

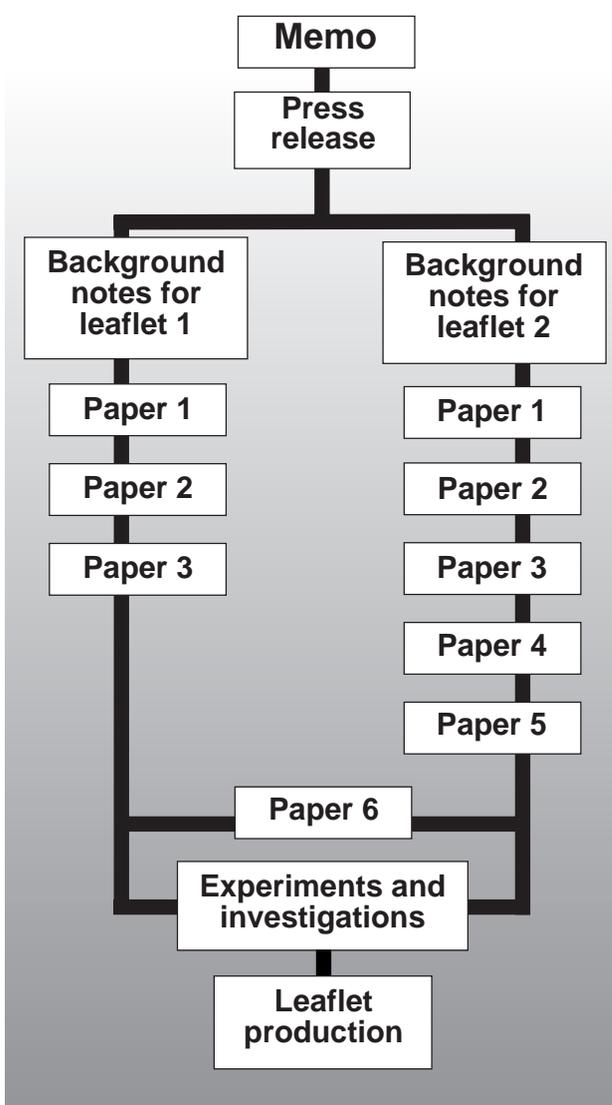
Pupil Research Brief

Teachers' Notes

Syllabus Coverage *Subject Knowledge and Understanding*

- air is almost 80% nitrogen
- nitrogen can be used to manufacture several important chemicals, including nitrogen-based fertilisers
- nitrogen-based fertilisers are important in agriculture for increasing the yield of crops
- ammonia is manufactured in the Haber process
- ammonium nitrate fertiliser is made by the neutralisation reaction between ammonia and nitric acid
- materials are returned to the environment either in waste or when living things die and decay
- materials decay because they are broken down (digested) by microbes
- the constant cycling of nitrogen is called the nitrogen cycle. In the nitrogen cycle green plants absorb nitrogen in nitrates from the soil. Plants use these nitrates to make proteins
- nitrifying bacteria convert ammonia compounds to nitrates

Route through the Brief



Introduction

In this Brief pupils take on the roles of researchers in a university chemistry department research team working on the development of fertilisers. Following a press release by the World Food Commission (WFC) announcing the setting up of an educational programme for use in a number of developing countries, the research team has been asked to produce two educational leaflets. The leaflets, covering the same topic, should be aimed at two different audiences; farmers and teachers. They should explain what fertilisers are, why they should be used and how they work. To enable these leaflets to reflect both the work of the department and other current research work, the researchers have to read a series of background papers and carry out experiments and investigations on the production of ammonium nitrate and its effects on plant growth. They then plan and produce an A4 size leaflet to address the issues outlined in their briefing sheet.

Teachers in Northern Ireland should not use the parts of the Brief which involve practical work with ammonium nitrate.

This Brief has differentiated routes. Lower-achieving pupils will produce the leaflet for the farmers and thus carry out the tasks relating to the production of

Pupil Research Brief

Teachers' Notes continued

that leaflet. Higher-achieving pupils will produce the leaflet for teachers and carry out the higher level tasks relating to the production of that leaflet.

Experimental and investigative skills

- planning experimental procedures
- obtaining evidence
- analysing evidence and drawing conclusions
- evaluating evidence

Prior knowledge

Before attempting this Brief pupils should have basic knowledge and understanding of natural cycles, acids and alkalis, indicators, and using equations to represent chemical reactions.

Running the Brief

Pupil grouping

Pupils could work in a number of groupings during this Brief. Suggestions are:

<i>Initial briefing</i>	-	whole class; teacher led
<i>Memo</i>	-	individuals, pairs or small groups
<i>Background papers</i>	-	individuals or pairs
<i>Experiments and investigations</i>	-	pairs or small groups
<i>Analysis of results</i>	-	individuals, pairs or small groups
<i>Production of leaflet</i>	-	individuals, pairs or small groups

Timing

The Brief should take 3-4 hours of classroom time. The production of the leaflet could be carried out as a homework activity. Extra time may be needed to write up individual investigation reports if these are to be used for examination assessment purposes. The optional investigation may add two hours or more, particularly if used for project work.

Activities

Pupils should be issued with the **Study Guide**, which provides them with a summary of what they should produce as they work through the Brief. It can also be used as a checklist so that they can monitor their own progress.

