Pharmaceutical Organic Chemistry-1

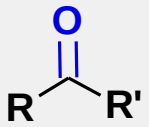
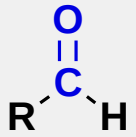
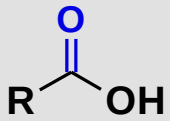
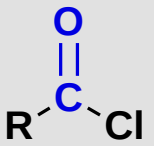
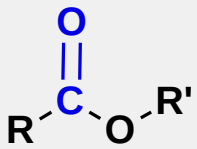
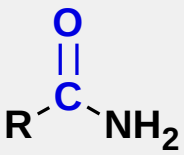
Chapter-5: Aldehydes & Ketones
+ MCQ'S

By : Mohammad Alkhawaldeh

Morphin 💊🩺

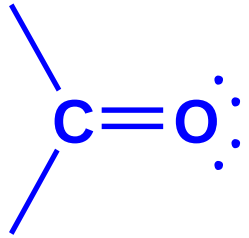
Aldehydes & Ketones

Common Classes of Carbonyl Compounds

Class	General Formula	Class	General Formula
Ketones		Aldehydes	
Carboxylic acids		Acid Chlorides	
Esters		Amides	

حيث

R = CH_3 واخواتها

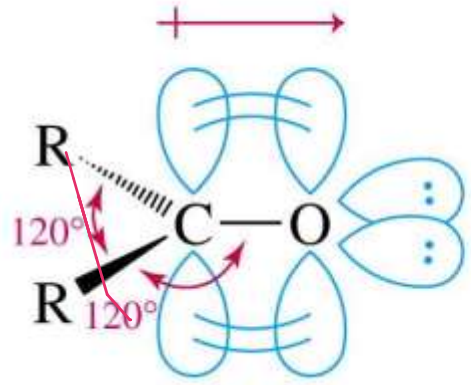


The carbonyl group

رابطة C=O:
أقصر من C=C
أقوى
أكثر polar
ليش Polar؟ لأن: Oxygen يسحب الإلكترونات
الكربون بصير δ+
الأكسجين δ−

✅ trigonal planar شكله

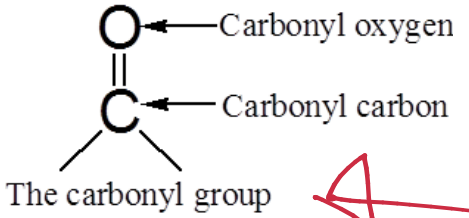
- Carbon is ***sp*² hybridized**.
- **C=O bond** is shorter, stronger, and more polar than C=C bond in alkenes.



	length	*energy*
ketone C=O bond	1.23 Å	178 kcal/mol (745 kJ/mol)
alkene C=C bond	1.34 Å	146 kcal/mol (611 kJ/mol)

Structure of Aldehydes and Ketones

- **Aldehydes and ketones** are characterized by the presence of the carbonyl group.



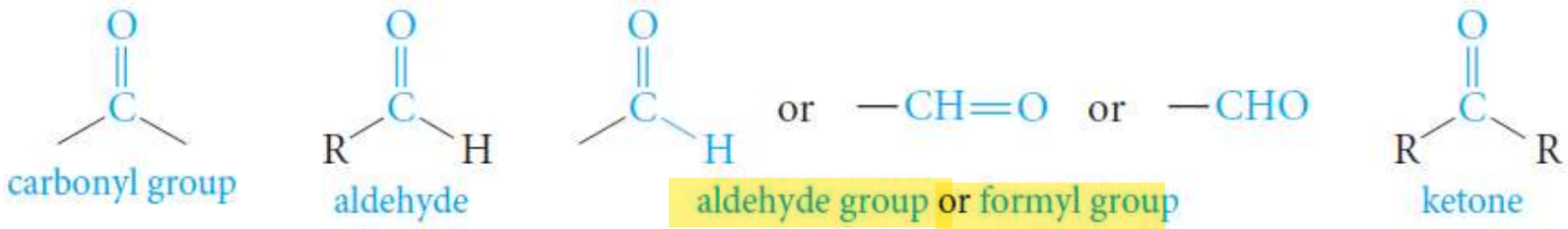
- **Aldehydes** have at least one hydrogen atom attached to the carbonyl carbon atom.

  The remaining group may be another hydrogen atom or any aliphatic or aromatic organic group.

  The -CH=O group characteristic of aldehydes is often called a formyl group.

مرتبط بـ Hydrogen واحد على الأقل
اسم المجموعة: Formyl group

- In **ketones,** the carbonyl carbon atom is connected to two other carbon atoms.



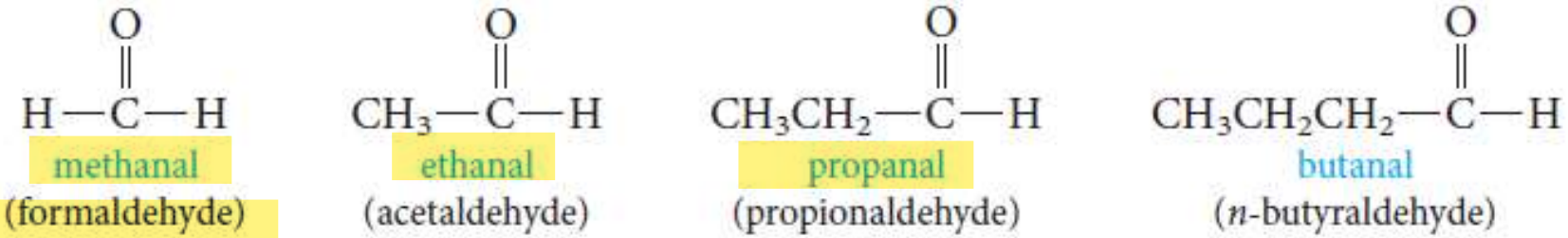
Nomenclature of Aldehydes

IUPAC System

- *Aliphatic aldehydes* ***are named by dropping the suffix -e from the name of the hydrocarbon that has the same carbon skeleton as the aldehyde and replacing it with the suffix -al.***

القانون السهل:
اسم الشسمو الديهايد بكون كالتالي معلم
نشيل -e بعدين نضيف -al

Alkane - e+ *al* = *Alkanal*



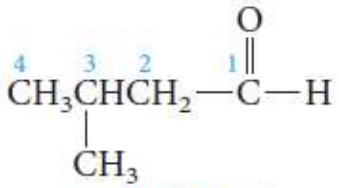
لـ ابسط نوع .

