chemistry

third semester

Grade 12 advanced

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Section 1: Introduction to hydrocarbons

Old organic compounds: compounds from living creatures (organic).

Example: Plants and animals produce a huge variety of carbon compounds.

Dalton's theory: John Dalton employed chemical and physical evidence known in his time, depending on facts and descriptive notes, to build his conception of the atom.

Figure 21.1 Living things contain, are made up of, and produce a variety of organic compounds.
Identify *two organic compounds that you have studied in a previous science course.*

Dalton's theory is based on three assumptions:

1 - The chemical element consists of tiny particles, small in size, and indivisible, known as atoms, which cannot be created or destroyed during chemical change.

2 - All atoms of one element have the mass and other properties, and differe from the atoms of other elements.

3 - The atoms of the elements react in fixed numerical proportions to form chemical compounds.

Scientists understand some facts through Dalton's theory:

1 - Compounds consist of arranged atoms bonded together by specific structures.

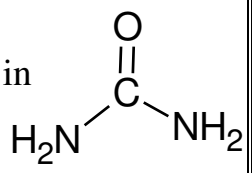
2 - Many new and useful materials were manufactured.

But: Scientists did not produce many organic compounds **explain.**

Because: They mistakenly believed that manufacturing organic compounds **need a mysterious biological force "vitalism "that** could synthesize carbon compounds

And it was: the idea of vital force was refuted by the German chemist Friedrich Wöhler (1800-1882).

Where: He prepared (the product) the first organic compound for the first time in the laboratory in 1828 AD, which is "**urea"**



However: Wöhler 's experiment did not immediately dispel the idea of vital force.

Thus: Fuehler's experiment urged chemists to carry out a series of similar experiments

Finally,☺ The idea that "preparing organic compounds needs vital force" has been invalidated and organic compounds have been prepared in the laboratory.

Organic Compounds: Compounds containing carbon atoms covalently bonded except carbon oxides, carbides and carbonates

Note: Carbon oxides, carbonates, and carbides are inorganic compounds

Q1: Which of the following is an organic compound

A - CO_2 B - CO C - SiC D - CH_4

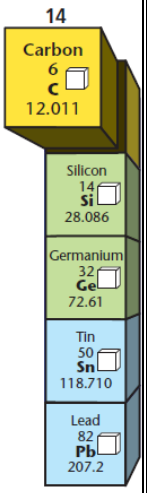
Q2: Which of the following is not an organic compound**:**

A - Na_2CO_3 B - C_2H_5OH C - CH_3NH_2 D - CH_4

Note: Chemists have known millions of different organic compounds, and they're still getting more of them**.**

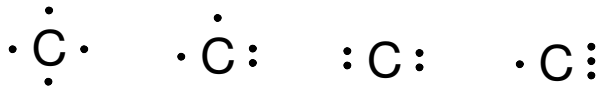
The advantages that made the carbon component occupy the largest position in terms of production of many of the compounds:

Carbon is present in group 14 in the periodic table, and it forms thousands of compounds, and it has some of the following properties:

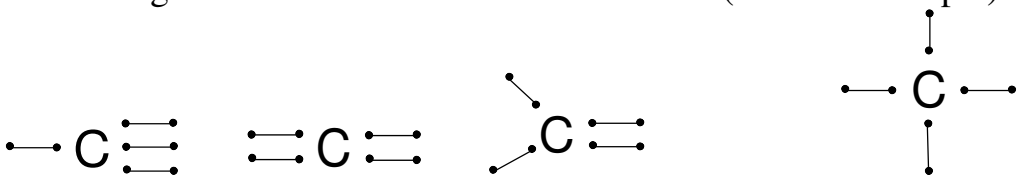


1 - Electronic distribution $1S^2\ 2S^2\ 2P^2$

2 - It has 4 valence electrons that enable it to make various covalent bonds.

