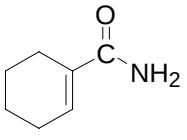
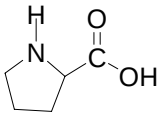
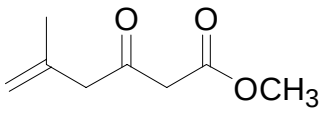
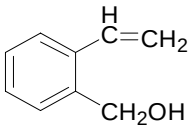
Chapter 3

3.1 Identify the functional groups in each of the following molecules:

(a) 

(b) 

(c) 

(d) 

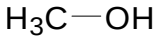
Solutions:

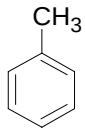
a. Amide, double bond
b. Amine, carboxylic acid
c. Double bond, ketone, ester
d. Aromatic ring, double bond, alcohol

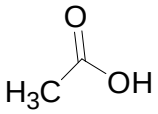
3.2 Propose structures for simple molecules that contain the following functional groups:

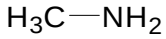
(a) Alcohol (b) Aromatic ring (c) Carboxylic acid
(d) Amine (e) both ketone and amine (f) two double bonds

Solutions:

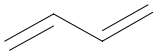
(a). 

(b). 

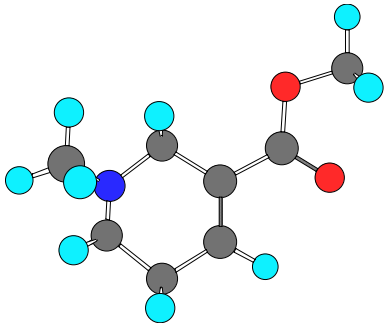
(c). 

(d). 

(e). 

(f). 

3.3 Identify the functional groups in the following model of arecoline, a veterinary drug used to control worms in animals. Convert the drawing into a line-bond structure and a molecular formula.



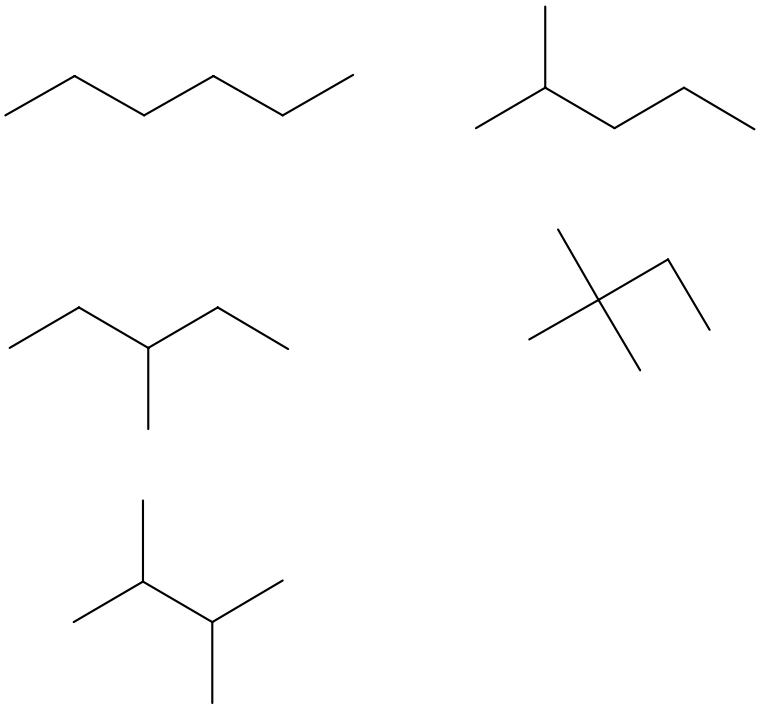
Solution:

Line-bond structure:

Molecular formula: $C_8H_{13}NO_2$

3.4 Draw structures of the five isomers of C_6H_{14}.

Solution:



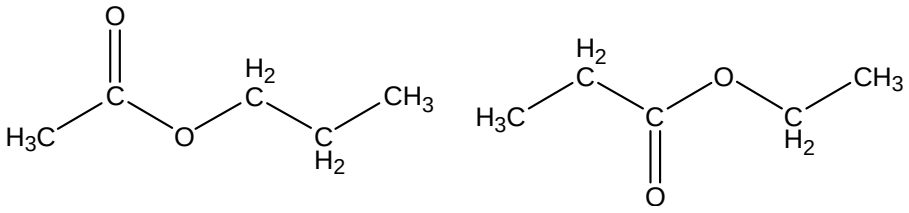
3.5 Propose structures that meet the following descriptions:

(a) Two isomeric esters with the formula $C_5H_{10}O_2$

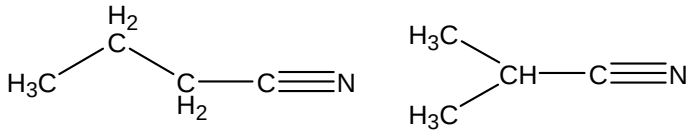
(b) Two isomeric nitriles with the formula C_4H_7N

Solution:

(a):



(b):



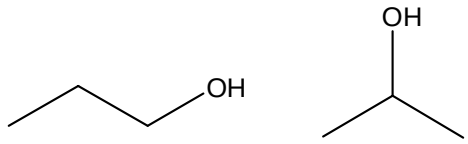
3.6 How many isomers are there with the following descriptions?

(a) Alcohols with the formula C_3H_8O

(b) Bromoalkanes with the formula C_4H_9Br

Solution:

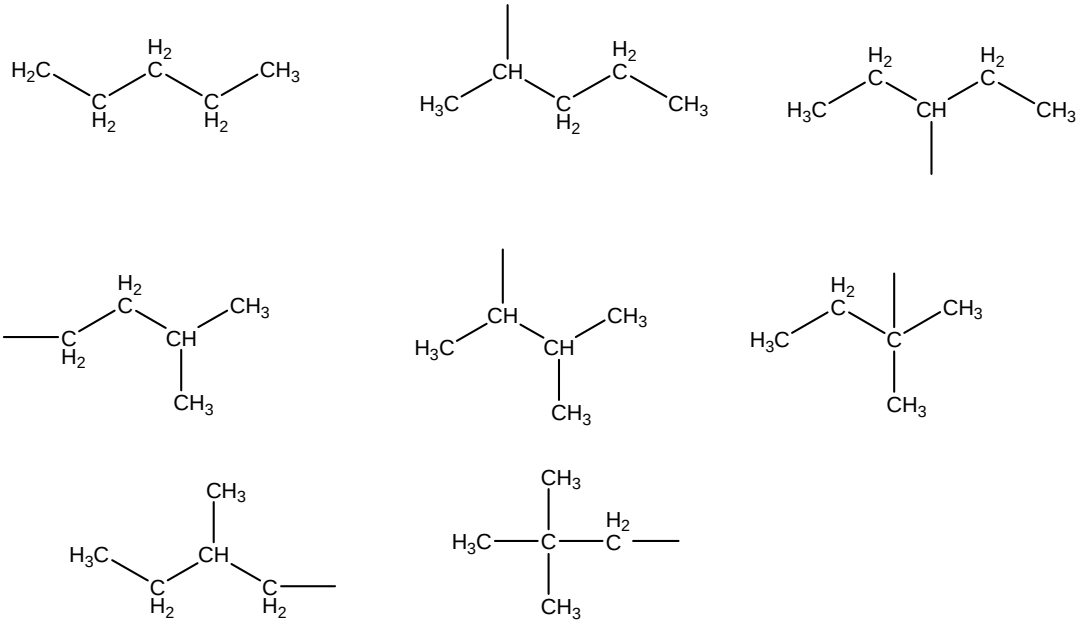
(a):



(b):4

3.7 Draw the eight 5-carbon alkyl groups(pentyl isomers).

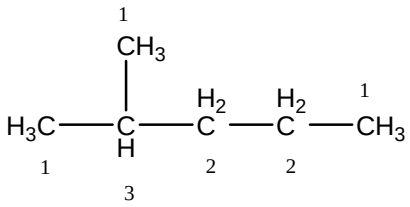
Solution



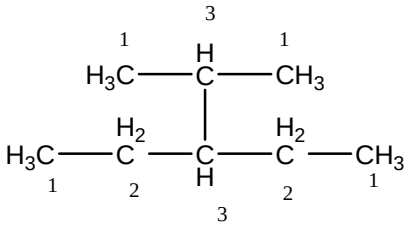
3.8 Identify the carbon atoms in the following molecules as primary, secondary, tertiary, or quaternary:

Solution:

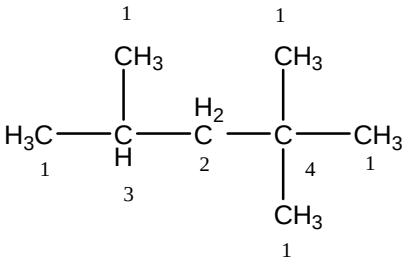
(a)



(b)

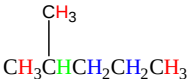


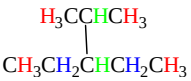
(c)

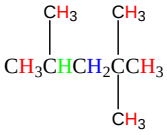


3.9 Identify the hydrogen atoms on the compounds shown in Problem 3.8 as primary, secondary, or tertiary.

Solution: The hydrogen in red is primary hydrogens; in blue is secondary hydrogens; in green is tertiary hydorgens

(a) 

(b) 

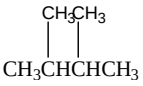
(c) 

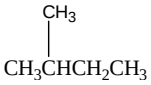
3.10 Draw structures of alkanes that meet the following descriptions:

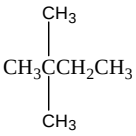
(a) An alkane with two tertiary carbons

(b) An alkane that contains an isopropyl group

(c) an alkane that has one quaternary and one secondary carbon

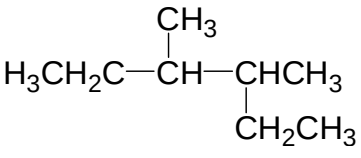
Solution: (a) 

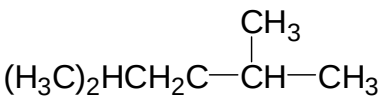
(b) 

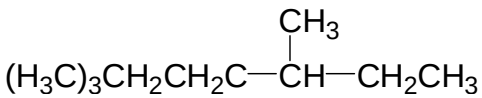
(c) 

3.11 Give IUPAC names for the following compounds:

(a) The three isomers of C_5H_{12}

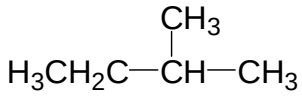
(b) 

(c) 

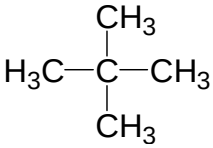
(d) 

Solution:

(a) $CH_3CH_2CH_2CH_2CH_3$ Pentane



2-Methylbutane



2,2-Dimethylpropane

(b) 3,4-Dimethylhexane

(c) 2,4-Dimethylpentane

(d) 2,2,5-Trimethylheptane

3.12 Draw structures corresponding to the following IUPAC names:

(a) 3,4-Dimethylnonane

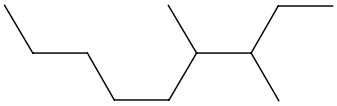
(b) 3-Ethyl-4,4-dimethylheptane

(c) 2,2-Dimethyl-4-propyloctane

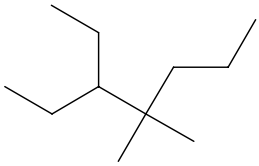
(d) 2,2,4-Trimethylpentane

Solution:

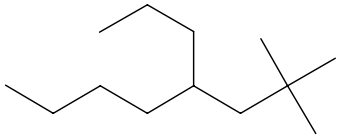
(a)



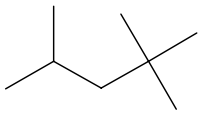
(b)



(c)



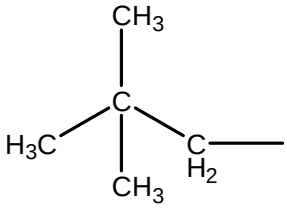
(d)



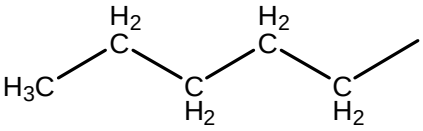
3.13 Name the eight 5-carbon alkyl groups you drew in problem 3.7.

(3.7 Draw the eight 5-carbon alkyl groups.)

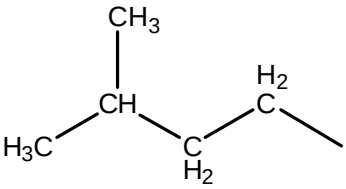
Solution:



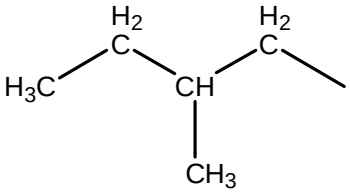
2,2-dimethylpropyl
or
neopentyl



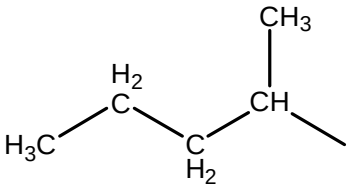
pentyl



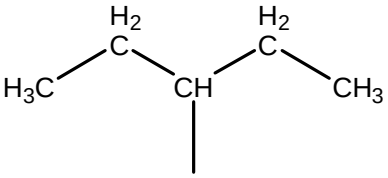
isopentyl
or
3-methylbutyl



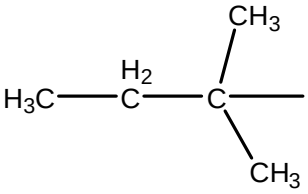
2-methylbutyl



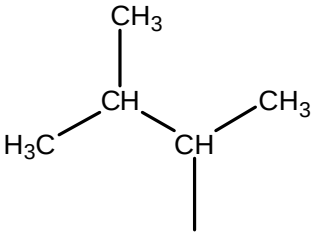
1-methylbutyl



1-ethylpropyl

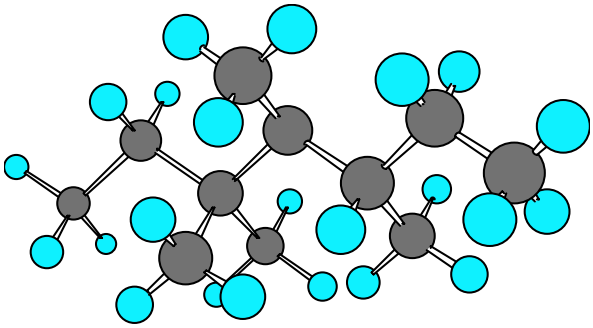


1,1-dimethylpropyl

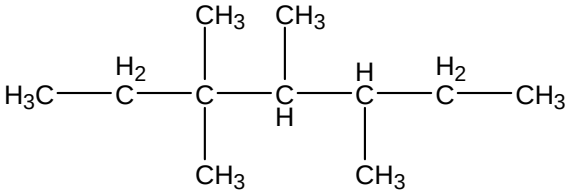


1,2-dimathylpropyl

3.14 Give the IUPAC name for the following hydrocabon, and covert the drawing into a skeletal structure.



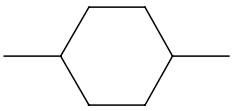
Solution:



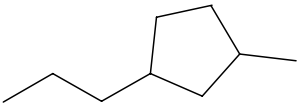
3,3,4,5-Tetramethyl-heptane

3.15: Give the names of the following cycloalkanes.

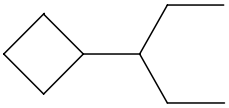
Solution:



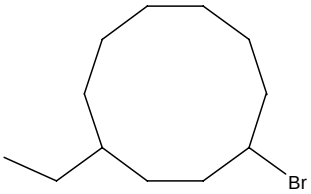
(a) 1,4-Dimethylcyclohexane



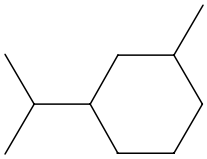
(b) 1-methyl-3propylcyclopentane



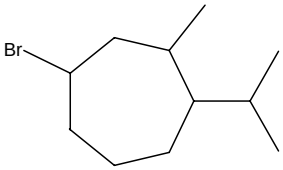
(c) 3-cyclobutylpentane



(d) 1-Bromo-4-ethylcyclodecane



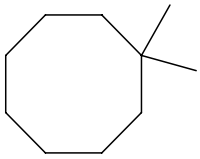
(e) 1-Isopropyl-3-methylcyclohexane



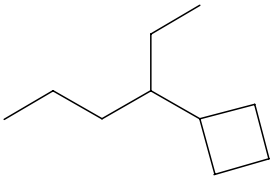
(f) 1-Bromo-4-Isopropyl-3-methylcycloheptane

3.16: Draw the structure.

