



تم تحميل هذا الملف من موقع المناهج الإماراتية

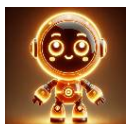
موقع المناهج ← المناهج الإماراتية ← الصف الحادي عشر المتقدم ← رياضيات ← الفصل الثالث ← ملفات متنوعة ← الملف

تاريخ إضافة الملف على موقع المناهج: 07:18:41 2026-06-05

ملفات اكتب للمعلم اكتب للطالب ا اختبارات الكترونية ا اختبارات ا حلول ا عروض بوربوينت ا أوراق عمل
منهج انجليزي ا ملخصات وتقارير ا مذكرات وبنوك ا الامتحان النهائي ا للمدرس

المزيد من مادة
رياضيات:

التواصل الاجتماعي بحسب الصف الحادي عشر المتقدم



صفحة المناهج
الإماراتية على
فيسبوك

الرياضيات

اللغة الانجليزية

اللغة العربية

التربية الاسلامية

المواد على تلغرام

المزيد من الملفات بحسب الصف الحادي عشر المتقدم والمادة رياضيات في الفصل الثالث

منهج ريفيل حلول مراجعة امتحانية تدريبات وأسئلة

1

منهج ريفيل مراجعة امتحانية تدريبات وأسئلة غير محلول

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ملزمة هيكل واختياري وأسئلة

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ملخص شامل مع قوانين الوحدة 9 المتتاليات

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EOT EXAM PRACTICE

11 ADVANCE

TERM 3

2025-2026

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Redox in Electrochemistry

Electrochemistry is the study of the redox processes by which chemical energy is converted to electrical energy and vice versa. Recall that all redox reactions involve a transfer of electrons from the species that is oxidized to the species that is reduced.

Figure 1 and **Figure 2**, on the next page, illustrate the simple redox reaction in which zinc atoms are oxidized to form zinc (Zn^{2+}) ions. The two electrons donated from each zinc atom are accepted by a copper (Cu^{2+}) ion, which becomes an atom of copper metal.

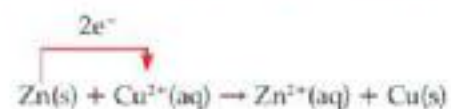


Figure 1 In a, zinc metal is immersed in 1M zinc sulfate solution, and copper metal in 1M copper(II) sulfate. In b, a wire joining the zinc and copper strips provides a pathway for the flow of electrons, but the pathway is not complete. Electron transfer is still not possible.

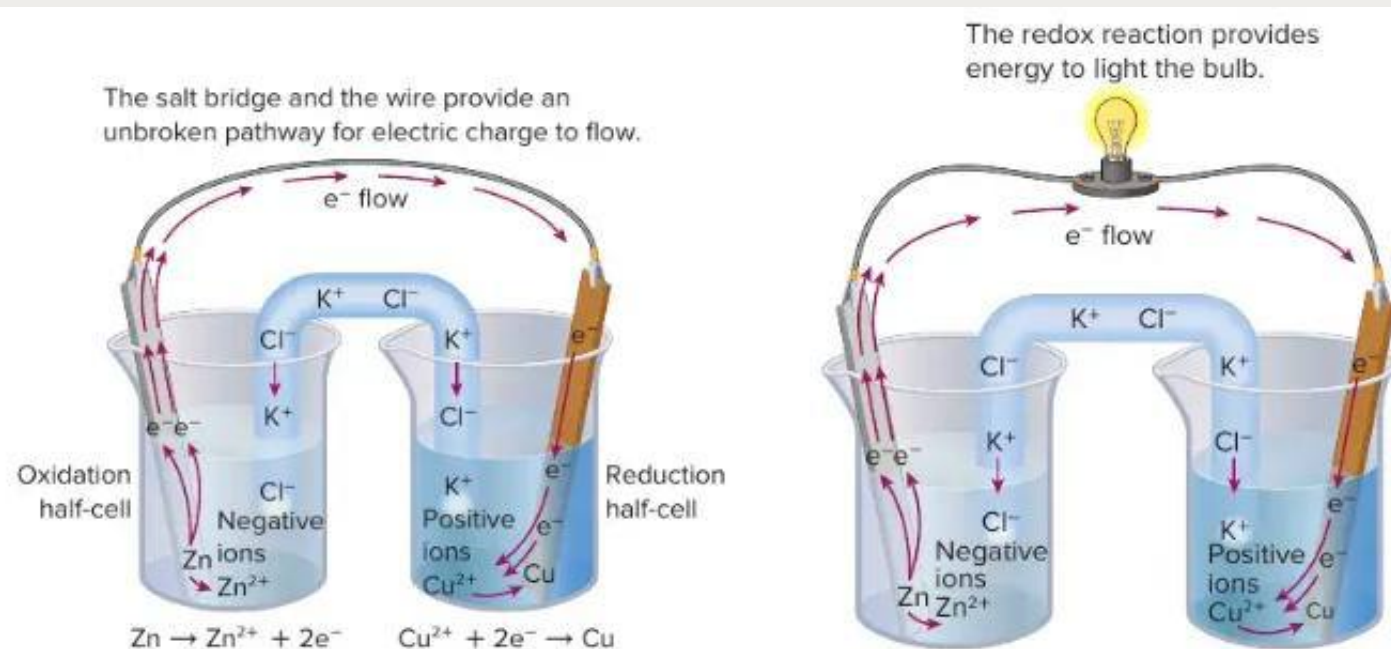
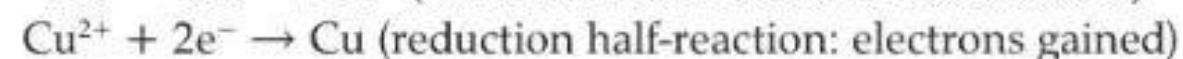
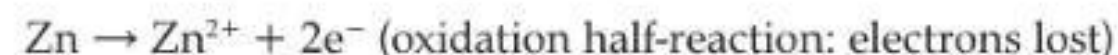


Figure 2 The addition of a salt bridge completes the pathway. Negative ions move through the salt bridge to the zinc side. Positive ions move through the bridge to the copper side.

Half-reactions

Two half-reactions make up this redox process:



What do you think would happen if you separated the oxidation half-reaction from the reduction half-reaction? Can a redox reaction occur? Consider **Figure 1a**, in which a zinc strip is immersed in a solution of zinc sulfate and a copper strip is immersed in a solution of copper(II) sulfate.

Two problems prevent a redox reaction from occurring. First, there is no way for zinc atoms to transfer electrons to copper(II) ions. This problem can be solved by connecting the zinc and copper strips with a metal wire, as shown in **Figure 1b**. The wire can serve as a pathway for electrons to flow from the zinc strip to the copper strip.

The second problem is that when the metal strips are placed in their solutions, oxidation begins at the zinc strip and reduction begins at the copper strip—but these reactions cannot continue. The reason is that as zinc is oxidized, positive zinc ions build up around the zinc electrode. As copper in the copper(II) sulfate solution is reduced, negative sulfate ions build up around the copper electrode. The buildup of charges stops any further reaction. To solve this problem, a salt bridge must be added to the system. A **salt bridge** is a pathway to maintain solution neutrality by allowing the passage of ions from one side to another, as shown in **Figure 2**. A salt bridge consists of a tube containing a conducting solution of a soluble salt, such as KCl, held in place by an agar gel or other permeable plug. Ions can move through it, but the solutions cannot.

When the connecting metal wire and the salt bridge are in place, the spontaneous redox reaction begins. Electrons flow through the wire from the oxidation half-reaction to the reduction half-reaction, while positive and negative ions move through the salt bridge. A flow of charged particles is called an electric current. In **Figure 2**, the flow of electrons through the wire and the flow of ions through the salt bridge make up the electric current. The energy of the flowing electrons can be used to light a bulb, as shown in **Figure 2**.

2	CHM.5.3.05.007.05 Use the half-cell standard reduction potentials to calculate the electrochemical cell standard potential, while determining whether the redox reactions are spontaneous or non-spontaneous	Textbook + Table 1+ Figure 6+ Example problem 1+ Practice Problems	31, 32, 33, 34
3	CHM.5.3.05.007.04 Write the cell notation and the overall chemical equation for a redox reaction occurring in a voltaic cell potential	Textbook + Example problem 1	31, 32

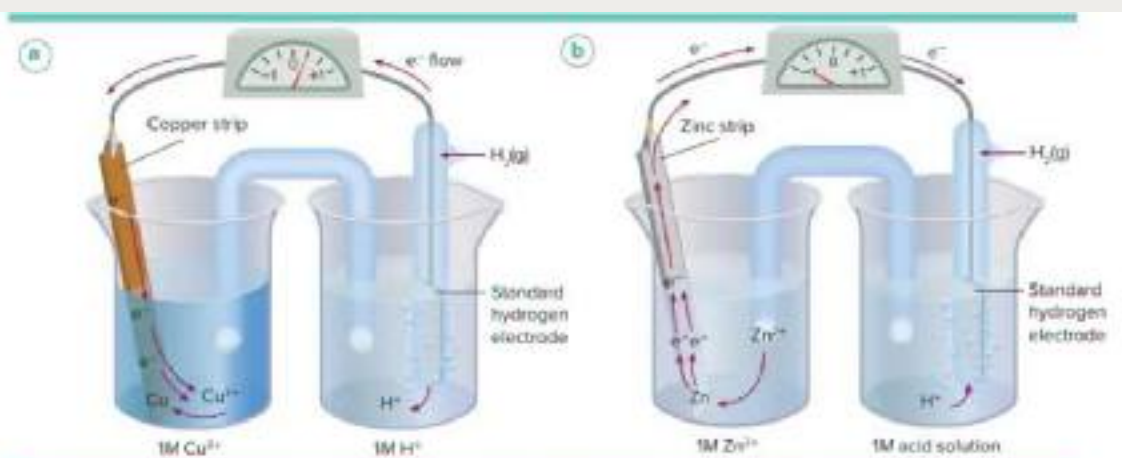
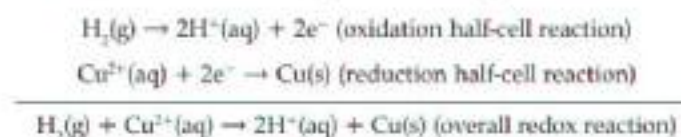


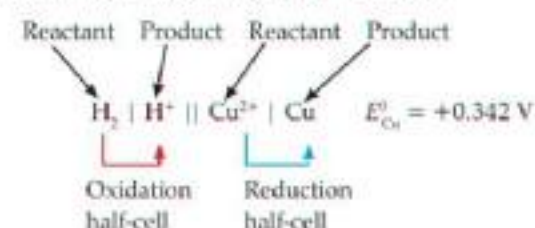
Figure 6 a. When a $\text{Cu}^{2+} | \text{Cu}$ electrode is connected to the hydrogen electrode, electrons flow toward the copper strip and reduce Cu^{2+} ions to Cu atoms. b. When a $\text{Zn} | \text{Zn}^{2+}$ electrode is connected to the hydrogen electrode, electrons flow away from the zinc strip and zinc atoms are oxidized to Zn^{2+} ions.

Determining electrochemical cell potentials

You can use **Table 1** to calculate the electric potential of a voltaic cell consisting of a copper electrode and a zinc electrode under standard conditions. The first step is to determine the standard reduction potential for the copper half-cell (E°_{Cu}). When the copper electrode is attached to a standard hydrogen electrode, as in **Figure 6a**, electrons flow from the hydrogen electrode to the copper electrode, and copper ions are reduced to copper metal. The E° , measured by a voltmeter, is +0.342 V. The positive voltage indicates that Cu^{2+} ions at the copper electrode accept electrons more readily than do H^+ ions at the standard hydrogen electrode. Therefore, oxidation takes place at the hydrogen electrode, and reduction takes place at the copper electrode.

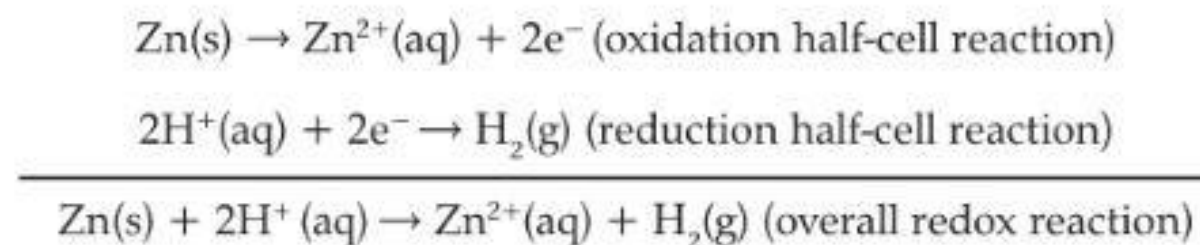


This reaction can be written in a form called cell notation.

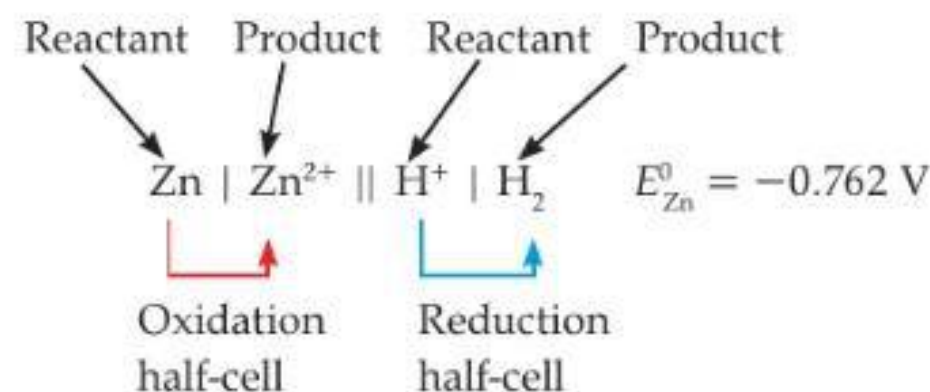


The two participants in the oxidation reaction are written first in reactant | product order. They are followed by a double vertical line (||) representing the connection between the half-cells. Then, the two participants in the reduction reaction are written in reactant | product order. For positive values of E° , it is customary to place a plus sign before the voltage.

The next step is to determine the standard reduction potential for the zinc half-cell (E°_{Zn}). When the zinc electrode is measured against the standard hydrogen electrode under standard conditions, as in **Figure 6b**, electrons flow from the zinc electrode to the hydrogen electrode. The E° of the zinc half-cell, measured by a voltmeter, is -0.762 V. This means that the H^+ ions at the hydrogen electrode accept electrons more readily than do the zinc ions. Thus, the hydrogen ions have a higher reduction potential than the zinc ions. Recall that the hydrogen electrode is assigned a zero potential, so the reduction potential of the zinc electrode must have a negative value. The two half-cell reactions and the overall reaction are written as follows.



This reaction can be written in the following cell notation.



The final step in calculating electrochemical cell potential is to combine the copper and zinc half-cells as a voltaic cell. This means calculating the voltaic cell's standard potential using the following formula.

2	CHM.5.3.05.007.05 Use the half-cell standard reduction potentials to calculate the electrochemical cell standard potential, while determining whether the redox reactions are spontaneous or non-spontaneous	Textbook + Table 1+ Figure 6+ Example problem 1+ Practice Problems	31, 32, 33, 34
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The final step in calculating electrochemical cell potential is to combine the copper and zinc half-cells as a voltaic cell. This means calculating the voltaic cell's standard potential using the following formula.

Formula for Cell Potential

$$E_{\text{cell}}^0 = E_{\text{reduction}}^0 - E_{\text{oxidation}}^0$$

E_{cell}^0 represents the overall standard cell potential.

$E_{\text{reduction}}^0$ represents the standard half-cell potential for the reduction.

$E_{\text{oxidation}}^0$ represents the standard half-cell potential for the oxidation.

The standard potential of a cell is the standard potential of the reduction half-cell minus the standard potential of the oxidation half-cell.

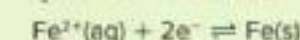
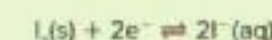
Because reduction occurs at the copper electrode and oxidation occurs at the zinc electrode, the E^0 values are substituted as follows.

$$\begin{aligned} E_{\text{cell}}^0 &= E_{\text{Cu}^{2+}|\text{Cu}}^0 - E_{\text{Zn}^{2+}|\text{Zn}}^0 \\ &= +0.342 \text{ V} - (-0.762 \text{ V}) \\ &= +1.104 \text{ V} \end{aligned}$$

Notice that the negative sign in the formula automatically changes the sign of the oxidation half-reaction, so you do not reverse the sign of the standard reduction potentials listed in **Table 1** when they are used for the oxidation half-reaction.

EXAMPLE Problem 1

CALCULATE A CELL POTENTIAL The following reduction half-reactions represent the half-cells of a voltaic cell.



Determine the overall cell reaction and the standard cell potential. Describe the cell using cell notation.

1 ANALYZE THE PROBLEM

You are given the half-cell equations and can find standard reduction potentials in **Table 1**. The half-reaction with the lower reduction potential will be an oxidation. With this information, you can write the overall cell reaction, calculate the standard cell potential, and describe the cell in cell notation.

Known

Standard reduction potentials for the half-cells

$$E_{\text{cell}}^0 = E_{\text{reduction}}^0 - E_{\text{oxidation}}^0$$

Unknown

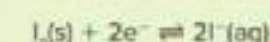
overall cell reaction = ?

$$E_{\text{cell}}^0 = ?$$

cell notation = ?

2 SOLVE FOR THE UNKNOWN

Find the standard reduction potentials of each half-reaction in **Table 1**.

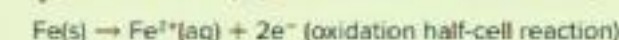


$$E_{\text{I}_2/\text{I}^-}^0 = +0.536 \text{ V}$$

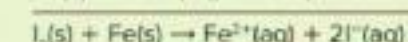


$$E_{\text{Fe}^{2+}/\text{Fe}}^0 = -0.447 \text{ V}$$

The reduction of iodine has the higher reduction potential, so this half-reaction proceeds in the forward direction as a reduction. The iron half-reaction proceeds in the reverse direction as an oxidation.



Rewrite the iron half-reaction in the correct direction.



Add the two equations.

The overall cell reaction is $\text{I}_2(\text{s}) + \text{Fe}(\text{s}) \rightarrow \text{Fe}^{2+}(\text{aq}) + 2\text{I}^-(\text{aq})$.

Calculate the standard cell potential.

$$E_{\text{cell}}^0 = E_{\text{reduction}}^0 - E_{\text{oxidation}}^0$$

State the formula for cell potential.

$$E_{\text{cell}}^0 = E_{\text{I}_2/\text{I}^-}^0 - E_{\text{Fe}^{2+}/\text{Fe}}^0$$

Substitute $E_{\text{I}_2/\text{I}^-}^0$ and $E_{\text{Fe}^{2+}/\text{Fe}}^0$ in the generic equation.

$$E_{\text{cell}}^0 = +0.536 \text{ V} - (-0.447 \text{ V})$$

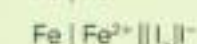
Substitute $E_{\text{I}_2/\text{I}^-}^0 = +0.536 \text{ V}$ and $E_{\text{Fe}^{2+}/\text{Fe}}^0 = -0.447 \text{ V}$.

$$E_{\text{cell}}^0 = +0.983 \text{ V}$$

Describe the cell using cell notation.



First, write the oxidation half-reaction using cell notation: reactant then product.



Next, write the reduction half-reaction to the right. Separate the half-cells by a double vertical line.

Cell notation: $\text{Fe} | \text{Fe}^{2+} || \text{I}_2 | \text{I}^-$

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PRACTICE Problems



ADDITIONAL PRACTICE

For each of these pairs of half-reactions, write the balanced equation for the overall cell reaction, and calculate the standard cell potential. Describe the reaction using cell notation. Refer to the module on redox reactions to review writing and balancing redox equations.

- $\text{Pt}^{2+}(\text{aq}) + 2\text{e}^{-} \rightleftharpoons \text{Pt}(\text{s})$ and $\text{Sn}^{2+}(\text{aq}) + 2\text{e}^{-} \rightleftharpoons \text{Sn}(\text{s})$
- $\text{Co}^{2+}(\text{aq}) + 2\text{e}^{-} \rightleftharpoons \text{Co}(\text{s})$ and $\text{Cr}^{3+}(\text{aq}) + 3\text{e}^{-} \rightleftharpoons \text{Cr}(\text{s})$
- $\text{Hg}^{2+}(\text{aq}) + 2\text{e}^{-} \rightleftharpoons \text{Hg}(\text{l})$ and $\text{Cr}^{2+}(\text{aq}) + 2\text{e}^{-} \rightleftharpoons \text{Cr}(\text{s})$
- CHALLENGE** Write the balanced equation for the cell reaction and calculate the standard cell potential for the reaction that occurs when these half-cells are connected. Describe the reaction using cell notation.
 $\text{NO}_3^{-} + 4\text{H}^{+} + 3\text{e}^{-} \rightleftharpoons \text{NO} + 2\text{H}_2\text{O}$
 $\text{O}_2 + 2\text{H}_2\text{O} + 4\text{e}^{-} \rightleftharpoons 4\text{OH}^{-}$

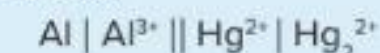
PRACTICE Problems



ADDITIONAL PRACTICE

Calculate the cell potential to determine if each of the following balanced redox reactions is spontaneous as written. Use **Table 1** to help you determine the correct half-reactions.

- $\text{Sn}(\text{s}) + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Sn}^{2+}(\text{aq}) + \text{Cu}(\text{s})$
- $\text{Mg}(\text{s}) + \text{Pb}^{2+}(\text{aq}) \rightarrow \text{Pb}(\text{s}) + \text{Mg}^{2+}(\text{aq})$
- $2\text{Mn}^{2+}(\text{aq}) + 8\text{H}_2\text{O}(\text{l}) + 10\text{Hg}^{2+}(\text{aq}) \rightarrow 2\text{MnO}_4^{-}(\text{aq}) + 16\text{H}^{+}(\text{aq}) + 5\text{Hg}_2^{2+}(\text{aq})$
- $2\text{SO}_4^{2-}(\text{aq}) + \text{Co}^{2+}(\text{aq}) \rightarrow \text{Co}(\text{s}) + \text{S}_2\text{O}_8^{2-}(\text{aq})$
- CHALLENGE** Using **Table 1**, write the equation and determine the cell voltage (E°) for the following cell. Is the reaction spontaneous?



