

What does this tell us about the **conformational isomers** of $C_6H_{10}O$?

DOU = 2, so all constitutional isomers will contain at least 2 rings; 2 π bonds; or 1 ring and 1 π bond.

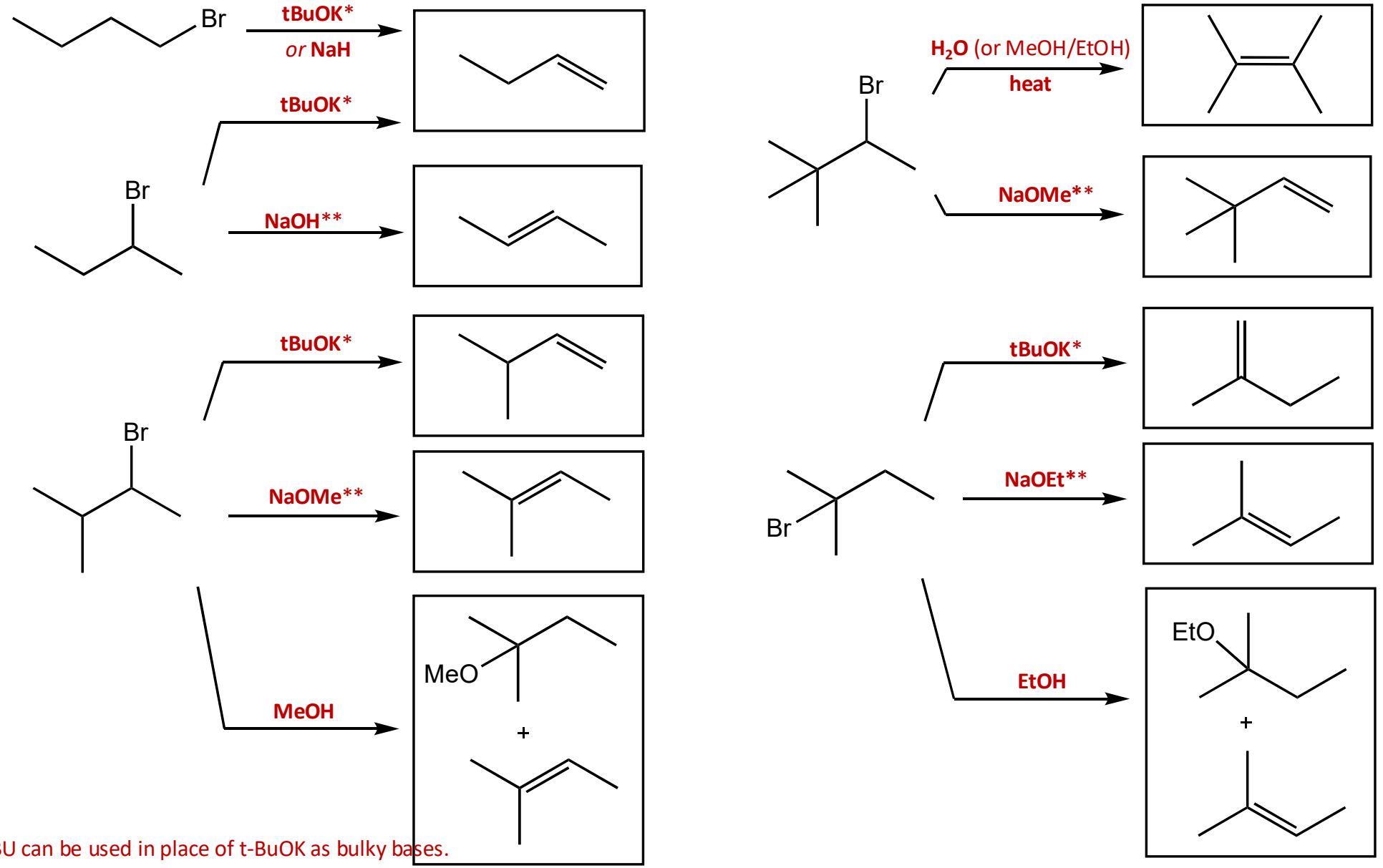
2. What determines the **stability** of an alkene?

(a) the isomer: E (trans) is more stable than Z (cis)

(b) the number of substituent branches: tetra > tri > di > mono-substituted

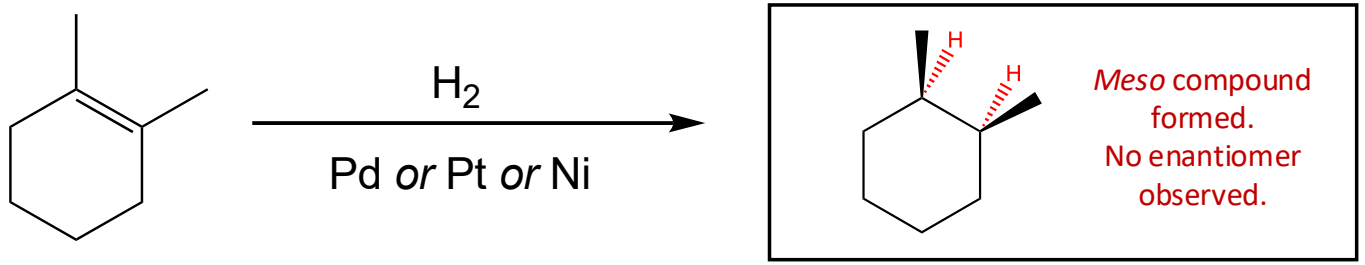
Choose an appropriate base for each reaction, using any of the following: NaOH, NaOEt, NaOMe, tBuOK, or NaH

You may also use the neutral versions of the above strong bases: H_2O, EtOH, MeOH, tBuOH. *(except H_2, which is an inert gas)*



*LDA, DBN, or DBU can be used in place of t-BuOK as bulky bases.

