

## Section 1.6: Carboxylic Acids, Esters, and Fats

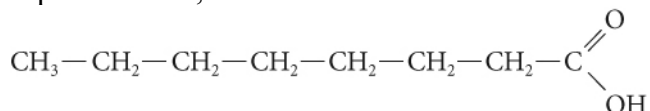
### Tutorial 1 Practice, page 48

1. (a) This compound contains a 10-carbon chain (including the carboxylic acid carbon): decane. There is one carboxyl group in the compound, so its name is decanoic acid.

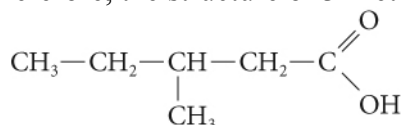
(b) This compound contains a 4-carbon chain (including the carboxylic acid carbon): butane. There is one carboxyl group in the compound, so its name is butanoic acid.

(c) This compound contains a 7-carbon chain (including the carboxylic acid carbon): heptane. There is one carboxyl group in the compound, so it is a heptanoic acid. The methyl substituent is on the third carbon, numbering from the carboxyl group, so the compound is 3-methylheptanoic acid.

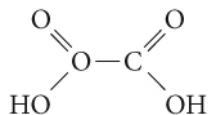
2. (a) First, draw the root structure, octane. Next, change a terminal carbon to a carboxyl group. Therefore, the structure of octanoic acid is:



(b) First, draw the root structure, pentane. Next, change a terminal carbon to a carboxyl group. The 3- prefix indicates that the methyl group is on the third carbon from the carboxyl group, so the carboxyl group must be on the end closest to the methyl group. Therefore, the structure of 3-methylpentanoic acid is:



(c) First, draw the root structure, ethane. Since ethane is a dioic acid, it has two carboxyl groups. Change the terminal carbon at each end to a carboxyl group. Therefore, the structure of ethanedioic acid is:



### Tutorial 2 Practice, page 50

1. (a) **Step 1:** Identify the two alkyl groups. There is a 2-carbon ethyl group and a 5-carbon pentyl group.

**Step 2:** Determine which group originates from the carboxylic acid and which originates from the alcohol. The pentyl group originated from the pentanoic acid. The ethyl group originated from ethanol.

**Step 3:** Write the name with the alcohol part first and the carboxylic acid part second. This ester is ethyl pentanoate.

(b) **Step 1:** Identify the two alkyl groups. There is a 1-carbon methyl group and a 10-carbon decyl group.

**Step 2:** Determine which group originated from the carboxylic acid and which originated from the alcohol. The decyl group originated from the decanoic acid. The methyl group originated from methanol.

**Step 3:** Write the name with the alcohol part first and the carboxylic acid part second. This ester is methyl decanoate.

(c) **Step 1:** Identify the two alkyl groups. There is a 1-carbon methyl group and a 4-carbon butyl group.

**Step 2:** Determine which group originated from the carboxylic acid and which originated from the alcohol. The methyl group originated from the methanoic acid. The butyl group originated from butan-1-ol.

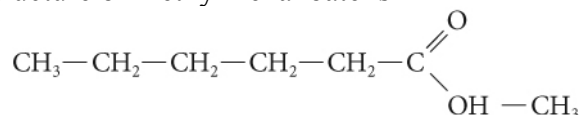
**Step 3:** Write the name with the alcohol part first and the carboxylic acid part second. This ester is butyl methanoate.

(d) **Step 1:** Identify the two alkyl groups. There is a phenyl group and a 3-carbon propyl group.

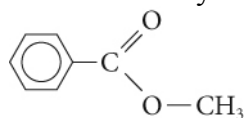
**Step 2:** Determine which group originated from the carboxylic acid and which originated from the alcohol. The phenyl group originated from the benzoic acid. The propyl group originated from propan-1-ol.

**Step 3:** Write the name with the alcohol part first and the carboxylic acid part second. This ester is propyl benzoate.

2. (a) The first part of the name is methyl, which indicates a 1-carbon alkyl group. The second part of the name, hexanoate, indicates a 6-carbon carboxyl part. Therefore, the structure of methyl hexanoate is

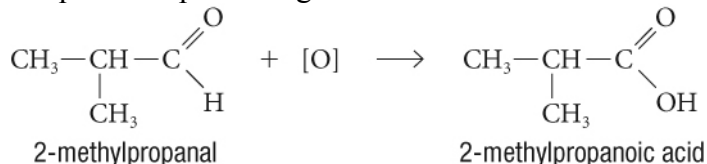


(b) The first part of the name is methyl, which indicates a 1-carbon alkyl group. The second part of the name, benzoate, indicates a phenyl carboxyl part. Therefore, the structure of methyl benzoate is

