شرح الدرس الثالث Compounds Carbonyl من وحدة Hydrocarbons Substituted and Their Reactions انسباير منهج

تم تحميل هذا الملف من موقع المناهج الإماراتية	
موقع المناهج ⇦ المناهج الإماراتية ⇦ الصف الحادي عشر المتقدم ⇦ كيمياء ⇦ الفصل الثالث ⇦ ملفات متنوعة ⇦ الملف	
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المزيد من الملفات بحسب الصف الحادي عشر المتقدم والمادة كيمياء في الفصل الثالث	
شرح الدرس الثاني Alcohols, Amines and Ethers من وحدة Hydrocarbons Substituted and Their Reactions انسباير منهج	1
شرح الدرس الأول Halides Alkyl and Halides Aryl من وحدة Hydrocarbons Substituted and Their Reactions انسباير منهج	2
قوانين الفصل الدراسي الثاني والثالث للوحدات (4+5+6+7)	3
شرح الدرس الخامس Hydrocarbons Aromatic من وحدة Hydrocarbons منهج انسباير	4
شرح الدرس الرابع Isomers Hydrocarbon من وحدة Hydrocarbons منهج انسباير	5

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Inspire Chemistry

Module 21

“Substituted Hydrocarbons & Their Reactions”

Carbonyl Compounds

Learning Outcomes:

- **Identify** the structures of carbonyl compounds, including aldehydes, ketones, carboxylic acids, esters, and amides.

- **Discuss** the properties of compounds containing the carbonyl group.

Focus Question

How do hydroxyl groups and carbonyl groups functionally compare?

New Vocabulary

carbonyl group

aldehyde

ketone

carboxyl group

carboxylic acid

ester

amide

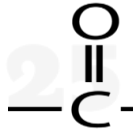
condensation reaction

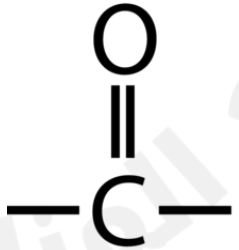
Review Vocabulary

electronegative: indicates the relative ability of an element's atoms to attract electrons in a chemical bond

Introduction

Real-World Reading Link

- Have you ever eaten a piece of fruit-flavored candy that tasted like real fruit? Many natural fruits, such as strawberries, contain dozens of organic molecules that combine to give the distinctive **aroma and flavor of fruits**.
- The **carbonyl group (**  **)** is found in many common types of artificial flavorings.

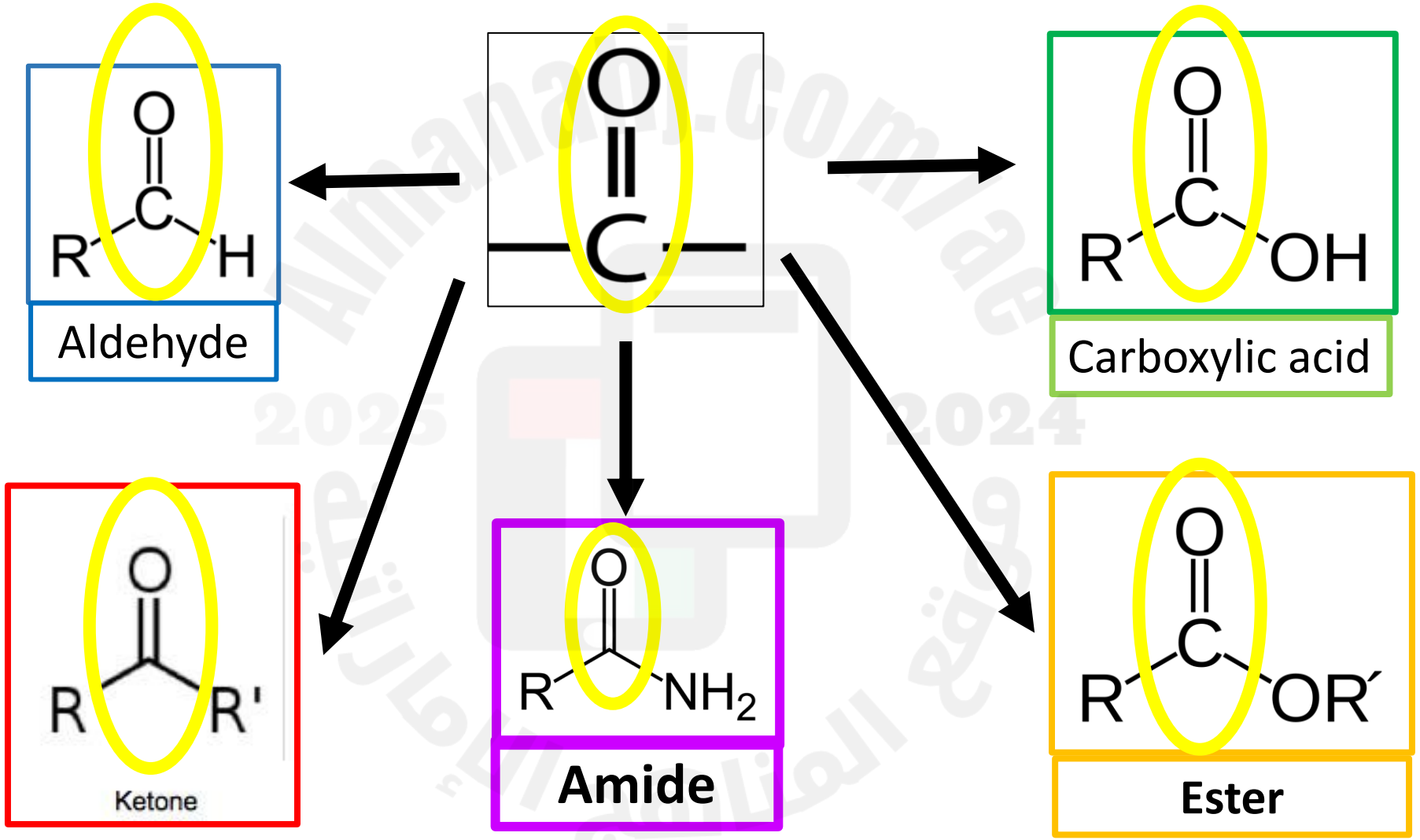


(Carbonyl Group)

Carbonyl Compounds

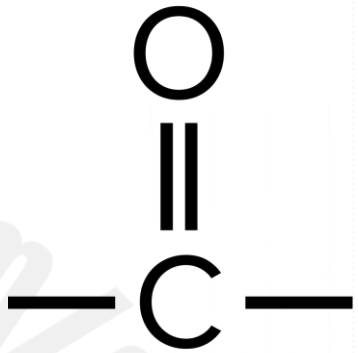
- Carbonyl compounds contain a **double-bonded** **oxygen** in the functional group.

Organic Compounds Containing the Carbonyl Group



Quiz

1. What is the functional group shown at right?



A a carbonyl group **CORRECT**

an aldehyde

a ketone

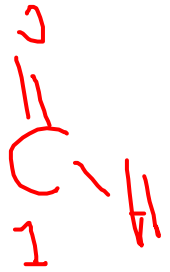
a carboxyl group

Aldehydes

- An **aldehyde** is an organic compound in which a carbonyl group located **at the end** of a carbon chain is bonded to a carbon atom on one side and a hydrogen atom on the other.
- Aldehydes have the general formula *CHO, where * represents an alkyl group or a hydrogen atom, as shown in **table.**

General Formula
*CHO *represents an alkyl group or a hydrogen atom
O ‖ — C — Carbonyl group