It is worth spending a little time at the start to set the scene. Then give out the **Memo**, the **Press release** and **Briefing notes for Leaflet 1**, with **Papers 1, 2, 3, 4 and 5** for those groups producing the leaflet for the farmers. Also give out the Memo, the press release and **Briefing notes for Leaflet 2**, with **Papers 1, 2, 3, 4 and 5** for the groups producing the leaflet for the teachers in the developing countries. Pupils may ask for **Paper 6** if they have problems getting started with the investigations. (Note: the second and third paragraph of the 'handwritten' note at the bottom of the page should be deleted for those pupils producing Leaflet 1 for farmers).

Pupils are guided through the Brief by the memo and the briefing notes for the leaflets which are fairly prescriptive so that they can work systematically and pay attention to detail. **Paper 1** provides background information on the nitrogen cycle and how current research on it could influence future industrial processes. **Paper 2** outlines the Haber process and makes brief reference to a field irrigation channel system which could develop from current research. **Paper 3** introduces the higher-achieving students to the concept of equilibrium and how the effects of pressure and temperature on it are applied in the Haber process. Current research into the use of enzymes as a possible lower energy alternative is also outlined. **Papers 4 and 5** provide relevant pupils with the experimental details of two techniques for making ammonium nitrate which they carry out and evaluate for inclusion in their leaflet. **Paper 6** provides the experimental details for comparing the effects on plant growth of using or not using a fertiliser. Paper 6 can be used where pupils have difficulty planning the investigation. The details described in the paper will need to be adapted by the pupils to carry out investigations on the effects of nitrogen on plant growth. Following all this, the pupils finally produce their leaflet for their respective target group.

Using IT. Pupils could use a pH probe instead of universal indicator when making the ammonium nitrate.

Investigation details

The Brief suggests two methods for making ammonium nitrate in Papers 4 and 5 for the pupils to evaluate. Method 1 outlined in Paper 4 describes a more accurate titration technique, whilst Paper 5 describes a simpler method (Method 2). Pupils producing the leaflet for farmers follow Method 2, whilst those producing the leaflet for teachers follow both methods and then evaluate them to decide which to include in their leaflet.

Pupil Research Brief

Teachers' Notes continued

Pupils producing the leaflet for farmers in developing countries are asked to investigate the effects on plant growth of using or not using a nitrogen-based fertiliser (ammonium nitrate). This they can carry out by adapting the method described in Paper 6 for investigating the effects of using or not using a general fertiliser containing a variety of minerals as well as ammonium nitrate. All they have to change in the method is the use of ammonium nitrate (same concentration, i.e. 4g in 100 cm³) instead of fertiliser. For further details please refer to Paper 6. However, some pupils might suggest that they should test for the effect of nitrogen by using culture solutions (see *Technical details* section below): one with all necessary minerals for plant growth, and a second with all necessary minerals except nitrogen (the *all minus one* approach). This is a more valid way of assessing the effect of removing nitrogen from the plant's mineral intake, since merely providing it with water only would deprive the plant of all essential minerals, thereby making it impossible to isolate the effect of nitrogen removal.

Pupils producing the leaflet for teachers in developing countries are asked to carry out the same investigation as described above, with the optional extension to investigate the effects of varying *concentrations* of ammonium nitrate on plant growth. This can also be achieved by adapting the method provided in Paper 6, i.e. by substituting varying concentrations of nitrogen (ammonium nitrate) instead of fertiliser. Again, some pupils might suggest a variation on the *all minus one* approach. They can also use this technique to carry out the optional additional investigation of the effects of different minerals on plant growth, where different minerals are removed from the plant, which still has all other essential minerals provided. Teachers in Northern Ireland should substitute ammonium sulphate for ammonium nitrate.

Technical details

Most of the information required, such as apparatus, solutions, experimental method, etc. is given in Papers 4, 5 and 6.

Where experiments using culture solutions are undertaken, Sach's Mineral Deficiency Water Culture sets can be used. These can be obtained from Philip Harris.

When using seedlings to demonstrate the effects of mineral deficiency, best results are obtained if the remains of the seed are removed from the seedling before putting it into the solution. The seed (cotyledons or endosperm) contains a supply of minerals for use by the plant in the early stages of

growth. Failure to remove this store results in little visible difference regardless of the culture solution used.

Safety issues

PLEASE NOTE: It is also important that you prepare your own risk assessments for the practical work in this Brief in the usual way.

Nitric Acid

0.1M to 0.5M Irritant
above 0.5M Corrosive.

If swallowed do NOT make pupil vomit. Wash mouth and give water to drink. Seek medical attention as soon as possible.

If inhaled remove to fresh air. Seek medical attention even if no symptoms can be seen.

If in eyes flood eye with flowing tap water for at least 10 minutes. Seek medical attention.

If on skin flood area with water. Remove contaminated clothing. Seek medical attention if area is large or blistering occurs.

Wear eye protection.

Ammonia solution

3M to 6M Irritant
above 6M Corrosive.

If swallowed do NOT make pupil vomit. Wash mouth and give water to drink. Seek medical attention.

If in eyes flood eye with flowing tap water for at least 10 minutes. Seek medical attention.

If on skin flood area with water. Remove contaminated clothing. Seek medical attention immediately if area is large or blistering occurs.

