Chemistry

Prescribed Practical Activities

Intermediate 1, Intermediate 2, Higher

3729

Spring 2000

HIGHER STILL

Chemistry

Prescribed Practical Activities

Intermediate 1/Intermediate 2/Higher

Support Materials

CONTENTS

INTERMEDIATE 1

INTRODUCTION

When a substance dissolves in a liquid it forms a solution. In this experiment the substance used will be sugar crystals and the liquid will be water.

The aim of the experiment is to find out how changing the temperature of the water changes the speed at which the sugar dissolves.

To make the experiment fair, only **one** factor - **the temperature of the water** - will **change**.

Other factors like the volume of water, the mass and size of the sugar crystals and how much we stir the mixture must be kept the **same**.

Requirements (what you need)

large glass beaker
test tubes and rack
stopper
thermometer
syringe
tripod
Bunsen burner and heating mat
large sugar crystals

Hazards

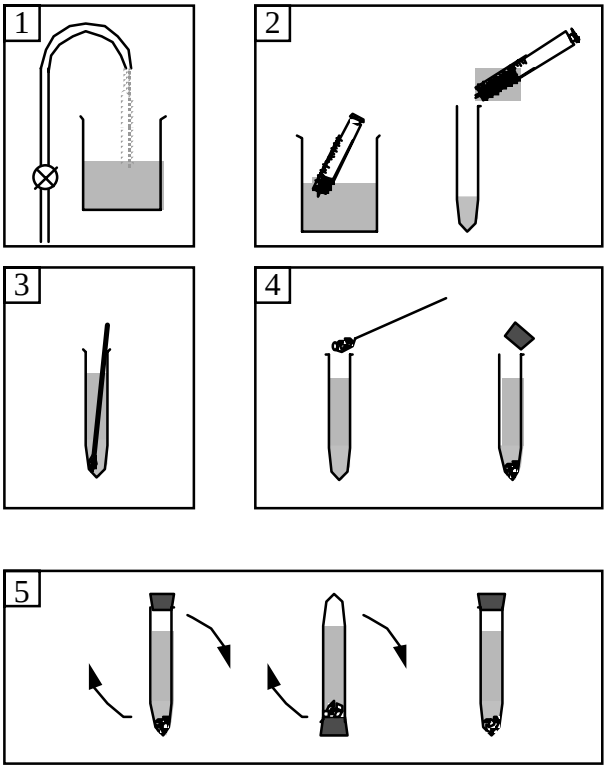
Possible burns from hot water at 60°C.

Care

Wear safety glasses.
When using the syringe always keep it pointing downwards.

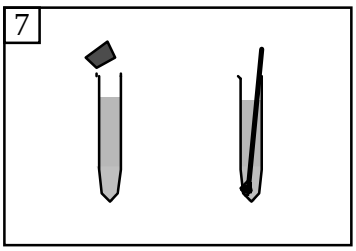
Procedure (what you do)

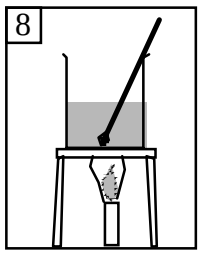
1. Fill the glass beaker half full with water.
2. Use a syringe to put water into a test tube. Add the water until it is about 3 cm from the top of the test tube.
3. Use a thermometer to **measure** the temperature of the water in the test tube. **Record** this temperature by writing it down in the table on your 'assessment' sheet.
4. Fill a spatula with sugar crystals and put them in the water in the test tube. Put a stopper on the test tube.
5. Turn the test tube upside down. Hold it upside down until the crystals fall to the bottom. This counts as **one 'upturn'**. Then turn the test tube the right way up again until the crystals fall to the bottom. This counts as the **second 'upturn'**.



6. Keep on doing this. **Count** how many 'upturns' you have to do before the crystals just 'disappear' (dissolve). **Record** this number by writing it down in the table on your 'assessment' sheet. This number of 'upturns' gives an idea of how quickly the sugar crystals dissolve.

7. Take the stopper out of the test tube. **Measure** the temperature of the solution in the test tube. **Record** this temperature in the table.





8. Put the beaker of water on top of the tripod. Light the Bunsen burner, put it under the tripod and heat the beaker of water until your thermometer shows that the temperature of the water is between 35 °C and 40 °C. Remove the Bunsen burner from below the beaker.
9. Use a syringe to put this warm water into a test tube. Add the warm water until it is about 3 cm from the top of the test tube. Use a thermometer to **measure** the temperature of this warm water and **record** it in the table.
0. Fill a spatula with sugar crystals. Make sure it is about the same amount as you used before. Put them in the warm water in the test tube and put a stopper on this test tube.
1. Turn the test tube upside down as you did before. Hold it upside down until the crystals fall to the bottom. You will remember that this counts as one 'upturn'. Then turn it the right way up again.
2. Carry on doing the 'upturns' at the **same** speed as you did before. **Count** how many 'upturns' you have to do before the crystals just dissolve ('disappear'). **Record** this number.
3. Take the stopper out of the test tube. **Measure** the temperature of the solution in the test tube and **record** it.
4. Repeat the experiment once more after heating the water to between 55 °C and 60 °C. Remember to **measure** and **record** the temperature of the water **before** the sugar crystals are added and **after** the sugar crystals have just dissolved.
   Also **count** and **record** the number of 'upturns' it takes until the crystals just dissolve.

INTERMEDIATE 1	**- The Effect of Temperature Changes on Dissolving Speed -**	**UNIT 1 PPA 1**

Name:	PC(a)	PC(b)			PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:								

- ASSESSMENT SHEET -

* *What was the aim of the experiment?*
PC(b)

Procedure

* *What factor did you change in your experiment?*
PC(b)

* *What did you count that told you how quickly the sugar crystals dissolved in the water?*
PC(b)

Results

* *Complete the following table:*
PC(c)

Temperature of water		† Average water temperature / °C	Number of 'upturns'
before dissolving / °C	after dissolving / °C		

† To work out the average water temperature add the two temperatures together and divide this number by 2.

Conclusion

* *What did you find out from this experiment?*
PC(d)

* *The experiment could be improved by doing it at more than three temperatures. Give a reason for this.*

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

sugar crystals (~2 g)

APPARATUS

test tubes (3)
test tube rack (1)
stopper (1)
250 cm^3 glass beaker (1)
0 - 100 °C thermometer (1)
20 cm^3 syringe (1)
tripod (1)
Bunsen burner (1)
heating mat (1)

Notes

Crystals of **preserving** sugar are suitable.

INTRODUCTION

The aim of this experiment is to find out how changing the concentration of sulphuric acid changes the speed that it reacts with magnesium.

When a piece of magnesium reacts with sulphuric acid bubbles of gas are formed. The piece of magnesium gets smaller and smaller until it 'disappears'. If we time how long it takes to 'disappear' we can get some idea of the reaction speed. The **longer** the time the **slower** the reaction speed.

We will do three experiments but only one factor - **the concentration of the sulphuric acid** - will **change** in each one. To change the concentration of the sulphuric acid we will add water to it - this dilutes the acid and makes it less concentrated. Other factors must be kept the **same**. This means that the pieces of magnesium ribbon we use must be the **same** size and the experiments must be carried out at the **same** temperature. Each experiment will be done at room temperature.

Requirements (what you need)

- 100 cm^3 glass beakers
- 50 cm^3 glass beaker
- 20 cm^3 syringe
- 10 cm^3 syringe
- timer
- dilute sulphuric acid
- 2 cm long pieces of clean magnesium ribbon
- deionised water

Hazards

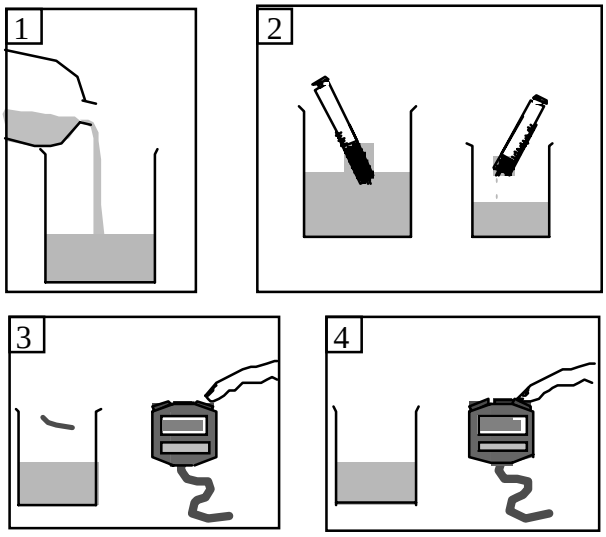
Dilute sulphuric acid is corrosive and magnesium ribbon is highly flammable.
When magnesium reacts with sulphuric acid, an acid mist is formed which irritates the eyes and throat.
Hydrogen gas is produced in the reaction and it is highly flammable.

Care

Wear safety glasses.
If any acid splashes on your skin, wash it off immediately.
Make sure there are no ignition sources around when you carry out the experiment.
When the magnesium reacts with the acid do not breathe in the acid mist.
When using the syringes always keep them pointing downwards.

Procedure (what you do)

1. Add dilute sulphuric acid to one of the 100 cm^3 glass beakers until it is half full.
   The acid has a concentration of 2 mol/l.
   Record this concentration by writing it down in the table on your 'assessment' sheet.
2. Using the 20 cm^3 syringe measure out 20 cm^3 of the acid into the 50 cm^3 glass beaker.
3. Add a piece of magnesium ribbon to the acid and at the same time start the timer.
4. When the magnesium has just 'disappeared' stop the timer and **record** the time to the nearest second. (Do **not** record the time shown on the timer in diagram 4)



5. Wash out the small beaker and dry it.
6. Fill the other 100 cm^3 beaker half full with water.
7. Using the 10 cm^3 syringe measure out 10 cm^3 of water into the small dry beaker. Then using the 20 cm^3 syringe measure out 10 cm^3 of the acid into the same beaker. This makes the concentration of the acid 1 mol/l. **Record** this new concentration in the table on your 'assessment' sheet.
8. Add a piece of magnesium ribbon to the diluted acid and **measure** and **record** the time it takes for the magnesium to just 'disappear'.
9. Repeat the experiment using 15 cm^3 of water and 5 cm^3 of acid.
   Measure and **record** the time it takes for the magnesium to just 'disappear'.
   The acid concentration this time is 0.5 mol/l. **Record** this concentration in the table on your 'assessment' sheet.

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

* *What was the aim of the experiment?*
PC(b)

Procedure

* *How did you change the concentration of the sulphuric acid?*
PC(b)

* *How did you get some idea of how quickly the magnesium reacted with the dilute sulphuric acid?*
PC(b)

Results

* *Complete the following table:*
PC(c)

Concentration of acid / mol/l	Time for magnesium to 'disappear' / s

CONCLUSION

* *What did you find out from this experiment?*
PC(d)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

$2\,mol\,l^{-1}$ sulphuric acid ($35\,cm^3$)
(110 cm^3 concentrated sulphuric acid per litre)

$2\,mol\,l^{-1}$ sulphuric acid
concentrated sulphuric acid


corrosive

magnesium ribbon (three 2 cm lengths)

magnesium


highly flammable

deionised water ($25\,cm^3$)

APPARATUS

$100\,cm^3$ glass beakers (2)
$50\,cm^3$ glass beaker (1)
$20\,cm^3$ syringe (1)
$10\,cm^3$ syringe (1)
timer (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
$2\,mol\,l^{-1}$ sulphuric acid from concentrated acid	Concentrated acid causes severe burns to eyes and skin.	Wear goggles or faceshield and nitrile gloves. Add concentrated acid slowly with stirring to chilled water of volume equal to about half the final volume.
magnesium ribbon	Highly flammable.	Provide in closed containers and carefully control distribution.

Notes

This experiment should be carried out in a well-ventilated room.
Measuring cylinders could be used in place of the syringes.

- Testing the pH of Solutions -

INTRODUCTION

The **pH scale** measures how acidic (or how alkaline) a solution is. The pH scale runs from just below 0 to just above 14.

Solutions with a **pH below 7** are **acidic**. Solutions with a **pH above 7** are **alkaline**. **Neutral** solutions have a **pH of 7**.

The pH of a solution can be found by using **pH indicator solution** or **pH paper**. When either of these is added to the solution it changes colour. Matching up this colour with one of those on a pH colour chart gives us the pH of the solution.

The aim of this experiment is to find the pH values of some household substances and to classify them as acidic, alkaline or neutral.

Decide whether you will use **pH indicator solution or pH paper** to test the substances. If you choose the indicator solution go to the section with the heading '**pH indicator solution**'. If you choose the paper go to the section with the heading '**pH paper**'.

pH indicator solution

Requirements (what you need)

test tubes and rack
pH colour chart
pH indicator solution
vinegar
soda water
common salt
sugar
deionised water
lemon juice
diluted household ammonia
bicarbonate of soda
automatic washing powder

Hazards

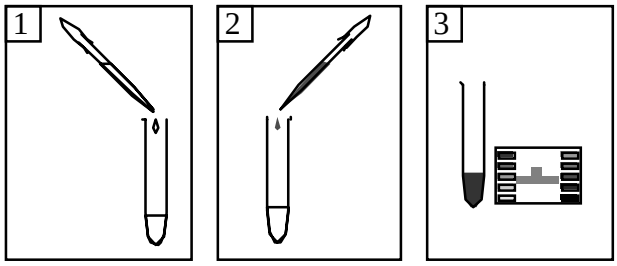
pH indicator solution is highly flammable.
Vinegar, lemon juice, diluted household ammonia and automatic washing powder irritate the eyes.

Care

Wear safety glasses.
Make sure there are no ignition sources around when you carry out this experiment.
If any chemical splashes on your skin, wash it off immediately.

Procedure (what you do)

1. Add some vinegar to a test tube to a depth of about 2 cm.
2. Add 2 or 3 drops (no more) of the pH indicator solution to the vinegar and shake the mixture.
3. To get the pH, match the colour of the solution to one of those on the colour chart.



4. **Record** this pH by writing it down in the table on your 'assessment' sheet.
5. **Repeat** steps 1 to 4 with lemon juice, soda water and diluted household ammonia. Remember to **record** the pH each time.
6. Add some water to a test tube to a depth of about 2 cm. Using a spatula add a tiny amount of common salt (about the size of half a pea) to the water and shake the mixture.

7. Add 2 or 3 drops (no more) of the pH indicator solution to the salt solution and shake the mixture.
8. **Measure** and **record** the pH, by matching the colour of the solution to one of those on the colour chart.
9. Repeat steps 6 to 8 with bicarbonate of soda, sugar and automatic washing powder. Remember to **record** the pH each time.

pH paper

Requirements (what you need)

dimple tray	pH paper (1 cm pieces)	deionised water
pH colour chart	vinegar	lemon juice
tweezers	soda water	diluted household ammonia
	common salt	bicarbonate of soda
	sugar	automatic washing powder

Hazards

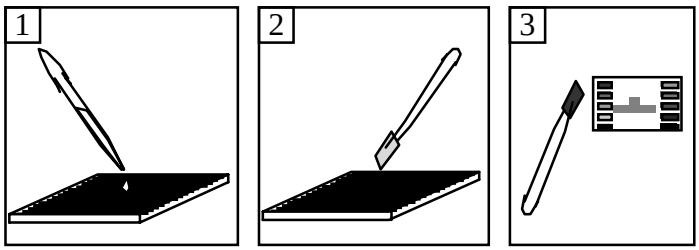
Vinegar, lemon juice, diluted household ammonia and automatic washing powder irritate the eyes.

Care

Wear safety glasses.
If any chemical splashes on your skin, wash it off immediately.

Procedure (what you do)

1. Add a few drops of vinegar to a dimple in the tray.
2. Using the tweezers dip a piece of pH paper into the vinegar.
3. To get the pH, match the colour of the pH paper to one of those on the colour chart.



4. **Record** this pH by writing it down in the table on your 'assessment' sheet.
5. **Repeat** steps 1 to 4 with lemon juice, soda water and diluted household ammonia. Remember to **record** the pH each time.
6. Add a few drops of water to a dimple in the tray. Using a spatula add a tiny amount of common salt (about the size of a lentil) to the water.
7. Using the tweezers dip a piece of pH paper into the salt solution.
8. **Measure** and **record** the pH, by matching the colour of the pH paper to one of those on the colour chart.
9. Repeat steps 6 to 8 with bicarbonate of soda, sugar and automatic washing powder. Remember to **record** the pH each time.

INTERMEDIATE 1	**- Testing the pH of Solutions -**	**UNIT 1 PPA 3**

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

* *What was the aim of the experiment?*
PC(b)

Procedure

* *How did you use the colour chart to get the pH value?*
PC(b)

Results / Conclusion

* *Complete the following table:* **PC(c), PC(d)**

Household substance	pH	Acidic / Alkaline / Neutral

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents for both experiments

deionised water (~ 20 cm^3 and a few drops)

vinegar (~ 2 cm^3 and a few drops)

lemon juice (~ 2 cm^3 and a few drops)

soda water (~ 2 cm^3 and a few drops)

2 % household ammonia (~ 2 cm^3 and a few drops)
(20 cm^3 household ammonia per litre)

household ammonia

irritant

common salt (~ 0.2 g and a few grains)

bicarbonate of soda (~ 0.2 g and a few grains)

sugar (~ 0.2 g and a few grains)

automatic washing powder (~ 0.2 g and a few grains)

Hazard warning label for automatic washing powder as per supplier's container.

ADDITIONAL REAGENT FOR 'PH INDICATOR SOLUTION' EXPERIMENT

Universal indicator or Full Range indicator (a few drops)

Universal indicator
Full Range indicator

highly flammable

Additional reagent for 'pH paper' experiment

pH paper (eight one cm pieces)

APPARATUS FOR 'PH INDICATOR SOLUTION' EXPERIMENT

test tubes (8)
test tube rack (1)
pH colour chart (1)

APPARATUS FOR 'PH INDICATOR SOLUTION' EXPERIMENT

dimple tray (1)

tweezers (1)

pH colour chart (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
Universal indicator and Full Range indicator	Highly flammable owing to ethanol content.	During dispensing ensure absence of ignition sources.
2 % solution of household ammonia from household ammonia	Fumes and solution are irritating to eyes, skin and respiratory system.	Wear eye protection and gloves and carry out dilution in a fume cupboard.
vinegar lemon juice automatic washing powder	All are irritating to eyes.	Wear eye protection.

