

**Regents Chemistry: Dr. Shanzer** 

## Workbook 2



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Regents Chemistry: Dr. Shanzer

# **Practice Packet**

**Chapter 8: Organic Chemistry** 



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## Chapter 8: Organic Chemistry

- Alkane a hydrocarbon containing only single covalent bonds saturated hydrocarbon
- Alkyl group a hydrocarbon substituent, the methyl group (-CH<sub>3</sub>) is an alkyl group
- Alkenes a hydrocarbon containing one or more carbon- carbon double bonds
- Alkynes a hydrocarbon containing a carbon-carbon triple bond
- Alkyl halides a halocarbon in which one ore more halogen atoms are attached to the carbon atoms
- Alcohol an organic compound having an -OH (hydroxyl) group
- Aldhyde an organic compound in which the carbon of the carbonyl group is joined to at least one hydrogen
- Addition reaction a reaction in which a substance is added at the double bond of an alkene or at the triple bond of an alkyne.
- **Branched-chain alkane** an alkane with one ore more alkyl groups attached to the parent structure
- **Carbonyl group** a functional group having a carbon atom and an oxygen atom joined by a double bond
- Carboxylic acid an organic acid containing a carboxyl group
- Carboxyl group a functional group consisting of a carbonyl group attached to a hydroxyl group
- **Condensed structural formula** a structural formal that leaves out some bonds and/or atom; the presence of these atoms or bonds is understood
- Ether an organic compound in which oxygen is bonded to two carbon groups
- **Esters** a derivative of a carboxylic acid in which the OH of the carboxyl group has been replaced by the –OR from an alcohol.
- **Esterfication** An ester is an organic compound where the hydrogen in the compound's carboxyl group is replaced with a hydrocarbon group.
- **Fatty acids** the name given to continuous-chain carboxylic acids that were first isolated from fats.
- **Functional group** a specific arrangement of atoms in an organic compound that is capable of characteristics chemical reactions
- Fermentation the production of ethanol from sugars by the action of yeast or bacteria

Hydrocarbon - contain only hydrogen and carbon

Halocarbons - any member of a class of organic compounds containing covalently bonded fluorine, chlorine, bromine or iodine

Hydroxyl group - the -OH functional groups present in alcohols.

- Homologous series a group of compounds in which there is a constant increment of change in molecular structure form one compound in the series to the next
- **Isomers** compounds that have the same molecular formula buy different molecular structures
- **Ketone** an organic compound in which the carbon of the carbonyl groups is joined to two other carbons
- Monomer a simple molecule that repeatedly combines to form a polymer
- **Polymer** a very large molecule formed by the covalent bonding of repeating small molecules, known as monomers
- Substituent an atom or group of atoms that can take the place of a hydrogen atom on a parent hydrocarbon
- Saturated compounds an organic compound in which all carbon atoms are joined by single covalent bonds
- **Straight-chain alkanes** a saturated hydrocarbon that contains any number of carbons atoms arranged one after the other
- Substitution reaction a common type of organic reaction, which involves the replacement of an atom or group of atoms by another atom or group of atoms
- **Soaoponification** the hydrolysis of fats or oils by a hot aqueous alkali-metal hydroxide, the making of soaps
- **Unsaturated compounds** an organic compound with one or more double or triple carbon-carbon bonds





## Organic versus Hydrocarbon

- Organic molecules must have the element C.
- Hydrocarbons can only have the elements H and C.
- Therefore hydrocarbons are organic but not all organic compounds are hydrocarbons:
  - CH<sub>4</sub> is a hydrocarbon and is organic
  - $\circ$  CCl<sub>4</sub> is organic but not a hydrocarbon
  - $\circ$  O<sub>2</sub> is neither organic nor a hydrocarbon

# Organic molecules Found in fossil fuels, plants and animals. Examples include gasoline, oil, kerosene, butane, propane...

## Hydrocarbon Properties

- Mostly insoluble
- Non-electrolytes (do not conduct electricity)
- React very slowly
- As size increases, the melting point and boiling point of the hydrocarbons increase.
- Small hydrocarbons may be gases and large hydrocarbons may be solids at room temperature.







- All single bonded hydrocarbons are in the same family known as alkanes.
- All double bonded hydrocarbons are in the same family known as alkenes.
- All triple bonded hydrocarbons are in the same family known as alkynes.
- Refer to table Q





(	Organi	ic Molecules
Ta Organi	ble P c Prefixes	
Prefix	Number of Carbon Atoms	Table P shows prefixes to determine how many
meth-	1	Carbon atoms a compound
eth-	2	has
prop-	3	1105.
but-	4	
pent-	5	
hex-	6	
hept-	7	
oct-	8	
non-	9	
dec-	10	

Give the prefix for the following:		
$\begin{array}{c} C_2H_6\\ C_3H_6\\ C_4H_6\\ C_5H_{12}\\ C_6H_{12}\\ C_7H_{14}\\ C_8H_{18}\\ C_9H_{16}\\ C_{10}H_{20} \end{array}$	Eth Prop But Pent Hex Hept Oct Non Dec	
0	•	









## Branched hydrocarbons

• When naming branched hydrocarbons, name the longest continuous chain and use that as the 'last name.' Make sure the multiple bond, if present, is part of that chain. Then name the shorter chains, specifying the position of each branch. Also make sure that your branches are numbered as low as possible.















