

UNIT 8 - TOPIC 2
ORGANIC HYDROCARBONS

Name _____

ESSENTIALS: Know, Understand, and Be Able To...

- Hydrocarbon compounds contain only carbon and hydrogen atoms, which bond to one another to form a variety of structures.
- Organic compounds are named using the IUPAC system.
- “**Saturated**” hydrocarbons contain all single bonds, and are called alkanes. “**Unsaturated**” organic compounds contain double (alkenes) or triple (alkynes) covalent bonds.
- Isomers** are molecules that have the same molecular formula, but different structural formulas.
- Classify hydrocarbons as alkanes, alkenes or alkynes, given structural, condensed, or molecular formulas.
- Draw structural formulas for alkanes, alkenes, and alkynes (containing a maximum of ten carbon atoms), when given the IUPAC name.
- Recognize the difference between saturated and unsaturated hydrocarbons, when given a structural or molecular formula.
- Recognize isomers when given structural formulas.

TEXT REFERENCES: p. 385-396

EXPLORE

- Video: Refining Petroleum
- Lab: Organic Chemistry Basics
(and separate credit sheet)

ELABORATE

- Assignments

ENVISION

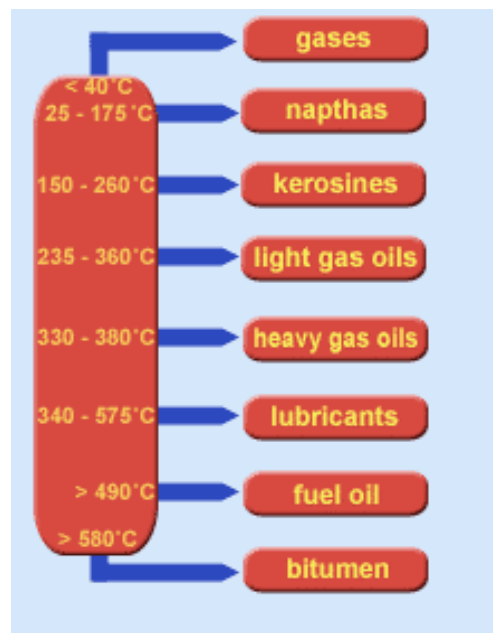
- Moodle Assignment

EVALUATE

- Quiz
- Quiz Corrections

Video: Refining Petroleum

Watch the Fractional Distillation/Cracking Tower videos on the teacher's website, then answer the following questions.



1. What is a hydrocarbon?
2. Where does crude oil come from?
3. Why do we need fractional distillation?
4. What 2 processes occur in the heating/cracking tower?
5. What is the physical property that allows us to separate the different components of crude oil?
6. In the distillation column, where would you find the material with the highest boiling points?
The lowest?
7. What is the relationship between a molecule's atomic mass and its boiling point?
8. List 5 different "everyday" products that come from refined crude oil.
9. Explain how a cracking tower works. (use the words boiling point, atomic mass, crude oil, and fractional distillation)

Lab: Organic Chemistry Basics

Part 1 Key Ideas:

1. What are the ways hydrocarbon compounds can be represented in terms of names, formulas and pictures?
2. What are the sources and uses of alkanes?

Pre-Lab:

1. What would you say the relationship is between the size, or molar mass of a hydrocarbon, and the strength of the "intermolecular forces" (particle attractions)? Use the data chart on p. 695 in your text, and use it to give "evidence" of your statement.



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2. Refer to p. 712 and 713 in your text.

a) What are the two major sources of the alkane hydrocarbons?

b) What are most of the alkane hydrocarbons used for?

c) Write the **combustion equation** for the burning of the alkane named "propane." Include **ENERGY** in your equation. Balance it once you have it written.

d) Which of the two products formed when burning hydrocarbons is the one that is considered a "greenhouse" gas, perhaps contributing to global warming? _____

Safety:

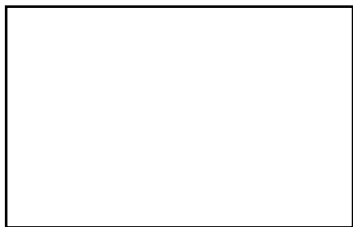
Nada.

