

# Introduction

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This collection of activities provides students with opportunities to practice the skills and techniques needed to meet the following assessment requirements of unit 1 and unit 3 of the *GCSE in Applied Science* specifications:

## Unit 1 (Developing scientific skills)

Carry out practical tasks: Qualitative and quantitative chemical analyses (the use of one standard procedure for each of the two types of analysis)

## Unit 3 (Science at work)

Making useful products (three chemicals made by different types of chemical reaction)

The activities fall into three categories:

- **Analysis** (matching the requirements of unit 1)
- **Preparation** (matching the requirements of unit 3)
- **Preparation and analysis** (matching the requirements of units 1 and 3)

# Analysis

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## Qualitative

- Identification of inks in felt tip pens using paper chromatography
- Identification of amino acids in fruit juices using paper chromatography
- Identification of lipsticks by thin layer chromatography
- Identification of active ingredients in over the counter (OTC) pain relievers using thin layer chromatography.

## Quantitative

- Determination of water hardness
- Analysis of sodium carbonate solution

- Determination of citric acid in *Hubba Bubba* bubble gum
- Analysis of washing soda crystals
- Analysis of calcium carbonate tablets
- Determination of chloride ions in river water
- Determination of hydrogen peroxide concentration by manganate(VII) titration.

These are 'standard procedures' and so in each case full experimental details are provided. The procedures for both qualitative and quantitative analyses are given in order of increasing complexity.

## Preparation

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- **Preparation of aluminium oxide** (*Time: students will need about one hour for laboratory work and a further hour for other activities*)
- **Preparation of magnesium oxide** (*Time: students will need about one hour for laboratory work and a further hour for other activities*)
- **Preparation of zinc sulfate crystals** (*Time: students will need about one hour for laboratory work and a further hour for other activities*)
- **Preparation of sodium citrate** (*Time: students will need about one hour for laboratory work and a further hour for other activities*)
- **Preparation of calcium benzoate** (*Time: students will need about one hour for laboratory work and a further hour for other activities*)
- **Preparation of copper** (*Time: students will need about one hour for laboratory work and a further hour for other activities*)
- **Preparation of ethyl butanoate** (*Time: students will need about one hour for laboratory work and a further hour for other activities*).

In each case full experimental details are provided. However, students must decide what apparatus and equipment is needed (as required in the specifications). Questions allow students to show understanding and to meet the full range of assessment criteria.

The procedures are in order of increasing complexity.

## Preparation and Analysis

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- **Preparation and analysis of an ORT solution** (*Time: Preparation – students will need about 30 minutes for laboratory work and a further half hour for other activities. Analysis – students will need about 30 minutes for laboratory work, plus a further hour for other activities.*)
- **Preparation and analysis of ammonium chloride** (*Time: Preparation – students will need about 45 minutes for laboratory work, plus a few minutes in the next lesson, and a further half hour for other activities. Analysis: students will need about 45 minutes for laboratory work, plus a further hour for other activities.*)
- **Preparation and analysis of magnesium oxide** (*Time: Preparation – students will need about one hour for laboratory work and a further hour for other activities. Analysis – students will need about 45 minutes for laboratory work, plus a further hour for other activities.*)
- **Preparation and analysis of 'magnesium hydroxide mixture** (*Time: Preparation – students will need about 30 minutes for laboratory work, plus a few minutes next lesson, and a further half hour for other activities. Analysis – students will need about 45 minutes for laboratory work, plus a further hour for other activities.*)

In each case full preparative and analytical details are provided. However, students must decide what apparatus and equipment is needed (as required in the specifications). Questions allow students to show understanding and to meet the full range of assessment criteria.

The procedures are in order of increasing complexity.

# Health and Safety

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All the activities described in this resource can be carried out safely in schools. The hazards have been identified and any risks from them reduced to insignificant levels by the adoption of suitable control measures. However, we also think it is worth explaining the strategies we have adopted to reduce the risks in this way.

