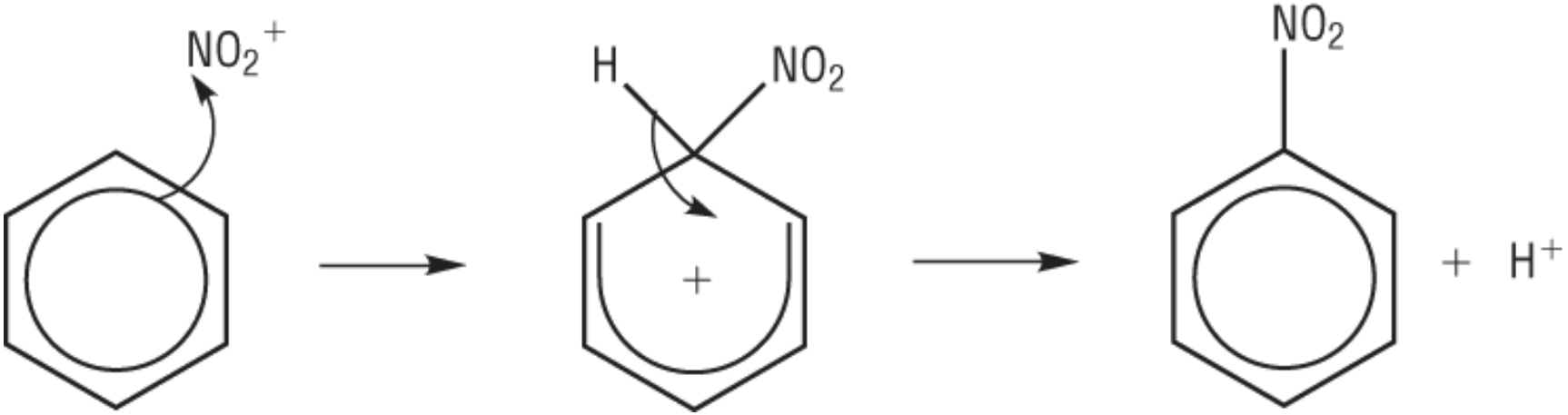
# Nitration of Benzene



- **Reactivity – high electron density above and below the carbon plane attracts electrophiles.**

- **Electrophilic substitution by nitration →**
- Conditions – 50˚c and sulfuric acid as the catalyst.
- $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + HSO_4^- + H_2O$



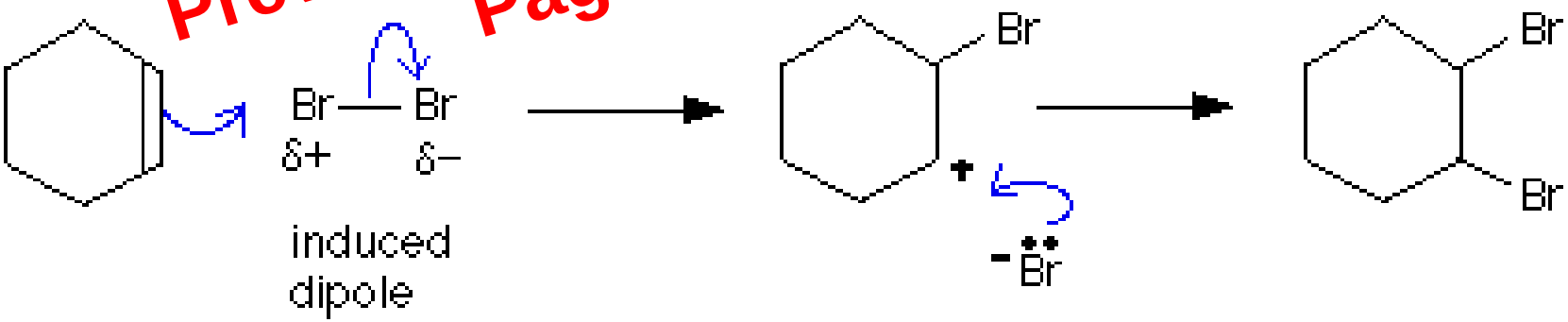

- $H^+ + HSO_4^- \rightarrow H_2SO_4$

- **Overall reaction:** $C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$

# The Reactivity of Alkenes and Benzene

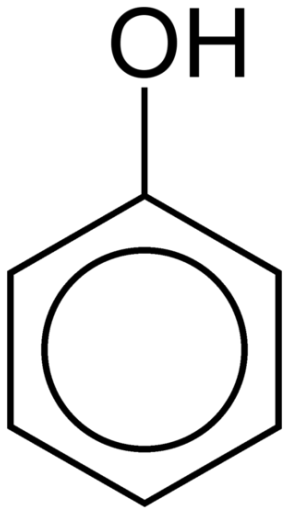


- **Cyclohexene and bromine water →**
- Bromine water is decolourised.




