

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

Overview:

Organic chemistry is the study of carbon compounds. Carbon has the ability to not only form bonds with other elements but also bond indefinitely with other carbon atoms. Therefore, there are an enormous number of organic compounds. To help with the study of organic compounds, a systematic means of naming these compounds has been developed. One of these rules is the use of prefixes indicating the number of carbon atoms in the molecule.

The Table:

This table gives the prefixes used to indicate the number of carbon atoms in the longest continuous chain of carbon atoms in the molecule. The prefixes for 5 through 10 carbon atoms are Greek numerical prefixes for that number of carbon atoms.

Additional information:

- Methane (CH_4) is also known as natural gas.
- Propane (C_3H_8) is used as a fuel for gas grills.
- Butane (C_4H_{10}) is used in lighters for gas grills.
- Octane (C_8H_{18}) is used in the anti-knock rating of gasoline.

Organic Prefixes

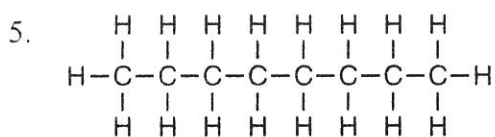
— Set 1 —

1. Which element must be present in an organic compound?
- (1) hydrogen
(2) oxygen
(3) carbon
(4) nitrogen
- 1 _____

2. What is the total number of carbon atoms in a molecule of ethanoic acid?
- (1) 1 (3) 3
(2) 2 (4) 4
- 2 _____

3. A molecule of butane and a molecule of 2-butene both have the same total number of
- (1) carbon atoms
(2) hydrogen atoms
(3) single bonds
(4) double bonds
- 3 _____

4. A molecule of octane has how many more carbon atoms than a molecule of methane?
- (1) 1 (3) 5
(2) 3 (4) 7
- 4 _____



The above hydrocarbon molecule would have a prefix of

- (1) meth- (3) oct-
(2) but- (4) non-
- 5 _____

— Set 2 —

6. Which would be the proper prefix of the following hydrocarbon
- $$\text{CH}_3\text{CH}_2\text{CHCH}_2$$
- (1) eth- (3) but-
(2) prop- (4) penti-
- 6 _____

7. The more carbon atoms a compound has, the more isomers it will have. Which prefix would indicate the greatest number of isomers?
- (1) hept- (3) meth-
(2) but- (4) dec-
- 7 _____

8. A molecule of a compound contains a total of 10 hydrogen atoms and has the general formula $\text{C}_n\text{H}_{2n+2}$. Which prefix is used in the name of this compound?
- (1) but- (3) oct-
(2) dec- (4) pent-
- 8 _____

9. What is the correct formula for pentene?
- (1) C_4H_8 (3) C_7H_{14}
(2) C_4H_{12} (4) C_5H_{10}
- 9 _____

10. Which hydrocarbon is unsaturated, containing a triple bond and has 8 carbon atoms?
- (1) butane (3) octyne
(2) butyne (4) decyne
- 10 _____

Table Q Homologous Series of Hydrocarbons

Name	General Formula	Examples	
		Name	Structural Formula
alkanes	C_nH_{2n+2}	ethane	<pre> H H H — C — C — H H H </pre>
alkenes	C_nH_{2n}	ethene	<pre> H H \ / C = C / \ H H </pre>
alkynes	C_nH_{2n-2}	ethyne	$H-C\equiv C-H$

n = number of carbon atoms

Overview:

Organic compounds may be classified in homologous series. A homologous series is a group of compounds having related structures and properties. Each member of a homologous series differs from the preceding by a common increment – this being one carbon atom and two hydrogen atoms. Any homologous series can be represented by a general formula.

The Table:

This table gives the Name, General Formula and Examples of the Structural Formula of three homologous series of hydrocarbons. A hydrocarbon is a compound composed of only carbon and hydrogen.

Homologous Series:

The *alkanes* are saturated hydrocarbons, having only single bonds between adjacent carbon atoms. The name of each alkane ends in –ane. The prefix from Table P indicates the number of carbon atoms. Their chemical formula must match the General Formula given in the table.