Nomenclature of Aldehydes

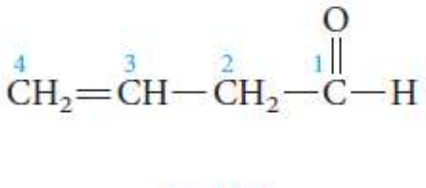
IUPAC System

نرقم السلسلة من جهة CHO و كربونتها هي الرقم 1

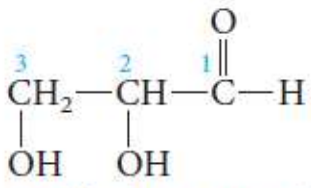
- ***Substituted aldehydes,*** *we number the chain starting with the aldehyde carbon.*
  - *-CH=O group is assigned the number 1 position.*
  - *Aldehyde group has priority over a double bond or hydroxyl group.*



3-methylbutanal

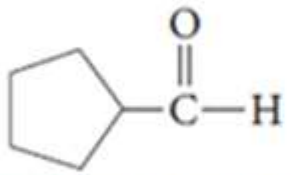


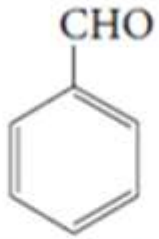
3-butenal

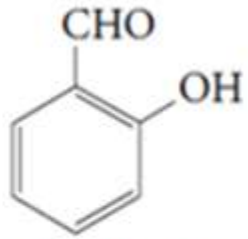


2,3-dihydroxypropanal
(glyceraldehyde)

- ***Cyclic aldehydes,*** *the suffix –carbaldehyde is used.*





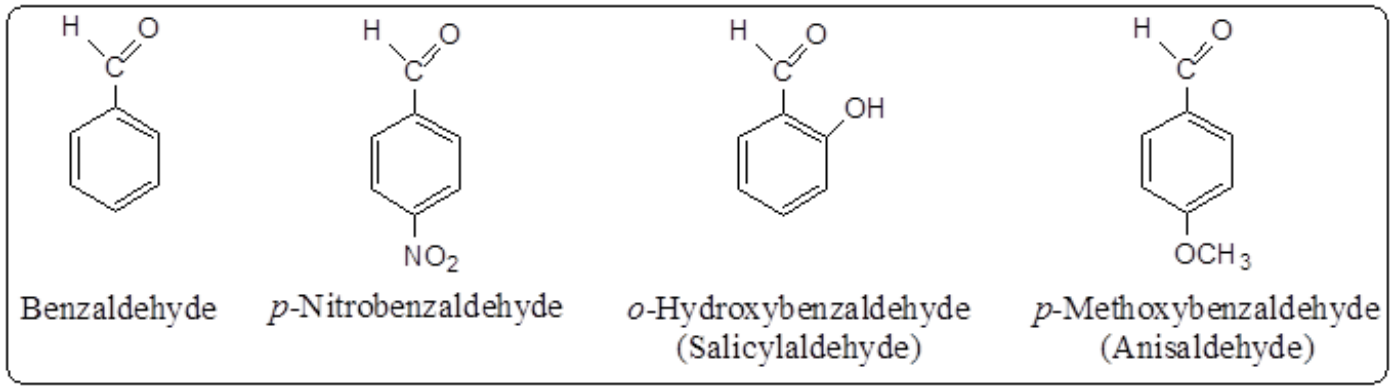


Common	formylcyclopentane	benzaldehyde	salicylaldehyde
(IUPAC)	(cyclopentancarbaldehyde)	(benzaldehyde)	(2-hydroxybenzaldehyde)

Nomenclature of Aldehydes

IUPAC System

- ***Aromatic aldehydes*** *are usually designated as derivatives of the simplest aromatic aldehyde,* ***benzaldehyde****.* Benzaldehyde كل ألدهيد راكب على بنزين نسميه



Benzaldehyde | *p*-Nitrobenzaldehyde | *o*-Hydroxybenzaldehyde (Salicylaldehyde) | *p*-Methoxybenzaldehyde (Anisaldehyde)

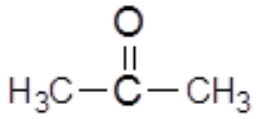
تسمية الكيتوز

Nomenclature of Ketone

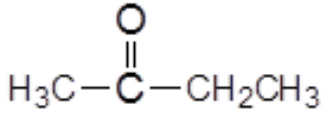
Common Names

- Common names of ketones are formed by adding the word *ketone* to the names of the alkyl or aryl groups attached to the carbonyl carbon. Alkyl ketone.
- In still other cases, traditional names are used.

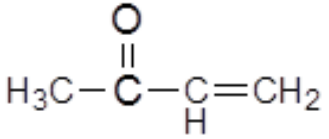
نكتب أسماء المجموعات ثم نضع Ketone ، بس هذا common name
انتبه مو مشان شي مشان صحتك يا غالي



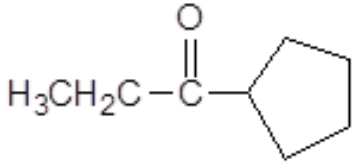
Acetone
(Dimethyl ketone)



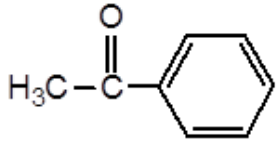
Ethyl methyl ketone



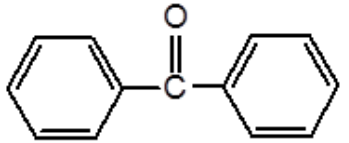
Methyl vinyl ketone



Cyclopentyl ethyl ketone



Methyl phenyl ketone
(Acetophenone)



Diphenyl ketone
(Benzophenone)

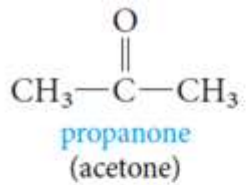
Nomenclature of Aldehydes

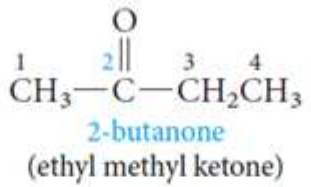
IUPAC System

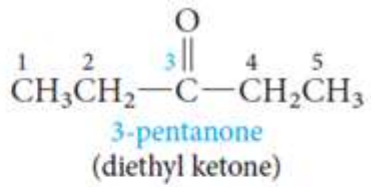
- In the IUPAC system, the ending for ketones is -one.
- The chain is numbered so that the carbonyl carbon has the lowest possible number.
- For cyclic ketones, numbering always starts from the C=O group.
- The prefix "oxo" is used when the ketone is not the principal functional group.

