Edexcel Chemistry A-level

Topic 6 - Organic Chemistry I

Flashcards

What does nomenclature mean?

What does nomenclature mean?

The system used for naming organic compounds

What does the term empirical formula mean?

What does the term empirical formula mean?

Simplest whole number ratio of atoms in a molecule

What does the term molecular formula mean?

What does the term molecular formula mean?

It provides the actual number of atoms of different elements in a molecule

What does the term displayed formula mean?

What does the term displayed formula mean?

It shows every atom and every bond in a molecule

What does the term structural formula mean?

What does the term structural formula mean?

It shows the arrangement of atoms in a molecule without showing every bond

Define skeletal formula

Define skeletal formula

A type of formula which is drawn as lines with each vertex being a carbon atom. Carbon atoms not drawn, assumed each C atom has all unspecified bonds as C-H

Define homologous series

Define homologous series

A series of organic compounds having the same functional group but with each successive member differing by CH_2

What is a functional group?

What is a functional group?

A group of atoms responsible for characteristic reactions of a compound

Give the suffixes for:

a) No double bonds
b) At least one double bond
c) An alcohol
d) An aldehyde
e) A ketone
f) A carboxylic acid

Give the suffixes for:

a) No double bonds -ane
b) At least one double bond -ene
c) An alcohol -ol
d) An aldehyde -al
e) A ketone -one
f) A carboxylic acid -oic acid

Give the prefixes for:

a) CH_3 group
b) C_2H_5 group
c) C_3H_7 group
d) C_4H_9 group
e) Cl group
f) Br group
g) I group

Give the prefixes for:

a) CH_3 group methyl-
b) C_2H_5 group ethyl-
c) C_3H_7 group propyl-
d) C_4H_9 group butyl-
e) Cl group chloro-
f) Br group bromo-
g) I group iodo-

What is the general formula of alkanes?

What is the general formula of alkanes?

C_nH_{2n+2}

What is the general formula of alkenes?

What is the general formula of alkenes?

C_nH_{2n}

What does saturated mean?

What does saturated mean?

Organic compounds which only contain single bonds

What are unsaturated compounds?

What are unsaturated compounds?

Organic compounds that contain at least one carbon carbon double covalent bond

Define structural isomerism

Define structural isomerism

When molecules have the same molecular formula but different structural formula

What are the 3 ways in which structural isomers can be formed?

What are the 3 ways in which structural isomers can be formed?

1. Alkyl groups can be in different places
2. Functional groups can be bonded to different parts
3. There can be different functional groups

What are stereoisomers?

What are stereoisomers?

Organic compounds with the same molecular formula but have different arrangement of atoms in space

What is E-Z isomerism and how are the E and Z isomers decided?

What is E-Z isomerism and how are E and Z isomers differentiated?

E-Z isomerism is caused by the limited rotation about C=C double bonds

If the two substituents with the highest atomic number are on the same side of the double bond, it is the Z (zusammen) isomer

If they are on different sides, it is the E (entgegen) isomer

What is Cis-trans isomerism?

What is Cis-trans isomerism?

Special type of E/Z isomerism where the two substituents on each carbon atom are the same

Is this an E or Z isomer?

Is this an E or Z isomer?

E isomer

What is homolytic fission?

What is homolytic fission?

It happens when each bonding atom receives one electron from the bonded pair forming two radicals

What is heterolytic fission?

What is heterolytic fission?

When one bonding atom receives both electrons from the bonded pair

What are radicals?

What are radicals?

Highly reactive, neutral species

How is a covalent bond formed from two radicals?

How is a covalent bond formed from two radicals?

The radicals collide and the electrons are involved the bond formation

What is an alkane?

What is an alkane?

A saturated hydrocarbons containing C-H bonds only

What is the general formula of an alkane?

What is the general formula of an alkane?

C_nH_{2n+2}

How are alkane fuels obtained?

How are alkane fuels obtained?

Alkane fuels are obtained from the fractional distillation, cracking and reforming of crude oil.

Describe the process of fractional distillation

Describe the process of fractional distillation of crude oil

1. The oil is pre-heated then passed into a column.
2. The fractions condense at different heights and the temperature of column decreases upwards
3. The separation of the fuels depends on boiling point which depends on size of molecules. The larger the molecule the larger the London forces
4. Similar molecules (size, bp, mass) condense together and so are collected at the same fraction
5. Small molecules condense at the top at lower temperatures and big molecules condense at the bottom at higher temperatures.

What is cracking?

What is cracking?

It is the process of converting large hydrocarbons to smaller molecules by breakage of C-C bonds

What is the reforming of crude oil?

What is the reforming of crude oil?

It is processing of straight-chain hydrocarbons into branched-chain alkanes and cyclic hydrocarbons for efficient combustion.

What is the shape and angle of an alkane?

What is the shape and angle of an alkane?

Tetrahedral

109.5°

Describe the σ (sigma) bond in alkane

Describe the σ bond in alkane

The sigma bond is a covalent bond which has a direct overlap of the electron clouds of the bonding atoms.

