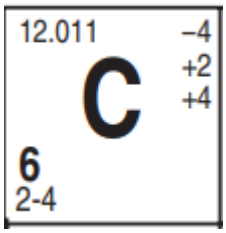
ORGANIC CHEMISTRY

Organic Chemistry is the study of _____ compounds. The name "ORGANIC" is a remnant of a time when it was thought that carbon compounds could only be made by living things; hence the name *organic*. Today it is widely recognized that organic chemistry contains far more compounds that only those made by living things. The number of organic compounds is enormous. Tens of thousands or new organic compounds are discovered every year, and there seems to be no end in sight to future discoveries.

Objective #1: Know the properties of Organic Compounds

- Compounds are _____ bonded
- _____ melting and boiling points
- _____ conductors
- Molecules tend to be _____ and don't dissolve easily in water (polar)
- React very _____ due to the large number of _____ within
- Organic compounds form _____ or _____ of carbon atoms



Number of bonds

Objective #2: Know the ways to represent Organic Compounds

a) Molecular Formula
- Chemical formula that indicates how many and what kind of atoms there are

b) Structural Formula
- Illustration that shows the bonds between the atoms, as well as the type of atoms and how many atoms there are

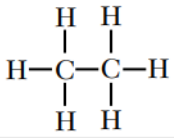
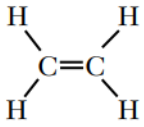
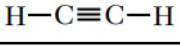
c) Condensed Structural Formula
- Shows the bonding pattern without the chemical bonds

Objective #3: Identify and Describe Hydrocarbons

Hydrocarbons are compounds that contain only _____ and _____ atoms.

A homologous series of compounds is a group of related compounds in which each member differs from the one before it by the same additional unit.

Table Q
Homologous Series of Hydrocarbons

Name	General Formula	Examples	
		Name	Structural Formula
alkanes	C_nH_{2n+2}	ethane	
alkenes	C_nH_{2n}	ethene	
alkynes	C_nH_{2n-2}	ethyne	

Note: n = number of carbon atoms

A) Straight-Chain Hydrocarbons

ALKANES: chain of carbon atoms with _____ bonds only;

- _____ because each of the four bonding sites around the carbon atom is occupied with a hydrogen atom

ALKENES: chain of carbon atoms with one _____ bond with in the chain, with the rest as single bonds

- _____ organic compounds

ALKYNES: chain of carbon atoms with one _____ bond with in the chain, with the rest as single bonds

- _____ organic compounds

1) Which of the following substances is organic?

a) NaCl b) NH_3 c) CH_4 d) H_2O

2) When 2 carbon atoms form a single bond, how many pairs of e- will be shared between them?_____

3) When 2 carbon atoms form a double bond, how many pairs of e- will be shared between them?_____

4) When 2 carbon atoms form a triple bond, how many pairs of e- will be shared between them?_____

5) An alkANE has 5 carbon atoms.

a) What is the general formula for alkanes? _____

b) How many Hydrogen atoms will it have? _____

6) An alkENE has 3 carbon atoms.

a) What is the general formula for alkenes? _____

b) How many Hydrogen atoms will it have? _____

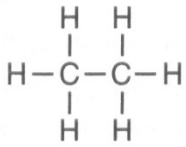
7) An alkYNE has 4 carbon atoms.

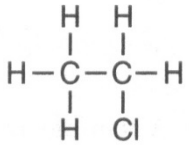
a) What is the general formula for alkynes? _____

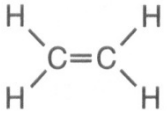
b) How many Hydrogen atoms will it have? _____

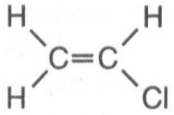
Organic Introduction Practice

1. Which formula represents an unsaturated hydrocarbon?

A) 

B) 

C) 

D) 

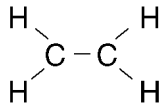
2. Which organic compound is a saturated hydrocarbon?

