Name Filled In Hour

CHM CON B Unit 9 Packet: Hydrocarbons

Learning Goals:

1. Write all 10 carbon prefixes.
2. Explain the –ane, -ene, and –yne endings.
3. Draw and name any alkane, alkene or alkyne.
4. Draw and name any branched alkane, alkene or alkyne.
5. Draw and name a branched alkene or alkyne with more than one double or triple bond.
6. Explain isomers and can identity isomers given names or structures.
7. Explain why isomers have different properties.
8. Name the three branch types for carbon.
9. Correctly number the carbon atoms of a hydrocarbon in order to name it.

VOCABULARY (I can define/describe the following terms in my own words)

- alkane
- alkene
- alkyne
- hydrocarbon
- isomer
- meth-
- eth-
- prop-
- but-
- pent-
- hex-
- hept-
- oct-
- non-
- dec-
- -ane
- -ene
- -yne
- -yl

ORGANIC CHEMISTRY— A VERY BRIEF INTRODUCTION

Organic chemistry is the chemistry of carbon, an element with unique properties that has created an entire sphere of science. As a result of these properties, the chemistry of carbon is also the chemistry of life, and everything that derives from it, from petrol to plastics. Here we give a brief primer of the central concepts and terms.

The Chemistry of Carbon

A carbon atom has six protons and therefore six electrons: two in its inner shell and four in its outer, valence, shell. These four electrons are the key to carbon's properties, allowing an atom of carbon to form four covalent bonds with other atoms, including other atoms of carbon; these bonds can be single, double or triple. Self-bonding means that carbon can form long chains, and these can act as skeletons to which other elements attach. The number of possible combinations of carbon atoms and their attachments is effectively limitless.

The enormous diversity and complexity of organic chemistry posed a huge challenge for early chemists, once they had begun to draw a distinction between organic and inorganic substances in the late 18th century. Lavoisier showed that the constituents of organic compounds were actually very limited—all included carbon and hydrogen, often with oxygen and occasionally nitrogen. But the further research into organic chemistry progressed, the harder it became to impose any systematic order. At least one pioneer in the field, the great German chemist Justus von Liebig (1803–1873), whose eponymous condenser made it dramatically easier to analyze organic compounds, became so exasperated that he gave up on trying to systematize and turned to applied organic chemistry instead. Not until 1858 was Friedrich August Kekulé (1829–1896) able pull together all the research and formulate a comprehensive theory of chemical structure, emphasizing the importance of carbon backbones or skeletons.

Hydrocarbons

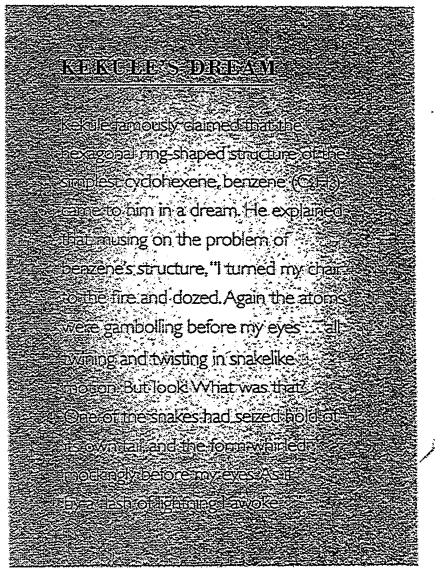
The simplest organic compounds are created when only hydrogen atoms are attached to this carbon skeleton; these are called "hydrocarbons," and even these are vastly diverse. The naming system for hydrocarbons is based on the type of bonds between atoms in the carbon chain. Molecules with only single bonds are known as alkanes. Molecules with one or more double bonds are called "alkenes," those with one or more triple bonds are called "alkynes," while those in which carbon atoms link up in a ring are called "cyclic hydrocarbons" or "cyclohexenes" (because the rings are made up of six carbon atoms). An important class of cyclohexenes is the aromatics, where the cyclohexene ring has alternating single and double bonds. In an alkane every carbon atom makes four bonds to four different atoms, and these molecules are thus said to be saturated.

