Introduction to Organic Chemistry

Organic chemistry is the study of carbon-containing compounds, usually bonded to hydrogen, oxygen and sometimes nitrogen. There are many types of organic molecules. Hydrocarbons are an example of some of the more simple organic compounds since they only contain carbon & hydrogen.

HYDROCARBONS

A Molecule containing only carbon & hydrogen, bonded together by covalent bonds.
Hydrocarbons differ from each other in two ways: 1) Number of carbon atoms & 2) The type of bond between the carbon atoms (single, double or triple bond).

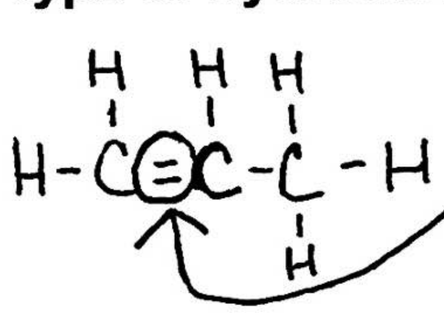
TYPES OF HYDROCARBONS

remember – carbon forms 4 bonds & hydrogen forms 1 bond.

Type of hydrocarbon	Bond found in the molecule	Ending used to name the hydrocarbon
Alkane	All single bonds	-ane ending
Alkene	1 double bond	-ene ending
Alkyne	1 triple bond	-yne ending

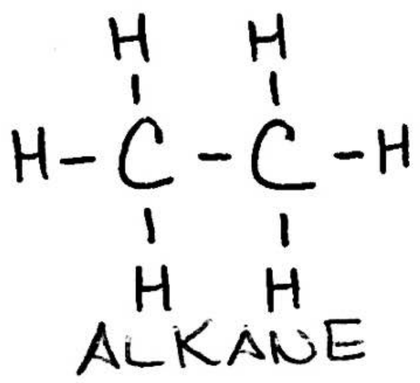
Q: Identify the type of hydrocarbon molecules below based on the number of bonds in the molecule.

Example:



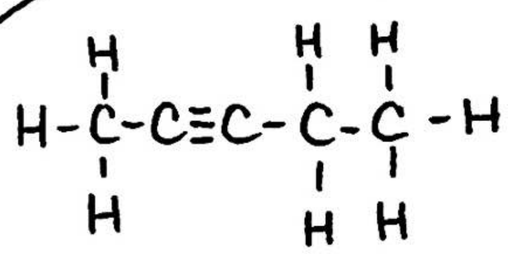
Alkene (there is a double bond in the molecule)

1.



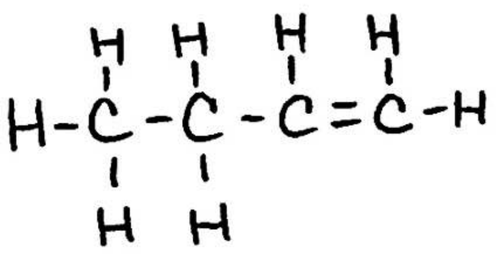
ALKANE

2.



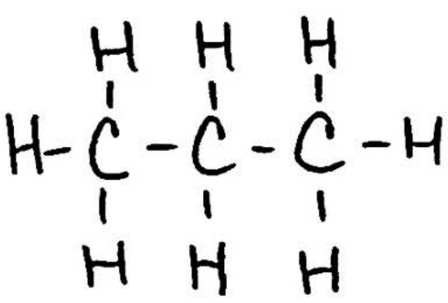
ALKYNE

3.



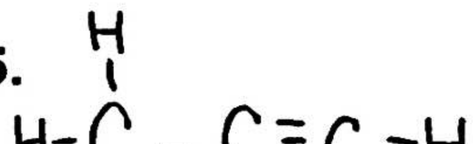
ALKENE

4.



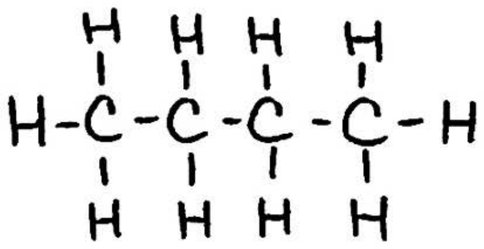
ALKANE

5.



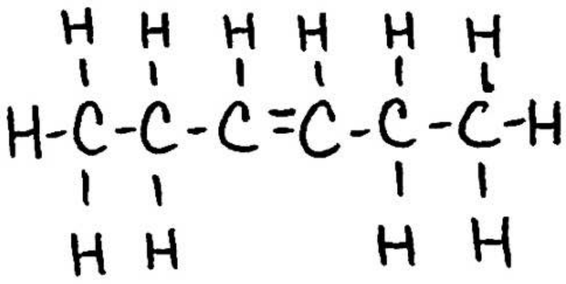
ALKYNE

6.



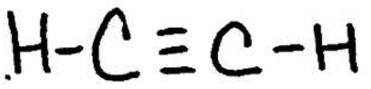
ALKANE

7.



ALKENE

8.



ALKYNE

NAMING HYDROCARBONS – USING PREFIXES

Prefixes are used when naming hydrocarbons to *indicate how many carbons are present in the molecule.* Table P lists the prefixes and the number of carbons that corresponds.

Q: How many carbons would be in the following hydrocarbons?

Example: Methane 1

1. Butene 4
2. Nonane 9
3. Ethyne 2
4. Hexane 6
5. Propene 3
6. Octyne 8
7. Decane 10
8. Heptene 7

Q. What prefixes should be used for the following hydrocarbon molecules? (remember, only look at the number of carbons)

Example: C_4H_8 = but-

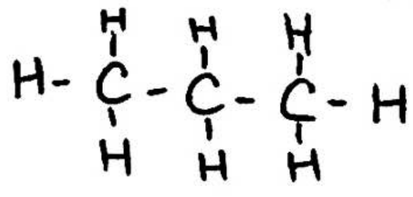
1. C_7H_{14} Hept-
2. $C_{10}H_{22}$ Dec-
3. C_8H_{14} Oct-
4. C_3H_6 Prop-
5. C_6H_{14} Hex-
6. C_2H_2 Eth-

NAMING HYDROCARBONS

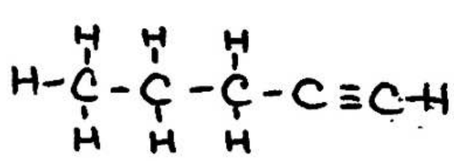
The name of a hydrocarbon has two parts: Prefix (# of carbons) + Ending (type of H.C.)
The endings used for the different types of hydrocarbons are:

Alkane = -ane Alkene = -ene Alkynes = -yne

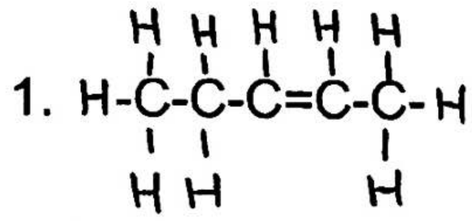
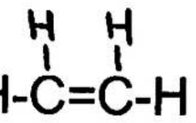
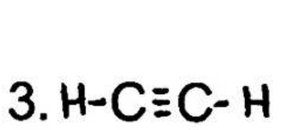
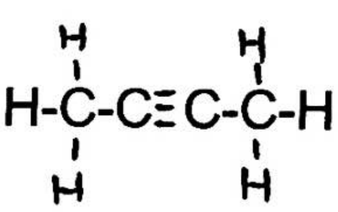
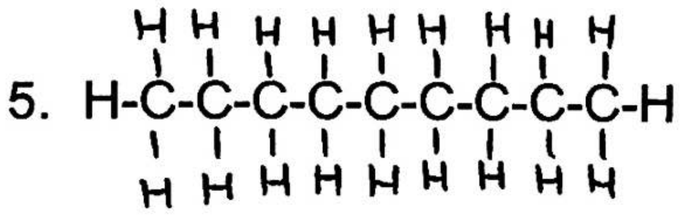
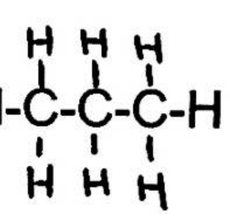
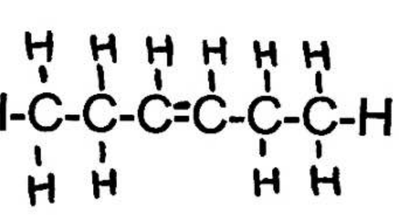
Example:



A 3 carbon alkane → Prop + ane = Propane



A 5 carbon alkyne → Pent + yne = Pentyne

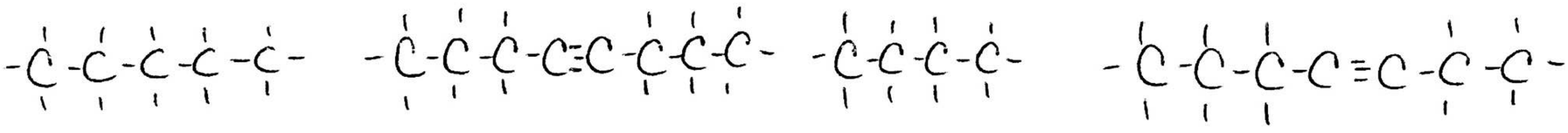
1. 
Pentene
2. 
Ethene
3. 
Ethyne
4. 
Butyne
5. 
Nonane
6. 
Propane
7. 
Hexene

DRAWING HYDROCARBONS

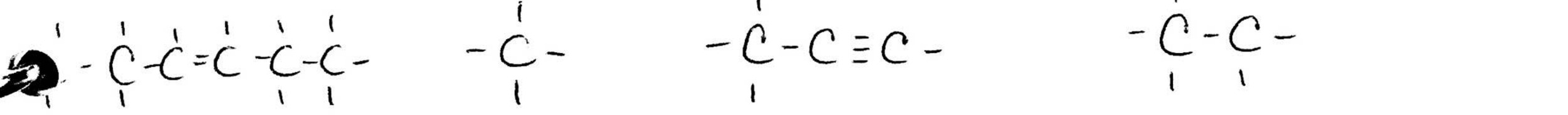
When drawing the structural formulas of hydrocarbons, you just follow the name of the hydrocarbon – the prefix will tell you how many carbons & the ending will tell you if you need a double or triple bond. For now, do not worry where you put the double/triple bond.