How reactive are alkanes?

How reactive are alkanes?

Very unreactive

What reactions will alkanes undergo?

What reactions will alkanes undergo?

Combustion and reaction with halogens

What type of reaction is combustion?

What type of reaction is combustion?

Oxidation reaction

What is complete combustion?

What is complete combustion?

Combustion that occurs with plentiful supply of air

Write an equation for the complete combustion of octane

Write an equation for the complete combustion of octane

$$C_8H_{18}(g) + 12.5\ O_2\ (g) \rightarrow 8CO_2\ (g) + 9H_2O(l)$$

What are the products of complete combustion when alkanes are used?

What are the products of complete combustion when alkanes are used?

Carbon dioxide and water

What is the colour of the bunsen burner flame during complete combustion?

What is the colour of the bunsen burner flame during complete combustion?

Blue flame

What is incomplete combustion and what products are formed in the case of alkanes?

What is incomplete combustion and what products are formed in the case of alkanes?

Combustion in a limited supply of oxygen

Products : water, carbon dioxide and carbon monoxide

Write an equation for the complete combustion of propane

Write an equation for the combustion of propane

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$$

What type of hydrocarbon are most likely to undergo incomplete combustion?

Which type of hydrocarbon are most likely to undergo incomplete combustion?

Longer chains

What are the pollutants formed in the combustion of alkanes?

What are the pollutants formed in the combustion of alkanes?

Carbon monoxide, oxides of nitrogen and sulfur, carbon particulates and unburned hydrocarbons

What is the environmental impact of carbon monoxide?

What is the environmental impact of carbon monoxide?

It is toxic/poisonous

What is the environmental impact of soot (carbon)?

What is the environmental impact of soot (carbon)?

Asthma, cancer, global dimming

What are the environmental impacts of nitrogen oxides?

What are the environmental impacts of nitrogen oxides?

NO is toxic and can form smog

NO_2 is toxic and acidic and forms acid rain

What are the environmental impacts of unbranched hydrocarbons?

What are the environmental impacts of unbranched hydrocarbons?

They contribute towards formation of smog

What is the importance of catalytic converter?

What is the importance of catalytic converter?

These remove CO, nitrogen and unburned hydrocarbons (e.g. octane, C8H18) from the exhaust gases, turning them into less toxic products CO_2 , N_2 and H_2O.

What are biofuels?

What are biofuels?

They are fuels developed from renewable resources. Alcohols and biodiesel are two examples of renewable plant- based fuels

What are the advantages and disadvantages of biofuels?

What are the advantages and disadvantages of biofuels?

Advantages

- Reduces of use of non-renewable fossil fuels
- Use of biodiesel is more carbon-neutral
- Fossil fuels can be used feedstock for organic compounds
- Less large scale pollution

Disadvantages

- Less food crops may be grown because crops for biofuel would be grown instead
- Reduction of rain forests have to be cut down to provide land
- Shortage of fertile soils

How are halogenoalkanes formed from alkanes?

How are halogenoalkanes formed from alkanes?

Radical substitution

In the presence of what does alkane react with halogens?

In the presence of what does alkane react with halogens?

UV light

What are the three stages of free radical substitution?

What are the three stages of free radical substitution?

Initiation - breaking halogen bond to form free radicals

Propagation - chain part of the reaction where prod s are formed but free radical remains

Termination - free radicals removed, stable products formed

Write equations for the reaction of CH_4 with Cl_2 to form CH_3Cl

Write equations for the reaction of CH_4 with Cl_2 to form CH_3Cl

Initiation: $Cl_2 \rightarrow 2Cl\bullet$ (in presence of UV light)

Propagation: $Cl\bullet + CH_4 \rightarrow HCl + \bullet CH_3$

$\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + Cl\bullet$

Termination:

$\bullet CH_3 + Cl\bullet \rightarrow CH_3Cl$

$2Cl\bullet \rightarrow Cl_2$

$\bullet CH_3 + \bullet CH_3 \rightarrow CH_3CH_3$

What are the limitations of free radical substitution?

What are the limitations of free radical substitution?

If there is excess halogen further substitution will take place therefore the desired product will be harder to separate from the others.

What are alkenes?

What are alkenes?

Unsaturated hydrocarbons that contain at least one C=C bond made up of a π bond and a σ bond

What is the general formula of alkenes?

What is the general formula of alkenes?

C_nH_{2n}

How is a π bond formed?

How is a π bond formed?

Electrons in the adjacent p orbitals overlap above and below the carbon atoms. They can only be made after a σ bond is formed

What bond restricts the rotation of carbon atoms?

What bond restricts the rotation of carbon atoms?

π bond

What is the angle and shape of a double bond?

What is the angle and shape of a double bond?

Trigonal planar

120°

What is the qualitative test for alkanes?

What is the qualitative test for alkanes?

This tests for C=C double bond using bromine water. If the alkane is present bromine water decolourises.

Are they more or less reactive than alkanes? Why?

Are they more or less reactive than alkanes? Why?

