

Pioneer Junior College
Higher 2 Chemistry (9647)
Organic Chemistry
Carbonyl Compounds (Tutor's Copy)

References

- 1 Organic Chemistry (6th Edition) – J. McMurry; *Brooks / Cole*
- 2 Chemistry for Advanced Level, Peter Cann Peter Hughes

Syllabus Content

- Aldehydes (exemplified by ethanal)
 - (i) Oxidation to carboxylic acid
 - (ii) Reaction with hydrogen cyanide
 - (iii) Characteristic tests for aldehydes
- Ketones (exemplified by propanone and phenylethanone)
 - (i) Reaction with hydrogen cyanide
 - (ii) Characteristic tests for ketones

Assessment Objectives

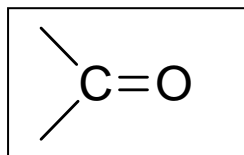
You should be able to:

- (a) describe the formation of aldehydes and ketones from, and their reduction to, primary and secondary alcohols respectively
- (b) describe the mechanism of the nucleophilic addition reactions of hydrogen cyanide with aldehydes and ketones
- (c) describe the use of 2,4-dinitrophenylhydrazine (2,4-DNPH) to detect the presence of carbonyl compounds
- (d) deduce the nature (aldehyde or ketone) of an unknown carbonyl compound from the results of simple tests (i.e. Fehling's and Tollens' reagents; ease of oxidation)
- (e) describe the reaction of $\text{CH}_3\text{CO}-$ compounds with alkaline aqueous iodine to give triiodomethane

Lecture outline

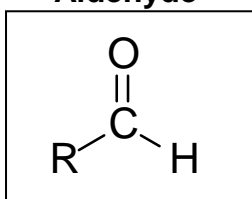
- 1 Introduction
- 2 Physical properties of aldehydes and ketones
- 3 Preparation of aldehydes and ketones
- 4 Reactions of carbonyl compounds
 - 4.1 Nucleophilic addition of HCN
 - 4.2 Condensation: Test for carbonyl compounds
 - 4.3 Reduction to alcohols
 - 4.4 Oxidation of aldehydes
 - 4.5 Triiodomethane (iodoform) reaction
 - 4.6 Distinguishing Tests
- 5 Uses of carbonyl compounds

1 Introduction – what are aldehydes and ketones?



Carbonyl compounds contain the C=O functional group (called carbonyl group). The two simplest classes of carbonyl compounds are **aldehydes** and **ketones** with the following structures:

Aldehyde

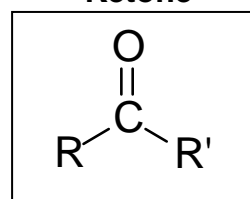


$R = H$ or alkyl or aryl group

Have **at least one H atom** directly bonded to carbonyl carbon

(Note: CHO group is always a **terminal** group in formula)

Ketone

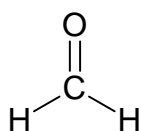


$R, R' =$ alkyl or aryl group

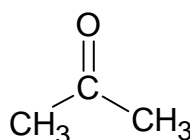
Have **two alkyl / aryl groups** bonded to carbonyl carbon

Quick Check 1

Give the structures of the aldehyde and ketone with the smallest number of carbon atoms.



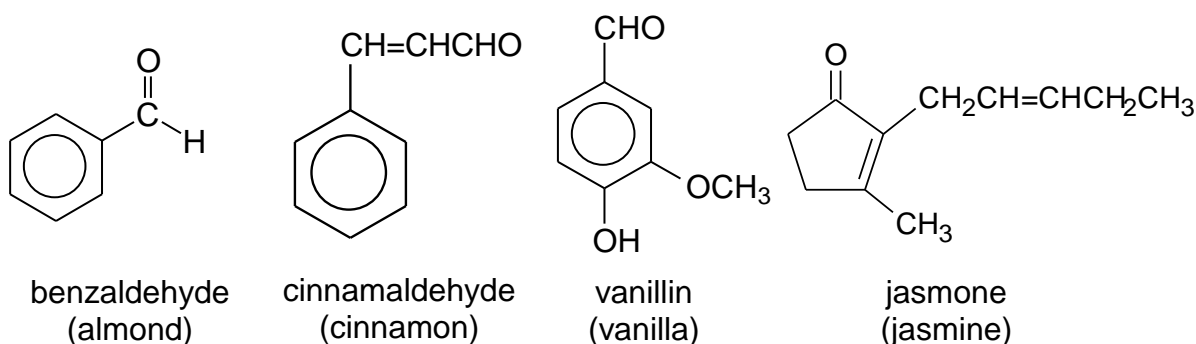
Methanal is the aldehyde with the smallest number of C atom (ie. 1).



Propanone is the ketone with the smallest number of C atom (ie. 3).

1.1 Common aldehydes and ketones found in our daily lives

Carbonyl compounds are of great importance in biochemistry as they are the main structural features of biologically important carbohydrates and other natural compounds. Having distinctive smells, aldehydes and ketones of higher molecular mass are used as flavouring and perfuming agents. Some carbonyl compounds with pleasant smells are shown on the next page.

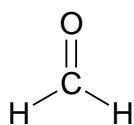


1.2 Nomenclature

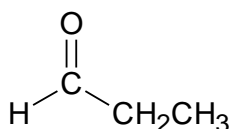
(a) Aldehydes

- Aldehydes are named by replacing the terminal 'e' of the '-ane' of the alkane name (with the same number of C atoms) with '-al'.

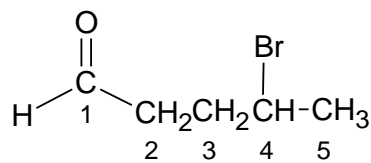
Example



methanal



propanal



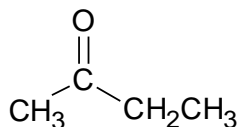
4-bromopentanal

- Parent carbon chain must contain the -CHO group and the -CHO carbonyl carbon is numbered as carbon 1.

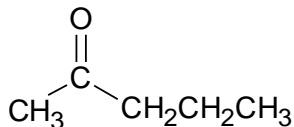
(b) Ketones

- Ketones are named by replacing the terminal 'e' of the '-ane' of the alkane name (with the same number of C atoms) with '-one'.
- The parent chain is the longest one that contains the ketone group.
- Numbering begins at the end nearer the carbonyl carbon.
- If necessary, add a number to indicate position of the carbonyl group.