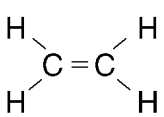
A) ethyne B) ethanol C) ethene D) ethane

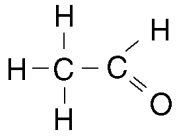
3. Which formula represents a hydrocarbon?

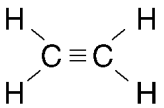
A) $CH_3CH_2CH_2CHO$ B) $CH_3CH_2CH_2CH_3$ C) $CH_3CH_2CH_2COOH$ D) $CH_3CH_2COOCH_3$

4. Which structural formula *correctly* represents a hydrocarbon molecule?

A) 

B) 

C) 

D) 

5. In saturated hydrocarbons, carbon atoms are bonded to each other by

A) single covalent bonds, only C) alternating single and double covalent bonds

B) double covalent bonds, only D) alternating double and triple covalent bonds

6. What is the general formula for the members of the alkane series?
   A) C_nH_{2n} B) C_nH_{2n-2} C) C_nH_{2n+2} D) C_nH_{2n-6}

7. In which group could the hydrocarbons all belong to the same alkene series?
   A) C_2H_2, C_2H_4, C_2H_6 B) C_2H_2, C_2H_4, C_4H_8 C) C_2H_4, C_2H_6, C_3H_6 D) C_2H_4, C_3H_6, C_4H_8

8. A molecule of propyne has
   A) all single bonds B) a double bond C) a triple bond D) no bonds

9. A double carbon-carbon bond is found in a molecule of
   A) pentane B) pentyne C) pentene D) pentanol

10. The multiple covalent bond in a molecule of butene is a
   A) double bond that has 6 shared electrons C) triple bond that has 6 shared electrons
   B) double bond that has 4 shared electrons D) triple bond that has 4 shared electrons

Objective #4: Naming and Drawing Straight – Chain Hydrocarbons

A) Naming Straight-Chain Hydrocarbons

1) Count the number of carbon atoms in the chain to determine the prefix using Reference Table P.

2) The suffix will depend on if there are single bonds only, a double bond somewhere in the chain or a triple bond somewhere in the chain.

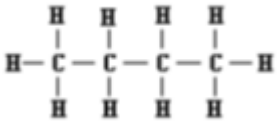
- If there are all single bonds only, end with the suffix _____.

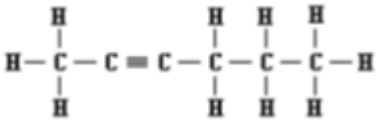
Table P
Organic Prefixes

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

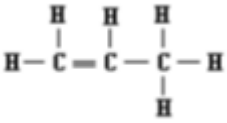
- If there is a double bond somewhere in the chain, end with the suffix _____. Then you must provide a number indicating what carbon atom in the chain the double bond falls after. Number in the direction that provides the lowest number

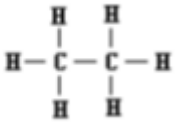
- If there is a triple bond somewhere in the chain, end with the suffix _____. Then you must provide a number indicating what carbon atom in the chain the triple bond falls after. Number in the direction that provides the lowest number

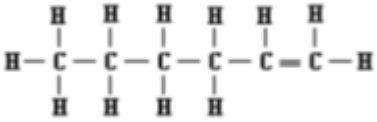
1) 

2) 

3) 

4) 

5) 

6) 

B) Drawing Straight-Chain Hydrocarbons

1) Use the prefix given in the name to draw the carbon chain without the bonds between them.

2) Use the suffix given to determine if there are only single bonds (-ane) between the carbon atoms, or if there is a double bond (-ene) or triple bond (-yne) somewhere in the chain.

- If the suffix is –ane, draw all single bonds between the carbon atoms, and then ensure that every carbon atom is bonded to the maximum number of hydrogen atoms possible.

- If the suffix is –ene, you must use the number provided to determine what carbon atom in the chain to place the double bond after. The rest of the carbon atoms in the chain are bonded with single bonds, and then ensure that every carbon atom is bonded to the maximum number of hydrogen atoms possible.