The *alkenes* are unsaturated hydrocarbons, having one double bond between two adjacent carbon atoms. The name of each alkene ends in –ene. The prefix from Table P indicates the number of carbon atoms. Their chemical formula must match the General Formula given in the table.

The *alkynes* are unsaturated hydrocarbons, having one triple bond between two adjacent carbon atoms. The name of each alkyne ends in –yne. The prefix from Table P indicates the number of carbon atoms. Their chemical formula must match the General Formula given in the table.

In the General Formula, n represents the number of carbon atoms in the molecule.

General Formula examples:

- (1) A hydrocarbon from the alkane series contains 4 carbon atoms. What is its molecular formula?

Solution: $n = 4$ and the general formula for alkanes is C_nH_{2n+2} .

Substitution gives: $C_4H_{2(4)+2} = C_4H_{10}$ (butane)

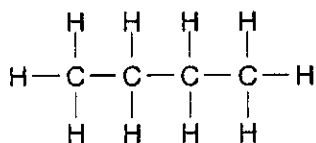
- (2) What homologous series does the hydrocarbon C_3H_4 belong to?

Solution: The number of carbon atoms is 3, thus $n = 3$.

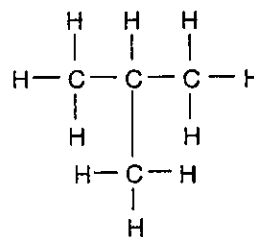
Substituting in the general formula for the alkyne series: $C_3H_{2(3)-2} = C_3H_4$

Additional information:

- A double bond consists of two shared pairs of electrons (4 electrons). A triple bond consists of three shared pairs of electrons (6 electrons).
- Isomers are compounds with the same molecular formula (number of atoms of each element) but different structural formulas. Structural formulas show the different arrangement of the atoms in the molecules of the isomers of a given compound. The greater the number of carbon atoms in the molecule, the greater the number of isomers. The first hydrocarbon to show isomerism is butane. The structural formulas for the two isomers of butane (C_4H_{10}) are:



Normal butane or n-butane



Isobutane or 2-methylpropane

- Hydrocarbons contain covalent bonds and the molecules are nonpolar.
- As the molecular mass increases in a homologous series of hydrocarbons, the boiling point of the compounds increases.

Set 1 — Homologous Series of Hydrocarbons

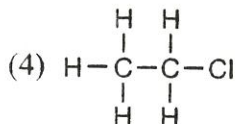
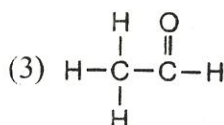
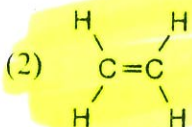
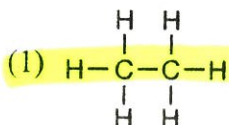
1. Which element has atoms that can form single, double, and triple covalent bonds with other atoms of the same element?
(1) hydrogen (3) fluorine
(2) oxygen (4) carbon 1 _____
2. What is the general formula for the members of the alkane series?
(1) C_nH_{2n}
(2) C_nH_{2n+2}
(3) C_nH_{2n-2}
(4) C_nH_{2n-6} 2 _____
3. Which hydrocarbon is saturated?
(1) propene
(2) ethyne
(3) butene
(4) heptane 3 _____
4. Which formula represents a saturated hydrocarbon?
(1) C_2H_2 (3) C_3H_4
(2) C_2H_4 (4) C_3H_8 4 _____
5. A double carbon-carbon bond is found in a molecule of
(1) pentane (3) pentyne
(2) pentene (4) pentanol 5 _____
6. Which formula represents an unsaturated hydrocarbon?
(1) C_2H_6 (3) C_5H_8
(2) C_3H_8 (4) C_6H_{14} 6 _____
7. Which general formula represents the homologous series of hydrocarbons that includes the compound 1-heptyne?
(1) C_nH_{2n-6}
(2) C_nH_{2n-2}
(3) C_nH_{2n}
(4) C_nH_{2n+2} 7 _____
8. Which formula represents propyne?
(1) C_3H_4 (3) C_5H_8
(2) C_3H_6 (4) C_5H_{10} 8 _____
9. What is the total number of electrons shared in the bonds between the two carbon atoms in a molecule of
 $H - C \equiv C - H$?
(1) 6 (3) 3
(2) 2 (4) 8 9 _____
10. Which formula represents an alkene?
(1) C_2H_6 (3) C_4H_{10}
(2) C_3H_6 (4) C_5H_{12} 10 _____

