

CIE Chemistry A-Level

Topic 14 - An Introduction to Organic Chemistry

Flashcards

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What is a functional group?



What is a functional group?

The group of atoms responsible for the characteristic reactions of a compound.



What is a homologous series?



What is a homologous series?

A series of organic compounds with the same functional group with successive members differing by -CH_2 .



What is an alkane? Include the general formula



What is an alkane? Include the general formula

A saturated hydrocarbon with general
formula C_nH_{2n+2} .

Suffix: -ane.



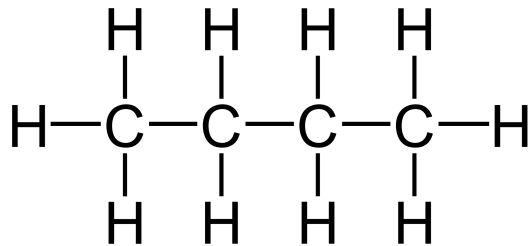
State the molecular, displayed and skeletal formulae of butane



State the molecular, displayed and skeletal formulae of butane

Molecular: C_4H_{10}

Displayed:



Skeletal:



What is an alkene? Include the general formula



What is an alkene? Include the general formula

An unsaturated hydrocarbon with the
general formula C_nH_{2n} .

Suffix: -ene.



Write the molecular, displayed and skeletal formulae of but-2-ene



Write the molecular and skeletal formulae of but-2-ene

Molecular: C_4H_8

Skeletal:



The number 2 in but-2-ene signifies that the double bond is between the 2nd and 3rd carbon.



What is an arene?

(A level only)



What is an arene? **(A level only)**

- An aromatic hydrocarbon.
- Aromatic means that it contains a benzene ring.
- Prefix: phenoyl- OR suffix: -benzene.



What is a halogenoalkane?



What is a halogenoalkane?

An alkane where a hydrogen atom has been replaced by a halogen atom.

Prefix: fluoro-/ chloro-/ bromo-/ iodo-.



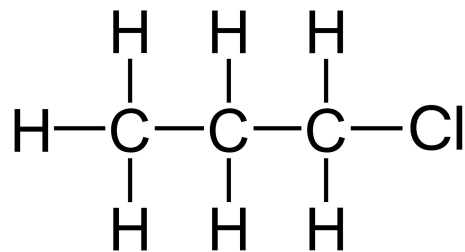
Write the molecular, displayed and skeletal formulae of 1-chloropropane.



Write the molecular, displayed and skeletal formulae of 1-chloropropane

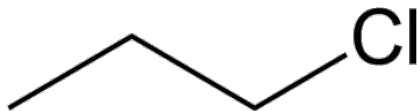
Molecular: $\text{C}_3\text{H}_7\text{Cl}$

Displayed:



The '1' refers to the carbon the halogen atom is bonded to.

Skeletal:

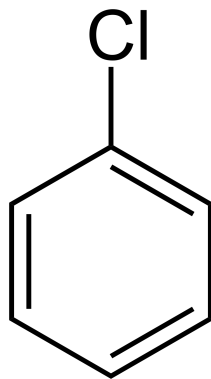


What is a halogenoarene? **(A level only)**



What is a halogenoarene? **(A level only)**

- An aromatic hydrocarbon whereby one or more hydrogen atoms bonded to the aromatic ring are replaced by a halogen atom.
- E.g. Chlorobenzene:



Naming: [fluoro-/ chloro-/ bromo-/ iodo-] - benzene



What is an alcohol? Include the general formula



What is an alcohol? Include the general formula

An organic compound with a lone hydroxyl group (-OH) attached to an alkyl group. The general formula is $C_nH_{2n+1}OH$.

Suffix: -ol.

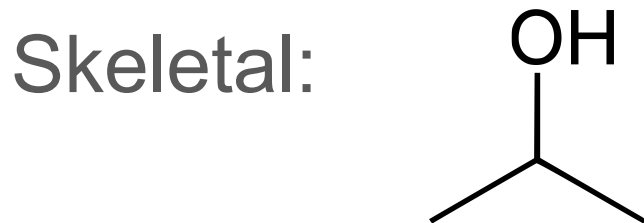


Write the molecular and skeletal formulae of propan-2-ol



Write the molecular and skeletal formulae of propan-2-ol

Molecular: $\text{C}_3\text{H}_8\text{O}$



The '2' refers to the position of the hydroxyl group.

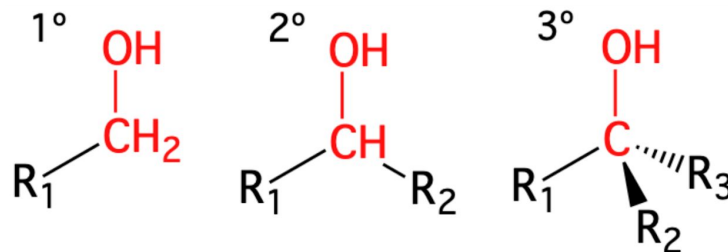


How are alcohols classified?



