Chapter 9 Review Problems

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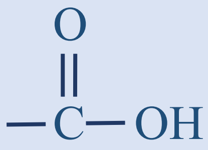
9.1) Organic compounds are categorized into various families by the presence of distinct functional groups. A functional group is an atom, group of atoms, or bond that gives a compound a particular set of physical and chemical properties.

Match each of the ***functional groups*** (on the **left**), with its ***description*** (on the **right**):

hydroxyl group	a carbon double bonded to an oxygen **(C=O)**
carboxyl group	a hydrogen bonded to an oxygen **(-OH)**
carbonyl group	

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9.1) Organic compounds are categorized into various families by the presence of distinct functional groups. A functional group is an atom, group of atoms, or bond that gives a compound a particular set of physical and chemical properties.

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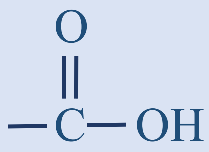
carbonyl group	

HINT: hydroxyl group ↔ a hydrogen bonded to an oxygen (-OH)

For more help:

See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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9.1) Organic compounds are categorized into various families by the presence of distinct functional groups. A functional group is an atom, group of atoms, or bond that gives a compound a particular set of physical and chemical properties.

Match each of the ***functional groups*** (on the **left**), with its ***description*** (on the **right**):

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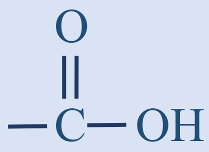
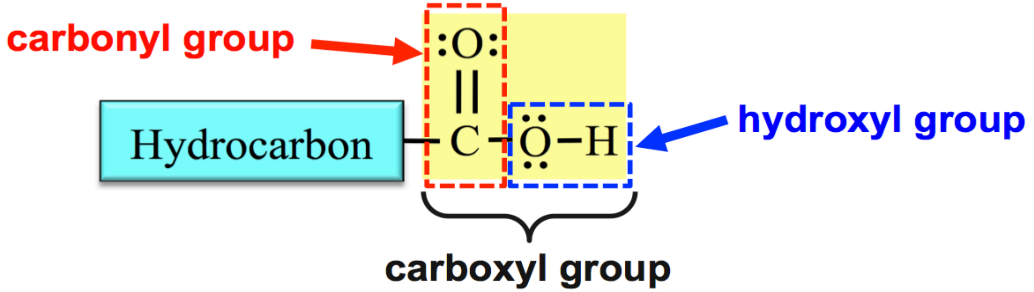
carbonyl group	

Carboxylic acids contain a *carboxyl* functional group attached to a hydrocarbon (alkyl group) part. Carboxyl groups contain both a carbonyl group (C=O), and a hydroxyl group (-OH) that are connected to each other and the hydrocarbon part as shown on the right.



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9.2) A common name for the carboxylic acid shown below is valeric acid. It has a very unpleasant odor. It is found naturally in the perennial flowering plant valerian, from which it gets its common name. Write the IUPAC name for this molecule.

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9.2) A common name for the carboxylic acid shown below is valeric acid. It has a very unpleasant odor. It is found naturally in the perennial flowering plant valerian, from which it gets its common name. Write the IUPAC name for this molecule.

HINT: Naming Carboxylic Acids

Find and name the **parent chain**.

- The parent chain of a carboxylic acid is the longest continuous chain of carbon atoms that contains the ***carbonyl carbon***. The ***carbonyl carbon*** is the carbon in the carbonyl group (**C=O**).
- Count the number of carbon atoms in the parent chain (*include the carbonyl carbon*). Starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the "**e**" at the end of the alkane name with "**oic acid**."
- If there are *no substituents on the parent chain*, as in this problem, no other steps are needed, the naming is complete.

For more help: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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9.2) A common name for the carboxylic acid shown below is valeric acid. It has a very unpleasant odor. It is found naturally in the perennial flowering plant valerian, from which it gets its common name. Write the IUPAC name for this molecule.

ANSWER: pentanoic acid

For more details:
See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

EXPLANATION: Naming Carboxylic Acids

Step 1: Find and name the **parent chain**.

- The parent chain of a carboxylic acid is the longest continuous chain of carbon atoms that contains the ***carbonyl carbon***. The ***carbonyl carbon*** is the carbon in the carbonyl group (**C=O**).
- Count the number of carbon atoms in the parent chain (*include the carbonyl carbon*). Starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the "**e**" at the end of the alkane name with "**oic acid**."
- The parent chain of a carboxylic acid in this problem contains ***five*** carbons is called pentan**oic acid**.

pentan**e** → pentan**oic acid**

- If there are *no substituents on the parent chain*, as in this problem the naming is complete. In this case the name of the molecule (above) would be **propanoic acid**.
- In carboxylic acids that contain substituents, you will need to continue by using three more steps.

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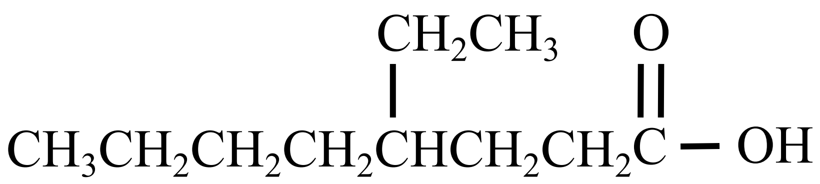
9.3) Write the IUPAC name for this molecule.



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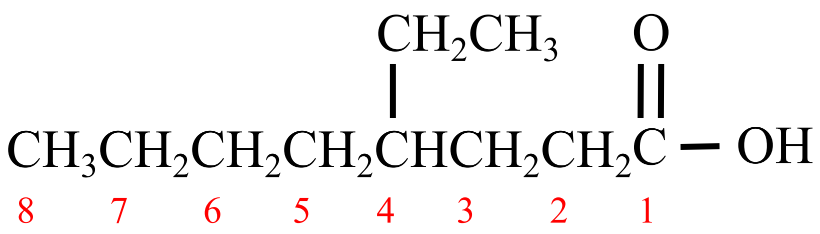
9.3) Write the IUPAC name for this molecule.



HINT: Naming Carboxylic Acids

Step 1: Find and name the **parent chain**.

Step 2: Name any alkyl group **substituents**.

Step 3: Determine the *point of attachment* of alkyl group(s) to the parent chain.

- Begin numbering the parent chains of carboxylic acids at the carbonyl carbon. The carbons in the parent chain are assigned position numbers (shown in red font).

Step 4: Construct the name of the carboxylic acid by placing the alkyl groups in alphabetical order and specifying their position numbers, followed by the name of the parent chain. Use a dash between position numbers and letters.

For more help: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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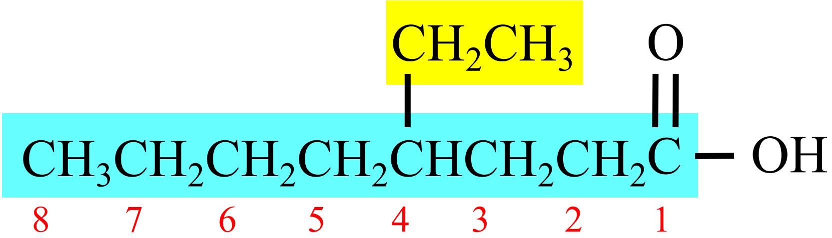
9.3) Write the IUPAC name for this molecule.



ANSWER: 4-ethyloctanoic acid

EXPLANATION: Naming Carboxylic Acids

Step 1: Find and name the **parent chain**.

- The parent chain of a carboxylic acid in this problem, highlighted in blue, contains ***eight*** carbons is called octan**oic acid**.

Step 2: Name any alkyl group **substituents**.

- There is one alkyl group substituent: ethyl. The ethyl group substituent is highlighted in yellow.

Step 3: Determine the *point of attachment* of alkyl group(s) to the parent chain.

- Begin numbering the parent chains of carboxylic acids at the carbonyl carbon. The carbons in the parent chain are assigned position numbers (shown in red font).

Step 4: Construct the name of the carboxylic acid by placing the alkyl groups in alphabetical order and specifying their position numbers, followed by the name of the parent chain. Use a dash between position numbers and letters.

- The ethyl substituent is attached to carbon number **4** of the parent chain. We write: 4-ethyl.
- The parent chain name is octanoic acid.
- The name of the molecule is 4-ethyloctanoic acid.

For more details:

See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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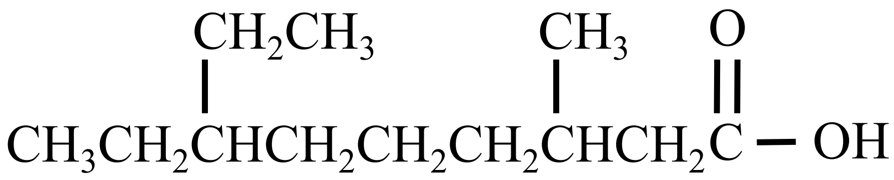
9.4) Write the IUPAC name for this molecule.



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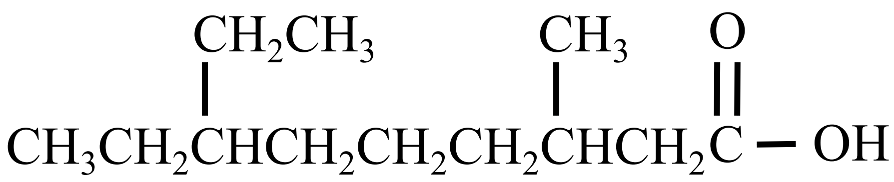
9.4) Write the IUPAC name for this molecule.



HINT: Naming Carboxylic Acids

Step 1: Find and name the **parent chain**.

Step 2: Name any alkyl group **substituents**.

Step 3: Determine the *point of attachment* of alkyl group(s) to the parent chain.

- Begin numbering the parent chains of carboxylic acids at the carbonyl carbon. The carbons in the parent chain are assigned position numbers.

Step 4: Construct the name of the carboxylic acid by placing the alkyl groups in alphabetical order and specifying their position numbers, followed by the name of the parent chain. Use a dash between position numbers and letters.

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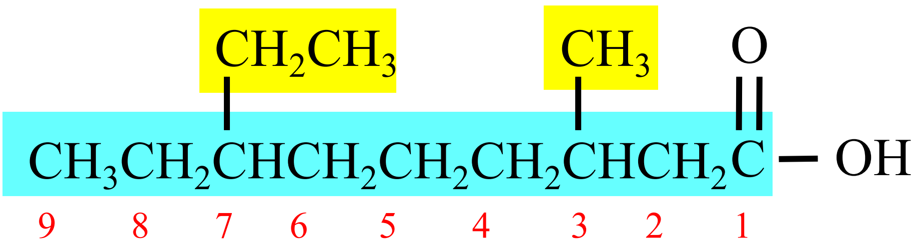
9.4) Write the IUPAC name for this molecule.



ANSWER: 7-ethyl-3-methylnonanoic acid

EXPLANATION: Naming Carboxylic Acids

Step 1: Find and name the **parent chain**.

- The parent chain of a carboxylic acid in this problem, highlighted in blue, contains ***nine*** carbons is called nonan**oic acid**.

Step 2: Name any alkyl group **substituents**.

- There are two alkyl group substituent: ethyl and methyl. The substituent are highlighted in yellow.

Step 3: Determine the *point of attachment* of alkyl group(s) to the parent chain.

- Begin numbering the parent chains of carboxylic acids at the carbonyl carbon. The carbons in the parent chain are assigned position numbers (shown in red font).

Step 4: Construct the name of the carboxylic acid by placing the alkyl groups in *alphabetical order* and specifying their position numbers, followed by the name of the parent chain. Use a dash between position numbers and letters.

- The ethyl substituent is attached to carbon number **7**, and the methyl substituent is attached to carbon number **3** of the parent chain. We write: 7-ethyl-3-methyl.
- The parent chain name is nonanoic acid.
- The name of the molecule is 7-ethyl-3-methylnonanoic acid.

For more details: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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9.5) Draw the line bond, condensed, **and** skeletal structure for **butanoic acid**.

- Remember that *lone pair*s are **always** shown in line bond structures, and are *optional* in condensed, and skeletal structures.

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Go to next question

9.5) Draw the line bond, condensed, **and** skeletal structure for **butanoic acid**.

- Remember that *lone pairs* are **always** shown in line bond structures, and are *optional* in condensed, and skeletal structures.

HINT:

To draw the *line bond structure*:

1) First draw the **carbons** of the ***parent chain***.
   - The parent chain is butanoic acid, therefore it contains ***four*** carbons.
2) Complete the carboxyl group by adding a double-bonded oxygen and a hydroxy group to a carbon *at the end of the parent chain*. It does not matter which end of the parent chain that you use as the carboxyl group, however it is usually drawn on the right-hand end of the parent chain.
3) Add enough lone pairs to the oxygens so that the octet rule is satisfied.
4) Add the carbon atom(s) of any substituents.
   - Because there are no substituents in butanoic acid, this step is not used in this problem.
5) To finish, add enough hydrogens to each carbon in order to satisfy the octet rule.

For more help: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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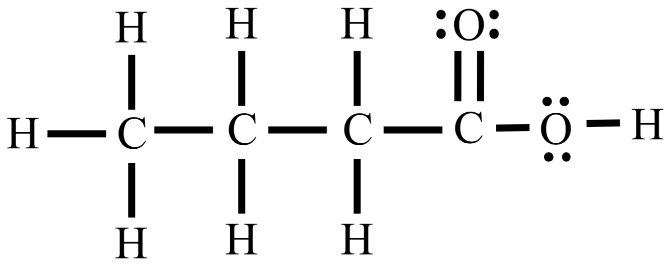
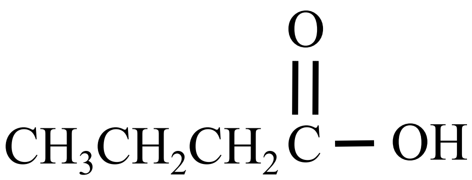
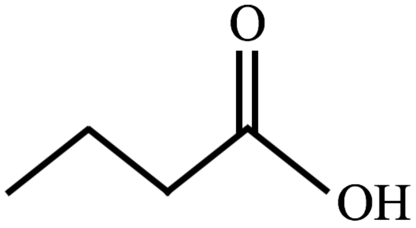
line bond structure



condensed structure



skeletal structure



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1) First draw the **carbons** of the ***parent chain***.
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3) Add enough lone pairs to the oxygens so that the octet rule is satisfied.
4) Add the carbon atom(s) of any substituents.
   - Because there are no substituents in butanoic acid, this step is not used in this problem.
5) To finish, add enough hydrogens to each carbon in order to satisfy the octet rule.

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For more details: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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9.6) Draw the line bond, condensed, **and** skeletal structure for **4-methylheptanoic acid**.

- Remember that *lone pair*s are **always** shown in line bond structures, and are *optional* in condensed, and skeletal structures.

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- Remember that *lone pair*s are **always** shown in line bond structures, and are *optional* in condensed, and skeletal structures.

HINT:

To draw the *line bond structure*:

1) First draw the **carbons** of the ***parent chain***.
   - The parent chain is heptanoic acid, therefore it contains ***seven*** carbons.
2) Complete the carboxyl group by adding a double-bonded oxygen and a hydroxy group to a carbon *at the end of the parent chain*.
   - It does not matter which end of the parent chain that you use as the carboxyl group, however it is usually drawn on the right-hand end of the parent chain.
3) Add enough lone pairs to the oxygens so that the octet rule is satisfied.
4) Add the carbon atom of any substituents.
   - For 4-methylheptanoic acid, the methyl group's carbon is attached to carbon number 4 of the parent chain. Note that the carbonyl carbon is assigned position number 1.
5) To finish, add enough hydrogens to each carbon in order to satisfy the octet rule.

For more help: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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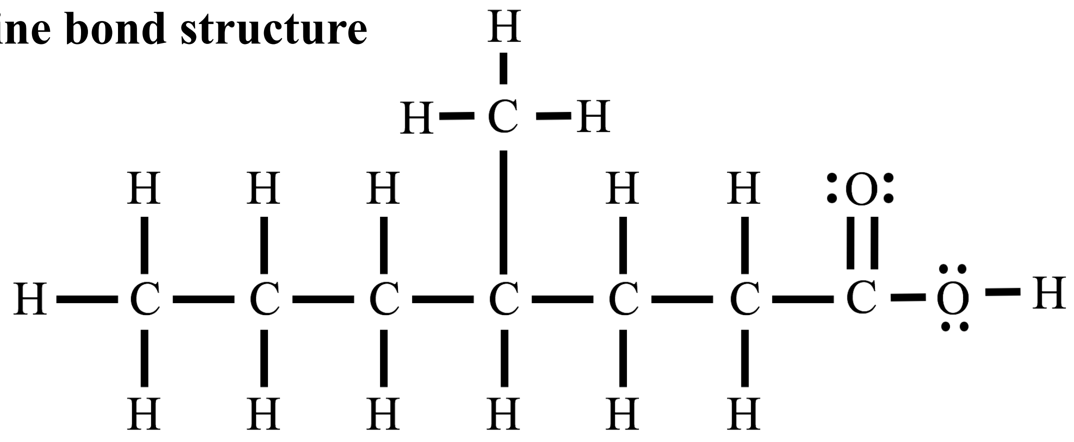
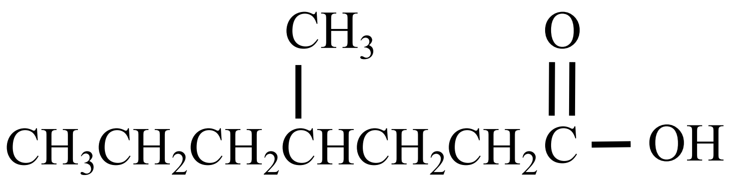
9.6) Draw the line bond, condensed, **and** skeletal structure for **4-methylheptanoic acid**.

- Remember that *lone pairs* are **always** shown in line bond structures, and are *optional* in condensed, and skeletal structures.

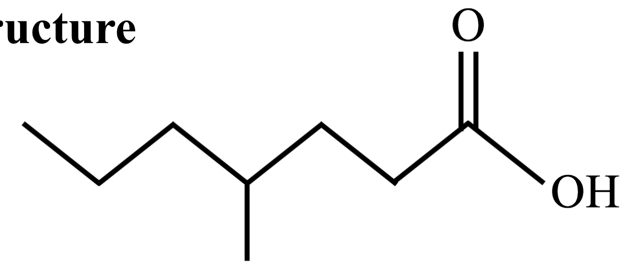
line bond structure



condensed structure



skeletal structure



To draw the *line bond structure*:

1) First draw the **carbons** of the ***parent chain***.
   - The parent chain is heptanoic acid, therefore it contains ***seven*** carbons.
2) Next, complete the carboxyl group by adding a double-bonded oxygen and a hydroxy group to a carbon *at the end of the parent chain*. It does not matter which end of the parent chain that you use as the carboxyl group, however it is usually drawn on the right-hand end of the parent chain.
3) Add enough lone pairs to the oxygens so that the octet rule is satisfied.
4) Next, add the carbon atom of any substituents.
   - For 4-methylheptanoic acid, the methyl group's carbon is attached to carbon number 4 of the parent chain. Note that the carbonyl carbon is assigned position number 1.
5) To finish, add enough hydrogens to each carbon in order to satisfy the octet rule.

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For more details: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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9.7) It is not uncommon to see carboxylic acids that contain other atoms or groups of atoms that are named as substituents. A hydroxyl group (-OH), fluorine atom, chlorine atom, or bromine atom that is bonded to the parent chain of a carboxylic acid is named as a substituent.

- The table shown here lists the names used for each of these substituents. Use position numbers and alphabetize these substituents, along with any alkyl group substituents, when naming carboxylic acids.

Names of Non Alkyl Substituents

Substituent	Name
OH	hydroxy
F	fluoro
Cl	chloro
Br	bromo

QUESTION: Draw the *condensed structure* for **3-hydroxypentanoic acid**.

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Names of Non Alkyl Substituents

Substituent	Name
OH	hydroxy
F	fluoro
Cl	chloro
Br	bromo

QUESTION: Draw the *condensed structure* for **3-hydroxypentanoic acid**.

HINT:

For 3-hydroxypentanoic acid, a hydroxyl group (OH) is attached to carbon number 3 of the parent chain.

For more help: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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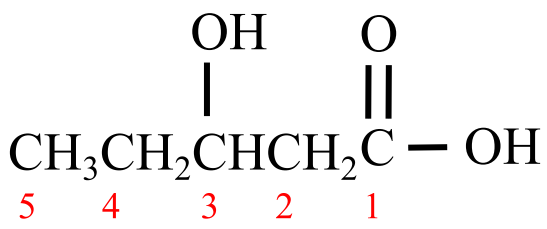
- The table shown here lists the names used for each of these substituents. Use position numbers and alphabetize these substituents, along with any alkyl group substituents, when naming carboxylic acids.

Names of Non Alkyl Substituents

Substituent	Name
OH	hydroxy
F	fluoro
Cl	chloro
Br	bromo

QUESTION: Draw the *condensed structure* for **3-hydroxypentanoic acid**.



EXPLANATION:

For 3-hydroxypentanoic acid, a hydroxyl group (OH) is attached to carbon number 3 of the parent chain.

For more details: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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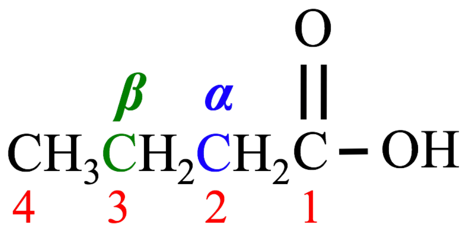
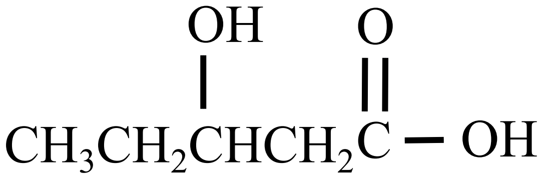
9.8) Two of the carbon positions in the parent chain of carboxylic acids are designated as "***α***" or "***β***."

- The ***α*** and ***β*** designations are not part of the IUPAC naming system, however they are commonly used.

The carbons that are designated as carbon number **2** and **3** in the IUPAC system are often referred to as the ***α*** carbon and ***β*** carbon, respectively. For example, the ***α*** carbon and ***β*** carbon are labeled in the structure of *butanoic acid* shown on the right.



In the previous question, you drew the *condensed structure* for **3-hydroxypentanoic acid**:



i) Label the ***α*** carbon and ***β*** carbon in the structure that you drew for **3-hydroxypentanoic acid**.

ii) Name **3-hydroxypentanoic acid** using the ***α***/***β*** designation method.

iii) Draw the condensed structure for ***α*-hydroxypentanoic acid**.

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Click here for a **hint**

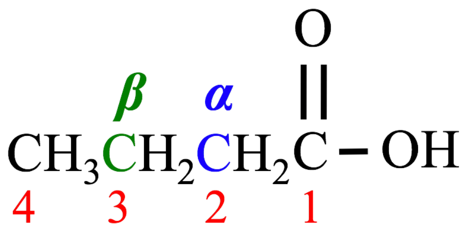
Click here to **check your answer**

Go to next question

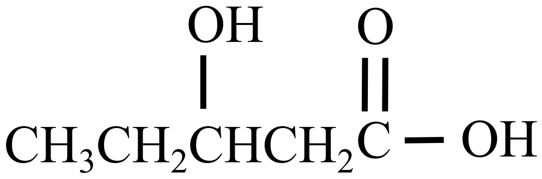
9.8) Two of the carbon positions in the parent chain of carboxylic acids are designated as "***α***" or "***β***."

- The ***α*** and ***β*** designations are not part of the IUPAC naming system, however they are commonly used.

The carbons that are designated as carbon number **2** and **3** in the IUPAC system are often referred to as the ***α*** carbon and ***β*** carbon, respectively. For example, the ***α*** carbon and ***β*** carbon are labeled in the structure of *butanoic acid* shown on the right.



In the previous question, you drew the *condensed structure* for **3-hydroxypentanoic acid**:



i) Label the ***α*** carbon and ***β*** carbon in the structure that you drew for **3-hydroxypentanoic acid**.

ii) Name **3-hydroxypentanoic acid** using the ***α***/***β*** designation method. **HINT: *β*-___________pentanoic acid**

iii) Draw the condensed structure for ***α*-hydroxypentanoic acid**.

HINT: For ***α***-hydroxypentanoic acid, a hydroxyl group (OH) is attached to the ***α*** carbon (carbon number **2**).

For more help: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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Click here to check your answer

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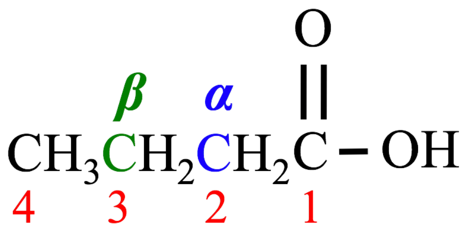
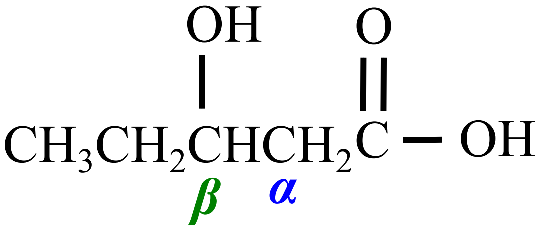
9.8) Two of the carbon positions in the parent chain of carboxylic acids are designated as "*α*" or "*β*."

- The *α* and *β* designations are not part of the IUPAC naming system, however they are commonly used.

The carbons that are designated as carbon number **2** and **3** in the IUPAC system are often referred to as the *α* carbon and *β* carbon, respectively. For example, the *α* carbon and *β* carbon are labeled in the structure of *butanoic acid* shown on the right.