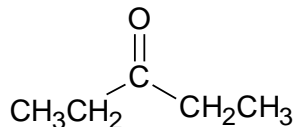
Example



butanone
(no ambiguity;
numbering not
required)

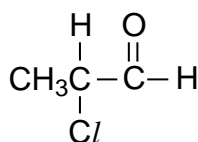


pentan-2-one
(not pentan-4-one)

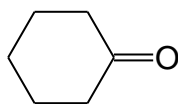


pentan-3-one

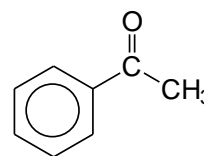
Quick-check 2: Name the following compounds



2-chloropropanal



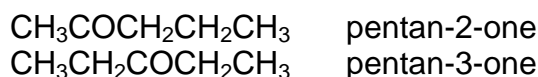
cyclohexanone



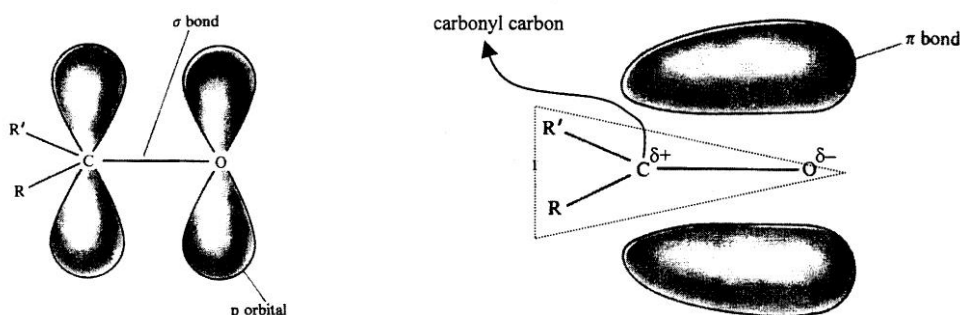
phenylethanone

1.3 Isomerism

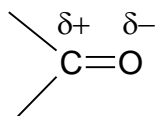
- Aldehydes and ketones have the general formula $\text{C}_n\text{H}_{2n}\text{O}$.
- Functional group isomerism** is possible when saturated aliphatic aldehydes and ketones have the same molecular formula. E.g. both propanal ($\text{CH}_3\text{CH}_2\text{CHO}$) and propanone (CH_3COCH_3) have the molecular formula $\text{C}_3\text{H}_6\text{O}$.
- Aldehydes and ketones can also be considered as **positional isomers** of each other.
- In propanal, $\text{CH}_3\text{CH}_2\text{CHO}$, the functional group (carbonyl) is on position 1 of the chain, whereas in propanone, CH_3COCH_3 , it is on position 2.
- Positional isomerism** is possible for ketones only: the carbonyl group may occur at different positions along the alkyl chain.



1.4 Nature of the carbonyl group



- The carbonyl C atom (sp^2 hybridised) of a carbonyl compound forms 3 σ bonds, which are coplanar.
- The unhybridised p orbital of the C atom overlaps **side-ways** with one of the half-filled p orbital of the O atom to form a π bond.
- Because of its larger electronegativity, the oxygen atom attracts the bonding electrons (in both σ and π bonds). This creates an electron deficient carbon (with $\delta+$ charge) and a permanent dipole is set up as shown.



The dipole in the carbonyl group not only affects the physical properties of aldehydes and ketones. It is also responsible for the chemical reactions of these compounds.

2 Physical properties of aldehydes and ketones

2.1 Boiling Point

Class of compound	Compound	M_r	Boiling Point / °C	Type of intermolecular forces overcome in boiling
Alkane	Butane $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$	58	0	van der Waals'
Aldehyde	Propanal $\text{CH}_3\text{CH}_2\text{CHO}$	58	48	permanent dipole-dipole
Ketone	Propanone CH_3COCH_3	58	56	permanent dipole-dipole
Alcohol	Propan-1-ol $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$	60	97	hydrogen bonds

Question

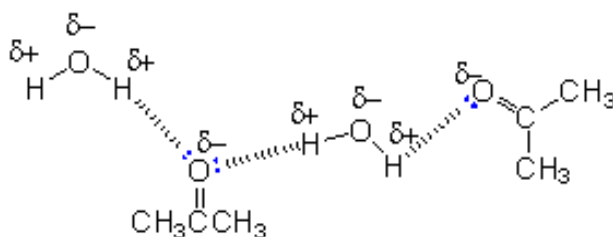
Why do carbonyl compounds have higher boiling points than alkanes of comparable M_r , but lower boiling points than alcohols?

- Ketones and aldehydes are **polar** due to the permanent dipole of $\text{C}=\text{O}$ group \Rightarrow permanent dipole-dipole (pdd) intermolecular forces of attraction
 - **Alkanes** are non-polar \Rightarrow weak van der Waals' forces between alkane molecules
 - As pdd attractions are **stronger** than weak van der Waals' forces, **more** energy is needed to overcome pdd intermolecular attractions of aldehydes & ketones, they thus have **higher** boiling points.
 - Ketones and aldehydes have lower boiling points than alcohols (in which hydrogen bonding occurs).
- \Rightarrow Since pdd attraction is **weaker** than hydrogen bonding in alcohols, **less** energy is required to overcome pdd forces, thus carbonyl compounds have lower boiling points than alcohols.

(Note: carbonyl compounds do not form hydrogen bonding between their molecules because they do not contain hydrogen atoms that have a large enough δ^+ charge as they do not have hydrogen atom directly bonded to N, O or F atom.)

2.2 Solubility in water

- The lower aliphatic aldehydes and ketones are soluble in water, as they are able to form hydrogen bonds with water molecules.



Hydrogen bonding between propanone and water molecules

- Solubility of the higher aldehydes and ketones decreases with increasing of number of carbon atoms. Higher members containing more than 5 carbons, and the aromatic compounds, are virtually insoluble in water. Why?

Answer: As number of carbon atoms increases, the hydrophobic non polar alkyl groups become larger, van der Waals forces between molecules become predominant and the alkyl groups can get in the way of the formation of hydrogen bonds with water molecules.

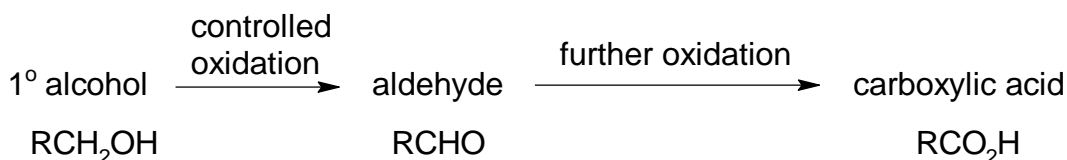
Candidates should be able to describe the formation of aldehydes and ketones from primary and secondary alcohols respectively.

