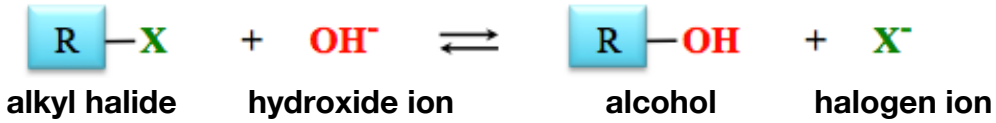
# *Reactions of Chapter 10 Worksheet and Key*

## 1) Alcohol Fermentation

Alcohol fermentation is a series of chemical reaction that convert sugar molecules, such a glucose, into ethanol and $CO_2$. The overall reaction of ethanol formation from a sugar molecule called glucose is shown below:

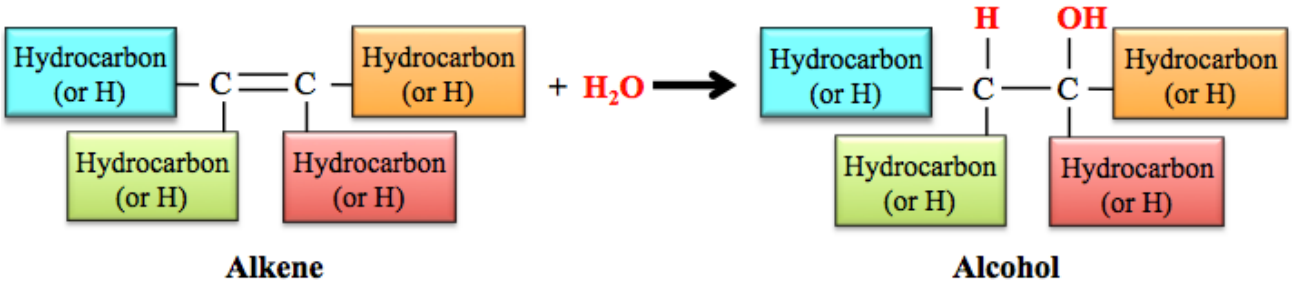

## 2) Nucleophilic Substitution

The general form of the equation for an $S_N2$ reaction for the production of alcohol is shown below (**X** represents F, Cl, Br, or I).




## 3) Hydration of Alkenes

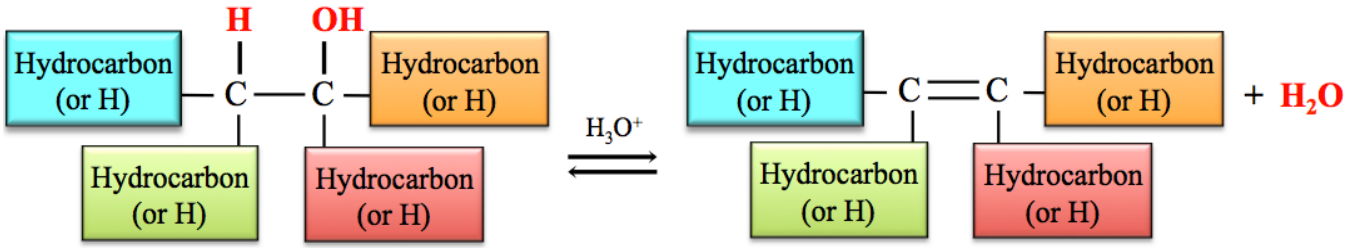
A hydrogen atom from $H_2O$ is added to one of the double bonded carbon atoms and the **-OH** from the $H_2O$ is added to the ***<u>other</u>*** double bonded carbon atom in the ***alk<u>ene</u>*** to produce the corresponding ***alcohol.*** The ***general form*** of the chemical equation for the hydration of an alkene reaction is shown below:




When an **<u>a</u>symmetric alkene** undergoes a hydration reaction, there are ***<u>two</u> different alcohol molecules produced*** - the product that is produced in greater quantity is called the **major product**, the product made in lesser quantity is called the **minor product**. It is possible to predict the major and minor products for the hydration of an asymmetric alkene using **Markovnikov's Rule**.

## 4) The *Dehydration* of Alcohols

A hydroxyl group (**OH**) is removed from a carbon atom and an **H** is removed from a carbon that is *adjacent* to the carbon that was bonded to the hydroxyl group. A double bond forms between these two carbons. The ***general form*** of the chemical equation for the *hydration of an alcohol reaction* is shown below:

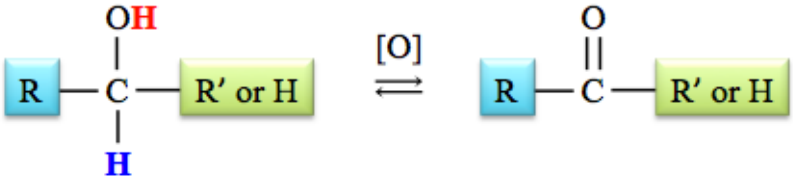



**alcohol** **alkene**

When an **asymmetric *2°* *or 3°* alcohol** undergoes a dehydration reaction, there are ***two different alkene molecules produced*** (*major* and *minor* products).

