

12.1 Nitrogen and sulfur

Name: _____ Class: _____ Date: _____

Total: 12 marks**KEY WORDS** acid rain 酸雨 • bond energy 键能 • triple bond 三键 • basicity 碱性 • coordinate bond 配位键

Objective

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

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 Worked examples

■ Unreactive nitrogen

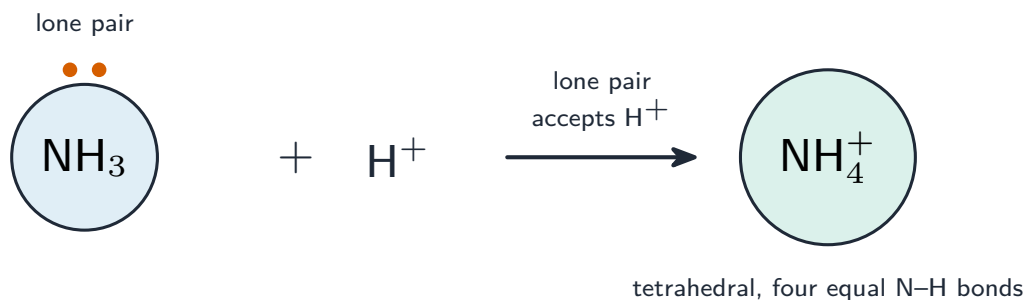


strong triple bond: very high
bond energy $\Rightarrow$ hard to break

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

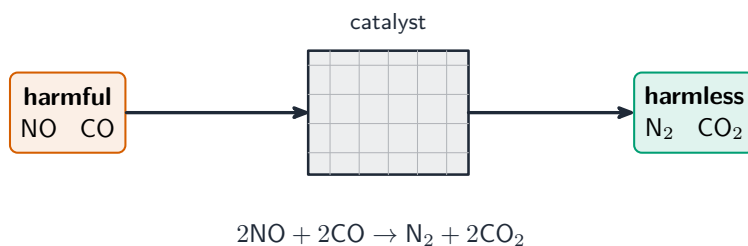
■ Ammonia as a base



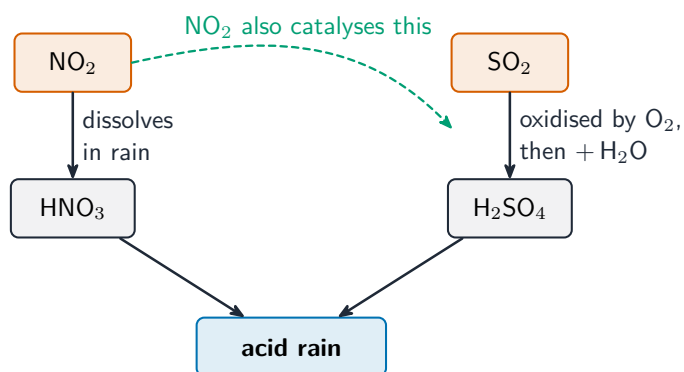
Ammonia is a base because the lone pair on N accepts a proton: $\text{NH}_3 + \text{H}^+ \rightarrow \text{NH}_4^+$

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

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



3.1 B. The lone pair on nitrogen accepts a proton.



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.