In the previous question, you drew the *condensed structure* for **3-hydroxypentanoic acid**:

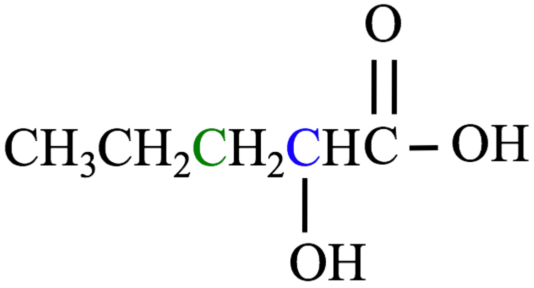


i) Label the *α* carbon and *β* carbon in the structure that you drew for **3-hydroxypentanoic acid**.

ii) Name **3-hydroxypentanoic acid** using the *α*/*β* designation method. ***β*-hydroxypentanoic acid**

iii) Draw the condensed structure for ***α*-hydroxypentanoic acid**.

For *α*-hydroxypentanoic acid, a hydroxyl group (OH) is attached to the *α* carbon (carbon number **2**).



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For more details: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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9.9) The ***carboxyl group*** is sometimes drawn as “**COOH**” or “**CO_2H**” in condensed structures:

Draw the condensed structure of *propanoic acid* using “**COOH**” to represent the carboxyl group.

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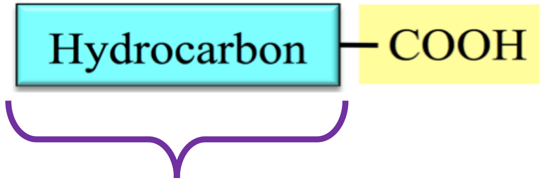
Go to next question

9.9) The ***carboxyl group*** is sometimes drawn as "**COOH**" or "**CO_2H**" in condensed structures:

Draw the condensed structure of *propanoic acid* using "**COOH**" to represent the carboxyl group.

HINT:



How many carbon atoms will be placed here for *propanoic acid*?

For more help: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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Click here to check your answer

Go to next question

9.9) The ***carboxyl group*** is sometimes drawn as “**COOH**” or “**CO_2H**” in condensed structures:

Hydrocarbon — COOH

Hydrocarbon — CO_2H

Draw the condensed structure of *propanoic acid* using “**COOH**” to represent the carboxyl group.

ANSWER:

CH_3CH_2COOH

For more details: See chapter 9 part 1 video or chapter 9 section 2 in the textbook.

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9.10) Pentanoic acid's water solubility is 3.7 grams per 100 ml of water. Hexanoic acid's water solubility is 1.0 grams per 100 ml of water. Explain why pentanoic acid is more soluble than hexanoic acid.

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Click here for a **hint**

Click here to **check your answer**

Go to next question

9.10) Pentanoic acid's water solubility is 3.7 grams per 100 ml of water. Hexanoic acid's water solubility is 1.0 grams per 100 ml of water. Explain why pentanoic acid is more soluble than hexanoic acid.

HINT: Consider how the size of the nonpolar hydrocarbon part of carboxylic acids affects their water solubility.

For more help: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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Click here to **check your answer**

Go to next question

9.10) Pentanoic acid's water solubility is 3.7 grams per 100 ml of water. Hexanoic acid's water solubility is 1.0 grams per 100 ml of water. Explain why pentanoic acid is more soluble than hexanoic acid.

ANSWER: As the nonpolar (hydrocarbon part) of carboxylic acids gets larger, their water solubility decreases.

EXPLANATION:

The water solubility of an organic compound depends on the compound's ability to interact with water. All carboxylic acid molecules have a significantly strong attraction to water through hydrogen bonding and dipole-dipole interactions. Small carboxylic acid molecules have significant water solubility. As the nonpolar hydrocarbon part of carboxylic acids gets larger, their water solubility decreases; this is true not only for carboxylic acids, but for all organic molecules.

- The trend of decreasing water solubility with increasing molecular size can be seen in the solubilities of the carboxylic acid molecules that are listed in the table shown here.

Water Solubility of Carboxylic Acids

Molecule Name	Condensed Structure	Water Solubility (g/100 mL)
methanoic acid	$HCOOH$	miscible*
ethanoic acid	CH_3COOH	miscible
propanoic acid	CH_3CH_2COOH	miscible
butanoic acid	$CH_3CH_2CH_2COOH$	miscible
pentanoic acid	$CH_3CH_2CH_2CH_2COOH$	3.7
hexanoic acid	$CH_3CH_2CH_2CH_2CH_2COOH$	1.0

*miscible indicates that the substance will mix/dissolve at any carboxylic acid to water ratio.

For more details: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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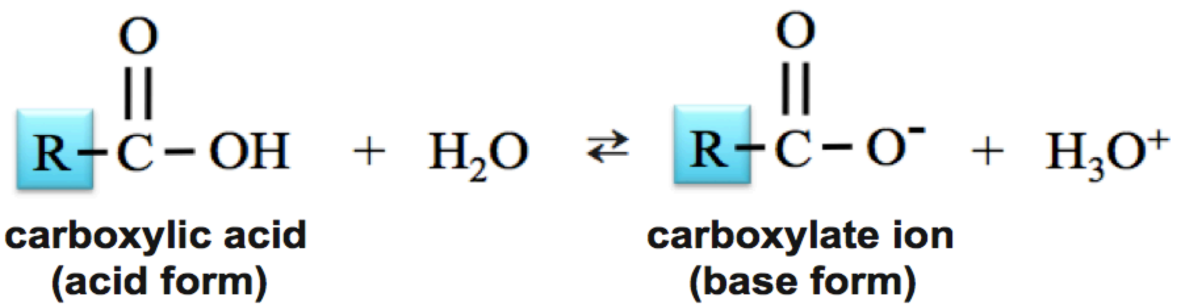
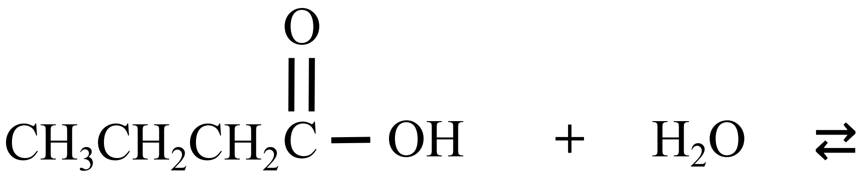
9.11) Carboxylic acids have the word "acid" in their names because they readily donate an H^+ in acid-base reactions. When placed in water, a carboxylic acid molecule acts as an acid and water acts as a base. An H^+ from the hydroxyl group (OH) of the carboxylic acid is donated to H_2O. The general form of the reaction of a carboxylic acids and water is shown below.



Add the products for the following reaction:



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Click here for a **hint**

Click here to **check your answer**

Go to next question

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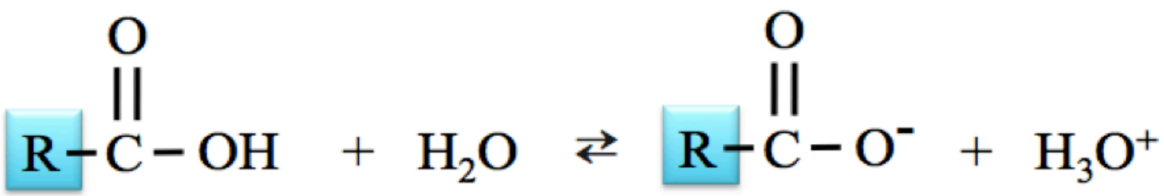


carboxylic acid (acid form) | carboxylate ion (base form)

Add the products for the following reaction:

$$CH_3CH_2CH_2C(=O)-OH \quad + \quad H_2O \quad \rightleftarrows$$

HINT: Consider the general form for the reaction to predict the products. Note that the letter "**R**" in the general structures represents either a hydrocarbon/alkyl group part or any other organic group of atoms. In this problem, the **R** group of the carboxylic acid reactant is "$CH_3CH_2CH_2$."

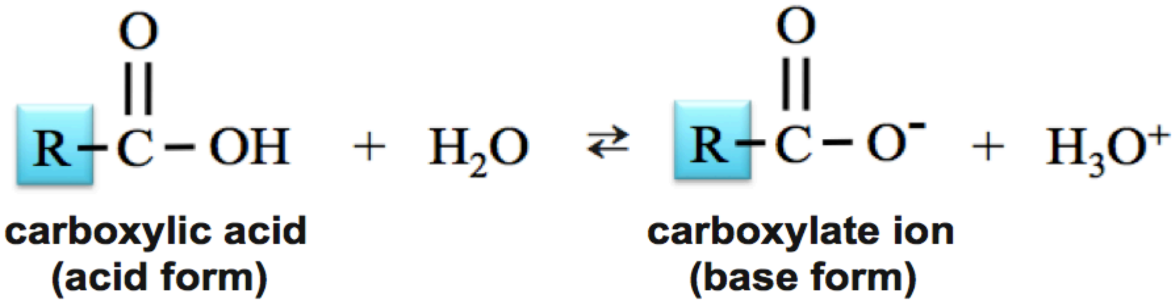
For more help: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

Go back

Click here to check your answer

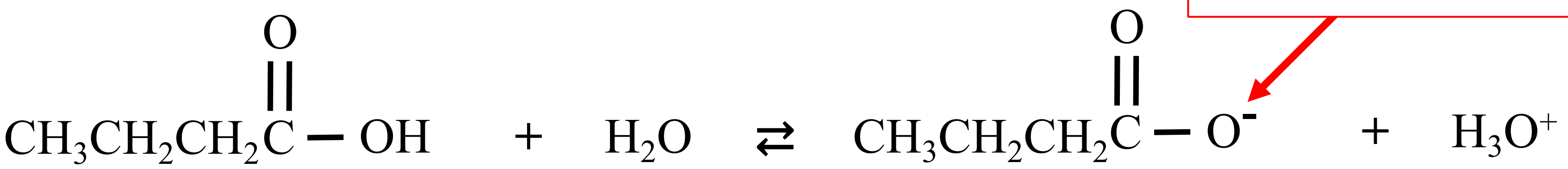
Go to next question

9.11) Carboxylic acids have the word "acid" in their names because they readily donate an H^+ in acid-base reactions. When placed in water, a carboxylic acid molecule acts as an acid and water acts as a base. An H^+ from the hydroxyl group (OH) of the carboxylic acid is donated to H_2O. The general form of the reaction of a carboxylic acids and water is shown below.



Add the products for the following reaction:

Note: Be sure to include the formal charge (-) on the carboxylate ion.



EXPLANATION:

Consider the general form for the reaction to predict the products. Note that the letter "**R**" in the general structures represents either a hydrocarbon/alkyl group part or any other organic group of atoms. In this problem, the **R** group is "$CH_3CH_2CH_2$."

For more details: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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Go to next question

9.12) In the previous problem, you added the products to complete the chemical equation show below. Write the systematic name of the carboxylic acid and the carboxylate ion in this reaction.

$$CH_3CH_2CH_2\overset{\overset{\displaystyle O}{\|}}{C}-OH \quad + \quad H_2O \quad \rightleftharpoons \quad CH_3CH_2CH_2\overset{\overset{\displaystyle O}{\|}}{C}-O^- \quad + \quad H_3O^+$$

carboxylic acid (acid form)

carboxylate ion (base form)

Name: ____________________

Name: ____________________

Go back

Click here for a **hint**

Click here to **check your answer**

Go to next question

9.12) In the previous problem, you added the products to complete the chemical equation show below. Write the systematic name of the carboxylic acid and the carboxylate ion in this reaction.

$$CH_3CH_2CH_2C(=O)-OH \quad + \quad H_2O \quad \rightleftarrows \quad CH_3CH_2CH_2C(=O)-O^- \quad + \quad H_3O^+$$

carboxylic acid (acid form) — **carboxylate ion (base form)**

Name: ________________ Name: ________________

HINT:

Carboxylate ions are named by replacing the "**-ic acid**" suffix of their acid form name with "**-ate ion**."

A few examples are shown below:

ethanoic acid → **ethanoate ion**

acetic acid → **acetate ion**

3-methylpentanoic acid → **3-methylpentanoate ion**

For more help: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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Click here to check your answer

Go to next question

9.12) In the previous problem, you added the products to complete the chemical equation show below. Write the systematic name of the carboxylic acid and the carboxylate ion in this reaction.

$$CH_3CH_2CH_2C(=O)-OH + H_2O \rightleftarrows CH_3CH_2CH_2C(=O)-O^- + H_3O^+$$

carboxylic acid (acid form)

carboxylate ion (base form)

Name: **butanoic acid**

Name: **butanoate ion**

EXPLANATION:

Carboxylate ions are named by replacing the "**-ic acid**" suffix of their acid form name with "**-ate ion**."

butanoic acid → **butanoate ion**

A few other examples are shown below:

ethanoic acid → **ethanoate ion**

acetic acid → **acetate ion**

3-methylpentanoic acid → **3-methylpentanoate ion**

For more details: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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Go to next question

9.13) Draw the **condensed structure *of the base form*** (carboxylate ion) for each of the following carboxylic acids ***and*** write the name of each carboxylate ion.

a) pentanoic acid

b) 4-ethyloctanoic acid

Go back

Click here for a **hint**

Click here to **check your answer**

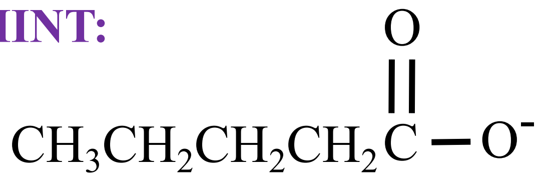
Go to next question

9.13) Draw the **condensed structure** ***of the base form*** (carboxylate ion) for each of the following carboxylic acids ***and*** write the name of each carboxylate ion.

a) pentanoic acid

b) 4-ethyloctanoic acid

HINT:

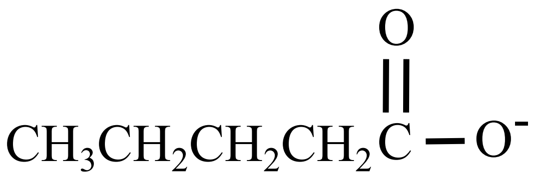


Carboxylate ions are named by replacing the "-**ic acid**" suffix of their acid form name with "-**ate ion**."

For more help: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

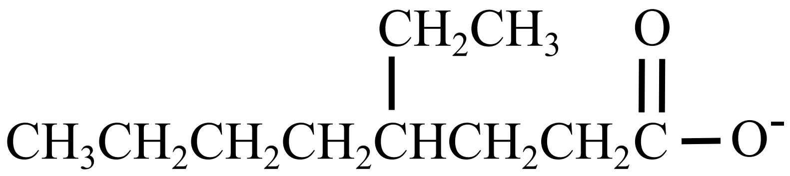
9.13) Draw the **condensed structure** ***of the base form*** (carboxylate ion) for each of the following carboxylic acids ***and*** write the name of each carboxylate ion.

a) pentanoic acid



pentanoate ion

b) 4-ethyloctanoic acid



4-ethyloctanoate ion

EXPLANATION:

Carboxylate ions are named by replacing the "**-ic acid**" suffix of their acid form name with "**-ate ion**."

pentanoic acid → **pentanoate ion**

4-ethyloctanoic acid → **4-ethyloctanoate ion**

For more details: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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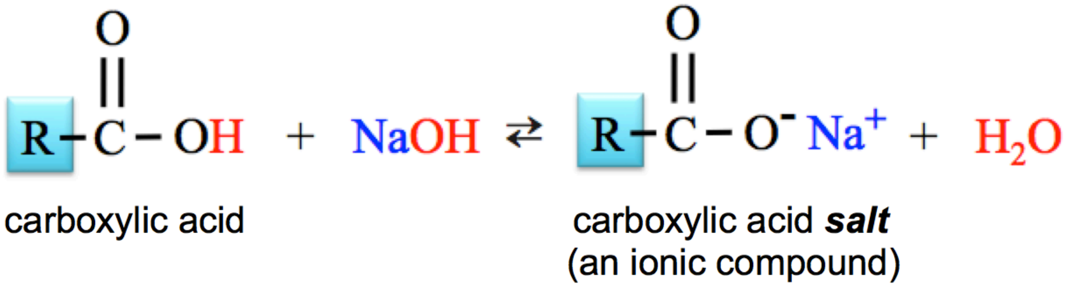
9.14) In a **neutralization reaction**, a carboxylic acid will react with a ***hydroxide-containing*** *base* compound to produce **H_2O** and *a* ***carboxylic acid salt***. The general form of the neutralization of a carboxylic acid reaction is shown below.



Add the products for the following neutralization reaction:

$$CH_3CH_2CH_2\overset{\overset{\displaystyle O}{\|}}{C}-OH \quad + \quad NaOH \quad \rightleftarrows$$

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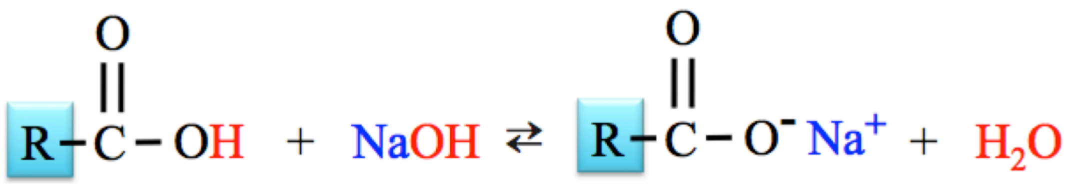
Click here for a **hint**

Click here to **check your answer**

Go to next question

9.14) In a **neutralization reaction**, a carboxylic acid will react with a ***hydroxide-containing*** *base* compound to produce **H_2O** and *a* ***carboxylic acid salt***. The general form of the neutralization of a carboxylic acid reaction is shown below.



carboxylic acid

carboxylic acid ***salt***
(an ionic compound)

Add the products for the following neutralization reaction:

$$CH_3CH_2CH_2\overset{\displaystyle O}{\overset{\|}{C}}-OH \quad + \quad NaOH \quad \rightleftarrows$$

HINT: Consider the general form for the reaction to predict the products. Note that the letter "**R**" in the general structures represents either a hydrocarbon/alkyl group part or any other organic group of atoms. In this problem, the **R** group of the carboxylic acid reactant is "$CH_3CH_2CH_2$."

For more help: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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Click here to **check your answer**

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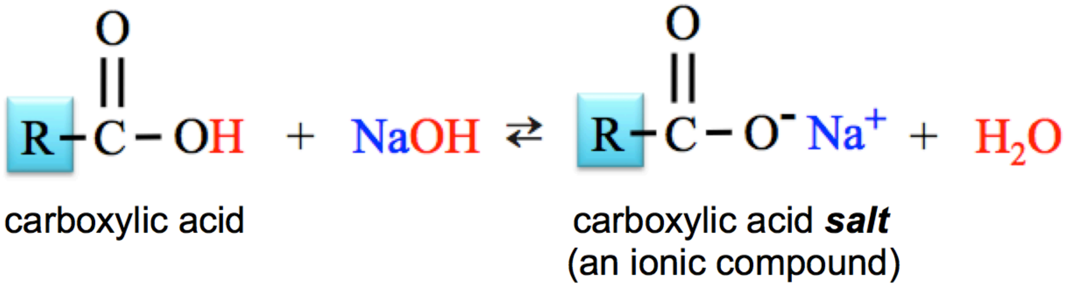
9.14) In a **neutralization reaction**, a carboxylic acid will react with a ***hydroxide-containing*** *base* compound to produce $\mathbf{H_2O}$ and *a **carboxylic acid salt***. The general form of the neutralization of a carboxylic acid reaction is shown below.



Add the products for the following neutralization reaction:

$$CH_3CH_2CH_2C(=O)-OH \quad + \quad NaOH \quad \rightleftarrows \quad CH_3CH_2CH_2C(=O)-O^-\,Na^+ \quad + \quad H_2O$$

EXPLANATION:

Consider the general form for the reaction to predict the products. Note that the letter "**R**" in the general structures represents either a hydrocarbon/alkyl group part or any other organic group of atoms. In this problem, the **R** group of the carboxylic acid reactant is "$CH_3CH_2CH_2$."

This is the same neutralization reaction that you learned in the previous chapter; the H^+ from the acid bonds to the OH^- to produce H_2O. The carboxylate ion and the sodium ion make an ionic compound called a *carboxylic acid salt*.

For more details: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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9.15) In an ***esterification reaction,*** a carboxylic acid reacts with an alcohol to produce an **ester** and water. This reaction is very important in the storage and metabolism of fat (triglycerides) and in other biological processes. The general form for the esterification reaction is:

$$\underset{\textbf{carboxylic acid}}{R-\overset{\displaystyle O}{\overset{\|}{C}}-OH} \quad + \quad \underset{\textbf{alcohol}}{H-OR'} \quad \rightleftarrows \quad \underset{\textbf{ester}}{R-\overset{\displaystyle O}{\overset{\|}{C}}-OR'} \quad + \quad \underset{\textbf{water}}{H_2O}$$

In order to keep track of them in the general reaction, we use "**R**" for the hydrocarbon part of the carboxylic acid, and "**R'** " for the hydrocarbon part of the alcohol. **R** and **R'** may, or may not, be identical.

Add the products for the following *esterification* reaction:

$$CH_3CH_2CH_2\overset{\displaystyle O}{\overset{\|}{C}}-OH \quad + \quad HO-CH_2CH_3 \quad \rightleftarrows$$

Go back

Click here for a **hint**

Click here to **check your answer**

Go to next question

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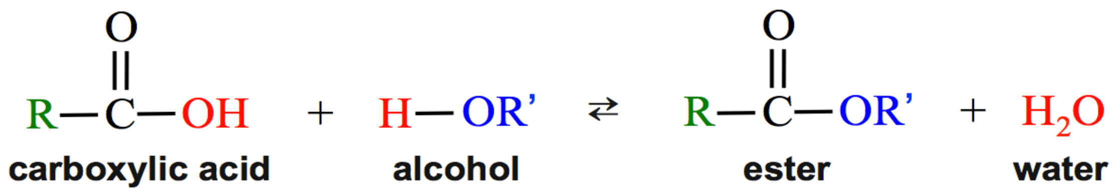
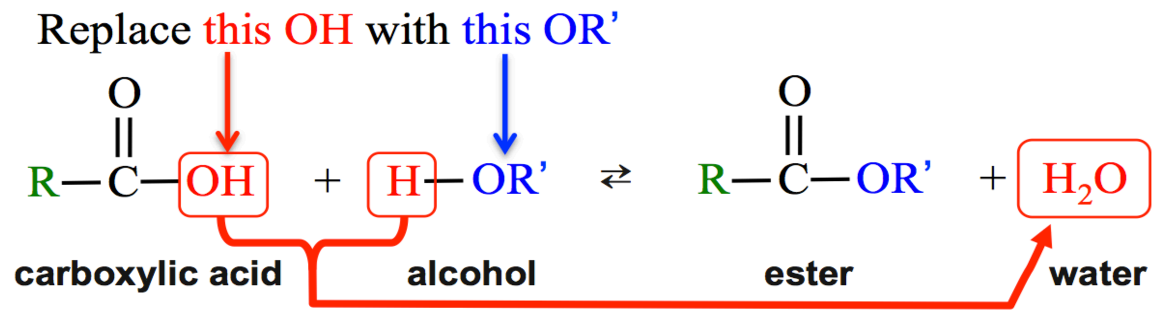
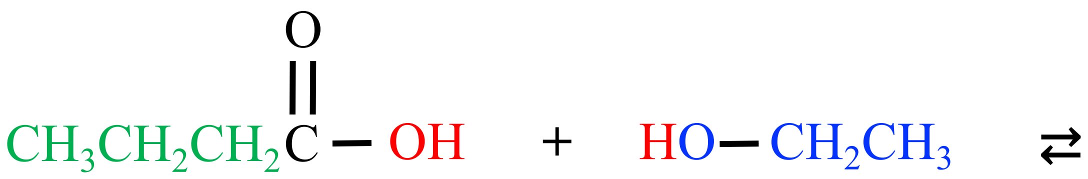


In order to keep track of them in the general reaction, we use "**R**" for the hydrocarbon part of the carboxylic acid, and "**R'**" for the hydrocarbon part of the alcohol. **R** and **R'** may, or may not, be identical.

HINT: An ester is produced when the **OH** from the carboxylic acid is replace with the **OR'** from the alcohol. The **OH** from the carboxylic acid combines with the **H** from the alcohol to produce $\mathbf{H_2O}$.



Add the products for the following *esterification* reaction:



For more help: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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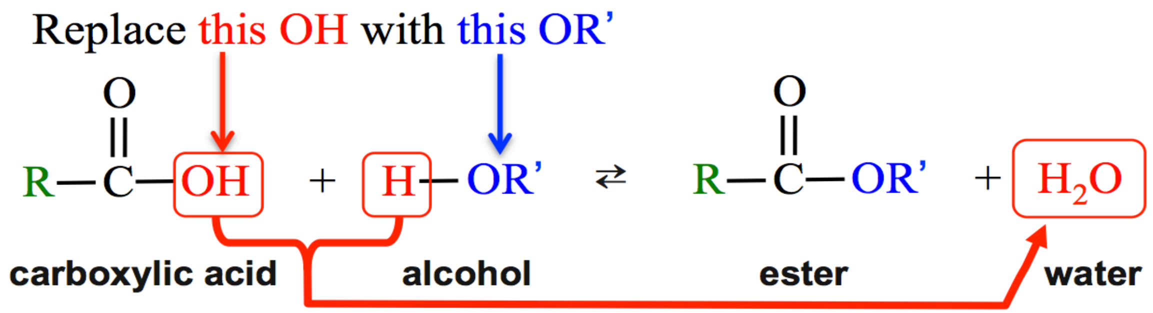
$$\underset{\text{carboxylic acid}}{R-\overset{\overset{\displaystyle O}{\|}}{C}-OH} + \underset{\text{alcohol}}{H-OR'} \rightleftarrows \underset{\text{ester}}{R-\overset{\overset{\displaystyle O}{\|}}{C}-OR'} + \underset{\text{water}}{H_2O}$$

In order to keep track of them in the general reaction, we use "**R**" for the hydrocarbon part of the carboxylic acid, and "**R'** " for the hydrocarbon part of the alcohol. **R** and **R'** may, or may not, be identical.