- The π-bond contains localised electrons – region of high electron density.
- Electrons repel electrons in the Br-Br bond – induced dipole.
- The π electron pair from cyclohexene breaks the double bond – new bond forms between carbon and bromine – positive carbocation formed.
- Bromide is attracted to the carbocation.

# Phenols






- **Phenols have an –OH group attached to a benzene ring.**
- Aromatic compounds with an –OH on the side chain are called aromatic alcohols.
- Phenol is solid at room temperature – slightly soluble in water.
- When dissolved in water, phenol forms a weak acidic solution by losing $H^+$ from the –OH.

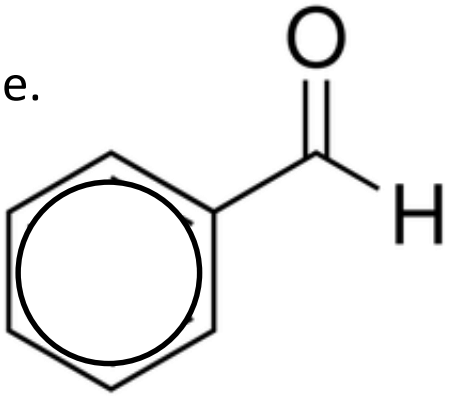
- Phenol is neutralised by aqueous sodium hydroxide to form the salt sodium phenoxide and water.
- $C_6H_5OH + NaOH \rightarrow C_6H_5O^-Na^+ + H_2O$

- When a reactive metal such as sodium is added to phenol, the metal effervesces producing hydrogen gas. It produces sodium phenoxide as well.

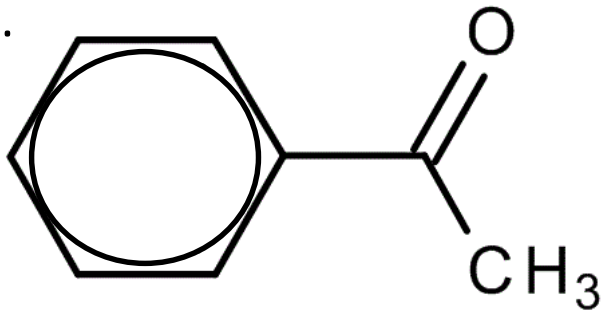
# Carbonyl Compounds



- The carbonyl bond **(C=O)** doesn't react in the same way as the double bond in an alkene.
- The oxygen is more electronegative than the carbon – this creates a dipole.
- **Aromatic aldehydes and ketones have a benzene ring and C=O.**
- Simplest aromatic aldehyde → Benzaldehyde.




- Simplest aromatic ketone → Phenylethanone.



# Esters



- **Esters from carboxylic acids →**
- **Carboxylic acid + Alcohol → Ester + Water**
- **Catalyst:** sulfuric acid.
- **Reaction:** esterification.

# Fats & Oils



- Fats protect organs, provide insulation and acts as an energy source.
- Animal and vegetable fats and oils are esters of long-chain carboxylic acids → fatty acids.
- **Fats →** melting point above room temperature.
- **Oils →** melting point below room temperature.

- **Triglycerides →**
- Occur naturally in animal and vegetable fats.
- They are triesters of an alcohol called propane–1,2,3–triol.
- Fatty acids can be saturated (no double bonds) or saturated (double bonds).

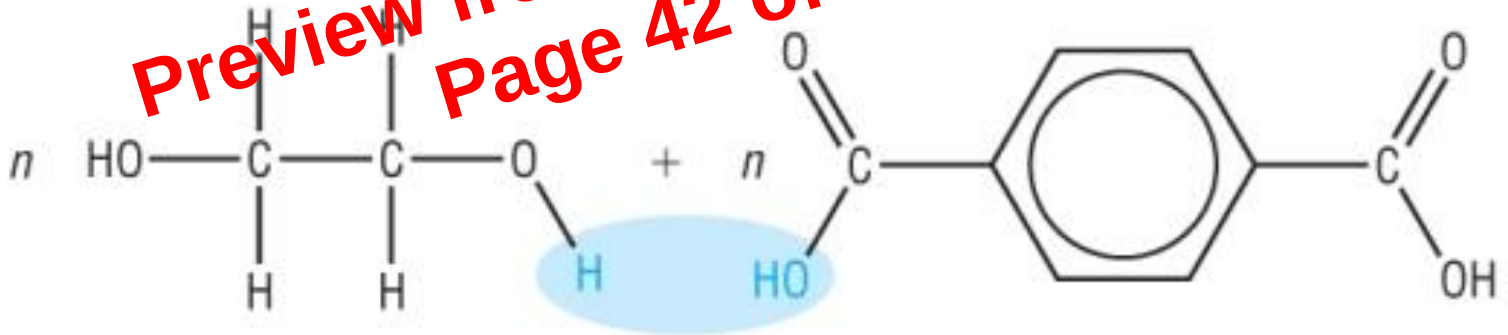
- **Nomenclature →** Example: Octadec–9,12–dienoic acid **→ 18:2 (9,12)**