11. Which compound is classified as a hydrocarbon?

- (1) ethane
- (2) ethanol
- (3) chloroethane
- (4) ethanoic acid

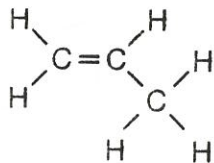
11 _____

12. Which formula represents an unsaturated hydrocarbon?



12 _____

13. Given the structural formula:

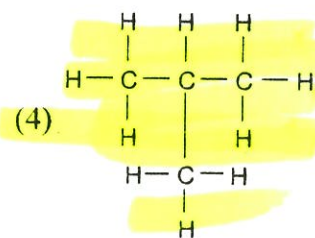
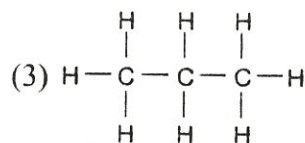
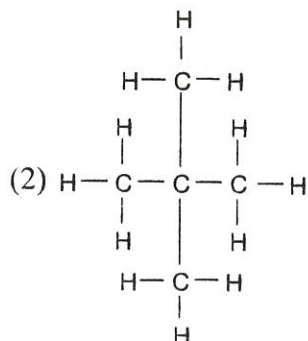
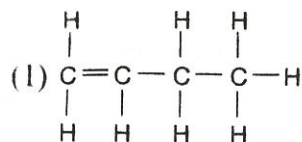


What is the IUPAC name of this compound?

- (1) propane
- (2) propene
- (3) propanone
- (4) propanal

13 _____

14. Which formula is an isomer of butane?



14 _____

15. Which compound is a saturated hydrocarbon?

- (1) hexane
- (2) hexene
- (3) hexanol
- (4) hexanal

15 _____

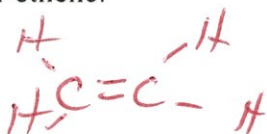
Base your answers to question 16 using the information below and your knowledge of chemistry.

Ethene (common name ethylene) is a commercially important organic compound. Millions of tons of ethene are produced by the chemical industry each year. Ethene is used in the manufacture of synthetic fibers for carpeting and clothing, and it is widely used in making polyethylene. Low-density polyethylene can be stretched into a clear, thin film that is used for wrapping food products and consumer goods. High-density polyethylene is molded into bottles for milk and other liquids.

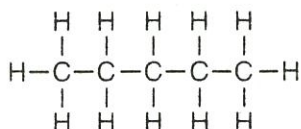
16. a) Explain, in terms of bonding, why ethene is an unsaturated hydrocarbon.

Ethene belongs to the alkene family + has double bonds + can react

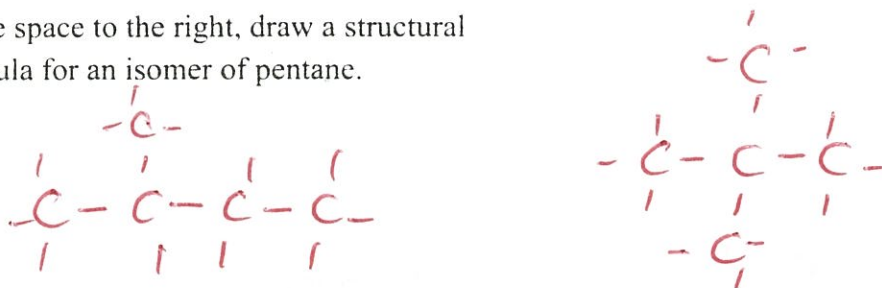
b) Draw the structural formula for ethene.