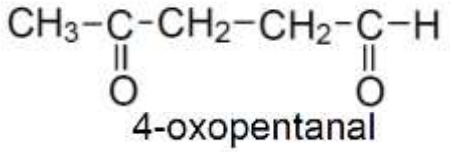
لما ما يكون الكيتون اقوى شي معو بنحطيه oxo

IUPAC (Common)

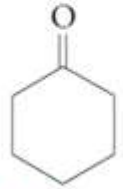


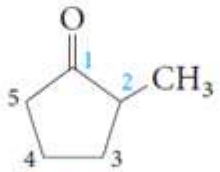


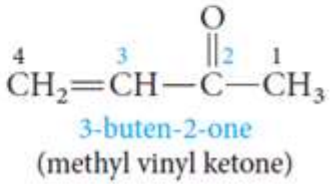


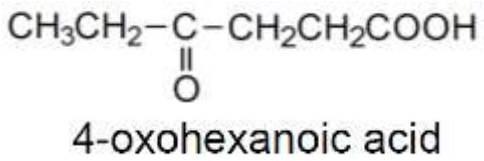


القانون 52 بقول ، العائلة بتنتهي ب one و بنوخذ الكربونيل الي يعطينا أقل رقم









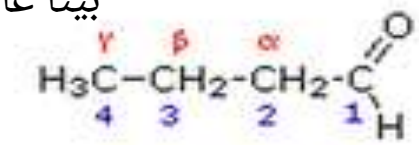
Nomenclature of Aldehydes Ketones

NOTES

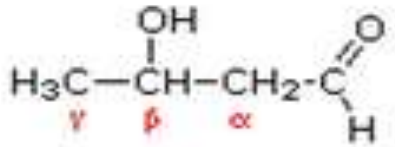
- **In common names** carbon atoms near the carbonyl group are often designated by Greek letters.
- The atom adjacent to the function is *alpha (α)*, the next removed is *beta (β)* and so on. Since ketones have two sets of neighboring atoms, one set is labeled *α, β* etc., and the other *α′, β′* etc.

يعني ببساطة اذا كان عنا الديهايد (كربونيل) بنستخدم ترقيم الاغريقي كالآتي ، الفا بيتا غاما الخ ...

Aldehydes

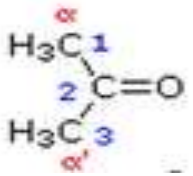


butanal
butyraldehyde



3-hydroxybutanal
β-hydroxybutyraldehyde
or aldol

Ketones



propanone
acetone

2-bromo-4,4-dimethylcyclohexanone

بالكيتون كونه عنا طرفين بالكربون بنستخدم ألفا و بيتا ع جهة ، و برايم الفا و برايم بيتا ع جهة أخرى

ترتيب الأولوية (احفظه):

- **The functional group priority order in nomenclature system** is as following:

Acid and derivatives >aldehyde> ketone> alcohol > amine > alkene > alkyne > ether

أشخاص قد فشخوك من قبل

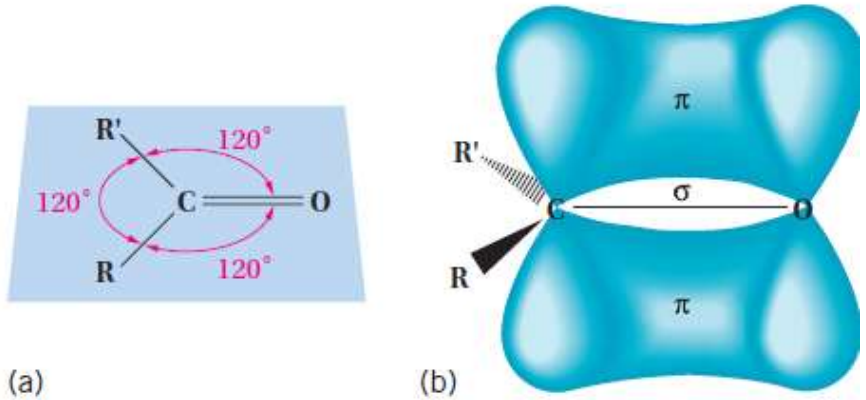
The Carbonyl Group

- The structure and properties of the carbonyl group.

رابطة C=O و فيها روابط سيغما و π

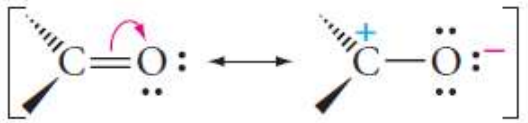
  - The carbon–oxygen double bond consists of a sigma bond and a pi bond.
  - The carbon atom is sp^2-hybridized. The three atoms attached to the carbonyl carbon lie in a plane with bond angles of 120°.
  - The pi bond is formed by overlap of a *p* orbital on carbon with an oxygen *p* orbital.
  - There are also two unshared electron pairs on the oxygen atom. الاوكسجين عنده: lone pairs 2
  - The C=O bond distance is 1.24A, shorter than the C-O distance in alcohols and ethers (1.43A) .

رابطة اقصر



The Carbonyl Group

- Oxygen is much more electronegative than carbon. Therefore, the electrons in the C=O bond are attracted to the oxygen, producing a highly polarized bond.

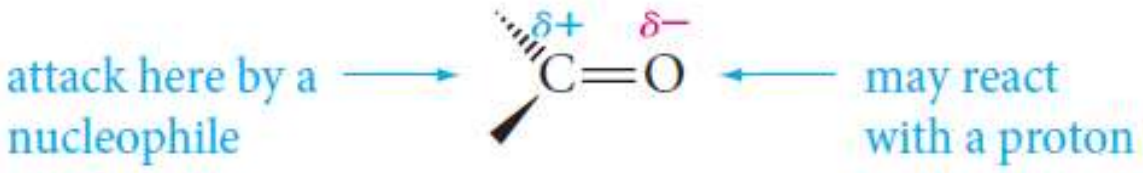


resonance contributors to the carbonyl group

polarization of the carbonyl group

- As a consequence of this polarization, *most carbonyl reactions involve* nucleophilic attack *at the carbonyl carbon*, often accompanied by addition of a proton to the oxygen (electron rich).

الكربون إلكتروفيلي ف الهجوم دايمًا عليه



Physical Properties of Aldehydes and Ketones

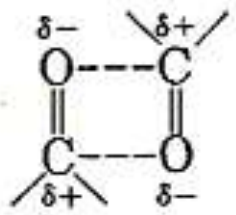
Boiling Points

ال BP للالديهايدات و الكيتونات أعلى من hydrocarbons وأقل من alcohols

- Carbonyl compounds boil at higher temperatures than hydrocarbons, but at lower temperatures than alcohols of comparable molecular weight.