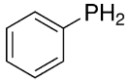


3- It creates 4 single covalent bonds and various bonds (double and triple)



4 - Carbon atoms are bonded with other elements such as:

S , O , N , H , P X(halogens)



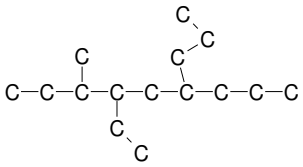
CH_4		CH_3NH_3	CH_3OCH_3	$CH_3S\ CH_3$	CH_3Cl
Methane	phenyl phosphene	methyl amine	dimethyl ether	dimethyl sulfide	chloro methane

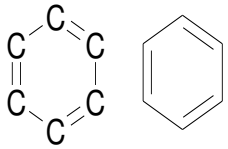
5 - Carbon atoms is bonding with their Similar ones, forming long (straight) chains و that range in length from two to millions of atoms.

C—C—C—C—C—C—C—C—C ……..

6- Create complex structures such as:

Branched chains , cyclic structures , (Fullerene)





Hydrocarbons (the simplest organic compounds): are compounds that contain only C and H elements.

hydrocarbon derivatives: compounds that contain C and H elements and Some atoms such as (S, O, N, and halogens).

Example: CH_4

1 - The simplest hydrocarbon molecule.
2 -one of the finest fuels.
3 -It consists of one carbon atom, 4 hydrogen atoms.
4 -The main component of natural gas.

Note: **Natural gas consists of** methane, ethane - propane - butane
60-90% 0-20%

In addition to very small quantities of oxygen, carbon dioxide, nitrogen, hydrogen sulfide, helium, and neon**.**

Figure 21.3 Methane—a hydrocarbon found in natural gas—is the simplest hydrocarbon.
Identify *In addition to hydrogen, what other elements readily bond with carbon?*

Types of bonds between carbon atoms

Single covalent bonds
Sharing between two atoms with a pair of electrons

multiple covalent bonds

Double covalent bonds
(Sharing between two atoms with two pairs of electrons)

Triple covalent bonds
(sharing between two atoms with three pairs of electrons)

Types of bonds between carbon atoms

Types of covalent bonds	number of electrons that each atom share	total number of shared electrons
Single covalent bonds	1	2
double covalent bonds	2	4
Triple covalent bonds	3	6

How to detect the type of covalent bond between carbon atoms:

♡Scientists have previously experimented with hydrocarbons that they obtained from animal fats and vegetable oils, and classified these hydrocarbons according to the extent of the amount of bromine consumed in the reaction with the hydrocarbons.

* **Hydrocarbon + bromine red solution**

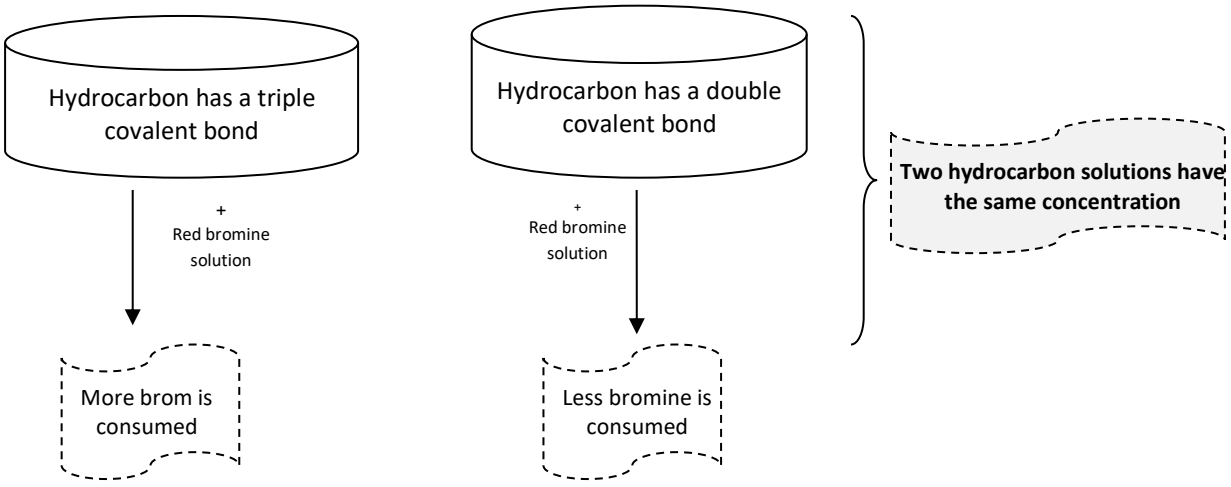
►If the color does not disappear (bromine reaction did not occur):

∴ The bonds between the carbon atoms is single bonds.