Notes

Household ammonia has a concentration of just under 6 $mol\,l^{-1}$ and as suggested a diluted solution should be provided for student use.

A 'biological' automatic washing powder should be avoided.

- Electrical Conductivity -

INTRODUCTION

A current of electricity is a flow of charged particles.

Some substances are **conductors** of electricity. This means they allow a current to pass through them. Other substances do not let a current pass through them and they are called **non-conductors**.

In this experiment we will look at **elements - metal** elements and **non-metal** elements.

The aim of this experiment is to test the electrical conductivity of some metals and non-metals and from the results work out a general rule about the electrical conductivity of elements.

Requirements (what you need)

low voltage source of electricity
bulb or buzzer or ammeter
connecting wires

samples of: aluminium
carbon (graphite)
copper
iron
nickel
sulphur
zinc

Hazard

Sulphur is highly flammable.

Care

Wear safety glasses.
When you are working with the sulphur make sure flames are absent.
If you use a power pack do not plug it into the mains until you have had the circuit checked by your teacher/lecturer.

Procedure (what you do)

1. Your teacher/lecturer will tell you how to set up the circuit you will need to test the electrical conductivity of the elements. **Do not switch on** the electrical source until your circuit has been checked by your teacher/lecturer.
2. Take one of the elements and test its electrical conductivity.
3. In the table on your 'assessment' sheet **record** the result by writing down
   - the name of the element
   - whether it is a metal or a non-metal (you can find this out by looking at your data booklet)
   - whether it is a conductor or a non-conductor.
4. Repeat the experiment with each of the remaining elements **recording** the result each time.

Note: In the table on your 'assessment' sheet you will find the names of some more elements. For safety reasons you have not been asked to test these.
You are told their electrical conductivities and all you have to do is find out whether each one
is a metal or a non-metal.

INTERMEDIATE 1	- Electrical Conductivity -	UNIT 2 PPA 1

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

* *What was the aim of the experiment?*
PC(b)

Procedure

* *Draw a labelled diagram of the electrical circuit you used.*
PC(b)

* *How were you able to tell if the element conducted electricity?*
PC(b)

Results

* *Complete the following table:*

PC(c)

Element	Metal / Non-metal	Conductor / Non-conductor
iodine		non-conductor
phosphorus		non-conductor
mercury		conductor
bromine		non-conductor
selenium		non-conductor

CONCLUSION

* *Write a general rule about the electrical conductivity of elements by completing the following sentences:*

PC(d)

……. conduct electricity but ……. do not conduct electricity.

The element which does not fit this rule is ……. .

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

Small samples of:

aluminium *(foil)*

carbon (graphite) *(lump charcoal or carbon rod)*

copper *(foil or wire)*

iron *(wire)*

nickel *(foil)*

sulphur *(lump or roll)*

sulphur

highly flammable

zinc *(granulated, foil or stick)*

APPARATUS

low voltage source of electricity
bulb or buzzer or ammeter (1)
connecting wires (3)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
sulphur	Highly flammable.	Use pieces of lump or roll sulphur.
pieces of metal foil	Possible sharp edges.	Wear eyes protection during cutting and dispensing.

Notes

Powdered samples of the elements should not be used on account of their greater flammability and toxicity if inhaled.

- Reaction of Metals with Acid -

INTRODUCTION

Different metals react at different speeds with acid. A metal which reacts **quickly** with acid is called a **reactive** metal. An **unreactive** metal reacts only slowly or does not react at all. By finding out how quickly different metals react with acid we can put them in **order of reactivity**.

When a metal does react with an acid bubbles of gas are produced. The speed at which the bubbles are given off tells us how reactive the metal is.

The aim of this experiment is to place the metals, zinc, magnesium and copper in order of reactivity by watching how quickly they react with hydrochloric acid.

Requirements (what you need)

test tubes
test tube rack
beaker
dilute hydrochloric acid
samples of zinc, magnesium and copper

Hazards

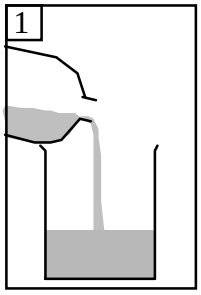
Dilute hydrochloric acid irritates the eyes and magnesium ribbon is highly flammable.
When a metal reacts with acid, an acid mist is formed which irritates the eyes and throat.
Hydrogen gas is produced in the reaction and it is highly flammable.

Care

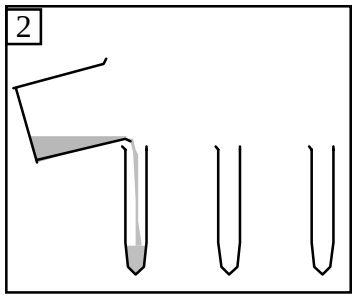
Wear safety glasses.
If any acid splashes on your skin, wash it off immediately.
Do not breathe in the acid mist.
Make sure there are no ignition sources around when you carry out the experiment.

Procedure (what you do)

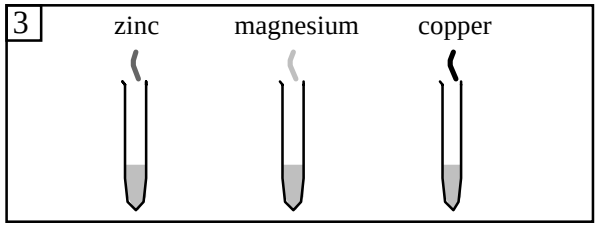
1. Add dilute hydrochloric acid to the beaker until it is half full.



2. Put three test tubes in the test tube rack.
   Pour some of the hydrochloric acid into the first test tube to a depth of about 4 cm.
   Pour the same volume of acid into the other two test tubes.



3. Add a piece of zinc to the first test tube.
   Add a piece of magnesium to the second test tube.
   Add a piece of copper to the third test tube.



4. Watch carefully what happens in each test tube.
   In the table on your 'assessment' sheet **record** your results by writing down
   - the name of each metal
   - whether bubbles of gas were given off or not
   - the speed at which the bubbles were given off.

- Reaction of Metals with Acid -

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

* *What was the aim of the experiment?*
PC(b)

Procedure

* *What allowed you to get some idea of the reactivity of the metals?*
PC(b)

Results

* *Complete the following table:*
PC(c)

Metal	Bubbles of gas produced?	Reaction speed

CONCLUSION

* *Put the metals in order of reactivity starting with the most reactive.*
PC(d)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

2 mol l^{-1} hydrochloric acid (~ 15 cm^3)
(172 cm^3 concentrated hydrochloric acid per litre)

2 mol l^{-1} hydrochloric acid


irritant

concentrated hydrochloric acid


corrosive

magnesium ribbon (~ 2 cm)

magnesium


highly flammable

ZINC (~ 2 X 0.5 CM STRIP)
(cut from zinc foil)

COPPER (~ 2 X 0.5 CM STRIP)
(CUT FROM COPPER FOIL)

APPARATUS

test tubes (3)
test tube rack (1)
100 cm^3 beaker (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
2 mol l^{-1} hydrochloric acid from concentrated acid	Fumes and solution of concentrated acid are corrosive to eyes, skin and respiratory system.	Wear goggles and carry out dilution in a fume cupboard.
magnesium ribbon	Highly flammable.	Provide in closed containers and carefully control distribution.
pieces of metal foil	Possible sharp edges.	Wear eye prtection during cutting and dispensing.

Notes

This experiment should be carried out in a well-ventilated room.

- Factors which affect Lathering -

INTRODUCTION

It is difficult to clean things in water alone because substances like oil and grease do not dissolve in water. This is why we have to add **detergents** to the water. Detergents break down grease and oil into very tiny drops which then mix with the water and can be washed away.

Most detergents produce a **lather** or foam when they are shaken with water.

The aim of this experiment is to investigate a factor which might affect the amount of lather produced when detergents are shaken with water.

Some of the factors we could investigate are:

- the type of detergent
- the volume of detergent
- the temperature of the water
- the amount of shaking
- the volume of water

To make the investigation fair we can only change one factor during the experiments. All the other factors must be kept the same.

From the first two factors in the list, choose **one** you would like to investigate.
If you choose the first one go to the section with the heading '**type of detergent**'. If you choose the second factor go to the section with the heading '**volume of detergent**'.

type of detergent

Requirements (what you need)

test tubes with stoppers to fit
test tube rack
ruler
syringe
timer
beaker

solutions of: automatic washing powder
non-automatic washing powder
dishwasher powder

Hazards

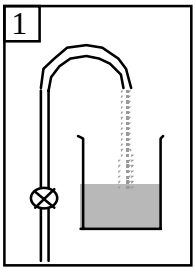
All the detergent solutions irritate the eyes.

Care

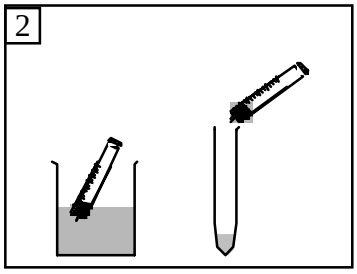
Wear safety glasses.
If any detergent solution splashes on your skin, wash it off immediately.
When using the syringe always keep it pointing downwards.

Procedure (what you do)

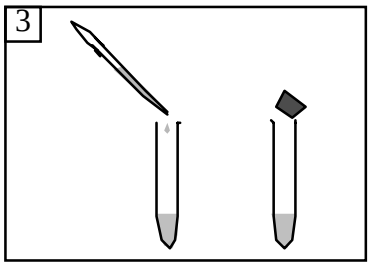
1. Fill the beaker half full with water.



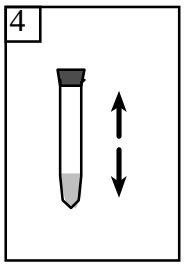
2. Using the syringe measure out 3 cm^3 of water into a test tube.



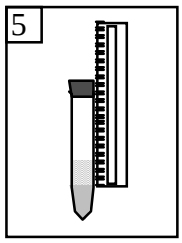
3. Add **two** drops of automatic washing powder solution to the water and stopper the tube.



4. With your thumb on the stopper shake the test tube hard for 15 seconds.



5. Let the solution settle for 15 seconds and then use the ruler to **measure** the height of the foam.
   Record your result by writing it down in the table on your 'assessment' sheet.



6. To obtain a duplicate result repeat steps 2 to 5 with two drops of the **same** automatic washing powder solution.
   Remember to **measure** and **record** the height of the foam.

7. Repeat the experiment first with the solution of the non-automatic washing powder and then with the solution of the dishwasher powder. Remember to do each one twice to get duplicate results.

volume of detergent

Requirements (what you need)

test tubes with stoppers to fit
test tube rack
ruler
syringe
timer
beaker
solution of washing-up liquid

Hazard

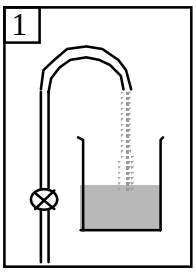
The solution of washing-up liquid irritates the eyes.

Care

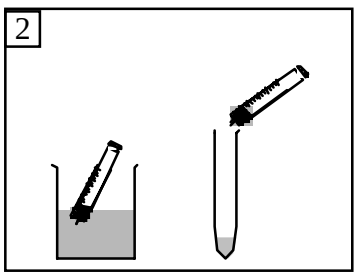
Wear safety glasses.
If any solution splashes on your skin, wash it off immediately.
When using the syringe always keep it pointing downwards.

Procedure (what you do)

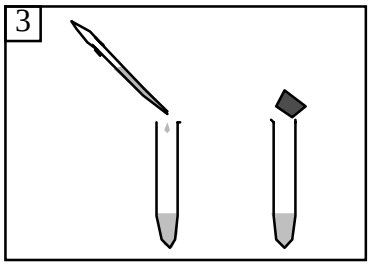
1. Fill the beaker half full with water.



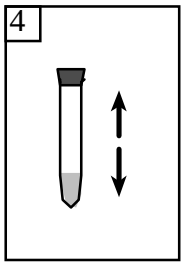
2. Using the syringe measure out 3 cm^3 of water into a test tube.



3. Add **one** drop of the solution of washing-up liquid to the water and stopper the tube.

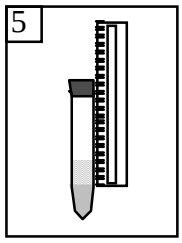


4. With your thumb on the stopper shake the test tube hard for 15 seconds.



5. Let the solution settle for 15 seconds and then use the ruler to **measure** the height of the foam.

   Record your result by writing it down in the table on your 'assessment' sheet.



6. To obtain a duplicate result repeat steps 2 to 5 with **one drop** of the solution of washing-up liquid.
   Remember to **measure** and **record** the height of the foam.

7. Repeat the experiment first with **two** drops of the solution of washing-up liquid and then with **three** drops of the same solution. Remember to do each one twice to get duplicate results.

INTERMEDIATE 1	**- Factors which affect Lathering -**	**UNIT 2 PPA 3**

Name:	PC(a)	PC(b)			PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:								

- ASSESSMENT SHEET -

* *What was the aim of the experiment? (Remember to say which factor you* **PC(b)** *were investigating)*

Procedure

* *Which factors were kept the same in the experiment? (Give at least four)*
PC(b)

* *How did you get some idea of the amount of lather formed?*
PC(b)

Results

* *Complete the following table:*
PC(c)

	Height of foam / cm		
	Result 1	Result 2	Average†

† To work out the average height of the foam add results 1 and 2 together and divide this number by 2.

Conclusion

* *What did you find out from this experiment?*
  PC(d)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents for 'type of detergent' investigation

5% automatic washing powder solution (a few drops)
(5 g automatic washing powder per 100 cm^3 water)

5% non-automatic washing powder solution (a few drops)
(5 g non-automatic washing powder per 100 cm^3 water)

5% dishwasher powder solution (a few drops)
(5 g dishwasher powder per 100 cm^3 water)

Reagent for 'volume of detergent' investigation

1% washing-up liquid solution (a few drops)
(1 cm^3 washing-up liquid per 100 cm^3 water)

Hazard warning labels for detergents as per suppliers' containers.
Dishwasher powder is the only one likely to carry a hazard sign viz. Irritant

APPARATUS FOR BOTH INVESTIGATIONS

test tubes with stoppers to fit (6)
test tube rack (1)
ruler (1)
5 cm^3 syringe (1)
timer (1)
50 cm^3 beaker (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
5% solutions of: automatic washing powder non-automatic washing powder dishwasher powder from solids 1% solution of: washing-up liquid	All are irritating to eyes.	Wear eye protection and gloves.

Notes

In view of the wide variety of detergents available a pre-class trial should be carried out in order to establish suitable concentrations and volumes of solutions to be used.

'Biological' detergents should be avoided as should products containing bleaches.

- Solubility -

INTRODUCTION

Compounds called **fertilisers** are added to the soil to help plants to grow well. A compound can be used as a fertiliser if it contains one of the **essential elements**, nitrogen (N), phosphorus (P) or potassium (K) and if it **dissolves in water**.

Ammonium compounds (N), potassium compounds (K), nitrate compounds (N) and phosphate compounds (P) are all possible fertilisers because each one contains an essential element. However, only the ones which are soluble in water will be able to fertilise plants.

The aim of this experiment is to test the solubility in water of some ammonium, potassium, nitrate and phosphate compounds in order to decide if they could be used as fertilisers.

Requirements (what you need)

test tubes
test tube rack
beaker

samples of: ammonium sulphate
potassium nitrate
sodium nitrate
calcium phosphate
ammonium phosphate

Hazards

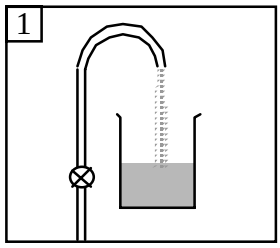
All the compounds are harmful if swallowed.
Calcium phosphate is powdery and the dust can irritate the eyes.

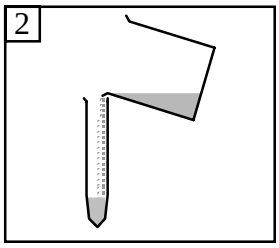
Care

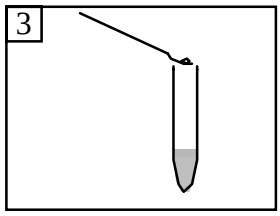
Wear safety glasses.
Any spillages of the compounds on the skin should be washed off immediately.

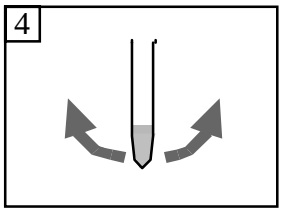
Procedure (what you do)

1. Fill the beaker half full with water.
2. Pour water into a test tube to a depth of 3 - 4 cm.
3. Using a spatula add a tiny amount (about the size of half a pea) of ammonium sulphate to the water.
4. Hold the test tube at the mouth and 'flick' it back and forth for several minutes.









5. Look at the mixture to see if the solid has dissolved.
6. In the table on your 'assessment' sheet **record** the result by writing down the name of the compound and whether it was soluble or insoluble.
7. Repeat the experiment with each of the remaining compounds **recording** the result each time.

INTERMEDIATE 1	**- Solubility -**	**UNIT 3 PPA 1**

Name:	PC(a)	PC(b)		PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:							

- ASSESSMENT SHEET -

* *What was the aim of the experiment?*
PC(b)

Procedure

* *Describe briefly how you tested the solubility of the compounds.*
PC(b)

Results

* *Complete the following table:*
PC(c)

Name of compound	Soluble / Insoluble

CONCLUSION

* *Which compound could not be used as a fertiliser?*
PC(d)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

ammonium sulphate (~0.2 g)

potassium nitrate (~0.2 g)

potassium nitrate

oxidising

sodium nitrate (~0.2 g)

sodium nitrate

oxidising

irritant

calcium phosphate (~0.2 g)

ammonium phosphate (~0.2 g)

APPARATUS

100 cm^3 beaker (1)
test tubes (5)
test tube rack (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
ammonium sulphate potassium nitrate sodium nitrate calcium phosphate ammonium phosphate	All five salts are harmful if ingested in quantity but the two nitrates are more harmful than the others. Dust from any of the solids can irritate the eyes. However of the five salts only calcium phosphate is powdery; the others are crystalline and unlikely to give rise to any dust. Friction of the nitrates with dust or organic matter may cause a reaction or fire.	Wear eye protection and gloves when dispensing into smaller containers. Wash well any area of spillage of the nitrates.

Notes

Some students may not be familiar with the 'flicking' technique of shaking. If this is the case then it should be demonstrated to them.