EXPLANATION: An ester is produced when the **OH** from the carboxylic acid is replace with the **OR'** from the alcohol. The **OH** from the carboxylic acid combines with the **H** from the alcohol to produce **H_2O**.



Add the products for the following *esterification* reaction:

$$CH_3CH_2CH_2\overset{\overset{\displaystyle O}{\|}}{C}-OH + HO-CH_2CH_3 \rightleftarrows CH_3CH_2CH_2\overset{\overset{\displaystyle O}{\|}}{C}-OCH_2CH_3 + H_2O$$

For more details: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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9.16) Draw the *condensed structure* of the **ester** that is formed when each of the following carboxylic acids react with 1-*propanol*. The structure of 1-*propanol* is $CH_3CH_2CH_2OH$.

a) pentanoic acid

b) ethanoic acid

c) 2-methylpropanoic acid

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Click here for a **hint**

Click here to **check your answer**

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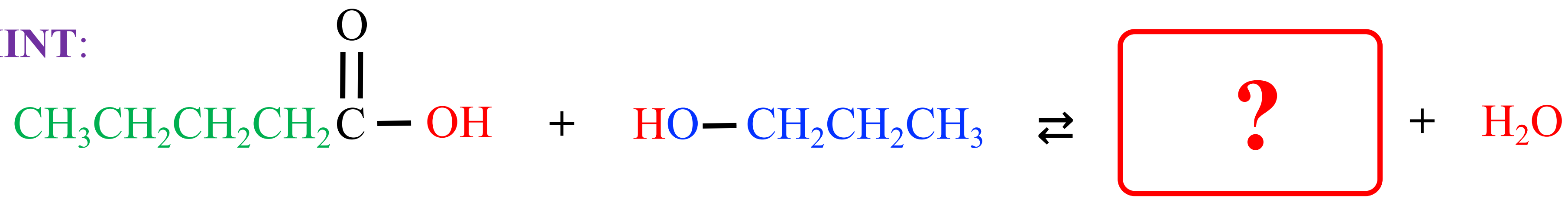
9.16) Draw the *condensed structure* of the **ester** that is formed when each of the following carboxylic acids react with *1-propanol*. The structure of *1-propanol* is $CH_3CH_2CH_2OH$.

a) pentanoic acid

HINT:



b) ethanoic acid

c) 2-methylpropanoic acid

An ester is produced when the **OH** from the carboxylic acid is replace with the **OR'** from the alcohol. The **OH** from the carboxylic acid combines with the **H** from the alcohol to produce $\mathbf{H_2O}$.

For more help: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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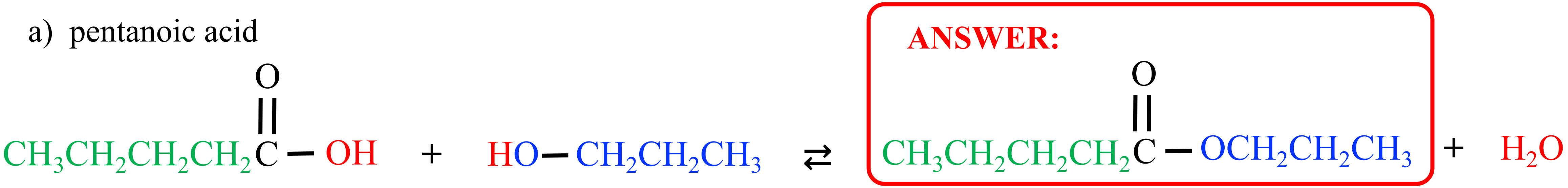
Click here to **check your answer**

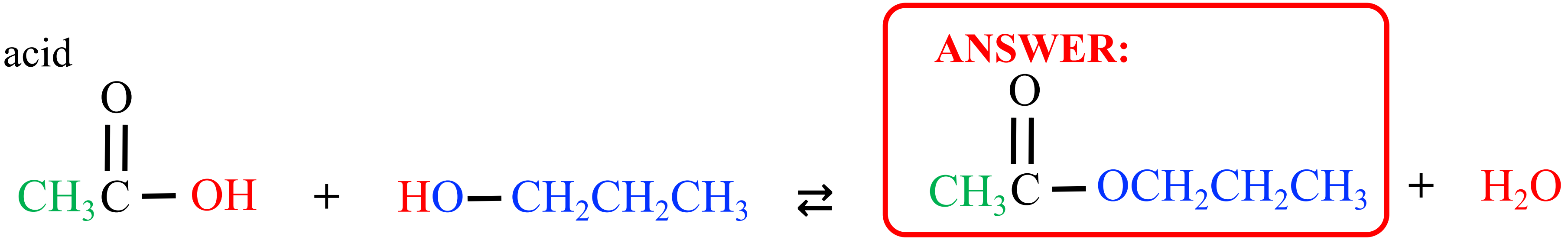
Go to next question

9.16) Draw the *condensed structure* of the **ester** that is formed when each of the following carboxylic acids react with *1-propanol*.
The structure of *1-propanol* is $CH_3CH_2CH_2OH$.

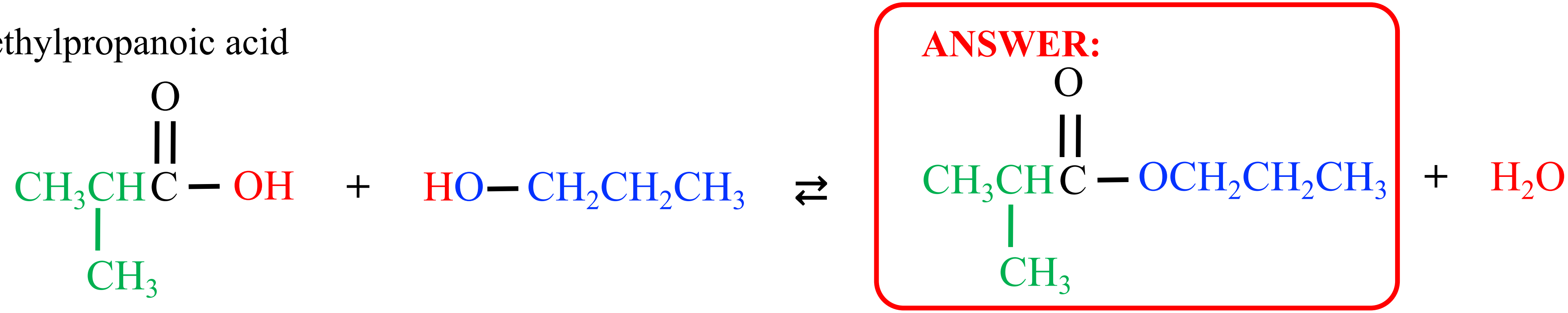
a) pentanoic acid



b) ethanoic acid



c) 2-methylpropanoic acid



EXPLANATION: An ester is produced when the **OH** from the carboxylic acid is replace with the **OR'** from the alcohol. The **OH** from the carboxylic acid combines with the **H** from the alcohol to produce **H_2O**.

For more details: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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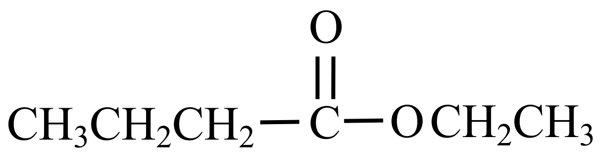
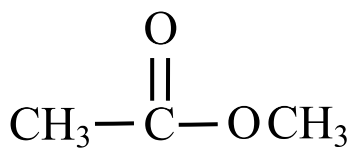
9.17) Name each of the **esters** shown below:





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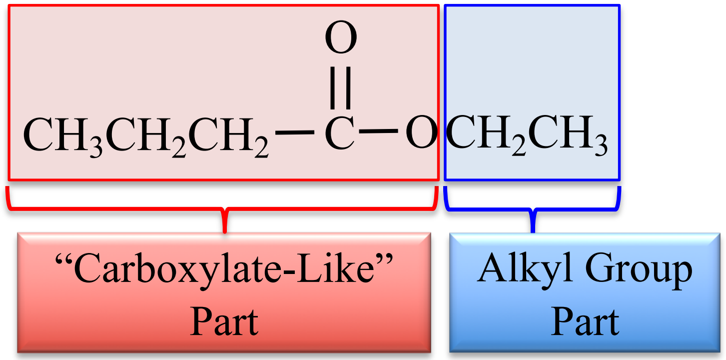
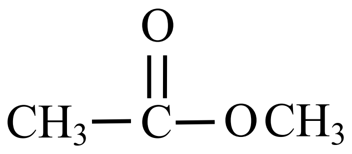
Click here for a **hint**

Click here to **check your answer**

Go to next question

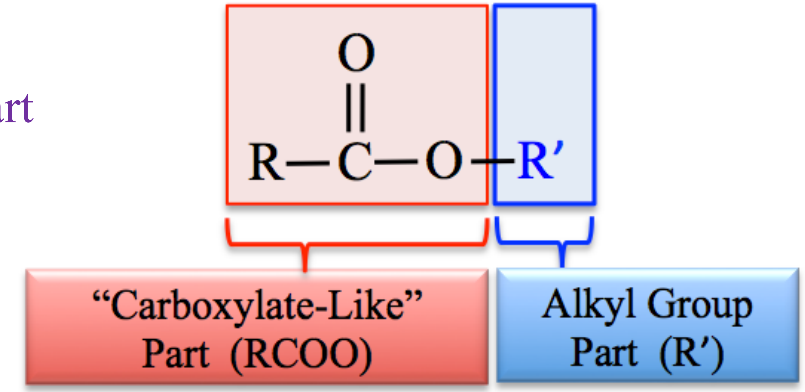
9.17) Name each of the **esters** shown below:





HINT: Naming Esters

The IUPAC method for naming esters involves naming the **R'** alkyl group part first, followed by the "*carboxylate-like*" part. These two parts of an ester molecule can be identified as shown in the illustration on the right.



STEPS:

1) Identify the alkyl group (**R'**) part and the carboxylate-like part.

2) The ester is named by writing the alkyl group (**R'**) part name first, then a space, followed by the name that the "carboxylate-like" part would have ***if it were an actual carboxylate ion***.

For more help: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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Click here to **check your answer**

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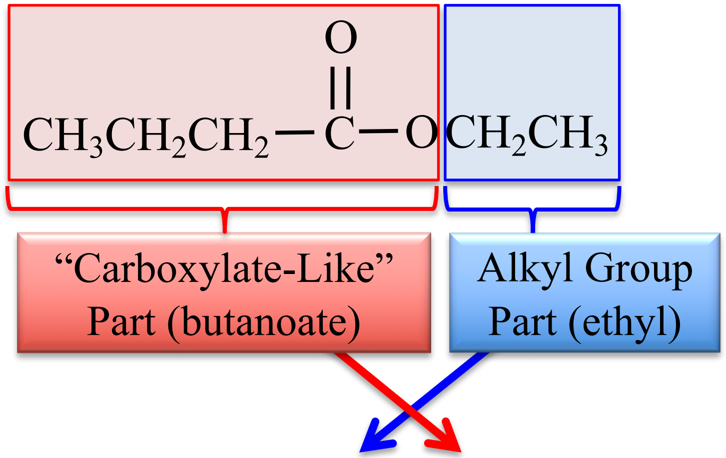
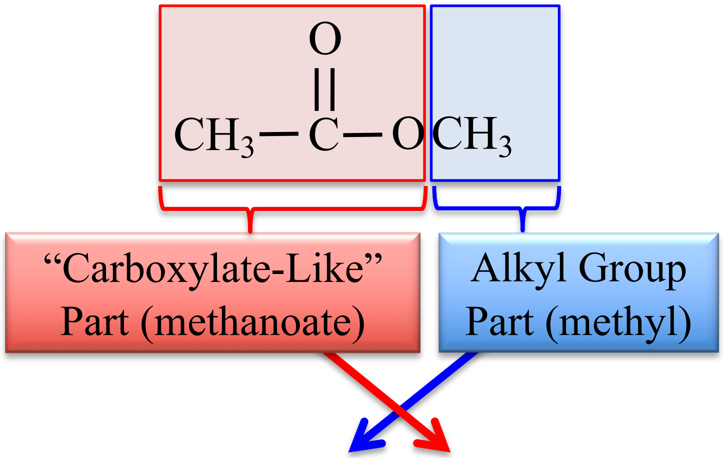
9.17) Name each of the **esters** shown below:



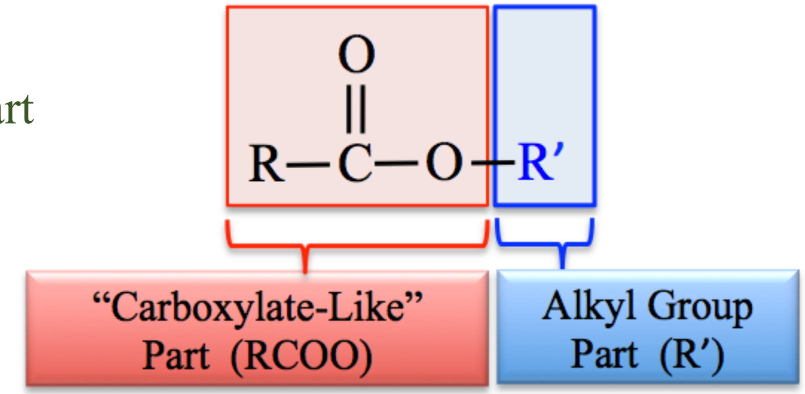
ethyl butanoate



methyl ethanoate

EXPLANATION: Naming Esters

The IUPAC method for naming esters involves naming the **R'** alkyl group part first, followed by the "*carboxylate-like*" part. These two parts of an ester molecule can be identified as shown in the illustration on the right.



STEPS:

1) Identify the alkyl group (**R'**) part and the carboxylate-like part.

2) The ester is named by writing the alkyl group (**R'**) part name first, then a space, followed by the name that the "carboxylate-like" part would have ***if it were an actual carboxylate ion***.

For more details: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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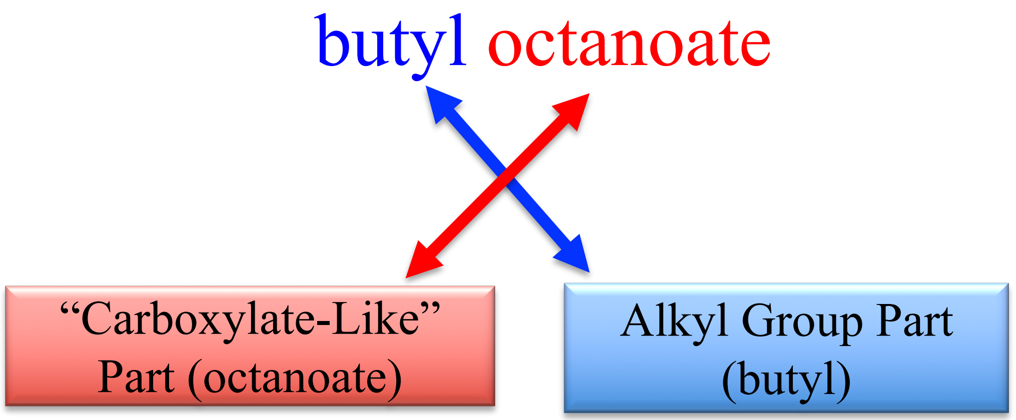
9.18) Draw the condensed structure of **butyl octanoate**.

9.18) Draw the condensed structure of **butyl octanoate**.

HINT:



For more help: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

Go back

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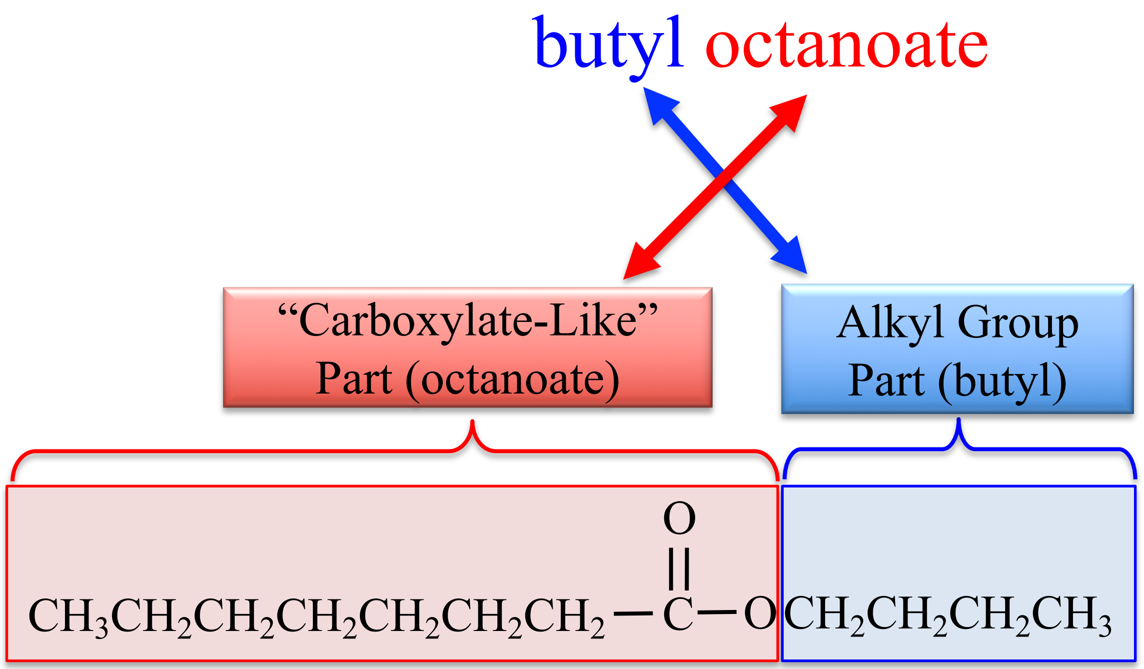
Go to next question

9.18) Draw the condensed structure of **butyl octanoate**.

ANSWER:

$$CH_3CH_2CH_2CH_2CH_2CH_2CH_2-\overset{\overset{O}{\|}}{C}-OCH_2CH_2CH_2CH_3$$

ILLUSTRATIVE EXPLANATION:



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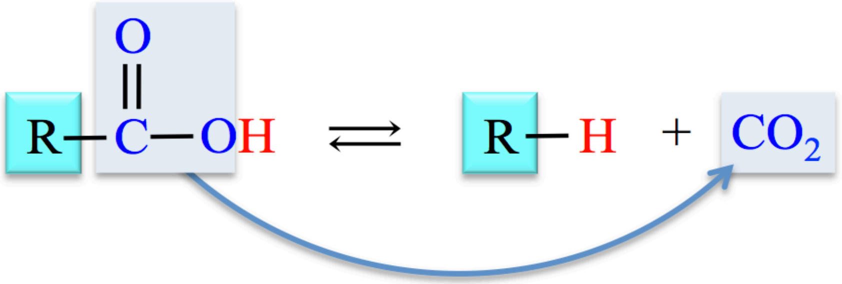
9.19) *Carboxylic acids* undergo a decomposition reaction called **decarboxylation**. This reaction is very important in the citric acid cycle and other biological processes. The carbon dioxide that we exhale is produced by decarboxylation reactions in two of the reactions of the citric acid cycle.

In decarboxylation reactions, a ***carboxyl group*** (COOH) is removed and ***replaced by a hydrogen atom***. The general form for the decarboxylation reaction is:



Add the products for the following *decarboxylation* reaction:

$$CH_3CH_2CH_2\overset{\overset{\displaystyle O}{\|}}{C}-OH \rightleftarrows$$

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Click here for a **hint**

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Go to next question

9.19) *Carboxylic acids* undergo a decomposition reaction called **decarboxylation**. This reaction is very important in the citric acid cycle and other biological processes. The carbon dioxide that we exhale is produced by decarboxylation reactions in two of the reactions of the citric acid cycle.

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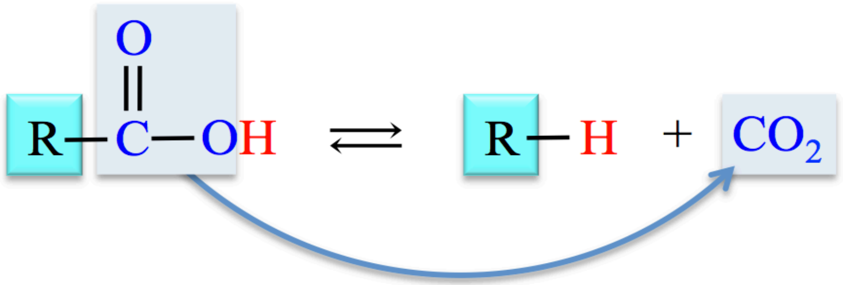

Add the products for the following *decarboxylation* reaction:

$$CH_3CH_2CH_2\overset{O}{\overset{\|}{C}}-OH \rightleftarrows$$

HINT: Consider the general form for the reaction to predict the products. Note that the letter "**R**" in the general structures represents either a hydrocarbon/alkyl group part or any other organic group of atoms. In this problem, the **R** group of the carboxylic acid reactant is "$CH_3CH_2CH_2$."

The carboxylic acid's ***carboxyl group*** (COOH) is removed and ***replaced by a hydrogen atom***. Carbon dioxide (CO_2) is *always* one of the products in decarboxylation reactions.

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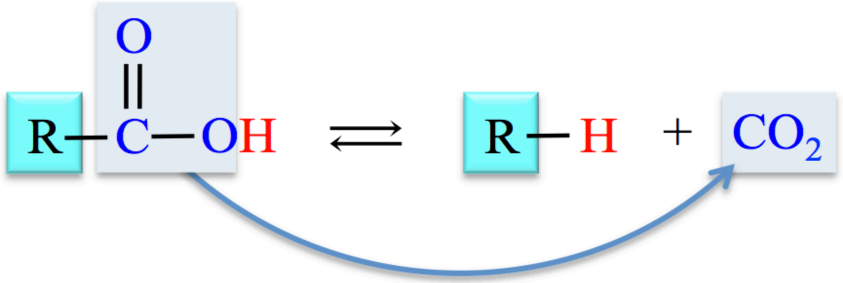
Go to next question

9.19) *Carboxylic acids* undergo a decomposition reaction called **decarboxylation**. This reaction is very important in the citric acid cycle and other biological processes. The carbon dioxide that we exhale is produced by decarboxylation reactions in two of the reactions of the citric acid cycle.

In decarboxylation reactions, a ***carboxyl group*** (COOH) is removed and ***replaced by a hydrogen atom***. The general form for the decarboxylation reaction is:



Add the products for the following *decarboxylation* reaction:

$$CH_3CH_2CH_2C(=O)-OH \rightleftarrows CH_3CH_2CH_2-H + CO_2$$

or

$$CH_3CH_2CH_3 + CO_2$$

EXPLANATION: The carboxylic acid's ***carboxyl group*** (COOH) is removed and ***replaced by a hydrogen atom***. Carbon dioxide (CO_2) is *always* one of the products in decarboxylation reactions.

For more details: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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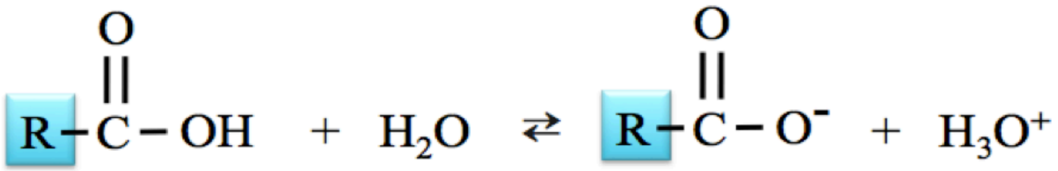
9.20) When a carboxylic acid is placed in water, it reacts with water and an equilibrium is established. The general form of the reaction of a carboxylic acids and water is shown below.



carboxylic acid (acid form) **carboxylate ion (base form)**

In many biochemical applications, it is of interest to understand whether the ***acid form*** or the ***base form*** of a species is predominant. We use the implications of the Henderson-Hasselbalch Equation to predict the predominant species at any particular pH.

The pK_a of *acetic acid* is about 4.74. Is the ***acid form*** or ***base form*** of acetic acid predominant at physiological pH (~7.4)?

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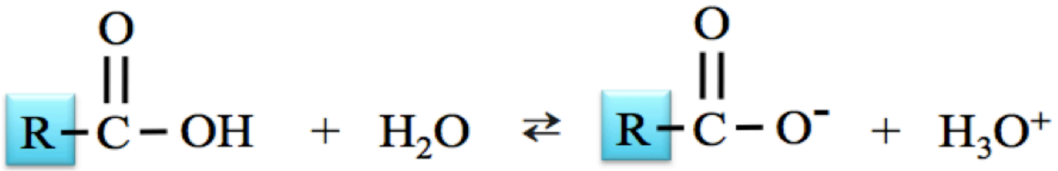
Click here for a **hint**

Click here to **check your answer**

Go to next question

9.20) When a carboxylic acid is placed in water, it reacts with water and an equilibrium is established. The general form of the reaction of a carboxylic acids and water is shown below.



carboxylic acid (acid form) — **carboxylate ion (base form)**

In many biochemical applications, it is of interest to understand whether the ***acid form*** or the ***base form*** of a species is predominant. We use the implications of the Henderson-Hasselbalch Equation to predict the predominant species at any particular pH.

The pK_a of *acetic acid* is about 4.74. Is the ***acid form*** or ***base form*** of acetic acid predominant at physiological pH (~7.4)?

