1.5 Aldehydes and Ketones

Saffron, produced from the stamens of the crocus flower, is the most expensive spice on Earth. The cost per gram of saffron is approximately equal to that of silver. An organic compound, safranal, is responsible for its characteristic aroma. The compounds responsible for the scents of saffron and many other spices, including cumin, vanilla, cinnamon, and ginger, all have a similar functional group: carbonyl. Not surprisingly, scents and perfumes contain many compounds with carbonyl groups. The solvents in some paint and fingernail polish removers, lacquers, and glues also have carbonyl groups.

The Carbonyl Group

A carbonyl group is an atom of carbon double-bonded to an atom of oxygen.

The carbonyl group is the functional group responsible for the properties of ketones and aldehydes.

The difference between the two classes of compound is the location of the carbonyl group within the molecule.

A carbonyl group

An aldehyde has its the carbonyl group bonded to at least 1 hydrogen atom, which means that it is located at the end of the parent chain of the molecule.

A ketone is an organic compound whose molecules have a carbonyl group bonded to 2 carbon atoms in the carbon chain.
Naming Aldehydes and Ketones

For an aldehyde, replace the final -e from the name of the parent alkane with the suffix -al.

(Position numbers are not used in naming aldehydes because the carbonyl group is always designated as carbon number 1 in the chain.)

Name the following:

1. 

2. 

3. 

4. 

Draw the following:

hexanal

7-hydroxyoctanal

butanal
4-methylpentanal

2-hydroxybutanal

To name a ketone, the -e of the parent alkane is replaced with the suffix -one.

Name the following:

![Ketone 1]

![Ketone 2]

![Ketone 3]

Draw the following:

4,4-dimethyl-heptan-2-one

4-methylheptan-3-one
Properties of Aldehydes and Ketones

- Because oxygen has a much higher electronegativity than carbon, electrons from the double bond are attracted to the oxygen atom. As a result, the molecules are polar.
- They have dipole–dipole attractions but, since the molecules do not contain a hydroxyl group, they do not form hydrogen bonds with one another. Therefore, their boiling points are lower than similar alcohols.
- The presence of the carbonyl oxygen does allow aldehydes and ketones to form attractions with water molecules, so these molecules are more soluble in water than are alkanes, but less soluble than are similarly sized alcohol molecules.
- Small aldehydes and ketones are completely soluble in water, but the solubility decreases as additional carbons are added to the chain.
- Aldehydes and ketones are often used as solvents in industrial processes.

Reactions of Aldehydes and Ketones

Controlled Oxidation

An alcohol during combustion is not completely oxidized. If there is only a limited quantity of oxygen present, an aldehyde or ketone is produced.

In these types of reactions, oxygen atoms can be supplied by air or by compounds known as oxidizing agents. The balanced chemical equation for the reaction of ethanol with oxygen from the air is
1°, 2° and 3° Alcohol Oxidations

\[
2 \text{C}_2\text{H}_5\text{OH}(l) + \text{O}_2(g) \rightarrow 2 \text{C}_2\text{H}_4\text{O}(l) + 2 \text{H}_2\text{O}(l)
\]

Hydrogenation of Aldehydes and Ketones

Hydrogenation of aldehydes or ketones occurs only under conditions of high temperature and pressure, and the presence of a catalyst. The product of this reaction is an alcohol.
Samples:

Draw the structural formula equations for the reactions that produce butanone and butanal.

Draw the structural formula equation representing the hydrogenation of propanone.

Name the reactants required to produce each of the following compounds, then illustrate the reactions using structural formulas.

(a) pentanone

(b) pentanal
Name the products resulting from the hydrogenation of each of the following compounds, then illustrate the reactions using structural formulas.
(a) ethanal

(b) butanone

Predict the products of the controlled oxidation of the following isomers:
(a) hexan-1-ol

(b) hexan-2-ol

(c) 2-methylpentan-2-ol

Worksheet 1.5: Aldehydes and Ketones

p.46 Q. 1, 2, 4 and

Predict the relative solubility of the following compounds in water, listing the compounds in increasing order of solubility. Give reasons for your answer.

(a) CH₃CCH₂CH₃  (b) CH₃CH₂CH₂CH₂OH  (c) CH₃CH₂CH₂CH₂CH₃