Example: Ethene (2 carbon, has a double bond)

1. Pentane
2. Octyne
3. Butane
4. Heptyne

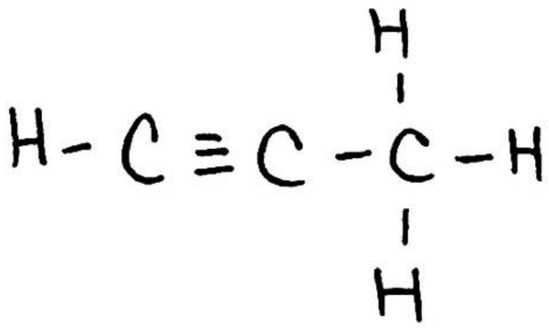


5. Hexene
6. Methane
7. Propyne
8. Ethane

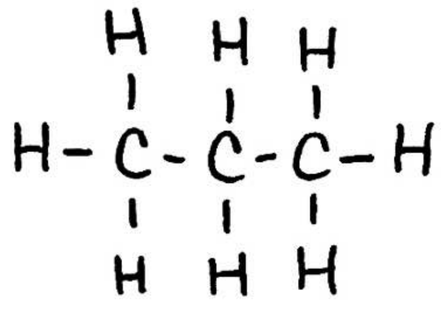


Label the Following as *alkanes, alkenes or alkynes.*

1) Alkynes

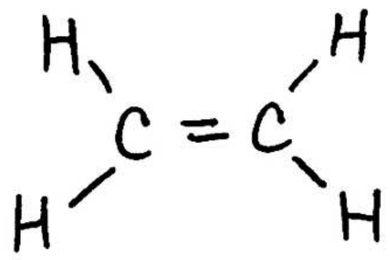


2) Alkane

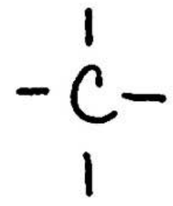


3) Alkyne

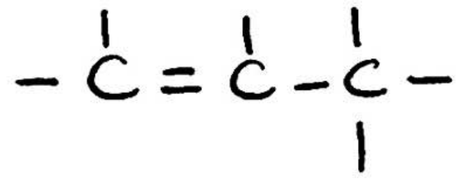
4) Alkenes



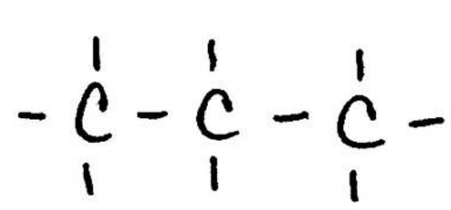
5) Alkane



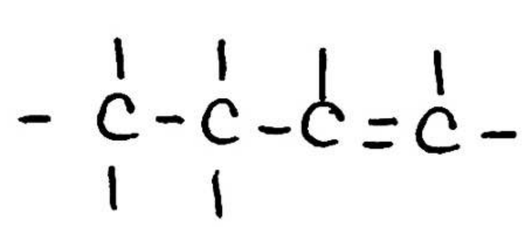
6) Alkene



7) Alkane

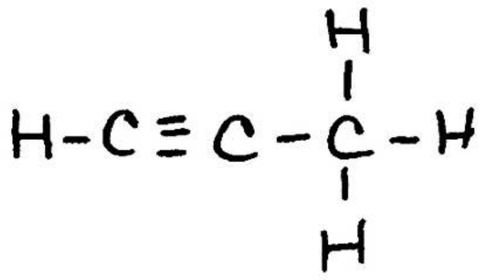


8) Alkene



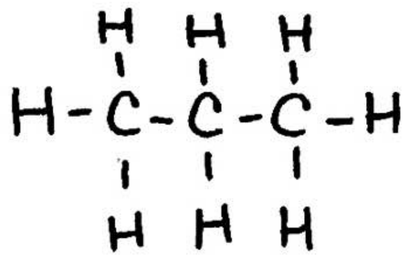
Name the following hydrocarbons.

1)



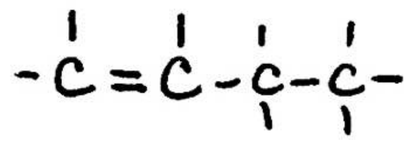
Propyne

2)



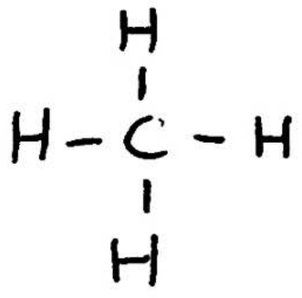
Propane

3)



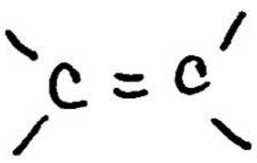
Butene

4)



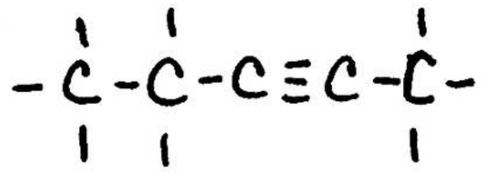
Methane

5)



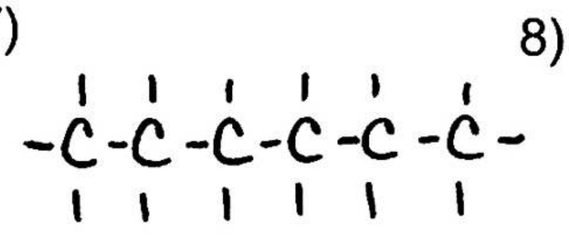
Ethene

6)



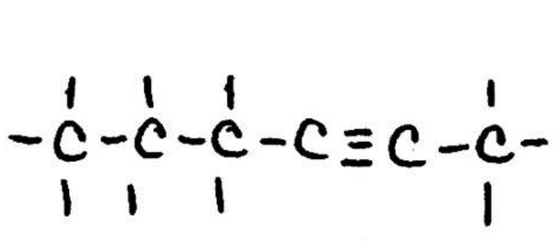
Pentyne

7)



Hexane

8)

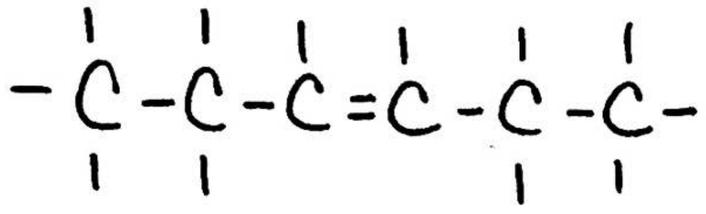


Hexyne

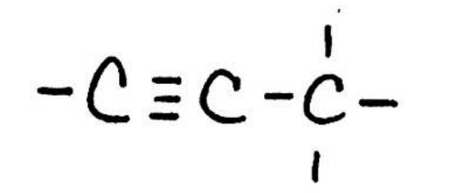
Name_____ Hydrocarbons

Draw the following hydrocarbons & write the formula.