**NaOEt, NaOMe, NaOH or NaH can be used interchangeably as small bases.

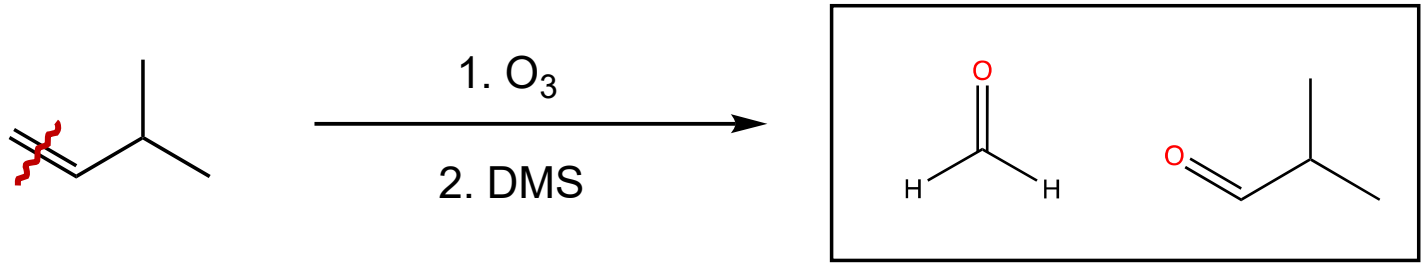


HYDROGENATION

Stereospecific: ***Syn*-addition** of H_2 across alkene

Heterogeneous Metal Catalyst required to lower E_A

- Wilkinson's catalyst can also be used
- $Ru(BINAP)Cl_2$ provides efficient enantioselectivity

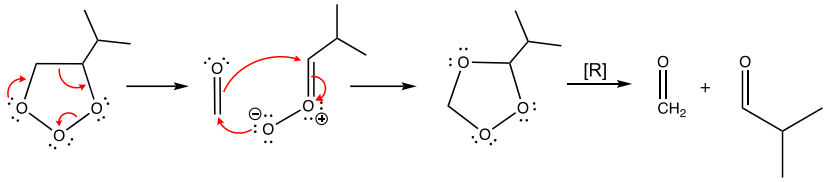


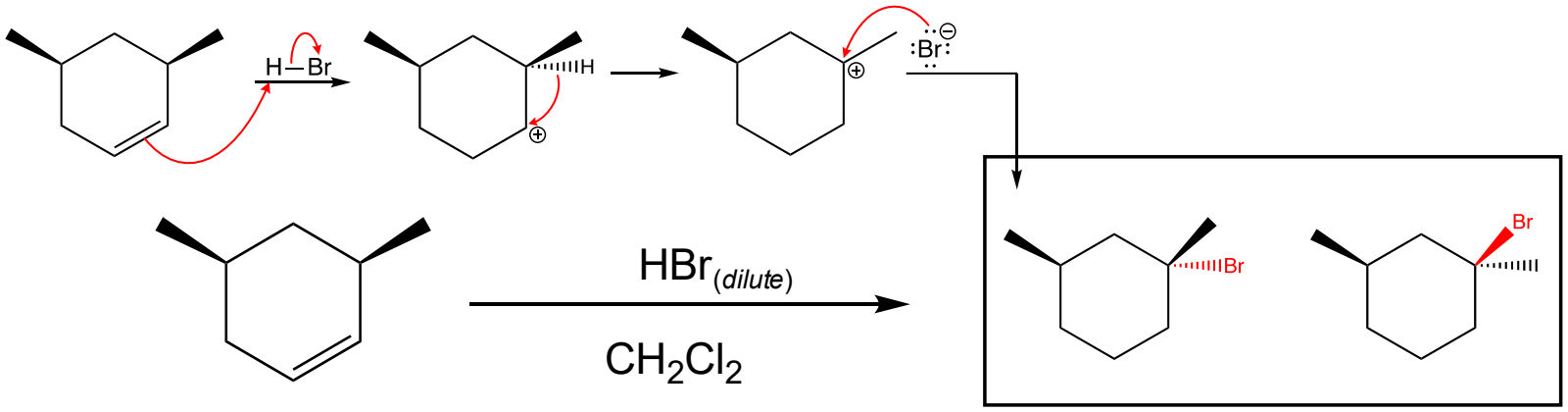
OZONOLYSIS

Oxidative cleavage of C=C bond

Proceeds via molozonide, which rearranges to form a ozonide. Cleavage occurs with mild reducing agent.