How are alcohols classified?

(R group - any alkyl chain)



- Primary, 1° - The carbon bonded to the hydroxyl group is bonded to one R group only.
- Secondary, 2° - The carbon bonded to the hydroxyl group is bonded to two R groups.
- Tertiary, 3° - The carbon bonded to the hydroxyl group is bonded to three R groups.



What is a phenol?

(A level only)

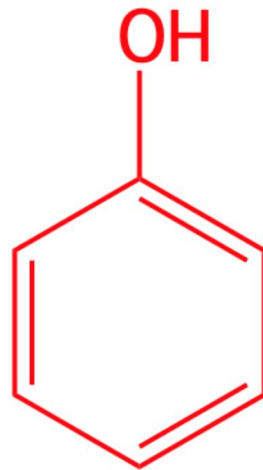


What is a phenol? **(A level only)**

A phenyl group ($-\text{C}_6\text{H}_5$) bonded to a hydroxyl group ($-\text{OH}$).

Phenol = $\text{C}_6\text{H}_5\text{OH}$.

Suffix: -phenol / -benzenol.



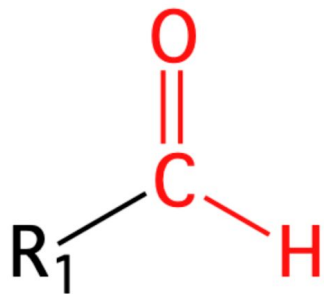
What is an aldehyde? Draw the functional group



What is an aldehyde? Draw the functional group

An organic compound with the -CHO functional group.

Suffix: -al.



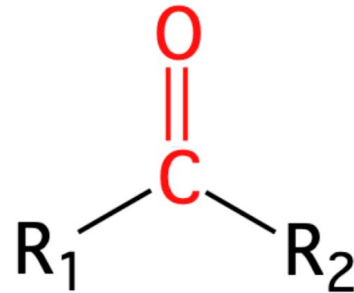
What is a ketone? Draw the functional group



What is a ketone? Draw the functional group

An organic compound with the RCO₂R functional group.

Suffix: -one.



E.g. propanone, more commonly known as acetone.



What is a carboxylic acid? Draw the functional group

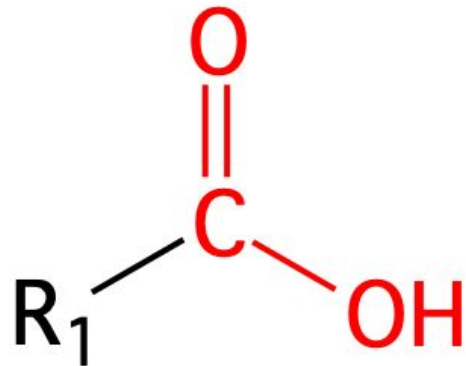


What is a carboxylic acid? Draw the functional group

An organic compound with the -COOH functional group.

Suffix: -oic acid.

E.g. ethanoic acid, a key component of vinegar.

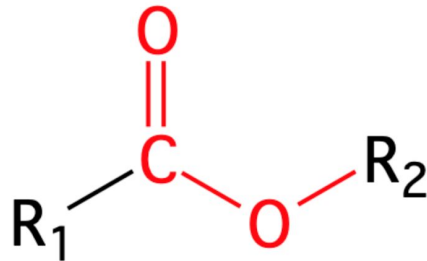


What is an ester? Draw the functional group

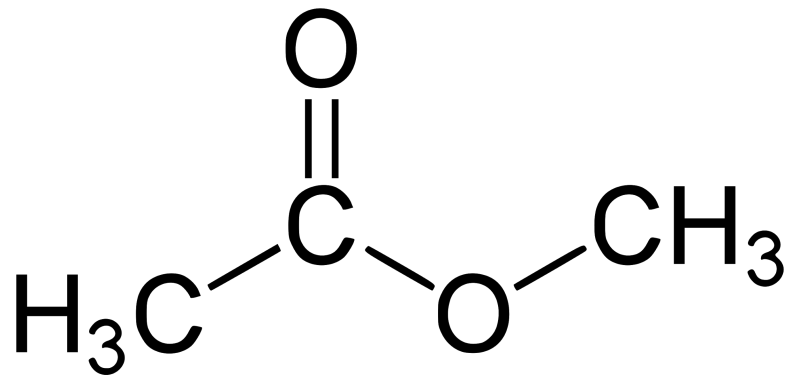


What is an ester? Draw the functional group

An organic compound commonly formed from a condensation reaction between alcohol and carboxylic acid functional groups.

