CAIE Chemistry A-level

Topic 14 - Hydrocarbons

Flashcards

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Why are alkanes generally unreactive?

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Why are alkanes generally unreactive?

- C-C and C-H bonds have a fairly high bond enthalpy and therefore require a lot of energy to overcome.
- The difference in electronegativities of C and H is so small, making it very resistant to reactions with polar reagents.

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Write the chemical equation for the complete combustion of ethane

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Write the chemical equation for the complete combustion of ethane

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

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Write an overall equation for the substitution reaction of ethane with chlorine. Include any conditions.

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Write an overall equation for the substitution reaction of ethane with chlorine. Include any conditions.

Conditions: UV light

$$C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$$

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What are the three steps of free radical substitution?

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What are the three steps of free radical substitution?

1. Initiation
2. Propagation
3. Termination

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Write the mechanism for the free radical substitution of ethane with chlorine

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Write the mechanism for the free radical substitution of ethane with chlorine

Initiation: $Cl_2 \rightarrow 2Cl\bullet$

Propagation: $C_2H_6 + \bullet Cl \rightarrow \bullet C_2H_5 + HCl$

$\bullet C_2H_5 + Cl_2 \rightarrow C_2H_5Cl + \bullet Cl$

Termination: $\bullet Cl + \bullet Cl \rightarrow Cl_2$

$\bullet C_2H_5 + \bullet Cl \rightarrow C_2H_5Cl$

$\bullet C_2H_5 + \bullet C_2H_5 \rightarrow C_4H_{10}$

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What is crude oil a source of?

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What is crude oil a source of?

Aliphatic and aromatic alkanes

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What is cracking?

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What is cracking?

The process in which complex organic molecules are broken down into smaller organic molecules, such as simple alkanes.

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Why is cracking used?

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Why is cracking used?

To obtain more useful and smaller alkanes and alkenes, of which there is a greater demand for.

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What are the conditions and reagents for the hydrogenation of alkenes?

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What are the conditions and reagents for the hydrogenation of alkenes?

Reagents: Hydrogen gas, nickel catalyst

Conditions: 150℃

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Write an equation for the hydrogenation of ethene

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Write an equation for the hydrogenation of ethene

$$C_2H_4 + H_2 \rightarrow C_2H_6$$

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What are the conditions and reagents for the hydration of alkenes?

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What are the conditions and reagents for the hydration of alkenes?

Reagents: Steam, H_3PO_4 catalyst

Conditions: 300℃, 60-70 atm

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Write an equation for the hydration of ethene

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Write an equation for the hydration of ethene

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

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Name the mechanism for the reaction which takes place between alkenes and hydrogen halides or halogens

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Name the mechanism for the reaction which takes place between alkenes and hydrogen halides or halogens

Electrophilic addition

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Write an equation for the reaction between ethene and bromine

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Write an equation for the reaction between ethene and bromine

$$C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$$

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Write an equation for the reaction between ethene and hydrogen bromide

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Write an equation for the reaction between ethene and hydrogen bromide

$$C_2H_4 + HBr \rightarrow C_2H_5Br$$

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What is Markovnikov's rule?

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What is Markovnikov's rule?

In the electrophilic addition of a hydrogen halide to an asymmetric alkene, the hydrogen atom will bond to the carbon that is already bonded to the most hydrogens. This leads to the formation of the major product.

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Draw the mechanism for the electrophilic addition reaction between ethene and bromine

