AQA GCSE Chemistry

Topic 10: Using resources

The Haber process and the use of NPK fertilisers (chemistry only)

Notes

(Content in bold is for Higher Tier only)

The Haber process

- Used to manufacture ammonia, which is used to produce nitrogen-based fertilisers
- The raw materials are nitrogen and hydrogen.
- Nitrogen is obtained from the air and hydrogen may be obtained from natural gas or other sources.
- The purified gases are passed over a catalyst of iron at a high temperature (about 450 °C) and a high pressure (about 200 atmospheres).
- Some of the hydrogen and nitrogen reacts to form ammonia.
- The reaction is reversible so ammonia breaks down again into nitrogen and hydrogen.

nitrogen + hydrogen ⇌ ammonia

- On cooling, the ammonia liquefies and is removed.
- The remaining nitrogen and hydrogen are recycled.
- Reaction conditions and compromise:
    - the Haber Process is in dynamic equilibrium- the forward and backward reactions keep going once equilibrium is reached
    - the chemical equation is $N_2 + 3H_2 \rightleftharpoons 2NH_3$, so there are less moles of gas on the product side (2 compared to 4), this means you would increase pressure to move equilibrium to the right so more ammonia is produced
    - the forwards reaction is exothermic, so a low temperature would favour the forwards reaction and mean more ammonia was produced
    - HOWEVER the actual conditions used are not low temperature and very high pressure because a low temperature leads to a reaction rate that is too slow and a very high pressure requires too much energy

Production and uses of NPK fertilisers

- Compounds of nitrogen, phosphorus and potassium are used as fertilisers to improve agricultural productivity
- NPK fertilisers contain compounds of <u>all three elements</u>
- Industrial production of NPK fertilisers can be achieved using a variety of raw materials in several integrated processes
- NPK fertilisers are formulations of various salts containing appropriate percentages of the elements
- Ammonia can be used to manufacture ammonium salts and nitric acid
- Potassium chloride, potassium sulfate and phosphate rock are obtained by mining, but phosphate rock cannot be used directly as a fertiliser
    - Phosphate rock is treated with nitric acid or sulfuric acid to produce soluble salts that can be used as NPK fertilisers

Use of Phosphate Rock

- The Earth's crust is rich in minerals that serve as essential raw materials for creating fertilizers.
- Phosphate rocks are a source of potassium chloride and potassium sulfate, which provide potassium.
- Since the rock is insoluble in water, it is generally reacted with acid to create useful water-soluble compounds.
    - Reacting the rock with nitric acid yields phosphoric acid and calcium nitrate. The phosphoric acid is neutralised with ammonia, producing ammonium phosphate.
    - Reacting the rock with sulfuric acid produces a mixture of calcium phosphate and calcium sulfate, known as single superphosphate.
    - Reacting the rock with phosphoric acid results in calcium phosphate, referred to as triple superphosphate.