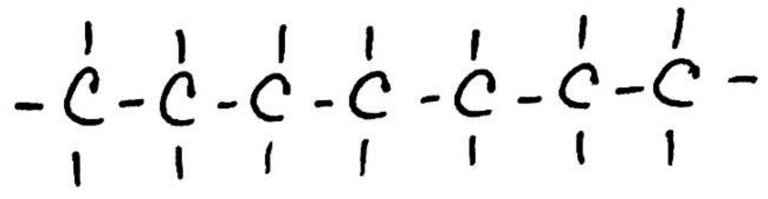
1. Hexene C_6H_{12}



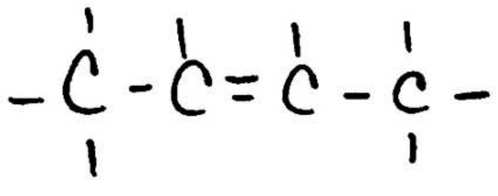
2. Propyne C_3H_4



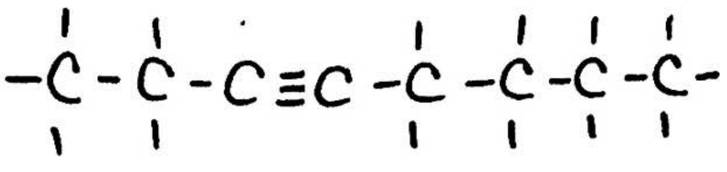
3. Heptane C_7H_{16}



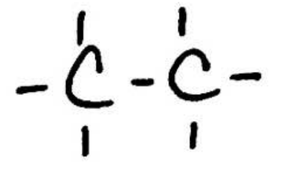
4. Butene C_4H_8



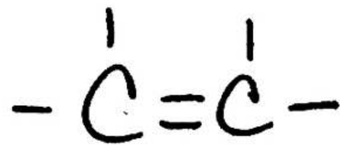
5. Octyne C_8H_{14}



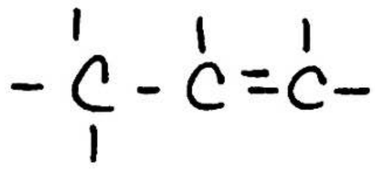
6. Ethane C_2H_6



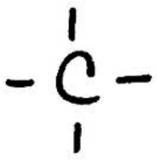
7. Ethene C_2H_4



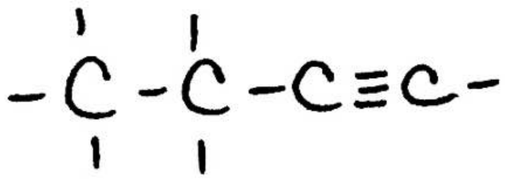
8. Propene C_3H_6



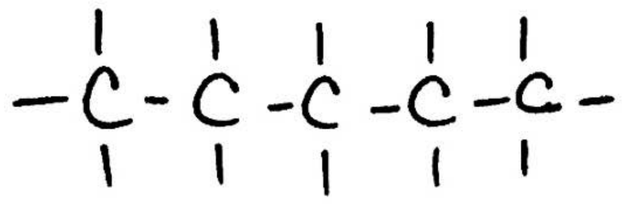
9. Methane CH_4



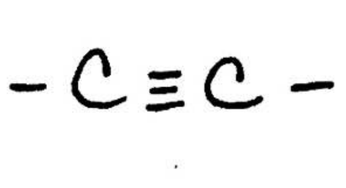
10. Butyne C_4H_6



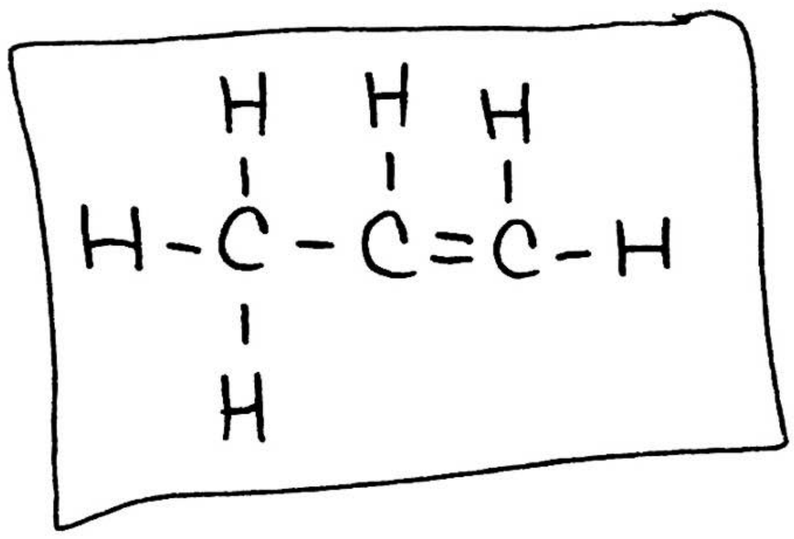
11. Pentane C_5H_{12}

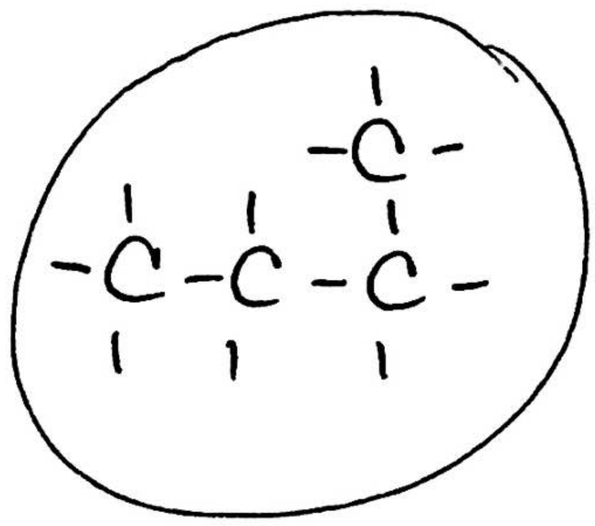


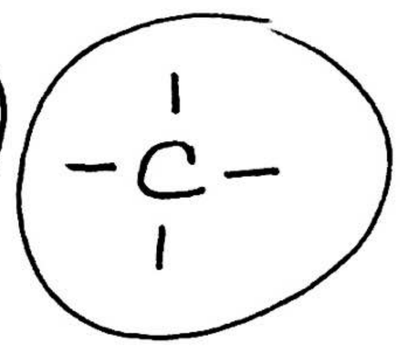
12. Ethyne C_2H_2

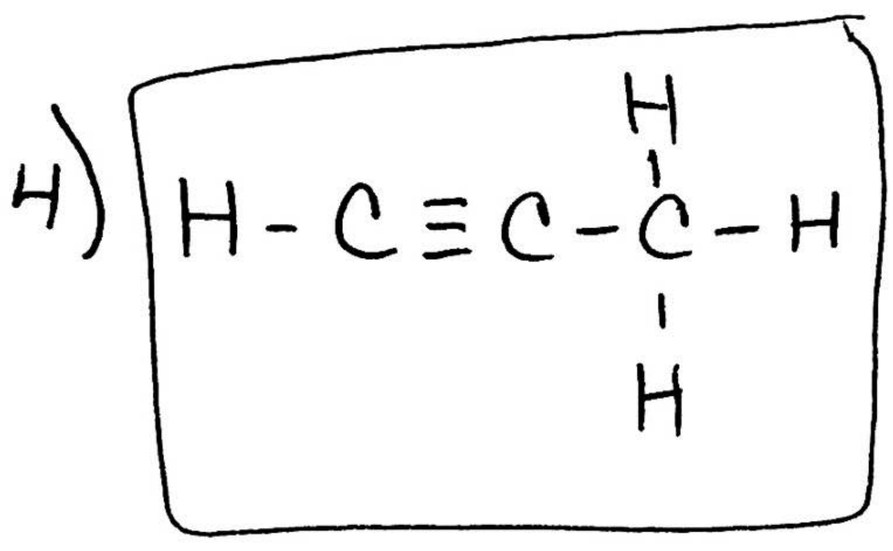


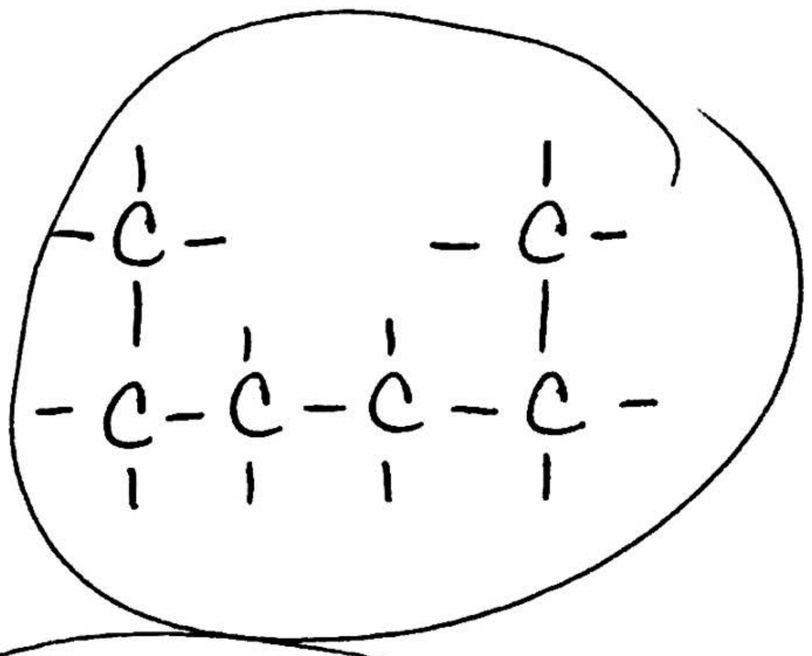
Circle the molecules that are saturated and put a box around the molecules that are unsaturated.