- Burning Carbohydrates -

INTRODUCTION

Carbohydrates are compounds of carbon, hydrogen and oxygen. **Starch** and **sugar** are carbohydrates and they provide us with the energy our bodies need.

The aim of this experiment is to show that heat energy is produced when starch and sugar are burned and to compare how much heat energy each produces.

We will burn **flour** as the 'starch' carbohydrate and **icing sugar** as the 'sugar' carbohydrate. The energy produced when they burn will be used to heat water. The rise in temperature of the water will give us some idea of how much heat energy has been produced.

To make the experiment fair the same amount of flour and icing sugar will be burned and the same volume of water will be heated.

Requirements (what you need)

spatula
boiling tube
beaker
thermometer
measuring cylinder
Bunsen burner and heating mat
clamp stand and clamp

flour
icing sugar

Hazard

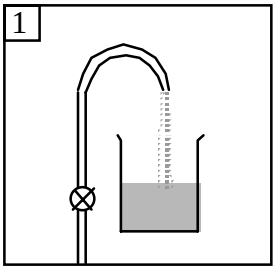
Flour dust will damage the lungs if inhaled.

Care

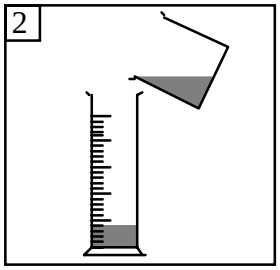
Wear safety glasses.
Avoid raising a dust from the flour.

Procedure (what you do)

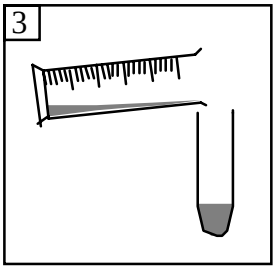
1. Fill the beaker half full with water.



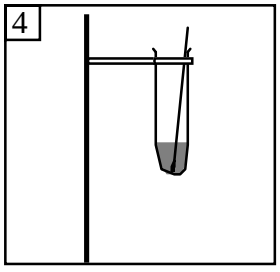
2. Add water to the measuring cylinder up to the 10 cm^3 mark.



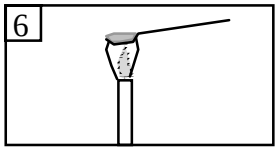
3. Pour this water into the boiling tube.



4. Clamp the boiling tube in a vertical position. **Measure** the temperature of the water in the boiling tube. **Record** this temperature by writing it down in the table on your 'assessment' sheet.



5. Light the Bunsen burner and add flour to the spatula to give a level spatulaful.
6. Heat the flour in the Bunsen flame until it just catches fire.



7. Quickly place the burning flour underneath the boiling tube so that the flames are touching the bottom of the boiling tube.

8. When the flour has stopped burning, stir the water with thermometer. **Measure** and **record** the final temperature of the water.
9. Repeat the experiment using icing sugar. Make sure the amount of icing sugar you burn is the same as the amount of flour you burned.
   Remember to **measure** and **record** the starting temperature of the water and the final temperature of the water.

INTERMEDIATE 1	**- Burning Carbohydrates -**	**UNIT 3 PPA 2**

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

* *What was the aim of the experiment?*
PC(b)

Procedure

* *Draw and label a diagram showing the water in the boiling tube being heated by the* **PC(b)** *burning carbohydrate. (In other words, draw a labelled diagram that would go with step 7 on the 'instructions' sheet)*

Results

* *Complete the following table:*
PC(c)

Carbohydrate	Starting temperature of water / °C	Final temperature of water / °C	Rise in temperature / °C

CONCLUSION

* *What did you find out from this experiment?*
PC(d)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

flour (~ 0.2 g)

icing sugar (~ 0.2 g)

APPARATUS

Nuffield type spatula (1)
boiling tube (1)
100 cm^3 beaker (1)
50 cm^3 measuring cylinder (1)
0 - 100 °C thermometer (1)
Bunsen burner (1)
heating mat (1)
clamp stand (1)
clamp (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
flour	Respiratory sensitiser.	Wear eye protection and avoid raising dust.

Notes

There is a possible danger of students getting their hands slightly burned when holding the spatula in the Bunsen flame.

This risk could be avoided by clamping the spatula or by using a combustion spoon with a wooden handle.

- Testing for Starch and Sugars in Food -

INTRODUCTION

Starch and **sugars** are important substances in the food we eat. They are called **carbohydrates** and our bodies use them to produce energy.

We can test for **starch** by adding iodine solution to a sample of food. If the **iodine solution** changes from **brown** to a **blue/black** colour then the food sample has starch in it.

We can use Benedict's test to find out if a food contains **sugars**. When the food sample is heated in **blue Benedict's solution** and an **orange/red solid** is formed then we know the food sample must have a sugar in it. However, if an orange/red solid is not formed we cannot say for sure that the food sample does not contain a sugar. Some sugars such as sucrose do not form an orange/red solid when they are heated in Benedict's solution.

The aim of this experiment is to test for starch and sugars in some food samples.

Requirements (what you need)

dimple tray
test tubes
test tube rack
large glass beaker
Bunsen burner and heating mat
tripod
iodine solution
Benedict's solution
samples of milk, bread, potato and egg white

Hazards

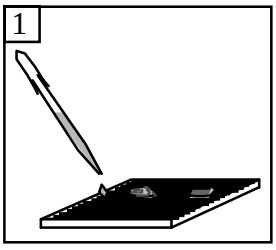
Benedict's solution is harmful if swallowed.
Iodine solution irritates the eyes.

Care

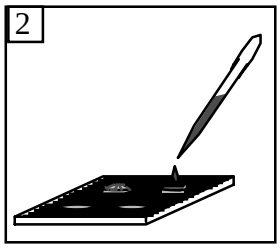
Wear safety glasses.
If any Benedict's solution splashes on your skin, wash it off immediately.
If any iodine solution splashes on your skin, wash it off with water and then with sodium thiosulphate solution.

Procedure (what you do)

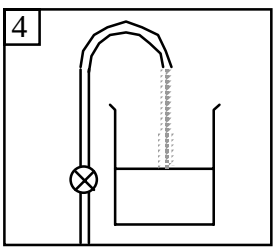
1. Add samples of milk, bread, potato and egg white to separate dimples in the tray.

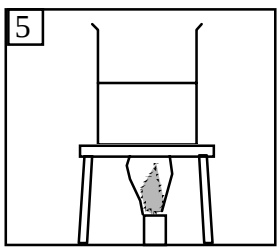


2. To each of the food samples add a few drops of iodine solution.



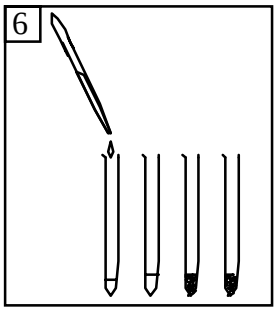
3. Watch what happens to the iodine solution and **record** your results by writing them down in the table on your 'assessment' sheet.
4. Fill the large glass beaker half full with water.
5. Put the beaker of water on the tripod.
   Light the Bunsen burner, put it under the tripod and heat the water until it boils.
   Remove the Bunsen burner from below the beaker.

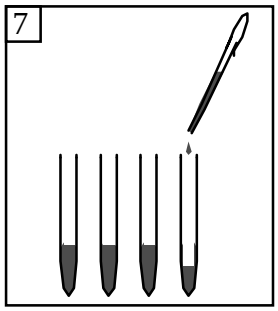




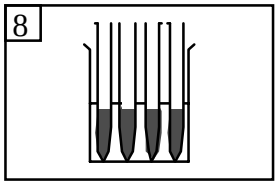
Or boil some water in a kettle and pour it into the beaker.

6. Add some milk to one test tube and egg white to another test tube to a depth of about 1 cm. Take a sample of bread and break it up into crumbs. Add the bread crumbs to a third test tube.
   Break up a sample of potato into tiny pieces and add them to a fourth test tube.
7. To each of these four test tubes add Benedict's solution to give a total depth of about 3 cm.





8. Place the test tubes in the hot water and watch what happens to the Benedict's solution.
   Record your results in the table on your 'assessment' sheet.



INTERMEDIATE 1	**- Testing for Starch and Sugars in Food -**	**UNIT 3 PPA 3**

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

* *What was the aim of the experiment?*
PC(b)

Procedure

* *How did you test for starch in the food samples?*
PC(b)

* *How did you test for sugars in the food samples?*
PC(b)

Results

* *Complete the following table:*
PC(c)

Food sample	Observations on adding iodine solution	Observations on heating with Benedict's solution

CONCLUSION

* *Complete the following table:*
PC(d)

Food sample	Is starch present?	Are sugars present?

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

milk (~ 2 cm^3)

egg white (~ 2 cm^3)

bread (~ 2 g)

potato (~ 2 g)

iodine solution (~ 2 cm^3)
(12.7 g iodine and 20 g potassium iodide per litre)

iodine

harmful

Benedict's solution (~ 15 cm^3)

Benedict's solution

harmful

APPARATUS

dimple tray (1)
test tubes (4)
test tube rack (1)
400 cm^3 glass beaker (1)
Bunsen burner (1)
heating mat (1)
tripod (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
iodine solution from solid	Solid burns eyes and skin; harmful if ingested. Vapour irritates the eyes.	Wear goggles and pvc gloves. Prepare in ventilated room and keep 1 mol l^{-1} sodium thiosulphate handy to treat any spills on the skin.
Benedict's solution	Harmful by ingestion owing to copper salts.	Wear eye protection. If prepared see recipe in Hazardous Chemicals Manual.

Notes

1 mol l^{-1} sodium thiosulphate should be available to students to treat any spillages of iodine solution.

Fehling's solutions No. 1 (harmful) and No. 2 (corrosive) can be used as an alternative to Benedict's solution.

Sandell's reagent can also be used as a substitute for Benedict's solution. Its preparation is described in the Hazardous Chemicals Manual under *Fehling's solutions No. 1 and No. 2*.

INTERMEDIATE 2

INTRODUCTION

The aim of this experiment is to find the effect of varying the concentration of sodium persulphate solution on the rate of its reaction with potassium iodide solution.

Small quantities of starch and sodium thiosulphate are included in the reaction mixture in order to provide us with a convenient way of following the course of the reaction. Initially the reaction mixture is colourless but after some time a blue/black colour suddenly appears as the starch reacts with the iodine produced in the reaction. This marks a point when the reaction has gone a set 'distance'.

If t is the time taken for the blue/black colour to appear then the rate of the reaction can be expressed as:

$$\text{rate} = \frac{1}{t}$$

If t is in seconds then the rate will have units, s^{-1}.

A series of experiments will be carried out in which only the concentration of the sodium persulphate solution will be varied. The concentration and volume of the potassium iodide solution will be kept constant as will the temperature at which the experiments are performed.

Requirements

syringes	sodium persulphate solution
100 cm^3 glass beakers	potassium iodide solution (including sodium thiosulphate)
timer	starch solution
white tile	deionised water

Hazards

There is a very small risk of skin sensitisation from the sodium persulphate solution.

Care

Wear eye protection and when working with the sodium persulphate solution, wear gloves to avoid contact with the skin.
When using the syringes always keep them pointing downwards.

Procedure

1. Using syringes measure out 10 cm^3 of sodium persulphate solution and 1 cm^3 of starch solution into a dry 100 cm^3 glass beaker and place the beaker on the white tile.
2. Fill another syringe with 10 cm^3 of potassium iodide solution. Quickly add this to the sodium persulphate solution in the glass beaker and at the same time start the timer.
3. When the reaction mixture suddenly goes blue/black in colour stop the timer and record the time in seconds.
4. Using syringes, measure out 8 cm^3 of sodium persulphate solution, 2 cm^3 of deionised water and 1 cm^3 of starch solution into a dry 100 cm^3 glass beaker. Adding water dilutes the sodium persulphate solution and so reduces its concentration.
5. Place this beaker on the white tile. Quickly add 10 cm^3 of potassium iodide solution to the diluted sodium persulphate solution and at the same time start the timer.
6. When the reaction mixture just turns blue/black stop the timer and record the time in seconds.
7. Repeat the experiment another two times:
   firstly with 6 cm^3 of sodium persulphate solution, 4 cm^3 of deionised water and 1 cm^3 of starch solution being added to the beaker before adding 10 cm^3 of potassium iodide solution and then **secondly** with 4 cm^3 of sodium persulphate solution, 6 cm^3 of deionised water and 1 cm^3 of starch solution being added to the beaker before adding 10 cm^3 of potassium iodide solution.
   In each case measure and record the time it takes for the blue/black colour to appear.

INTERMEDIATE 2	- The Effect of Concentration Changes on Reaction Rate -	UNIT 1 PPA 1

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

Procedure

* *How was the concentration of the sodium persulphate solution varied?*
PC(b)

* *How was the rate of the reaction determined?*
PC(b)

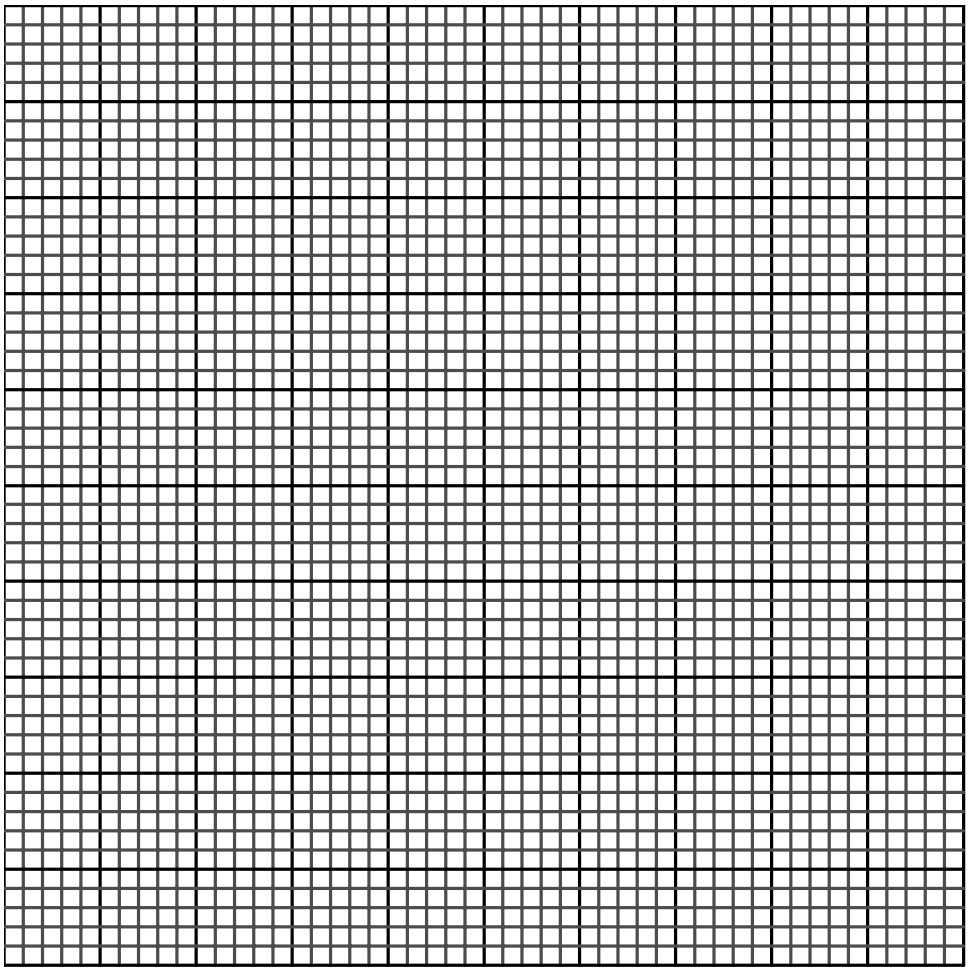
Results

* *Complete the following table apart from the bottom row of entries:*
PC(c)

Experiment	1	2	3	4
Volume of sodium persulphate / cm^3	10	8		
Volume of water / cm^3	0	2		
Time for blue/black colour to appear / s				
Rate / s^{-1}				

* Work out the rate of each reaction and add these to the table above.
PC(d)

* Draw a line graph of 'reaction rate / s^{-1}' against 'volume of sodium persulphate.
PC(d) solution / cm^3' (Since the total volume of the reaction mixture was the same in each experiment we can assume that the volume of the sodium persulphate solution is a measure of its concentration)



CONCLUSION

* *State the conclusion of the experiment.*
PC(d)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

0.10 mol l^{-1} sodium persulphate (28 cm^3)
(23.8 g sodium persulphate per litre)

0.10 mol l^{-1} sodium persulphate


irritant

sodium persulphate


oxidising


harmful

potassium iodide/sodium thiosulphate solution (40 cm^3)
(50 g potassium iodide plus 6 cm^3 1.0 mol l^{-1} sodium thiosulphate per litre)

1 % fresh starch solution (4 cm^3)
(Mix 1 g soluble starch to a thin paste with water, then add to 100 cm^3 boiling water)

deionised water (12 cm^3)

APPARATUS

selection of syringes - 1 cm^3 (1), 10 cm^3 (3)
100 cm^3 glass beakers (4)
timer (1)
white tile (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
0.1 mol l^{-1} sodium persulphate from solid	The compound is a skin and respiratory sensitiser. It has a short shelf life and pressure may build up in container.	Wear goggles and pvc gloves. Open cautiously and handle gently to avoid raising an aerosol.

Notes

To reduce the risk of contamination a separate syringe for each solution is recommended.

Graduated pipettes or measuring cylinders could be used in place of the syringes.

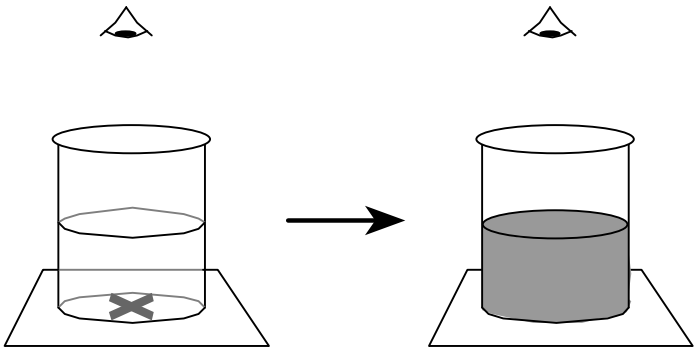
The starch could be included in the potassium iodide solution but it rapidly deteriorates on standing.