More reactive due to high electron density of double bond and the fact the pi-bond is slightly easier to break

What intermolecular forces of attraction do they have?

What intermolecular forces of attraction do they have?

Only London forces due to non-polar bonds

Write an equation for the complete combustion of pent-2-ene

Write an equation for the complete combustion of pent-2-ene.

$$CH_3CH{=}CHCH_2CH_3 + 7½O_2 \rightarrow 5CO_2 + 5H_2O$$

What are the types of isomers that can be formed using alkenes?

What are the types of isomers that can be formed using alkenes?

E/Z isomers - due to the restricted rotation

Cis-trans isomers - if two of the same substituents are attached to each carbon

What is an electrophile?

What is an electrophile?

Species that are electron pair acceptors

What is the most stable type of carbocation intermediate? Why?

What is the most stable type of carbocation intermediate? Why?

Alkyl groups have a positive inductive effect, so the most stable carbocation is the one bonded to the most other carbon atoms i.e. A tertiary carbocation

Major products will be formed from which kinds of carbocations?

Major products will be formed from which kinds of carbocations?

Tertiary (or the most stable available)

What conditions are needed for the electrophilic addition of H_2O to an alkene? What is this type of reaction called?

What conditions are needed for the electrophilic addition of H_2O to an alkene? What is this type of reaction called?

Steam in the presence of an acid catalyst, usually phosphoric acid

Reaction is called hydration

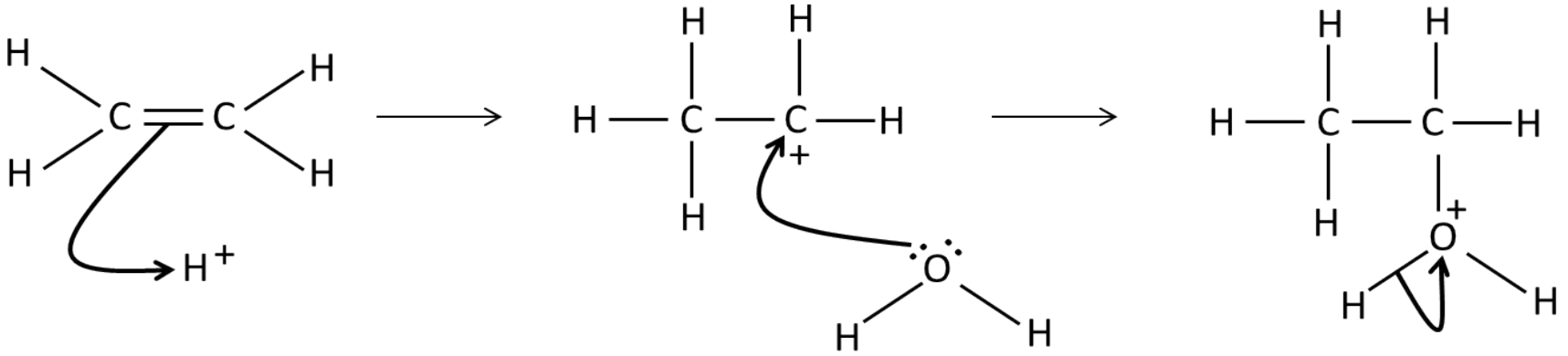
What are the product(s) of the hydration reaction?

What are the product(s) of the hydration reaction?

An alcohol

Draw a mechanism for the addition of water to ethene

Draw a mechanism for the addition of water to ethene



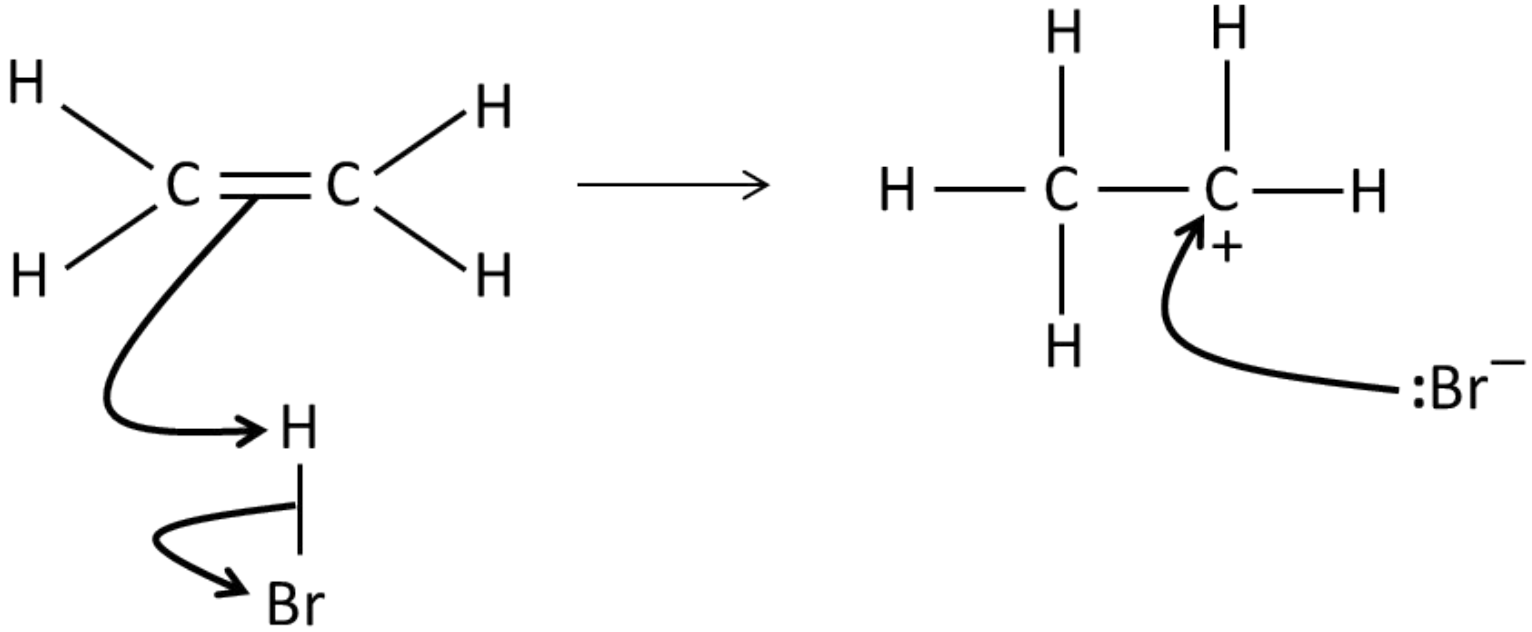
What conditions are needed for the electrophilic addition of a hydrogen halide to an alkene?