$CH_3(CH_2)_4CH_3$	$CH_3(CH_2)_3CH{=}O$	$CH_3(CH_2)_3CH_2OH$
hexane (bp 69°C)	pentanal (bp 102°C)	pentanol (bp 118°C)

- This is due to the intermolecular forces of attraction, called dipole-dipole interactions, which is stronger than van der Waals attractions but not as strong as hydrogen bonds.



Dipole-dipole attractions among carbonyl compounds

طب ليش يابو حامد ؟
Dipole–dipole
interactions مش قوي زي
hydrogen bonding

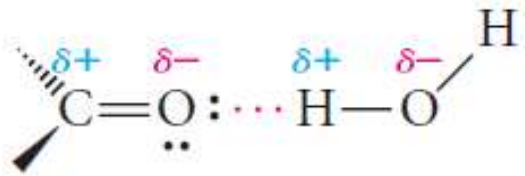
Physical Properties of Aldehydes and Ketones

Solubility

ما عندهم O–H ولا شخصية

- Carbonyl compounds as aldehydes and ketones have a C=O bond, but no O-H bond, cannot form hydrogen bonds with themselves.
- The polarity of the carbonyl group also affects the solubility properties of aldehydes and ketones.
- Carbonyl compounds with low molecular weights are soluble in water as they can form hydrogen bonds with O-H or N-H compounds.

VALID



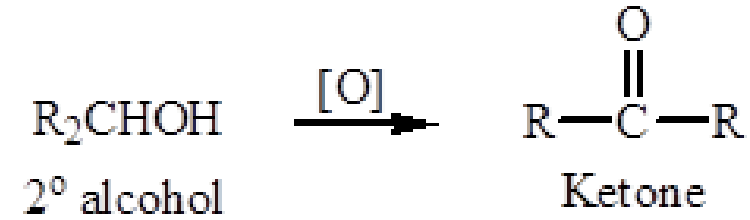
Preparation of Aldehydes and Ketones

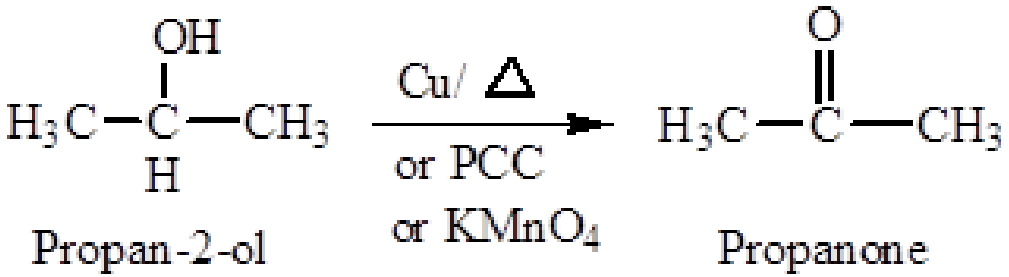
تحضير الاديهايد و كيتون بطريقة سهلة و مجربة و مواد متوفرة بكل بيت

1) Oxidation of Primary and Secondary Alcohols

- Oxidation of **secondary alcohols** yields ketones.

Primary alcohol → Aldehyde
Secondary alcohol → Ketone





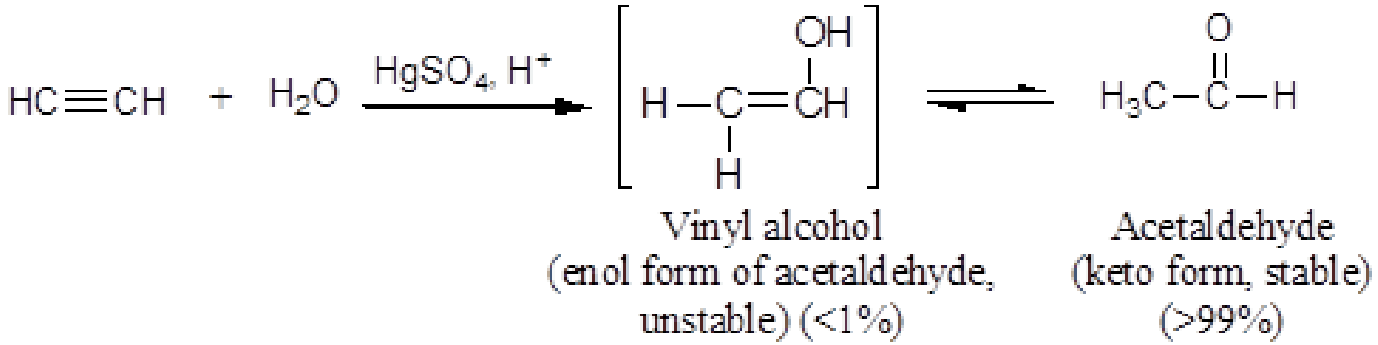
Preparation of Aldehydes and Ketones

هدرجة الالكاينات

2) Hydration of Alkynes

مثلا عدنة استيلين لو عملناله تفاعل مال هايدريشن ديعيطنا اسيتل الديهايد

- Hydration of acetylene yields acetaldehyde (catalyzed by acid and mercuric).