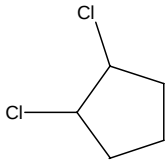
Solution:



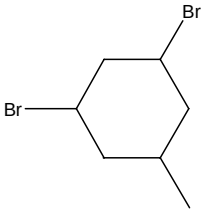
(a) 1,1-Dimethylcyclooctane



(b) 3-cyclobutylhexane

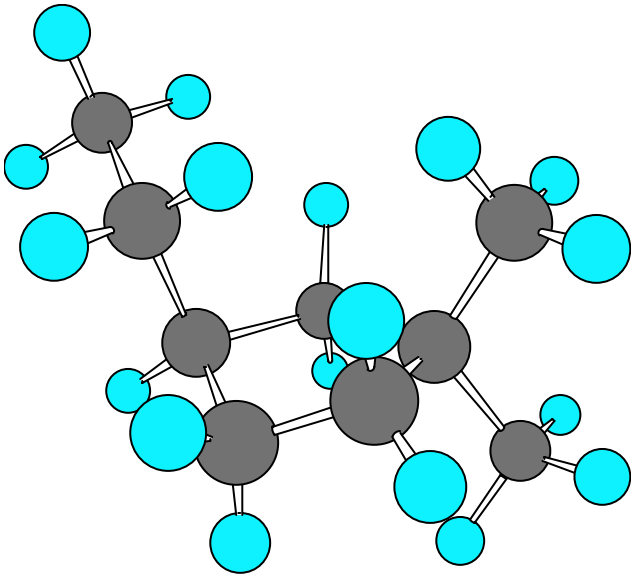


(c) . 1,2-Dichlorocyclopentane



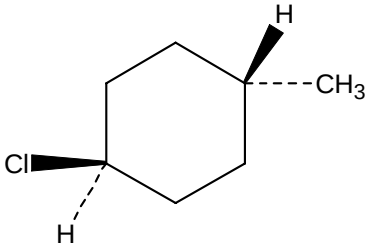
(d) 1,3-dibromo-5-methyl-cyclohexane

3.17 Name the following cycloalkane:



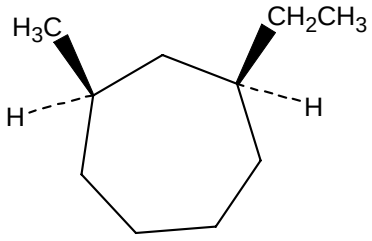
Solution: 3-Ethyl-1,1-dimethylcyclopentane

3.18 Name the following substances, including the cis- or trans- prefix:



(a)

Solution: trans-1-Chloro-4-methylcyclohexane



(b)

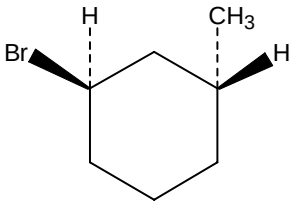
Solution: cis-1-Ethyl-3-methylcycloheptane

3.19: Draw the structures of the following molecules:

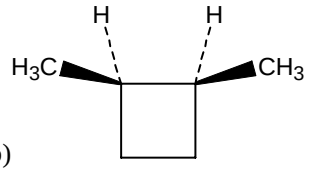
(a) trans-1-bromo-3-methylcyclohexane (b) cis-1,2-dimethylcyclobutane

(c) trans-1-tert-butyl-2-ethylcyclohexane.

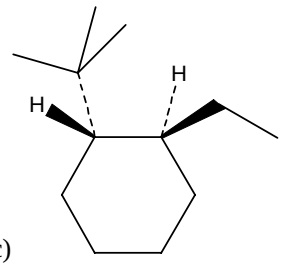
Solution:



(a)

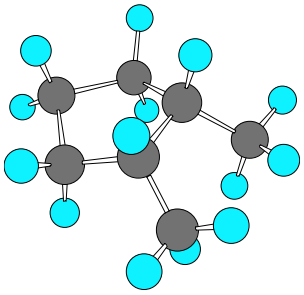


(b)

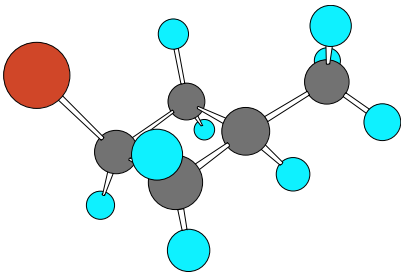


(c)

3.20: Name the following substance, including the cis- or trans- prefix (red-brown=Br).



(a)

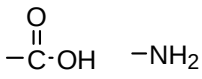


(b)

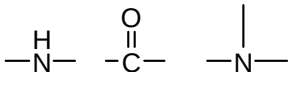
Solution: (a) cis-1,2-dimethylcyclopentane.

(b)cis-1-bromo-3-methylcyclobutane.

3.21 Identify the functional groups in the following substances, and convert each drawing into a molecular formula (red=O, blue=N):

Solution: (a) The functional groups: 

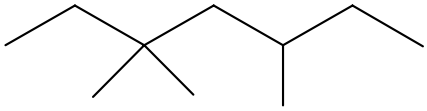
The molecular formula: $C_9H_{11}NO_2$

(b) The functional groups: 

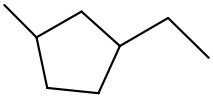
The molecular formula: $C_{14}H_{22}N_2O$

3.22 Give IUPAC names for the following hydrocarbons, and convert each drawing into a skeletal structure (yellow-green=Cl):

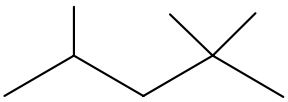
Solution: (a) Name: 3,3,5-Trimethylheptane

The skeletal structure: 

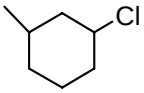
(b) Name: 1-Ethyl-3-methylcyclopropane

The skeletal structure: 

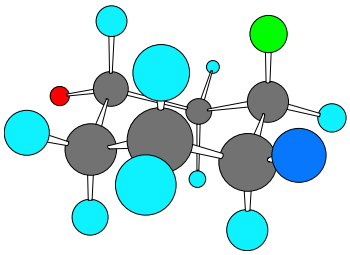
(c) Name: 2,2,4-Trimethylpropane

The skeletal structure: 

(d) Name: 1-Chloro-3-methylcyclohexane

The skeletal structure: 

3.23 The following cyclohexane derivative has three substitutions-red, green, and blue. Identify each pair of relationships(red-green, red-blue, and blue-green), as cis or trans.

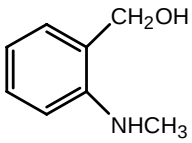


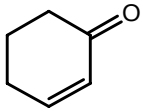
Solution: red-blue: trans.

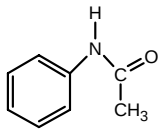
red-green: trans.

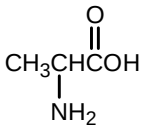
Blue-green: cis.

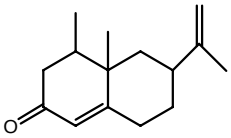
3.24 Locate and identify the functional groups in the following molecules:

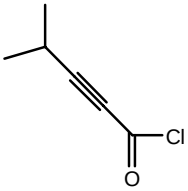
(a) 

(b) 

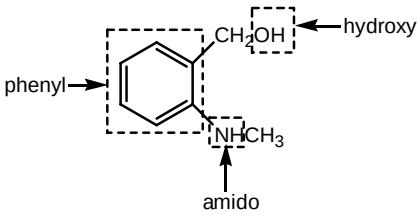
(c) 

(d) 

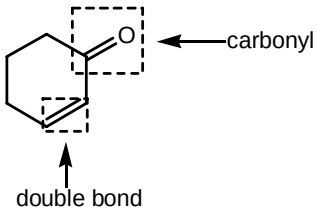
(e) 

(f) 

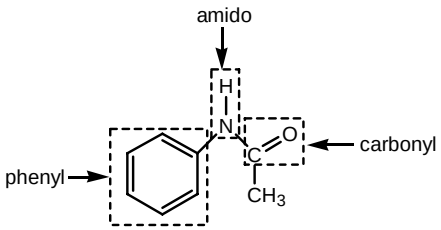
Solution: (a)



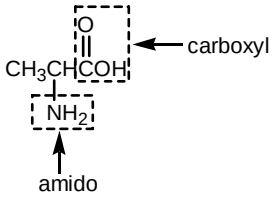
(b)



