5.4: Aldehydes and Ketones

The functional group in ketones is the **carbonyl group**, consisting of a carbon atom joined with a double covalent bond to an oxygen atom. In ketones, the carbonyl group is attached to two alkyl groups and no H atoms. In aldehydes, the carbonyl group is attached to at least one H atom; it is also attached to either another H atom or an alkyl group. In other words, in an aldehyde, the carbonyl group always occurs at the end of a carbon chain; in a ketone, the carbonyl group occurs in the interior of a carbon chain.

This difference in the position of the carbonyl group affects the chemical reactivity of the molecule, and is used in a test to distinguish aldehydes from ketones.

Naming Aldehydes and Ketones

The IUPAC names for **aldehydes** are formed by taking the parent alkane name, dropping the final *-e*, and adding the suffix ***-al***. The simplest aldehyde consists of a carbonyl group with no attached alkyl group; its formula is HCHO. It has only one C atom; thus the parent alkane is methane and the aldehyde is methan*al*, although it is more often known by its common name—formaldehyde. The next simplest aldehyde is a carbonyl group with a methyl group attached; this two-carbon aldehyde is called ethanal, also known as acetaldehyde.

Ketones are named by replacing the *-e* ending of the name of the corresponding alkane with ***-one***. The simplest ketone is propanone, CH3COCH3, commonly known as acetone. If, in a ketone, the carbon chain containing the carbonyl group has five or more carbon atoms, it is necessary to use a numerical prefix to specify the location of the carbonyl group. For example, in 2-pentanone, the carbonyl group is the second carbon atom in the carbon chain.

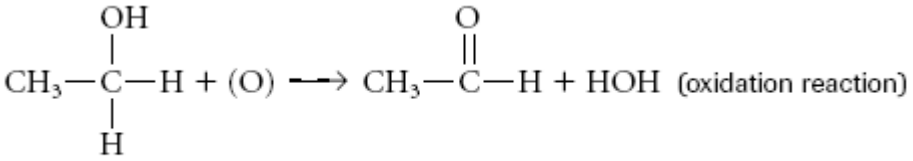
Properties of Aldehydes and Ketones

Aldehydes and ketones have lower boiling points than analogous alcohols, and are less soluble in water than alcohols; this is to be expected as they do not contain -OH groups and so do not participate in hydrogen bonding. However, the carbonyl group is a strongly polar group due to the four shared electrons in the double C=O bond. Thus, aldehydes and ketones are more soluble in water than are hydrocarbons. The ability of these compounds to mix with both polar and nonpolar substances makes them good solvents.

Preparing Aldehydes and Ketones from Alcohols: Oxidation Reactions*

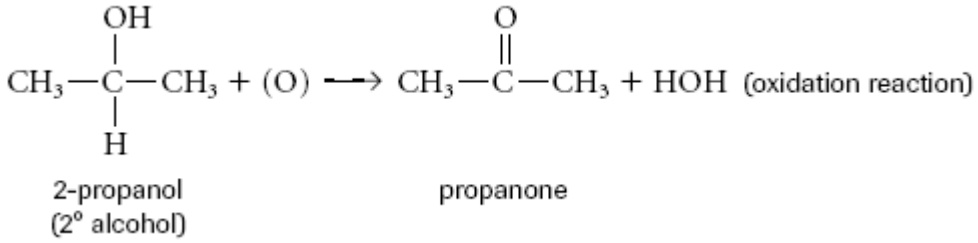
***the term oxidation reaction generally implies a gain of oxygen or a loss of hydrogen

When a *primary* alcohol is oxidized, an H atom remains on the C atom, and an aldehyde is produced.

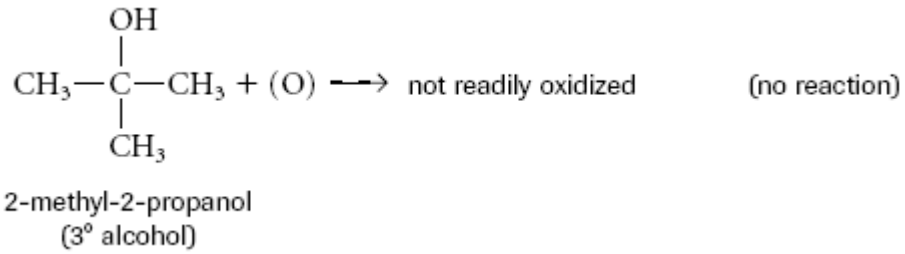


ethanol (1° alcohol) ethanal

When a *secondary* alcohol is similarly oxidized, the carbonyl group formed is necessarily attached to two alkyl groups, forming a ketone.