# Condensation Polymerisation

## Polyesters

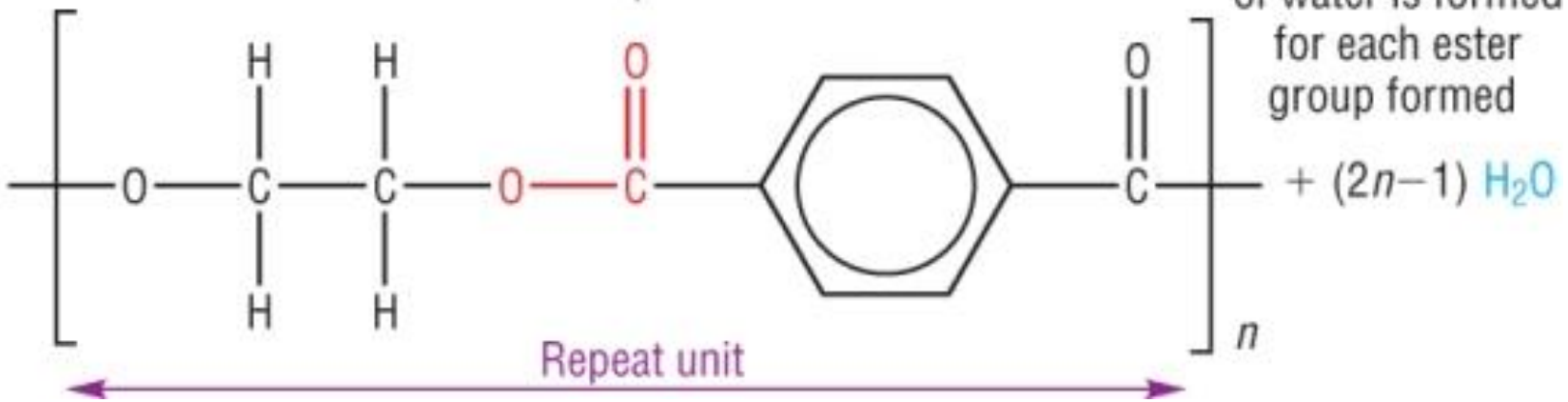


- **Diol & Dicarboxylic acid →**




Ethane-1,2-diol

Benzene-1,4-dicarboxylic acid



# Thin-Layer Chromatography



- **Stationary phase** → thin layer of an adsorbent such as silica gel or alumina coated on a flat, inert support – TLC plate.
- **Mobile phase** → liquid solvent.
- **Producing chromatogram** →
- Small sample of mixture is dissolved.
- Spot of sample is placed on the pencil line of the TLC plate.
- Jar is sealed to saturate the space with solvent vapour – slows down evaporation of solvent.
- As solvent rises, it meets the sample – components are swept upwards with the solvent.
- Some components bind to the adsorbent strongly, others more weakly.
- To achieve maximum separation, solvent is left to rise close to the top.
- Position of solvent is marked – it then evaporates.
- Separated components appear as a spot – some are coloured, others need a locating agent or radiation to be seen.

# Nuclear Magnetic Resonance



- NMR is used to examine molecular structure in detail.

- **Requirements →**
- Strong magnetic field applied using an electromagnet.
- Low-energy radio-frequency radiation.

- In the nucleus, protons and neutrons are called nucleons.
- Nucleons have a property called spin – can be one of two directions.
- Opposite spins pair up.
- Nuclei of some isotopes have an uneven number of nucleons – the unpaired nucleon produces a small residual nuclear spin – generates a magnetic field.

- Nuclei with a magnetic field can line up in a strong magnetic field either with the field or opposed to.

- Nuclei that oppose the magnetic field have a higher energy.
- Stronger the magnetic field, the larger the energy gap → **ΔE.**

# NMR Spectra of -OH & -NH Protons



- **Difficult to identify –OH and –NH protons →**
- Peaks can have a value over a wide chemical shift range.
- Signals are often broad.
- Usually no splitting pattern.

- **$D_2O$ → Deuterium oxide "heavy water".**
- Deuterium does not produce a signal.
- **Use of $D_2O$ →**
- First, a proton NMR spectrum is run.
- Small amount of $D_2O$ is added.
- Second proton NMR spectrum is run – any peak due to –OH and –NH protons disappear.
-
- Deuterium in $D_2O$ exchanges with the hydrogen in –OH and –NH.
- E.g. $CH_3CH_2OH + D_2O \rightarrow CH_3CH_2OD + HOD$.

- NMR peaks for –OH and –NH protons do not split – shows as a broad singlet.
- Traces of water in solvent form hydrogen bonds with –OH and –NH – results in broad signal.
- Protons on adjacent carbon atoms are not split by –OH or –NH.