HINT: Compare the pH to the pK_a

Solution Condition	Relative Amounts of Acid and Base Forms
$pH < pK_a$	$[HA] > [A^-]$
$pH > pK_a$	$[A^-] > [HA]$
$pH = pK_a$	$[HA] = [A^-]$

- When the **pH** of a solution is ***less*** than the $\mathbf{pK_a}$ of an acid, then the concentration of the ***acid form***, [HA], is ***greater than*** the concentration of the ***base form***, $[A^-]$. In this case, we say that ***the acid form is predominant***.
- When the **pH** of a solution is ***greater*** than the $\mathbf{pK_a}$ of an acid, then the concentration of the ***base form***, [A], is ***greater than*** the concentration of the ***acid form***, [HA]. In this case, we say that ***the base form is predominant***.
- When the **pH** of a solution is ***equal to*** the $\mathbf{pK_a}$ of an acid, then the concentration of the ***acid form***, [HA], is ***equal to*** the concentration of the ***base form***, $[A^-]$.

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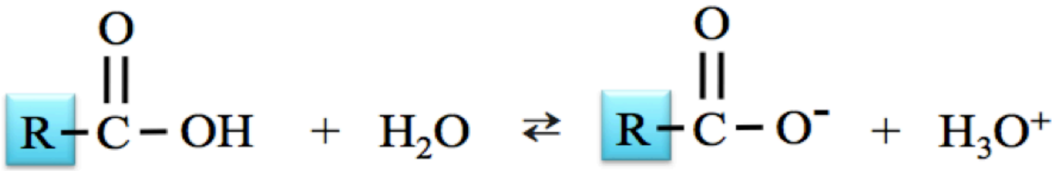
For more help: See chapter 9 part 3 video or chapter 9 section 3 in the textbook.

Click here to check your answer

Go to next question

9.20) When a carboxylic acid is placed in water, it reacts with water and an equilibrium is established. The general form of the reaction of a carboxylic acids and water is shown below.



carboxylic acid (acid form) **carboxylate ion (base form)**

In many biochemical applications, it is of interest to understand whether the ***acid form*** or the ***base form*** of a species is predominant. We use the implications of the Henderson-Hasselbalch Equation to predict the predominant species at any particular pH.

The pK_a of *acetic acid* is about 4.74. Is the ***acid form*** or ***base form*** of acetic acid predominant at physiological pH (~7.4)?

ANSWER: The ***base form*** of acetic acid is predominant.

Solution Condition	Relative Amounts of Acid and Base Forms
$pH < pK_a$	$[HA] > [A^-]$
$pH > pK_a$	$[A^-] > [HA]$
$pH = pK_a$	$[HA] = [A^-]$

EXPLANATION:
Compare the pH to the pK_a

The **pH** (7.4) is ***greater than*** than the **pK_a** (4.74), therefore the concentration of the ***base form***, is ***greater than*** the concentration of the ***acid form***. In this case, we say that ***the base form is predominant***.

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For more details: See chapter 9 part 2 video or chapter 9 section 2 in the textbook.

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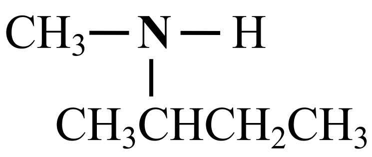
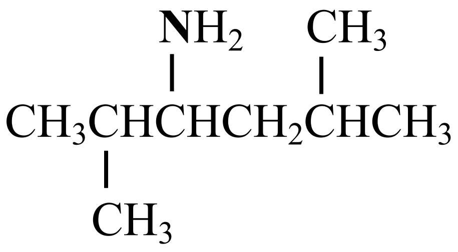
9.21) Identify each of the amines shown below as either primary (1°), secondary (2°), or tertiary (3°).

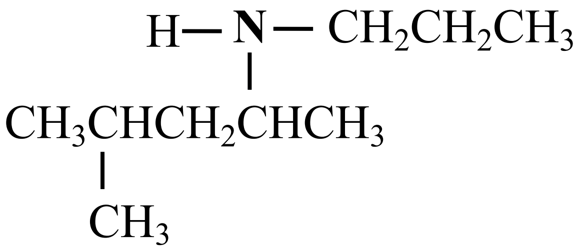
a)



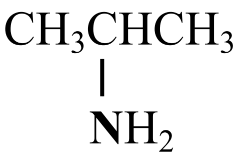
b)



c)

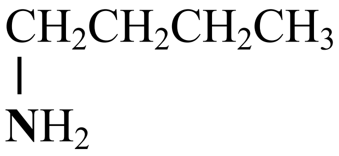


d)



e)

f)



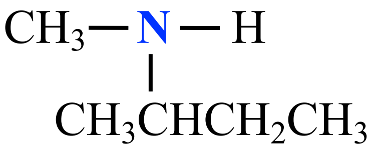
Go back

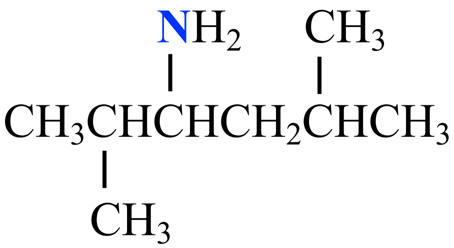
Click here for a **hint**

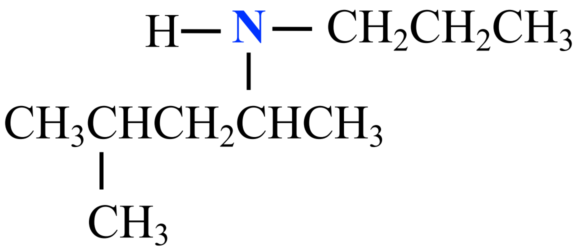
Click here to **check your answer**

Go to next question

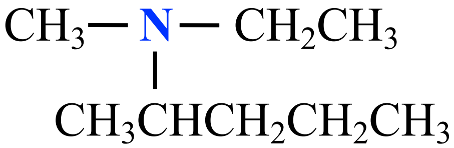
9.21) Identify each of the amines shown below as either primary (1°), secondary (2°), or tertiary (3°).

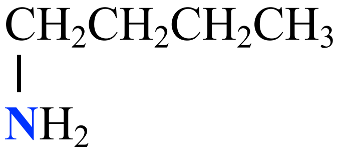
a) 

b) 

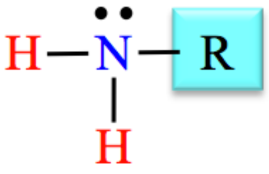
c) 

d) 

e) 

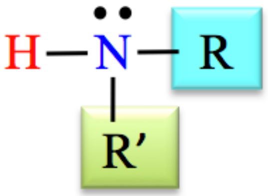
f) 

HINT: Amines are classified as primary (1°), secondary (2°), or tertiary (3°) based on the number of **R** groups that they contain. The general forms of the three categories of amines are shown on the right.



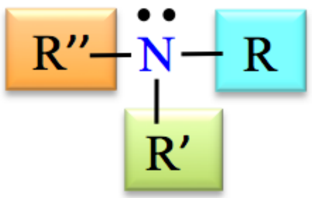
primary (1°) amine

NH_2R



secondary (2°) amine

NHR_2



tertiary (3°) amine

NR_3

- In **primary** (1°) amines, a nitrogen is bonded to ***one*** R group and two hydrogen atoms.
- In **secondary** (2°) amines, a nitrogen is bonded to ***two*** R groups and one hydrogen atom.
- In **tertiary** (3°) amines, a nitrogen is bonded to ***three*** R groups

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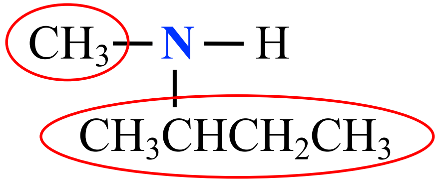
For more help: See chapter 9 part 3 video or chapter 9 section 3 in the textbook.

Click here to check your answer

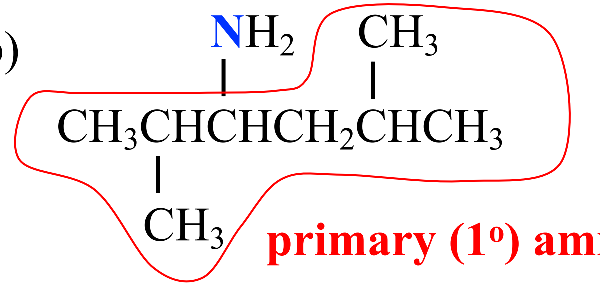
Go to next question

9.21) Identify each of the amines shown below as either primary (1°), secondary (2°), or tertiary (3°).

a) 

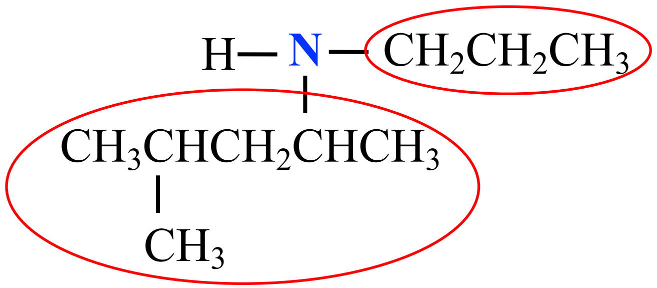
secondary (2°) amine

The nitrogen is bonded to ***two* R** groups and ***one*** hydrogen atom.

b) 

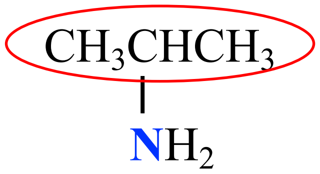
primary (1°) amine

The nitrogen is bonded to ***one* R** group and ***two*** hydrogen atoms.

c) 

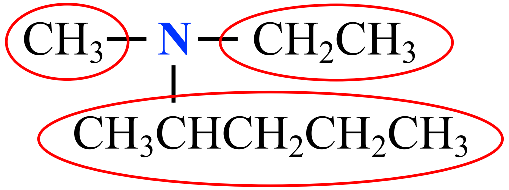
secondary (2°) amine

The nitrogen is bonded to ***two* R** groups and ***one*** hydrogen atom.

d) 

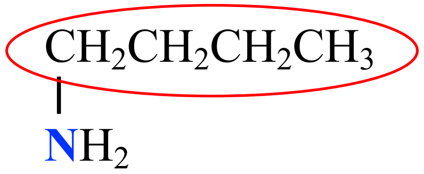
primary (1°) amine

The nitrogen is bonded to ***one* R** group and ***two*** hydrogen atoms.

e) 

tertiary (3°) amine

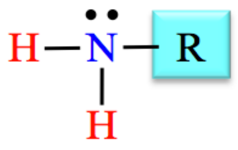
The nitrogen is bonded to ***three* R** groups.

f) 

primary (1°) amine

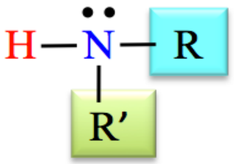
The nitrogen is bonded to ***one* R** group and ***two*** hydrogen atoms.

EXPLANATION: Amines are classified as primary (1°), secondary (2°), or tertiary (3°) based on the number of **R** groups that they contain. The general forms of the three categories of amines are shown on the right.



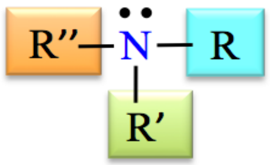
primary (1°) amine

NH_2R



secondary (2°) amine

NHR_2



tertiary (3°) amine

NR_3

For more details: See chapter 9 part 3 video or chapter 9 section 3 in the textbook.

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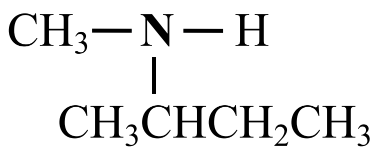
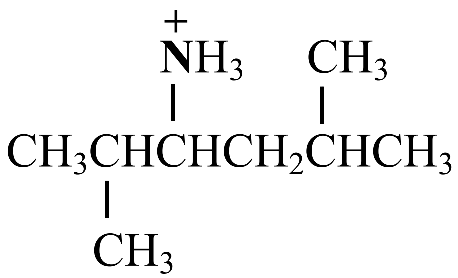
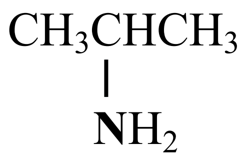
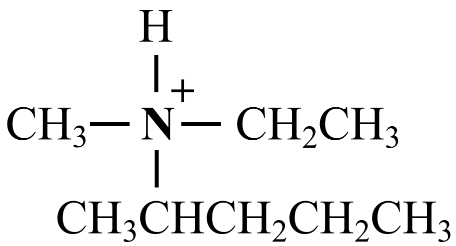
Go to next question

9.22) Which of the the species shown below are ***quaternary ammonium ions***?

a) 

b) 

c) 

d) 

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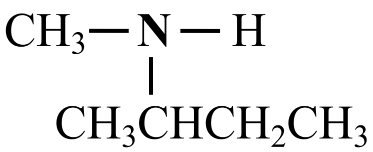
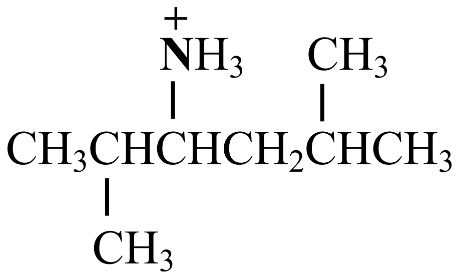
Click here for a **hint**

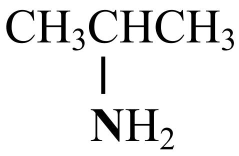
Click here to **check your answer**

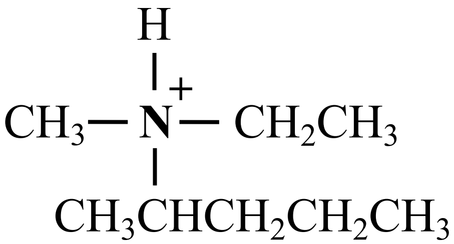
Go to next question

9.22) Which of the the species shown below are ***quaternary ammonium ions***?

a) 

b) 

c) 

d) 

HINT:

A ***quaternary ammonium ion*** is formed when an additional hydrogen or alkyl group (R) is *added* to an ***amine***.

For more help: See chapter 9 part 3 video or chapter 9 section 3 in the textbook.

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Click here to **check your answer**

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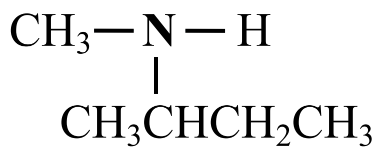
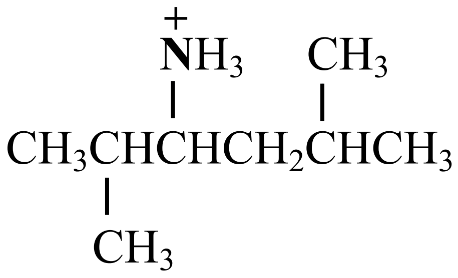
9.22) Which of the the species shown below are ***quaternary ammonium ions***? **ANSWER: (b) and (d)**

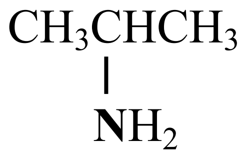
a)



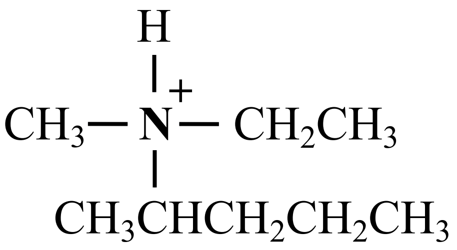
b)



c)



d)



EXPLANATION:

A ***quaternary ammonium ion*** is formed when an additional hydrogen or alkyl group (R) is *added* to an ***amine***. The nitrogen in a quaternary ammonium ion does not have a lone pair and, therefore has a formal charge of 1+.

For more details: See chapter 9 part 3 video or chapter 9 section 3 in the textbook.

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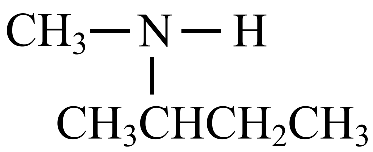
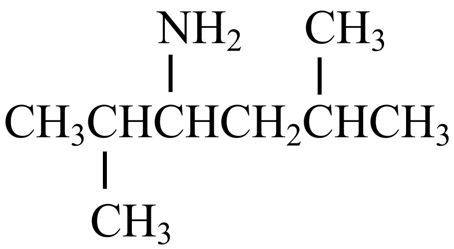
9.23) Draw the **skeletal structure** of each of the ***amines*** shown below:

a) 

b) 

c) $CH_3CH_2CH_2CH_2-NH_2$

Go back

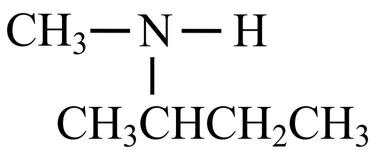
Click here for a **hint**

Click here to **check your answer**

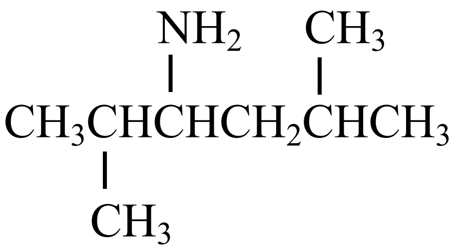
Go to next question

9.23) Draw the **skeletal structure** of each of the ***amines*** shown below:

a)

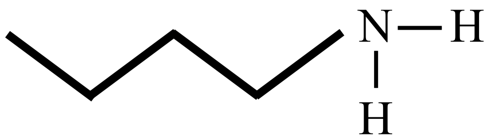


b)



HINT:

c) $CH_3CH_2CH_2CH_2-NH_2$



or

For more help: See chapter 9 part 3 video or chapter 9 section 3 in the textbook.

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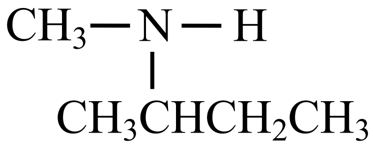
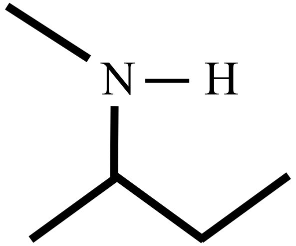
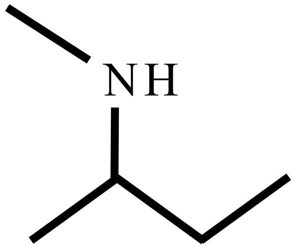
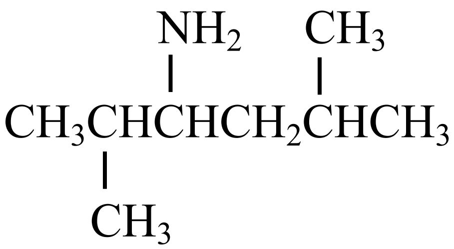
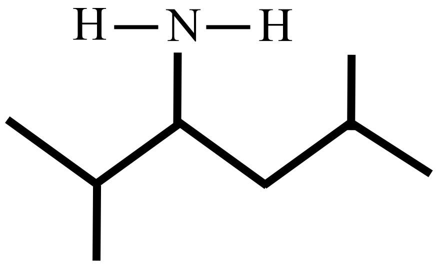
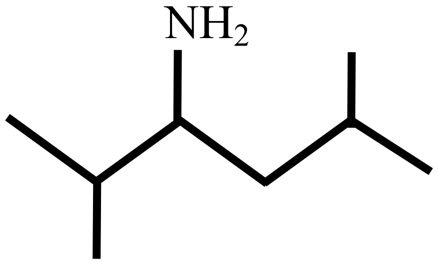
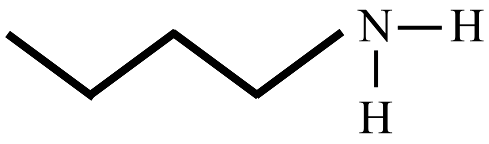
Click here to **check your answer**

Go to next question

9.23) Draw the **skeletal structure** of each of the ***amines*** shown below:

a)   or 

b)   or 

c) $CH_3CH_2CH_2CH_2{-}NH_2$  or 

For more details: See [chapter 9 part 3 video]() or chapter 9 section 3 in the textbook.

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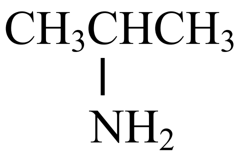
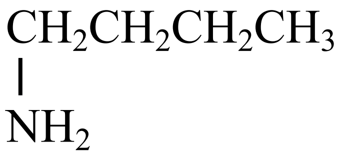
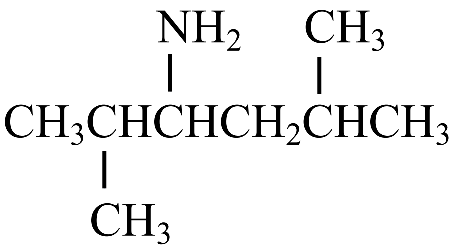
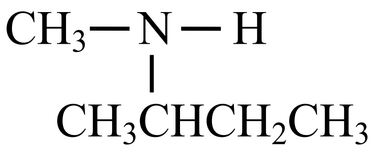
9.24) Write the **systematic names** for each of the amines shown below.

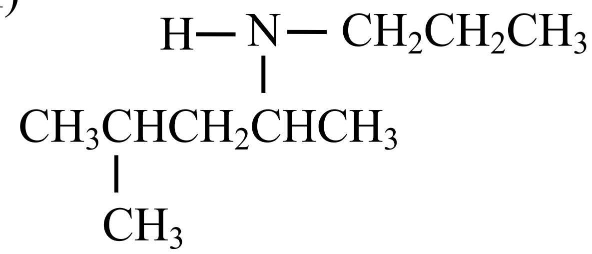
a) 

b) 

c) 

d) 

e) 

f) 

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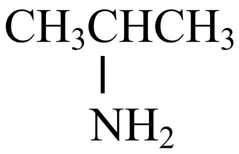
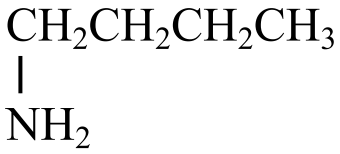
Click here for a **hint**

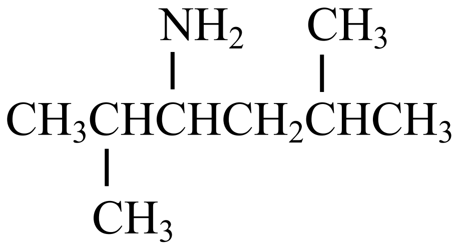
Click here to **check your answer**

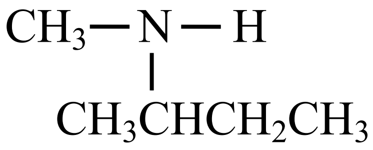
Go to next question

9.24) Write the **systematic names** for each of the amines shown below.

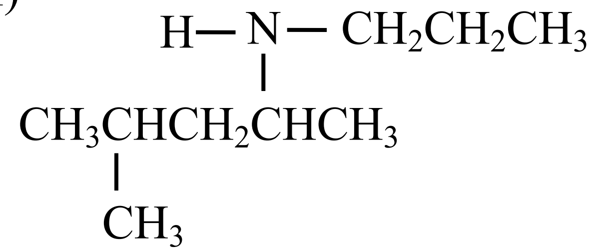
a) 

b) 

c) 

d) 

e) 

f) 

HINT: Naming Amines

Step 1. Find and name the *parent chain*.

The *parent chain is the longest, continuous chain of carbon atoms that* ***contains the point of attachment to the nitrogen***. Starting with the alkane name that corresponds to the number of carbon atoms in the ***parent chain***, replace the "**e**" at the end of the alkane name with "**amine**."

For amines with ***more than two carbons***, the position of *the point of attachment to the* ***nitrogen*** must be indicated by adding a number ***before the parent chain name***. Assign *position numbers* to the carbons in the parent chain. Position number **1** is assigned to the carbon at the *end of the parent chain* that is **nearest to the point of attachment to the nitrogen**.

Step 2. Name any alkyl group substituents.

Alkyl group substituents that are attached to the parent chain are named in the same way as you did for alkanes. For secondary and tertiary amines, the ***nonparent chain*** **R** group(s) *attached to the nitrogen* are named as substituents by writing "***N*-**" in front of the **R** group substituent name.

Step 3. Construct the name of the amine by placing the alkyl groups in alphabetical order and specifying their position, followed by the name of the parent chain.

For more help: See chapter 9 part 3 video or chapter 9 section 3 in the textbook.