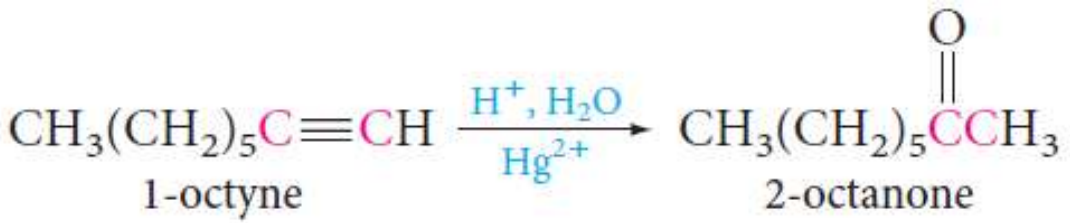


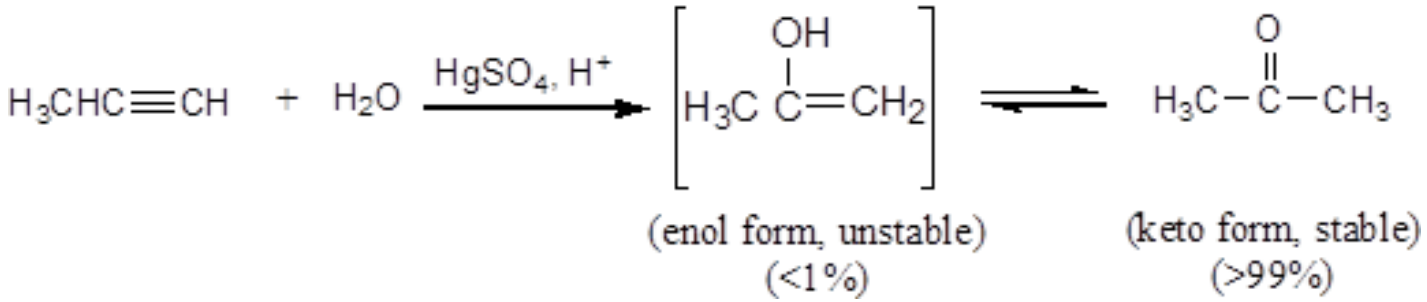
Preparation of Aldehydes and Ketones

2) Hydration of Alkynes

✅هدرجة الTerminal الاكاين ما عدا ال Acetylene راح يعطينا كيتون

- Hydration of terminal alkynes EXCEPT acetylene yields ketones (catalyzed by acid and mercuric).



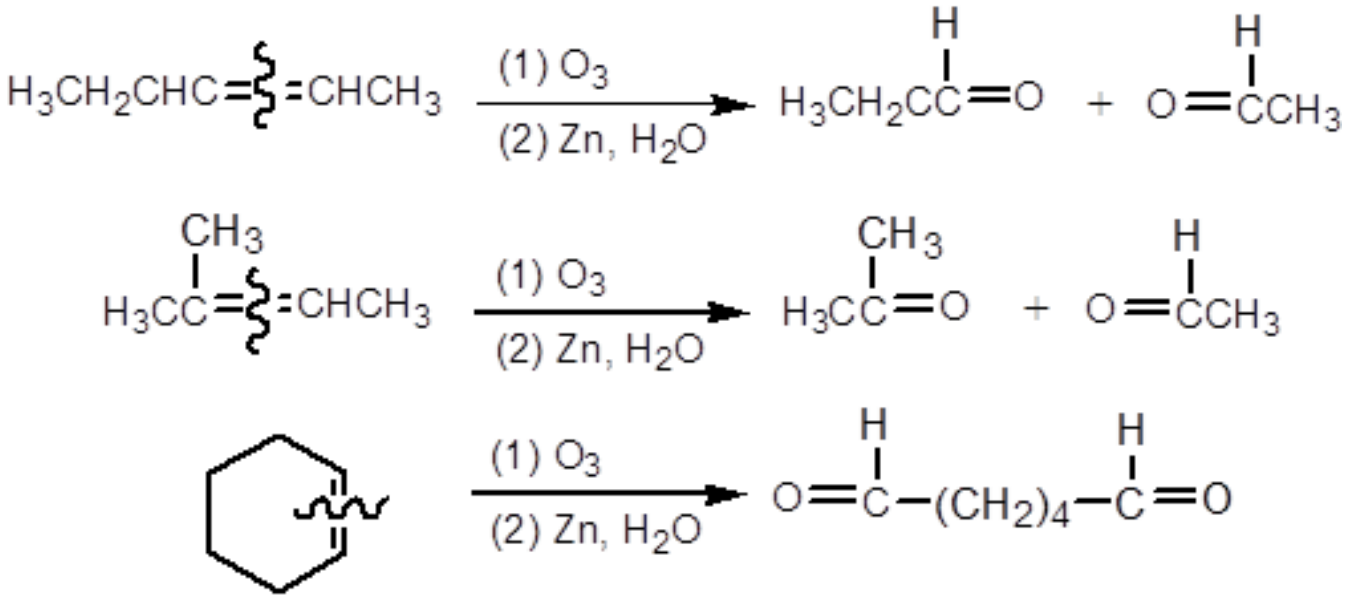


Preparation of Aldehydes and Ketones

3) Ozonolysis of Alkenes

يعتمد على شكل الألكين
بكسر الرابطة المزدوجة

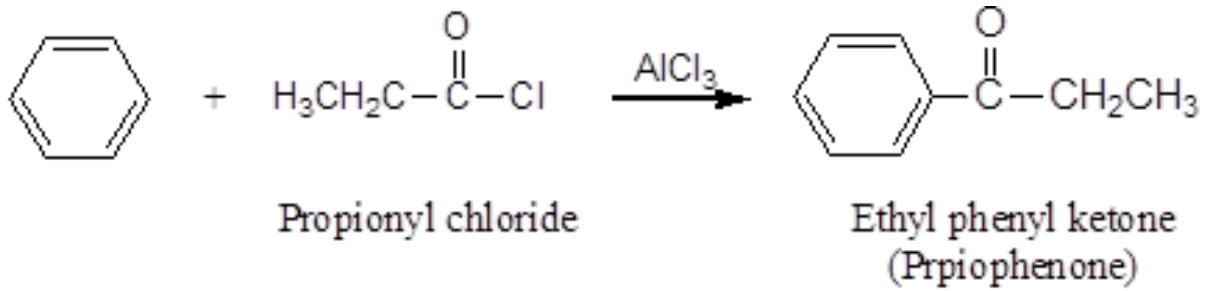
Product (aldehyde or ketone) depends on the structure of alkene.



Preparation of Aldehydes and Ketones

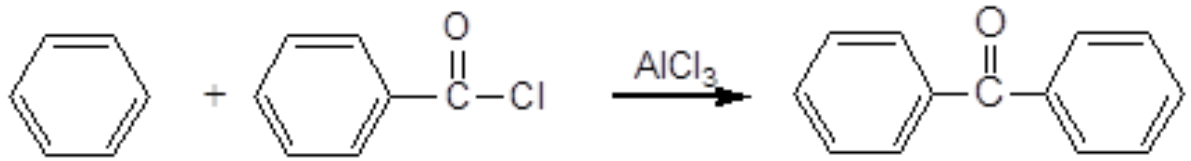
4) Friedel-Crafts Acylation

Preparing ketones that contain an aromatic ring.