►If the color disappears (a bromine reaction occurred):

∴ The covalent carbon atoms are multiplied

How to detect and distinguish between covalent bonds (double and triple) between carbon atoms**:**



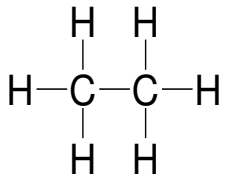
From these experiments, the scientists concluded that:

1 - **saturated hydrocarbon** is the one that does not react with bromine (it has only single covalent bonds)

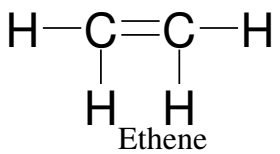
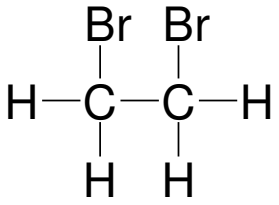
2 - **unsaturated hydrocarbon** that reacts with bromine (has double or triple covalent bonds)

Note: This conclusion is the result of scientists being affected by the concept that the unsaturated solution is able to dissolve more solute**.**

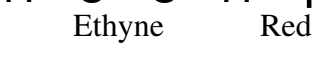
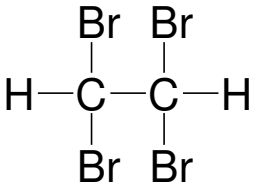
Explaination using equations:

A)  + Br_2 ⟶ Addition reaction does not take place because of absence of multiple bonds

Ethane Red bromine solution

B)  + Br_2 ⟶ 

Ethene Red bromine solution

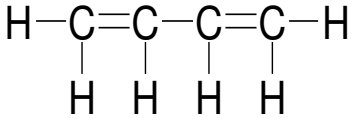
C)  + $2\,Br_2$ ⟶ 

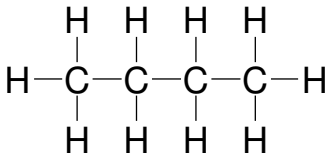
Ethyne Red bromine solution

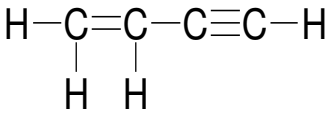
Q: **Arrange in ascending the amount of bromine consumed in the previous reactions**

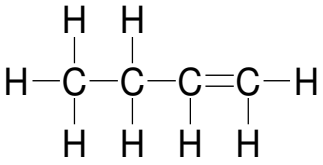
The least consumed for bromine ..... → ..... → ..... the most consumed for bromine

Q: Which of the following hydrocarbons (which have the same concentration) consumes more bromine in addition reaction:

A) 

B) 

C) 

D) 

Models used in organic chemistry

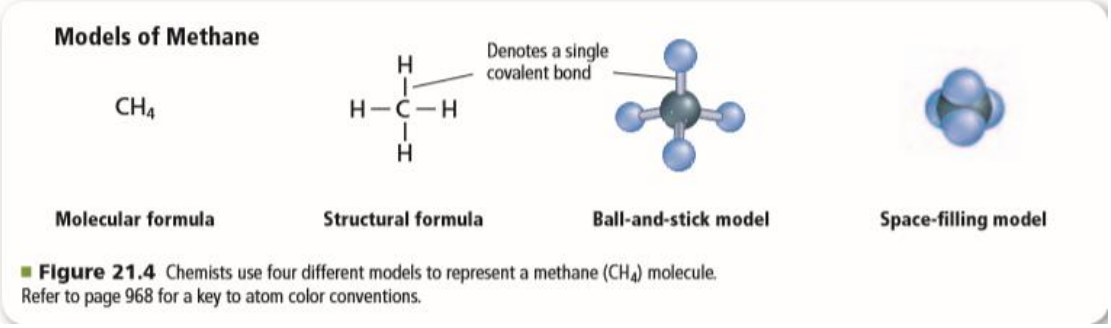


Figure 21.4 Chemists use four different models to represent a methane (CH_4) molecule.
Refer to page 968 for a key to atom color conventions.