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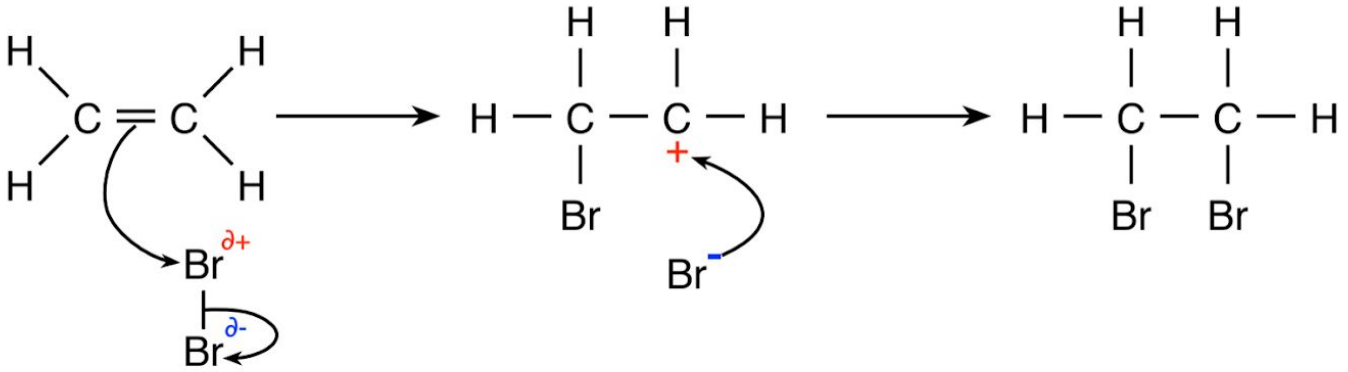
Draw the mechanism for the electrophilic addition reaction between ethene and bromine



The electron dense C=C bond induces a dipole in the Br_2 molecule. The π bond breaks and a carbon atom forms a bond with a bromine atom. This leaves a (positive) carbocation that is attracted to the negative bromide ion and hence forms a covalent bond with it.

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Draw the mechanism for the electrophilic addition reaction between propene and hydrogen bromide (forming the minor product)

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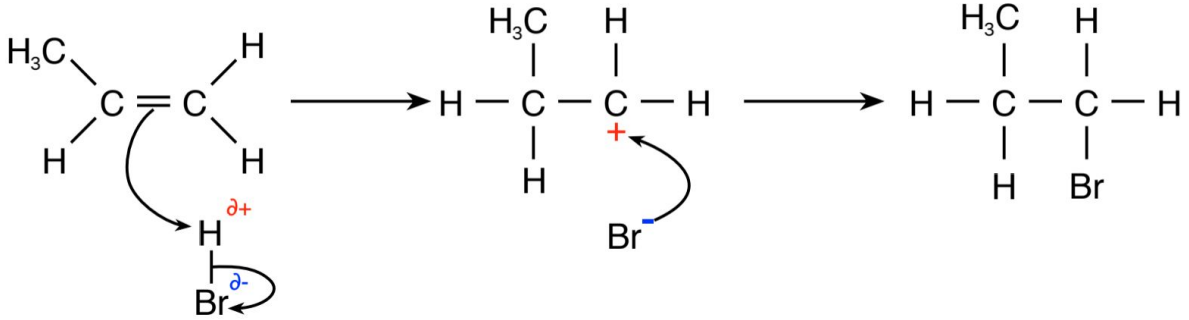
Draw the mechanism for the electrophilic addition reaction between propene and hydrogen bromide (forming the minor product)



The electron dense C=C double bond is attracted to the slightly positive hydrogen, causing the π bond to break and a bond to form between the carbon and hydrogen atom. This leaves a (positive) carbocation that is attracted to the negative bromide ion and hence forms a covalent bond with it.

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How are carbocations classified?

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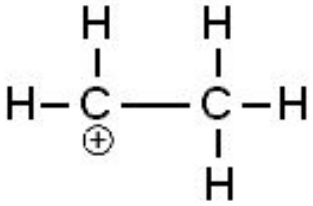
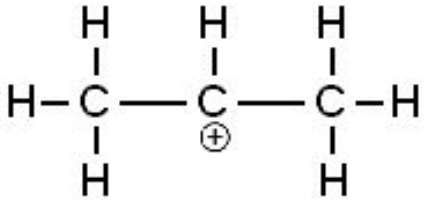
How are carbocations classified?