Propionyl chloride

Ethyl phenyl ketone
(Prpiophenone)



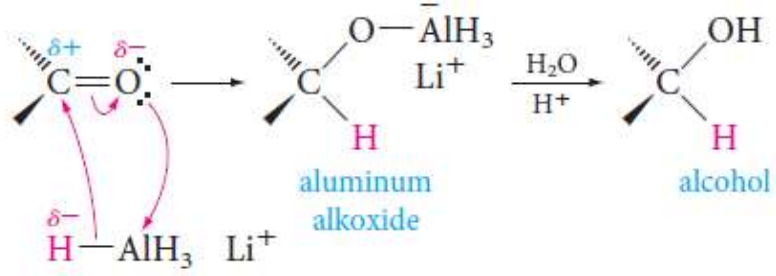
Benzoyl chloride

Diphenyl ketone
(Benzophenone)

Reactions of Aldehydes and Ketones

A) Reduction of Carbonyl Compounds

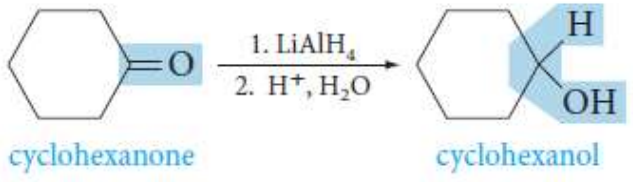
- Aldehydes and ketones are easily reduced to primary and secondary alcohols, respectively.
- The most common metal hydrides used to reduce carbonyl compounds are lithium aluminum hydride ($LiAlH_4$) and sodium borohydride ($NaBH_4$).



Reduction:
Aldehyde → 1° Alcohol
Ketone → 2° Alcohol

العوامل المختزلة :
$LiAlH_4$ ليلى
$NaBH_4$ نبها

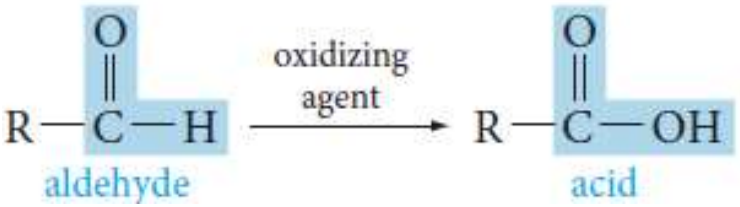
- **Example:**



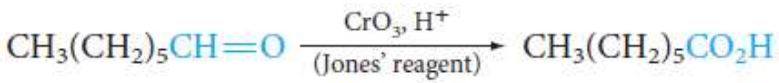
فقط للالديهايد

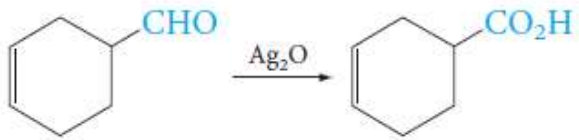
B) Oxidation of Carbonyl Compounds

- Oxidation of aldehydes gives a carboxylic acid with the same number of carbon atoms.
- Because the reaction occurs easily, many oxidizing agents, such as $KMnO_4$, CrO_3, Ag_2O and peracids (such as, perchloric acid HClO4, and permanganic acid HMnO4). will work.



- **Example:**



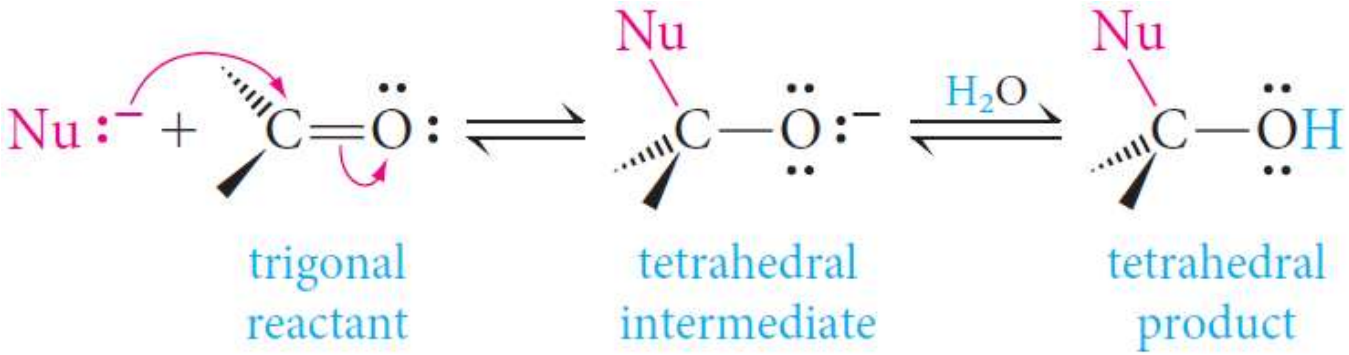


Ketones ❌ ما بتتأكسد

C) Nucleophilic Addition Reactions

الكربون δ+ ف النيوكليوفيل بهجم عليه نعم صحيح وهو كذلك

- Nucleophiles attack the carbon atom of a carbon-oxygen double bond because that carbon has a partial positive charge.
- The overall reaction involves addition of a nucleophile and a proton across the pi bond of the carbonyl group (when carried out in alcohol or water).

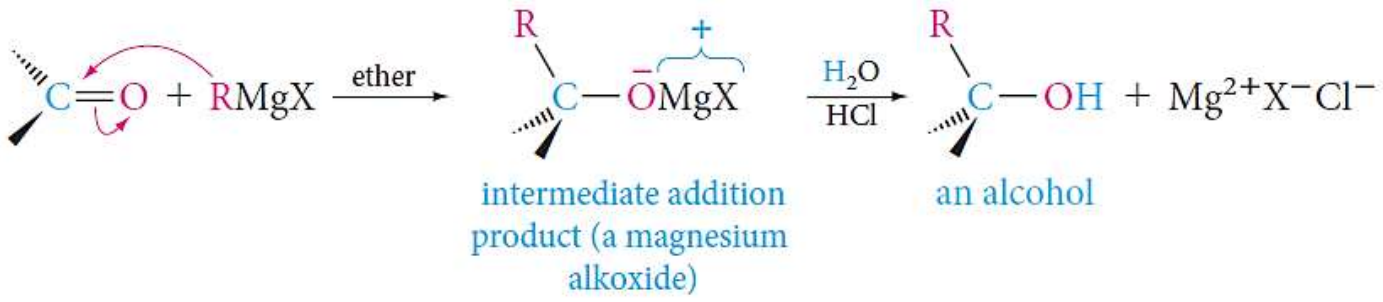


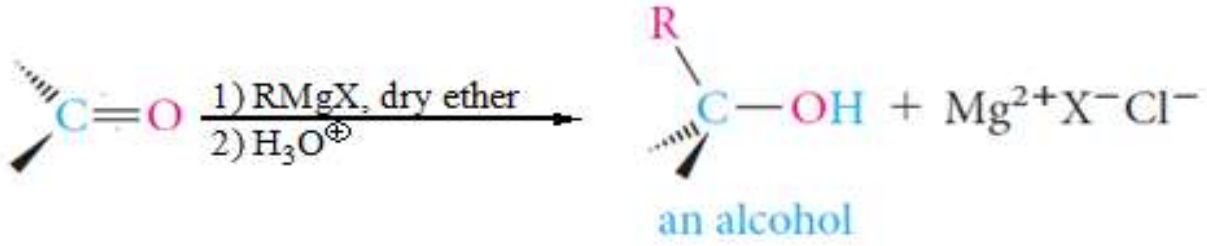
C) Nucleophilic Addition Reactions

1) Addition of Grignard Reagents: Formation of Alcohols

- *Grignard reagents act as carbon nucleophiles toward carbonyl compounds.*

- The reaction of a Grignard reagent with a carbonyl compound provides a useful route to alcohols.



