Week 31

A-Level Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

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19. Nitrogen compounds

Starter Quiz · 课前小测

A-Level Chemistry Name: _____ Score: _____

1. An amine contains the:

   ☐ $-NH_2$ group

   ☐ –OH group

   ☐ –COOH group

   ☐ C=C bond

2. Heating a halogenoalkane with KCN in ethanol makes a nitrile, which usefully:

   ☐ adds one carbon to the chain

   ☐ removes a carbon

   ☐ adds an –OH group only

   ☐ forms an alkene

3. A primary amine is made by heating a halogenoalkane with:

   ☐ ammonia in ethanol, under pressure

   ☐ aqueous NaOH

   ☐ acidified dichromate

   ☐ bromine water

4. Adding HCN to an aldehyde or ketone gives a hydroxynitrile by:

   ☐ nucleophilic addition across the C=O bond

   ☐ free-radical substitution

   ☐ elimination

   ☐ oxidation

5. The reaction is a nucleophilic substitution because:

   ☐ the lone pair on ammonia attacks the slightly positive carbon, displacing the halogen

   ☐ a radical attacks the carbon

   ☐ a proton is transferred

   ☐ electrons are transferred to ammonia

6. Amines act as bases because the nitrogen lone pair can accept a _____.

7. Nitriles contain the –C≡N functional group and can be reduced to amines.

   ☐ True ☐ False

8. Hydrolysing a nitrile with dilute acid turns –CN into:

   ☐ –COOH (a carboxylic acid)

   ☐ –OH (an alcohol)

   ☐ $–NH_2$ (an amine)

   ☐ a C=C bond

9. Why is an excess of ammonia used?

   ☐ so the amine product does not react further

   ☐ to lower the temperature

   ☐ to make the reaction reversible

   ☐ to remove water

10. Reducing a nitrile (with H_2 and a catalyst) gives:

    ☐ an amine

    ☐ a carboxylic acid

    ☐ an alkene

    ☐ a ketone

A-Level Chemistry

1. **–NH_2 group**

   An amine has an –NH_2 group, where nitrogen replaces a hydrogen of ammonia.

2. **adds one carbon to the chain**

   The CN group adds a carbon (a nucleophilic substitution); HCN with a carbonyl gives a hydroxynitrile instead.

3. **ammonia in ethanol, under pressure**

   Ammonia (in ethanol, under pressure) substitutes the halogen to give the amine.

4. **nucleophilic addition across the C=O bond**

   CN^- adds across the carbonyl; the O^- then takes an H^+ — nucleophilic addition.

5. **the lone pair on ammonia attacks the slightly positive carbon, displacing the halogen**

   Ammonia is the nucleophile; its nitrogen lone pair attacks the C–X carbon and pushes out the halogen.

6. **proton**

   $R–NH_2 + H^+ \rightarrow R–NH_3^+$.

7. **True**

   They add one carbon to the chain.

8. **–COOH (a carboxylic acid)**

   Hydrolysis converts the nitrile group to a carboxylic acid (with an ammonium salt by-product).

9. **so the amine product does not react further**

   The amine is itself a nucleophile and could react again; excess ammonia favours the primary amine.

10. **an amine**

    Reduction of a nitrile gives an amine — a route to a longer-chain amine.

A-LEVEL CHEMISTRY • EXERCISE SHEET

19.1 Primary amines

Name: _____ Class: _____ Date: _____ **Total: 8 marks**

KEY WORDS amine 胺 • primary amines 伯胺 • halogenoalkane 卤代烷 • nucleophilic substitution 亲核取代 • nitrile 腈

Objective

Build the skills to answer exam questions on **primary amines** 伯胺 — making them from a **halogenoalkane** 卤代烷 and ammonia.

You must be able to:

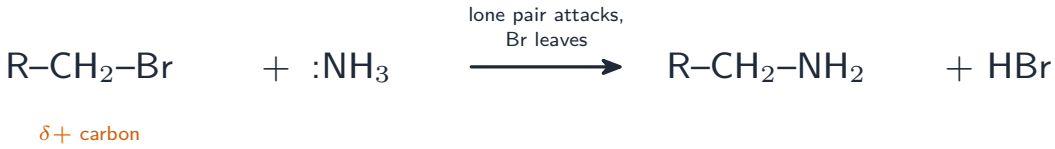
- recall the reaction of a halogenoalkane with ammonia to make a primary amine
- describe it as a nucleophilic substitution

1 Worked examples

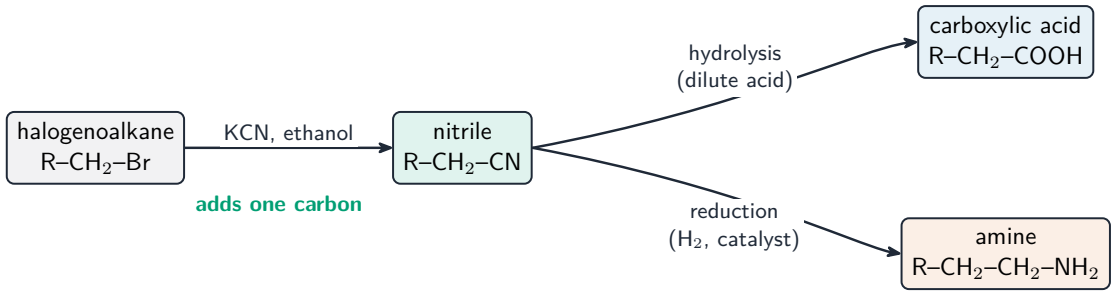
■ Making a primary amine

An **amine** has an $-NH_2$ group. Heat a halogenoalkane with **ammonia** in ethanol, under pressure:

$$C_2H_5Br + NH_3 \rightarrow C_2H_5NH_2 + HBr$$



A nucleophilic substitution: ammonia's lone pair attacks the δ+ carbon, displacing the halogen



Amines via the nitrile route

Use an **excess** of ammonia, or the amine made reacts again with more halogenoalkane.

