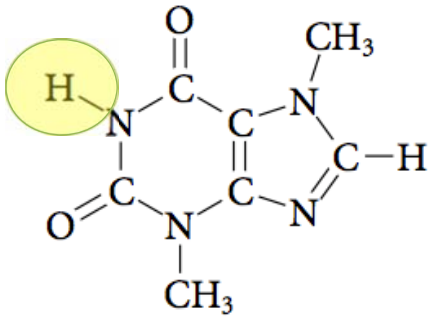
Grade 12 Chemistry

Organic Chemistry

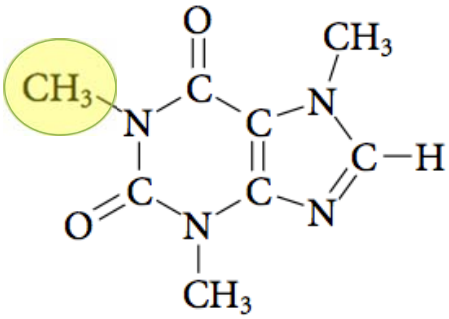
Class 3

Organic Reactions

- Organic compounds are synthesized (man-made) in large quantities industrially by adding or removing key functional groups from available molecules
- Ex: Caffeine can be extracted from coffee beans and tea leaves but to meet the large demand, a compound called theobromine is obtained from cocoa fruits and modified by adding a methyl group to make caffeine



theobromine



caffeine

Beverage	Serving Size	Caffeine Content (mg)
Coffee, Brewed	8 oz	120 mg
Coffee, Decaffeinated	8 oz	5 mg
Starbucks Grande (medium) Coffee	8 oz	330 mg
Black Tea	8 oz	45 mg
Green Tea	8 oz	20 mg
White Tea	8 oz	15 mg
Diet Coke	12 oz	47 mg
Coca-Cola Classic	12 oz	35 mg

Reaction Types

- **Addition Reaction** – atoms are added to a double or triple bond OR a C=O bond

Example 1

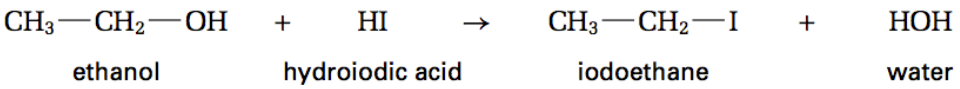
ethene + hydrobromic acid → bromoethane

Example 2

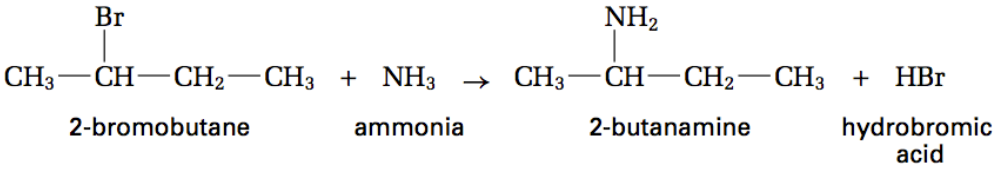
butyne + bromine → 1,2-dibromobutene

- **Substitution Reaction** – A hydrogen atom or functional group is replaced by a different functional group
- Commonly found in alcohols, alkyl halides and aromatic compounds

Example 1

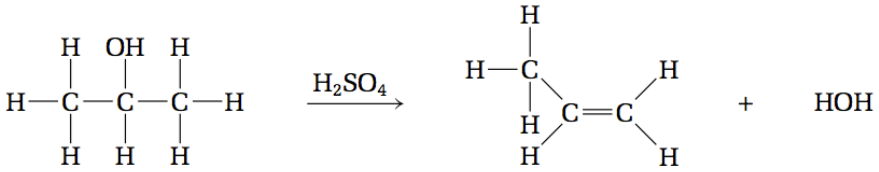


Example 2

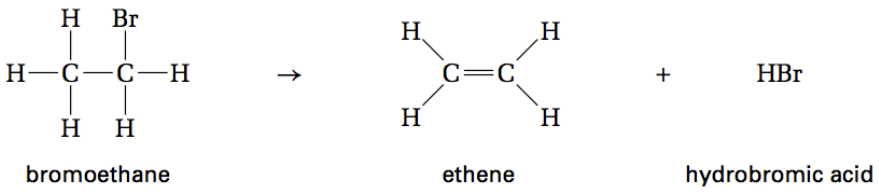


- **Elimination Reaction** – Atoms are removed from a molecule to form a double bond
- Commonly found in alcohols, alkyl halides