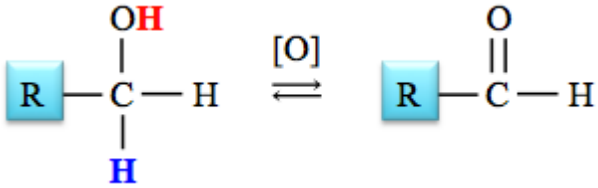
## 5) The *Oxidation* of Alcohols

When an alcohol is oxidized, the hydrogen from the hydroxy group (**OH**) and a hydrogen attached to *the carbon that is carrying the hydroxy group* are both removed, *and* the C-O *single* bond is changed to *double* bond. The general form of the equation for the ***oxidation of an alcohol*** is shown below.



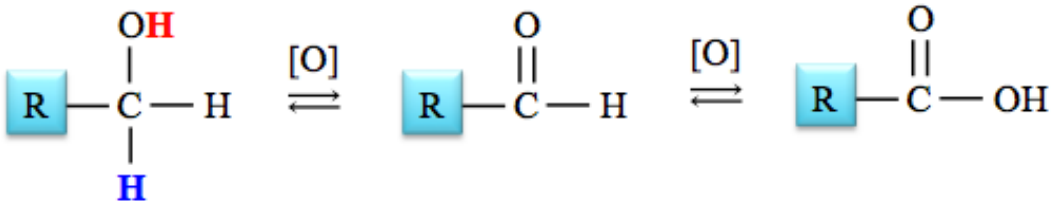

### Oxidation of Primary (1°) Alcohols

Oxidation of a ***primary (1°) alcohol*** produces an ***aldehyde***:




**a primary alcohol** **an aldehyde**

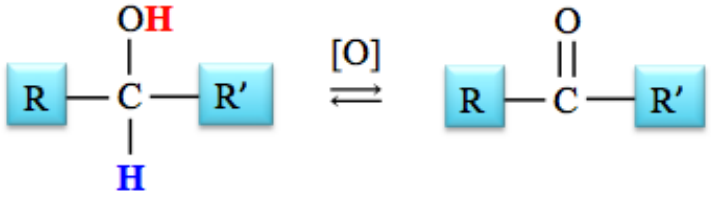
Certain oxidizing agents, such as $CrO_3$ or $MnO_4^-$, and/or enzymes can further oxidized aldehydes to produce carboxylic acids.




**1◦ alcohol** **aldehyde** **carboxylic acid**

**Oxidation of Secondary (2◦) Alcohols**

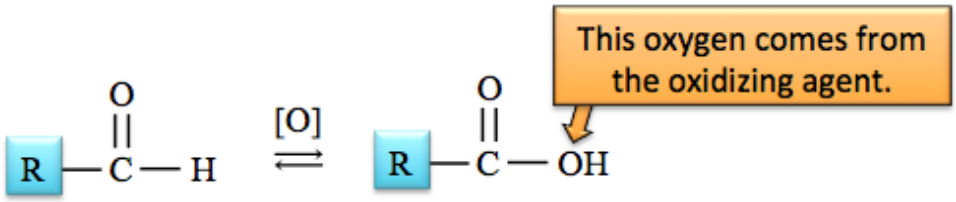
The oxidation of a secondary alcohol produces a ***ketone*** as shown below.




**Tertiary (3◦) alcohols** cannot be converted to aldehydes or ketones by oxidation.

## 6) The Oxidation of Aldehydes

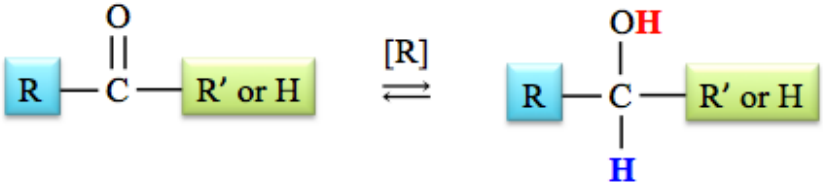
***Aldehydes*** can be oxidized to ***carboxylic acids***. The general form of the chemical equation for the oxidation of an aldehyde is shown below.




**aldehyde** **carboxylic acid**

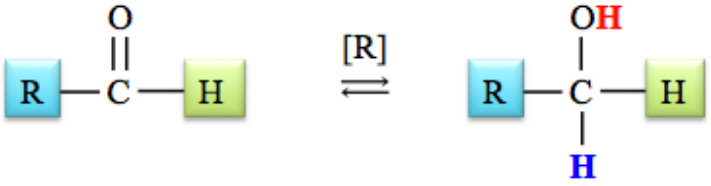
## 7) The Reduction of Aldehydes and Ketones

Reduction of aldehydes and ketones is the reverse of the oxidation of alcohol reactions. The general form of the equation for the ***reduction of an aldehyde or ketone*** is shown below.