Wear eye protection.
Ventilate area.

Ammonium Nitrate Oxidising agent.

Can explode on heating if impure. (Do not contaminate with organic matter nor grind it.)

If swallowed wash mouth and give water to drink. Seek medical attention if more than very small amount swallowed.

If in eyes flood eye with flowing tap water for at least 10 minutes. Seek medical attention.

If on skin: Flood area with water. Remove contaminated clothing.

Wear eye protection.

Pupil Research Brief

Teachers' Notes continued

Assessment issues for *Experimental and Investigative Science* (National Curriculum for England and Wales)

P	Planning	O	Obtaining evidence
A	Analysing evidence	E	Evaluating evidence

This Brief provides opportunities for pupils to gain high marks in all skill areas. The amount of guidance given to planning by Paper 6 will have to be considered when assessing **Skill Area P**.

The methods for making ammonium nitrate outlined in Paper 4 and Paper 5 are not suitable for assessment purposes. The investigation into the effect of nitrogen on plant growth based on Paper 6 can be carried out in several ways. If pupils plan a simple 'with and without nitrogen' procedure, they are likely to restrict themselves to low to middle marks. If they plan to vary the amount of nitrogen available to the plant they could reach middle to high marks, although to do this they should take control the availability of other nutrients, i.e. use a full culture solution and a 'full culture without nitrogen' culture solution.

Assessment issues for *Experimental and Investigative Science* (Northern Ireland Curriculum)

P	Planning	O	Obtaining evidence
I	Interpreting and Evaluating		

See notes for England and Wales.

Scottish syllabus coverage

Standard Grade Chemistry: *Fertilisers*

Further pupil research opportunities

Pupils could investigate the effects of fertilisers on waterways and their consequent eutrophication by investigating the effects of fertilisers/ammonium nitrate on the growth and reproduction of duckweed. Five duckweed plants should be placed in each experimental beaker containing 200 cm³ of a fertiliser solution of varying concentrations and placed on a sunny window. The pupils should count the duckweed plants and observe the condition of the duckweed in each beaker over several weeks, and draw conclusions based on their knowledge of the stages leading to eutrophication.

Feed the World

Setting the Scene

You will be working as a member of a university chemistry department research team. The World Food Commission (WFC) has issued a press release asking scientists to help set up an educational programme for use in developing countries. You will carry out research into fertilisers. You will use your findings to help you produce a leaflet for either farmers or teachers in these countries

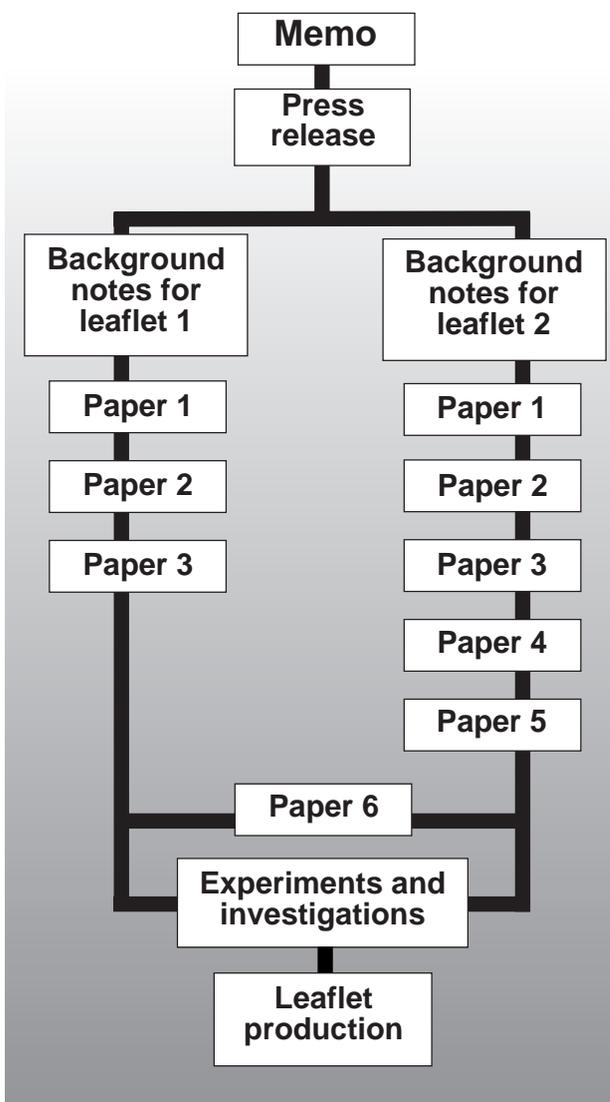
Pupil Research Brief

Study Guide

Syllabus Targets *Science you will learn about in this Brief*

- air is almost 80% nitrogen
- nitrogen can be used to manufacture several important chemicals, including nitrogen-based fertilisers
- nitrogen-based fertilisers are important in agriculture for increasing the yield of crops
- ammonia is manufactured in the Haber process
- ammonium nitrate fertiliser is made by the neutralisation reaction between ammonia and nitric acid
- materials are returned to the environment either in waste or when living things die and decay
- materials decay because they are broken down (digested) by microbes
- the constant cycling of nitrogen is called the nitrogen cycle. In the nitrogen cycle green plants absorb nitrogen in nitrates from the soil. Plants use these nitrates to make proteins
- nitrifying bacteria convert ammonia compounds to nitrates

Route through the Brief



Outcome Checklist

You will produce a leaflet for farmers or teachers in a developing country. A memo and a set of notes guide you through the Brief. You should make sure you produce the following items as you work through the Brief.