7 6 5 4 3 2 1  

$$CH_3 - CH_2 - CH_2 - CH - CH - CH - CH_3 - CH_3$$
  
 $CH_2 CH_3 CH_3$   
Use prefixes to indicate the appearance of a  
group more than once in the structure. And list  
them in alphabetical order  
 $Di = twice$   
 $Tri = three times$   
 $Tetra = four times$   
• Penta= five times

































## **Objective**:

How do we use Table R to recognize structural and molecular formulas for organic molecules containing functional groups?



os of pound	Functional Group	General Formula	Example
halide (halocarbon)	- F (flasso-) - CI (chlaro-) - Br (hrums-) - I (lodo-)	R—X (X represents any halogest)	CIL/CIICICH, 2-chiceopropute
aleohol	-011	#-0H	CIL/CIL/CIL/OII 1-propand
ether	-0-	R=0=R	Cit_OCit_Cit_ methyl ethyl ether
ahlethydde		л-с-н	CIL/CIL/C-II
ketnase.		8-C-#	CILCCH_CH_CH_
reginit acid	-Ê-on	A-C-011	cut'cut'c-ou
ister	-0-o-	8-C-0-#	O EIL/CIL/COCIL, methyl proparate
anite		R-N-K	CIL <sub>2</sub> CIL <sub>2</sub> CIL <sub>2</sub> NIL <sub>2</sub> 1-proparation
anide	e i	P R R-C-NII	











































## Sketch Notes

## Sketch Notes

The Stock System and IUPAC nomenclature has been used to name Inorganic compounds, or compounds, or by definition compounds that do not contain primarily Carbon and Hydrogen (example: NaCl). **Organic compounds** contain **Carbon** as a primary element in the composition of the molecule. The carbon atoms are connected to each other to form the backbone of a molecule. The term "organic" finds its roots in the fact that these compounds were first identified as those that make up the components of living organisms (tissues, enzymes, etc.). Many organic compounds are referred to as hydrocarbons, due to their containing carbon and hydrogen only. (This term is especially applicable to the petroleum industry, where most of the compounds are of this type). However, other types of organic compounds also include elements such as oxygen, sulfur, and nitrogen, which have a wide range of effects on their properties. This activity is designed to address only simple hydrocarbons.



- 1. Using model 1, how many bonds does Carbon always make in an organic compound?
- 2. The molecules above are called hydrocarbons. What are the only elements that hydrocarbons possess?
- 3. Using model 1, draw a compound containing 4 carbon atoms.

Organic compounds that only have **single bonds** are called **saturated** hydrocarbons. This is because they contain the maximum number of hydrogen atoms bonded to the carbon chain. Organic compounds that contain a **double or triple bond** are referred to as **unsaturated**.

Model	2
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#### Homologous Series of Hydrocarbons

Name	General	Examples		
	Formula	Name	Structural Formula	
alkanes	$C_n H_{2n+2}$	ethane	$\begin{array}{ccc} H & H \\ I & I \\ H-C-C-H \\ I & I \\ H & H \end{array}$	
alkenes	$C_n H_{2n}$	ethene	H H H H	
alkynes	$C_n H_{2n-2}$	ethyne	н−с≡с−н	

**Note:** *n* = number of carbon atoms

- 4. What is the name of the series of saturated hydrocarbons that possess only single bonds?
- 5. What is the name of the series of unsaturated hydrocarbons that possess 1 double bond?
- 6. What is the name of the series of unsaturated hydrocarbons that possess 1 triple bond?
- 7. Using the general formula how many hydrogen atoms would a compound contain if it had 5 Carbon atoms and only single bonds?
- 8. Using the general formula how many hydrogen atoms would a compound contain if it had 5 Carbon atoms and a double bond?
- 9. Using the general formula how many hydrogen atoms would a compound contain if it had 5 Carbon atoms and a triple bond?

Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

#### Model 3 Organic Prefixes

### NAMING ALKANES (saturated hydrocarbons)

10. Referring to model 1, which are all alkanes, what is similar about their names? What is different?

11. Referring to models 2 and 3, what does the *eth-* in ethane tell you?

12. Referring to models 2 and 3, determine the name of the following compounds:

a.  $C_4H_{10}$  b.  $C_5H_{12}$  c.  $C_6H_{14}$  d.  $C_7H_{16}$ 

13. How many C atoms and H atoms do the following compounds contain:

a. octane b. butane

#### NAMING ALKENES (unsaturated hydrocarbons)

- 14. Referring to models 2 and 3, what is different about the name of compounds containing a double bond versus a single bond?
- 15. Name the following alkenes:

a.  $C_4H_8$  b.  $C_5H_{10}$  c.  $C_6H_{12}$  d.  $C_7H_{14}$ 

- 16. If you are given the following molecular formulas:  $C_5H_{12}$  and  $C_5H_{10}$  how can you distinguish which is an alkane and which is an alkene?
- 17. Name the two compounds in question 16.

#### NAMING ALKYNES (unsaturated hydrocarbons)

18. Referring to models 2 and 3, what is different about the name of compounds containing a triple bond versus a single or double bond?