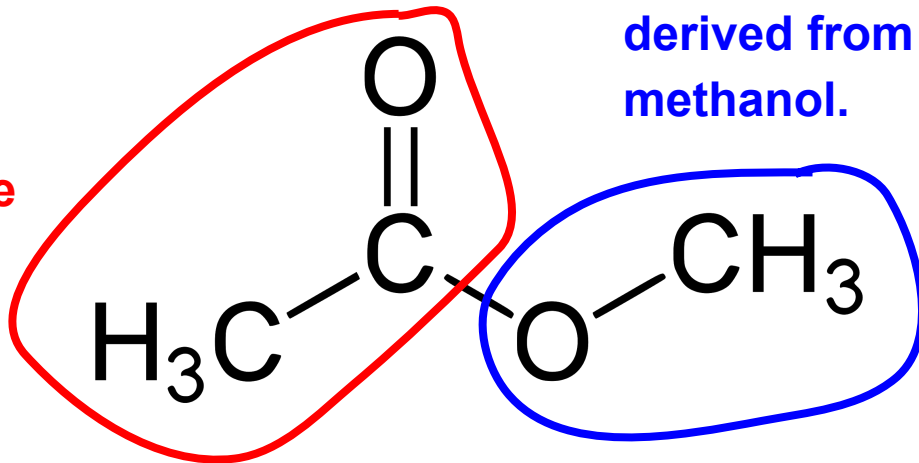


Name the ester shown below



Name the ester shown below

This part of the molecule is derived from the carboxylic acid, ethanoic acid.



This part of the molecule is derived from the alcohol, methanol.

Methyl ethanoate



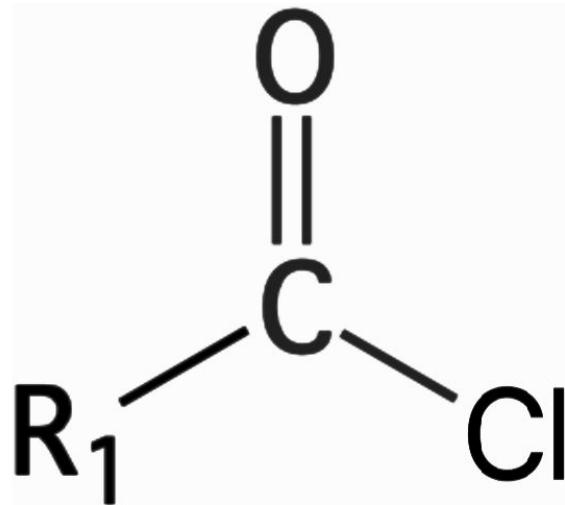
What is an acyl chloride? Draw the
functional group
(A level only)



What is an acyl chloride? Draw the functional group **(A level only)**

A carboxylic acid derivative where the -OH group in -COOH has been replaced with a chlorine atom to form a -COCl group.

Suffix: -oyl chloride.

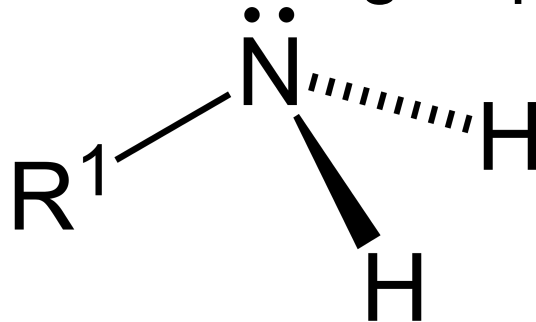


What is a primary amine? Draw the functional group



What is a primary amine? Draw the functional group

- An amine is a derivative of ammonia.
- In a primary amine, one hydrogen atom in ammonia is substituted with an alkyl group.
- Suffix: -amine.

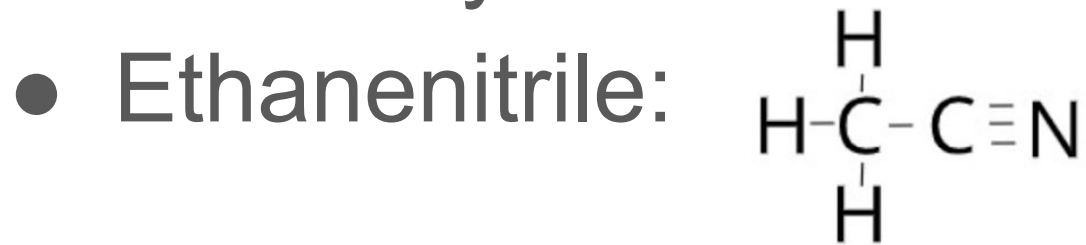


What is a nitrile? Draw the displayed formula of ethanenitrile



What is a nitrile? Draw the displayed formula of ethanenitrile

- An organic compound with a -CN functional group.
- Prefix: cyano- OR suffix: -nitrile.



