

National 5 Chemistry

Unit 3:

Chemistry In Society

Student:

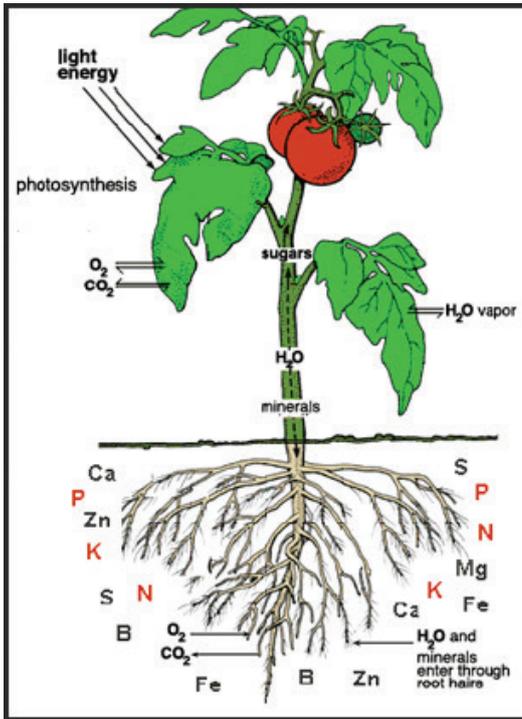
Topic 8

Fertilisers & Analysis

Topics	Sections	Done	Checked
8.1 Nutrients & Fertilisers	1. Source of Nutrients		
	2. Nitrogen Fixing		
	3. Fertilisers - Haber & Ostwald Processes		
	4. Comparing Fertilisers		
	5. Pollution Problems		
	<i>Self-Check Questions 1 - 3</i>	Score: /	
8.2 Qualitative Analysis	1. Testing for Gases		
	2. Testing for Metals 1		
	3. Testing for Metals 2		
	4. Testing for Halide Ions		
	5. Testing for Negative Ions		
	<i>Self-Check Questions 1 - 4</i>	Score: /	
8.3 Quantitative Analysis	1. Titration - Acid / Base		
	2. Titration - Redox		
	3. Colorimetry		
	<i>Self-Check Questions 1 - 4</i>	Score: /	
Consolidation Work	Consolidation A	Score: /	
	Consolidation B	Score: /	
	Consolidation C	Score: /	
	Consolidation D	Score: /	
<i>End-of-Topic Assessment</i>	Score: %	Grade:	

8.1 Nutrients & Fertilisers

SOURCE OF NUTRIENTS



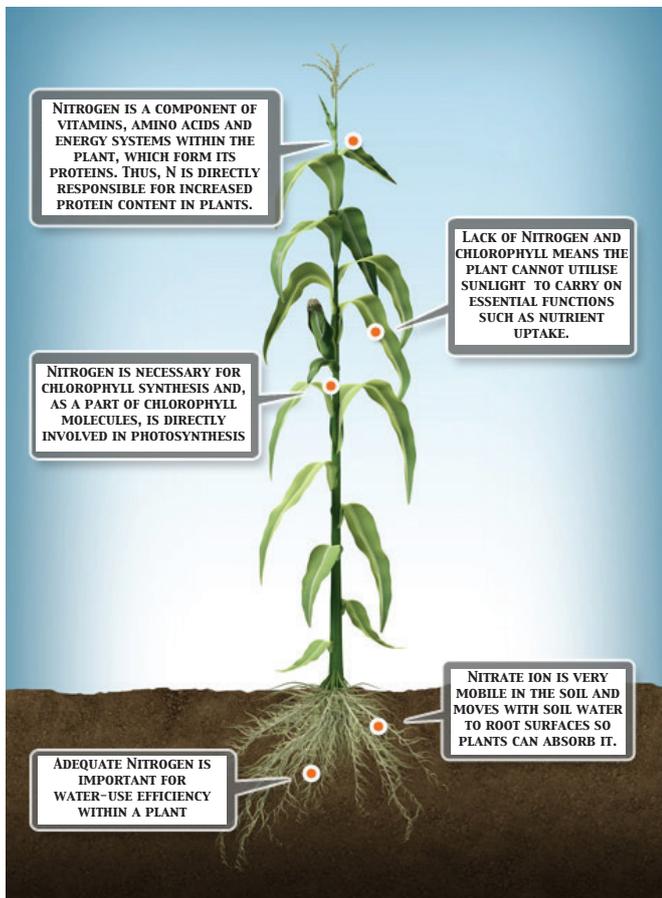
All living things are made mainly from the elements **hydrogen**, **carbon**, **nitrogen** and **oxygen**

Other important elements that are essential for growth are **sulphur**, **potassium** and **phosphorus**.

Plants obtain what they need mainly from the **soil**, for example, **hydrogen** and **oxygen** from **water**. The **air** can also be a source, especially of **carbon** from **carbon dioxide**.

To be absorbed by **plants** the **elements** need to be in the form of simple, water **soluble compounds** which can pass through the walls of **root** cells.

These compounds which provide the elements for a plant to grow are called **nutrients**.

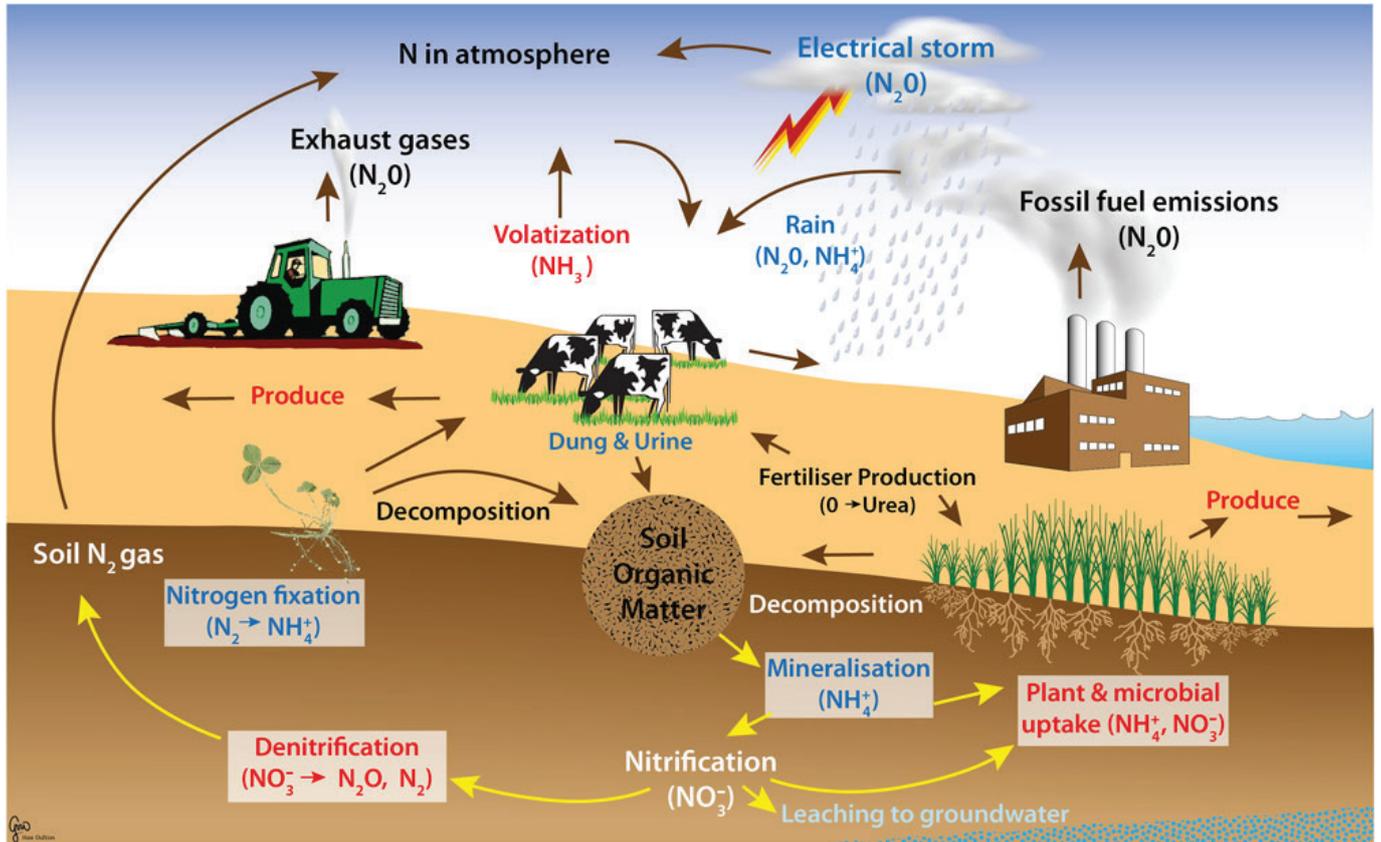


Of particular importance are the **NPK** elements - **N (nitrogen)**, **P (phosphorus)** and **K (potassium)**.