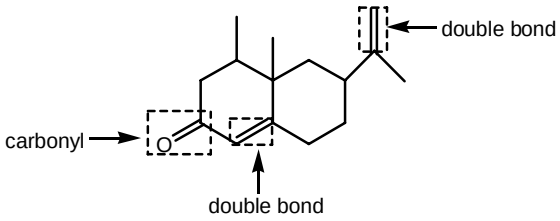
(c)



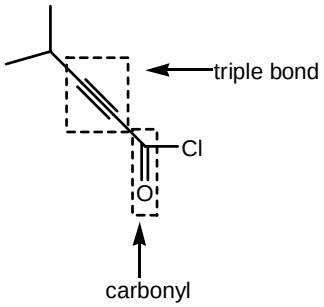
(d)



(e)



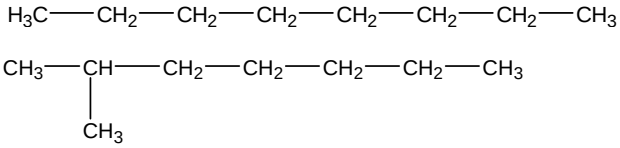
(f)

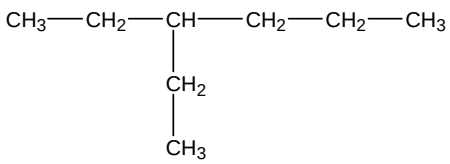


3.25 Draw structures that meet the following descriptions (there are many possibilities):

(a) Three isomers with the formula C_8H_{18}

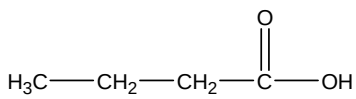
Solution:

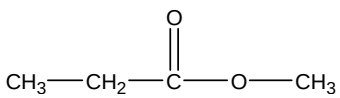




(b) Two isomers with the formula $C_4H_8O_2$

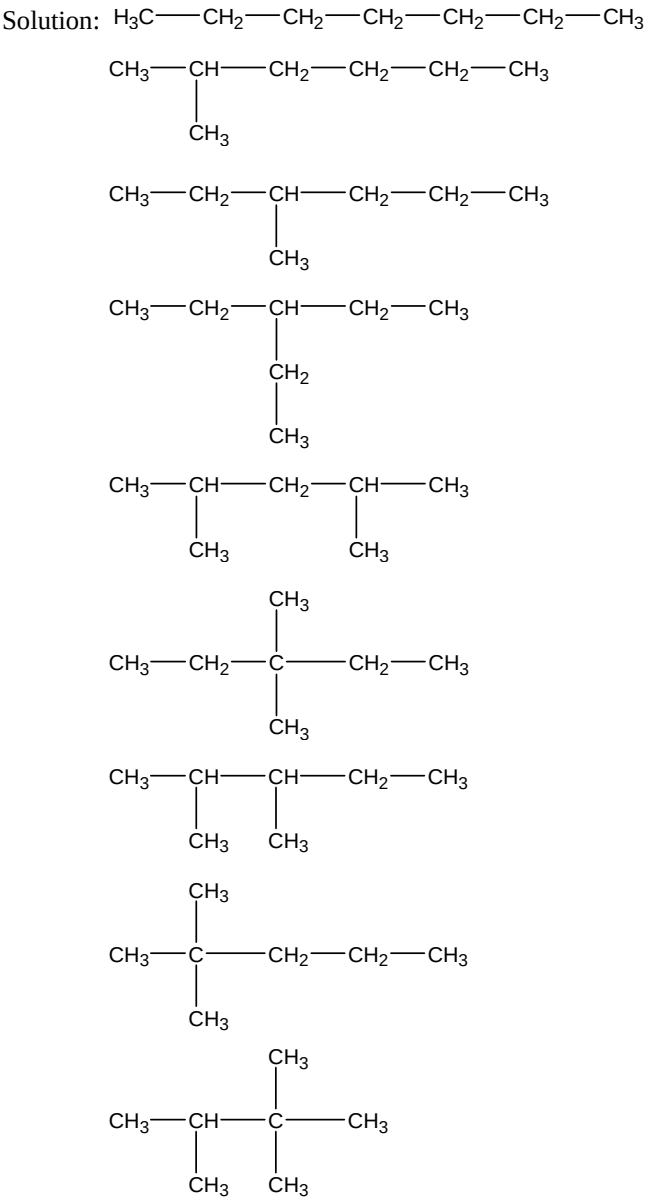
Solution:





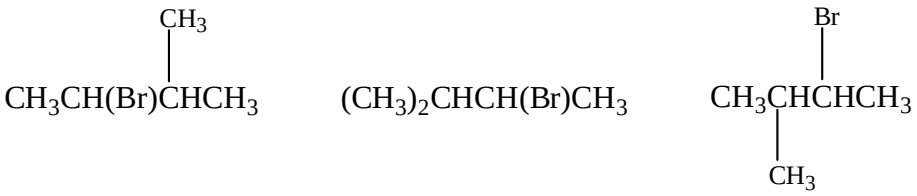
3.26 Draw structures of the nine isomers of C_7H_{16}

Solution:



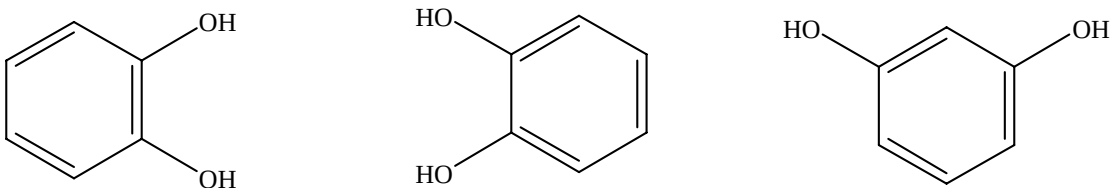
3.27 In each of the following sets, which structures represent the same compound and which represent different compounds?

(a)



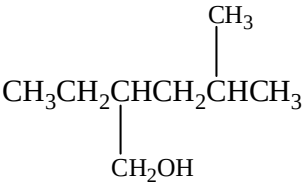
Solution: They represent the same compound 2-Bromo-3-methyl-butane.

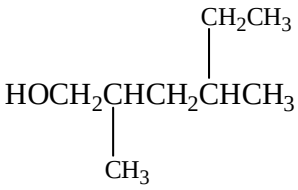
(b)

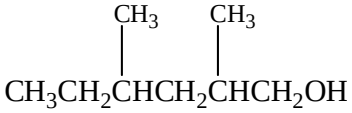


Solution: The first and the second represent the same compound Benzene-1, 2-diol. The third one represents different compound Benzene-1, 3-diol.

(c)



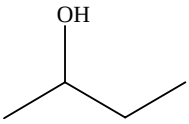




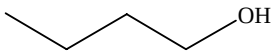
Solution: The second and the third represent the same compound 2,4-Dimethyl-hexan-1-ol. The first one represents different compound 2-Ethyl-4-methyl-pentan-1-ol.

3.28 There are seven constitutional isomers with the formula $C_4H_{10}O$. Draw as many as you can.

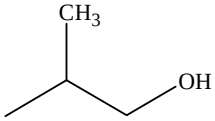
Solution:



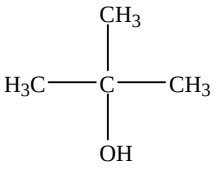
Butan-2-ol



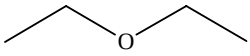
Butan-1-ol



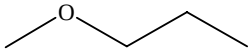
2-Methyl-propan-1-ol



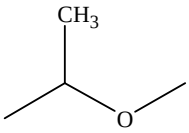
2-Methyl-propan-2-ol



Ethoxy-ethane



1-Methoxy-propane



2-Methoxy-propane

3.29 Propose structure that meet the following descriptions:

(a). A ketone with five carbons

(b).A four-carbon amide

(c).A five-carbon ester

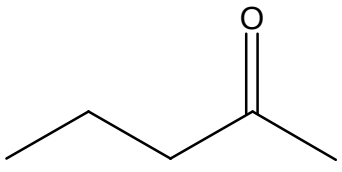
(d).An aromatic aldehyde

(e).A keto ester

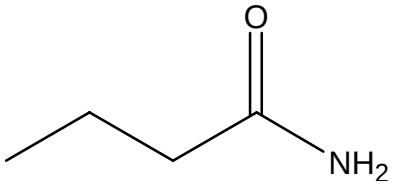
(f).An amino alcohol

Solution:

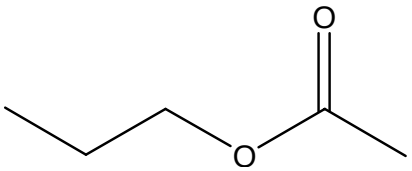
(a).



