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| **Exam & State:** | HSC Exam in NSW |
| **Subject:** | Chemistry |
| **Type of Exam Preparation Material:** | Study Notes |
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## Summary

In general, this document provides content, analysis and examples behind the course dot points as outlined in the Board of Studies chemistry syllabus. By breaking down the three core modules (production of materials, the acidic environment, chemical monitoring and management) into their subtopics and concepts, and structuring these notes accordingly, the relevant information is provided in a clear and concise form. With the inclusion of useful diagrams and important molecular formula presented in a visual manner, the notes should be easily accessible by all students of varying abilities.


## Useful for

Year 12 students taking chemistry for the HSC would find this exam preparation material useful as a comprehensive summary of the fundamentals behind what should be known and learnt for the final exam. This document can be used as a learning aid, to clarify or even enhance the student's knowledge regarding the relevant course content. The notes can also serve as a quick and easy point of reference when revising for the exam or explaining a particular topic/concept.

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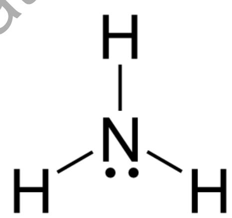
## 2. CHEMICAL PROCESSES IN INDUSTRY REQUIRE MONITORING AND MANAGEMENT TO MAXIMISE PRODUCTION.

**Identify and describe the industrial uses of ammonia.**

- Fertilisers – [ammonium nitrate/sulfate] for food crops
- Household cleaners (for windows and floors)
- Fibres and plastics and other synthetic polymers
- Refrigerants
- Vitamins, drugs and dyes
- Catalysts, used in the process of making plastics

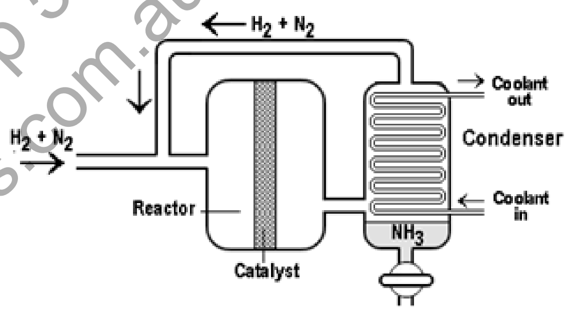
**Identify that ammonia can be synthesised from its component gases, nitrogen and hydrogen.**

- **Haber process**: $N_2 + 3H_2 \leftrightarrow 2NH_3$ $\Delta H = -92$ kJ $mol^{-1}$ [gaseous states]
- **Hydrogen** is obtained by re-forming light petroleum fractions or natural gas by reacting it with steam (inexpensive), or from the electrolysis of water (expensive)
- **Nitrogen** is obtained from the removal of oxygen from air by chemical processes involving methane (inexpensive) or fractional distillation of liquid air (expensive)



**Describe that synthesis of ammonia occurs as a reversible reaction that will reach equilibrium.**

1. Purified mixture of $N_2$ and $H_2$ is heated to 400°C -450°C, pressure of 250atm
2. Passed into tungsten steel 'bombs' (catalytic towers) where about 10% of the mixture converts to ammonia
3. $NH_3$ is removed
4. $N_2$ and $H_2$ is continually added to the recirculating hydrogen-nitrogen stream (reaction never reaches equilibrium since reactants keep being added)
5. Unreacted gases are recycled up to 6 times ensuring nearly 100% yield of ammonia




**Identify the reaction of hydrogen with nitrogen as exothermic.**

- Bonds are broken and other bonds formed
- Exothermic nature maintains the catalyst at its optimum functioning temperature around 500°C–600°C

**Explain why the rate of reaction is increased by higher temperatures.**

- Higher temperatures → particles move and vibrate faster → more collisions → increases rate of reaction
- Energetic 'hot' molecules have greater kinetic energies to overcome the activation energy barrier and so allow the reaction to occur

**Explain why the yield of product in the Haber process is reduced at higher temperatures.**

- $N_2 + 3H_2 \leftrightarrow 2NH_3$ + heat [exothermic]
- Increasing heat shifts the equilibrium left (decreasing $NH_3$)
- Although increasing the temperature increase the *rate* of reaction, the forward reaction is not favoured (Le Chatelier's principle)