Using Standard Reduction Potentials

The Example Problem showed you how to use the data from **Table 1** to calculate the standard potential (voltage) of voltaic cells. Another important use of standard reduction potentials is to determine if a proposed reaction under standard conditions will be spontaneous. How can standard reduction potentials indicate spontaneity? Electrons in a voltaic cell always flow from the half-cell with the lower standard reduction potential to the half-cell with the higher standard reduction potential, giving a positive cell voltage. To predict whether any proposed redox reaction will occur spontaneously, simply write the process in the form of half-reactions and look up the reduction potential of each. Use the values to calculate the potential of a voltaic cell operating with these two half-cell reactions. If the calculated potential is positive, the reaction is spontaneous. If the value is negative, the reaction is not spontaneous. However, the reverse of a nonspontaneous reaction will occur because it will have a positive cell voltage, which means that the reverse reaction is spontaneous.

Reversing Redox Reactions

When a battery is connected in a circuit, electrons from the anode flow to the cathode, where they are used in a reduction reaction. How can a secondary battery be recharged? Compare the electrochemical cells in **Figure 18**. The beakers on the left contain zinc strips in solutions of zinc ions. The beakers on the right contain copper strips in solutions of copper ions. One electrochemical cell is supplying power to a light bulb by means of a spontaneous redox reaction. In this cell, electrons flow spontaneously from the zinc side to the copper side.

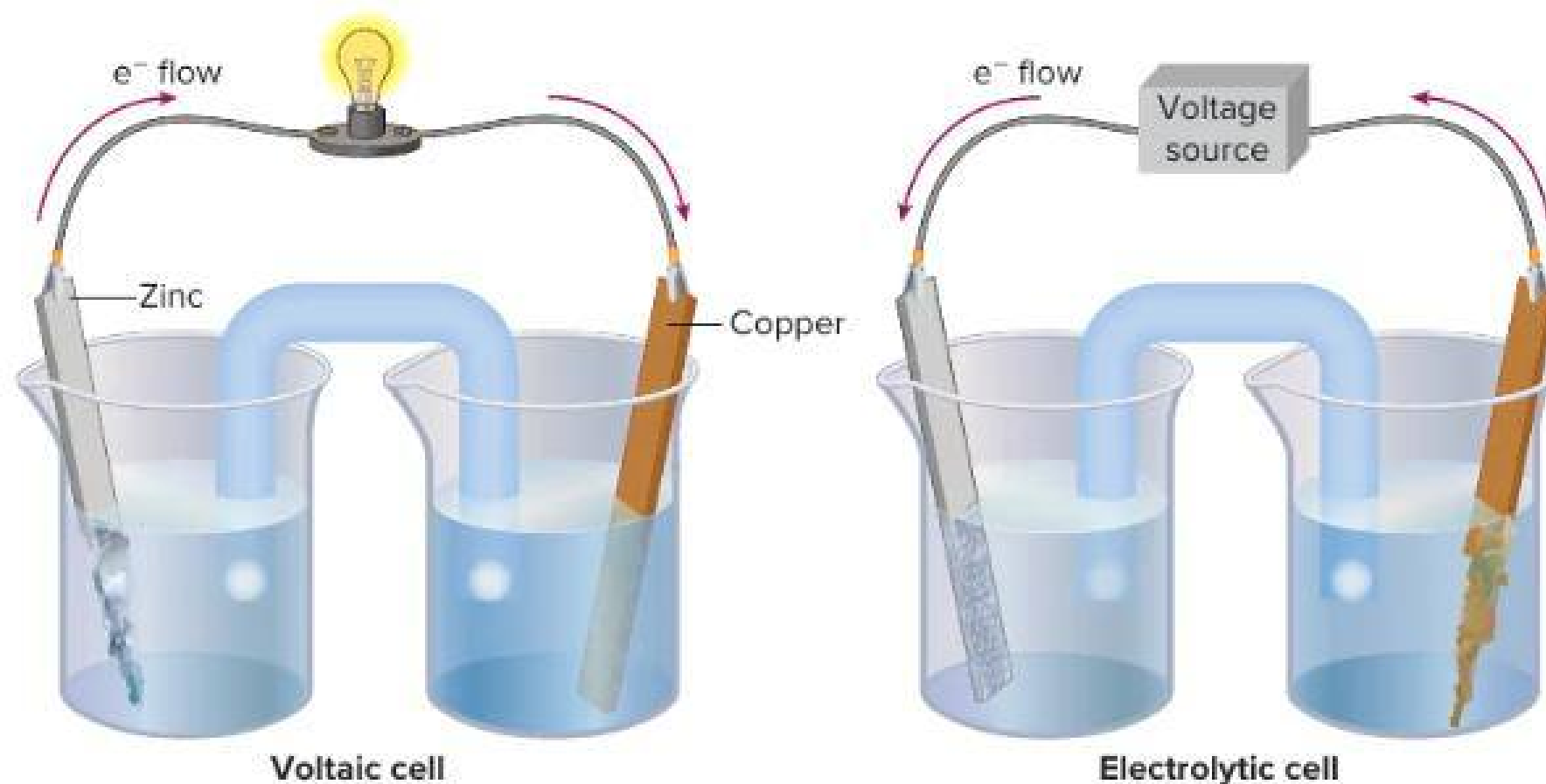


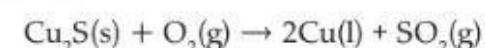
Figure 18 The zinc-copper electrochemical cell can be a voltaic cell or an electrolytic cell.

Infer In each electrochemical cell, which metal is oxidized? What is reduced?

The Hall-Héroult process uses huge amounts of electrical energy. For this reason, aluminum is often produced in plants built close to large hydroelectric power stations, where electrical energy is less expensive. The vast amount of electricity needed to produce aluminum from ore is the primary reason for recycling aluminum. Recycled aluminum has already undergone electrolysis, so the only energy required to make it usable again is the heat needed to melt it in a furnace.

Purification of ores

Electrolysis is also used in the purification of metals such as copper. Most copper is mined in the form of the ores chalcopyrite (CuFeS_2), chalcocite (Cu_2S), and malachite ($\text{Cu}_2\text{CO}_3(\text{OH})_2$). The sulfides are most abundant and yield copper metal when heated strongly in the presence of oxygen.



The copper obtained from this process contains many impurities and must be refined, so the molten copper is cast into large, thick plates. These plates are then used as an anode in an electrolytic cell containing a solution of copper(II) sulfate. The cathode of the cell is a thin sheet of pure copper. As current is passed through the cell, copper atoms in the impure anode are oxidized to copper(II) ions. The copper ions migrate through the solution to the cathode, where they are reduced to copper atoms. These atoms become part of the cathode, while any impurities fall to the bottom of the cell.

Electroplating

Objects are electroplated when a uniform coating is deposited usually as a protective or decorative layer. The substance used is typically a metal. Electroplating with a metal such as silver is accomplished with a method similar to that used to refine copper. The object to be silver-plated is the cathode of an electrolytic cell. The anode is a silver bar or sheet, as shown in **Figure 22**.

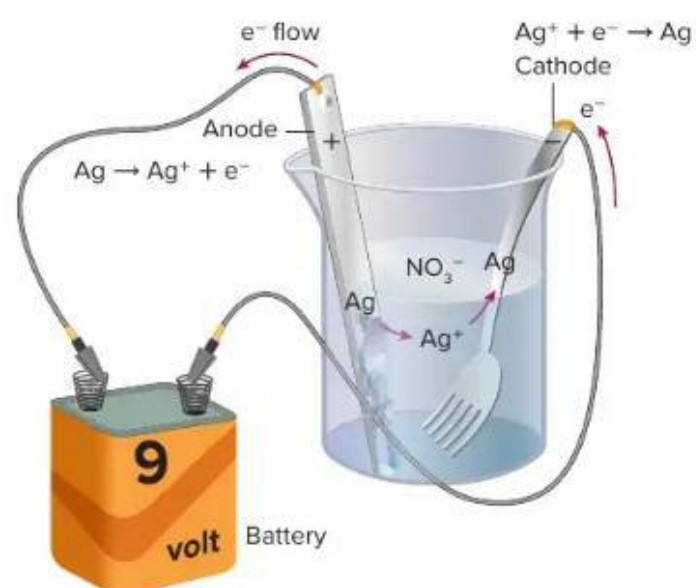


Figure 23 A pen made of solid gold would be very expensive and heavy. Electroplating gold gives the same effect with a smaller mass and lower cost.

At the anode, silver is oxidized to silver ions as electrons are removed by the power source. At the cathode, the silver ions are reduced to silver metal by electrons from the external power source. The silver forms a thin coating over the object being plated. Current passing through the cell must be carefully controlled in order to get a smooth, even metal coating.

Other metals are also used for electroplating. For example, you might have seen items that are electroplated with gold, such as the pen shown in **Figure 23**. Exposed steel parts on bicycles and automobiles can be plated by nickel and then chrome to prevent corrosion.

Organic chemistry Today, the term **organic compound** is applied to all carbon-containing compounds with the primary exceptions of carbon oxides, carbides, and carbonates, which are considered inorganic. Because there are so many organic compounds, an entire branch of chemistry, called organic chemistry, is devoted to their study. Recall that carbon is an element in group 14 of the periodic table, as shown in **Figure 2**. With the electron configuration of $1s^2 2s^2 2p^2$, carbon nearly always shares its electrons and forms four covalent bonds. In organic compounds, carbon atoms are bonded to hydrogen atoms or atoms of other elements that are near carbon in the periodic table—especially nitrogen, oxygen, sulfur, phosphorus, and the halogens.

Most importantly, carbon atoms also bond to other carbon atoms and form chains from two to thousands of carbon atoms in length. Also, because carbon forms four bonds, it forms complex, branched-chain structures, ring structures, and even cage-like structures. With all of these bonding possibilities, chemists have identified millions of different organic compounds and are synthesizing more every day.

✓ **READING CHECK** Explain why carbon forms many compounds.

Why does carbon form so many compounds?

- Each carbon has 4 valence electrons
 - each valence electron is available to form one bond with other atoms
- Carbon can form strong covalent bonds with other carbon atoms
- Bonds between carbon atoms can be single or multiple (e.g. double or triple)

1. A carbon atom has **four electrons** in its outer energy level.
2. A carbon atom can form **four covalent bonds** with atoms of carbon or with other elements.
3. Carbon can form **single, double, or triple** covalent bonds
4. **Variety of arrangements** like straight chain, ring and branched compounds
5. Carbon forms large number of compounds because of tetravalency and **catenation property**.

■ **Figure 21.2** Carbon is found in group 14 of the periodic table. It can bond to four other elements and form thousands of different compounds.

14
Carbon 6 C 12.011
Silicon 14 Si 28.086
Germanium 32 Ge 72.61
Tin 50 Sn 118.710
Lead 82 Pb 207.2

6	CHM.5.6.01.001.07 Explain why carbon forms many compounds CHM.5.6.01.003.14 Identify the main (general) characteristic of an organic compound	Textbook + Figure 2	60
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Which of the following structures is possible to be formed by carbon atom?
أي التركيبات التالية من المحتمل أن تكونها ذرة الكربون؟

1	تركيبات مستقيمة Chain structures
2	تركيبات ذات سلاسل متفرعة Branched structures
3	تركيبات حلقية Ring structures
4	تركيبات شبيهة باللقاص Cagelike structures

a. ☐ 1 and 2 ☐ 2 و 1

b. ☐ 3 and 4 ☐ 4 و 3

c. ☒ 1, 2 and 3 ☐ 3 و 2 و 1

d. ☐ 1, 2, 3 and 4 ☐ 4 و 3 و 2 و 1

Which of the following are **inorganic** compounds?
أي مما يلي تعد مركبات غير عضوية؟

1	أكاسيد الكربون Carbon oxides
2	الكربيدات Carbides
3	الكربونات Carbonates
4	الهيدروكربونات Hydrocarbons

a. ☐ 2 and 4

b. ☐ 1 and 3

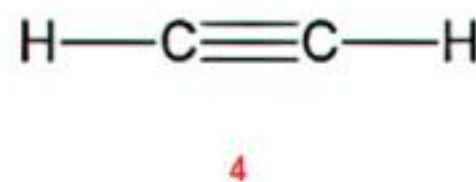
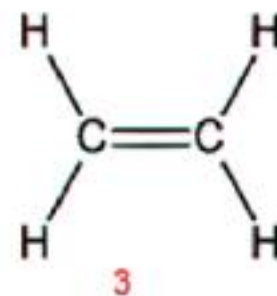
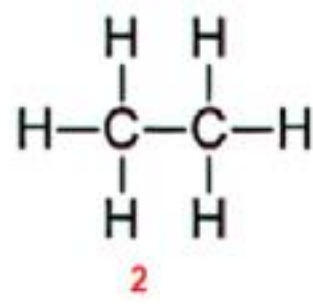
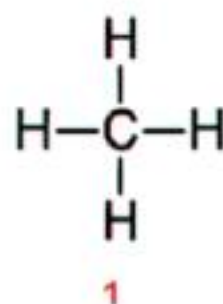
c. ☐ 2, 3 and 4 ☐ 4 و 3 و 2

d. ☐ 1, 2 and 3 ☐ 3 و 2 و 1

6	CHM.5.6.01.001.07 Explain why carbon forms many compounds CHM.5.6.01.003.14 Identify the main (general) characteristic of an organic compound	Textbook + Figure 2	60
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Which hydrocarbons shown below react with bromine?

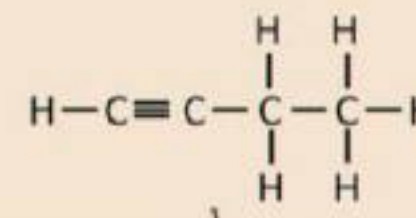
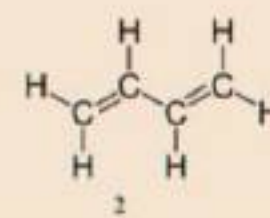
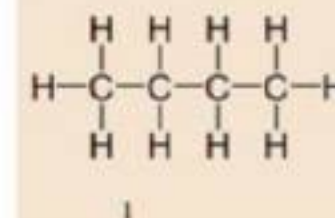
أي الهيدروكربونات المبينة أدناه تتفاعل مع البروم؟



- a. 1 فقط
- b. 3 و 2
- c. 4 و 3
- d. 4 و 1

Which of the hydrocarbons shown below react with bromine?

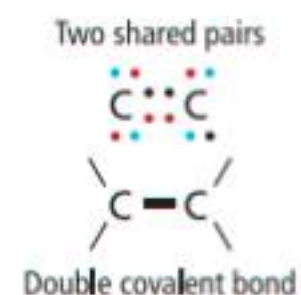
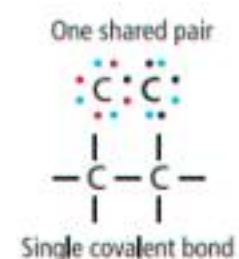
أي الهيدروكربونات المبينة أدناه يتفاعل مع البروم؟



- a. 1 فقط
- b. 3 فقط
- c. 3 و 2
- d. 3 و 1

- A hydrocarbon having **only single bonds** is defined as a **saturated hydrocarbon**.
- A hydrocarbon that has at least one **double or triple bond** between carbon atoms is an **unsaturated hydrocarbon**.

■ **Figure 5** Carbon can bond to other carbon atoms in double and triple bonds. These Lewis structures and structural formulas show two ways to denote double and triple bonds.



Three shared pairs

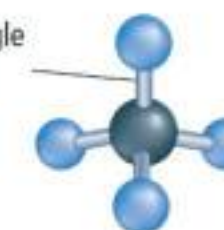
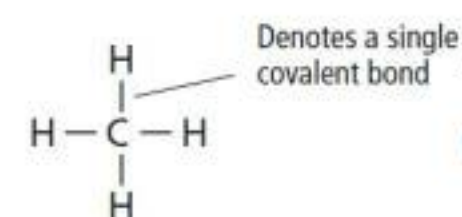


Triple covalent bond

- and • = carbon electrons
- = electron from another atom

Models of Methane

CH₄



Molecular formula

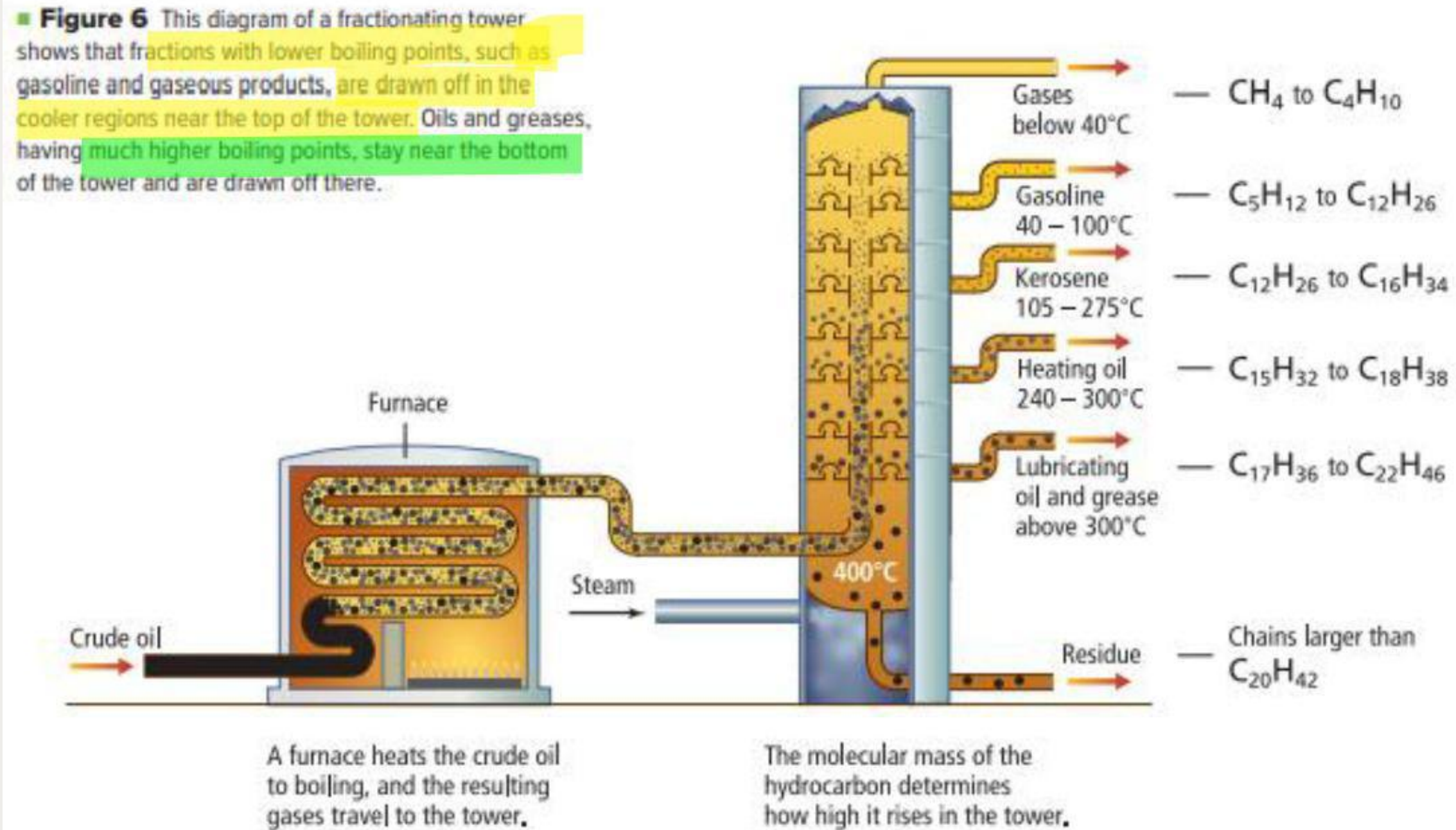
Structural formula

Ball-and-stick model

Space-filling model

■ **Figure 21.4** Chemists use four different models to represent a methane (CH₄) molecule. Refer to page 968 for a key to atom color conventions.

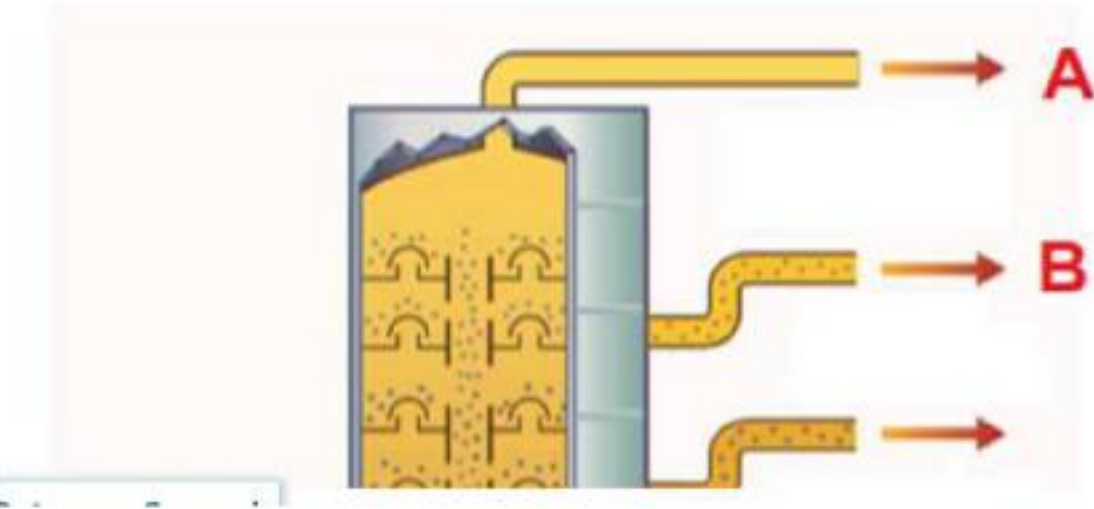
- Petroleum (crude oil) is separated into simpler components or fractions.
- Separation is carried out in a process called **fractional distillation**, also called fractionation,
- which involves boiling the petroleum and collecting components or fractions as they condense at different temperatures.
- Fractional distillation is done in a **fractionating tower** like the one shown in figure.