The lack of any of these 3 can have serious consequences for the **health** of the plant.

There are many **natural processes** which would normally ensure that these **essential nutrients** are **recycled** but the **harvesting** of crops often disrupts these processes.

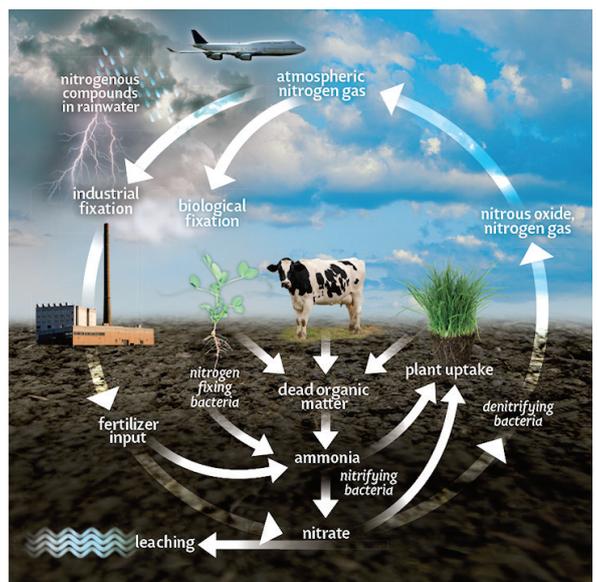
As a result, **farmers** rely more and more on **artificial fertilisers** to maintain levels of these **nutrients** in the soil.



NITROGEN FIXING

Although 78 % of the air is *nitrogen*, very few plants can use *nitrogen* directly. Instead they need *compounds* of nitrogen rather than 'Free' Nitrogen gas. Nitrogen in compounds is called *Fixed Nitrogen*. Nature has two main ways of converting 'free' Nitrogen gas into Fixed Nitrogen :

(i) *Lightning* - an *electrical* spark in air can cause *nitrogen* gas and *oxygen* gas present in air to react to form *nitrogen oxides*. When added to *water*, these *nitrogen oxides* can form an *acid* solution containing *nitrate* ions, NO_3^- . The *spark* in a car *engine* also causes *nitrogen oxides* to be produced. But any advantage in terms of replacing nitrogen in the soil is outweighed by the increase in acidity in the soil - "*ACID RAIN*".

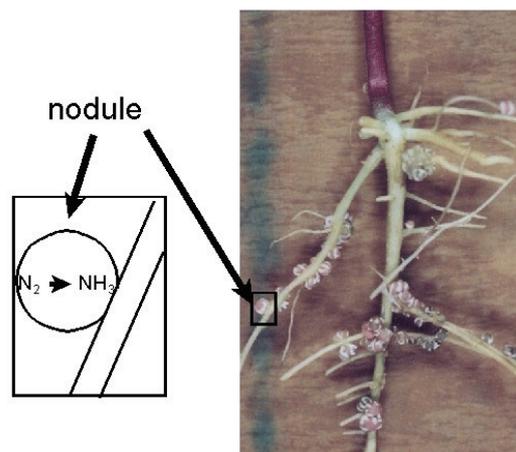


(ii) *Nitrogen Fixing Bacteria* - are among the very few organisms that can turn *nitrogen* from the *air* directly into *nitrogen compounds*

Nitrogen fixing bacteria live freely in the **soil** or inside the **roots** of certain kinds of plant. The root-living **bacteria** cause swellings or **nodules** to form on the roots. The plant benefits from these **nitrogen fixing bacteria** because it gets **nitrites** from them. The bacteria take **sugars** and other **nutrients** from the plant.

Among the plants which benefit in this way are the **clover**, **pea** and **bean** plants. Early **farmers** used these crops to 'rest' fields as part of **crop rotation**.

Bean Root Nodules



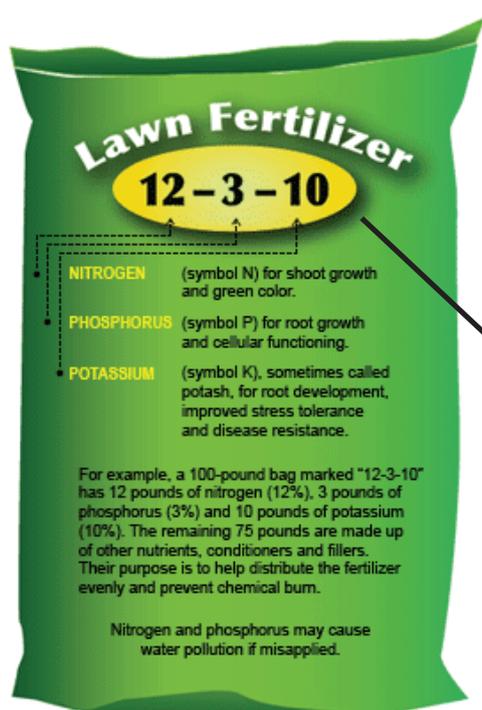
Inside nodules the bacteria fix nitrogen (i.e., convert N_2 into ammonia).

The amount of **fixed nitrogen** in the soil is increased by both **lightning** and **nitrogen fixing bacteria**.

Fertilisers

Fertilisers have two main uses. They:

- (i) increase the **rate** and **amount** of growth.
- (ii) replace **nutrients** removed by harvesting.



The three main elements in the nutrients needed by plants are **nitrogen** (**N**), **phosphorus** (**P**) and **potassium** (**K**).

The fertilisers which supply these three elements are known as **NPK** fertilisers. The amount of each element present in a particular fertiliser is usually given as a **percentage** (%).

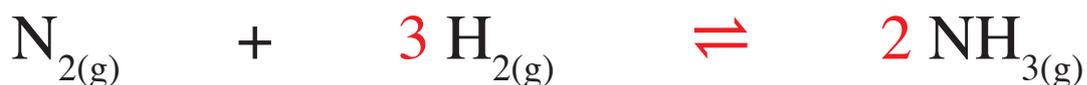
Different fertilisers supply different NPK proportions because

- (i) plants have **different** NPK needs.
- and (ii) soils vary in their ability to supply **nutrients**.

In more recent years, under the pressure of increasing **population** and demand for food, **farmers** have increasingly looked to artificial **fertilisers** to supply their crops need for **nutrients**.

Two of the most important processes in the industrial manufacture of fertilisers are the **Haber Process**, used to make **ammonia** ($\text{NH}_3(\text{g})$), which in turn is used in the **Ostwald Process** to eventually make **nitric acid** ($\text{HNO}_3(\text{aq})$).

HABER PROCESS -



Hydrogen gas, made from **methane** or **oil**.