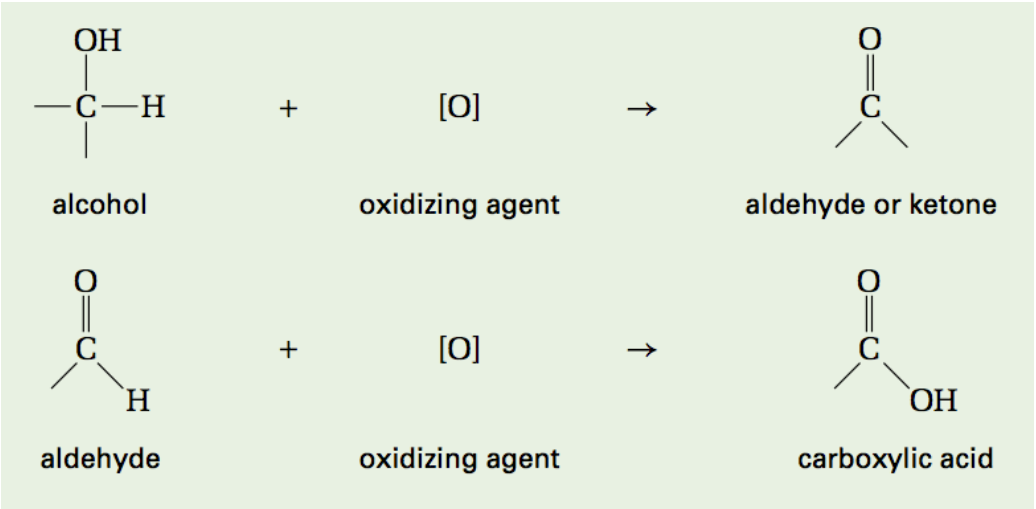
Example 1

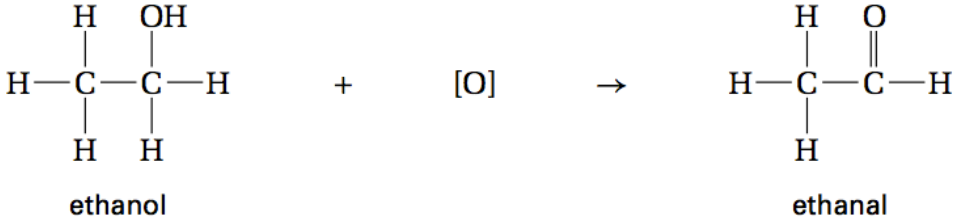


Example 2

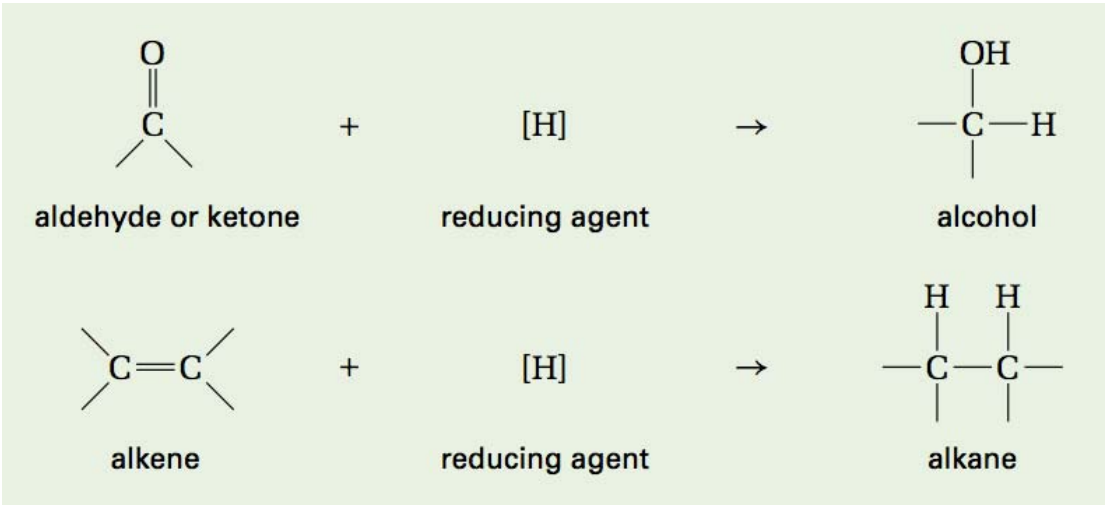


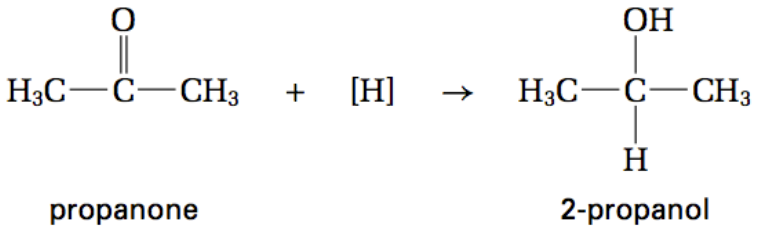
- **Oxidation** – reaction in which carbon forms more bonds to oxygen
- Commonly found to produce aldehydes and ketones in the presence of an oxidizing agent such as $KMnO_4$, $K_2Cr_2O_7$ and O_3
- Symbol is [O]
- Identify an oxidation by counting and comparing the number of C-H and C-O bonds



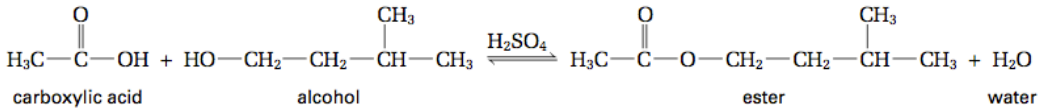


- **Reduction** – reaction in which carbon forms fewer bonds to oxygen
- Commonly found in aldehydes, ketones, carboxylic acids, alkenes, and alkynes
- Requires a reducing agent such as $LiAlH_4$ and H_2/Pt
- Symbol is [H]
- Identify reduction by counting and comparing the number of C-H and C-O bonds

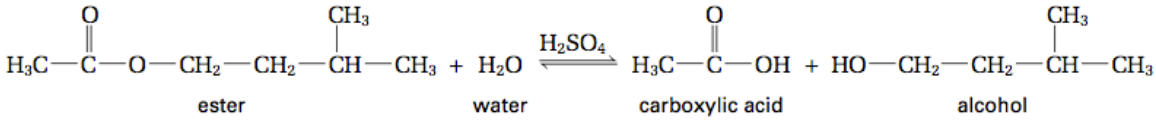




- **Condensation Reactions** – two molecules combine to form one molecule with the production of water



- **Hydrolysis Reactions** – water is added to a bond, splitting it into two.