19. Name the following alkynes:

a.  $C_4H_6$  b.  $C_5H_8$  c.  $C_6H_{10}$  d.  $C_7H_{12}$ 

20. Which compound is an alkyne?  $C_9H_{18}$  or  $C_9H_{16}$ 

Structural formulas show the arrangement of the atoms within the molecules as far as which atoms are bonded to which and whether single, double or triple bonds are used.



- $\begin{array}{ccc} \text{21. Using model 4 above, draw the structural formula for the following alkanes.} \\ \text{a. } C_4H_{10} & \text{b. } C_5H_{12} & \text{c. } C_6H_{14} \end{array}$
- 22. Name the compounds in question 21.



23. Based upon model 5 and your knowledge of alkenes, why does the compound methene not exist?

- 24. Why do the carbon atoms with the double bond contain 1 less Hydrogen atoms then carbon atoms that contains a single bond?
- 25. Using model 5 above, draw the structural formula for the following alkenes. (Refer to table P and Q in your reference table). Then name the compounds you drew.

a.  $C_5H_{10}$  b.  $C_6H_{12}$  c.  $C_7H_{14}$ 

When naming alkenes you must give the location of the double bond in the name when there are more than 3 carbon atoms in the compound. You do this by numbering the carbon atoms and stating which number carbon the double bond is on. You can number the carbon atoms from left to right or right to left which ever gives the double bond the lowest possible numbered location. This is because compounds are not stationary in the "real world" and are therefore constantly moving. See Model 6 below.



26. Why is the third compound in model 6 not called 3-butene?

27. Referring to the models, following compounds:

Drawing structural formulas for alkynes is exactly the same as alkenes except they contain a triple bond instead of a double bond.



28. Why do the carbons with the triple bond contain no bonded hydrogen atoms?

- 29. Using model 2 above, draw the structural formula for the following alkynes. Then name the compounds you drew.
  - a.  $C_5H_8$  b.  $C_6H_{10}$  c.  $C_7H_{12}$

30. Name the following compounds:



	Chapter 8: Organic Chemistry					
Ca	rbon	<u>Alkanes</u>	Alkenes	Alkynes		
	1	Methane CH <sub>4</sub>				
	2	Ethane C <sub>2</sub> H <sub>6</sub>	Ethene C <sub>2</sub> H <sub>4</sub>	Ethyne C <sub>2</sub> H <sub>2</sub>		
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					

## Video 8.1 Hydrocarbons

1. How many carbon atoms are in each compound?

a.	Methane	f.	Hexane	 k.	Decane	
b.	Ethane	g.	Ethyne	 I.	Butyne	
c.	Ethene	h.	Propane	 m.	Butane	
d.	Pentane	i.	Heptane	 n.	Propyne	
e.	Propene	j.	Octane	 0.	Butene	

### 2. For each compound fill in each blank:

		Number of Carbon atoms	Series	Formula
a.	Methane			
b.	Butane		<u> </u>	
c.	Propyne			
d.	Pentane			
e.	Octane			
f.	Heptene			
g.	Propene			
h.	Butyne			
i.	Decane			
j.	Nonane			
k.	Heptane			
I.	Ethyne			
m.	Hexyne			
n.	Ethane			
0.	Propane		<u> </u>	
p.	Decene			
q.	Octyne			

3. How many times does carbon bond and why?

#### Video Lesson 8.1:

Answer the following questions.

- 1. \_\_\_\_ All organic compounds must contain:
  - 1. hydrogen 3. carbon
  - 2. nitrogen 4. oxygen
- 2. \_\_\_\_ Which element is composed of atoms that can form more than one covalent bond with one another?

3. carbon

3. mainly polar

3. alkyne

- 1. hydrogen
- 2. helium 4. calcium
- 3. \_\_\_\_ What is the total number of valence electrons in a carbon atom in the ground state
  - 1. 12
     3. 6

     2. 2
     4. 4
- 4. \_\_\_\_ Which property is generally characteristic of an organic compound?
  - 1. low melting point
  - 2. high melting point 4. mainly nonpolar
- 5. \_\_\_\_ In general, which property do organic compounds share?
  - 1. high melting points
  - 2. high electrical conductivity
  - 3. readily soluble in water
  - 4. slow reaction rate

6. \_\_\_\_ A hydrocarbon molecule containing one triple bond is classified as an:

- 1. alkene
- 2. alkane 4. alkadience
- 7. \_\_\_\_ What is the total number of hydrogen atoms in a molecule of butane?
  - 1. 10 3. 8
  - 2. 6 4. 4
- 8. \_\_\_\_ By how many carbon atoms does each member of a homologous series differ from the previous member?
  - 1. 1 3. 3
  - 2. 2 4. 4
- 9. \_\_\_\_ Which of the following is a saturated hydrocarbon?
  - 1. ethene3. propene
  - 2. ethyne 4. propane

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 $\mathbf{D}_{123}^{123} \mathbf{R}_{130}^{130} \cdot \mathbf{S}_{100}^{10} \mathbf{H}_{1000}^{10} \mathbf{H}_{1000}^{10} \mathbf{R}_{1000}^{10} \mathbf{R$ 

- 10. \_\_\_\_Which compound is a member of the same homologous series as C<sub>3</sub>H<sub>6</sub>?
  - C<sub>2</sub>H<sub>4</sub>
     C<sub>2</sub>H<sub>6</sub>