Notes for Leaflet 1

- a leaflet for farmers

Paper 1 and 2

- notes to help you write your leaflet

Paper 5

- notes on the experiment

Paper 6

- an investigation report

Notes for Leaflet 2

- a leaflet for teachers

Paper 1, 2 and 3

- notes to help you write your leaflet

Paper 4 and 5

- notes on the experiments

Paper 6

- an investigation report

Central University

From: Professor Indira Khapoor
To: Research Teams
Subject: Fertilisers: education programme for developing countries
Date:

Memo

Please read the copy of a press release from the World Food Commission (WFC), which I've attached to this memo. The WFC is asking scientists from across the world to help set up an educational programme for use in a number of developing countries where it has support programmes working at the moment. I think that some of the work we do here could be relevant. The press release says that any Research Department interested in helping should contact the Commission. I have done so, and they have suggested how we can help.

We have been asked to produce two educational leaflets covering the same topics but aimed at two different audiences. They should explain: **what fertilisers are, why they should be used, and how they work**. The first leaflet should be aimed at farmers, many of whom have little scientific knowledge. The second should be aimed at teachers who work with young people, quite a few of whom will become farmers themselves. Research teams from other universities will be producing other leaflets, covering such topics as technical information about different types of fertiliser, when to use them, and possible problems associated with their use.

I would like you and your research team to have a go at producing the two leaflets. You could divide the team into two groups who could produce one leaflet each. I have put together some background material, together with some of my own notes, which should help you with the task. Where we refer to practical work (outlined in Papers 4 and 5), you should carry it out yourselves first to check that all the instructions make sense, and secondly that useful results can be obtained.

Documents attached

1. World Food Commission Press Release
2. my two sets of notes on how to proceed with each leaflet
3. Background Papers 1,2 and 5 for Leaflet 1, Background Papers 1-5 for Leaflet 2. Background Paper 6 is available if you need it.

World Food Commission

The need for food

Each day in many parts of the world, people are dying due to lack of food. In some countries people exist on a repetitive diet of rice or bread. Some people can grow enough vegetables and keep enough animals to have a healthy, satisfying diet. In richer countries people often demand exotic food which is relatively cheap to buy and easy to prepare.

How can we reconcile these situations? It is possible to transport food from those with more than enough to those with insufficient, but how many people are willing to reduce their standard of living for people that they will never meet? The best alternative is to provide anyone who needs it with the means to grow enough food for a healthy, satisfying diet.

In trying to address these issues, the WFC is asking the world's scientists to help set up an education programme for use in a number of developing countries. We would like ideas for educational programmes and materials which could be used by local teachers to help educate school pupils, college students on agricultural courses and farmers. We would also like to see materials produced which could be sent directly to farmers. The main topic for the education programme is the use of fertilisers to increase crop yields.

We would like any Research Department who is interested in contributing to this programme to get in touch with the Commission. We will discuss how you can help, and give you a target to achieve.

WFC Fertilisers Project

Notes for Leaflet 1

Target Audience: farmers with little scientific knowledge.

Aim: to explain how nitrogen-based fertilisers can increase crop yield.

Format: the leaflet should fit onto two sides of A4. The paper could be folded to produce a small booklet, with four sides. Use diagrams where they help to get the information across.

You will need to cover the following topics.

1. The nitrogen cycle

(See Paper 1, or any appropriate science text book). The important points to get across here are:

- how plants take nitrogen from the soil
- what plants use the nitrogen for
- natural ways that nitrogen is returned to the soil

You should also mention how farmers can help this natural process by using either manure or compost from unused parts of the crop.

2. How nitrogen-based fertilisers are made

(See Paper 2, or any appropriate science text book). The important points to get across here are:

- why ammonia is used to make fertilisers
- how ammonia is made (very briefly - don't use any chemical formulae - they are not needed)
- how fertilisers can be used to put back the nitrogen which is used by plants for healthy growth and removed when they are taken out of the soil (you will need to research this)
- how fertilisers can be made (see Paper 5) - try it yourself

3. What happens when plants are grown with and without nitrogen-based fertiliser?

You will need to plan an investigation into what happens to plants growing with and without nitrogen.

If you have problems getting started on this, I have a paper (Paper 6) which might help you.

Finish off with a short summary which explains how important it is to put back nitrogen into the soil (using natural or chemical fertilisers), and how this could improve crop yield.

WFC Fertilisers Project

Notes for Leaflet 2

Target Audience: Teachers.

Aim: to provide teachers with a summary of the information they could use in teaching about the value of using fertilisers to increase crop yield, and to explain how nitrogen-based fertilisers are produced.

Format: the leaflet should fit onto four sides of A4. The sheets could be folded to produce a smaller booklet, with eight sides. Use diagrams where they help to get the information across.

You will need to include the following topics.