3 Preparation of aldehydes and ketones

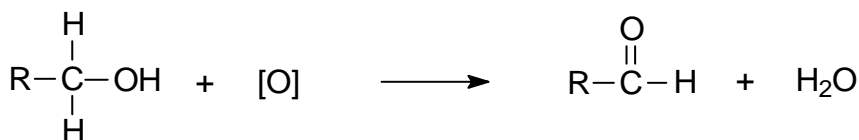
Oxidation of alcohols (Refer to *Hydroxy Compounds* lecture notes)

3.1 Preparation of aldehyde: controlled oxidation of primary (1°) alcohols`

- Primary alcohols are easily oxidised to aldehydes (which are in turn oxidised to carboxylic acids):



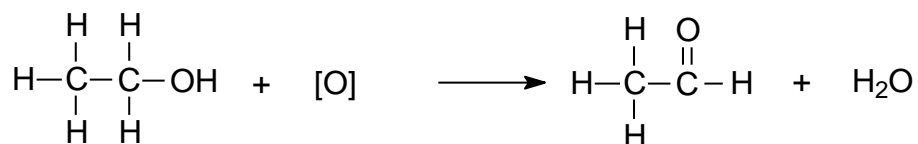
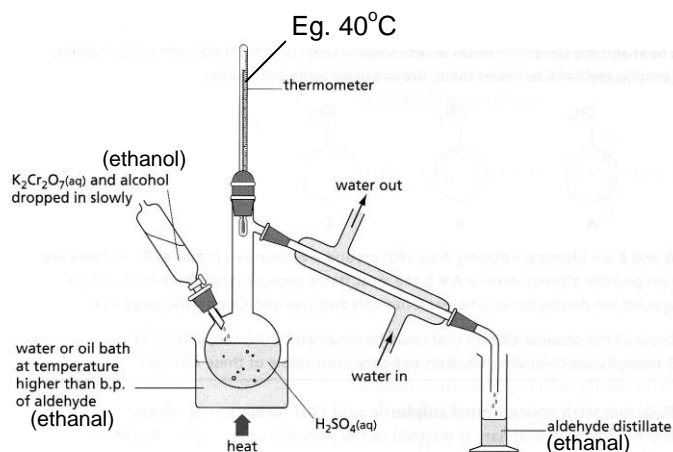
- Controlled oxidation of 1° alcohol will give the corresponding aldehyde.



Reagent and conditions: $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$, $\text{H}_2\text{SO}_4(\text{aq})$, **distil**

Observation: Orange solution ($\text{Cr}_2\text{O}_7^{2-}$) turns green (Cr^{3+})

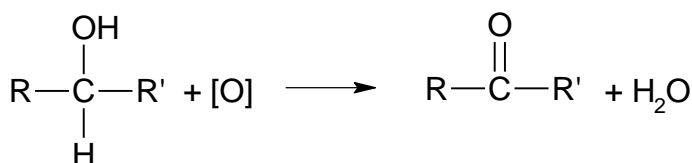
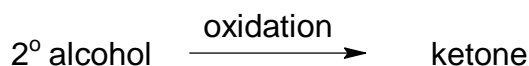
Note: Acidified KMnO_4 should **not** be used as it is too powerful an oxidising agent to stop oxidation at the aldehyde: it oxidises 1° alcohols to carboxylic acids.

Example: Oxidation of ethanol to ethanal**Preparation of ethanal:** (an illustration of how distillation is performed)

- Ethanol and sodium dichromate(VI) are added to hot sulfuric acid.
- Once the ethanal is formed, it is **distilled** off (Note: ethanal has a lower boiling point than ethanol or ethanoic acid. Why?)
- Temperature is maintained between the boiling points of ethanal (21°C) and ethanol (78°C) to ensure that no ethanol or ethanoic acid (118°C) is distilled out and collected as a liquid (receiving tube is placed in ice bath).
⇒ Thus, only ethanal is distilled out as a distillate.
- Ethanol stays in solution until it is oxidised.
- Pure ethanal can be obtained by redistillation.

3.2 Preparation of ketones

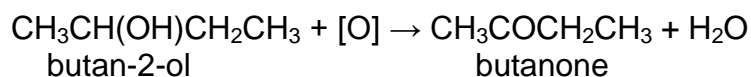
Method 1: Ketones are prepared by oxidising 2° alcohols.



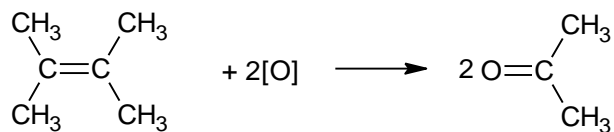
Reagent and conditions: K₂Cr₂O₇(aq) or KMnO₄, H₂SO₄(aq), heat

Observation: Orange solution (Cr₂O₇²⁻) turns green (Cr³⁺)
or Purple solution (MnO₄⁻) turns colourless (Mn²⁺).

Example



Method 2: Oxidative cleavage of alkenes (less common)



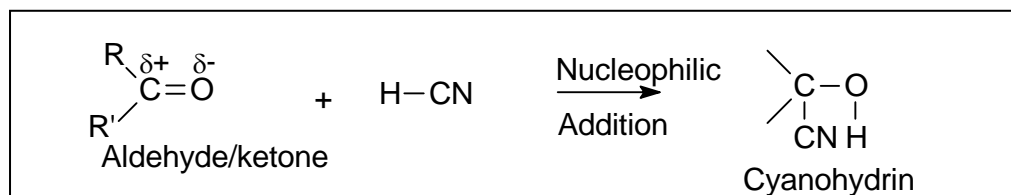
Reagent: $\text{KMnO}_4(\text{aq})$ with $\text{H}_2\text{SO}_4(\text{aq})$

Condition: Heat

Observation: Purple solution (MnO_4^-) turns colourless (Mn^{2+})

4 Chemical reactions of aldehydes and ketones

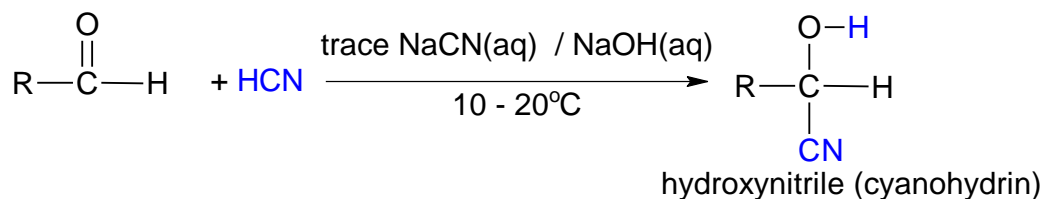
- Like the C=C in alkenes, the C=O group is unsaturated. It can undergo addition reaction to form saturated compounds.
- As mentioned in Section 1.4, the C=O group is polar. The partially positively charged ($\delta+$) C atom of the C=O group is susceptible to attack by nucleophiles.
- A nucleophile is a substance that is “nucleus-loving”. Remember that a nucleus is positively charged.
- Nucleophiles are molecules or anions with at least one lone pair of electrons (they are attracted to a positive or partial positive atom). Examples of nucleophiles include :NH₃, H₂O:, :OH⁻, :CN⁻ and :H⁻
- The electron-rich nucleophiles are readily attracted to $\delta+$ carbon and add to the unsaturated C=O double bond.
- You will study the nucleophilic addition (e.g. of H-CN) to carbonyl group:



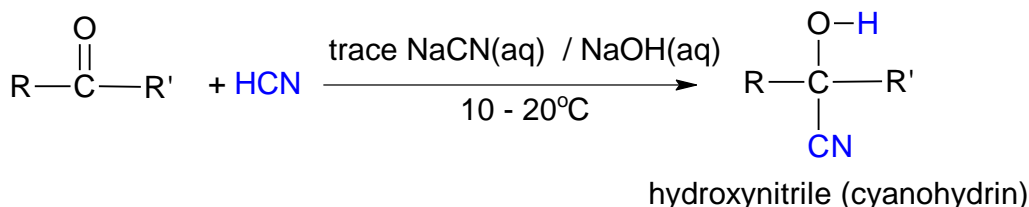
R and R': either alkyl/aryl group or H (depending on whether it is aldehyde/ketone)

4.1 Nucleophilic Addition with HCN

Aldehydes



Ketones



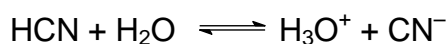
Reagent and conditions: HCN, trace amount of NaCN(aq) or NaOH(aq), 10 - 20°C

- Aldehydes and ketones react with hydrogen cyanide (HCN) in the presence of a trace amount of NaOH or NaCN to form hydroxynitrile (commonly known as cyanohydrin).
- This reaction is important for **increasing** the number of carbon atoms in an aldehyde/ketone.

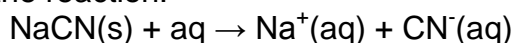
Candidates should be able to: describe the mechanism of the nucleophilic addition reactions of hydrogen cyanide with aldehydes and ketones.

4.1.1 Mechanism: Nucleophilic addition of HCN

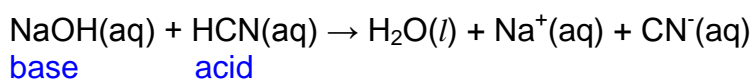
- Hydrogen cyanide HCN is a weak acid that dissociates *partially* in water, thus it is a very poor source of CN^- .
- With a low concentration of CN^- , the reaction will be very slow ([relationship between concentration and rate taught later in "Kinetics"](#)).



- Thus trace amount of NaCN is added to provide an additional source of CN^- to speed up the reaction.



- Alternatively, trace amount of NaOH can be added to react with HCN via an acid-base reaction. This also generates CN^- for reaction.



Mechanism of nucleophilic addition

Generation of nucleophile: $\text{NaCN(s)} + \text{aq} \rightarrow \text{Na}^+(\text{aq}) + \text{CN}^-(\text{aq})$

Step 1

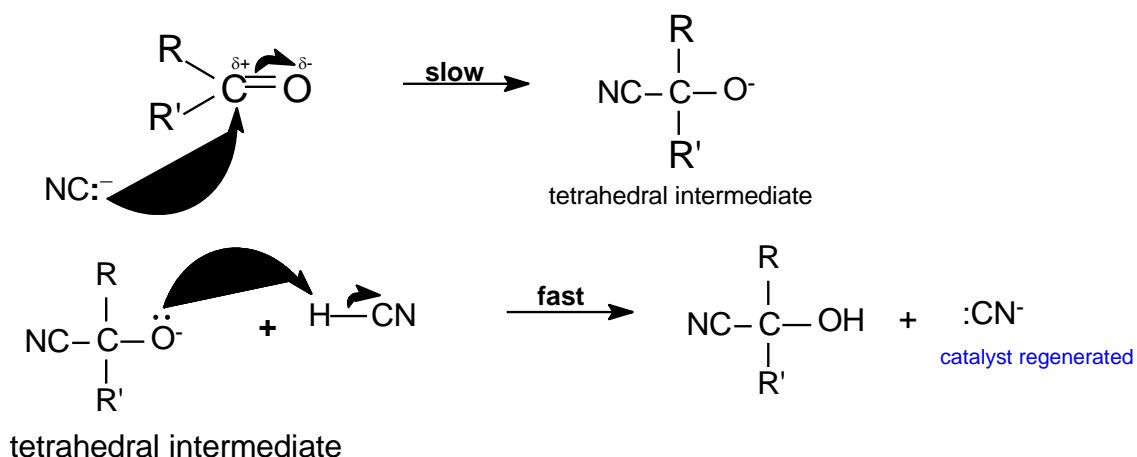
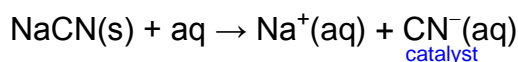
- In the first step, nucleophile :CN^- attacks δ^+ carbonyl carbon
- This repels the electron pair of the carbon-oxygen π -bond away from the carbonyl C atom towards the more electronegative O atom, breaking π bond, and forming a new σ bond between C of CN^- and the C atom of carbonyl group. (**SLOW**)
- Thus, forming a tetrahedral intermediate anion, an alkoxide ion.

Step 2

- The negatively charged oxygen in tetrahedral intermediate will **accept H^+** readily by attacking an undissociated HCN molecule, regenerating the CN^- catalyst.

Important! Make sure you are able to give this mechanism.

