12.1 Nitrogen and sulfur

Name: _____ Class: _____ Date: _____ **Total: 12 marks**

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

Objective

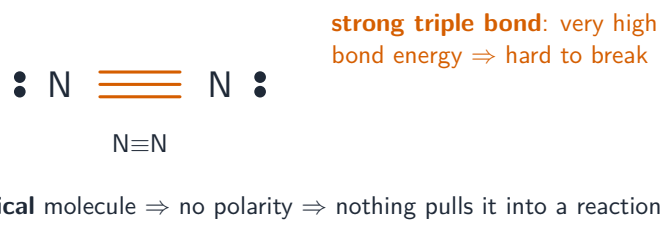
Build the skills to answer exam questions on **nitrogen and sulfur** – the unreactivity of nitrogen, the **basicity** of **ammonia**, oxides of nitrogen, and **acid rain**.

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

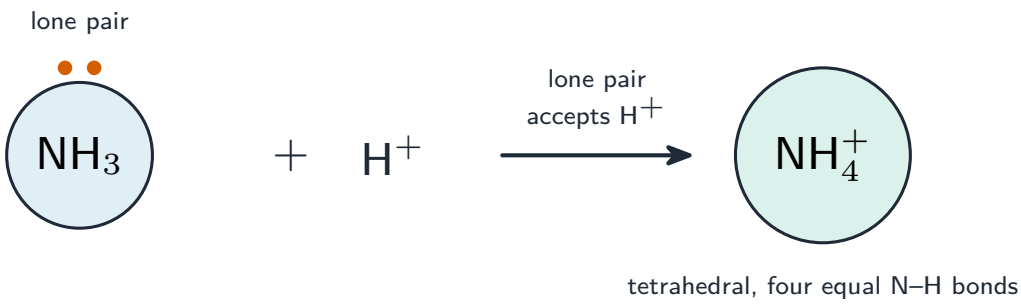
1 Key knowledge and worked examples

Unreactive nitrogen



N_2 is unreactive: a very strong triple bond (high bond energy) and a symmetrical, non-polar molecule

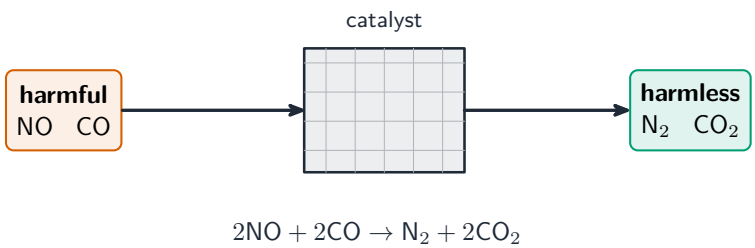
Ammonia as a base



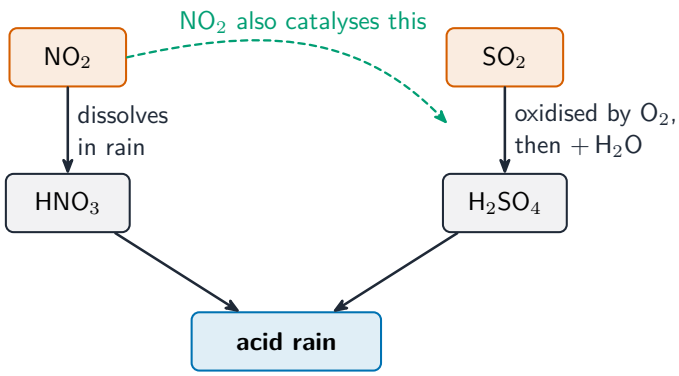
Ammonia is a base because the lone pair on N accepts a proton: $NH_3 + H^+ \rightarrow NH_4^+$

The new N–H bond is a **coordinate bond** (both electrons from N). Warming an ammonium salt with a base displaces ammonia: $NH_4Cl + NaOH \rightarrow NaCl + NH_3 + H_2O$.

Nitrogen oxides and acid rain



A catalytic converter: $2NO + 2CO \rightarrow N_2 + 2CO_2$



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]