Haloalkane Substitution

A Level

Part A 2-Iodobutane and sodium ethoxide

What is the product of a nucleophilic substitution reaction between 2-iodobutane and sodium ethoxide ($\mathrm{NaOC_2H_5}$)?

- $\mathrm{CH_3CH{=}CHCH_3}$
- $\mathrm{CH_3CH_2CH(OCH_3)CH_2CH_3}$
- $\mathrm{CH_3CH_2CH(CH_3)OCH_2CH_3}$
- $\mathrm{(CH_3)_2CHCH_2OCH_2CH_3}$

Part B $\mathrm{C_2H_5X + OH^-}$

Why does the reaction

$$\mathrm{C_2H_5X + OH^- \longrightarrow C_2H_5OH + X^-}$$

take place more rapidly in aqueous solution when X is I than when X is Br?

- The $\mathrm{I^-}$ ion is a stronger nucleophile than the $\mathrm{Br^-}$ ion.
- The $\mathrm{I^-}$ ion is less hydrated in solution than the $\mathrm{Br^-}$ ion.
- The $\mathrm{C{-}Br}$ bond is weaker than the $\mathrm{C{-}I}$ bond.
- The $\mathrm{C{-}Br}$ bond is stronger than the $\mathrm{C{-}I}$ bond.

Part A adapted with permission from UCLES, A-Level Chemistry, June 1994, Paper 4, Question 22;
Part B adapted with permission from UCLES, A-Level Chemistry, June 1995, Paper 4, Question 20

Haloalkane Substitution Mechanism

A Level

Part A Energy profile

Halogenoalkanes react with aqueous alkali. One mechanism of this reaction has the energy profile shown below.

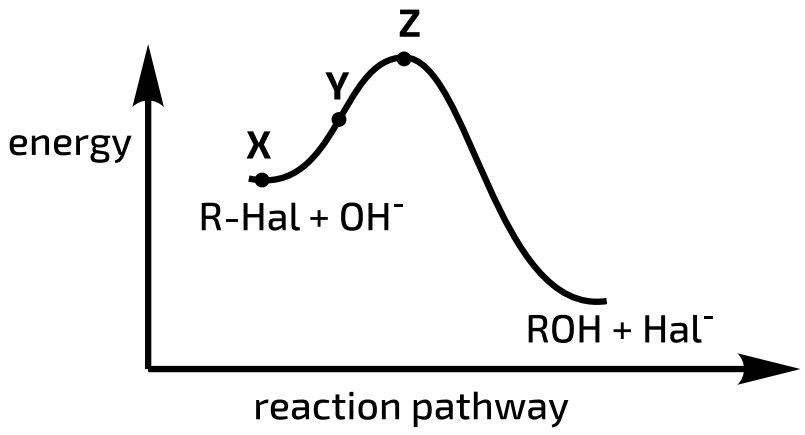


Figure 1: Energy profile for haloalkane with aqueous alkali

Which of the following statements are correct?

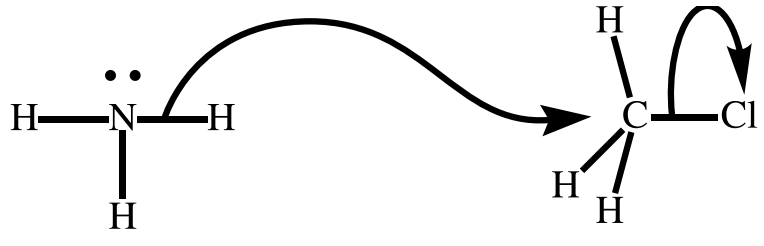
1. The reaction is an example of nucleophilic substitution.
2. Between **X** and **Z** the $\mathrm{C-Hal}$ bond will be lengthening.
3. The energy difference between **X** and **Y** represents the activation energy.

