Name KEY Date

Hydrocarbon Compounds

ORGANIC UNIT REVIEW

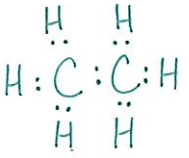
Answer highlighted questions only.

Having studied this chapter and done the problems, you should be able to:

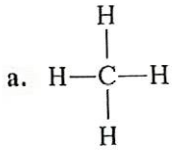
1. Characterize a hydrocarbon. (What is a hydrocarbon?) 25·1

a compound consisting of primarily carbon & hydrogen

2. Draw electron dot structures of simple alkanes. 25·1
Example: Draw the electron dot structure for ethane (C_2H_6).



3. Recognize structural, condensed, and molecular formulas of the continuous-chain hydrocarbons containing up to ten carbons. (Name the following:) 25·2

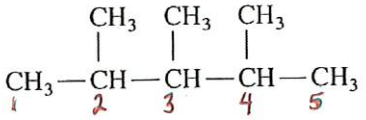
a.  methane

b. C_5H_{12} pentane

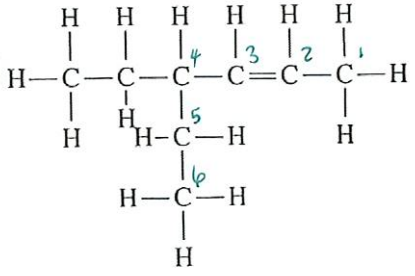
c. $CH_3—CH_2—CH_2—CH_3$ butane

d. $CH_3(CH_2)_8CH_3$ decane

4. Given the structural formula of an alkane, alkene, or alkyne, name it according to IUPAC rules. 25·2-25·5
(Name the molecule)

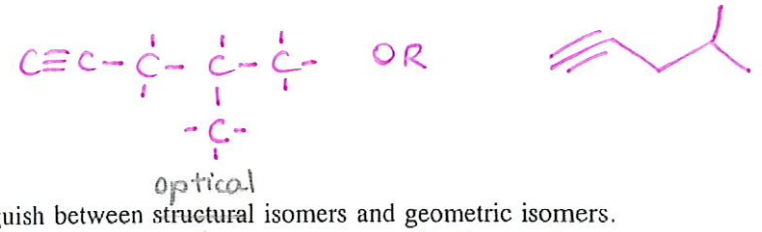
a. 

2,3,4-trimethylpentane

b. 
4-ethyl-2-hexene

5. Given the IUPAC names of an alkane, alkene, or alkyne, draw its structural formula. *25·2-25·5*

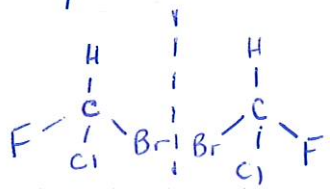
4-methyl-1-pentyne



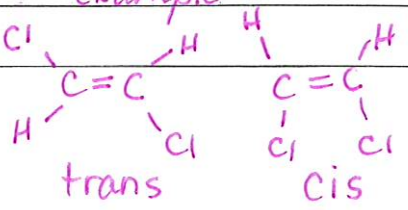
6. Distinguish between structural isomers and geometric isomers. *25·4-25·6*

mirror images ↓ cis/trans

example:



example:



8. Describe the bonding and structure of benzene. *25·8*

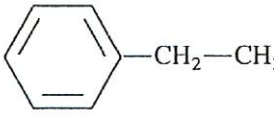
use words

Kekule structures (resonance)

* alternating double and single bonds in a ring of 6 carbons
* Kekule structures are often used to describe/show structure and these would be considered resonance structures since the double bonds are not locked in between the same carbons

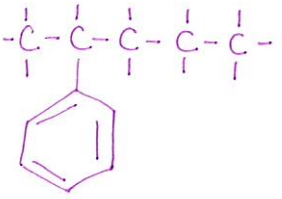
9. Name and draw the structures of simple cyclic and aromatic compounds. *25·8*

a) Name this compound.



ethylbenzene or phenylethane

b) Draw 2-phenylpentane.



10. Describe the formation of petroleum and natural gas deposits. (already answered) *25·9*

They originated in marine life buried in ocean sediments millions of years ago. Heat, pressure, and bacteria changed this residue into petroleum and natural gas.