Older samples of persulphate may have deteriorated badly and may not work well. A pre-class trial is advised for old samples.

INTRODUCTION

The aim of this experiment is to find the effect of varying temperature on the rate of reaction between sodium thiosulphate solution and hydrochloric acid.

Initially the reaction mixture is clear but gradually becomes cloudy as solid sulphur is formed in the reaction. We can follow the course of the reaction by placing the reaction mixture over a cross drawn on a piece of paper and timing how long it takes for the cross to be obscured by the sulphur:



A series of experiments will be carried out in which only the temperature of the reaction mixture will be varied. The concentrations and volumes of the reactants will be kept constant.

The amount of sulphur needed to obscure the cross will be the same in each experiment but the time it takes for this to happen will vary. If the time taken to obscure the cross is t then we can express the rate as:

$$\text{rate} = \frac{1}{t}$$

If t is in seconds then the rate will have units, s^{-1}.

Requirements

syringes ($20\,cm^3$ and $1\,cm^3$)
$100\,cm^3$ glass beakers
$250\,cm^3$ glass beaker
timer
thermometer
tripod
Bunsen burner and heating mat
paper with 'cross' mark
sodium thiosulphate solution
hydrochloric acid

Hazards

Hydrochloric acid irritates the eyes.
The sulphur dioxide produced in the reaction irritates the lungs and may trigger off wheezing if you are asthmatic. Consult your teacher/lecturer.

Care

Wear eye protection and avoid breathing the fumes of sulphur dioxide.
When using the syringes always keep them pointing downwards.

Procedure

1. Add about $100\,cm^3$ of sodium thiosulphate solution to the large glass beaker.
2. Using a syringe measure $20\,cm^3$ of sodium thiosulphate solution from the large beaker into a small glass beaker and place the reaction mixture on a piece of paper with a cross marked on it.

3. Fill the small syringe with 1 cm^3 of hydrochloric acid. Quickly add this to the sodium thiosulphate solution in the small beaker and at the same time start the timer.
4. Measure and record the time it takes for the cross to be obscured as you look down into the solution. Measure and record the temperature of the reaction mixture.
5. Fill the beaker with cold water before you dispose of the solution down the sink. This reduces the amount of sulphur dioxide released into the atmosphere.
6. Heat the remaining sodium thiosulphate solution in the large beaker until its temperature is about 30 °C but do **not** record this temperature.
7. Measure out 20 cm^3 of the warm sodium thiosulphate solution into a small glass beaker† and place it over the cross. Add 1 cm^3 of hydrochloric acid and measure and record the time taken for the cross to be obscured. Measure and record the temperature of the reaction mixture.
8. Repeat the experiment after heating the sodium thiosulphate solution to about 40 °C and then again after heating the sodium thiosulphate solution to about 50 °C. Do **not** heat the sodium thiosulphate solution beyond this temperature.

† If you are using the same small glass beaker as you used in the first part of the experiment, then make sure it has been thoroughly cleaned.

INTERMEDIATE 2	- The Effect of Temperature Changes on Reaction Rate -	UNIT 1 PPA 2

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

Procedure

* *How was the rate of the reaction determined?*
PC(b)

* *Apart from the volumes and concentrations of the reactants, what other factor was* **PC(b)** *kept constant?*

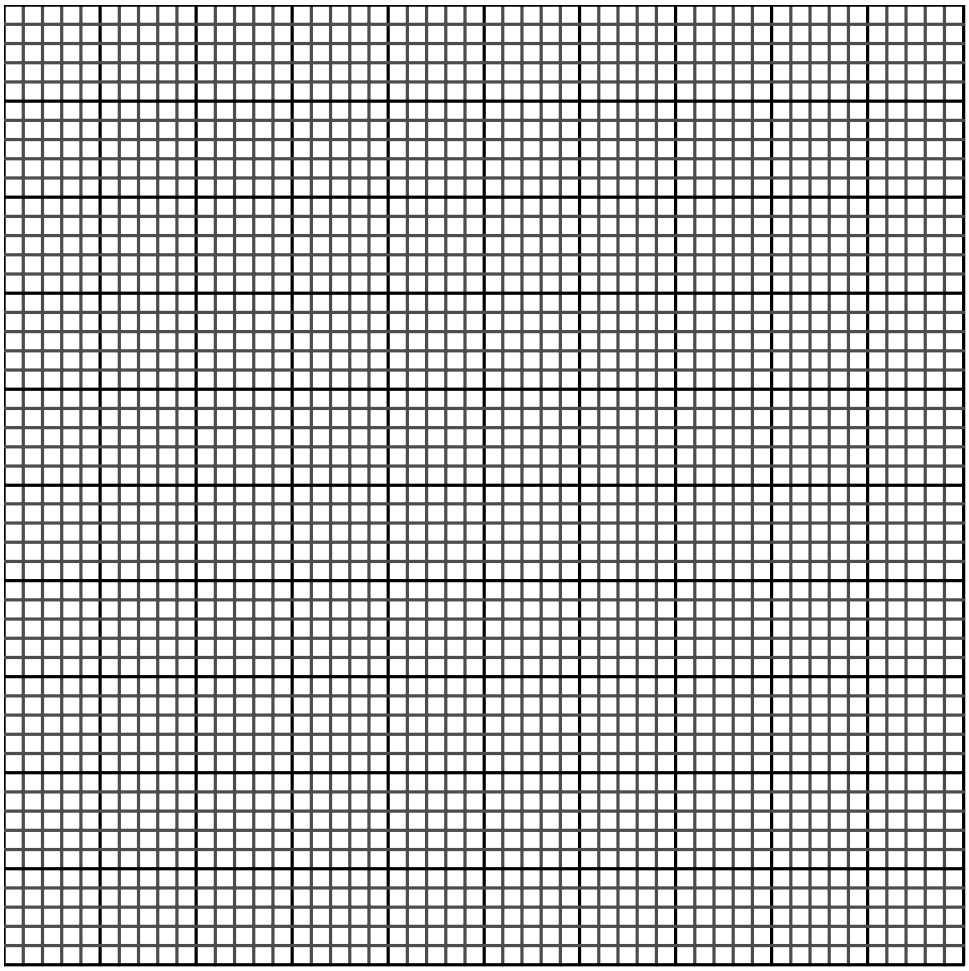
Results

* *Complete the following table apart from the bottom row of entries:*
PC(c)

Experiment	1	2	3	4
Temperature of reaction mixture / °C				
Time for cross to be obscured / s				
Rate / s^{-1}				

* *Work out the rate of each reaction and add these to the table above.*
PC(d)

* *Draw a line graph of 'reaction rate / s^{-1}' against 'temperature / °C'.*
PC(d)



CONCLUSION

* *State the conclusion of the experiment.*
PC(d)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

0.10 mol l^{-1} sodium thiosulphate (80 cm^3)
(24.8 g sodium thiosulphate 5-hydrate per litre)

1.0 mol l^{-1} hydrochloric acid (4 cm^3)
(86 cm^3 concentrated hydrochloric acid per litre)

1.0 mol l^{-1} hydrochloric acid


irritant

concentrated hydrochloric acid


corrosive

APPARATUS

syringes - 1 cm^3 (1), 20 cm^3 (1)
100 cm^3 glass beakers (4)
250 cm^3 glass beakers (1)
timer (1)
0 - 100 °C thermometer (1)
tripod (1)
Bunsen burner (1)
heating mat (1)
paper with 'cross' mark (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
1 mol l^{-1} hydrochloric acid from concentrated acid	Fumes and solution of concentrated acid are corrosive to eyes, skin and respiratory system.	Wear goggles and carry out dilution to 1 mol l^{-1} in a fume cupboard.
0.1 mol l^{-1} sodium thiosulphate from solid	Solid may irritate eyes.	Wear eye protection.

Notes

This experiment should be carried out in a well-ventilated room.

Students who are asthmatic should be warned that the sulphur dioxide released may provoke an attack.

To reduce the risk of contamination a separate syringe for each solution is recommended.

Graduated pipettes or measuring cylinders could be used in place of the syringes.

Conical flasks could be used in place of the beakers thus reducing the amount of sulphur dioxide released into the atmosphere.

Immediately a measurement or run has been completed a few cm^3 of $2.0\,mol\,l^{-1}$ sodium carbonate could be added to the reaction mixture before filling the container with cold water. This would further limit the release of sulphur dioxide.

- Electrolysis -

INTRODUCTION

When an ionic compound is dissolved in water it conducts electricity. A conducting solution of this kind is an example of an electrolyte. Since opposite charges attract, the positively charged ions in the electrolyte move to the negative electrode while the negatively charged ions move to the positive electrode. The ions undergo chemical changes at the electrodes which result in the decomposition or breakdown of the electrolyte. This process of passing a current of electricity through an electrolyte is known as electrolysis.

The aim of this experiment is to electrolyse copper chloride solution and to identify the products at the positive and negative electrodes.

Requirements

electrolytic cell with carbon electrodes
low voltage source of electricity
connecting wires
copper(II) chloride solution
blue litmus paper

Hazards

Copper(II) chloride solution irritates the eyes and skin.
The gas given off during electrolysis may provoke an attack if you are asthmatic. Consult your teacher/lecturer.

Care

Wear eye protection and immediately wash your hands if any copper(II) chloride solution spills on them.
When smelling the gas released during the electrolysis do it very cautiously using the technique described below.
If you use a power pack do not plug it into the mains until you have had the circuit checked by your teacher/lecturer.

Procedure

1. Add copper(II) chloride solution to the electrolytic cell.
2. As directed by your teacher/lecturer set up a circuit containing the electrolytic cell but **do not switch on** the electrical source until your circuit has been checked by your teacher/lecturer.
3. Switch on the source of electricity. Observe and record what is happening at the positive electrode (the one connected to the red terminal of the electrical source).
4. Hold a piece of moist blue litmus paper over the positive electrode and record what happens to the litmus paper.
5. Switch off the source of electricity.
6. To smell the gas given off at the positive electrode follow the technique outlined below.
   First breathe in deeply to fill the lungs with **uncontaminated** air.
   With your nose at least 30 cm from the electrolytic cell gently waft your hand over the cell towards your nose and take just a sniff of the gas. Record the smell.
7. Empty out the electrolytic cell and look closely at the electrode which had been connected to the negative terminal of the electrical source. Record your observations.

INTERMEDIATE 2	- Electrolysis -	UNIT 1 PPA 3

Name:	PC(a)	PC(b)		PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:							

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

Procedure

* *Draw a labelled diagram of the circuit.*
PC(b)

Results

* *Complete the following table.*
PC(c)

Observations at	
positive electrode	negative electrode

Conclusion

* *State the conclusion of the experiment.*
PC(d)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

$0.10\,mol\,l^{-1}$ copper(II) chloride
(17.0 g copper(II) chloride 2-hydrate per litre)

copper(II) chloride 2-hydrate

toxic

blue litmus paper

APPARATUS

electrolytic cell (1)
carbon electrodes (2)
low voltage source of electricity
connecting wires (2)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
$0.1\,mol\,l^{-1}$ copper(II) chloride from dihydrate	Solid is toxic by ingestion and irritating to the eyes, skin and respiratory system.	Wear goggles and pvc gloves. Do not use the anhydrous salt. The hydrate is crystalline and not dusty and in any case dissolves more readily.

Notes

The electrolysis should be carried out on a small scale and in a well-ventilated room.

Students who are asthmatic should be warned that the chlorine released may provoke an attack.

Various types of electrolytic cells can be used but the current should be kept below 0.3 A to limit the amount of chlorine released.

pH paper can be used as an alternative to litmus paper.

- Testing for Unsaturation -

INTRODUCTION

Alkanes and cycloalkanes are described as **saturated** hydrocarbons because the carbon-carbon bonds they contain are all single covalent bonds. Hydrocarbons which contain at least one carbon-carbon double bond are said to be **unsaturated**.

The presence of unsaturation in organic compounds can be shown by using bromine solution. It has an orange/red colour as a result of the bromine molecules it contains. When bromine solution is shaken with an unsaturated hydrocarbon the bromine molecules 'add on' across the carbon-carbon double bonds and the reaction mixture rapidly turns colourless. When a saturated hydrocarbon and bromine solution are mixed the orange/red colour remains.

The aim of this experiment is to test for unsaturation in four different hydrocarbons labelled A (C_6H_{14}), B (C_6H_{12}), C (C_6H_{12}) and D (C_6H_{10}) and in the light of the results suggest a possible structure for each one.

Requirements

test tubes and rack

hydrocarbons **A**, **B**, **C** and **D**

bromine solution

Hazards

Bromine solution causes burns and is toxic.
All the hydrocarbons are highly flammable and irritating to the eyes, skin and lungs. In addition, hydrocarbons **A** and **D** are harmful.

Care

Wear eye protection and gloves.
If any hydrocarbon splashes on your skin, wash it off immediately.
If any bromine solution splashes on your skin, wash it off immediately with sodium thiosulphate solution.
Make sure sources of ignition are absent.

Procedure

For each of the hydrocarbons **A**, **B**, **C** and **D** follow the procedure outlined below:

1. Add the hydrocarbon to a test tube to a depth of about 0.5 cm.
2. To the hydrocarbon add about 10 drops of bromine solution.
3. Shake the contents of the test tube by 'waggling' it. Do **not** place your thumb on the mouth of the test tube.
4. Record your observations.

INTERMEDIATE 2	**- Testing for Unsaturation -**	**UNIT 2 PPA 1**

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

* *What is the main difference between saturated and unsaturated hydrocarbons in terms of structure?*

Procedure

* *Describe briefly how you tested for unsaturation in the hydrocarbons.*
PC(b)

Results / Conclusions

* *Complete the following table:* **PC(c), PC(d)**

Hydrocarbon	Molecular formula	Observations on adding bromine solution	Saturated or unsaturated?
A	C_6H_{14}		
B	C_6H_{12}		
C	C_6H_{12}		
D	C_6H_{10}		

- Testing for Unsaturation -

* *Draw a possible full structural formula for each of the hydrocarbons.*
PC(d)

A (C_6H_{14})

B (C_6H_{12})

C (C_6H_{12})

D (C_6H_{10})

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

hydrocarbon **A** (~1 cm^3)
(hexane)

hydrocarbon A
hexane


harmful


highly flammable

hydrocarbon **B** (~1 cm^3)
(hex-1-ene)

hydrocarbon B
hex-1-ene


irritant


highly flammable

hydrocarbon **C** (~1 cm^3)
(CYCLOHEXANE)

hydrocarbon C
cyclohexane


highly flammable

hydrocarbon **D** (~1 cm^3)
(CYCLOHEXENE)

hydrocarbon D
cyclohexene


harmful


highly flammable

bromine solution (~2 cm^3)
(DILUTE SOLUTION OF BROMINE IN WATER)

bromine solution
bromine


toxic


corrosive

APPARATUS

test tubes (4)

test tube rack (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
hexane hex-1-ene cyclohexane cyclohexene	All highly flammable. All are irritating to the eyes, skin and respiratory system but irreversible damage is caused by prolonged exposure to hexane.	Wear eye protection and nitrile gloves. Ensure absence of ignition sources and carry out decanting in a fume cupboard or well-ventilated room. Provide in small reagent bottles (50 or 100 cm^3).
bromine water by dilution of bromine	Bromine causes severe burns and vapour is very toxic. Bromine water causes burns and is to be treated as toxic.	Wear goggles and nitrile gloves. Keep 1 mol l^{-1} sodium thiosulphate handy to treat any spills on the skin. Provide bromine water in small dropper bottles. In preparing the bromine solution it is worth considering the breaking of a small vial by shaking it hard in a stoppered reagent bottle half filled with water.

Notes

This experiment should be carried out in a well-ventilated room or in a fume cupboard.

$1\,mol\,l^{-1}$ sodium thiosulphate should be available to students to treat any spillages of bromine solution.

For alternatives to bromine water see *Bromine* in Hazardous Chemicals Manual.

INTRODUCTION

Cracking is an industrial process in which alkanes are split into a mixture of smaller molecules some of which are unsaturated.

Cracking is important for two reasons:

- it converts long-chain alkanes from crude oil into shorter alkanes for which there is a greater demand
- it produces unsaturated hydrocarbons which are important starting materials in the manufacture of plastics.

High temperatures are needed to crack alkanes and this is expensive. However, if a catalyst is used the process can be carried out at much lower temperatures.

The aim of this experiment is to crack liquid paraffin (a mixture of alkanes of chain length C_{20} and greater) and to demonstrate that some of the products are unsaturated.

Requirements

test tubes and rack
stopper fitted with glass delivery tube
clamp stand and clamp
Bunsen burner and heating mat
mineral wool
tongs
liquid paraffin
aluminium oxide catalyst
bromine solution

Hazards

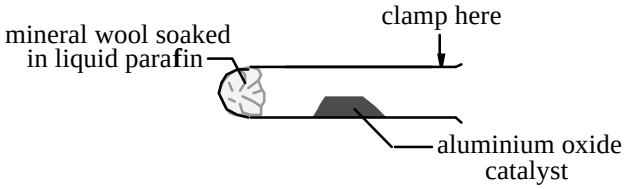
Bromine solution causes burns and is toxic.
Mineral wool can irritate the skin and is suspected of being a carcinogen.
There is a danger of **'suck-back'** in this experiment (see below).

Care

Wear eye protection and gloves.
If any bromine solution splashes on your skin, wash it off immediately with sodium thiosulphate solution.
Use tongs when handling the mineral wool.
Avoid breathing the gases produced in the cracking process.

Procedure

1. Add liquid paraffin to a dry test tube to a depth of about 1 cm.
2. Add a plug of mineral wool to soak up and support the liquid paraffin.
3. Clamp the test tube at its mouth and in a horizontal position.
4. Add a spatulaful of aluminium oxide catalyst to the middle of this test tube.



5. Add bromine solution to a second test tube to a depth of about 3 cm and place it in the test tube rack.
6. Fit the stopper and delivery tube to the clamped test tube and arrange the apparatus so that the end of the delivery tube is dipping into the bromine solution.

   DO NOT START HEATING YET.

7. Check with your teacher/lecturer that the apparatus is assembled correctly.
8. Check with your teacher/lecturer that you know how to avoid 'suck-back' and what to do if 'suck-back' does occur.
9. Heat the catalyst strongly for several seconds and then flick the flame onto the mineral wool for a few seconds in order to vapourise some of the liquid paraffin.
10. Continue heating the catalyst and from time to time transfer the heat to the mineral wool. At the same time observe what is happening to the bromine solution.
11. When a change has been observed in the bromine solution and **before** you stop heating, lift the clamp stand so that the delivery tube is removed from the bromine solution. This will prevent the possibility of 'suck-back'.

