# ALCOHOLS

## Learning Objectives

- ✔ Understand and be able to apply the classification of alcohols
- ✔ Understand the oxidation of alcohols and their products

# ALCOHOLS

## Success Criteria

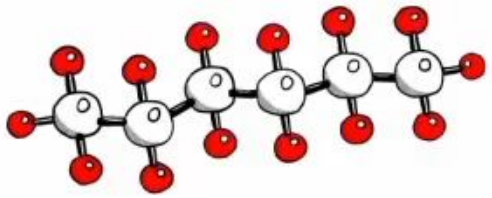
- ✔ Name and classify alcohols.
- ✔ Explain some physical properties of alcohols.
- ✔ Write oxidation products of primary and secondary alcohols.

# ALCOHOLS

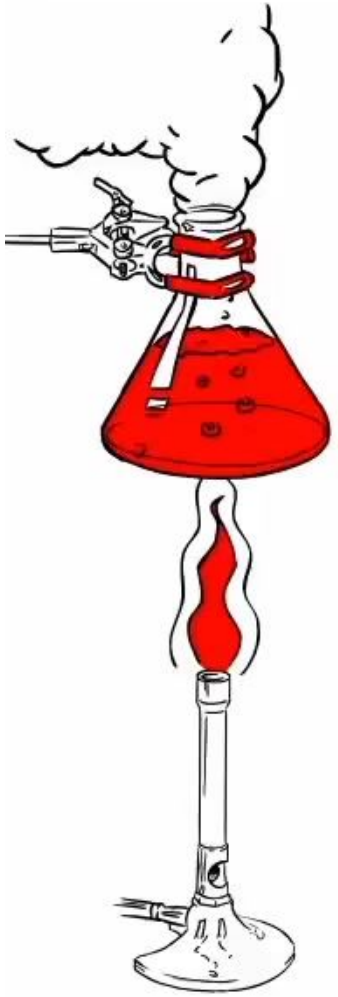
## Keywords

- ✔ Alcohol
- ✔ Aldehyde
- ✔ Carboxylic acid
- ✔ Primary alcohol
- ✔ Secondary alcohol
- ✔ Tertiary alcohol
- ✔ Distillation
- ✔ Reflux

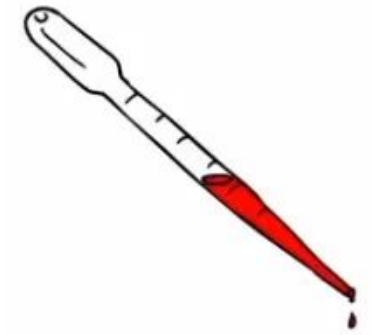
# Video Clip Activity



the virtualschool



## What are Alcohols?



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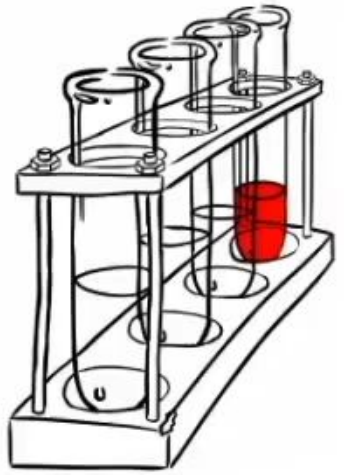


# What are alcohols?

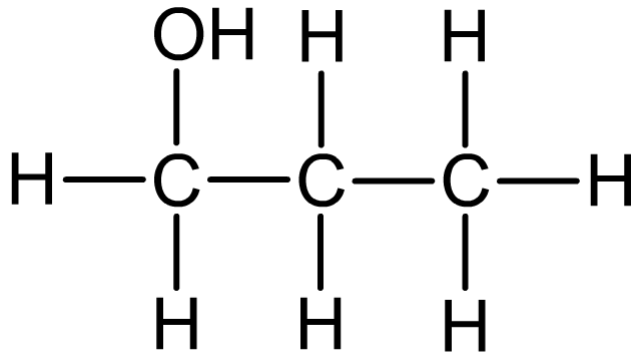
**Alcohols** are a **homologous series** of organic compounds with the general formula $C_nH_{2n+1}OH$ and names ending *–ol*.

The functional group in alcohols is the **hydroxyl group**: –OH.

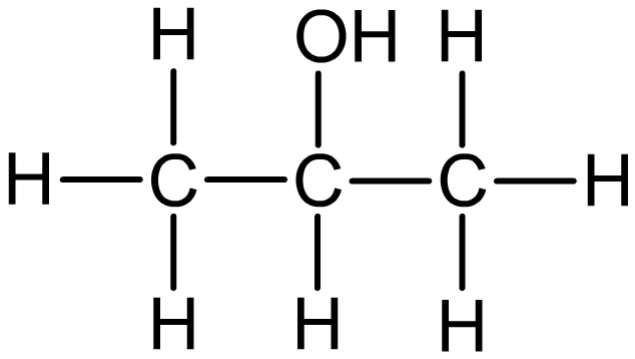
| No. of carbon atoms | Molecular formula | Name |
|---|---|---|
| 1 | $CH_3OH$ | methanol |
| 2 | $C_2H_5OH$ | ethanol |
| 3 | $C_3H_7OH$ | propanol |
| 4 | $C_4H_9OH$ | butanol |
| 5 | $C_5H_{11}OH$ | pentanol |
| 6 | $C_6H_{13}OH$ | hexanol |

# Naming alcohols

Alcohols with three or more carbon atoms display **positional isomerism**.
The number of the carbon to which the hydroxyl groups is attached is written before the *–ol*.