1. The nitrogen cycle

(See Paper 1 or any appropriate science text book). This section should cover:

- the importance of nitrogen in living things
- a summary of the natural nitrogen cycle. (This could be in the form of a glossary, or as notes written on a large diagram of the nitrogen cycle)

2. Making ammonia using the Haber Process (Papers 2 and 3). This should include:

- a flowchart showing the process, labelled to show the sources of the reactants (where we get them from) and the chemical reactions taking place
- an account of the conditions necessary for an optimum yield of ammonia. A glossary of terms would be useful here. Decide on which words need to be explained - a good starting point would be some of the words in italics on Paper 3

3. Current research into new ways to fix nitrogen and make ammonia (Papers 1, 2 and 3)

Use this to explain how researchers have found ways to fix nitrogen and produce ammonia at normal temperatures and pressures.

Suggestions for practical work

I think it would be good to suggest a couple of experiments or investigations for the teachers to use. I have included two different methods for making ammonium nitrate (Papers 4 and 5). Try them out, and decide on which one to include. I would also suggest you:

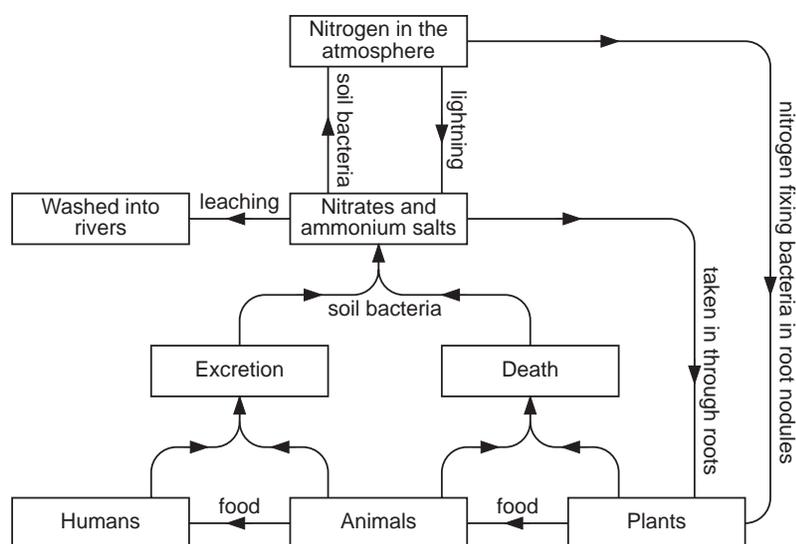
- plan and carry out an investigation into the effects of growing plants with and without nitrogen
- investigate plant growth with varying amounts of nitrogen

If you have problems getting started on this, I have a paper (Paper 6) which might help you. If you have time, you could also investigate what happens when plants are deprived of other minerals. Include a list of the minerals which are needed by plants for healthy growth and what the mineral does inside the plant. This could be a chart. Use a science text book to help you with this.

The Struggle for Nitrogen

Paper 1

Apart from water, which makes up 65% of the body, humans are mostly made up of chemicals called *proteins*: 18% of our bodies are proteins, including parts of muscles, bones, organs (like the kidneys and the brain), blood and hair, as well as important chemicals like *hormones* and *enzymes*. Proteins are long-chain molecules, containing thousands of atoms and are made up of smaller molecules, called *amino acids*, joined end to end. All amino acids contain the element nitrogen. Nitrogen makes up 78% of the atmosphere, but the human body has no way of changing it into amino acids. The only way we can build up amino acids is through our food; by eating plants, or animals that eat plants. Only plants can use nitrogen to make chemicals which can be changed into amino acids. The way that nitrogen moves between the atmosphere, plants and animals is shown in the *nitrogen cycle* diagram below.



The nitrogen cycle

Nitrogen from the atmosphere (together with water and oxygen) is changed by lightning into soluble nitrates and ammonium salts, which can be taken in by plant roots. Some leguminous plants (peas, beans, and clover) have special *bacteria* in swellings (nodules) in their roots, which can change nitrogen into ammonia (*nitrogen fixation*). Biological nitrogen fixation in bacteria is carried out by an enzyme called *nitrogenase*. Researchers are currently trying to understand the role of nitrogenase in the fixation of nitrogen. They are attempting to recreate the reaction under laboratory conditions so that ultimately they may use it industrially to manufacture ammonia more efficiently and more cheaply. Plants, and the animals that eat them, change ammonium salts, nitrates and ammonia into amino acids and proteins. When living things die or excrete (expel waste), bacteria change their residues back into nitrates and ammonium salts, while other bacteria change these chemicals back into nitrogen gas.

The natural nitrogen cycle has two problems:

- 1 nitrates and ammonium salts are being *leached* into rivers and not replaced;
- 2 it cannot produce enough plants to satisfy the demands of the expanding human population.

Scientists have to work out how best to put nitrogen back into the nitrogen cycle.