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25 Hydrocarbon Compounds

Skillsheet

Understanding Chemical Terminology II

This Skillsheet explains how simple hydrocarbons and their related compounds are named.

Hydrocarbons, compounds containing only hydrogen and carbon, are named by the number of carbon atoms and the way they are bonded to each other. Hydrocarbon molecules can form a variety of patterns: chains, branched chains, or rings.

The first step in naming a straight-chain hydrocarbon is to count the number of carbon atoms. The prefix corresponding to this number is the first part of the name. The prefixes are as follows:

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

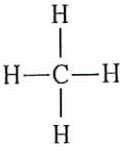
Next, determine how the carbons are bonded.

1. If all bonds between the carbons are single, the name of the compound ends in *-ane*. The general name for these compounds is alkanes.

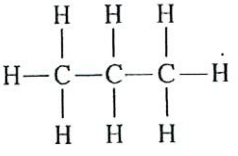
2. If there is a double bond in the chain, the name ends in *-ene*. The general name for these compounds is alkenes. The location of the bond is shown with a number.

3. If there is a triple bond in the chain, the name ends in *-yne*. The location of the bond is shown with a number. The general name for these compounds is alkynes.

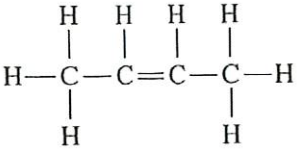
Examples.



meth + ane = methane



prop + ane = propane



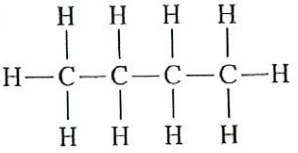
but + ene
= butene
= 2-butene
(The number refers to the double bond on the second carbon.)

Figure 1

Practice Problems

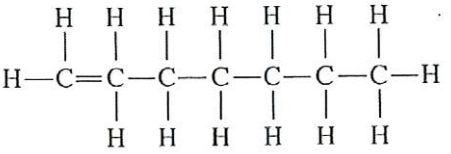
Name the following:

1.



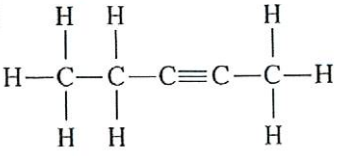
butane

2.



1-heptene

3.



2-pentyne

Figure 2

Figure 3 shows an example of a branched chain. Notice that there are seven carbon atoms in the compound. They are arranged in a straight chain of six carbons with the seventh on a branch. Number the carbons in the straight chain. If you start at the left, it is carbon #2 that has the branch attached. If you start at the right, the branch is on carbon #5. Now compare Figures 3, 4, and 5. These diagrams represent the same molecule as "seen" from different directions, or rotated into different positions.

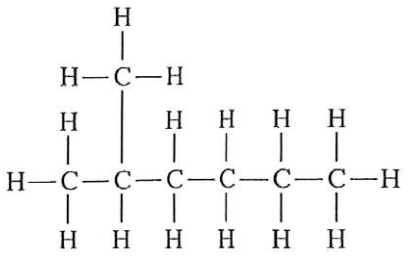


Figure 3

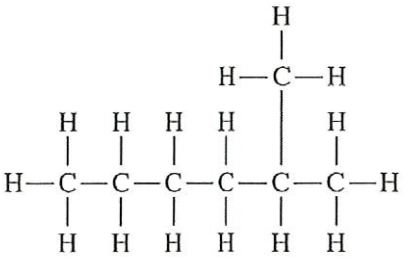


Figure 4

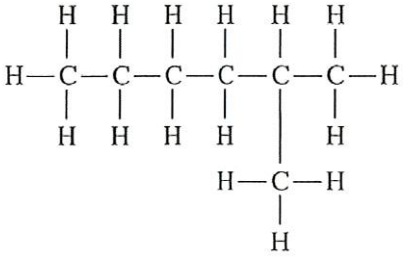


Figure 5

It is very important to be able to recognize the same molecule from different perspectives. One way to do so is to apply the following rules in naming a compound.

1. Count the carbons in the longest chain. Count from both directions. Choose the direction that results in the lower number for the carbon to which the branch is attached. (In Figures 3, 4, and 5 the number of the carbon with the branch is 2.)

2. Now count the carbons in the branch. In the example, there is one carbon in the branch. The prefix for one carbon is *meth-*. Add *-yl* to the prefix for the name of the branch. Thus, the one-carbon branch is named methyl.