Materials: Molecular model kits, brain

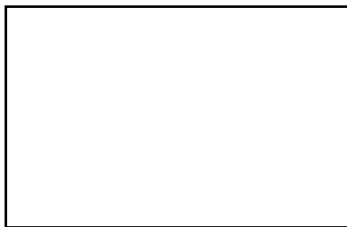
Part 1: Saturated Hydrocarbons (Alkanes)

Procedure: Just follow along in order. This lab is designed to "lead" you to know how to recognize alkane formulas, how to name them, and how to draw them. Model kits are available to build 3D representations. Use them, it helps!

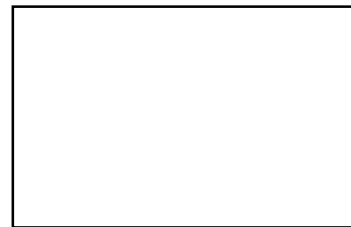
1. a. Draw electron-dot and structural formula of **methane** as seen on page 694. These are all useful ways of representing hydrocarbons.



Electron Dot Diagram



Structural Formula



Space Filling Model

b. Assemble a model of methane (CH_4). Compare your model to the electron-dot and structural formulas you drew above. Note that the angles defined by bonds between atoms are not 90° , as you might think by looking at the structural formula!! If you were to build a close-fitting box to surround a CH_4 molecule, the box would be shaped like a triangular pyramid, or a pyramid with a triangle as a base. A **tetrahedron** is the name given to this three-dimensional shape. This arrangement of atoms (tetrahedral) around carbon is typical of many carbon compounds.

c. Why would the shape of a methane molecule be tetrahedral? **Remember:** *The four pairs of electrons in the bonds surrounding the carbon atom, all with negative charges, repel one another!*

***The angle formed by each C—H bond is 109.5° ,
a value that has been verified with several experimental methods.

2. Build models of a two-carbon and a three-carbon alkane molecule. Remember that each carbon atom has 4 valence electrons, and therefore will form 4 total covalent bonds. In an alkane, these bonds are all single.

a. How many hydrogen atoms are present in the two-carbon alkane? _____

b. How many hydrogen atoms are present in the three-carbon alkane? _____

c. Read the last paragraph on p. 694 of your text. Based on what you read, why are the two models you just built considered to be in the category of hydrocarbons called "alkanes?"

3. a. Draw structural formulas for the two and three carbon alkanes.

2-carbon alkane structural formula	3-carbon alkane structural formula

b. The molecular formulas of the first two alkanes are CH_4 and C_2H_6 . What is the molecular formula of the third? _____

4. Examine your three-carbon alkane model and the structural formula you drew for it. Note that the middle carbon atom is attached to two hydrogen atoms, but the carbon atom at each end is attached to three hydrogen atoms.

a. This molecule can be represented by a "condensed formula", as shown below:



Formulas such as these provide convenient information about how atoms are arranged in molecules. For many purposes, such "condensed" formulas are more useful than molecular formulas such as C_3H_8 . Why do you think this is so?

b. Consider the formulas of the first few alkanes: CH_4 , C_2H_6 , and C_3H_8 . Given the pattern represented by that series, predict the formula of the four carbon alkane: _____

c. Look up the general molecular formula of all alkane molecules on Reference Table Q.

Alkane General Family Formula: _____

This info is on Chart Q!