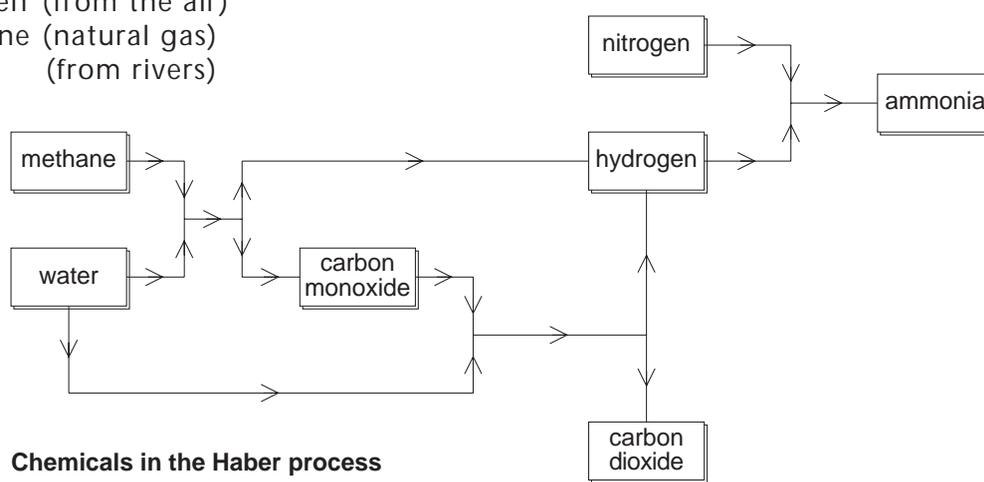
Ammonia Synthesis

Paper 2

Fertilisers containing nitrogen are made from *ammonia*, NH_3 . The search to make ammonia from its elements, nitrogen and hydrogen, was finally ended in 1908, when the German scientist *Fritz Haber* found a way of reacting nitrogen gas with hydrogen gas directly.

The process has been refined over the years until, with the aid of *catalysts* and suitable conditions of *temperature* and *pressure*, ammonia is now manufactured on a large scale from three common substances:

- nitrogen (from the air)
- methane (natural gas)
- water (from rivers)



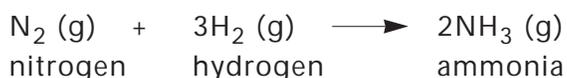
After sulphur is removed, methane is reacted with steam to form carbon monoxide and hydrogen:



The carbon monoxide is reacted with more steam to form carbon dioxide and hydrogen:



The carbon dioxide is removed, then the hydrogen is reacted with nitrogen to make ammonia:



Since all these reactions are *reversible* (go in both directions at the same time), it is important that the conditions of temperature and pressure are carefully chosen, together with a catalyst (a substance that speeds up a reaction, but does not itself change).

Current research suggests that it may be possible to produce a suitable electrolytic method for converting atmospheric nitrogen into ammonia at normal pressures. This will probably never replace the Haber process for large scale production of ammonia, but it could supply irrigation channels with ammonia using cheap sources of electricity such as wind, tidal or solar power.

How far, how fast?

Paper 3

In many chemical reactions, not all of the *reactants* (what you start off with) react to form the *product* (what you end up with). These reactions are reversible, which means that they are moving in both directions at once. For example, in the ammonia synthesis:



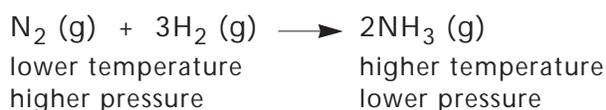
Nitrogen and hydrogen are reacting to form ammonia, and at the same time ammonia is breaking down to form nitrogen and hydrogen. Eventually, these reactions settle down until the forward reaction (left to right) and the backward reaction (right to left) are happening at the same rate (speed). This is called *equilibrium*.

The position of equilibrium can be changed: if it moves to the right, more ammonia is made; if to the left, less ammonia is made. A movement to the right is obviously needed in industry. These changes can be made by changing the *conditions* (temperature, pressure or concentration). Most reactions are either *exothermic* (heat is given out) or *endothermic* (heat is taken in). These reactions will obviously cause a change of temperature. The ammonia synthesis is exothermic: as ammonia is made, the reaction gets hotter.

Reactions involving gases cause changes in pressure: if more molecules of gas are produced than react, the pressure increases. In the ammonia synthesis, the pressure decreases (1N₂ and 3H₂ [4 molecules] form 2NH₃ [2 molecules]).

In an equilibrium reaction: *if the conditions are changed, the equilibrium moves to reverse the change.*

The ammonia synthesis can be summarised as follows:



If the *temperature is raised*, the equilibrium moves to lower the temperature, and so *less ammonia* is made.

If the *pressure is raised*, the equilibrium moves to lower the pressure, and so *more ammonia* is made.

So the best conditions for a high yield of ammonia are a *low temperature* and a *high pressure*.

Many chemical reactions take place comparatively slowly. In industry, it is not only important to get a high yield, but to get it quickly, so the *rate of the reaction* must be increased. One of the ways to increase the rate of the ammonia synthesis is to raise the temperature, but unfortunately this also lowers the yield. A compromise is used, with a moderate temperature.

Another way of increasing the rate of a reaction is to use a *catalyst*. This has no effect on the position of equilibrium, and so no effect on the yield.

The actual conditions for the ammonia synthesis are:

- moderate temperature (~450°C)
- high pressure (200 atmospheres)
- catalyst (iron).

How far, how fast?

Paper 3 continued

The industrial process thus requires a great deal of energy.

Biological nitrogen fixation in bacteria is carried out by an enzyme called nitrogenase. This consists of two proteins, one containing the metal iron (Fe) and the other containing the metals molybdenum (Mo) and iron.

The advantage of biological nitrogen fixation over the Haber process is that it takes place at normal temperature and pressure. This means the process uses less energy.