8	CHM.5.6.01.005.07 Describe the process used to separate petroleum compounds by explaining the physical property used during the process	Textbook + Figure 6	62, 63
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When separating Crude oil components in the fractionating tower in the figure below. Which of the following is **correct**?

عند فصل مكونات النفط الخام في برج التجزئة في الشكل أدناه، أي مما يأتي **صحيح**؟



- a. Hydrocarbons with larger carbon chains are drawn off at **B**
- b. Hydrocarbons with much higher boiling points are drawn at **D**
- c. Hydrocarbons with shorter carbon chains are drawn off at **C**
- d. Hydrocarbons with Larger molecular masses are drawn off at **A**

What fractions of the crude oil are drawn off in the cooler regions near the top of the fractional tower shown below?

ما مكونات النفط الخام التي يتم سحبها للخارج في المناطق الأكثر برودة بالقرب من أعلى برج التجزئة الموضح أدناه؟



- a. Fractions with lower boiling point
- b. Fractions with higher boiling point
- c. Fractions with many carbon atoms
- d. Fractions with higher molecular mass

- The temperature inside the fractionating tower is controlled so that it remains near **400°C at the bottom**, where the petroleum is boiling, and gradually decreases toward the top.
- The condensation temperatures (**boiling points**) generally decrease as molecular mass decreases.
- Therefore, as the vapors travel up through the column, the hydrocarbons condense and are drawn off.

■ **Figure 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.

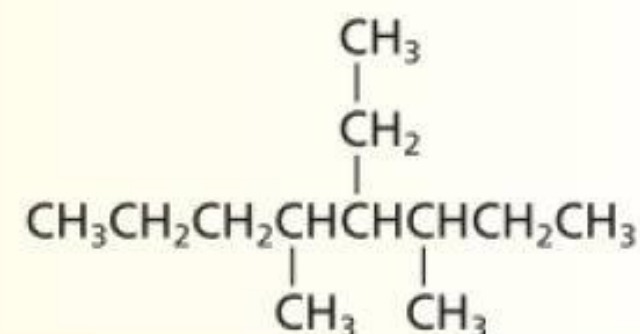
Infer What types of emissions must be controlled by refineries to protect the environment?

Emission of harmful gases

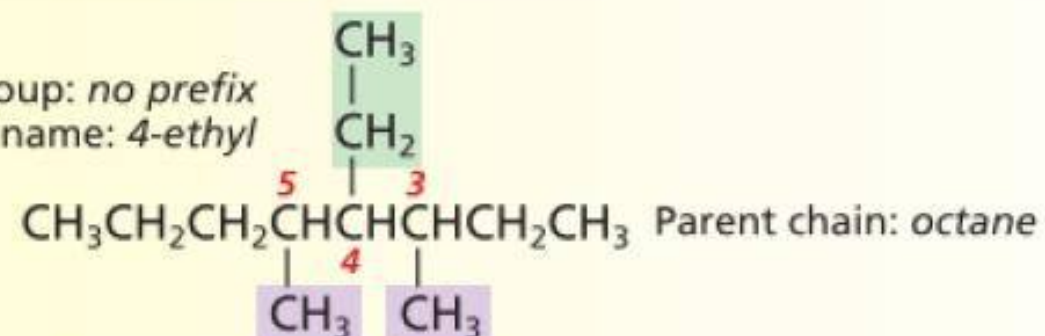


EXAMPLE 1**NAMING BRANCHED-CHAIN ALKANES**

Name the alkane shown.



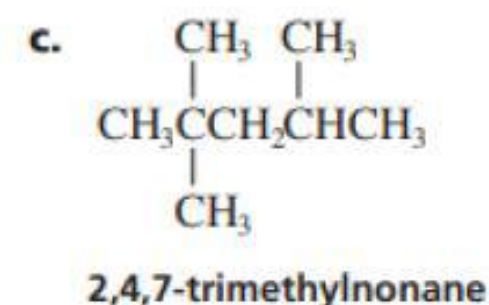
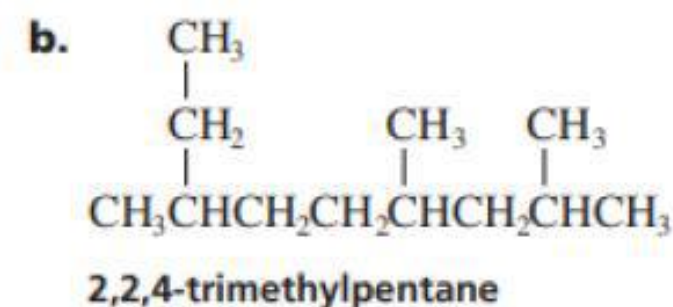
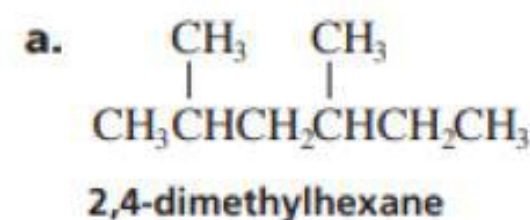
One ethyl group: *no prefix*
Position and name: *4-ethyl*



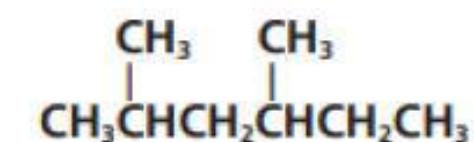
Two methyl groups: use *dimethyl*
Position and name: *3,5-dimethyl*

The name should be written as
4-ethyl-3,5-dimethyloctane

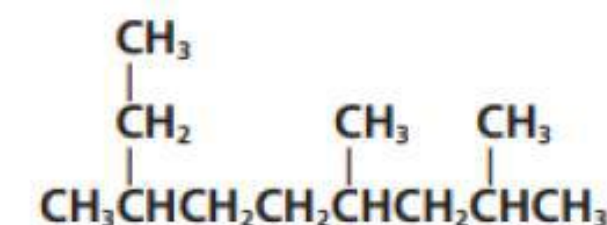
8. Use IUPAC rules to name the following structures.

9. **Challenge** Draw the structures of the following branched-chain alkanes.

a. 2,3-dimethyl-5-propyldecane

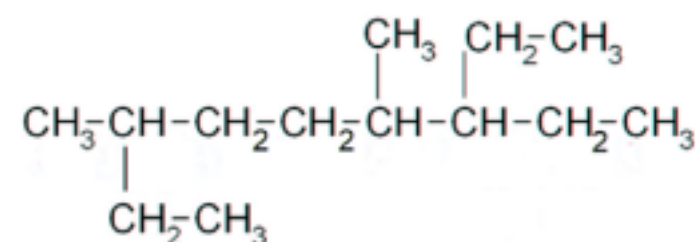


b. 3,4,5-triethyloctane



Using IUPAC rules, what is the **correct** name
of the structural formula shown below?

مستخدمًا قواعد IUPAC ، ما الاسم الصحيح للصيغة البنائية الموضحة
أدناه؟



3,7-diethyl-4-methyloctane

7،3-ثاني إيثيل-4-ميثيل أوكتان

.a

2,6-diethyl-5-methyloctane

6،2-ثاني إيثيل-5-ميثيل أوكتان

.b

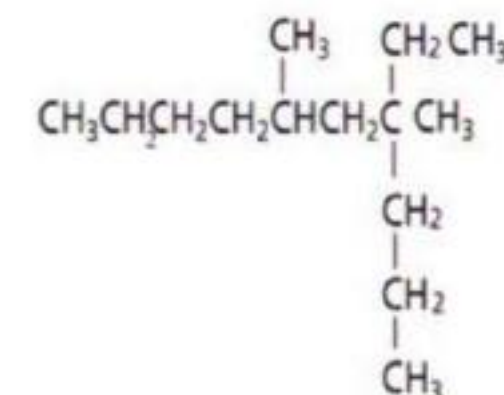
3-ethyl-4,7-dimethylnonane

3-إيثيل-4،7-ثاني ميثيل نونان

.c

Using IUPAC rules, what is the **correct** name
of the structure shown below?

مستخدمًا قواعد (IUPAC) ، ما الاسم الصحيح
للصيغة البنائية الموضحة أدناه؟



a.

4-ethyl-4,6-dimethyldecane

4-إيثيل-6،4-ثاني ميثيل ديكان



b.

4,6-dimethyl-4-ethyldecane

4،6-ثاني ميثيل-4-إيثيل ديكان



c.

7-ethyl-5,7-dimethyldecane

7-إيثيل-5،7-ثاني ميثيل ديكان



d.

5,7-dimethyl-7-ethyldecane

7،5-ثاني ميثيل-7-إيثيل ديكان



Name	Molecular Formula (C_nH_{2n+2})	Condensed Structural Formula
methane	CH_4	CH_4
ethane	C_2H_6	CH_3CH_3
propane	C_3H_8	$CH_3CH_2CH_3$
butane	C_4H_{10}	$CH_3CH_2CH_2CH_3$
pentane	C_5H_{12}	$CH_3CH_2CH_2CH_2CH_3$
hexane	C_6H_{14}	$CH_3CH_2CH_2CH_2CH_2CH_3$
heptane	C_7H_{16}	$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$
octane	C_8H_{18}	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$
nonane	C_9H_{20}	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$
decane	$C_{10}H_{22}$	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

Table 21.1 Simple Alkanes			
Molecular Formula	Structural Formula	Ball-and-Stick Model	Space-Filling Model
Ethane (C_2H_6)	$\begin{array}{c} H & H \\ & \\ H-C & -C-H \\ & \\ H & H \end{array}$		
Propane (C_3H_8)	$\begin{array}{c} H & H & H \\ & & \\ H-C & -C & -C-H \\ & & \\ H & H & H \end{array}$		
Butane (C_4H_{10})	$\begin{array}{c} H & H & H & H \\ & & & \\ H-C & -C & -C & -C-H \\ & & & \\ H & H & H & H \end{array}$		

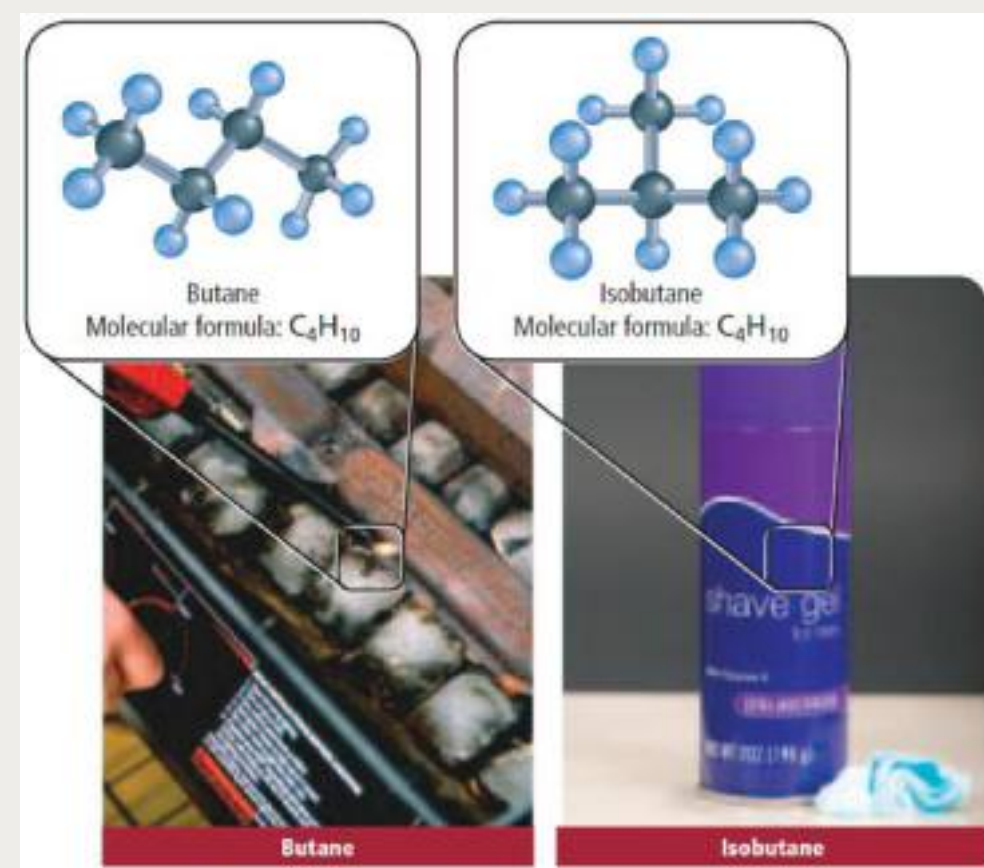
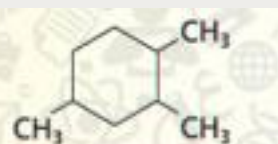


Table 21.3 Common Alkyl Groups					
Name	Methyl	Ethyl	Propyl	Isopropyl	Butyl
Condensed structural formula	CH_3-	CH_3CH_2-	$CH_3CH_2CH_2-$	CH_3CHCH_3 	$CH_3CH_2CH_2CH_2-$
Structural formula	$\begin{array}{c} H \\ \\ H-C-H \\ \\ H \end{array}$	$\begin{array}{c} H \\ \\ H-C-H \\ \\ H-C-H \\ \\ H \end{array}$	$\begin{array}{c} H \\ \\ H-C-H \\ \\ H-C-H \\ \\ H-C-H \\ \\ H \end{array}$	$\begin{array}{c} H \\ \\ H-C-H \\ \\ -C-H \\ \\ H-C-H \\ \\ H \end{array}$	$\begin{array}{c} H \\ \\ H-C-H \\ \\ H-C-H \\ \\ H-C-H \\ \\ H-C-H \\ \\ H \end{array}$

- ❖ An organic compound that contain hydrocarbon ring is called **cyclic hydrocarbon**.
- ❖ Cyclic hydrocarbons that contains only **single bonds** are called **Cycloalkanes**.

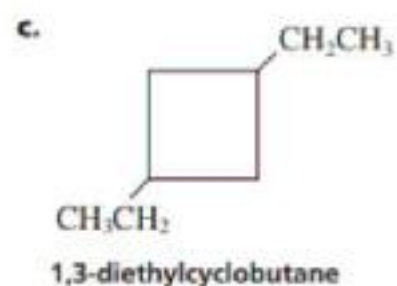
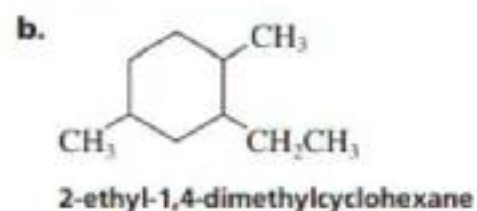
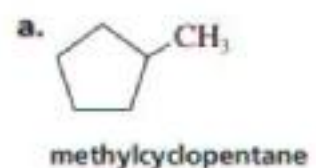
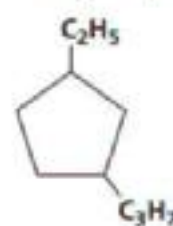
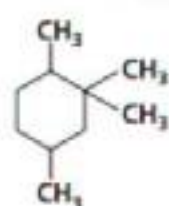
NAMING CYCLOALKANES

Name the cycloalkane shown.



Steps :

- Name the carbon ring for example : Cyclohexane
- Number in such a way that the substituents gets lowest possible number. Here are 2 ways of numbering.
- Name the substituents.
- Add prefix to the substituents (di , tri , tetra) for the same substituent if repeated.
- Consider alphabetic order for substituents.
- Put the name together. Number are separated by commas and hyphens between numbers and words.

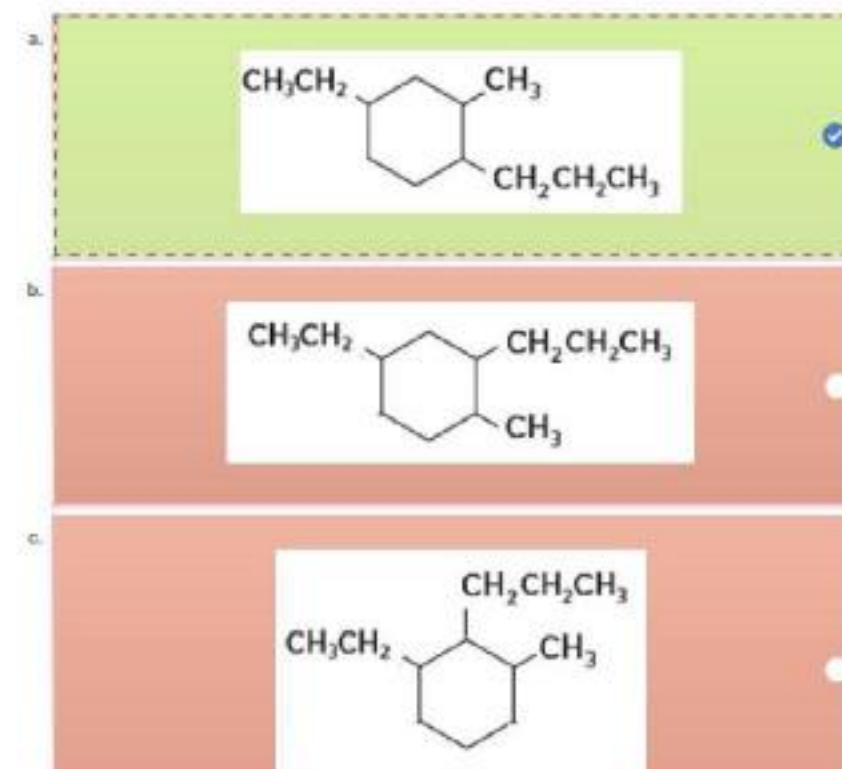
10. Use IUPAC rules to name the following structures.**11. Challenge** Draw the structures of the following cycloalkanes.**a.** 1-ethyl-3-propylcyclopentane**b.** 1,2,2,4-tetramethylcyclohexane

What is the **correct** structural formula for the following cycloalkane?

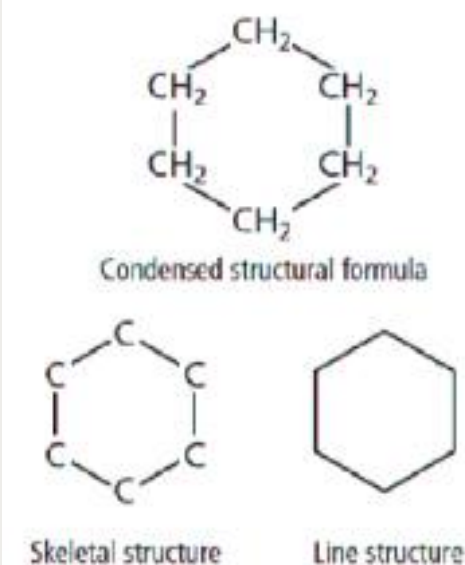
(4-ethyl-2-methyl-1-propylcyclohexane)

ما الصيغة البنائية **المسحجة** للألكان الحلقي التالي؟

(4- إيثيل -2- ميثيل -1- بروبيل هكسان حلقي)



■ **Figure 21.10** Cyclohexane can be represented in several ways.



11	CHM.5.6.01.016 Use the structures and functional groups to interpret the physical properties of organic compounds (e.g, melting point, boiling point and solubility in water).	Textbook + Table 4 + Check your progress	74, 75
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Properties of Alkanes: Physical properties

	Comparing Physical Properties	
Substance and formula	Water (H ₂ O)	Methane (CH ₄)
Molecular mass	18 amu	16 amu
State at room temperature	liquid	gas
Boiling point	100°C	−162°C
Melting point	0°C	−182°C

- Alkanes have low melting and boiling point than water
- Alkanes are not miscible (dissolve) with water
- Alkanes are non-polar and soluble in non-polar substances only

Alkanes are non-polar compounds

They are good solvents for many non-polar substances

Why are alkane molecules good solvents for other nonpolar substances?

ما السبب في أن جزيئات الألكانات مذيبات جيدة للمواد غير القطبية الأخرى؟

a

Because all the bonds in alkanes are nonpolar

لأن جميع الروابط في الألكانات غير قطبية

b

Because alkane molecules form hydrogen bonds with each other

لأن جزيئات الألكانات تُشكل روابط هيدروجينية بعضها مع بعض

c

Because alkane molecules bonds have very large electronegativity difference

لوجود اختلافات كبيرة جدًا في السالبية الكهربية في روابط جزيئات الألكانات

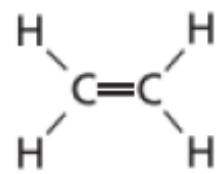
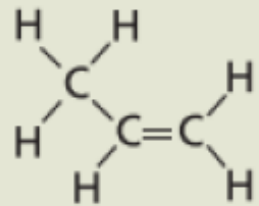
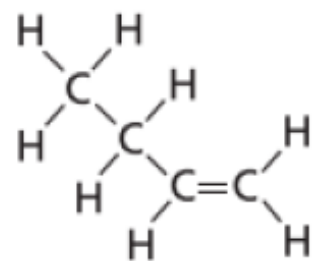
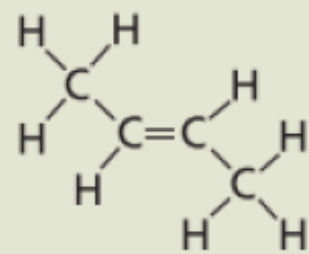
d

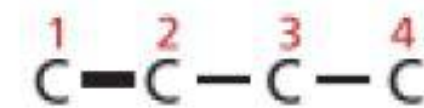
Because alkane molecules are similar in size to other nonpolar substances

لأن جزيئات الألكانات متشابهة من حيث الحجم مع المواد الأخرى غير القطبية

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موقع المناهج الإماراتية

Table 5 Examples of Alkenes

Name	Ethene	Propene	1-Butene	2-Butene
Molecular formula	C_2H_4	C_3H_6	C_4H_8	C_4H_8
Structural formula				
Condensed structural formula	$CH_2=CH_2$	$CH_3CH=CH_2$	$CH_3CH_2CH=CH_2$	$CH_3CH=CHCH_3$



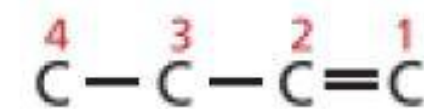
1-Butene



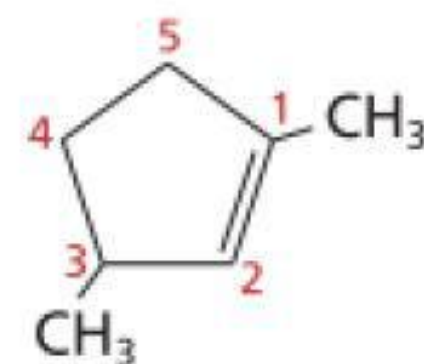
2-Butene



3-Butene



1-Butene

a. Straight-chain alkenes**b. Cyclic alkenes**

■ **Figure 12** When naming either branched or straight-chain alkenes, they must be numbered using IUPAC rules.