17. Given the structural formula of pentane:



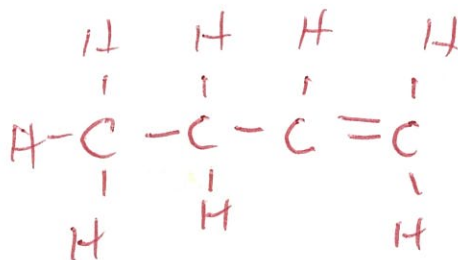
In the space to the right, draw a structural formula for an isomer of pentane.



Base your answers to question 18 on the condensed structural formula below.



18. In the space below, draw the structural formula for this compound.



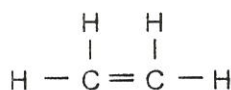
Set 2 — Homologous Series of Hydrocarbons

19. Which compound is an unsaturated hydrocarbon?

- (1) hexanal
- (2) hexane
- (3) hexanoic acid
- (4) hexyne

19 _____

20. Given the compound:



The symbol = represents

- (1) one pair of shared electrons
- (2) two pairs of shared electrons
- (3) a single covalent bond
- (4) a coordinate covalent bond

20 _____

21. Which general formula represents the compound $\text{CH}_3\text{CH}_2\text{CCH}$?

- (1) C_nH_n
- (2) C_nH_{2n}
- (3) $\text{C}_n\text{H}_{2n-2}$
- (4) $\text{C}_n\text{H}_{2n+2}$

C_4H_6

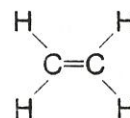
21 _____

22. Which formula represents an unsaturated hydrocarbon?

- (1) CH_2CHCl
- (2) $\text{CH}_3\text{CH}_2\text{Cl}$
- (3) $\text{CH}_3\text{CH}_2\text{CH}_3$
- (4) CH_3CHCH_2

22 _____

23. What is the correct name for the substance represented by the structural formula below?



- (1) acetylene
- (2) benzene
- (3) ethene
- (4) propene

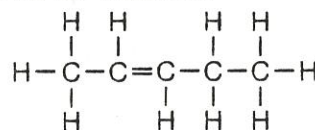
23 _____

24. What is the maximum number of covalent bonds that can be formed by one carbon atom?

- (1) 1
- (2) 2
- (3) 3
- (4) 4

24 _____

25. Given the formula:



What is the IUPAC name of this compound?

- (1) 2-pentene
- (2) 2-pentyne
- (3) 2-butene
- (4) 2-butyne

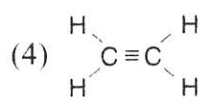
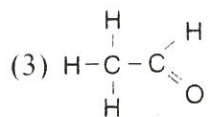
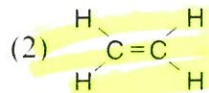
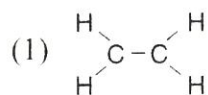
25 _____

26. Which compound is a saturated hydrocarbon?

- (1) CH_2CH_2
- (2) CH_3CH_3
- (3) CH_3CHO
- (4) $\text{CH}_3\text{CH}_2\text{OH}$

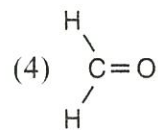
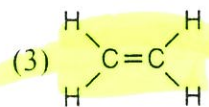
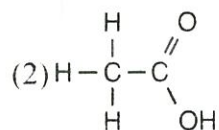
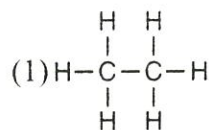
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27. Which structural formula correctly represents a hydrocarbon molecule?



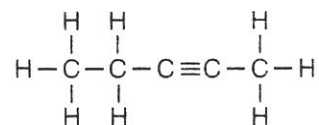
27 _____

28. Which structural formula represents an unsaturated hydrocarbon?



28 _____

29. What is the IUPAC name of the compound with the structural formula shown below?



(1) 2-pentene

(2) 3-pentene

(3) 2-pentyne

(4) 3-pentyne

29 _____

30. The three isomers of pentane have different

(1) formula masses

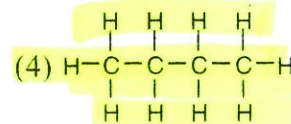
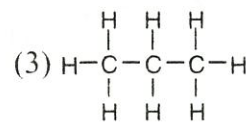
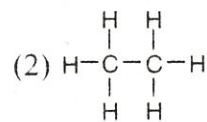
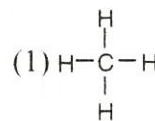
(2) molecular formulas

(3) empirical formulas

(4) structural formulas

30 _____

31. Which compound has an isomer?



31 _____

Overview:

In Table Q you were introduced to homologous series of hydrocarbons. In this table other homologous series of organic compounds are shown. These organic compounds are formed when one or more hydrogen atoms of a hydrocarbon were replaced by other atoms or groups of atoms. These groups of atoms are called functional groups. A functional group is a particular arrangement of atoms, which gives characteristic properties to an organic molecule.