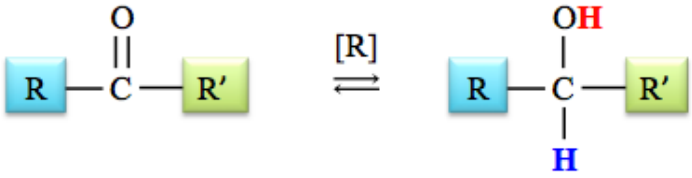

**aldehyde or ketone** **alcohol**

***Aldehydes*** are reduced to ***primary alcohols*.**




**aldehyde** **a primary (1°) alcohol**

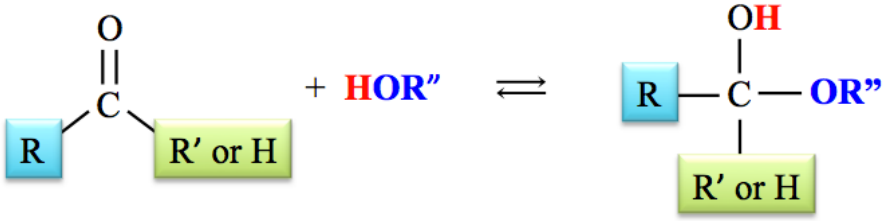
***Ketones*** are reduced to ***secondary alcohols*.**




**ketone** **a secondary (2°) alcohol**

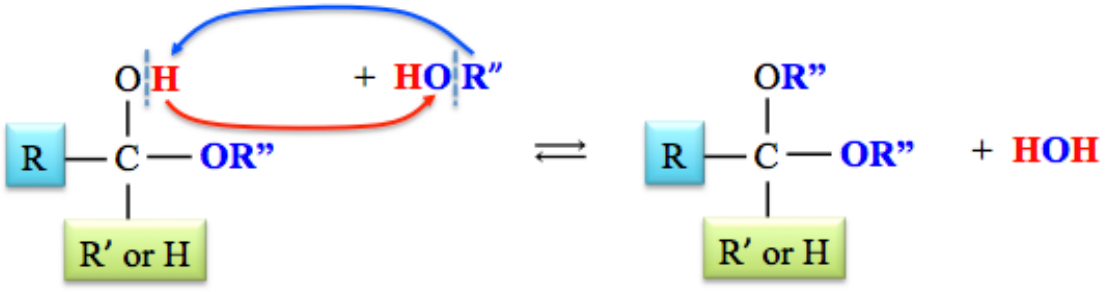
**8) The Reaction of Aldehydes or Ketones with Alcohols: Hemiacetal and Acetal Production**

An ***aldehyde <u>or</u> a ketone*** will react with an ***alcohol*** to form a **hemiacetal**.




**aldehyde or ketone** **alcohol** **hemiacetal**

The ***hemiacetal*** that is formed can react with a *second alcohol molecule* to form an **acetal** and an $H_2O$ molecule.




**hemiacetal** **alcohol** **acetal** **$H_2O$**

## Questions:

1) Draw the condensed structure for the organic molecule that is produced when **butanal** is **oxidized**.

2) Draw the condensed structure for the **aldehyde** that is produced when **ethanol** is oxidized**.**

3) Draw the condensed structure for the organic molecule that is produced when **2-butanol** is oxidized.

4) Write the chemical equation for the formation of (a) the **hemiacetal**, and, (b) the **acetal** when **2-methyl-propanal** reacts with **methanol**.

5) Draw the condensed structure for the organic molecule that is produced when **propanone** is **reduced**.

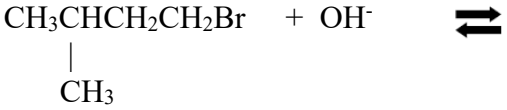
6) Write the chemical equation for the ***hydration*** of **cis-3-hexene** ***and*** explain why there is only one possible product (no major or minor product) for this particular reactant.

7) Draw the condensed structure of the major **and** minor products for the ***dehydration*** reaction of **2-pentanol**.

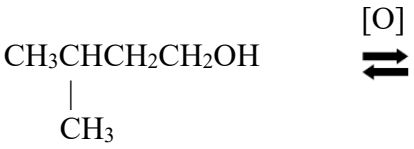
8) Write the chemical equation for the ***hydration*** of **cyclopentene.**

9) Complete the following reactions. If there is more than one possible product, draw both products and label the major and minor product. If no reaction is possible, write "NO REACTION".

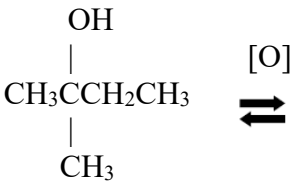
a)



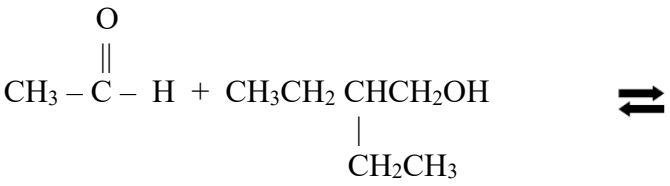
b) write the product formed using excess oxidizing agent



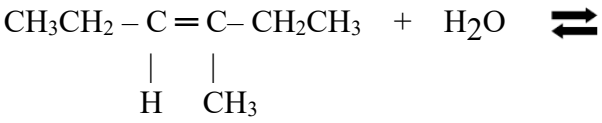
c)



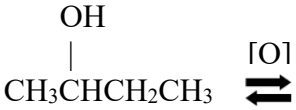
d) Draw the hemiacetal product.