- If the suffix is –yne, you must use the number provided to determine what carbon atom in the chain to place the triple bond after. The rest of the carbon atoms in the chain are bonded with single bonds, and then ensure that every carbon atom is bonded to the maximum number of hydrogen atoms possible.

1) methane

2) 1 – butene

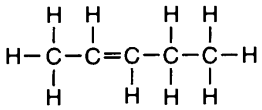
3) propyne

4) 3 - heptene

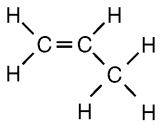
5) pentane

6) 2 – hexyne

Hydrocarbon Naming and Formula Practice

1. Given the structure:  What is the IUPAC name of this compound?

A) 2-pentene B) 2 – butane C) 2-pentyne D) 2-butyne

2. Given the structural formula:  What is the IUPAC name of this compound?

A) propane B) propene C) propanone D) propanal

3. What is the correct formula for butene?

A) C_4H_4 B) C_4H_6 C) C_4H_8 D) C_4H_{10}

4. Which general formula represents the homologous series of hydrocarbons that includes the compound l-heptyne?

A) CnH2n-6 B) CnH2n-2 C) CnH2n D) CnH2n+2

5. Which compound is an unsaturated hydrocarbon?

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

6. Given the structural formula: H—C≡C—H
What is the total number of electrons shared in the bond between the two carbon atoms?

A) 2 B) 3 C) 4 D) 6

7. Which formula represents propyne?

A) C_3H_4 B) C_3H_6 C) C_5H_8 D) C_5H_{10}

8. What is the name of a compound that has the molecular formula C_4H_6?

A) butane B) butene C) benzene D) butyne

Objective #5: Naming and Drawing Branched Chain Hydrocarbons

Branched chain hydrocarbons have **s**mall _____ of carbons off a longer main chain organic compound. To distinguish a "branch" from the main chain, a _____ ending is used.

- 1 carbon branch: _____
- 2 carbon branch: _____
- 3 carbon branch: _____

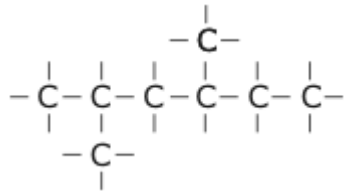
A) To name branched chain hydrocarbons

1) Number the carbon atoms in the main chain (longest stretch of carbon atoms) in such a way that the location of the branches will have the lowest numbers possible.

2) Start with the branches. Provide the number of the carbon atom in the chain that it falls on, along with the appropriate branch name. If there is more than one branch of carbon atoms on the main chain, start with the lowest number first and proceed from there.

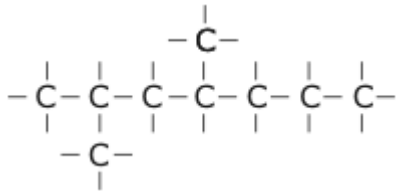
3) Then name the main chain. Use Table P for the prefix and Table Q for the suffix.

1)



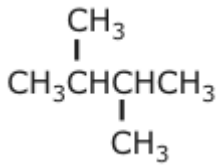
_____

2)



_____

3)



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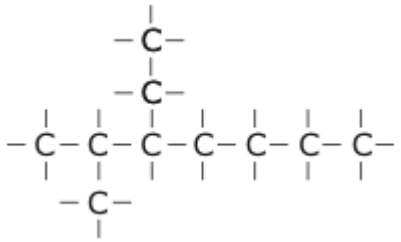
4)



B) To draw branched chain hydrocarbons

1) Use the prefix from Table P to determine how many carbon atoms to place in the main chain. The –ane ending will indicate that all the carbon atoms in the main chain are bonded with a single bond.

2) Number the main chain of carbon atoms. This time the direction you choose to number does not matter.