- **1**, **2** and **3** are correct
- **1** and **2** only are correct
- **2** and **3** only are correct
- **1** only is correct
- **3** only is correct

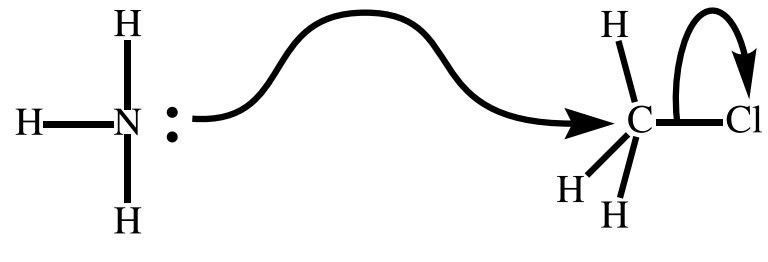
Part B Curly arrow mechanism

Which diagram correctly represents the transfer of electrons when ammonia reacts with a chloroalkane (alkyl chloride)?

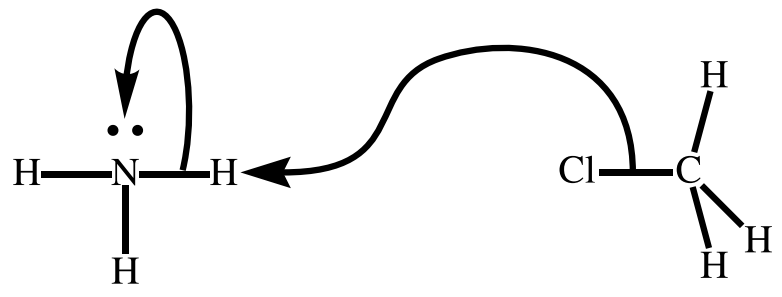
A



B



C



D

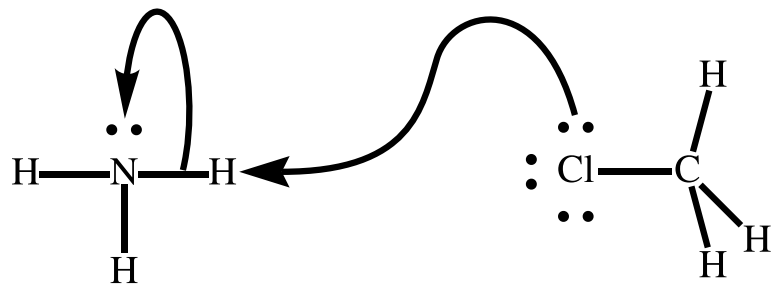


Figure 2: Possible mechanisms for ammonia with chloroalkane

- **A**
- **B**
- **C**
- **D**

Part A adapted with permission from UCLES, A-Level Chemistry, June 1993, Paper 4, Question 37;
Part B adapted with permission from UCLES, A-Level Chemistry, June1994, Paper 4, Question 26

Gameboard:
STEM SMART Chemistry Week 25

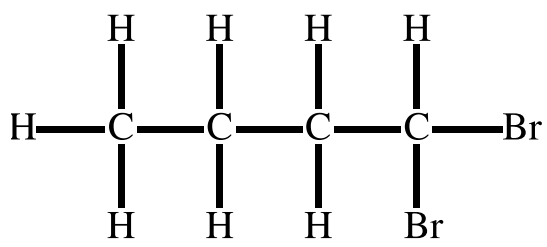
Alkene Bromination

A Level

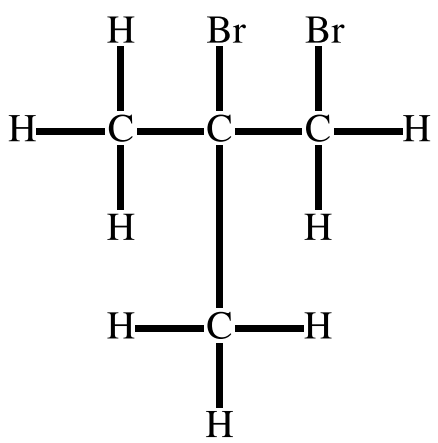
Part A Bromination of C_4H_8

Which of the following compounds could be formed by the action of bromine on an alkene of formula C_4H_8?