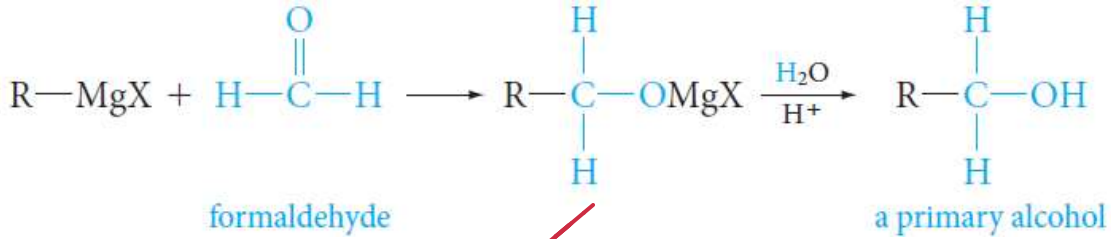


- The type of carbonyl compound chosen determines the class of alcohol produced.

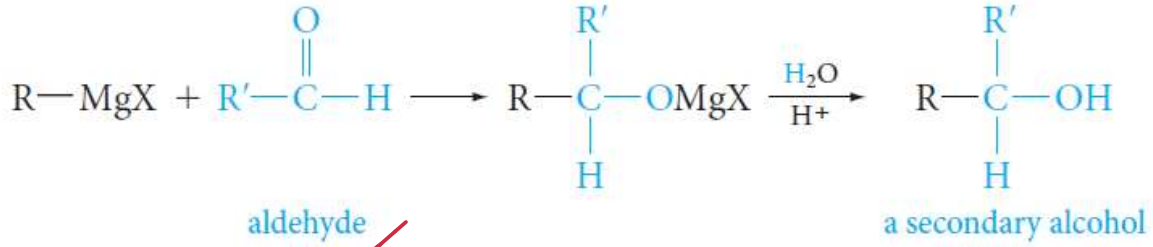
C) Nucleophilic Addition Reactions

1) Addition of Grignard Reagents: Formation of Alcohols

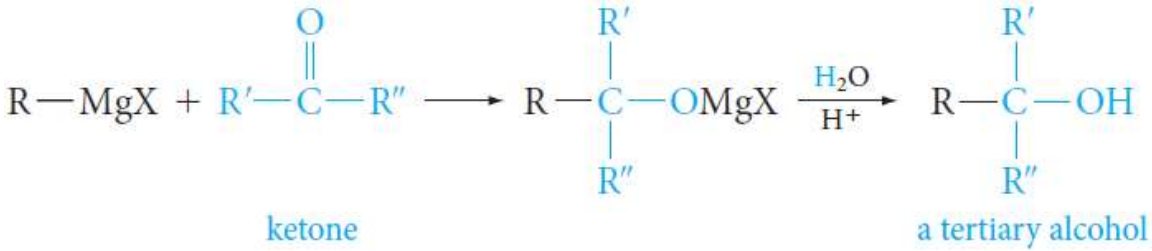
- *Formaldehyde gives primary alcohols*.



- Other *aldehydes give secondary alcohols*



- *Ketones give tertiary alcohols*.



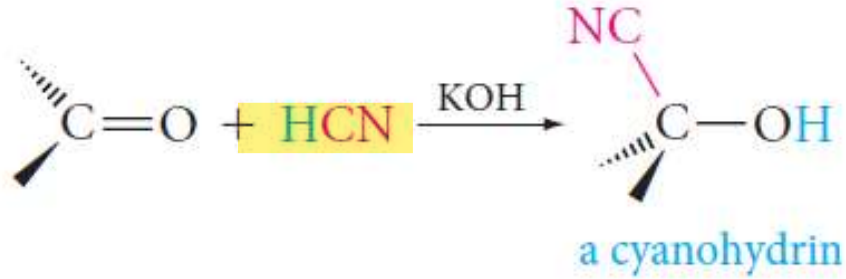
Aldehyde → 2° Alcohol
Ketone → 3° Alcohol
Formaldehyde → 1° Alcohol

C) Nucleophilic Addition Reactions

HCN

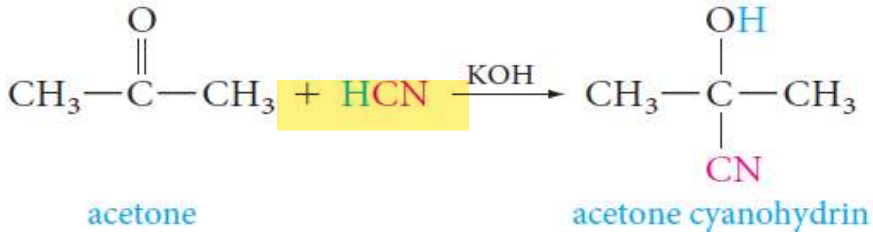
2) Addition of Hydrogen Cyanide: Formation of Cyanohydrins

- Hydrogen cyanide adds to the carbonyl group of aldehydes and ketones to form cyanohydrins, compounds with a hydroxyl and a cyano group attached to the same carbon.