Naming Aldehydes

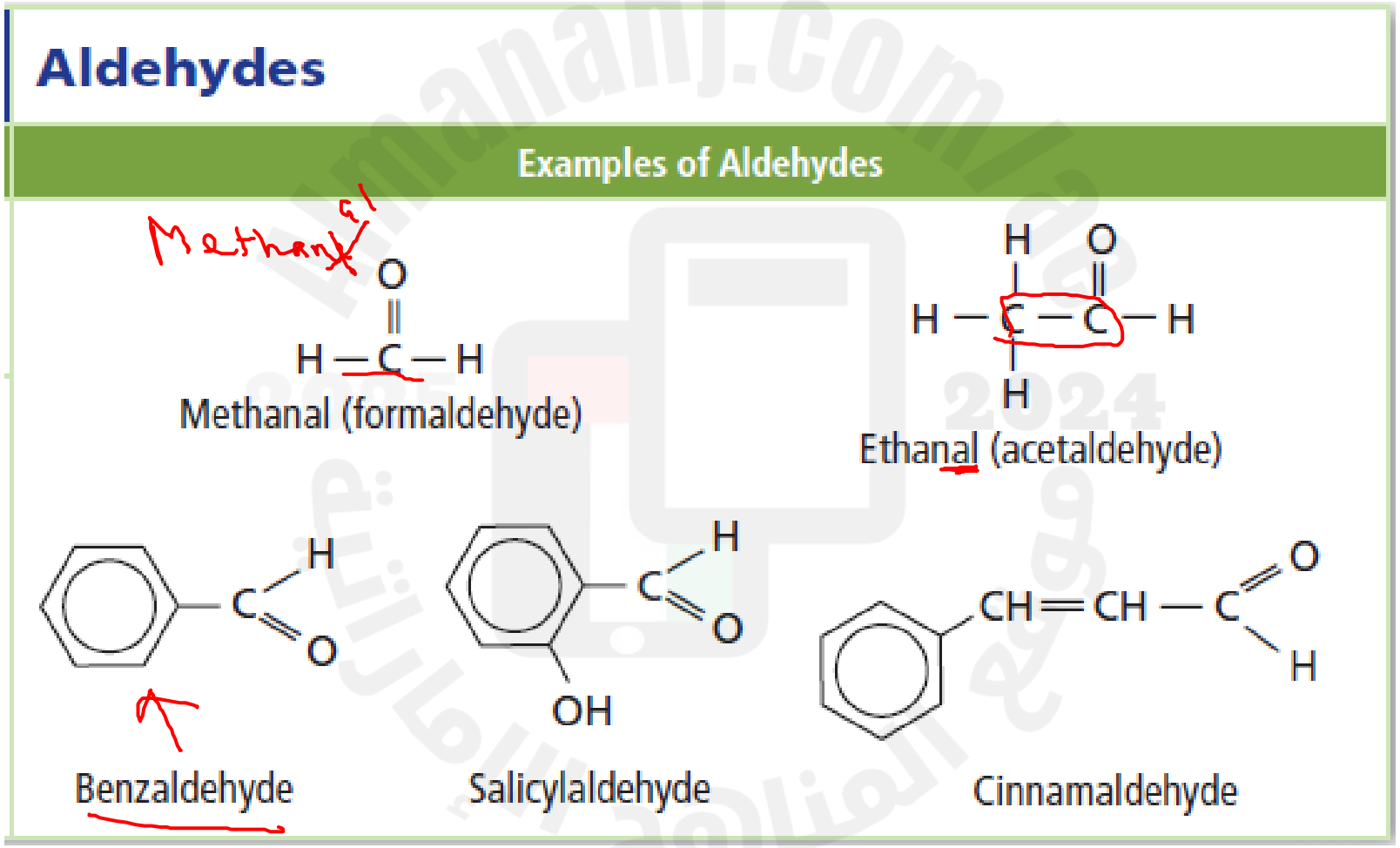


- Aldehydes are formally named by changing the final *-e* of the name of the alkane with the same number of carbon atoms to the suffix *-al*.

- Because the carbonyl group in an aldehyde always occurs at the end of a carbon chain, no numbers are used in the name unless branches or additional functional groups are present.

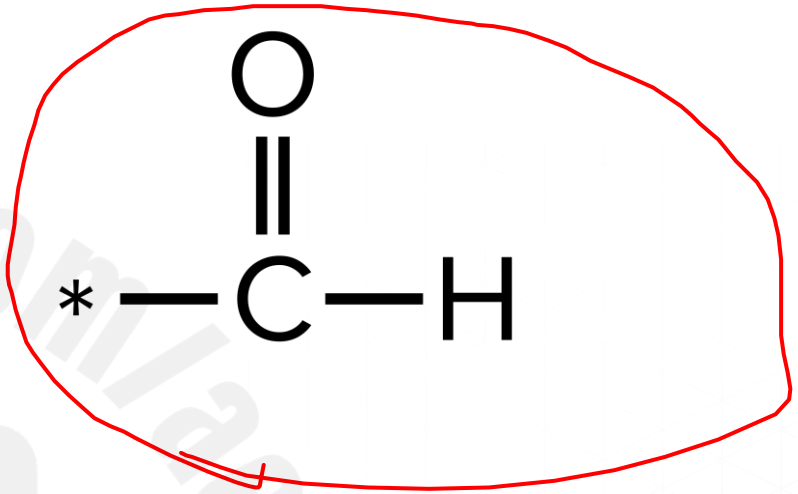
- Methanal is also commonly called formaldehyde.
- Ethanal has the common name *acetaldehyde.*

Examples of Aldehydes



Quiz

2. What has the general formula shown at right?



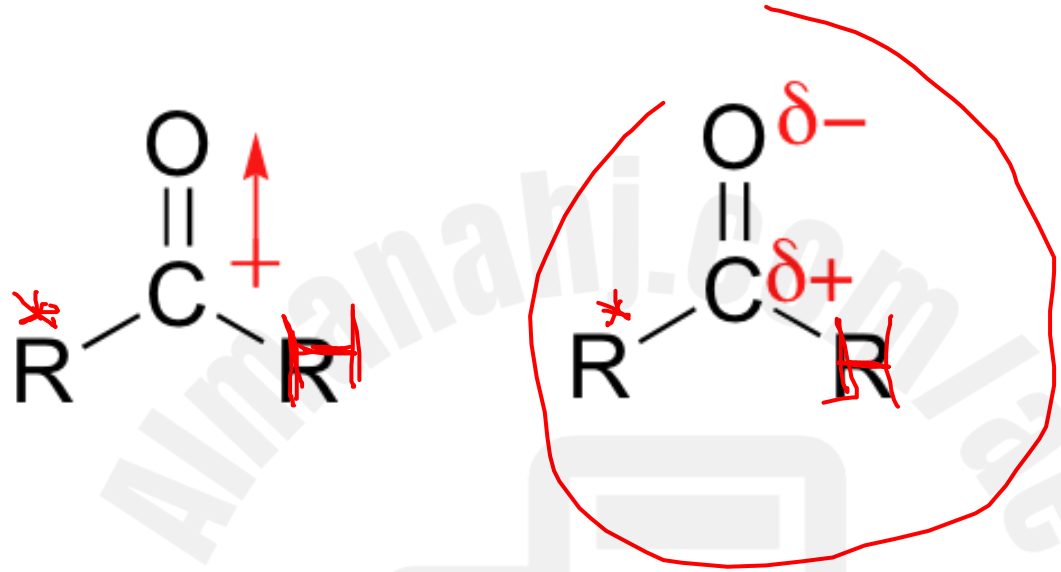
- a carbonyl group
- **B** an aldehyde **CORRECT**
- a ketone
- an ester

Properties of Aldehydes

- An aldehyde molecule contains a **polar**, **reactive structure**.
- However, like ethers, aldehyde molecules **cannot form hydrogen bonds** among themselves **because the molecules have no hydrogen atoms bonded to an oxygen atom**.

- Therefore, **aldehydes** have **lower boiling points than alcohols** with the **same number of carbon atoms**.
- Water molecules can form hydrogen bonds with the oxygen atom of aldehydes, so **aldehydes are more soluble in water than alkanes but not as soluble as alcohols or amines**.

Properties of Aldehydes



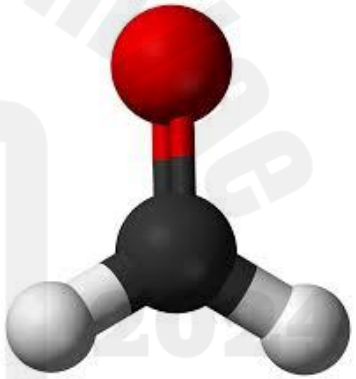
An aldehyde molecule contains a **polar**, **reactive structure.**

<u>But aldehyde molecules cannot form hydrogen bonds</u>

Uses of Aldehydes

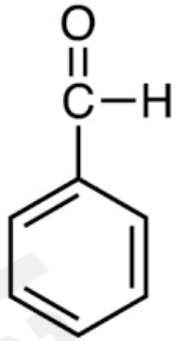
- **Formaldehyde** has been used for preservation(حفظ العينات) for many years.

- Industrially, large quantities of **formaldehyde** are reacted with urea to manufacture a type of **grease-resistant**, **hard plastic used to make buttons**, **appliance and automotive parts**, and **electrical outlets**, as well as the **glue that holds the layers of plywood together**.

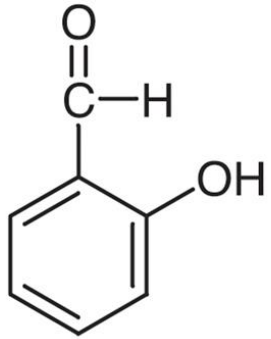


Uses of Aldehydes

- **Benzaldehyde** and **salicylaldehyde**, are two components that **give almonds(اللوز) their natural flavor**.

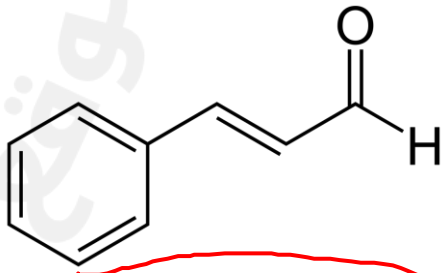


Benzaldehyde



salicylaldehyde

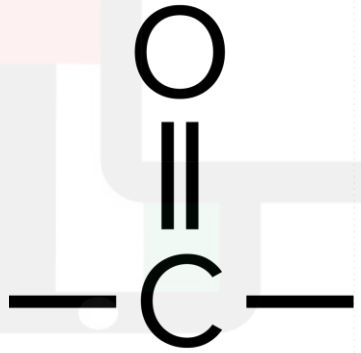
- The **aroma and flavor of cinnamon**, a spice that comes from the bark of a tropical tree, are produced largely by **cinnamaldehyde**.



cinnamaldehyde

Organic Compounds Containing the Carbonyl Group

- An oxygen atom double-bonded to a carbon atom is a **carbonyl group.**
- This group is the functional group in organic compounds known as aldehydes and ketones.



