

Exercise walk-through

12.1

Nitrogen and sulfur

A-Level Chemistry

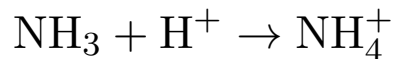
Why nitrogen is unreactive

The molecule also has no **polarity** – it is perfectly symmetrical, so nothing pulls other molecules towards it. N_2 has a **triple bond** (bond energy $\approx 945 \text{ kJ mol}^{-1}$) and a non-polar molecule. Breaking $\text{N}\equiv\text{N}$ needs a lot of energy, so nitrogen is inert at room temperature.

The Haber process forces it: high T , high p , and an iron catalyst.

Ammonia and the ammonium ion

NH_3 is a weak base: the nitrogen lone pair accepts H^+ to give the **ammonium** ion NH_4^+ .



Test: damp red litmus turns blue. With HCl you get white NH_4Cl smoke.

Displacement of ammonia from its salts

The reaction

Warm any ammonium salt with a strong alkali (NaOH) and **displacement** occurs: $\text{NH}_4^+ + \text{OH}^- \rightarrow \text{NH}_3 + \text{H}_2\text{O}$.

The test

Ammonia gas turns damp red litmus **blue** – the standard test for an ammonium salt.

Why it works

The alkali is a stronger base than water, so it takes the proton back off the ammonium ion.

Warm, alkali, damp red litmus. Three words that identify NH_4^+ in any qualitative-analysis question.

Exercises 2.1·2.2

2.1 State **two** reasons why nitrogen gas is unreactive. [2]

2.2 Write the equation for ammonia acting as a base towards H^+ . [1]

Exercises 2.1·2.2

2.1 State **two** reasons why nitrogen gas is unreactive. [2]

2.1

- the $\text{N}\equiv\text{N}$ triple bond is very strong (high bond energy); the molecule is non-polar / symmetrical
-

2.2 Write the equation for ammonia acting as a base towards H^+ . [1]

2.2

- $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$

Exercises 3.1-3.2

3.1 Ammonia acts as a Brønsted–Lowry base because:

[1]

☐

A it donates a proton

B the lone pair on nitrogen accepts a proton

C it is a gas

D it contains hydrogen

3.2 In a catalytic converter, nitrogen monoxide is removed by reacting with:

[1]

☐

A oxygen

B carbon monoxide

C water

D sulfur dioxide

Exercises 3.1·3.2

3.1 Ammonia acts as a Brønsted–Lowry base because:

[1]

☐

- A it donates a proton
- B the lone pair on nitrogen accepts a proton
- C it is a gas
- D it contains hydrogen

3.1 B

- The lone pair on nitrogen accepts a proton

3.2 In a catalytic converter, nitrogen monoxide is removed by reacting with:

[1]

☐

- A oxygen
- B carbon monoxide
- C water
- D sulfur dioxide

3.2 B

- $2\text{NO} + 2\text{CO} \rightarrow \text{N}_2 + 2\text{CO}_2$

Exercise 3.3

3.3 (a) Describe how nitrogen monoxide is formed inside a car engine, and write an equation. [2]

(b) Explain the **two** ways that oxides of nitrogen contribute to acid rain. [3]

Exercise 3.3

3.3 (a) Describe how nitrogen monoxide is formed inside a car engine, and write an equation. [2]

(b) Explain the **two** ways that oxides of nitrogen contribute to acid rain. [3]

3.3

(a)

- the high temperature in the engine makes nitrogen and oxygen from the air react;
$$\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$$

(b)

- directly: NO_2 dissolves in rain to form nitric acid; as a catalyst: NO_2 catalyses the oxidation of SO_2 to SO_3 , which forms sulfuric acid in the rain

Exercise 3.4

3.4 Describe a chemical test for an ammonium salt.

[2]

Exercise 3.4

3.4 Describe a chemical test for an ammonium salt.

[2]

3.4

- warm the salt with sodium hydroxide; ammonia gas is given off – sharp smell and damp red litmus turns blue