In the general formula, what does "n" represent? _____

So even without assembling a model, you can predict the formula of a five-carbon alkane:

If $n = 5$, then $2n + 2 = 12$, and the formula is: _____

5. Using the general alkane formula, predict molecular formulas for the rest of the first ten alkanes.

C6 _____

C7 _____

C8 _____

C9 _____

C10 _____

6. Each **name of an alkane** is composed of a **prefix**, which indicates the number of carbon atoms in the backbone carbon chain, is followed by the alkane **family suffix** "-ane".

To a chemist, **Meth-** means one carbon atom,
 Eth- means two,
 Prop- means three,
 But- means four.

This info is on Charts P & Q!

For alkanes with five to ten carbon atoms, the prefix is derived from *Greek*

_____ means five,
Hex means _____,
Hept means _____,
_____ means eight,
Non means _____,
_____ means ten.

7. Write structural formulas for butane and pentane, using the " C_nH_{2n+2} " family general formula.

butane	pentane
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8. Name the alkanes below and write molecular formulas

$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$ _____

$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ _____

9. Write the molecular formula of an alkane containing 25 carbon atoms.

10. Determine the **molar mass** (gram formula mass) of the alkane C_6H_{14} _____ grams per mole

11. These molar masses represent certain alkanes. Figure out which ones they are. Give name, structural and condensed formulas for each.

	Name	Structural Formula	Condensed Formula
a. 30 g/mol.			
b. 58 g/ mol.			
c. 114 g/mol.			

ENRICHMENT/BONUS: (Submit on separate paper) +4 pts

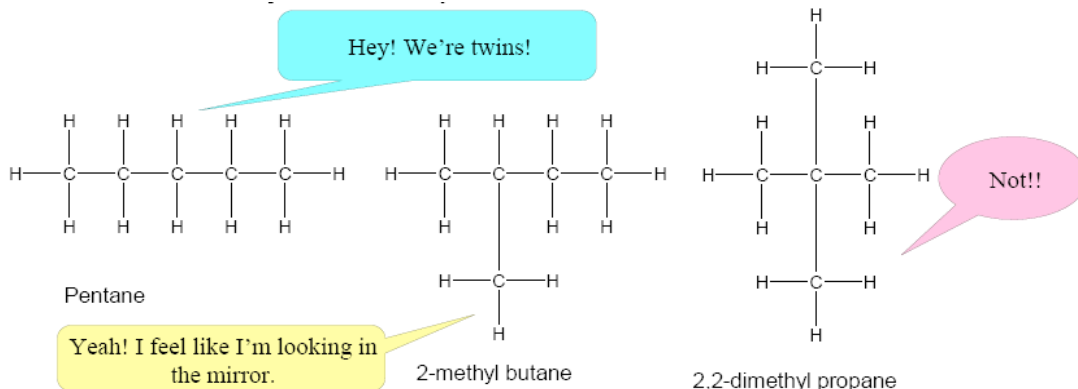
1. Research one or more of the following of interest to you. Write 2-3 paragraphs in your own words, summarizing your findings. Include the references you used.
 - a. The discovery of oil in the US and the first drilling for oil ever done.
 - b. How oil is drilled out of the ground.
 - c. The extraction of oil from "oil shale" and "oil sand" deposits.
 - d. The refining process used to extract particular components out of "crude oil."
 - e. The likelihood of finding natural gas, oil or coal deposits underground in Western NY.

Take Part 1 Lab Quiz NOW before moving on to part 2

Part 2: Isomers of Alkanes

Preparation:

1. Attend a mini-lesson on drawing and naming branched alkanes, OR read p. 697-699 in the text.
2. These are the three isomers of pentane. Why are all 3 considered to be varieties of pentane? They all have the same _____ formulas but different _____ formulas.



3. Sometimes substituent groups (branches) of a particular kind that show up more than once on the longest carbon chain. In this case we use a naming trick, as seen on the structure to the right above.

Instead of naming the compound 2-methyl, 2-methyl propane, it was called 2,2-dimethyl propane... much sweeter!

What do you think these prefixes mean in terms of # of branches of a certain type?

