

2.5.1 Halogenoalkanes: reaction choice and hydrolysis evidence

Name: _____ Class: _____ Date: _____

Total: 20 marks

KEY WORDS nucleophile

Objective

Use solvent and nucleophile conditions to predict products and compare controlled hydrolysis rates. All questions and marking guidance are original.

1 Key knowledge and worked examples

A nucleophile donates an electron pair to a partially positive carbon. In substitution a group is replaced; in elimination adjacent atoms/groups are removed and a double bond forms. Aqueous OH^- favours alcohol formation; hot ethanolic OH^- favours elimination.

■ Worked route

$\text{CH}_3\text{CH}_2\text{Br} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{Br}^-$ with warm aqueous KOH. Alcoholic KCN gives $\text{CH}_3\text{CH}_2\text{CN}$, adding one carbon. Excess alcoholic ammonia under pressure gives $\text{CH}_3\text{CH}_2\text{NH}_2$; another NH_3 removes a proton from the initial alkylammonium ion.

Compare hydrolysis at equal concentration, temperature and volumes. Silver nitrate detects released halide as AgX ; water is the nucleophile and ethanol helps mixing. Weaker C–I breaks more readily than C–Br and C–Cl. Precipitate time is indirect evidence, not a complete reaction mechanism.

2 Practice

2.1 Classify $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br}$, $\text{CH}_3\text{CHBrCH}_3$ and $(\text{CH}_3)_3\text{CBr}$ as primary, secondary or tertiary. Explain the classification rule. [4]

2.2 Give the product and reagent conditions to convert bromoethane to ethanol and to ethene. [4]

2.3 Give the organic product from bromoethane with alcoholic KCN and explain the carbon count. [2]

3 Exam-style questions

3.1 For primary bromoethane with OH^- , describe the two electron-pair arrows and the products. Then explain the additional step needed when NH_3 replaces OH^- as nucleophile. [5]

3.2 Matched primary chloro-, bromo- and iodoalkanes are tested with aqueous AgNO_3 in ethanol. Predict the hydrolysis order, explain it, and give two controls. Explain why differing precipitate solubilities limit a precise kinetic comparison. [5]

Solutions

Original marking guidance: M1 method, A1 accuracy, B1 explanation.

2.1 Primary, secondary and tertiary respectively. Count carbon groups attached to the carbon bearing Br, not the total carbons or the name locant.

2.2 Ethanol with warm aqueous KOH; ethene with hot ethanolic KOH.

2.3 Propanenitrile, $\text{CH}_3\text{CH}_2\text{CN}$. The cyanide carbon joins the original two-carbon chain, giving three carbons.

3.1 One arrow starts at an oxygen lone pair and ends at the C bearing Br; the other starts at C–Br and ends at Br. Ethanol and Br^- form. Ammonia first gives $\text{CH}_3\text{CH}_2\text{NH}_3^+$; a second NH_3 removes H^+ to give ethylamine and NH_4^+ .

3.2 Iodo > bromo > chloro, because C–I is weakest and C–Cl strongest of these bonds. Match temperature and concentrations/volumes. Different detection thresholds/precipitate solubilities mean visible appearance is not a direct identical-conversion measurement in all cases.