The Table:

The table shows the Class of Compound, Functional Group, General Formula and an Example of a compound containing that functional group. The R (in the General Formula) represents what is left of the hydrocarbon molecule after one or more of the hydrogen atoms of that molecule have been replaced by a different atom or group of atoms called the functional group. The name of the new compound is based on the nature of the functional group. The names of the compounds in each series are based on the name of the hydrocarbon containing the same number of carbon atoms as in the longest continuous chain of carbon atoms in the molecule that contains the functional group.

To better understand how this table works, the first two Classes of Compounds (halide and alcohol) will be explained in detail. (See next page.)

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	$\begin{array}{c} O \\ \\ -C-H \end{array}$	$\begin{array}{c} O \\ \\ R-C-H \end{array}$	$\begin{array}{c} O \\ \\ CH_3CH_2C-H \end{array}$ propanal
ketone	$\begin{array}{c} O \\ \\ -C- \end{array}$	$\begin{array}{c} O \\ \\ R-C-R' \end{array}$	$\begin{array}{c} O \\ \\ CH_3CCH_2CH_2CH_3 \end{array}$ 2-pentanone
organic acid	$\begin{array}{c} O \\ \\ -C-OH \end{array}$	$\begin{array}{c} O \\ \\ R-C-OH \end{array}$	$\begin{array}{c} O \\ \\ CH_3CH_2C-OH \end{array}$ propanoic acid
ester	$\begin{array}{c} O \\ \\ -C-O- \end{array}$	$\begin{array}{c} O \\ \\ R-C-O-R' \end{array}$	$\begin{array}{c} O \\ \\ CH_3CH_2COCH_3 \end{array}$ methyl propanoate
amine	$\begin{array}{c} \\ -N- \end{array}$	$\begin{array}{c} R' \\ \\ R-N-R'' \end{array}$	$CH_3CH_2CH_2NH_2$ 1-propanamine
amide	$\begin{array}{c} O \\ \\ -C-NH \end{array}$	$\begin{array}{c} O \quad R' \\ \quad \\ R-C-NH \end{array}$	$\begin{array}{c} O \\ \\ CH_3CH_2C-NH_2 \end{array}$ propanamide

R represents a bonded atom or group of atoms.

Halides:

The first row shows the class of compounds called the halides or halocarbons. A halide is produced when a Group 17 element (the halogens) replaces a hydrogen atom in a hydrocarbon molecule. These elements are shown as the Functional Group. The general formula for a halide is then R-X, where X represents any halogen. In the example shown, a chlorine atom has taken the place of one hydrogen atom from the hydrocarbon molecule. In naming the compound, the name of the halogen is modified to end in -o, hence chloro-. The rest of the name is derived from the name of the corresponding hydrocarbon with the same number of carbon atoms, in this case propane (3 carbon atoms, see Table P). The number 2 in the name represents the position of the chlorine atom in the chain of carbon atoms, in this case, the second from either end.

Alcohols:

The second row shows the class of compounds known as the alcohols. All alcohols must contain the -OH functional group. The general formula is then R-OH. The example shows this functional group (-OH) attached to the end of this molecule. The naming of the alcohols is done by replacing the final -e of the hydrocarbon name with -ol.

As the table shows, each class of compounds has a different functional group. The name of the compound indicates the functional group present in the compound. The name of the parent hydrocarbon is usually modified by replacing the final -e of the name with a suffix indicating that class of compounds or functional group. *For example:*

alcohols end in -ol	ketones end in -one	organic acids end in -oic
aldehydes end in -al	esters end in -ate	amines end in -ine

If necessary, the longest chain of carbon atoms is numbered to show the position of the functional group in that chain, using the smallest number.