Reducing agents: DMS or Zn/H_2O





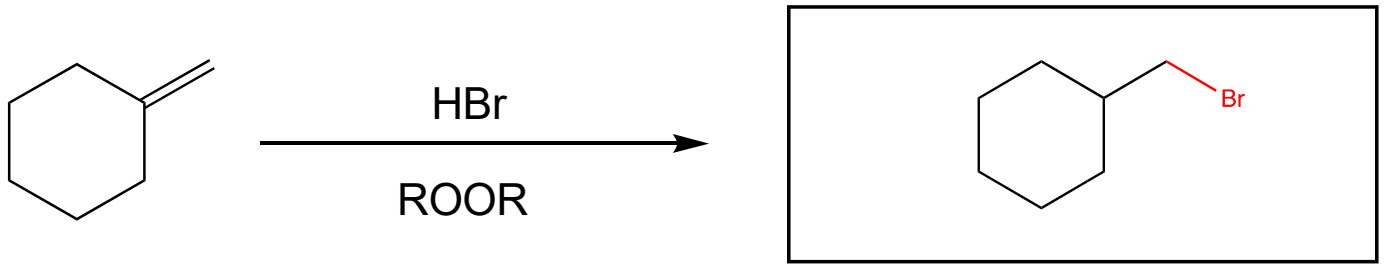
HYDROHALOGENATION

Regioselective: **Markovnikov of X**

RDS: Carbocation intermediate

- rearrangement possible
- racemixture formed (w. minor non-rearranged)

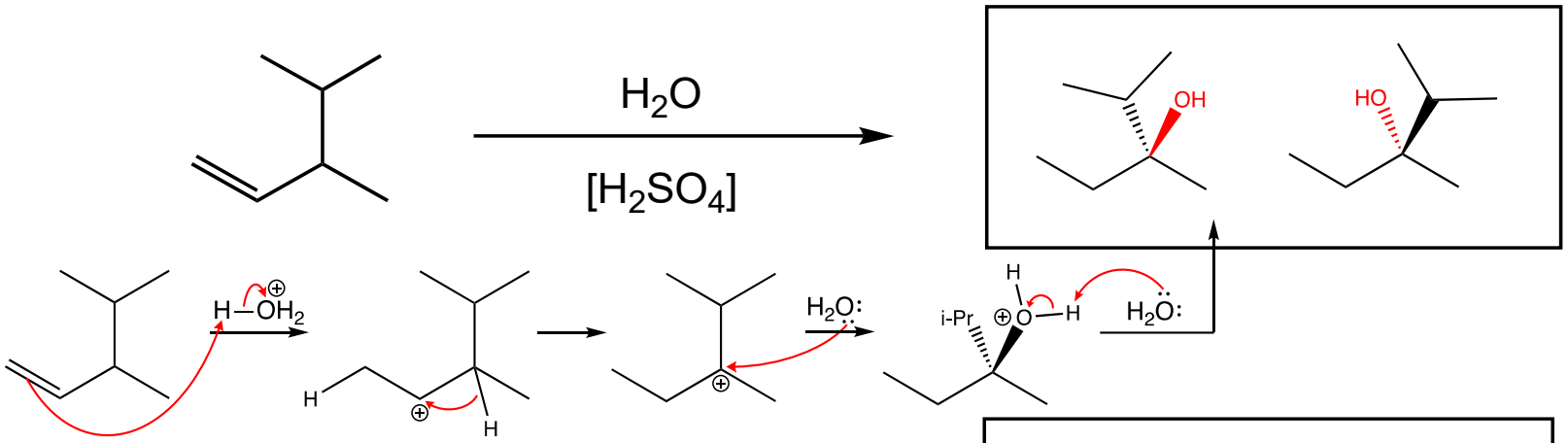
Possible for HCl, HBr, HI



Regioselective: ***anti*-Markovnikov of Br**

Radical mechanism

Only efficient for HBr (not HCl, HI)