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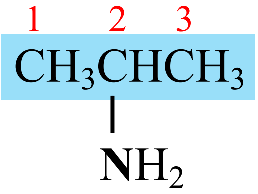
Click here to check your answer

Go to next question

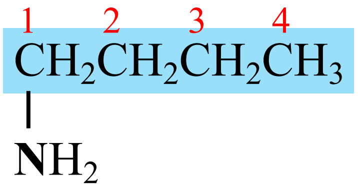
9.24) Write the **systematic names** for each of the amines shown below.

a)



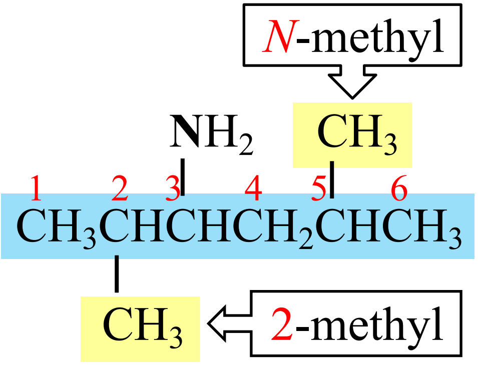
2-propanamine

b)



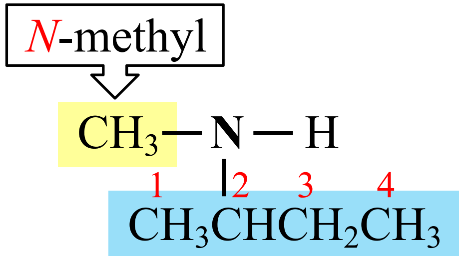
1-butanamine

c)



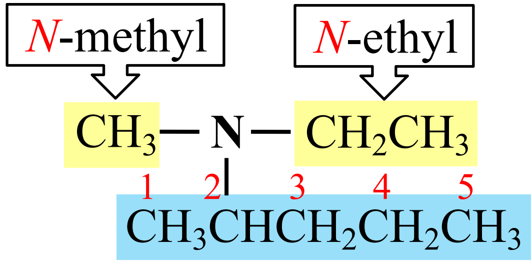
2,5-dimethyl-3-hexanamine

d)



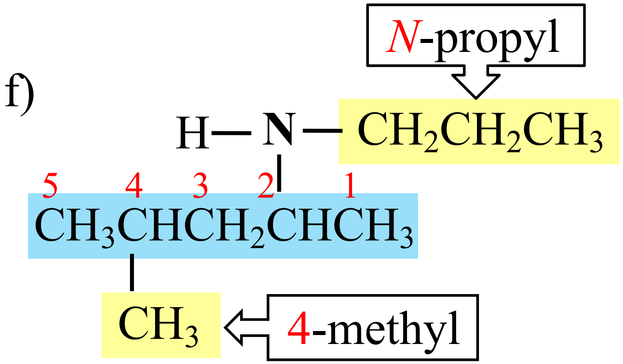
***N*-methyl-2-butanamine**

e)



***N*-ethyl-*N*-methyl-2-pentanamine**

f)



4-methyl-*N*-propyl-2-pentanamine

EXPLANATION: Naming Amines

Step 1. Find and name the *parent chain*.

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Step 3. Construct the name of the amine by placing the alkyl groups in alphabetical order and specifying their position, followed by the name of the parent chain.

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For more details: See chapter 9 part 3 video or chapter 9 section 3 in the textbook.

Go to next question

9.25) Draw the condensed **and** skeletal structure of each of the amines listed below.

a) 1-pentanamine

b) 3-pentanamine

c) 4-ethyl-*N*-methyl-2-heptanamine

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Click here for a **hint**

Click here to **check your answer**

Go to next question

9.25) Draw the condensed **and** skeletal structure of each of the amines listed below.

a) 1-pentanamine

HINT:

NH_2
|
$CH_2CH_2CH_2CH_2CH_3$

b) 3-pentanamine

c) 4-ethyl-*N*-methyl-2-heptanamine

For more help: See chapter 9 part 3 video or chapter 9 section 3 in the textbook.

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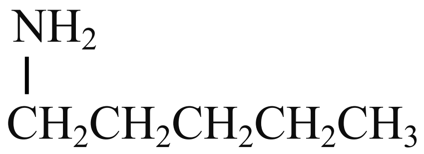
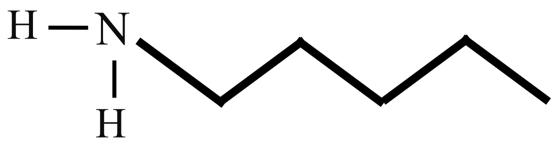
Click here to check **your answer**

Go to next question

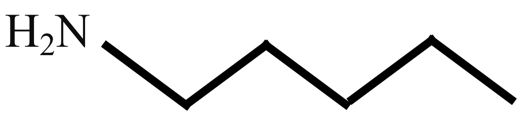
9.25) Draw the condensed **and** skeletal structure of each of the amines listed below.

a) 1-pentanamine

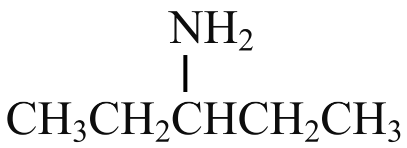


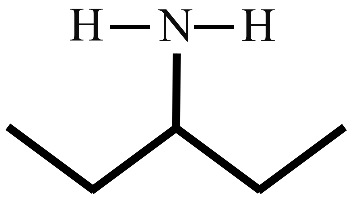


or



b) 3-pentanamine





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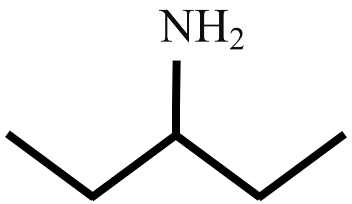
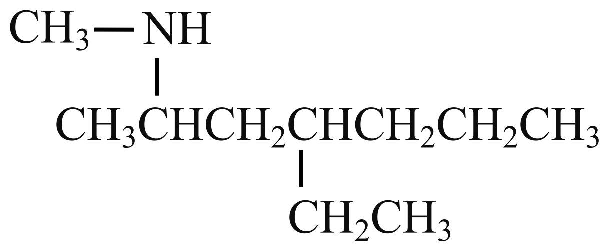
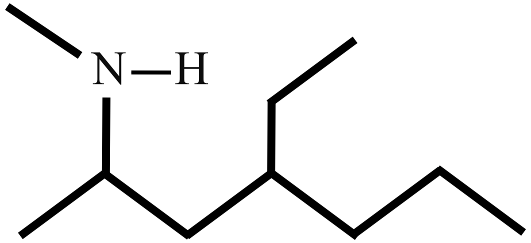


c) 4-ethyl-*N*-methyl-2-heptanamine





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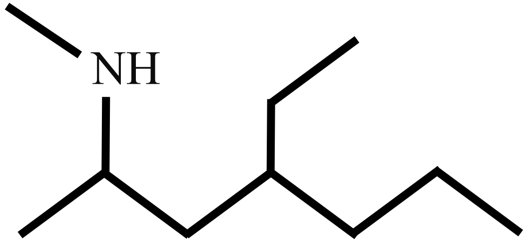

For more details: See chapter 9 part 3 video or chapter 9 section 3 in the textbook.

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9.26)

i) The term "______________" is used for physiologically active amines that occur in nature.

a) amphetamine
b) amide
c) alkaloid
d) quaternary ammonium ion

ii) Cyclic compounds that contain atoms other than carbon are known as ______________ compounds.

a) heterocyclic
b) supplemental
c) amino
d) dual-ring

iii) A secondary amine will always have "_______" as part of its systematic name.

a) *N,N,N*-
b) *N,N*-
c) *N*-
d) Mr. or Ms.

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Click here for a **hint**

Click here to **check your answer**

Go to next question

9.26)

i) The term "______________" is used for physiologically active amines that occur in nature.

HINT:
a) ~~amphetamine~~
b) amide
c) alkaloid
d) ~~quaternary ammonium ion~~

ii) Cyclic compounds that contain atoms other than carbon are known as ______________ compounds.

HINT:
a) heterocyclic
b) ~~supplemental~~
c) amino
d) ~~dual-ring~~

iii) A secondary amine will always have "_______" as part of its systematic name.

a) *N,N,N*-
b) *N,N*-
c) *N*-
d) Mr. or Ms.

HINT: For secondary amines, there is one, *nonparent chain* **R** group *attached to the nitrogen.*

For more help: See chapter 9 part 4 video or chapter 9 section 3 in the textbook.

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Click here to **check your answer**

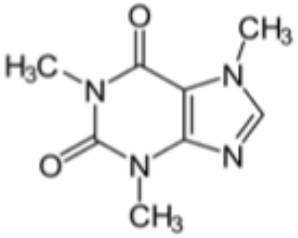
Go to next question

9.26)

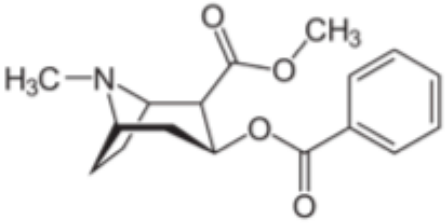
i) The term "______________" is used for physiologically active amines that occur in nature.

a) amphetamine
b) amide
c) alkaloid
d) quaternary ammonium ion

Some examples of ***alkaloids*** are:



caffeine

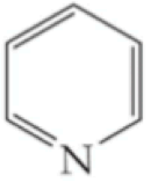


cocaine

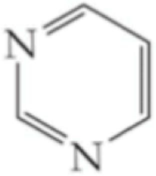
ii) Cyclic compounds that contain atoms other than carbon are known as ______________ compounds.

a) heterocyclic
b) supplemental
c) amino
d) dual-ring

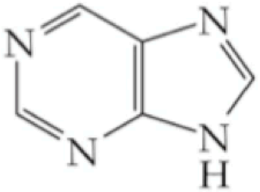
Examples of heterocyclic compounds are:



pyridine



pyrimidine



purine

iii) A secondary amine will always have "________" as part of its systematic name.

a) *N,N,N*-
b) *N,N*-
c) *N*-
d) Mr. or Ms.

For secondary amines, there is one, *nonparent chain* **R** group *attached to the nitrogen.* This nonparent chain R group is named as a substituent by writing "***N*-**" in front of the **R** group name.

For more details: See chapter 9 part 4 video or chapter 9 section 3 in the textbook.

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9.27) An amine acts as a _____________ when it reacts with water to produce a quaternary ammonium ion and a hydroxide ion.

a) acid
b) base
c) amphipathic compound

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Click here for a **hint**

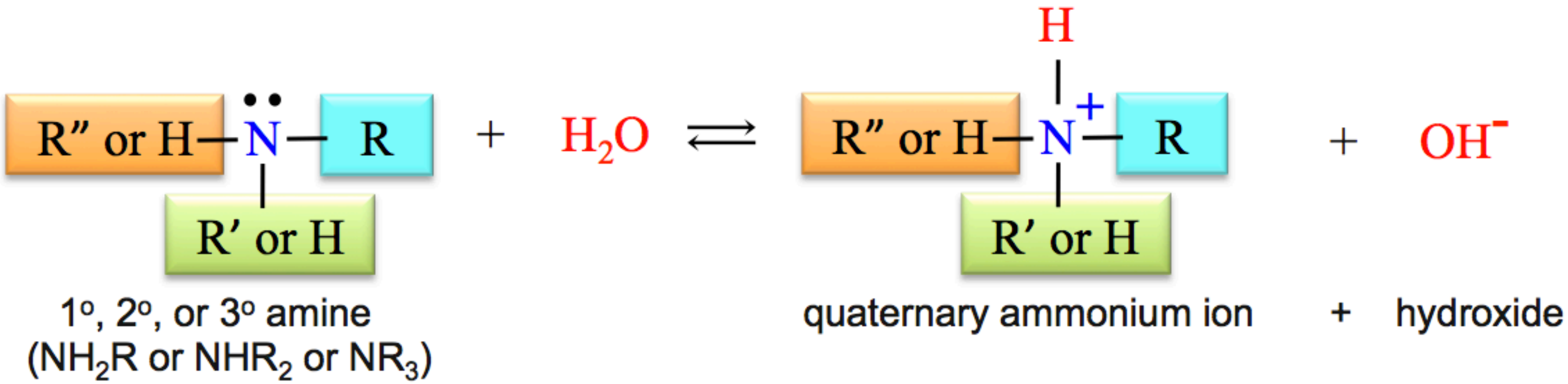
Click here to **check your answer**

Go to next question

9.27) An amine acts as a ____________ when it reacts with water to produce a quaternary ammonium ion and a hydroxide ion.

a) acid
b) base
c) amphipathic compound

HINT: The general form of the reaction of an amine with water is shown below.



When an amine reacts with H_2O, the amine ***accepts*** a hydrogen ion (H^+). The hydrogen ion comes from H_2O.

For more help: See chapter 9 part 5 video or chapter 9 section 3 in the textbook.

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Click here to **check your answer**

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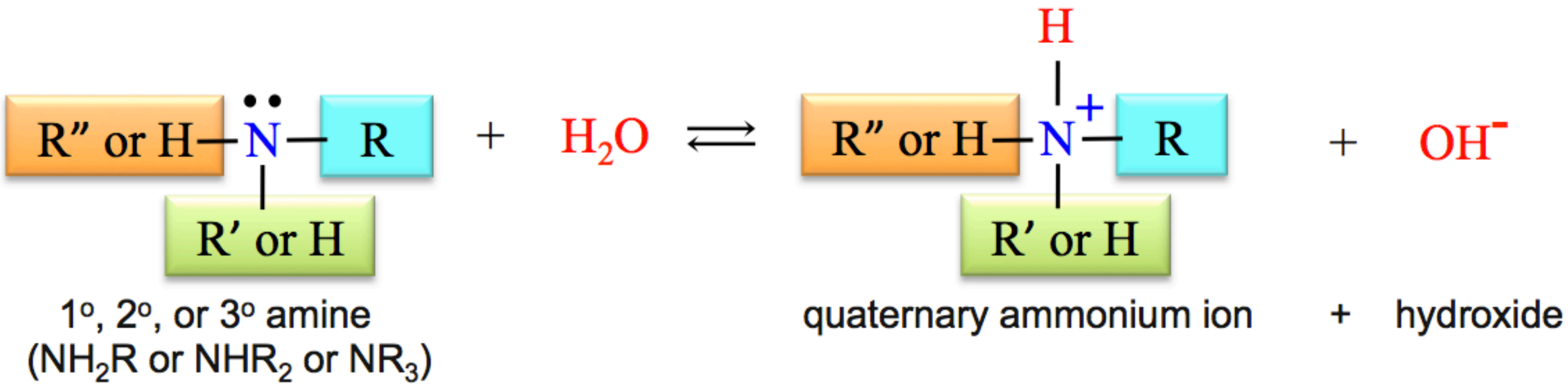
9.27) An amine acts as a ____________ when it reacts with water to produce a quaternary ammonium ion and a hydroxide ion.

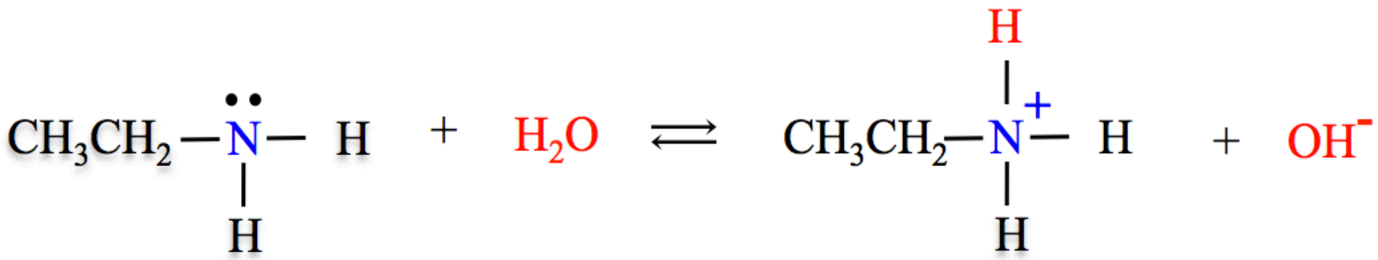
a) acid
b) base
c) amphipathic compound

EXPLANATION: The general form of the reaction of an amine with water is shown below.



When an amine reacts with H_2O, the amine ***accepts*** a hydrogen ion (H^+). The amine acts as a **base**. The hydrogen ion comes from H_2O; H_2O acts as an acid in this reaction.

A specific example of the reaction of an amine with water is the reaction of ethanamine with water:



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For more details: See chapter 9 part 5 video or chapter 9 section 3 in the textbook.

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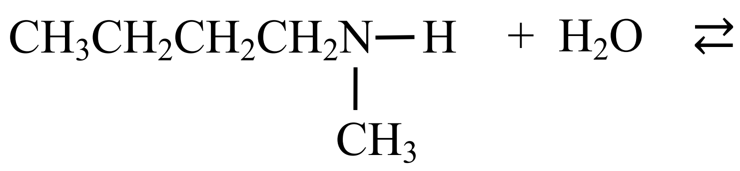
9.28) Add the products for the following reaction:



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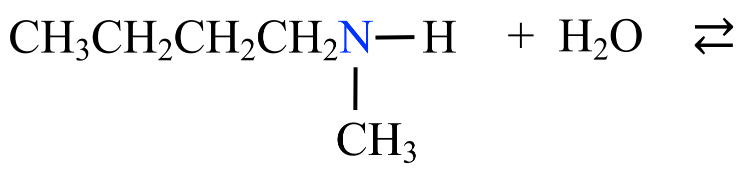
Click here for a **hint**

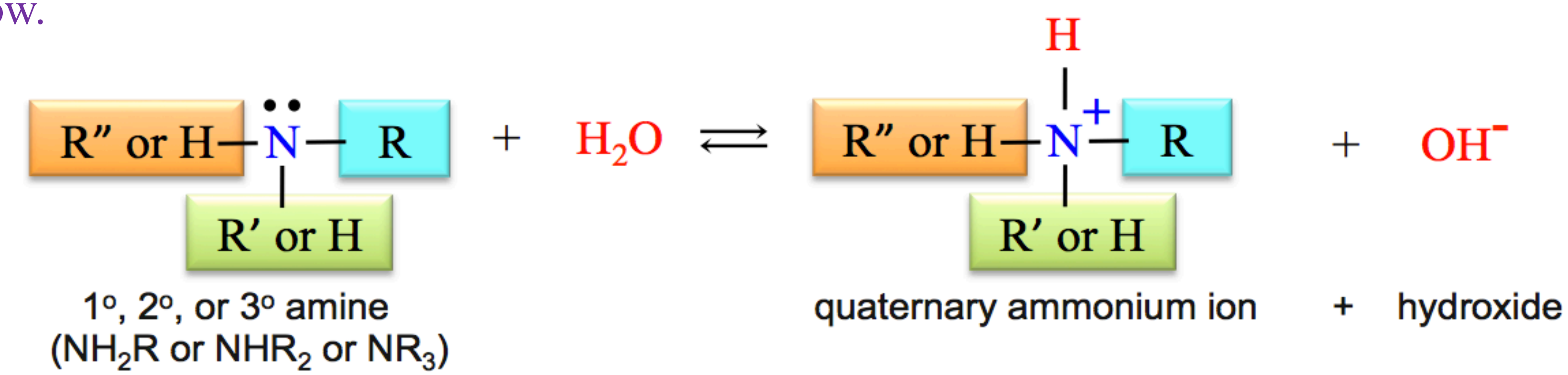
Click here to **check your answer**

Go to next question

9.28) Add the products for the following reaction:



HINT: An **amine** reacts with water to produce a **quaternary ammonium ion** and a **hydroxide ion**. The lone pair on the amine **nitrogen** forms a bond to the **H^+** from water. The general form of the reaction of an amine with water is shown below.



For more help: See chapter 9 part 5 video or chapter 9 section 3 in the textbook.

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Click here to check your answer

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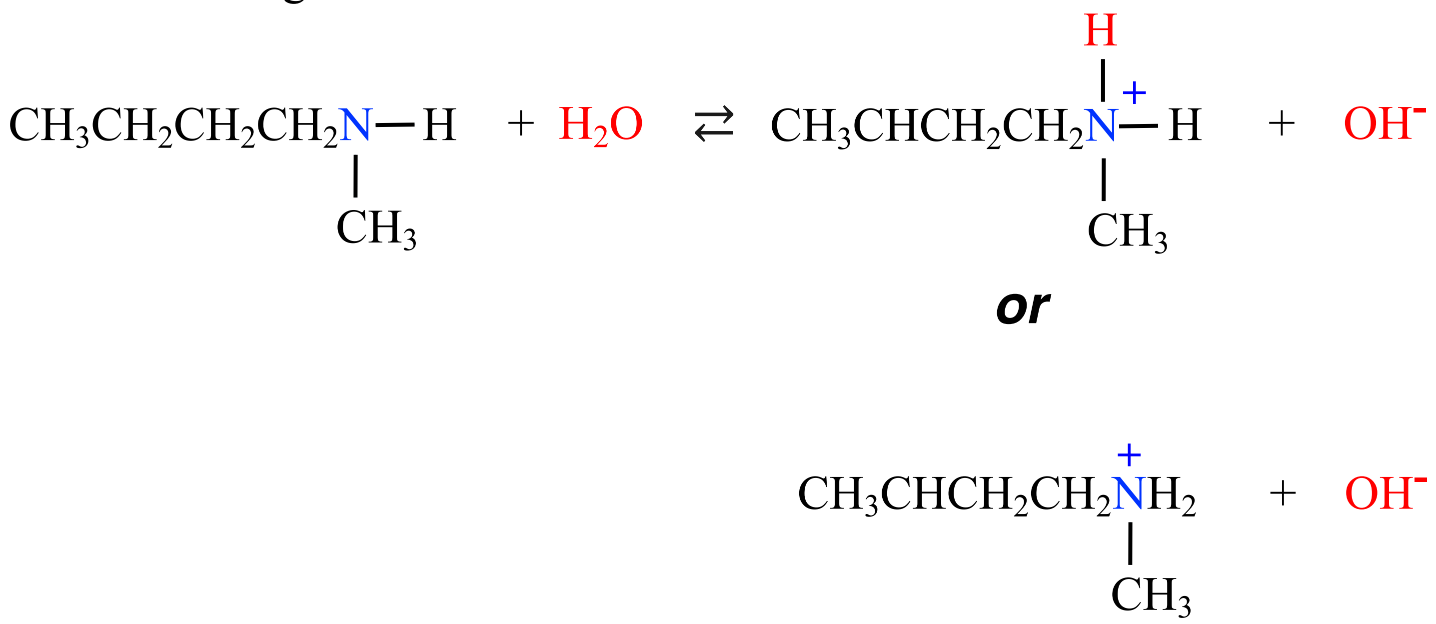
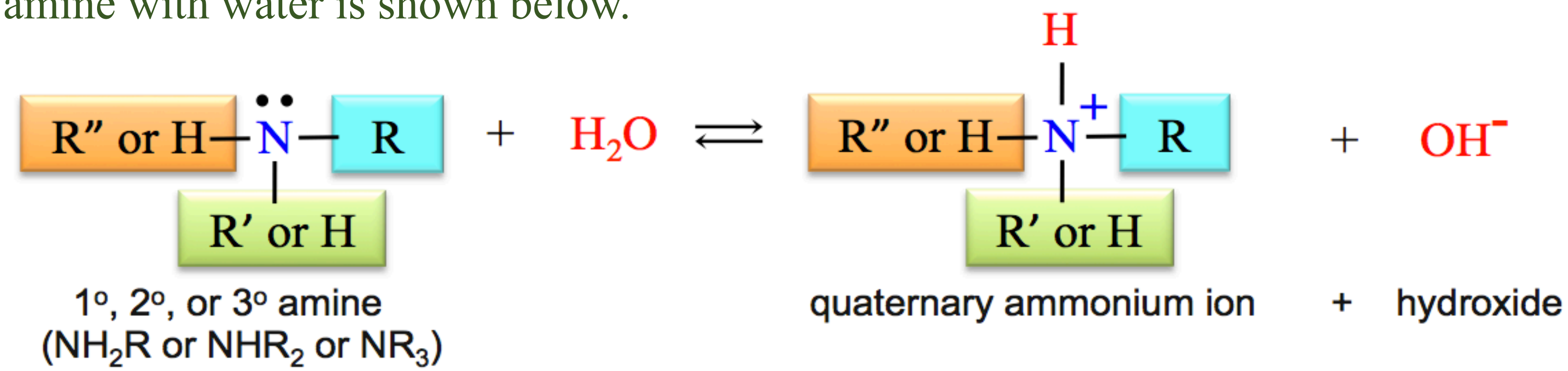
9.28) Add the products for the following reaction:



EXPLANATION: An **amine** reacts with water to produce a **quaternary ammonium ion** and a **hydroxide ion**. The lone pair on the amine **nitrogen** forms a bond to the **H**$^+$ from water**.** The general form of the reaction of an amine with water is shown below.



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For more details: See chapter 9 part 5 video or chapter 9 section 3 in the textbook.

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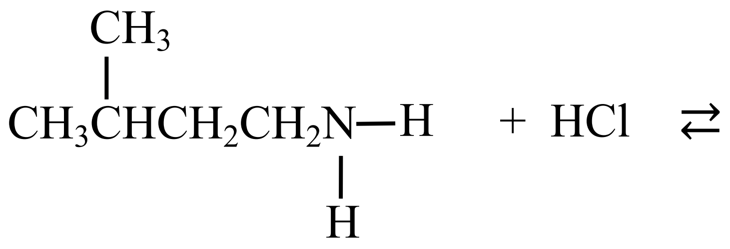
9.29) Add the products for the following reaction between an **amine** and an **acid** (HCl):



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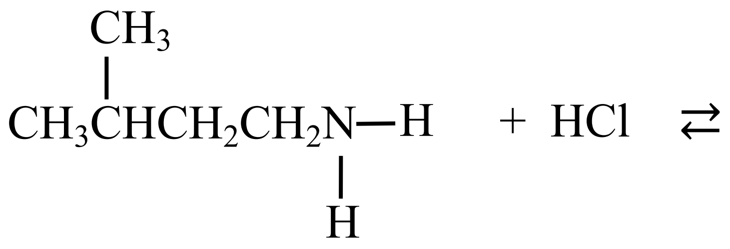
Click here for a **hint**

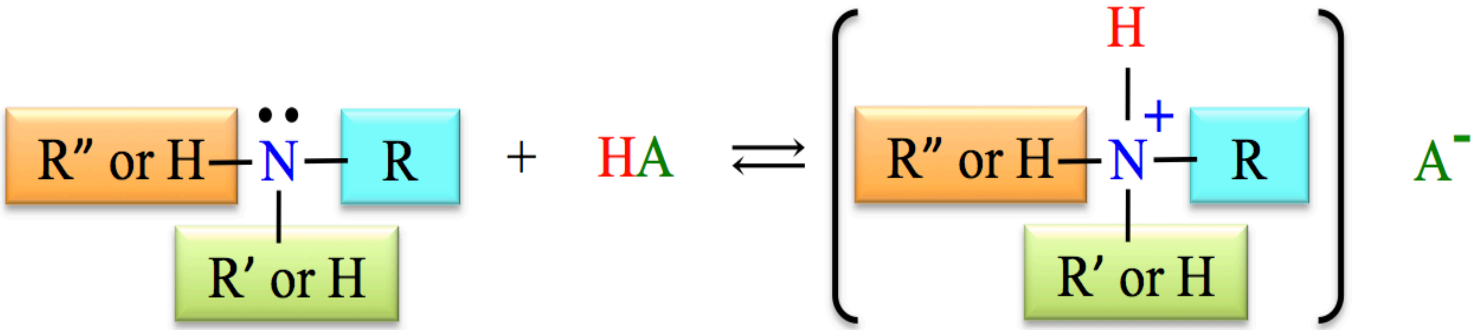
Click here to **check your answer**

Go to next question

9.29) Add the products for the following reaction between an **amine** and an **acid** (HCl):



HINT: An ***amine*** will react with an ***acid*** to produce *a* ***quaternary ammonium compound*** in a **neutralization reaction**. The lone pair on the amine nitrogen forms a bond to the H^+ from the acid. The general form of the equation for the reaction of an amine with an acid is shown below:



For more help: See chapter 9 part 5 video or chapter 9 section 3 in the textbook.