How many hydrogen atoms are in an alkene (straight series) with 6 carbon atoms and one double bond between two carbon atoms?

ما عدد ذرات الهيدروجين الموجودة في الألكين (سلسلة مستقيمة) الذي له 6 ذرات كربون ورابطة ثنائية واحدة بين ذرتي الكربون؟

6

.a

12

.b

14

.c

16

.d

Some unsaturated hydrocarbons contain more than one double (or triple) bond. The number of double bonds in such molecules is shown by using a prefix (*di-*, *tri-*, *tetra-*, and so on) before the suffix *-ene*. The positions of the bonds are numbered in a way that gives the lowest set of numbers. Which numbering system would you use in the example in **Figure 13b**? Because the molecule has a seven-carbon chain, you would use the prefix *hepta-*. Because it has two double bonds, you would use the prefix *di-* before *-ene*, giving the name *heptadiene*. Adding the numbers 2 and 4 to designate the positions of the double bonds gives the name *2,4-heptadiene*.

How many hydrogen atoms are in an alkene

كم عدد ذرات الهيدروجين الموجودة في جزيء الألكين الذي

with nine carbon atoms and one double bond?

له تسع ذرات كربون ورابطة ثنائية واحدة؟

Learning Outcomes Covered

◦ CHM.5.6.01.013

a.

18



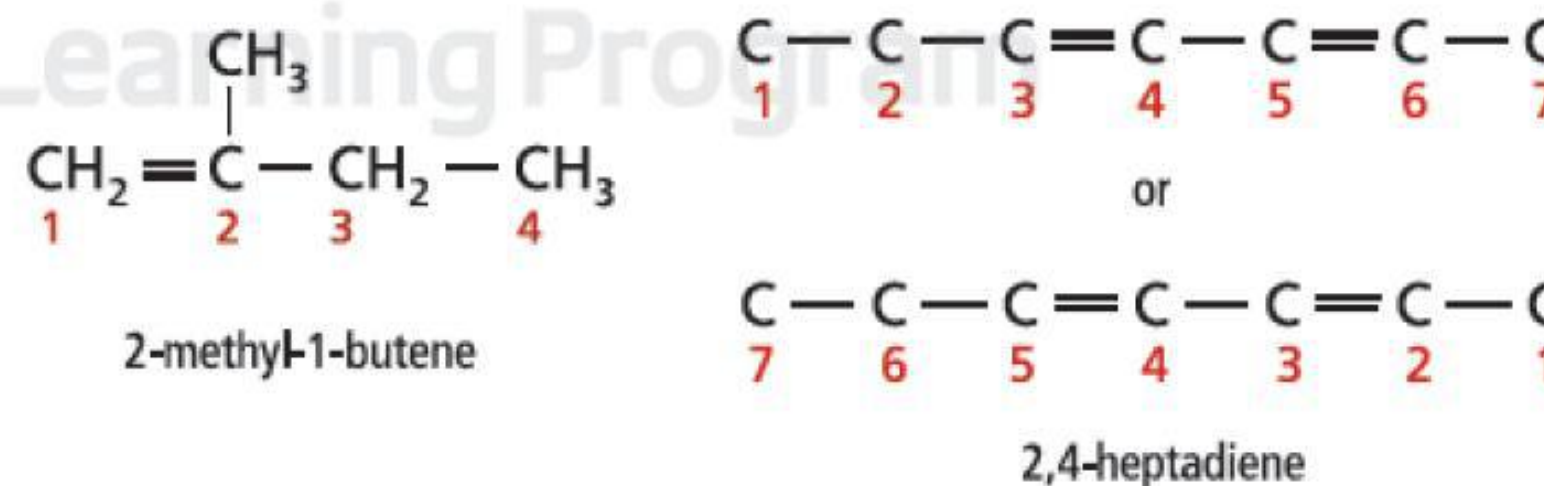
b.

20



c.

16



a. Single double bond

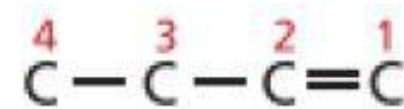
b. Two double bonds



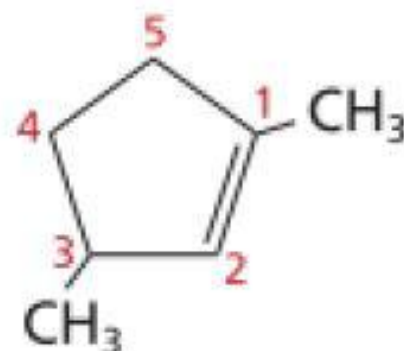
1-Butene



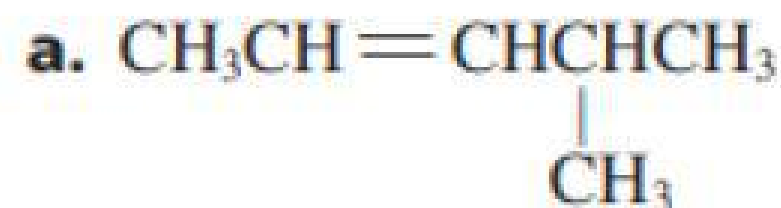
2-Butene

~~3-Butene~~

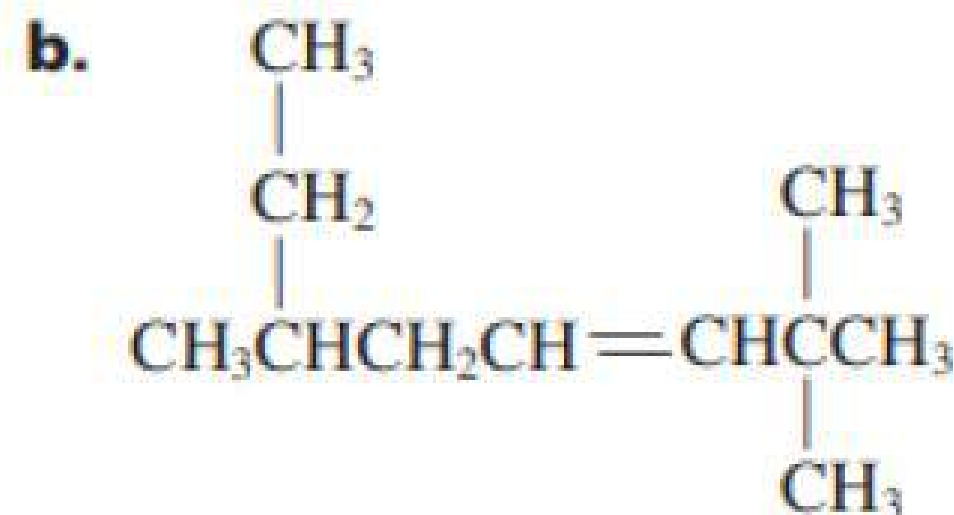
1-Butene

a. Straight-chain alkenes**b. Cyclic alkenes**

■ **Figure 12** When naming either branched or straight-chain alkenes, they must be numbered using IUPAC rules.

17. Use IUPAC rules to name the following structures.

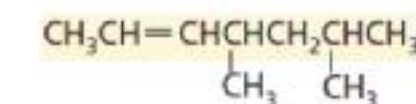
4-methyl-2-pentene



2,2,6-trimethyl-3-octene

18. Challenge Draw the structure of 1,3-pentadiene.**Naming Branched-Chain Alkenes**

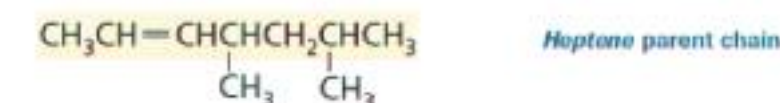
Name the alkene shown.

**1 Analyze the Problem**

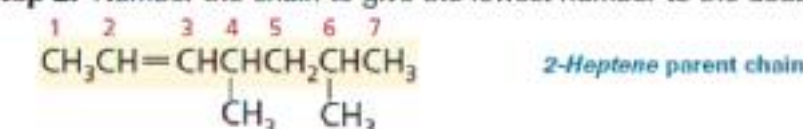
You are given a branched-chain alkene that contains one double bond and two alkyl groups. Follow the IUPAC rules to name the organic compound.

2 Solve for the Unknown

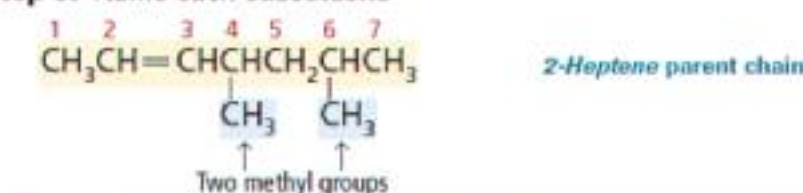
Step 1. The longest continuous-carbon chain that includes the double bond contains seven carbons. The 7-carbon alkane is heptane, but the name is changed to *heptene* because a double bond is present.



Step 2. Number the chain to give the lowest number to the double bond.



Step 3. Name each substituent.



Step 4. Determine how many of each substituent is present, and assign the correct prefix to represent that number. Then, include the position numbers to get the complete prefix.



Step 5. The names of substituents do not have to be alphabetized because they are the same. Apply the complete prefix to the name of the parent alkene chain. Use commas between numbers, and hyphens between numbers and words. Write the name 4,6-dimethyl-2-heptene.

Naming alkynes Straight-chain alkynes and branched-chain alkynes are named in the same way as alkenes. The only difference is that the name of the parent chain ends in *-yne* rather than *-ene*. Study the examples in **Table 6**. Alkynes with one triple covalent bond form a homologous series with the general formula C_nH_{2n-2} .

■ **Figure 21.15** These three molecular models represent ethyne.

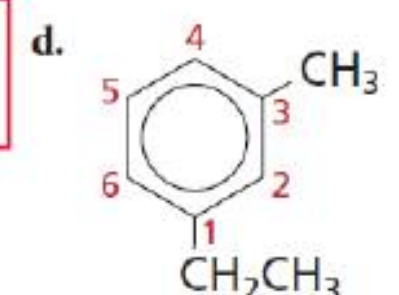
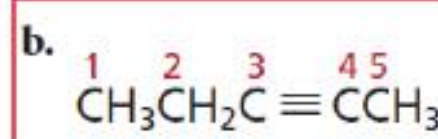
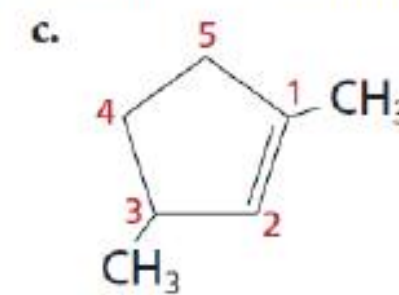
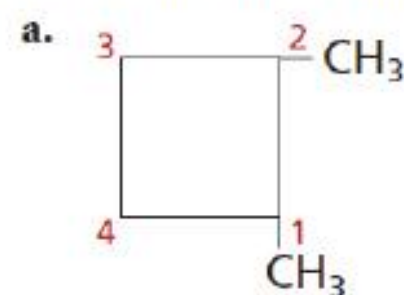


Models of ethyne (acetylene)

Table 6 Examples of Alkynes

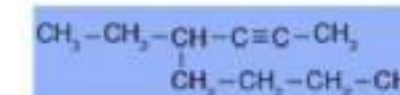
Name	Molecular Formula	Structural Formula	Condensed Structural Formula
Ethyne	C_2H_2	$H - C \equiv C - H$	$CH \equiv CH$
Propyne	C_3H_4	$H - C \equiv C - \begin{array}{c} H \\ \\ C - H \\ \\ H \end{array}$	$CH \equiv CCH_3$
1-Butyne	C_4H_6	$H - C \equiv C - \begin{array}{c} H & H \\ & \\ C & - C - H \\ & \\ H & H \end{array}$	$CH \equiv CCH_2CH_3$
2-Butyne	C_4H_6	$\begin{array}{c} H & & H \\ & & \\ H - C & - C \equiv C & - C - H \\ & & \\ H & & H \end{array}$	$CH_3C \equiv CCH_3$

83. Determine whether each of the following structures shows the correct numbering. If the numbering is incorrect, redraw the structure with the correct numbering.



Using IUPAC rules, what is the **correct** name of the following structure?

استخدمنا قواعد IUPAC، ما الاسم الصحيح لتسمية البنية التالية؟



- a. 
- b. 
- c. 
- d. 

14	CHM.5.6.01.013.07 Use IUPAC system to name alkynes (straight chain and branched)	Textbook+ Figure 15 + Table 6	79, 80
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Which of the following is represented by the following general formula C_nH_{2n-2} ?
أي مما يلي تمثله الصيغة العامة التالية C_nH_{2n-2} ?

Learning Outcomes Covered

- CHM.5.6.01.003

a. Alkane ألكان

b. Alkene ألكين

c. Cycloalkane ألكان حلقي

d. Alkyne ألكاين

Using IUPAC rules, what is the **correct** name of the structural formula shown below?
مُستخدماً قواعد IUPAC ، ما الاسم **الصحيح** للصيغة البنائية الموضحة أدناه؟

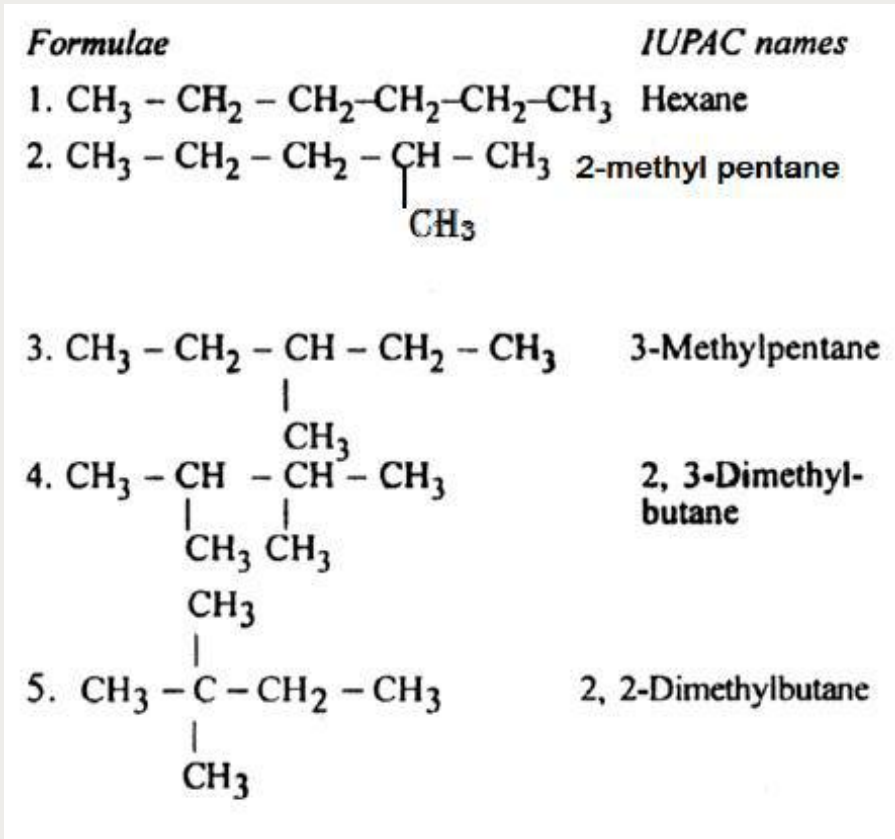
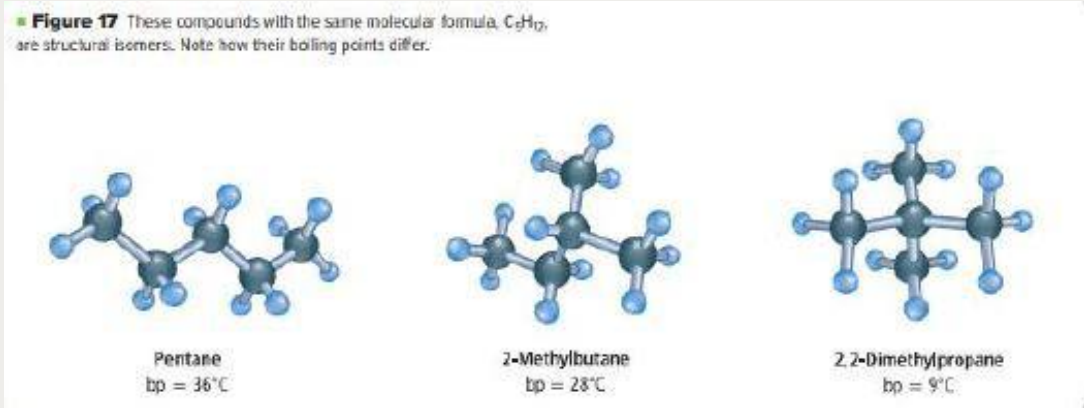
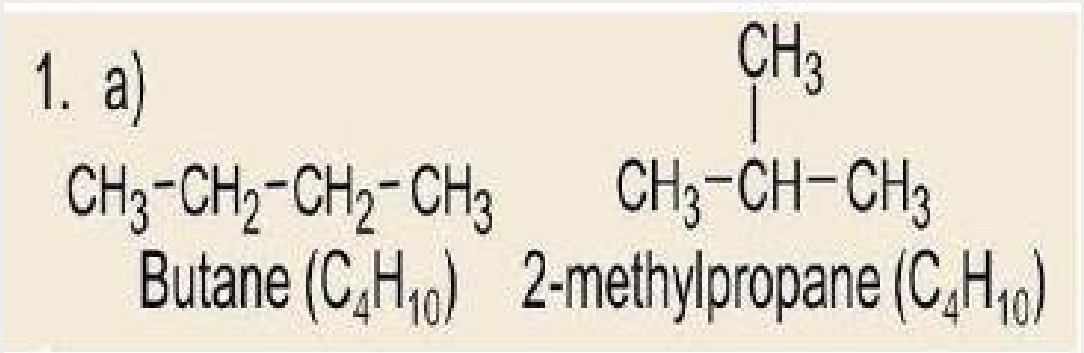
$$\begin{array}{ccccccc}
 & & & H & H & & \\
 & & & | & | & & \\
 H & -C \equiv C- & C & -C & -H \\
 & & | & | & & & \\
 & & H & H & & &
 \end{array}$$

a. 1-Butyne 1-بيوتاين

b. 3-Butyne 3-بيوتاين

c. 1-Butene 1-بيوتين

15	CHM.5.6.01.011.01 Compare and contrast structural and geometric isomers	Textbook+ Figures 17, 18	82, 83
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Which of the following is **NOT** a structural isomer of other three compounds? أي مما يلي ليس أيزومر بنيائي للمركبات الثلاثة الأخرى؟

3،2-ثاني ميثيل بيوتان 2,3-Dimethylbutane	2-ميثيل بيوتان 2-methylbutane	2،2-ثاني ميثيل البروبان 2,2-Dimethylpropane	بنتان Pentane
---	----------------------------------	--	------------------

a. بنتان
Pentane ☐

b. 3،2-ثاني ميثيل بيوتان
2,3-Dimethylbutane ☒

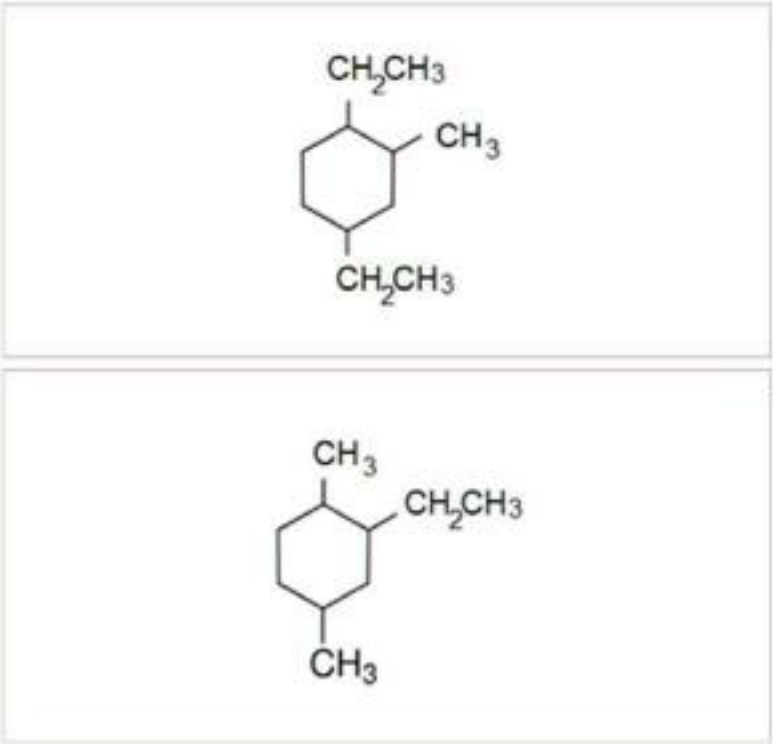
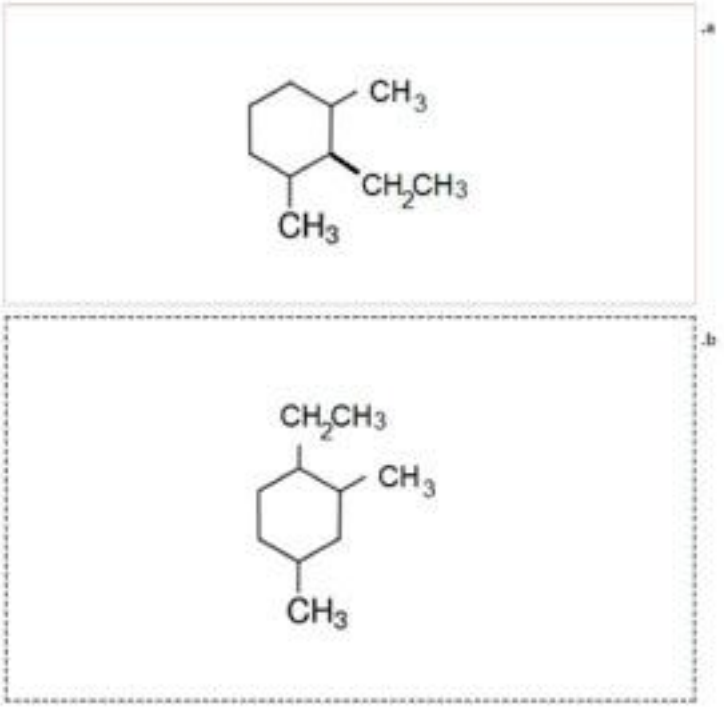
c. 2،2-ثاني ميثيل البروبان
2,2-Dimethylpropane ☐

d. 2-ميثيل بيوتان
2-methylbutane ☐

15	CHM.5.6.01.011.01 Compare and contrast structural and geometric isomers	Textbook+ Figures 17, 18	82, 83
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What is the **correct** structural formula for the following cycloalkane?