3. Select the prefix appropriate for the number of carbons in the straight chain. In the example there are six carbons in the chain, so the prefix is *hex-*.

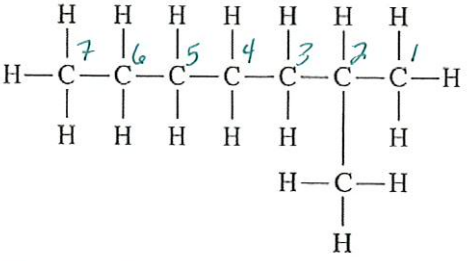
4. Select the correct ending depending on the type of bonds between the carbon atoms. In the example, the ending should be *-ane* because all the bonds between carbon atoms are single. The name of the compound is 2-methylhexane.

The 2 indicates to which carbon the methyl group is attached. The word hexane describes the longest straight chain.

Practice Problems

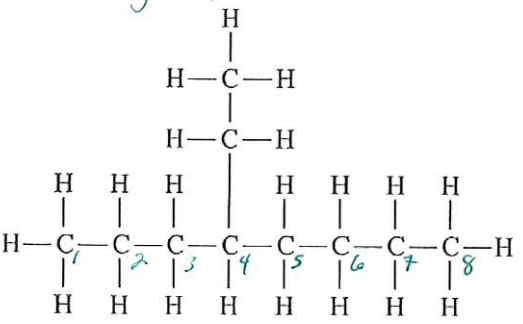
Using the four-step procedure given above, name the following compounds.

4.



2-methylheptane

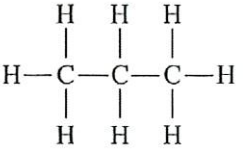
5.



4-ethyloctane

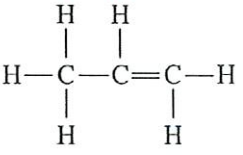
6. Name the following molecules.

a.



propane

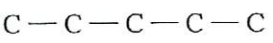
b.



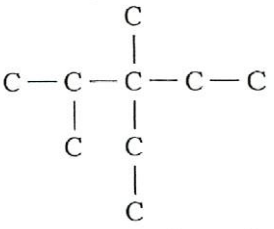
propene

Name _____ Section _____ Date _____

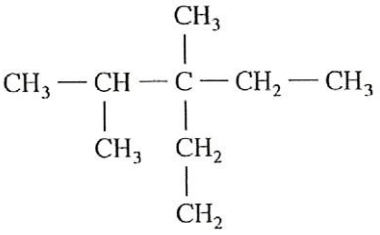
Solution Write down, in a horizontal row, the number of carbon atoms corresponding to the parent compound (pentane, 5 carbons)



Number the carbon atoms in the chain from left to right, then add the alkyl groups to the correct carbon atoms.

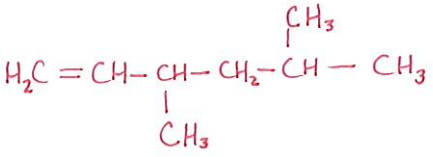


Finally, add the correct number of hydrogen atoms so that each carbon has four bonds.



You Try It

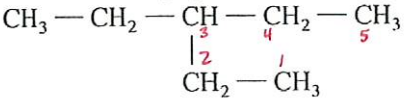
3. Write the structural formula for 3,5-dimethyl-1-hexene. *25 · 5*



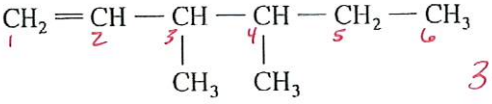
OR

Problems For You to Try

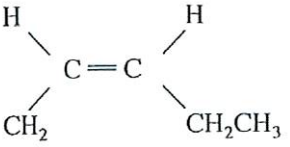
4. Name the following hydrocarbons. *25 · 3, 5*

a. 

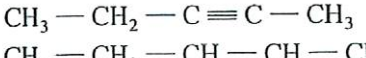
3-ethylpentane

b. 

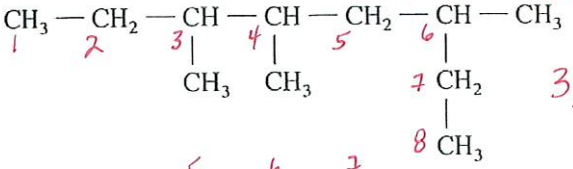
3-4-dimethyl-1-hexene

c. 

