3055 BA SANGAM COLLEGE

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WORKSHEET 18

School: Ba Sangam College **Year:** 13
Subject: Chemistry **Name:**

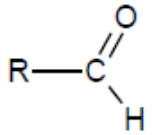
Strand	**4 - Materials**
Sub strand	**4.2- Organic Chemistry**
Content Learning Outcome	**-Recognise the carbonyl group of the aldehyde and ketones.** **-State the general formula of aldehydes and ketones and name them using IUPAC nomenclature.** **-Recognise the structural difference between aldehydes and ketones.** **-Describe the preparation of aldehydes and ketones.**

Aldehydes and Ketones

Aldehydes and ketones have the **carbonyl** (**C=O**) functional group.

Aldehydes

- Aldehydes are organic compounds with the general formula: R-COH.



Aldehydes

- They have the carbonyl (C=O) group on the terminal (end) carbon.
- An aldehyde has a hydrogen atom bonded to the carbonyl group.

Note

-more easily oxidised than alcohols.
-unless the aldehyde is removed as it is formed during the oxidation of alcohol, it will react with the remaining oxidising agent and will be converted to carboxylic acids.
-If an aldehyde is required, it has to be distilled off as soon as it is made, otherwise it will be oxidised fully to carboxylic acid.

Nomenclature of Aldehydes

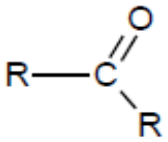
-Aldehydes are named similar to alcohols, except that the '**-ol**' part of the alcohol is changed to '**al**'.
-The parent chain is the longest chain that includes the *aldehyde group*. The numbering of the chain always start by assigning the carbon of the aldehyde group position 1. For example, ethanol becomes ethanal, propanol becomes propanal and 2-methylpropan-1-ol becomes 2-methylpropanal.

Physical Properties of Aldehydes

- Methanal is a gas at room temperature, other low carbon atom aldehydes are liquids.
- Aldehydes have unpleasant, pungent smell.
- C_1-C_4 aldehydes are soluble in water since they can form hydrogen bonds with water molecules.
- Aldehydes cannot form hydrogen bonds between their own molecules so they boil at a lower temperature than alcohols of comparable molecular masses.

Ketones

- Ketones are organic compounds with the general formula: R-CO-R.



Ketones

-Ketones have carbonyl group (C = O) on a middle (non-terminal) carbon.
-ketones have two carbon atoms bonded to the carbonyl group.
-Ketones strongly resist oxidation, so a ketone does not have to be separated from the oxidising agent as it is formed.

Nomenclature of Ketones

-Ketones are named similar to alcohols, except that the '**-ol**' part of the alcohol is changed to

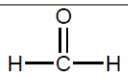
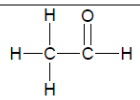
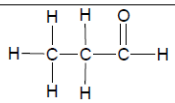
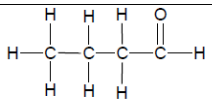
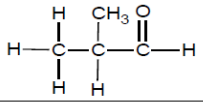
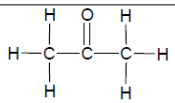
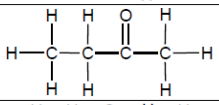
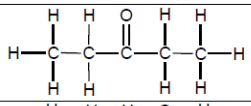
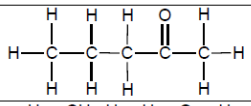
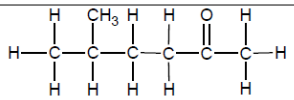
'**one**'. If there are more than 4 carbon atoms, the position of the carbonyl group must be specified. -The parent chain must include the carbonyl group and be numbered from whichever end reaches the carbonyl carbon first. For example, propan-2-ol becomes propan-2-one and butan-2-ol becomes butan-2-one.
-Ketones are structural isomers of aldehydes.

Physical Properties of Ketones

- Ketones have pleasant sweet odours.
- They are liquid at room temperature.
- C1-C4 ketones are soluble in water since they can form hydrogen bonds with H_2Omolecules.

Note: Aldehydes have at least one hydrogen attached to the carbonyl group (C=O). Ketones do not have any hydrogen attached to the carbonyl group (C=O).

Examples of Some Aldehydes and Ketones

Structural Formula	Name
Aldehydes	
	Methanal
	Ethanal
	Propanal
	Butanal
	2-methylpropanal
Ketones	
	Propanone
	Butan-2-one
	Pentan-3-one
	Pentan-2-one
	5-methylhexan-2-one

Test to distinguish between aldehydes and ketones

1. **Warm with acidified potassium dichromate solution**

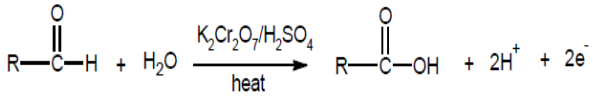
Observation

a. **Ketone -** No Change

b. **Aldehyde -** Oxidised to carboxylic acid.

Change in colour occurs as the orange acidified dichromate ions ($Cr_2O_7^{2-}$) are reduced to green chromium ions (Cr^{3+}).

Balanced oxidation reaction equation



Balanced reduction reaction equation

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

Overall reaction equation

$$3RCHO + Cr_2O_7^{2-} + 8H^+ \rightarrow 3RCOOH + 2Cr^{3+} + 4H_2O$$

2. Warm with acidified potassium permanganate solution

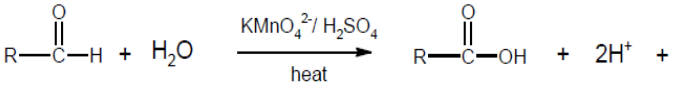
Observation

a. **Ketone -** No Change

b. **Aldehyde -** Oxidised to carboxylic acid.

