The Story of Fritz Haber

Contents: Reading and questions relating to the life and work of the inventor of the Haber Process.

Time: 1 period or more, depending on amount of discussion.

Intended use: GCSE Chemistry and Integrated Science. Links with work on ammonia and the Haber Process.

Aims:

- To complement prior work on the Haber Process and the manufacture of fertilizers
- To show, through the life of Haber, the problem of the social responsibility of the scientist
- To develop awareness of the way scientific discoveries can be put to both beneficial and detrimental use
- To provide opportunities to practise skills in reading, comprehension and discussion.

Requirements: Students' worksheets No. 207

This passage of reading and associated questions can be used in class or for homework. The questions can be effectively tackled as a group discussion activity by groups of three, four or five students working together. If the unit is used for homework it should be followed up later with class discussion. It is assumed that the chemistry of the Haber Process will have already been covered.

Notes on some of the questions

Q.2 The renewable resources involved are nitrogen and water (if this is the hydrogen source). The iron catalyst is also effectively renewable, since iron is so abundant. Non-renewable resources consumed include methane (if this is the hydrogen source) and/or the fuel to heat the process. Fuel is the largest single cost — fertilizers represent nearly half of the total energy input to British agriculture.

Q.3 Haber was working for BASF, who in fact originally asked him to investigate the synthesis of nitrogen oxides from air, with a view to manufacturing nitric acid for fertilizer manufacture.

Q.9 Perhaps the most obvious example is the development of nuclear weapons in the 1940s. Teachers might like to refer to the case of Einstein and later of Oppenheimer and Fermi in the Manhattan Project. Information on this topic can be found in the SISCON reader *The Atomic Bomb* (published by ASE/Blackwell). It is worth noting that the destructive power of these modern weapons is far greater than anything Haber worked on in the First World War.

Acknowledgements Figure 1 supplied by BASF; Figures 2 and 3, ICI Agricultural Division; Figure 4 and 5, Imperial War Museum.

THE STORY OF FRITZ HABER

The followng piece is about the life of Fritz Haber, inventor of the Haber Process. Read it, then answer the questions that follow.

The Haber Process is an elegant and efficient piece of chemistry. It takes nitrogen from the air, and there is plenty of that available, and hydrogen from water or natural gas, likewise plentiful sources. It converts these elements into ammonia by the use of heat, pressure and a catalyst made of a cheap, abundant material — iron. The ammonia, in the form of ammonium sulphate or ammonium nitrate, is fed to plant crops which turn it into protein, which is eaten by animals. After the natural process of death and decay, the nitrogen either returns to the plants or goes back into the air. Apart from the fuel needed for heating the Haber Process, no non-renewable resources have been used up. This process has an unlimited capacity for providing fixed nitrogen. It would be difficult to produce enough food for the ever-growing population of the earth without it.

Figure 1 Fritz Haber

But there is another side to this apparently happy story. As well as being used for producing fertilizers, ammonia is used to make nitric acid, and nitric acid is needed for the manufacture of high explosives. Explosives have important peaceful uses, in mining, quarrying and tunnelling, but they are also used in war. Thus the Haber Process, as well as helping feed millions of people, also has some responsibility for hundreds of thousands, if not millions of deaths in the two world wars.

This contradiction can be seen running through the life of the man who discovered the Haber Process. With him we can see the whole problem of the way science can be used for both good and evil.

Fritz Haber was born in 1868 in Breslau, Germany. He studied science in Berlin and worked in the Karlsruhe Engineering School, researching into chemical technology. By 1906 he had done several successful pieces of research and become a professor at Karlsruhe. This was a time of great industrial and technical expansion and progress in Germany, and science flourished.

Like other countries, Germany needed supplies of nitrogen compounds to make fertilizers and explosives. The main source of these compounds was the deposits of sodium nitrate in Chile, South America. But by the beginning of this century, these supplies were running out. In any case, a home-based supply of nitrogen compounds was much preferable for Germany than having to import sodium nitrate from across the world — particularly at a time when the British Navy controlled most of the oceans. German scientists began to look for ways of making nitrogen compounds for fertilizers from the nitrogen in the air. Haber was asked by a chemical company to look into the problem. He tried to find a way of making ammonia from atmospheric nitrogen. After many failures and frustrations, Haber perfected the process that carries his name and is now used all over the world.