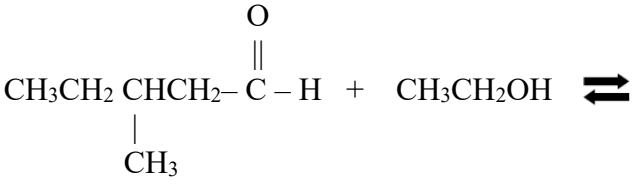
e)



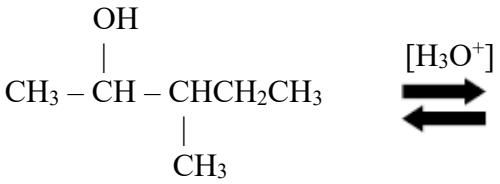
f)



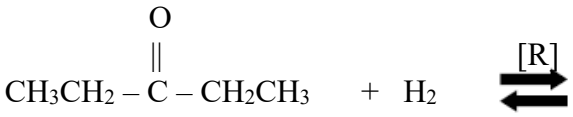
g) Draw the **acetal** product.



h)

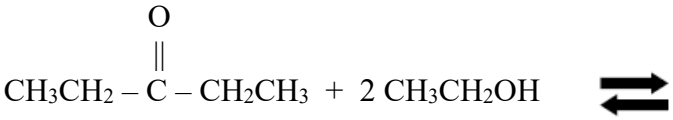



i)

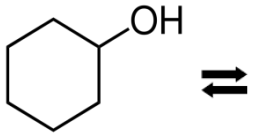



j)

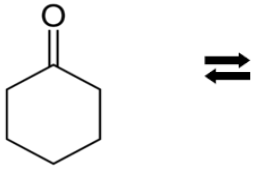

k)




l) Dehydration



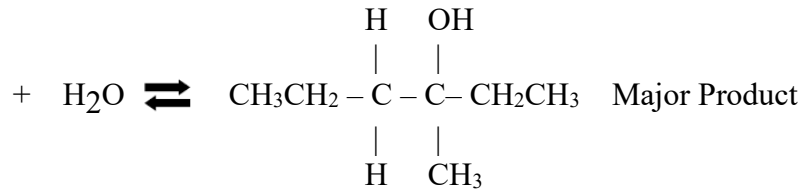

m) Reduction



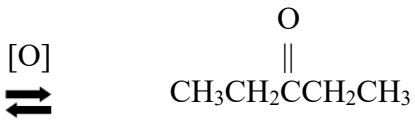
10) Fill in the missing reactant(s):

a)

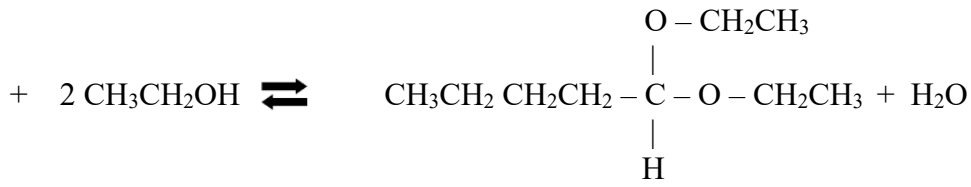

b)



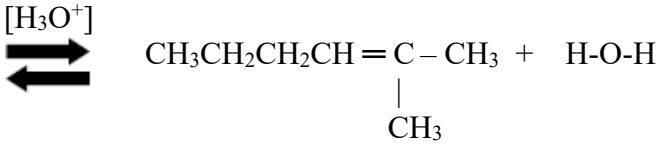

c)




d)

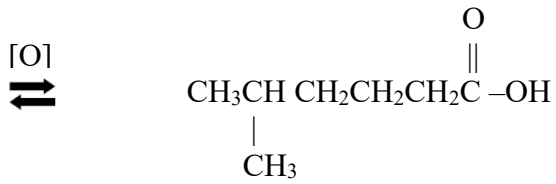



e)

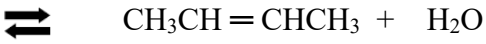



Major Product

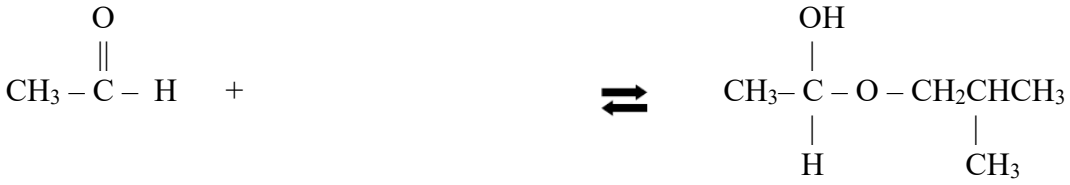
f) Draw the **alcohol** that is ***oxidized*** when excess $MnO_4^-$ is used as an oxidizing agent.




g)

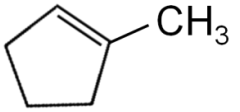



h)



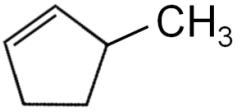

i)

j)




Major Product

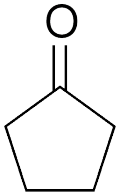
⇄ + $H_2O$




Minor Product

k)

[O] ⇄




l)