INTERMEDIATE 2	**- Cracking -**	**UNIT 2 PPA 2**

Name:	PC(a)	PC(b)			PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:								

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

Procedure

* Draw a labelled diagram of the assembled apparatus used to crack liquid paraffin and **PC(b)** to test the products for unsaturation.

* *Explain what is meant by 'suck-back' and the steps you took to prevent it.*
PC(b)

Results

* *Record your observations.*
PC(c)

Conclusions

* *State the conclusions of the experiment.* **PC(d)**

* *Suppose docosane, $C_{22}H_{46}$, (an alkane in liquid paraffin) cracks to produce octadecane, $C_{18}H_{38}$.*
*Using **molecular formulae** write an equation for this cracking process and **name** the other product.*

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

liquid paraffin (~1 cm^3)

aluminium oxide (~0.5 g)

bromine solution (~3 cm^3)
(VERY DILUTE SOLUTION OF BROMINE IN WATER)

bromine solution
bromine


toxic


corrosive

APPARATUS

test tubes (2)
test tube rack (1)
stopper fitted with glass delivery tube (1)
clamp stand and clamp (1)
Bunsen burner (1)
heating mat (1)
mineral wool
tongs (1)

mineral wool


irritant

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
bromine water by dilution of bromine	Bromine causes severe burns and vapour is very toxic. Bromine water causes burns and is to be treated as toxic.	Wear goggles and nitrile gloves. Keep 1 mol l^{-1} sodium thiosulphate handy to treat any spills on the skin. Provide bromine water in small dropper bottles. In preparing the bromine solution it is worth considering the breaking of a small vial by shaking it hard in a stoppered reagent bottle half filled with water.
mineral wool	Mineral wools can irritate the skin and are suspect weak carcinogens.	Handle with tongs/gloves.

Notes

This experiment should be carried out in a well-ventilated room or in a fume cupboard.

$1\,mol\,l^{-1}$ sodium thiosulphate should be available to students to treat any spillages of bromine solution.

Aluminium silicate, steel wool and broken pieces of unglazed porcelain can be used as substitutes for the aluminium oxide catalyst.

Scrunched up filter paper could be used as an alternative and safer reservoir for the liquid paraffin. Heating should be discontinued when the paper shows the first signs of charring.

The gaseous products could be bubbled through bromine solution contained in a fermentation lock - this will reduce the possibility of 'suck-back'.

For alternatives to bromine water see *Bromine* in Hazardous Chemicals Manual.

- Hydrolysis of Starch -

INTRODUCTION

Starch is a condensation polymer made from glucose monomer units. When these large starch molecules react with water they break down into smaller sugar molecules. The starch is said to be hydrolysed. We can tell if starch has been hydrolysed by testing for the small sugar molecules that are formed in the process. This can be achieved by heating the reaction mixture with Benedict's solution. Benedict's solution is blue but turns cloudy orange if certain sugar molecules† are present.

Starch hydrolysis is a very slow reaction but it can be speeded up by using an enzyme or an acid as catalyst.

The aim of this experiment is to hydrolyse starch in the presence of either an enzyme or an acid and to demonstrate that the enzyme or acid catalyses the reaction.

Decide which catalyst (**the enzyme or the acid**) you are going to use and then proceed to the appropriate section below.

† Not all sugars give a positive test with Benedict's solution but those formed in starch hydrolysis do.

Enzyme

Requirements

- test tubes and rack
- large glass beaker
- syringes
- thermometer
- tripod
- Bunsen burner and heating mat
- starch solution
- amylase (enzyme) solution
- Benedict's solution

Hazards

Amylase is harmful if a mist is formed.
Benedict's solution contains copper salts and so is harmful if swallowed. It irritates the eyes and skin.

Care

Wear eye protection.
If any chemical splashes on your skin, wash it off immediately.
When adding amylase solution to a test tube do it slowly and carefully to avoid creating a mist.
When using the syringes always keep them pointing downwards.

Procedure

1. Half fill the beaker with water and heat it until it reaches about 40 °C but no more.
2. Using a syringe add 3 cm^3 of starch solution to each of two test tubes.
3. To one of the test tubes add 1 cm^3 of water from a syringe - this will be the control. To the other test tube carefully add 1 cm^3 of amylase solution.
4. Place both test tubes in the beaker of warm water and leave them for 5 minutes.
5. After 5 minutes, use a syringe to add 2 cm^3 of Benedict's solution to each test tube.
6. Keep the test tubes in the beaker of water and then heat the water until it boils.
7. Observe and record what happens to the Benedict's solution in each test tube.

- Hydrolysis of Starch -

Acid

Requirements

- small glass beakers
- tripods
- Bunsen burners and heating mats
- syringes
- starch solution
- dilute hydrochloric acid
- Benedict's solution
- sodium hydrogencarbonate

Hazards

Benedict's solution contains copper salts and so is harmful if swallowed.
Both Benedict's solution and dilute hydrochloric acid irritate the eyes and skin.
On adding sodium hydrogencarbonate to hydrochloric acid an acid mist is formed which irritates the lungs.

Care

Wear eye protection.
If any chemical splashes on your skin, wash it off immediately.
Avoid breathing in the acid mist.
When using the syringes always keep them pointing downwards.

Procedure

1. Using a syringe add 10 cm^3 of starch solution to each of two small beakers.
2. To one of the beakers add 1 cm^3 of water from a syringe - this will be the control. To the other beaker add 1 cm^3 of dilute hydrochloric acid.
3. Place the beakers on the tripods and heat the reaction mixtures until they boil. Continue gentle boiling of the mixtures for 5 minutes and then remove the Bunsen burners.
4. Take great care in this next step since the mixture will froth up quite violently.
   Using a spatula add a tiny amount (equivalent to half a pea) of sodium hydrogencarbonate† to the beaker containing the acid/starch mixture. It is **not** necessary to add sodium hydrogencarbonate to the other mixture.
5. Continue adding tiny amounts of sodium hydrogencarbonate until no more bubbles of gas are produced.
6. Using a syringe add 5 cm^3 of Benedict's solution to each beaker and heat the reaction mixtures.
7. Observe and record what happens to the Benedict's solution in each beaker.

† The sodium hydrogencarbonate is added to neutralise the acid catalyst since Benedict's test won't work in acidic conditions.

INTERMEDIATE 2	- Hydrolysis of Starch -	UNIT 2 PPA 3

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

* *State the aim of the experiment clearly indicating which catalyst you used.*
PC(b)

Procedure

* *What control was used and why was it necessary?*
PC(b)

* *How were you able to tell if the starch had been hydrolysed?*
PC(b)

Results

* *Complete the following table.*
PC(c)

Reaction mixture	Observations on heating with Benedict's solution

CONCLUSION

* *State the conclusion of the experiment.*
PC(d)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents for both experiments

Benedict's solution (4 cm^3 and 10 cm^3)

Benedict's solution

harmful

1% fresh starch solution (6 cm^3 and 20 cm^3)
(Mix 1 g soluble starch to a thin paste with water, then add to 100 cm^3 of boiling water)

ADDITIONAL REAGENT FOR 'ENZYME' EXPERIMENT

1% fresh amylase solution (1 cm^3)
(1 g amylase per 100 cm^3 water)

amylase solution
amylase

harmful

Additional reagents for 'acid' experiment

2 mol l^{-1} hydrochloric acid (1 cm^3)
(172 CM^3 CONCENTRATED HYDROCHLORIC ACID PER LITRE)

2 mol l^{-1} hydrochloric acid

irritant

concentrated hydrochloric acid

corrosive

SODIUM HYDROGENCARBONATE (~2 G)

APPARATUS FOR 'ENZYME' EXPERIMENT

test tubes (2)
test tube rack (1)
250 cm^3 glass beaker (1)
0 - 100 °C thermometer (1)
tripod (1)
Bunsen burner (1)
selection of syringes - 1 cm^3 (1), 5 cm^3 (2)
heating mat (1)

APPARATUS FOR 'ACID' EXPERIMENT

50 cm^3 glass beakers (2)
tripods (2)
Bunsen burners (2)
heating mats (2)
selection of syringes - 1 cm^3 (1), 5 cm^3 (1), 10 cm^3 (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
1 % amylase solution from solid	Potent respiratory sensitiser; may cause asthma.	Wear dust mask when preparing solution. Avoid raising a dust.
2 mol l^{-1} hydrochloric acid from concentrated acid	Fumes and solution of concentrated acid are corrosive to eyes, skin and lungs.	Wear goggles and carry out dilution to 2 mol l^{-1} in a fume cupboard.
Benedict's solution	Harmful by ingestion owing to copper salts.	Wear eye protection. If prepared see recipe in Hazardous Chemicals Manual.

Notes

Fehling's solution No.1 (harmful) and No.2 (corrosive) can be used as an alternative to Benedict's solution.

Sandell's reagent can also be used as a substitute for Benedict's solution. Its preparation is described in the Hazardous Chemicals Manual under *Fehling's solutions No.1 and No.2*.

Graduated pipettes or measuring cylinders could be used in place of the syringes.

- Preparation of a Salt -

INTRODUCTION

A salt is formed when the hydrogen ions of an acid are replaced by metal ions or ammonium ions. For example, if the hydrogen ions in sulphuric acid were replaced by magnesium ions then the salt magnesium sulphate would be formed.

The aim of this experiment is to prepare a pure sample of magnesium sulphate.

Making magnesium sulphate can be achieved in a number of ways. These include reacting an excess of magnesium or magnesium carbonate with sulphuric acid. An excess has to be used to make sure all the acid is used up. If any acid remained then the salt would be impure.

The fact that a gas is produced on reacting magnesium or magnesium carbonate with an acid allows us to tell when all the acid has been consumed. At this point no more bubbles of gas will appear and the excess magnesium or magnesium carbonate will remain as a solid in the reaction mixture.

Decide which method you will use to make magnesium sulphate (reacting magnesium with sulphuric acid **or** reacting magnesium carbonate with sulphuric acid) and then proceed as outlined below.

Requirements

small glass beaker
measuring cylinder
glass rod
filter funnel and paper
conical flask
evaporating basin
tripod
Bunsen burner and heating mat
hand lens

dilute sulphuric acid
magnesium turnings or magnesium carbonate

Hazards

Sulphuric acid irritates the eyes and skin and magnesium turnings are highly flammable.
When magnesium and magnesium carbonate react with sulphuric acid an acid mist is formed which irritates the lungs.
In the magnesium/sulphuric acid reaction hydrogen is given off and it is highly flammable.

Care

Wear eye protection.
If any sulphuric acid splashes on your skin, wash it off immediately.
Avoid breathing in the acid mist.
On reacting magnesium with sulphuric acid make sure all ignition sources are absent.

Procedure

1. Using a measuring cylinder add 20 cm^3 of dilute sulphuric acid to the beaker.
2. Add a spatulaful of magnesium or magnesium carbonate to the acid and stir the reaction mixture with the glass rod.
3. If all the solid reacts add another spatulaful of magnesium or magnesium carbonate and stir the mixture.
4. Continue adding the magnesium or magnesium carbonate until no more bubbles of gas are produced and some of the solid remains unreacted.
5. Place the filter funnel in the neck of the conical flask. Fold the filter paper and insert it in the funnel.

6. Carefully pour the reaction mixture into the filter paper.
7. When the filtration is complete, transfer the salt solution from the conical flask into the evaporating basin.
8. Place the evaporating basin on the tripod and carefully heat the salt solution until about half the water has boiled off.
9. Let the basin cool before transferring it to a safe place. Leave it until your next lesson to allow the solution to crystallise slowly.
10. Transfer the crystals onto a piece of filter paper. Examine them with a hand lens and draw one of the crystals.

INTERMEDIATE 2	- Preparation of a Salt -	UNIT 3 PPA 1

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

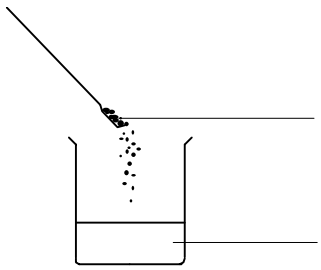
* *State the aim of the experiment indicating the names of the chemicals used to make the salt.*
PC(b)

Procedure

* *Why was an excess of magnesium or magnesium carbonate added to the acid?*
PC(b)

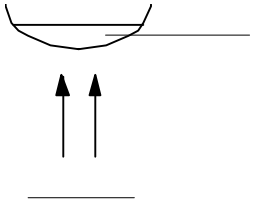
* *The three steps involved in preparing magnesium sulphate are the 'reaction' step, the*
PC(b) *'filtration' step and the 'evaporation' step.*
Label the diagrams which illustrate the 'reaction' step and the 'evaporation' step and draw a labelled diagram of the assembled apparatus used in the 'filtration' step.

'reaction'



'filtration'

'evaporation'



- Preparation of a Salt -

Results

* *Draw a crystal of magnesium sulphate.* **PC(c)**

Conclusion

* *Write a word equation for the reaction you carried out to prepare the salt.* **PC(d)**

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

$0.5\,mol\,l^{-1}$ sulphuric acid ($20\,cm^3$)
($27.5\,cm^3$ concentrated sulphuric acid per litre)

$0.5\,mol\,l^{-1}$ sulphuric acid


irritant

concentrated sulphuric acid


corrosive

MAGNESIUM TURNINGS (~0.5 G)

magnesium


highly flammable

or magnesium carbonate hydrated (~1.5 g)

APPARATUS

$100\,cm^3$ glass beaker (1)
$50\,cm^3$ measuring cylinder (1)
glass rod (1)
filter funnel (1)
filter paper circle (1)
$250\,cm^3$ conical flask (1)
evaporating basin (1)
tripod (1)
Bunsen burner (1)
heating mat (1)
hand lens (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
$0.5\,mol\,l^{-1}$ sulphuric acid from concentrated acid	Concentrated acid causes severe burns to eyes and skin.	Wear goggles or faceshield and pvc gloves. Add concentrated acid slowly with stirring to chilled water of volume equal to about half the final volume.
magnesium turnings	Highly flammable.	Arrange provision for students in 0.5 g portions if the discipline requires strict control.

Notes

This experiment should be carried out in a well-ventilated room or in a fume cupboard.

- Factors Affecting Voltage -

INTRODUCTION

A cell is a device in which a chemical reaction is used to produce electricity. One type of cell, known as a simple cell, can be made by dipping two **different** metals into a solution which is able to conduct a current of electricity. The metals are the electrodes of the cell and the conducting solution is called the electrolyte. By connecting the two electrodes to a voltmeter, the voltage which the cell generates can be measured.

The aim of this experiment is to investigate a factor which might affect the size of the voltage generated by a simple cell.

Some factors which could be investigated include:

- the metals used
- the electrolyte used
- the concentration of the electrolyte.

From the first **two** in this list of factors choose **one** to investigate and proceed to the appropriate section below.

Metals

Requirements

beaker with electrode holder
connecting wires
voltmeter
emery paper
rods of copper, zinc and iron
sodium chloride solution

Care

Wear eye protection.

Procedure

1. Half fill the beaker with sodium chloride solution.
2. Clean the copper and zinc rods with emery paper and wash them. Insert these rods into the electrode holder and place it in the beaker. Make sure the rods are dipping into the sodium chloride solution.
3. Connect the rods to the voltmeter and measure and record the voltage generated by the cell.
4. To obtain duplicate results, remove the rods and repeat steps 2 and 3.
5. Repeat the experiment two more times: first with the copper and iron rods and then with the zinc and iron rods. Each time measure and record the voltage generated by the cell and obtain duplicate results.

Electrolyte

Requirements

beaker with electrode holder
connecting wires
voltmeter
emery paper
rods of copper and zinc
sodium chloride solution
hydrochloric acid
sodium hydroxide solution

Hazards

Hydrochloric acid and sodium hydroxide solution irritate the eyes and skin.

Care

Wear eye protection.
If any hydrochloric acid or sodium hydroxide solution splashes on your skin, wash it off immediately.

Procedure

1. Half fill the beaker with sodium chloride solution.
2. Clean the copper and zinc rods with emery paper and wash them. Insert these rods into the electrode holder and place it in the beaker. Make sure the rods are dipping into the sodium chloride solution.
3. Connect the rods to the voltmeter and measure and record the voltage generated by the cell.
4. To obtain duplicate results, remove the rods and repeat steps 2 and 3.
5. Repeat the experiment two more times: first with the hydrochloric acid as electrolyte and then with the sodium hydroxide solution. Each time measure and record the voltage generated by the cell and obtain duplicate results.

INTERMEDIATE 2	**- Factors Affecting Voltage -**	**UNIT 3 PPA 2**

Name:	PC(a)	PC(b)	PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:						

- ASSESSMENT SHEET -

* *State the aim of the experiment clearly indicating the factor you are investigating.*
PC(b)

Procedure

* *Draw a labelled diagram of the circuit used.*
PC(b)

* *Which factors were kept the same in the experiment? (Mention at least three)*
PC(b)

Results

* *Complete the following table:* **PC(c)**

	Voltage 1 / V	Voltage 2 / V	Average voltage / V

Conclusion

* *State the conclusion of the experiment.* **PC(d)**

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents for both investigations

copper rod (1)

zinc rod (1)

0.1 mol l^{-1} sodium chloride
(5.8 g sodium chloride per litre)

Additional reagent for 'metals' investigation

iron rod (1)

Additional reagents for 'electrolyte' investigation

0.1 mol l^{-1} hydrochloric acid
(8.6 cm^3 concentrated hydrochloric acid per litre)

concentrated hydrochloric acid

corrosive

0.1 mol l^{-1} sodium hydroxide
(4.0 G SODIUM HYDROXIDE PER LITRE)

0.1 mol l^{-1} sodium hydroxide

irritant

sodium hydroxide

corrosive

APPARATUS FOR BOTH INVESTIGATIONS

100 cm^3 glass beaker (1)
electrode holder (1)
connecting wires (2)
voltmeter (1)
emery paper

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
0.1 mol l^{-1} hydrochloric acid from concentrated acid	Fumes and solution of concentrated acid are corrosive to eyes, skin and respiratory system.	Wear goggles and carry out dilution in a fume cupboard.
0.1 mol l^{-1} sodium hydroxide from solid	Solid is corrosive. A slight aerosol is formed.	Wear goggles and pvc gloves. Prepare in well-ventilated room.