2 Practice

2.1 State the reagents and conditions to make ethylamine from bromoethane. [2]

2.2 Name the type of mechanism of this reaction. [1]

3 Exam-style questions

3.1 Why is an excess of ammonia used when making a primary amine? [1]

- **A** to speed up the reaction
- **B** to stop the amine reacting further with the halogenoalkane
- **C** to lower the temperature
- **D** to act as a catalyst

3.2 The species that attacks the halogenoalkane is: [1]

- **A** the lone pair on nitrogen of ammonia
- **B** the H^+ ion
- **C** a free radical
- **D** the bromide ion

3.3 (a) Write the equation for the reaction of bromoethane with ammonia. [1]

(b) Explain why this reaction is classed as nucleophilic substitution. [2]

Solutions

2.1 ammonia (NH_3) in ethanol; heated under pressure.

2.2 nucleophilic substitution.

3.1 B. Excess ammonia stops the amine reacting further with the halogenoalkane.

3.2 A. The lone pair on the nitrogen of ammonia is the nucleophile.

3.3 (a) $C_2H_5Br + NH_3 \rightarrow C_2H_5NH_2 + HBr$.
(b) ammonia (a nucleophile) uses its lone pair to attack the $\delta+$ carbon and replaces the halogen — a substitution.

A-LEVEL CHEMISTRY • EXERCISE SHEET

19.2 Nitriles and hydroxynitriles

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS hydrolysis 水解 • nitrile 腈 • carboxylic acid 羧酸 • hydroxynitrile 羟基腈 • nitriles and hydroxynitri

Objective

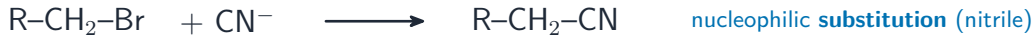
Build the skills to answer exam questions on **nitriles and hydroxynitriles** 腈和羟基腈 — making them and the **hydrolysis** 水解 of nitriles.

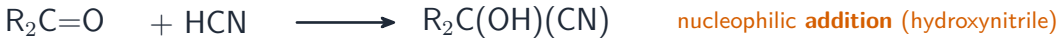
You must be able to:

- recall how nitriles are made (halogenoalkane + KCN) and hydroxynitriles (carbonyl + HCN)
- describe the hydrolysis of nitriles to carboxylic acids

1 Worked examples

Two ways cyanide adds a carbon

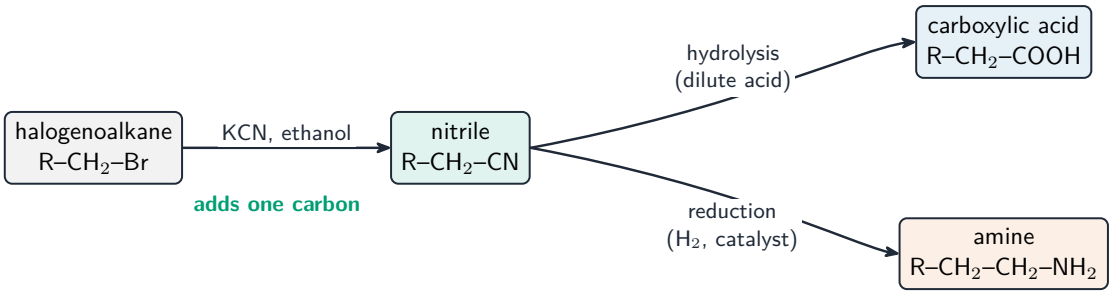




*KCN + halogenoalkane → nitrile (nucleophilic substitution); HCN + carbonyl → hydroxynitrile (nucleophilic addition). Both **add one carbon***

$$C_2H_5Br + KCN \rightarrow C_2H_5CN + KBr$$

Hydrolysis of nitriles



A nitrile hydrolyses to a carboxylic acid (dilute acid or alkali, then acidify) or reduces to an amine

$$CH_3CN + 2H_2O + HCl \rightarrow CH_3COOH + NH_4Cl$$

2 Practice

2.1 State the reagents and conditions to make a nitrile from a halogenoalkane. [2]

2.2 State what functional group a nitrile is changed into by hydrolysis. [1]

3 Exam-style questions

3.1 The reaction of KCN with a halogenoalkane is useful in synthesis because it: [1]

- **A** removes a carbon
- **B** adds one carbon to the chain
- **C** forms a double bond
- **D** makes an ester

3.2 Hydrolysis of ethanenitrile, CH_3CN, with dilute acid gives: [1]

- **A** ethanol
- **B** ethanoic acid
- **C** ethylamine
- **D** ethanal

3.3 (a) Write the equation for the reaction of bromoethane with KCN. [1]

(b) Describe how the nitrile product can be converted into a carboxylic acid. [2]

3.4 State the reagent and condition to make a hydroxynitrile from propanone (a ketone), and name the mechanism. [2]

Solutions

2.1 potassium cyanide (KCN) in ethanol; and heat.

2.2 a carboxylic acid (–COOH).

3.1 B. KCN adds one carbon to the chain (forming the nitrile).

3.2 B. Hydrolysis of a nitrile gives the carboxylic acid (ethanoic acid).

3.3 (a) $C_2H_5Br + KCN \rightarrow C_2H_5CN + KBr$.
(b) warm the nitrile with dilute acid (or dilute alkali then acidify); the –CN group is hydrolysed to –COOH.

3.4 HCN with a KCN catalyst (and heat); nucleophilic addition.