What is an amide?

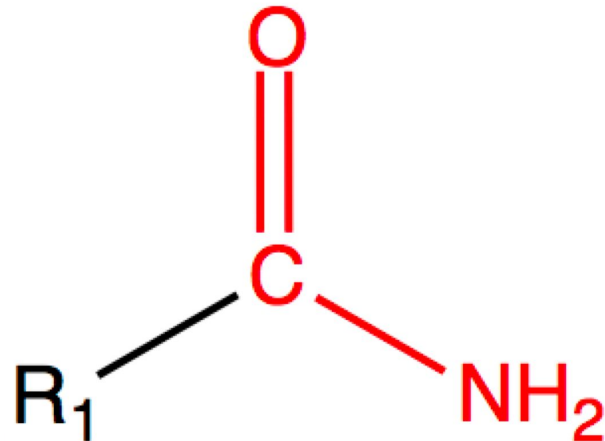
(A level only)



What is an amide? **(A level only)**

Formed from the condensation reaction between a carboxylic acid and an amine functional group.

Suffix: -amide



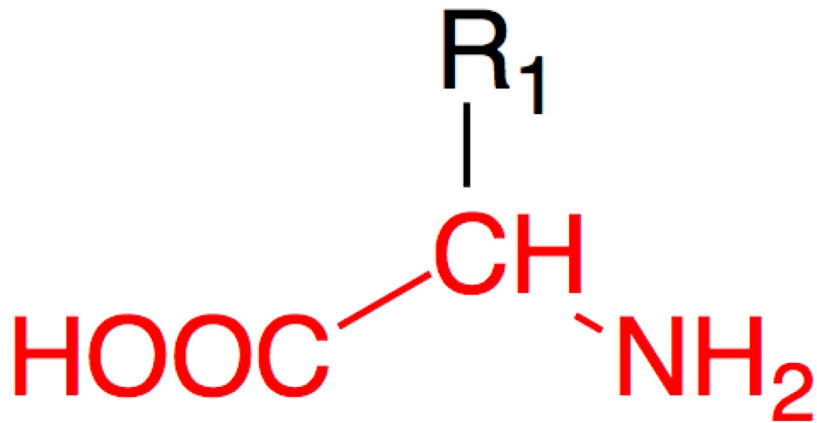
What is an amino acid?

(A level only)



What is an amino acid? (A level only)

- An organic compound that has both a carboxylic acid and amine functional group.
- In an alpha-amino acid, both groups are attached to the same carbon atom.
- Naming: Amino- -oic acid.



What is an aliphatic hydrocarbon?



What is an aliphatic hydrocarbon?

A compound containing only carbon and hydrogen atoms in which the carbon atoms are arranged in a linear or branched structure.



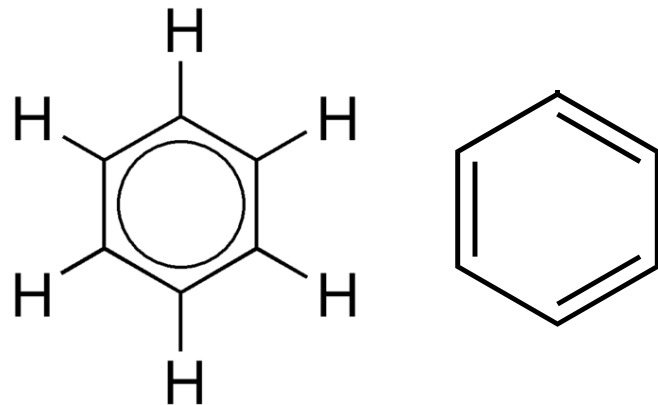
What is benzene?



What is benzene?

Benzene is an aromatic hydrocarbon/
arene.

Molecular formula: C_6H_6



Describe how to name an organic compound.



Describe how to name an organic compound

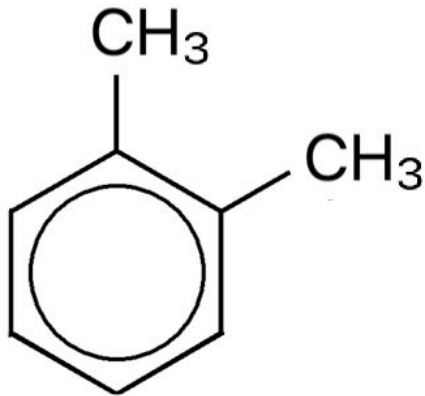
- Identify the longest carbon chain that contains the functional group (this is the stem).
- Identify the functional group (this is the prefix / suffix).
- Count the number of carbon atoms so that the functional group has the lowest number.
- Add any side chains or less important functional as prefixes (in alphabetical order).
- If there are 2 or more identical groups, use the prefixes di-/ tri-/ tetra- before that part of the name.