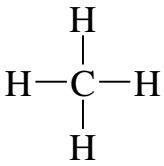
1 - Molecular Formula: A formula that shows types and numbers of atoms (represented in the digital lower suffixes)

(**It** does not give any information about the geometry of the particle)

Example: CH_4 = molecular formula

Types of atoms: C, H Number of atoms: 1C, 4H The total number of atoms: 5

2 - Structural formula: give the general arrangement of atoms in a molecule and show types and numbers of atoms and the bonds between them

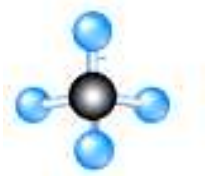


It considered "the most important molecular models" (and do not accurately show 3D dimentional)

Note: The covalent bond is represented by a single straight-line mean two bonded electrons.

3 - Ball -and- stick model: give three-dimensional geometry, and clearly show the shape of the molecule.

Important clarification: A model used in chemistry that shows the molecular structure of a chemicalmolecule in a three-dimensional shape, where it shows the positions of atoms and the chemical bonds between them. The atoms are represented by connected **balls** by **sticks that represent the bonds**. Double and triple bonds are represented by two or three curved sticks, respectively.



Note: atoms of each element are represented by balls of a specific color.

4 - space-filling model: is a type of three-dimensional (3D) molecular model where the atoms are represented by spheres

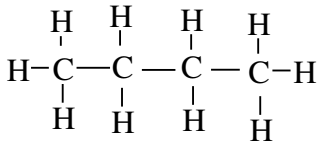
Important clarification: the three-dimensional model used in chemistry, where each ball represents one of the atoms of the compound, so that the diameters of the balls correspond to the diameters of the atoms, as well as the distance between the centers of the balls is proportional to the distance between the nuclei of the atoms with the same scale of drawing, and the different elements are represented by balls of different colors.

Explain: **The structural formula is preferred to the molecular formula**: it explains the chemical bonds and the general arrangement of atoms in a molecule

Explain: **The ball-and-stick model is preferred than the structural formula**: because it shows the chemical bonds and the general arrangement of atoms in a molecule in addition to the accurate geometrical shape.

Explain: space-filling model is preferable than Ball -and- stick model model: because it gives a more realistic picture of the particle.

Important formulas: complete the following:

Molecular formula	C_4H_{10}	C_6H_{14}
Structural formula		
condensed formula Preferred formula: **Explain**: (Because it saves space by not showing how hydrogen atoms branched out of carbon atoms(	$CH_3 - CH_2 - CH_2 - CH_3$ $CH_3CH_2CH_2CH_3$ **Carbon bonds can be removed) (to save space**	
	$CH_3 - (CH_2)_2 - CH_3$	

COMPLETE THE FOLLOWING:

Molecular formula : C_7H_{16}

Structural formula : ----------

Expected condensed formula : ----------

Molecular formula : $C_{30}H_{62}$

Expected condensed formula : ----------

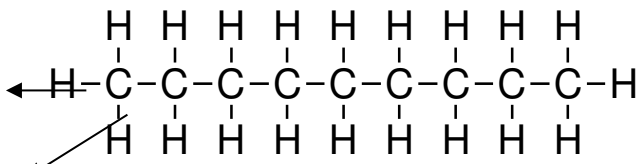
Molecular formula : $C_{100}H_{202}$

Expected condensed formula : ----------

Explain: We sometimes use condensed formula for writing organic compounds or hydrocarbons

To save space, as it does not show branching of hydrogen atoms from carbon atoms

$CH_3-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_2-CH_3$



$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

$CH_3(CH_2)_7CH_3$

Don't forget: condensed formula is written in several ways:

A) By bonds : $CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$

B) without bonds : $CH_3CH_2CH_2CH_2CH_2CH_3$

C) By Combining repeating units between brackets, followed by a bottom number representing the number of these units $CH_3(CH_2)_4CH_3$

Homogeneous chain: the series of compounds that differ from each other in a repeated unit.