Notes

Electrodes made from zinc foil, copper foil (or wire) and iron wire could be used in place of the rods.

- Reactions of Metals with Oxygen -

INTRODUCTION

Some metals, like potassium and sodium, are highly reactive but others, like platinum and gold, are unreactive. The majority of metals however lie between these two extremes.

We can put metals in order of reactivity by comparing their reactions with a variety of chemicals. In this experiment their reactions with oxygen will be compared. Potassium permanganate will be used to provide the oxygen - it does this when it decomposes on heating.

The aim of this experiment is to place zinc, copper and magnesium in order of reactivity by observing the ease with which they react with oxygen.

Requirements

- dry test tubes
- clamp stand and clamp
- Bunsen burner and heating mat
- mineral wool
- tongs
- samples of zinc, copper and magnesium
- potassium permanganate

Hazards

Potassium permanganate irritates the eyes and is harmful if swallowed.
Magnesium is highly flammable.
Mineral wool irritates the eyes, skin and lungs.

Care

Wear eye protection.
Use tongs when handling the mineral wool.
Apart from when it is being heated in the test tube keep flames away from the magnesium.
When you are heating the magnesium shade your eyes with your free hand and do **not** look directly at the magnesium.

Procedure

Your teacher/lecturer will demonstrate the experiment using one of the metals.

1. To a dry test tube add potassium permanganate crystals to a depth of about 1 cm.
2. Place a loose plug of mineral wool immediately above the potassium permanganate crystals.
3. Clamp the test tube at the mouth and in a horizontal position. Make sure that the mouth of the test tube is not pointing at anyone.
4. Add a piece of zinc to the test tube placing it about half-way along the tube. Make sure the zinc is well separated from the potassium permanganate.
5. Heat the contents of the test tube as demonstrated by your teacher/lecturer.
6. Observe the metal as it reacts with oxygen and record your observations.
7. Repeat steps 1 - 6 with copper and then with magnesium. Each time record your observations.

INTERMEDIATE 2	- Reactions of Metals with Oxygen -	UNIT 3 PPA 3

Name:	PC(a)	PC(b)		PC(c)	PC(d)	Teacher's/Lecturer's Initials	
Date:							

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

Procedure

* *Draw a labelled diagram of the assembled apparatus.*
PC(b)

Results

* *Complete the following table:* **PC(c)**

	Observations

Conclusion

* *State the conclusion of the experiment.* **PC(d)**

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

potassium permanganate (~5 g) — **potassium permanganate**


oxidising


harmful

magnesium ribbon (~2 cm) — **magnesium ribbon**


highly flammable

zinc (~2 x 0.5 cm strip)
(cut from zinc foil)

copper (~2 x 0.5 cm strip)
(CUT FROM COPPER FOIL)

APPARATUS

dry test tubes (3)

clamp stand and clamp (1)

Bunsen burner (1)

heating mat (1)

mineral wool — **mineral wool**


irritant

tongs (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
potassium permanganate	Powerful oxidising agent which will ignite organic material. Harmful if ingested.	Wear eye protection and pvc gloves for filling smaller bottles. Avoid contact with organic compounds or dust.
mineral wool	Mineral wools can irritate the eyes and skin and are suspect weak carcinogens.	Handle with tongs, gloves.
magnesium ribbon	Highly flammable.	Store and provide in closed containers.
metals in general	Incompatible with potassium permanganate.	
pieces of metal foil	Possible sharp edges.	Wear eye protection during cutting and dispensing.

Notes

It has been recommended that the experiment be demonstrated with one of the metals in view of the difficulty in providing fail-safe written instructions on heating reactive metals in an atmosphere of oxygen.

Some samples of mineral wools and especially Rocksil wool contain oxidisable impurities which can react vigorously with potassium permanganate. Check with the supplier that the wool is free of such impurities. If in doubt, roast the sample beforehand to oxidise the impurities.

Glass wool (irritating) can be used as a substitute for mineral wool.

Metal powders should not be used in this experiment.

HIGHER

INTRODUCTION

The aim of this experiment is to find the effect of varying the concentration of iodide ions on the rate of reaction between hydrogen peroxide and an acidified solution of potassium iodide:

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \longrightarrow 2H_2O(l) + I_2(aq)$$

The course of this reaction can be followed by carrying it out in the presence of small quantities of starch and sodium thiosulphate solutions. As the iodine molecules are produced they immediately react with the thiosulphate ions and are converted back to iodide ions:

$$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

During this period the reaction mixture remains colourless. But once the thiosulphate ions have been used up, a blue/black colour suddenly appears because the iodine molecules now get the chance to react with the starch.

A series of experiments will be carried out in which only the concentration of the iodide ions will be varied. The concentrations and volumes of the other chemicals involved will be kept constant as will the temperature at which the experiments are performed.

Since the amount of thiosulphate ions initially present will be the same in each experiment, the appearance of the blue/black colour will always represent the same extent of reaction. So if t is the time it takes for the blue/black colour to appear then we can take $1/t$ as a measure of the reaction rate.

Requirements

selection of syringes
$100\,cm^3$ glass beakers
white tile
timer

$1\,mol\,l^{-1}$ sulphuric acid
$0.1\,mol\,l^{-1}$ potassium iodide
$0.1\,mol\,l^{-1}$ hydrogen peroxide
$0.005\,mol\,l^{-1}$ sodium thiosulphate
1% starch solution
deionised water

Hazards

Both $1\,mol\,l^{-1}$ sulphuric acid and $0.1\,mol\,l^{-1}$ hydrogen peroxide irritate the eyes.

Care

Wear eye protection.
If any chemical splashes on your skin, wash it off immediately.
When using the syringes always keep them pointing downwards.

Procedure

1. Using syringes make up the following mixtures in five dry $100\,cm^3$ glass beakers.

Mixture	1	2	3	4	5
Volume of sulphuric acid / cm^3	10	10	10	10	10
Volume of sodium thiosulphate / cm^3	10	10	10	10	10
Volume of starch / cm^3	1	1	1	1	1
Volume of potassium iodide / cm^3	25	20	15	10	5
Volume of water / cm^3	0	5	10	15	20

2. Place the beaker containing mixture 1 on the white tile.
3. Measure 5 cm^3 of hydrogen peroxide into a syringe. Add it to mixture 1 as quickly as possible and at the same time start the timer.
4. Carefully swirl the reaction mixture in the beaker from time to time. When the blue/black colour just appears stop the timer and record the time (in seconds).
5. Repeat steps 2 to 4 with each of the remaining solutions.

Note: Since the total volume of the reaction mixture was the same in each experiment we can assume that the volume of the potassium iodide solution is a measure of its concentration.

HIGHER CHEMISTRY	- The Effect of Concentration Changes on Reaction Rate -	UNIT 1 PPA 1

Name:	PC(a)	PC(b)	PC(c)	PC(d)	PC(e)	Teacher's/Lecturer's Initials	
Date:							

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

Procedure

* *Describe how the concentration of the potassium iodide solution was varied.*
PC(b)

* *How was the rate of the reaction determined?*
PC(b)

Results

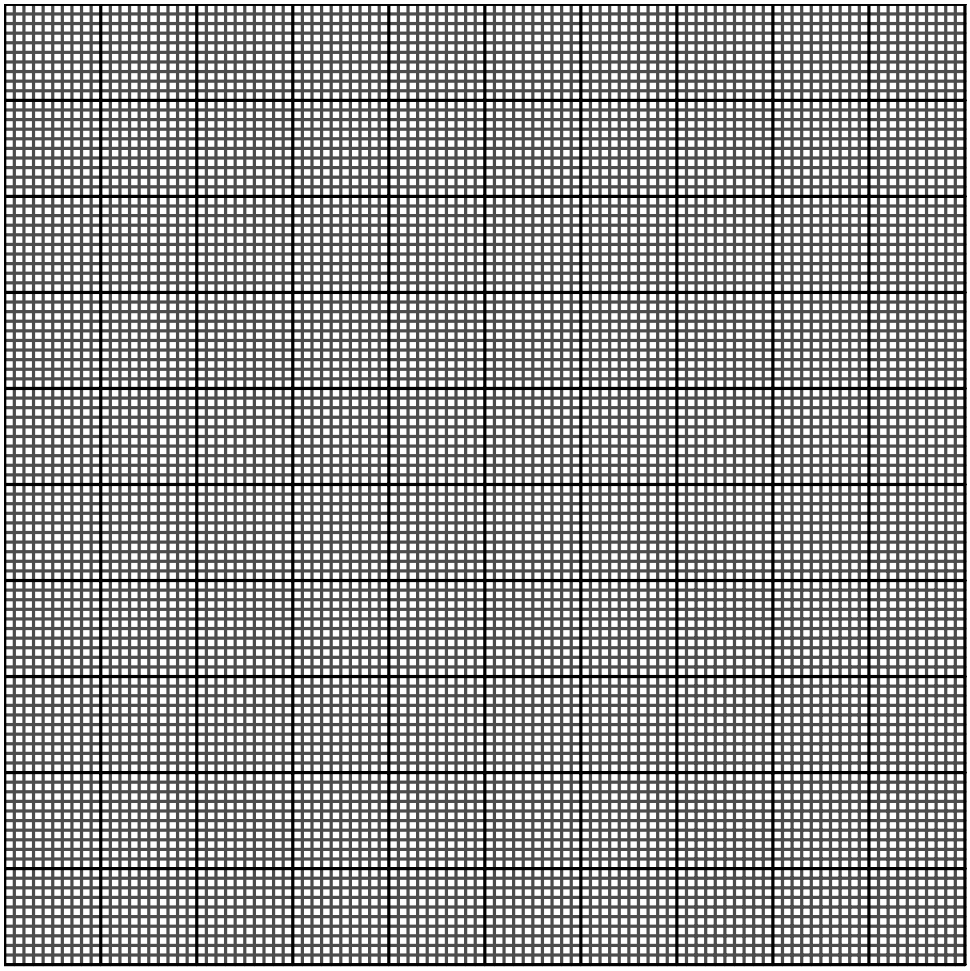
* *Complete the following table:*
PC(c)

Mixture					
Volume of potassium iodide / cm^3					
Volume of water / cm^3					
Time / s					

* *Work out the rate of each reaction and add these to the table above.*
PC(d)

* *Draw a line graph of 'reaction rate / s^{-1}' against 'volume of potassium iodide solution / cm^3'.*
PC(d)

(Since the total volume of the reaction mixture was the same in each experiment we can assume that the volume of the potassium iodide solution is a measure of its concentration)



Conclusion

* *State the conclusion of the experiment.*
PC(e)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

1 mol l^{-1} sulphuric acid (50 cm^3)
(55 cm^3 concentrated sulphuric acid per litre)

1 mol l^{-1} sulphuric acid


irritant

concentrated sulphuric acid


corrosive

0.1 mol l^{-1} potassium iodide (75 cm^3)
(16.6 g potassium iodide per litre)

0.1 mol l^{-1} hydrogen peroxide (25 cm^3)
(56 cm^3 hydrogen peroxide (20 volumes) per litre)

hydrogen peroxide
(20 volumes)


irritant

0.005 mol l^{-1} sodium thiosulphate (50 cm^3)
(1.24 g sodium thiosulphate 5-hydrate per litre)

1 % fresh starch solution (5 cm^3)
(Mix 1 g soluble starch to a thin paste with water, then add to 100 cm^3 boiling water)

deionised water (50 cm^3)

Apparatus

100 cm^3 glass beakers (5)
selection of syringes - 1 cm^3 (1), 5 cm^3 (1), 10 cm^3 (2), 20 cm^3 (2)
white tile (1)
timer (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
1 mol l^{-1} sulphuric acid from concentrated acid	Concentrated acid causes severe burns to eyes and skin.	Wear goggles or faceshield and pvc gloves. Add concentrated acid slowly with stirring to chilled water of volume equal to about half the final volume.
0.1 mol l^{-1} hydrogen peroxide by dilution	Irritates eyes. Pressure may build up in unvented bottle.	Wear eye protection and pvc gloves. Use 20 volumes hydrogen peroxide for dilution. Open cautiously.

Notes

To reduce the risk of contamination a separate syringe for each solution is recommended.

Graduated pipettes and/or burettes could be used in place of the syringes.

INTRODUCTION

The aim of this experiment is to find the effect of varying temperature on the rate of reaction between oxalic acid and an acidified solution of potassium permanganate:

$$5(COOH)_2(aq) + 6H^+(aq) + 2MnO_4^-(aq) \longrightarrow 2Mn^{2+}(aq) + 10CO_2(g) + 8H_2O(l)$$

Initially the reaction mixture is purple in colour due to the presence of the permanganate ions but it will turn colourless as soon as they are used up. This colour change allows us to follow the course of the reaction.

A series of experiments will be carried out in which only the temperature of the reaction mixtures will be kept constant. The concentrations and volumes of the reactants will be kept constant.

Since the amount of permanganate ions initially present will be the same in each experiment, the point at which the purple colour disappears will always represent the same extent of reaction. So if t is the time it takes for the colour change to occur then we can take $1/t$ as a measure of the reaction rate.

Requirements

selection of syringes
100 cm^3 glass beakers
white tile
timer
tripod
Bunsen burner and heating mat
thermometer

0.2 $mol\,l^{-1}$ oxalic acid
1 $mol\,l^{-1}$ sulphuric acid
0.02 $mol\,l^{-1}$ potassium permanganate
deionised water

Hazards

0.2 $mol\,l^{-1}$ oxalic acid, 1 $mol\,l^{-1}$ sulphuric acid and 0.02 $mol\,l^{-1}$ potassium permanganate irritate the eyes and are harmful if swallowed.

Care

Wear eye protection.
If any chemical splashes on your skin, wash it off immediately.
When using the syringes always keep them pointing downwards.

Procedure

1. Using syringes add 5 cm^3 of sulphuric acid, 2 cm^3 of potassium permanganate solution and 40 cm^3 of water to a 100 cm^3 dry glass beaker.
2. Heat the mixture to about 40 °C.
3. Place the beaker on a white tile and measure 1 cm^3 of oxalic acid solution into a syringe.
4. Add the oxalic acid to the mixture in the beaker as quickly as possible and at the same time start the timer.
5. Gently stir the reaction mixture with the thermometer.
6. When the reaction mixture just turns colourless stop the timer and record the time (in seconds). Measure and record the temperature of the reaction mixture.
7. Repeat the experiment another three times but heat the initial sulphuric acid/potassium permanganate/water mixtures first to 50 °C, then to 60 °C and finally to 70 °C.
   In each experiment, measure and record the time it takes for the reaction mixture to just turn colourless and measure and record its temperature when this happens.

HIGHER CHEMISTRY	- The Effect of Temperature Changes on Reaction Rate -	UNIT 1 PPA 2

Name:	PC(a)	PC(b)	PC(c)	PC(d)	PC(e)	Teacher's/Lecturer's Initials	
Date:							

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

Procedure

* *State two factors which had to be kept constant in the experiments.*
PC(b)

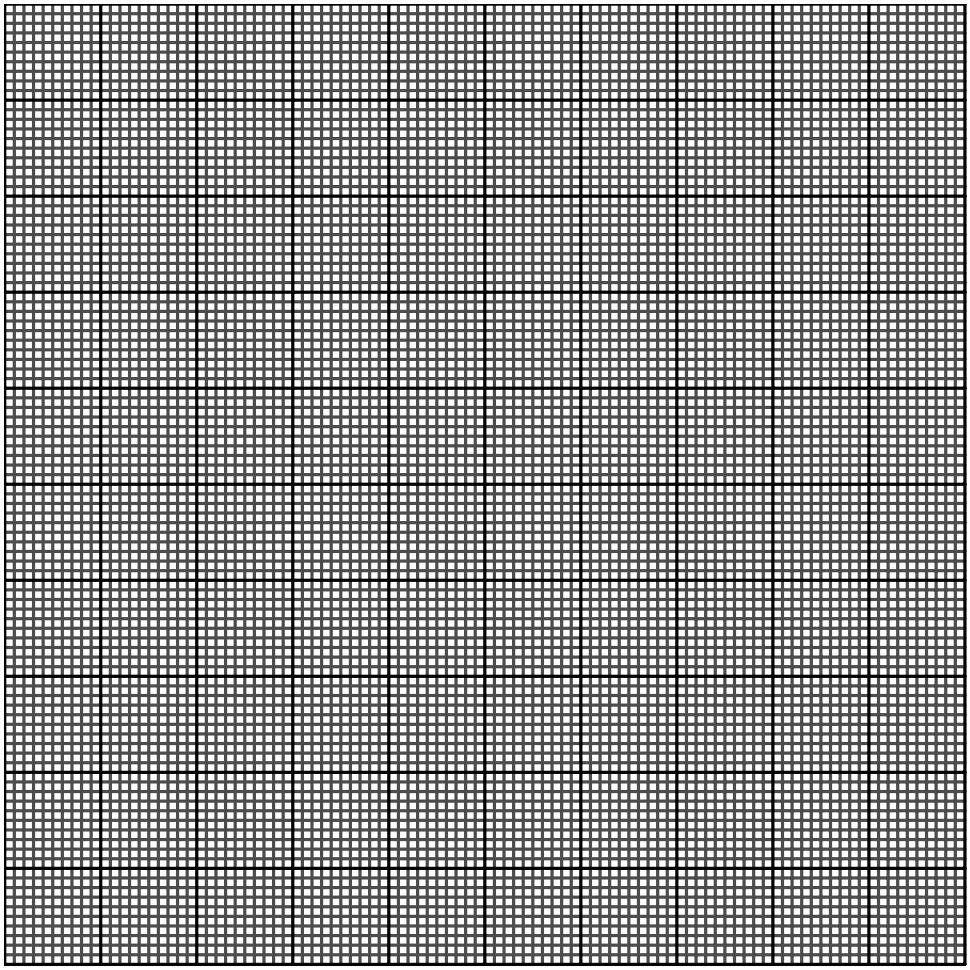
* *How was the rate of the reaction determined?*
PC(b)

Results

* *Present your results in tabular form.*
PC(c)

* *Work out the rate of each reaction and add these to your results table.*
PC(d)

* *Draw a line graph of 'reaction rate / s^{-1}' against 'temperature / °C'.*
PC(d)



Conclusion

* *State the conclusion of the experiment.*
PC(e)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

$0.20\,mol\,l^{-1}$ oxalic acid ($4\,cm^3$)
(25.2 g oxalic acid 2-hydrate per litre)

oxalic acid


harmful

$1.0\,mol\,l^{-1}$ sulphuric acid ($20\,cm^3$)
(55 cm^3 concentrated sulphuric acid per litre)

$1\,mol\,l^{-1}$ sulphuric acid


irritant

concentrated sulphuric acid


corrosive

$0.020\,mol\,l^{-1}$ potassium permanganate ($8\,cm^3$)
(3.16 g potassium permanganate per litre)

potassium permanganate


oxidising


harmful

deionised water ($160\,cm^3$)

Apparatus

$100\,cm^3$ glass beakers (4)
selection of syringes - $1\,cm^3$ (1), $2\,cm^3$ (1), $5\,cm^3$ (1), $20\,cm^3$ (1)
white tile (1)
timer (1)
tripod (1)
Bunsen burner (1)
heating mat (1)
0 - 100 °C thermometer (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
0.20 mol l^{-1} oxalic acid from solid	Harmful by ingestion or by contact with eyes or skin.	Wear eye protection and pvc gloves.
1.0 mol l^{-1} sulphuric acid from concentrated acid	Concentrated acid causes severe burns to eyes and skin.	Wear goggles or faceshield and pvc gloves. Add concentrated acid slowly with stirring to chilled water of volume equal to about half the final volume.
0.020 mol l^{-1} potassium permanganate	Solid and concentrated solutions harmful if ingested; strongly irritating to eyes.	Wear eye protection and pvc gloves for preparation from solid or from ampoule. Wash up well any spillages and avoid contact between solid and organic compounds or powerful reducing agents.