There is a distinction between molecular and structural formula for an organic compound, because of the potential for double and triple bonds and for branching of carbon chains. For instance, the hydrocarbon butane has the molecular formula C_4H_{10}, but it can adopt one of two forms with different structural formulae. In normal butane the structural formula shows the carbon atoms in a straight chain:

$$CH_3–CH_2–CH_2–CH_3$$

This is a condensed structural formula, different from an expanded one which shows each hydrogen atom separately and all the bonds between each atom. Note that carbon atoms on the end of the chain have three spare bonds and therefore bond to three hydrogen atoms, while those in the middle of the chain use up two bonds linking to the carbon atoms on either side and therefore bond to only two hydrogen atoms.

Another arrangement is possible given this molecular formula, with one carbon atom branching off the chain:



$$CH_3–CH(CH_3)–CH_3$$

A compound with the same molecular formula but different structural formula is known as an isomer, so this is known as isobutane.

When an element other than hydrogen bonds with an organic molecule it is known as a functional group. Important functional groups include the alcohols, where an –OH group is bound to the carbon backbone; and the amines, where a nitrogen containing functional group, $–NH_2$, is involved. The simplest form of alcohol is methanol (aka methyl or wood alcohol): CH_3OH. Ethanol, the alcohol found in wine, beer and spirits, is CH_3CH_2OH.

Multiple Choice Questions for Hydrocarbon Article

1. A How is a condensed structural formula different from an expanded structural formula?
   a. Expanded formulas show each hydrogen atom separately and all the bonds between each atom.
   b. Expanded formulas show the carbon atoms in a straight chain.
   c. Expanded formulas are the same for each isomer of a hydrocarbon.
   d. Structural formulas show each hydrogen atom separately and all the bonds between each atom.

2. C Which is a true statement about hydrocarbons?
   a. Alkenes have single bonds only.
   b. Alkanes contain double bonds.
   c. Alkynes have triple and single bonds.
   d. Alkenes have double and triple bonds.

3. A What element MUST be present in an organic compound?
   a. Carbon
   b. Nitrogen
   c. Hydrogen
   d. Oxygen

4. D How many covalent bonds can a carbon atom make?
   a. 1
   b. 2
   c. 3
   d. 4

5. B How many hydrogen atoms will bond to a carbon atom in the MIDDLE of a hydrocarbon chain?
   a. 1
   b. 2
   c. 3
   d. 4

6. C How many hydrogen atoms will bond to a carbon atom on the END of a hydrocarbon chain?
   a. 1
   b. 2
   c. 3
   d. 4

7. C What is the definition of an isomer?
   a. A functional group
   b. Isobutane
   c. A compound with the same molecular formula but different structural formula.
   d. A compound with the same structural formula but different molecular formula.

Hydrocarbon Notes

1. What are **hydrocarbons**? Simplest organic compounds involving only hydrogen & carbon.
2. What are **alkanes**?

   Molecules with only single bonds
3. What are **alkenes**?

   molecules with one or more double bonds.
4. What are **alkynes**?

   molecules with one or more triple bonds.

Looking at the given formulas, come up with the other formulas.

Number of Carbon Atoms	Alkanes	Alkenes	Alkynes
1	CH_4	------	-------
2	C_2H_6	C_2H_4	C_2H_2
3	C_3H_8	C_3H_6	C_3H_4
4	C_4H_{10}	C_4H_{10}	C_4H_6
5	C_5H_{12}	C_5H_{10}	C_5H_8
6	C_6H_{14}	C_6H_{12}	C_6H_{10}
7	C_7H_{16}	C_7H_{14}	C_7H_{12}
8	C_8H_{18}	C_8H_{16}	C_8H_{14}
9	C_9H_{20}	C_9H_{10}	C_9H_{16}
10	$C_{10}H_{22}$	$C_{10}H_{20}$	$C_{10}H_{18}$

Using the above information, figure out the relationship between the number of carbon atoms and the number of hydrogen atoms for each type of hydrocarbon.

5. What is the relationship between carbon and hydrogen for alkanes?

   Twice as many hydrogens as carbons plus two more carbons. $2C + 2$
6. What is the relationship between carbon and hydrogen for alkenes?

   Twice as many hydrogens as carbons. $2C$
7. What is the relationship between carbon and hydrogen for alkynes?

   Twice as many hydrogens as carbons minus 2 carbons.