What conditions are needed for the electrophilic addition of a hydrogen halide to an alkene?

Hydrogen halide gases must be at room temperature

Draw a mechanism for the reaction of HBr and ethene

Draw a mechanism for the reaction of HBr and ethene.



What is the reaction called when a halogen is added to alkene?

What is the reaction called when a halogen is added to alkene?

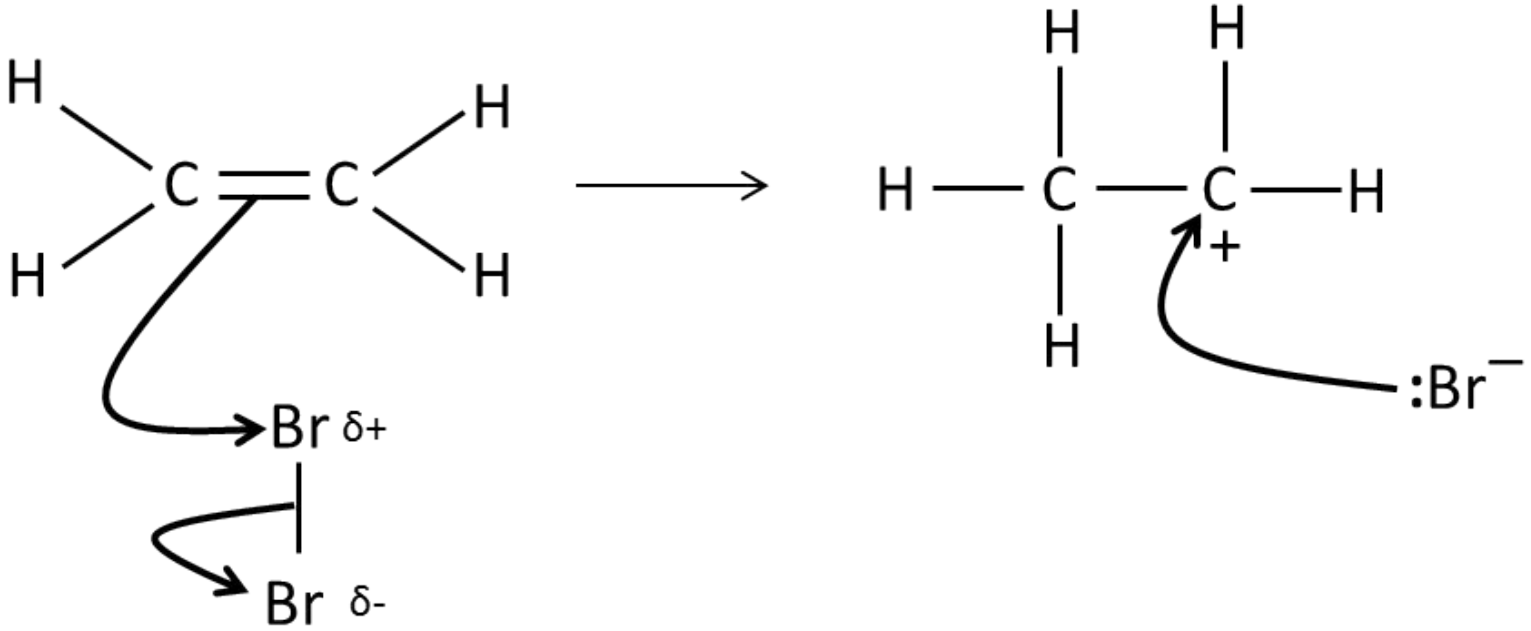
Halogenation

How does a molecule with a non-polar bond react as if it is an electrophile?