Additional information:

- The -OH of the alcohols does not ionize to produce the hydroxide ion (see Table E) that produces a basic solution.
- Esterification is the reaction between an acid and an alcohol to produce an ester and water. Organic esters are characterized by a pleasant taste and fragrance. They are used in artificial flavorings.
- Examples of organic compounds found in Table R:

Ethyl alcohol ($\text{CH}_3\text{CH}_2\text{OH}$) is the alcohol found in alcoholic beverages and is the product of the fermentation reaction.

2-propanol ($\text{CH}_3\text{CHOHCH}_3$) is rubbing alcohol.

Diethyl ether ($\text{C}_2\text{H}_5\text{OC}_2\text{H}_5$) is operating room ether.

Methanal (HCHO), an aldehyde, also called formaldehyde, is a liquid used to preserve animal specimens.

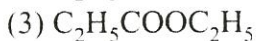
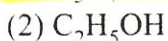
Propanone (CH_3COCH_3), a ketone, also called acetone, is a common industrial solvent.

Ethanoic acid (CH_3COOH), an organic acid, also called acetic acid, is in vinegar.

Set 1 — Organic Functional Groups

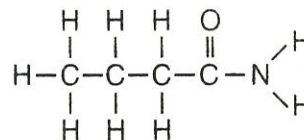
1. The functional group ---COOH is found in
 (1) esters
 (2) aldehydes
 (3) alcohols
 (4) organic acids 1 _____
2. One molecule of propanol contains a total of
 (1) one ---OH group
 (2) two ---CH_3 groups
 (3) three ---OH groups
 (4) three ---CH_3 groups 2 _____
3. If a compound contains only one ---OH functional group attached to the end carbon in the chain, it is classified as a
 (1) halide
 (2) alcohol
 (3) ether
 (4) ketone 3 _____
4. Given the structural formula:
- $$\begin{array}{ccccccc}
 & \text{H} & \text{H} & & \text{H} & \text{H} & \\
 & | & | & & | & | & \\
 \text{H} & -\text{C} & -\text{C} & -\text{O} & -\text{C} & -\text{C} & -\text{H} \\
 & | & | & & | & | & \\
 & \text{H} & \text{H} & & \text{H} & \text{H} &
 \end{array}$$
- The compound represented by this formula can be classified as an
 (1) organic acid
 (2) ether
 (3) ester
 (4) aldehyde 4 _____
5. The organic compound represented by the condensed structural formula
 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
 is classified as an
 (1) alcohol
 (2) aldehyde
 (3) ester
 (4) ether 5 _____
6. What is the IUPAC name for the compound that has the condensed structural formula $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$?
 (1) butanal (3) propanal
 (2) butanol (4) propanol 6 _____
7. The compounds 2-butanol and 2-butene both contain
 (1) double bonds, only
 (2) single bonds, only
 (3) carbon atoms
 (4) oxygen atoms 7 _____
8. Given the formulas of four organic compounds:
- | | |
|--|--|
| $ \begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad \\ \text{(a) } \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $ | $ \begin{array}{c} \text{H} \quad \text{O} \quad \text{H} \\ \quad \quad \\ \text{(c) } \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $ |
| $ \begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad \\ \text{(b) } \text{H}-\text{C}-\text{C}-\text{C}-\text{OH} \\ \quad \\ \text{H} \quad \text{H} \end{array} $ | $ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{(d) } \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{OH} \quad \text{H} \end{array} $ |
- Which pair below contains an alcohol and an acid?
 (1) *a* and *b* (3) *b* and *d*
 (2) *a* and *c* (4) *c* and *d* 8 _____

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



9 _____

10. Given the formula:



This compound is classified as

(1) an aldehyde

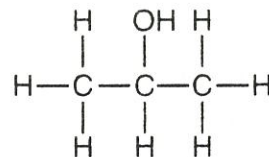
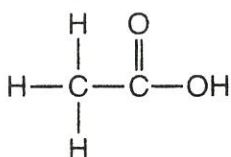
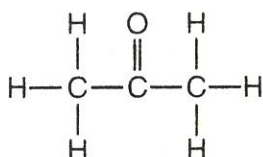
(2) an amide