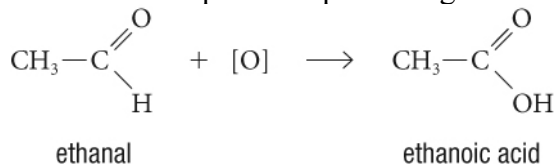


### Tutorial 3 Practice, page 53

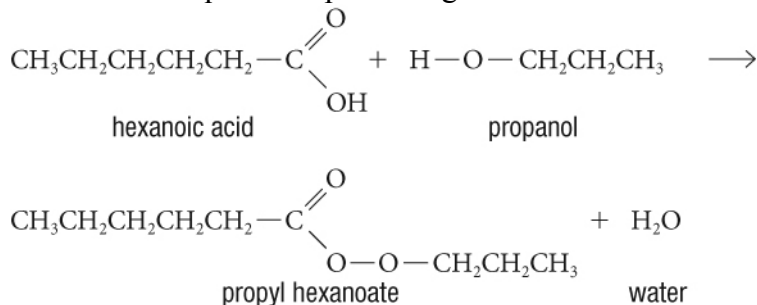
1. (a) 2-methylpropanoic acid can be produced from the oxidation of 2-methylpropanal. The equation representing the reaction is



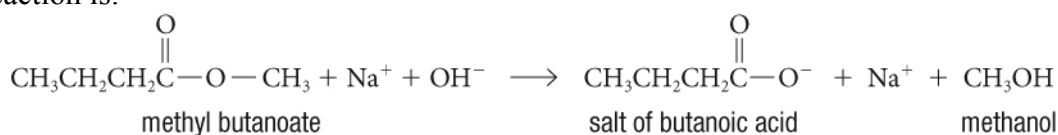
(b) Ethanoic acid is a carboxylic acid. Ethanoic acid can be produced from the oxidation of ethanal. The equation representing the reaction is



(c) The esterification reaction between propanol and hexanoic acid produces propyl hexanoate. The equation representing the reaction is:



(d) The hydrolysis of methyl butanoate in the presence of sodium hydroxide solution produces the sodium salt of butanoic acid and methanol. The equation representing the reaction is:



### Research This: Banning Trans Fat, page 54

**A.** Answers may vary. Sample answer: I think that *trans* fats should be banned from processed food. *Trans* fats are created by hydrogenating unsaturated fats. *Trans* fats are used to provide desirable texture to certain processed foods and to preserve the shelf life of the products. They also allow food processors to incorporate some of the properties of saturated fats at a lower cost. While these are important benefits, the risks associated with consuming *trans* fats are too great to allow the use of these fats. *Trans* fats have been conclusively linked to heart disease. They operate by raising levels of LDL (bad) cholesterol and lowering levels of HDL (good) cholesterol. Heart disease is widespread in our society, and it is our responsibility to do everything we can as a society to reduce its prevalence. Sometimes, as with *trans* fats, small sacrifices have to be made for greater gains.

### Section 1.6 Questions, page 55

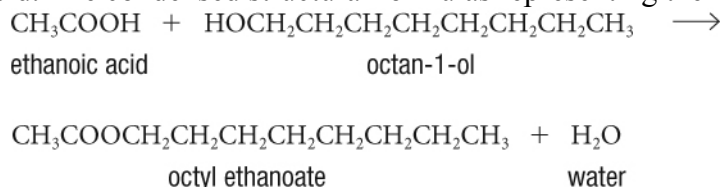
1. (a) The condensed structure of 3-methylhexanoic acid is  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{COOH}$ .

(b) The condensed structure of propyl pentanoate is  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_2\text{CH}_3$ .

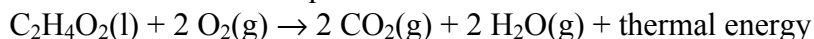
2. (a) The alkyl groups are methyl and pentyl. The pentyl group originated from the pentanoic acid. The methyl group originated from methanol. The compound is methyl pentanoate.

(b) The alkyl groups are methyl and butyl. The butyl group originated from the butanoic acid. The methyl group originated from methanol. The compound is methyl butanoate.

