CARBONYL COMPOUNDS

= substances containing the carbonyl group ……

Aldehydes have the C=O group at the end of the chain, the aldehydic group is then ……...

Naming of aldehydes:

In the systematic name there is a suffix …… after the stem indicating the number of carbon atoms **including** the one for the carbonyl group.

1. *Fill in the table*

HCHO			octanal
	ethanal		pentanal
C_3H_7CHO		$C_6H_{13}CHO$	
C_2H_5CHO			hexanal

Ketones have the oxygen on a non-terminal carbon atom in the chain, keto group is ……..

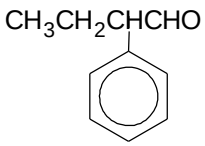
Systematic name: suffix ..... after a stem indicating the **overall** number of carbon atoms + the number indicating the position of the carbonyl group in the chain

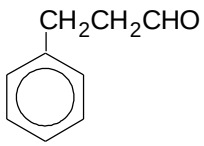
2. *Fill in the table*

CH_3-CO-CH_3			heptan-3-one
	butanone	$C_3H_7COC_2H_5$	
$CH_3COCH_2CH_2CH_3$			hexan-2-one
	pentan-3-one	$CH_3COC_5H_{11}$	

3. *Name the following carbonyl compounds:*

a. $CH_3CH_2CH_2CH_2CHO$ b. $CH_3CH(CH_3)COCH_3$ c. $CH_3CH(CH_3)CHO$

d. 

e. 

f. HCHO

4. *Write down the structural formulae for the following compounds:*

a. cyclohexanone *b. 3-methylbutanal* *c. 2,2-dimethylpropanal*

d. 3-phenylbutan-2-one *e. phenylpropanone* *d. 4-phenylpentanal*

5. *Of the compounds in 1 and 2, which are structural isomers?*

The nature of the - CO group

Physical properties

6. *Estimate the type and the extent of interactive forces between C_2H_6 (M_R = 30), CH_3OH (M_R = 30) and HCHO (M_R = 30) and put these compounds in order with respect to increasing boiling point.*

   C_2H_6

   CH_3OH

   HCHO

Methanal is a gas, other important carbonyl compounds are ……...
Early members are soluble in water due to …….. ……. between hydrogen from water and oxygen from the carboxylic group.
As the length of the non-polar chain increases the influence of C=O group on the properties …….

Chemical properties

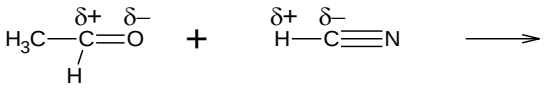
The ……. charge on the carbon atom makes carbonyl compounds attractive towards …….

1. **……. addition $A_{…..}$**
   The readiness to undergo A_N decreases with increasing number of carbon atoms, ketones are generally less reactive than aldehydes. This is caused by alkyl groups that tend to …… electrons to the carbon atom of the carbonyl group. The positive charge on it is cancelled somwhat.

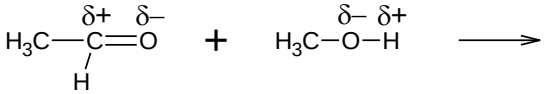
7. *Put HCHO,CH_3COCH_3 and CH_3CHO in order with respect to decreasing reactivity.*

   Benzyldehyde C_6H_5CHO is even less reactive because of the delocalization of the positive charge over the benzene ring.

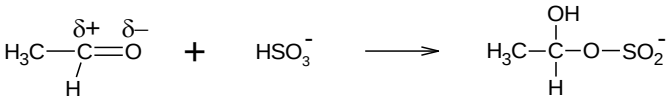
   a. reaction with HCN → hydroxynitriles



   b. reactions with alcohols → hemiacetals



c. reactions with hydrogensulphites → sulphites



8. *Give the name and structural formula of the organic product formed in each of the following reactions:*

   a. *ethanal + HCN →*

   b. *pentan-2-one + KCN →*

   c. *methanal + HSO_3^- →*

   d. *butanal + CH_3OH →*

2. Redox reactions

- **reduction** (hydrogenation)

  Aldehydes are reduced to …….. alcohols, ketones are reduced to …… alcohols. The most common reducing agents: $LiAlH_4$ (lithium tetrahydridoaluminate), $NaBH_4$ (sodium borohydride) or H_2 in the presence of a nickel catalyst.

- **oxidation**

  Ketones are resistant towards oxidation while aldehydes may be oxidised to …….. This is the principle way to recognize aldehydes from ketones.

  Tollens' reaction

  aldehyde + Tollens reagent ($AgNO_3$ + NH_3(aq)) → carboxylic acid + Ag

  Fehling's reaction

  aldehyde + Fehling reagent ($CuSO_4$ in alkaline conditions) → carboxylic acid + Cu_2O

9. *From the following compounds select those that will react with*

   a. *Tollens' reagent*

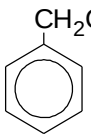
   b. *Fehling´s solution*

   ethanal, propanone, phenylethanone, propanal, methanal

10. *Give the names and formulae of the organic products formed in each of the following reactions:*

    a. $(CH_3)_2CHCHO$ + Tollens' reagent →

    b. 3-methylbutan-2-one + $LiAlH_4$ →

c.  + $NaBH_4$ →

Cannizaro´s reaction

It is a disproportionation reaction that takes place on aldehydes with no H atoms on the α-carbon. E.g. methanal is in the presence of NaOH simultaneously oxidised to …….. and reduced to…….

2 HCHO →

2 C_6H_5CHO →

3. Reactions on the α -carbon

a. halogenation → α - halogenocompounds

$CH_3COCH_3 + Cl_2$ →

b. haloform reaction, takes place in alkaline conditions with an excess of halogen. Iodoform reactions are used for testing for the presence of -$COCH_3$ group.

1. R-$COCH_3 + 3I_2$ →

2. R-$COCI_3 + OH^-$ → yellow precipitate of iodoform

This reaction is positive also with -CHOH-CH_3 group because it is oxidised by iodine to ……..

11. By drawing the structures of the following compounds, state which will give a positive iodoform test:

a. benzaldehyde *d. butanone* *f. phenylethanone*

b. propanal *e. 2-methylpropan-2-ol* *g. propan-2-ol*

c. ethanol

4. Addition – elimination reaction

a. reactions with hydroxylamine → oximes

$R_1R_2C=O + NH_2OH$ → → H_2O + oxime

b. reactions with hydrazine → hydrazones

$R_1R_2C=O + NH_2NH_2$ → → H_2O + hydrazone

Tautomerism

enol form keto form (more stable)

Manufacture and preparation

1. oxidation of alcohols
   aldehydes: primary alcohols
   ketones: secondary alcohols

12. Give the names and formulae of the alcohols which can be oxidised to give the following carbonyl compounds:

c. butanal	*f. cyclohexanone*	*i. pentan-2-one*
d. 3-methylbutan-2-one	*g. benzaldehyde*	*j. phenylethanone*
e. 2-methylpropanal	*h. 3-phenylbutanal*	

2. acetaldehyde is made by hydration of ethyne

3. acetone is produced by oxidation of cumene

Uses of carbonyl compounds

Methanal (formaldehyde)

Ethanal

Propanone

Benzaldehyde

Cyclohexanone