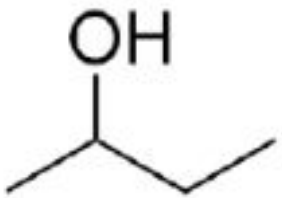



**propan-1-ol**

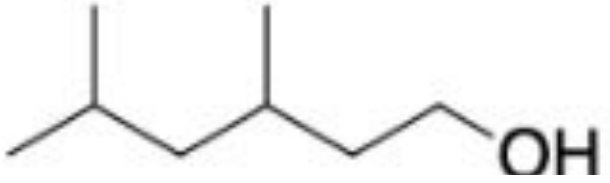



**propan-2-ol**

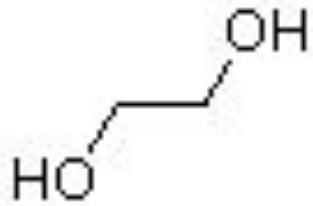
# Naming alcohols



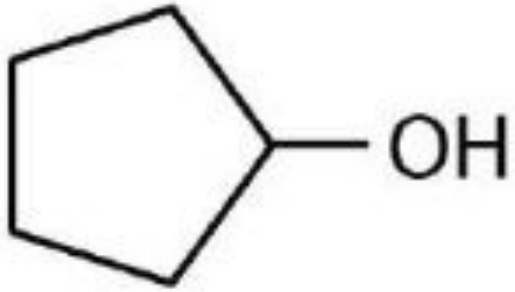

butan-2-ol



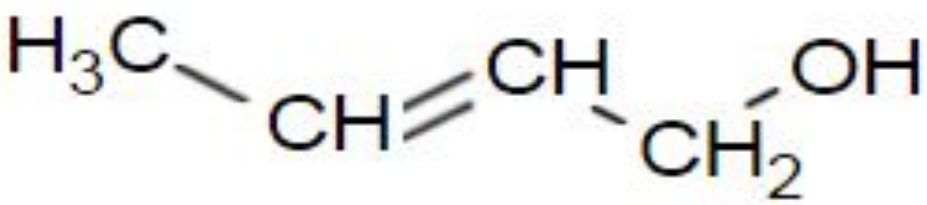

3,5-dimethylhexan-1-ol




1,2-ethanediol




cyclopentanol



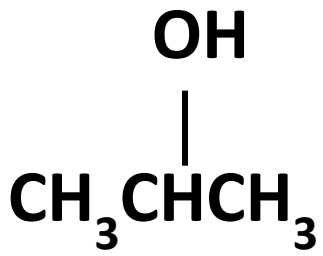

2-buten-1-ol

# Task 1: IUPAC nomenclature

A. $CH_3CH_2CH_2CH_2OH$

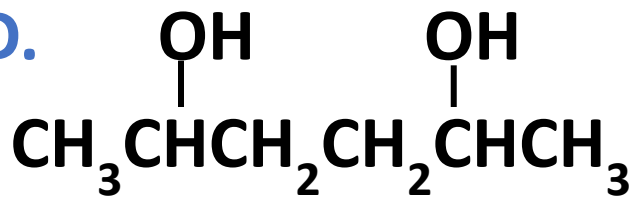
Butan-1-ol

C.



Propan-2-ol

D.

