

Radical and nucleophilic substitution reactions

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

Compare your work with these answers and the marking points. Credit is given for correct steps, so look for the specific mark you missed and revise the related mechanism.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB R3.4

Question 1 Radical substitution (3 marks)

- a. $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$ (UV light).
- b. $\text{Cl}\cdot + \text{CH}_4 \rightarrow \cdot\text{CH}_3 + \text{HCl}$ and $\cdot\text{CH}_3 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\cdot$.

Marking: 1 initiation, 1 each propagation step.

Question 2 Mechanism (3 marks)

- a. **Nucleophilic substitution (SN2).**
- b. The **lone pair on OH⁻** attacking the $\delta+$ carbon, forming a new bond.
- c. It is **inverted**.

Marking: 1 mark each.

Question 3 Classify (1 mark)

- a. **Tertiary:** the carbon bonded to Br is attached to three other carbons.

Marking: 1 mark.

Question 4 Comparing rates (3 marks)

- a. **1-iodobutane > 1-bromobutane > 1-chlorobutane.**
- b. The C-I bond (228 kJ mol^{-1}) is weaker than C-Br (290) and C-Cl (346). Less energy is needed to break it, so it is hydrolysed faster.

Marking: 1 for order, 1 for bond enthalpy trend, 1 for link to rate.

Question 5 Reagents (2 marks)

- a. **KCN (potassium cyanide) in ethanol and heat under reflux.**

Marking: 1 for KCN in ethanol, 1 for reflux.

Question 6 Percentage yield (3 marks)

- a. $n = 6.00 \div 92.5 = 0.06486 \text{ mol}$; theoretical mass = $0.06486 \times 74.0 = 4.80 \text{ g}$; yield = $3.10 \div 4.80 \times 100 = \mathbf{64.6 \%}$.

Marking: 1 for amount, 1 for theoretical mass, 1 for yield.

Question 7 SN1 or SN2 (3 marks)

- a. **rate = $k[(\text{CH}_3)_3\text{CBr}]$** .
b. The slow step is the loss of Br^- to form the carbocation, which involves only the halogenoalkane. The nucleophile reacts in a fast step afterwards.

Marking: 1 for equation, 1 for slow step, 1 for nucleophile in the fast step.

Question 8 Ozone layer (2 marks)

- a. **$\text{Cl}\cdot + \text{O}_3 \rightarrow \text{ClO}\cdot + \text{O}_2$; $\text{ClO}\cdot + \text{O} \rightarrow \text{Cl}\cdot + \text{O}_2$** .

Marking: 1 each step.