[R] ⇄ $CH_3CH_2OH$

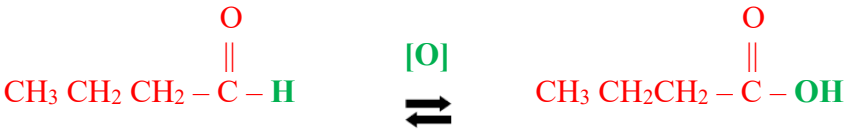
m)

⇄

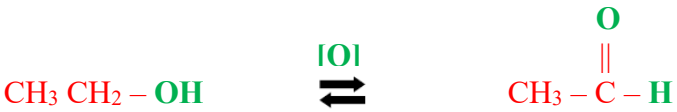
$$CH_3CH_2-\underset{\displaystyle OCH_2CH_3}{\overset{\displaystyle OCH_2CH_3}{\overset{|}{\underset{|}{C}}}}-CH_2CH_3 \quad + \quad H_2O$$

# Key

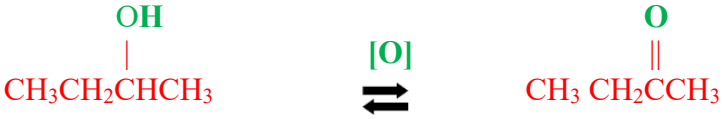
1) Draw the condensed structure for the organic molecule that is produced when **butanal** is **oxidized**.



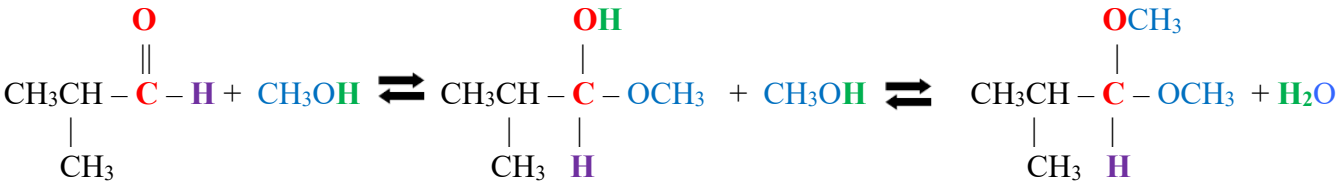

2) Draw the condensed structure for the **aldehyde** that is produced when **ethanol** is **oxidized.**




3) Draw the condensed structure for the organic molecule that is produced when **2-butanol** is **oxidized**.

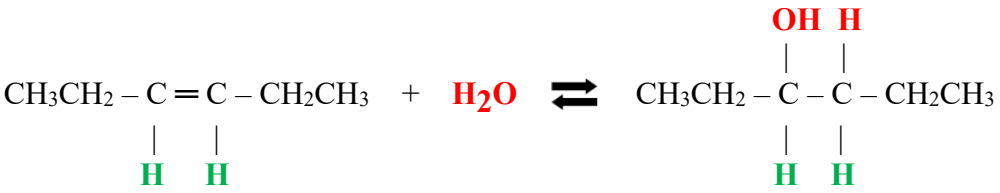



4) Write the chemical equation for the formation of (a) the **hemiacetal** and, (b) the **acetal** when **2-methyl-propanal** reacts with **methanol**.



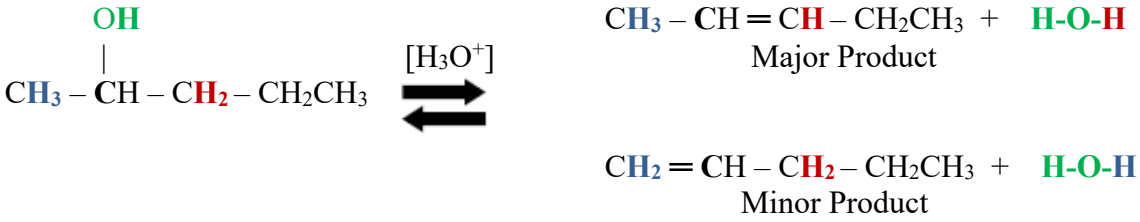

5) Draw the condensed structure for the organic molecule that is produced when **propanone** is **reduced**.

6) Write the chemical equation for the hydration of **cis-3-hexene *and*** explain why there is only one possible product (no major or minor product) for this particular reactant.

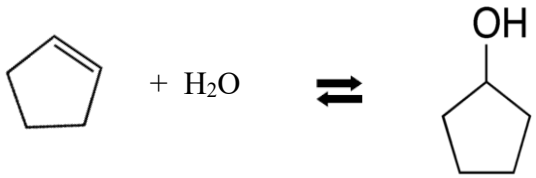


- There is only one product because the alkene is symmetric. No matter what carbon receives the **OH**, the product is 3-hexanol.

7) Draw the condensed structure of the major **and** minor product for the ***dehydration*** reaction of **2-pentanol**.