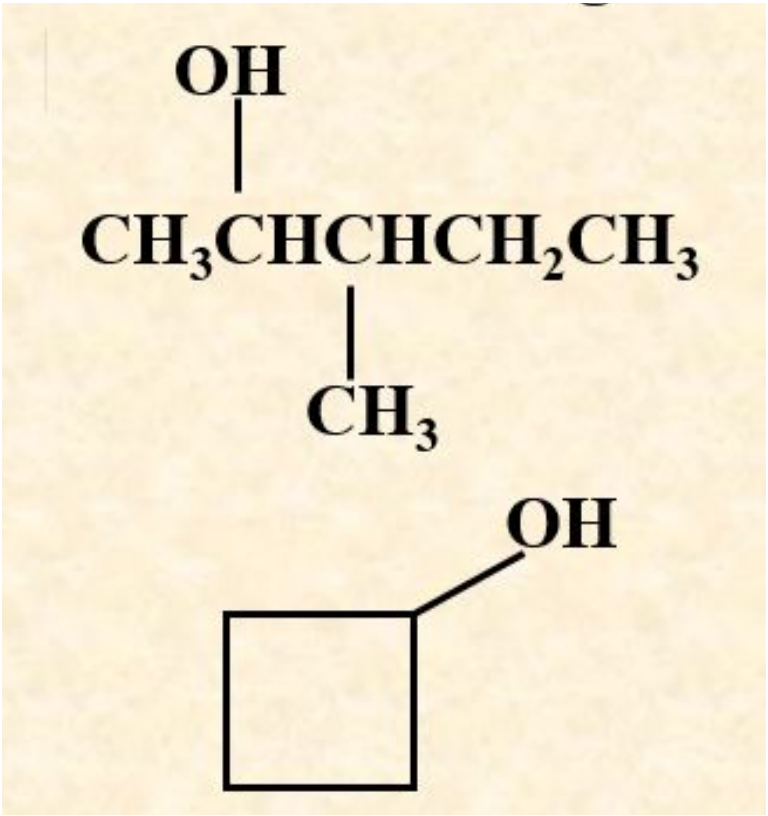


Hexane-2,5-diol

B

3-methylpentan-2-ol

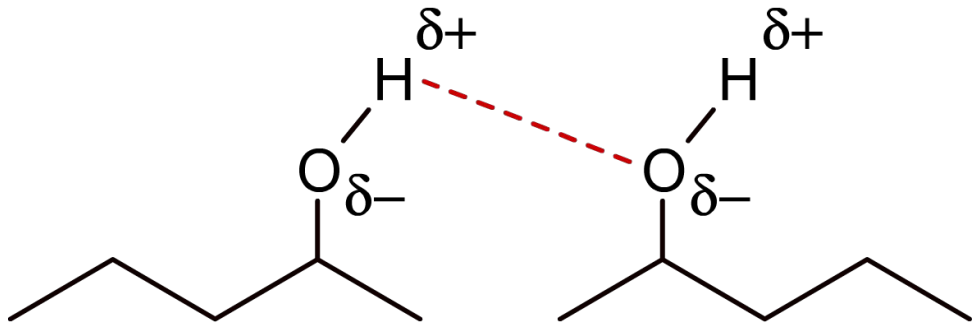
E



cyclobutanol

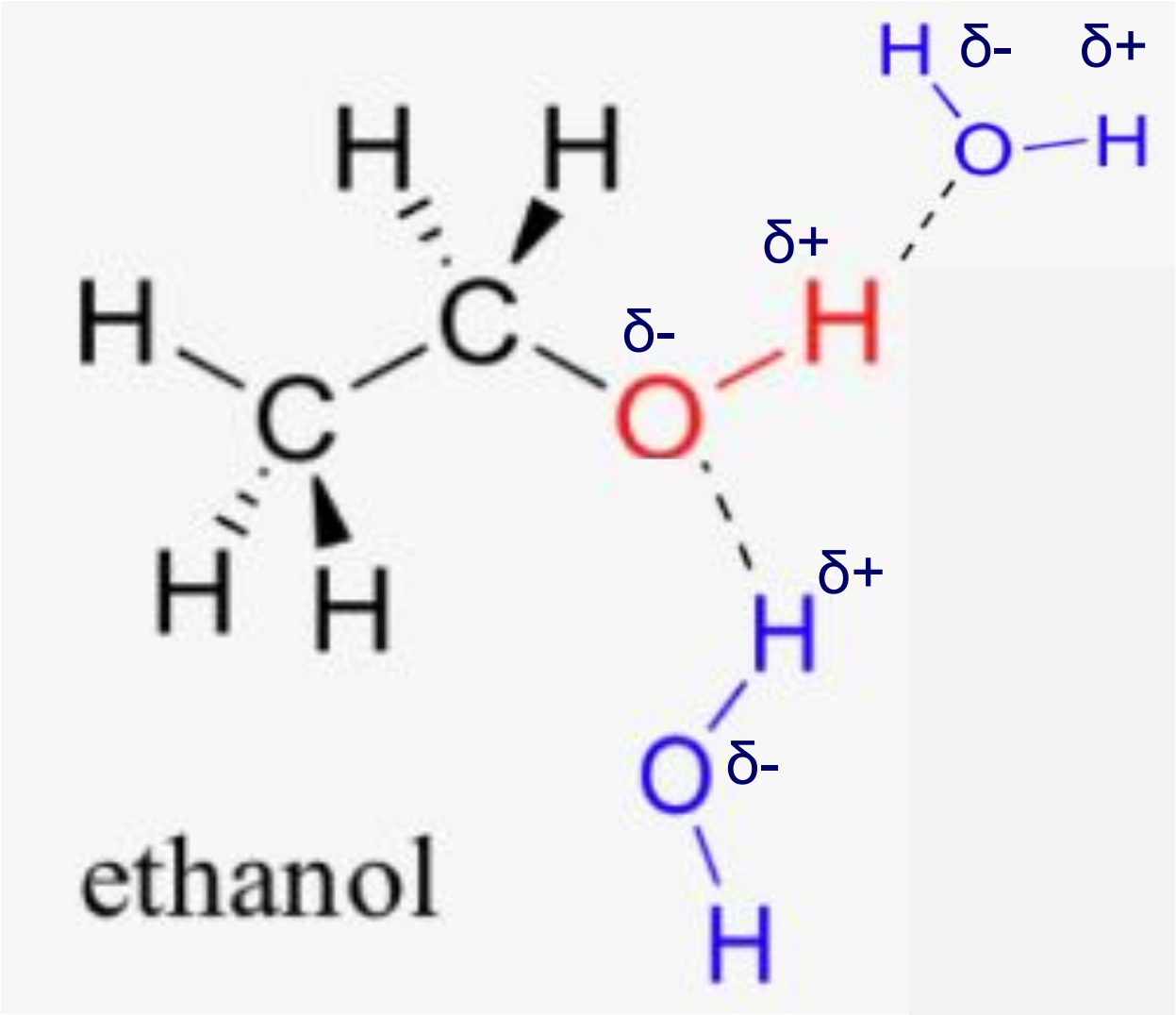
# Alcohols and hydrogen bonding

The presence of the hydroxyl group with its electronegative oxygen atom means that alcohols are **polar**. They can therefore take part in hydrogen bonding.




**Hydrogen bonding** between alcohol molecules means that an alcohol's boiling point is higher than that of an alkane of similar molecular mass. For example, methanol ($M_r$ = 32) boils at 64.7 °C but ethane ($M_r$ = 30) boils at -88.6 °C.