Checkpoint

Identify the types of reaction:

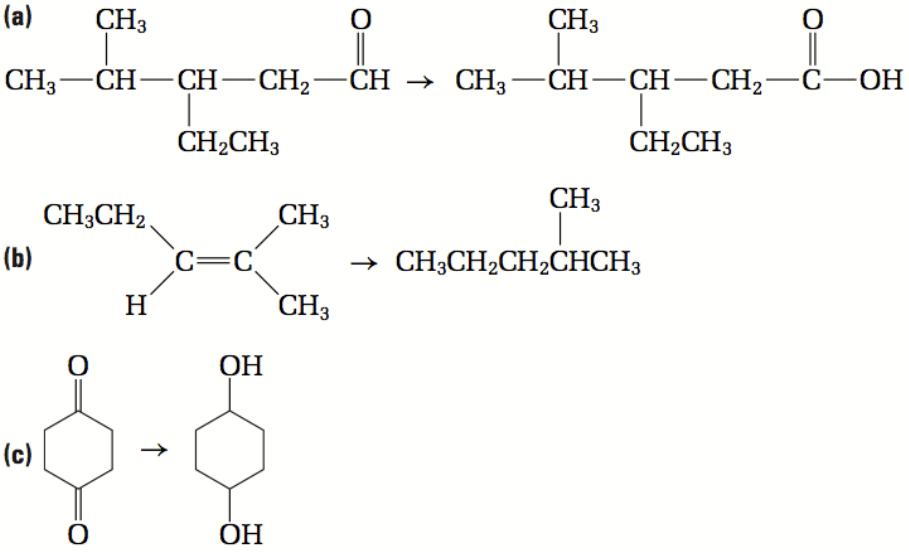
(a) $HO-CH_2CH_2CH_3 \rightarrow CH_2=CHCH_3 + H_2O$

(b) $H_2C=CHCH_2CH_3 + H_2 \rightarrow CH_3CH_2CH_2CH_3$

(c) $CH_3CH(CH_3)CH_2CH_2Br + NaOH \rightarrow CH_3CH(CH_3)CH_2CH_2OH + NaBr$

Checkpoint

Identify the types of reaction:

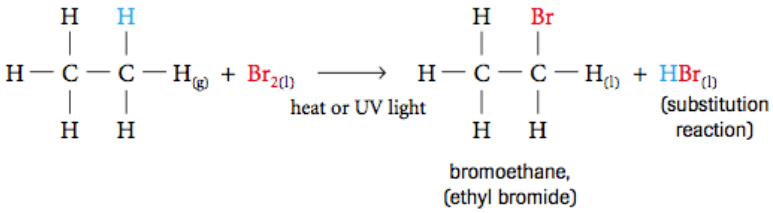


Reactions of Alkanes

- Combustion Reactions

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$

- Halogenation – replacement of hydrogen atoms with halogen atoms



  - Uses a free radical substitution reaction

Reactions of Alkenes

- Addition:
  - Symmetrical alkene – identical groups on either side of the double bond

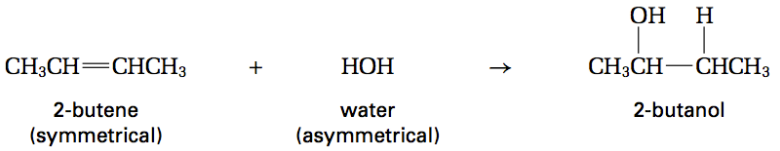


Figure 2.3 The addition of water to 2-butene

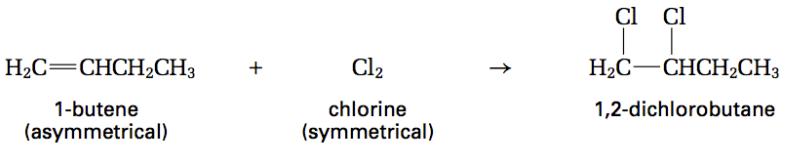


Figure 2.4 The addition of chlorine to 1-butene

Alkenes can add:
- X_2
- H_2
- HX
- H_2O

  - Asymmetrical alkene – different groups on either side of the double bond

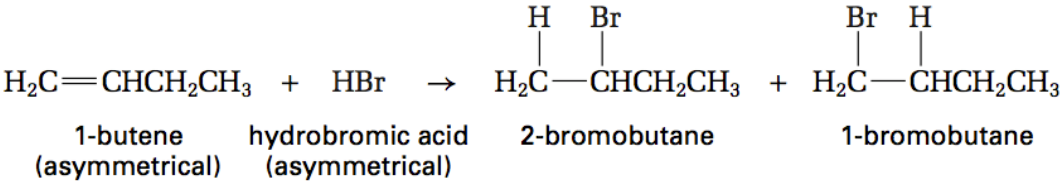
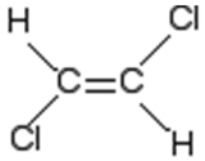