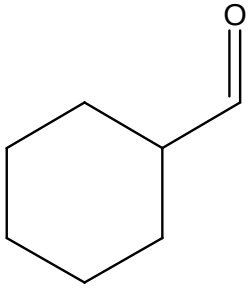
(b).

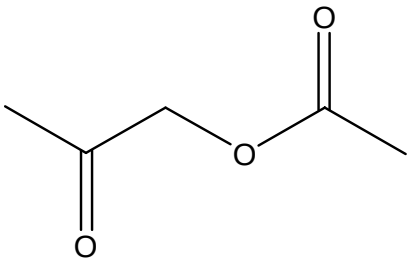


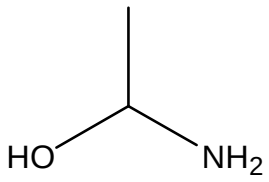
(c).



(d).



(e). 

(f). 

3.30 Propose structure for the following:

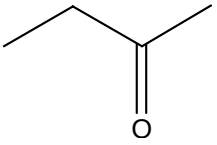
(a). A ketone,C_4H_8O (b).A nitrile,C_5H_9N

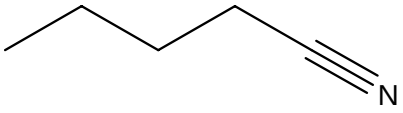
(c).A dialdehyde, $C_4H_6O_2$ (d).A bromoalkene, $C_6H_{11}Br$

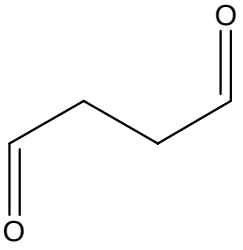
(e).A alkane, C_6H_{14} (f).An cycloalkane, C_6H_{12}

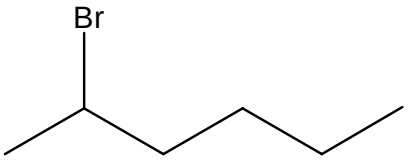
(g).A diene(dialkene), C_5H_8 (h).A keto alkene, C_5H_8O

Solution:

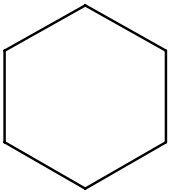
(a). 

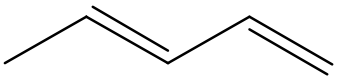
(b). 

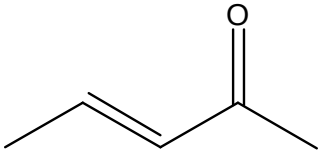
(c). 

(d). 

(e). 

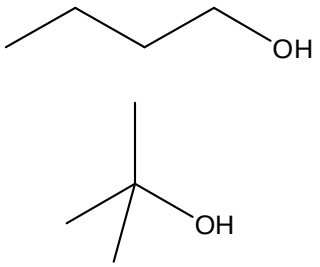
(f). 

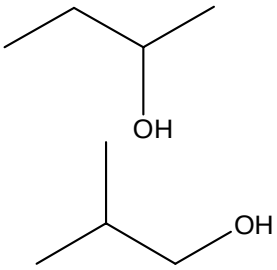
(g). 

(h). 

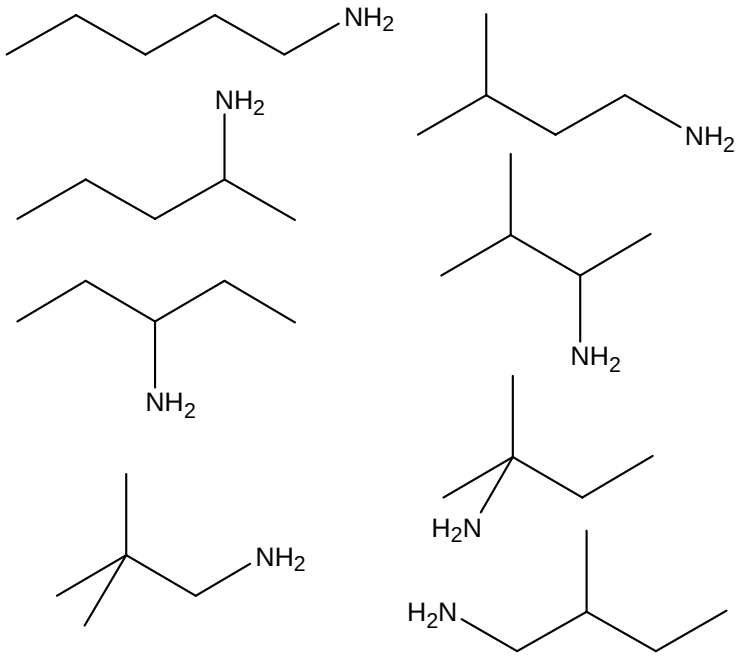
3.31 Draw as many compounds as you can that fit the following description:

(a) Alcohols with formula $C_4H_{10}O$

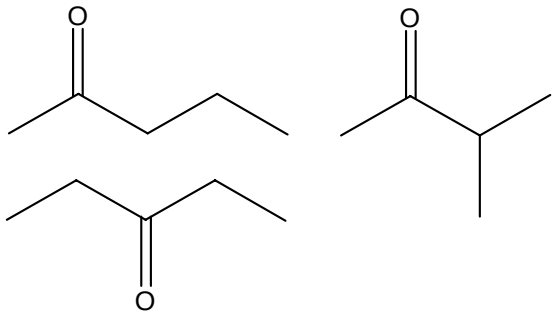




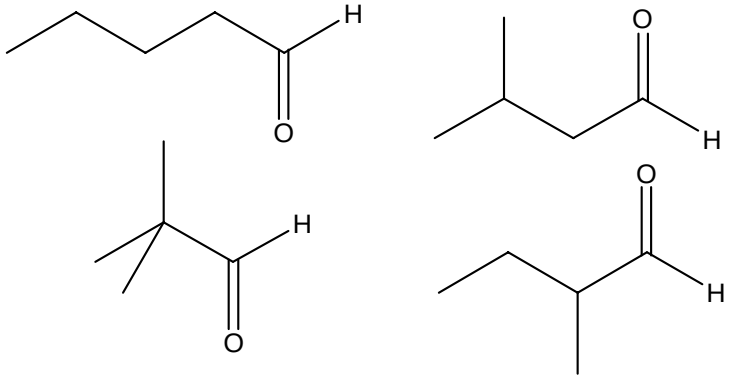
(b) Amines with formula $C_5H_{13}N$



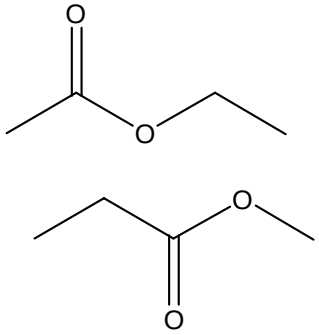
(c) Ketones with formula $C_5H_{10}O$



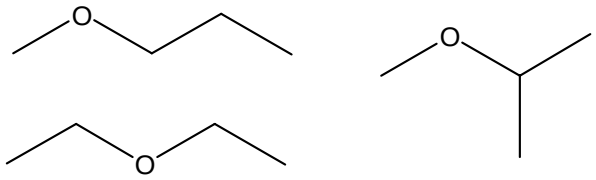
(d) Aldehydes with formula $C_5H_{10}O$



(e) Esters with formula $C_4H_8O_2$



(f) Ethers with formula $C_4H_{10}O$

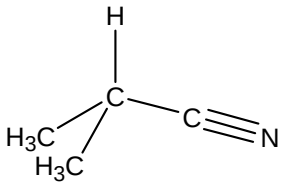


3.32 Draw compounds that contain the following:

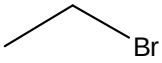
(a) A primary alcohol

CH_3OH

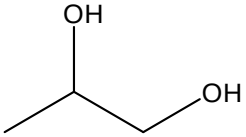
(b) A tertiary nitrile



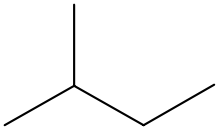
(c) A secondary bromoalkane



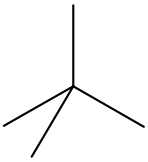
(d) Both primary and secondary alcohols



(e) An isopropyl group

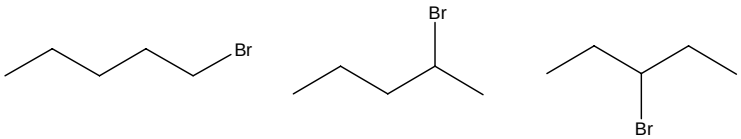


(f) A quaternary carbon



3.33 Draw and name all monobromo derivations of pentane, $C_5H_{11}Br$.

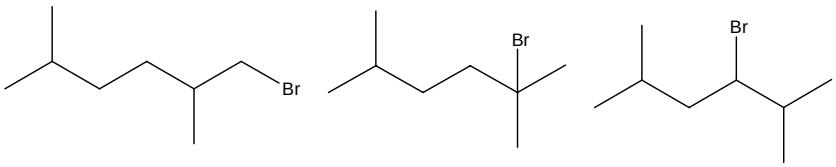
Solution:



1-bromopentane 2-bromopentane 3-bromopentane

3.34 Draw and name all monochloro derivations of 2, 5-dimethylhexane, $C_8H_{17}Cl$.

Solution:



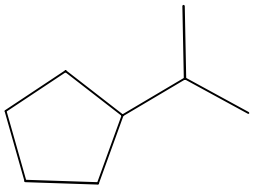
1-bromo-2, 5-dimethylhexane 2-bromo-2, 5-dimethylhexane 3-bromo-2, 5-dimethylhexane

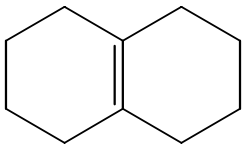
3.35 Predict the hybridization of the carbon atom in each of the following functional groups:

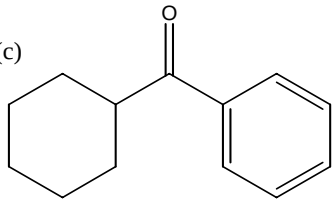
(a) Ketone (b) Nitrile (c) Carboxylic acid

Solution: (a) sp^2 (b) sp (c) sp^2

3.36 What is the molecular formula of each of the following condensed structures

(a) 

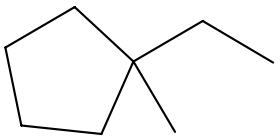
(b) 

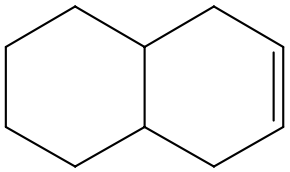
(c) 

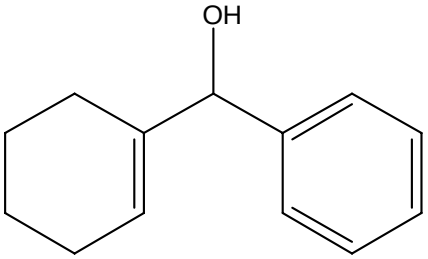
Solution: (a) C_8H_{16} (b) $C_{10}H_{16}$ (c) $C_{13}H_{16}O$

3.37 Draw the structure of a constitutional isomer for each of the molecules shown in Proble 3.36.

Solution:

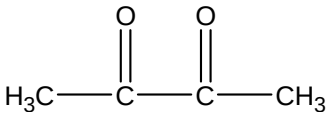
(a) C_8H_{16} 

(b) $C_{10}H_{16}$ 

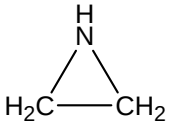
(c) $C_{13}H_{16}$ 

3.38 Draw the structures of the following molecules:

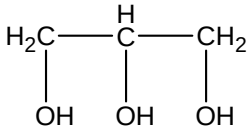
(a) Biacetyl, $C_4H_6O_2$, a substance with the aroma of butter; it contains no rings or carbon-carbon multiple bonds.

Solution: 

(b) Ethylenimine, C_2H_5N, a substance used in the synthesis of melamine polymers; it contains no multiple bonds.

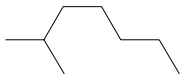
Solution: 

(c) Glycerol, $C_3H_8O_3$, a substance used in cosmetics; it has an –OH group on each carbon.

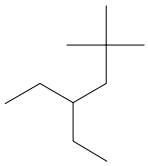
Solution: 

3.39 Draw structures for the following:

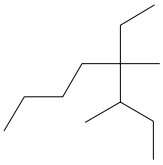
(a) 2-Methylheptane



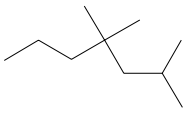
(b) 4-Ethyl-2,2-dimethylhexane



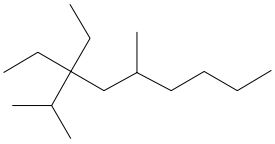
(c) 4-Ethyl-3,4-dimethyloctane



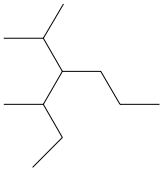
(d) 2,4,4-Trimethylheptane



(e) 3,3-Diethyl-2,5-dimethylnonane



(f) 4-Isopropyl-3-methylheptane



3.40 Draw a compound that:

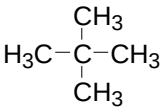
(a) Has only primary and tertiary carbons

(b) Has no primary carbons

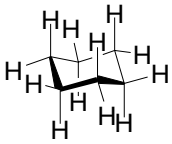
(c) Has four secondary carbons

Solution:

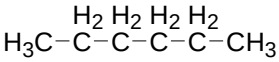
(a)



(b)



(c)

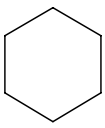


3.41 Draw a compound that:

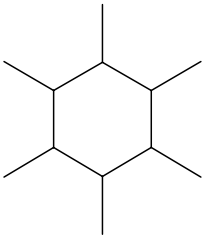
(a) Has no primary hydrogens. (b) Has only primary and tertiary hydrogens.

Solution:

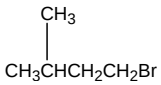
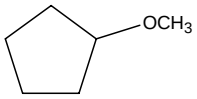
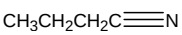
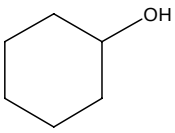
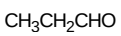
(a)

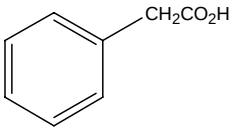


(b)

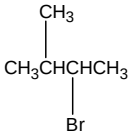


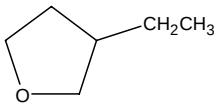
3.42 For each of the following compounds, draw an isomer with the same functional groups:

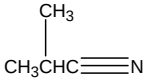
(a)  (b)  (c)  (d)  (e)  (f)

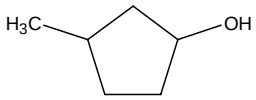


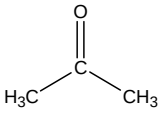
Solution:

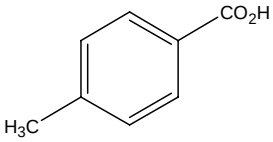
(a) 

(b) 

(c) 

(d) 

(e) 

(f) 

3.43 Draw structures for the following compounds:

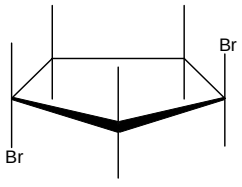
(a) trans-1,3-Dibromocyclopentane

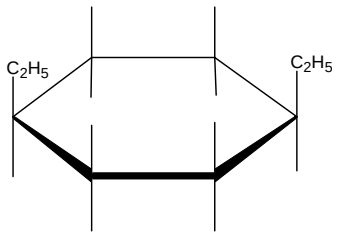
(b) cis-1,4-Diethylcyclohexane

(c) trans-1-Isopropyl-3-methycycloheptane

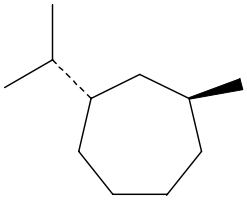
(d) Dicyclohexylmethane

Solution:

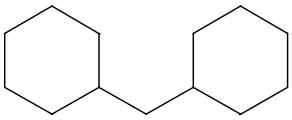
a) 

b) 

c)

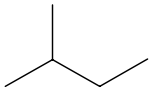


d)

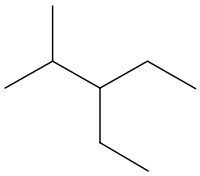


3.44 Identify the kinds of carbons(1`,2`,3`,or 4`) in the following molecules:

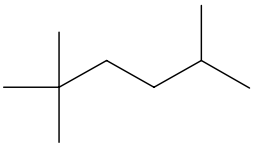
a)