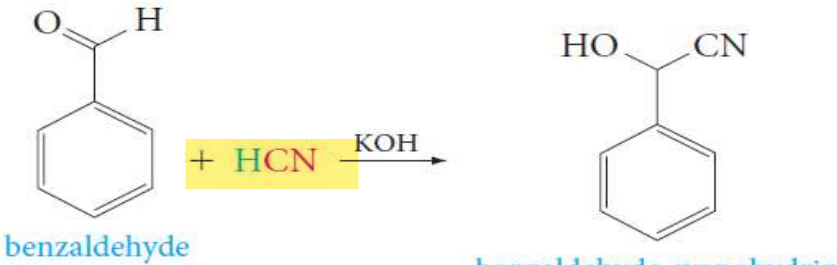


a cyanohydrin

- **Example**



acetone — acetone cyanohydrin



benzaldehyde — benzaldehyde cyanohydrin

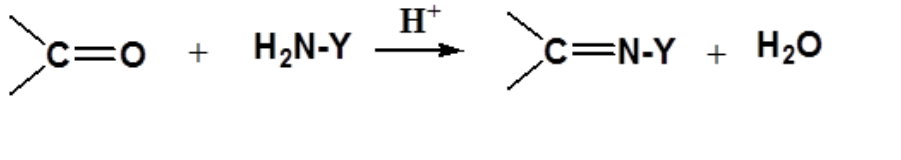
Reactions of Aldehydes and Ketones

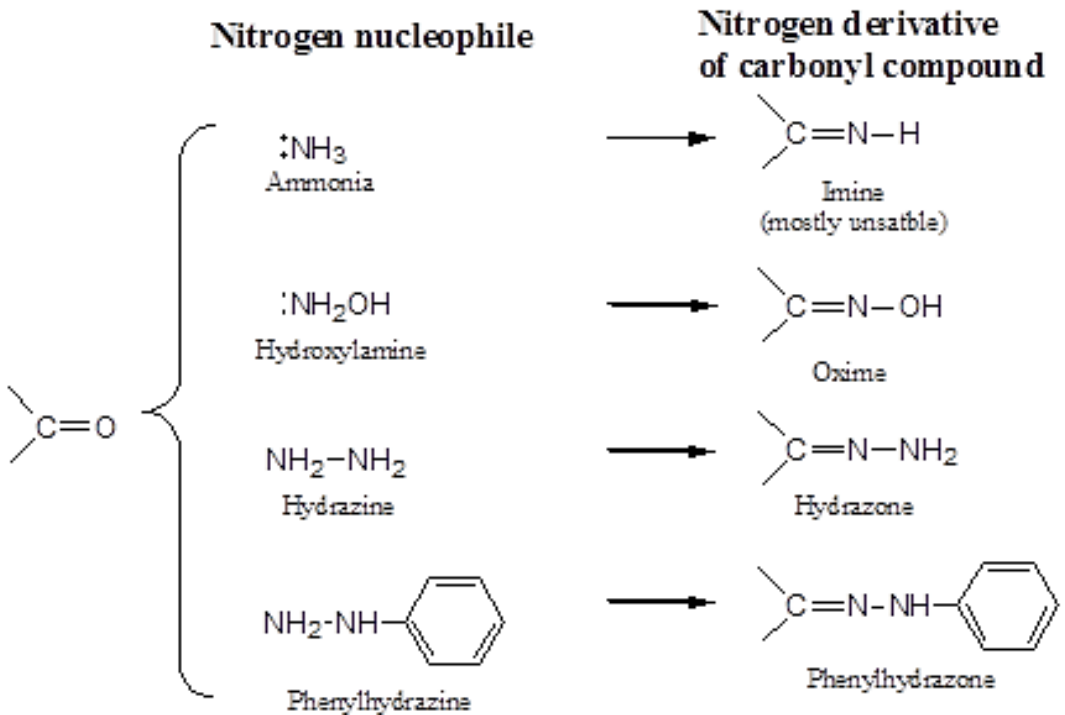
C) Nucleophilic Addition Reactions

وهو ببساطة إضافة النيتروجين و مشتقاته و بيعطوا Imiens و مركبات أخرى

3) Addition of Ammonia and Ammonia Derivatives

The addition of nitrogen nucleophile, such as ammonia(NH_3) and substituted ammonia (NH_2-Y).





أشخاص قد تعرفهم في الفاينل

Aldehydes & Ketones – MCQs and True/False

Q1. Which of the following functional groups characterizes aldehydes?
A) –CO–
B) –CHO
C) –COOH
D) –OH

Q2. In aldehydes and ketones, the carbonyl carbon is:
A) sp
B) sp^2
C) sp^3
D) not hybridized

Q3. The C=O bond is more polar than the C=C bond because:
A) Carbon is more electronegative
B) Oxygen is more electronegative
C) Carbon has lone pairs
D) Oxygen is less electronegative

Q4)
Which compound is a ketone?
A) CH_3CHO
B) $HCHO$
C) CH_3COCH_3
D) C_6H_5CHO

Q5. The –CHO group is called:
A) Acetyl group
B) Carbonyl group
C) Formyl group
D) Hydroxyl group

Q6. Aldehydes are named by replacing the suffix:
A) -ane with -one
B) -ol with -al
C) -e with -al
D) -e with -one

Q7. Numbering in aldehydes starts from:
A) Any end
B) The longest chain
C) The carbonyl carbon
D) The methyl group

Q8. Which has higher priority?
A) Ketone
B) Alcohol
C) Alkene
D) Aldehyde

Q9. Carbonyl group consists of:
A) Two sigma bonds
B) One sigma and one pi bond
C) Two pi bonds
D) One sigma bond

Q10. Higher boiling points of aldehydes are due to:
A) Hydrogen bonding

B) Ionic bonding
C) Dipole–dipole interactions
D) Covalent bonding

Q11. Which cannot hydrogen bond with itself?
A) Alcohol
B) Aldehyde
C) Carboxylic acid
D) Amine

Q12. Oxidation of secondary alcohol gives:
A) Aldehyde
B) Ketone
C) Acid
D) Alkene

Q13. Hydration of acetylene gives:
A) Acetone
B) Ethanol
C) Acetaldehyde
D) Formaldehyde

Q14.
Which reagent is commonly used to reduce aldehydes and ketones?
A) $KMnO_4$
B) CrO_3
C) $LiAlH_4$
D) H_2SO_4

Q15. Which is easily oxidized?
A) Ketone
B) Aldehyde
C) Ether
D) Alkane

T/F16. A ketone has a hydrogen on the carbonyl carbon.

T/F17. The carbonyl carbon is electrophilic.

T/F18. Aldehydes are planar around C=O.

T/F19. Ketones oxidize easily to acids.

T/F20. Low MW aldehydes are water soluble.

T/F21. Grignard reagents are nucleophiles.

T/F22. Formaldehyde + Grignard $\rightarrow$ tertiary alcohol.

T/F23. Cyanohydrins form from HCN addition.

T/F24. Nucleophile attacks oxygen in C=O.

T/F25. Ketone reduction gives secondary alcohol.

Answer Key

1. B
2. B
3. B
4. C
5. C
6. C
7. C
8. D
9. B
10. C
11. B
12. B
13. C
14. C
15. B
16. False
17. True
18. True
19. False
20. True
21. True
22. False
23. True
24. False
25. True