"Tri-" _____ "Tetra-" _____

4. So draw this: 4-ethyl-2,2,3-trimethyl pentane

5. The structure above is an isomer of what alkane? _____

Procedure:

1. Assemble a model of a molecule with the formula C_4H_{10} . There are only two possible structures (isomers) of with this formula. Figure out how to build them both.
2. Draw the structural formulas for BOTH of the two C_4H_{10} isomers.

3. As you might expect, alkanes containing larger numbers of carbon atoms also have larger numbers of isomers. In fact, the number of different isomers increases rapidly as the number of carbon atoms increases. As seen in the pre-lab, there are three pentane (C_5H_{12}) isomers.

Draw all the possible (there are 5) structural isomers of C_6H_{14} . Name each according to IUPAC rules. Use the models as needed to help you visualize the possibilities and rule out structures that are actually identical. Before you move on, check your answers with a peer or your teacher.

4. Write structures for the following:

3-methyl pentane

3,4-dimethyl hexane

2,3,4-trimethyl heptane

5. For each structure in question #4, indicate which straight chain alkane it is an isomer of

3-methylpentane (meth = 1 and pent = 5)
therefore this is an isomer of the 6 carbon alkane:

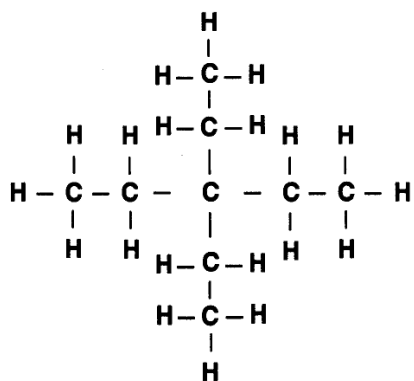
Isomer of :

Hexane (C_6H_{14})

3,4-dimethyl hexane

2,3,4-trimethyl heptane

6. a) Name this structure:



b) What alkane is this an isomer of? _____

A couple of text questions for practice:

p. 699 #3a.

p. 700 #6

p. 720 #53.

ENRICHMENT/BONUS: (Submit on separate paper) +3 pts

The compound "iso-octane" is the primary ingredient in gasoline. Its IUPAC name is 2,2,4-trimethyl pentane. When make fuel blends, this compound is mixed with heptane. Both these compounds are found in and extracted from crude oil.

1. Draw the structures for both compounds.
2. Find out how an "octane rating" is assigned to gasoline. For example, when you pump gas, you typically have a choice of three grades, "87 octane" (the cheapest), 89 and 91 octane. What do the numbers mean in these ratings? Write an explanation in your own words, explaining the chemistry of the fuel blends.

Take Part 2 Lab Quiz NOW before moving on to part 3

Part 3: Unsaturated Hydrocarbons-Alkenes/Alkynes

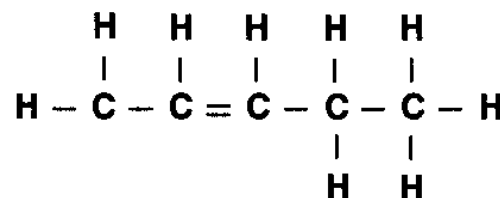
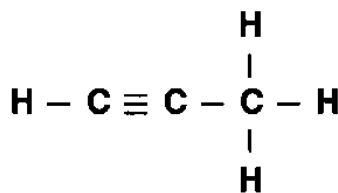
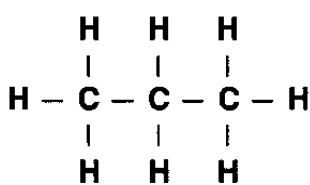
Part 3 Key Ideas:

1. What makes a hydrocarbon "unsaturated?"
2. What are the ways unsaturated compounds can be represented in terms of names, formulas and pictures?

