CIE Chemistry A-Level

Topic 13 - Nitrogen and Sulfur

Flashcards

Why is nitrogen very unreactive?

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- Nitrogen exists as a diatomic molecule whereby 2 nitrogen atoms are joined by a triple bond (N≡N).
- The enthalpy of this bond is very high and hence requires a lot of energy to break.
- There isn't a permanent dipole in the molecule so it is fairly resistant to electrophilic and nucleophilic attack.

How does ammonia act as a base?

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Ammonia (NH_3) is a weak base because there is a lone pair of electrons on the nitrogen atom that allow the molecule to accept a proton, forming an ammonium ion, NH_4^+.

Describe the bonding and structure of ammonia

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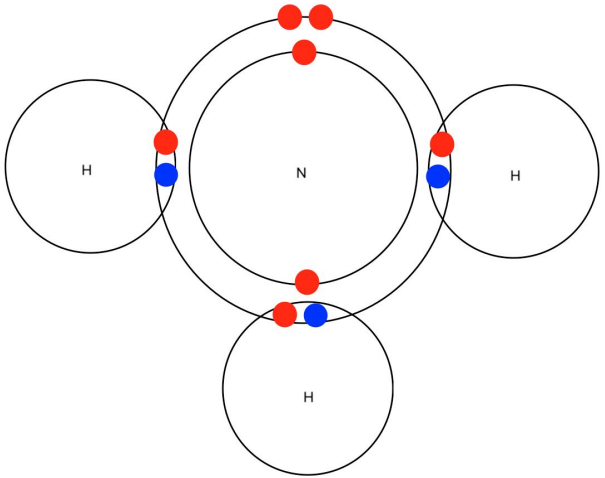
There are 3 bonding pairs of electrons (N-H covalent bonds. In addition to this, there is 1 lone pair of electron. Shape is pyramid 107° bond angle.



Describe the bonding and structure of ammonium ions

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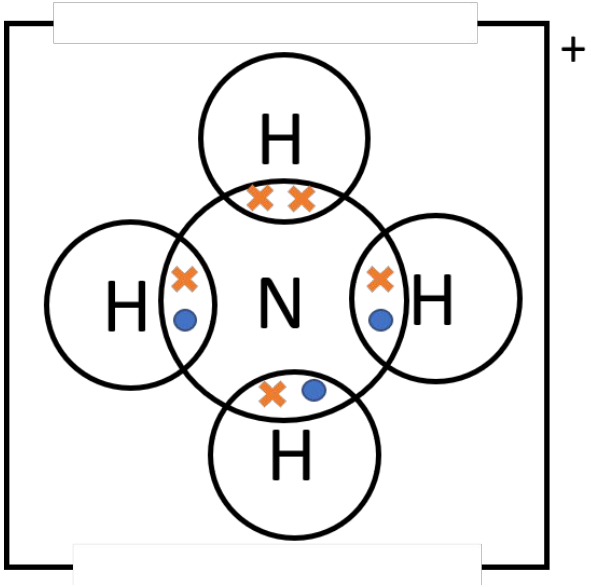
- 4 bonding pairs, no lone pairs.
- One dative covalent bond.
- Tetrahedral shape and bond angle of 109.5°.



How is an ammonium ion formed during the reaction between hydrochloric acid and ammonia?

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Full equation: $NH_{3(aq)} + HCl_{(aq)} \rightarrow NH_4Cl_{(aq)}$

Ionic equation: $NH_{3(aq)} + H^+_{(aq)} \rightarrow NH_4{}^+{}_{(aq)}$

Ammonia accepts a proton from the acid to form an ammonium ion.

What can be used to displace ammonia from its salts? What is formed during this reaction?

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When an alkali is reacted with an ammonium salt, ammonia is displaced. This also forms a salt and water.

Write an equation for the reaction of ammonium chloride with sodium hydroxide

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$$NH_4Cl_{(s)} + NaOH_{(aq)} \rightarrow NH_{3(g)} + H_2O_{(l)} + NaCl_{(aq)}$$

What is the industrial importance of ammonia and its compounds?

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- Ammonium nitrate is used as a plant fertiliser.
- Ammonium hydroxide is used in household cleaning products.
- Purifies water supplies and is used in wastewater treatment.
- Used as a refrigerant gas and in air-conditioning equipment.
- Used to make explosives, dyes, polymers, paints, detergents and drugs.

What are the environmental consequences of excessive / uncontrolled fertiliser use?

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Eutrophication:

- Rainwater causes excess fertilisers to leach into lakes and rivers.
- Excessive algal growth occurs and algal bloom forms on the water surface.
- The algal bloom prevents light reaching the plants below the water meaning they die as a result of being unable to photosynthesis.
- Dead plants are broken down by decomposers which, along with the algae, use up the oxygen dissolved in the water for respiration.
- This leaves little oxygen for respiration in other organisms such as fish. As a result, the fish die.

Name the following compounds:
N_2O, NO and NO_2

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- N_2O = Nitrous oxide
- NO = Nitric oxide
- NO_2 = Nitrogen dioxide

State the colours of the following gases: N_2O, NO and NO_2

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N_2O, NO and NO_2

- N_2O = colourless
- NO = colourless
- NO_2 = reddish-brown

How are oxides of nitrogen produced naturally?

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By lightning:

$$N_2 + O_2 \rightarrow 2NO$$
$$NO + \tfrac{1}{2}O_2 \rightarrow NO_2$$

By microbes in the soil: produce nitrous oxide, N_2O, nitrate ions (NO_3^-), nitrite ions (NO_2^-) and other nitrogen-containing compounds.

How are oxides of nitrogen produced by human activity?

How are oxides of nitrogen produced by human activity?

- Made via fossil fuel combustion.
- Can also be formed in nitric acid manufacture.
- NO made as a result of the high pressures and temperatures of car engines ($N_2 + O_2 \rightarrow 2NO$).

Describe how catalytic converters work

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- Nitrogen monoxide is formed in car engines: $N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)}$.
- A catalytic converter removes a majority of NO so it isn't released into the atmosphere: $2NO_{(g)} + 2CO_{(g)} \rightarrow N_{2(g)} + CO_{2(g)}$.
- A ceramic honeycomb structure is coated in a thin layer of metal catalysts (such as platinum and rhodium).

Why are atmospheric oxides of nitrogen pollutants?

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- Nitrogen monoxide can catalyse a the oxidation of SO_2, causing acid rain.
- Nitrogen dioxide can also contribute to photochemical smog.

How does nitrogen dioxide catalyse the oxidation of atmospheric sulfur dioxide?

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Nitrogen dioxide catalyses the conversion of SO_2 into SO_3:

$$NO_{2(g)} + SO_{2(g)} \rightarrow SO_{3(g)} + NO_{(g)}.$$

Nitrogen monoxide reacts with oxygen to reform the catalyst:

$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}.$$

How does the combustion of sulfur-contaminated fossil fuels lead to the formation of atmospheric sulfur dioxide?

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- Fossil fuels (such as coal and oil) contain small amounts of sulfurous compounds.
- When combusted, sulfur dioxide will be released.

How does acid rain form?

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Sulfur dioxide reacts with oxygen in the atmosphere to form sulfur trioxide (catalysed by nitrogen monoxide). Sulfur trioxide dissolves in water vapour in the clouds to form dilute sulfuric acid. This falls as acid rain.

Write an equation to show the formation of acid rain from sulfur trioxide (include state symbols).

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$$SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$$

What are the main environmental consequences of acid rain?

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- Corrosion of buildings/statues made from limestone.
- Corrosion of ironwork.
- Acidification of lakes and rivers.
- Damage to vegetation.