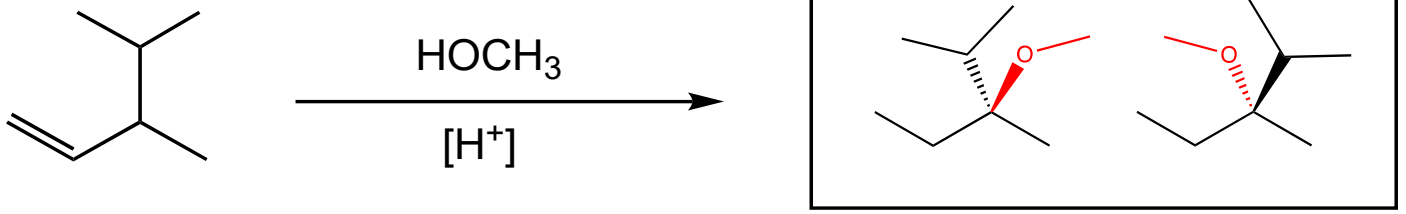
ACID-CATALYZED HYDRATION

Regioselective: **Markovnikov of OH**

RDS: Carbocation intermediate

– rearrangement possible

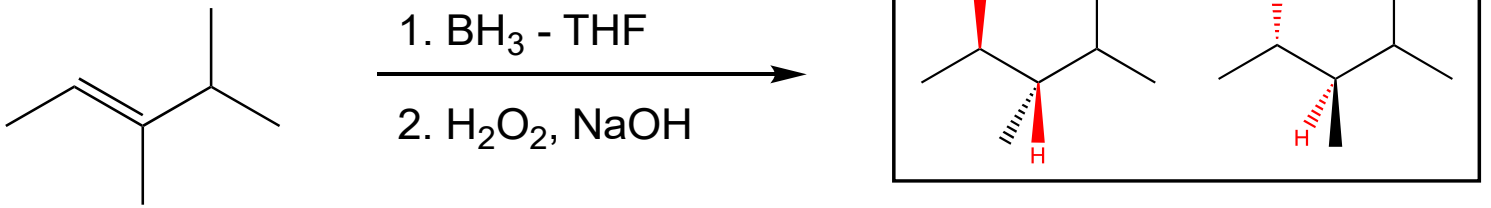
– racemixture formed



ACID-CATALYZED ETHER FORMATION

Regioselective: **Markovnikov of OR**

***** Same mechanism as above.



HYDROBORATION-OXIDATION

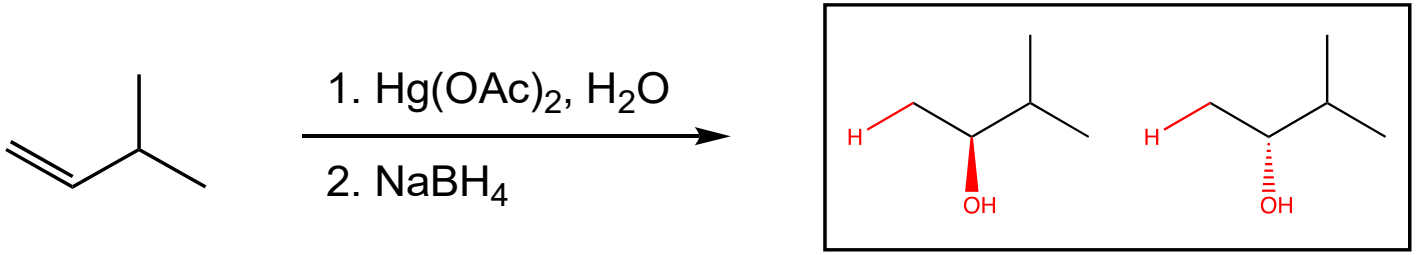
Regioselective: ***anti*-Markovnikov of OH**

Stereospecific: ***Syn*-addition** of OH and H

– THF required to stabilize borane

– Boron bonds to less substituted carbon

Proceeds via trialkylborane, then trialkoxyborane

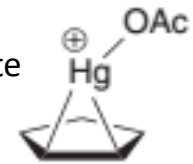


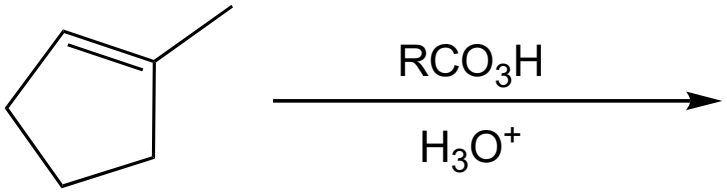
Regioselective: **Markovnikov of OH (*or* Nuc)**

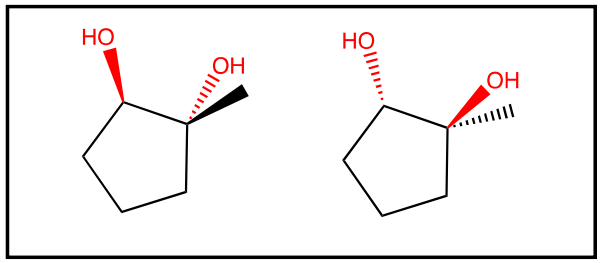
– can be used with any protic nucleophile

Proceeds via *mercurinium ion* intermediate

–––> prevents rearrangement





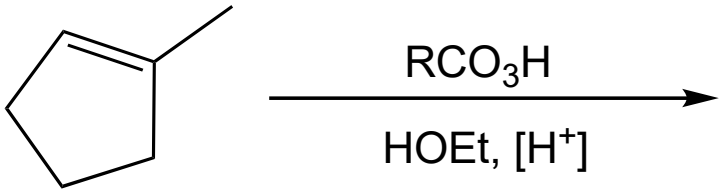


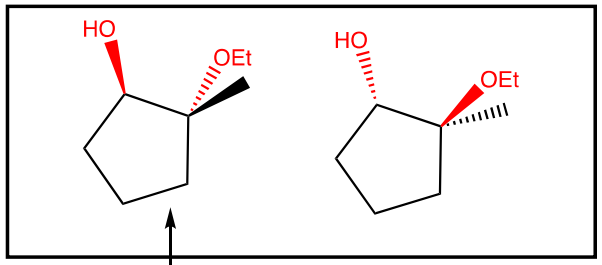
EPOXIFICATION & *ANTI*-DIHYDROZYLATION

Stereospecific: ***Anti*-addition of OH**
– forms *trans* diol



Proceeds via protonated epoxide.
Possible with peroxy acid (RCO_3H) or mCPBA.

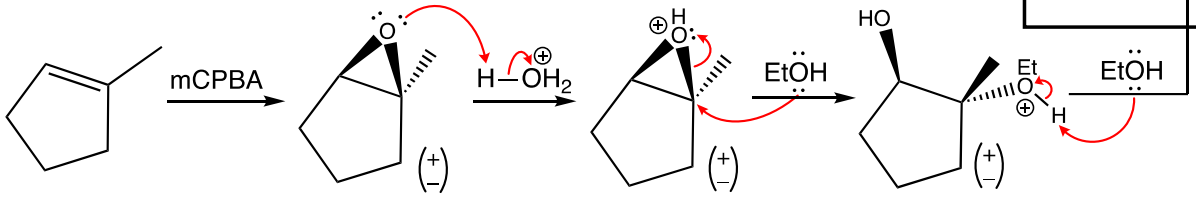


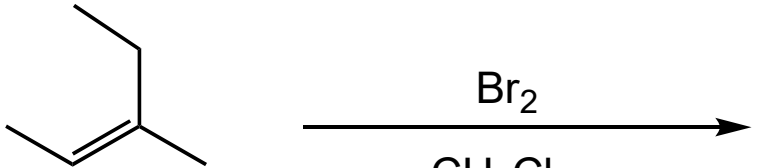


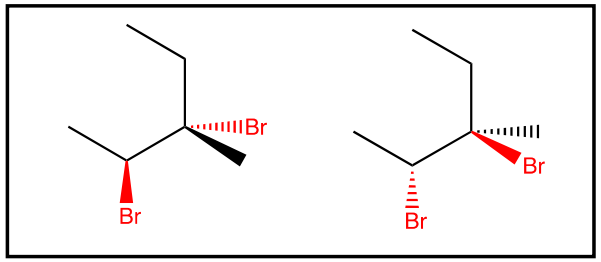
EPOXIFICATION & ETHER FORMATION

Regioselective: **Markovnikov of Solvent**
Stereospecific: ***Anti*-addition** of Cl_2 or Br_2

* Proceeds via same mechanism as above, but epoxide is attacked by solvent.