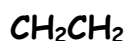
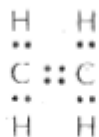
Preparation:

1. Read over p. 702 in a text. What is the difference between "saturated" and "unsaturated" hydrocarbons?
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-

2. Check out the structures below. Circle the ones that are **unsaturated**.

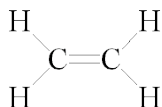


3. Examine the various ways of representing **ethene**, C_2H_4 . Next to each, indicate how you can tell this is NOT an alkane.



Electron-dot Formula

Condensed Formula



Structural Formula

Molecular Formula

4. Look at p. 702 and 703 again. What is it that makes a molecule an "ALKENE"? _____

What is it that allows a hydrocarbon molecule to be classified as an "ALKYNE"? _____

Procedure:

1. Build models of a three-carbon and a four-carbon alkene molecule.

a. How many hydrogen atoms are present in the three-carbon alkene? _____

b. How many hydrogen atoms are present in the four-carbon alkene? _____

2. Write the molecular formulas for:

a. Ethene: _____

b. Propene: _____

c. Butene: _____

d. An alkene with 16 Carbons: _____

e. OK, did you figure it out yet?

What is the "General Family Formula" of the Alkenes? _____

This info is on Chart Q!

3. Look at your model of butene (C_4H_8). Besides the structure you made, there are 2 other isomers of butene. Remember that alkenes **MUST** contain a double bond!

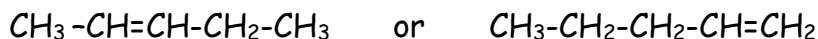
***Draw the structural formulas of the 3 isomers of butene. Name each. Take a peek at p. 702 at the bottom for help with the names. You could ask your Teacher as well!**

a.

b.

c.

4. Are these structures isomers of each other or just different orientations of the same molecule?



Explain how you know by either: Naming each, or drawing the structural formula of each...

5. Now get busy figuring out the ALKYNE family. Assemble a model of a 2 - carbon hydrocarbon molecule with a carbon-carbon triple bond. Your completed model represents the smallest member of the hydrocarbon series known as **alkynes**.

* Based on your understanding of how alkanes and alkenes are named, write structural *and* molecular formulas for:

STRUCTURAL _____ MOLECULAR

a. propyne

b. 2-butyne

c. 1-butyne

d. 2-pentyne

6. Based on the molecular formulas you wrote above, what appears to be the "General Family Formula" of the Alkynes?

"General Family Formula" of the Alkynes: _____

This info is on Chart Q!

7. Above each compound, write whether it is an alkane, alkene or alkyne. Below each, name it.

C_6H_{10}	<u>Alkene</u> C_5H_{10}	C_4H_{10}	C_7H_{14}	C_8H_{18}	C_9H_{16} <u>Nonyne</u>
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ENRICHMENT/BONUS: (Submit on separate paper) +3 pts

People who study the effects of types of foods on the body make a big deal about saturated vs. unsaturated fats in one's diet. Research the following. Include references used.

1. An example of an unsaturated fat and a saturated fat common to the human diet. Draw the structures of each and identify what is causing it to be saturated or not.
2. Which type of fat is considered "good" for you? Why? Why is the other type not good for you? Answer in terms of the CHEMISTRY of these molecules!

Take Part 3 Lab Quiz NOW, then submit completed lab credit sheet.