   $2C - 2$

exercise 15-A

NAMING HYDROCARBONS

The name for a hydrocarbon generally consists of two parts. The first part indicates the number of carbon atoms in the chain:

1	C atom	meth	6	C atoms	hex
2	C atoms	eth	7	C atoms	hept
3	C atoms	prop	8	C atoms	oct
4	C atoms	but	9	C atoms	non
5	C atoms	pent	10	C atoms	dec

The second part of the name of a hydrocarbon is the same as that of its series. When you know the series to which a hydrocarbon belongs, you have other information available:

Series	Name Ending	General Formula	Bonding in C Chain
Alkane	ane	C_nH_{2n+2}	single bonds only
Alkene	ene	C_nH_{2n}	one double bond —C=C—
Alkyne	yne	C_nH_{2n-2}	one triple bond —C≡C—

You will use the above information as you answer the questions in this Exercise.

1. How many carbon atoms are in each hydrocarbon?

(a) methane 1
(b) ethane 2
(c) ethene 2
(d) pentane 5
(e) propene 3
(f) hexane 6
(g) ethyne 2
(h) propane 3
(i) heptane 7
(j) octene 8
(k) decane 10
(l) butyne 4
(m) butene 4
(n) propyne 3
(o) butane 4

2. For each compound listed below, underline the name ending, then fill in the blanks with the indicated information:

COMPOUND	NUMBER OF C ATOMS	SERIES TO WHICH IT BELONGS	GENERAL FORMULA OF THE SERIES
(a) methane	1	alkane	C_nH_{2n+2} CH_4
(b) butene	4	alkene	C_nH_{2n} C_4H_8
(c) propyne	3	alkyne	C_nH_{2n-2} C_3H_4
(d) pentane	5	alkane	C_nH_{2n+2} C_5H_{12}
(e) octane	8	alkane	C_nH_{2n+2} C_8H_{18}

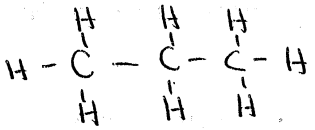
COMPOUND	NUMBER OF C ATOMS	SERIES TO WHICH IT BELONGS	GENERAL FORMULA OF THE SERIES
(f) heptene	7	alkene	C_nH_{2n} C_7H_{14}
(g) propene	3	alkene	C_nH_{2n} C_3H_6
(h) butyne	4	alkyne	C_nH_{2n-2} C_4H_6
(i) decane	10	alkane	C_nH_{2n+2} $C_{10}H_{22}$
(j) nonane	9	alkane	C_nH_{2n+2} C_9H_{20}
(k) heptane	7	alkane	C_nH_{2n+2} C_7H_{16}
(l) ethyne	2	alkyne	C_nH_{2n-2} C_2H_2
(m) hexyne	6	alkyne	C_nH_{2n-2} C_6H_{10}
(n) ethene	2	alkene	C_nH_{2n} C_2H_4
(o) propane	3	alkane	C_nH_{2n+2} C_3H_8

3. Name each of the formulas by first writing down the carbon-count "prefix," then add the ending indicating the series to which the compound belongs:

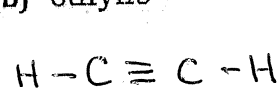
(a) C_2H_2 ethyne
(b) C_5H_{12} pentane
(c) C_3H_8 propane
(d) C_2H_2 ethyne
(e) CH_4 methane
(f) C_3H_6 propene
(g) C_7H_{12} heptyne
(h) C_5H_{10} pentene
(i) C_2H_4 ethene
(j) C_3H_4 propyne
(k) C_4H_6 butyne
(l) C_6H_{12} hexene
(m) C_8H_{18} octane
(n) $C_{10}H_{18}$ decyne
(o) C_2H_6 ethane