Regulations made under the Health and Safety at Work etc Act 1974 require a risk assessment to be carried out before hazardous chemicals are used or made, or a hazardous procedure is carried out. Risk assessment is your employer's responsibility. The task of assessing risk in particular situations may well be delegated by the employer to the head of science/chemistry, who will be expected to operate within the employer's guidelines. Following guidance from the Health and Safety Executive most education employers have adopted various nationally available texts as the basis for their model risk assessments. These commonly include the following:

Safeguards in the School Laboratory, 10<sup>th</sup> edition, ASE, 1996

Topics in Safety, 3<sup>rd</sup> edition, ASE, 2001

Hazcards, CLEAPSS, 1995 or later updates

Laboratory Handbook, CLEAPSS, 2001 or later updates

Safety in Science Education, DfEE, HMSO, 1996

Hazardous Chemicals – an interactive manual for science education, SSERC, 2002 (CD-ROM)

If your employer has adopted one or more of these publications, you should follow the guidance given there, subject only to a need to check and consider whether minor modification is needed to deal with the special situation in your class/school. We believe that all the activities in this resource are compatible with the model risk assessments listed above. However, the teacher must still verify that what is proposed does conform to any code of practice produced by their employer. You also need to consider your local circumstances. Is your fume cupboard reliable? Are your students reliable?

Risk assessments involve answering two questions:

- How likely is it that something will go wrong?
- How serious would it be if it did go wrong?

How likely it is that something will go wrong depends on who is doing it and what sort of training and experience they have had. In most of the publications listed above there are suggestions as to whether an activity should be a teacher demonstration only, or could be done by students of various ages. Your employer will probably expect you to follow this guidance.

Teachers tend to think of eye protection as the main control measure to prevent injury. In fact, personal protective equipment, such as goggles or safety spectacles, is meant to protect from the unexpected. If you expect a problem, more stringent controls are needed. A range of control measures may be adopted, the following being the most common. Use:

- a less hazardous (substitute) chemical;
- as small a quantity as possible;
- as low a concentration as possible;
- a fume cupboard; and
- safety screens (more than one is usually needed, to protect both teacher and students).

The importance of lower concentrations is not always appreciated, but the following information, showing the hazard classification of a range of common solutions, should make the point.

Ammonia (aqueous)	irritant if = 3 mol dm <sup>-3</sup>	corrosive if = 6 mol dm <sup>-3</sup>
Sodium hydroxide mol dm <sup>-3</sup>	irritant if = 0.05 mol dm <sup>-3</sup>	corrosive if = 0.5
Ethanoic (acetic) acid mol dm <sup>-3</sup>	irritant if = 1.5 mol dm <sup>-3</sup>	corrosive if = 4

Throughout this resource, we make frequent reference to the need to wear eye protection. Undoubtedly, chemical splash goggles, to the European Standard EN 166 3 give the best protection but students are often reluctant to wear goggles. Safety spectacles give less protection, but may be adequate if nothing which is classed as corrosive or toxic is in use. Reference to the above table will show, therefore, that if sodium hydroxide is in use, it should be more dilute than 0.5 mol dm<sup>-3</sup>.

A more complete table is shown overleaf.

### Hazards of common laboratory solutions at various concentrations

For brevity the symbol M is used for mol dm<sup>-3</sup>

Reagent / solution	Concentration	Symbol
Ammonia	6 M or more	<b>Corrosive</b>
	3 M* or more but less than 6 M	<b>Irritant</b>
Barium salts	0.05 M* or more	<b>Harmful</b>
Benedict's Reagent	Typical formulation as CLEAPSS <i>Recipe Card</i>	<b>Low hazard (Harmful Product)</b>
Biuret solution A	Typical formulation, 2 M sodium hydroxide if less than 0.5 M sodium hydroxide	<b>Corrosive Irritant</b>
Bromine water	0.06 M or more 0.006 M* or more but less than 0.06 M	<b>Toxic &amp; Corrosive Harmful &amp; Irritant</b>
Copper(II) chloride	1.4 M or more	<b>Toxic</b>
	0.15 M* or more but less than 1.4 M	<b>Harmful</b>
Copper salts <i>except</i> chloride	1 M* or more	<b>Harmful</b>
Ethanedioic acid and ethanedioates	0.3 M* or more	<b>Harmful</b>
Ethanoic (acetic) acid	4 M or more	<b>Corrosive</b>
	1.5 M* or more but less than 4 M	<b>Irritant</b>
Fehling's solution B	Typical formulation, 4 M sodium hydroxide	<b>Corrosive</b>
Hydrochloric acid	6.5 M or more	<b>Corrosive</b>
	2 M* or more but less than 6.5 M	<b>Irritant</b>
Hydrogen peroxide	5.9 M or more (>71 vol)*	<b>Corrosive</b>
	1.5 M* or more (>18 vol) but less than 5.9 M	<b>Irritant</b>
Indicators	if made up in ethanol etc	<b>Highly Flammable</b>