3) With the number provided for each branch, locate the carbon atom in the main chain and place the correct number of carbon atoms off the main chain for the branch. It does not matter if you place the chain on above or below the main chain.

4) Then ensure that every carbon atom in the main chain AND the branch is bonded to the maximum number of hydrogen atoms possible.

1) 2-propyl butane

2) 3-ethyl pentane

2) 2-methyl-2-ethyl pentane

3) 2,4 – dimethyl hexane

Objective #6: Identifying, Naming and Drawing Organic Compounds with Functional Groups

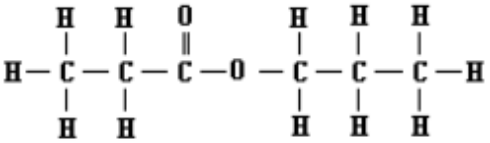
Some organic compounds contain a carbon chain with other elements besides hydrogen atoms attached

- some of the hydrogen atoms are replaced with a _____, _____ and/or _____ atom(s)

Table R
Organic Functional Groups

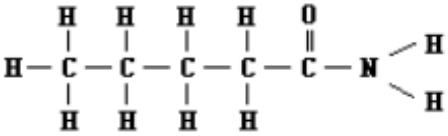
Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	—F (fluoro-) —Cl (chloro-) —Br (bromo-) —I (iodo-)	$R-X$ (X represents any halogen)	$CH_3CHClCH_3$ 2-chloropropane
alcohol	—OH	$R-OH$	$CH_3CH_2CH_2OH$ 1-propanol
ether	—O—	$R-O-R'$	$CH_3OCH_2CH_3$ methyl ethyl ether
aldehyde	$-C(=O)-H$	$R-C(=O)-H$	$CH_3CH_2C(=O)-H$ propanal
ketone	$-C(=O)-$	$R-C(=O)-R'$	$CH_3C(=O)CH_2CH_2CH_3$ 2-pentanone
organic acid	$-C(=O)-OH$	$R-C(=O)-OH$	$CH_3CH_2C(=O)-OH$ propanoic acid
ester	$-C(=O)-O-$	$R-C(=O)-O-R'$	$CH_3CH_2C(=O)OCH_3$ methyl propanoate
amine	$-N-$	$R-N(R')-R''$	$CH_3CH_2CH_2NH_2$ 1-propanamine
amide	$-C(=O)-NH$	$R-C(=O)-NH$	$CH_3CH_2C(=O)-NH_2$ propanamide

Note: R represents a bonded atom or group of atoms.



Identify family: _____

Name: _____



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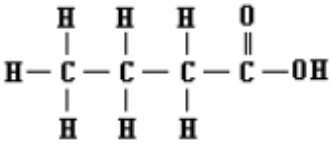

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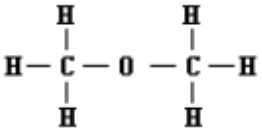

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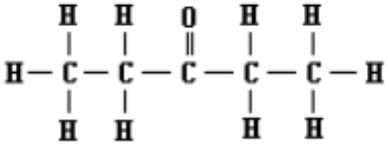

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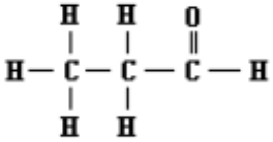

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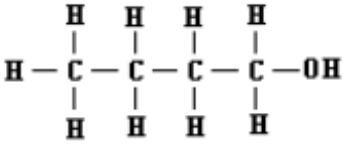

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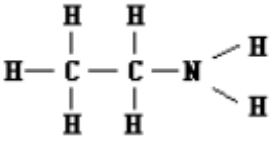
Name: _____



Identify family: _____

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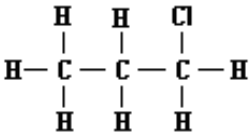


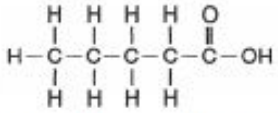
Identify family: _____

Name: _____

Name	Family	Structural Formula
1-iodopropane		
2-Pentanone		
Ethanamine		
Butanamide		
Methyl Ethanoate		
Methyl propyl ether		
2-Pentanol		
Propanoic Acid		
Butanal		

Functional Group Questions

___ 1. Given the formula for an organic compound:



This compound is classified as an

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

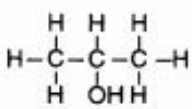
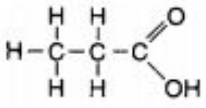
___ 2. Which of these compounds has chemical properties most similar to the chemical properties of ethanoic acid?