- 3. C<sub>3</sub>H<sub>4</sub>
- 11. \_\_\_\_ Which hydrocarbon is a member of the series with the general formul  $C_n H_{2n-2}$ ?
  - 1. ethyne 3. butane
  - 2. ethane 4. benzene
- 12. \_\_\_\_ Which compound belongs to the alkene series?
  - 1.  $C_2H_2$

3. C<sub>6</sub>H<sub>6</sub>

4. ionic

- 2. C<sub>2</sub>H<sub>4</sub> 4. C<sub>6</sub>H<sub>14</sub>
- 13. \_\_\_\_ Which type of bond occurs in a saturated hydrocarbon molecule?
  - 1. single covalent 3. triple covalent
  - 2. double covalent
- 14. \_\_\_\_ In which group could the hydrocarbons all belong to the same homologous series?
  - 1. C<sub>2</sub>H<sub>2</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>
  - 2. C<sub>2</sub>H<sub>4</sub>, C<sub>3</sub>H<sub>4</sub>, C<sub>4</sub>H<sub>8</sub>
  - 3.  $C_2H_4$ ,  $C_2H_6$ ,  $C_3H_6$
  - 4.  $C_2H_4$ ,  $C_3H_6$ ,  $C_4H_8$
- 15. \_\_\_\_ Which formula represents butane?
  - $1. \quad CH_3CH_3$
  - 2.  $CH_3CH_2CH_3$
  - 3. CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub>
  - 4.  $CH_3CH_2CH_2CH_2CH_3$
- 16. \_\_\_\_ Which formula represents an unsaturated hydrocarbon?

A) H O  

$$H = C - C - H$$
  
 $H = C - C - H$   
 $H = C - C - C - H$   
 $H = C - C - C - H$   
 $H = C - C - C - H$   
 $H = H = H$   
C) H H  
 $H = C - C - C - C - H$   
 $H = H$   
 $H = H$   
D) H H H H  
 $H = C - C - C - C - H$   
 $H = H$   
 $H$ 

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#### Video Lesson 8.2

Structure of Hydrocarbons

1. ethane	5. ethyne
2. propene	6. 3,3-dimethyl pentane
3 2-hutene	7 2 3 – dimethyl pentane
o. 2 butche	7.2,0° anneary i pertaine
4. methane	8. 2-butyne

## Naming Hydrocarbons





- 1. Which element is present in all organic compounds?
  - 2) hydrogen 1) carbon
  - 3) nitrogen 4) oxygen
- 2. What is the IUPAC name of the organic compound that has the formula shown below?



- 1) 1,1-dimethylbutane
- 2) 2-methylpentane
- 3) hexane
- 4) 4-methylpentane
- 3. Which formula represents 2-butene?



4. Which formula represents propyne?

1)	C3H4	2)	C <sub>3</sub> H <sub>6</sub>
$\dot{\mathbf{n}}$	Calle		Call

3) C5H8 4) C5H10



- molecule of 2,2,4-trimethylpentane.
  - 8. Given the formula representing a compound:

What is a chemical name of this compound?

1) 2-pentene	2) 2-pentyne
3) 3-pentene	4) 3-pentyne

9. Which condensed structural formula represents an $\frac{1}{2}$	10. Given the structural formula for ethyne:
unsaturated compound?	H−C≡C−H
1) CH <sub>3</sub> CHCHCH <sub>3</sub> 2) CH <sub>3</sub> CH <sub>2</sub> CH <sub>3</sub>	What is the total number of electrons shared between the carbon atoms?
3) CH <sub>3</sub> CH <sub>3</sub> 4) CH <sub>4</sub>	1) 6 2) 2 3) 3 4) 4

#### **EXTENSION:**

1. Draw the structural formula for the following compounds:

a.  $C_8H_{16}$  b.  $C_4H_6$ 

c. 2-hexene

d. 2-heptyne

e. 3-hexene

f. 1-heptyne

2. Which of the above hydrocarbons are parts of the same homologous series (family)?

Isomers are two compounds with the same molecular formula  $(C_nH_n)$  but a different structural formula (how it is drawn). Therefore, isomers have different properties and names.

3. Which of the above hydrocarbons are isomers?

### Video Lesson 8.3: Isomers

1. Record the Structural formula, molecular formula, and condensed formula for the following:

Name	Structural	Molecular	Condensed
2, 3-dimethyl butane			
2, 2-dimethyl butane			
2-heptyne			
3-hexene			
2-methyl 1-pentene			

- 2. Were any of the above isomers? Explain your answer.
- 3. Draw an isomer of 2-heptyne below. Give the name of your isomer: \_\_\_\_\_\_
- 4. Name the following and identify the isomers.



5. Which of the hydrocarbons in the table above were saturated?

## **Isomers 8.3**

- - O H H H = | | | H-C-C-C-C-H | | | H H H

Which formula represents an isomer of this compound?

The two isomers of butane have different

 formula masses
 empirical formulas
 molecular formulas
 structural formulas

 The isomers butane and methylpropane differ in their

 molecular formulas
 structural formulas
 structural formulas

 total number of atoms per molecule

 total number of bonds per molecule
 Which two compounds are isomers of each other?

