Name _____ AP CHEM __/__/__

Chapter 22 Outline – Organic and Biological Molecules

There are a myriad or carbon compounds, several million are now known, and the number continues to grow rapidly. The study of carbon-containing compounds and their properties is called **organic chemistry**.

Organic Prefixes	
# Carbons	Prefix
1	meth-
2	eth-
3	prop-
4	but-
5	pent-
6	hex-
7	hept-
8	oct-
9	non-
10	dec-
11	undec-
12	dodec-
13	tridec-
14	tetradec-
15	pentadec-

Alkanes: Saturated Hydrocarbons

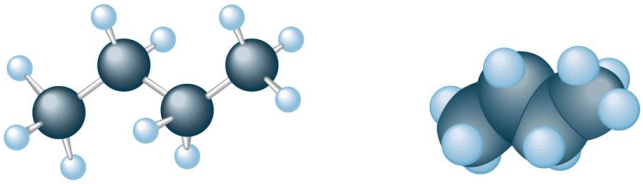
- Hydrocarbons are compounds composed of carbon and hydrogen. Those compounds whose carbon-carbon bonds are all single bonds are said to be **saturated**, because each carbon is bound to four atoms, the maximum number. Hydrocarbons containing carbon-carbon double and triple bonds are said to be **unsaturated**.
- Alkanes in which the carbon atoms form long "strings" or chains are called **normal**, **straight-chain**, or **unbranched hydrocarbons**. (The chains are actually zig-zag.)
- All alkanes can be represented by the formula $\mathbf{C_nH_{2n+2}}$. For example, nonane, which has 9 carbon atoms is represented by the formula C_9H_{20}.
- Alkanes are named using the prefixes listed to the right. More below.
- The properties of the first ten normal alkanes are listed below.

TABLE 22.1 Selected Properties of the First Ten Normal Alkanes

Name	Formula	Molar Mass	Melting Point (°C)	Boiling Point (°C)	Number of Structural Isomers
Methane	CH_4	16	−182	−162	1
Ethane	C_2H_6	30	−183	−89	1
Propane	C_3H_8	44	−187	−42	1
Butane	C_4H_{10}	58	−138	0	2
Pentane	C_5H_{12}	72	−130	36	3
Hexane	C_6H_{14}	86	−95	68	5
Heptane	C_7H_{16}	100	−91	98	9
Octane	C_8H_{18}	114	−57	126	18
Nonane	C_9H_{20}	128	−54	151	35
Decane	$C_{10}H_{22}$	142	−30	174	75

Isomerism in Alkanes

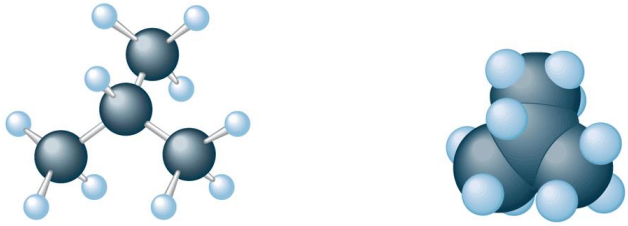
- Butane and all succeeding members of the alkanes exhibit **structural isomerism**.
- Structural isomerism occurs when two molecules have the same atoms but different bonds. For example, butane can exist as a straight-chain molecule (normal butane) or with a branched-chain structure (called isobutane). These are shown to the right.



(a)

Nomenclature

- Rules for naming alkanes
  1. All alkanes have names that end in –ane.
  2. When alkane groups appear as substituents, they are named by dropping the –ane and adding –yl.
  3. The positions of substituent groups are specified by numbering the longest chain of carbon atoms sequentially, starting at the end closest to the branching.
  4. The location and name of each substituent are followed by the root alkane name. Substituents are listed in alphabetical order, and the prefixes di-, tri-, etc. used to indicate multiple identical substituents.



(b)

- For example: Draw the structural isomers for the alkane, C_6H_{14} and give the systematic name for each one. (this will be shown in class)

- You try: Determine the structure for each of the following compounds:
  a. 4-ethyl-3,5-dimethylnonane b. 4-ethylheptane

Cyclic Alkanes

- Besides forming chains, alkanes also form rings. The cyclic alkanes have the general formula C_nH_{2n}.
- Cyclohexane can exist in two forms, the chair and the boat forms. The two hydrogen atoms above the ring in the boat form are quite close to each other, and the resulting repulsion between these atoms causes the chair form to be preferred. At 25°C more than 99% of cyclohexane exists in the chair form. They are shown below.
- In class I will review cyclic alkane nomenclature. Include examples here.

Alkenes

- Multiple carbon bonds (double and triple bonds) result when hydrogen atoms are removed from alkanes. Hydrocarbons that contain at least one carbon-carbon double bond are called alkenes.
- Alkene Nomencalture
    - The root hydrocarbon name ends in -ene rather than -ane.
    - In alkenes containing more than three carbon atoms, the location of the double bond is indicated by the lowest-numbered carbon atom involved in the bond.
- Identical substituents on the same side of the double bond are designated **cis** and those on opposite sides are labeled **trans**.
- In class I will review alkene structures and nomenclature. Include examples here.

Alkynes

- Alkynes are unsatured hydrocarbons containing at least one triple carbon bond.
- In alkyne nomenclature, -yne is used as a suffix instead of –ane and –ene.
- In class I will review alkyne structures and nomenclature. Include examples here.

Aromatic Hydrocarbons

- A special class of cyclic unsaturated hydrocarbons is known as the aromatic hydrocarbons. The simplest of these is benzene, C_6H_6.
- Draw the resonance structures of benzene below.