Alcohols **can mix with water** because their molecules **can form hydrogen bonds** with water molecules.

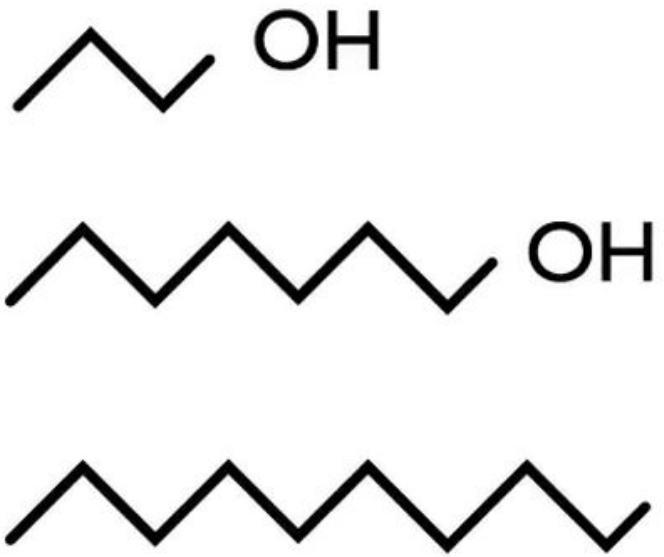



# Solubility of Alcohols in Water

# Boiling point of alcohols

low boiling point

Weaker van der Waals forces




Stronger van der Waals forces


very high boiling point

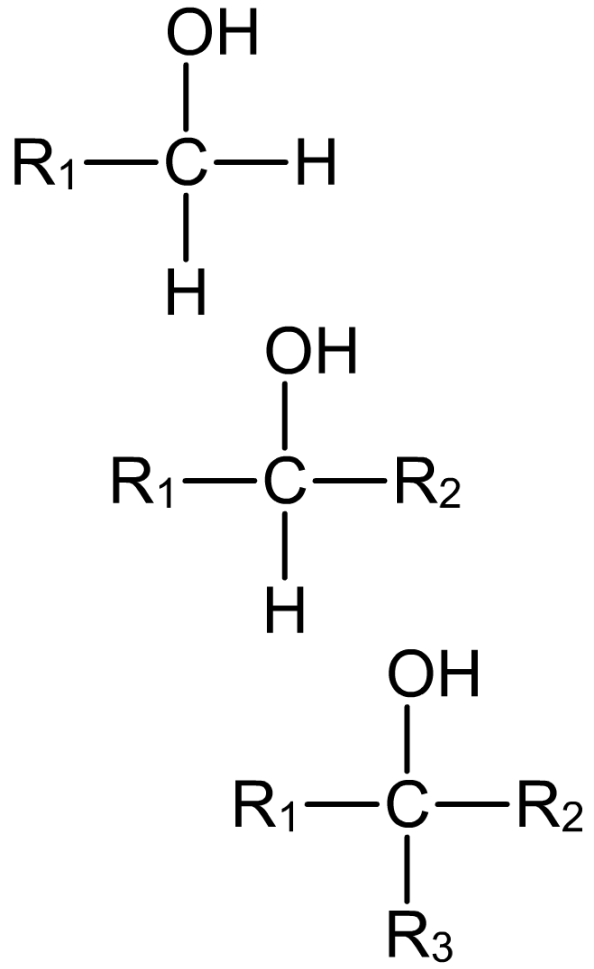
# Primary, secondary and tertiary alcohols

A chain of carbon atoms can be represented by R when drawing the structure. This is referred to as an **R group**.