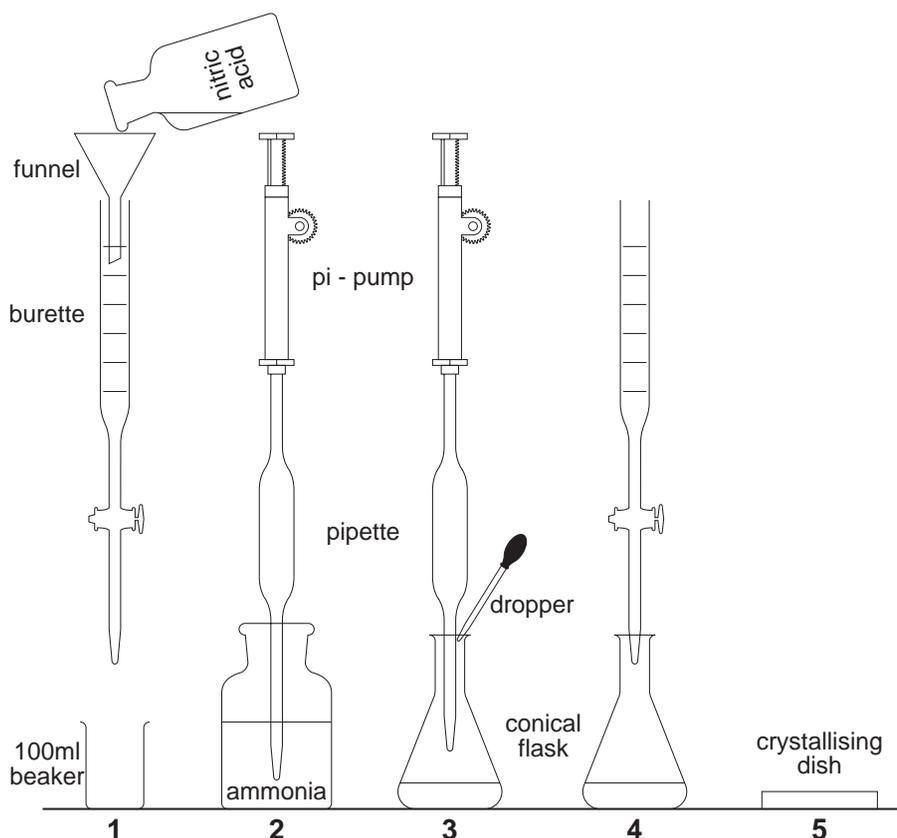
Research analysis shows that the nitrogen molecule becomes attached to the molybdenum/iron protein, allowing it to be reduced to ammonia. Energy for the process is generated by reactions of a chemical also found in human cells, called *ATP*.

Research groups in England, Russia and the USA have used solutions of compounds of the metals vanadium (V) and molybdenum to change nitrogen (N_2) to hydrazene (N_2H_2) and ammonia (NH_3).

Making Ammonium Nitrate

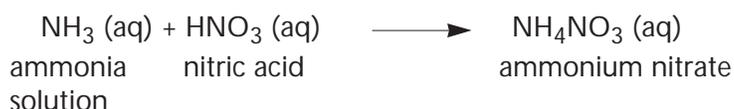
Paper 4

method 1



Wear eye protection!