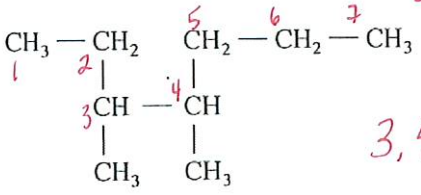
cis-2-pentene

d. 

2-pentyne

e. 

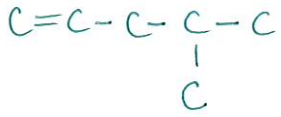
3,4,6-trimethyloctane

f. 

3,4-dimethylheptane

5. Write structural formula for these hydrocarbons
   a. 4-methyl-1-pentene
   b. 3,3-dimethyl-1-butyne
   c. 3,4-diethylhexane
   d. trans-2-heptene
   e. 2,3,4,5-tetramethylnonane
   f. 3,5-dimethyloctane

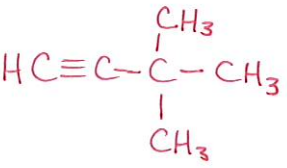
5a)



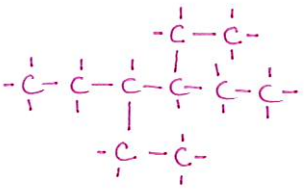
OR

b)

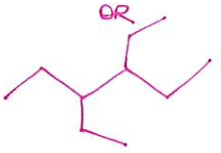
OR



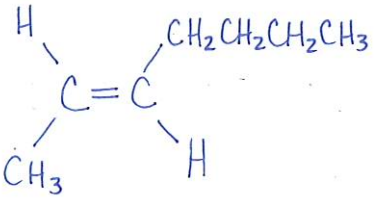
c)



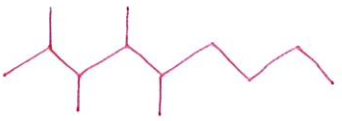
OR



d)



e)



f)

Name _____ Section _____ Date _____

25 Hydrocarbon Compounds

Reviewsheet

A. Completion

Use this completion exercise to check your knowledge of the terms and your understanding of the concepts introduced in this chapter. Each blank can be completed with a term, short phrase, or number.

The branch of chemistry that deals with __1__ compounds is called __2__ chemistry. Carbon makes stable __3__ bonds with other carbons to form chain and ring compounds. __4__ are compounds containing only carbon and hydrogen. Many hydrocarbons exhibit __5__ isomerism. Structural isomers have the same __6__ formula but different molecular __7__.

Alkanes contain only carbon–carbon __8__ bonds. The groups attached to single bonds in continuous–chain alkanes rotate freely about the bonds at room temperature. Alkenes are __9__ hydrocarbons. That is, they contain one or more carbon–carbon __10__ bonds. Alkynes are also unsaturated compounds. They contain one or more carbon–carbon __11__ bonds. Rotation about the multiple bonds of alkenes and alkynes does not occur at ordinary conditions.

Aromatic hydrocarbons, or __12__, are related to the hydrocarbon __13__. Benzene is rather unusual among hydrocarbons. As a result of __14__, the interior bonds of the benzene ring are somewhere between ordinary single bonds and double bonds. Benzene is less reactive than ordinary alkenes because of this unusual bonding.

__15__, or open–chain, hydrocarbons come from __16__. Aromatic hydrocarbons come from coal. Many useful hydrocarbons are obtained directly from crude petroleum by __17__. The molecular structures of the hydrocarbons present in natural petroleum can be reorganized into other useful products by the __18__ process.