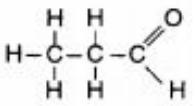
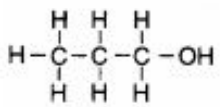
A) C_3H_7COOH B) C_2H_5OH
C) $C_2H_5COOC_2H_5$ D) $C_2H_5OC_2H_5$

___ 3. A compound with the formula CH_3CH_2OH is classified as an

A) alkane B) alkene
C) alcohol D) acid

___ 4. Which compound is a primary alcohol?

A)  B) 

C)  D) 

___ 5. The compound 2-propanol is classified as a

A) primary alcohol
B) secondary alcohol
C) tertiary alcohol
D) dihydroxy alcohol

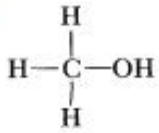
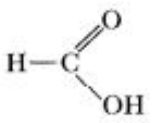
___ 6. The organic compound represented by the condensed structural formula $CH_3CH_2CH_2CHO$ is classified as an

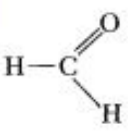
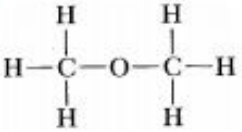
A) alcohol B) aldehyde
C) ester D) ether

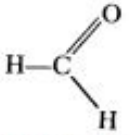
___ 7. Which formula represents a ketone?

A) HCOOH B) HCHO
C) CH_3COCH_3 D) CH_3CH_2OH

___ 8. Which is the structural formula of an aldehyde?

A)  B) 

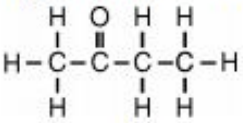
C)  D) 

___ 9. 

Which is represented by the structural formula above?

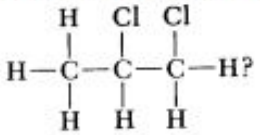
A) an aldehyde B) an alcohol
C) an alkane D) an acid

___ 10. What is the IUPAC name of the compound with the following structural formula?



A) propanone B) propanal
C) butanone D) butanal

___ 11. What is the correct IUPAC name for



A) 1,2-dichlorobutane B) 2,3-dichlorobutane
C) 1,2-dichloropropane D) 2,3-dichloropropane

___ 12. The isomers 1-chloropropane and 2-chloropropane differ only in

A) molecular composition
B) molecular structure
C) the number of chloro- groups per molecule
D) the number of carbon atoms per molecule

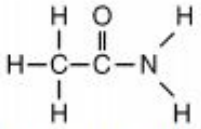
___ 13. Which compound is an ester?

A) CH_3COOH B) CH_3CHO
C) CH_3COOCH_3 D) CH_3COCH_3

___ 14. The compound $CH_3CH_2COOCH_3$ is an example of

A) an ester B) an alcohol
C) an acid D) a polymer

___ 15. Given the structural formula:



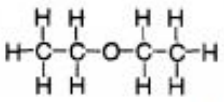
This compound is classified as an

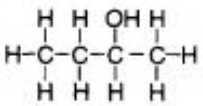
A) amide B) amine
C) aldehyde D) alcohol

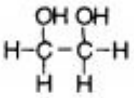
___ 16. Which class of organic compounds has molecules that contain nitrogen atoms?