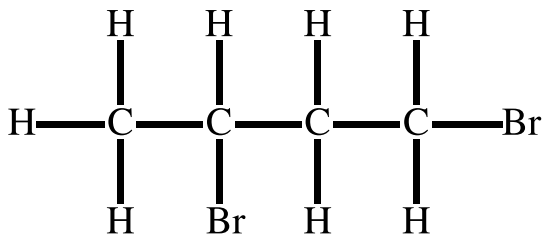
A



B



C



D

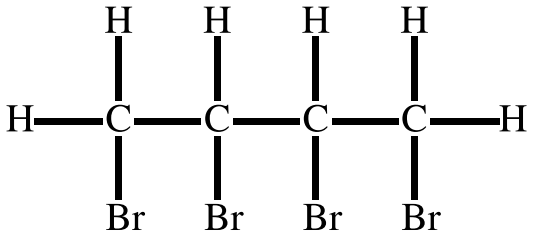
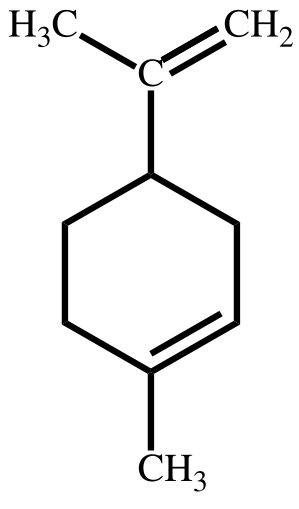


Figure 1: Possible products of C_4H_8 with bromine

- A
- B
- C
- D

Part B Bromination of limonene

Limonene is an oil formed in the peel of citrus fruits.

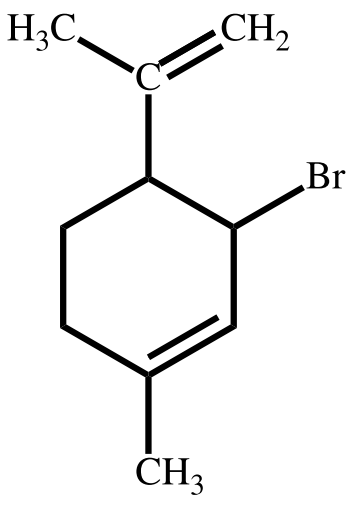


Limonene

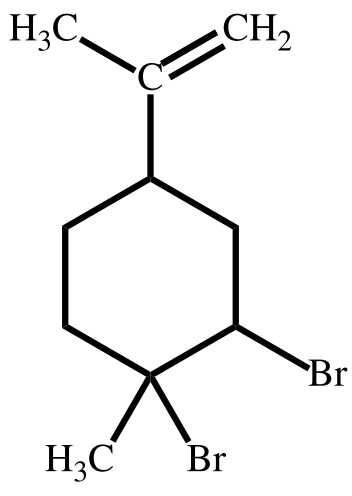
Figure 2: Structure of limonene

Which product is formed when limonene reacts with excess molecular bromine at room temperature in the dark?

