This page explains how aldehydes and ketones are made in the lab by the oxidation of primary and secondary alcohols.

### Oxidizing alcohols to make aldehydes and ketones

The oxidizing agent used in these reactions is normally a solution of sodium or potassium dichromate(VI) acidified with dilute sulfuric acid. If oxidation occurs, the orange solution containing the dichromate(VI) ions is reduced to a green solution containing chromium(III) ions.

The net effect is that an oxygen atom from the oxidizing agent removes a hydrogen from the -OH group of the alcohol and one from the carbon to which it is attached.

![Diagram showing the oxidation process](image)

**[O]** is often used to represent oxygen coming from an oxidising agent.

R and R’ are alkyl groups or hydrogen. They could also be groups containing a benzene ring, but I'm ignoring these to keep things simple.

If at least one of these groups is a hydrogen atom, then you will get an aldehyde. If they are both alkyl groups then you get a ketone. If you now think about where they are coming from, you will get an aldehyde if your starting molecule looks like this:

\[
\text{H} \\
R-\text{C-O-H} \\
\text{H}
\]

This is a primary alcohol

In other words, if you start from a primary alcohol, you will get an aldehyde. You will get a ketone if your starting molecule looks like this:

\[
\text{H} \\
R-\text{C-C-H} \\
\text{H}
\]

This is a secondary alcohol

... where R and R’ are both alkyl groups. Secondary alcohols oxidize to give ketones.
Making aldehydes

Aldehydes are made by oxidising primary alcohols. There is, however, a problem.

The aldehyde produced can be oxidised further to a carboxylic acid by the acidified potassium dichromate(VI) solution used as the oxidising agent. In order to stop at the aldehyde, you have to prevent this from happening.

To stop the oxidation at the aldehyde, you . . .

- use an excess of the alcohol. That means that there isn’t enough oxidizing agent present to carry out the second stage and oxidize the aldehyde formed to a carboxylic acid.
- distil off the aldehyde as soon as it forms. Removing the aldehyde as soon as it is formed means that it doesn’t stay in the mixture to be oxidized further.

If you used ethanol as a typical primary alcohol, you would produce the aldehyde ethanal, CH$_3$CHO. The full equation for this reaction is fairly complicated, and you need to understand about electron-half-equations in order to work it out.

\[
3\text{CH}_3\text{CH}_2\text{OH} + \text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ \rightarrow 3\text{CH}_3\text{CO}_2\text{H} + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}
\]

In organic chemistry, simplified versions are often used which concentrate on what is happening to the organic substances. To do that, oxygen from an oxidising agent is represented as [O]. That would produce the much simpler equation:

\[
\text{CH}_3\text{CH}_2\text{OH} + \text{[O]} \rightarrow \text{CH}_3\text{CHO} + \text{H}_2\text{O}
\]

This means "oxygen from an oxidising agent".

Secondary alcohols

Secondary alcohols are oxidised to ketones. There is no further reaction which might complicate things. For example, if you heat the secondary alcohol propan-2-ol with sodium or potassium dichromate(VI) solution acidified with dilute sulphuric acid, you get propanone formed.

Playing around with the reaction conditions makes no difference whatsoever to the product. Using the simple version of the equation:

\[
\text{H} + \text{CH}_3\text{C-O-H} + \text{[O]} \rightarrow \text{CH}_3\text{C}=\text{O} + \text{H}_2\text{O}
\]

propan-2-ol propanone

Contributors