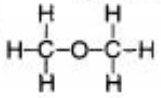
A) alcohol B) amine
C) ether D) ketone

___ 17. Which structural formula represents diethyl ether?

A) 

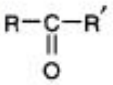
B) 

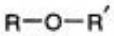
C) 

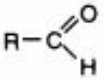
D) 

___ 18. What is the general formula for an ether?

A) 

B) 

C) 

D) 

___ 19. 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

___ 20. Atoms of which element can bond with each other to form ring and chain structures in compounds?

A) C B) Ca C) H D) Na

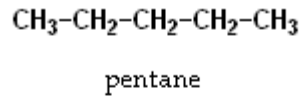
Objective #7: Draw and Identify Organic Isomers

Isomers are organic compounds with the same _____ formulas but different _____ formulas, as well as different chemical and physical properties

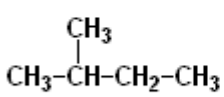
- There are usually many different ways to draw the isomers of an organic compound

Examples:

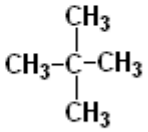
C_5H_{12}



pentane

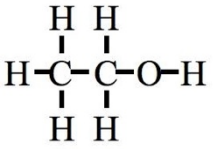


2 methyl butane

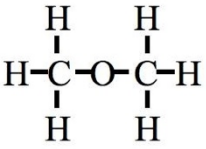


2,2 dimethyl pentane

C_2H_6O



ethanol



methyl methyl ether

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1. Draw the isomers for C_4H_{10}.

2. Draw all the isomers of C_4H_6.

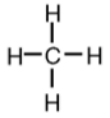
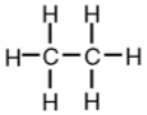
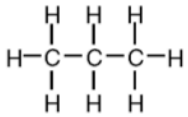
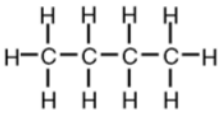
3. Draw all the isomers of C_4H_9Cl.

Isomer Questions

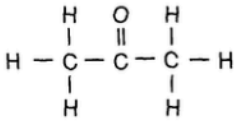
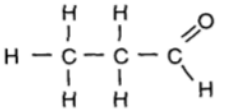
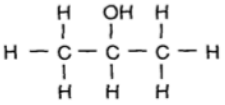
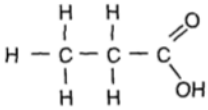
___ 1. Which two compounds are isomers of each other?

A) CH_3OCH_3 and CH_3CH_2OH
B) CH_3CH_2Cl and C_6H_5Cl
C) CH_3COCH_3 and CH_3OCH_3
D) $CH_3(CH)_2CH_3$ and $CH_3(CH)_2CH_3$

___ 2. Which compound has an isomer?

A) 
B) 
C) 
D) 

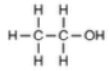
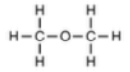
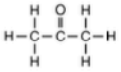
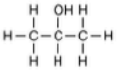
___ 3. Which structural formula represents an isomer of 1-propanol?

A) 
B) 
C) 
D) 

___ 4. The compounds CH_3OCH_3 and CH_3CH_2OH are isomers of each other. These two compounds must have the same

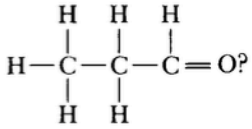
A) density
B) reactivity
C) melting point
D) molecular formula

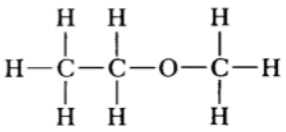
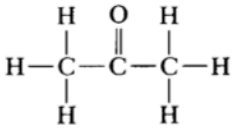
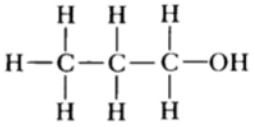
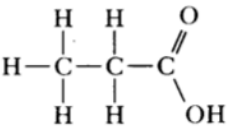
___ 5. Given the structural formulas:

Formula A 
Formula B 
Formula C 
Formula D 

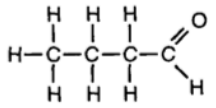
Which two formulas represent compounds that are isomers of each other?