- 1) CH<sub>3</sub>CH<sub>2</sub>COOH and CH<sub>3</sub>COOCH<sub>2</sub>CH<sub>3</sub>
- 2) CH<sub>3</sub>CH<sub>2</sub>CHO and CH<sub>3</sub>COCH<sub>3</sub>
- 3) CH<sub>3</sub>CHBrCH<sub>3</sub> and CH<sub>2</sub>BrCHBrCH<sub>3</sub>
- 4) CH<sub>3</sub>CHOHCH<sub>3</sub> and CH<sub>3</sub>CHOHCH<sub>2</sub>OH
- 6. Given the formulas for two compounds:

These compounds differ in

- 1) gram-formula mass
- 2) molecular formula
- 3) percent composition by mass
- 4) physical properties at STP
- 7. Two substances have different physical and chemical properties. Both substances have molecules that contain two carbon atoms, one oxygen atom, and six hydrogen atoms. These two substances must be
  - 1) isomers of each other
  - 2) isotopes of each other
  - 3) the same compound
  - 4) the same hydrocarbon

8. Given the st Formula A	ructural form Formula B	ulas: Formula C	Formula D	9. The compounds CH <sub>3</sub> OCH <sub>3</sub> and CH <sub>3</sub> CH <sub>2</sub> OH are isomers of each other. These two compounds must
Which two t	$ \begin{array}{c} H & H \\ H - C - O - C - H \\ H & H \end{array} $	$\begin{array}{c} H & O & H \\ H & -C - C - C - H \\ H & H \end{array}$	$\begin{array}{c} H & OH H \\ I & I & I \\ H - C - C - C - H \\ I & I \\ H & H \end{array}$	have the same 1) density 2) reactivity 3) molting point
isomers of e	ach other?	esent compo	unds that are	<ul><li>4) molecular formula</li></ul>
<ol> <li>A and B</li> <li>B and D</li> </ol>	2) 4)	A and C C and D		<ul> <li>10. Which pair of compounds are isomers?</li> <li>1) NO<sub>2</sub> and N<sub>2</sub>O<sub>4</sub></li> <li>2) P<sub>2</sub>O<sub>5</sub> and P<sub>4</sub>O<sub>10</sub></li> <li>3) HCOOH and CH<sub>3</sub>COOH</li> <li>4) CH<sub>3</sub>OCH<sub>3</sub> and C<sub>2</sub>H<sub>5</sub>OH</li> </ul>

## Chapter 8: Organic Chemistry

## VideoLesson 8.4: Functional Groups

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For the following compounds, determine the family and draw the compound:

Name	Family	Structural Formula	Condensed Formula
Butanoic acid			
Methanal			
Butanamide			
3-iodo octane			
Methyl pentanoate			
Ethanol			
2-heptanone			
Diethyl ether			
2-pentanol			
Ethanoic acid			
2-propanamine			
Hexanal			
Ethyl methanoate			

Classify each of the following structural formulas and write each name



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#### Video Lesson 8.5: Organic Reactions

*Combustion*:Many organic compounds react with excess oxygen to form carbon dioxide and water. On Table I of your reference, the first 6 reactions are combustion reactions. Write a balance reaction for the combustion of:

- 1. Ethane:
- 2. Pentane:

*Substitution:* Saturated hydrocarbons(ALKANES) may replace a hydrogen atom in the molecule with another element usually a halogen.

Example  $C_2H_6$ +  $Cl_2 \rightarrow C_2H_5Cl$  + HCl

Draw the structural formulas for the above reaction:

Name the product C<sub>2</sub>H<sub>5</sub>Cl\_\_\_\_\_ Write a balanced reaction for the substitution of bromine onto propane.

Draw the structure of and name two possible halocarbon isomers formed in the above reaction.

*Addition*:Unsaturated hydrocarbons (ALKENES or (ALKYNES) can add a atom of hydrogen or of a halogen at the site of a double or triple bond. When hydrogen is added, the process is called HYDROGENATION. When a halogen is added, the process is called HALOGENATION.

 $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$ 

Name the product\_\_\_\_\_

Now write structural formulas for the addition of Cl<sub>2</sub> onto 2 butene. Name the product. Notice that, unlike substitution, only one product is possible!

When hydrogen is added to propene, what is the name of the new hydrocarbon thae forms?Write a balanced equation to illustrate this reaction.

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**Polymerization:** (Large molecules can form when individual units of molecules (*monomers*) are chained together to form a *polymer*. If the individual monomer is an unsaturated hydrocarbon, <u>addition polymerization</u> my occur as the double (or triple) bond is "broken open" and a chain is formed:(



*Esterification:* Esters are compounds which have pleasant odors. They are formed by the reaction between organic acids and alcohols.

Ethanoic acid and methanol will react to form methyl ethanoate. The structural formulas for this reaction are shown below.



Now draw the structures, determine the products and name eac reactant and organic product in the following esterification reactions:

 $C_2H_5COOH + C_2H_5OH \rightarrow$ 

 $\rm HCOOH + C_{3}H_{7}OH \rightarrow$ 

 $C_3H_7COOH + CH_3OH \rightarrow$ 

*Fermentation:* In the fermentation process, enzymes found in living things, such as yeast, convert carbohydrates usually sugar into carbon dioxide and alcohol.