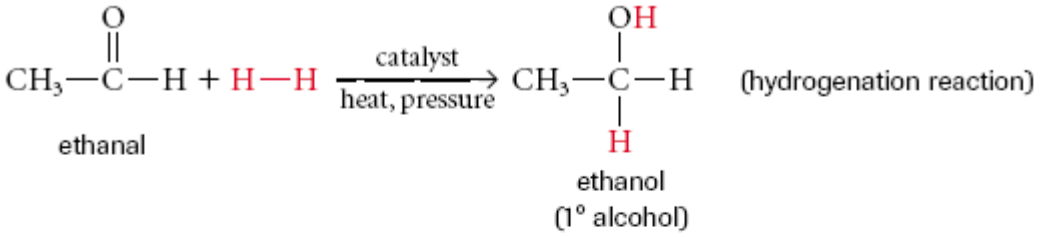


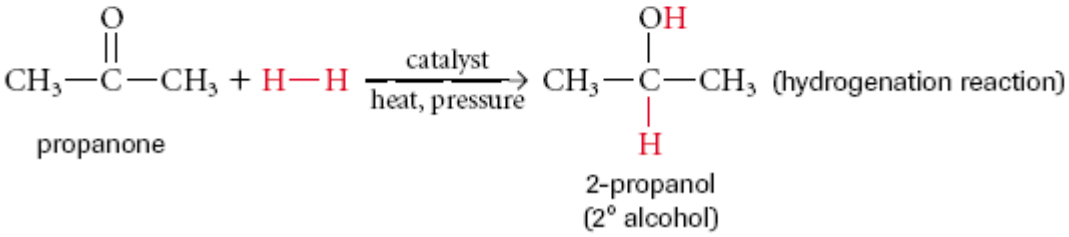
Tertiary alcohols do not undergo this type of oxidation; no H atom is available on the central C atom.



From Aldehydes and Ketones to Alcohols: Hydrogenation Reactions

The C=O double bond in carbonyl groups can undergo an addition reaction with hydrogen, although not with other reactants. High temperatures and pressures and the presence of a catalyst are needed for this hydrogenation reaction. When the H atoms are added to the carbonyl group, an -OH group results, producing an alcohol.





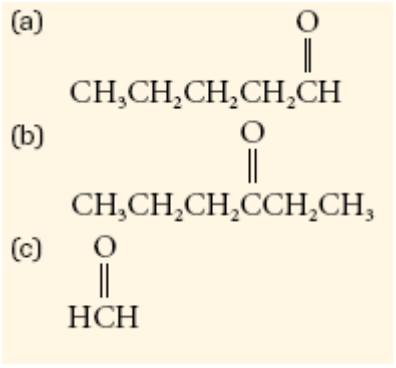
SCH4C

Worksheet 5.4: Aldehydes and Ketones

1. Draw structural diagrams for each of the following compounds:
   (a) ethanal
   (b) 2-hexanone
   (c) pentanal
   (d) benzaldehyde

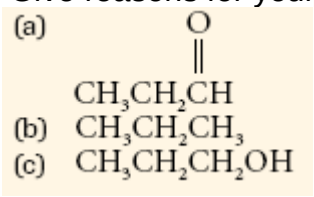
2. Write IUPAC names for
   (a) all possible heptanones.
   (b) all possible heptanals.

3. Write the IUPAC names for the following compounds:



4. Write the IUPAC name for the following compounds:
   (a) acetone
   (b) formaldehyde
   (c) acetaldehyde

5. Arrange the following compounds in increasing order of predicted boiling points. Give reasons for your answer.



6. Draw structural diagrams and write IUPAC names to illustrate the controlled oxidation of the following alcohols. Is the product an aldehyde or a ketone?
   (a) 2-pentanol
   (b) 1-hexanol

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