Hydrocarbon Derivatives

- The vast majority of organic molecules contain elements in addition to carbon and hydrogen.
- Hydrocarbon derivatives, molecules that are fundamentally hydrocarbons but that have additional atoms or groups of atoms called functional groups.
- The common functional groups are listed below. These MUST be memorized.

Functional Group	Compound Structure	Naming Suffix	Example	
Alcohol	R - OH	-ol	$CH_3 - CH_2 - OH$	ethanol
Ether	R - O - R	-ether	$CH_3 - CH_2 - O - CH_2 - CH_3$	diethyl ether
Aldehyde	R - C – H ‖ O	-al	$CH_3 - C - H$ ‖ O	ethanal
Organic Acid	R - C - OH ‖ O	- oic acid	$CH_3 - C - OH$ ‖ O	ethanoic acid
Ester	R – C – O –R ‖ O	-oate	$CH_3 – C – O – CH_2 – CH_3$ ‖ O	ethyl ethanoate
Ketone	R - C - R ‖ O	-one	$CH_3 - C - CH_3$ ‖ O	propanone
Amine	$R - NH_2$	-amine	$CH_3 - CH_2 - NH_2$	ethyl amine

Collected AP Questions MC(1984, 1988, 1994, 1999) Essay (1980 – 2006)

1. Which of the following pairs of compounds are isomers?

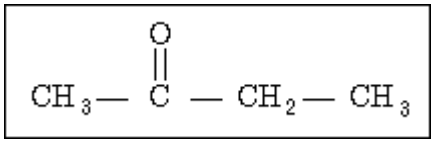
(A) $CH_3-CH_2-CH_2-CH_3$ and $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$

(B) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_3$ and $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}=CH_2$

(C) CH_3-O-CH_3 and $CH_3-\overset{\displaystyle O}{\overset{\|}{C}}-CH_3$

(D) CH_3-OH and CH_3-CH_2-OH

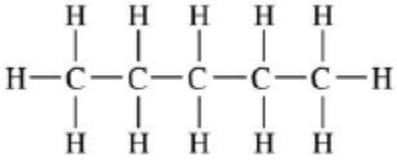
(E) CH_4 and $CH_2=CH_2$



2. The organic compound represented above is an example of
(A) an organic acid (B) an alcohol (C) an ether (D) an aldehyde (E) a ketone

1998 - #9c
Dimethyl ether, $H_3C\text{-}O\text{-}CH_3$, is not very soluble in water. Draw a structural isomer of dimethyl ether that is much more soluble in water and explain the basis of its increased water solubility.

2002 - #3
(e) The structural formula of one isomer of pentane is shown to the right. Draw the structural formulas for the other two isomers of pentane. Be sure to include all atoms of hydrogen and carbon in your structures.



2003 – #8 a & c
Using the information in the table above, answer the following questions about organic compounds.
(a) For propanone,
(i) draw the complete structural formula (showing all atoms and bonds);
(c) Draw the complete structural formula for an isomer of the molecule you drew in part (a) (i).

Answers
1. Which of the following pairs of compounds are isomers?

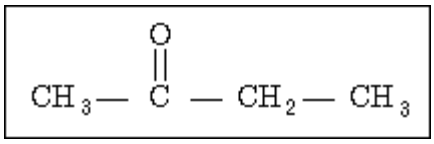
(A) $CH_3-CH_2-CH_2-CH_3$ and $CH_3-CH(CH_3)-CH_3$

(B) $CH_3-CH(CH_3)-CH_3$ and $CH_3-CH(CH_3)=CH_2$

(C) CH_3-O-CH_3 and $CH_3-C(=O)-CH_3$

(D) CH_3-OH and CH_3-CH_2-OH

(E) CH_4 and $CH_2=CH_2$

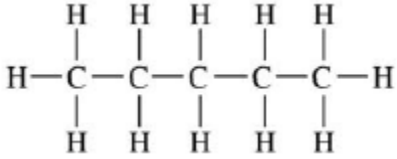


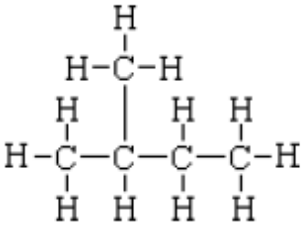
2. The organic compound represented above is an example of
(A) an organic acid (B) an alcohol (C) an ether (D) an aldehyde **(E) a ketone**

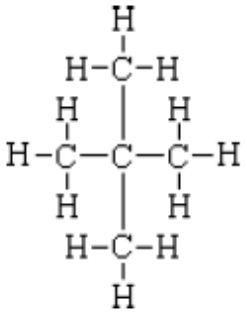
1998 - #9c
Dimethyl ether, $H_3C\text{-}O\text{-}CH_3$, is not very soluble in water. Draw a structural isomer of dimethyl ether that is much more soluble in water and explain the basis of its increased water solubility.
CH_3CH_2OH; Response must indicate that a clear ethanol structure. The hydroxyl group forms hydrogen bonds with water molecules. Response must mention/indicate involvement of hydroxyl group

2002 - #3

(e) The structural formula of one isomer of pentane is shown below. Draw the structural formulas for the other two isomers of pentane. Be sure to include all atoms of hydrogen and carbon in your structures.





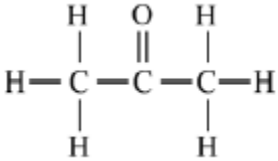


2003 – #8 a & c

Using the information in the table above, answer the following questions about organic compounds.

(a) For propanone,

(i) draw the complete structural formula (showing all atoms and bonds);



(c) Draw the complete structural formula for an isomer of the molecule you drew in part (a) (i).