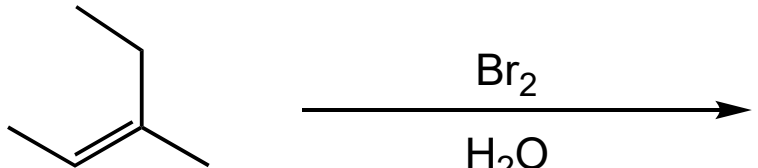


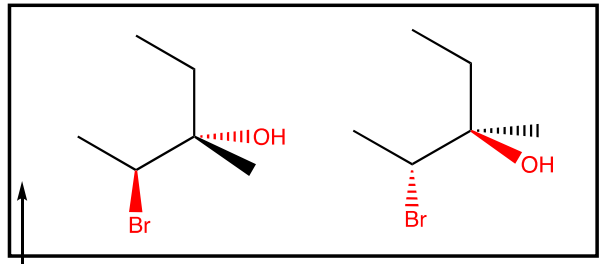
HALOGENATION

Stereospecific: ***Anti*-addition** of Cl_2 or Br_2

Proceeds via bromonium (or chloronium) ion, followed by S_N2 attack by halide.



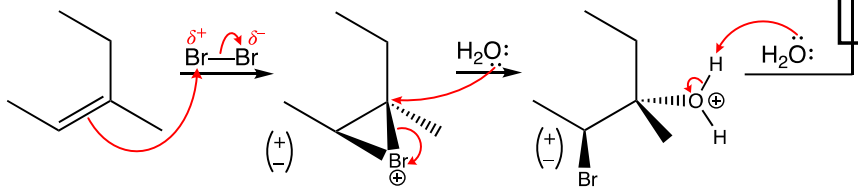




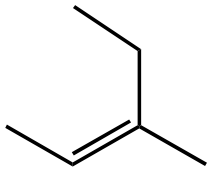
HALOHYDRIN FORMATION

Regioselective: **Markovnikov of OH**
Stereospecific: ***Anti*-addition** of Br/Cl and OH

Proceeds via bromonium (or chloronium) ion, followed by S_N2 attack by H_2O solvent.

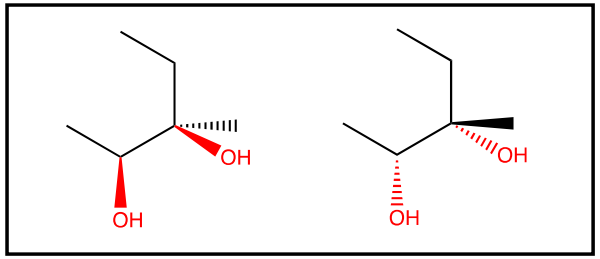


***NBS / DMSO, H_2O** also works



$KMnO_4$, NaOH

cold



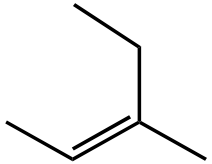
***SYN*–DIHYDROXYLATION (Method 1)**

Stereospecific: ***Syn*-addition of OH**

– forms *syn* diol

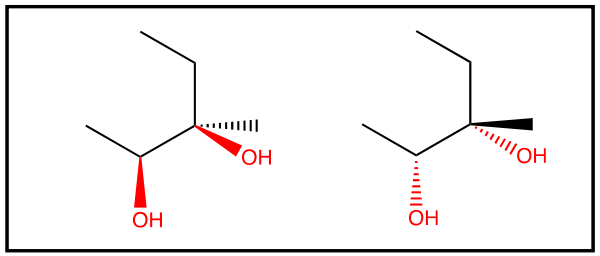
Proceeds via cyclic manganese ester.

Strong oxidizing agent —–> must be used *cold*



1. OsO_4

2. $NaHSO_3$, H_2O



***SYN*–DIHYDROXYLATION (Method 2)**

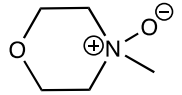
Stereospecific: ***Syn*-addition of OH**

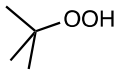
– forms *syn* diol

Proceeds via cyclic osmate ester.