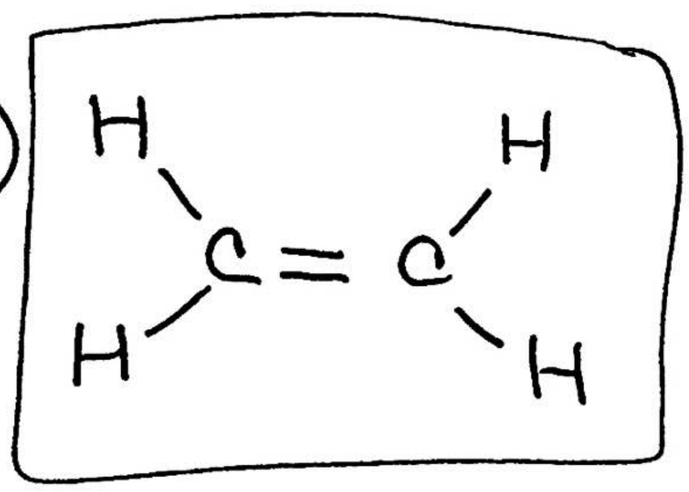
1) 

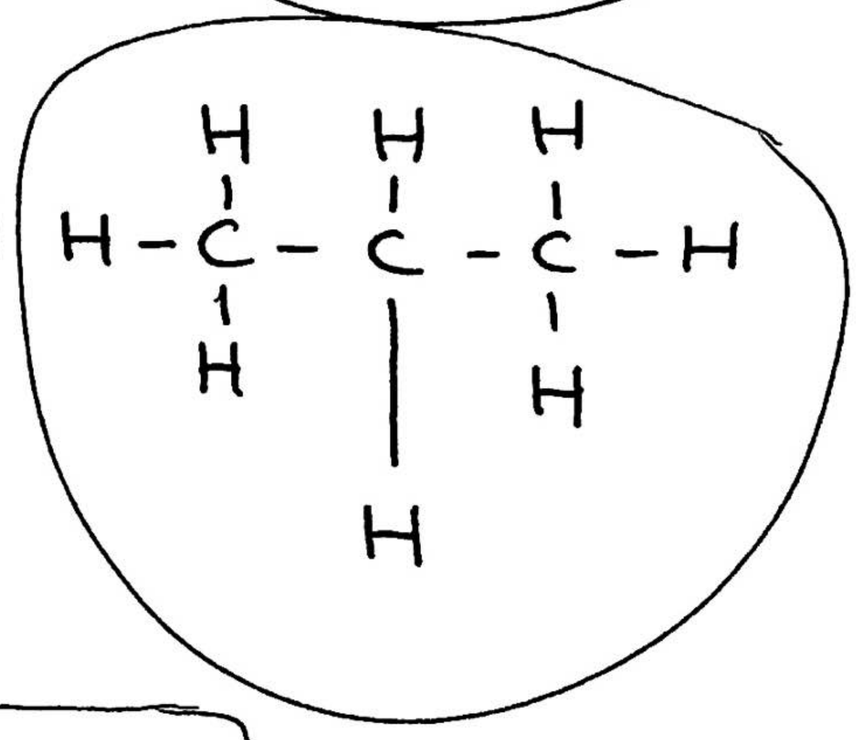
2) 

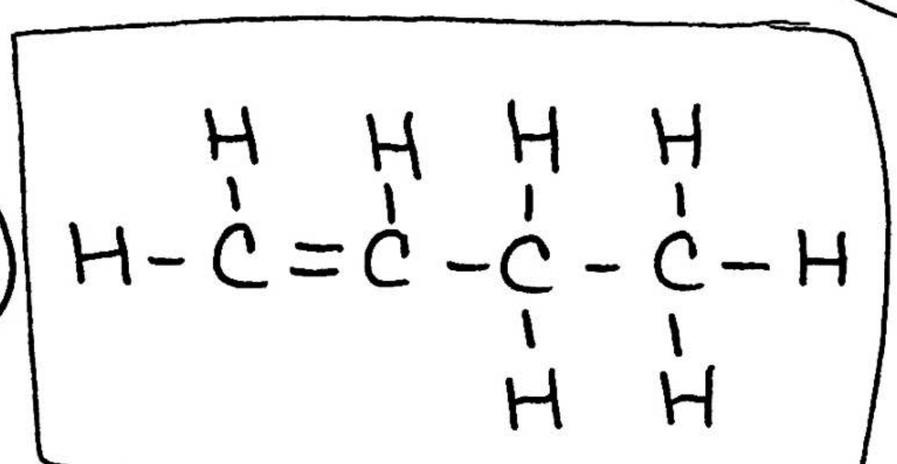
3) 

4) 

5) 

6) 

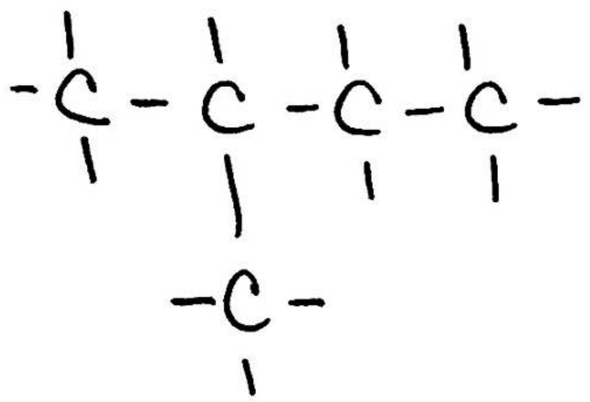
7) 

8) 

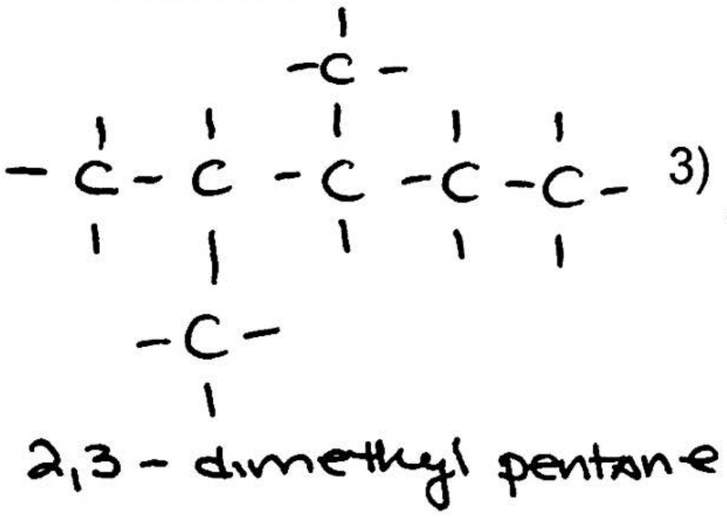
Name Key

Hydrocarbons w/sidechains

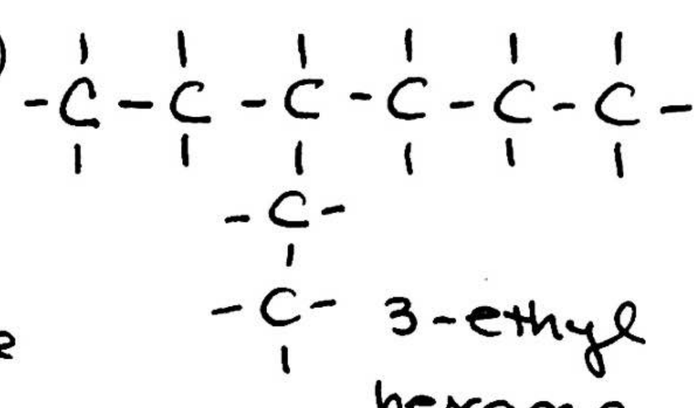
Name the following hydrocarbons with side chains.