3. Octyl ethanoate can be synthesized by the esterification of octan-1-ol and ethanoic acid. The condensed structural formulas representing the reaction are:

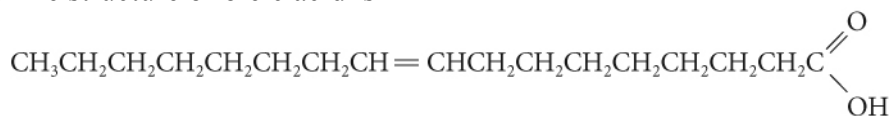


4. A balanced chemical equation for the combustion of ethanoic acid is



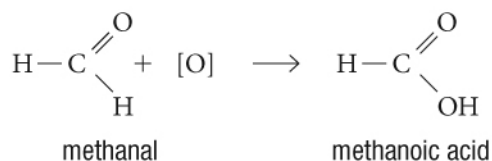
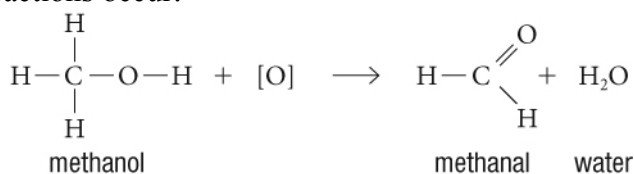
5. Since ethanoic acid molecules have two polar groups, a carbonyl and a hydroxyl group, they are very polar. The molecules form hydrogen bonds with water. Ethanol molecules have one hydroxyl group so they are less polar. Their molecules also form hydrogen bonds with water. Ethane is a saturated hydrocarbon and its molecules are non-polar. The molecules do not form hydrogen bonds with water. Therefore, the solubility of ethanoic acid is greater than the solubility of ethanol, which is greater than the solubility of ethane. The melting point of ethanoic acid is greater than the melting point of ethanol, which is greater than the melting point of ethane because of the dipole interactions of the relatively more polar carboxyl group.

6. The structure of oleic acid is

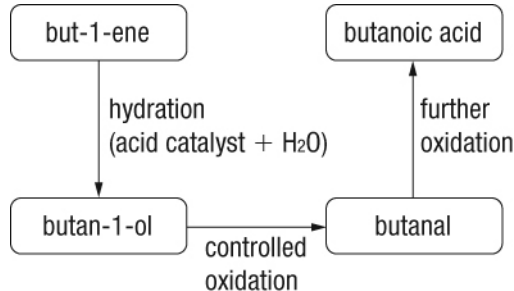


7. Olive oil is a liquid at room temperature. That means it has a lower melting point than most lipids containing saturated fatty acids. The major fatty acid components are likely unsaturated. Fatty acid chains that contain double bonds can have a *cis* formation or a *trans* formation. *Cis* formations produce kinks in the fatty acid chains and prevent them from packing together tightly, so it takes less thermal energy to separate the fatty acid chains. Therefore, the melting point is lower. To convert olive oil into margarine, the unsaturated fatty acid components need to be hydrogenated to change them into saturated fatty acids, which are solid at room temperature.

8. There are two main steps in synthesizing a carboxylic acid using methanol. First, react methanol with an oxidizing agent to form methanal. Then, oxidize methanal to form the carboxylic acid, methanoic acid. The following equations represent the order in which the reactions occur:



9. Answers may vary. Sample answer: The following flow chart shows the steps needed to transform but-1-ene to butanoic acid.

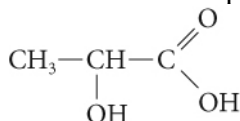


10. (a) The melting point of methanol should be between the melting points of methane ( $-182\text{ }^{\circ}\text{C}$ ) and methanoic acid ( $8\text{ }^{\circ}\text{C}$ ).

(b) The melting point of methanol is  $-98\text{ }^{\circ}\text{C}$ .

(c) Methanol has a carbon chain that is similar to that of methane and of methanoic acid. Methanoic acid molecules have two polar groups, a carbonyl and a hydroxyl group, so they are very polar. Methanol molecules have one hydroxyl group, so they are less polar. Methane is a saturated hydrocarbon so its molecules are non-polar. Therefore, methanol has a melting point that is between the melting point of methanoic acid and the melting point of methane, because the melting point is affected by the dipole interactions of the polar molecules. The more polar the molecules, the more energy is required to break apart molecules, and hence the higher the melting point.

11. Answers may vary. Sample answer: Students' posters should include the following information. Sour milk and yogurt contain lactic acid (2-hydroxypropanoic acid). The structure of the compound is:



The compound is produced industrially by the fermentation of sugars by microorganisms, such as *Lactobacillus* bacteria.

12. Answers may vary. Sample answer: Two examples of saponification reactions taking place in the environment are the following: Saponification occurs in oil paintings with lead-based pigments. The saponification reaction between oils and lead compounds forms lead soap aggregates, which appear as protrusions that distort the appearance of the painting. Therefore this reaction is not beneficial. Saponification reactions can occur when kitchen fires are extinguished with a wet chemical fire extinguisher. These types of fire extinguishers contain alkaline compounds such as potassium acetate that react with the cooking oil to create a layer of soapy foam. This blankets and cools the fire, extinguishing it. This reaction is thus beneficial to the environment. Because different saponification reactions can have positive and negative effects, I think that saponification reactions, on balance, are neither beneficial nor damaging, but neutral.