A) *A* and *B*
B) *A* and *C*
C) *B* and *D*
D) *C* and *D*

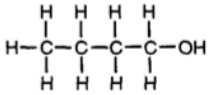
___ 6. Which structural formula represents an isomer of  ?

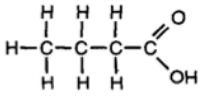
A) 
B) 
C) 
D) 

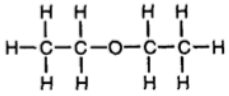
___ 7. Given the compound:

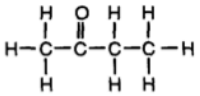


Which structural formula represents an isomer?

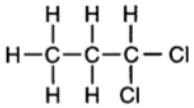
A) 

B) 

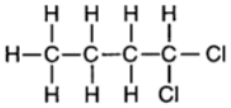
C) 

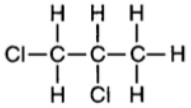
D) 

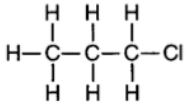
___ 8. Given the compound:

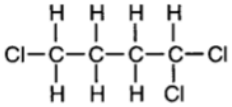


Which structural formula represents an isomer?

A) 

B) 

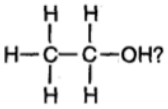
C) 

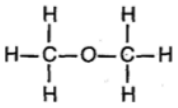
D) 

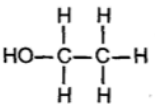
___ 9. Which compound is an isomer of propanoic acid (CH_3CH_2COOH)?

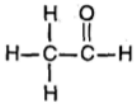
A) $CH_2CHCOOH$
B) $CH_3CH_2CH_2COOH$
C) $CH_3CH(OH)CH_2OH$
D) $HCOOCH_2CH_3$

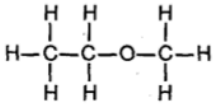
___ 10. Which is an isomer of



A) 

B) 

C) 

D) 

___ 11. Which compounds are isomers?

A) CH_3OH and CH_3CH_2OH
B) CH_4 and CCl_4
C) CH_3CH_2CHO and CH_3COCH_3
D) CH_3CH_2OH and CH_3CH_2COOH

___ 12. Which formula represents an isomer of the compound propanoic acid, CH_3CH_2COOH?

A) $CH_3CH_2CH_2OH$
B) $CH_3CH_2CH_2COOH$
C) $CH_3CH(OH)CH_2OH$
D) CH_3COOCH_3

Objective #8: Know the Types of Organic Reactions

Reaction #1: Combustion

When sufficient oxygen is present, hydrocarbons will burn to produce _____ and _____.

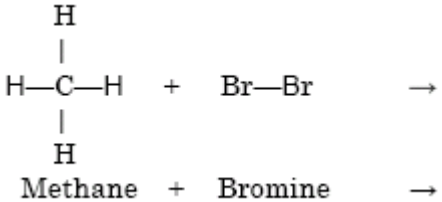
Write the balanced equation for the complete combustion of propane (C_3H_8).

propane + oxygen → _____ + _____

Reaction #2: Substitution

A substitution reaction involves the replacement of one or more _____ atoms in a _____ hydrocarbon with another _____ or _____.

For example, _____ atoms can replace hydrogens

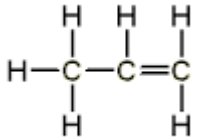


Methane + Bromine → _____ + _____

Reaction #3: Addition

Addition reactions involve adding one or more atoms at a _____ or _____ bond.

When propene and bromine react below, the _____ bond is _____ and turned into a _____ bond, and the bromine atoms are added to the carbon chain to produce ONE product.