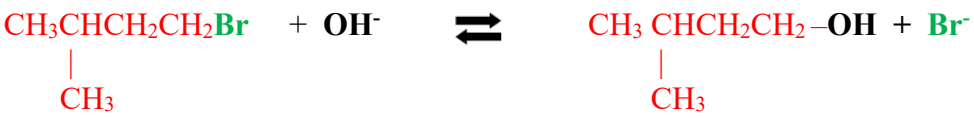


8) Write the chemical equation for the ***hydration*** of **cyclopentene.**

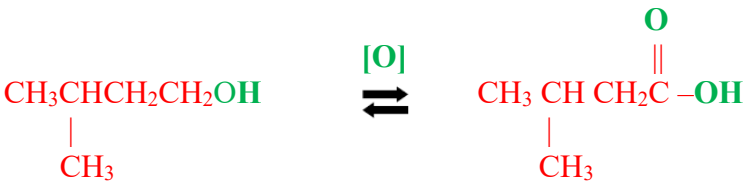


9) Complete the following reactions. If there is more than one possible product, then draw both products and label the major and minor product. If no reaction is possible, write "NO REACTION".

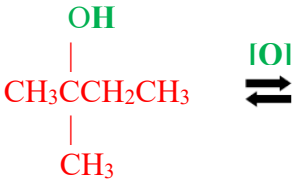
a)



b) write the product formed using excess oxidizing agent

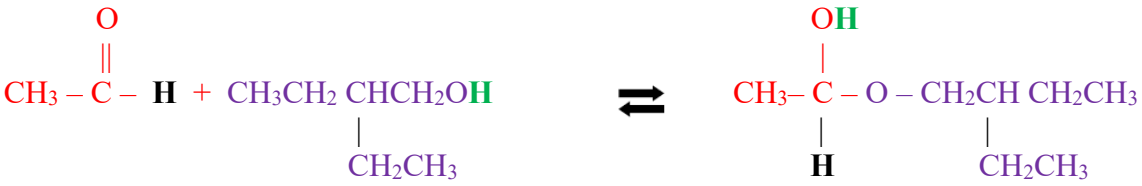


c)

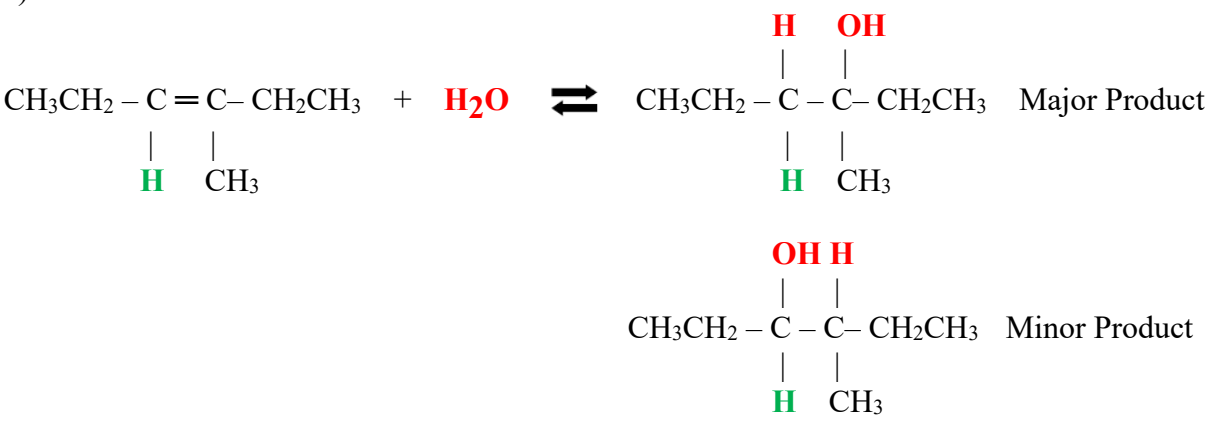



NO REACTION, 3º ALCOHOLS CAN NOT BE OXIDIZED

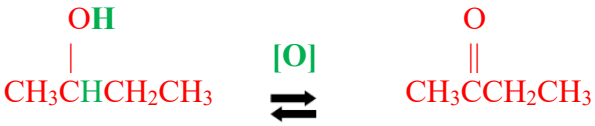
d) draw the hemiacetal product



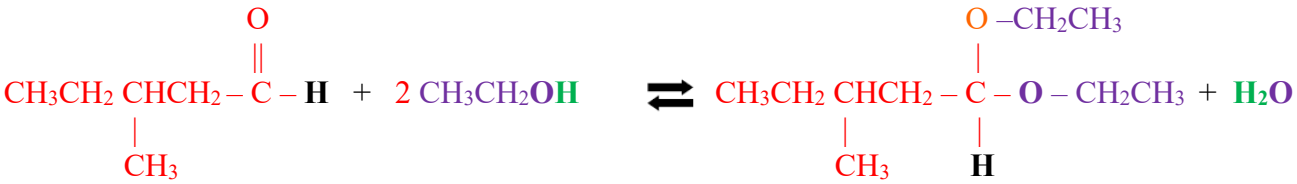

e)