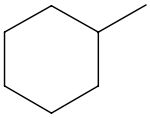
b)



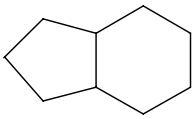
c)



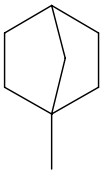
d)



e)

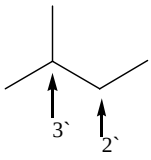


f)



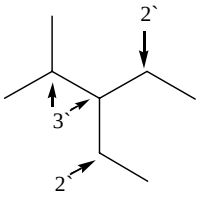
Solution:

a)

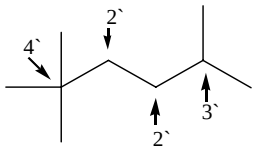


the carbons which are not identified are all 1`

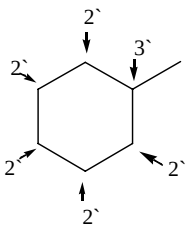
b)



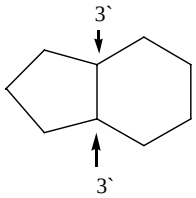
c)



d)

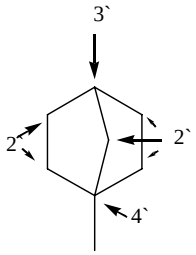


e)



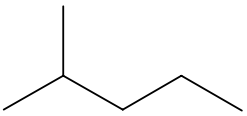
others are all 2`

f)

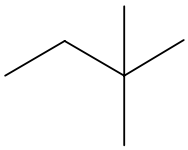


3.45 Give IUPAC names for the following compounds.

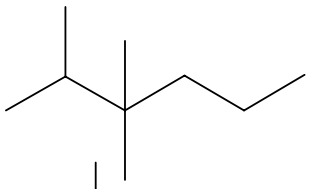
(a)



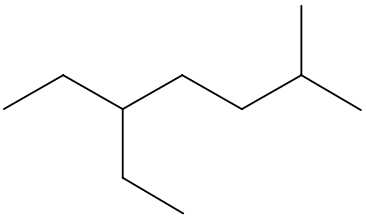
(b)



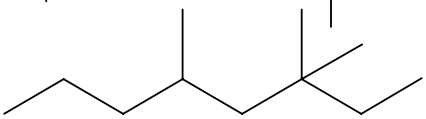
(c)



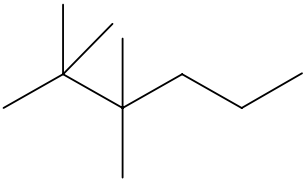
(d)



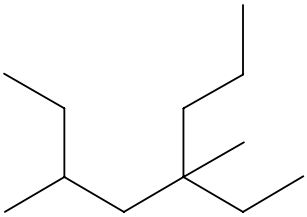
(e)



(f)



(g)



SOLUTION:

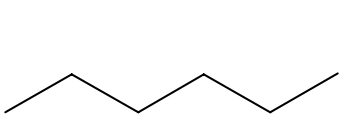
(a) 2-methylpentane. (b) 2,2-dimethylbutane (c) 2,33-trimethylhexane

(d) 2-methyl-5-ethylheptane (e) 2-ethyl-2, 4-dimethylheptane

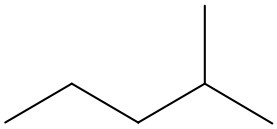
(f) 2,2,3,3-trtromethylhexane (g) 5-ethyl-3, 5-dimethyloctane

3.46 Name the five isomers of C_6H_{14}.

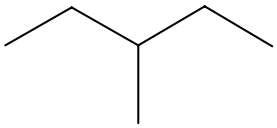
SOLUTION:



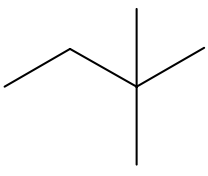
hexane



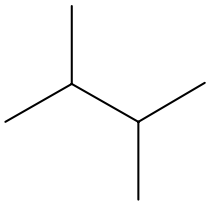
2-methylpentane



3-methylpentane



2,2-dimethylbutane



2,3-dimethylbutane

3.47 Explain why each of the following name is incorrect:

(a) 2,2-Dimethyl-6-ethylheptane

(b) 4-Ethyl-5,5-dimethylpentane

(c) 3-Ethyl-4,4-dimehylhexane

(d) 5,5,6-Trimethyloctane

(e) 2-Isopropyl-4-methylheptane

(f) cis-1,5-Dimethylcyclohexane

Solution:

(a) The longest chain has 8 carbons, so the correct name should be 2,2,7-trimethyl-octane.

(b) A pentane can't have a substituent at the 5^{th} carbon, so the correct name should be 3-ethyl-2-methylhaxane.

(c) The substituents should be cited in alphabetical order, so the correct name should be 4,4-Dimehy-3-ethylhexane.

(d) We should begin at the end nearer the first branch point when number the carbons, so the correct name should be 3,4,4-Trimethyloctane.

(e) We should choose the chain with the larger number of branch points as the parent, so the correct name should be 2,3,5-trimethylhexane.

(f) The second substituent should has as low a nember as possible, so the correct name should be cis-1,2-dimethylcyclohexane.

3.48 Propose structures and give IUPAC names for the following:

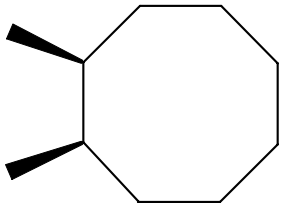
(a) A dimethylcyclooctane

(b) A diethyldimethylhexane

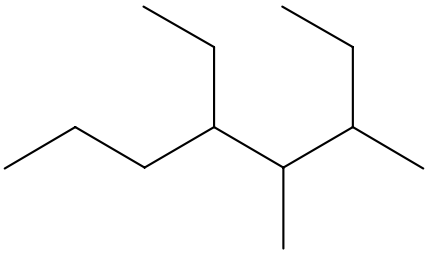
(c) A cyclic alkane with three methyl groups

(d) A (3-methylbutyl)-substituented alkane

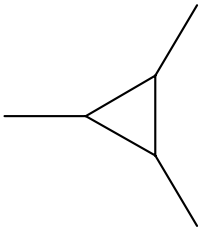
Solution:



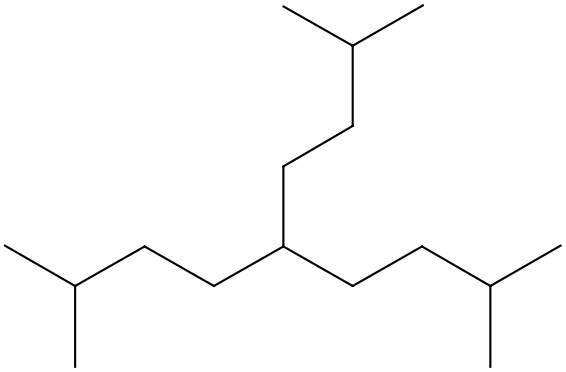
(a) cis-1,2dimethylcyclooctane



(b) 1,2-diethyl-3,4-dimethylhexane



(c) 1,2,3-trimethylcyclopropane

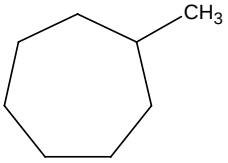


(d) 2,8-dimethyl-5-(3-methylbutyl)-nonane

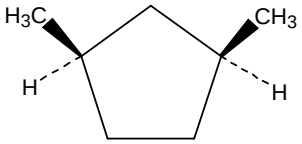
Organic Chemistry Homework (2004.5.7)

By Liu, Xiaoyuan

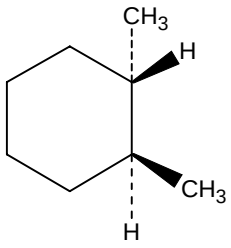
3.49 Give IUPAC names for the following compounds:



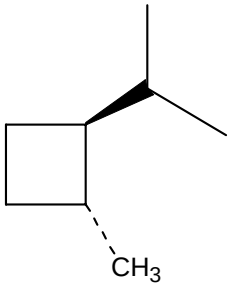
(a) methylcycloheptane



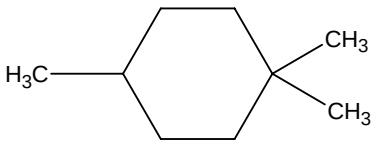
(b) cis-1,3-dimethylcyclopentane



(c) trans-1,2-dimethylcyclohexane



(d) trans-1-i-propyl-2-methylcyclobutane

(e) 

1,1,4-trimethylcyclohexane

3.50 Glucose has the following structure. Identify each pair of relationships among the —OH groups as cis or trans.

Solution: red-blue: trans

red-green: cis

blue-green: trans

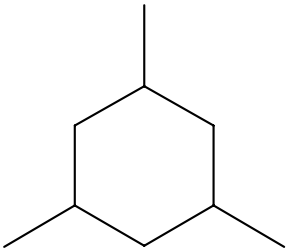
blue-black: cis

green-black: trans

3.51 Draw 1,3,5-trimethylcyclohexane using a hexagon to represent the ring. How many cis-trans stereoisomers are possible?