 $Glucose(C_6H_{12}O_6)$  is fermented in the presence of the enzyme *zymase* in yeast to form ethanol and carbon dioxide. Write a balanced equation to represent this reaction:

**Saponification:** The hydrolysis of fats by basis is saponification or *soap-making*. This process was made "famous" by a scene from the (movie "Fight(Club". The main(characters in the film steal human fat from a liposuction clinic and react it with lye (NaOH) to form soap.

The reaction looks like this:

 $C_{17}H_{35}COO_{3}C_{3}H_{5} + 3NaOH \rightarrow C_{3}H_{5}(OH)_{3} + 3(C_{17}H_{35}COONa)$ 

The presence of the Na and the NaOH makes this reaction very recognizable! Occasionally, KOH is used instead of NaOH....

## Video Lesson 8.5: Organic Reactions

### Match the reaction to its name:

1. Addition	a. blank
2. Substitution	b. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
3. Combustion	c. $(C_{17}H_{35}COO)_{3}C_{3}H_{5} + 3 \text{ NaOH} \rightarrow C_{3}H_{5}(OH)_{3} + 3C_{17}H_{35}COONa$
4. blank	d. $C_6H_{12}O_6 \rightarrow C_2H_5OH + CO_2$
5. Polymerization	e. $n(CH_2CH_2) \rightarrow (CH_2CH_2)_n$
6. Fermentation	f. $C_2H_6 + CI_2 \rightarrow C_2H_5CI + HCI$
7. Esterification	g. $C_3H_6COOH + C_2H_5OH \rightarrow C_3H_6COOC_2H_5 + H_2O$
8. Saponification	h. $C_3H_6 + I_2 \rightarrow C_3H_6I_2$

#### Name the reaction:

9. A saturated alkane reacts with fluorine	
10. Small alkene chains connect to form larger alkane chains	
11. Sugar is decomposed to form an alcohol	
12. blank	
13. An unsaturated hydrocarbon reacts with bromine	
14. An alcohol and an organic acid are reacted	
15. A base is added to a fat molecule to form a soap	
16. Hydrocarbons are burned in the presence of oxygen	
17. Another name for hydrogenation*	
18. Another name for halogenation*	

Draw all organic reactants and products. Then name and give the formula for the missing substance in the reaction. Give the reaction type.

19.  $C_2H_4 + F_2 \rightarrow$ 

Rxn: \_\_\_\_\_

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20. $C_3H_6 + H_2 \rightarrow$	Rxn:
21. $C_2H_6 + Cl_2 \rightarrow \_$ + HCl	Rxn:
22. C₄H <sub>10</sub> + Br <sub>2</sub> → + HBr	Rxn:
23. $CH_4 + O_2 \rightarrow \underline{\qquad} + H_2O$	Rxn:
24. $C_3H_8 + O_2 \rightarrow CO_2 + \_$	Rxn:
$25. C_6H_{12}O_6 \rightarrow 2CO_2 + 2_{\underline{}}$	Rxn:
26. blank	
27. C₂H₅OH + C₃H7COOH → H2O +	Rxn:
28. $C_5H_{10} + F_2 \rightarrow$	Rxn:

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 Which formula represents the product of the addition reaction between ethene and chlorine, Cl<sub>2</sub>
 ?



2. Given the balanced equation for an organic reaction:

 $\begin{array}{l} C_2H_2+2Cl_2 \rightarrow C_2H_2Cl_4 \\ \mbox{This reaction is best classified as} \end{array}$ 

- 1) addition 2) esterification
- 3) fermentation 4) substitution
- 3. Given the equation:

 $\mathrm{C_{2}H_{6}+Cl_{2}} \rightarrow \mathrm{C_{2}H_{5}Cl+HCl}$ 

This reaction is best described as

- 1) addition involving a saturated hydrocarbon
- 2) addition involving an unsaturated hydrocarbon
- 3) substitution involving a saturated hydrocarbon
- 4) substitution involving an unsaturated hydrocarbon
- 4. Given the equation:



Which type of reaction is represented by this equation?

- 1) combustion 2) esterification
- 3) polymerization 4) substitution
- 5. The reaction that joins thousands of small, identical molecules to form one very long molecule is called
  - 1) esterification
- fermentation
   substitution
- 3) polymerization

6. Given the reaction: O II CH<sub>3</sub>C—O—C<sub>2</sub>H<sub>5</sub> + H<sub>2</sub>O Ο ICH<sub>3</sub>C—OH + HOC<sub>2</sub>H<sub>5</sub> = This reaction is an example of 1) fermentation 2) saponification 3) hydrogenation 4) esterification 7. When butane burns in an excess of oxygen, the principal products are 1) CO<sub>2</sub> and H<sub>2</sub>O 2) CO<sub>2</sub> and H<sub>2</sub> 3) CO and H<sub>2</sub>O 4) CO and H<sub>2</sub> 8. Which reaction results in the production of soap? 1) esterification 2) fermentation 3) polymerization 4) saponification 9. Which formula correctly represents the product of an addition reaction between ethene and chlorine? 1)  $CH_2Cl_2$ 2) CH<sub>3</sub>Cl 3)  $C_2H_4Cl_2$ 4) C<sub>2</sub>H<sub>3</sub>Cl 10. Given the balanced equation representing a reaction:  $CH_3CH_2CH_3 + Br_2 \rightarrow CH_3CH_2CH_2Br + HBr$ This organic reaction is best classified as 1) an addition reaction 2) an esterification reaction 3) a polymerization reaction 4) a substitution reaction 11. Which type of reaction is represented by the equation below?