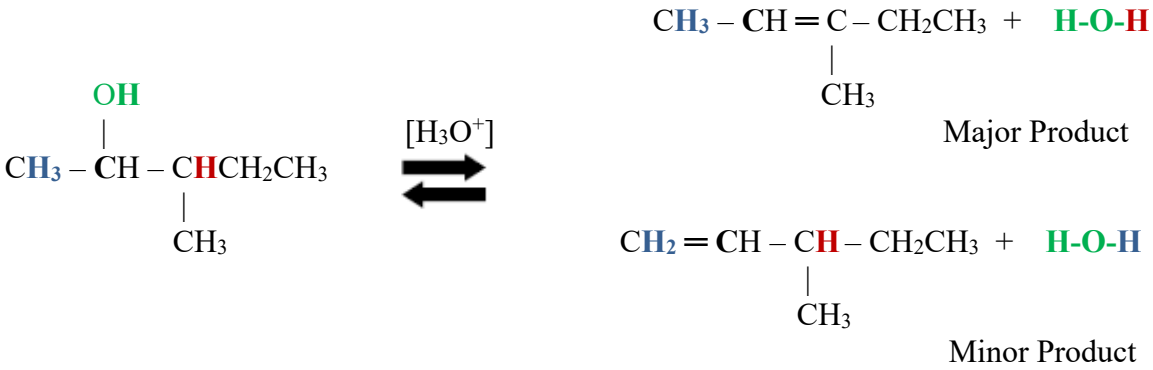

f)



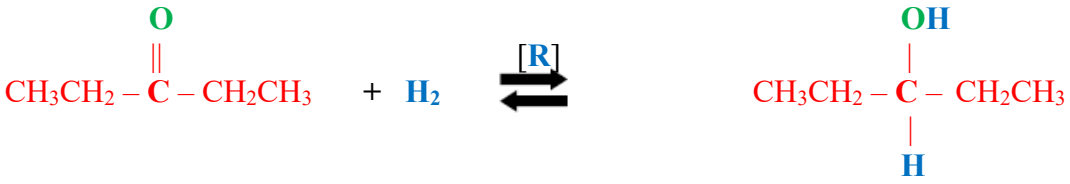

g) Draw the **acetal** product.



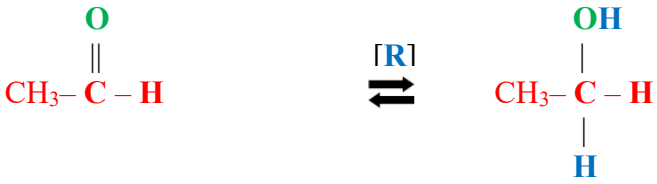
h)



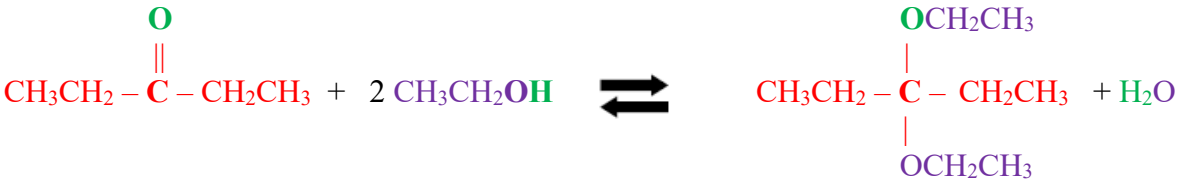

i)



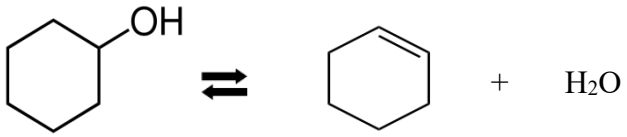

j)



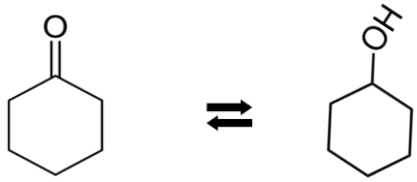

k)




l) Dehydration

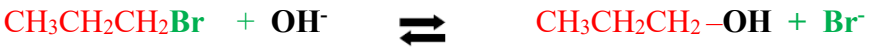



m) Reduction

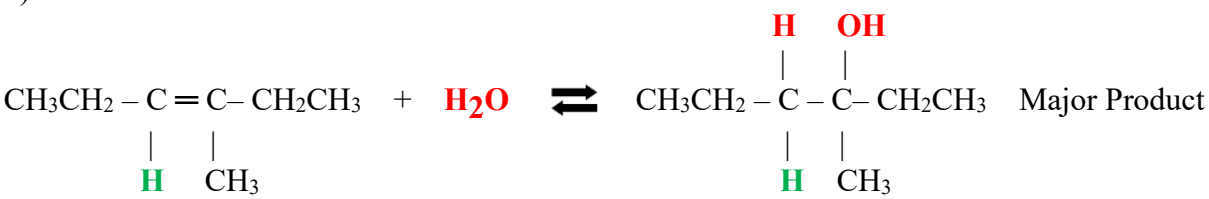


10) Fill in the missing reactant(s):

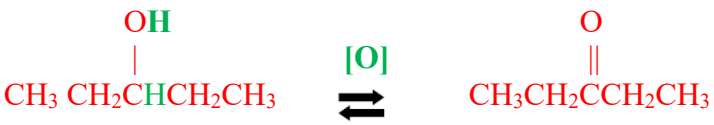
a)