C=C double bond with a high electron density induces a temporary dipole in the halogen molecule → δ+ atom attracted to double bond

Draw a mechanism for the reaction between bromine and ethene

Draw a mechanism for the reaction between bromine and ethene



How can an alkene be converted into alkane? What is the reaction called and what are the required conditions?

How can an alkene be converted into alkane? What is the reaction called and what are the required conditions?

Alkene + hydrogen = Alkane

Hydrogenation

Conditions → 150°C, nickel catalyst

What is an addition polymer?

What is an addition polymer?

Many monomers bonded together via rearrangement of bonds without the loss of any atom or molecule

What are monomers? What form do they usually take?

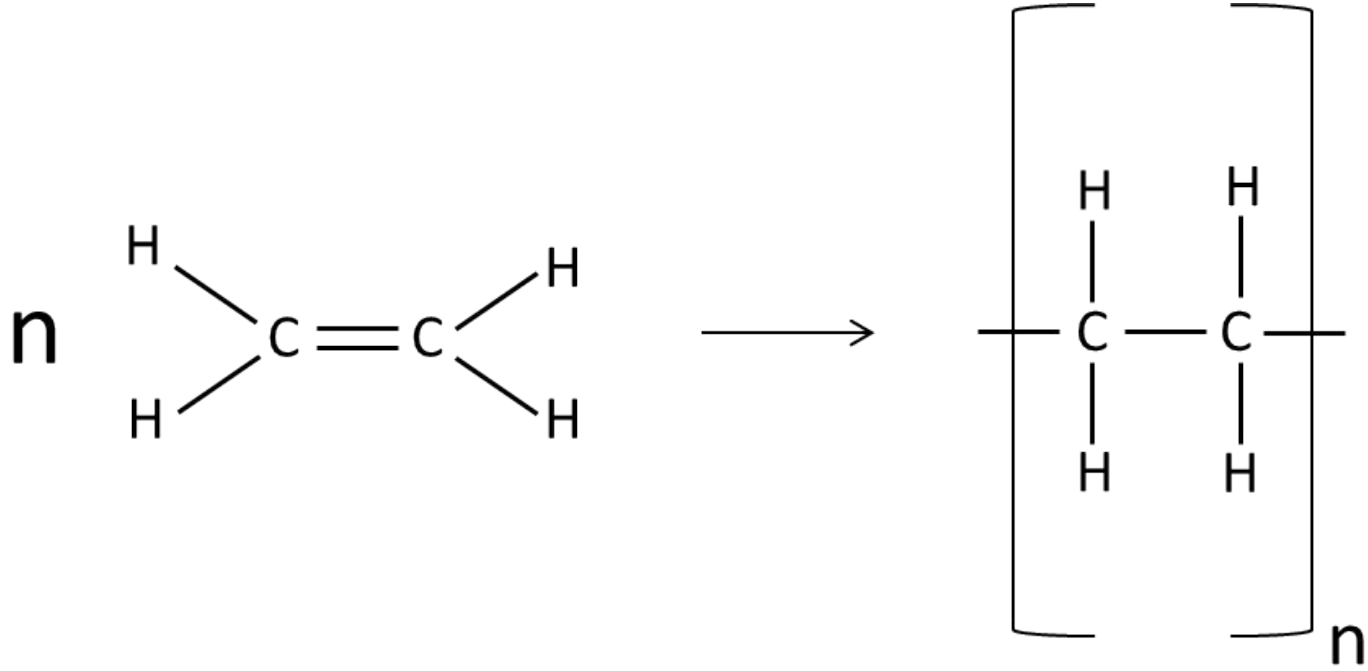
What are monomers? What form do they usually take?

Molecules which combine to form a polymer

Usually have a C=C bond which breaks to leave a repeating pattern

Draw how you would represent the polymerisation of ethene

Draw how you would represent the polymerisation of ethene.



What are the ways in which plastics can be disposed? (6)

What are the ways in which plastics can be disposed?

- Landfill
- Combustion
- Electricity generation
- Reuse
- Recycle
- Organic feedstock

What are the disadvantages of recycling?

What are the disadvantages of recycling?

- Plastics must be sorted into different types
- Expensive
- Labour intensive
- Requires high technology

How can chemists limit the problems caused by polymer disposal?

How can chemists limit the problems caused by polymer disposal?

- Developing biodegradable polymers
- Removing toxic waste gases caused by incineration of plastics

Explain what happens in organic feedstock

Explain what happens in organic feedstock

Plastics are separated and broken down into small organic molecules through a series of reaction. The molecules can then be used produce plastics and in other industries

What are halogenoalkanes?

What are haloalkanes?

Saturated organic compounds that contain carbon atoms and at least one halogen atoms

Are halogenoalkanes soluble in water?

Are halogenoalkanes soluble in water?

Insoluble as C-H bonds are non-polar, not compensated for enough by C-X bond polarity

Do halogenoalkanes have a polar bond? Why?