Nitrogen gas, from the air (**fractional distillation** of liquid air)

Trays of

Iron Catalyst

H_2 and N_2 mixed in a **3 : 1** ratio

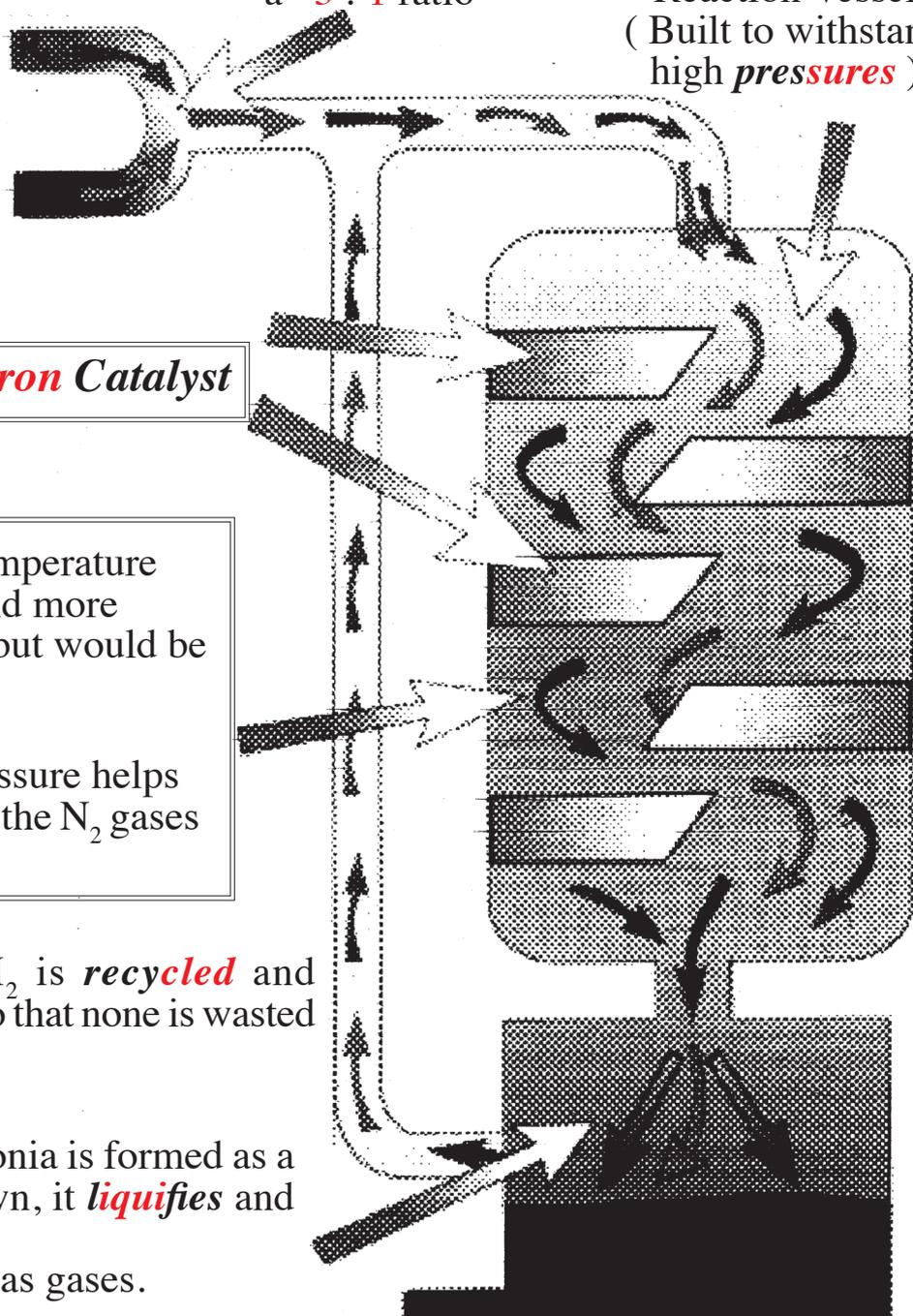
Reaction Vessel (Built to withstand high **pressures**)

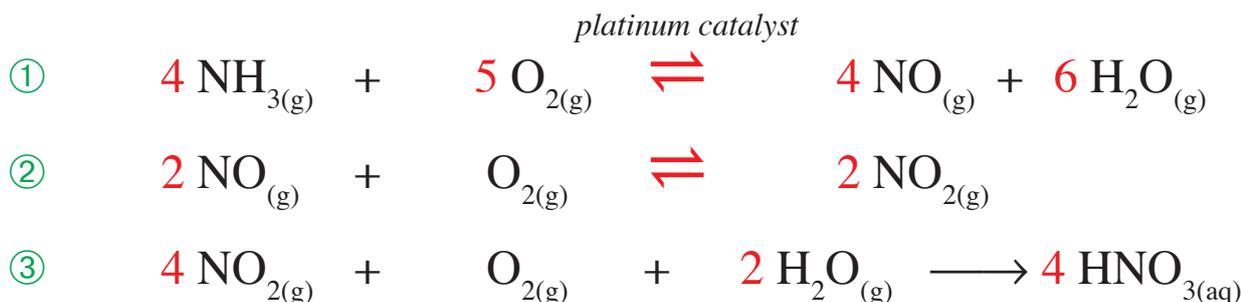
500 °C a **lower** temperature would yield more ammonia but would be too **slow**

350 atm A **high** pressure helps the H_2 and the N_2 gases react

Unreacted N_2 and H_2 is **recycled** and passed through again so that none is wasted

Condensor. The ammonia is formed as a **gas** but as it cools down, it **liquifies** and is removed
The N_2 and H_2 remain as gases.

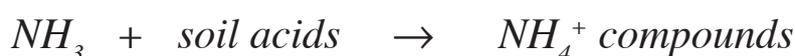


OSTWALD PROCESS -

Both these processes require difficult conditions to ensure success, particularly when compared with the conditions that *nitrogen fixing bacteria* operate under to achieve the same effect - *soluble nitrogen compounds*.

Conditions	Nitrifying Bacteria	Haber Process
Starting Materials	N ₂ / H ₂ O / nutrients	CH ₄ / H ₂ O / N ₂
Catalyst	enzymes	iron
Pressure	normal	150 - 250 atmospheres
Temperature	normal	400 - 500 °C

If soil conditions are suitable, *liquid ammonia* (*NH₃*) itself can be injected into the soil to act as a fertiliser. The ammonia reacts with *acids* in the soil to produce the *salts* needed by the plants.



Ammonia and nitric acid, of course, combine to produce a particularly useful fertiliser which will deliver a 'double dose' of *nitrogen* to plants.



Many *fertilisers* will try and deliver a 'double dose' of the *NPK* elements, which is why compounds such as:-



are widely used
KHS Apr 2014

Comparing Fertilisers



Compounds that contain *significant* amounts of the **NPK** elements are likely to be suitable for use as **fertilisers**.

The differences between **fertilisers** is often denoted using the **Percentage Composition** for each of the **NPK** elements.

Percentage compositions (see *Calculations Booklet*) provide an easy way of comparing potential compounds.

Urea, $\text{CO}(\text{NH}_2)_2$, **ammonium sulphate**, $(\text{NH}_4)_2\text{SO}_4$, and **ammonium nitrate**, NH_4NO_3 , are three **compounds** that are often used in **fertilisers**.