Notes

At temperatures below 40°C the colour change in the reaction mixture is gradual and difficult to pin-point.

To reduce the risk of contamination a separate syringe for each solution is recommended.

Graduated pipettes and/or burettes could be used in place of the syringes.

- Enthalpy of Combustion -

INTRODUCTION

The enthalpy of combustion of a substance is the energy released when one mole of the substance is completely burned in oxygen.

The aim of this experiment is to determine the enthalpy of combustion of ethanol i.e. the enthalpy change for the reaction:

$$CH_3CH_2OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l)$$

A measured mass of ethanol is burned in a spirit burner and the heat released is transferred to a copper can containing a known volume of water. From the resulting temperature rise, the enthalpy of combustion of ethanol can be calculated.

In this experiment we assume that all the heat released in the combustion reaction is absorbed only by the water in the copper can.

Requirements

spirit burner (containing ethanol)
copper can
clamp stand and clamp
draught shield
thermometer
measuring cylinder
balance

Hazards

Ethanol is highly flammable and the main risk is from burns. Since a small amount is burned the build up of any products of incomplete combustion is negligible.

Care

Wear eye protection.
Ensure the spirit burner is always sitting in a stable position.
Should you have to re-fill the spirit burner, allow it to cool and then fill it away from sources of ignition.

Procedure

1. Weigh the spirit burner (already containing ethanol) with its cap on and record its mass. (The cap should be kept on to cut down the loss of ethanol through evaporation)
2. Using the measuring cylinder, measure out 100 cm^3 of water into the copper can.
3. Set up the apparatus as directed by your teacher/lecturer.
4. Measure and record the temperature of the water.
5. Remove the cap from the spirit burner and immediately light the burner.
6. Slowly and continuously stir the water with the thermometer. When the temperature has risen by about 10 °C, recap the spirit burner and measure and record the maximum temperature of the water.
7. Reweigh the spirit burner and record its mass.

Calculation

(a) The heat energy gained by the water (E_h) can be calculated using the formula:

$$E_h = \mathbf{c\ m\ \Delta T}$$

where

c = the specific heat capacity of the water (the heat energy needed to raise the temperature of 1 kg of water by 1 °C) and has the value 4.18 $kJ\,kg^{-1}\,°C^{-1}$.

m = the mass (in kg) of water being heated. (The density of water is 1.00 $g\,cm^{-3}$ or 1.00 $kg\,l^{-1}$)

ΔT = the rise in temperature in °C.

(b) The difference in the initial and final masses of the spirit burner gives us the mass of ethanol burned (say **x** g) and so the heat energy we calculate in step (a) is equal to that released by burning **x** g of ethanol. We are assuming that all the heat energy released by the burning ethanol is absorbed only by the water.

(c) We can work out the mass of one mole of ethanol and knowing how much heat energy is released when **x** g of ethanol is burned we can calculate the heat energy released when **one mole** of ethanol is burned. This will be equal to the enthalpy of combustion of ethanol.

HIGHER CHEMISTRY	- Enthalpy of Combustion -	UNIT 1 PPA 3

Name:	PC(a)	PC(b)	PC(c)	PC(d)	PC(e)	Teacher's/Lecturer's Initials	
Date:							

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

Procedure

* *Draw a labelled diagram of the assembled apparatus.*
PC(b)

* *List the five measurements that were made during the experiment.*
PC(b)

Results

* *Present your results in an appropriate manner.*
PC(c)

Calculation / Conclusion

* *Carry out a calculation to determine the enthalpy of combustion of ethanol.* **PC(d), PC(e)**

(Ask your teacher/lecturer for a HELP SHEET if you are unsure about how to complete the calculation)

The data book value for the enthalpy of combustion of ethanol is very much greater than experimental value.

* *Suggest sources of error which could account for this difference.*

- HELP SHEET –

CALCULATION

Suppose 0.25 g of ethanol had been burned and the temperature of the water had risen by 12.5 °C.

The heat energy gained by the water (E_h) is calculated using the formula:

$$E_h = \boldsymbol{c\ m\ \Delta T}$$

where ***c*** = *the specific heat capacity of the water and it has the value 4.18 kJ kg^{-1} °C^{-1}.*

m = *the mass of water being heated and in this experiment it is 0.10 kg.*

ΔT = *the rise in temperature in °C.*

$$E_h = 4.18 \times 0.10 \times 12.5$$
$$= 5.225\,\text{kJ}$$

We assume that the heat energy released by the burning ethanol is gained only by the water.

The heat energy released on burning 0.25 g of ethanol = 5.225 kJ

Ethanol: CH_3CH_2OH

Mass of 1 mole = 2(12) + 6(1) + 16 = 46 g

We can now calculate the heat energy released on burning 1 mole of ethanol.

$$0.25\,\text{g} \longleftrightarrow 5.225\,\text{kJ}$$
$$46\,\text{g} \longleftrightarrow 5.225 \times \frac{46}{0.25}$$
$$= 961\,\text{kJ}$$

The enthalpy of combustion of ethanol = -961 kJ mol^{-1}

(A negative sign is used because combustion is an exothermic reaction)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

ethanol

ethanol

highly flammable

Apparatus

spirit burner containing ethanol (1)
copper can (1)
clamp stand (1)
clamp (1)
draught shield (1)
0 - 50 °C thermometer (1)
100 cm^3 measuring cylinder (1)
access to balance (0.01 g readability)

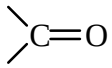
Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
ethanol	Highly flammable.	Wear eye protection Ensure absence of ignition sources when dispensing.

Notes

An aluminium can or glass beaker could be used in place of the copper can.

INTRODUCTION

Both aldehydes and ketones contain the carbonyl group, 

In aldehydes a hydrogen atom is bonded to the carbonyl group but in ketones the carbonyl group is always flanked by carbon atoms:

aldehyde ketone

This structural difference accounts for the fact that aldehydes can undergo mild oxidation to form carboxylic acids but ketones resist oxidation. Oxidising agents can therefore be used to distinguish between aldehydes and ketones.

The aim of this experiment is to use the mild oxidising agents, acidified potassium dichromate solution, Benedict's solution and Tollens' reagent, to distinguish between two given carbonyl compounds one of which is an aldehyde and the other a ketone.

Requirements

- test tubes and rack
- test tube holder
- Bunsen burner and heating mat
- tripod
- large beaker
- carbonyl compounds **X** and **Y**
- 0.1 mol l^{-1} potassium dichromate
- 1 mol l^{-1} sulphuric acid
- Benedict's solution
- Tollens' reagent (a solution of silver nitrate in aqueous ammonia)

Hazards

Carbonyl compounds **X** and **Y** are highly flammable and their vapours irritate the eyes, skin and lungs. Compound **X** is toxic by skin absorption and by swallowing. Compound **Y** is harmful if swallowed.
0.1 mol l^{-1} potassium dichromate is toxic if swallowed. It is carcinogenic and very toxic by inhalation. It is also a skin sensitiser and is very toxic to the aquatic environment.
1 mol l^{-1} sulphuric acid irritates the eyes.
Benedict's solution contains copper salts and so is harmful if swallowed.
Tollens' reagent contains diluted sodium hydroxide which irritates the skin and eyes.

Care

Wear eye protection and immediately wash off any chemical spillages on the skin.
When working with Tollens' reagent and compounds **X** and **Y** wear gloves.

Procedure

1. Before collecting the carbonyl compounds **X** and **Y** set up a water bath and heat the water until it boils. Turn off the Bunsen.
   Alternatively, boil some water in a kettle and pour it into the large beaker.
2. Add sulphuric acid to each of two test tubes to a depth of about 2 cm. Then add potassium dichromate solution to both to give a total depth of about 3 cm in each.
3. To one of these test tubes add about 5 drops of compound **X** and to the other add about **5** drops of compound **Y**.
4. Place both test tubes in the water bath and observe and record any changes.

5. Add Benedict's solution to each of two test tubes to a depth of about 3 cm.
6. Repeat steps 3 and 4.
7. Add Tollens' reagent to each of two **very clean** test tubes to a depth of about 3 cm.
8. Repeat steps 3 and 4 and **immediately** after, wash the contents of the test tubes down the drain with large amounts of water.

HIGHER CHEMISTRY	- Oxidation -	UNIT 2 PPA 1

Name:	PC(a)	PC(b)		PC(c)	PC(d)	PC(e)	Teacher's/Lecturer's Initials	
Date:								

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

* *Why can mild oxidising agents be used to distinguish between aldehydes and ketones?*

Procedure

* *Why were the reaction mixtures **not** heated directly using a Bunsen burner?*
PC(b)

Results

* *Record your observations in tabular form.*
PC(c)

CONCLUSION

* *State the conclusion of the experiment.*
PC(e)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

compound **X** (~1 cm^3)
(propanal)

compound X
propanal


irritant


highly flammable

compound **Y** (~1 cm^3)
(propanone)

compound Y
propanone


highly flammable

0.1 mol l^{-1} potassium dichromate (~2 cm^3)
(29.4 g potassium dichromate per litre)

0.1 mol l^{-1} potassium dichromate
potassium dichromate


toxic

1 mol l^{-1} sulphuric acid (~4 cm^3)
(55 cm^3 concentrated sulphuric acid per litre)

1 mol l^{-1} sulphuric acid


irritant

concentrated sulphuric acid


corrosive

Benedict's solution (~6 cm^3)

Benedict's solution


harmful

TOLLENS' REAGENT (~6 CM^3)
(Tollens' reagent must be prepared just prior to its use.
To 5 cm^3 of 0.05 mol l^{-1} silver nitrate add about 5 drops of 2 mol l^{-1} sodium hydroxide. Then add 2 mol l^{-1} ammonia solution drop by drop until the precipitate just dissolves)

Tollens' reagent


explosive

2 mol l^{-1} sodium hydroxide


corrosive

APPARATUS

test tubes (6)
test tube rack (1)
test tube holder (1)
Bunsen burner(1)
heating mat (1)
tripod (1)
400 cm^3 glass beaker (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
1 mol l^{-1} sulphuric acid from concentrated acid	Concentrated acid causes severe burns to eyes and skin.	Wear goggles or faceshield and pvc gloves. Add concentrated acid slowly with stirring to chilled water of volume equal to about half the final volume.
0.1 mol l^{-1} potassium dichromate from solid	Toxic by ingestion. Carcinogenic and very toxic by inhalation. Skin sensitiser. Very toxic to the aquatic environment.	Wear eye protection and nitrile gloves. Because of coarse granular nature of crystals it is easy to prepare solution without forming a dust aerosol.
Benedict's solution	Harmful by ingestion owing to copper salts.	Wear eye protection. If prepared see recipe in Hazardous Chemicals Manual.
Tollens' reagent	Both 2 mol l^{-1} sodium hydroxide and solid silver nitrate are corrosive.	Wear eye protection and gloves. Must be prepared immediately before use.
propanal	Highly flammable (fl. pt. 15 °C). Toxic by skin absorption and by ingestion. Vapour is harmful and irritates eyes, skin and lungs.	Wear eye protection and nitrile gloves. Dispense in fume cupboard or in well-ventilated room. Supply in small reagent bottles (50 or 100 cm^3).
propanone	Highly flammable (fl. pt. -20 °C). Low toxicity but harmful by ingestion. Vapour irritates eyes, skin and lungs.	Wear eye protection and nitrile gloves. Dispense in fume cupboard or in well-ventilated room.

Notes

This experiment should be carried out in a well-ventilated room.

Propanal has been recommended as the aldehyde rather than ethanal since the latter is more volatile and is a carcinogen.

Glucose solution could be used in place of propanal - it gives a better 'silver mirror' test.

It is important that the Tollens' reagent be prepared just prior to its being used since it becomes explosive on evaporation. For the same reason residues must be washed down the drain with copious amounts of water.

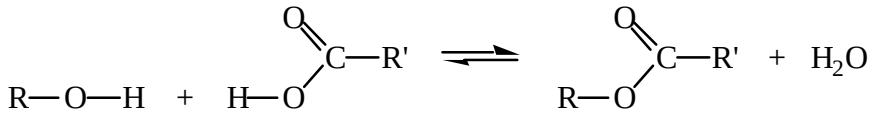
Fehling's solutions No. 1 (harmful) and No. 2 (corrosive) can be used as an alternative to Benedict's solution.

Sandell's reagent can also be used as a substitute for Benedict's solution. Its preparation is described in the Hazardous Chemicals Manual under *Fehling's solutions No. 1 and No. 2*.

- Making Esters-

INTRODUCTION

One way of preparing esters is to condense an alcohol with a carboxylic acid:



alcohol carboxylic acid ester

The reaction is slow at room temperature and the yield of ester is low. The rate can be increased by heating the reaction mixture and by using concentrated sulphuric acid as a catalyst. The presence of the concentrated sulphuric acid also increases the yield of ester.

The aim of this experiment is to prepare an ester and to identify some of the characteristic properties of esters.

Requirements

test tube and rack
test tube holder
paper towel
rubber band
large beaker
small beaker
tripod
Bunsen burner and heating mat
cotton wool

samples of alcohols (methanol, ethanol, propan-1-ol, butan-1-ol and pentan-1-ol)
samples of carboxylic acids (methanoic acid, ethanoic acid, propanoic acid, benzoic acid and salicylic acid)
concentrated sulphuric acid
1 mol l^{-1} sodium hydrogencarbonate

Hazards

Concentrated sulphuric acid causes severe burns to the eyes and skin.
Methanol, ethanol and propan-1-ol are highly flammable and butan-1-ol and pentan-1-ol are flammable.
All the alcohols are harmful by inhalation, skin absorption and by swallowing. Methanol is toxic.
The eyes may be damaged by alcohol splashes.
Methanoic, ethanoic and propanoic acids are corrosive and the benzoic and salicylic acids are irritating to the eyes and skin.

Care

Wear goggles and immediately wash off any chemical spillages on the skin.
Wear gloves when working with the concentrated sulphuric acid.
When smelling the ester product do it very cautiously using the technique described below.

Procedure

Decide which ester you are to make and follow the procedure outlined below.

1. Before collecting the alcohol and carboxylic acid set up a water bath using the larger beaker and heat the water until it boils. Turn off the Bunsen.
   Alternatively, boil some water in a kettle and pour it into the large beaker.
2. Add the alcohol to a test tube to a depth of about 1 cm. To this add about the same volume of carboxylic acid. If the acid is a solid then use a spatulaful.
3. In the interests of safety your teacher/lecturer may carry out the next step.
   Add about 5 drops of concentrated sulphuric acid to the reaction mixture.

4. Soak the paper towel in cold water, fold it up and wrap it round the neck of the test tube. Secure it with a rubber band. This arrangement acts as a condenser when the reaction mixture is being heated.
5. Place a loose plug of cotton wool in the mouth of the test tube. This will contain any chemicals which may spurt out of the reaction mixture when it is heated.
6. Place the test tube in the hot water bath.
7. While the reaction mixture is being heated add about 20 cm^3 of sodium hydrogencarbonate solution to the small beaker.
8. After about 10 minutes, take the test tube from the water bath and remove the plug of cotton wool. Slowly pour the reaction mixture into the sodium hydrogencarbonate solution. This neutralises the sulphuric acid and any remaining carboxylic acid and so removes the smell of the carboxylic acid.
9. Gently swirl the contents of the beaker and look to see if there is any sign of the ester separating from the aqueous mixture.
10. To smell the ester follow the technique outlined below.
    First breathe in deeply to fill the lungs with **uncontaminated** air.
    With your nose at least 30 cm from the mouth of the beaker gently waft the vapour towards your nose and take just a sniff.