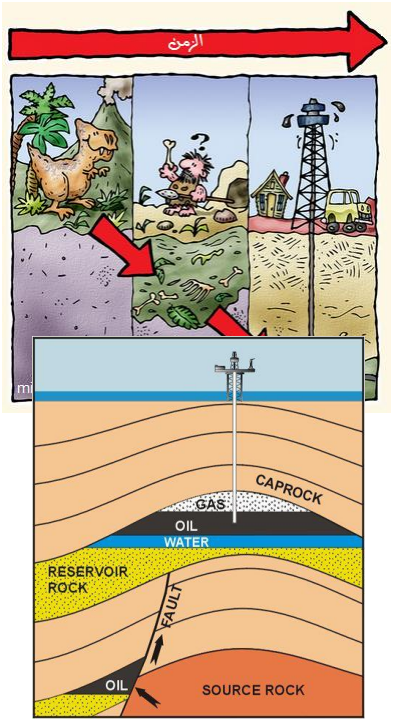
$CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

$CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

$CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

Hydrocarbon separation:

Important introduction: fossil fuels (crude oil) (petroleum)



- ♣ It is a remnant of the microorganism that has lived in the oceans for millions of years.
- ♣ Over time, these remains at the ocean floor form thick layers of sediment Clay-like.
- ♣ sediment Clay-like changed by the heat released from the ground and pressure to mud rocks rich in oil and natural gas.
- ♣ Oil penetrates through certain types of rock with pores and accumulates in depths of the crust.
- ♣ Natural gas is usually found with oil deposits, and they are formed together at the same time in the same way.
- ♣ Natural gas is mainly formed from methane, but it also contains small amounts of other hydrocarbons that have two to four carbon atoms.

Explain: The oil is not used in its crude form. Because it is a complecated mixture containing more than a thousand of different compounds, and therefore is separated into simpler components.

Fractional distillation (**fractionation**): It is the process of separating many components of complex composition of the oil into simpler components or parts, **depending on** the difference in boiling point as The components are condensed at different temperatures.

Note: The separation of the components depends on the fact that each component of the oil has its own boiling point.

- ♣ Fractional distillation is performed in **Fractional towers**.

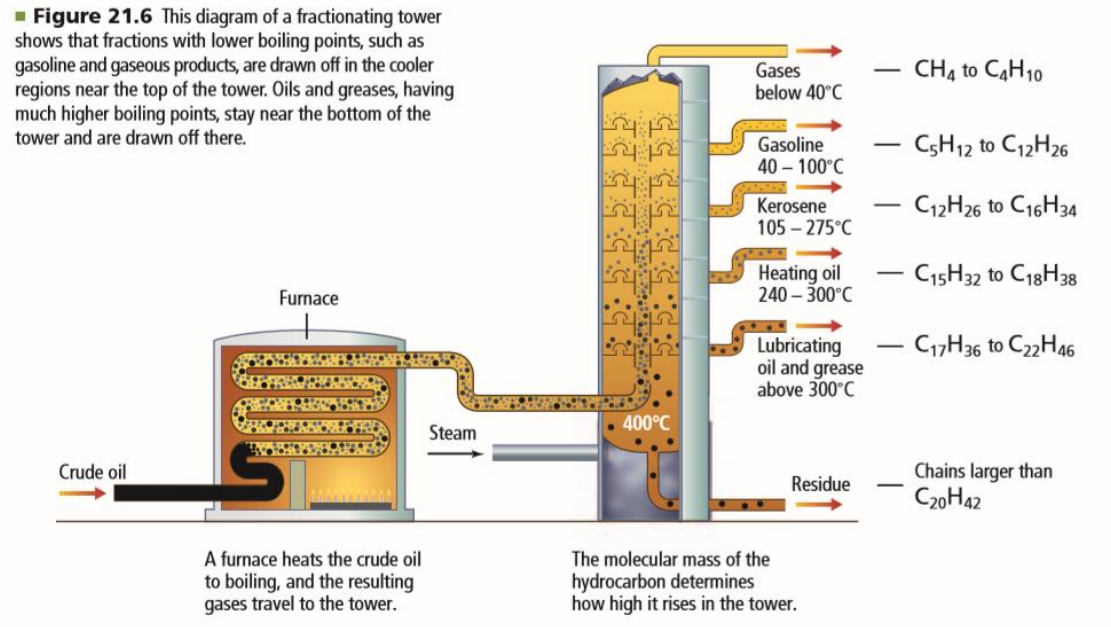


Figure 21.7 Fractional distillation towers separate large quantities of petroleum into usable components. Thousands of products we use in our homes, for transportation, and in industry result from petroleum refining.
Infer *What types of emissions must be controlled by refineries to protect the environment?*

♣ The temperature is controlled inside the tower, so it is close to 400°C at the bottom of the tower (boiling place of oil)

♣ The temperature gradually decreases towards the top of the tower

Generally: the condensation temperature of the components (boiling points) decreases with the decrease of their molecular mass.