(1-ethyl -2,4- dimethyl cyclohexane)



ما الصيغة البنائية **الصحيحة** للألكان الحلقي التالي؟
(1- إيثيل -2، 4- ثنائي ميثيل هكسان حلقي)

Which of the following is **not** a structural isomers of the molecular formula C_5H_{12} ?

أي مما يلي **ليس** من الأيزومرات البنائية للصيغة الجزيئية C_5H_{12} ؟

- a

Pentane

البنطان
- b

2-Methylbutane

2- ميثيل بيوتان
- c

2, 2-Dimethylpropane

2 ، 2- ثنائي ميثيل بروبان
- d

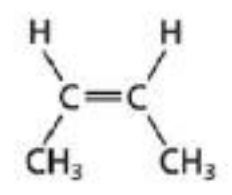
2, 3-Dimethylbutane

2 ، 3- ثنائي ميثيل بيوتان

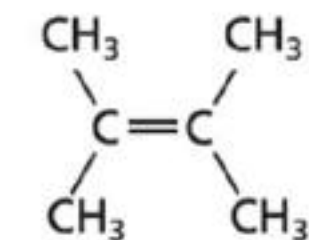
15	CHM.5.6.01.011.01 Compare and contrast structural and geometric isomers	Textbook+ Figures 17, 18	82, 83
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Which of the following **does not** form geometric isomers?
أي مما يلي **لا يكون** أيزومرات هندسية؟

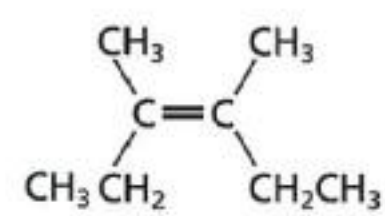
a.



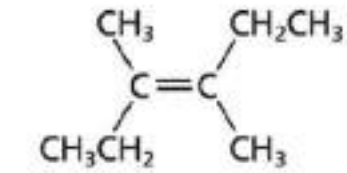
d.



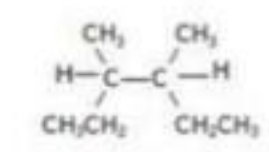
b.

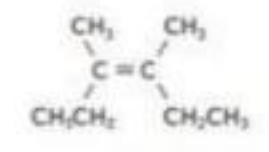


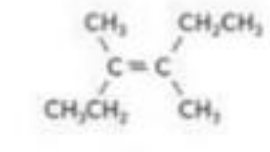
c.

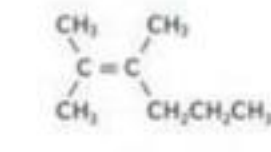


Which of the following is a pair of geometrical isomers?
أي مما يلي زوج من الأيزومرات الهندسية؟


D


C


B


A

a. B and C C, B ☒

b. A and D D, A ☐

c. C and A A, C ☐

d. B and D D, B ☐

15	CHM.5.6.01.011.01 Compare and contrast structural and geometric isomers	Textbook+ Figures 17, 18	82, 83
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GEOMETRIC ISOMERS

VERSUS

STRUCTURAL ISOMERS

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GEOMETRIC ISOMERS	STRUCTURAL ISOMERS
Geometric isomers are isomers with the same molecular formula and connectivity but differ in spatial arrangement due to restricted rotation around a bond or a ring, leading to different geometric configurations	Structural isomers are isomers with the same molecular formula but different structural arrangements of atoms, resulting in different chemical properties
Have the same bonding order	Have different bonding orders between atoms
Typically have only a few possibilities (usually cis and trans)	A single molecule can have many structural isomers
Ex: butane and ethanol, which have the same number of carbon and hydrogen atoms but differ in functional groups	Ex: dichloroethane, which has cis and trans isomers

Figure 21.18 The single-bonded carbons in ethane are free to rotate around the bond. The double-bonded carbons in ethene resist being rotated.

Explain How do you think this difference in ability to rotate would affect atoms or groups of atoms bonded to single-bonded and double-bonded carbon atoms?

Single covalent bond

Carbons free to rotate

Ethane

Double covalent bond

Carbons fixed in position: no rotation possible

Ethene

Regarding the two compounds in the table below.

فيما يتعلق بالمركبين في الجدول أدناه، أي مما يأتي صحيح؟

Which of the following is true?

2	1
----------	----------

Rotation is possible in compound **1** and it cannot form geometric isomers

Rotation is possible in compound **2** and it cannot form geometric isomers

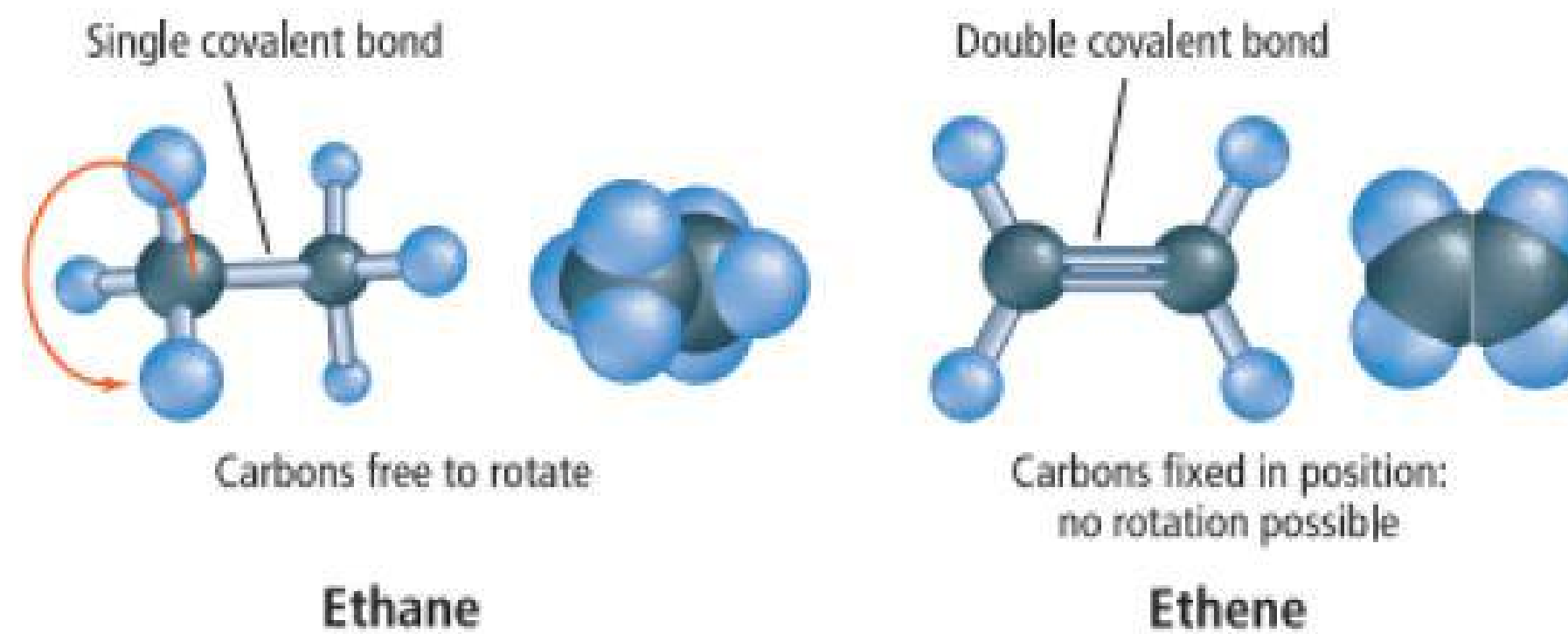
Rotation is possible in both compounds **1, 2** and they cannot form geometric isomers

Rotation is impossible in both compounds **1,2** and they can form geometric isomers

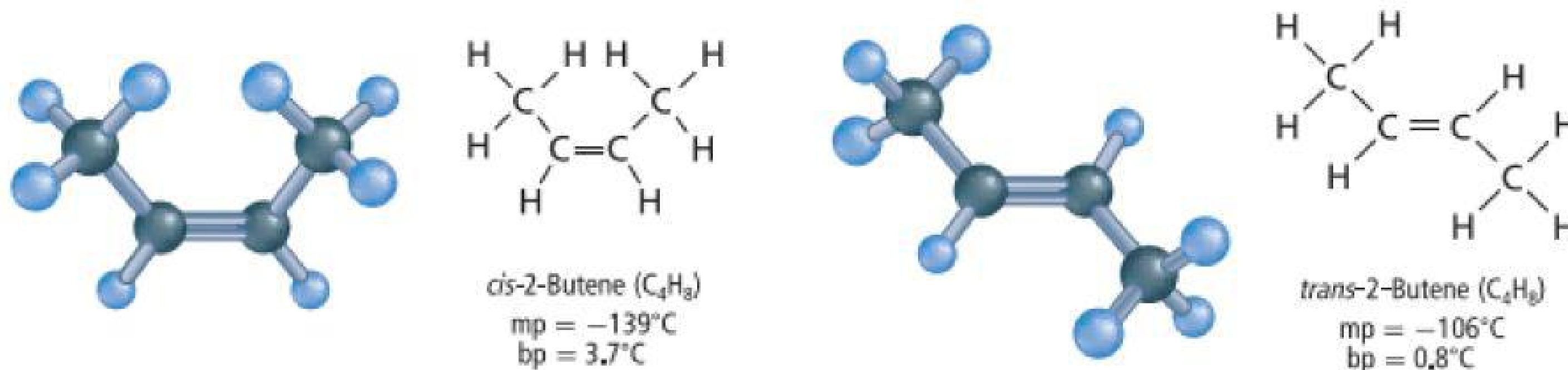
■ **Figure 18** The single-bonded carbons in ethane are free to rotate around the bond. The double-bonded carbons in ethene resist being rotated.

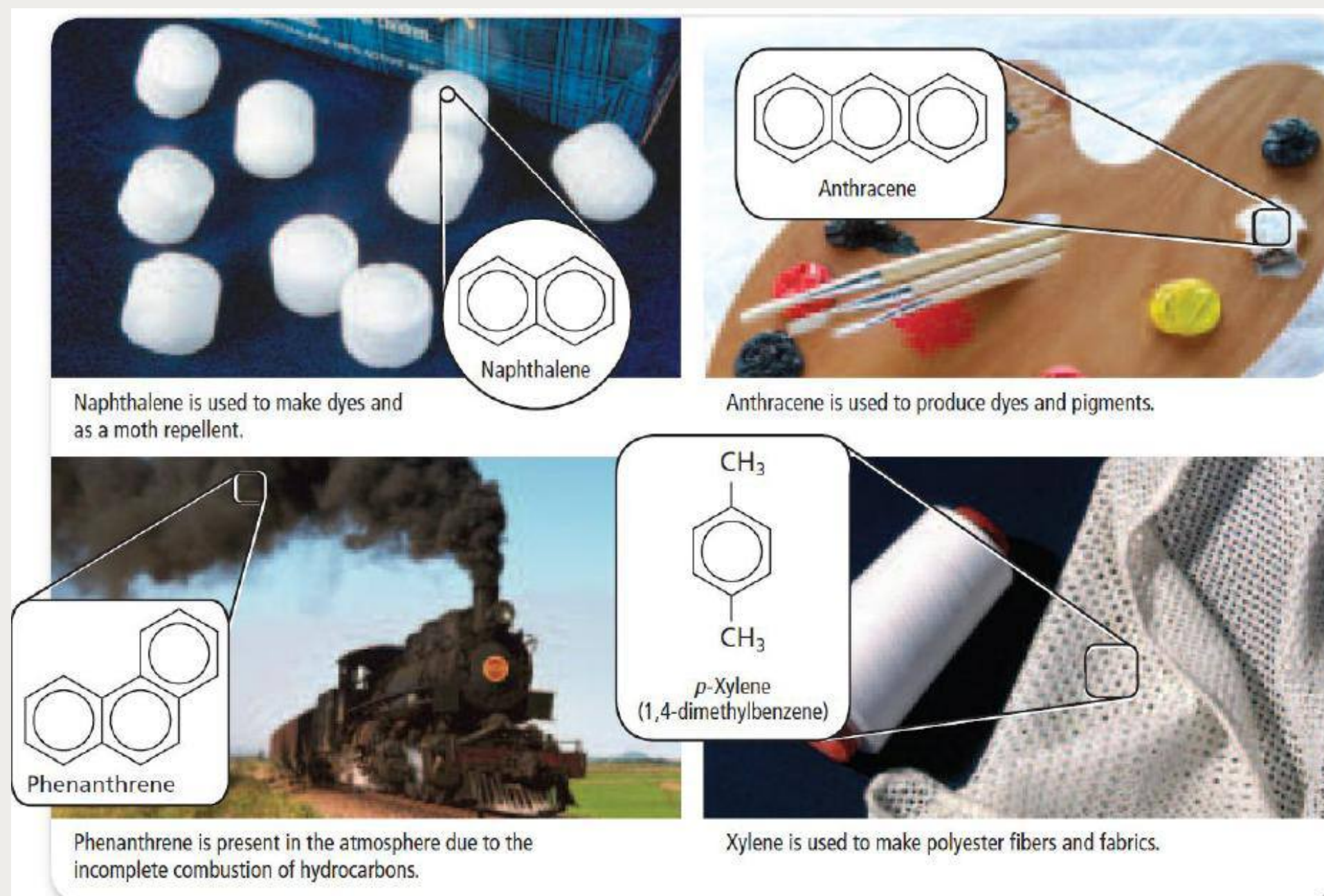
Explain How do you think this difference in ability to rotate would affect atoms or groups of atoms bonded to single-bonded and double-bonded carbon atoms?

Double bonded compounds only shows geometric isomerism

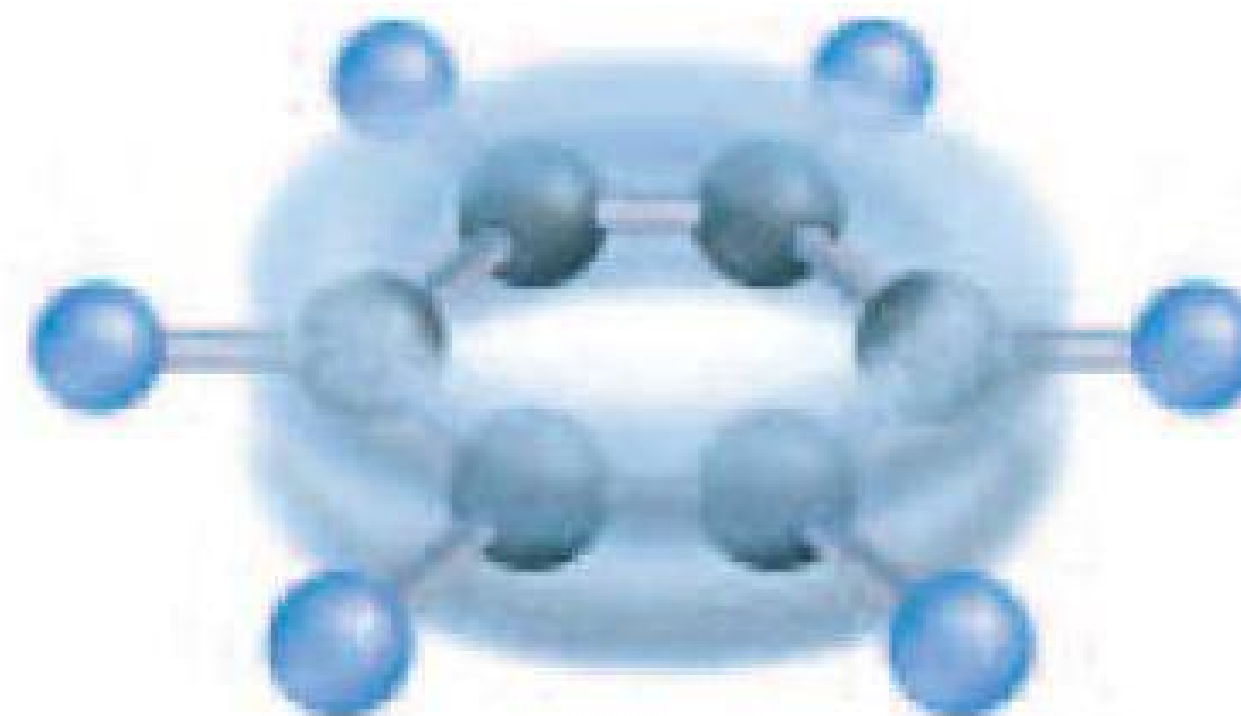


■ **Figure 19** These isomers of 2-butene differ in the arrangement in space of the two methyl groups at the ends. The double-bonded carbon atoms cannot rotate with respect to each other, so the methyl groups are fixed in one of these two arrangements.





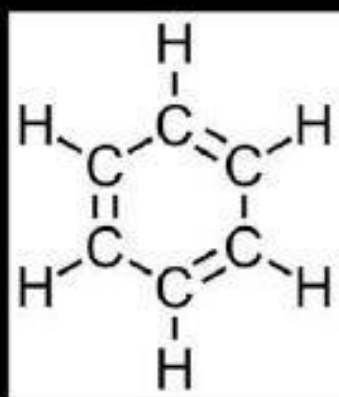
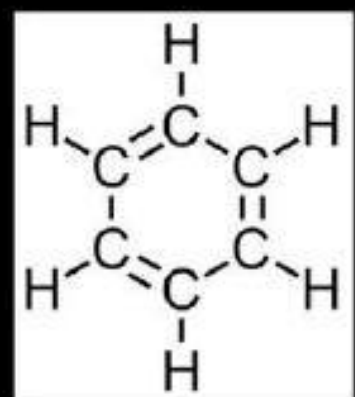
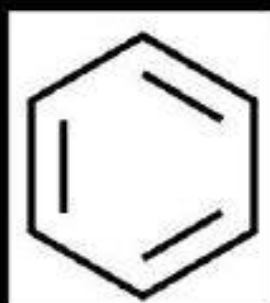
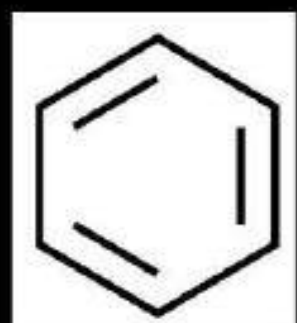
■ **Figure 21.26** Aromatic hydrocarbons are found in the environment due to the incomplete combustion of hydrocarbons and are used to make a variety of products.



■ **Figure 21.25** Benzene's bonding electrons spread evenly in a double-donut shape around the ring instead of remaining near individual atoms.

Structure of benzene

The Kekulé structure of benzene consists of alternating single and double carbon to carbon bonds.