Step 2 can also include: • NMO

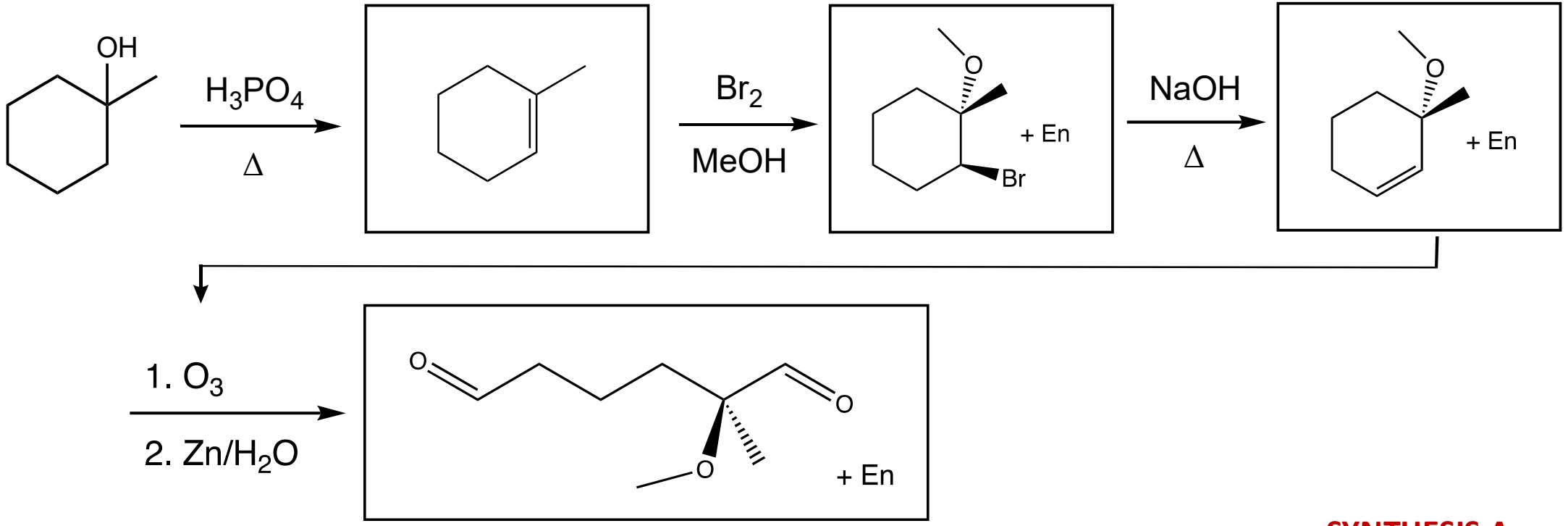
• *tert*-butyl hydroperoxide



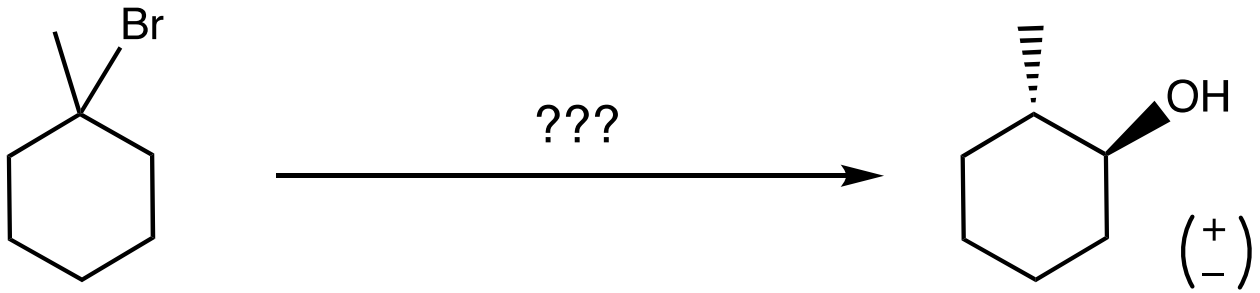


PUT IT ALL TOGETHER. Give the major product(s) formed in the first reaction. Provide reasonable synthesis strategies for the two reactions in #2. Each synthesis requires more than one step.

1.

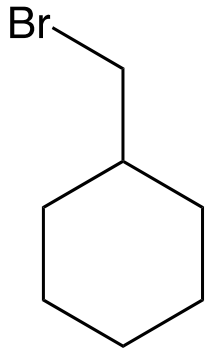


2.



SYNTHESIS A

OR



SYNTHESIS B

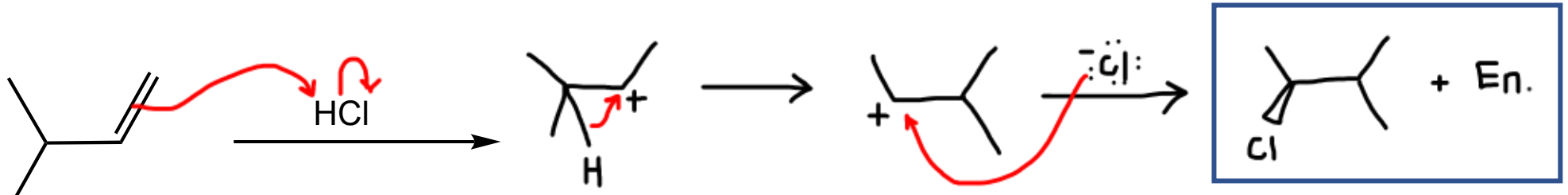
SYNTHESIS A

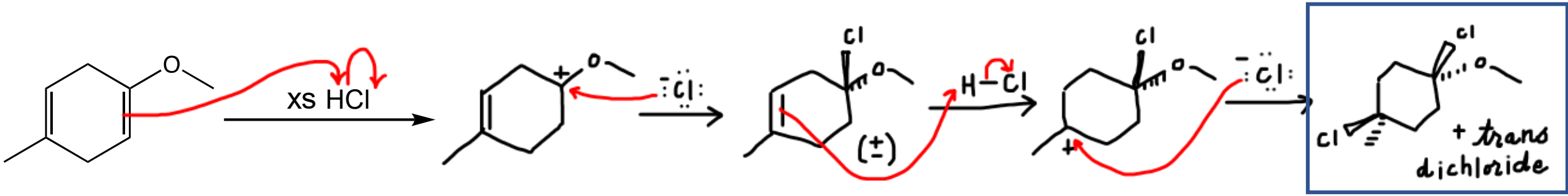
1. NaOH (small base), heat
2. a) $BH_3 \bullet THC$
   b) H_2O_2, NaOH