- **Primary (1°) alcohols** have one R group attached to the carbon with -OH group

- **Secondary (2°) alcohols** have two R groups attached to the carbon with -OH group

- **Tertiary (3°) alcohols** have three R groups attached to the carbon with -OH group



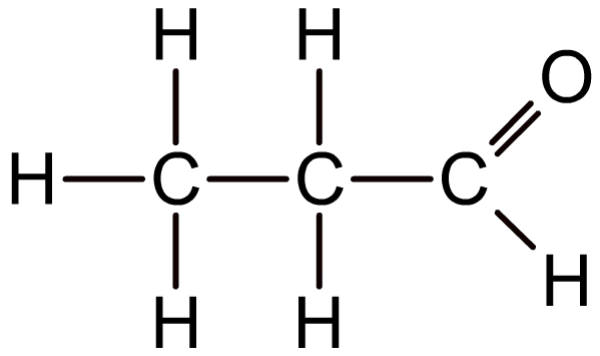
# Oxidation of 1° alcohols: aldehydes

**Primary** alcohols can be oxidized to **aldehydes** by an oxidizing agent such as an aqueous solution of acidified potassium dichromate(VI).

When the symbol equation is written, the oxidizing agent is represented by [O]:

$$RCH_2OH + [O] \rightarrow RCHO + H_2O$$

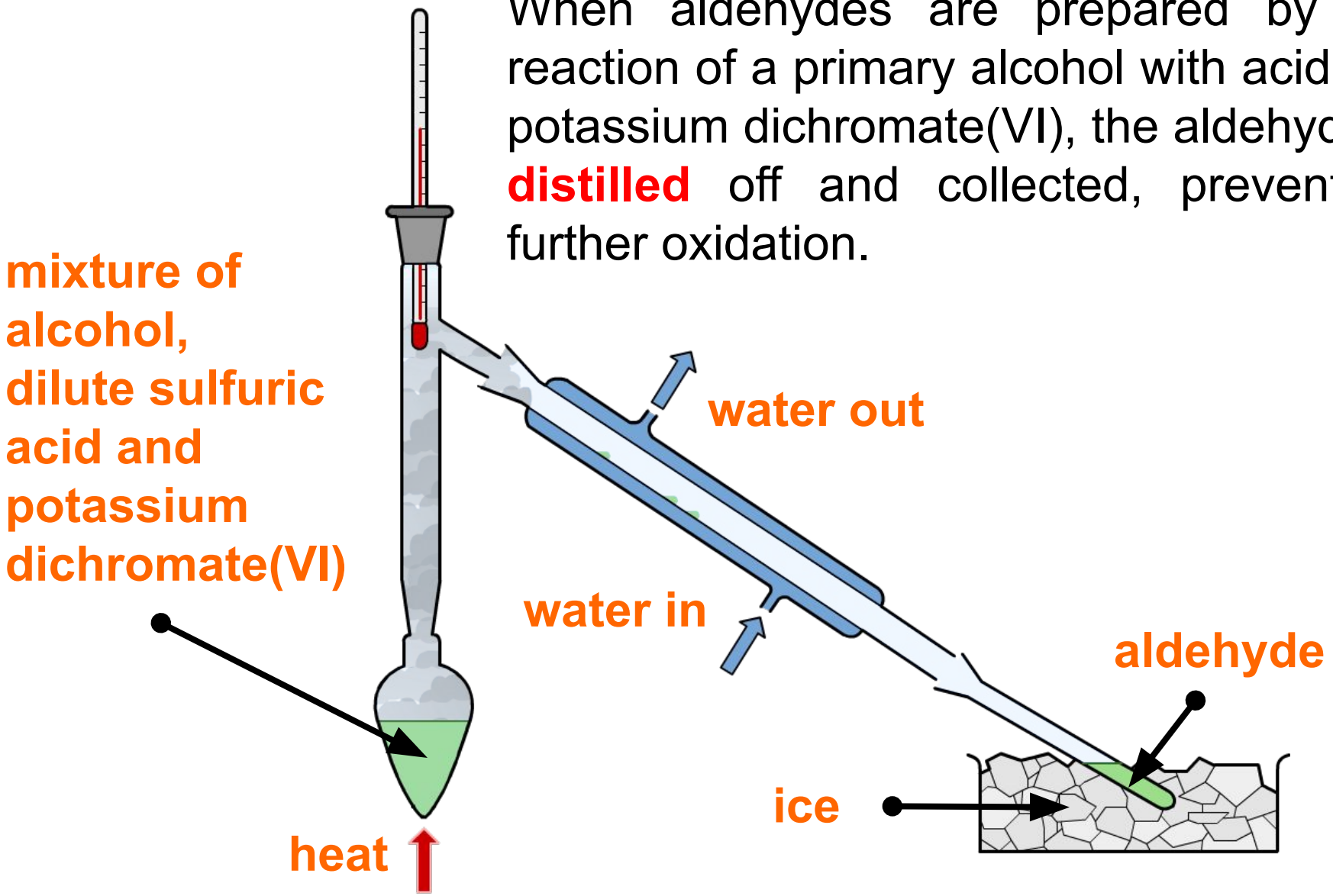
Aldehydes contain a carbonyl group (C=O) at the end of the carbon chain, and are named using the suffix *–al*.




propanal

# Synthesis of aldehydes

When aldehydes are prepared by the reaction of a primary alcohol with acidified potassium dichromate(VI), the aldehyde is **distilled** off and collected, preventing further oxidation.