$$2 \times \text{N} = 2 \times 14 = 28$$

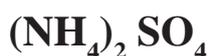
$$1 \times \text{O} = 1 \times 16 = 16$$

$$1 \times \text{C} = 1 \times 12 = 12$$

$$4 \times \text{H} = 4 \times 1 = 4$$

$$\text{formula mass} = 76$$

$$\% \text{N} = 28/76 \times 100 = 37\%$$



$$2 \times \text{N} = 2 \times 14 = 28$$

$$8 \times \text{H} = 8 \times 1 = 8$$

$$1 \times \text{S} = 1 \times 32 = 32$$

$$4 \times \text{O} = 4 \times 16 = 64$$

$$\text{formula mass} = 128$$

$$\% \text{N} = 28/128 \times 100 = 22\%$$



$$2 \times \text{N} = 2 \times 14 = 28$$

$$4 \times \text{H} = 4 \times 1 = 4$$

$$3 \times \text{O} = 3 \times 16 = 48$$

$$\text{formula mass} = 80$$

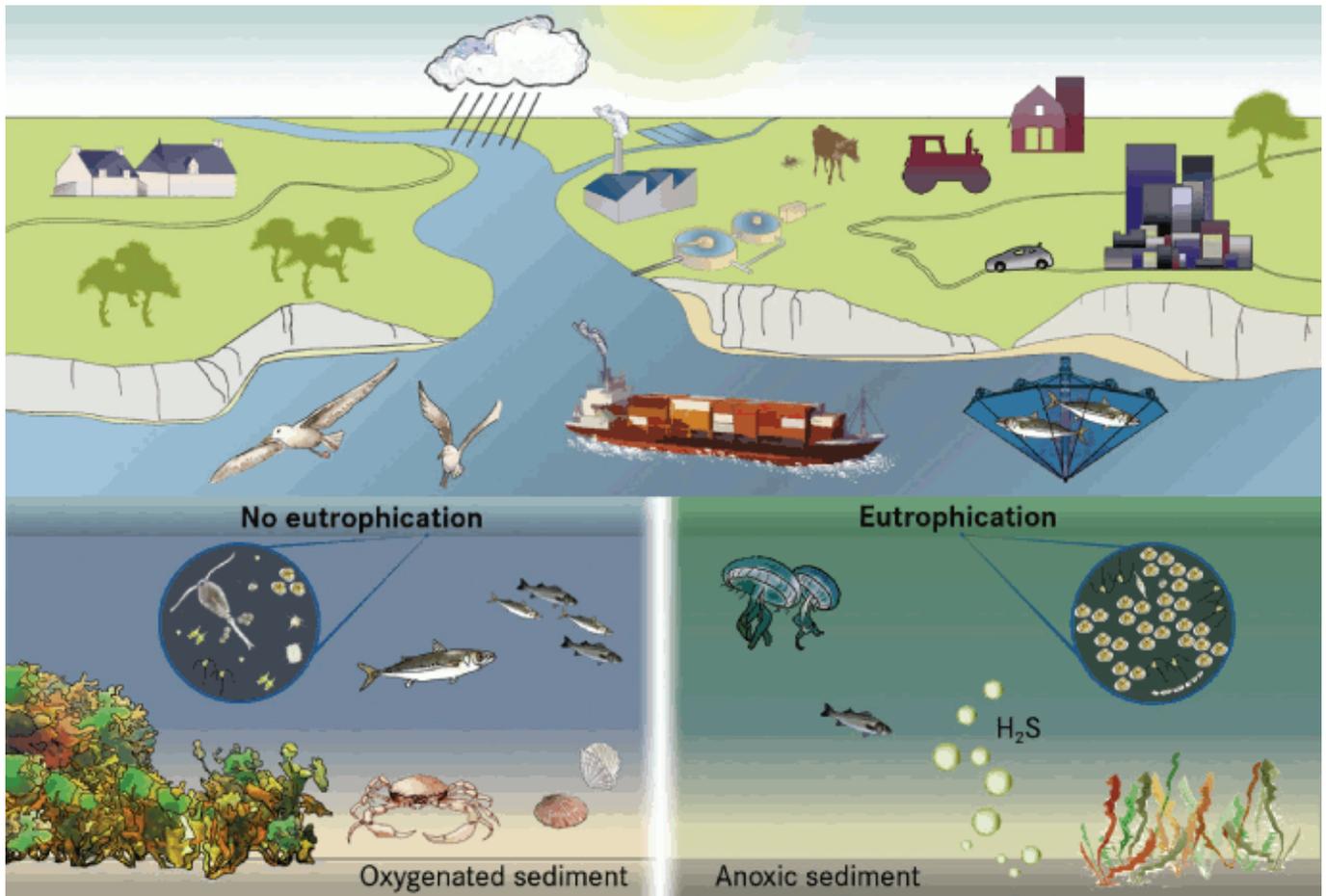
$$\% \text{N} = 28/80 \times 100 = 70\%$$

Solubility also has to be considered carefully. Many **phosphates**, for example, are **very insoluble** and would not be able to be **absorbed** by plants. Too **soluble** and the **fertiliser** would be too easily **leached** out of the soil by rain.

	bromide	carbonate	chloride	iodide	nitrate	phosphate	sulfate	oxide	hydroxide
aluminium	vs	—	vs	vs	vs	i	vs	i	i
ammonium	vs	vs	vs	vs	vs	vs	vs	—	—
barium	vs	i	vs	vs	vs	i	i	vs	vs
calcium	vs	i	vs	vs	vs	i	s	s	s
copper(II)	vs	i	vs	—	vs	i	vs	i	i
iron(II)	vs	i	vs	vs	vs	i	vs	i	i
iron(III)	vs	—	vs	—	vs	i	vs	i	i
lead(II)	s	i	s	i	vs	i	i	i	i

Pollution Problems

The **increased** use of **fertilisers** and the **leaching** of these **fertilisers** into **rivers** and **seas** has led to major problems.



Eutrophication is when the **environment** becomes enriched with **nutrients**. This can be a problem in **marine habitats** such as lakes as it can cause **algal blooms**.



Fertilisers are often used in farming, sometimes these fertilisers run-off into nearby water causing an increase in nutrient levels.



This causes phytoplankton to grow and reproduce more rapidly, resulting in algal blooms.



The algae may use up all the oxygen in the water, leaving none for other marine life. This results in the death of many aquatic organisms such as fish, which need the oxygen in the water to live.



The bloom of algae may also block sunlight from photosynthetic marine plants under the water surface.



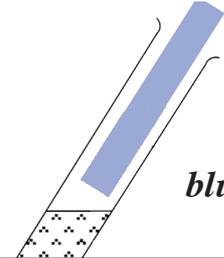
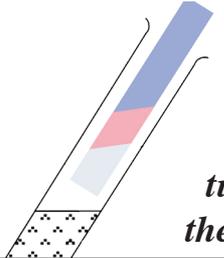
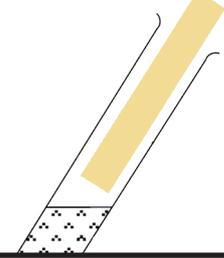
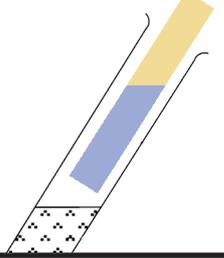
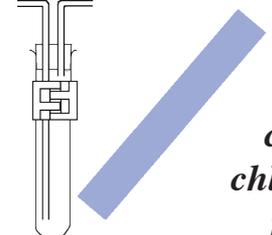
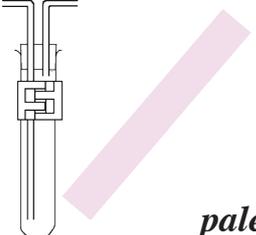
Some algae even produce toxins that are harmful to higher forms of life. This can cause problems along the food chain and affect any animal that feeds on them.

8.2 Qualitative Analysis

Qualitative Analysis is concerned with testing for the **presence** of certain chemicals - it **doesn't** tell you **how much** (**Quantitative Analysis**).

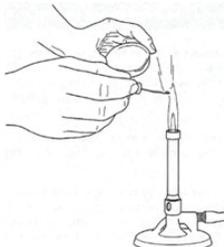
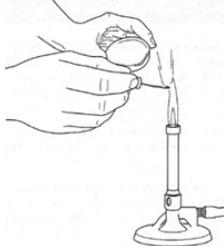
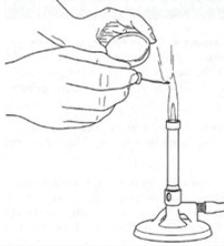
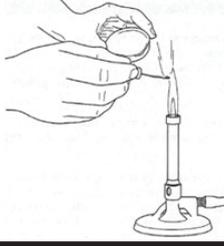
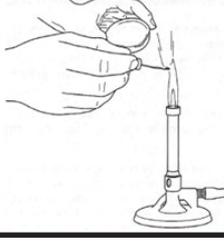
Testing for Gases

These are the tests for the most common gases met.