Carbonyl group

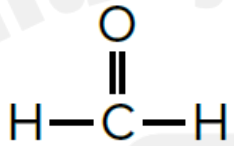
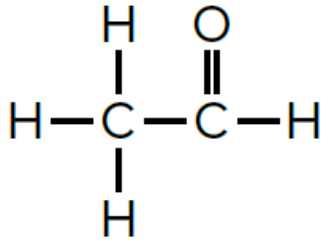
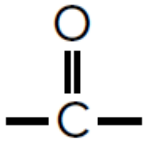
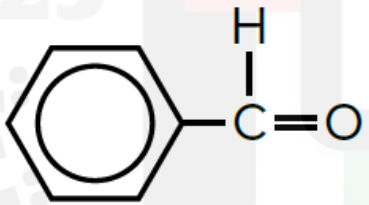
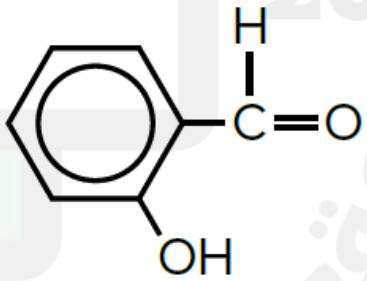
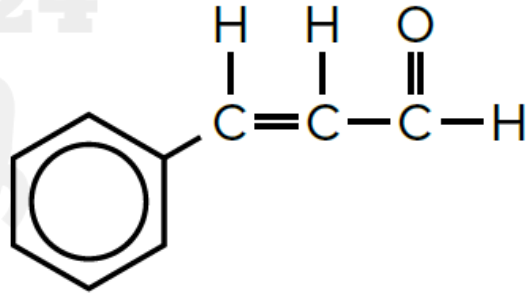
Aldehydes

- **Aldehydes** are organic compounds with a carbonyl group located at the end of the carbon chain bonded to a carbon atom on one side and a hydrogen on the other side.

- Aldehydes are named with the suffix *–al.*

Aldehydes

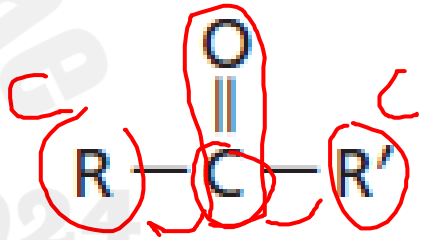
Table 7 Aldehydes

General Formula	Examples of Aldehydes
*CHO *represents an alkyl group or a hydrogen atom	 Methanal (formaldehyde)  Ethanal (acetaldehyde)
 Carbonyl group	 Benzaldehyde  Salicylaldehyde  Cinnamaldehyde

Ketones

- A carbonyl group can also be located within a carbon chain rather than at the end.
- **A ketone** is an organic compound in which the **carbon of the carbonyl group** is bonded **to two other carbon atoms**. Ketones have the general formula shown in the picture.

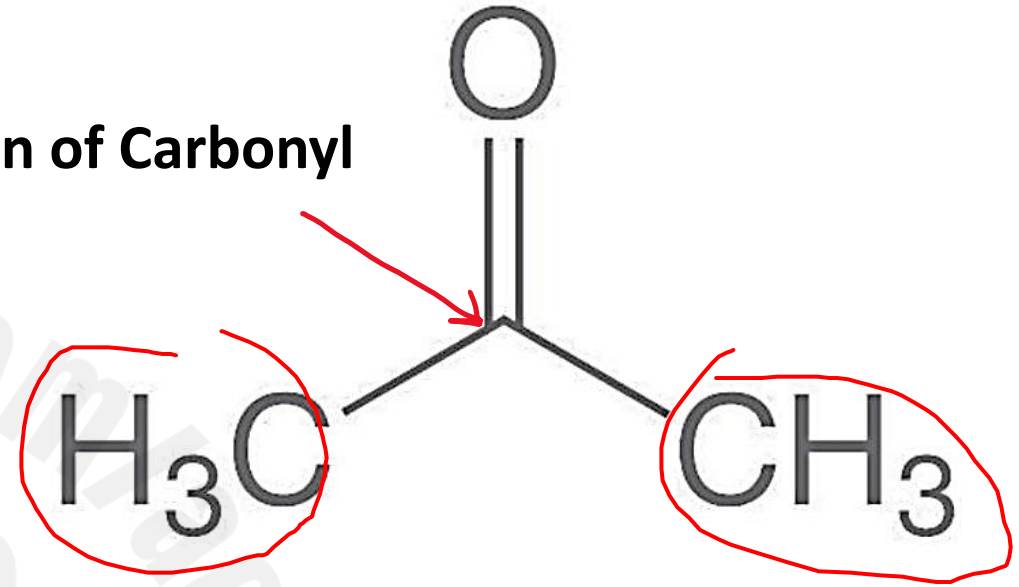
General Formula



where R and R′ represent carbon chains or rings bonded to functional groups

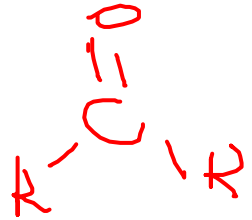
Ketones

The carbon of Carbonyl

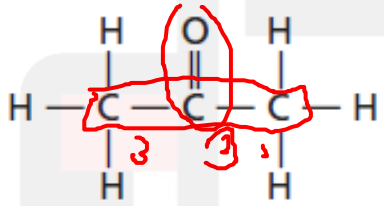


- The carbon atoms on either side of the carbonyl group are bonded to other atoms.
- The **simplest** ketone, commonly known as **acetone**, has only hydrogen atoms bonded to the side carbons.

Naming Ketones



- Ketones are formally named by changing the ***-e*** at the end of the **alkane** name **to –*one***.
- and including a **number** before the name to **indicate the position of the ketone group.**

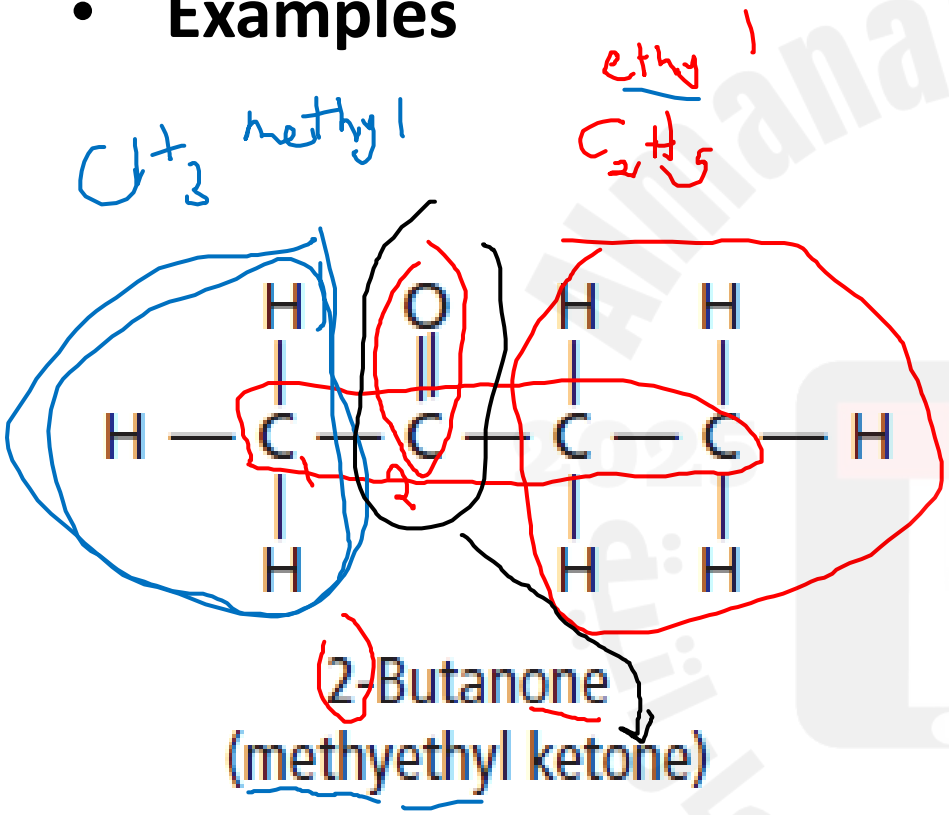


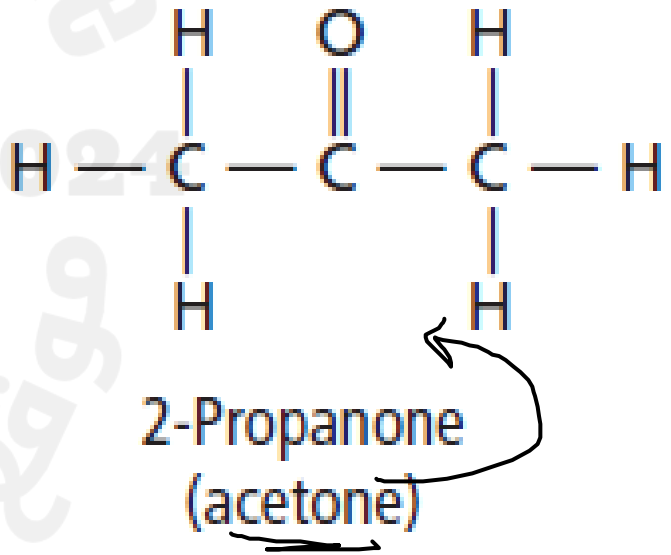
2-Propanone
(acetone)

- In the previous example, the alkane name **propane** is changed to **propan*one***. The carbonyl group can be located **only in the center, but the prefix *2*- is usually added to the name for clarity**.