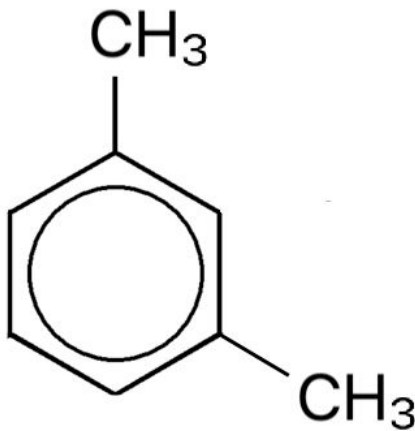
Draw and name the different structural isomers of dimethylbenzene
(A level only)



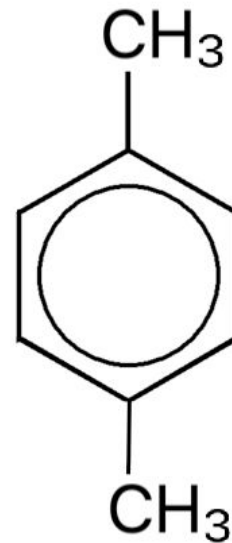
Draw and name the different structural isomers of dimethylbenzene (**A level only**)



1,2-Dimethylbenzene



1,3-Dimethylbenzene



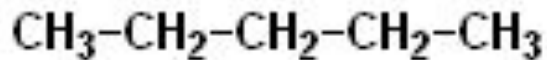
1,4-Dimethylbenzene



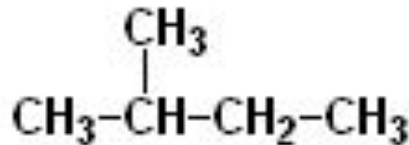
Draw and name the structural isomers of
the aliphatic hydrocarbon C_5H_{12}



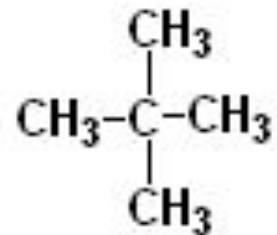
Draw and name the structural isomers of the aliphatic hydrocarbon C_5H_{12}



pentane



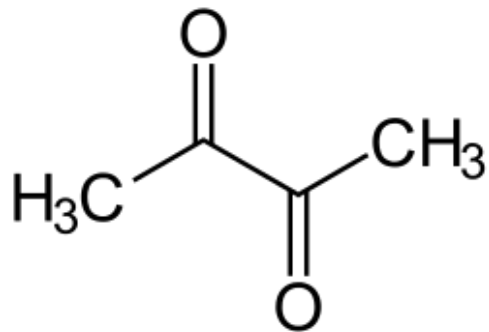
methylbutane



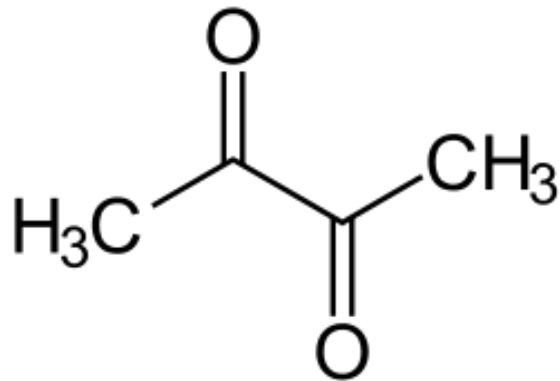
dimethylpropane



What is the molecular formula of the compound below?



What is the molecular formula of the compound below?

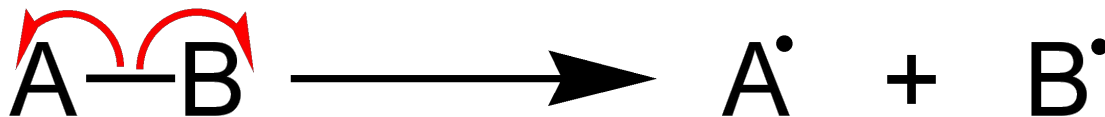


What is homolytic fission?



What is homolytic fission?

A covalent bond breaks. Each bonding atom receives an electron from the bonding pair, forming two radicals (highly reactive, neutral species).