Do halogenoalkanes have a polar bond? Why?

Yes polar, as halogen has a higher electronegativity than C (halogen is δ-, carbon is δ+)

What type of intermolecular forces do they have? Why?

What type intermolecular forces do they have? Why?

Permanent dipole-dipole and London forces of attraction

C-X bond polarity creates permanent dipoles

When would they have higher boiling points?

When would they have higher boiling points?

Increase Carbon chain length

Halogen further down group 7

How would the mass of a haloalkane compare with the mass of an alkane of the same chain length?

How would the mass of a haloalkane compare with the mass of an alkane of the same chain length?

Greater as mass of halogen > mass of H

What is the most important factor in determining halogen reactivity?

What is the most important factor in determining halogen reactivity?

The strength of carbon halogen bond

What would bond polarity suggest the order of reactivity would be?

What would bond polarity suggest the order of reactivity would be?

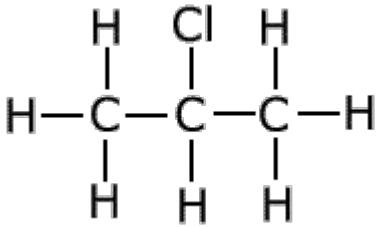
C-F would be most reactive as most polar bond

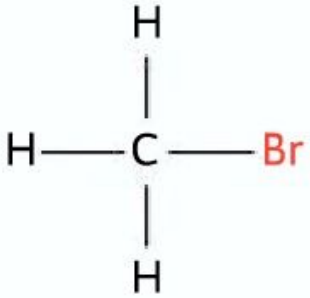
What would bond enthalpies suggest the order of reactivity would be?

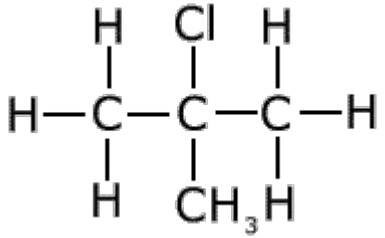
What would bond enthalpies suggest the order of reactivity would be?

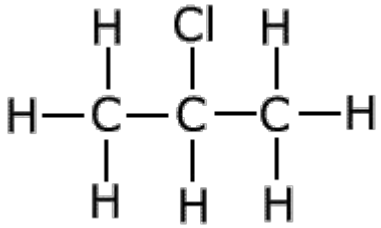
C-I would be most reactive as lowest bond enthalpy

Name the classification of these halogenoalkanes.

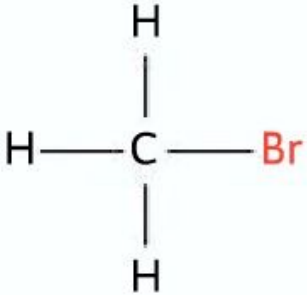




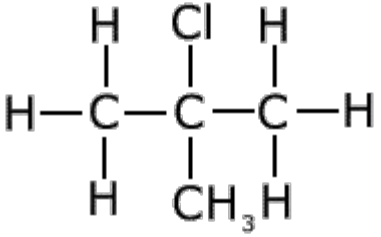




Secondary



Primary



Tertiary

What is the trend in reactivity of primary, secondary and tertiary halogenoalkanes?

What is the trend in reactivity of primary, secondary and tertiary haloalkanes?

- The tertiary halide produces a precipitate almost instantly.
- The secondary halide gives a slight precipitate after a few seconds.
- The primary halide takes considerably longer to produce a precipitate.

Define nucleophile

Define nucleophile

Electron pair donor

Give 3 examples of nucleophiles

Give 3 examples of nucleophiles

$:OH^-$

$:CN^-$

$:NH_3$

What is nucleophilic substitution?

What is nucleophilic substitution?

A reaction where a nucleophile donates a lone pair of electrons to δ+ C atom, δ− atom leaves molecule (replaced by nucleophiles)

What is hydrolysis?

What is hydrolysis?

A reaction where water is a reactant

What reactant often produces hydroxide ions for hydrolysis?

What reactant often produces hydroxide ions for hydrolysis?