1) 

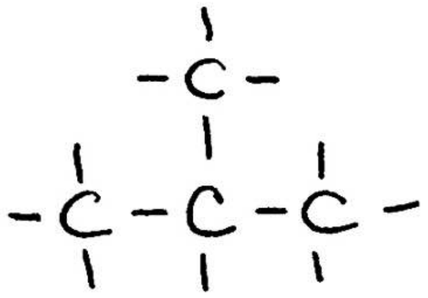
2 - methyl butane

2) 

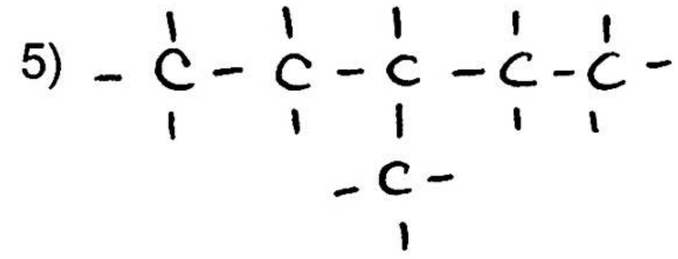
2,3 - dimethyl pentane

3) 

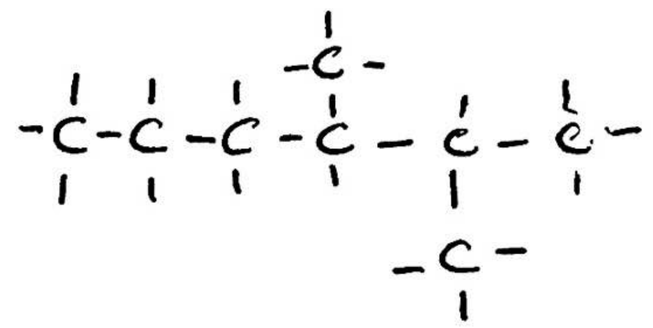
3 - ethyl hexane

4) 

2 - methyl propane

5) 

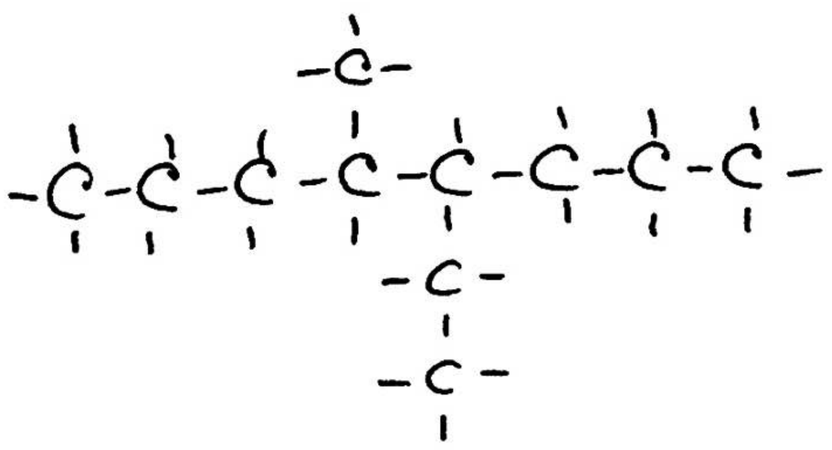
3,3 - dimethyl pentane

6) 

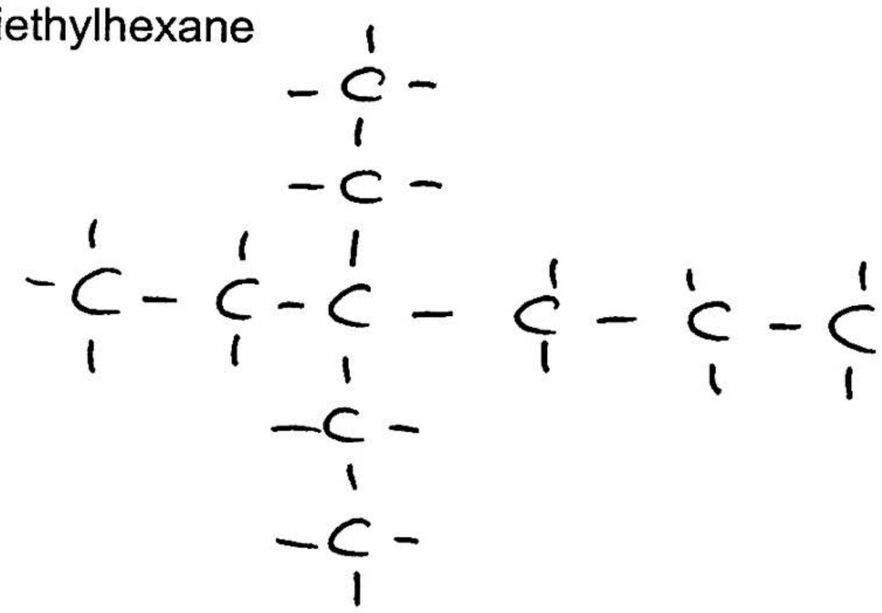
2,3 - dimethyl hexane

Draw the following hydrocarbons.

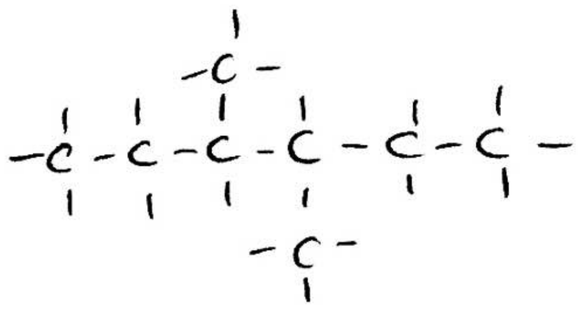
1) 4-methyl – 5 ethyloctane



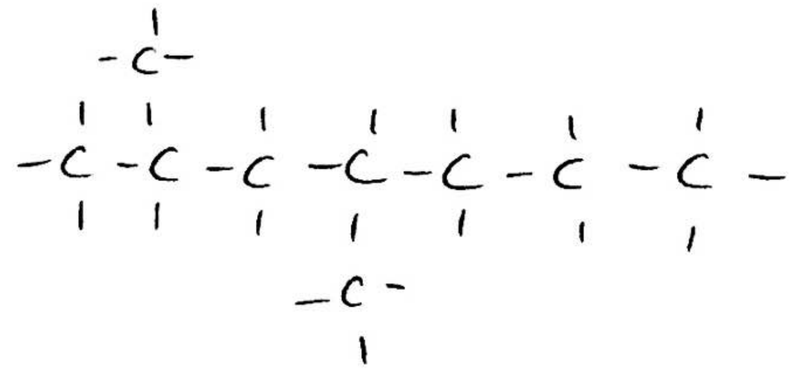
2) 3,3 – diethylhexane



3) 3,4 – dimethylhexane



4) 2,4 – dimethylheptane



Hydrocarbon Practice Problems

1. 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

2. Which compound is a saturated hydrocarbon?

*Alkane

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

3. Which compound is a member of the same homologous series as C_3H_8? (Alkane)

A) CH_4 B) C_4H_8 C) C_5H_8 D) C_5H_{10}

4. 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- (Table Q)

5. Which organic compound is a saturated hydrocarbon?

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

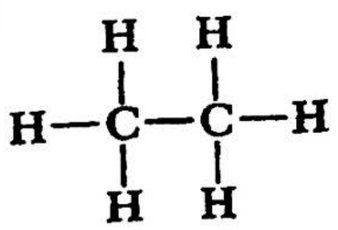
6. In saturated hydrocarbons, carbon atoms are bonded to each other by

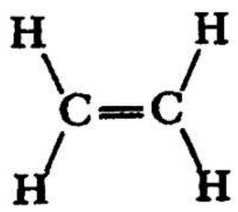
A) single covalent bonds, only
B) double covalent bonds, only
C) alternating single and double covalent bonds
D) alternating double and triple covalent bonds

7. What is the general formula for the members of the alkane series? (Table Q)

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

8. Which structural formula represents a saturated hydrocarbon? (Alkane)

A)


B)


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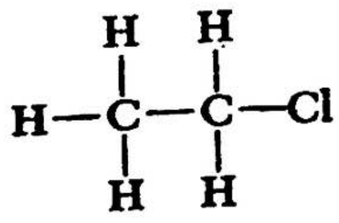
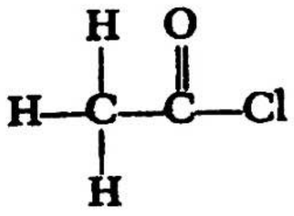


D)


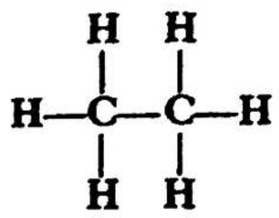
9. Ethane, ethene, and ethyne are all similar in that they are

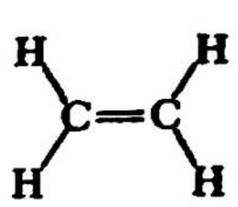
A) hydrocarbons
B) unsaturated compounds
C) saturated
D) cyclic compounds

10. A molecule of an unsaturated hydrocarbon must have

A) at least one single carbon-carbon bond
B) at least one multiple carbon-carbon bond
C) two or more single carbon-carbon bonds
D) two or more multiple carbon-carbon bonds

11. Which formula represents an unsaturated hydrocarbon?

A)


B) Double or Triple bond


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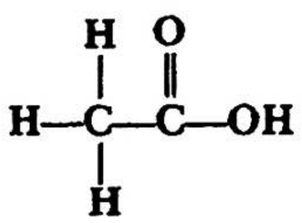

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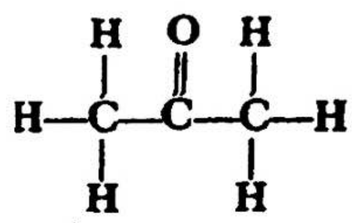
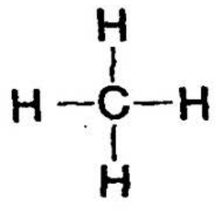