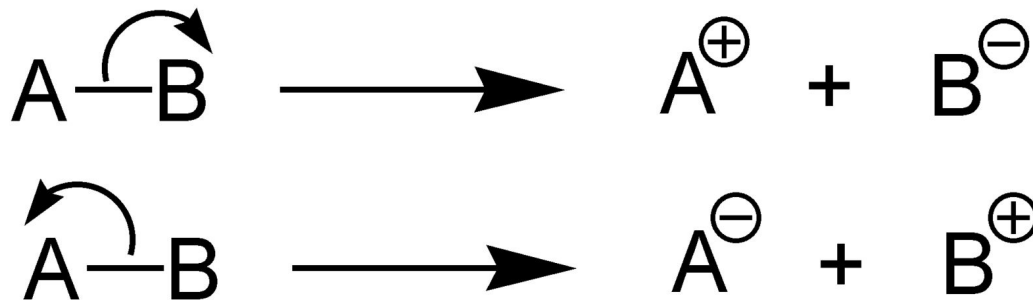


What is heterolytic fission?



What is heterolytic fission?

A covalent bond breaks. One bonding atom receives both electrons from the bonding pair.



[Jürgen Martens](#), [CC BY-SA 3.0](#)



What is a free radical?



What is a free radical?

A highly reactive neutral species with an unpaired electron.



What are the three steps in a free radical substitution mechanism?



What are the three steps in a free radical substitution mechanism?

1. Initiation
2. Propagation
3. Termination



What is an electrophile?



What is an electrophile?

An electron pair acceptor



What is an nucleophile?



What is an nucleophile?

An electron pair donor



What is an addition reaction?



What is an addition reaction?

An addition reaction is a reaction where two reactants react to form one product.

The atom economy is 100%.



What is a substitution reaction?



What is a substitution reaction?

A substitution reaction is a reaction where an atom/ group is replaced by another atom/ group.

Atom economy is less than 100%.



What is an elimination reaction?



What is an elimination reaction?

- An elimination reaction is a reaction where 2 substituents are removed from a molecule.
- E.g. a dehydration reaction (a molecule of water is produced).



What is a hydrolysis reaction?



What is a hydrolysis reaction?

The splitting of a compound/ molecule using water.



What is a condensation reaction?



What is a condensation reaction?

The formation of a compound with the release of water.



What is oxidation?



What is oxidation?

Loss of electrons / increase in oxidation number.



What is reduction?



What is reduction?

Gain of electrons / decrease in oxidation number.



In organic redox reactions, how can oxidising and reducing agents be represented?



In organic redox reactions, how can oxidising and reducing agents be represented?

- Oxidising reagents: [O]
- Reducing reagents: [H]



What is electron repulsion theory?



What is electron repulsion theory?

- Electron pairs are areas of negative charge that repel each other.
- Lone pairs of electrons offer more repulsion than bonding pairs.



Describe the shape and bond angles of ethene



Describe the shape and bond angles of ethene

- Bond shape: Trigonal Planar
- Bond angle: 120°



Describe the shape and bond angles in ethane



Describe the shape and bond angles in ethane

- Bond shape: Tetrahedral
- Bond angle: 109.5°



Explain the bond shape and angle in an ethane molecule.



Explain the bond shape and angle in an ethane molecule.

- Both carbon atoms promote an electron from the 2s orbital to the 2p orbital to form four identical sp^3 hybrid orbitals.
- These sp^3 orbitals arrange themselves as far apart as possible from each other.
- Each carbon atom then forms sigma bonds with the three hydrogen atoms. A sigma bond also forms between the two carbon atoms when the sp^3 orbitals overlap end-to-end.
- There are 4 bonding pairs of electrons which causes a tetrahedral bond shape and a bond angle of 109.5° .



Explain the bond shape and angle in an ethene molecule.



Explain the bond shape and angle in an ethene molecule.

- Both carbon atoms promote an electron from the 2s orbital to the 2p orbital to form three identical sp^2 hybrid orbitals. (The other 2p orbital is unchanged).
- The three sp^2 orbitals arrange themselves as far apart as possible from each other.
- 2 sp^2 orbitals forms a sigma bond with a hydrogen. A sigma bond forms between the carbon atoms when the sp^2 orbitals overlap end-to-end, followed by a pi bond when the p-orbitals overlap sideways.
- There are 3 areas of electron density, creating a trigonal planar shape and a bond angle of 120° .



Describe the shape and bond angle of
benzene
(A level only)



Describe the shape and bond angle of benzene
(A level only)

Planar, 120°



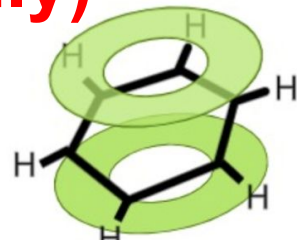
Describe the bonding in benzene

(A level only)



Describe the bonding in benzene (**A level only**)

Delocalised structure of benzene:



- Each carbon atom uses two electrons to form sigma bonds with the adjacent carbon atoms. One electron is used to form a sigma bond with a hydrogen atom.
- The remaining electron on each carbon atom is delocalised to form a delocalised π system (an area of electron density).