1.	carbon	25·0
2.	organic	25·0
3.	covalent	25·1
4.	hydrocarbons	25·0
5.	structural	25·4
6.	molecular	25·4
7.	structures	25·4
8.	single	25·2
9.	unsaturated	25·4
10.	double	25·4
11.	triple	25·4
12.	arene	25·8
13.	benzene	25·8
14.	resonance	25·8
15.	alkane	25·9
16.	petroleum	25·9
17.	refining	25·9
18.	cracking	25·9

B. True–False

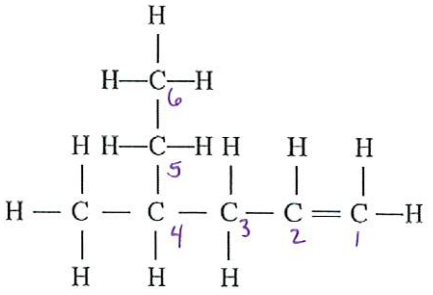
Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

___	**19.** The first organic compound synthesized by Friedrich Woehler was urea.	*25·0*
NT	**20.** Because a carbon atom contains 6 valence electrons, it forms 3 covalent bonds.	*25·1*
AT	**21.** The methane molecule has a tetrahedral shape.	*25·1*
ST	**22.** Continuous chain alkanes contain 10 carbon atoms in a straight chain.	*25·2*
ST	**23.** The IUPAC system uses common names such as acetylene.	*25·2*
AT	**24.** A substituent can take the place of a hydrogen atom on a parent hydrocarbon molecule.	*25·3*
ST	**25.** An alkane with one or more alkyl groups is called an alkyne.	*25·3*
ST	**26.** Hydrocarbons are numbered from right to left.	*25·3*
AT	**27.** When naming branched chain hydrocarbons, the names of the substituent alkyl groups are listed in alphabetical order.	*25·3*
ST	**28.** Hydrocarbons are saturated.	*25·5*
ST	**29.** Arenes contain 6 carbon atoms.	*25·8*
AT	**30.** Benzene is the simplest arene.	*25·8*
ST	**31.** All hydrocarbon compounds which do not contain rings are called aliphatic compounds.	*25·8*
___	**32.** Meta–xylene is another name for 1,3–dimethylbenzene.	*25·8*
NT	**33.** Carbon monoxide is the product of the complete combustion of a hydrocarbon.	*25·9*

C. Questions

Answer the following questions in the space provided.

34. Name the following compound. *25·3, 25·5*



4-methyl-1-hexene

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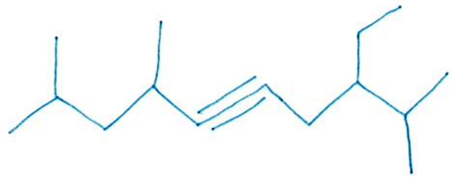
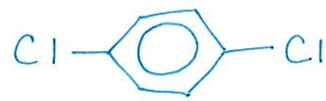
35. Draw the structural formula for the following compound: 2,4,9–trimethyl–7–ethyl–5–decyne. *25·5*



36. Draw the structural formula for *para*–dichlorobenzene. *25·8*



37. Draw three structural isomers of pentane. C_5H_{12} *25·4*

38. Balance the equation for the incomplete combustion of pentane forming CO and H_2O. *25·9*

$C_5H_{12} + \frac{11}{2}O_2 \longrightarrow 5CO + 6H_2O$

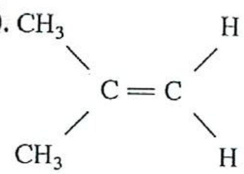
OR

$2C_5H_{12} + 11O_2 \rightarrow 10CO + 12H_2O$

D. Additional True–False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

AT 39. The *trans* configuration has substituted groups on opposite sides of the double bond. *25·6*

NT 40.  has *cis* and *trans* isomers. *25·6*

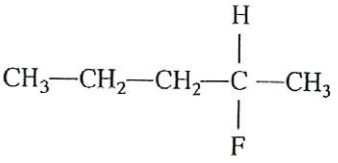
___ 41. Compounds whose molecules contain an asymmetric carbon have handedness. *25·7*

NT 42. Stereoisomers are the same as structural isomers. *25·7*

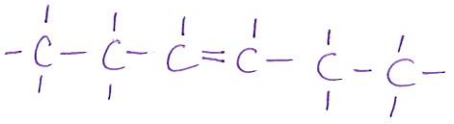
E. Additional Questions

Answer the following questions in the space provided.