Therefore: the hydrocarbon vapor is condensed and withdrawn during the rise of various gases inside the tower.

There is a problem in the Fractional towers: the amount of materials, which have daily consumption and use (such as gasoline) **are of low production**,where a materials which are not used daily are of high production, such as heavy oils. **Therefore, there is a problem between supply and demand** .

Idea for solving the problem:

Thermal cracking: Breaking heavy (large) long-chain, of low usage into short chains with useful usage.

Conditions of thermal cracking: 1 - absence of oxygen 2 - presence of a catalyst

Example: converting the long chain of decane $C_{10}H_{22}$ to two useful components heptane C_7H_{16} and propane C_3H_6

decane $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$

Thermal cracking

propene $CH_3\text{-}CH{=}CH_2$ + **Heptane** $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$

Benefits of thermal cracking: the production of raw materials for the manufacture of many different products, such as plastic products, films (tapes) and synthetic fibers.

Gasoline Classification: Gasoline (automotive fuel) is a mixture of hydrocarbons with single covalent bonds of 5-12 carbon atoms.

Note: gasoline is a mixture, not a pure substance

Explain: The gasoline used in the early nineteenth century differs from the one used today

Because the gasoline extracted (distilled) from the oil **was modified** by a **fractional distillation process** by adjusting its composition and adding materials that **improve** its work in modern car engines and also reduce pollution resulting from car exhaust.

Important precautions when burning gasoline:

1 - It is imperative that the compustion of the gasoline and air mixture in the vehicle's engine cylinder occurs at the right moment and that the fuel be completely burned

2 - If compustion occurs before or after the appropriate time, this will lead to a loss of a lot of energy, a decrease in fuel efficiency, and the engine will be damaged prematurely.

Example: straight Hydrocarbons (non-branched) chains burn unequally, and these chains -due to pressure and heat- tend to burn early **before** the plunger is in the correct position and before the combustion candle is ignited.

Thus: early combustion leads to a humming frequency or noise called **knocking**.

Therefore: A new system is in place to prevent knocking and ease of combustion of fuel, which is the **octane number**

Octane number or (**octane rating**): A measure of fuel efficiency.

Note: The higher the octane number, the more fuel efficient.

Note: octane is rated depending on gasoline pumps

Example: octane 89 (Average grade gasoline) octane 91 or more Excellent gasoline

Note: In the UAE: octane ranges from 91 to 95

ORGANIC CHEMISTRY

Hydrocarbons

Intriduction to hydrocarbons

Alkanes

Alkenes and Alkynes

Hydrocarbon Isomeres

Aromatic Hydrocarbons

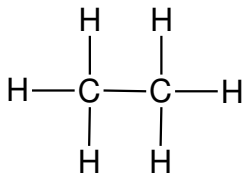
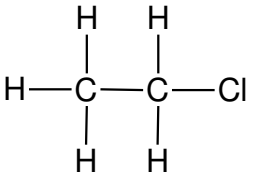
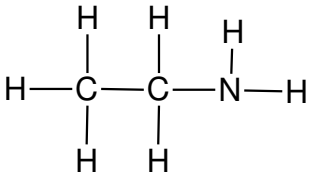
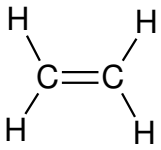
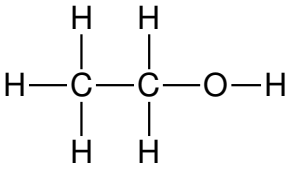
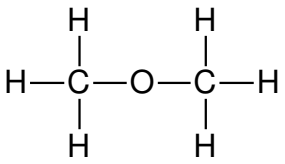
Hydrocarbons Derivatives