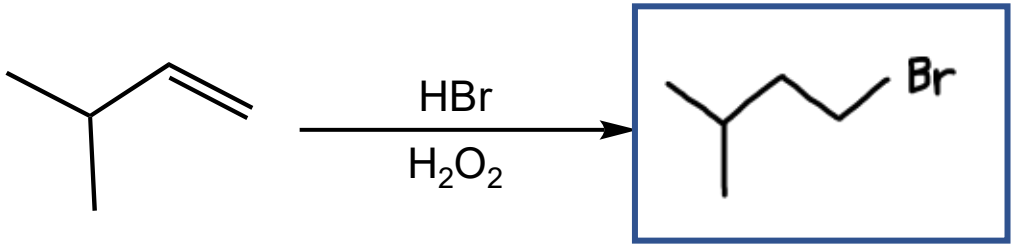
SYNTHESIS B

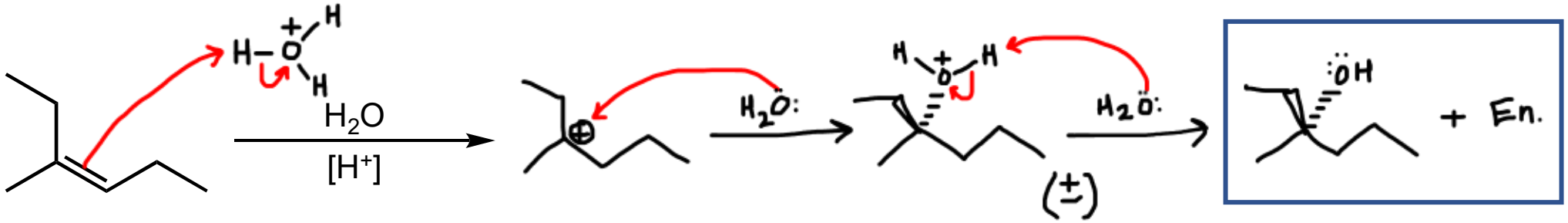
1. t-BuOK (bulky base), heat
2. HBr, ROOR

Give the major product(s) formed in each reaction.