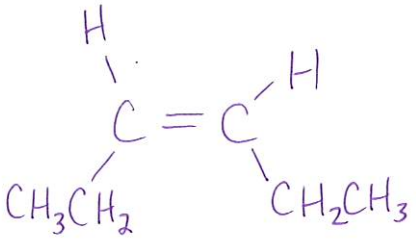
43. Identify the asymmetric carbon in this compound. *25·7*



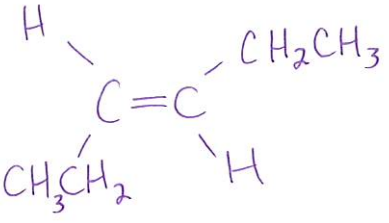
44. Draw the *cis* and *trans* isomers for 3–hexene. *25·6*



cis



trans



Name _____ Section _____ Date _____

26 Functional Groups and Organic Reactions

Objectives Worksheet

Chapter Objectives

Having studied this chapter and done the problems, you should be able to:

1. Recognize and identify a molecule's functional groups. *26·1*

a. $CH_3—CH_2—Cl$ alkyl halide (haloalkane)

b. $CH_3—\overset{\overset{O}{\|}}{C}—CH_2—CH_3$ Ketone

c. $CH_3—\overset{\overset{O}{\|}}{C}—OH$ carboxylic acid (specifically acetic acid)

d. $CH_3—\overset{\overset{H}{|}}{N}—CH_3$ amine

2. Relate differences in physical properties of alcohols to molecular structure. *26·5*

3. Characterize a substitution reaction. (Describe) *26·3*

* an atom or a group of atoms is replaced by another atom or group of atoms

4. Identify an alcohol as primary, secondary, or tertiary. (depends on C bonds) *26·4*
Examples:

a. $CH_3—\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}—OH$ tertiary

b. $CH_3—CH_2—\underset{\underset{OH}{|}}{CH}—CH_3$ secondary

c. $CH_3—CH_2—CH_2—OH$ primary

5. Write structures for the products of an addition reaction. *26·6*

$$H—\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}—\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}=C\begin{matrix}H\\ \diagup\\ \diagdown\\ H\end{matrix} + HOH \rightarrow \quad H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\overset{\overset{OH}{|}}{\underset{\underset{H}{|}}{C}}-H$$

Name _____ Section _____ Date _____

26A Functional Groups and Organic Compounds

Extra Practice Problems

Naming Functional Groups

Many organic compounds are hydrocarbons, containing only the elements carbon and hydrogen. Other organic compounds may also contain oxygen, nitrogen or a halogen. These compounds are typically identified by a functional group. In fact, each general class of organic compounds, such as the alcohols or the ethers, has a characteristic functional group.

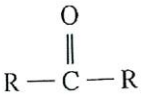
Example B *26 · 1*

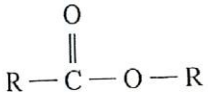
Write a general formula for a compound with the following functional group.

a. hydroxyl (alcohol)
b. carbonyl (ketone)
c. ester (ester)

Solution

a. R — OH

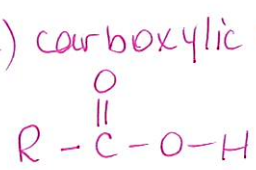
b.


c.


You Try It *26 · 1*

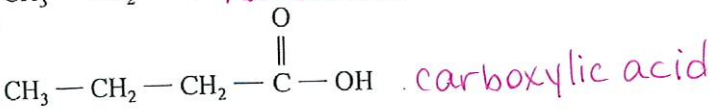
1. Write a general formula for a compound with the following functional group.
   a. amino (amine)
   b. ether (ether)
   c. carboxyl (carboxylic acid)

a) amine $R-NH_2$ b) ether $R-O-R$ c) carboxylic acid



Example B *26 · 1*

Identify the functional group in each of the following compounds.

a. $CH_3 — O — CH_3$ ether
b. $CH_3 — CH_2 — Cl$ haloalkane
c.

carboxylic acid

You Try It

2. Identify the functional group in each compound. *26 · 1*

a. $CH_3 — CH_2 — NH_2$ amine

b.