Gas	Test Used	Test Result	Comments
O_2 oxygen	 glowing splint	 relights	oxygen will make a burning splint brighter but this is not as obvious
H_2 hydrogen	 burning splint	 burns with a squeaky pop	any source of a flame or even an electric spark can be used
CO_2 carbon dioxide	 lime water	 turns cloudy	lime (CaO) forms hydroxide in solution and solid chalk ($CaCO_3$) with CO_2
Cl_2 chlorine	 blue litmus paper	 turns red then white	Cl_2 is acidic but it also bleaches - any coloured paper could be used. Smell.
NH_3 ammonia	 pH paper	 turns blue	There are many acidic gases but NH_3 is the 'only' alkali gas you will meet. Smell.
H_2O water vapour	 dried cobalt chloride paper	 turns pale-pink	Many coloured compounds rely on the presence of water for their colour.

Testing for Metals 1

Metals in **Group 1 (Alkali Metals)** and **Group 2 (Alkaline Earth Metals)** along with **Copper** give characteristic colours in a flame - **The Flame Test**. (Colours for many of these metals are in **Data Booklet**)

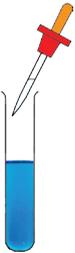
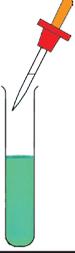
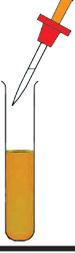
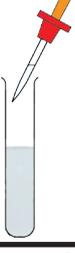
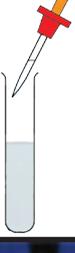
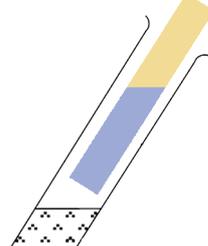
<i>Metal (atom or ion)</i>	<i>Test Used</i>	<i>Test Result</i>	<i>Comments</i>
Na <i>sodium</i>	 Flame Test		<i>always a very strong colour - seen when salty water boils over on a gas cooker</i>
K <i>potassium</i>	 Flame Test		<i>can be very pale and short-lived - best seen when K reacts with water and H₂ burns</i>
Ca <i>calcium</i>	 Flame Test		<i>orange is quite different from the very yellowy orange of sodium</i>
Ba <i>barium</i>	 Flame Test		<i>often very pale and difficult to see</i>
Sr <i>strontium</i>	 Flame Test		<i>Lithium has a very similar strong red flame described as scarlet red</i>
Cu <i>copper</i>	 Flame Test		<i>One of the strongest colours seen and both blue and green seen.</i>

The other elements will also emit light when 'excited' in a flame but this light is not in the **visible spectrum** so we cannot detect it. We have machines called **Spectrophotometers**, however, which can detect these elements.



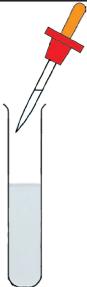
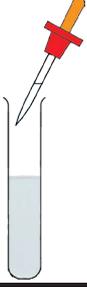
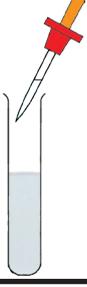
Testing for Metals 2

The remaining metals in **Group 2 (Alkaline Earth Metals)** along with **Aluminium** and the **Transition Metals** form **precipitates** with **hydroxide solutions**, many have **characteristic colours**. **Ammonium** ions are included as they also form positive ions.

Cation (Positive Ion)	Test Used	Test Result	Comments
Cu^{2+} copper	 Add OH^-	 blue solid	copper (II) compounds can be recognised by their blue colour
Fe^{2+} iron (II)	 Add OH^-	 green solid	the green turns brown as Fe^{2+} ions are easily oxidised to Fe^{3+} ions
Fe^{3+} calcium	 Add OH^-	 brown solid	Fe^{3+} ions are the more stable and many iron compounds are brown e.g. rust
Zn^{2+} zinc	 Add OH^-	 white solid	zinc is unusual for a transition metal in that it has no coloured compounds
Ca^{2+} Mg^{2+} Al^{3+} various	 Add OH^-	 white solid	$\text{Al}(\text{OH})_3$ will dissolve in excess OH^- whilst a Flame Test can identify $\text{Ca}(\text{OH})_2$
NH_4^+ ammonium	 Add OH^- & Heat	 releases NH_3 gas	This is the reverse of NH_3 dissolving to form an alkali solution (NH_4OH).

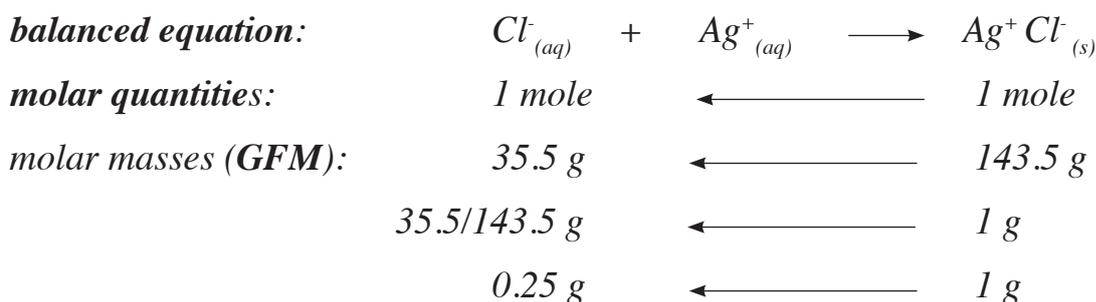
Testing for Halide Ions

The **Halogens** are the **Group 7** elements and form many compounds (**Salts**) which contain the **fluoride** (F^-), **chloride** (Cl^-), **bromide** (Br^-) or **iodide** (I^-) ions.

Anion (Negative Ion)	Test Used	Test Result	Comments
F^- fluoride	 Add $AgNO_3$	 no solid	Fluoride is found naturally in low concentration in drinking water and foods
Cl^- chloride	 Add $AgNO_3$	 white solid	The chloride ion make up 1.94% of sea water.
Br^- bromide	 Add $AgNO_3$	 cream solid	Seafoods and deep sea plants generally have high levels of bromide ions.
I^- iodide	 Add $AgNO_3$	 yellow solid	In everyday life, iodide is most commonly encountered as a component of iodised salt.

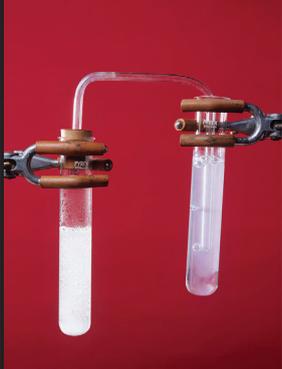
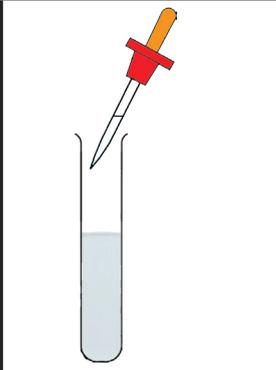
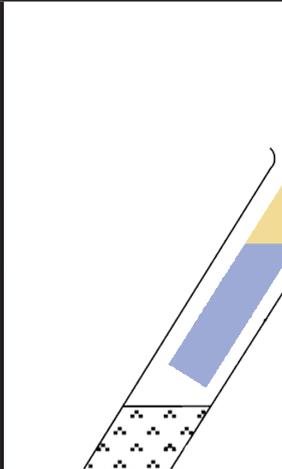
Qualitative methods can often be used to find out **how much** of a substance is present - **Quantitative Analysis**.

For example, adding **excess** (more than enough) $AgNO_3$ to a sample of salt water will **precipitate** out solid $AgCl$. Filtering, drying and weighing the **precipitate** will allow the **quantity** of Cl^- present to be calculated.



Testing for Negative Ions

The **three** remaining negative ions that you may need to know how to Test for are **nitrate** (NO_3^-), **sulphate** (SO_4^{2-}) and **carbonate** (CO_3^{2-}) ions.