Naming Ketones

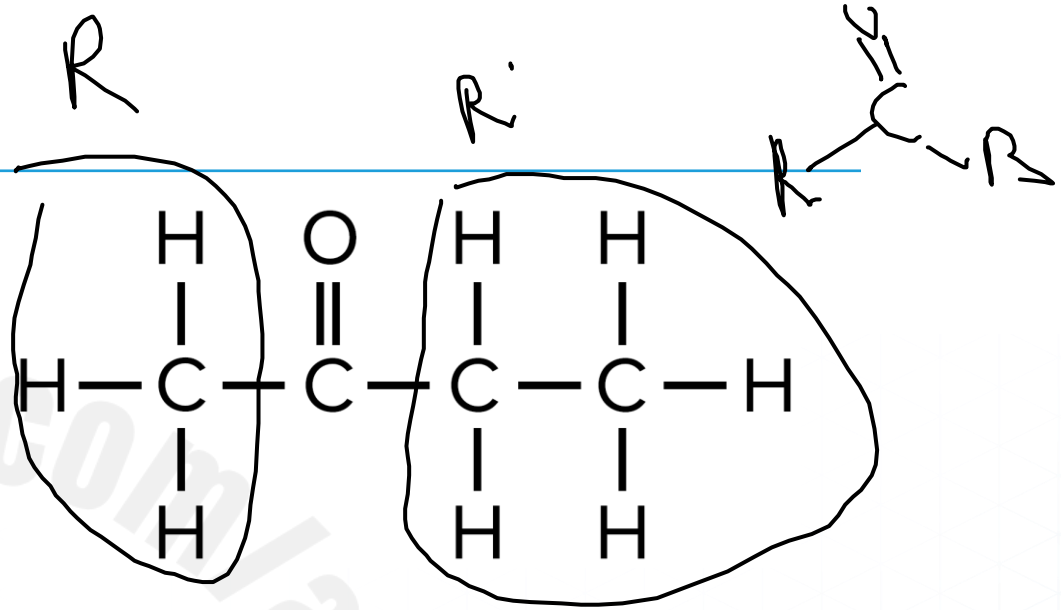
- **Examples**





Quiz

3. What is the name of the compound with the formula shown at right?



- 2-butanal
- **B** 2-butanone **CORRECT**
- ethyl methyl ether
- methyl ethanoate

Properties and Uses of Ketones

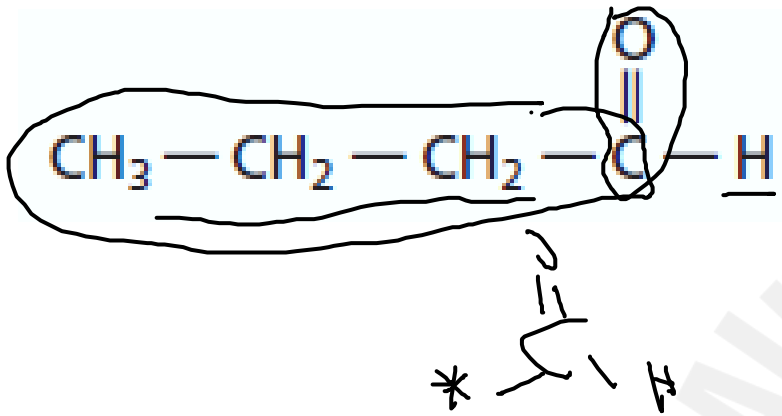
- Ketones and aldehydes share many chemical and physical properties because their structures are similar.
- **Ketones are polar molecules** and are **less reactive than aldehydes**. For this reason, ketones are **popular solvents** for other moderately polar substances, including waxes, plastics, paints, lacquers, varnishes, and glues.
- Like aldehydes, **ketone molecules cannot form hydrogen bonds with each other but can form hydrogen bonds with water molecules**. Therefore, ketones are somewhat **soluble in water**.
- Acetone is completely miscible with water.

Properties of Ketones

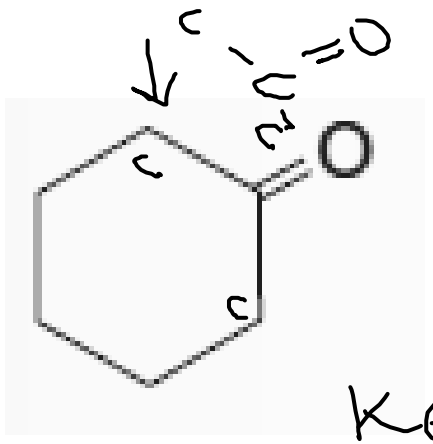
A Ketone molecule contains a **polar**, **less reactive than aldehydes.**
<u>But ketone molecules cannot form hydrogen bonds</u>

Plenary

- Name the following compound



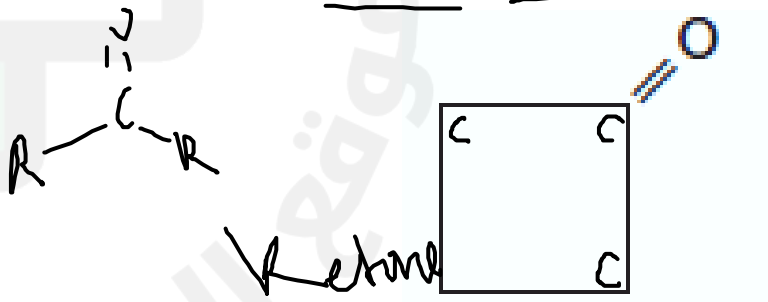
Butanal



Cyclohexanone

Ketone

Cyclobutanone



Ketone

Key Concepts

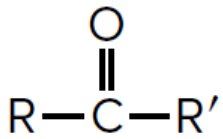
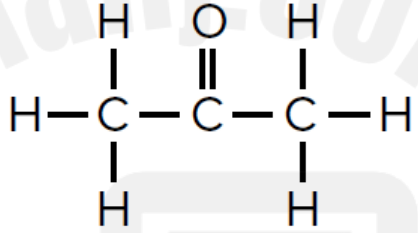
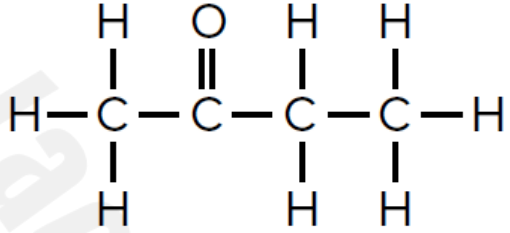
- Carbonyl compounds are organic compounds that contain the C=O group.
- Five important classes of organic compounds containing carbonyl compounds are aldehydes, ketones, carboxylic acids, esters, and amides.

Ketones

- A **ketone** is an organic compound in which the carbon of the carbonyl group is bonded to two other carbon atoms.
- Ketones are named by changing the *–e* at the end of the alkane name to *–one,* and including a number before the name to indicate the position of the ketone group.

Ketones

Table 8 Ketones

General Formula	Examples of Ketones	
		
where R and R´ represent carbon chains or rings bonded to functional groups	2-Propanone (acetone)	2-Butanone (methyl ethyl ketone)

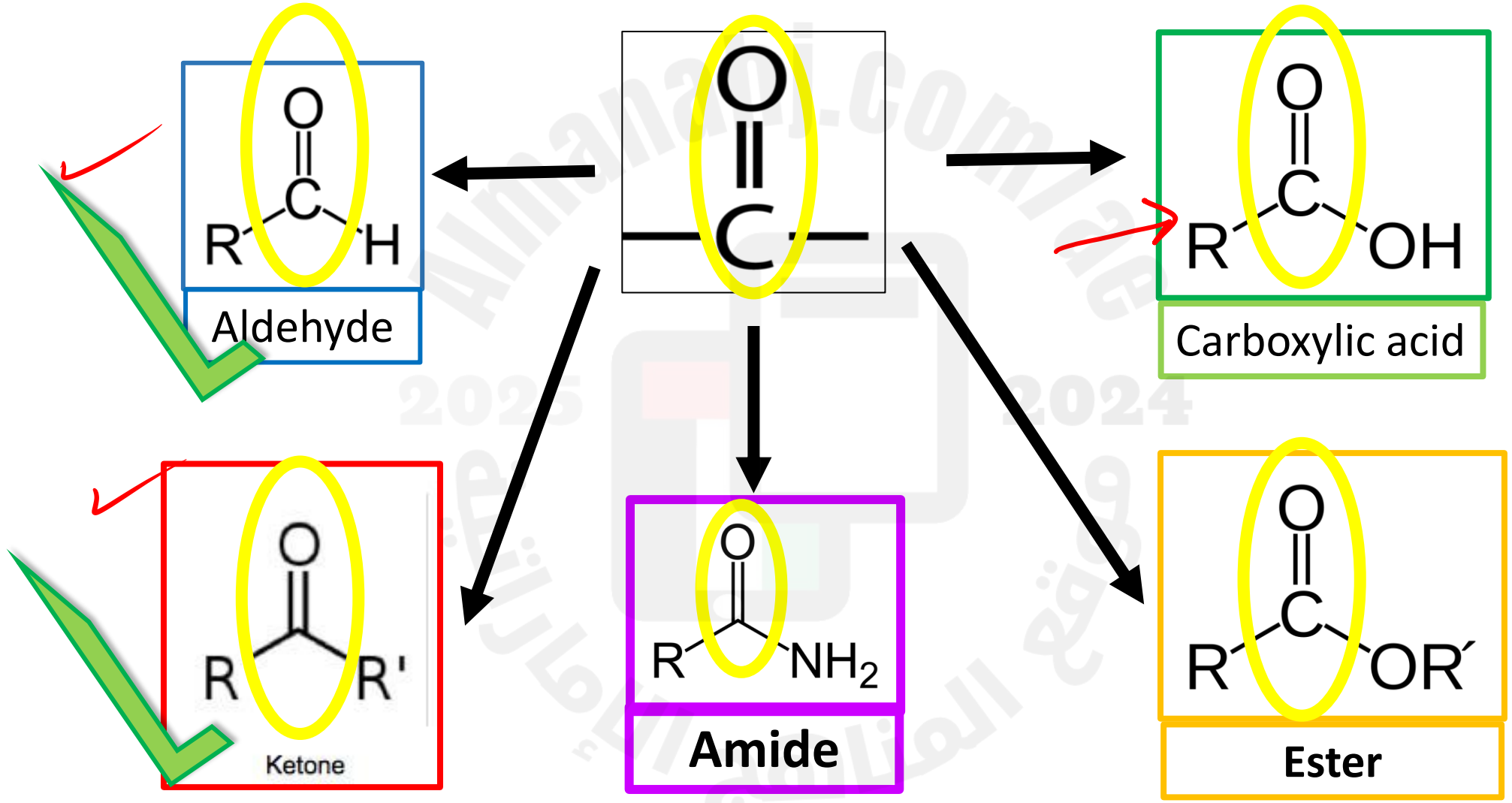
Properties of Aldehydes and Ketones

- Aldehydes and ketones share many chemical and physical properties because their structures are similar.
- Both aldehydes and ketones form hydrogen bonds with water, but not with themselves. Both are somewhat soluble in water.
- Formaldehyde is used as a preservative.
- Other aldehydes give flavor to natural foods, such as almonds and cinnamon.
- Ketones are popular solvents for other moderately polar substances, such as waxes, plastics, paints, lacquers, varnishes, and glues.