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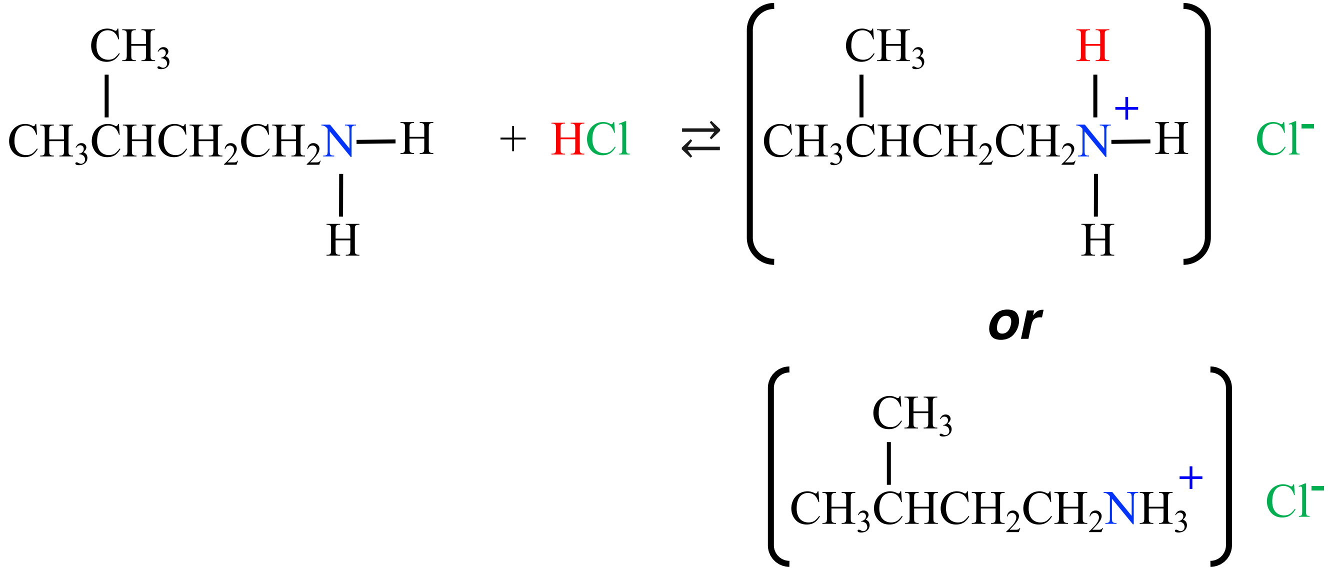
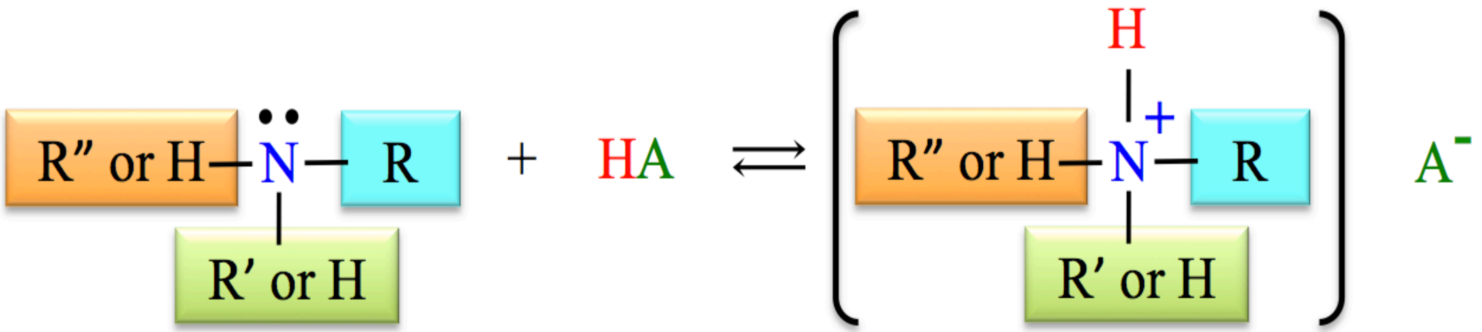
Click here to check your answer

Go to next question

9.29) Add the products for the following reaction between an **amine** and an **acid** (HCl):



EXPLANATION: An ***amine*** will react with an ***acid*** to produce *a* ***quaternary ammonium compound*** in a **neutralization reaction**. The lone pair on the amine nitrogen forms a bond to the H^+ from the acid. The general form of the equation for the reaction of an amine with an acid is shown below:



For more details: See chapter 9 part 5 video or chapter 9 section 3 in the textbook.

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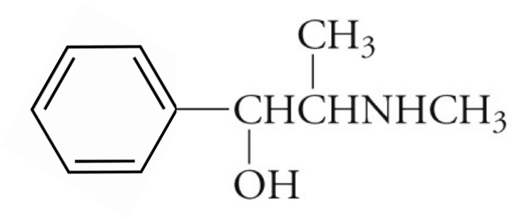
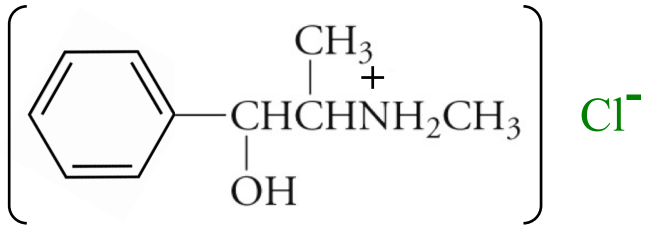
9.30) The structural formulas of *pseudoephedrine* (a free base) and *pseudoephedrine hydrochloride* (a quaternary ammonium compound) are shown below. Which of these two compounds would you predict to be more water-soluble?

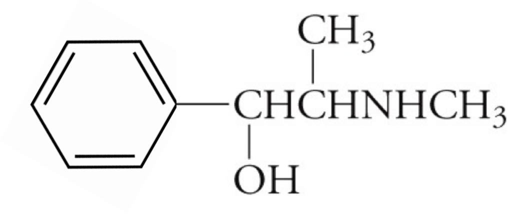


pseudoephedrine

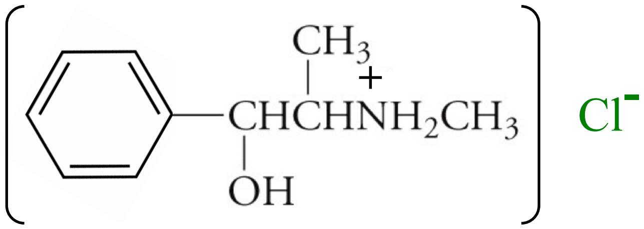


pseudoephedrine hydrochloride

9.30) The structural formulas of *pseudoephedrine* (a free base) and *pseudoephedrine hydrochloride* (a quaternary ammonium compound) are shown below. Which of these two compounds would you predict to be more water-soluble?



pseudoephedrine



pseudoephedrine hydrochloride

HINT:

The species that has that has the **most/strongest *noncovalent interactions*** with water molecules will be more water-soluble.

For more help: See chapter 9 part 5 video or chapter 9 section 3 in the textbook.

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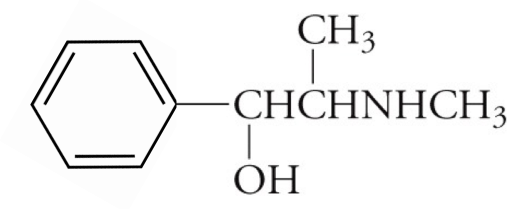
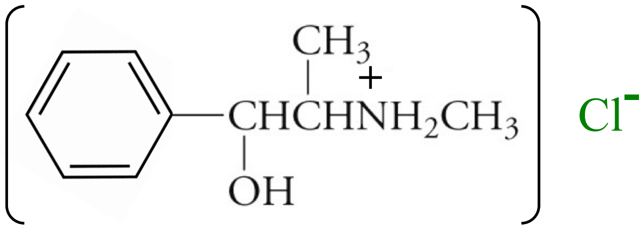
Click here to **check your answer**

Go to next question

9.30) The structural formulas of *pseudoephedrine* (a free base) and *pseudoephedrine hydrochloride* (a quaternary ammonium compound) are shown below. Which of these two compounds would you predict to be more water-soluble?



pseudoephedrine



pseudoephedrine hydrochloride

more water-soluble

EXPLANATION:

Amines that are used as medications, both legal and illegal, are often administered as quaternary ammonium ions in order to increase their water-solubility. The water-solubility of the a quaternary ammonium compound is greater than that of its conjugate amine *because it is capable on interacting with water through ion-dipole noncovalent interactions as a result of the positive charge of the ion*. The anions of such quaternary ammonium compound medications are often chloride or sulfate since they are prepared by reaction of the amine - sometimes called the "free base" - with hydrochloric acid (HCl) or sulfuric acid (H_2SO_4). For example, pseudoephedrine hydrochloride, used in the decongestant sold as Allegra D by Bayer Healthcare, and as Benadryl by Johnson and Johnson, can be prepared by the reaction of pseudoephedrine and HCl.

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For more details: See chapter 9 part 5 video or chapter 9 section 3 in the textbook.

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9.31) Which of the following *increases* the pH when added to pure water?

a) ethanol

b) propanoic acid

c) methanamine

d) methanol

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Click here for a **hint**

Click here to **check your answer**

Go to next question

9.31) Which of the following *increases* the pH when added to pure water?

a) ethanol

b) propanoic acid

HINT:

Alcohols do not react with water to produce H_3O^+ or OH^-. It is for this reason that they do not change the pH when placed in water.

c) methanamine

For more help: See chapter 9 part 5 video or chapter 9 section 3 in the textbook.

d) methanol

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Click here to **check your answer**

Go to next question

9.31) Which of the following compounds *increases* the pH when added to pure water?

a) ethanol

Alcohols do not react with water to produce H_3O^+ or OH^-. It is for this reason that they do not change the pH when placed in water.

b) propanoic acid

Carboxylic acids react with water to produce H_3O^+. The production on H_3O^+ ***decreases*** the pH. Recall that when the H_3O^+ concentration increases, the pH decreases because of the negative sign in the definition of pH: $pH = -\log[H_3O^+]$.

c) methanamine

Amines act react with water to produce OH^-. The production of OH^- ***increases*** the pH. Recall that when the OH^- concentration increases, the H_3O^+ must decrease because their product is constant: $[H_3O^+][OH^-] = 1.0 \times 10^{-14}$. When the OH^- concentration increases and the H_3O^+ concentration decreases, the pH increases.

d) methanol

Alcohols do not react with water to produce H_3O^+ or OH^-. It is for this reason that they do not change the pH when placed in water.

For more details: See chapter 9 part 5 video or chapter 9 section 3 in the textbook.

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Go to next question

9.32) Draw the ***general form*** of an **amide**.

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Click here for a **hint**

Click here to **check your answer**

Go to next question

9.32) Draw the ***general form*** of an **amide**.

HINT: ***Amides*** contain both a ***carbonyl group*** **(C=O)**, ***and*** a nitrogen **(N)**, with the nitrogen bonded to the *carbonyl* carbon.

For more help: See chapter 9 part 6 video or chapter 9 section 4 in the textbook.

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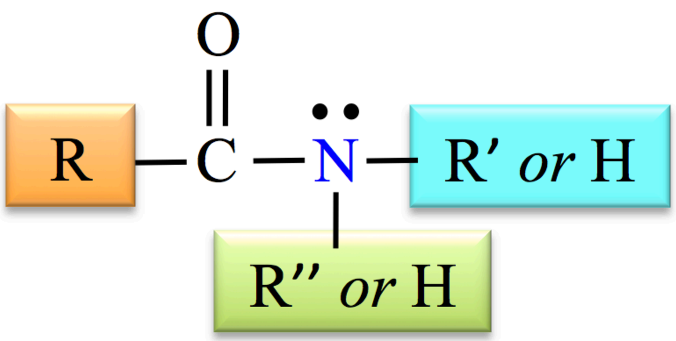
Click here to **check your answer**

Go to next question

9.32) Draw the ***general form*** of an **amide**.

ANSWER:



EXPLANATION: ***Amides*** contain both a ***carbonyl group*** **(C=O)**, ***and*** a nitrogen **(N)**, with the nitrogen bonded to the *carbonyl* carbon.

For more details: See chapter 9 part 6 video or chapter 9 section 4 in the textbook.

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Go to next question

9.33) Name the molecule that is shown below.

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Click here to **check your answer**

Go to next question

9.33) Name the molecule that is shown below.

HINT: Naming Amides

Step 1: Find and name the parent chain.

The parent chain of an amide is the longest continuous chain of carbon atoms that includes the ***carbonyl carbon*** - *just as we did with carboxylic acids.*

Starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the "**e**" at the end of the alkane name with "**amide**."

Step 2: Name any alkyl group substituents. **NOT NEEDED FOR THIS PROBLEM**. THERE ARE **NO** ALKYL GROUPS PRESENT.

Step 3: Determine the *point of attachment* of any alkyl groups. **NOT NEEDED FOR THIS PROBLEM**.

Step 4: Construct the name of the amide by placing the alkyl groups in alphabetical order and specifying their positions, followed by the name of the parent chain.

For more help: See chapter 9 part 6 video or chapter 9 section 4 in the textbook.

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Click here to **check your answer**

Go to next question

9.33) Name the molecule that is shown below.

ANSWER: pentanamide

EXPLANATION: Naming Amides

Step 1: Find and name the parent chain.

The parent chain of an amide is the longest continuous chain of carbon atoms that includes the ***carbonyl carbon*** - *just as we did with carboxylic acids.*

Starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the "**e**" at the end of the alkane name with "**amide**."

- The amide in this problem contains *five* carbons; it is called pentan***amide***.

Step 2: Name any alkyl group substituents. **NOT NEEDED FOR THIS PROBLEM**. THERE ARE **NO** ALKYL GROUPS PRESENT.

Step 3: Determine the *point of attachment* of any alkyl groups. **NOT NEEDED FOR THIS PROBLEM**.

Step 4: Construct the name of the amide by placing the alkyl groups in alphabetical order and specifying their positions, followed by the name of the parent chain.

- Because there are no alkyl group substituents in this problem, the name of this molecule is: **pentanamide**

For more details: See chapter 9 part 6 video or chapter 9 section 4 in the textbook.

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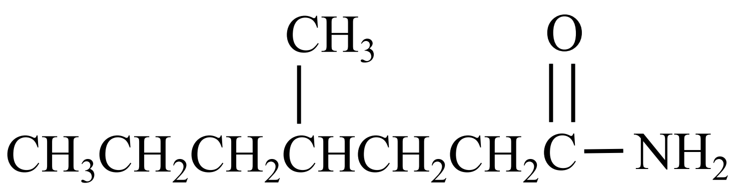
Go to next question

9.34) Name the molecule that is shown below.



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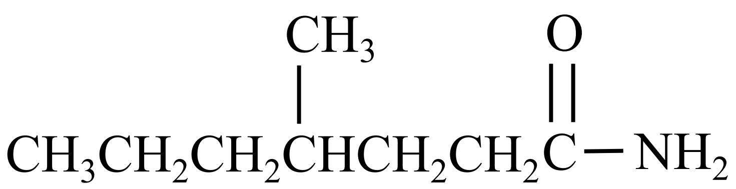
Click here for a **hint**

Click here to **check your answer**

Go to next question

9.34) Name the molecule that is shown below.



HINT: Naming Amides

Step 1: Find and name the parent chain.

The parent chain of an amide is the longest continuous chain of carbon atoms that includes the ***carbonyl carbon*** - *just as we did with carboxylic acids.*

Starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the "**e**" at the end of the alkane name with "**amide**."

Step 2: Name any alkyl group substituents.

- Alkyl groups are named in the same way as was done for hydrocarbons.

Step 3: Determine the *point of attachment* of any alkyl groups.

- Substituents are assigned positions based on their point of attachment to the parent chain or to the nitrogen. Begin numbering the parent chain at the *carbonyl carbon*.

Step 4: Construct the name of the amide by placing the alkyl groups in alphabetical order and specifying their positions, followed by the name of the parent chain.

- Use a ***dash*** between positions and *letters*.
- Add the labels di, tri, or tetra in front of the alkyl group name **if** two, three, or four (respectively) identical substituents are present.

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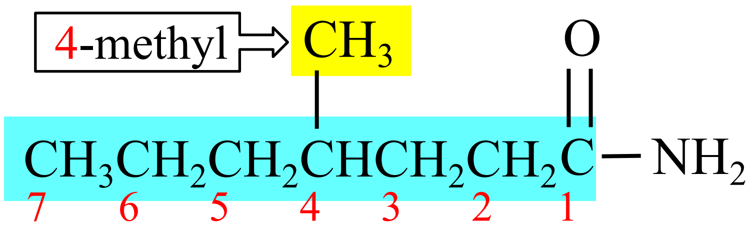
For more help: See chapter 9 part 6 video or chapter 9 section 4 in the textbook.

Click here to **check your answer**

Go to next question

9.34) Name the molecule that is shown below.



ANSWER: 4-methylheptanamide

EXPLANATION: Naming Amides

Step 1: Find and name the parent chain.

The parent chain of an amide is the longest continuous chain of carbon atoms that includes the ***carbonyl carbon*** - *just as we did with carboxylic acids.*

Starting with the alkane name that corresponds to the number of carbon atoms in the parent chain, replace the "**e**" at the end of the alkane name with "**amide**."

- The amide in this problem contains *seven* carbons; it is called heptan***amide***.

Step 2: Name any alkyl group substituents.

- Alkyl groups are named in the same way as was done for hydrocarbons.

Step 3: Determine the *point of attachment* of any alkyl groups.

- Substituents are assigned positions based on their point of attachment to the parent chain or to the nitrogen. Begin numbering the parent chain at the *carbonyl carbon*. For this molecule, we write **4-methyl**.

Step 4: Construct the name of the amide by placing the alkyl groups in alphabetical order and specifying their positions, followed by the name of the parent chain.

- Use a ***dash*** between positions and *letters*.
- Add the labels di, tri, or tetra in front of the alkyl group name **if** two, three, or four (respectively) identical substituents are present. (Not need in this problem.)

The name of this molecule is: **4-methylheptanamide**

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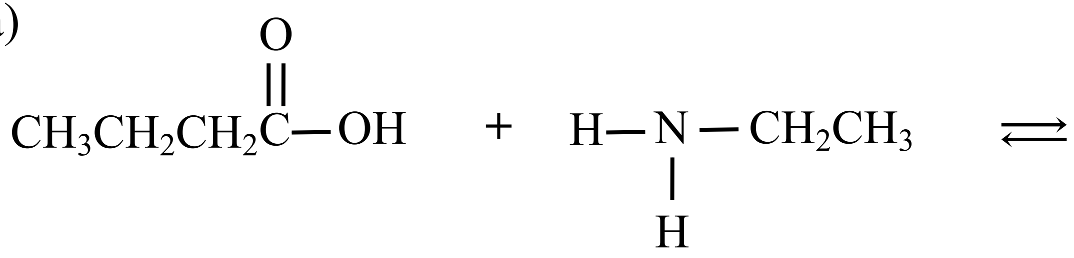
For more details: See chapter 9 part 6 video or chapter 9 section 4 in the textbook.

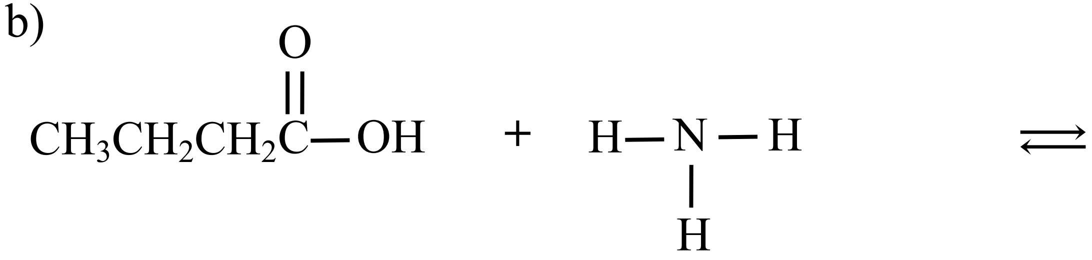
Go to next question

9.35) Add the products for each of the following reactions.

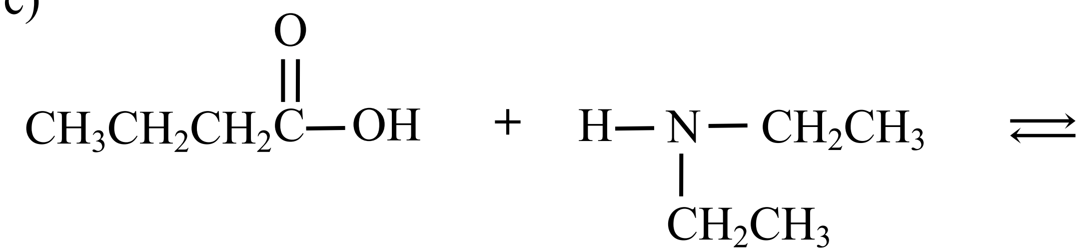
a)



b)



c)



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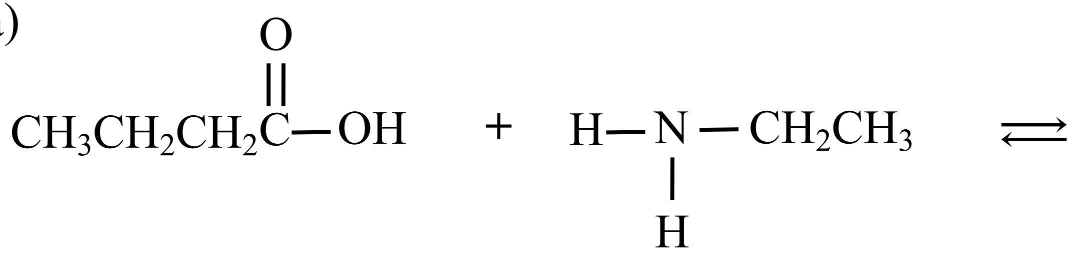
Click here for a **hint**

Click here to **check your answer**

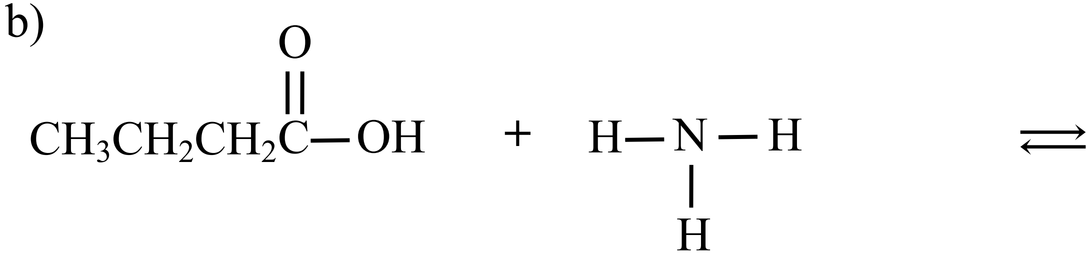
Go to next question

9.35) Add the products for each of the following reactions.

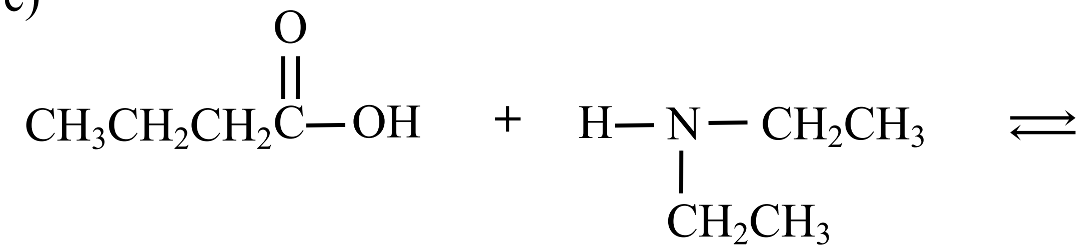
a)



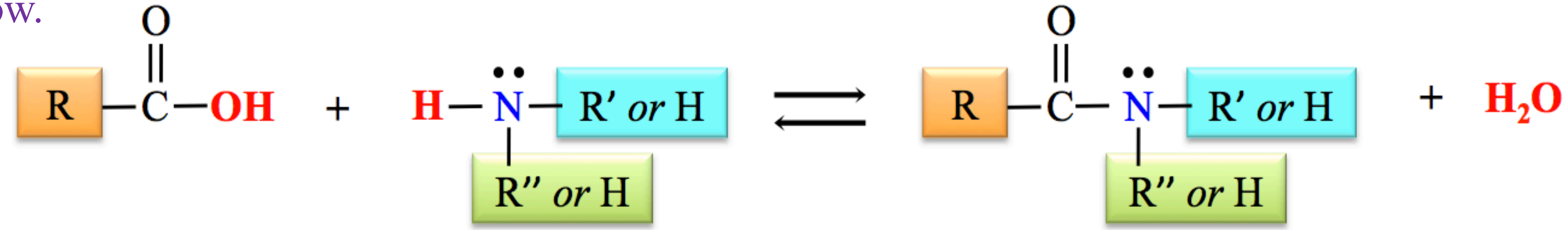
b)



c)



HINT: An **amide** is produced when a ***carboxylic acid*** reacts with an ***amine*** or ***ammonia*** (NH_3). The general form of this reaction is shown below.