(3) an amine

(4) a ketone

10 _____

Given the three organic structural formulas shown below:



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

(1) ester, organic acid, ketone

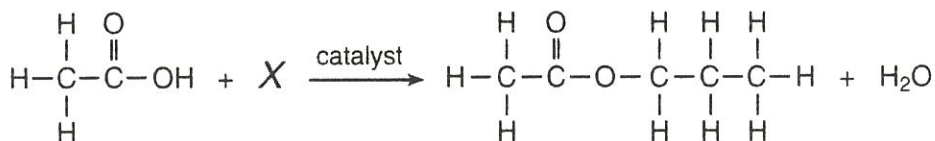
(3) ketone, aldehyde, alcohol

(2) ester, aldehyde, organic acid

(4) ketone, organic acid, alcohol

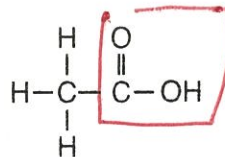
11 _____

Base your answers to question 12 using the information below and your knowledge of chemistry.



The incomplete equation below represents an esterification reaction. The alcohol reactant is represented by **X**.

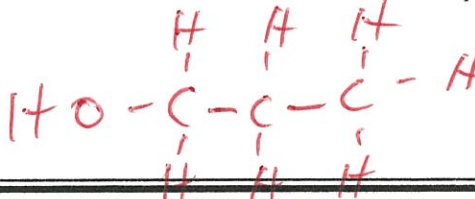
12. a) On the accompanying structural formula, circle the acid functional group, only.



b) Write an IUPAC name for the reactant represented by its structural formula in this equation.

Ethanoic Acid.

c) In the space in below, draw the structural formula for the alcohol represented by **X**.

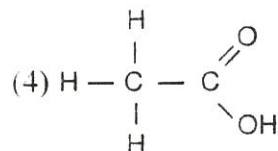
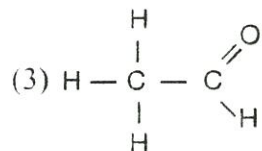
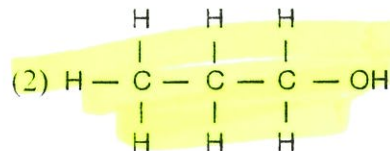
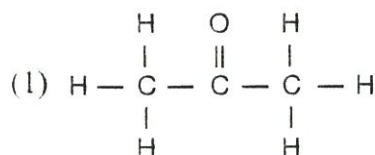


Set 2 — Organic Functional Groups

13. Which compound is an alcohol?

- (1) propanal (3) butane
 (2) ethyne (4) methanol 13 _____

14. Which structural formula represents an alcohol?

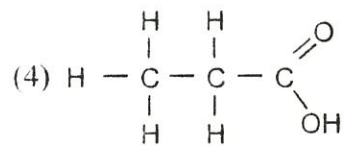
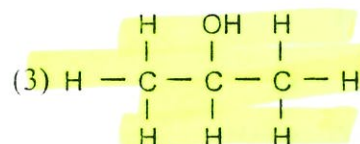
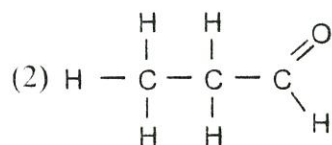
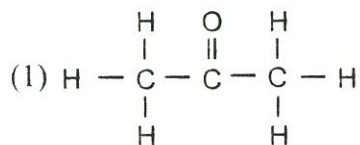


14 _____

15. Which formula does not show a functional group?

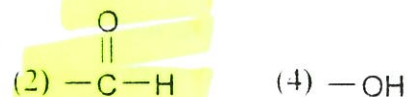
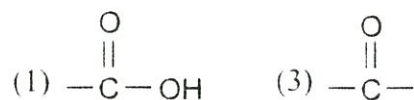
- (1) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
 (2) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
 (3) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
 (4) $\text{CH}_3\text{CH}_2\text{COOCH}_3$ 15 _____