Iodine	1 M* or more	<b>Harmful</b>
Iron(II) salts (ferrous)	1 M* or more	<b>Harmful</b>
Iron(III) salts (ferric)	0.75 M* or more	<b>Irritant</b>
Lead salts	0.01 M or more 0.001 M* or more but less than 0.01 M	<b>Toxic</b> <b>Harmful</b>
Mercury salts	0.004 M or more 0.002 M* or more but less than 0.004 M	<b>Toxic</b> <b>Harmful</b>
Methanal (formaldehyde)	25% or more 1%* or more but less than 25%	<b>Toxic</b> <b>Harmful</b>
Nessler's Reagent		<b>Toxic</b>
Nickel salts	0.5 M* or more	<b>Harmful</b>
Nitric acid	0.5 M or more 0.1 M* or more but less than 0.5 M	<b>Corrosive</b> <b>Irritant</b>
Phosphoric acid	2.5 M or more 0.1 M* or more but less than 2.5 M	<b>Corrosive</b> <b>Irritant</b>
Potassium or sodium chromate or dichromate	0.2 M or more 0.003 M or more, but less than 0.2M	<b>Very toxic</b> <b>Toxic</b>
Potassium hexacyanoferrates (ferro- or ferricyanides)	Any	<b>Low Hazard</b>
Potassium hydroxide	0.5 M or more 0.05 M* or more but less than 0.5 M	<b>Corrosive</b> <b>Irritant</b>
Potassium manganate (VII)	Any	<b>Low Hazard</b>
Silver nitrate	0.5 M or more 0.2 M* or more but less than 0.5 M	<b>Corrosive</b> <b>Irritant</b>
Sodium chlorate(I) (hypochlorite)	10% or more available chlorine 5%* or more but less than 10% av. chlorine	<b>Corrosive</b> <b>Irritant</b>
Sodium hydroxide	0.5 M or more	<b>Corrosive</b>

	0.05 M* or more but less than 0.5 M	<b>Irritant</b>
Sodium nitrate	0.7 M or more 0.1 M* or more but less than 0.7 M	<b>Toxic</b> <b>Harmful</b>
Sulfuric acid	1.5 M or more 0.5 M or more but less than 1.5 M	<b>Corrosive</b> <b>Irritant</b>
Zinc sulfate	1 M or more	<b>Irritant</b>

\* For concentrations less than those mentioned the solution is low hazard. The pure solute will generally present the same hazard as the most concentrated solution listed above. For named reagents, there are often quite wide variations in the formulation.

# Answers

## Preparation of Aluminium Oxide

### 1. Precipitation

aluminium chloride solution + sodium hydroxide solution	→	aluminium hydroxide + sodium chloride solution
$\text{AlCl}_3 (\text{aq}) + 3\text{NaOH} (\text{aq})$	→	$\text{Al}(\text{OH})_3 (\text{s}) + 3\text{NaCl} (\text{aq})$

### 2. (Thermal) decomposition

aluminium hydroxide	→	aluminium oxide + water (steam)
$2\text{Al}(\text{OH})_3 (\text{s})$	→	$\text{Al}_2\text{O}_3 (\text{s}) + 3\text{H}_2\text{O} (\text{g})$

### 3. Other costs: labour, laboratory overheads (heating, lighting, rental)

### 4. There are two types of reason:

- loss during mechanical transfers
- incomplete reactions.

### 5. In a precipitation reaction the reactants are moving independently and randomly in solution. They collide with one another easily, leading to reaction.

In the reaction between a solid and a liquid reaction only takes place at the surface of the solid. The product must 'float' away from the surface exposing more solid for further reaction.

## Preparation of Magnesium Oxide

### 1. Precipitation

sodium hydroxide solution + magnesium sulfate solution	→	magnesium hydroxide + sodium sulfate solution
$\text{NaOH} (\text{aq}) + \text{MgSO}_4 (\text{aq})$	→	$\text{Mg}(\text{OH})_2 (\text{s}) + \text{Na}_2\text{SO}_4 (\text{aq})$

### 2. (Thermal) decomposition

magnesium hydroxide	→	magnesium oxide + water (steam)
$\text{Mg(OH)}_2 (\text{s})$	→	$\text{MgO} (\text{s}) + \text{H}_2\text{O} (\text{g})$

- Other costs: labour, laboratory overheads (heating, lighting, rental)
- There are two types of reason:
  - loss during mechanical transfers
  - incomplete reactions.
- In a precipitation reaction the reactants are moving independently and randomly in solution. They collide with one another easily, leading to reaction

In the reaction between a solid and a liquid reaction only takes place at the surface of the solid. The product must 'float' away from the surface exposing more solid for further reaction.