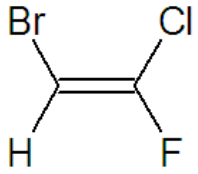
Figure 2.5 The addition of hydrobromic acid to 1-butene

- **Markovnikov's Rule** – the halogen atom or OH group is usually added to the more substituted carbon atom
- "The rich get richer" – the H binds to the side with more H

Checkpoint

Name the following:





Draw structural diagrams to represent the elimination reaction of 2-chloropentane to form an alkene. Name the products.

Checkpoint

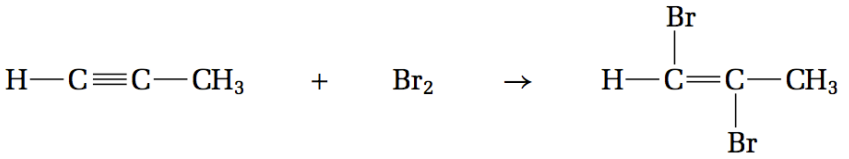
Draw the reactants and products of the following incomplete reaction:

2-methylpent-2-ene + hydrochloric acid → ?

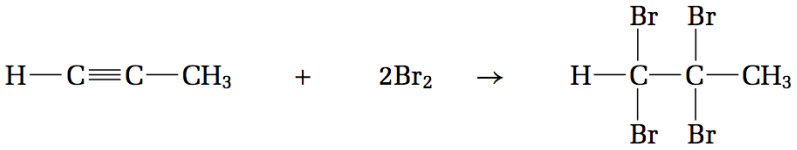
Use Markovnikov's rule to predict which of the two isomeric products will form in a greater amount.

Reactions of Alkynes

- Addition Reaction: Alkyne → Alkene → Alkane



propyne (1 molecule) + bromine (1 molecule) → 1,2-dibromopropene



propyne (1 mol) + bromine (2 mol) → 1,1,2,2-tetrabromopropane

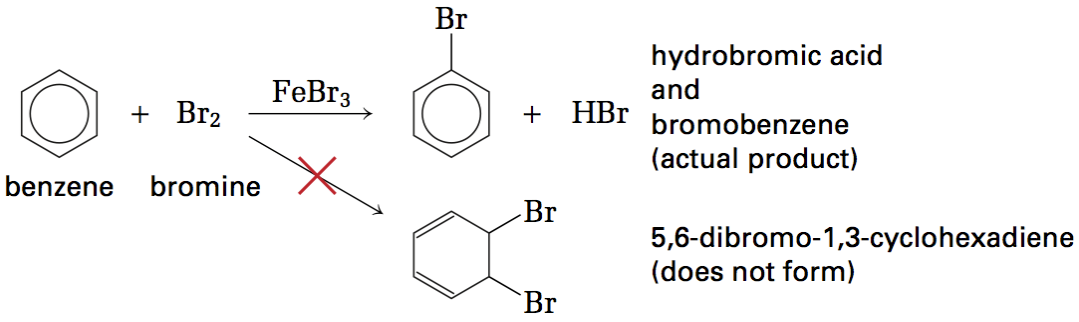
Checkpoint

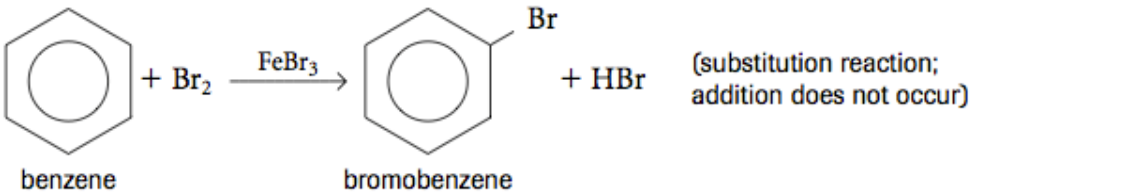
Predict the products from the following reaction:

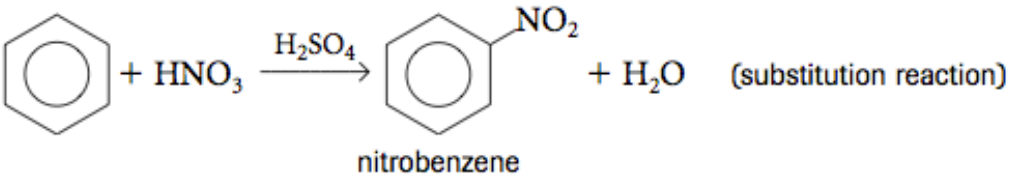
1-butyne (1 mol) + hydrobromic acid (1 mol) →

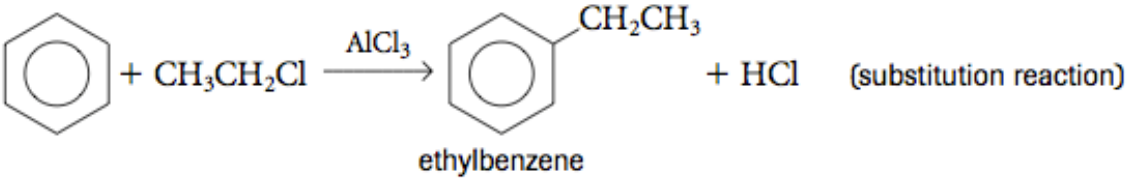
Reactions of Aromatic Compounds

- Substitution Reactions – one of the hydrogen atoms are replaced by a functional group
  - Addition reactions DO NOT occur since the product would be less stable than benzene









Checkpoint

Predict and name the products of reactions involving the following reactants:

a) Cyclohexene and hydrogen bromide

b) Benzene and chloroethane

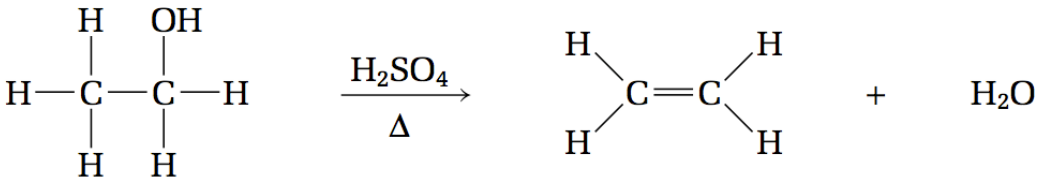
Reactions of Alcohols

- Substitution Reactions – When a halogen acid (HCl, HBr, HI) reacts with alcohol, the halogen is substituted for the OH group
- Reverse occurs with OH^- in a basic solution

Acid $CH_3—CH_2—OH + HCl \rightarrow CH_3—CH_2—Cl + H_2O$

Base $CH_3—CH_2—Cl + OH^- \rightarrow CH_3—CH_2—OH + Cl^-$

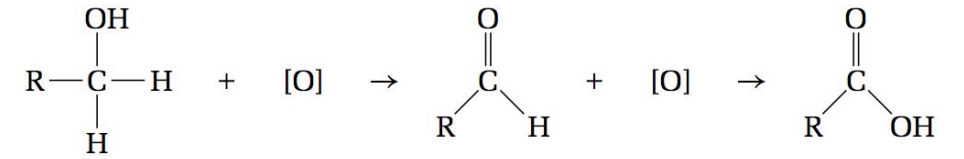
- Elimination Reaction (Dehydration Reaction) – when an alcohol is heated in the presence of the strong acid and a dehydrating agent H_2SO_4