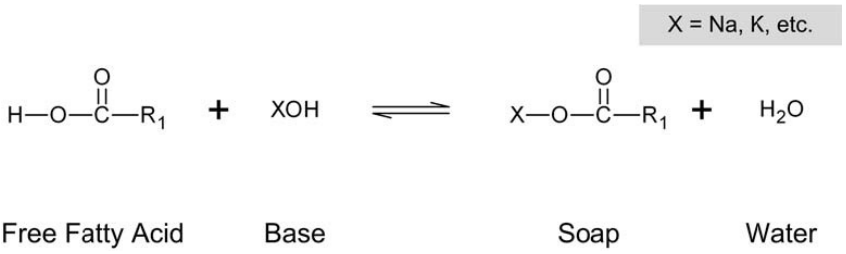


Propene Bromine _____

Reaction 4: Saponification

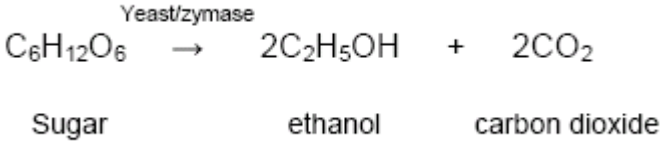
A _____ reacts with a strong base (-OH ion) to produce _____ (rearrange: S A P O)

- Most common strong base used in making soap is _____



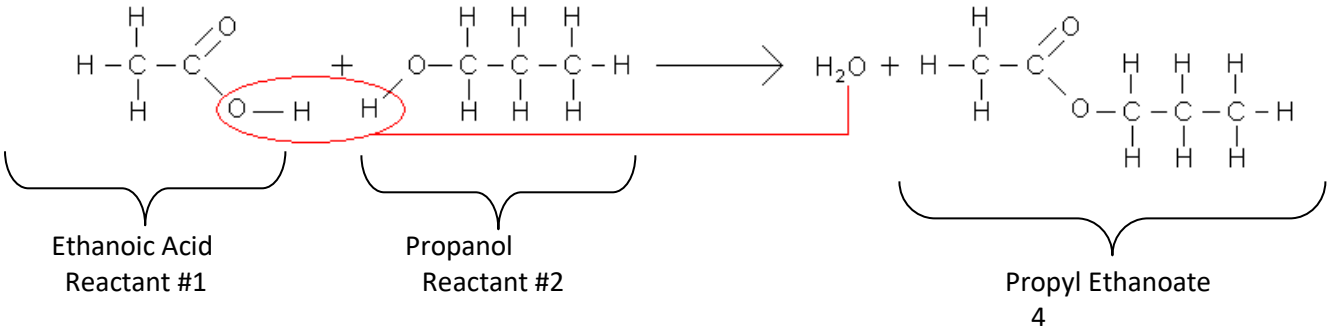
Reaction #5: Fermentation

In a fermentation reaction, yeast cells break down _____ into an _____ and _____.



Reaction #4: Esterification

Esterification is the reaction between an _____ and an _____ to produce an _____ plus _____. Many compounds found in fruits can be prepared in the laboratory using an esterification reaction.



Draw the structure for each of the *reactants* in the reaction: butanoic acid + 1-ethanol → X + H_2O and circle the atoms to be removed to make water. Then identify, draw and name "X".

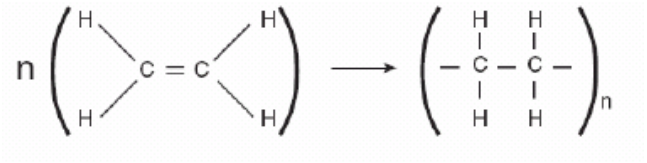
Reaction #7: Polymerization

Polymers are organic compounds made up of _____ of smaller units covalently bonded together.

The formation of these larger polymer molecules is called _____.

- Each individual unit of a polymer is called a _____. Naturally occurring polymers include _____, _____ and _____.

A) Addition Polymerization: Addition polymerization occurs to make SATURATED hydrocarbons. As unsaturated molecules join up, a long molecular chain is built up and the multiple bond is replaced with a single bond.



(n is a large number, generally > 2000)

B) Condensation Polymerization

Condensation polymerization reactions result from the bonding of _____ by removing _____ and joining up the monomers.