Carbonyl Compounds

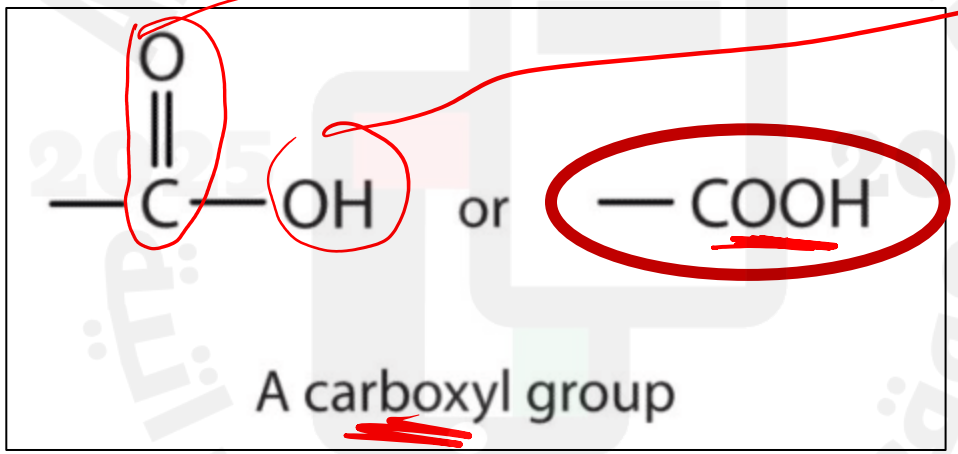
- Carbonyl compounds contain a **double-bonded** **oxygen** in the functional group.

Organic Compounds Containing the Carbonyl Group



Carboxylic Acids

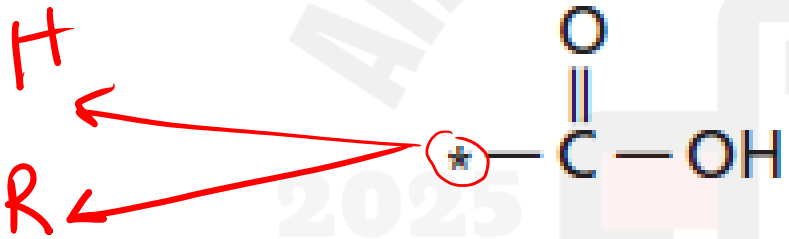
- A **carboxylic acid** is an organic compound that has a carboxyl group.
- **Carboxyl group** consists of a **carbonyl group** bonded to a **hydroxyl group.**



A carboxyl group is usually represented in condensed form by writing –COOH.
For example, acetic acid, the acid found in vinegar, can be written as CH_3COOH

Carboxylic Acids (General Formula)

General Formula

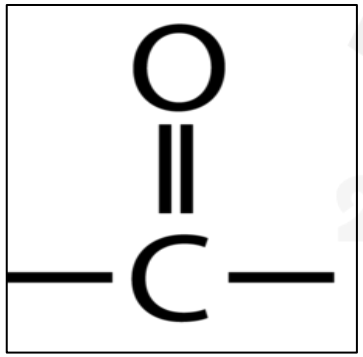


where R represents carbon chains or rings bonded to functional groups

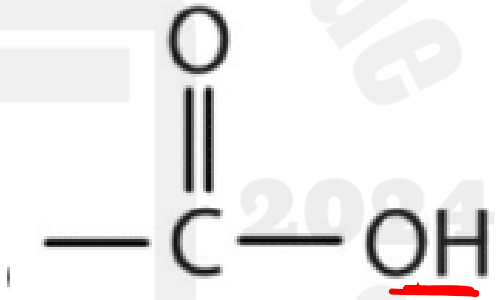
Activity

- What is the difference between carbonyl and carboxyl group?

  (Hint: draw them both and compare)



carbonyl



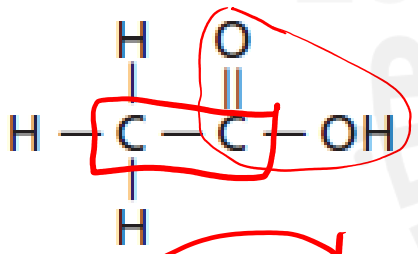
carboxyl

alkane

Naming Carboxylic Acids

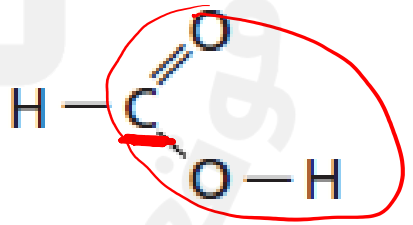
- The formal name is formed by **changing the *-ane*** of the parent alkane **to *-anoic acid***. Thus, the formal name of acetic acid is ethanoic acid.

Examples



Ethanoic acid (acetic acid)

Ethane → Ethanoic Acid



Methanoic acid (formic acid)

Methane → Mathanoic Acid

Properties of Carboxylic 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.
- Recall: The ionization of ethanoic acid.

$$CH_3COOH(aq) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$$

Ethanoic acid (acetic acid) — Ethanoate ion (acetate ion)

Properties of Carboxylic acid = Acids

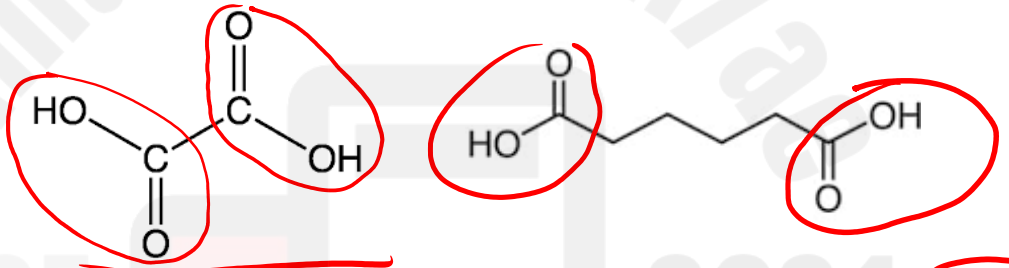
- Carboxylic acids can ionize in water solution because the **two oxygen atoms** are highly electronegative and attract electrons away from the hydrogen atom in the –OH group.

- 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**.

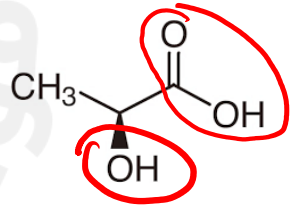
Dicarboxylic Acid

- An acid with two carboxyl groups is called a **dicarboxylic acid**.

- Some important carboxylic acids, such as **oxalic acid** and **adipic acid**, have two or more carboxyl groups.



- Others have additional functional groups such as hydroxyl groups, as in the **lactic acid** found in yogurt.



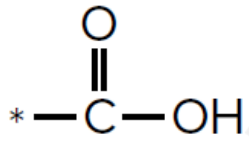
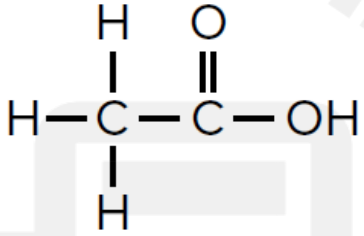
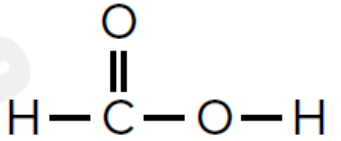
- Typically, these acids are **more soluble in water** and often **more acidic** than acids with only a carboxyl group.

Carboxylic Acids

- **Carboxyl groups** are carbonyls bonded to a hydroxyl group. They are represented as –COOH.
- **Carboxylic acids** are organic compounds that have a carboxyl group.
- Carboxylic acids are named by changing the *–ane* to *–anoic acid.*

Carboxylic Acids

Table 9 Carboxylic Acids

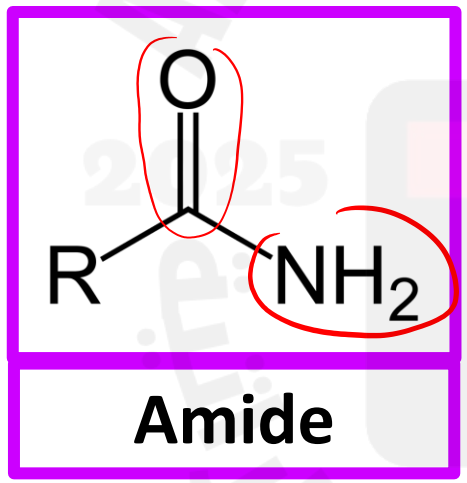
General Formula	Examples of Carboxylic Acids
 where * represents a hydrogen atom, carbon chain, or ring bonded to the functional group	 Ethanoic acid (acetic acid)  Methanoic acid (formic acid)

Carboxylic Acids

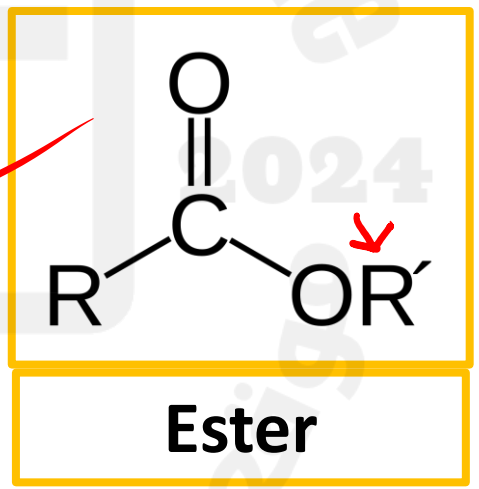
- Carboxylic acids are polar and reactive, and ionize partially in water to form hydronium ions, so they are considered weak acids.
- They have properties of other acids. For example, they turn blue litmus paper red, and they have a sour taste.
- Methanoic acid, also called formic acid, is used by ants as a defense.
- Ethanoic acid, also called acetic acid, is the acid found in vinegar.
- Lactic acid, found in yogurt, is a carboxylic acid with additional hydroxyl groups.