Solution:

The structure of 1,3,5-trimethylcyclohexane as follow:



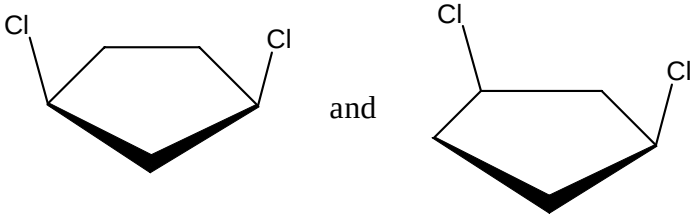
And two cis-trans stereoisomers are possible.

3.52 Tell whether the following pairs of compounds are identical, constitutional isomers or stereoisomers:

(a) Cis-1, 3-dibromocyclohexane and trans-1, 4-dibromocyclohexane

(b) 2,3-dimethylhexane and 2,5,5-trimethylpentane

(c)



Solution:

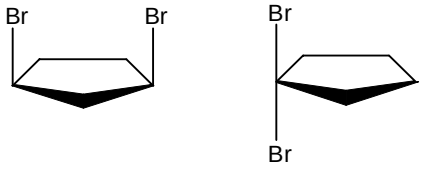
(a) Constitutional isomers

(b) Constitutional isomers

(c) Identical

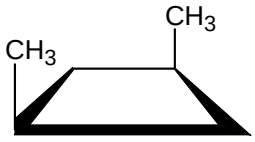
a) Draw two constitutional isomers of cis-1,2-dibromocyclopentane.

Solution:



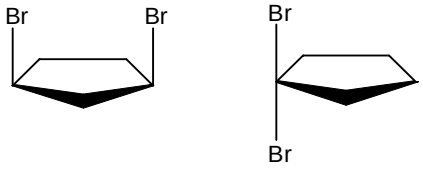
b) Draw a stereoisomer of trans-1,3-dimethylcyclobutane.

Solution:



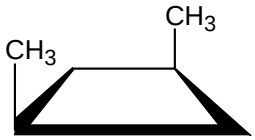
3.53 Draw two constitutional isomers of cis-1,2-dibromocyclopentane.

Solution:



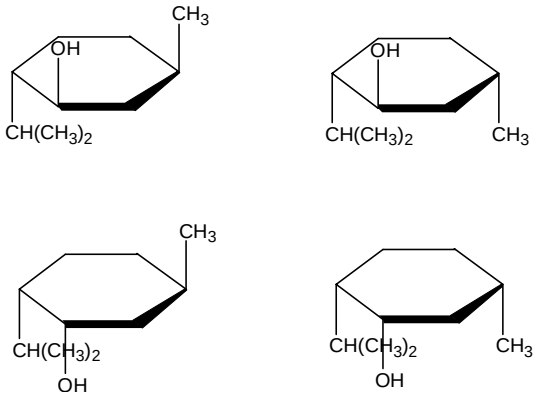
3.54 Draw a stereoisomer of trans-1,3-dimethylcyclobutane.

Solution:



3.55 There are four cis-trans isomers of menthol, including the one shown. Draw the other three.

Answer:

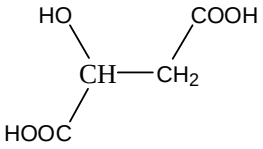


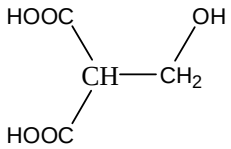
3.56 Malic acid, C4H6O5, has been isolated from apples. Since this compounds reacts with 2 molar equivalents of base, it is a dicarboxylic acid.

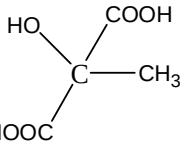
(a) Draw at least five possible structures.

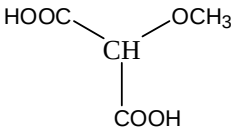
(b) If malic acid is a secondary alcohol, what is its structure?

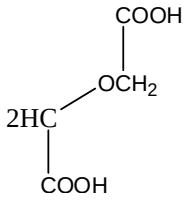
Answer:



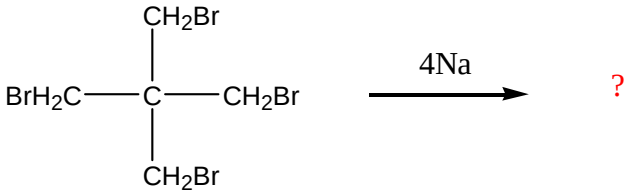






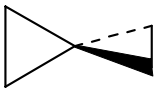


3.57 cyclopropane was first prepared by reaction of 1,3-dibromopropane with sodium metal. Formulate the cyclopropane-forming reaction and then predict the product of the following reaction. What geometry do you expect for the product? (Try building a molecular model.)



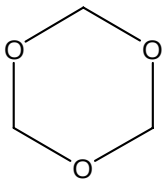
Solution:

The product is:



3.58 Formaldehyde, $H_2C{=}O$ is known to all biologists because of its usefulness as a tissue preservative. When pure, formaldehyde trimerizes to give trioxane, $C_3H_6O_3$, which, surprisingly enough, has no carbonyl groups. Only one monobromo derivative $(C_3H_5BrO_3)$ of trioxane is possible. Propose a structure for trioxane.

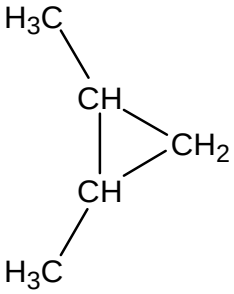
Solution:



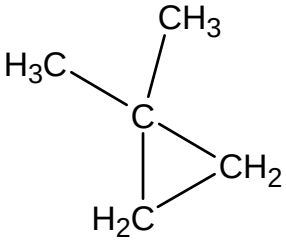
3.59 Draw the five cycloalkanes with the formula C_5H_{10}

Solution:

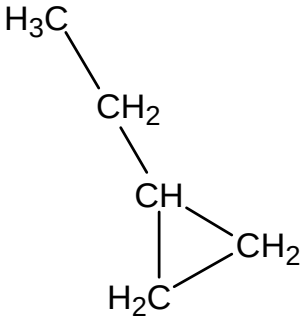
(a)



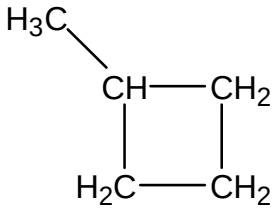
(b)



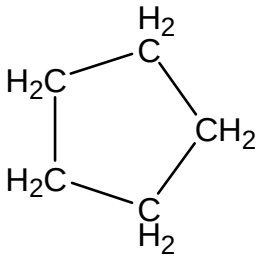
(c)



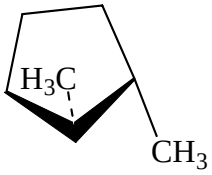
(d)

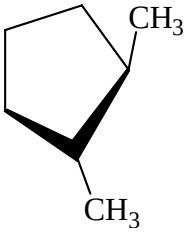


(e)



3.60 There are two different substance named trans-1,2-dimethylcyclopentane.Make molecular models, and see if you can find the relationship between them.

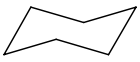




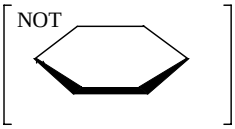
Solutions:

They are enantiomers.

3.61 Cyclohexane has a pucked shape like a lounge chair rather than a flat shape. Why? (See section 4.8 and 4.9)



Cyclohexane



Solution:

First the C-C-C angels of Cyclohexane can reach the strain-free tetrahedral value, second in a newman projection, the chair Cyclohexane has no torsional strain, and all neighboring C-H bonds are staggered. The two reasons result the chair form lower energy and more stable.