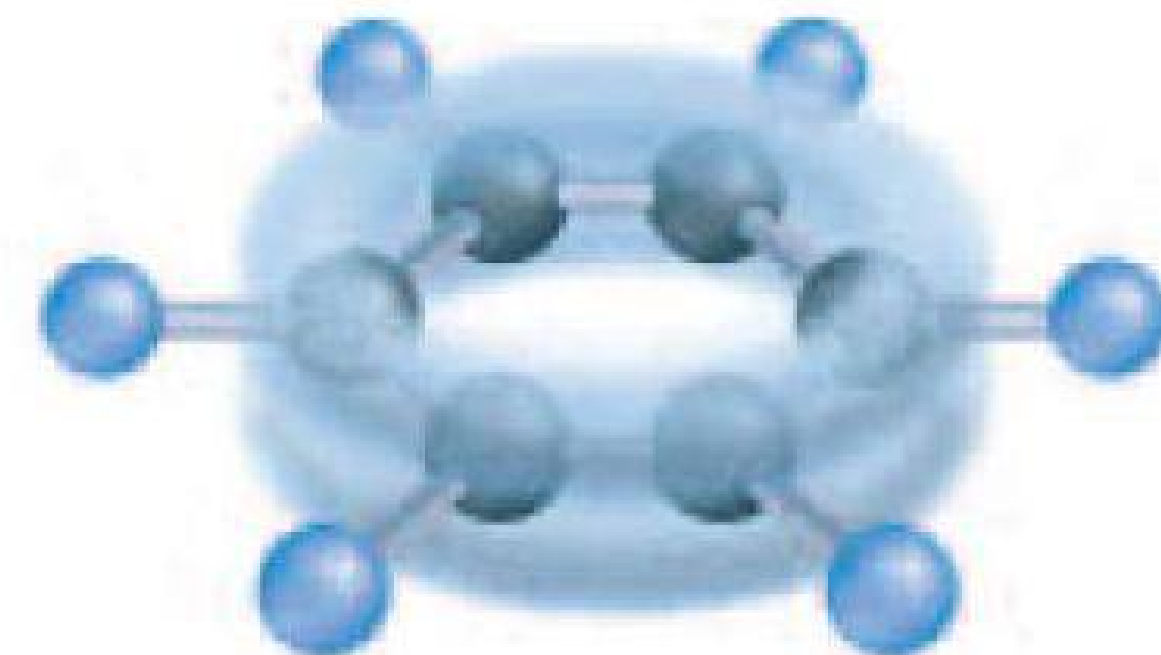


All C to C bonds would be different lengths and strengths.

The enthalpy of hydrogenation of benzene would be -320 kJ mol^{-1}

Benzene would undergo addition reactions.

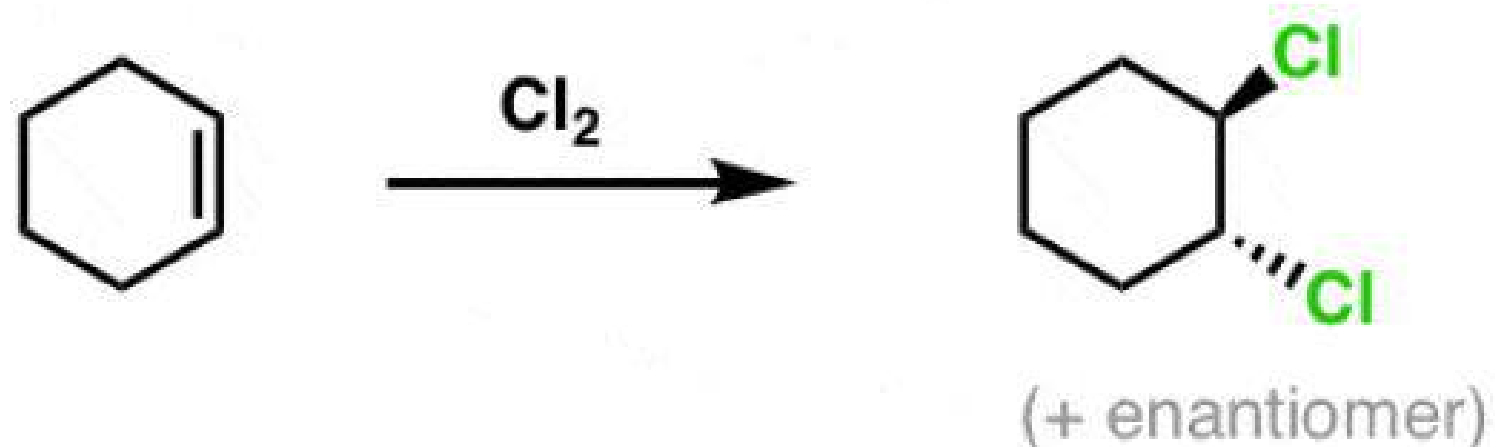
- Two possible isomers produced in 1,2-disubstituted benzene compounds.



■ **Figure 21.25** Benzene's bonding electrons spread evenly in a double-donut shape around the ring instead of remaining near individual atoms.

Benzene undergoes substitution reactions, not addition reactions

A typical alkene (e.g. cyclohexene): addition



**Bonds
Formed**

C-Cl

C-Cl

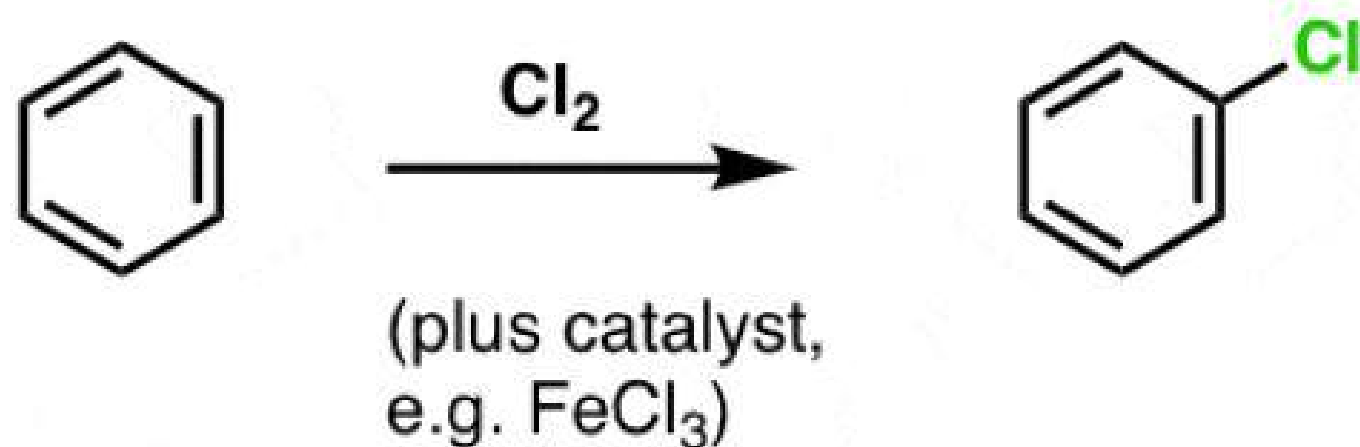
**Bonds
Broken**

C-C (π)

Cl-Cl

An *addition* reaction

Benzene: undergoes substitution, not addition



**Bonds
Formed**

C-Cl

**Bonds
Broken**

C-H

A *substitution* reaction

Carcinogens

Many aromatic compounds, particularly benzene, toluene, and xylene, were once commonly used as industrial and laboratory solvents. However, tests have shown that the use of such compounds should be limited because they can affect the health of people who are exposed to them regularly. Health risks linked to aromatic compounds include respiratory ailments, liver problems, and damage to the nervous system. Beyond these hazards, some aromatic compounds are carcinogens, which are substances that can cause cancer.

Some of these compounds are still used today. For example, toluene is still used in some paints, paint thinners, silicone sealers, and nail polish removers. It is also an important ingredient in the manufacturing of explosives for the mining industry. TNT, or trinitrotoluene requires toluene in its production. Benzene is an additive in gasoline and is used in the production of plastics, synthetic fibers, detergents and resins.

With these chemicals still in use today, extra care must be taken to avoid unnecessary health risks. Proper ventilation in areas where these chemicals are used and respirators worn by those handling the chemicals are just two of the many precautions that can be taken.

As scientists research and develop new organic compounds, proper safety precautions must always be taken until the properties of the new compound are fully understood.



Figure 28 Benzopyrene is a cancer-causing chemical that is found in soot, cigarette smoke, and car exhaust.

The first known carcinogen was an aromatic substance discovered around the turn of the twentieth century in chimney soot. Chimney sweeps in Great Britain were known to have abnormally high rates of cancer. Scientists discovered that the cause of the cancer was the aromatic compound benzopyrene, shown in **Figure 28**. This compound is a by-product of the burning of complex mixtures of organic substances, such as wood and coal. Some aromatic compounds found in gasoline are also known to be carcinogenic.

Table 1 Organic Compounds and Their Functional Groups

Compound Type	General Formula	Functional Group
Halocarbon	$R-X$ ($X = F, Cl, Br, I$)	Halogen
Alcohol	$R-OH$	Hydroxyl
Ether	$R-O-R'$	Ether
Amine	$R-NH_2$	Amino
Aldehyde	$\begin{array}{c} O \\ \\ * - C - H \end{array}$	Carbonyl
Ketone	$\begin{array}{c} O \\ \\ R - C - R' \end{array}$	Carbonyl
Carboxylic acid	$\begin{array}{c} O \\ \\ * - C - OH \end{array}$	Carboxyl
Ester	$\begin{array}{c} O \\ \\ * - C - O - R \end{array}$	Ester
Amide	$\begin{array}{c} O \quad H \\ \quad \\ * - C - N - R \end{array}$	Amide

Which of the following is **correct** regarding

substituted hydrocarbons in the table below?

أي مما يأتي **صحيح** فيما يتعلق بمشتقات الهيدروكربونات

في الجدول أدناه؟

$\begin{array}{c} \text{O} \\ \parallel \\ *-\text{C}-\text{OH} \end{array}$	$\begin{array}{c} \text{O} \quad \text{H} \\ \parallel \quad \\ *-\text{C}-\text{N}-\text{R} \end{array}$	$\text{R}-\text{O}-\text{R}'$	$\begin{array}{c} \text{O} \\ \parallel \\ *-\text{C}-\text{H} \end{array}$	الصيغة العامة General Formula
ألدهيد Aldehyde	أميد Amide	إيثر Ether	حمض كربوكسيلي Carboxylic acid	1
حمض كربوكسيلي Carboxylic acid	أميد Amide	إيثر Ether	ألدهيد Aldehyde	2
حمض كربوكسيلي Carboxylic acid	أميد Amide	ألدهيد Aldehyde	إيثر Ether	3
إيثر Ether	حمض كربوكسيلي Carboxylic acid	ألدهيد Aldehyde	أميد Amide	4

a.

1



b.

2



c.

3

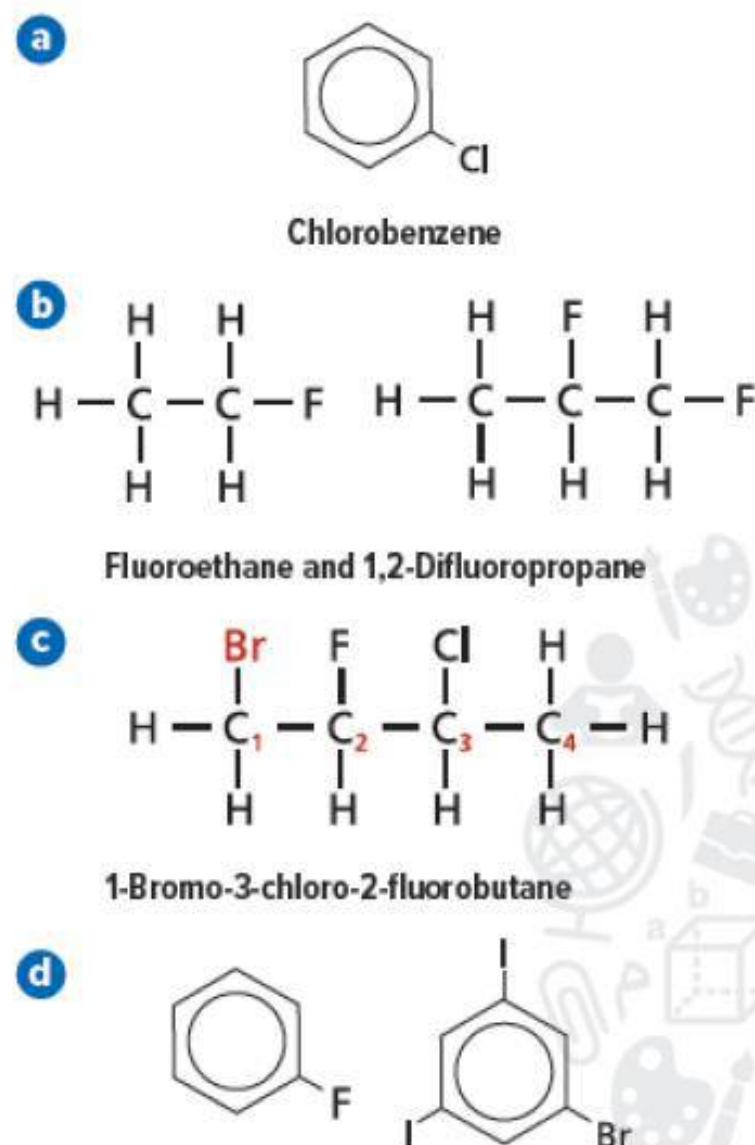


d.

4



- **Alkyl halide** : is an organic compound containing a halogen atom covalently bonded an **aliphatic carbon** atom.
- **Aryl halide** : is an organic compound containing a halogen atom bonded to a **benzene ring or other aromatic** group.

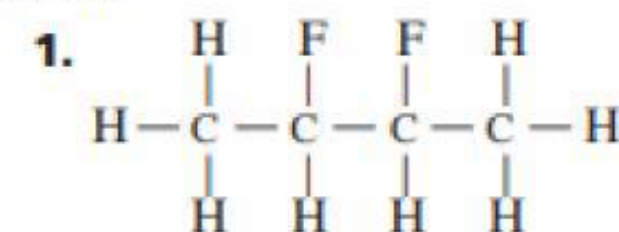


Naming halocarbons Organic molecules containing functional groups are given IUPAC names based on their main-chain alkane structures. For the alkyl halides, a prefix indicates which halogen is present. The prefixes are formed by changing the *-ine* at the end of each halogen name to *-o*. Thus, the prefix for fluorine is *fluoro-*, chlorine is *chloro-*, bromine is *bromo-*, and iodine is *iodo-*, as shown in **Figure 3b**.

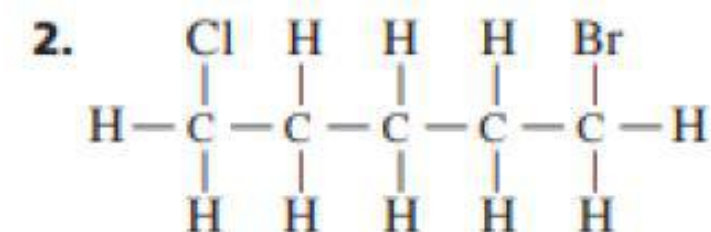
If more than one kind of halogen atom is present in the same molecule, the atoms are listed alphabetically in the name. The chain also must be numbered in a way that gives the lowest position number to the substituent that comes first in the alphabet. Note how the alkyl halide in **Figure 3c** is named.

Similarly, the benzene ring in an aryl halide is numbered to give each substituent the lowest position number possible, as shown in **Figure 3d**.

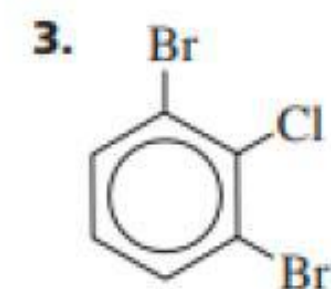
Name the alkyl or aryl halide whose structure is shown.



2,3-difluorobutane



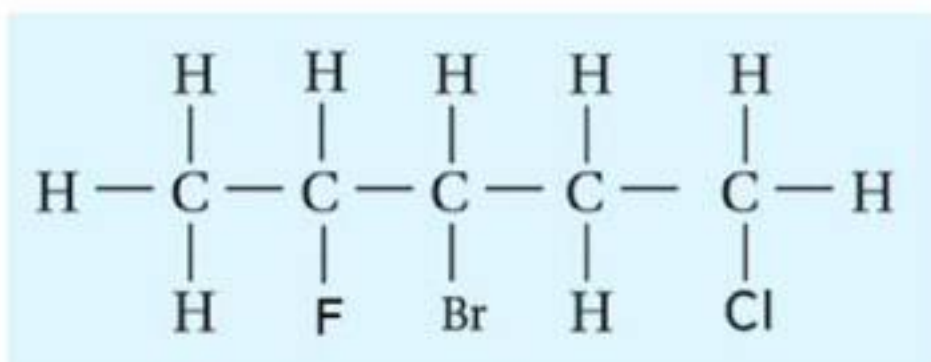
1-bromo-5-chloropentane



1,3-dibromo-2-chlorobenzene

What is the **correct** name for the alkyl halide in the figure below?

(Using IUPAC rules)



ما الاسم الصحيح لهاليد الألكيل في الشكل أدناه؟
(تستخدمنا قواعد IUPAC)

a. 3 - Bromo - 1 - chloro - 4 - fluor pentane

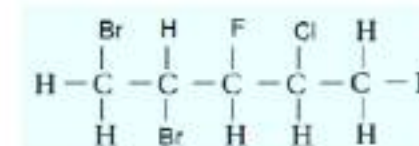
b. 3 - Bromo - 4 - fluor 1 - chloro pentane

c. 3 - Bromo - 2 - fluor - 5 - chloro pentane

d. 3 - Bromo - 5 - chloro - 2 - fluor pentane

Using IUPAC rules, what is the name of the following alkyl halide?

تستخدمنا قواعد تسمية IUPAC ، ما اسم هاليد الألكيل التالي؟



2-Chloro-3-fluoro-4,5-dibromopentane

2-كلورو-3-فلورو-4,5-ديبروموبنتان

1,2-Dibromo-4-chloro-3-fluoropentane

1,2-ديبرومي-4-كلورو-3-فلوروبنتان

4,5-Dibromo-2-chloro-3-fluoropentane

4,5-ديبرومي-2-كلورو-3-فلوروبنتان

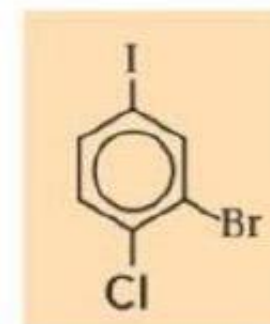
4-Chloro-3-fluoro-1,2-dibromopentane

4-كلورو-3-فلورو-1,2-ديبروموبنتان

What is the **correct** name of the compound

shown in the figure below?

(Using IUPAC rules)



ما الاسم **الصحيح** للمركب الموضح في الشكل أدناه

(مستخدماً قواعد IUPAC)

Learning Outcomes Covered

◦ CHM.5.6.01.013

a.

1- Bromo-2 - chloro - 5 - iodobenzene

1 - برومو - 2 - كلورو - 5 - يودوبنزين



b.

1- Chloro -2 - bromo - 4 - iodobenzene

1 - كلورو - 2 - برومو - 4 - يودوبنزين



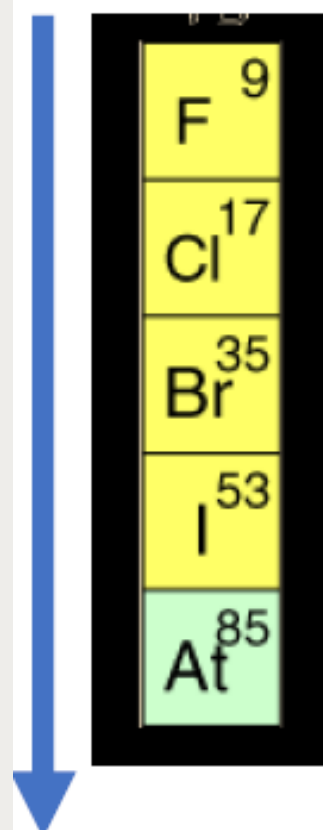
c.

2- Bromo -1 - chloro - 4 - iodobenzene

2- برومو - 1 - كلورو - 4 - يودوبنزين



Alkyl chloride has a higher boiling point and a higher Density than the alkane with the same number of carbon atoms.

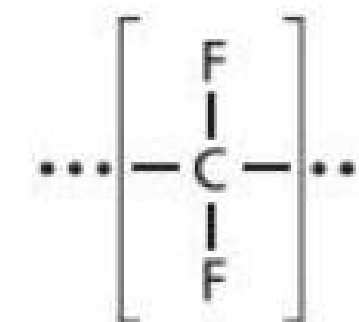


Boiling points and densities increase as the halogen changes from fluorine to chlorine, bromine, and iodine.

Table 2 A Comparison of Alkyl Halides and Their Parent Alkanes

Structure	Name	Boiling Point (°C)	Density (g/mL) in Liquid State
CH ₄	methane	−162	0.423 at −162°C (boiling point)
CH ₃ Cl	chloromethane	−24	0.911 at 25°C (under pressure)
CH ₃ CH ₂ CH ₂ CH ₂ CH ₃	pentane	36	0.626
CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ F	1-fluoropentane	62.8	0.791
CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ Cl	1-chloropentane	108 <i>Increases</i>	0.882 <i>Increases</i>
CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ Br	1-bromopentane	130	1.218
CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ I	1-iodopentane	155	1.516

Figure 4 Polytetrafluoroethene (PTFE) is made up of hundreds of units. PTFE provides a nonstick surface for many kitchen items, including bakeware.



PTFE



PTFE Application

22	CHM.5.6.01.016.01 Explain why the densities and the boiling points of alkyl halides increase in order of going down the column of halides in the periodic table, from fluorine to iodine	Textbook + Table 2	102
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Which of the following alkyl halides has the **lowest** density?

أي من هاليدات الألكيل التالية له **أقل** كثافة؟

a. 1-fluoropentane 1-فلورو بنتان

b. 1-chloropentane 1-كلورو بنتان

c. 1-bromopentane 1-برومو بنتان

d. 1-iodopentane 1-يودو بنتان

Which of the following statements is **correct** regarding alkyl halides in the table below?

أي العبارات التالية **صحيحة** فيما يتعلق بهاليدات الألكيل في الجدول أدناه؟

a. The boiling point of **1 – iodopentane** is the **lowest** among the four compounds

b. The boiling point of **1 – fluoropentane** is the **highest** among the four compounds

c. The attraction of temporary dipoles in **1 –iodopentane** is **strongest**

d. The attraction of temporary dipoles in **1 – fluoropentane** is **strongest**

1 – فلورو بنتان 1-fluoropentane	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{F}$
1 – كلورو بنتان 1-chloropentane	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$
1 – برومو بنتان 1-bromopentane	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$
1 – يودو بنتان 1-iodopentane	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{I}$

Which of the following does **not** explain the increasing of the boiling points and densities of the alkyl halides as the halogen changes from fluorine to chlorine, bromine, and iodine?