Primary



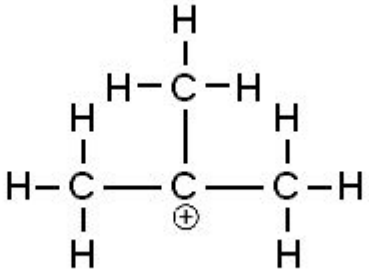
Carbocation is bonded to one alkyl group.

Secondary



Carbocation is bonded to two alkyl groups.

Tertiary



Carbocation is bonded to three alkyl groups.

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What is the trend in carbocation stability?

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What is the trend in carbocation stability?

Primary → Secondary → Tertiary

→ *stability increases* →

The more alkyl groups attached to the carbocation, the more the positive charge is spread out, increasing the stability.

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In terms of carbocation stability, what will be the major product in the addition reaction between a hydrogen halide and an unsymmetrical alkene?

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In terms of carbocation stability, what will be the major product in the addition reaction between a hydrogen halide and an unsymmetrical alkene?

The major product will be the one whose carbocation intermediate has the greater stability. For example, a secondary carbocation is more likely to form than a primary carbocation.

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How can alkenes be oxidised to form a diol? Write an equation for the oxidation of ethene

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How can alkenes be oxidised to form a diol? Write an equation for the oxidation of ethene

Manganate(VII) ions are strong oxidising agents. When cold, dilute, acidified $KMnO_4$ is added to an alkene, there is a colour change from purple to colourless as the alkene is reduced to a diol.

$$C_2H_4 + H_2O + [O] \rightarrow (CH_2OH)_2$$

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What happens when an alkene is oxidised with hot, concentrated acidified potassium manganate solution?

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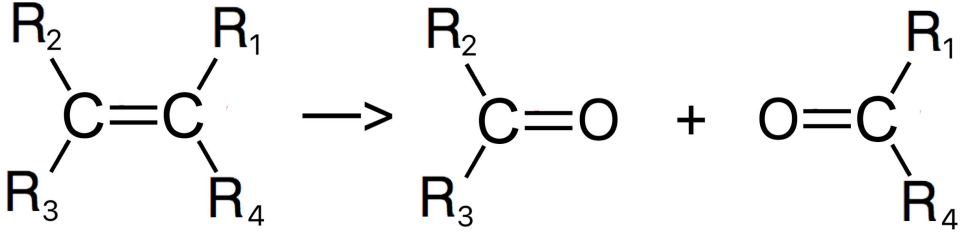
What happens when an alkene is oxidised with hot, concentrated acidified potassium manganate solution?

The C=C double bond is broken and replaced with two C=O bonds, forming two carbonyl compounds:



What occurs next is based on whether the R groups are alkyl groups or hydrogen atoms

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After an alkene has been oxidised using hot, concentrated $H^+/Cr_2O_7^{2-}$, both R groups of one of the products are alkyl groups. What happens to this product?

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After an alkene has been oxidised using hot, concentrated $H^+/Cr_2O_7^{2-}$, both R groups of one of the products are alkyl groups. What happens to this product?

The alkene was split into a ketone (where both R groups are alkyl groups) and another carbonyl. Ketones cannot be oxidised further so no further reaction occurs.

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After an alkene has been oxidised using hot, concentrated $H^+/Cr_2O_7^{2-}$, one of the products has the following R groups: an alkyl chain and a hydrogen atom. What happens to this product?

CC BY NC ND

After an alkene has been oxidised using hot, concentrated $H^+/Cr_2O_7^{2-}$, one of the products has the following R groups: an alkyl chain and a hydrogen atom. What happens to this product?

The alkene was split into an aldehyde (with an alkyl group and a hydrogen atom as the R groups) and another carbonyl.

The aldehyde is further oxidised to form a carboxylic acid.