## Preparation of Zinc Sulfate Crystals

- Acid-base neutralisation
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zinc oxide + sulfuric acid	→	zinc sulfate solution + water
$\text{ZnO} (\text{s}) + \text{H}_2\text{SO}_4 (\text{aq})$	→	$\text{ZnSO}_4 (\text{aq}) + \text{H}_2\text{O} (\text{l})$

- Other costs: labour, laboratory overheads (heating, lighting, rental); wear and tear on equipment.
- The theoretical yield depends on the quantity of reactant that is not in excess. Therefore, this quantity needs to be known accurately (the volume of  $1.0 \text{ mol dm}^{-3}$  sulfuric acid), but the reactant in excess (zinc oxide) does not need to be measured accurately.
- There are two types of reason:
  - loss during mechanical transfers
  - incomplete reactions.
- The rate of reaction would be:

- faster; the more concentrated the sulfuric acid the higher the frequency of collisions leading to reaction;
- slower; the more dilute the sulfuric acid the lower the frequency of collisions leading to reaction;
- slower; sulfuric acid particles in solution have less energy and move more slowly, meaning that the frequency of collisions leading to reaction is reduced.

## Preparation of Sodium Citrate

1. Organic acid (because there are carbon atoms in the formula).
2. Citric acid occurs in citrus fruits such as lemons and limes.
3. Acid-base neutralisation.
- 4.

citric acid solution + sodium hydroxide solution	→	trisodium citrate solution + water
$C_3H_5O(COOH)_3 (aq) + 3NaOH (aq)$	→	$C_3H_5O(COONa)_3 (aq) + 3H_2O (l)$

5. (c) electricity, gas and water supplies; labour; wear and tear on apparatus and equipment.
6. There are two types of reason:
  - loss during mechanical transfers
  - incomplete reactions.
7. The rate of reaction would be:
  - faster; grinding the crystals to a powder increases the surface area and, therefore, the frequency of collisions;
  - slower; the more dilute the solution the less frequently collisions will occur;
  - slower; the sodium hydroxide solution will have less energy and the dissolved particles will move more slowly, reducing the frequency of collisions.
8. Monosodium citrate -  $C_3H_5O(COOH)_2(COONa)$   
 Disodium citrate -  $C_3H_5O(COOH)(COONa)_2$
9. Acidity regulators act as buffers. They 'resist' changes in pH when an acid or alkali is added.

10. Acids, antioxidants, mineral salts.

## Preparation of Calcium Benzoate

1. It is an organic acid because it is a compound of carbon. Also the combination of elements -COOH is used to represent a carboxylic acid.
2. Acid-carbonate reaction (a special example of acid-base)

benzoic acid + calcium carbonate	→	calcium benzoate + water + carbon dioxide
$2\text{C}_6\text{H}_5\text{COOH (aq)} + \text{CaCO}_3 \text{ (s)}$	→	$(\text{C}_6\text{H}_5\text{COO})_2 \text{Ca (aq)} + \text{H}_2\text{O (l)} + \text{CO}_2 \text{ (g)}$

3. Because carbon dioxide, a gas, is formed.
4. Other costs: labour, laboratory overheads (heating, lighting, rental)
5. Because it is used in excess, in other words the yield depends on the quantity of benzoic acid.
6. There are two reasons:
  - loss during mechanical transfers
  - incomplete reactions.
7. The reaction would be:
  - slower; solid has smaller surface area, therefore less collisions with benzoic acid particles in solution;
  - slower; benzoic acid would be more dilute, therefore less frequent collisions;
  - slower; particles have less energy and move more slowly, therefore less frequent collisions.

## Preparation of Copper

1. Redox (reduction and oxidation)

2.

zinc + copper sulfate solution	→	zinc sulfate solution + copper
Zn (s) + CuSO <sub>4</sub> (aq)	→	ZnSO <sub>4</sub> (aq) + Cu (s)

3. Other costs: labour, laboratory overheads (heating, lighting, rental).

5. Because it is used in excess, in other words the yield depends on the quantity of zinc powder.

6. There are two reasons:

- loss during mechanical transfers
- incomplete reactions.