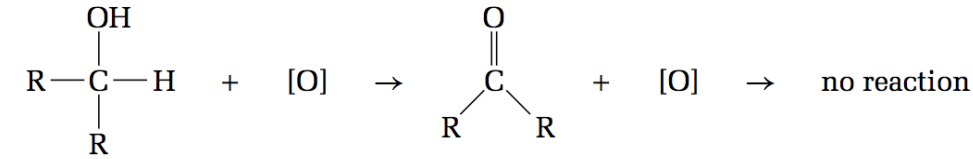
ethanol ethene water

- Δ means heat

- Oxidation – in the presence of an oxidizing agent, alcohols can be oxidized to form an aldehyde or a ketone

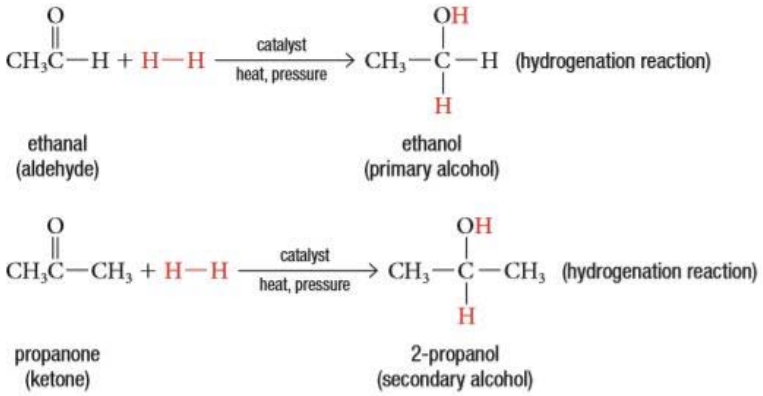


primary alcohol aldehyde carboxylic acid



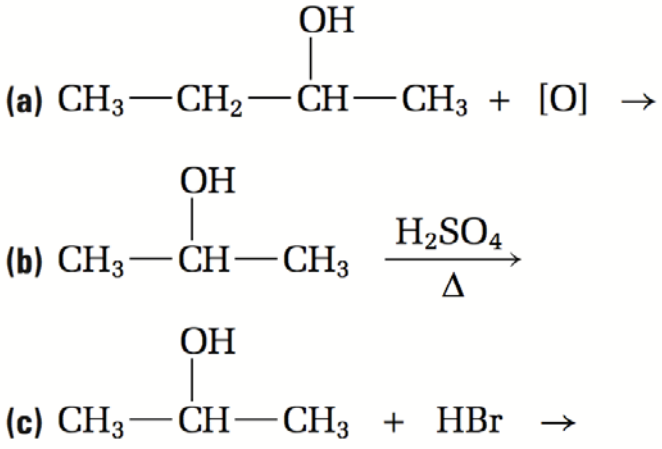
secondary alcohol ketone

- Aldehydes and ketones can also undergo reduction (hydrogenation) at high temperatures and pressures and in the presence of a catalyst
- The product is its corresponding alcohol



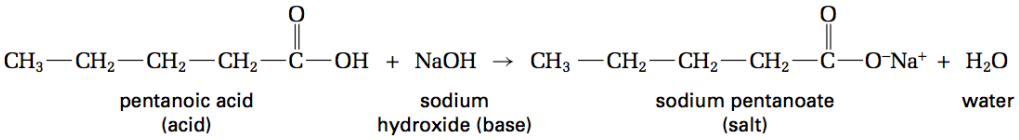
Checkpoint

Name each type of reaction. Then predict and name the products.