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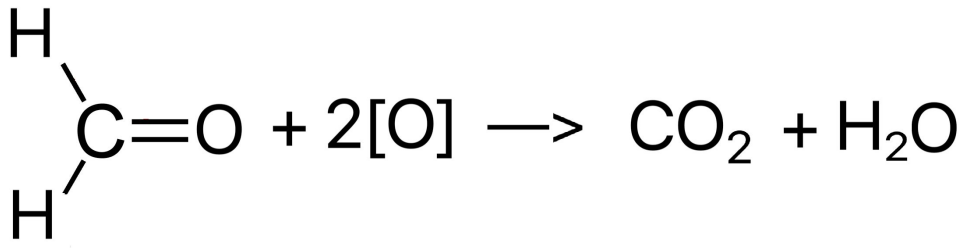
After an alkene has been oxidised using hot, concentrated $H^+/Cr_2O_7^{2-}$, both R groups of one of the products are hydrogen atoms. What happens to this product?

CC BY NC ND

After an alkene has been oxidised using hot, concentrated $H^+/Cr_2O_7^{2-}$, both R groups of one of the products are hydrogen atoms. What happens to this product?

The alkene was oxidised to form methanal (with 2 hydrogen atoms as R groups) and another carbonyl. Methanal will be completely oxidised to form carbon dioxide and water:



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What is addition polymerisation?

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What is addition polymerisation?

The joining together of unsaturated alkene monomers to form a long chain polymer. No other products are formed so the atom economy is 100%.

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How do alkenes undergo addition polymerisation?

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How do alkenes undergo addition polymerisation?

The π bond breaks and each electron goes towards forming a σ bond with an adjacent monomer unit.

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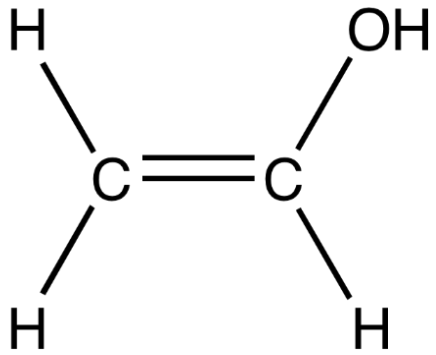
Deduce the repeat unit of the addition polymer formed from the monomer below



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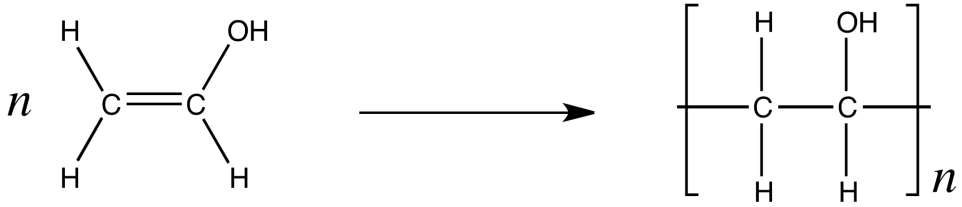
Deduce the repeat unit of the addition polymer formed from the monomer below



To find the repeat unit:

- Turn the double C=C into a single C-C.
- Add and extend bonds out from the sides of the carbon atoms.
- Add square brackets around the molecule.

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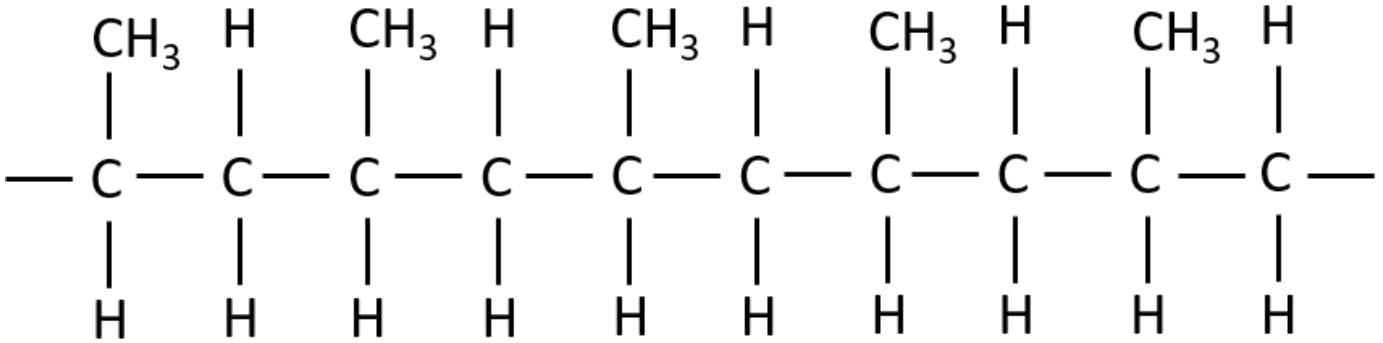
Identify the monomer that formed the addition polymer below