Mechanism name: Nucleophilic addition



4.1.1.1 Stereochemistry of nucleophilic addition

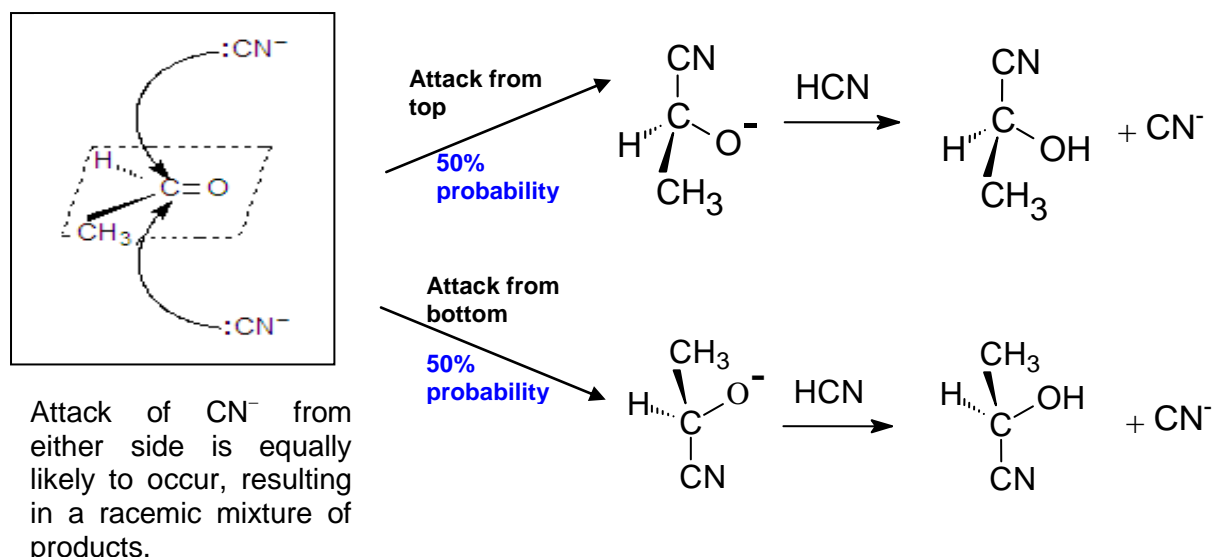
Question

Do you think the product obtained from the reaction between ethanal and HCN will show any optical activity?

Answer:

No. This is because the product obtained is a **racemic mixture**.

- Since the C=O group is **planar**, there is an **equal** chance of the nucleophile attacking the carbonyl carbon from the **top** as well as from the **bottom**.
- If a *chiral centre* is created during the nucleophilic addition reaction, this results in the formation of equimolar quantities of the two enantiomers (optical isomers), forming a **racemic mixture**.
- Thus, the lack of net optical activity.



- Why are aldehydes more susceptible to nucleophilic addition than ketones?
(Similar to 2007 "A" level exam P3 Question 4(b)(iv)).

The two reasons to this are given below.

- 1 The presence of two electron-donating alkyl groups in ketones reduces the partial positive charge on the carbonyl carbon atom, making it less susceptible to nucleophilic attack.
- 2 The presence of two bulky alkyl groups in ketones causes steric hindrance to the approach of attacking nucleophile.

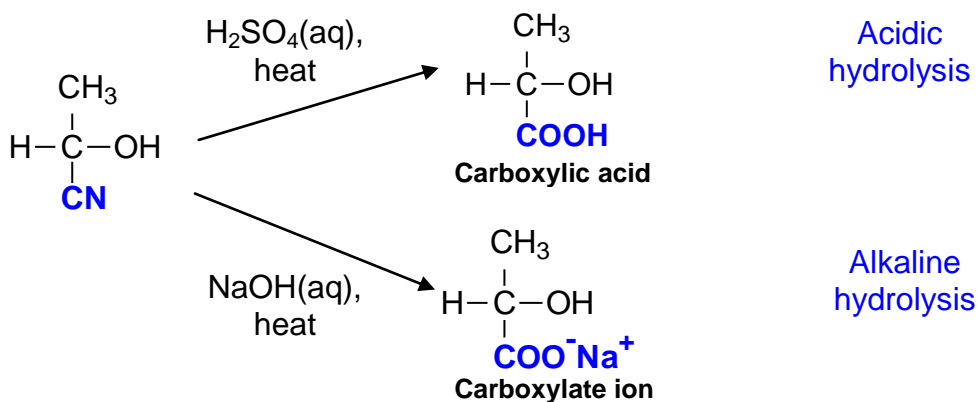
4.1.2 Usefulness of cyanohydrin

- Besides increasing the carbon chain of a molecule by 1 carbon atom, cyanohydrin formation provides a useful method to convert an aldehyde or ketone into different functional groups (OH & CN bonded to the same carbon).

- The nitrile group ($-\text{C}\equiv\text{N}$) can undergo 2 main types of reactions:
 - Hydrolysis
 - Reduction

(a) Hydrolysis of nitrile

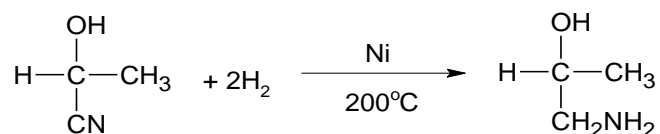
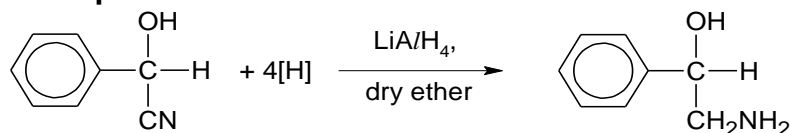
- The nitrile group can be hydrolysed by mineral acids or alkali to give a carboxylic acid or a carboxylate salt respectively.



(b) Reduction of nitrile

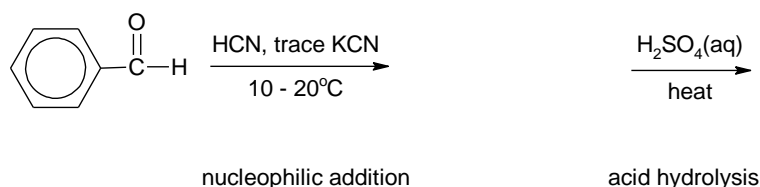
- The nitrile group can be reduced to give an amine.
- One reducing agent that can be used is LiAlH_4 in dry ether. Reduction can also be carried out using H_2 , Ni catalyst at 200°C .

Example



Quick Check 3

Draw the structures of the products. State the type of reaction undergone.



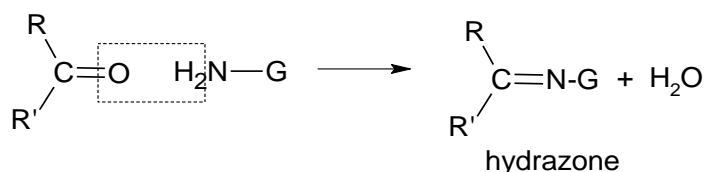
Important note: In addition to nucleophilic addition of HCN to aldehydes and ketones, you must know the addition of Grignard reagent to aldehydes and ketones (See Tutorial Q7)

Candidates should be able to describe the use of 2,4-dinitrophenylhydrazine (2,4-DNPH) to detect the presence of carbonyl compounds.

4.2 Condensation reaction with hydrazine compounds

Condensation reaction involves 2 compounds undergoing an *addition* reaction accompanied by *elimination* of H₂O / other small molecule e.g. HCl, NH₃.

