Making ammonia - the Haber process

Background

During the last century, the populations of Europe and America rose very rapidly. More food and more crops were needed to feed more and more people. So farmers began to use **nitrogen compounds** as fertilisers. The main source of nitrogen compounds for fertilisers was sodium nitrate from Chile. By 1900 supplies of this were running out. Another supply of nitrogen had to be found or many people would starve. The obvious source of nitrogen was the **air** (about 78% of the air is nitrogen). Unfortunately, nitrogen is not very reactive. This made it difficult to convert it into ammonium salts and nitrates for use as fertilisers. A German chemist called Fritz Haber solved the problem.

In 1904, Haber began studying the reaction between nitrogen and hydrogen. By 1908 he had found the conditions needed to make **ammonia** (NH_3). Eventually, the Haber process became the most important method of manufacturing ammonia.

1. Why did farmers start to use nitrogen compounds as fertilisers?

2. What problem did farmers face in 1900?

3. How long did it take Fritz Haber to work out the conditions needed to make nitrogen and hydrogen react together?

4. What does the Haber process make?

5. Haber was an apprentice plumber before studying to become a chemist.
   How was Haber's background useful to him as a chemist?

The Haber process

The raw materials for the Haber process are Natural gas, air and water. In the first stage, Natural gas (which is mostly methane) is reacted with steam to produce carbon dioxide and hydrogen. To speed up the reaction, a catalyst is used. A high temperature and a high pressure also speeds up the reaction.

In the second stage, some of the hydrogen from the first stage is burnt in air. The oxygen in the air reacts with the hydrogen to make steam. The reason for this second stage is to remove the oxygen from the air to leave nitrogen behind. It also makes a lot of the heat needed in the Haber process.

In the third stage, hydrogen from the first stage is mixed with nitrogen from the second stage. The two gases are put under high temperature and high pressure. Usually 400°C and 150–300 atmospheres of pressure are used. Iron is also added as a catalyst. Some of the gases are converted to ammonia. The ammonia is cooled to turn it into a liquid. The liquid ammonia is then run off from the gases. The unconverted gases are then recycled to have another chance of reacting.

6. What are the raw materials for the Haber process?

7. Why is iron used in the Haber process?

8. How are the reactions made to run quickly in the Haber process?

9. The equation for the main reaction is: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. Write the word equation for it.

10. Draw a flow chart to show what happens in the three stages of the Haber process.