$$CH_3 — CH_2 — CH_2 — \overset{\overset{O}{\|}}{C} — H$$

aldehyde

c. $HO — CH_2 — CH_3$ alcohol

Problems For You to Try

3. Write a structural formula containing three carbon atoms for each type of compound. *26 · 1*

a. aldehyde
b. amine
c. ester
d. ether
e. fluorocarbon
f. alcohol
g. carboxylic acid
h. ketone

a) aldehyde $CH_3CH_2CH_2\overset{\overset{O}{\|}}{C}-H$

b) amine $CH_3CH_2CH_2NH_2$

c) ester $CH_3\overset{\overset{O}{\|}}{C}-O-CH_2CH_3$

d) ether $CH_3CH_2-O-CH_3$

e) fluorocarbon $CH_3\underset{\underset{F}{|}}{C}HCH_3$

f) alcohol CH_3CH_2CH-OH

g) carboxylic acid $CH_3CH_2\overset{\overset{O}{\|}}{C}-OH$

h) Ketone $CH_3\overset{\overset{O}{\|}}{C}CH_3$

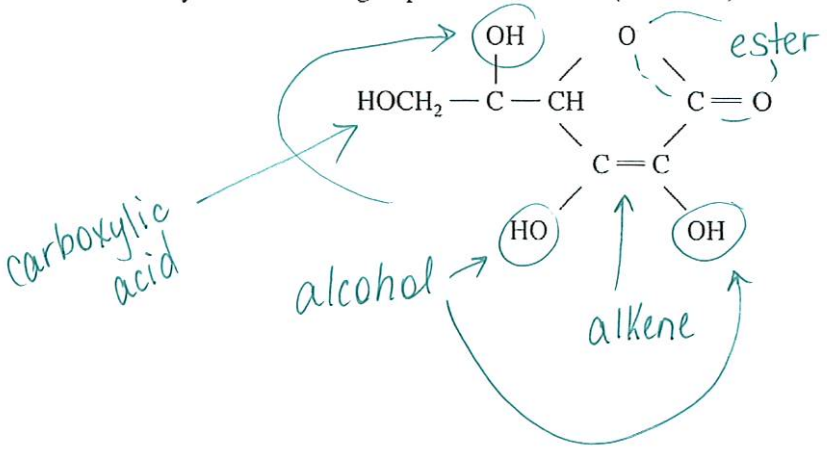
4. Identify the functional groups in the amino acid serine. *26 · 1*

$$HO — CH_2 — \underset{\underset{NH_2}{|}}{CH} — COOH$$

alcohol; carboxylic acid; amine

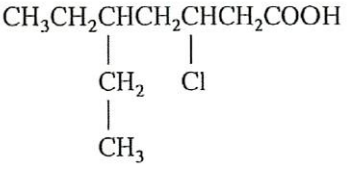
hydroxyl, amino, carboxylic acid

5. Identify the functional groups in ascorbic acid (vitamin C). *26 · 1*



You Try It

1. Name this compound. *26 · 1*



Your Solution

Example B

Name the functional group of each of these: *26 · 1*

a. butanal aldehyde
b. 2-pentyne alkyne
c. hexanoic acid carboxylic acid
d. 3-pentanol alcohol

You Try It

2. Write the formula for a 3-carbon organic compound with the indicated functional group. *26 · 1*

a. ester
b. alkyne
c. ketone

a) ester $CH_3\overset{O}{\overset{\|}{C}}OCH_3$

b) alkyne $HC\equiv C-CH_3$

c) Ketone $CH_3\overset{O}{\overset{\|}{C}}CH_3$

Example C

Write formulas for the compounds in Example B. *26 · 1*

Solution

a. Four carbons with a — CHO group.

$CH_3CH_2CH_2CHO$

b. Five carbons with a triple bond between carbons 2 and 3.

$CH_3C\equiv CCH_2CH_3$

c. Six carbons with a — COOH group.

$CH_3CH_2CH_2CH_2CH_2COOH$

d. Five carbons with a — OH group on carbon number 3.

$CH_3CH_2CHOHCH_2CH_3$

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You Try It

3. Name the compounds in Problem 2. *26·1*

Your Solution

Example D

Draw and name the structural isomers of C_3H_8O *25·4*

Solution

a. $CH_3CH_2CH_2OH$ 1-propanol
b. $CH_3CHOHCH_3$ 2-propanol
c. $CH_3CH_2OCH_3$ ethylmethyl ether