Anion (Negative Ion)	Test Used		Test Result	
CO_3^{2-} carbonate		Add acid Test for CO_2		Fizzes Lime Water goes cloudy
SO_4^{2-} sulphate		Add Barium Chloride solution		white precipitate of BaSO_4
NO_3^- nitrate		Add NaOH/Al powder & Heat Add more NaOH Test for NH_3		NH_3 gas turns pH paper blue

8.3 Quantitative Analysis

Titration - Acid / Base

You first met **Quantitative Analysis** In Topic 4 when you used **titration** to determine the *acidity of lemonade* in terms of cm^3 of NaOH needed.

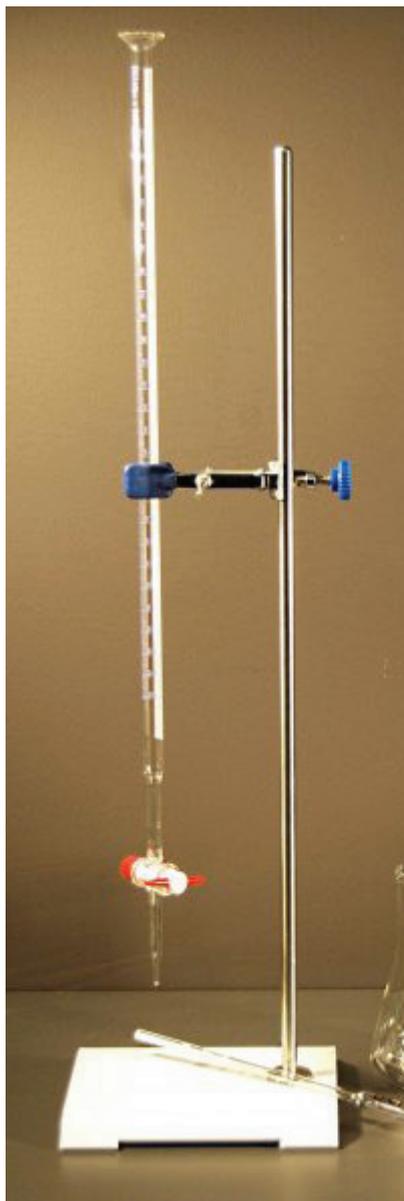
$$\frac{C_{\text{ACID}} \times V_{\text{ACID}}}{n_{\text{ACID}}} = \frac{C_{\text{ALK}} \times V_{\text{ALK}}}{n_{\text{ALK}}}$$

You have since learnt how to use the **formula** opposite to **calculate** a concentration.

Use the **video provided** to complete the following:

ACID: HCl V_{ACID} : ? C_{ACID} : **0.1** mol l⁻¹

ALK: NaOH V_{ALK} : **25** cm³ C_{ALK} : ?



Run	Volume of Acid added (cm ³)		
	Initial	Final	Titre
rough	0.00	24.40	24.40
1	0.00	23.85	23.85
2	23.85	47.65	23.80
3	0.00	23.80	23.80
Average Titre (cm ³)			23.82

Balanced Equation:



$$n_{\text{ACID}} = 1 \quad n_{\text{ALK}} = 1$$

Now use this to calculate the concentration of the alkali, $\text{NaOH}_{(\text{aq})}$.

$$\frac{0.1 \times 23.82}{1} = \frac{C_{\text{ALK}} \times 25}{1}$$

$$C_{\text{ALK}} = 0.1 \times 23.82 / 25$$

$$C_{\text{ALK}} = 0.095 \text{ mol l}^{-1}$$

Titration - RedOx

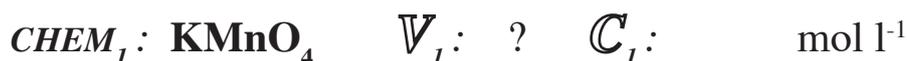
In fact, you can use a **titration** with any two chemicals - particularly if there is a strong **colour change** to help identify the **end-point**.

$$\frac{C_1 \times V_1}{n_1} = \frac{C_2 \times V_2}{n_2}$$

We simply modify the **formula** used earlier to **calculate** the **concentration** of our 'unknown'.



Use the **animation provided** to complete the following:



Run	Volume of $KMnO_4$ added (cm ³)		
	Initial	Final	Titre
rough	0.00		
1	0.00		
2	0.00		
3	0.00		
Average Titre (cm ³)			

Balanced Equation:

$$n_1 = 1 \quad n_2 = 5$$

Now use this to calculate the concentration of the iron, $Fe^{2+} (aq)$.

$$\frac{x}{1} = \frac{C_2 \times 25}{5} \quad C_2 = (5 \times 23.82 \times 23.82) / 25$$

$$C_2 = 0.095 \text{ mol l}^{-1}$$

This could be used, for example, to check the iron content in a vitamin tablet

Colorimetry

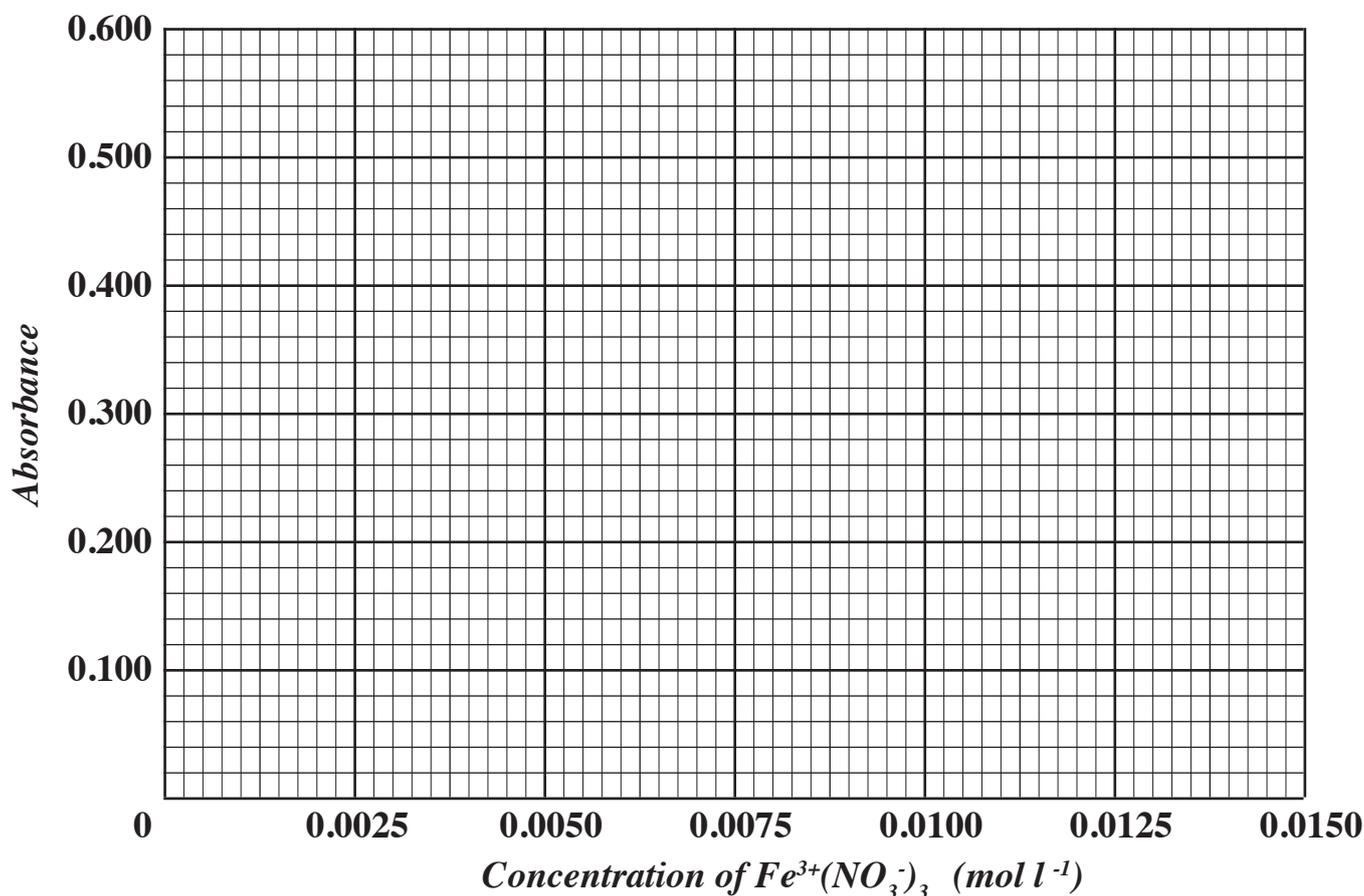


An alternative technique to *titration* is *colorimetry* - measuring the *intensity of light absorbed* by a *coloured substance*.