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For more help: See chapter 9 part 6 video or chapter 9 section 4 in the textbook.

Click here to **check your answer**

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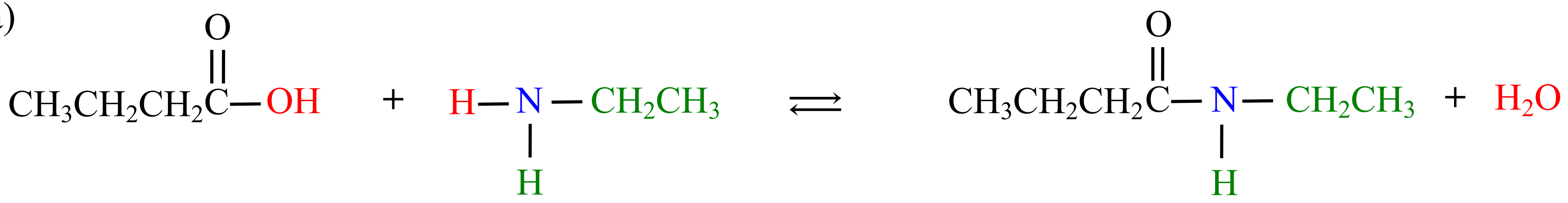
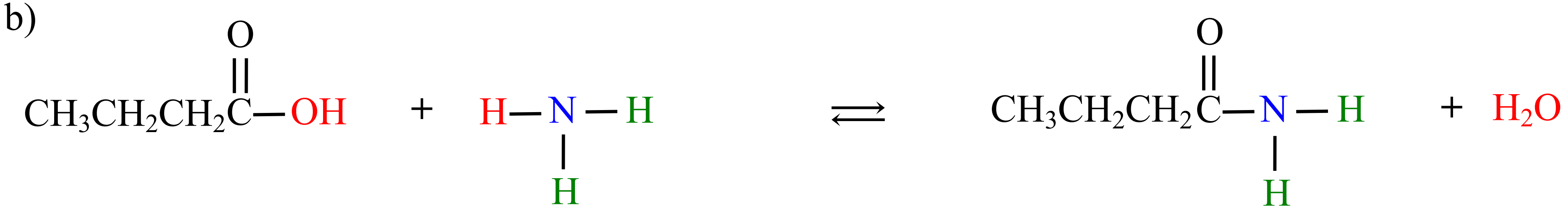
9.35) Add the products for each of the following reactions.

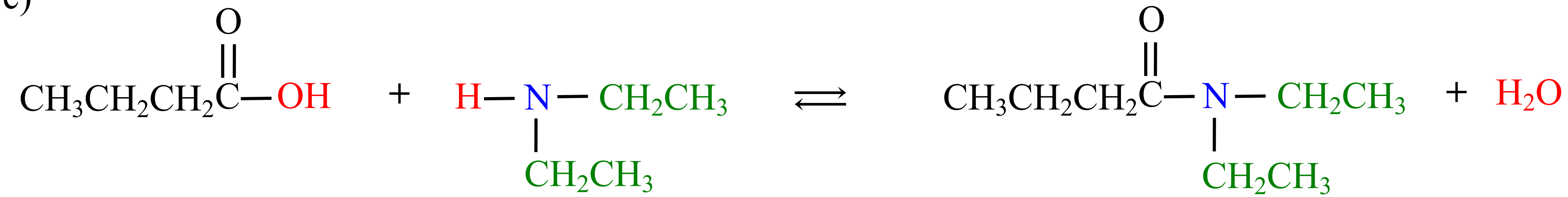
a)



b)

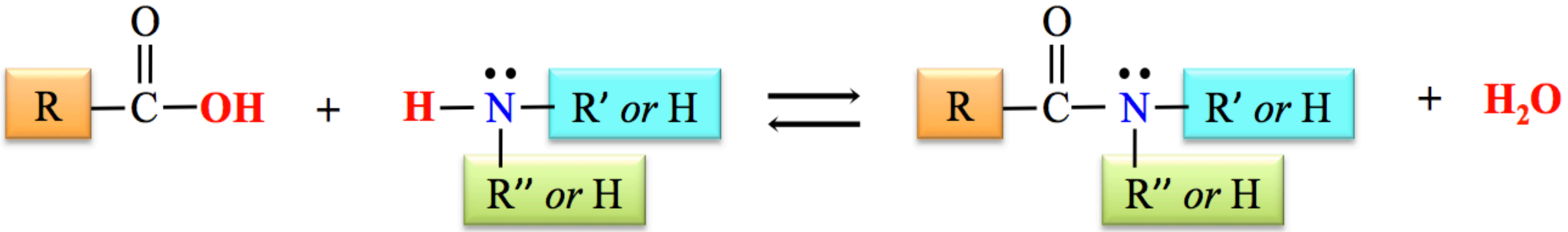


c)



EXPLANATION: Formation of Amides

An **amide** is produced when a ***carboxylic acid*** reacts with an ***amine*** or ***ammonia*** (NH_3). The general form of this reaction is shown below.



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For more details: See chapter 9 part 6 video or chapter 9 section 4 in the textbook.

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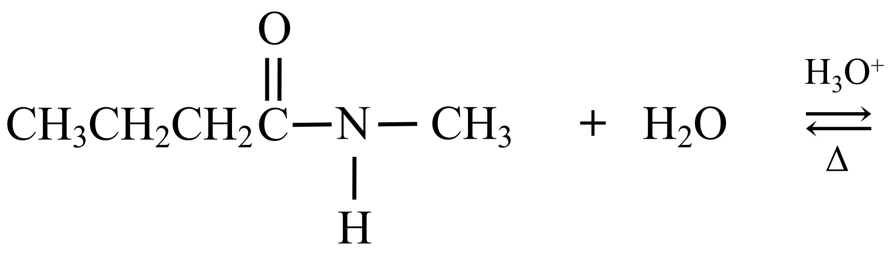
9.36) Add the products for the following reaction **and** name both of the products.



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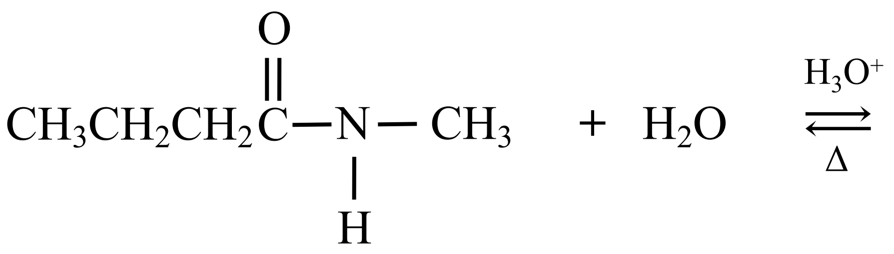
Click here for a **hint**

Click here to **check your answer**

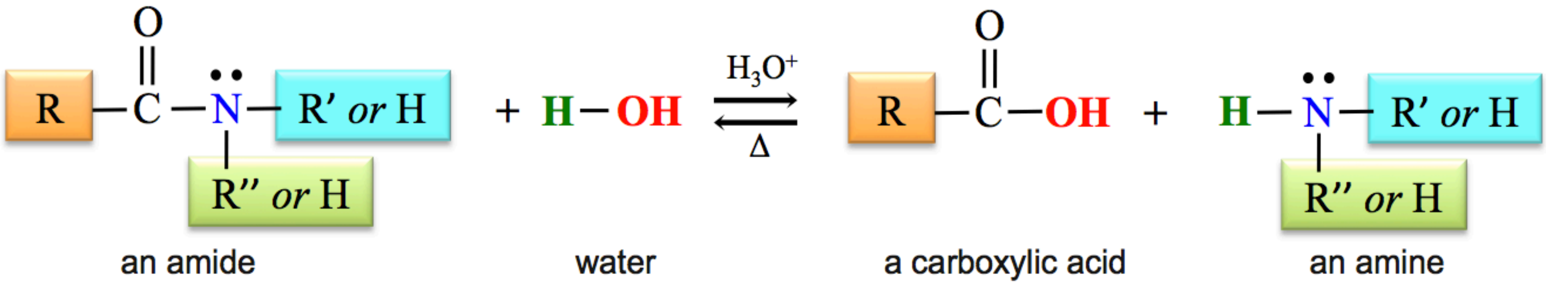
Go to next question

9.36) Add the products for the following reaction **and** name both of the products.



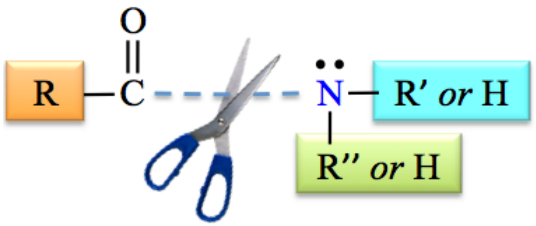
HINT: Hydrolysis of Amides

With heat and an acid catalyst, an **amide** can be hydrolyzed to produce a **carboxylic acid** and an **amine** (or ammonia).

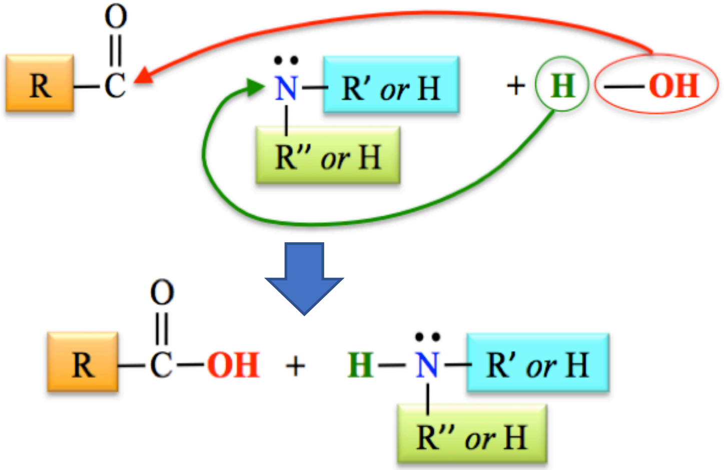


Beginning with the structure of **any** amide and water, an ***easy way to predict and draw the products*** of this reaction is to:

1) Break the bond between the **carbonyl group** and the **nitrogen**.



2) Bond the **OH** from water to the **carbonyl carbon**, and bond the **H** from **water** to the **nitrogen**.



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For more help: See chapter 9 part 6 video or chapter 9 section 4 in the textbook.

Click here to check your answer

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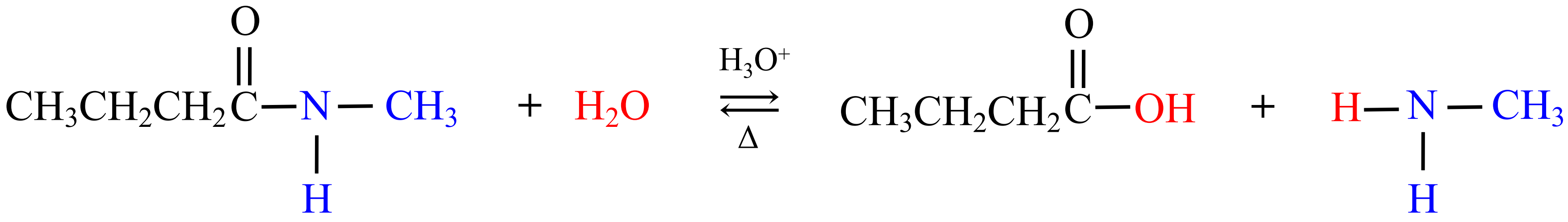
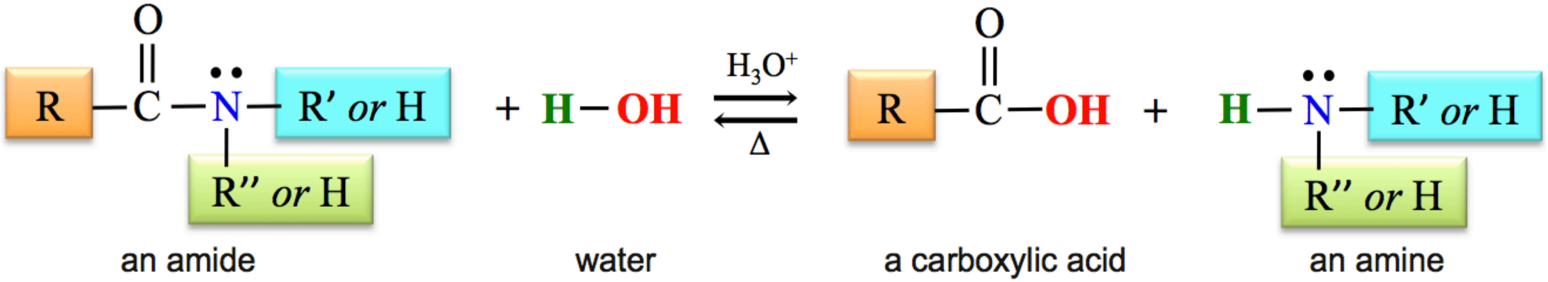
9.36) Add the products for the following reaction **and** name both of the products.

butanoic acid **methanamine**



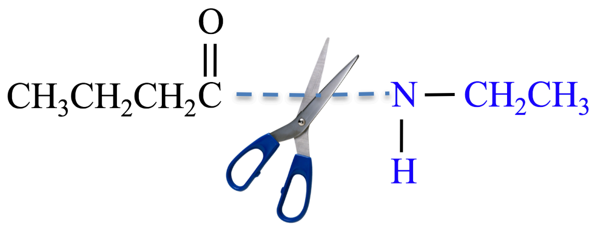
EXPLANATION: Hydrolysis of Amides

With heat and an acid catalyst, an **amide** can be hydrolyzed to produce a **carboxylic acid** and an **amine** (or ammonia).

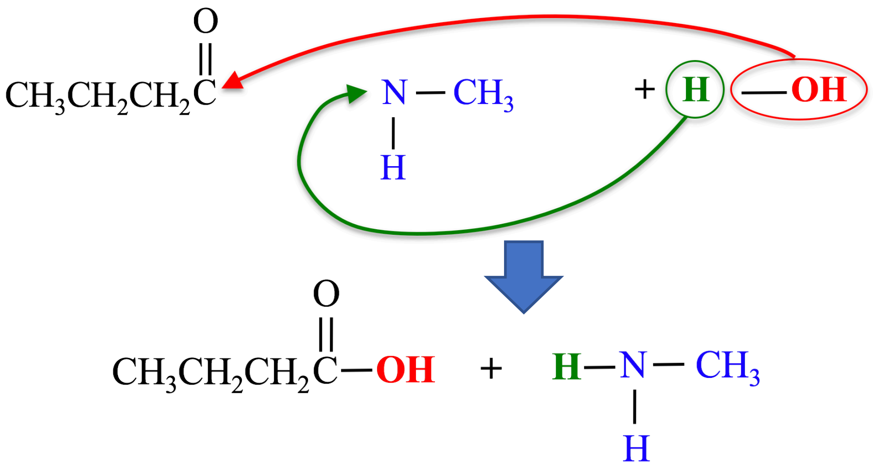


An ***easy way to predict and draw the products*** of this reaction is to:

1) Break the bond between the **carbonyl group** and the **nitrogen**.



2) Bond the **OH** from water to the **carbonyl carbon**, and bond the **H** from **water** to the **nitrogen**.



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For more details: See chapter 9 part 6 video or chapter 9 section 4 in the textbook.

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9.37) Write the definition for each of the following terms/phrases.

a) stereoisomers:

b) geometric isomers:

c) chiral carbon:

d) enantiomer:

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Click here for a **hint**

Click here to **check your answer**

Go to next question

9.37) Write the definition for each of the following terms/phrases.

a) stereoisomers:

b) geometric isomers:

HINT:

See chapter 9 part 7 video or chapter 9 section 5 in the textbook.

c) chiral carbon:

d) enantiomer:

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Click here to **check your answer**

Go to next question

9.37) Write the definition for each of the following terms/phrases.

a) stereoisomers: Stereoisomers are molecules that have the same molecular formula, have the same atomic connections, but have different three-dimensional arrangements of the atoms. Stereoisomers ***cannot*** be converted from one to another without breaking and reforming bonds (it is not possible for one stereoisomer to take the shape of another stereoisomer by rotation around a bond).

b) geometric isomers: When stereoisomers exist because of limited bond rotation, they are called geometric isomers. Geometric isomers can occur for certain cycloalkanes and alkenes. We designated the geometric isomers as either cis or trans.

c) chiral carbon: A carbon atom that carries four different groups is called a "chiral carbon."

d) enantiomer: The two distinct, three-dimensional arrangements of the atoms around the chiral carbon are mirror images of each other. When four different groups are arranged in the tetrahedral geometry (we called it AB_4), the mirror images are not identical. Another way to describe nonidentical mirror images is with the term "nonsuperimposable mirror images." Stereoisomers such as these, which are nonsuperimposable mirror images of each another, are called enantiomers.

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For more details: See chapter 9 part 7 video or chapter 9 section 5 in the textbook.

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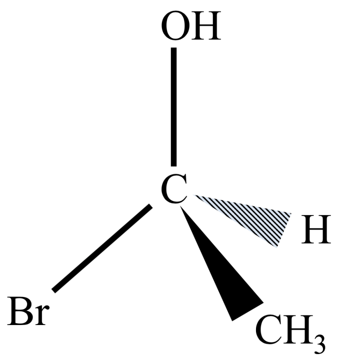
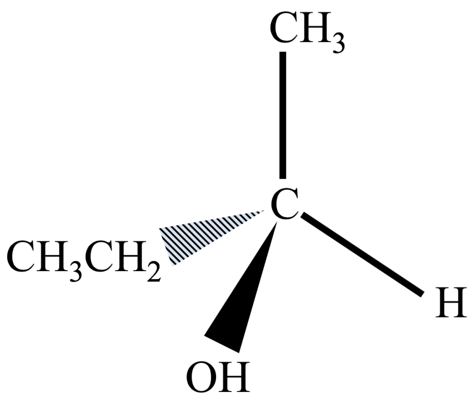
9.38) When a molecule has a chiral carbon, the two distinct, three-dimensional arrangements of the atoms around the chiral carbon are *nonsuperimposable* mirror images of each other. Stereoisomers such as these, which are nonsuperimposable mirror images of each another, are called **enantiomers**. Draw a ***wedge and dash illustration*** of the **mirror image** of each molecule shown below.

a)



b)



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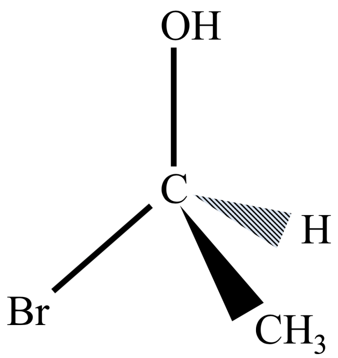
Click here for a **hint**

Click here to **check your answer**

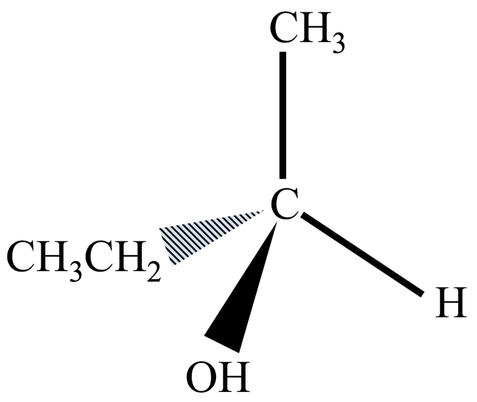
Go to next question

9.38) When a molecule has a chiral carbon, the two distinct, three-dimensional arrangements of the atoms around the chiral carbon are *nonsuperimposable* mirror images of each other. Stereoisomers such as these, which are nonsuperimposable mirror images of each another, are called **enantiomers**. Draw a ***wedge and dash illustration*** of the **mirror image** of each molecule shown below.

a)

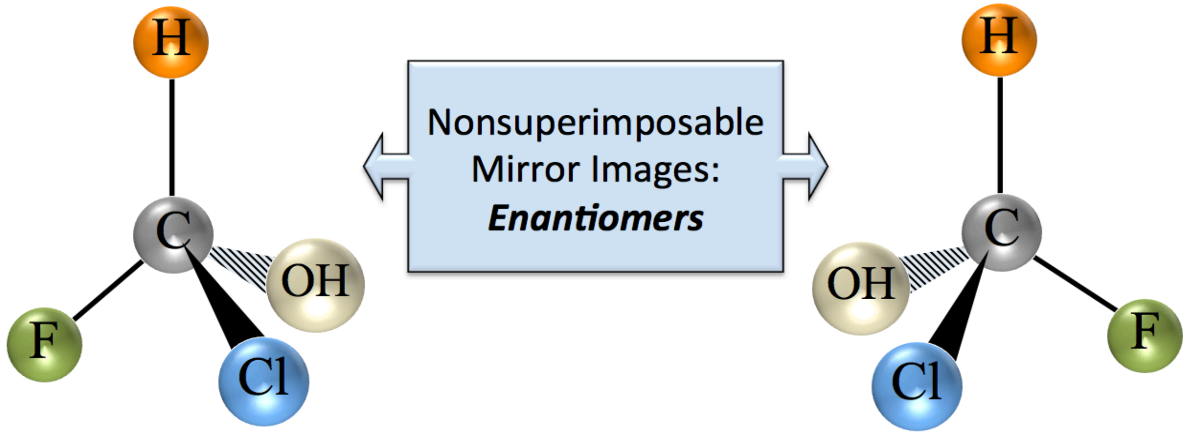


b)



HINT:

The ***wedge and dash illustrations*** of a pair of stereoisomers (*an enantiomer pair*) that results from the presence of a ***chiral carbon*** is shown below.



Recall that in *wedge and dash* illustrations of three-dimensional objects, ***solid wedges*** indicate bonds that would be coming ***out and above*** the page (toward the viewer). ***Dashed shapes*** indicate bonds that would be coming ***out and behind*** the page (away from the viewer). Regular lines (neither wedge nor dash) indicate bonds that would exist ***on the plane*** of the page.

For more help, see chapter 9 part 7 video or chapter 9 section 5 in the textbook.

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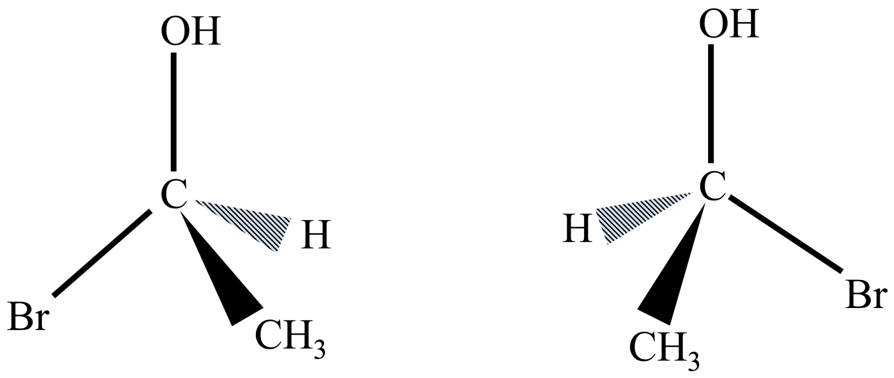
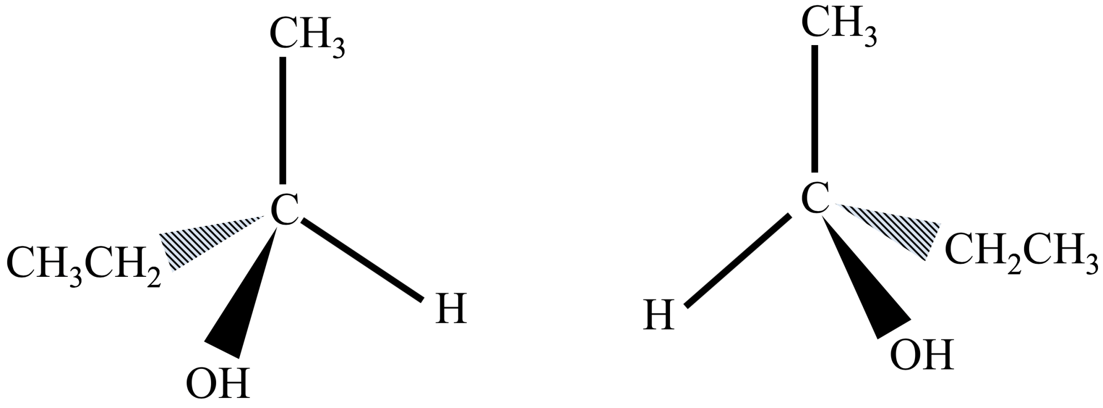
9.38) When a molecule has a chiral carbon, the two distinct, three-dimensional arrangements of the atoms around the chiral carbon are *nonsuperimposable* mirror images of each other. Stereoisomers such as these, which are nonsuperimposable mirror images of each another, are called **enantiomers**. Draw a ***wedge and dash illustration*** of the **mirror image** of each molecule shown below.

a)



b)



EXPLANATION:

In *wedge and dash* illustrations of three-dimensional objects, ***solid wedges*** indicate bonds that would be coming ***out and above*** the page (toward the viewer). ***Dashed shapes*** indicate bonds that would be coming ***out and behind*** the page (away from the viewer). Regular lines (neither wedge nor dash) indicate bonds that would exist ***on the plane*** of the page.