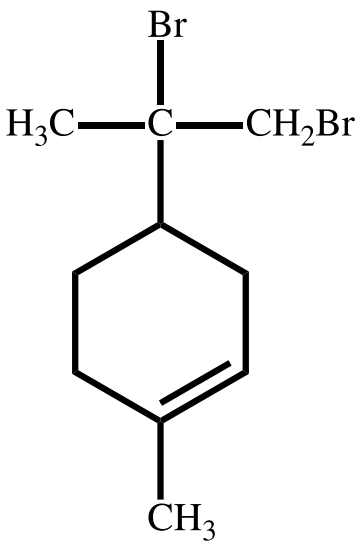
A



B



C



D

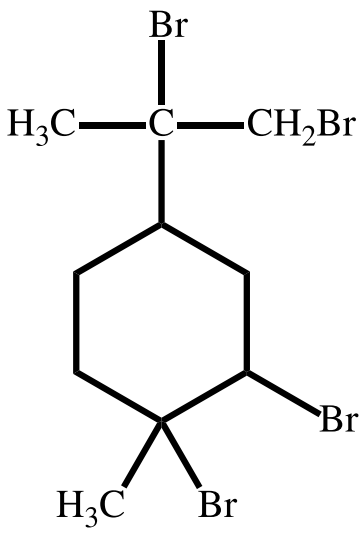


Figure 3: Possible products of limonene bromination

- ○ **A**

- B
- C
- D

Part A adapted with permission from UCLES, A-Level Chemistry, November 1994, Paper 4, Question 22;
Part B adapted with permission from UCLES, A-Level Chemistry, November 1996, Paper 4, Question 22

Gameboard:
STEM SMART Chemistry Week 25

Alkene Bromination Mechanism

A Level

Part A Curly arrows

What is the sequence of curly arrows denoting movement of electrons in the first step of the reaction between ethene and bromine (below)?

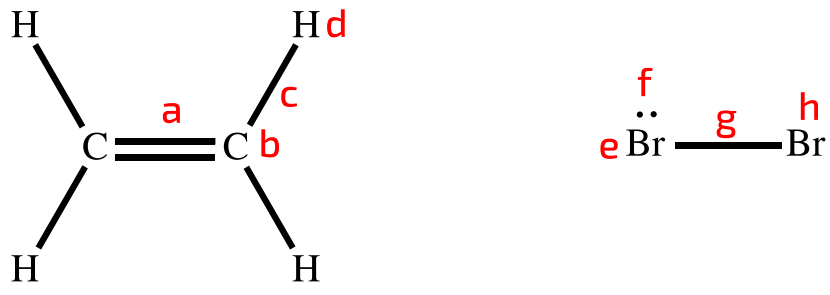


Figure 1: Bromination mechanism

For example in the reaction below, if you think the mechanism is as shown, your answer would be **cdef**.

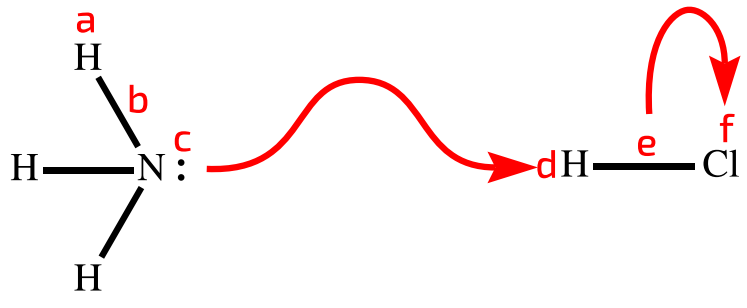


Figure 2: Sequence **cdef**

Ethene bromination sequence:

Part B Reaction type

What type of reaction is this?

Created for isaacphysics.org by R. Less

Gameboard:

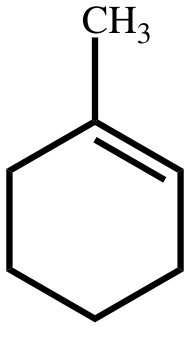
STEM SMART Chemistry Week 25

Alkenes With HBr

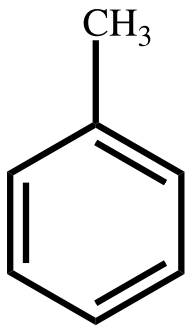
A Level

Part A 1-Methylcyclohexene with HBr

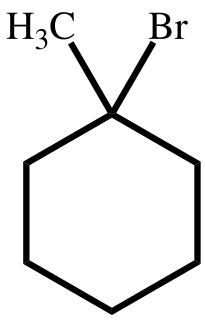
Which of the following structures represents the main organic compound produced when hydrogen bromide is added to 1-methylcyclohexene (shown below)?