Figure 2 Many farmers use fertilizers to try to improve crop yields

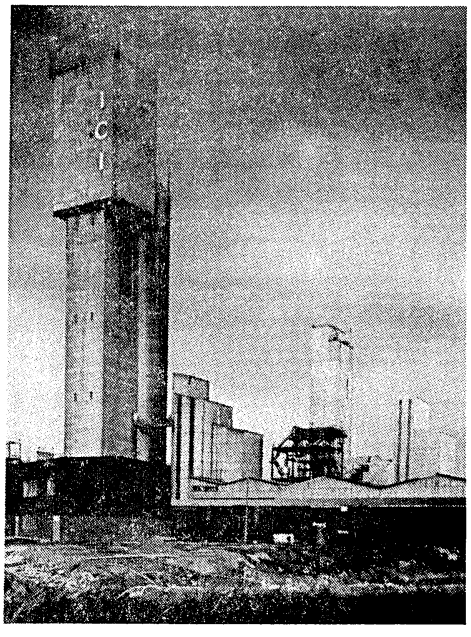

Figure 3 ICI 'NITRAM' plants which produce ammonium nitrate

By 1912 Haber was one of the most respected scientists in Germany. He was asked to be head of the Kaiser Wilhelm Institute for Physical Chemistry, which was to be part of a great new scientific centre. One of his first projects at the institute was to work on a safety device to detect dangerous gases in mines. As war approached, scientists at the Kaiser Wilhelm Institute, like

scientists in Britain and France, turned their attention to the use of science in warfare. Haber was asked to look into the possibility of chemical warfare, and he did so with great efficiency.

The use of chemicals in warfare was not new. In the early months of the First World War the Russians had tried to use chlorine as a poison gas, without success. In the cold winter the gas sank into the snow, to reappear in the spring when the opposing armies were far away. Haber's job was to find a way of distributing the gas efficiently, and this he succeeded in doing. In April 1915, 5000 cylinders of chlorine were released against French and Canadian troops, with horrifying results. Fifteen thousand casualties were counted, a third of them fatal. Later in the same battle, the Allies retaliated with their own gas attack. This showed that Haber was not the only one working on poison warfare.

Figure 4 Soldiers wearing gas masks in a trench near Ypres in the first World War

Figure 5 A gas sentry on duty

Haber was in favour of massive gas attacks to bring the war to a quick end. He developed further poisons, including mustard gas. He had no worries about using science in warfare. He said 'A man belongs to the world in times of peace, but to his country in times of war'. His wife, however, was tormented by the part her husband played in the war, and in 1916 she committed suicide.

The military authorities did not share Haber's enthusiasm for gas warfare, not because they thought it was immoral, but because they did not believe it could work effectively. In the end gas proved to be a weak and little-used weapon in the First World War, though it was a powerful psychological threat to both sides.

After the war, Haber was disapproved of by many of the Allies because of his work on poison warfare. In 1919 when he was awarded the Nobel Prize for chemistry, several Frenchmen who were offered Nobel awards refused them because of Haber's involvement. Perhaps this was a little strange, in view of the fact that Nobel was himself the inventor of dynamite.

Haber, however, continued to be a great patriot and to work for his country. After the war the Allies demanded huge payments from Germany to pay for war damage. Raising the money for these payments was an enormous problem. The sum of money needed was equivalent to fifty thousand tons of gold — and it was to gold that Haber turned his attention.

Haber had the idea of getting gold from the sea to meet the payments. He had heard the oceans contained an estimated eight thousand million tons of gold compounds. He invented a process for getting the gold from the sea by precipitating it as gold sulphide. He organized several trials in specially designed ships, but he was unsuccessful. The estimates of the amount of gold in the sea were about a thousand times too high, which made getting the metal out practically impossible. His attempts to use science to solve his country's economic difficulties had failed. He continued, however, to be a successful scientist as chairman of the Kaiser Wilhelm Institute, and became a respected figure equal in status to other great scientists of the time such as Albert Einstein and Nils Bohr.

Should Haber have acted differently? We have the great contribution of the Haber Process to the good of the world through the manufacture of fertilizers. But we also have its contribution to war and destruction through its link with the manufacture of explosives. And Haber was heavily involved in the first successful use of chemical warfare. It can, of course, be said that if he had not developed it, others would. But Haber was a brilliant scientist and succeeded where others might well have failed. The great English scientist Michael Faraday was asked to develop poison warfare in the Crimean War but refused.

Scientists have to make many decisions. Often moral problems are involved in making these decisions, as well as scientific ones. Haber seems to have ignored the moral considerations when he worked on poison warfare. Or did he? He acted out of patriotism throughout, so perhaps by his own standards he acted morally. But taken to extremes patriotism can have terrible results, as it did in Germany in the 1930s when it developed into Nazism. In 1933 Haber, the patriot, was driven out of his country into exile by the threat of the Nazis — because he was a Jew.

Questions to answer and discuss

1 *What is meant by 'fixed nitrogen', and why do we need it?*

2 *What is the difference between 'renewable' and 'non-renewable' resources? What renewable resources does the Haber Process use? What non-renewable resources does it use?*

3 *Why was Haber first asked to look at the possibility of making ammonia from atmospheric nitrogen?*

4 *Why did Haber try to extract gold from the sea? Why did he fail?*

5 *In what ways do you think Haber contributed to the well-being of the world?*

6 *In what ways do you think he contributed to the suffering of the world?*

7 *Haber made many discoveries and inventions. For which is he remembered today? Why do you think he is remembered for this, but not for his other work?*

8 *Should a scientist's conscience be involved in scientific work? Should scientists think about the uses to which their work might be put, or should they just get on with solving the scientific problems?*

9 *What other examples are there of scientists whose work has been put to destructive uses?*