Pairs of enantiomers have very similar ***physical properties***. For this reason, they are very difficult to separate (purify) from each other. For example, their boiling points are so similar that separation by distillation is not possible.

They do differ in a couple of important ways. An important difference in enantiomers is the way they behave in ***biological systems***. Since enantiomers do not have identical three-dimensional shapes, they do not behave identically when interacting with biomolecules such as enzymes or the receptors that are responsible for taste.

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For more details: See chapter 9 part 7 video or chapter 9 section 5 in the textbook.

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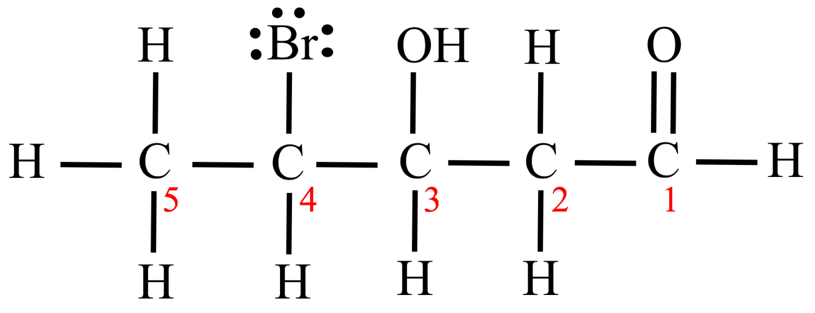
9.39) The line bond structure of 4-bromo-3-hydroxypentanal is shown below. The carbons are numbered in red font. Redraw the molecule and *circle* the chiral carbon(s).



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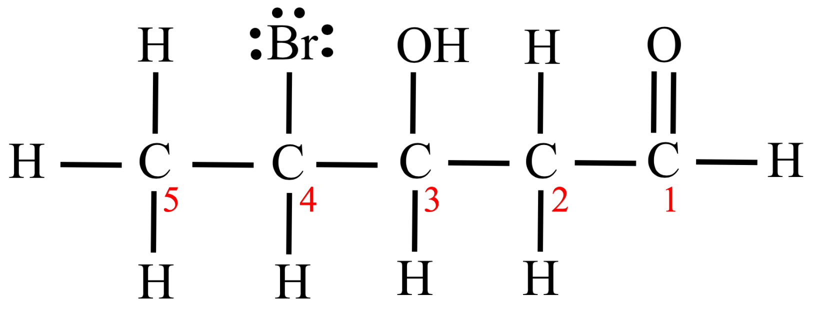
Go to next question

9.39) The line bond structure of 4-bromo-3-hydroxypentanal is shown below. The carbons are numbered in red font. Redraw the molecule and *circle* the chiral carbon(s).



HINT:

A carbon is **chiral** if it is bonded to ***four different groups***.

IMPORTANT: A mistake that chemistry students sometimes make is to consider only the four ***atoms*** to which a carbon is bonded. Be careful; you must consider the entire ***group of atoms to which a carbon is bonded in order to determine if that carbon is chiral***.

For more help, see [chapter 9 part 7 video] or chapter 9 section 5 in the textbook.

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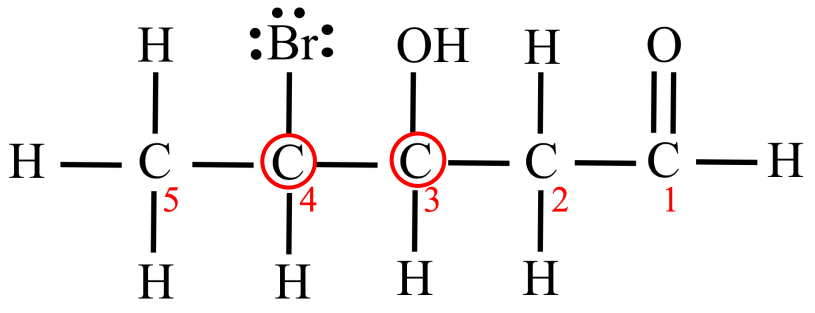
9.39) The line bond structure of 4-bromo-3-hydroxypentanal is shown below. The carbons are numbered in red font. Redraw the molecule and *circle* the chiral carbon(s).



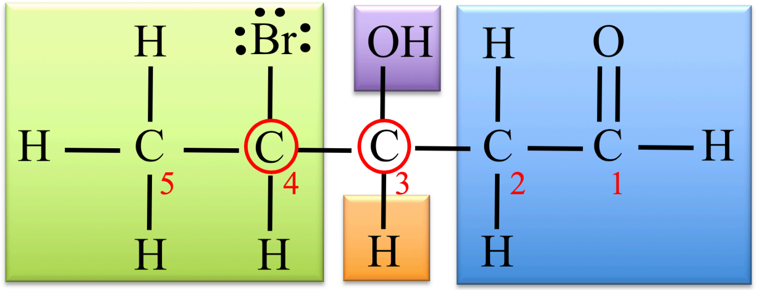
EXPLANATION: A carbon is **chiral** if it is bonded to ***four different groups***.

Carbon number 1 is **not** chiral. It is only bonded to ***three*** groups.

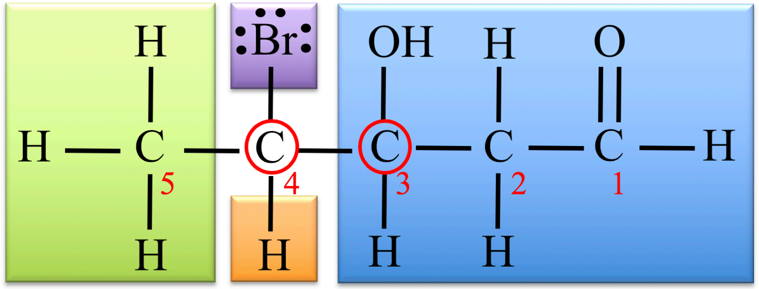
Carbon number 2 is **not** chiral. It is bonded to four groups, however, the four groups are not all ***different*** from each other. Two of the groups are hydrogens.

Carbon number 3 is chiral; it is bonded to ***four different groups.***

IMPORTANT: A mistake that chemistry students sometimes make is to consider only the four ***atoms*** to which a carbon is bonded. Be careful; you must consider the entire ***group of atoms to which a carbon is bonded in order to determine if that carbon is chiral***. It is for this reason that I highlighted the *entire groups* that are bonded to carbon number **3** in the illustration shown on the right.



Carbon number 4 is chiral; it is bonded to ***four different groups.*** The *entire groups* that are bonded to carbon number **4** in the illustration shown on the right.



Carbon number 5 is **not** chiral. It is bonded to four groups, however, the four groups are not all ***different*** from each other. Three of the groups are hydrogens.

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For more details: See chapter 9 part 7 video or chapter 9 section 5 in the textbook.

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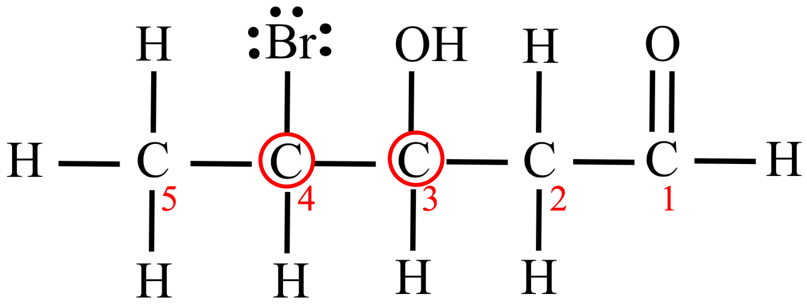
9.40) In the previous problem, you saw that there were two chiral carbons in 4-bromo-3-hydroxypentanal. That molecule is drawn below with the chiral carbons circled. What is the ***maximum number of stereoisomers*** that can exist for this molecule?



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Go to next question

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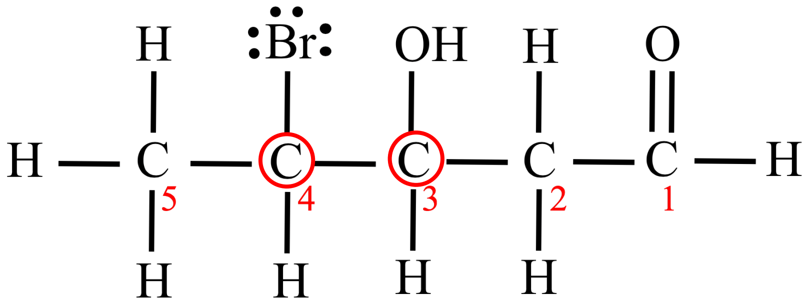

HINT:

When ***more than one chiral carbon*** is present in a molecule, then more than one pair of enantiomers will exist.

The ***number of stereoisomers*** that can exist depends on the ***number of chiral carbons***.

If "**n**" represents *the number of chiral carbons* in a molecule, then the maximum number of stereoisomers is calculated as follows:

Maximum Number of Stereoisomers = 2^n

For more help, see chapter 9 part 7 video or chapter 9 section 5 in the textbook.

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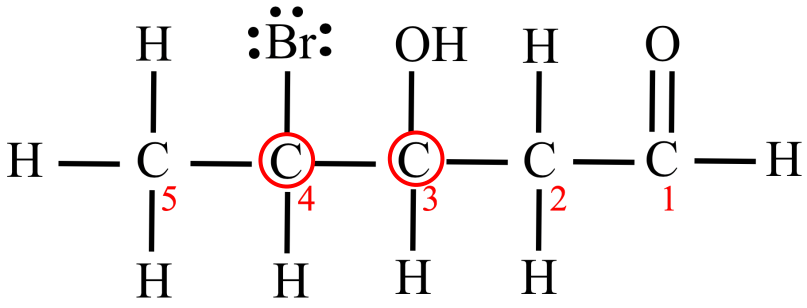
Click here to **check your answer**

Go to next question

9.40) In the previous problem, you saw that there were two chiral carbons in 4-bromo-3-hydroxypentanal. That molecule is drawn below with the chiral carbons circled. What is the ***maximum number of stereoisomers*** that can exist for this molecule?

ANSWER: four



EXPLANATION:

When ***more than one chiral carbon*** is present in a molecule, then more than one pair of enantiomers will exist.

The ***number of stereoisomers*** that can exist depends on the ***number of chiral carbons***.

If "**n**" represents *the number of chiral carbons* in a molecule, then the maximum number of stereoisomers is calculated as follows:

Maximum Number of Stereoisomers = 2^n

In this problem, there are two chiral carbons, so "**n**" = **2** and the maximum number of stereoisomers = $2^2 = 2 \times 2 = 4$.

For more details: See chapter 9 part 7 video or chapter 9 section 5 in the textbook.

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9.41)

i) Draw the ***condensed structure*** of 5-bromo-3,6,6-trimethyl-2-octanamine.

ii) What is the ***maximum number of stereoisomers*** that can exist for this molecule?

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HINT:

When ***more than one chiral carbon*** is present in a molecule, then more than one pair of enantiomers will exist.

The ***number of stereoisomers*** that can exist depends on the ***number of chiral carbons***.

If "**n**" represents *the number of chiral carbons* in a molecule, then the maximum number of stereoisomers is calculated as follows:

Maximum Number of Stereoisomers = 2^n

For more help, see chapter 9 part 7 video or chapter 9 section 5 in the textbook.

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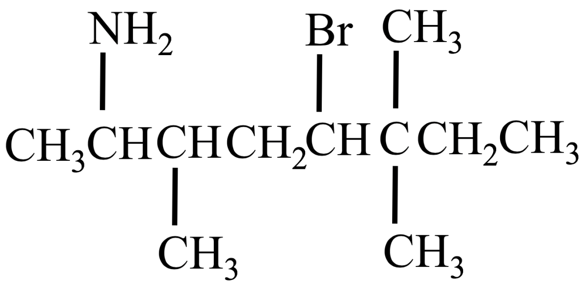
9.41)

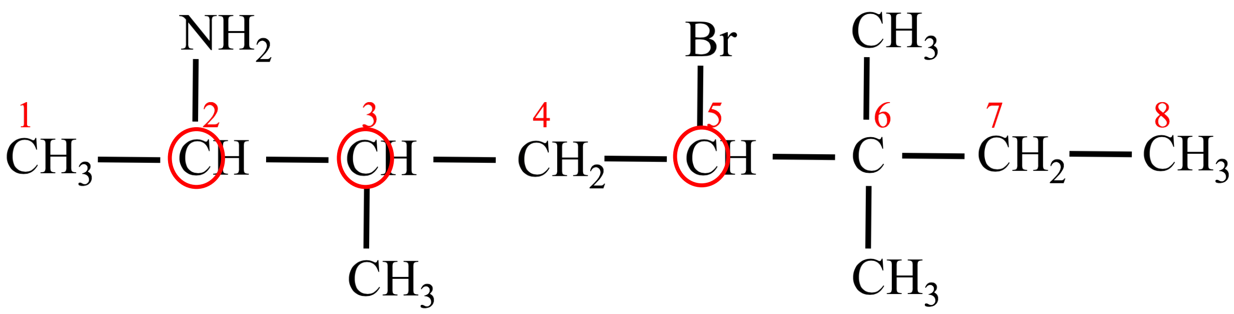
i) Draw the ***condensed structure*** of 5-bromo-3,6,6-trimethyl-2-octanamine.



ii) What is the ***maximum number of stereoisomers*** that can exist for this molecule? **ANSWER: eight**

EXPLANATION: The ***number of stereoisomers*** that can exist depends on the ***number of chiral carbons***.

In order to identify chiral carbons, you may find it helpful to add the carbon-carbon bonds to your condensed structure as shown below.



The chiral carbons in this molecule are circled.

Maximum Number of Stereoisomers = 2^n, where "**n**" represents *the number of chiral carbons* in a molecule

In this problem, there are **three** chiral carbons, so "**n**" = **3** and the maximum number of stereoisomers = **2^3 = 2** x **2** x **2** = **8**.

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For more details: See chapter 9 part 7 video or chapter 9 section 5 in the textbook.

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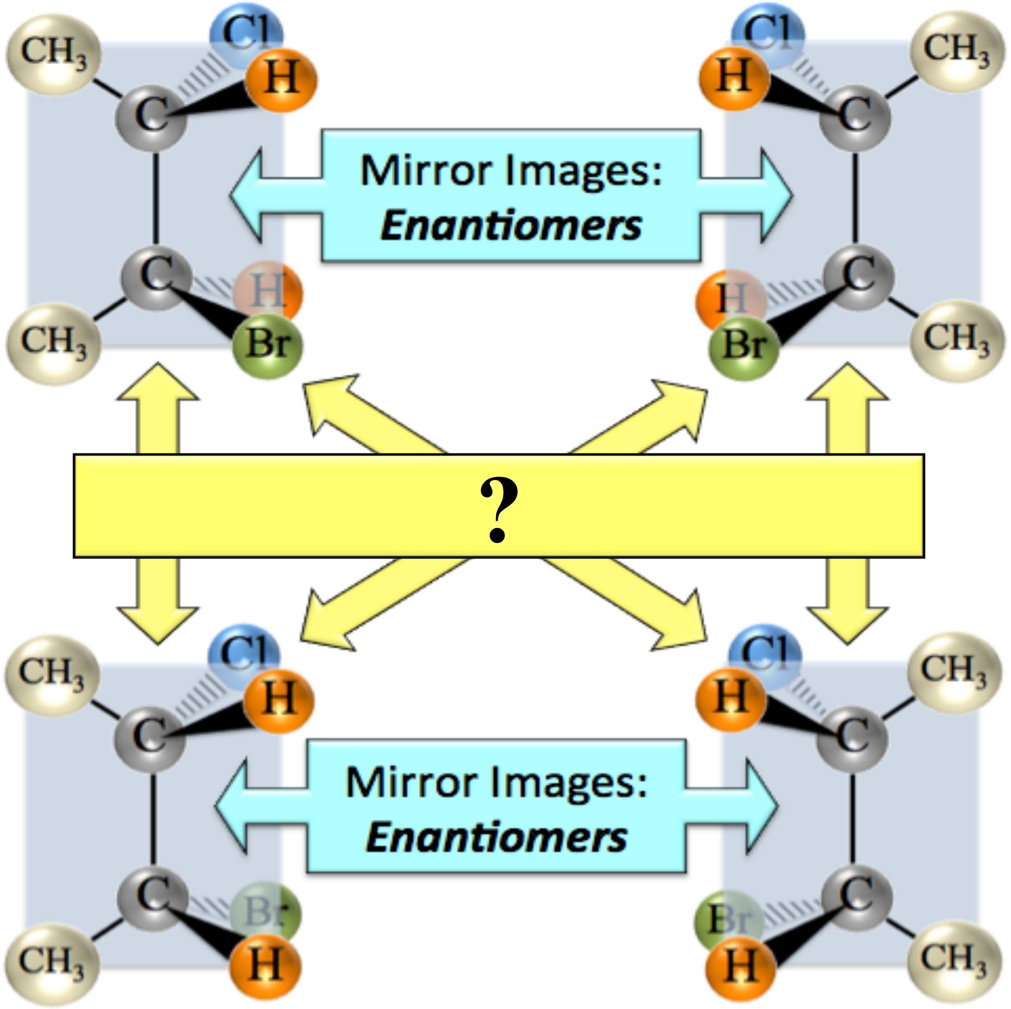
9.42) 2-Bromo-3-chlorobutane has ***two*** *chiral carbons* and there exist $\mathbf{2^n = 2^2}$ = **four** stereoisomers. The **four** stereoisomers of 2-bromo-3-chlorobutane, ***two pairs*** of nonsuperimposable mirror images, are shown on the right.

Nonsuperimposable mirror image molecules are called ***enantiomers***.

Nonsuperimposable molecules ***that are not mirror images of each other,*** *but are* in the group of $\mathbf{2^n}$ stereoisomers, are called ________________________.

a) structural isotopes
b) conformational isomers
c) non-mirror duplicates
d) diastereomers



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Click here to **check your answer**

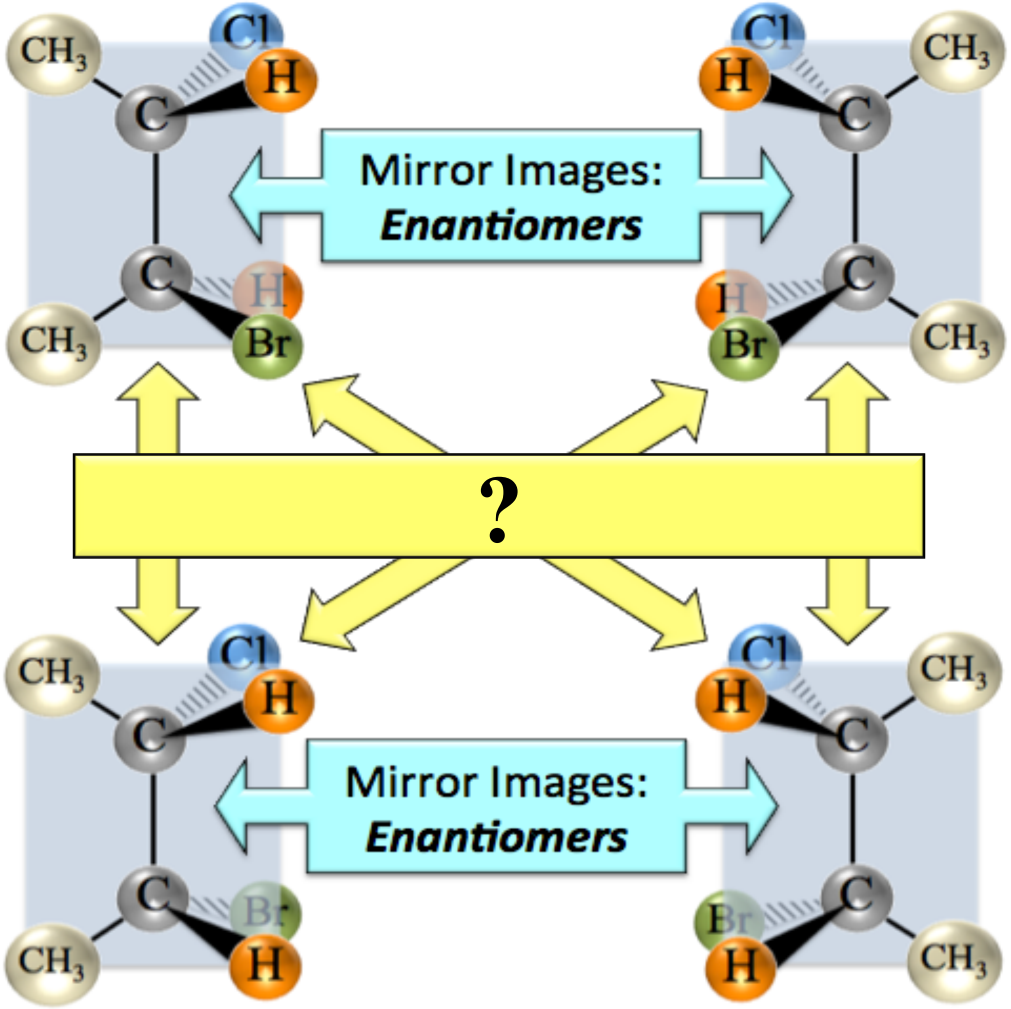
This is the last problem.

9.42) 2-Bromo-3-chlorobutane has ***two*** *chiral carbons* and there exist **$2^n = 2^2$ = four** stereoisomers. The **four** stereoisomers of 2-bromo-3-chlorobutane, ***two pairs*** of nonsuperimposable mirror images, are shown on the right.

Nonsuperimposable mirror image molecules are called ***enantiomers***.

Nonsuperimposable molecules ***that are not mirror images of each other,*** *but are* in the group of **2^n** stereoisomers, are called ______________________.

HINT:
- a) ~~structural isotopes~~
- b) conformational isomers
- c) ~~non-mirror duplicates~~
- d) diastereomers



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Click here to check your answer

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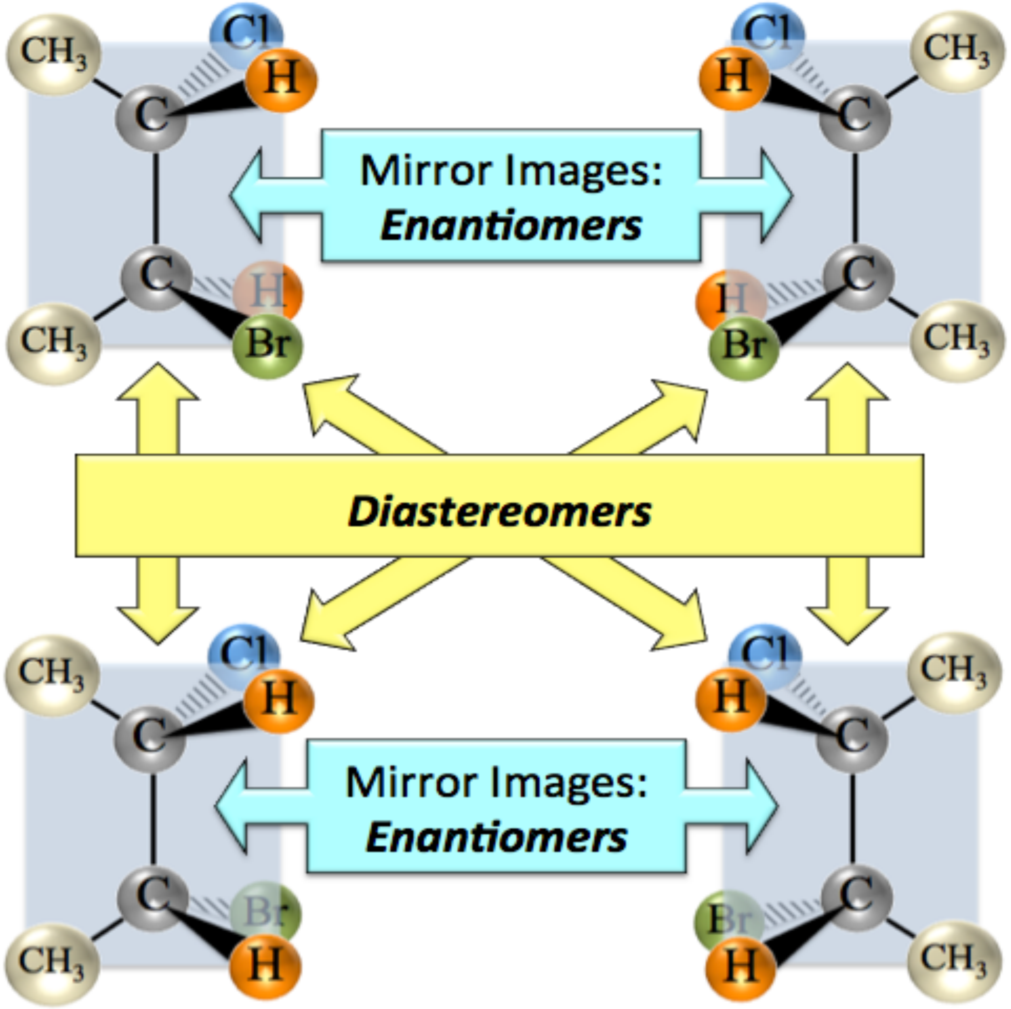
a) structural isotopes
b) conformational isomers
c) non-mirror duplicates
d) diastereomers

EXPLANATION: In the image shown here, the ***enantiomer*** relationships are indicated with blue arrows, and the ***diastereomer*** relationships are indicated with yellow arrows. It may be helpful for you to compare and contrast *enantiomers* and *diastereomers* by using a "family relationship" analogy of *siblings* (for enantiomers) and *cousins* (for diastereomers).



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For more details: See chapter 9 part 7 video or chapter 9 section 5 in the textbook.

This is the last problem.