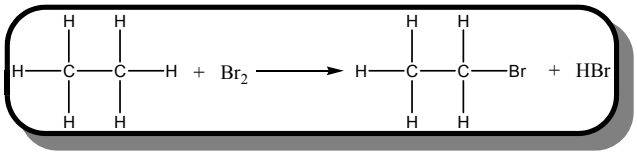
Understanding Organic Reactions

Hydrocarbons participate in a variety of chemical reactions. Some are described below.

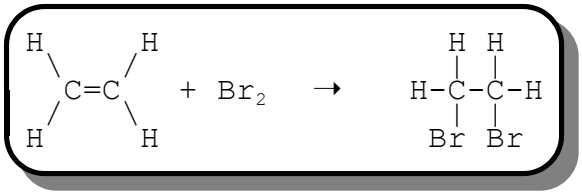
Combustion. Fossil fuels such as the gasoline used in automobiles or the propane used in gas barbecues are hydrocarbons. When they burn, they release carbon dioxide and water. ($C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$). Of course, when there is insufficient oxygen, as in an automobile engine, the carbon does not oxidize completely, and carbon monoxide and water forms. ($2C_8H_{18} + 17O_2 \rightarrow 16CO + 18H_2O$). That is why automobile exhaust contains carbon monoxide.

Substitution. Saturated hydrocarbons have all their bonding sites filled with hydrogen. The only way to attach any other elements to the carbon chain of a saturated hydrocarbon is to replace the hydrogen. The replacement of the hydrogen with another element is called substitution. The diagram to the right shows halogen substitution.



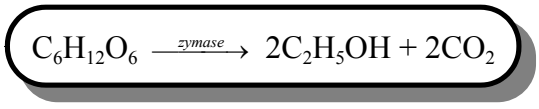
ethane + bromine →1-bromoethane + hydrogen bromide

Addition. When there is a point of unsaturation, it is possible to add elements to the hydrocarbon chain at that point without removing any hydrogens. This is called addition. Unsaturated bonds are more reactive than saturated bonds and alkynes are even more reactive than alkenes, so additon of halogens occurs at room temperature. Addition of hydrogen to an alkene or an alkyne (or other carbon compounds with double or triple bonds) is called hydrogenation. It is the processed used to make margarine from vegetable oil.



ethene + bromine → 1,2 -dibromoethane

Fermentation. Beverage alcohol is formed by yeast. It forms as a result of the enzymatic breakdown of organic molecules during anaerobic respiration. It is called fermentation.

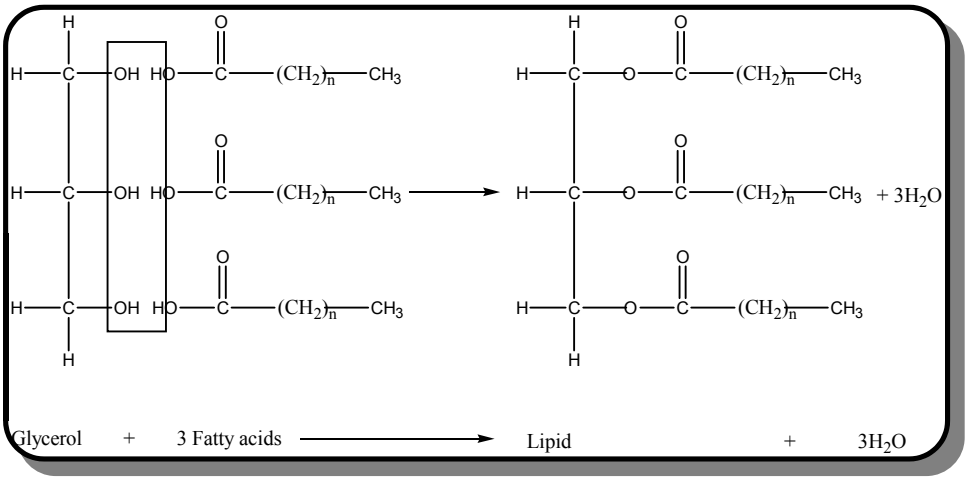


glucose → ethanol + carbon dioxide

Esterification. Esterification is the formation of esters (RCOOR). Esters form from a reaction between an organic acid and an alcohol. The alcohol and acid join by dehydration synthesis. The reaction looks similar to an acid base neutralization. Esters are responsible for fruit flavorings and aromas of flowers. They are synthesized as artificial flavors. Lipids (fats and oils) are formed by esterification of glycerol (1,2,3-propanetriol) by fatty acids (long chain organic acids)

Alcohol + Acid → Ester + Water

Saponification. Saponification is the hydrolysis of fats by bases. When sodium hydroxide reacts with a fat it produces organic salts called soaps plus glycerol as a byproduct. The reaction looks much like the reverse of the formation of the fat, except that the fatty acid becomes a sodium salt [$Na^+ CH_3(CH_2)_nCOO^-$].



Formation of fat by esterification

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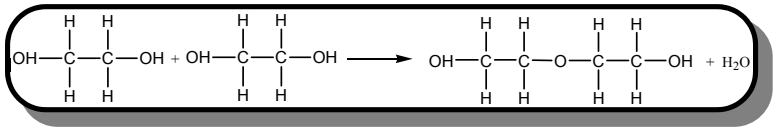
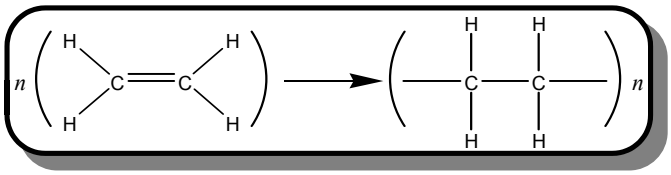
Polymerization. Polymerization is the formation of large molecules from repeating units of smaller ones. A polymer is a large molecule formed from many smaller, repeating units or *monomers*. Polymers can form by ***condensation*** – joining monomers by dehydration synthesis. Condensation polymers must have at least two functional groups. The process can be repeated to form long chain polymers. Examples include silicones, polyesters, polyamides, phenolic plastics, and nylons. ***Addition polymerization*** involves opening up double and triple bonds of unsaturated hydrocarbons. Examples include vinyl plastics - polyethylene and polystyrene.



Polymerization by condensation



Addition polymerization

Answer the questions below based on the reading above and on your knowledge of chemistry.

1. What forms from the complete combustion of a hydrocarbon? _____

2. A hydrocarbon reacts with fluorine. Under which conditions will substitution occur, and under which conditions will addition occur? _____

3. What is butylpentanoate? How does it form? _____

4. How is soap made? _____

5. What is the process of joining many small molecules into larger molecules is called? _____

6. Teflon, a common non-stick cooking surface, is a polymer of tetrafluoroethene. Draw a structural formula of tetrafluoroethene. Then show the result of the reaction using structural formulas. What type of polymerization is this?