Note:  $\boldsymbol{\mathsf{N}}$  and  $\boldsymbol{\mathsf{n}}$  are very large numbers equal to about 2000.



- 1) esterification 2) fermentation
- 3) saponification 4) polymerization
- 12. Which reaction produces ethanol?
  - 2) esterification
  - combustion
     fermentation
- 4) polymerization

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Base your answers to questions **13** and **14** on the following information.

The equation below represents the reaction between butanoic acid and an unidentified reactant, X.

13Draw a structural formula for the unidentified reactant, *X*, in the equation.

14. Identify the type of organic reaction represented by the equation.

Which compound is represented by x?

1) 
$$CH_3CH_2OH$$
  
2)  $CH_3C-H$   
3) O  
 $H$   
 $CH_3OCH_2CH_3$   
2)  $CH_3C-H$   
 $H$   
 $CH_3CCH_3$ 

- 16. What are the two main products of a fermentation reaction?
  - 1) ethanol and carbon dioxide
  - 2) ethanol and water
  - 3) sugar and carbon dioxide
  - 4) sugar and water
- 17. Which reaction best represents the complete combustion of ethene?
  - 1)  $C_2H_4 + HCl \rightarrow C_2H_5Cl$
  - 2)  $C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$
  - 3)  $C_2H_4 + 3 O_2 \rightarrow 2 CO_2 + 2 H_2O$
  - 4)  $C_2H_4 + H_2O \rightarrow C_2H_5OH$

- 1. Which compound is a saturated hydrocarbon?
  - A) propanal B) propane
  - C) propene D) propyne
- 2. Which compound is a member of the same homologous series as C<sub>3</sub>H<sub>8</sub>?
  - A) CH<sub>4</sub> B) C<sub>4</sub>H<sub>8</sub>
  - C) C5H8 D) C5H10
- 3. What is the IUPAC name of the organic compound that has the formula shown below?



- A) 1,1-dimethylbutane
- B) 2-methylpentane
- C) hexane
- D) 4-methylpentane
- 4. Hydrocarbons are compounds that contain
  - A) carbon, only
  - B) carbon and hydrogen, only
  - C) carbon, hydrogen, and oxygen, only
  - D) carbon, hydrogen, oxygen, and nitrogen, only
- 5. A molecule of a compound contains a total of 10 hydrogen atoms and has the general formula  $C_nH_{2n+2}$ .

Which prefix is used in the name of this compound?

- A) but- B) dec- C) oct- D) pent-
- 6. Which compound is a saturated hydrocarbon?

A) CH <sub>2</sub> CH <sub>2</sub>	B) CH <sub>3</sub> CH <sub>3</sub>
C) CH <sub>3</sub> CHO	D) CH <sub>3</sub> CH <sub>2</sub> OH

7. Which formula represents an unsaturated hydrocarbon?

8. Which formula represents an unsaturated hydrocarbon?

A) C <sub>5</sub> H <sub>12</sub>	B) C6H14
C) C7H16	D) C8H14

9. Which formula represents an unsaturated hydrocarbon?

A) 
$$H O$$
  
 $I = I$   
 $H - C - C - H$   
 $H$   
B)  $H H H$   
 $H - C - C - C - H$   
 $H - C - C - C - H$   
 $H H$   
 $H - H$   
 $H - C - C - C - H$   
 $H H$   
 $H - H$ 

10. A straight-chain hydrocarbon that has only one double bond in each molecule has the general formula

A)	$C_nH_{2n-6}$	B)	$C_nH_{2n-2}$
C)	$C_nH_{2n}$	D)	$C_nH_{2n+2}$

11. Which formula represents 2-butene?

A) H H H H  

$$I = I = I$$
  
 $H = C - C - C - C - H$   
 $H = H + H + H$   
B) H H H H H C) H H H H  
 $C = C - C = C$   
 $C = C - C - C - H$   
 $H = H + H + H$   
D) H H  
 $I = I + I$   
 $H = H + H + H$   
A carbon-carbon triple bond is found in a molecular

- 12. A carbon-carbon triple bond is found in a molecule of
  - A) butaneB) butanoneC) buteneD) butyne
- 13. Which compound is an alkyne?

A) $C_2H_2$	B) C2H4
C) C4H8	D) C4H10

14. Which general formula represents the compound CH<sub>3</sub>CH<sub>2</sub>CCH?

A) C <sub>n</sub> H <sub>n</sub>	B) CnH2n
C) $C_nH_{2n-2}$	D) $C_nH_{2n+2}$

15. Which compound is an unsaturated hydrocarbon?

A) hexanal	B) hexane
C) hexanoic acid	D) hexyne

16. Which element is present in all organic compounds?

A) carbon	B) hydrogen
C) nitrogen	D) oxygen

- Butanal and butanone have different chemical and physical properties primarily because of differences in their
  - A) functional groups
  - B) molecular masses
  - C) molecular formulas
  - D) number of carbon atoms per molecule