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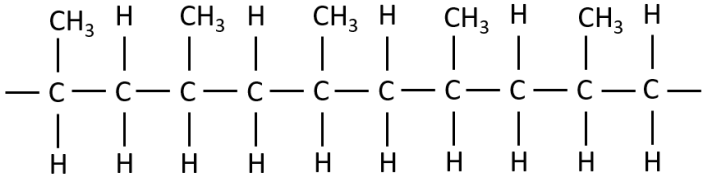
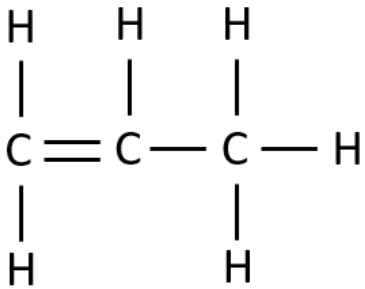
Identify the monomer that formed the addition polymer below



Propene:



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Why are polymers difficult to dispose of?

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Why are polymers difficult to dispose of?

- They are non-biodegradable.
- The combustion of polymers can often form harmful compounds, such as HCl for chlorinated polymers.

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Why are alkanes suitable for use as fuels?

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Why are alkanes suitable for use as fuels?

Alkanes have high standard enthalpy changes of combustion so they release a lot of energy upon combustion.

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What are the problems with carbon monoxide?

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What are the problems with carbon monoxide?

- Carbon monoxide is poisonous.
- It irreversibly binds to haemoglobin, reducing the amount of oxygen that can be carried in the blood.
- Cells may become deoxygenated, leading to cell death.
- If too much CO is inhaled, this could lead to death.

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Why are atmospheric oxides of nitrogen pollutants?

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Why are atmospheric oxides of nitrogen pollutants?

- Nitrogen monoxide can contribute to the production of acid rain by reacting with chemicals in the clouds.
- Nitrogen dioxide can contribute to photochemical smog.

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Describe how a catalytic converter works

CC BY NC ND

Describe how a catalytic converter works

Nitrogen monoxide is formed in car engines:

$$N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)}$$

A catalytic converter has a ceramic honeycomb structure coated in a thin layer of metal catalysts (such as platinum and rhodium). The converter removes the majority of NO so that it isn't released into the atmosphere:

$$2NO_{(g)} + 2CO_{(g)} \rightarrow N_{2(g)} + CO_{2(g)}$$

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What are the environmental consequences of unburnt hydrocarbons?

CC BY NC ND

What are the environmental consequences of unburnt hydrocarbons?

Hydrocarbons in the atmosphere can absorb infrared radiation, contributing to the greenhouse effect.

CC BY NC ND

What are the environmental consequences of the emission of greenhouse gases?

CC BY NC ND

What are the environmental consequences of the emission of greenhouse gases?

Greenhouse gases cause the greenhouse effect:

- Electromagnetic radiation from the sun passes through the atmosphere. Some radiation is absorbed by Earth so temperature increases.
- Heat is radiated from the Earth as infrared radiation which is absorbed by greenhouse gases in the atmosphere. This causes the bonds in these molecules to vibrate before this energy is re-emitted.
- As a result, the atmosphere warms up even further, contributing to global warming.

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