4. Write the structural formula for each of the following:

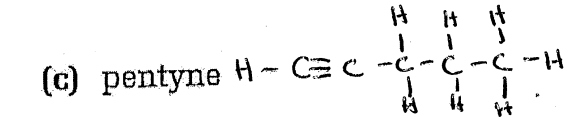
(a) propane C_3H_8



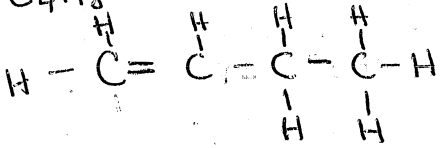
(b) ethyne C_2H_2



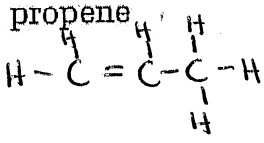
(c) pentyne C_5H_8



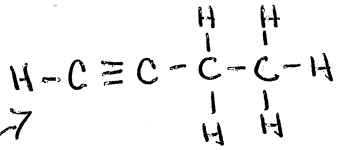
(d) butene C_4H_8



(e) propene C_3H_6



(f) butyne C_4H_6



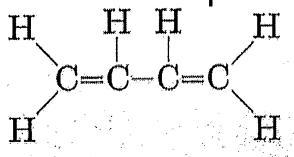
After completing Exercise 15-A naming hydrocarbons, create a graphic organizer that you can use to name and write the formulas for all three types of hydrocarbons correctly. Use the space below to draw your completed organizer.

Concept Check #1

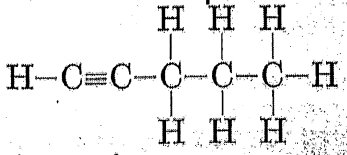
1,3 - butadiene 1 - pentyne 2 - butyne

1. Name the following compounds.

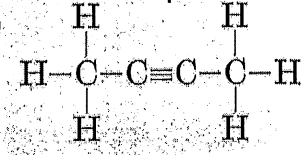
a.



b.



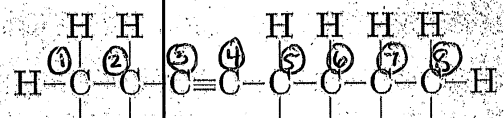
c.

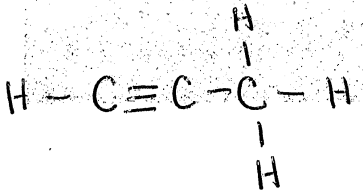


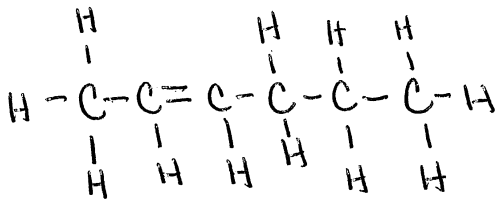
2. Draw the structural formulas for the following hydrocarbons.

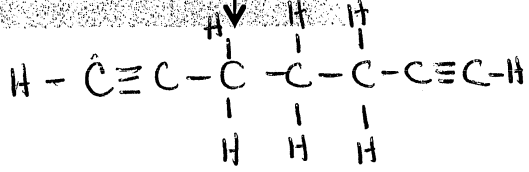
a. propyne **b.** 2-hexene **c.** 1, 6-heptadiyne

3. Correctly number the carbon atoms in the following compound.









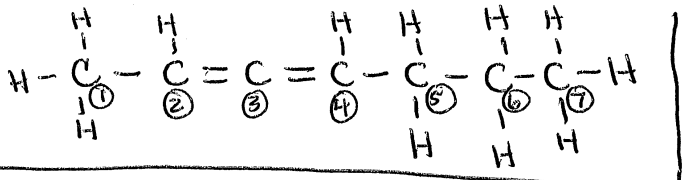
Naming Hydrocarbons Notes

Naming straight-chain hydrocarbons:

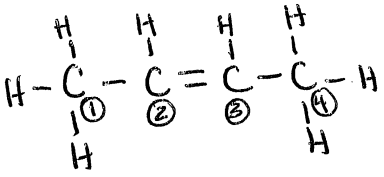
① Number the carbons so that the multiple bond is the lowest # possible - start from left OR right.

② If there is more than 1 multiple bond, di- and tri- are used between the prefix and the suffix of the hydrocarbons.