For example, copper coins are now *copper plated steel* and the *exact amount of iron present* can be measured using *colorimetry*.

The *absorbance* is *dependent* on the *concentration* of the substance so solutions containing *known* amounts of iron (III) ions (*brown* in colour because they *absorb blue light* - transmitting a mixture of red & green) are measured and a *Calibration Curve* drawn.

Concentration of $Fe^{3+}(NO_3^-)_3$ ($mol\ l^{-1}$)	Absorbance
0.0000	0.000
0.0025	0.130
0.0050	0.250
0.0075	0.352
0.0100	0.449
0.0125	0.543



A pupil weighed out a 2p 'copper' coin (7.212 g) and dissolved it in concentrated nitric acid and (once cooled) transferred the coin solution to a 100 cm³ volumetric flask: **Coin Solution 1**



At this stage, the iron colour is too intense for the colorimeter so it was diluted by a factor of 1000 (1000 x more dilute): **Coin Solution 2**

A sample from **Coin Solution 2** was placed in the *colorimeter* and an **absorbance of 0.060** was measured. This can be used to **calculate** the **% of iron** in the 2p 'copper' coin.

① From the graph, **absorbance** of **0.060** = **0.00125** mol l⁻¹ of Fe³⁺

② 1000 cm³ = 1 litre and

$$\begin{array}{c} \triangle \\ \hline n \\ \hline C \quad V \\ \hline \end{array} \quad n = C \times V$$

so **number of moles** of Fe³⁺ = **0.00125** x **1** = **0.00125** moles

③ **number of moles** of Fe³⁺ in 1cm³ pipette = **moles** of Fe³⁺ in 1l flask
= **0.00125** moles

④ **number of moles** of Fe³⁺ in 100cm³ flask = **100** x **0.00125**
= **0.125** moles

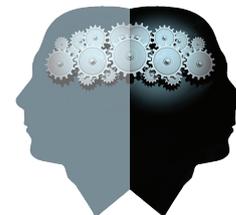
⑤ **relative atomic mass** of Fe = **55.847**

$$\begin{array}{c} \triangle \\ \hline m \\ \hline n \quad gfm \\ \hline \end{array} \quad m = n \times gfm$$

so **mass of iron** = **0.125** x **55.847** = **6.981** g

⑥ **% Fe** = (**6.981** / **7.212**) x **100**
= **96.8** %

N5 Knowledge Met in this Section



Fertilisers

- Plants require **nutrients** (substances that help them grow)
- Nutrients include compounds of **nitrogen**, **phosphorus** and **potassium** (**NPK**)
- Crops remove nutrients from the soil
- **Fertilisers** are substances which restore the elements essential for plant growth to the soil
- *Farmers use a wide variety of NPK fertilisers because different crops need fertilisers with different proportions of nitrogen, phosphorus and potassium*
- **Nitrogen fixing bacteria** in root nodules of some plants (peas, beans, clover, etc) can convert atmospheric nitrogen into nitrogen compounds (plant nutrients)
- *Bacterial methods of fixing nitrogen (atmospheric nitrogen → nitrogen compounds) are cheaper than chemical methods (artificial fertilisers)*
- **Natural fertilisers** include plant compost and animal manure. Both contain nitrogen compounds and are important in **recycling** nitrogen into the soil
- **Synthetic fertilisers** are man-made. They include **ammonia** and **ammonium salts**, **potassium salts**, **nitrates** and **phosphates**
- Compounds used as fertilisers must be **soluble** in water so they can be absorbed by plants
- Synthetic fertilisers can be washed into rivers, lochs, etc. where they can cause **pollution**
- The ways in which nitrogen compounds are recycled between animals and plants are shown in the **Nitrogen Cycle**
- There are various ways in which nitrogen can be gained and lost in the nitrogen cycle

Ammonia and Nitric acid

- **Ammonia** (NH₃) is used as a fertiliser and is used to **make** other fertilisers
- Ammonia reacts with acids forming **ammonium salts** e.g.

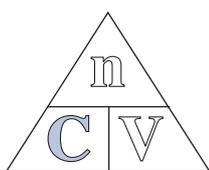
$$2\text{NH}_3 + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4 \text{ (ammonium sulphate)}$$
- The fertilisers **ammonium nitrate**, **ammonium sulphate** and **ammonium phosphate** are made by reacting ammonia with nitric, sulphuric and phosphoric acids
- Nitric acid is used in the production of **nitrate** fertilisers, e.g. **ammonium nitrate**

Qualitative Analysis

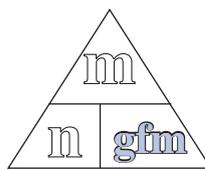
- Test for **oxygen** is that it **relights a glowing splint**
- Test for **hydrogen** is that it **burns with a squeaky pop**
- Test for **carbon dioxide** is that it turns **lime water cloudy**
- Test for **chlorine** is that it **bleaches coloured indicator paper**
- Test for **ammonia** is that it turns **pH paper blue**
- Test for **water vapour** is that it turns dried **cobalt chloride paper** from **blue to pink**
- **Flame Tests** can be used to test for many metals with **characteristic colours** in the **Data Booklet**
- Many metals form **hydroxide precipitates** with **characteristic colours**
- Test for **ammonium ion** is that it **releases ammonia gas** when **heated with hydroxide**
- Most **Halogen ions (Halides)** produce **precipitates** with **silver nitrate** solution with a range of **colours**
- Test for **carbonate ion** is that it turns dried **produces CO₂** with **acid**
- Test for **sulphate ion** is that it produces a **white precipitate** with **barium chloride** solution
- Test for **nitrate ion** is that it produces **ammonia** when **heated with aluminium and excess hydroxide**

Quantitative Analysis

- **Titration** is one of the main techniques used to determine the **amount** of a substance present
- **Weighing precipitates**, after **filtration** and **drying**, can be used to determine the **amount** of a substance present
- **Colour intensity** when using machines such as **Colorimeters** or **Spectrophotometers** can be used to determine the **amount** of a substance present
- Calculations can involve: **balanced equations**



$$n = C \times V$$



$$m = n \times gfm$$

C_1	\times	V_1	$=$	C_2	\times	V_2
<hr/>				<hr/>		
n_1				n_2		

CONSOLIDATION QUESTIONS A

Q1. Int2

$$4\text{NH}_3 + x\text{O}_2 \rightarrow 4\text{NO} + y\text{H}_2\text{O}$$

The equation will be balanced when

A $x = 5, y = 6$
B $x = 5, y = 10$
C $x = 3, y = 6$
D $x = 3, y = 10$.

Q2. SC

The table shows information about some useful compounds.

Compound	Formula
Y	Na_3PO_4
ammonia	NH_3
ammonium nitrate	NH_4NO_3

a) Name compound Y.

b) Compound Y can be used as a fertiliser. Why are fertilisers added to soil?

c) Name the catalyst used in the industrial manufacture of ammonia.

d) What is present in the root nodules of some plants which convert nitrogen from the atmosphere into nitrogen compounds?