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



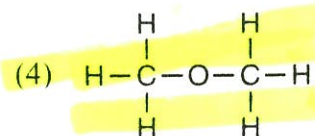
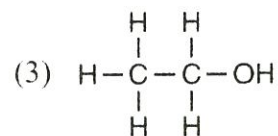
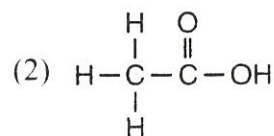
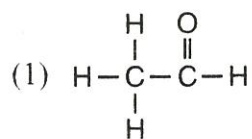
16 _____

17. Which functional group, when attached to a chain of carbon atoms, will produce an organic molecule with the characteristic properties of an aldehyde?



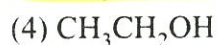
17 _____

18. Which structural formula represents an ether?



18 _____

19. Which formula represents a ketone?



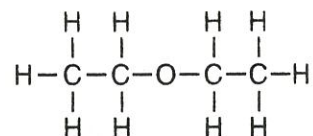
19 _____

20. Which organic compounds are often used to create fragrances for the perfume industry?

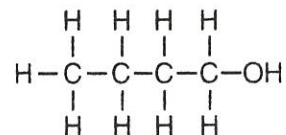


20 _____

21. Given the formulas for two compounds:



and



These compounds differ in

(1) gram-formula mass

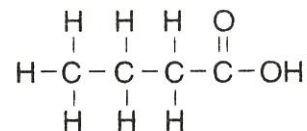
(2) molecular formula

(3) percent composition by mass

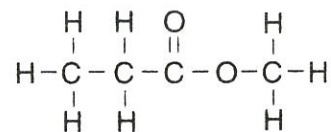
(4) physical properties at STP

21 _____

22. Given the structural formulas for two organic compounds:



and



The differences in their physical and chemical properties are primarily due to their different

(1) number of carbon atoms

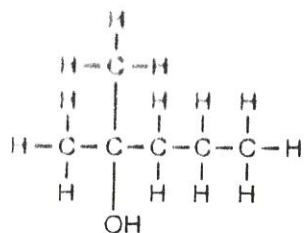
(2) number of hydrogen atoms

(3) molecular masses

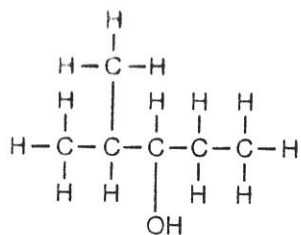
(4) functional groups

22 _____

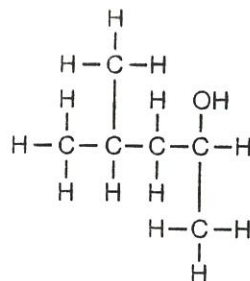
23. Which structural formula is correct for 2-methyl-3-pentanol?



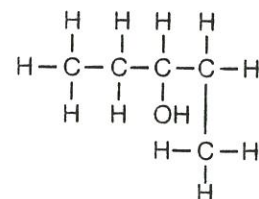
(1)



(2)



(3)



(4)

23 _____

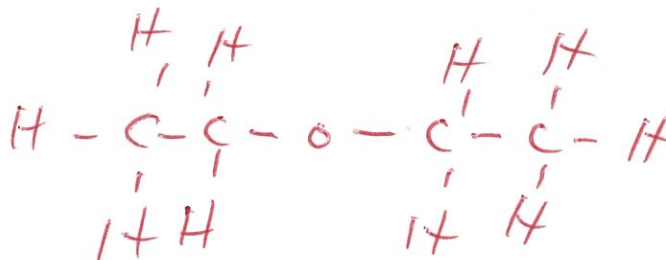
24. Given the equation: butanoic acid + 1-pentanol $\xrightarrow{\text{catalyst}}$ water + X

To which class of organic compounds does product X belong? Ester

Base your answers to question 25 using the information below and your knowledge of chemistry.

Diethyl ether is widely used as a solvent.

25. a) In the space provided below, draw the structural formula for diethyl ether.



b) In the space provided below, draw the structural formula for an alcohol that is an isomer of diethyl ether.