# Oxidation of 1° alcohols: carboxylic acids

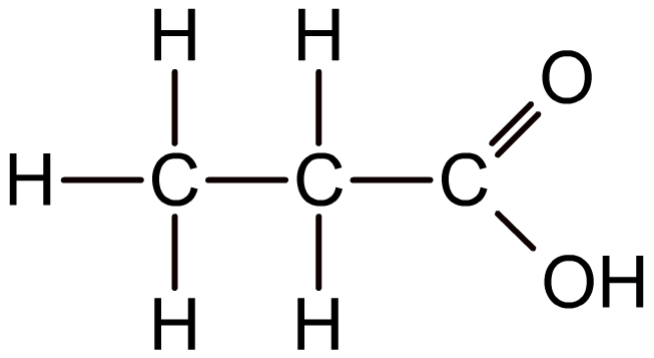
If primary alcohols are reacted with an excess of oxidizing agent and **refluxed**, they can be oxidized to aldehydes and then oxidixed further to **carboxylic acids**.

$$RCH_2OH + [O] \rightarrow RCHO + H_2O$$

$$RCHO + [O] \rightarrow RCOOH$$

**Carboxylic acids** contain a carbonyl group (C=O) at the end of the carbon chain, with a hydroxyl group (OH) attached to the carbon.

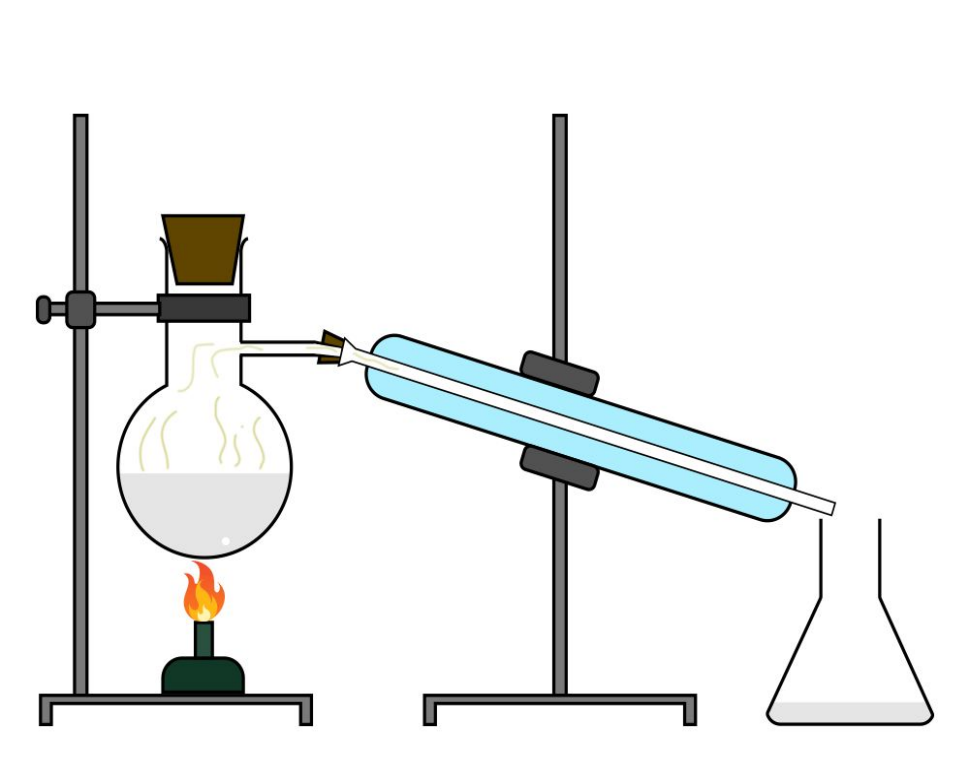
Carboxylic acid are named using the suffix *–oic acid*.