أي مما يأتي **لا** يفسر ارتفاع درجات الغليان والكثافة لهاليدات الألكيل عند الانتقال من الفلور إلى الكلور والبروم واليود؟

a.

Increasing numbers of electrons that lie farther from the halogen nucleus

زيادة عدد الإلكترونات البعيدة عن نواة الهالوجين

b.

The easily shifting of electrons position and, as a result, to form temporary dipoles

تغيير الإلكترونات البعيدة عن النواة مكانها بسهولة مكونة أقطاباً مؤقتة

c.

The attraction of the temporary dipoles, and the increasing of energy needed to separate the molecules

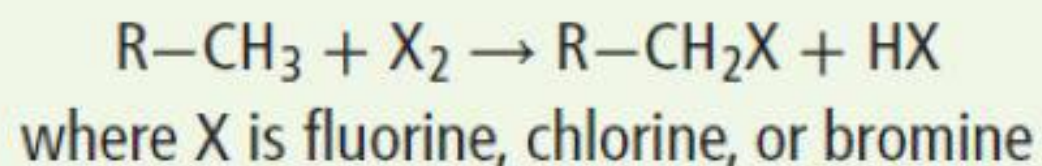
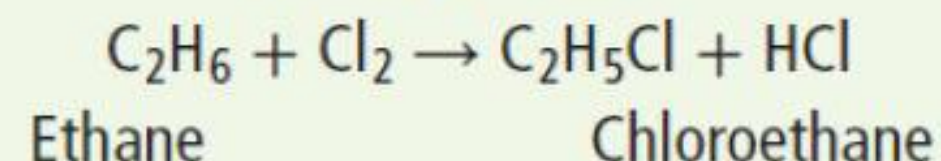
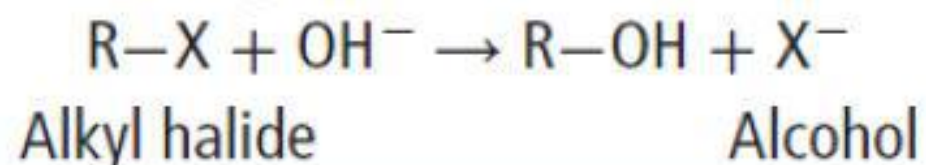
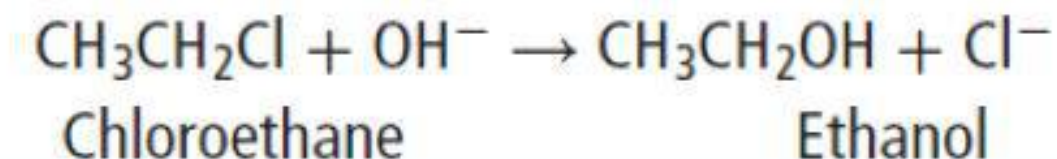
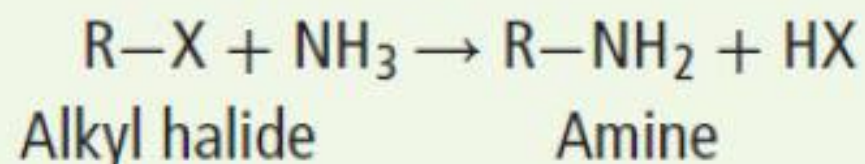
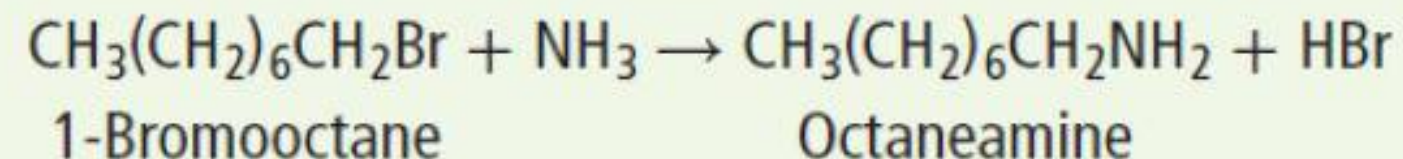
تجاذب الأقطاب المؤقتة وزيادة الطاقة اللازمة لفصل الجزيئات

d.

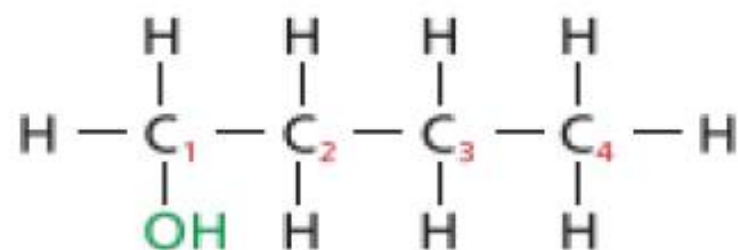
Decreasing the size of the halogen atom as the halogen changes from fluorine to chlorine, bromine, and iodine

نقص حجم ذرة الهالوجين عند الانتقال من الفلور إلى الكلور والبروم واليود

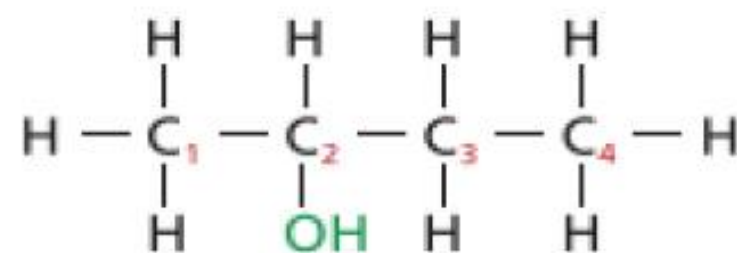
A **substitution reaction** is one in which one atom or a group of atoms in a molecule is replaced by another atom or group of atoms.

Table 22.3**Substitution Reactions****Generic Substitution Reaction****Example of General Substitution Reaction (Halogenation)****General Alkyl Halide-Alcohol Reaction****Example of an Alkyl Halide-Alcohol Reaction****General Alkyl Halide-Ammonia Reaction****Example of an Alkyl Halide-Ammonia Reaction**

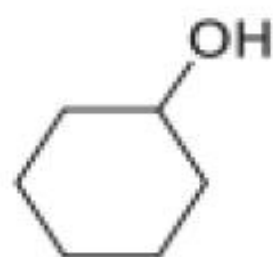
■ **Figure 8** The names of alcohols are based on alkane names.



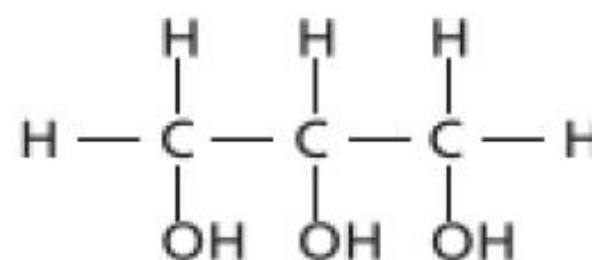
a. 1-Butanol



b. 2-Butanol



c. Cyclohexanol



d. 1,2,3-Propanetriol (glycerol)

Table 4 Alcohols

General Formula	Simple Alcohol and Simple Hydrocarbon	
ROH R represents carbon chains or rings bonded to the functional group	Methane (CH_4) Alkane	Methanol (CH_3OH) Alcohol

- **IUPAC nomenclature rules for alcohols:**

1) Find the parent compound name, which is the longest continuous carbon chain containing the hydroxyl group

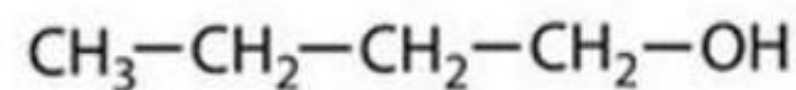
2) Replace “-e” with “-ol”

- For example; **ethane**
ethan(e) + ol

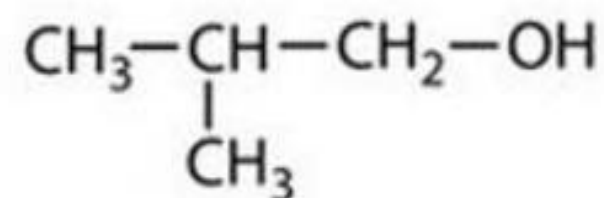
3) Number the parent chain so that the carbon attached to the hydroxyl has the lowest possible number

4) Add substituent names as prefixes to the main name

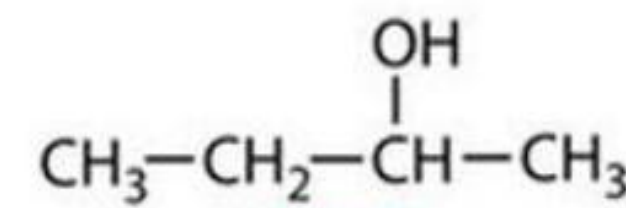
5) Alcohols with two hydroxyls are named “-diols”



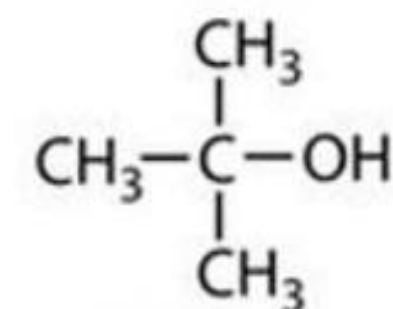
1-butanol



2-methyl-1-propanol



2-butanol



2-methyl-1-propanol

24	CHM.5.6.01.013.14 Use the IUPAC system to name alcohols	Textbook + Table 3 + Figures 7, 8	104, 106
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Section 22.2 Assessment

Which of the following is an alcohol?

A. cyclohexamine

B. 1-chlorobutanol

C. bromobutene

D. butylpropyl ether

Section 22.2 Assessment

Which functional group is present in an alcohol?

A. hydroxyl group

B. halogen

C. aromatic ring

D. amino group

Regarding the compounds in the table below.

Which of the following is **correct**?

(Using IUPAC rules)

فيما يتعلق بالمركبات في الجدول أدناه.

أي مما يأتي **صحيح**؟

(استخدمنا قواعد IUPAC)

1	2	3	4

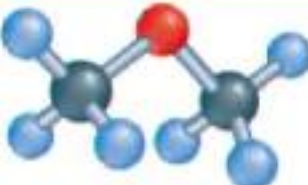
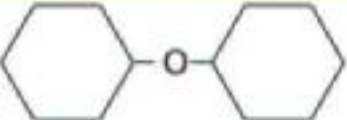
a. Compound 1 is called ethyl butyl ether
المركب 1 يُسمى إيثيل بيوتيل إيثر ☒

b. Compound 2 is called cyclopentanol
المركب 2 يُسمى بنتانول حلقي ☐

c. Compound 3 is called 1,2,3-Propanetriol
المركب 3 يُسمى 1 و 2 و 3 -بروبان تريول ☐

d. Compound 4 is called cyclopentyl ether
المركب 4 يُسمى شالر. بنتان حلقي. إيثر ☐

Table 5 Ethers

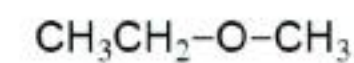
General Formula	Methanol and Methyl ether
ROR' where R and R' represent carbon chains or rings bonded to functional groups	 Methanol bp = 65°C  Methyl ether bp = -25°C
Examples of Ethers	
 Cyclohexyl ether	$CH_3CH_2CH_2-O-CH_2CH_2CH_3$ Propyl ether
$CH_3CH_2-O-CH_2CH_2CH_2CH_3$ Butyl ethyl ether	$CH_3CH_2-O-CH_3$ Ethyl methyl ether

What is the **correct** structural formula for the following ether?

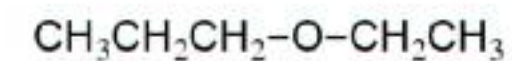
ما الصيغة البنائية الصحيحة للإيثر التالي؟

(Methyl propyl ether)

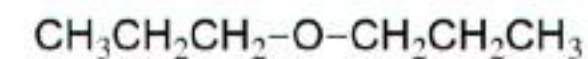
(ميثيل بروبييل إيثر)



a



b



c



d

25	CHM.5.6.01.013.17 Use the IUPAC system to name ethers	Textbook + Table 4	107, 108
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What is the **correct** structural formula for the following ether?

(Methyl propyl ether)

ما الصيغة البنائية الصحيحة للإيثر التالي؟

(ميثيل بروبيل إيثر)

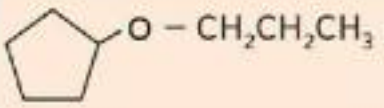
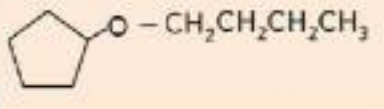
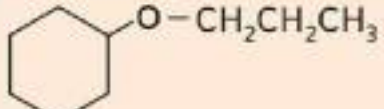
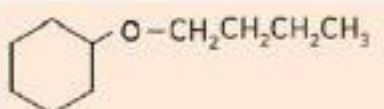
- a. $\text{CH}_3\text{CH}_2\text{-O-CH}_3$
- b. $\text{CH}_3\text{CH}_2\text{CH}_2\text{-O-CH}_2\text{CH}_3$
- c. $\text{CH}_3\text{CH}_2\text{CH}_2\text{-O-CH}_2\text{CH}_2\text{CH}_3$
- d. $\text{CH}_3\text{CH}_2\text{CH}_2\text{-O-CH}_3$

Which of the following is the formula of

(Butyl cyclopentyl ether?)

أي مما يأتي هي صيغة

(بيوتيل بنتيل حلقي إيثر)؟

- a. 
- b. 
- c. 
- d. 

Property	Ether	Alcohol
Volatility	Ethers are more volatile (no hydrogen bonding)	Alcohol is less volatile (due to Hydrogen bonding)
Boiling point	Lower boiling point (no hydrogen bonding)	Higher boiling point (due to Hydrogen bonding)
Solubility in water	Much less soluble in water (no Hydrogen to donate to make a Hydrogen bonding)	Soluble in water (due to Hydrogen bonding)
Example	$\text{CH}_3\text{CH}_2-\text{O}-\text{CH}_3$ Ethyl methyl ether	ethanol $ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{OH} \\ \quad \\ \text{H} \quad \text{H} \end{array} $

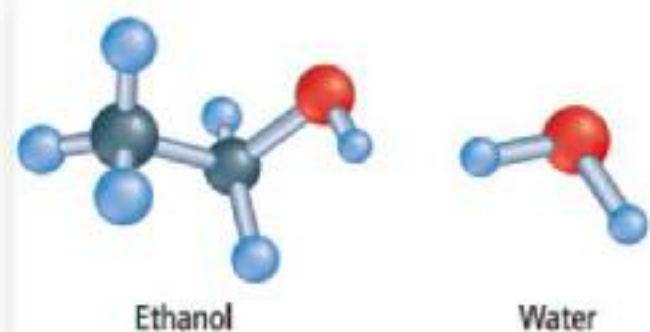


Figure 7 The covalent bonds from oxygen have approximately the same bonding angle in ethanol and water.

Ethanol forms **Hydrogen bonds** with water molecule and hence they are completely miscible (soluble) in water. Also, their melting and boiling points are high compared to any other hydrocarbon of similar size.

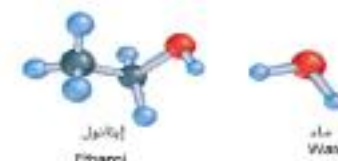
Table 5 Ethers

General Formula	Methanol and Methyl ether
ROR' where R and R' represent carbon chains or rings bonded to functional groups	Methanol bp = 65°C Methyl ether bp = -25°C
Examples of Ethers	
Cyclohexyl ether	$CH_3CH_2CH_2-O-CH_2CH_2CH_3$ Propyl ether
$CH_3CH_2-O-CH_2CH_2CH_2CH_3$ Butyl ethyl ether	$CH_3CH_2-O-CH_3$ Ethyl methyl ether

Naming of ether follow alphabetic order on their side of '-O-'.

Which of the following is **correct** regarding the two models shown below?

أي مما يلي **صحيح** فيما يتعلق بالموديلين الموضحين أدناه؟



1	الزاوية بين الروابط التساهمية للأكسجين تقريباً هي نفسها في كل منهما
2	مجموعة الهيدروكسيل متوسطة القطبية في كل منهما
3	يتمزج الإيثانول مع الماء كلياً بسبب القطبية والروابط الهيدروجينية

The covalent bonds from oxygen have approximately the same bonding angle in both

The hydroxyl group is moderately polar in both

Ethanol is completely miscible with water because of polarity and hydrogen bonding

1 and 2

1, 2

a.

2 and 3

2, 3

b.

1 and 3

1, 3

c.

1, 2 and 3

1, 2, 3

d.

Boiling Points

The boiling points of **ethers** are **lower** than those of **alcohols** having the same molecular weights.

compound	Formula	MW	Bp (°C)
Ethanol	$\text{CH}_3\text{-CH}_2\text{-OH}$	46	78
Dimethyl ether	$\text{CH}_3\text{-O-CH}_3$	46	-25
Propane	$\text{CH}_3\text{-CH}_2\text{-CH}_3$	44	-42

Solubility in water

- Ethers are **much less** soluble in water than alcohols. (Because they don't have -OH group, So they are not hydrogen bond donors).
- **More water-soluble** than hydrocarbons of similar molecular weight (Because they are polar)..

Volatility

An **ether** is **more volatile** than an alcohol having the same molecular formula. This is due to. **intermolecular hydrogen bonding** in **alcohols**.

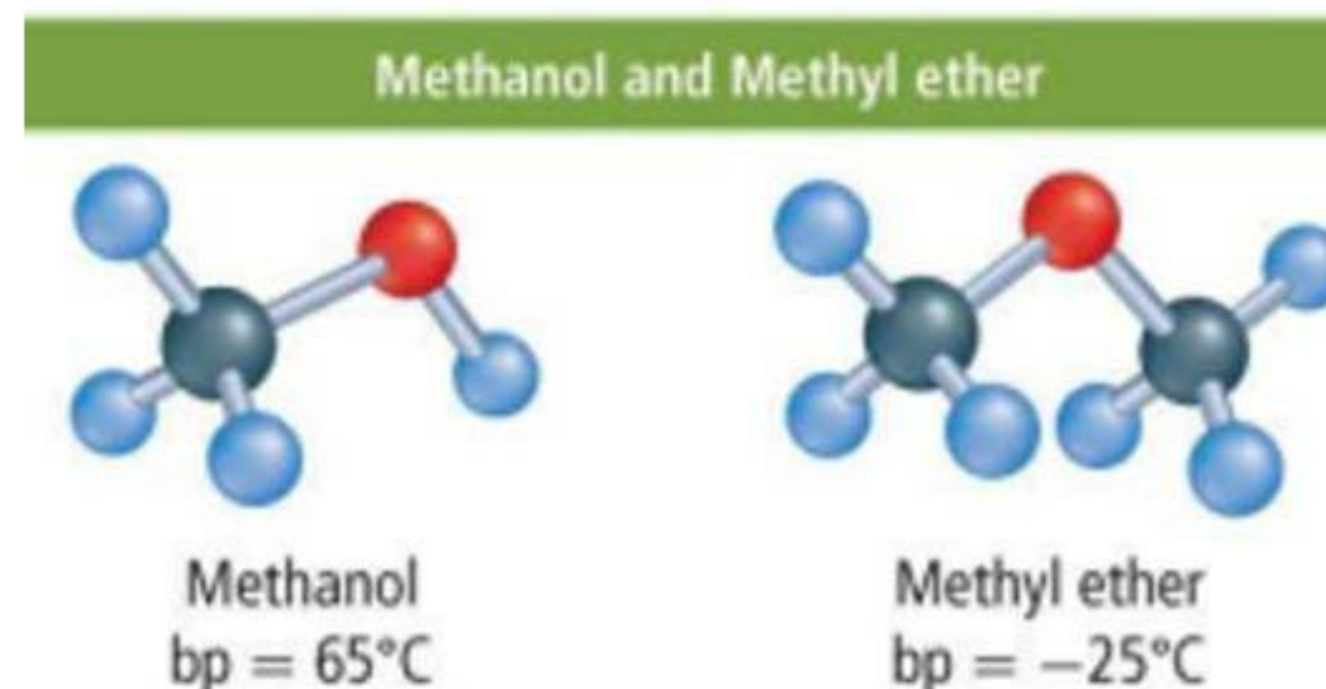




Figure 7 The covalent bonds from oxygen have approximately the same bonding angle in ethanol and water.

Ethers **cannot form hydrogen bonds with each other**.
Therefore, ethers are generally **more volatile**

Ethers have much **lower boiling points** than alcohols of similar size and mass.
(More volatile)

Ethers are much **less soluble** in water than alcohols because they have no hydrogen to donate to a hydrogen bond.

Table 5 Ethers	
General Formula	Methanol and Methyl ether
ROR' where R and R' represent carbon chains or rings bonded to functional groups.	Methanol bp = 65°C Methyl ether bp = -25°C
Examples of Ethers	
Cyclohexyl ether $\text{CH}_3\text{CH}_2-\text{O}-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ Butyl ethyl ether	$\text{CH}_3\text{CH}_2\text{CH}_2-\text{O}-\text{CH}_2\text{CH}_2\text{CH}_3$ Propyl ether $\text{CH}_3\text{CH}_2-\text{O}-\text{CH}_3$ Ethyl methyl ether

Ethers are generally more volatile and have much lower boiling points than alcohols of similar size and mass. **What explains these properties?**

يكون الإثير أكثر قابلية للتطاير ودرجة غليانه أقل من الكحولات
المساوية له في الكتلة الجزيئية والحجم.
ما الذي يفسر هذه الخصائص؟

1	عدم وجود ذرات هيدروجين مرتبطة مع ذرة الأكسجين في الإثير Ethers have no hydrogen atoms bonded to the oxygen atom
2	لا يمكن لجزيئات الإثير تكوين روابط هيدروجينية بين بعضها البعض Ether's molecules cannot form hydrogen bonds with each other
3	يمكن لذرة الأكسجين في الإثير أن ترتبط مع ذرات الهيدروجين من جزيئات الماء The oxygen atom in ether can bond with hydrogen atoms of water molecules

- a. ☐ 1 only
- b. ☐ 2 only
- c. ☒ 1 and 2
- d. ☐

Comparing Solubility and Boiling Points

	Compound	Molar Mass	Boiling Point (°C)	Soluble in Water?
Alkane	$\text{CH}_3\text{—CH}_2\text{—CH}_3$	44	-42	No
Ether	$\text{CH}_3\text{—O—CH}_3$	46	-23	Yes
Alcohol	$\text{CH}_3\text{—CH}_2\text{—OH}$	46	78	Yes

Ethers are generally more volatile and have much lower boiling points than alcohols of similar size and mass

What explain this?