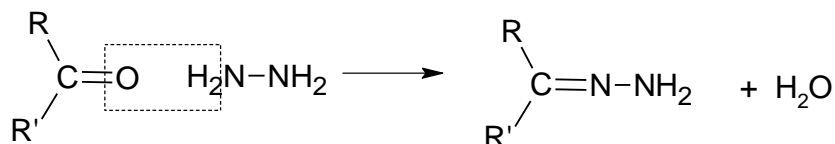
- Nitrogen containing nucleophiles readily add to carbonyl compounds. But the initially formed addition compounds cannot be isolated as they readily lose H₂O (*elimination*) to give stable compounds containing a C=N bond.
- Thus carbonyl compounds undergo condensation reactions with hydrazine and its derivatives. A water molecule is eliminated.



R, R' = H, alkyl or aryl group and G = various groups

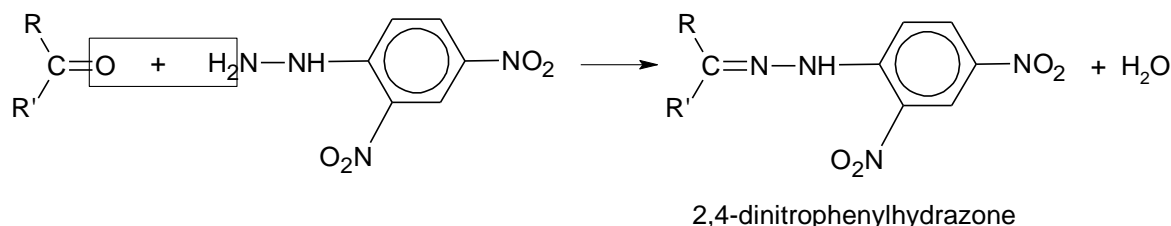
Example

1 Reaction of carbonyl compounds with hydrazine, H₂N-NH₂



2 Reaction with 2,4-dinitrophenylhydrazine (Brady's reagent) – an important test for carbonyl compounds

- Only aldehydes and ketones undergo condensation with 2,4-dinitrophenylhydrazine to produce 2,4-dinitrophenylhydrazone, an orange crystalline solid / precipitate.
- This is used to test for presence of aldehydes or ketones.**



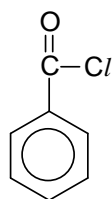
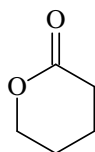
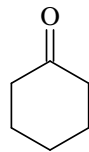
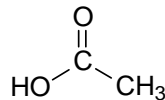
Reagent: 2,4-dinitrophenylhydrazine

Observation: Orange precipitate of 2,4-dinitrophenylhydrazone formed.

- The actual identity of the aldehyde or ketone can be determined by measuring the melting point of the 2,4-dinitrophenylhydrazone formed.

Quick Check 4

Which of the following compounds will give an orange precipitate with 2,4-dinitrophenylhydrazine reagent?

**A****B****C****D**

Ans:

Candidates should be able to describe the reduction of aldehydes and ketones to primary and secondary alcohols respectively.

4.3 Reduction of aldehydes / ketones to alcohols

- There are 3 main ways to reduce aldehydes to primary alcohols and ketones to secondary alcohols respectively.

(1) H_2 , Ni catalyst, 200°C .

Hydrogen adds across the carbonyl group, reducing aldehydes to primary alcohols and ketones to secondary alcohols.

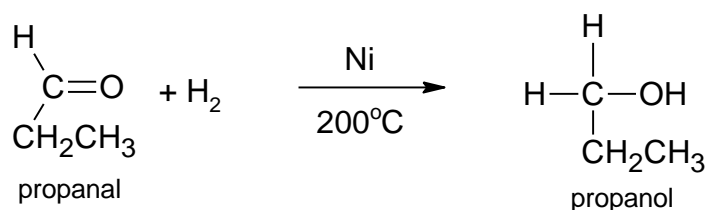
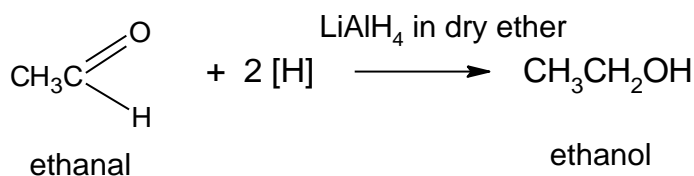
Other methods (laboratory) used:

(2) LiAlH_4 in dry ether

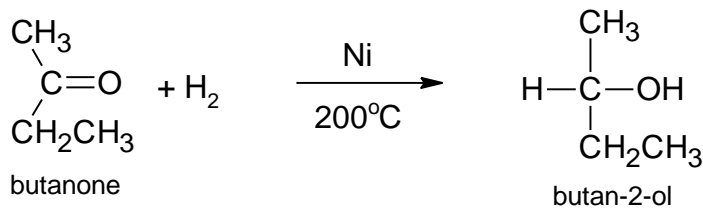
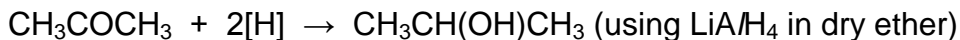
(3) A less powerful reducing agent, NaBH_4 in methanol can also be used.

Example**(a) Reduction of aldehydes to give 1° alcohols**

Examples:



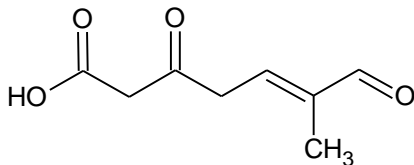
(b) Reduction of ketones to give 2° alcohols



Limitations of reducing agents

- (a) LiAlH_4 in dry ether CANNOT reduce alkenes ($\text{C}=\text{C}$). Why?
 (b) H_2 , Ni and 200°C CANNOT be used to reduce carboxylic acids.
 (c) NaBH_4 in methanol can ONLY be used to reduce aldehydes or ketones.

Question: Draw the structure of the product formed when compound **A** shown below is subjected to



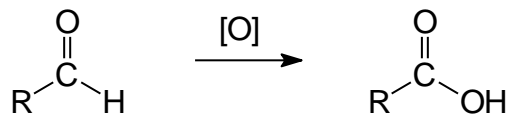
Compound A

- (a) LiAlH_4 in dry ether
- (b) H_2 , Ni and 200°C
- (a) NaBH_4 in methanol

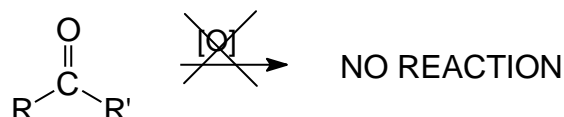
Candidates should be able to: deduce the nature (aldehyde or ketone) of an unknown carbonyl compound from the results of simple tests (i.e. Fehling's and Tollens' reagents; ease of oxidation)

4.4 Oxidation of aldehydes

- An aldehyde has a **hydrogen atom** bonded **directly** to the carbonyl carbon. This enables it to be readily oxidised to **carboxylic acids**.



- Ketones are not oxidised because they do not have a hydrogen atom directly attached to the C=O group.