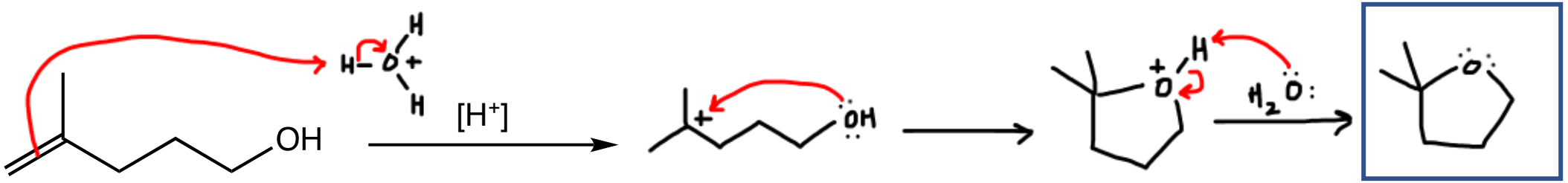


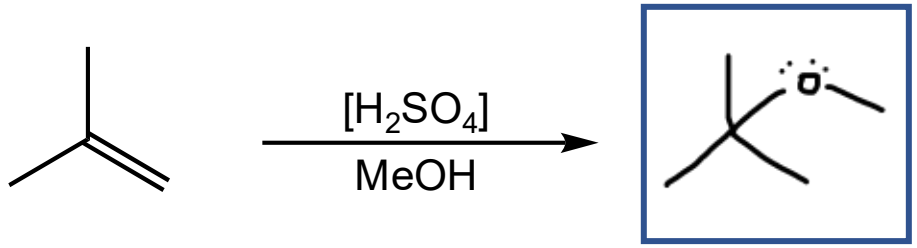


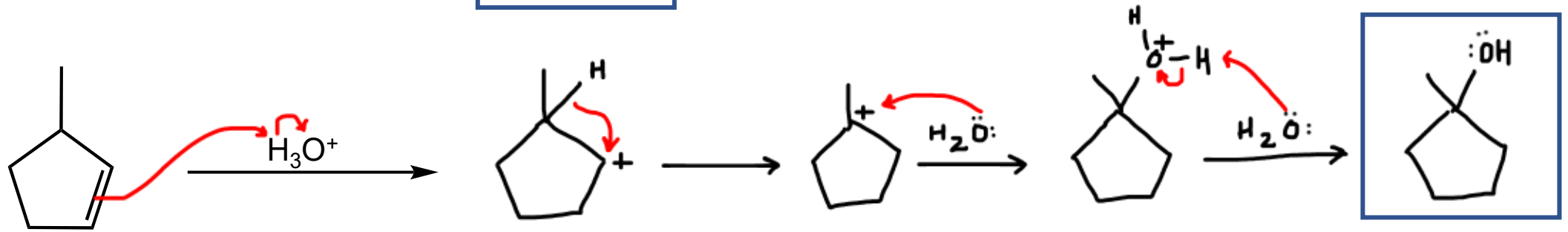


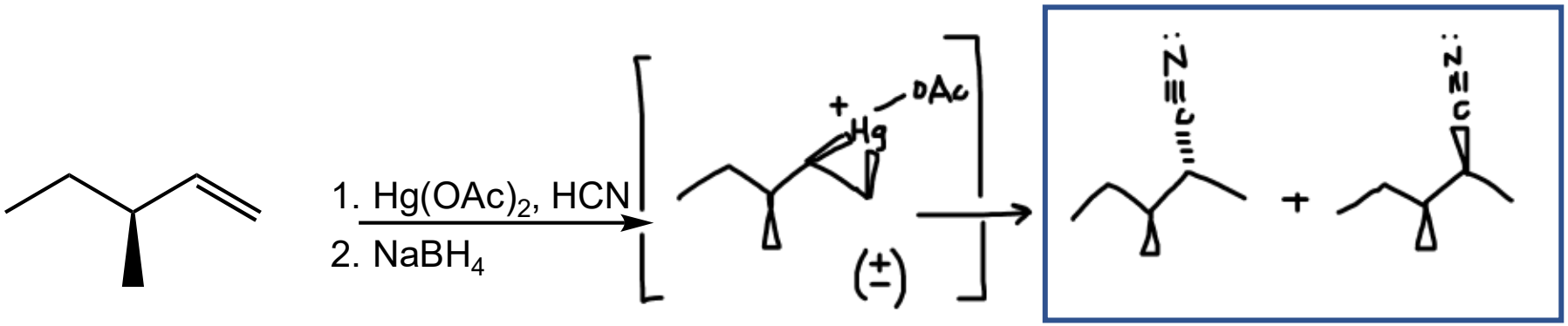


Give the major product(s) formed in each reaction.

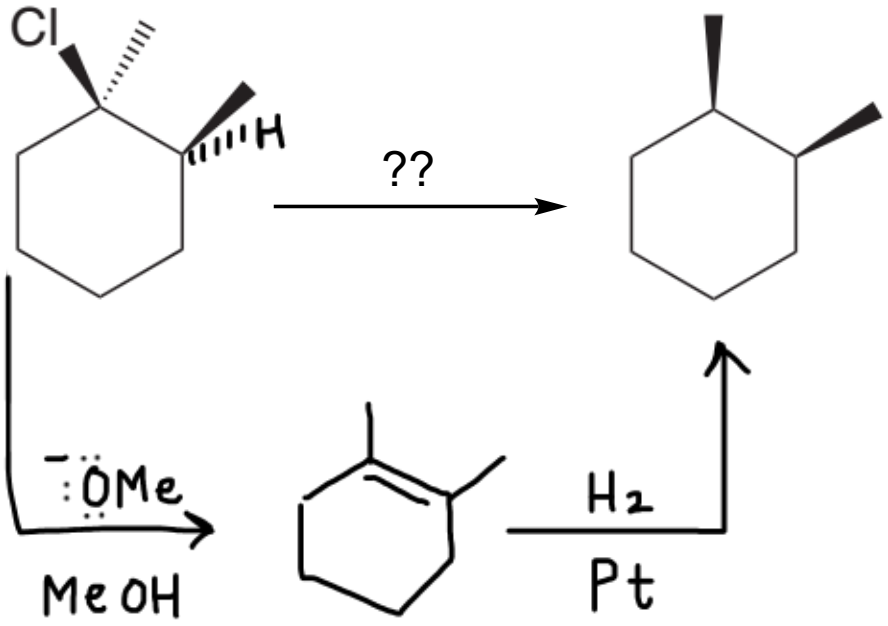


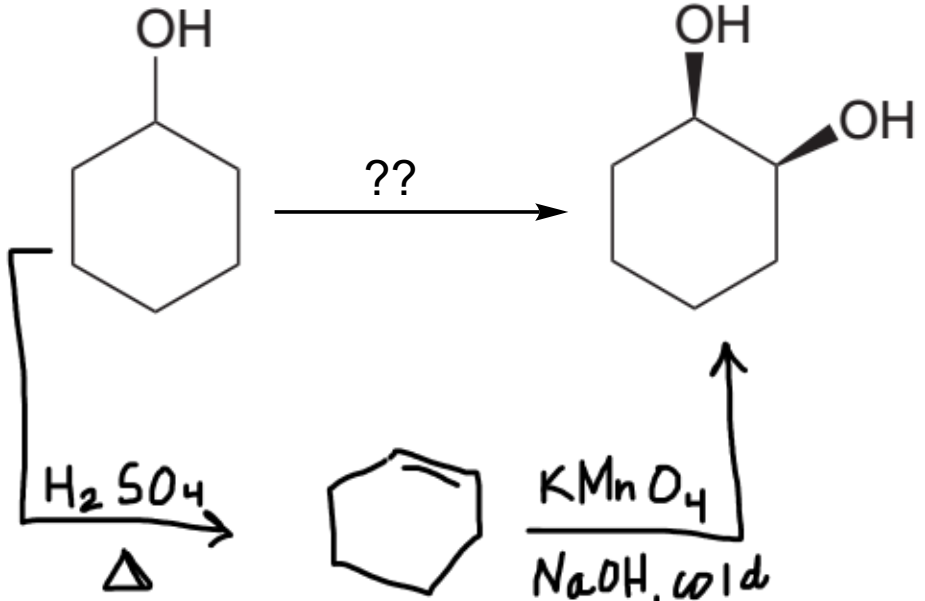






List the appropriate reactants to form the following products.





Draw the reactant and/or product for each reaction below.