12. A double carbon-carbon bond is found in a molecule of

A) pentane B) pentene
C) pentyne D) pentanol

13. Which structural formula represents an unsaturated hydrocarbon?

A)


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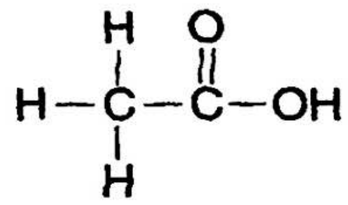

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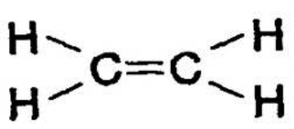
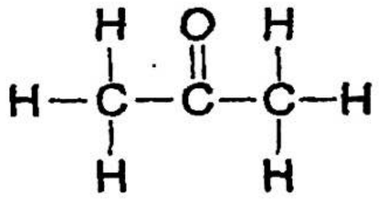


D)


14. A carbon-carbon triple bond is found in a molecule of

A) butane B) butanone
C) butene D) butyne (Alkyne)

Hydrocarbon Practice Problems

15. Which compound is an unsaturated hydrocarbon?

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

16. Which formula represents propyne?

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

17. What is the total number of electron pairs that are shared between the two carbon atoms in a molecule of ethyne?

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

18. Given the structural formula for ethyne:

H—C≡C—H

What is the total number of electrons shared between the carbon atoms?

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

19. Which series of hydrocarbons contains one triple covalent bond?

(A) alkyne B) alkadiene
C) alkane D) alkene

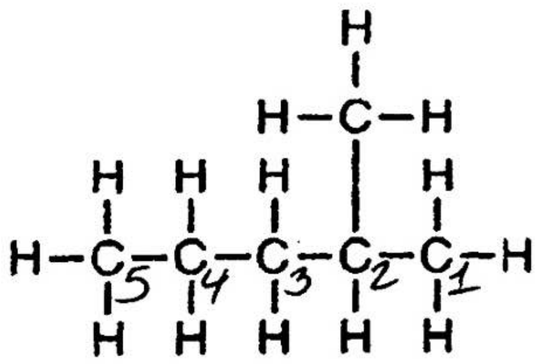
20. What is the total number of pairs of electrons shared between the two adjacent carbon atoms in an ethyne molecule? (Alkyne)

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

21. Which hydrocarbon is saturated? (Alkane)

A) C_2H_2 B) C_3H_4 C) C_4H_6 (D) C_4H_{10}

22. What is the IUPAC name of the organic compound that has the formula shown below?

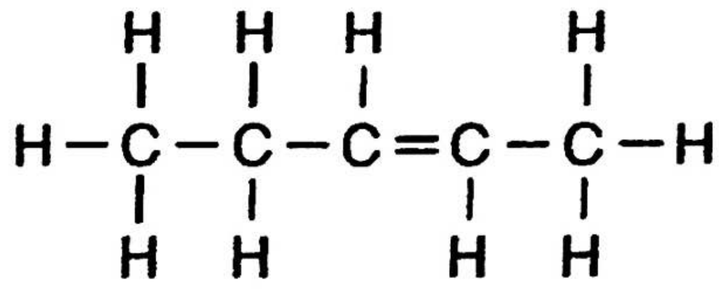


A) 1,1-dimethylbutane (B) 2-methylpentane
C) hexane D) 4-methylpentane

23. Which compound is a saturated hydrocarbon?

(A) CH_2CH_2 B) CH_3CH_3
C) CH_3CHO D) CH_3CH_2OH

24. Given the formula representing a compound:



What is a chemical name of this compound?

(A) 2-pentene B) 2-pentyne
C) 3-pentene D) 3-pentyne

25. Which formula represents an unsaturated hydrocarbon?

A) CH_4 (B) C_2H_4 C) C_3H_8 D) C_4H_{10}

26. 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}

27. Which compound is classified as a hydrocarbon?

A) butanal (B) butyne
C) 2-butanol D) 2-butanone

28. What is the number of electrons shared in the multiple carbon-carbon bond in one molecule of 1-pentyne?

(A) 6 B) 2 C) 3 D) 8

29. Which compound is an alkyne?

(A) C_2H_2 B) C_2H_4 C) C_4H_8 D) C_4H_{10}

30. Which atoms can bond with each other to form chains, rings, or networks?

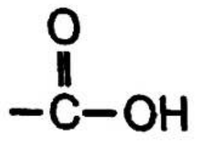
(A) carbon atoms B) hydrogen atoms
C) oxygen atoms D) nitrogen atoms

31. A molecule of an organic compound contains at least one atom of

(A) carbon B) chlorine
C) nitrogen D) oxygen

Function Group Practice Problems

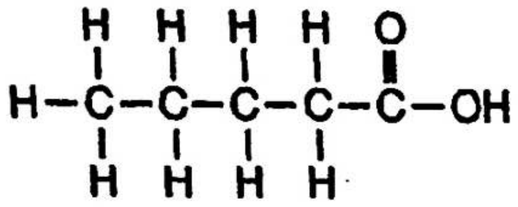
1. Given a formula of a functional group:



An organic compound that has this functional group is classified as

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

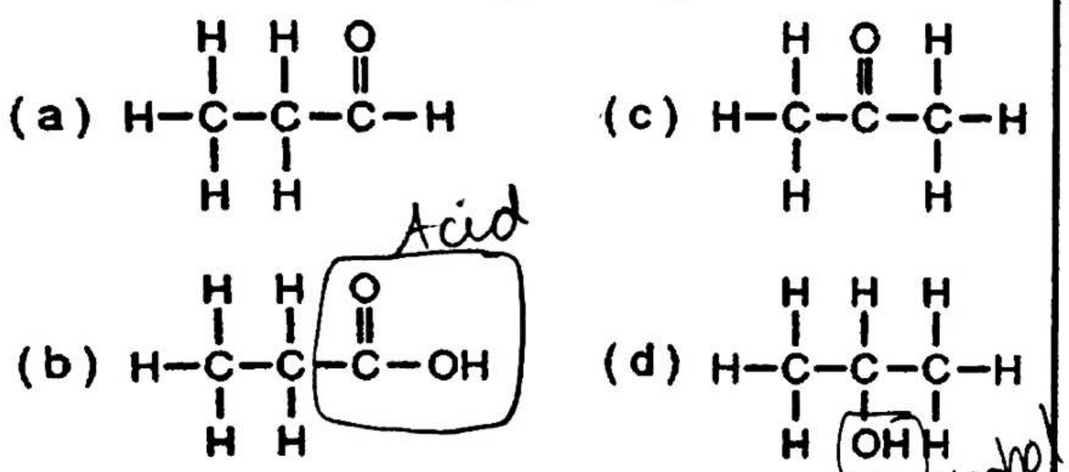
2. Given the formula for an organic compound:



This compound is classified as an

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

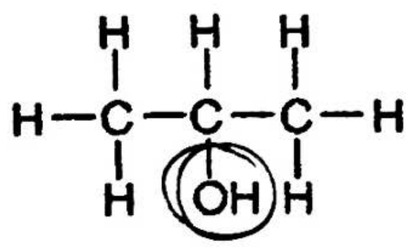
3. Given the formulas of four organic compounds:



Which pair below contains an alcohol and an acid?

A) *a* and *b*
B) *a* and *c*
C) *b* and *d*
D) *c* and *d*

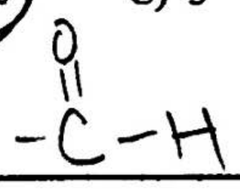
4. Which type of organic compound is represented by the structural formula shown below?



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

5. 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



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

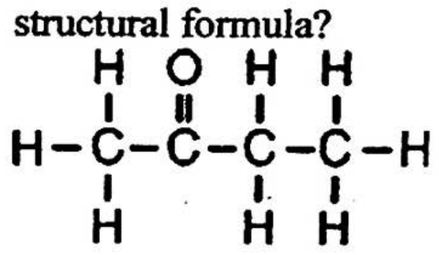
7. What is the IUPAC name for the compound that has the condensed structural formula $CH_3CH_2CH_2CHO$?

A) butanal
B) butanol
C) propanal
D) propanol

8. Which atom is bonded to the carbon atom in the functional group of a ketone?

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

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

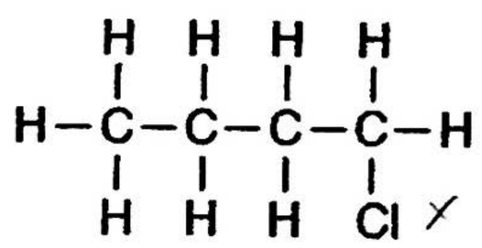


4 Carbons

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

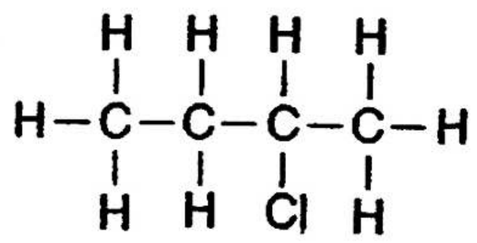
10. Which formula represents a molecule of 2-chlorobutane?