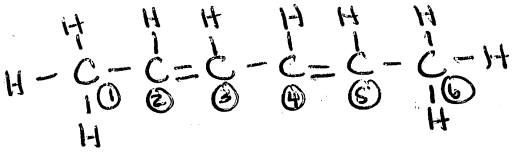
Examples: 2,3 - heptadiene (7 carbons; 2,3 = pos. of bonds; di = 2 dbl bonds)



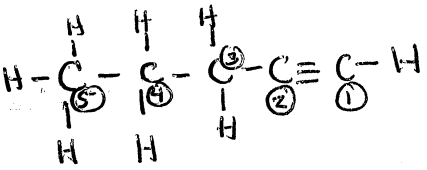
2 - butene



2,4 - hexadiene



1- pentyne



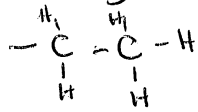
Naming nonlinear (not straight) hydrocarbons:

① Number the longest chain of carbons (you may turn a corner) multiple bonds must be included in parent chain

② Branches and multiple bonds should have the lowest possible carbon #'s. Multiple bonds take priority over branches.

Examples: New suffix -yl - branch groups

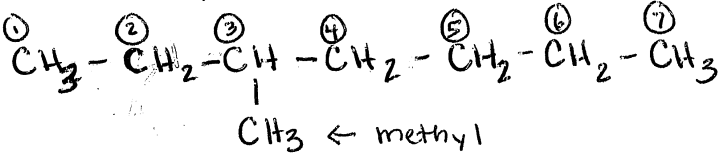
methyl = 1C $-CH_3$

ethyl = 2C  or CH_2-CH_3

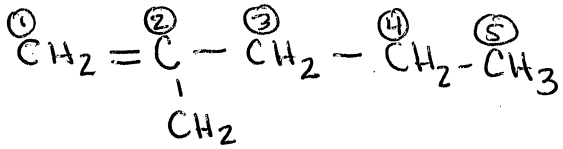
propyl = 3C $CH_2-CH_2-CH_3$

isopropyl = 4C $CH_2-CH_2-CH_2-CH_3$

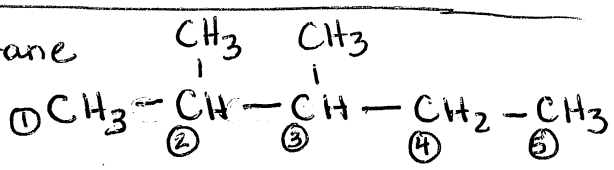
3 methyl heptane



2 ethyl - 1 pentene



2,3 dimethyl - pentane

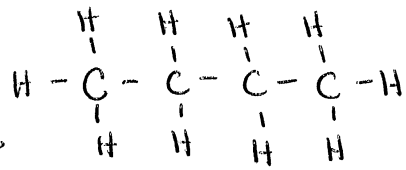


Isomer Notes

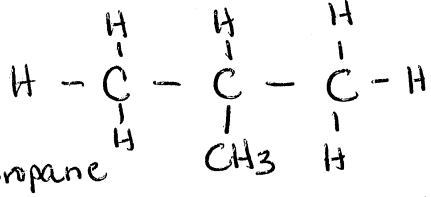
Butane has 2 isomers: butane and 2-methylpropane. Draw both isomers of butane below.

(A) (B)

C_4H_{10}



(A) butane

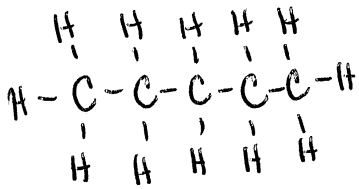


(B) 2methylpropane

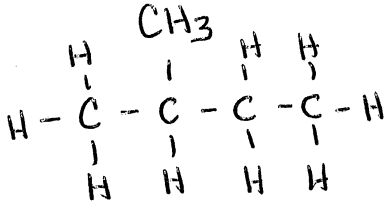
Pentane has 3 isomers: pentane, 2 – methylbutane and 2,2 – dimethylpropane. Draw each below.

(A) (B) (C)

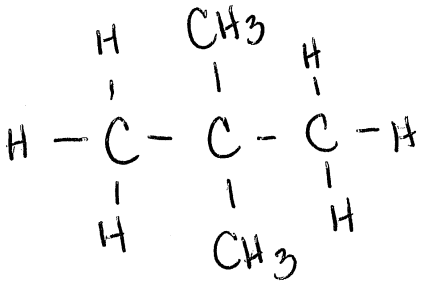
C_5H_{12}



(A)



(B)



(C)

(A) (B) (C) (D) (E)

Hexane has 5 isomers: hexane, 2 – methylpentane, 3 – methylpentane, 2,3 – dimethylpentane, 2,3 – dimethylbutane and 2,2 – dimethylbutane.
Draw each below.