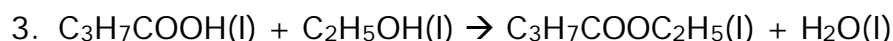
7. The reaction would be:

- slower; copper sulfate would be more dilute, therefore less frequent collisions;
- faster; particles have more energy and move more quickly, therefore more frequent collisions;
- slower; solid has smaller surface area, therefore less collisions with copper sulfate particles in solution.

## Preparation of Ethyl Butanoate

1. Organic because they contain carbon atoms.

2. Esterification.



3. Other costs: labour, laboratory overheads (heating, lighting, rental).

4. Because in real pineapples there are many other chemicals present. It is the combined effect of these compounds that add up to the taste and smell of real pineapples.

5. 3-methylbutyl ethanoate – banana

3-methylbutyl pentanoate – apple

2-methylpropyl methanoate – raspberry.

6. Carbon dioxide.

## Preparation and Analysis of an ORT Solution

### Answers to preparation questions

1. Ingredients:

sodium chloride NaCl

potassium chloride KCl

sodium hydrogencarbonate NaHCO<sub>3</sub>

glucose C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> (an organic compound because it contains carbon but is neither a carbonate nor a hydrogencarbonate).

2. Manufacturing overheads (services such as electricity, gas and water; premises rent), labour, and costs of packaging.

3. The pH will be >7; this is because sodium hydrogencarbonate solutions are alkaline.

(HCO<sub>3</sub><sup>-</sup> + H<sub>2</sub>O ? H<sub>2</sub>CO<sub>3</sub> + OH<sup>-</sup>).

4. Common salt (sodium chloride) and baking soda (sodium hydrogencarbonate).

### Answers to analysis questions

1.

sodium hydrogencarbonate solution + hydrochloric acid	→	sodium chloride solution + carbon dioxide + water
NaHCO <sub>3</sub> (aq) + HCl (aq)	→	NaCl (aq) + CO <sub>2</sub> (g) + H <sub>2</sub> O (l)

2. Because the solution would be diluted and the samples taken for analysis not representative of the ORT solution.

3. Because the amounts of solutes present are the same no matter how much water is present.

4. Silver nitrate solution; precipitation; eg sodium chromate(VI) or eosin Y; coloured product between excess silver nitrate and indicator.

## Preparation and Analysis of Ammonium Chloride

**Answers to preparation questions**

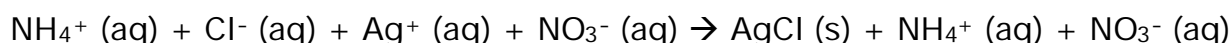
- $\text{NH}_3 (\text{aq}) + \text{HCl} (\text{aq}) \rightarrow \text{NH}_4\text{Cl} (\text{aq})$
- Ammonia =  $14 + (3 \times 1) = 17$   
Hydrochloric acid =  $1 + 35.5 = 36.5$
- 17 g
- Ammonium chloride =  $14 + (4 \times 1) + 35.5 = 53.5$   
From the equation 17 g ammonia (1 mole) gives 53.5 g ammonium chloride (1 mole).
- There will be loss of materials when they are transferred from one vessel to another. Some reactions (though not this one) do not go to completion and the percentage yield is less than 100%.
- In solution the solute particles are free to move around, colliding with another and undergoing reaction. In the reaction between a solid and a liquid, reaction only takes place at the surface of the solid. The product must 'float' away from the surface exposing more solid for further reaction.
- It is a source of nitrogen, one of the elements essential for the healthy growth of plants.
- Ammonium chloride ('jelly' or 'paste') is an electrolyte (conductor of electricity).

**Answers to analysis questions**

1. a)

ammonium chloride solution + silver nitrate solution	→	silver chloride + ammonium nitrate
$\text{NH}_4\text{Cl} (\text{aq}) + \text{AgNO}_3 (\text{aq})$	→	$\text{AgCl} (\text{s}) + \text{NH}_4\text{NO}_3 (\text{aq})$

b) Ammonium chloride solution consists of ammonium ions ( $\text{NH}_4^+$ ) and chloride ions ( $\text{Cl}^-$ ). Silver nitrate solution consists of silver ions ( $\text{Ag}^+$ ) and nitrate ions ( $\text{NO}_3^-$ ). Silver ions and chloride ions combine to make insoluble silver chloride. Ammonium ions and nitrate ions remain in solution and take no part in the reaction (there are called 'spectator ions').



2. The indicator forms a coloured compound with silver nitrate. When silver nitrate has reacted with all the sodium chloride in solution, the next drop reacts with the indicator to give a distinctive coloured product.