Organic Compounds Derived from Carboxylic Acids

- The hydrogen or the hydroxyl group of a carboxylic acid is replaced by a different atom or group of atoms. The two most common classes are **esters** and **amides**.

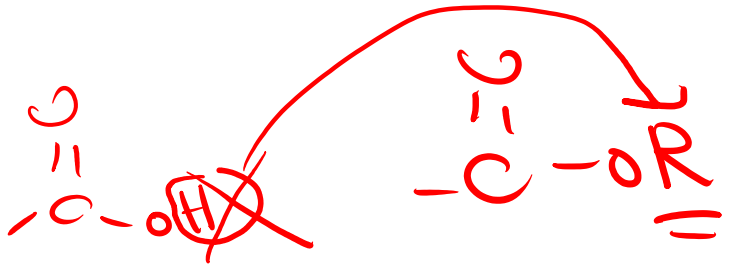


Amide

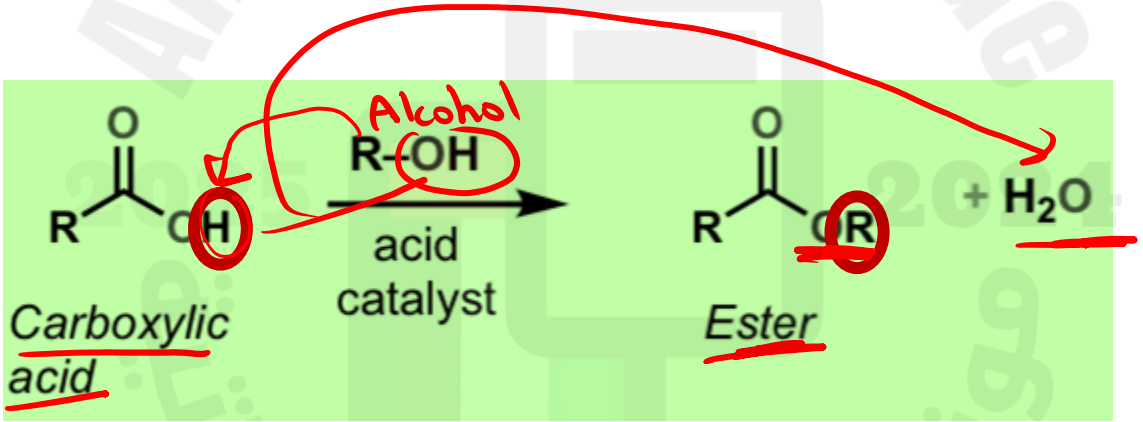


Ester

Esters



- An **ester** is any organic compound with a carboxyl group in which **the hydrogen of the *hydroxyl group has been replaced by an alkyl group*.**



Naming esters

- Write the **name** of the **alkyl group** followed by the **name of the acid** with the *-ic acid* ending replaced by ***-ate***.
- Note how the name *propyl* results from the structural formula.
- The name shown in parentheses is based on the name *acetic acid,* the common name for ethanoic acid.

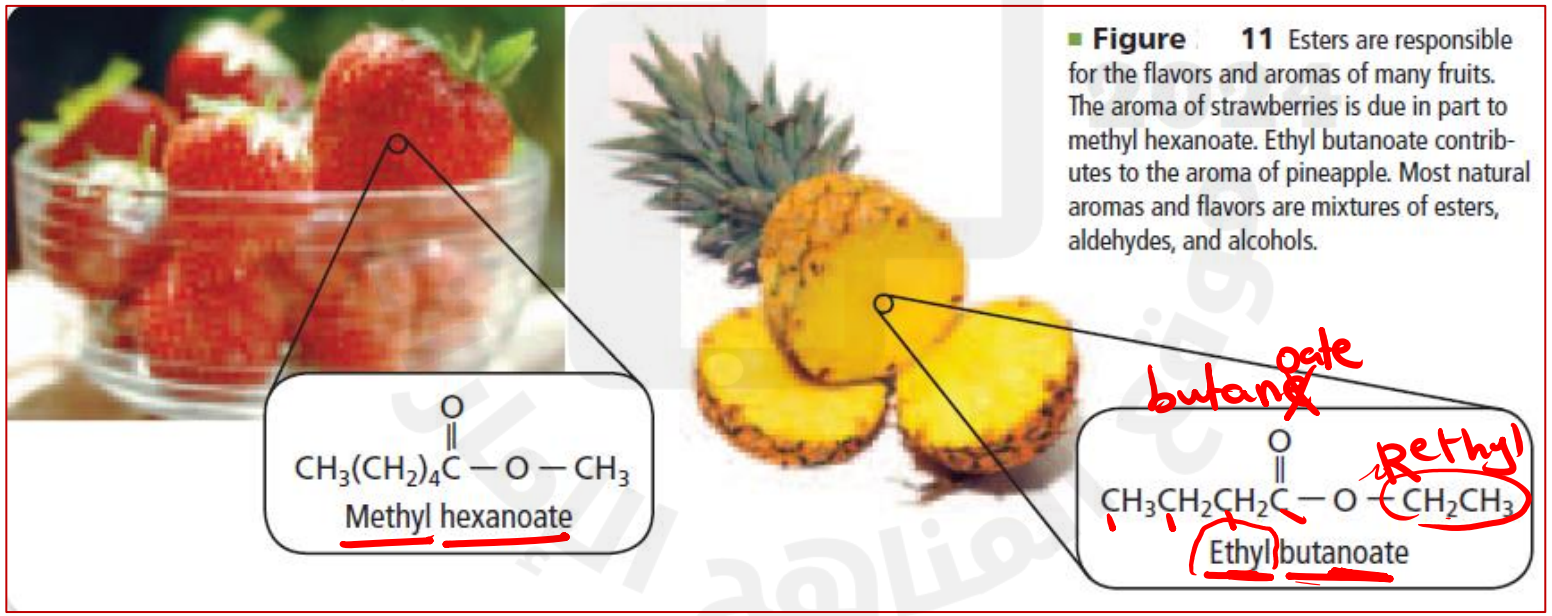
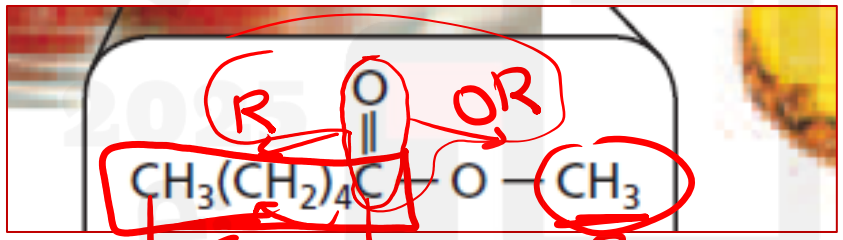


Figure 11 Esters are responsible for the flavors and aromas of many fruits. The aroma of strawberries is due in part to methyl hexanoate. Ethyl butanoate contributes to the aroma of pineapple. Most natural aromas and flavors are mixtures of esters, aldehydes, and alcohols.

Naming esters

- Write the **name** of the **alkyl group** followed by the **name of the acid** with the *-ic acid* ending replaced by –***ate***.
- Note how the name *propyl* results from the structural formula.
- The name shown in parentheses is based on the name *acetic acid,* the common name for ethanoic acid.

Ester

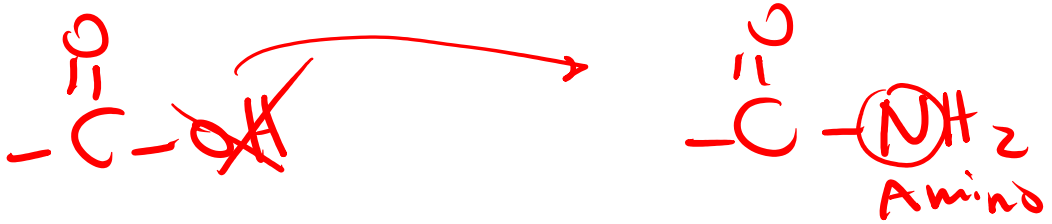


Methyl hexanoate ~~acid~~ ⇒ Methyl hexanoate

Properties of Esters

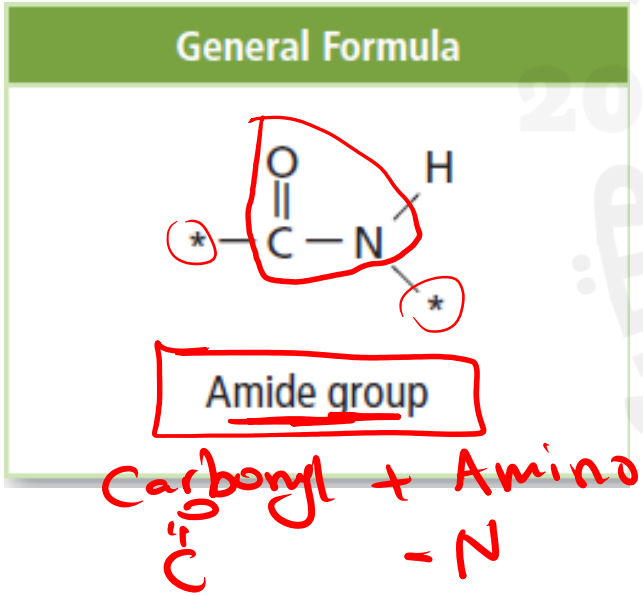
- polar molecules and many are volatile and sweet-smelling.

