

# Alkenes: double bonds and addition reactions

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

The model answers below give the expected working and a marking guide. Award marks for correct reasoning, even if a final number differs slightly by rounding. Do not give marks for a mechanism whose arrow starts from the hydrogen.

**Level:** Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.3.4

## Question 1 Bonding in propene (2 marks)

- a. **8  $\sigma$  bonds and 1  $\pi$  bond** (6 C-H, 2 C-C  $\sigma$ ; plus one  $\pi$ ).
- b. About **120°**.

Marking: 1 mark for 8  $\sigma$  and 1  $\pi$ ; 1 mark for 120°.

## Question 2 Test for a double bond (2 marks)

- a. Shake with bromine water; the colour changes from orange-brown to **colourless**.
- b.  $\text{C}_2\text{H}_4 + \text{Br}_2 \rightarrow \text{C}_2\text{H}_4\text{Br}_2$  (1,2-dibromoethane).

Marking: 1 for reagent and colourless; 1 for the balanced equation.

## Question 3 Mechanism of addition (3 marks)

- a. **Electrophilic addition**.
- b. Intermediate  **$\text{CH}_3\text{CH}_2^+$**  (with  $\text{Br}^-$ ); product  **$\text{CH}_3\text{CH}_2\text{Br}$** .

Marking: 1 for the name; 1 for the carbocation; 1 for bromoethane.

## Question 4 Markovnikov product (3 marks)

- a. **2-bromobutane**.
- b. H adds to the terminal carbon, giving a secondary carbocation. Two alkyl groups push electron density towards it, making it more stable than the primary ion that leads to 1-bromobutane, so it forms faster.

Marking: 1 for the name; 1 for secondary versus primary; 1 for alkyl groups stabilising.

## Question 5 Industrial hydration (2 marks)

- a. Phosphoric acid on silica; about **300 °C**.

- b. Very high pressure is expensive and makes ethene polymerise, so 65 atm is a compromise.

*Marking: 1 for catalyst and temperature; 1 for cost or polymerisation.*

### Question 6 Yield of 2-bromobutane (3 marks)

- a.  $n = 5.60 / 56.0 = 0.100$  mol; mass =  $0.100 \times 136.9 = \mathbf{13.7 \text{ g}}$ .  
b.  $10.2 / 13.69 \times 100 = \mathbf{74.5 \%}$ .

*Marking: 1 for amount; 1 for mass; 1 for percentage.*

### Question 7 Polymer from but-1-ene (2 marks)

- a.  **$-\text{CH}_2-\text{CH}(\text{CH}_2\text{CH}_3)-$** .  
b. It contains only strong non-polar C-C and C-H bonds and no C=C, so no electrophile or nucleophile can attack it easily.

*Marking: 1 for the repeat unit with the ethyl branch; 1 for the explanation.*

### Question 8 Why bromine adds (3 marks)

- a. The  $\pi$  electrons repel the electrons in  $\text{Br}_2$ , inducing a dipole ( $\text{Br}\delta+$  near the alkene). The positive end is attacked by the  $\pi$  electrons.  
b. **1,2-dibromoethane**.

*Marking: 1 for the induced dipole; 1 for the electrophilic end; 1 for the name.*