A)

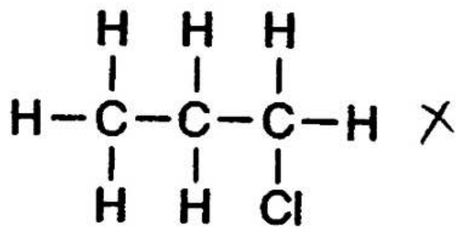


on 2nd C — Cl — 4 carbon alkane

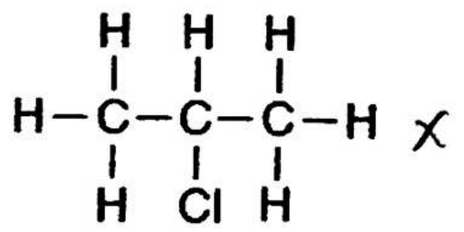
B)



C)



D)



Function Group Practice Problems

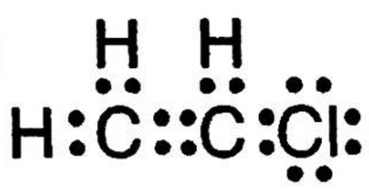
11. Which class of compounds contains *at least one* element from Group 17 of the Periodic Table?

A) aldehyde B) amine

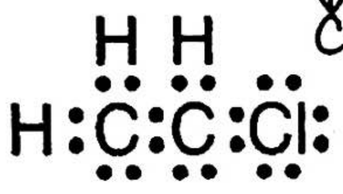
C) ester D) halide

12. Which Lewis electron-dot diagram represents chloroethene?

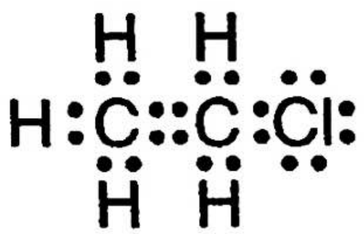
A)



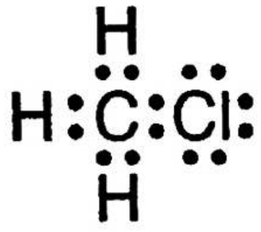
B)



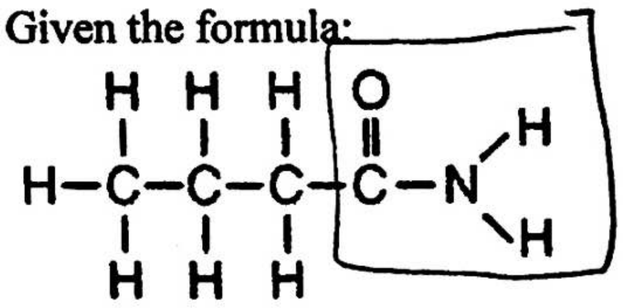
C)



D)



13. Given the formula:

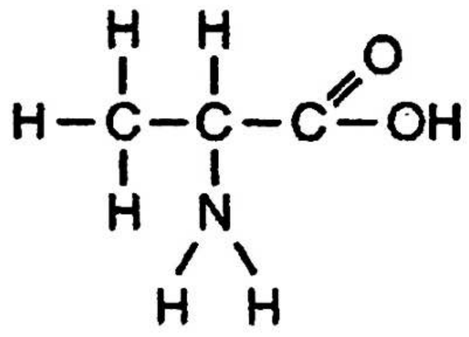


This compound is classified as

A) an aldehyde B) an amide

C) an amine D) a ketone

14. Given the structural formula:



This structural formula represents a molecule of

A) an aldehyde B) an ester

C) a ketone D) an amino acid

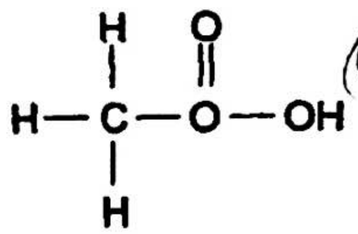
15. Which class of organic compounds has molecules that contain nitrogen atoms?

A) alcohol B) amine

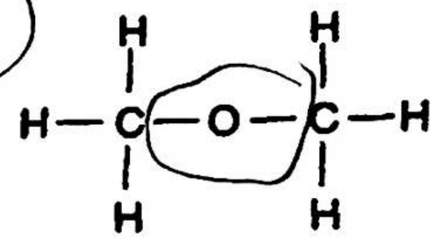
C) ether D) ketone

16. Which structural formula represents an ether?

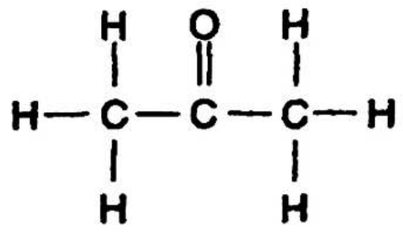
A)



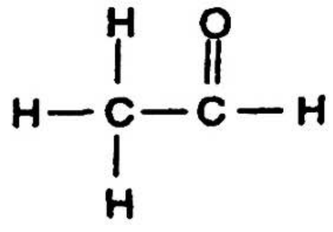
B)



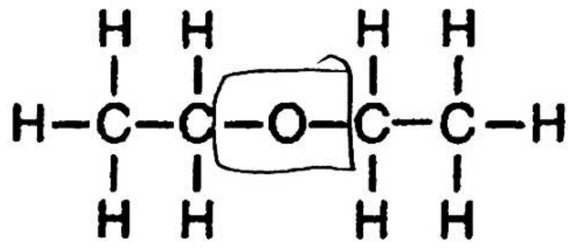
C)



D)



17. Given the structural formula:



The compound represented by this formula can be classified as an

A) organic acid B) ether

C) ester D) aldehyde

Name: Answer Key

Organic Reactions

3 1. Which substances are products of a fermentation reaction?

1) water and carbon dioxide
2) soap and glycerol
3) alcohol and carbon dioxide
4) ester and water

Sugar → Alcohol + CO_2

2 2. The principal products of saponification, a reaction between a fat and a base, are soap and

1) water
2) glycerol
3) carbon dioxide
4) ethyl alcohol

2 3. When C_3H_8 burns completely in an excess of oxygen, the products formed are Combustion

1) CO and H_2O
2) CO_2 and H_2O
3) CO and H_2
4) CO_2 and H_2

1 4. Which type of reaction is represented by the equation

Alkane

$CH_4 + Br_2 \rightarrow CH_3Br + HBr$?

1) substitution
2) addition
3) esterification
4) polymerization

4 5. Which organic reaction involves the bonding of monomers by a dehydration process?

1) substitution
2) oxidation
3) addition polymerization
4) condensation polymerization

n (monomers) → (monomer)$_n$ + H_2O

3 6. Which equation represents an addition reaction?

1) $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$
2) $C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$
3) $C_3H_6 + Cl_2 \rightarrow C_3H_6Cl_2$
4) $C_4H_{10} + Cl_2 \rightarrow C_4H_9Cl + HCl$

HC + Halogen → 1 product

3 7. Given the equation:

$C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$

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

7) Esterification:

Alcohol + Org. Acid → Ester + H_2O

+ Scantsx

2 8. Which equation represents fermentation?

1) $C_2H_6 + Cl_2 \rightarrow C_2H_6Cl + HCl$
2) $C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$
3) $CH_3COOH + CH_3OH \rightarrow CH_3COOCH_3 + H_2O$
4) $nC_2H_4 \rightarrow (C_2H_4)n$

1 9. Which reaction is an organic reaction?

1) $C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O\ (g)$ ✓
2) $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O\ (g)$
3) $3\ Cu^{2+}(aq) + 2\ Fe(s) \rightarrow 3\ Cu(s) + 2\ Fe^{3+}(aq)$
4) $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

3 10. Which reaction best represents the complete combustion of ethene? → C_2H_4

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) $C_2H_4 + H_2O \rightarrow C_2H_5OH$

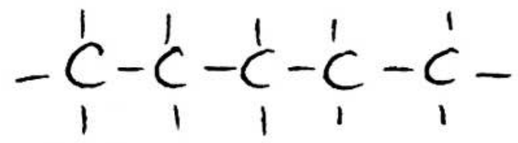
2 11. What is the name of the process that begins with the joining of monomer molecules?

1) fermentation
2) polymerization
3) esterification
4) hydrogenation

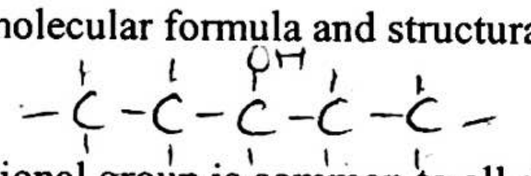
3 12. The reaction $nC_2H_4 \rightarrow (-C_2H_4-)_n$ is an example of

1) saponification
2) esterification
3) polymerization
4) fermentation

13. Write the molecular formula and structural formula of pentane.



14. *a* Write the molecular formula and structural formula of 3-pentanol.