Water

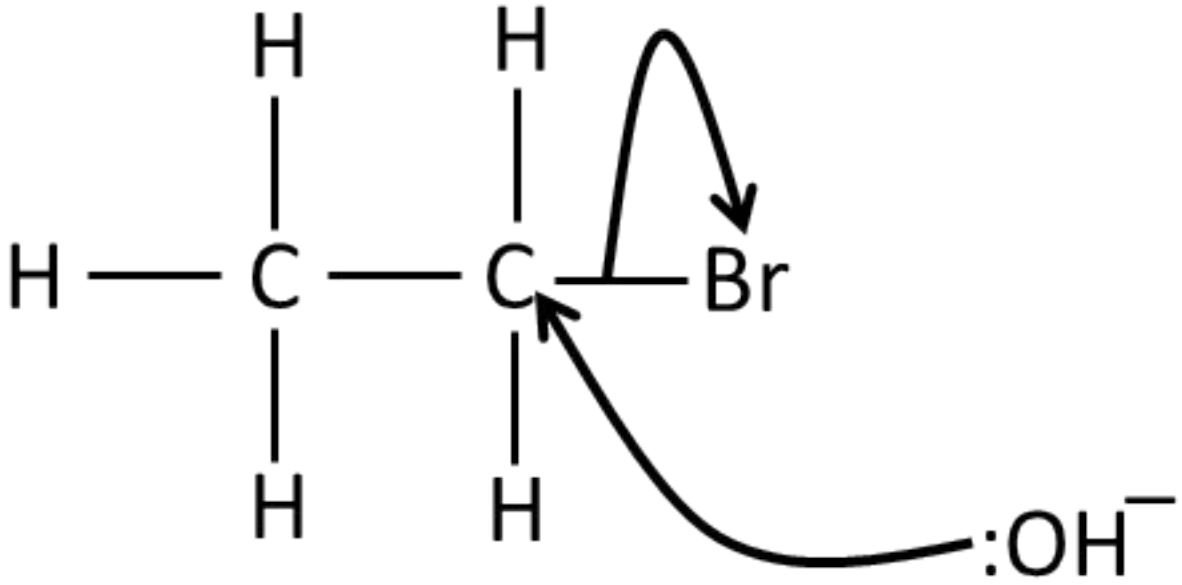
What fission does water undergo to produce OH^- ?

What fission does water undergo to produce OH- ?

Heterolytic fission

Draw the mechanism for the reaction of bromoethane with NaOH (aq)

Draw the mechanism for the reaction of bromoethane with NaOH (aq).



What are the conditions/ reactants needed for the elimination reaction of haloalkanes?

What are the conditions/reactants needed for the elimination reaction of haloalkanes?

NaOH or KOH dissolved in ethanol (no water present)

Heated

What is formed in the elimination reaction of haloalkanes?

What is formed in the elimination reaction of haloalkanes?

An alkene, water and halogen ion

How can you convert a haloalkane into an amine?

How can you convert a haloalkane into an amine?

Reagent: NH_3 dissolved in ethanol

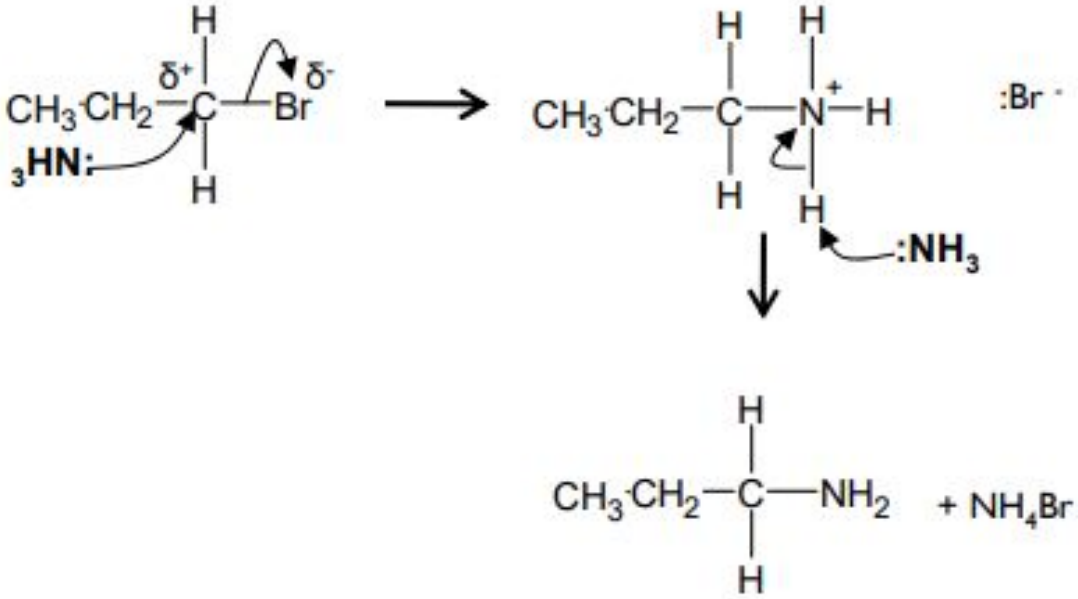
Conditions: Heating under pressure in a sealed tube

Mechanism: Nucleophilic Substitution

Type of reagent: Nucleophile - ammonia

Outline the mechanism of the reaction of 1- bromopropane with ammonia

Outline the mechanism of the reaction of 1- bromopropane with ammonia



How do you convert halogenoalkane into alkene?

How do you convert halogenoalkane into alkene?

Use ethanolic potassium hydroxide to produce alkenes (where the hydroxide ion acts as a base)

How do you produce nitriles from haloalkane?

How do you produce nitriles from haloalkane?

Use potassium cyanide to produce nitriles (where the cyanide ion acts as a nucleophile)

How can you compare the rate of hydrolysis of haloalkanes?