You Try It

4. Draw the seven structural isomers of $C_4H_{10}O$. Name each isomer. *25·4*

Your Solution

Problems For You to Try

5. Name these organic compounds OR classify if you cannot name *26·1*

a. $CH_3CH_2CH_2COOH$ carboxylic acid

b. $CH_3CH_2CH_2OCH_2CH_2CH_2CH_3$ ether

c. $CH_3CH(Cl)-CH(Cl)CH_3$ haloalkane

d. $CH_3CH_2CH_2CH=CH_2$ alkene OR 1-pentene

e. $CH_3CH_2CH(CH_3)CH_2CH_2CH_2OH$ alcohol

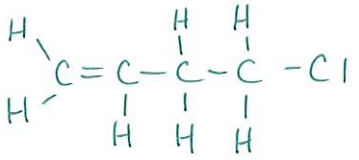
f. $CH_3CH_2CH_2C(=O)CH_3$ Ketone OR pentanone

g. $CH_3CH_2C(=O)-O-CH_2CH_3$ ester

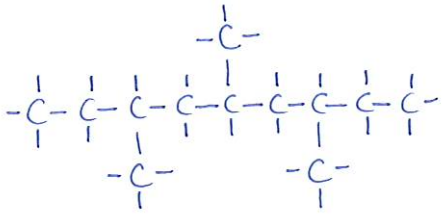
h. $CH_3\overset{5}{C}H(\overset{4}{C}H_3)-\overset{3}{C}H(\overset{4}{C}H_3)-\overset{2}{C}\equiv\overset{1}{C}CH_3$ alkyne 3,4-dimethyl-1-pentyne

6. Write formulas for the following compounds. (draw first)
   a. 3,5,7-trimethylnonane
   b. 4-chloro-1-butene
   c. 3-methylhexanal
   d. methylformate
   e. 3-bromopentanoic acid
   f. 3-pentanone (diethylketone)
   g. 3,3-dimethyl-1-butanol
   h. dimethyl ether

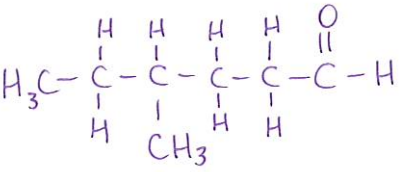
b) 4-chloro-1-butene



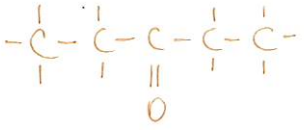
a) 3,5,7-trimethylnonane



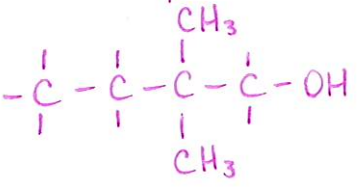
c) 3-methylhexanal



f) 3-pentanone



g) 3,3-dimethyl-1-butanol



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____ **43.** Simple sugars are aldehydes that have numerous hydroxy groups attached. *26·13*

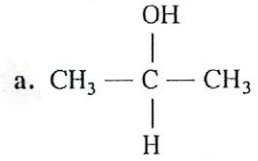
____ **44.** In the nucleic acid DNA, the base thymine bonds to adenine. *26·17*

____ **45.** The bonding between the base–pairs of RNA is covalent. *26·16*

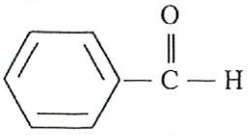
D. Questions

Answer the following questions in the space provided.

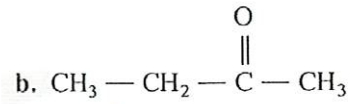
46. Identify the functional group in each of the following compounds. *26·1*

a. 

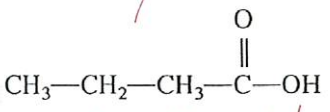
a. alcohol

c.  (two groups)

c. phenyl / aldehyde

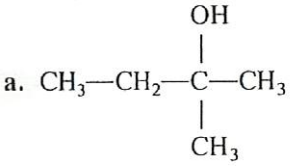
b. 

b. Ketone

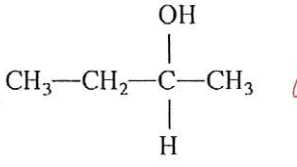
d. 

d. carboxylic acid

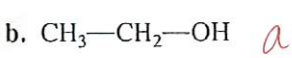
47. Identify the following compounds as primary, secondary, or tertiary alcohols. *26·4*

a.  alcohol

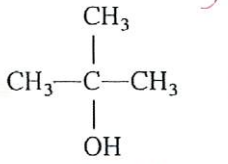
a. tertiary

c.  alcohol

c. secondary

b.  alcohol

b. primary

d.  alcohol

d. tertiary