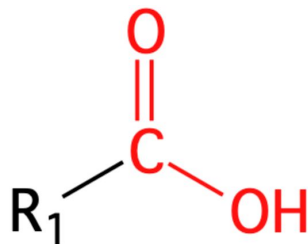


Predict the shape and bond angle
around carbon in RCOOH



Predict the shape and bond angle around carbon in RCOOH

- 3 areas of electron density like ethene
- Bond shape: Trigonal planar
- Bond angle: 120°



What is structural isomerism?



What is structural isomerism?

Compounds with the same molecular formula but different structural formulae.



What are the 3 divisions of structural isomerism?



What are the 3 divisions of structural isomerism?

1. Positional
2. Chain
3. Functional group



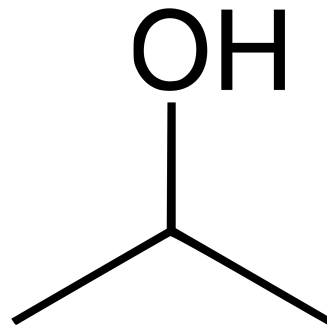
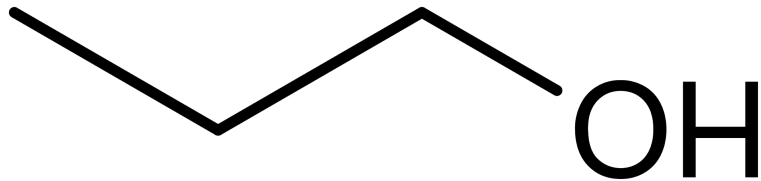
Why are propan-1-ol and propan-2-ol structural isomers?



Why are propan-1-ol and propan-2-ol structural isomers?

Positional isomerism

The position of the functional group has changed.



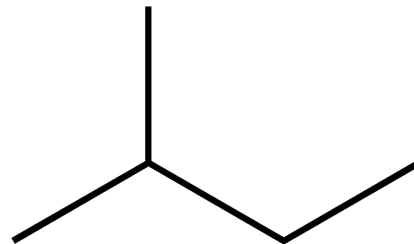
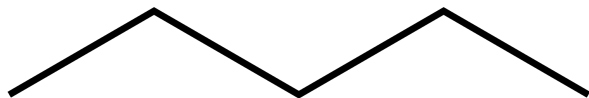
Why are pentane and 2-methylbutane structural isomers?



Why are pentane and 2-methylbutane structural isomers?

Chain isomerism

Branching changes the structural formula of a compound.



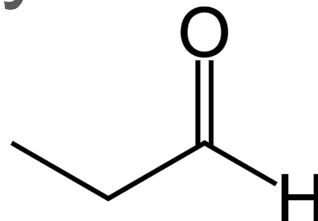
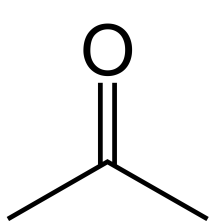
Why are propanal and propanone structural isomers?



Why are propanal and propanone structural isomers?

Functional group isomerism

The functional group has changed
(molecular formula stays the same).



What is stereoisomerism?



What is stereoisomerism?

Compounds with the same molecular and structural formulae but a different arrangement of atoms in space.



What causes geometrical (cis-trans) stereoisomerism?



What causes geometrical (cis-trans) stereoisomerism? What do cis and trans mean?

Cause by the limited rotation around the carbon-carbon pi bond. Any groups bonded to the carbon are fixed in position.



How do you determine whether an stereoisomer is cis or trans?



How do you determine whether an stereoisomer is cis or trans?

- In trans (or *E*) isomers, high priority groups are on opposite sides of the C=C (above and below).
- In cis (or *Z*) isomers, high priority groups are on the same side of the C=C (above or below).



How can you identify the highest priority group?



How can you identify the highest priority group?

- For molecules where only single atoms are attached to the carbons in the $C=C$, the highest priority group has the highest atomic mass.
- For non-complex small groups such as $-CH_3$, look at the atomic mass of the atom attached directly to the $C=C$ (in $-CH_3$ this would be the carbon atom- ignore the hydrogen atoms). The one with the greatest atomic mass is the high priority group.
- For more complex groups (i.e. CH_3CH_2Cl), don't just observe the atomic mass of the carbon as it is directly attached to the $C=C$, look at what the carbon is directly attached to etc.

