

12.1 Nitrogen and sulfur

Name: _____ Class: _____ Date: _____

Total: 12 marks

KEY WORDS acid rain • bond energy • triple bond • basicity
• coordinate bond

Objective

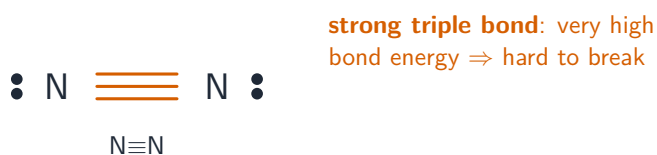
Build the skills to answer exam questions on **nitrogen and sulfur** – the unreactivity of nitrogen, the **basicity** of **ammonia**, oxides of nitrogen, and **acid rain**.

You must be able to:

- explain the lack of reactivity of nitrogen
- explain the basicity of ammonia and the formation of the ammonium ion
- describe the sources, catalytic removal, and role in acid rain of nitrogen oxides

1 Key knowledge and worked examples

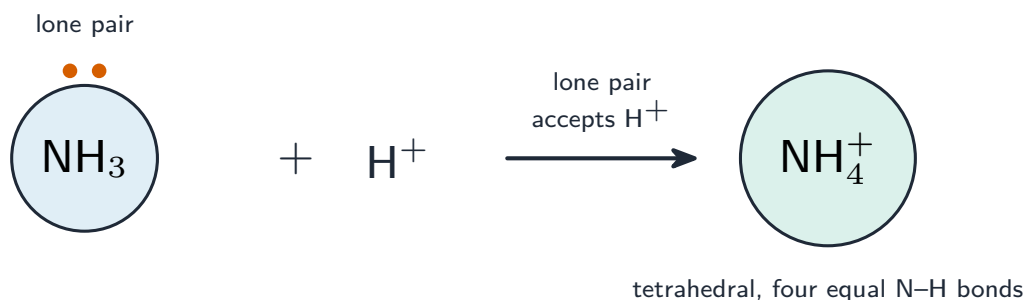
■ Unreactive nitrogen



symmetrical molecule $\Rightarrow$ no polarity $\Rightarrow$ nothing pulls it into a reaction

N₂ is unreactive: a very strong triple bond (high bond energy) and a symmetrical, non-polar molecule

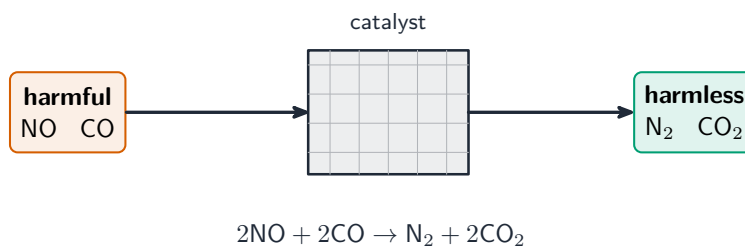
■ Ammonia as a base



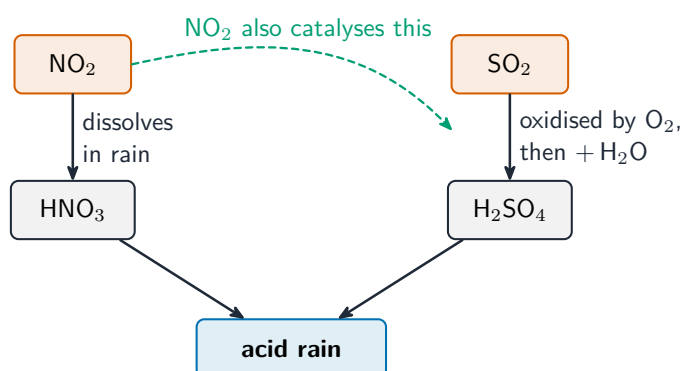
Ammonia is a base because the lone pair on N accepts a proton: $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$

The new N-H bond is a **coordinate bond** (both electrons from N). Warming an ammonium salt with a base displaces ammonia: $\text{NH}_4\text{Cl} + \text{NaOH} \rightarrow \text{NaCl} + \text{NH}_3 + \text{H}_2\text{O}$.

■ Nitrogen oxides and acid rain



A catalytic converter: $2\text{NO} + 2\text{CO} \rightarrow \text{N}_2 + 2\text{CO}_2$



NO_2 forms nitric acid directly and catalyses the oxidation of SO_2 to sulfuric acid – both cause acid rain

2 Practice

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]

3 Exam-style questions

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

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]

3.4 Describe a chemical test for an ammonium salt. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

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

2.2

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

3.1 B

- The lone pair on nitrogen accepts a proton

3.2 B

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

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

3.4

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