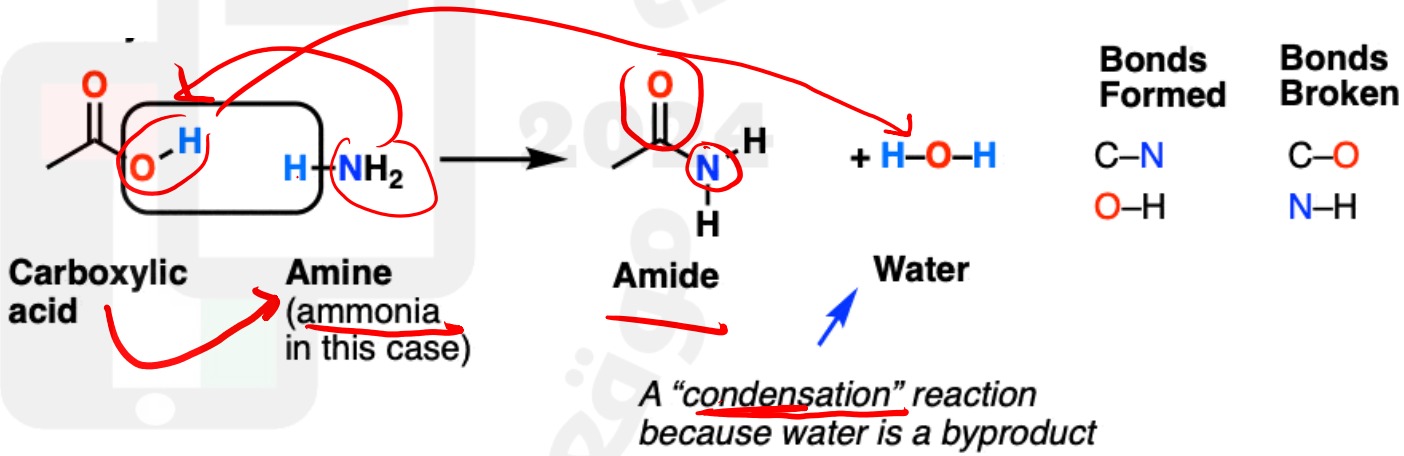
- Therefore, esters are manufactured for use as flavors in many foods and beverages and as fragrances in candles, perfumes, and other scented items.



Amides

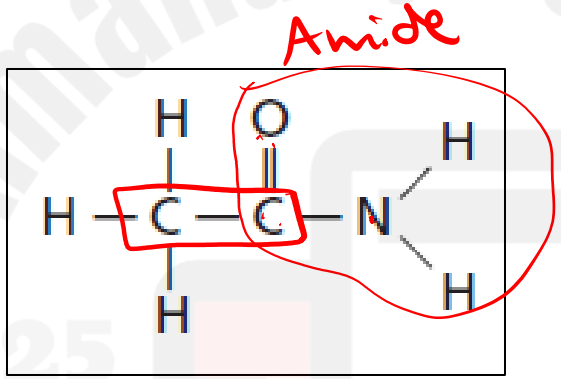
- An **amide** is an organic compound in which the **–OH group of a carboxylic acid** is replaced by a **nitrogen atom** bonded to other atoms.





Amides

- The general structure of an amide is shown in **table.**
- Amides are named by writing the name of the alkane with the same number of carbon atoms, and then replacing the final **-*e*** with **-*amide*.**



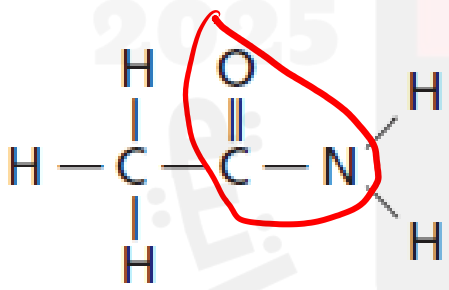
Ethanamide

Ethanamide

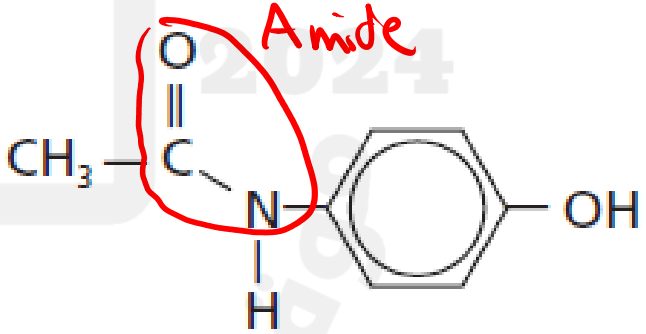
Amides

- The general structure of an amide is shown in **table.**
- Amides are named by writing the name of the alkane with the same number of carbon atoms, and then replacing the final ***-e*** with ***-amide*.**
- Thus, the amide shown in **table** is called ethanamide, but it can also be named **acetamide** from its common name, **acetic acid**.

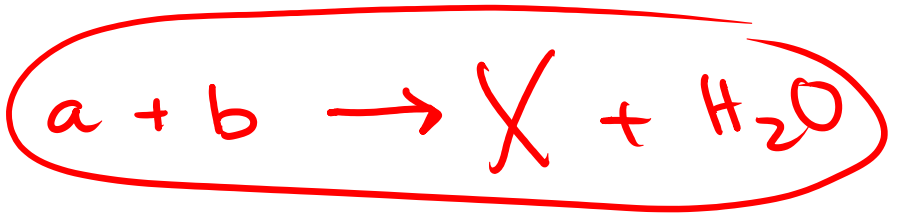
Examples of Amides



Ethanamide (acetamide)



Acetaminophen



Condensation Reactions

- In a **condensation reaction**, two smaller organic molecules combine to form a more complex molecule, accompanied by the loss of a small molecule such as water.

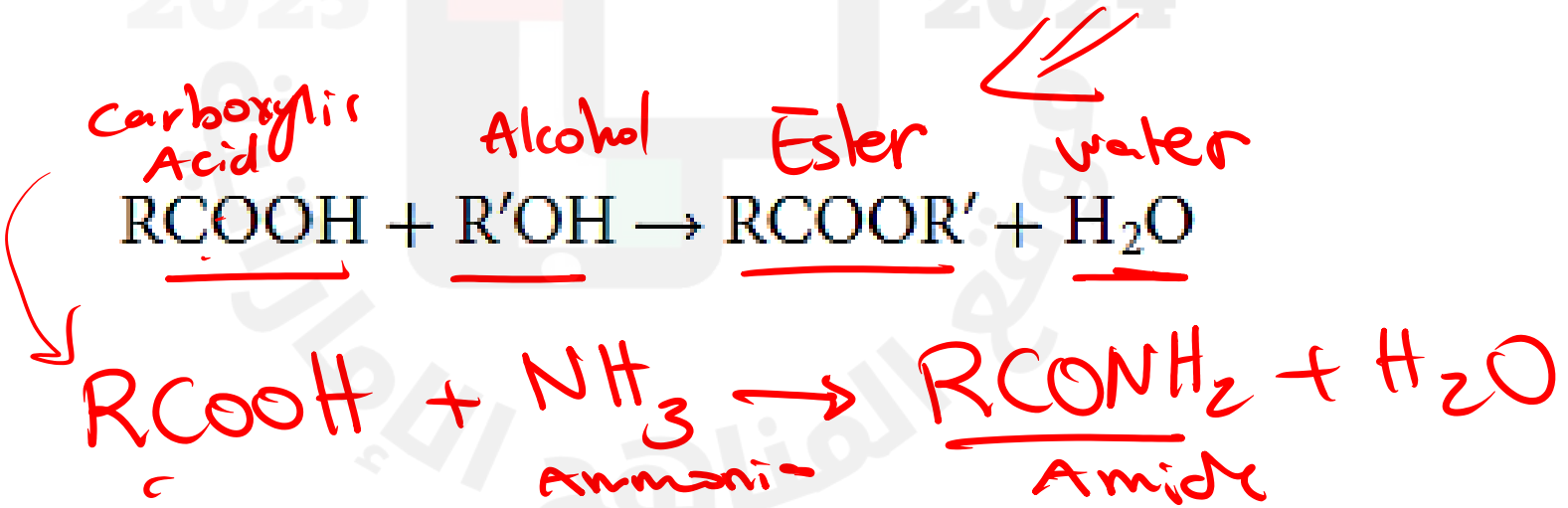
- In essence, a condensation reaction is an elimination reaction in which a bond is formed between two atoms not previously bonded to each other.

