

# CAIE Chemistry A-level

## Topic 12 - Nitrogen and Sulfur

### Flashcards

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# Why is nitrogen very unreactive?



## Why is nitrogen very unreactive?

- Nitrogen exists as a diatomic molecule whereby 2 nitrogen atoms are joined by a triple bond ( $\text{N}\equiv\text{N}$ ).
- 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?



## How does ammonia act as a base?

Ammonia ( $\text{NH}_3$ ) 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,  $\text{NH}_4^+$ .

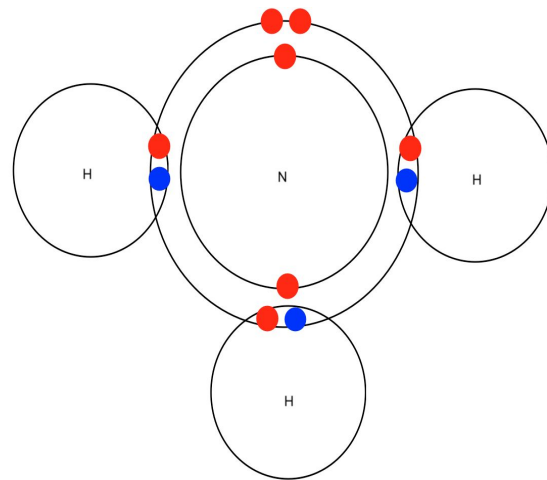


Describe the bonding and structure of ammonia



# Describe the bonding and structure of ammonia

There are 3 bonding pairs of electrons (N-H covalent bonds). In addition to this, there is 1 lone pair of electron. The shape is pyramidal and it has a  $107^\circ$  bond angle.



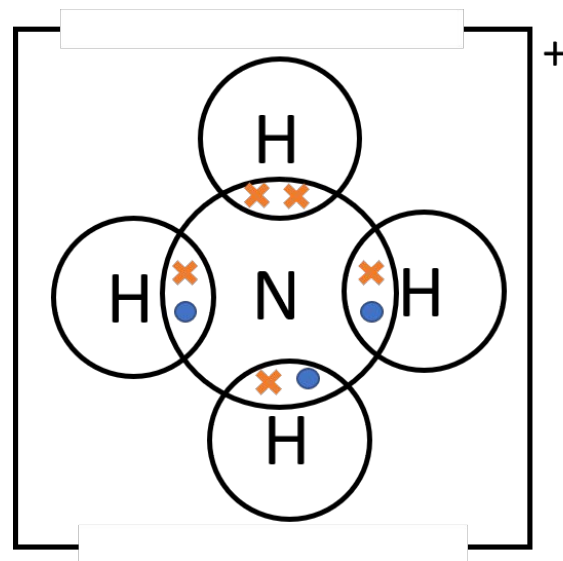
Describe the bonding and structure of ammonium ions





# Describe the bonding and structure of ammonium ions

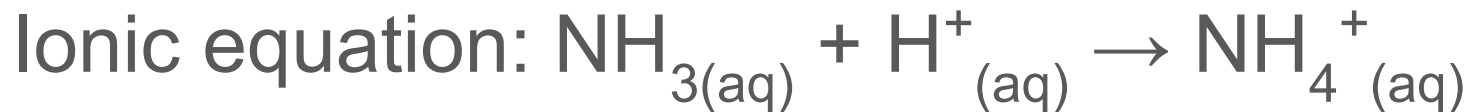
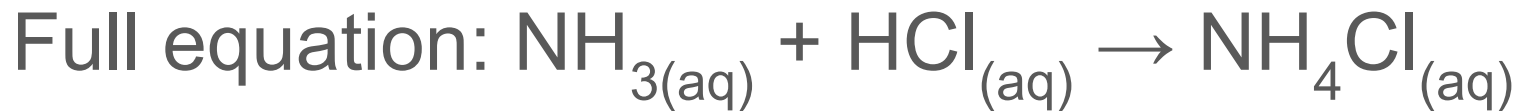
- 4 bonding pairs, no lone pairs.
- One dative covalent bond.
- Tetrahedral shape and bond angle of  $109.5^\circ$ .



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



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



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?