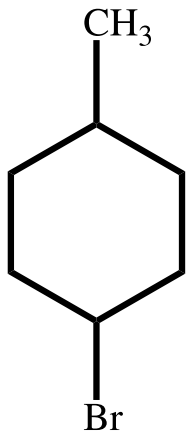
A



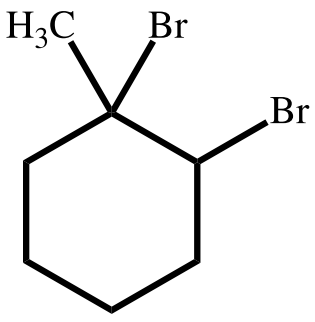
B



C



D



E

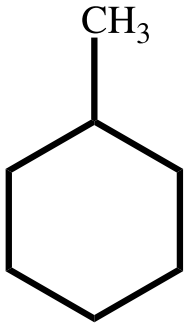


Figure 1: 1-methylcyclohexene and possible products of reaction with HBr

- **A**
- **B**
- **C**
- **D**
- **E**

Part B Methylpropene with HBr

Methylpropene has the structure shown below.

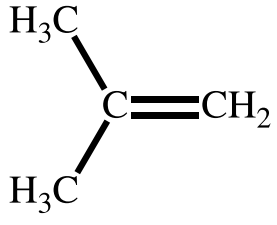


Figure 2: Structure of methylpropene

What is the **major** product formed when methylpropene reacts with HBr?

Use the structure editor to generate a SMILES string.

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

Part A adapted with permission from OCSEB, A-Level Chemistry, June 1998, Paper 1, Question 22;
Part B created for Isaac Physics by R. Less

Gameboard:
STEM SMART Chemistry Week 25

Alkene Reactions

A Level

Propene reacts under the following conditions to give compounds **A**, **B** and **C**.

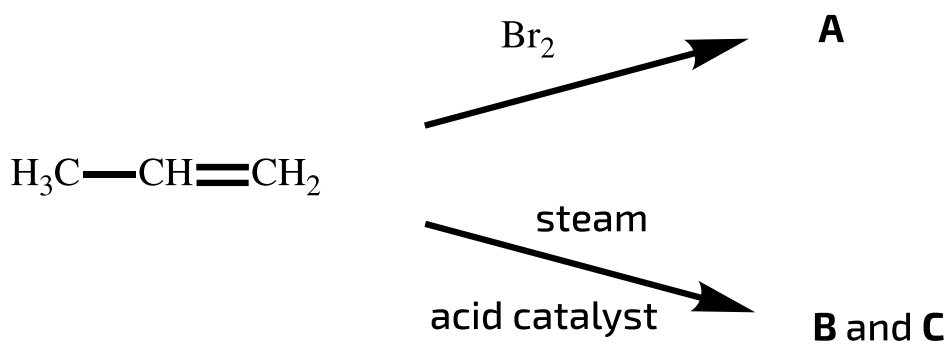


Figure 1: Propene with bromine and steam in presence of an acid catalyst

Part A with Br_2

What is product **A**?

Use the structure editor to generate a SMILES string.

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

Part B with steam / acid catalyst

What are products **B** and **C**?

Use the structure editor to generate SMILES strings.

Give your answer in the format "**B**, **C**" (space after comma).

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

More Alkene Bromination

A Level

Compound **A** undergoes the following reactions:

$$\mathbf{A} \xrightarrow[\text{bromine in trichloroethane}]{\text{(I)}} \mathrm{CH_3CHBrCHBrCH_3} \xrightarrow{\text{(II)}} \mathrm{CH_2{=}CH{-}CH{=}CH_2}$$

Part A Bromination of compound $\mathbf{A}$

What is compound **A**? (There are two possible isomers - give the structure of either)

Use the structure editor to generate a SMILES string.

Click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

Part B Step (II)

What type of reaction is step (II)?

Part C Ethene with aqueous bromine

Ethene reacts with aqueous bromine to give the two products, CH_2BrCH_2Br and CH_2BrCH_2OH.

Which statement is correct for these products?