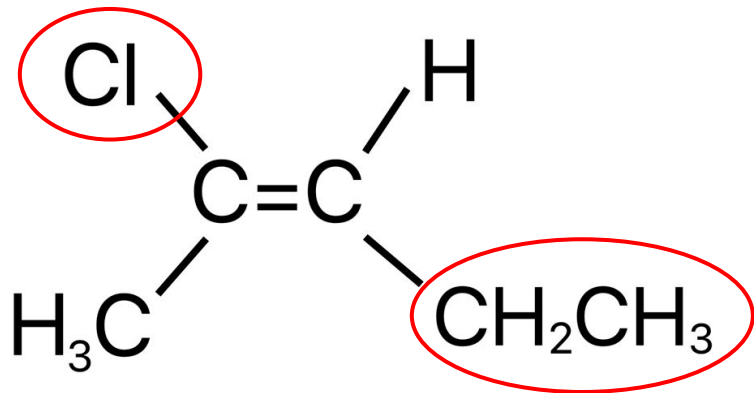


Draw the cis and trans isomers of
2-chloropent-2-ene



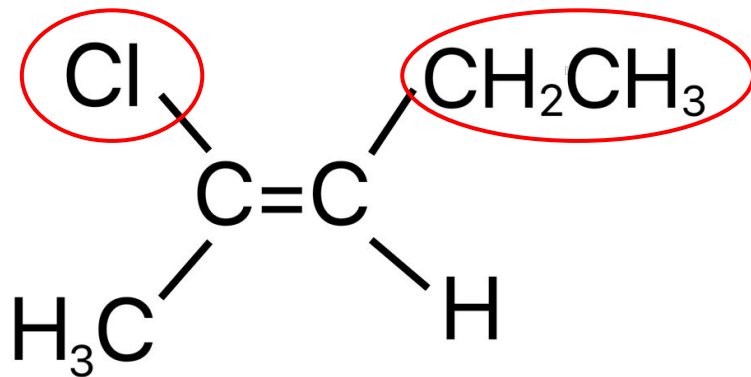
Draw the cis and trans isomers of 2-chloropent-2-ene

trans-2-Chloropent-2-ene



The high priority groups are on opposite sides of C=C.

cis-2-chloropent-2-ene



The high priority groups are on the same side of C=C.



What causes optical isomerism? What are optical isomers?



What causes optical isomerism? What are optical isomers?

- Optical isomerism is a type of **stereoisomerism** found in molecules that contain a chiral centre.
- Optical isomers or *enantiomers* are non-superimposable, mirror images of each other.



What is a chiral centre?



What is a chiral centre?

In organic chemistry, a chiral centre is in the form of a carbon atom bonded to four different groups. Compounds may contain more than 1 chiral centre.

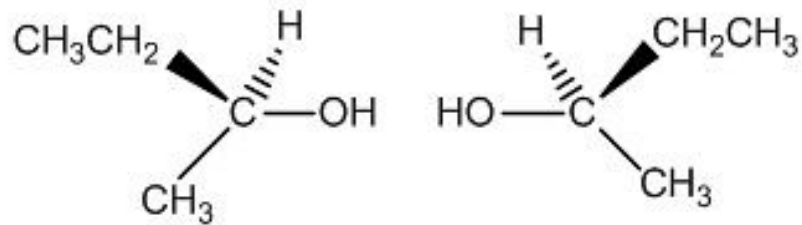


Draw diagrams to show the optical isomers of butan-2-ol. Why can butan-2-ol form optical isomers?



Draw diagrams to show the optical isomers of butan-2-ol. Why can butan-2-ol form optical isomers?

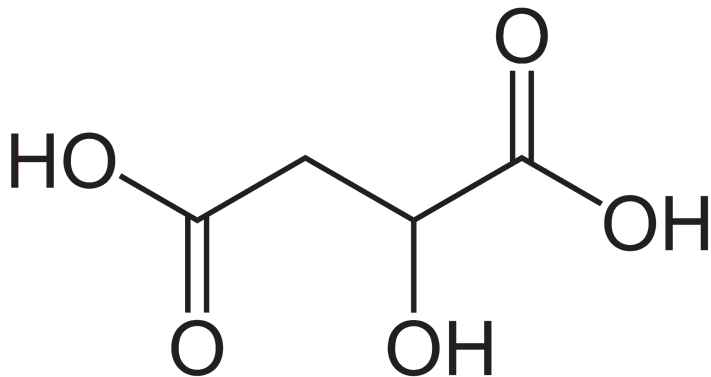
Optical isomers:



The central carbon in the diagrams is chiral because it is attached to four different groups: -OH, -CH₃, -H, and -CH₂CH₃. The two isomers are non-superimposable mirror images of each other.



Identify the chiral centre in the molecule below



Identify the chiral centre in the molecule below

This carbon is chiral as it is bonded to 4 different groups:
-H, -OH, -COOH, -CH₂COOH