- This difference in ease of oxidation provides a way to distinguish aldehydes from ketones.
- We will study the oxidation of aldehydes by the following oxidising agents:

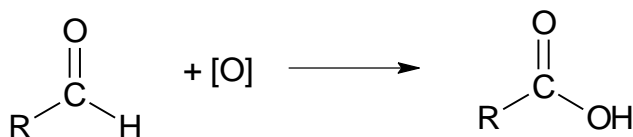
(a) acidified KMnO_4 or acidified $\text{K}_2\text{Cr}_2\text{O}_7$

(b) Tollens' reagent

(c) Fehling's solution

4.4.1 Oxidation of aldehyde by acidified KMnO_4 / acidified $\text{K}_2\text{Cr}_2\text{O}_7$

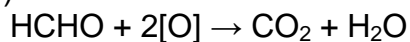
- Aldehydes are easily oxidised by acidified KMnO_4 or $\text{K}_2\text{Cr}_2\text{O}_7$ to yield carboxylic acids.



Reagent and conditions: $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ or KMnO_4 , with $\text{H}_2\text{SO}_4(\text{aq})$, heat

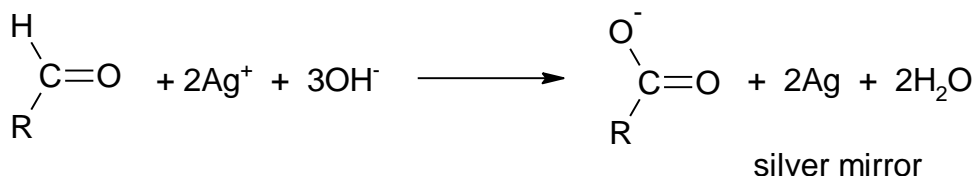
Observation: Orange solution ($\text{Cr}_2\text{O}_7^{2-}$) turns green (Cr^{3+})
or Purple solution (MnO_4^-) turns colourless (Mn^{2+})

- In the **special** case of methanal, HCHO , it will first be oxidised to methanoic acid, HCO_2H which is further oxidised to give CO_2 (*Refer to later topic: Carboxylic acids*)



4.4.2 Oxidation of aldehyde by Tollens' Reagent

- **Tollens' Reagent:** Colourless solution containing complexed Ag^+ ions: $[\text{Ag}(\text{NH}_3)_2]^+$ - formed from aqueous AgNO_3 with excess aqueous ammonia, thus it is also known as ammoniacal silver nitrate.
- **All** aldehydes can be oxidised by Tollens' reagent to the corresponding carboxylate ion while the silver(I) ion is reduced to silver metal which appears as a silver mirror or a grey precipitate.



Reagent and conditions: Tollens' reagent and warm

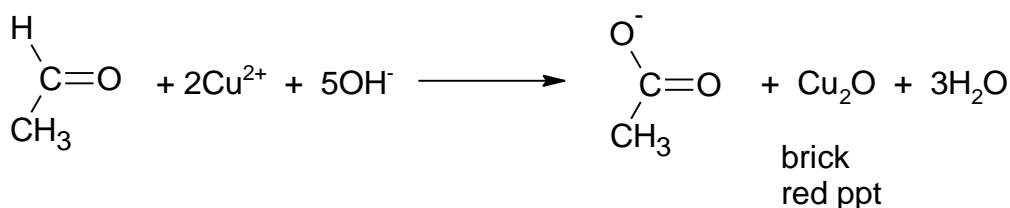
Observation: Silver mirror formed.

- Silver metal formed on test-tube wall gives the appearance of a **silver mirror**.
- Tollens' reagent oxidises **ALL aldehydes (-CHO group)** to form silver mirror.

- As ketones cannot be oxidised, this can be used to distinguish between aldehydes and ketones.

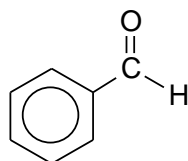
4.4.3 Oxidation of aldehyde by Fehling's Solution

- **Fehling's Solution:** Blue alkaline solution of complexed Cu(II) ions
- [Prepared by mixing equal volumes of Fehling's A (CuSO_4 solution) and Fehling's B (sodium potassium tartrate)]
- All aldehydes, **except benzaldehyde**, can be oxidised by Fehling's solution to the corresponding carboxylate ion while the copper(II) ion is reduced to give copper(I) oxide, Cu_2O which is a brick-red precipitate.



Reagent and conditions: Fehling's solution and warm

Observation: Brick-red precipitate of Cu_2O formed.



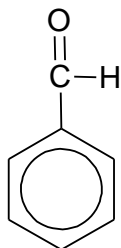
Benzaldehyde has **NO** reaction with Fehling's solution.

NOTE: Fehling's solution is a *milder* oxidising agent (than Tollens'), that it oxidizes **ALL aldehydes except benzaldehyde**

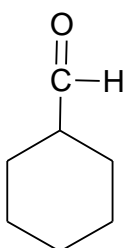
- Besides using this test to distinguish between aldehydes and ketones, it can be used to distinguish between benzaldehyde and aliphatic aldehydes.

Quick Check 5

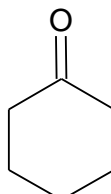
Which of the following compounds will form a brick-red precipitate with Fehling's reagent?



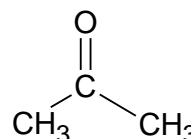
A



B



C



D

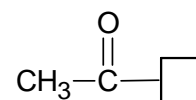
Summary: Reaction of Tollens' reagent & Fehling's solution with carbonyl compounds

Carbonyl Cpd Test	Any aldehyde (except benzaldehyde)	Benzaldehyde	Ketone
Tollens' reagent, warm	Silver mirror of Ag	Silver mirror of Ag	No silver mirror
Fehling's solution, warm	Brick red precipitate of Cu ₂ O	No brick red precipitate	No brick red precipitate

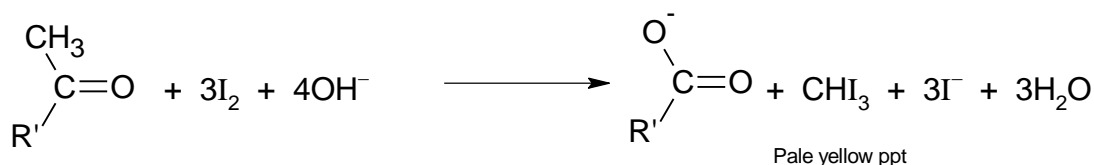
Candidates should be able to describe the reaction of CH₃CO– compounds with alkaline aqueous iodine to give tri-iodomethane

4.5 Triiodomethane (iodoform) reaction

- When aldehydes or ketones with a **methyl carbonyl group**, are warmed with alkaline aqueous iodine, a **yellow** precipitate (triiodomethane, CHI₃) forms.