Assignment: Orgo Drill

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

- 1
- 2
- 3
- 4

2. Which of the following hydrocarbons has the highest normal boiling point?

- butene
- ethene
- pentene
- propene

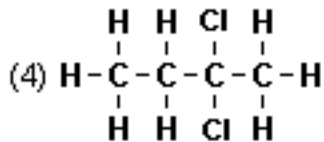
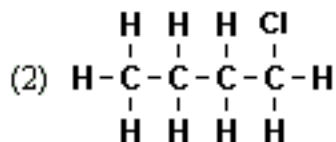
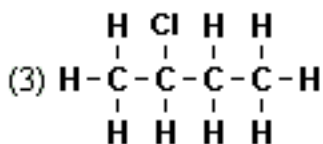
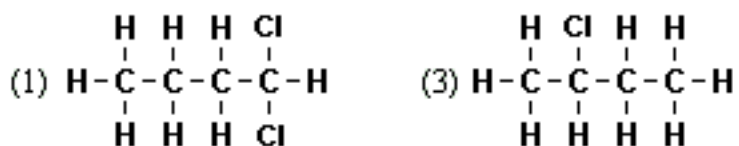
3. Which property is generally characteristic of an organic compound?

- low melting point
- high melting point
- soluble in polar solvents
- insoluble in nonpolar solvents

4. What is the general formula for the members of the alkene series?

- C_nH_{2n}
- C_nH_{2n+2}
- C_nH_{2n-2}
- C_nH_{2n-6}

5. What is the structural formula for 2-chlorobutane?



6. Which of the following hydrocarbons has the lowest normal boiling point?

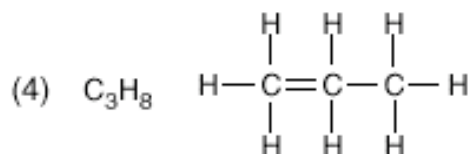
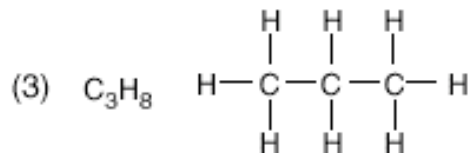
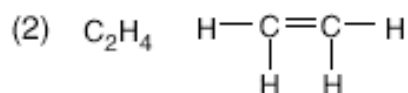
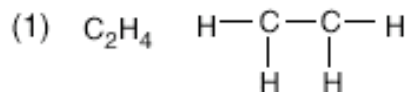
- ethane
- propane

- butane
- pentane

7. Which compound is an isomer of pentane?

- butane
- propane
- methyl butane
- methyl propane

8. The empirical formula of a compound is CH_2 . Which molecular formula is correctly paired with a structural formula for this compound?



9. What is the total number of valence electrons in a carbon atom in the ground state?

- 6
- 2
- 12
- 4

10. Which element is present in all organic compounds?

- H
- He
- C
- Ca

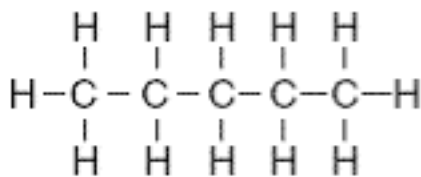
11. Which is the structural formula of ethene?



12. In saturated hydrocarbons, carbon atoms are bonded to each other by

1. single covalent bonds, only
2. double covalent bonds, only
3. alternating single and double covalent bonds
4. alternating double and triple covalent bonds

13. Which structural formula represents a molecule that is *not* an isomer of pentane?



14. A molecule of ethane and a molecule of ethene both have the same

1. empirical formula
2. molecular formula
3. number of carbon atoms
4. number of hydrogen atoms

15. If a hydrocarbon molecule contains a triple bond, its IUPAC name ends in

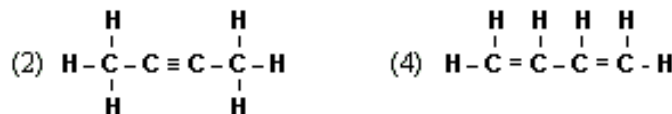
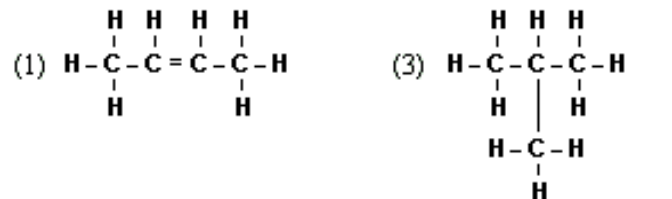
1. "ane"
2. "ene"
3. "one"
4. "yne"

