

Exercise walk-through

1.5.2

Electron arrows and addition mechanisms

Pearson Edexcel · International A-Level · Chemistry

What does a jump establish?

Your turn

Three successive ionisation energies are close; the fourth is much larger. What follows from the jump alone?

- A. Three outer electrons; period still unknown
- B. Period 3; group still unknown
- C. Four outer electrons
- D. The atom has four occupied shells

Compare fuels using their whole pathway

- 1** Cracking makes smaller hydrocarbons including alkenes; balance atoms in proposed products.
- 2** CO reduces oxygen transport; nitrogen/sulfur oxides can contribute to acid pollution.
- 3** Bioethanol growth can absorb CO₂, but processing and transport still emit. Hydrogen production also matters.

Choose reagents and conditions

- 1 **1** H_2/Ni adds hydrogen; steam/acid catalyst adds water; Br_2 adds bromine across $\text{C}=\text{C}$.
- 2 **2** Cold dilute acidified manganate(VII) gives a diol. Bromine decolourisation supports unsaturation, not a unique identity.
- 3 **3** Addition polymerisation opens $\text{C}=\text{C}$, retains side groups and loses no small molecule.

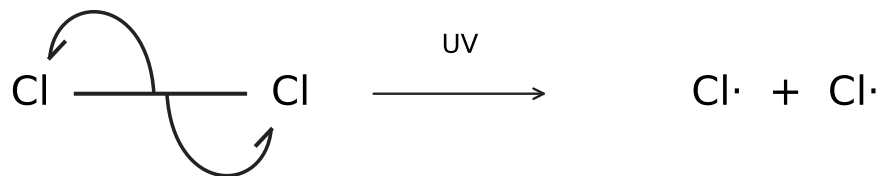
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Homolysis: one electron from the bond goes to each chlorine atom.
Each curly half-arrow tracks one electron.

Award for $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$ and UV, two half-arrows starting at the bond and ending at different Cl atoms.

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2.2 $\text{Cl} \cdot + \text{CH}_4 \rightarrow \text{HCl} + \text{CH}_3 \cdot$; $\text{CH}_3 \cdot + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl} \cdot$; $2\text{CH}_3 \cdot \rightarrow \text{C}_2\text{H}_6$.
Propagation regenerates a radical, allowing further reaction with the remaining molecules. Termination consumes radicals without regenerating one.

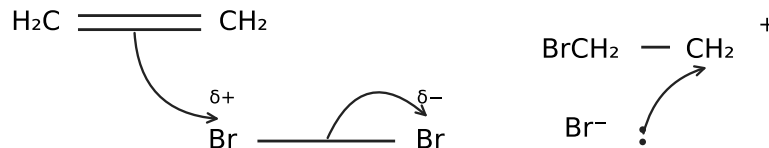
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Product: $\text{BrCH}_2\text{-CH}_2\text{Br}$

Simple electrophilic-addition model: π pair $\rightarrow \text{Br}\delta^+$; Br-Br pair $\rightarrow \text{Br}\delta^-$.
A bromide lone pair supplies the second C-Br bond.

Award induced $\text{Br}\delta^+\text{-Br}\delta^-$ polarity, π -bond pair arrow to $\text{Br}\delta^+$ and Br-Br pair arrow to $\text{Br}\delta^-$, $\text{BrCH}_2\text{CH}_2^+$ plus Br^- with a lone-pair arrow to the positive carbon, and 1,2-dibromoethane product. This syllabus-level model makes no claim about a unique stereochemical product from every substituted alkene.

Exercises 3.1·3.2

3.1 Explain why HBr addition to propene mainly gives 2-bromopropane rather than 1-bromopropane. Give the structural formula and class of each possible carbocation. [4]

3.2 A methane/chlorine reaction gives chloromethane, dichloromethane and small amounts of ethane. Explain the origin of the latter two products and why the process is unsuitable for obtaining only pure chloromethane directly. [3]

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3.2 Chloromethane can undergo further radical substitution to form dichloromethane.

Two methyl radicals can combine in termination to form ethane. Further substitution and competing termination products create a mixture requiring separation rather than one directly pure product.

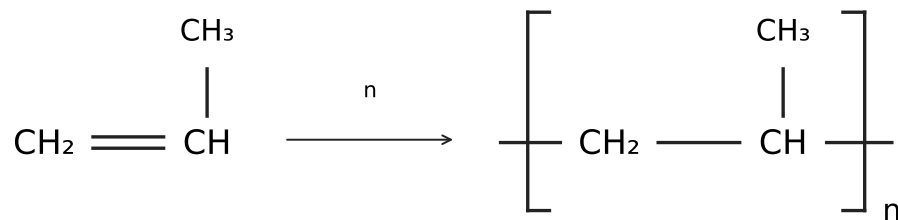
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Propene → poly(propene); continuation bonds cross the brackets.
Side groups stay attached; no small molecule is eliminated.

Award correct monomer and methyl side group, single-bond backbone, continuation bonds/brackets/n and balanced n monomers. Both monomer C_3H_6 and repeat-unit composition have empirical ratio CH_2 , so empirical formula does not reveal molecular size or connectivity.

Exercise 3.4

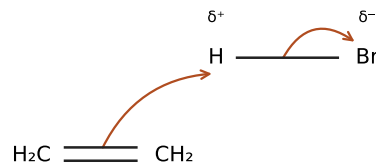
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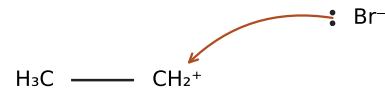
3.4

1 Form the ethyl carbocation

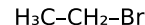


π pair $\rightarrow$ H; H–Br pair $\rightarrow$ Br

2 Bromide donates its lone pair



↓



bromoethane

$\text{H}\delta^+-\text{Br}\delta^-$ polarity; pair arrow from $\text{C}=\text{C}$ to H and pair arrow from H–Br to Br; CH_3CH_2^+ plus Br^- and bromide lone-pair arrow to the positive carbon; bromoethane $\text{CH}_3\text{CH}_2\text{Br}$. The two ethene carbons are equivalent, so either direction of proton addition leads to the same connectivity.