تكون الإثيرات أكثر قابلية للتطاير ودرجة غليانها أقل من الكحولات
المساوية لها في الكتلة الجزيئية والحجم.
ما الذي يفسر ذلك؟

a.

The presence of hydrogen atoms bonded to the oxygen atom in ether

وجود ذرات هيدروجين مرتبطة مع ذرة الأكسجين في الإثير

b.

Ether's molecules can form hydrogen bonds with each other

يمكن لجزيئات الإثير تكوين روابط هيدروجينية بين بعضها البعض

c.

Ether have no hydrogen atoms bonded to the oxygen

عدم وجود ذرات هيدروجين مرتبطة مع ذرة الأكسجين في الإثير

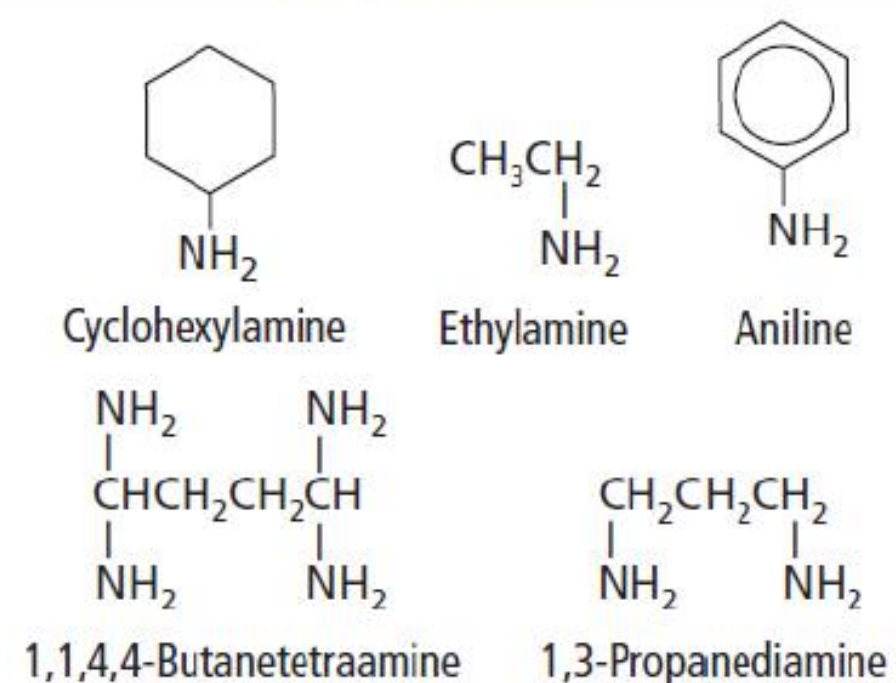
d.

The oxygen atom in ether can act as a hydrogen atom receptor from water molecules

يمكن لذرة الأكسجين في الإثير أن تعمل كمستقبل لذرات الهيدروجين من جزيئات الماء

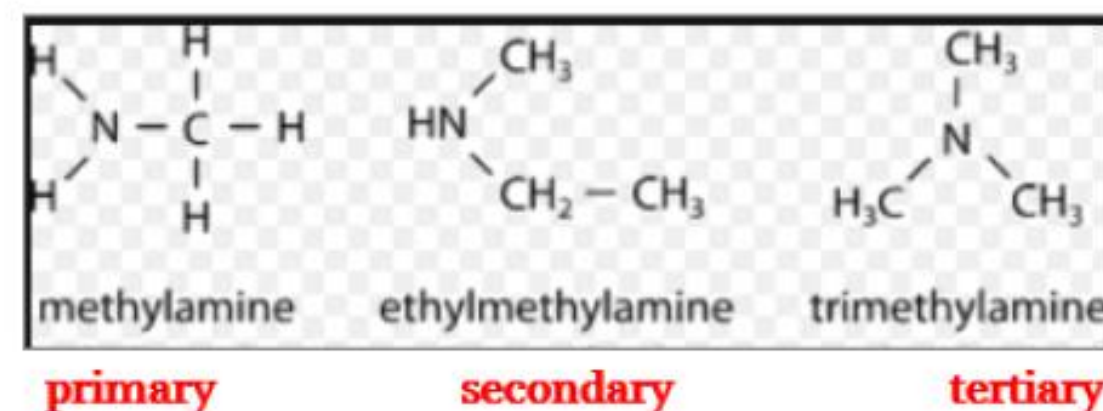
Table 22.6 Amines**General Formula**

where R represents a carbon chain or ring bonded to the functional group

Examples of Amines

Amines

- **Amines** contain nitrogen atoms bonded to carbon atoms in aliphatic chains or aromatic rings and have the general formula RNH_2 .
- Chemists consider amines **derivatives of ammonia** (NH_3).
- Amines are considered **primary, secondary, or tertiary amines** depending on whether one, two, or three of the hydrogens in ammonia have been replaced by organic groups.



When two organic groups both consists of aliphatic
chains of carbon atoms replace two hydrogen atoms
in ammonia molecule this produce.....

عندما تحل مجموعتان عضويتان تتكون كل منهما من سلسلة
أليفاتية من ذرات الكربون محل ذرتي هيدروجين في جزيء الأمونيا
فإنه ينتج

Learning Outcomes Covered

- CHM.5.6.01.015

a.

primary amine

أمين أولي

b.

secondary amine

أمين ثانوي

c.

tertiary amine

أمين ثالثي

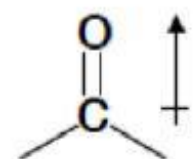
28	CHM.5.6.01.016.06 Explain the physical properties of aldehydes and ketones	Textbook + Tables 7, 8	111, 112, 113
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Table 22.7	Aldehydes
General Formula	Examples of Aldehydes
*CHO *represents an alkyl group or a hydrogen atom	$\text{H}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{H}$ Methanal (formaldehyde) $\text{H}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{H}$ Ethanal (acetaldehyde) $\text{C}_6\text{H}_5-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{H}$ Benzaldehyde $\text{C}_6\text{H}_4(\text{OH})-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{H}$ Salicylaldehyde $\text{C}_6\text{H}_5-\text{CH}=\text{CH}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{H}$ Cinnamaldehyde
>C=O Carbonyl group	

Table 22.8	Ketones
General Formula	Examples of Ketones
$\text{R}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\text{R'}$ where R and R' represent carbon chains or rings bonded to functional groups	$\text{H}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\text{H}$ 2-Propanone (acetone) $\text{H}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\overset{\text{O}}{\underset{\text{ }}{\text{C}}}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-\text{H}$ 2-Butanone (methyl ethyl ketone)

Properties of Aldehydes and Ketones

- Aldehydes and ketones are polar molecules because the C=O bond has a dipole moment:

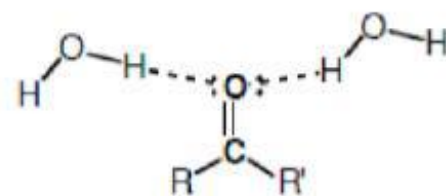


For acetone: dipole moment = 2.7 D
boiling point = 56.5 °C

For propene: dipole moment = 0.4 D
boiling point = -47.4 °C

For i-propanol: dipole moment = 1.7 D
boiling point = 82.3 °C

- Their polarity makes aldehydes and ketones have higher boiling points than alkenes of similar molecular weight.
- Aldehydes and ketones are not hydrogen bond donors (they can't donate a proton); therefore, they have lower boiling points than alcohols of similar molecular weight.
- Aldehydes and ketones are hydrogen bond acceptors; this makes them have considerable solubilities in water.



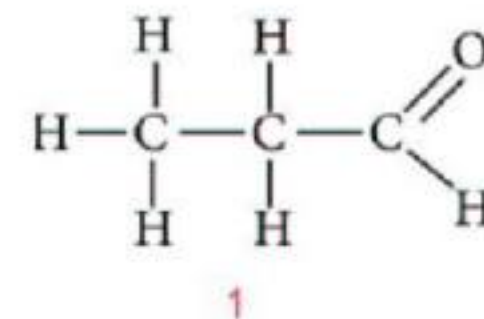
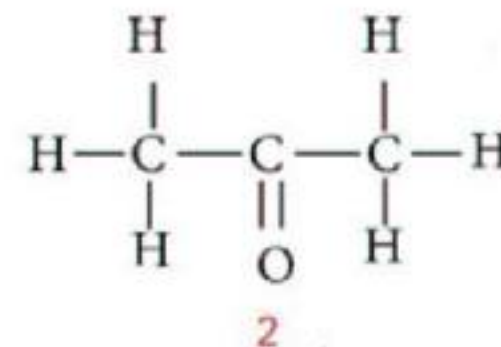
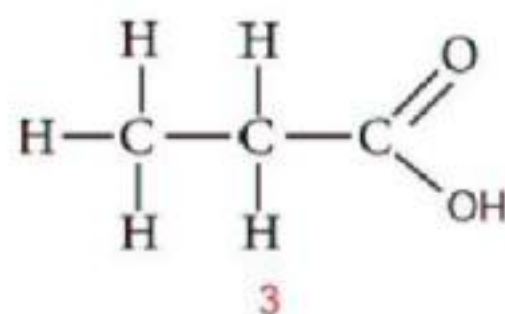
Ketones such as acetone are good solvents because they dissolve both aqueous and organic compounds
Recall that acetone is a **polar, aprotic** solvent.

28	CHM.5.6.01.016.06 Explain the physical properties of aldehydes and ketones	Textbook + Tables 7, 8	111, 112, 113
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- Carboxylic acids can ionize in water solution ??? Why
- because the two oxygen atoms are highly electronegative and attract electrons away from the hydrogen atom in the –OH group.

56

Which of the following statements is **incorrect** regarding the following three structural formulas?



The molecules of the three formulas (**1**, **2**, and **3**) are polar and reactive

جزيئات الصيغ الثلاث (**1** و **2** و **3**) قطبية ونشطة

b.

The compound with formula **3** has a sour, acidic taste

المركب ذو الصيغة **3** له طعم حمضي لاذع

c.

Formula **1** molecules are less reactive than formula **2** molecules

جزيئات الصيغة **1** أقل نشاطاً من جزيئات الصيغة **2**

d.

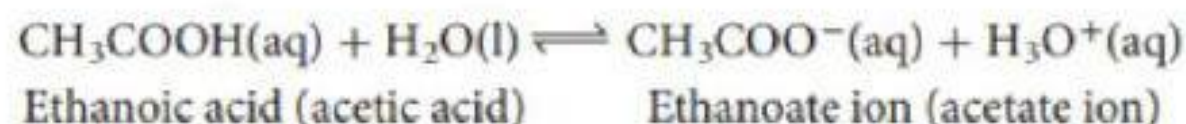
CARBOXYLIC ACIDS

- a carboxylic acid is an organic compound that has a carboxyl group.
- a **carboxyl group** consists of a carbonyl group bonded to a hydroxyl group.

6. Carboxylic Acids

General Formula	Examples of Carboxylic Acids
$\begin{array}{c} \text{O} \\ \parallel \\ \text{R}-\text{C}-\text{OH} \end{array}$ where R represents carbon chains or rings bonded to functional groups	$\begin{array}{c} \text{H} \quad \text{O} \\ \quad \parallel \\ \text{H}-\text{C}-\text{C}-\text{OH} \\ \\ \text{H} \end{array}$ Ethanoic acid (acetic acid) $\begin{array}{c} \text{O} \\ \parallel \\ \text{H}-\text{C} \\ \diagup \quad \diagdown \\ \text{O} \quad \text{H} \end{array}$ Methanoic acid (formic acid)

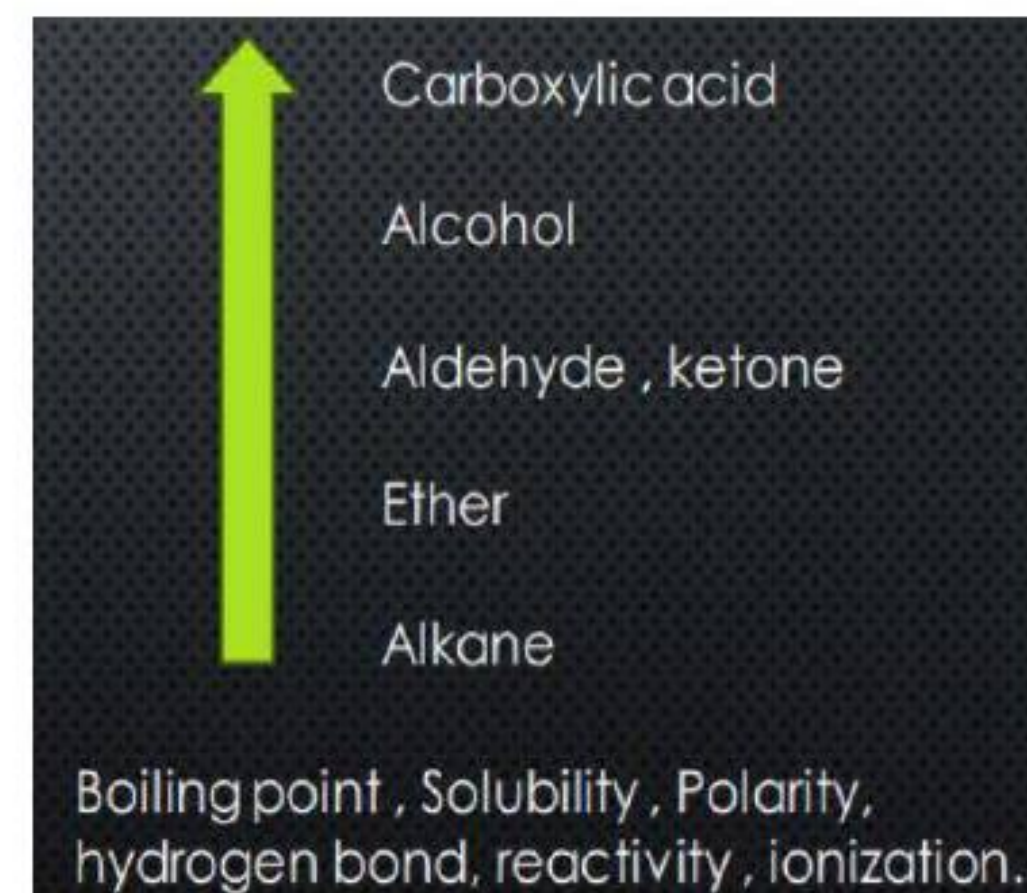
Carboxylic acids are polar and reactive. Those that dissolve in water ionize weakly to produce hydronium ions, the anion of the acid in equilibrium with water, and the unionized acid. The ionization of ethanoic acid is an example.



Carboxylic acids can ionize in water solution because the two oxygen atoms are highly electronegative and attract electrons away from the hydrogen atom in the -OH group. As a result, the hydrogen proton can transfer to another atom that has a pair of electrons not involved in bonding, such as the oxygen atom of a water molecule. Because they ionize in water, soluble carboxylic acids turn blue litmus paper red and have a sour taste.

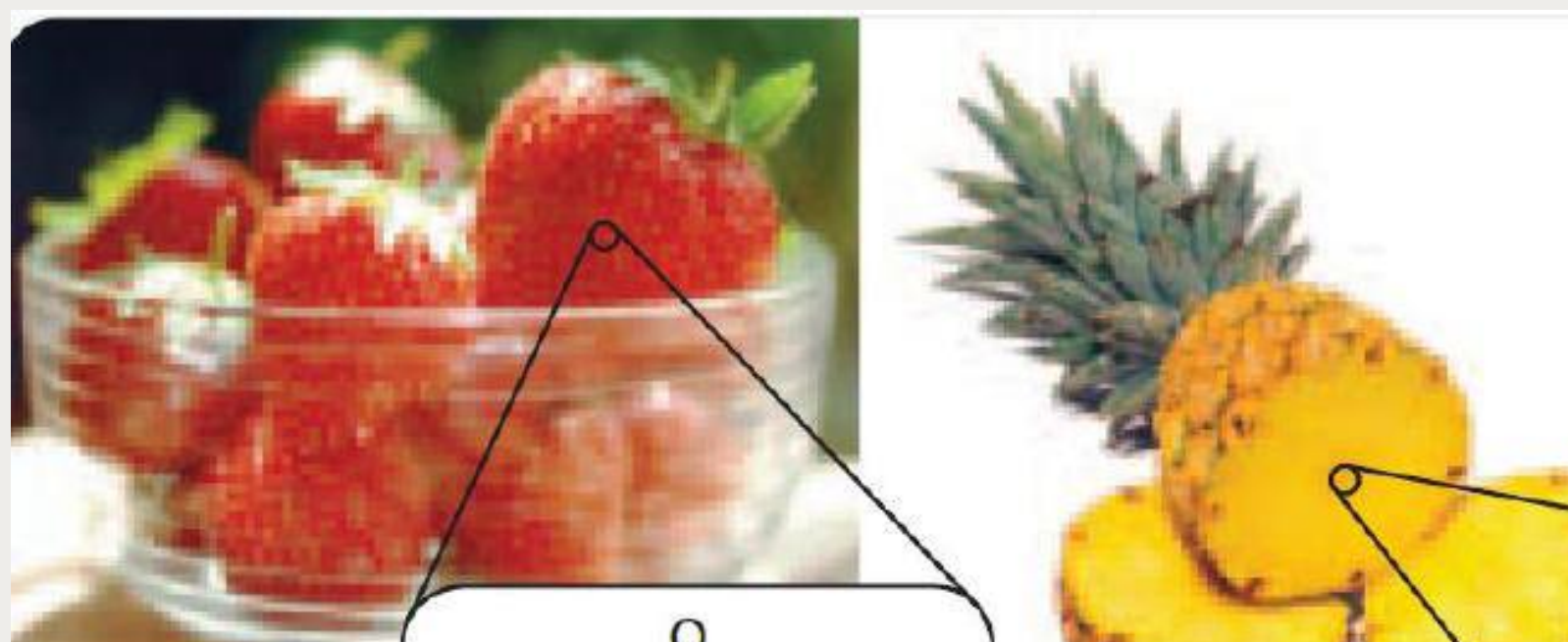
Carboxylic acid has a higher polarity, B.P and solubility than aldehyde and ketone.

Carboxylic acids can ionize in water, because the two oxygen atoms are highly electronegative and attract electrons away from the hydrogen atom in the OH group.



30	CHM.5.6.01.013.27 Draw the structure of an ester given its formula	Textbook + Table 10 + Figure 13	115, 116
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Table 22.10	Esters
General Formula	Example of an Ester
$\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{O}-\text{R} \end{array}$ Ester group	$\begin{array}{c} \text{Ethanoate group} \quad \text{Propyl group} \\ \text{CH}_3-\overset{\text{O}}{\underset{ }{\text{C}}}-\text{O}-\text{CH}_2\text{CH}_2\text{CH}_3 \\ \text{Ester group} \\ \text{Propyl ethanoate} \\ \text{(propyl acetate)} \end{array}$



■ **Figure 22.11** Esters are responsible for the flavors and aromas of many fruits. The aroma of strawberries is due in part to methyl hexanoate. Ethyl butanoate contributes to the aroma of pineapple. Most natural aromas and flavors are mixtures of esters, aldehydes, and alcohols.

$$\text{CH}_3(\text{CH}_2)_4\overset{\text{O}}{\underset{||}{\text{C}}}-\text{O}-\text{CH}_3$$

Methyl hexanoate

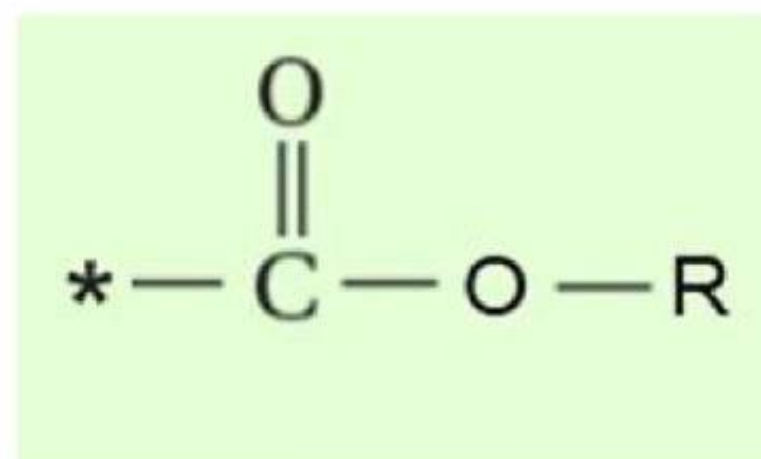
$$\text{CH}_3\text{CH}_2\text{CH}_2\overset{\text{O}}{\underset{||}{\text{C}}}-\text{O}-\text{CH}_2\text{CH}_3$$

Ethyl butanoate

30	CHM.5.6.01.013.27 Draw the structure of an ester given its formula	Textbook + Table 10 + Figure 13	115, 116
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Which substituted hydrocarbons has the following general formula?

ما المشتقات الهيدروكربونية التي لها الصيغة العامة التالية؟



- a. Amide أميد
- b. Ester إستر
- c. Carboxylic acid حمض كربوكسيلي
- d. Aldehyde ألدهيد