**Analyse the impact of increased pressure on the system involved in the Haber process.**

- $N_2 + 3H_2 \leftrightarrow 2NH_3$
- For every 4 moles of gases reacting, 2 moles of $NH_3$ is produced
- Increased pressure → shifts equilibrium right (lesser number of moles)
  - Pushes molecules closer together, increasing their chance of hitting and sticking to the catalyst where they can react
- At 200°C and 1000atm, there is almost 100% conversion to ammonia (uneconomic)
- Economic considerations against very high pressures:

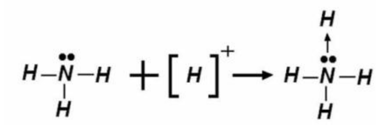
- **Damage caused by humans:**
  - Ozone depletion – especially by CFCs and halons
  - Enhanced greenhouse effect – increased levels of $CO_2$
  - Pollution of troposphere – by acid rain and photochemical smog

**Describe ozone as an upper atmosphere UV radiation shield and a lower atmosphere pollutant.**

- **Ozone ($O_3$):** very reactive, pale blue gas toxic at concentrations >1ppm
- **Ozone production:**
  - Nitrogen oxides react with unburnt hydrocarbons in sunlight and decompose, oxygen free radical reacts with oxygen molecule to form ozone: $NO_2 \rightarrow NO + O\bullet$ *THEN* $O\bullet + O_2 \rightarrow O_3$
  - UV light or lighting acts on oxygen at high altitudes, oxygen free radical reacts with oxygen molecule to form ozone: $O_2 \rightarrow 2O\bullet$ *THEN* $O_2 + O\bullet \rightarrow O_3$
  - Also emitted from ionisers, electrostatic precipitators, photocopying machines, laser printers
- **Ozone in the lower atmosphere** (troposphere)
  - Atmospheric pollutant
  - Powerful oxidizing agent
  - Damages plants, paints and buildings
  - Affects health:
    - Increases likelihood of respiratory conditions e.g. asthma
    - Irritates eyes and airways
    - Increases chances of infection
- **Ozone in the upper atmosphere** (stratosphere)
  - Forms a very thin layer acting as a UV radiation shield (absorbs most of the sun's UV light, allowing only small amounts to reach Earth)

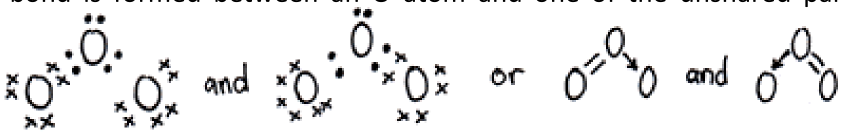
**Describe the formation of a coordinate covalent bond.**

- **Coordinate covalent bond:**
  - Covalent bond where both of the shared electrons have been donated by the same atom
  - Formed from any compounds containing a lone pair of electrons
- **Example**: $NH_3$
  - Nitrogen has 5 valence electrons (3 are shared with H, leaving 1 pair unshared)
  - In the $NH_4^+$ ion, the ammonia molecule joins with a $H^+$ ion
    - This bond, sometimes shown with an arrow, is a *coordinate covalent bond* where both electrons are provided by the N atom



**Demonstrate the formation of coordinate covalent bonds using Lewis electron dot structures.**

- In $O_2$, there's a double bond between the oxygen atoms: O=O
- Around each O atom there are 6 valence electrons. When $O_2$ forms, 2 unshared pairs of electrons are left (on each O atom)
- In $O_3$, a coordinate covalent bond is formed between an O atom and one of the unshared pairs of electrons on the $O_2$ molecule




**Compare the properties of the oxygen allotropes $O_2$ and $O_3$.**

| Property | Oxygen, $O_2$ | Ozone, $O_3$ |
|---|---|---|
| Colour | Colourless as a gas<br>Pale blue as a liquid/solid | Pale blue as a gas<br>Deep indigo-blue liquid<br>Deep violet crystalline |
| Odour | Odourless | Sharp, pungent |
| Molecular shape | Linear | Bent |