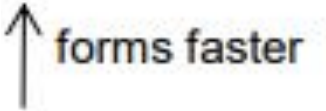
How can you compare the rate of hydrolysis of haloalkanes?

Aqueous silver nitrate is added to a halogenoalkane and a silver halide precipitation is formed. The quicker the precipitate is formed the faster the rate of hydrolysis.

AgI (s) - yellow precipitate

AgBr(s) – cream precipitate

AgCl(s) – white precipitate



What is the functional group of an alcohol?

What is the functional group of an alcohol?

Hydroxyl group -OH

What is the general formula of an alcohol?

What is the general formula of an alcohol?

$C_nH_{2n+1}OH$

How do you name alcohols (one prefix, one suffix)?

How do you name alcohols (one prefix, one suffix)?

Hydroxyl- OR -ol

What kind of intermolecular forces do alcohols have? Why?

What kind of intermolecular forces do alcohols have? Why?

Hydrogen bonding, due to the electronegativity difference in the OH bond

How do alcohols' melting point and boiling point compare to other hydrocarbons' of similar C chain lengths? Why?

How do alcohols' melting point and boiling point compare to other hydrocarbons' of similar C chain lengths? Why?

Higher, because they have hydrogen bonding (strongest type of intermolecular force) → stronger than London forces

Are alcohols soluble in water? Why does solubility depend on chain length?

Are alcohols soluble in water? Why does solubility depend on chain length?

Soluble when short chain - OH hydrogen bonds to hydrogen bond in water

Insoluble when long chain - non-polarity of C-H bond takes precedence

What makes an alcohol primary?

What makes an alcohol primary?

C bonded to OH is only bonded to one other C atom

What makes an alcohol secondary?

What makes an alcohol secondary?

C bonded to OH is bonded to two other C atoms

What makes an alcohol tertiary?

What makes an alcohol tertiary?

C bonded to OH is bonded to three other C atoms

Write an equation for the combustion of ethanol

Write an equation for the combustion of ethanol

$$C_2H_5OH\ (l) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 3H_2O\ (l)$$

What forms if you partially oxidise a primary alcohol?

What forms if you partially oxidise a primary alcohol?

An aldehyde

What conditions are needed to partially oxidise a primary alcohol?

What conditions are needed to partially oxidise a primary alcohol?

Dilute sulphuric acid, potassium dichromate (VI), distill product as it's produced, gentle heating

Write an equation for the partial oxidation of ethanol

Write an equation for the partial oxidation of ethanol

$$CH_3CH_2OH\ (l) + [O] \rightarrow CH_3CHO\ (g) + H_2O\ (l)$$

What forms if you fully oxidise a primary alcohol?

What forms if you fully oxidise a primary alcohol?

A carboxylic acid

What conditions are needed to fully oxidise a primary alcohol?

What conditions are needed to fully oxidise a primary alcohol?

Concentrated sulphuric acid, potassium dichromate (VI), reflux, strong heating

Write an equation for the full oxidation of ethanol

Write an equation for the full oxidation of ethanol

$$CH_3CH_2OH\ (l) + 2[O] \rightarrow CH_3COOH\ (g) + H_2O\ (l)$$

What forms if you oxidise a secondary alcohol?

What forms if you oxidise a secondary alcohol?

A ketone

What conditions are needed for the oxidation of a secondary alcohol?

What conditions are needed for the oxidation of a secondary alcohol?

Concentrated sulphuric acid, potassium dichromate (VI), strong heating

Write an equation for the oxidation of propan-2-ol

Write an equation for the oxidation of propan-2-ol.

$CH_3CH(OH)CH_3$ (l) + [O] → CH_3COCH_3 (g) + H_2O (l)

Is it possible to oxidise tertiary alcohol?

Is it possible to oxidise tertiary alcohol?

No

What is a dehydration reaction?

What is a dehydration reaction?

A reaction where water is lost to form an organic compound

What are the products of dehydration reaction of alcohol and the conditions needed?

What are the products of dehydration reaction of alcohol?

Alkene and water

Concentrated sulfuric acid or concentrated phosphoric acid and 170°C

How can you produce chloroalkanes from alcohols?

How can you produce a chloroalkanes from alcohols?

Use PCl_5 (PCl3 / conc HCl / SOCl2 / mixture of NaCl + H2SO4 can all also be used for substituting a Cl)

E.g $CH_3CH_2OH + PCl_5 \Rightarrow CH_3CH_2Cl + POCl_3 + HCl$

How can you produce bromoalkanes from alcohols?

How can you produce bromoalkanes from alcohols?

Use 50% concentrated sulfuric acid and potassium bromide

How can you produce iodoalkanes from alcohols?

How can you produce iodoalkanes from alcohols?

Use red phosphorus and iodine

$$PI_3 + 3CH_3CH_2OH \quad 3CH_2CH_2I + H_2PO_3$$

How do you prepare and purify of a liquid organic compound?

How do you prepare and purify of a liquid organic compound?

1. Heat under reflux
2. Extract with a solvent in a separating funnel
3. Distill
4. Dry with an anhydrous salt
5. Determine boiling temperature