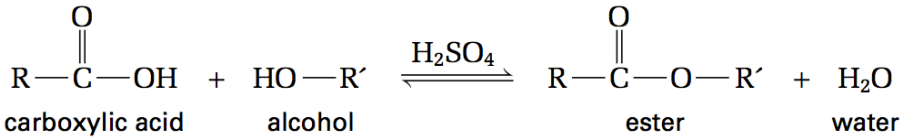


Reactions of Carboxylic Acids

- Neutralization – Carboxylic acid reacts with a base to produce a salt and water

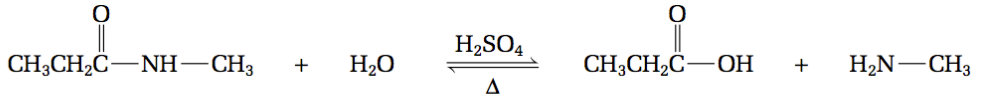


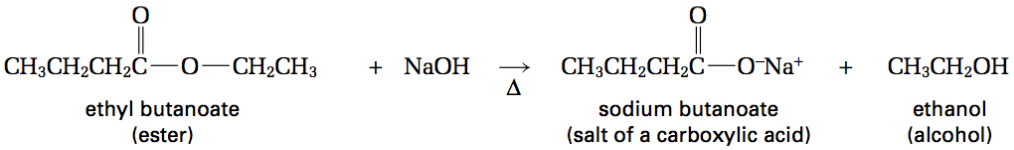
- Esterification Reaction – Carboxylic acid reacts with an alcohol to produce an ester and water



Reactions of Esters and Amides

- Hydrolysis – ester or amide bond is cleaved or split in two to form two products
  - Amide → Carboxylic Acid and Amine
  - Ester → Carboxylic Acid and Alcohol





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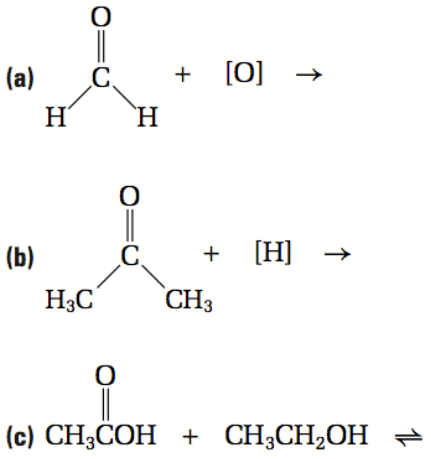
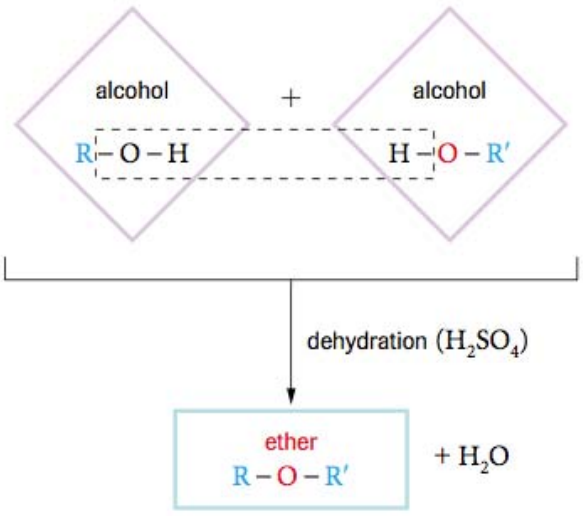
Name each type of reaction. Then predict and name the products.



Synthesis of Ethers

- Condensation Reactions (requires catalyst)



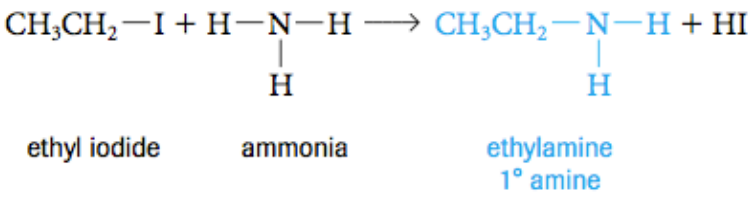
Example:

$$CH_3OH_{(l)} + CH_3OH_{(l)} \xrightarrow{H_2SO_4} CH_3OCH_{3(l)} + HOH_{(l)}$$

methanol + methanol → methoxymethane + water

Reactions of Amines

- Alkyl Halide + Ammonia



  - The 1° amine can be further reacted with alkyl halides to form 2° and 3° amines