**propanoic acid**

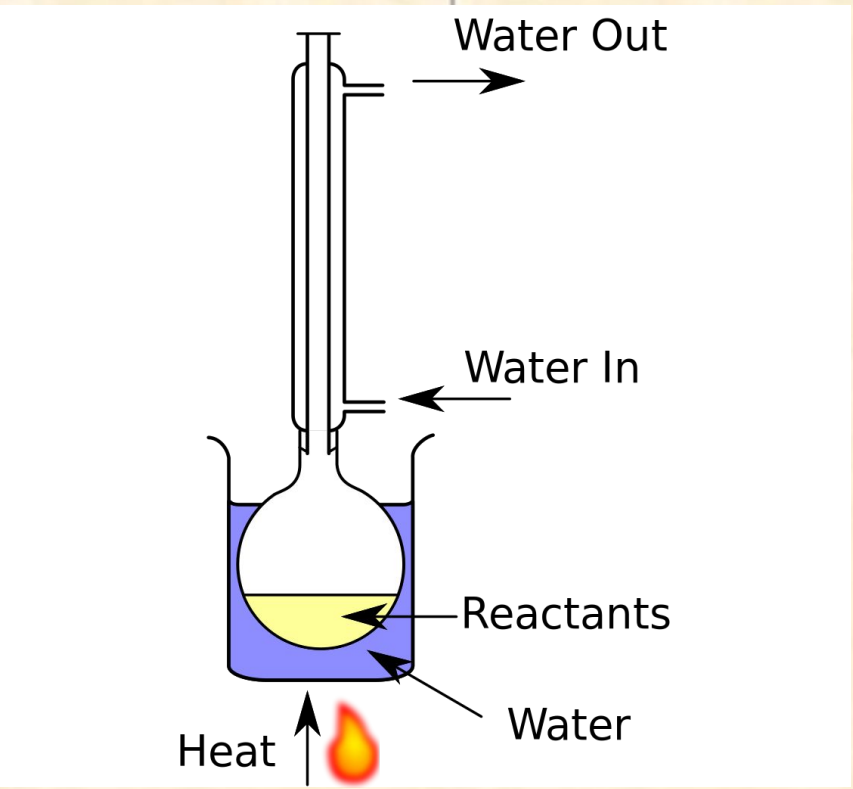
# Distillation V.S. Reflux

## OXIDATION TO ALDEHYDES
## DISTILLATION



Aldehyde has a lower boiling point so distils off before being oxidised further

## OXIDATION TO CARBOXYLIC ACIDS
## REFLUX



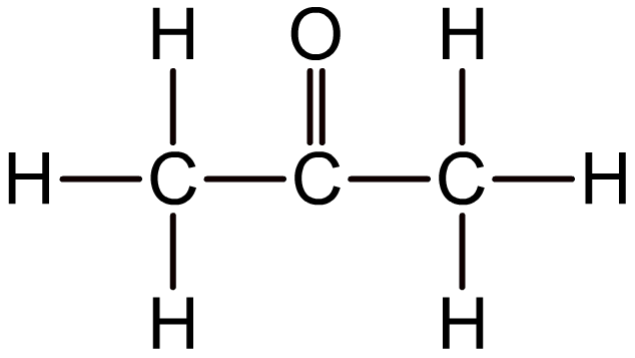

Aldehyde condenses back into the mixture and gets oxidised to the acid

# Oxidation of 2° alcohols: ketones

**Secondary** alcohols can be oxidized to **ketones** by an oxidizing agent such as an aqueous solution of acidified potassium dichromate(VI).

$$R_1CH(OH)R_2 + [O] \rightarrow R_1COR_2 + H_2O$$

**Ketones** contain a carbonyl group (C=O) attached to any carbon in the chain except a terminal carbon atom, and are named using the suffix –*one*.



propanone

**Tertiary** alcohols are **resistant to oxidation** due to the lack of hydrogen atoms on the carbon atom to which the hydroxyl group is attached.

# DISTINGUISHING ALDEHYDES FROM KETONES

| **Test 1** | **Test 2** | **Test 3** |
|---|---|---|
| **Dichromate test** | **Fehling's Test** | **Tollens' Test** |
| Heat with ORANGE acidified $Cr_2O_7^{2-}$ | Heat with BLUE alkaline $Cu^{2+}$ ( + NaOH) | Heat with COLOURLESS alkaline $Ag^+$ ( + $NH_3$) |
| For Aldehyde : | | |
| ORANGE □ GREEN SOLN [$Cr^{3+}(aq)$] | BLUE SOLN □ BRICK-RED PPT [$Cu_2O(s)$] | COLOURLESS SOLN □ SILVER MIRROR [Ag(s)] |
| Cr(+6) □ (+3) | Cu(+2) □ (+1) | Ag(+1) □ (0) |
| **ALDEHYDE IS OXIDISED TO THE CARBOXYLIC ACID.** | | |
| **For Ketone :** | | |
| Remains ORANGE | Remains BLUE | Remains COLOURLESS |

# Task 2: MCQ on Oxidation of alcohols

## Oxidation of alcohols

**Question: 1/5**

What reaction conditions are required to produce **butanone**?

**A)** Butan-2-ol heated with an aqueous solution of acidified potassium dichromate(VI).

**B)** Butan-1-ol distilled with an aqueous solution of acidified potassium dichromate(VI).

**C)** Butanal refluxed with excess concentrated sulfuric acid.

# Oxidation of alcohols

**Question: 2/5**

What reaction conditions are required to produce **ethanoic acid**?