Q3. SC

Potassium hydroxide reacts with sulphuric acid to form potassium sulphate, which can be used as a fertiliser..

$$\text{KOH} + \text{H}_2\text{SO}_4 \longrightarrow \text{K}_2\text{SO}_4 + \text{H}_2\text{O}$$

a) Balance the equation

b) Name the type of reaction taking place

c) Calculate the percentage, by mass, of potassium in potassium sulphate, K_2SO_4 .
 Show your working clearly.
 _____ %

d) Ammonium phosphate is also used as a fertiliser. Write the ionic formula for ammonium phosphate.

e) Describe how you would test for the presence of the ammonium ion.

CONSOLIDATION QUESTIONS

B

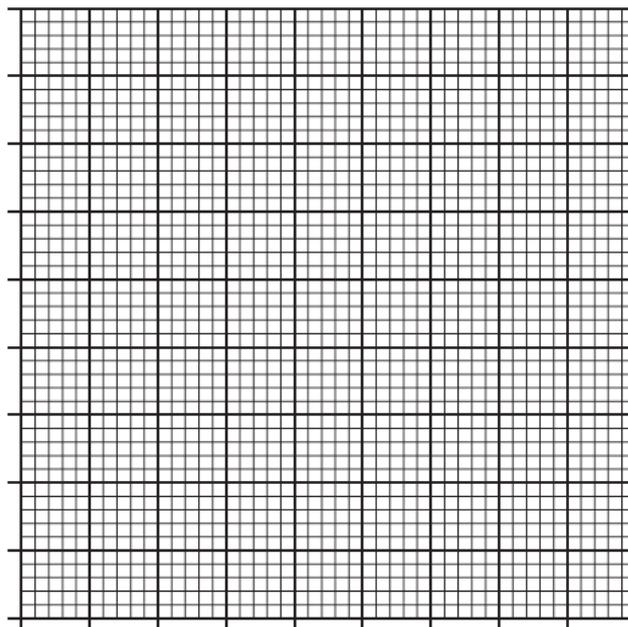
Q1.

SC

Ammonia is produced in the Haber process.

The percentage yield of ammonia, obtained at different pressures, is shown in the table.

Pressure/ atmospheres	Percentage yield of ammonia
50	6
100	10
150	14
200	19
250	22
350	29
400	32



a) Draw a line graph of the results.
Use appropriate scales to fill most of the graph paper.

b) Using your graph, estimate the yield of ammonia at 300 atmospheres.
_____ %

c) Temperature is another factor which affects the percentage yield of ammonia.

Suggest a reason why 500 °C is the temperature chosen to operate an industrial ammonia plant rather than 200 °C.

d) Describe how you would test for the presence of ammonia gas.

e) Ammonia can be reacted with phosphoric acid to produce a useful fertiliser $(\text{NH}_4)_3\text{PO}_4$

Calculate the percentage of the fertiliser that will be nitrogen.

Temperature/°C	Percentage yield of ammonia
200	88
300	67
400	49
500	18

e) Calculate the mass of fertiliser $(\text{NH}_4)_3\text{PO}_4$ that could be produced by reacting 34kg of ammonia with excess phosphoric acid.



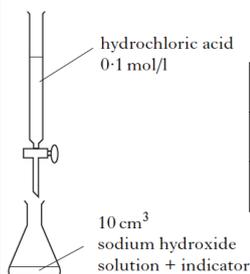
CONSOLIDATION QUESTIONS

C

Q1.

SC

A student carried out a titration using the chemicals and apparatus below.



	Rough titre	1st titre	2nd titre
Initial burette reading/cm ³	0.3	0.2	0.5
Final burette reading/cm ³	26.6	25.3	25.4
Volume used/cm ³	26.3	25.1	24.9

- a) Using the results in the table, calculate the average volume of hydrochloric acid required to neutralise the sodium hydroxide solution.

_____ cm³

- b) The equation for the reaction is:



Using your answer from part a), calculate the concentration of the sodium hydroxide solution.

Show your working clearly.

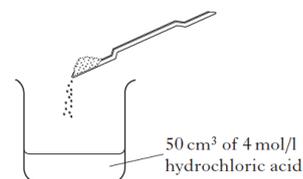
Q2.

SC

Indigestion is caused by excess acid in the stomach. Indigestion remedies containing calcium carbonate neutralise some of this acid.

Christine carried out an experiment to find the mass of calcium carbonate required to neutralise a dilute hydrochloric acid solution.

She added calcium carbonate until all the acid had been used up.



- a) Calculate the number of moles of dilute hydrochloric acid used in the experiment.

_____ mol

- b) The equation for the reaction is:



Using your answer from part a), calculate the number of moles of calcium carbonate required to neutralise the dilute hydrochloric acid.

_____ mol

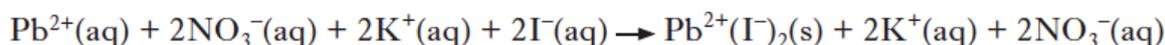
- c) Using your answer from part b), calculate the *mass* of calcium carbonate (CaCO₃) required to neutralise the acid.

_____ g

Q3.

SC

The presence of lead in a solution of lead (II) nitrate can be determined by adding some potassium iodide to the solution.



- a) Identify the *two* spectator ions in the reaction.
 _____ and _____
- b) Name the type of reaction taking place.

- c) Describe what you would see that confirms the presence of lead in the solution.
- d) Describe how you could test for the presence of potassium ions in the final solution.

CONSOLIDATION QUESTIONS

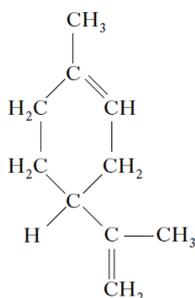
D

Q1.

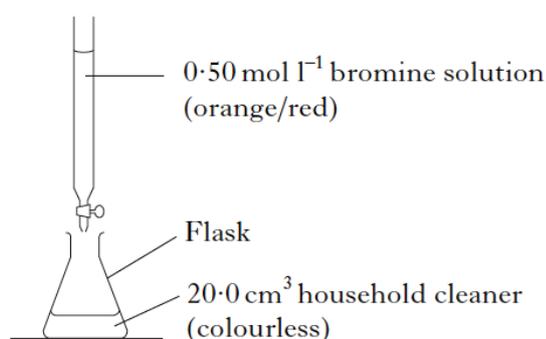
Int 2

Some household cleaners contain the chemical limonene which gives them a lemon smell.

The structure of limonene is shown opposite.



Using bromine solution, a student carried out titrations to determine the concentration of limonene in a household cleaner.



Titration	Initial burette reading (cm ³)	Final burette reading (cm ³)	Titre (cm ³)
1	0.5	17.1	16.6
2	0.2	16.3	16.1
3	0.1	16.0	15.9

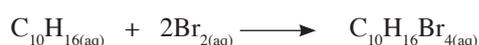
a) What colour change would be seen in the flask that indicates the end point of the titrations?

_____ to _____

b) What average volume should be used in calculating the concentration of limonene?

_____ cm³

c) The equation for the reaction between limonene and bromine solution is shown.



Calculate the concentration of limonene in the household cleaner.

_____ mol l⁻¹

Q2.

Int 2

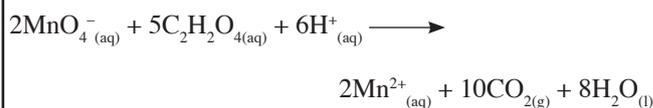
Rhubarb contains oxalic acid, C₂H₂O₄.



Oxalic acid reacts with acidified potassium permanganate solution and decolourises it.

The juice extracted from 10.0g of rhubarb required 25 cm³ of 1.0 mol l⁻¹ potassium permanganate to react with.

The equation for the reaction is:



a) Calculate the number of moles of permanganate ions (MnO₄⁻) in 25 cm³ of a 1.0 mol l⁻¹ solution.

_____ mol

b) The above equation shows that 2 moles of permanganate ions react with 5 moles of oxalic acid.

How many moles of oxalic acid (C₂H₂O₄) reacted with 25 cm³ of 1.0 mol l⁻¹ permanganate (MnO₄⁻) solution?

_____ mol

c) What mass of oxalic acid was contained in 10.0g of rhubarb

_____ g