- 18. Ethanol and dimethyl ether have different chemical and physical properties because they have different
  - A) functional groups
  - B) molecular masses
  - C) numbers of covalent bonds
  - D) percent compositions by mass
- 19. Which two compounds have the same molecular formula but different chemical and physical properties?
  - A) CH<sub>3</sub>CH<sub>2</sub>Cl and CH<sub>3</sub>CH<sub>2</sub>Br
  - B) CH<sub>3</sub>CHCH<sub>2</sub> and CH<sub>3</sub>CH<sub>2</sub>CH<sub>3</sub>
  - C) CH<sub>3</sub>CHO and CH<sub>3</sub>COCH<sub>3</sub>
  - D) CH<sub>3</sub>CH<sub>2</sub>OH and CH<sub>3</sub>OCH<sub>3</sub>
- 20. The isomers butane and methylpropane differ in their
  - A) molecular formulas
  - B) structural formulas
  - C) total number of atoms per molecule
  - D) total number of bonds per molecule
- 21. Given the formulas for two compounds:



These compounds differ in

- A) gram-formula mass
- B) molecular formula
- C) percent composition by mass
- D) physical properties at STP

#### 22. Given the structural formulas:



23. Given the formula for an organic compound:

This compound is classified as an

A)	aldehyde	B)	amine
C)	ester	D)	organic acid

24. What is the total number of carbon atoms in a molecule of ethanoic acid?

A) 1 B) 2 C) 3 D) 4

25. Given the three organic structural formulas shown below:



Which organic compound classes are represented by these structural formulas, as shown from left to right?

- A) ester, organic acid, ketone
- B) ester, aldehyde, organic acid
- C) ketone, aldehyde, alcohol
- D) ketone, organic acid, alcohol

26. Which structural formula is correct for 2-methyl-3-pentanol?



27. What is the total number of pairs of electrons shared between the carbon atom and the oxygen atom in a molecule of methanal?

A) 1 B) 2 C) 3 D) 4

28. The reaction between an organic acid and an alcohol produces

A)	an aldehyde	B) a ketone
C)	an ether	D) an ester

29. Given the structural formula:



The compound represented by this formula can be classified as an

A) organic acid	B) ether
C) ester	D) aldehyde

30. Given the balanced equation for an organic reaction:

 $C_2H_2 + 2Cl_2 \rightarrow C_2H_2Cl_4$ 

This reaction is best classified as

- A) addition B) esterification
- C) fermentation D) substitution
- 31. Given the equation:

 $C_2H_6+Cl_2 \rightarrow C_2H_5Cl+HCl$ 

This reaction is best described as

- A) addition involving a saturated hydrocarbon
- B) addition involving an unsaturated hydrocarbon
- C) substitution involving a saturated hydrocarbon
- D) substitution involving an unsaturated hydrocarbon
- 32. The reaction that joins thousands of small, identical molecules to form one very long molecule is called
  - A) esterification B) fermentation
  - C) polymerization D) substitution

33. Given the reaction:

$$\begin{array}{c} O \\ I \\ CH_3C - OH + HOC_2H_5 \end{array} \xrightarrow{O} CH_3C - O - C_2H_5 + H_2O \end{array}$$

This reaction is an example of

- A) fermentation B) saponification C) hydrogenation D) esterification
- 34. What are the two main products of a fermentation reaction?
  - A) ethanol and carbon dioxide
  - B) ethanol and water
  - C) sugar and carbon dioxide
  - D) sugar and water
- 35. Which reaction results in the production of soap?
  - A) esterification B) fermentation
  - C) polymerization D) saponification

Base your answers to questions **36** through **38** on the information below.

Gasoline is a mixture composed primarily of hydrocarbons such as isooctane, which is also known as 2,2,4-trimethylpentane.

Gasoline is assigned a number called an octane rating. Gasoline with an octane rating of 87 performs the same as a mixture that consists of 87% isooctane and 13% heptane.

An alternative fuel, E-85, can be used in some automobiles. This fuel is a mixture of 85% ethanol and 15% gasoline.

- 36. In the space below, draw a structural formula for a molecule of 2,2,4-trimethylpentane.
- 37. State the octane rating of a gasoline sample that performs the same as a mixture consisting of 92% isooctane and 8% heptane.
- 38. Identify the functional group in a molecule of ethanol in the alternative fuel E-85.

Base your answers to questions **39** through **43** on the information below.

Biodiesel is an alternative fuel for vehicles that use petroleum diesel. Biodiesel is produced by reacting vegetable oil with CH<sub>3</sub>OH. Methyl palmitate, C<sub>15</sub>H<sub>31</sub>COOCH<sub>3</sub>, a compound found in biodiesel, is made from soybean oil. One reaction of methyl palmitate with oxygen is represented by the balanced equation below.

 $2C_{15}H_{31}COOCH_3 + 49O_2 \rightarrow 34CO_2 + 34H_2O + energy$ 

- 39. Identify the type of organic reaction represented by the balanced equation.
- 40. Identify the class of organic compounds to which methyl palmitate belongs.
- 41. Explain, in terms of *both* atoms and molecular structure, why there is no isomer of CH<sub>3</sub>OH.
- 42. Write the IUPAC name for the compound that reacts with vegetable oil to produce biodiesel.
- 43. State evidence from the balanced equation that indicates the reaction is exothermic.