**A)** Ethanol refluxed with excess concentrated sulfuric acid.

**B)** Ethanol distilled with an aqueous solution of acidified potassium dichromate(VI).

**C)** Ethanol refluxed with excess acidified potassium dichromate(VI).

# Oxidation of alcohols

**Question: 3/5**

What reaction conditions are required to produce **propanone**?

**A)** Propan-1-ol distilled with an aqueous solution of acidified potassium dichromate(VI).

**B)** Propan-2-ol heated with an aqueous solution of acidified potassium dichromate(VI).

**C)** Propan-1-ol refluxed with excess concentrated sulfuric acid.

# Oxidation of alcohols

**Question: 4/5**

What reaction conditions are required to produce **propanal**?

**A)** Propan-1-ol refluxed with excess concentrated sulfuric acid.

**B)** Propan-2-ol heated with an aqueous solution of acidified potassium dichromate(VI).

**C)** Propan-1-ol distilled with an aqueous solution of acidified potassium dichromate(VI).

# Oxidation of alcohols

**Question: 5/5**

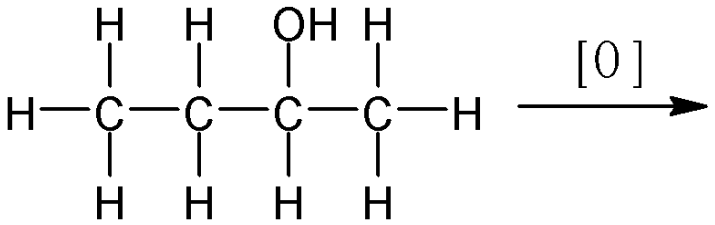
What reaction conditions are required to produce **hexanoic acid**?

**A)** Hexan-3-ol refluxed with excess acidified potassium dichromate(VI).

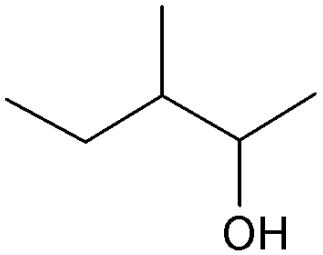
**B)** Hexan-1-ol refluxed with excess acidified potassium dichromate(VI).

**C)** Hexanone refluxed with excess acidified potassium dichromate(VI).

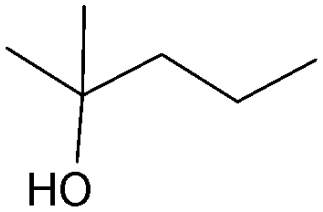
# Task 3: Predict the oxidation product in each of the following.




[O] →



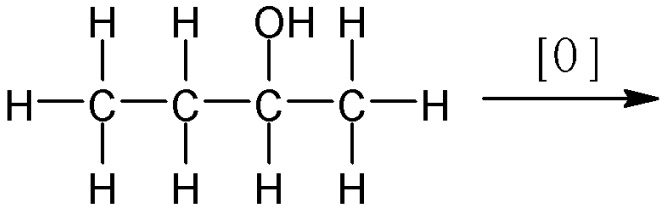

[O] →



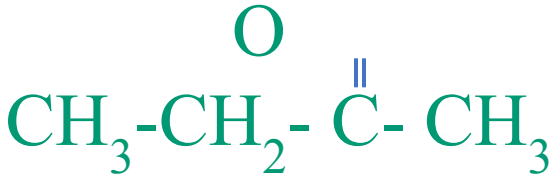

[O] →

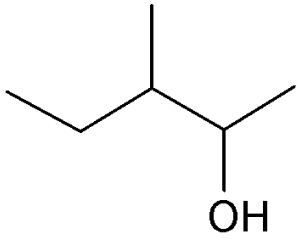
$CH_3CH_2OH$ [O] →

# ANSWERS

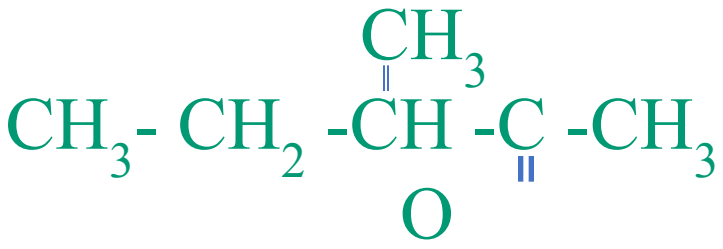


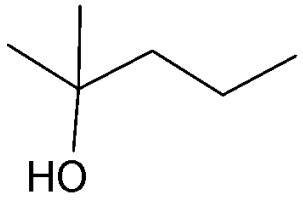

[O] →




[O] →




[O] →

NO REACTION

$CH_3CH_2OH$ [O] →

# Reflection

- What has been learned
- What remained unclear
- What is necessary to work on