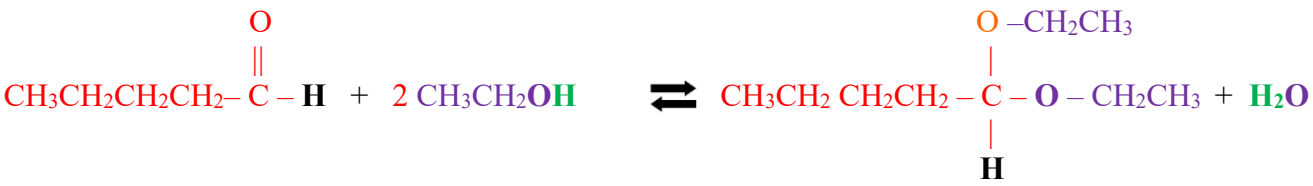

b)



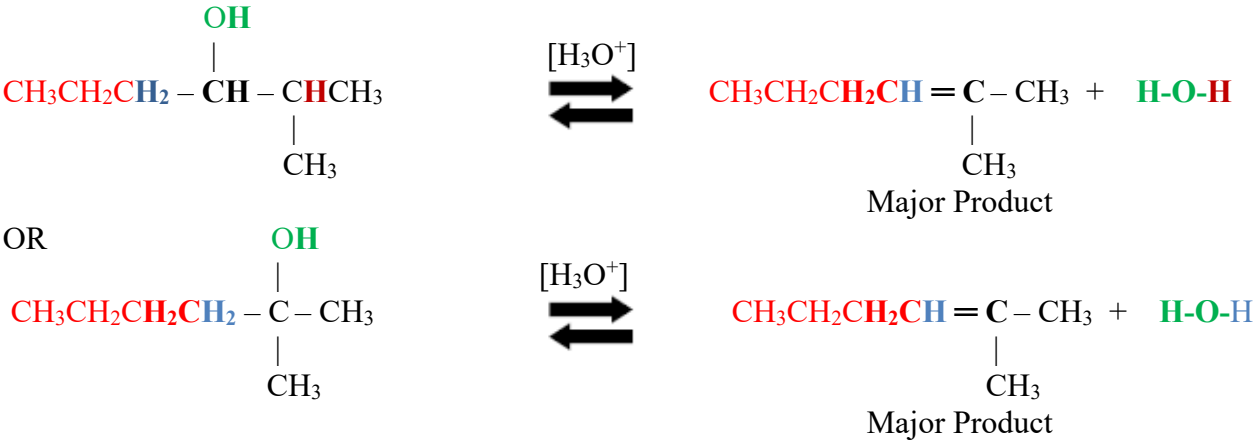

c)



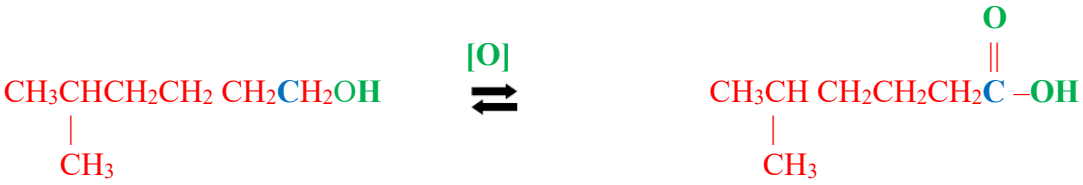

d)



e) Two possible answers:

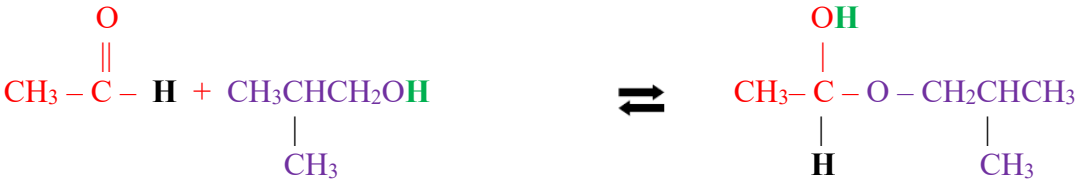



f) Draw the alcohol that is oxidized when excess $MnO_4^-$ is used as an oxidizing agent.



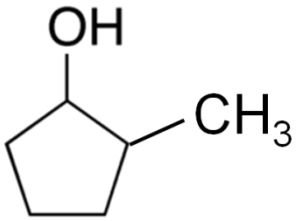

g)

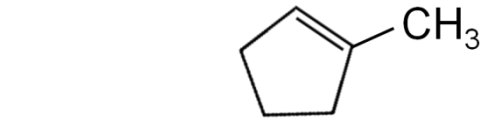

h)




i)

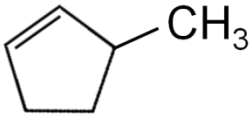
j)



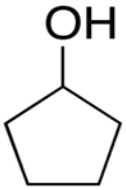

Major Product

+ $H_2O$

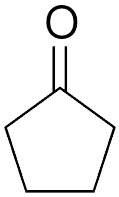



Minor Product

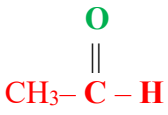
k)




[O]




l)




[R]

$CH_3CH_2OH$

m)