See back of this page!

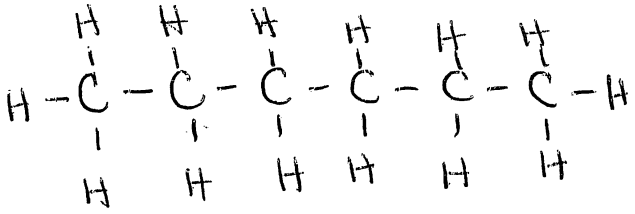
What is an isomer? A compound with the same molecular formula but different structural formula

All isomers of butane have 4 C atoms & 10 H atoms.

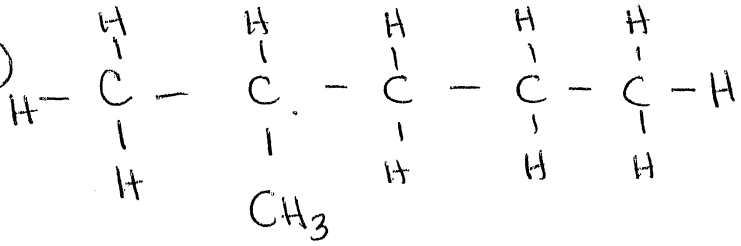
All isomers of pentane have 5 C atoms & 12 H atoms.

All isomers of hexane have 6 C atoms & 14 H atoms.

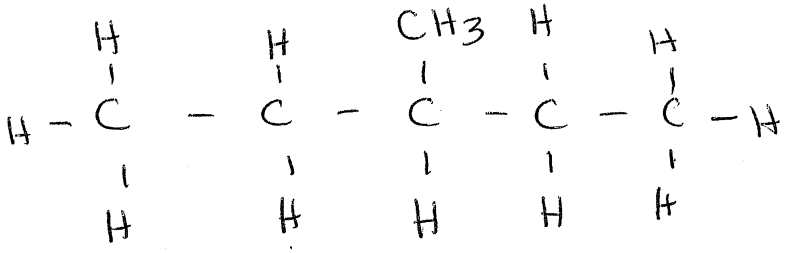
(A)



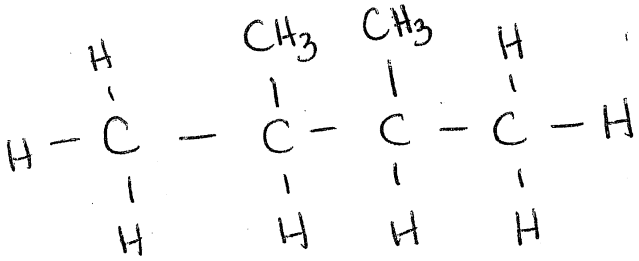
(B)



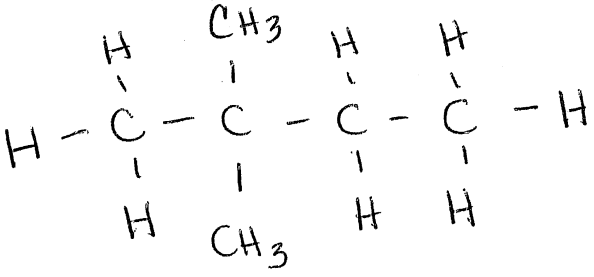
(C)



(D)



(E)



Suffix of a hydrocarbon with only single bonds	Prefix for hydrocarbons having one carbon	Prefix for hydrocarbons having two carbons	Name for hydrocarbons with only single bonds
Suffix of a hydrocarbon with one or more double bonds	Suffix of a hydrocarbon with one or more triple bonds	Prefix for hydrocarbons having three carbons	Name for hydrocarbons with one or more double bonds
Name for hydrocarbons with one or more triple bonds	Prefix for hydrocarbons having four carbons	Prefix for hydrocarbons having five carbons	Prefix for hydrocarbons having ten carbons

Simplest type of organic molecules having only Carbon and Hydrogen atoms	Prefix for hydrocarbons having nine carbons	Prefix for hydrocarbons having six carbons	Suffix for the branched portion of hydrocarbons
Prefix for hydrocarbons having seven carbons	Prefix for hydrocarbons having eight carbons	A compound with the same molecular formula but different structural formulas	