3. Solution B – it has the higher density

Solution A

Solution B

No. It is impossible to make anything without at least a trace of impurities, however small.

It is easier to transfer liquids (by pouring and through pipes) than transfer solids.

## Preparation and Analysis of Magnesium Oxide

### Answers to preparation questions

1. Oxidation

2.

magnesium + oxygen	→	magnesium oxide
$\text{Mg (s)} + \text{O}_2 \text{ (g)}$	→	$\text{MgO (s)}$

3. Other costs: labour, laboratory overheads (heating, lighting, rental).

4. There are two types of reason:

loss during mechanical transfers

incomplete reactions (though in this case the reaction goes to completion).

5. The magnesium could be powdered rather than ribbon. This would give a much higher surface area for reaction. Oxygen rather than air could be used (i.e. a higher concentration of oxygen).

### Answers to analysis questions

1.

magnesium oxide + sulfuric acid	→	magnesium sulfate + water
$\text{MgO (s)} + \text{H}_2\text{SO}_4 \text{ (aq)}$	→	$\text{MgSO}_4 \text{ (aq)} + \text{H}_2\text{O (l)}$

2.

sulfuric acid + sodium hydroxide	→	sodium sulfate + water
$\text{H}_2\text{SO}_4 (\text{aq}) + \text{NaOH} (\text{aq})$	→	$\text{Na}_2\text{SO}_4 (\text{aq}) + \text{H}_2\text{O} (\text{l})$

3. A known amount of sulfuric acid (volume and concentration) is added to the magnesium oxide. It is in excess (there is more than is needed to react with the magnesium oxide). This excess is found by titration against a standard sodium hydroxide solution. By difference, the amount of sulfuric acid that reacted with magnesium oxide can be calculated.

## Preparation and Analysis of Magnesium Hydroxide Mixture

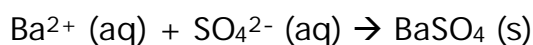
### Answers to preparation questions

1. Precipitation

2.

Magnesium sulfate solution + sodium hydroxide solution	→	magnesium hydroxide + sodium sulfate solution
$\text{MgSO}_4 (\text{aq}) + 2\text{NaOH} (\text{aq})$	→	$\text{Mg}(\text{OH})_2 (\text{s}) + \text{Na}_2\text{SO}_4 (\text{aq})$

- 3.
- $\text{BaCl}_2 (\text{aq}) + \text{Na}_2\text{SO}_4 (\text{aq}) \rightarrow \text{BaSO}_4 (\text{s}) + 2\text{NaCl} (\text{aq})$



4. Manufacturing overheads (services such as electricity, gas and water; premises rent), labour, costs of packaging

### Answers to analysis questions

1.

magnesium hydroxide + sulfuric acid	→	magnesium sulfate + water
$\text{Mg}(\text{OH})_2 (\text{s}) + \text{H}_2\text{SO}_4 (\text{aq})$	→	$\text{MgSO}_4 (\text{aq}) + 2\text{H}_2\text{O} (\text{l})$

2.

magnesium oxide + sulfuric acid	→	magnesium sulfate + water
$\text{MgO (s)} + \text{H}_2\text{SO}_4 \text{ (aq)}$	→	$\text{MgSO}_4 \text{ (aq)} + \text{H}_2\text{O (l)}$

3.

sulfuric acid + sodium hydroxide	→	sodium sulfate + water
$\text{H}_2\text{SO}_4 \text{ (aq)} + \text{NaOH (aq)}$	→	$\text{Na}_2\text{SO}_4 \text{ (aq)} + \text{H}_2\text{O (l)}$

4. A known amount of sulfuric acid (volume and concentration) is added to the magnesium hydroxide. It is in excess (there is more than is needed to react with the magnesium hydroxide). This excess is found by titration against a standard sodium hydroxide solution. By difference, the amount of sulfuric acid that reacted with magnesium hydroxide can be calculated.
5. Sulfuric acid of lower concentration could be used (e.g.  $0.10 \text{ mol dm}^{-3}$  rather than  $0.50 \text{ mol dm}^{-3}$ ) and a smaller volume of this more dilute acid could be used (e.g.  $20 \text{ cm}^3$  rather than  $25 \text{ cm}^3$ ). The sodium hydroxide solution used for the back titration must also be more dilute (e.g.  $0.20 \text{ mol dm}^{-3}$  rather than  $1.00 \text{ mol dm}^{-3}$ ).