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

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



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



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



Name the following compounds:  
 $N_2O$ ,  $NO$  and  $NO_2$





Name the following compounds:  $\text{N}_2\text{O}$ ,  $\text{NO}$  and  $\text{NO}_2$

$\text{N}_2\text{O}$  = Nitrous oxide

$\text{NO}$  = Nitric oxide

$\text{NO}_2$  = Nitrogen dioxide



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



State the colours of the following gases:

$\text{N}_2\text{O}$ ,  $\text{NO}$  and  $\text{NO}_2$

$\text{N}_2\text{O}$  = colourless

$\text{NO}$  = colourless

$\text{NO}_2$  = reddish-brown



# How are oxides of nitrogen produced naturally?



## How are oxides of nitrogen produced naturally?

By lightning: 
$$\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$$



Alternatively, microbes in the soil produce nitrous oxide ( $\text{N}_2\text{O}$ ) nitrate ions ( $\text{NO}_3^-$ ), nitrite ions ( $\text{NO}_2^-$ ) and other nitrogen-containing compounds.



How are oxides of nitrogen produced by human activity?



# How are oxides of nitrogen produced by human activity?

- Made from fossil fuel combustion.
- Formed in nitric acid manufacture.
- NO made as a result of the high pressures and temperatures of car engines:  $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$ .



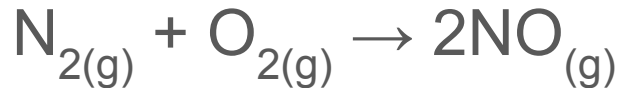
# Describe how catalytic converters work



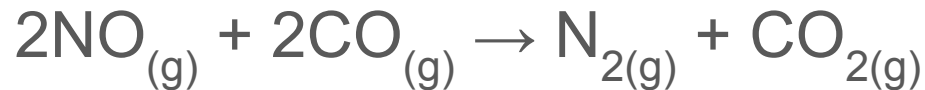


# Describe how catalytic converters work

Nitrogen monoxide is formed in car engines:



A catalytic converter is made up of a ceramic honeycomb structure coated in a thin layer of metal catalysts (such as platinum and rhodium). The catalytic converter removes a majority of NO so that it isn't released into the atmosphere:



# Why are atmospheric oxides of nitrogen pollutants?



# Why are atmospheric oxides of nitrogen pollutants?

- Oxides of nitrogen can react with oxygen and water in the clouds to produce nitric acids (acid rain).
- Nitrogen monoxide can catalyse the oxidation of  $\text{SO}_2$ , causing acid rain.
- Nitrogen dioxide can contribute to photochemical smog.

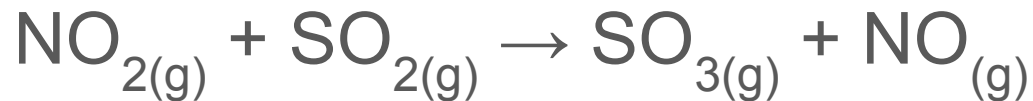


How does nitrogen dioxide catalyse the oxidation of atmospheric sulfur dioxide?



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

Nitrogen dioxide catalyses the conversion of  $\text{SO}_2$  into  $\text{SO}_3$ :



Nitrogen monoxide reacts with oxygen to reform the catalyst:



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



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

Fossil fuels (such as coal and oil) contain small amounts of sulfurous compounds.

Sulfur dioxide is released when these compounds undergo combustion.



# How does acid rain form?





## How does acid rain form?

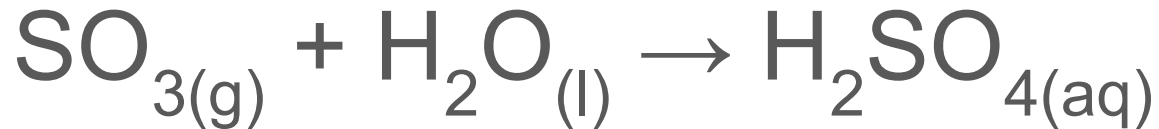
Sulfur dioxide reacts with oxygen in the atmosphere to form sulfur trioxide (catalysed by nitrogen monoxide). Sulfur trioxide dissolves in water vapour in the clouds to form dilute sulfuric acid. This falls as acid rain.



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



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



What are the main environmental consequences of acid rain?



# What are the main environmental consequences of acid rain?

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