16. Which is a saturated hydrocarbon?

1. ethene
2. ethyne
3. propene
4. propane



17. Which hydrocarbon is a member of the alkane series?



19. Which formula represents an alkene?

1. CH₄
2. C₂H₂
3. C₃H₆
4. C₄H₁₀

20. Which is the general formula for the alkyne series of hydrocarbons?

1. C_nH_{2n+2}
2. C_nH_{2n}
3. C_nH_{2n-2}
4. C_nH_{2n-6}

21. In which pair of hydrocarbons does each compound contain only one double bond per molecule?

1. C₂H₂ and C₂H₆
2. C₂H₂ and C₃H₆
3. C₄H₈ and C₂H₄
4. C₆H₆ and C₇H₈

22. The compound C₄H₁₀ belongs to the series of hydrocarbons with the general formula

1. C_nH_{2n}
2. C_nH_{2n+2}
3. C_nH_{2n-2}
4. C_nH_{2n-6}

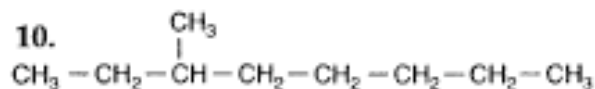
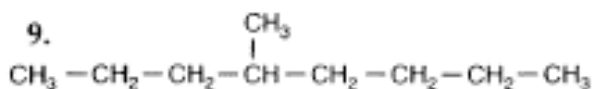
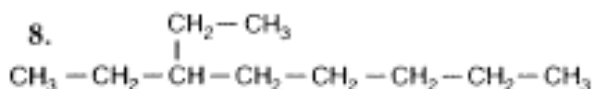
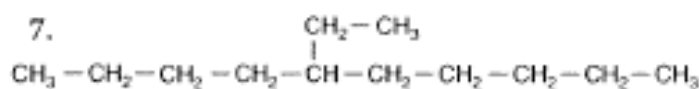
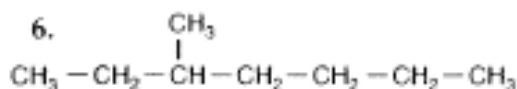
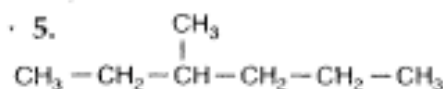
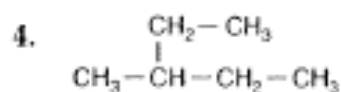
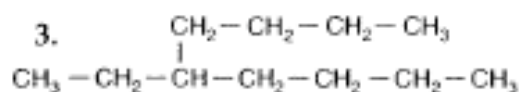
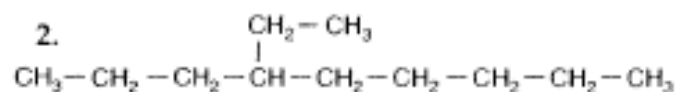
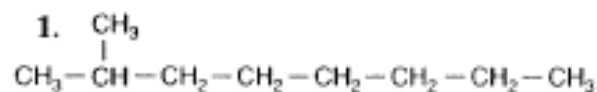
Assignment: Drawing Hydrocarbons

Draw the structure of the compounds below.

1. ethane	5. ethyne
2. propene	6. 3,3-dimethyl pentane
3. 2-butene	7. 2,3-dimethyl pentane
4. methane	8. n-butyne

Assignment: Condensed Formula Practice

Give the IUPAC name for the following molecules:



Write condensed structural formulas for the following:

↳ Like #1-10

11. 4-methyloctane

12. 4-ethyldecane

13. 3-ethylpentane

14. 3-ethylhexane

15. 5-butyldecane

16. 4-ethylheptane

17. 3-methylnonane

18. 2-methylheptane

19. 4-propylheptane

20. 5-butylnonane