- Both products can be hydrolysed to form the same diol.
- Both products are obtained in this reaction by nucleophilic addition.
- Both products possess an overall dipole.
- Both products are obtained in this reaction by electrophilic substitution.
- Reaction of ethene with aqueous HBr gives the same products.

Part A adapted with permission from UCLES, A-Level Chemistry, June1991, Paper 3, Question 8;
Part B adapted with permission from UCLES, A-Level Chemistry, November 1993, Paper 4, Question 24

Gameboard:
STEM SMART Chemistry Week 25

Free Radical Reactions

A Level

Part A CFCs

In the upper atmosphere, chlorofluoroalkanes (CFCs) are broken down to give chlorine radicals but not fluorine radicals.

What is the best explanation for this?

- Chlorine has a higher molecular weight.
- The $\mathrm{C-F}$ bond is stronger than the $\mathrm{C-Cl}$ bond.
- Fluorine has a lower atomic number.
- Fluorine has a higher ionisation energy than chlorine.

Part B Chlorination of methane

Methane reacts with chlorine in the presence of sunlight. Which statement about the intermediates is correct?

- They contain an odd number of electrons.
- They are more energetically stable than the reactants.
- They combine to form HCl.
- They are positively charged ions.

Part A adapted with permission from UCLES, A-Level Chemistry, November 1997, Paper 3, Question 25;
Part B adapted with permission from UCLES, A-Level Chemistry, November 1998, Paper 3, Question 21

Ethene Oxidation

A Level

Part A Ethene to ethanal

Aldehydes and ketones are produced industrially by the catalytic oxidation of alkenes, *e.g.* ethanal is manufactured from ethene as shown below:

$$\mathrm{H_2C{=}CH_2} + \frac{1}{2}\mathrm{O_2} \xrightarrow{\text{catalyst}} \mathrm{CH_3CHO}$$

This process is also used industrially with but-2-ene.

Which of the following represents the structure of the compound which would be produced from but-2-ene?

- $\mathrm{CH_3CH_2CHO}$
- $\mathrm{CH_3COCH_3}$
- $\mathrm{CH_3COCH_2CH_3}$
- $\mathrm{(CH_3)_2CHCHO}$
- $\mathrm{CH_3CH_2CH_2CHO}$

Part B Ethene with bromine and sodium nitrate

When ethene reacts with bromine in the presence of concentrated aqueous sodium nitrate, the product contains the following compound:

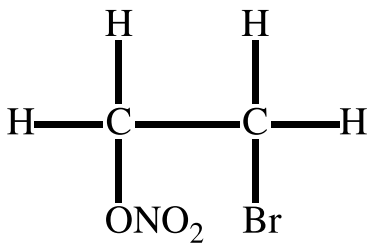
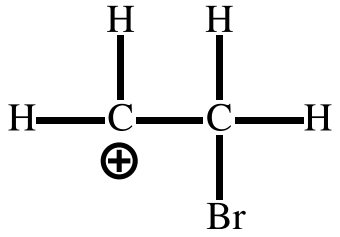


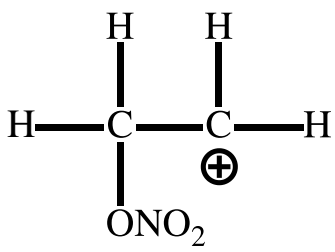
Figure 1: Reaction product

What is the intermediate formed in this reaction?