Change in colour occurs as the purple acidified permanganate ions (MnO_4^-) are reduced to colourless manganese ions (Mn^{2+}).

Balanced oxidation reaction



Balanced reduction reaction equation

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

Overall reaction equation

$RCHO + MnO_4^- + 6H^+ + 3e^- \rightarrow RCOOH + Mn^{2+} + 3H_2$

3. Warm with Tollens' reagent (Silver mirror test)

Note: Tollens' reagent contains diamminesilver(I) ion ($[Ag(NH_3)_2]^+$).

Observation

a. **Ketones** – No Change

b. **Aldehydes** - Oxidised to carboxylic acid.

Silver mirror is seen on the glassware containing the aldehyde as the silver ion is reduced to silver. This test is also known as **silver mirror test** since a silver mirror is formed on the inside of the test-tube.

Balanced oxidation reaction equation

$RCHO + 3OH^- \rightarrow RCOO^- + 2H_2O + 2e^-$

Balanced reduction reaction equation

$Ag(NH_3)_2^+ + e^- \rightarrow Ag + 2NH_3$

Overall reaction equation

$2Ag(NH_3)_2^+ + RCHO + 3OH^- \rightarrow 2Ag + RCOO^- + 4NH_3 + 2H$

4. Warm with Benedict's or Fehling's solution

Note: Fehling's solution and Benedict's solution contains Cu^{2+} ions that act as oxidising agents.

Observation

a. **Ketones** – No Change

b. **Aldehydes** – Oxidised to a salt of the corresponding carboxylic acid.

The blue solution produces a dark reddish orange precipitate of copper(I) oxide (Cu_2O) as the copper (II) is reduced to copper(I).

Aldehydes reduce the complexed copper (II) ion to copper(I) oxide.

Balanced oxidation reaction equation

$RCHO + 3OH^- \rightarrow RCOO^- + 2H_2O + 2e^-$

Balanced reduction reaction equation

$2Cu^{2+} + 2OH^- + 2e^- \rightarrow Cu_2O + H_2O$

Overall reaction equation

$RCHO + 2Cu^{2+} + 5OH^- \rightarrow RCOO^- + Cu_2O + 3H_2O$

Note: In all the above reactions, "R" represents alkyl groups such as CH_3 and CH_3CH_2.

Exercise

1. What functional group does aldehydes and ketones have?

_____

_____

_____

_____

_____

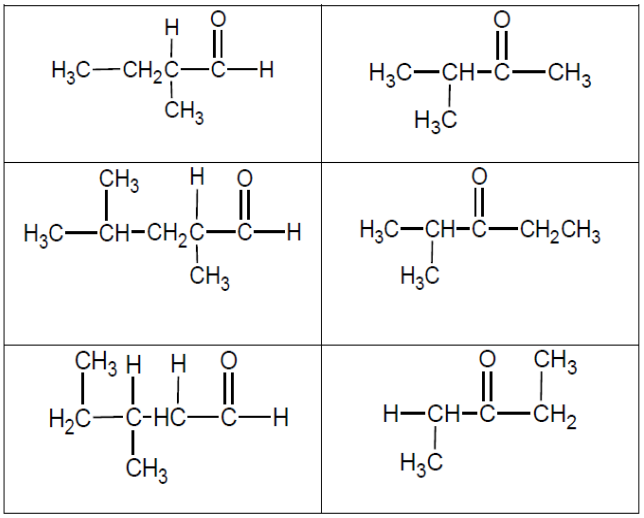
2. Give the general formula of an aldehyde and a ketone.

_____

_____

_____

3. Name the following aldehyde and ketones.



4. Explain the following statements.

a. Small aldehydes and ketones are soluble in water.

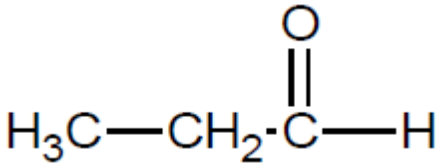
b. Aldehydes and ketones have a lower boiling point than the corresponding alcohols of comparable molecular masses.

5. Which of the following has the highest boiling point? Explain your choice.
   A. Butanal
   B. Butan-1-ol
   C. Propanal
   D. Propan-1-ol

6. Consider the following test reagents:
   A. Bromine water
   B. $HCl/ZnCl_2$
   C. $H+/MnO^{2-}$

Select the test reagent that would enable you to distinguish between propanal and propanone. Also state what will be observed when that test reagent is added to propanal and propanone respectively.

7. Consider the molecule given below:



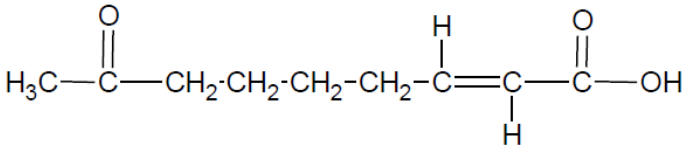
Which of the following are the products of the reaction of Tollens' reagent with the above molecule?
A. Propanoic acid and Ag
B. Propanone and Ag^+
C. Propanoic acid and Ag^+
D. Propanone and Ag

8. Consider a set of organic compounds given below:

CH_3CH_2COH	$CH_3CH_2CH_2OH$	CH_3COCH_3	$CH_3CHOHCH_3$

From the above compounds, identify a compound that is a/an:
a. ketone
b. aldehyde
c. primary alcohol
d. secondary alcohol

9. Shown below is a large organic molecule.



Identify and name three functional groups present in this molecule.

10.a. When an aldehyde reacts with Fehling's solution, what reaction does the aldehyde undergo?

b. Give the change in colour that occurs when an aldehyde is reacted with the Fehling's solution and state the species responsible for the respective colours.