(Note:  represents either H or alkyl/aryl group)



(where R' is H, alkyl or aryl group)

Reagent and conditions: I₂(aq), NaOH(aq), warm

Observation: Yellow precipitate of CHI₃ observed.

Type of reaction: Oxidation

- A method often used to distinguish carbonyl compounds with a methyl carbonyl $\begin{array}{c} \text{O} \\ || \\ \text{CH}_3-\text{C}- \end{array}$ group from the others.
- The iodoform reaction can also be used to **shorten** a carbon chain **by 1 carbon** atom, by breaking a C–C bond and **removing a methyl (CH₃)** group.

Note:

Alcohols containing the $\begin{array}{c} \text{OH} \\ | \\ \text{R}-\text{C}-\text{CH}_3 \\ | \\ \text{H} \end{array}$ structure will also give a positive iodoform test.

(Refer to 2014 *Hydroxy Compounds* lecture notes section 5.5 pg 14).

4.6 Distinguishing Tests

To distinguish aldehydes/ ketones from other groups of organic compounds

- Use 2,4-dinitrophenylhydrazine (orange precipitate observed for aldehydes and ketones only)

To distinguish **between** aldehydes and ketones

- Use Tollens' reagent and warm (positive for all aldehydes – silver mirror)
- Use Fehling's solution and warm (positive test - brick red precipitate for all aldehydes except benzaldehyde)
- Use K₂Cr₂O₇ and H₂SO₄(aq) and heat (positive for aldehydes – orange solution turns green)
- Use KMnO₄ and H₂SO₄(aq) and heat (positive for aldehydes – purple solution is decolourised.)

To identify methyl carbonyl compounds with $\begin{array}{c} \text{O} \\ || \\ \text{CH}_3-\text{C}-\square \end{array}$

- Use I₂(aq) and NaOH(aq) and warm. A yellow precipitate of CHI₃ is formed.

To identify methanal, HCHO (special case of aldehyde)

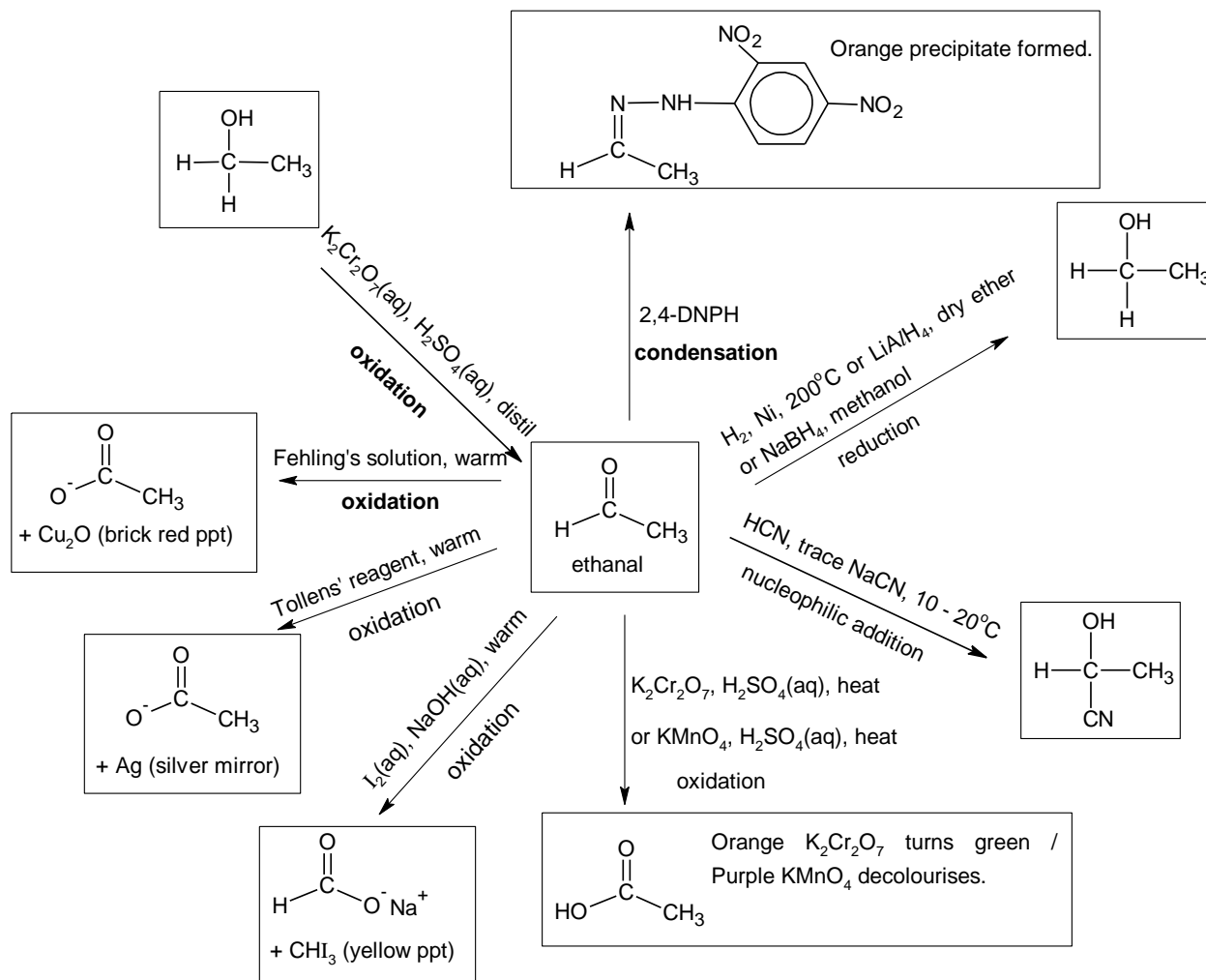
- When heated with KMnO_4 and H_2SO_4 , methanal decolourises purple KMnO_4 . Colourless gas (CO_2) evolved gives a white precipitate with limewater.
- Use Fehling's solution and warm. Methanal gives a deposit of pink copper metal.

5 Uses of carbonyl compounds

Carbonyl Compounds	Uses
Methanal, HCHO	It is used with phenol to make Bakelite, a heat insulator. Formalin is a 40% solution of methanal in water used to preserve biological specimen.
Ethanal, CH_3CHO	It is used as a starting organic compound for the production of ethanoic acid and DDT.
Butanal, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$	It gives a buttering smell and is used in margarine.
Propanone, CH_3COCH_3	It is widely used as an industry solvent and in making Perspex.
Benzaldehyde, $\text{C}_6\text{H}_5\text{CHO}$	It is used in small amount in perfumes and flavourings.

Summary

Reactions involving aldehyde (exemplified by ethanal)



Reaction involving ketone (exemplified by propanone)