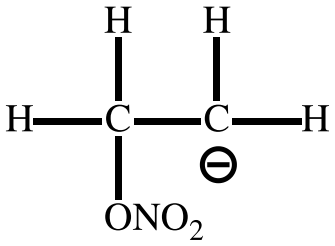
A



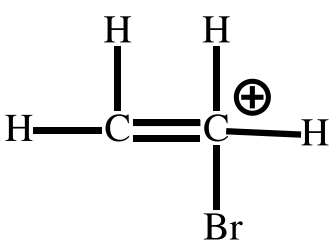
B



C



D



E

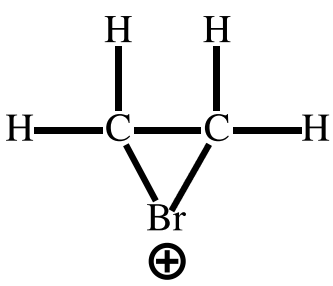


Figure 2: Possible intermediates

- **A**
- **B**
- **C**
- **D**
- **E**

Part A adapted with permission from UCLES, A-Level Chemistry, November 1993, Paper 4, Question 22;
Part B adapted with permission from UCLES, A-Level Chemistry, November 1995, Paper 4, Question 22

Epoxy Precursor

A Level

Epoxy resins are polymers which are used as adhesives. One monomer used in their manufacture has the displayed formula:

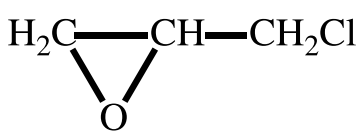


Figure 1: Epoxy resin monomer

This is manufactured from propene in three stages:

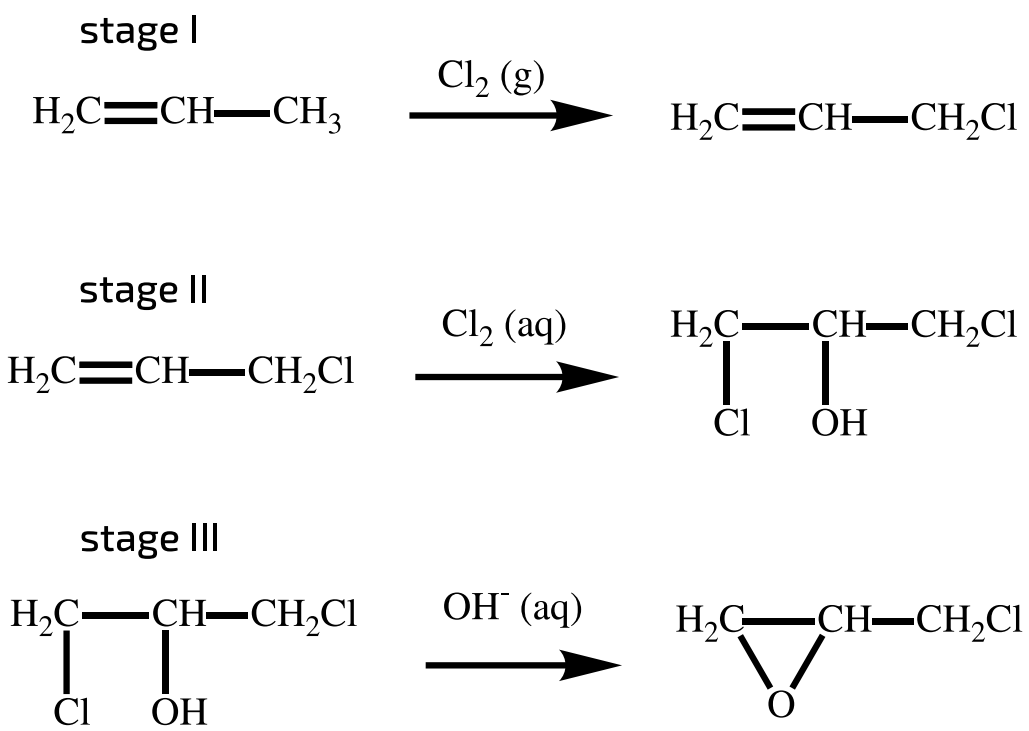


Figure 2: Three stages of epoxy monomer manufacture from propene

Part A Stage I

What type of reaction mechanism takes place between propene and chlorine gas in stage I?

Suggest what conditions are necessary for this reaction.

Part B Stage II

What type of reaction mechanism takes place when the aqueous chlorine reacts in stage II?

Part C Stage III

What type of organic reaction takes place in stage III?

Adapted with permission from UCLES, A-Level Chemistry, November 1994, Paper 3, Question 4