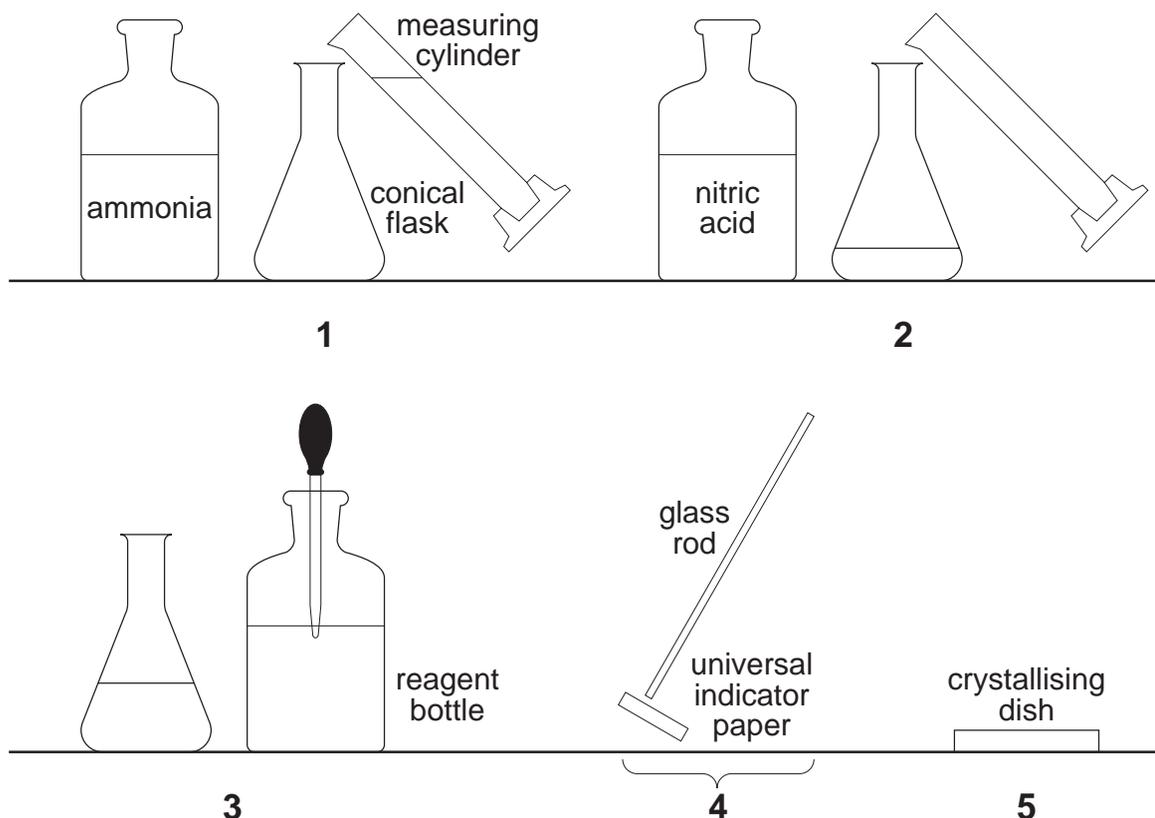
- 1 Set up a burette on a stand, with a 100cm³ beaker under the tap. Using a small funnel, carefully fill the burette up to the zero mark with dilute nitric acid. Run a little acid into the beaker until the tube below the tap has no air in it. Refill the burette to the zero mark.
- 2 Using a pi-pump or similar pipette filler, carefully fill a pipette to the mark with dilute ammonia solution.
- 3
 - a) Transfer the ammonia to a conical flask.
 - b) Add 5-10 drops of indicator solution.
- 4 Carefully add the nitric acid from the burette to the flask, swirling the liquid gently, until the indicator starts to change colour. Continue swirling, adding the acid a drop at a time, until the indicator changes colour *with one drop*. Make a careful note of the volume of acid added.
- 5 Repeat steps 1 to 3a but do not *add the indicator solution*. Add the same volume of nitric acid that you used before. Pour some of the solution into a crystallising dish and leave it to crystallise.



Making Ammonium Nitrate

Paper 5

method



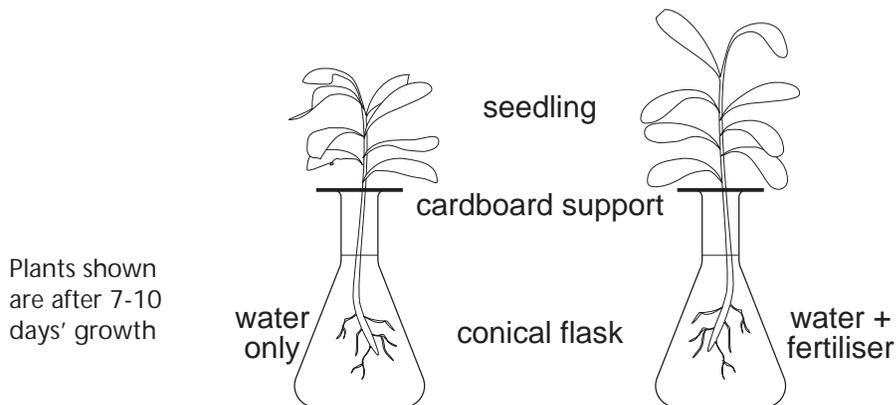
Wear eye protection!

- 1 Using a measuring cylinder, put 10cm³ of ammonia solution into a conical flask.
- 2 Using a second measuring cylinder, add 10cm³ of dilute nitric acid to the ammonia in the flask. Stir the flask with a glass rod and test the solution by using the rod to put a drop onto a piece of universal indicator paper.
- 3 If the solution is acid, add a drop of ammonia solution using a dropper, if the solution is alkaline, add a drop of nitric acid using a dropper. Stir and test the solution with a glass rod and universal indicator paper.
- 4 Continue steps 3 and 4 until the solution is neutral (green, or you get a colour change with one drop.)
- 5 Pour some of the solution into a crystallising dish and leave it to crystallise.



Fertiliser and Plant Growth

Paper 6



1. Dissolve around 4g of fertiliser in 100cm³ of distilled water and pour it into a 100cm³ conical flask.
2. Put 100cm³ of distilled water into a second conical flask.
3. Take two identically sized seedlings (wheat, barley or broad bean) and put each through a hole in a piece of cardboard, so that the leaves are supported.
4. Put one seedling into the water and the other into the fertiliser solution, so that the roots are under the liquid.
5. Leave the seedlings for 2-3 weeks, topping up with distilled water if necessary so that the roots remain under water. It may be necessary to blow air from an aquarium aerator or a straw into the liquid from time to time to make sure that the roots get enough oxygen.
6. Note any differences in growth over this period of time.

The experiment above outlines a method to investigate what happens when plants are grown with and without fertiliser. The fertiliser used in this experiment actually contained more than just nitrogen (it also included phosphorus and potassium, as well as nine other minerals needed for healthy plant growth). You will need to plan that investigation differently to enable you to carry out your task to show the effect of growing plants with and without nitrogen.

You could also investigate the effect of using various amounts of nitrogen.

You should then be able to describe in the leaflet current research we are carrying out to show what happens when plants grow without nitrogen, or with insufficient nitrogen.