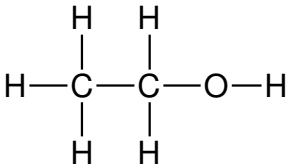
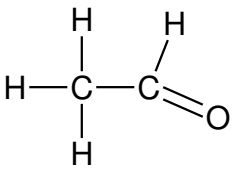
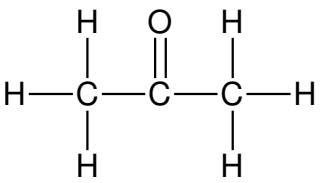
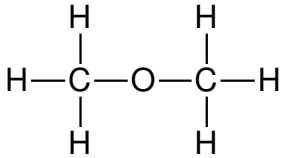
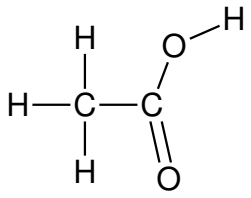
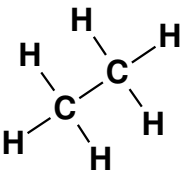
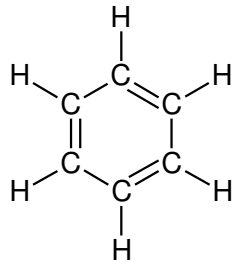
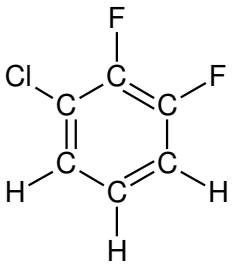
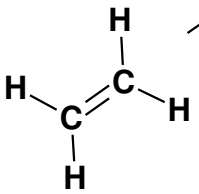
Alkyel Halides and Aryl Halides

Alcoholes – Ethers - Amines

Carbonyl compounds

Other reactions of Organic compounds

Section 21.1 Assessment

Section Summary

- Organic compounds contain carbon, which is able to form straight chains and branched chains.
- Hydrocarbons are organic substances composed of carbon and hydrogen.
- The major sources of hydrocarbons are petroleum and natural gas.
- Petroleum can be separated into components by the process of fractional distillation.

1. MAIN Idea **Identify** three applications of hydrocarbons as a source of energy and raw materials.
2. **Name** an organic compound and explain what an organic chemist studies.
3. **Identify** what each of the four molecular models highlights about a molecule.
4. **Compare and contrast** saturated and unsaturated hydrocarbons.
5. **Describe** the process of fractional distillation.
6. **Infer** Some shortening products are described as "hydrogenated vegetable oil," which are oils that reacted with hydrogen in the presence of a catalyst. Form a hypothesis to explain why hydrogen reacted with the oils.
7. **Interpret Data** Refer to **Figure 21.6.** What property of hydrocarbon molecules correlates to the viscosity of a particular fraction when it is cooled to room temperature?

Section 21.1

Mastering Concepts

38. **Organic Chemistry** Why did Wohler's discovery lead to the development of the field of organic chemistry?
39. What is the main characteristic of an organic compound?
40. What characteristic of carbon accounts for the large variety of organic compounds?
41. Name two natural sources of hydrocarbons.
42. Explain what physical property of petroleum compounds is used to separate them during fractional distillation.
43. Explain the difference between saturated hydrocarbons and unsaturated hydrocarbons.

Mastering Problems

44. **Distillation** Rank the compounds listed in **Table 21.7** in the order in which they will be distilled out of a mixture. Rank the compounds in order of first to distill to last to distill.

Table 21.7 Alkane Boiling Points

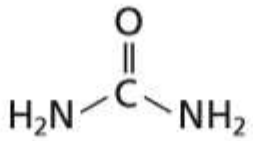
Compound	Boiling Point (°C)
hexane	68.7
methane	−161.7
octane	125.7
butane	−0.5
propane	−42.1

45. How many electrons are shared between two carbon at oms in each of the following carbon-carbon bonds?

a. single bond

b. double bond

c. triple bond



■ **Figure 21.29**

46. **Figure 21.29** shows two models of urea, a molecule that Friedrich Wöhler first synthesized in 1828.

a. Identify the types of models shown.

b. Is urea an organic or an inorganic compound? Explain your answer.

47. Molecules are modeled using molecular formulas, struc tural formulas, ball-and-stick models, and space-filling models. What are the advantages and disadvantages of each model?