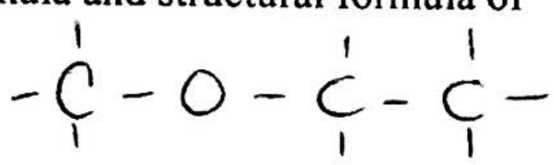


$C_5H_{11}OH$

b What functional group is common to all alcohols?

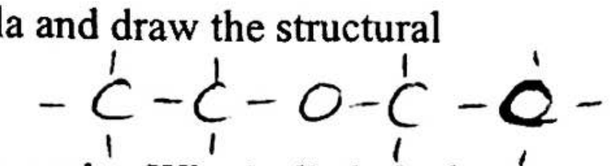
-OH

15. Write the molecular formula and structural formula of methyl ethyl ether.



16. Diethyl ether is historically used as an anesthetic. It is insoluble in water but mixes with many organic solvents and is widely used as a solvent itself, e.g., for fats and oils.

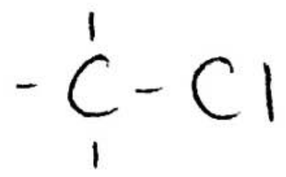
a) Write the molecular formula and draw the structural formula of diethyl ether.



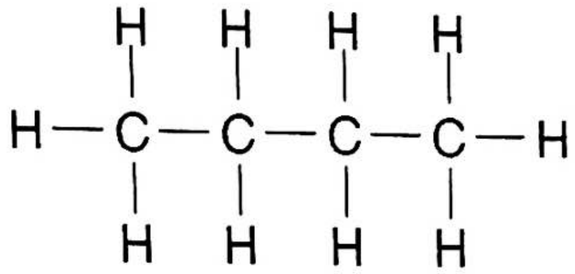
b) Based upon its structural formula. Why is diethyl ether such a good solvent of fats and oils?

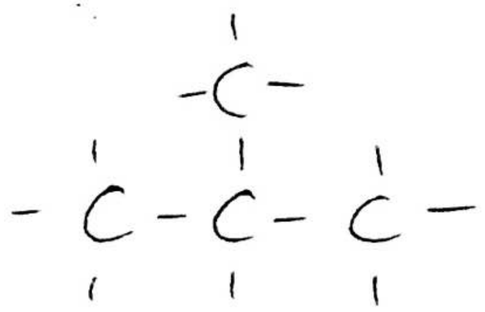
It's non-polar

17. Write the molecular formula and structural formula of chloromethane.



18. Given the structural formula for butane:

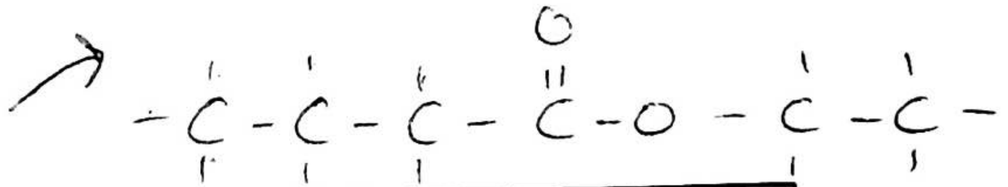




Draw the structural formula of an isomer of butane.

19. Given the ester: ethyl butanoate

a. In the space provided below, draw the structural formula for this ester.



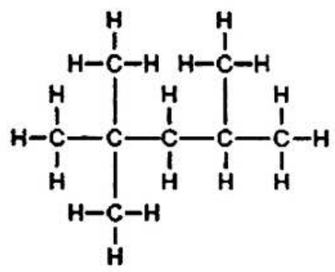
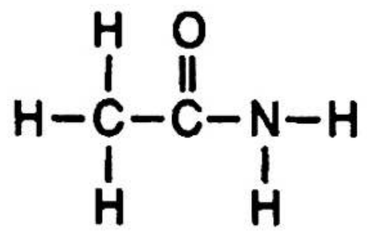
b. Determine the gram formula mass of this ester. C → (12)(6) = 72 O → (16)(2) = 32
H → (1)(12) = 12

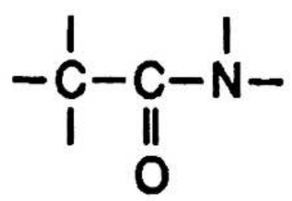
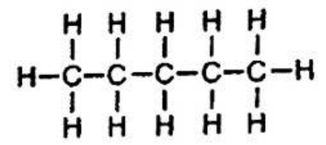
72
12
+32
116

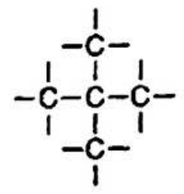
20. How is the bonding between carbon atoms different in unsaturated hydrocarbons and saturated hydrocarbons?

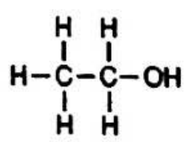
There are all single bonds between the carbons in saturated hydrocarbons.

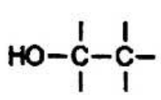
Answer Key
RR Organic

1. B
2. A
3. B
4. B
5. A
6. B
7. B
8. B
9. D
10. C
11. A
12. C
13. D
14. A
15. B
16. D
17. A
18. C
19. A
20. A
21. A
22. A
23. A
24. A
25. A
26. D
27. B
28. D
29. B
30. A
31. D
32. B
33. B
34. D
35. D
36. B
37. B
38. C
39. C
40. D
41. –Zymase provides an alternate reaction pathway. –A reaction that involves zymase has a lower activation energy.
42. – –OH –alcohol group
43. fermentation
44. —covalent bonds and ionic bonds —polar and nonpolar —single and double
45. ester *or* esters
46. saponification
47. The molecular formulas of the two hydrocarbons are the same, but the structural formulas are different.
48. —A hydrocarbon 1 molecule has two carbon-carbon double bonds and a hydrocarbon 2 molecule has one carbon-carbon triple bond. —Both hydrocarbons have at least one multiple covalent bond between two carbon atoms.
49. – alkene *or alkenes.*
50. – addition – halogenation – bromination
51. alcohol *or* alcohols.
52. Acceptable responses include, but are not limited to: • propene
53. Acceptable responses include, but are not limited to: The C_3H_6 is unsaturated because each molecule has a double covalent bond between two of its carbon atoms. There is a carbon-carbon double bond in each molecule
54. –OH *or* alcohol *or* hydroxyl
55. 
56. 92
57. 


58. amine *or* –COOH
59. • nonpolar covalent • covalent • a network of covalent bonds
60. 


61. • All of the carbon-carbon bonds are single covalent bonds. • There are only single bonds between the carbon atoms.
62. • alkane • C_nH_{2n+2}
63. Examples: The balanced equation shows energy as a product of the reaction.; Energy is on the right side of the arrow.
64. Example: combustion
65. Answer: ester
66. Examples: With only one carbon atom bonded to one oxygen atom, there can be no rings or chains with branches in the molecular structure.; There are too few atoms to create a different molecular structure.
67. Answer: methanol *or* methyl alcohol
68. **Examples of 1-credit responses:**





Answer Key
RR Organic

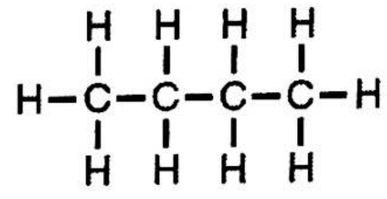
69. _____$C_6H_{12}O_6$ $\xrightarrow{\text{zymase}}$ _2_ C_2H_5OH + _2_ CO_2 + Energy

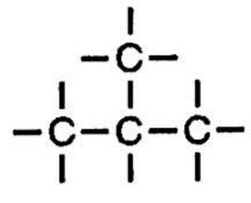
70. *Examples:* – esterification – dehydration synthesis

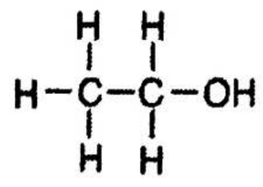
71. *Examples:* – A butanoic acid molecule has four carbon atoms and an ethanol molecule has two carbon atoms. – Butanoic acid has a different functional group than ethanol. – A butanoic acid molecule has more hydrogen atoms than an ethanol molecule. – In a butanoic acid molecule, one oxygen atom has a double bond and in an ethanol molecule, the oxygen atom has two single bonds.

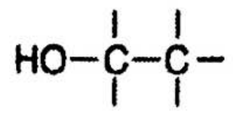
72. 231 K

73. *Examples:* – pentane – C_5H_{12}

74. 



75. 



76. $C_6H_{12}O_2$

77. *Examples:* – esterification – dehydration synthesis

78. The molecules of

79. *Examples:* – A 2-methylpropane molecule has only single carbon-carbon bonds. – There are only single bonds in methylpropane. – no multiple bonds between carbon atoms

80. *Examples:* – halide – halocarbon – alkyl halide

81. +5

82. The activation energy results from striking the balls together.

83. $\frac{6690g}{62.0g/mol}$ and 108 mol

84. Water and 1,2-ethanediol molecules are both polar.

85. alcohol

86.