section 4

new bonds are formed

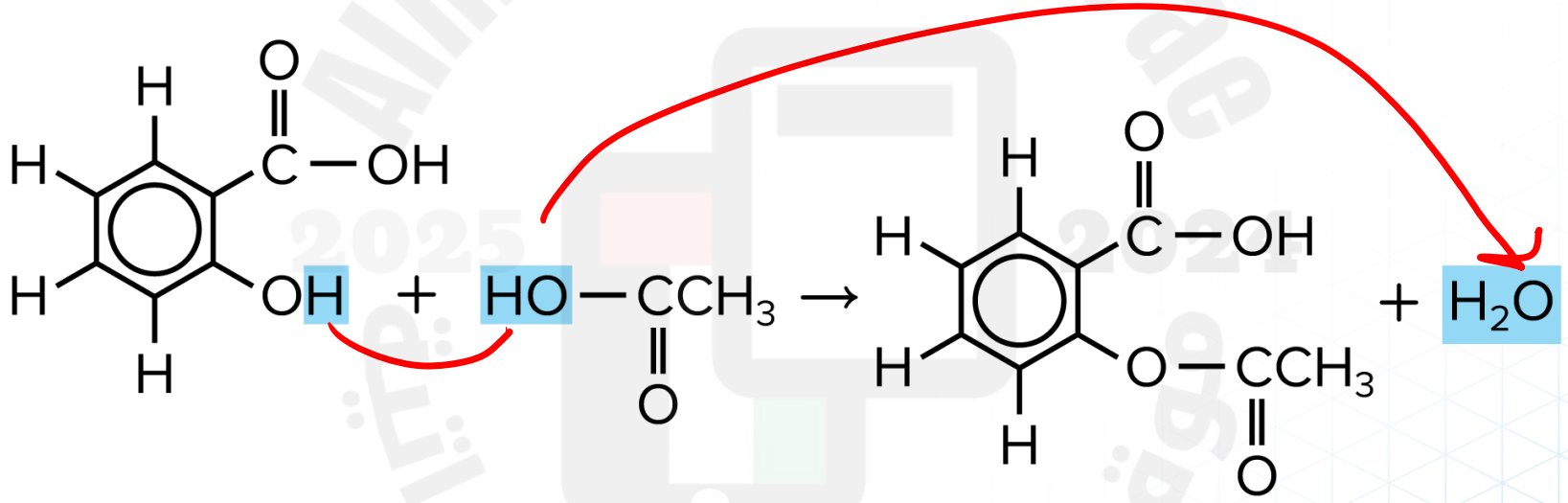
Condensation Reactions

- The most common condensation reactions involve the **combining of carboxylic acids with other organic molecules.**
- A common way to **synthesize an ester is by a condensation reaction** between a carboxylic acid and an alcohol.
- Such a reaction can be represented by the following general equation.



Condensation Reactions

- In a **condensation reaction,** two smaller organic molecules combine to form a more complex molecule, accompanied by the loss of a small molecule, such as water.



Organic Compounds Derived from Carboxylic Acids

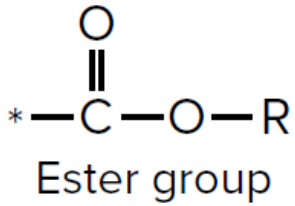
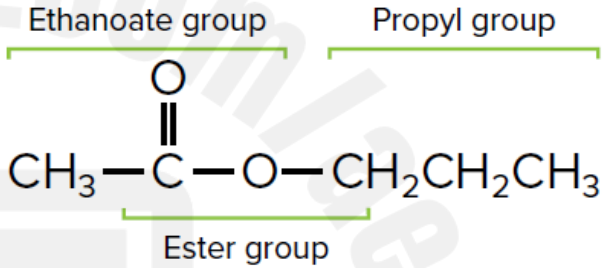
- Esters and amides are both derived from carboxylic acids.
- They have structures in which the hydrogen or the hydroxyl group of a carboxylic acid is replaced by a different atom or group of atoms.
- An **ester** is any organic compound with a carboxyl group in which the hydrogen in the hydroxyl group is replaced by an alkyl chain.

Esters

- To name an ester, write the alkyl group followed by the name of the acid with the *–oic acid* ending replaced with *–oate.*
- Esters are polar molecules, and many are volatile and sweet-smelling.
- Many esters are found in fruits and flowers.

Esters

Table 10 Esters

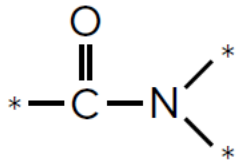
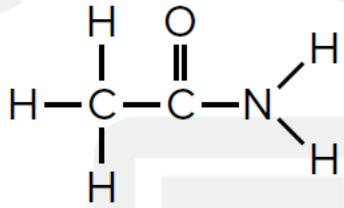
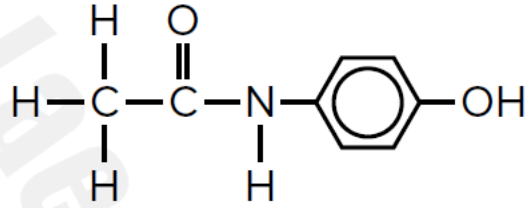
General Formula	Examples of an Ester
 Ester group	 Propyl ethanoate (propyl acetate)

Amides

- An **amide** is an organic compound in which the –OH group of a carboxylic acid is replaced by a nitrogen atom bonded to other atoms.
- The amide functional group is found repeated many times in natural proteins and some synthetic materials.

Amides

Table 11 Amides

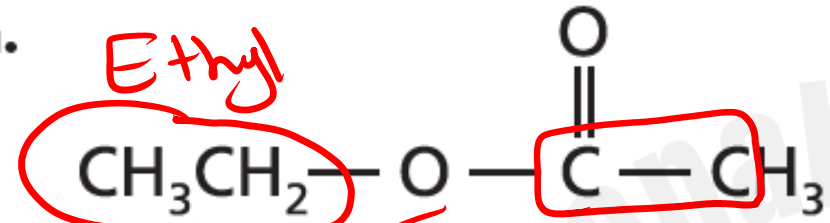
General Formula	Examples of Amides
 Amide group	 Ethanamide (acetamide)
	 Acetaminophen

14. MAINIDEA Classify each of the carbonyl compounds as one of the types of organic substances you have studied in this section.

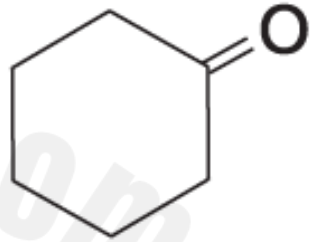
Ester

a.

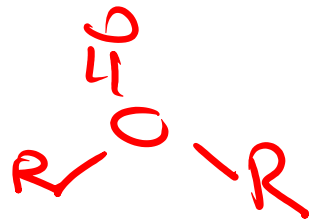
Ethyl



c.



Ketone

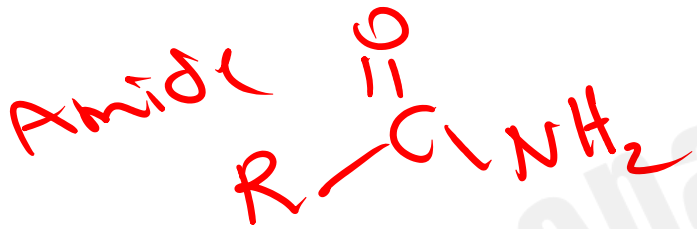


Ethyl ethanoate

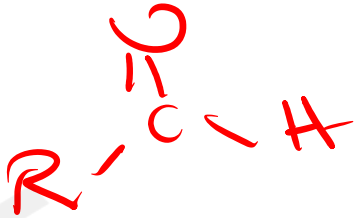
cyclohexanone

14. MAINIDEA Classify each of the carbonyl compounds as one of the types of organic substances you have studied in this section.

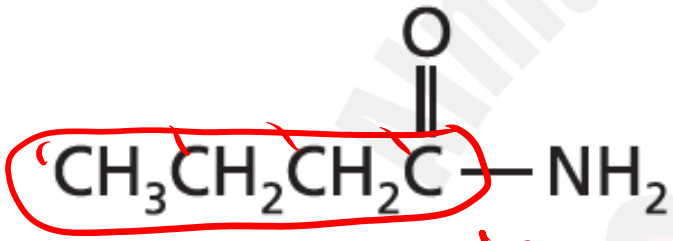
Amide



Aldehyde

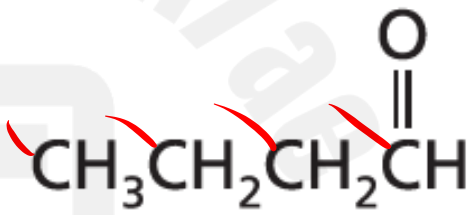


b.



butanamide

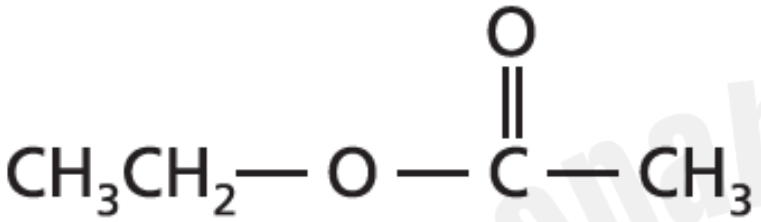
d.



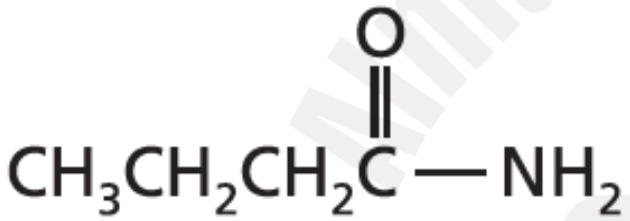
butanal

14. MAINIDEA Classify each of the carbonyl compounds as one of the types of organic substances you have studied in this section.

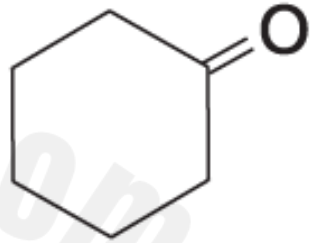
a.



b.



c.



d.

a. Ester (Ethyl ethanoate)
b. Amide (Butanamide)
c. Ketone (Cyclohexanone)
d. Aldehyde (Butanal)

Quiz

4. Esters and amides both have structures in which the hydrogen or hydroxyl group of a(n) _____ is replaced by a different atom or group of atoms.

 aldehyde

 ketone

 ether

D carboxylic acid **CORRECT**