HIGHER CHEMISTRY	- Making Esters-	UNIT 2 PPA 2

Name:	PC(a)	PC(b)	PC(c)	PC(d)	PC(e)	Teacher's/Lecturer's Initials	
Date:							

- ASSESSMENT SHEET -

* *State the aim of the experiment naming the ester you made.*
PC(b)

Procedure

* *Draw a labelled diagram of the assembled apparatus used to prepare an ester.*
PC(b)

* *How was the reaction rate increased?*
PC(b)

* *What was the function of the 'wet paper towel' condenser?*
PC(b)

Results

* *State two pieces of evidence which suggested that an ester had been formed.*
PC(c)

Conclusion

* *Using full structural formulae, write an equation for the condensation reaction you carried out and name the ester formed.*
PC(e)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

selection of alcohols (~ 1 cm^3)
(methanol, ethanol, propan-1-ol, butan-1-ol and pentan-1-ol)

methanol  toxic  highly flammable

ethanol
propan-1-ol  highly flammable

butan-1-ol
pentan-1-ol  harmful  flammable

selection of carboxylic acids (~ 1 cm^3 or 1 spatulaful)
(methanoic acid, ethanoic acid, propanoic acid, benzoic acid and salicylic acid)

ethanoic acid  corrosive  flammable

methanoic acid
propanoic acid  corrosive

benzoic acid
salicylic acid  harmful

CONCENTRATED SULPHURIC ACID (A FEW DROPS)

concentrated sulphuric acid  corrosive

1.0 $mol\,l^{-1}$ sodium hydrogencarbonate (~ 20 cm^3)
(84.0 g sodium hydrogencarbonate per litre)

APPARATUS

test tube (1)
test tube rack (1)
test tube holder (1)
paper towel (1)
rubber band (1)
400 cm^3 glass beaker (1)
100 cm^3 glass beaker (1)
tripod (1)
Bunsen burner (1)
heating mat (1)
cotton wool

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
methanol ethanol propan-1-ol butan-1-ol pentan-1-ol	All harmful to varying extent by ingestion, inhalation and by skin absorption. Methanol is more toxic than the others. Methanol, ethanol and propan-1-ol are highly flammable and the others are flammable.	Wear eye protection and pvc gloves. Ensure absence of ignition sources. Dispense into small reagent bottles (say 50 or 100 cm^3) in a well-ventilated room or preferably in a fume cupboard.
methanoic acid ethanoic acid propanoic acid benzoic acid salicylic acid	The three aliphatic acids are corrosive. Methanoic acid is quite toxic and ethanoic acid is flammable. The two aromatic acids are very irritating to the skin.	Wear goggles and pvc gloves during dispensing. Ensure absence of ignition sources.
concentrated sulphuric acid	Causes severe burns to eyes and skin.	Wear goggles or faceshield and pvc gloves.

Notes

This experiment should be carried out in a well-ventilated room.

- Factors Affecting Enzyme Activity -

INTRODUCTION

Enzymes are globular protein molecules which catalyse biochemical reactions. An enzyme is very specific usually catalysing only one reaction of one particular compound. The latter is known as the substrate and it binds on to an enzyme's active site where it undergoes reaction. The active site has a unique shape which is matched by that of the substrate molecule. This allows an enzyme to accept only its substrate molecule and reject all others. Any change which alters the shape of the active site will affect an enzyme's activity.

The aim of this experiment is to investigate the effect of pH or temperature changes on enzyme activity.

We will study catalase, an enzyme widely distributed in living organisms.
It catalyses the decomposition of hydrogen peroxide into water and oxygen:

$$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$$

Choose the factor you will investigate (**either** pH **or** temperature) and proceed to the appropriate section below.

pH

Requirements

test tube with side arm
delivery tube
stopper
syringes
small beaker
clamp stand and clamp
timer
potato discs (catalase source)
hydrogen peroxide (30 volumes)
buffer solutions (pH 4, 7 and 10)
0.1 mol l^{-1} sodium hydroxide (pH 13)
0.1 mol l^{-1} hydrochloric acid (pH 1)

Hazards

Hydrogen peroxide is irritating especially to the eyes.
0.1 mol l^{-1} sodium hydroxide, 0.1 mol l^{-1} hydrochloric acid and the pH 10 buffer solution are irritating to the eyes.

Care

Wear eye protection and immediately wash off any chemical spillages on the skin.
When using the syringes always keep them pointing downwards.

Procedure

1. Attach the delivery tube to the side arm of the test tube and clamp the test tube in a vertical position.
2. Half fill the beaker with water.
3. Arrange the apparatus so that the bent end of the delivery tube is beneath the surface of the water in the beaker.
4. Using a syringe, add 5 cm^3 of the pH 7 buffer solution into the test tube along with 3 potato discs.
5. Leave the mixture to stand for three minutes and during this time measure 1 cm^3 of hydrogen peroxide into a syringe.
6. Add the hydrogen peroxide to the test tube and immediately start the timer and stopper the test tube. Then count and record the number of bubbles of oxygen given off during the next 3 minutes.

7. Repeat the experiment with each of the two remaining buffer solutions and then with 0.1 mol l^{-1} hydrochloric acid (pH 1) and finally with 0.1 mol l^{-1} sodium hydroxide solution (pH 13).
   In each experiment remember to:
   - leave the buffer/potato disc mixture to stand for 3 minutes before adding the hydrogen peroxide
   - count and record the number of bubbles of oxygen produced during the first 3 minutes of reaction.

Temperature

Requirements

test tube with side arm
delivery tube
stopper
syringes
small beaker and large beaker
clamp stand and clamp
timer
tripod
Bunsen burner and heating mat
thermometer
potato discs (catalase source)
hydrogen peroxide (30 volumes)
deionised water

Hazard

Hydrogen peroxide is irritating especially to the eyes.

Care

Wear eye protection and immediately wash off any hydrogen peroxide spillage on the skin.
When using the syringes always keep them pointing downwards.

Procedure

1. Half fill both beakers with water from the cold tap and place the larger one on the tripod.
2. Attach the delivery tube to the side arm of the test tube, place the test tube in the large beaker of water and clamp it in a vertical position.
3. Arrange the apparatus so that the bent end of the delivery tube is beneath the surface of the water in the small beaker.
4. Using a syringe, add 5 cm^3 of deionised water into the test tube along with 3 potato discs.
5. Place the thermometer in the test tube and leave the mixture to stand until its temperature remains steady. Measure and record this steady temperature.
6. Measure 1 cm^3 of hydrogen peroxide into a syringe.
7. Add the hydrogen peroxide to the test tube and immediately start the timer and stopper the test tube. Then count and record the number of bubbles of oxygen given off during the next 3 minutes.
8. Repeat the experiment another four times after heating the water in the large beaker first to 30 °C, then to 40 °C, then to 50 °C and finally to 60 °C. It is not necessary to heat the water to these precise temperatures - they are only approximate values.
   In each experiment remember to:
   - leave the water/potato disc mixture to stand until its temperature remains steady
   - measure and record this steady temperature just before adding the hydrogen peroxide
   - count and record the number of bubbles of oxygen produced during the first 3 minutes of reaction.

HIGHER CHEMISTRY	- Factors Affecting Enzyme Activity -	UNIT 2 PPA 3

Name:	PC(a)	PC(b)	PC(c)	PC(d)	PC(e)	Teacher's/Lecturer's Initials	
Date:							

- ASSESSMENT SHEET -

* *State the aim of the experiment mentioning which factor you investigated, the enzyme used and the*

PC(b)

reaction it catalysed.

Procedure

* *Draw a labelled diagram of the assembled apparatus.*

PC(b)

* *How was the activity of the enzyme measured?*

PC(b)

Results

* *Record your results in tabular form.*

PC(c)

Conclusion

* *State the conclusion of the experiment.*
PC(e)

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents for both investigations

hydrogen peroxide (30 volumes) ($5\,cm^3$)

hydrogen peroxide (30 volumes)

irritant

potato discs
(size: ~15 mm diameter x 1 mm thick)

Additional reagents for 'pH' investigation

pH 4 buffer solution ($5\,cm^3$)
pH 7 buffer solution ($5\,cm^3$)
pH 10 buffer solution ($5\,cm^3$)
(buffer solutions are most conveniently prepared from commercially available tablets or capsules)

pH 10 buffer solution

irritant

$0.1\,mol\,l^{-1}$ hydrochloric acid ($5\,cm^3$)
($8.6\,cm^3$ concentrated hydrochloric acid per litre)

concentrated hydrochloric acid

corrosive

$0.1\,mol\,l^{-1}$ sodium hydroxide ($5\,cm^3$)
(4.0 g sodium hydroxide per litre)

$0.1\,mol\,l^{-1}$ sodium hydroxide

irritant

sodium hydroxide

corrosive

ADDITIONAL REAGENT FOR 'TEMPERATURE' INVESTIGATION

deionised water ($25\,cm^3$)

APPARATUS FOR BOTH INVESTIGATIONS

test tube with side arm (1)
delivery tube (1)
stopper (1)
syringes - $5\,cm^3$ (1), $1\,cm^3$ (1)
$100\,cm^3$ glass beaker (1)
clamp stand (1)
clamp (1)
timer (1)

ADDITIONAL APPARATUS FOR 'TEMPERATURE' INVESTIGATION

tripod (1)
Bunsen burner (1)
heating mat (1)
$400\,cm^3$ glass beaker (1)
0 - 100 °C thermometer (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
hydrogen peroxide (30 volumes)	Irritating to eyes, lungs and skin. Possible pressure build up in bottle.	Wear eye protection and open bottle cautiously especially if it is not a vented type.
pH 4, pH 7 and pH 10 buffers from tablets or capsules	pH 10 buffer is an irritant.	Wear eye protection and gloves.
0.1 mol l^{-1} sodium hydroxide from solid	Solid is corrosive. Alkaline aerosol released.	Wear goggles and pvc gloves. Prepare in ventilated room.
0.1 mol l^{-1} hydrochloric acid from concentrated acid	Concentrated acid - liquid and vapour are corrosive to eyes, skin and respiratory system.	Wear goggles and prepare in a fume cupboard.
potato discs	Nil.	

Notes

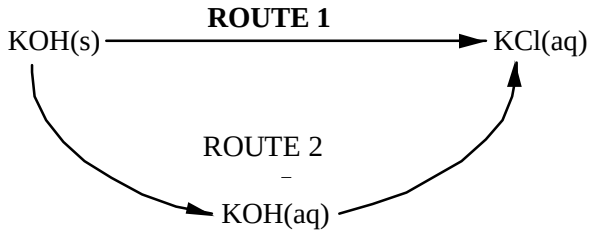
The potato discs can be prepared using a cork borer and slicing the potato cylinders.

Since catalase concentration in potatoes will vary it is advisable to trial this experiment and if necessary adjust the hydrogen peroxide concentration and/or the number of potato discs to give an appropriate rate of hydrogen peroxide decomposition.

Alternative sources of catalase could be used e.g. fresh liver or the commercially available catalase from bovine liver. With these alternatives the reaction rate will be faster and it may therefore be easier to measure the volume of oxygen rather than count the number of bubbles.

INTRODUCTION

Solid potassium hydroxide can be converted into potassium chloride solution by two different routes:



Route 1 is the direct route whereby potassium chloride solution is made by adding solid potassium hydroxide directly to hydrochloric acid. Let's suppose it has an enthalpy change of ΔH_1.

$$KOH(s) + HCl(aq) \longrightarrow KCl(aq) + H_2O(l) \qquad \Delta H_1$$

Route 2 is the indirect route and involves two steps. In the first of these solid potassium hydroxide is dissolved in water:

$$KOH(s) + aq \longrightarrow KOH(aq) \qquad \Delta H_{2a}$$

The resulting potassium hydroxide solution is then added to hydrochloric acid to form potassium chloride solution:

$$KOH(s) + HCl(aq) \longrightarrow KCl(aq) + H_2O(l) \qquad \Delta H_{2b}$$

According to Hess's Law the overall enthalpy change involved in converting solid potassium hydroxide into potassium chloride solution will be the same no matter whether the direct or indirect route is taken.

The aim of this experiment is to confirm Hess's Law.

Requirements

thermometer
measuring cylinders
plastic beakers or polystyrene cups
balance
potassium hydroxide
1 mol l^{-1} hydrochloric acid

Hazards

Solid potassium hydroxide and the potassium hydroxide solution you make are corrosive.
1 mol l^{-1} hydrochloric acid irritates the eyes.

Care

Wear goggles and wash your hands immediately if the solid potassium hydroxide makes any contact.
If any potassium hydroxide solution or acid splashes on your skin, wash it off immediately.

Procedure

ROUTE 1 (direct route)

1. Using the measuring cylinder, measure out 25 cm^3 of 1 mol l^{-1} hydrochloric acid into a plastic beaker or polystyrene cup.
2. Measure and record the temperature of the acid.
3. Weigh out accurately about 1.2 g of potassium hydroxide into a plastic beaker or polystyrene cup and record the mass. Make sure the mass of potassium hydroxide does not exceed 1.4 g.
4. Add the acid to the potassium hydroxide. Slowly and continuously stir the reaction mixture with the thermometer until all the solid reacts.
5. Measure and record the highest temperature reached by the reaction mixture.

ROUTE 2 (indirect route)

Step A

The solution you prepare in this step is needed in step **B** - **DON'T THROW IT AWAY!**

1. Using the measuring cylinder, measure out 25 cm^3 of water into a plastic beaker or polystyrene cup.
2. Measure and record the temperature of the water.
3. Weigh out accurately about 1.2 g of potassium hydroxide into a plastic beaker or polystyrene cup and record the mass. Make sure the mass of potassium hydroxide does not exceed 1.4 g.
4. Add the water to the potassium hydroxide. Slowly and continuously stir the reaction mixture with the thermometer until all the solid dissolves.
5. Measure and record the highest temperature reached by the solution.
6. Keep the solution you have just prepared but allow it to cool down for some time before proceeding to step **B**.

Step B

1. Using the measuring cylinder, measure out 25 cm^3 of 1 mol l^{-1} hydrochloric acid into a plastic beaker or polystyrene cup.
2. Measure and record the temperature of the acid.
3. Measure and record the temperature of the potassium hydroxide solution you prepared in step **A**.
4. Add the acid to the potassium hydroxide solution and stir the reaction mixture slowly and continuously with the thermometer.
5. Measure and record the highest temperature reached by the reaction mixture.

Calculation

Note: In calculating the heat energies absorbed by the reaction mixtures we treat the latter as if they were entirely made up of water. This means that we assume their specific heat capacities and densities to be the same as those for water i.e. 4.18 kJ kg^{-1} $°C^{-1}$ and 1.00 g cm^{-3} (or 1.00 kg l^{-1}).

Route 1 - calculation of ΔH_1

(a) The heat energy gained by the reaction mixture (E_h) can be calculated using the formula:

$$E_h = \mathbf{c\,m\,\Delta T}$$

where **c** = the specific heat capacity
m = the mass (in kg)
ΔT = the rise in temperature (in °C).

(b) We assume that all the heat energy released in the reaction is absorbed only by the reaction mixture. So the heat energy we calculated in stage (a) is equal to that released when, say, **x** g of potassium hydroxide reacts with the acid.

(c) We can work out the mass of one mole of potassium hydroxide and knowing how much heat energy is released when **x** g of potassium hydroxide reacts with the acid we can calculate the heat energy released when **one mole** of potassium hydroxide reacts. This will be equal to the enthalpy change for route 1 i.e. ΔH_1.

Route 2 - calculation of ΔH_{2a} and ΔH_{2b}

(a) ΔH_{2a}, the enthalpy change for the first step of route 2, can be calculated in a similar fashion to that described above.

(b) ΔH_{2b}, the enthalpy change for the second step, can be calculated in the same way but remember
   (i) the mass of the reaction mixture is the combined masses of the potassium hydroxide solution and the hydrochloric acid
   (ii) the initial temperature of the reaction mixture will be the average of the initial temperatures of the potassium hydroxide solution and the hydrochloric acid
   (iii) the mass of potassium hydroxide used will be identical to that used in calculating ΔH_{2a}.

HIGHER CHEMISTRY	- Hess's Law -	UNIT 3 PPA 1

Name:	PC(a)	PC(b)		PC(c)	PC(d)	PC(e)	Teacher's/Lecturer's Initials	
Date:								

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

Procedure

* *Use equations to describe the two routes whereby you converted solid potassium hydroxide into potassium*
PC(b)
chloride solution and label them with the appropriate ΔH values.

* *Write down the relationship between the ΔH values for Hess's Law to hold true.*

Results

* *Record your results in an appropriate manner.*
PC(c)

Calculation / Conclusion

* *Carry out a calculation to show the confirmation of Hess's Law.* **PC(d), PC(e)**

(Ask your teacher/lecturer for a HELP SHEET if you are unsure about how to complete the calculation)

- HELP SHEET –

CALCULATION

Route 1 - calculation of ΔH_1

Suppose 1.25 g of potassium hydroxide had been added to 25 cm^3 of hydrochloric acid and the temperature of the reaction mixture had risen by 23.5 °C.

The heat energy gained by the reaction mixture (E_h) is calculated using the formula:

$$E_h = \boldsymbol{c\ m\ \Delta T}$$

where ***c*** = *the specific heat capacity of the water and it has the value 4.18 kJ kg^{-1} $°C^{-1}$.*

m = *the mass of solution being heated and in this experiment it is 0.025 kg.*

$\boldsymbol{\Delta T}$ = *the rise in temperature in °C.*

$$E_h = 4.18 \times 0.025 \times 23.5$$
$$= 2.456\,kJ$$

We assume that the heat energy released in the reaction is gained only by the reaction mixture.

The heat energy released on reacting 1.25 g of potassium hydroxide with hydrochloric acid = 2.456 kJ

potassium hydroxide: KOH

Mass of 1 mole = 39 + 16 + 1 = 56 g

We can now calculate the heat energy released on reacting 1 mole of potassium hydroxide with hydrochloric acid.

$$1.25\,g \longleftrightarrow 2.456\,kJ$$
$$56\,g \longleftrightarrow 2.456 \times \frac{56}{1.25}$$
$$= 110\,kJ$$

Hence $\Delta H_1 = -110\,kJ\,mol^{-1}$ *(A negative sign is used because the reaction is exothermic)*

Route 2 - calculation of ΔH_{2a}

Suppose 1.18 g of potassium hydroxide had been added to 25 cm^3 of water and the temperature had risen by 10 °C.

$$E_h = 4.18 \times 0.025 \times 10$$
$$= 1.045\,kJ$$

The heat energy released on reacting 1.18 g of potassium hydroxide with water = 1.045 kJ

We can now calculate the heat energy released on reacting 1 mole (56 g) of potassium hydroxide with water.

$$1.18\,g \longleftrightarrow 1.045\,kJ$$
$$56\,g \longleftrightarrow 1.045 \times \frac{56}{1.18}$$
$$= 49.6\,kJ$$

Hence $\Delta H_{2a} = -49.6\,kJ\,mol^{-1}$

Route 2 - calculation of ΔH_{2b}

Suppose the temperature of the reaction mixture had risen by 5.5 °C when 25 cm^3 of hydrochloric acid had been added to the 25 cm^3 of potassium hydroxide solution prepared in the first step of route 2.

The mass of the reaction mixture will be 0.050 kg (the combined masses of the two solutions)

$$E_h = 4.18 \times 0.050 \times 5.5$$
$$= 1.150\ kJ$$

Knowing that the mass of potassium hydroxide present in the potassium hydroxide solution is 1.18 g we can now calculate the heat energy released when 1 mole of potassium hydroxide (56 g) solution reacts with hydrochloric acid.

$$1.18\ g \longleftrightarrow 1.150\ kJ$$
$$56\ g \longleftrightarrow 1.150 \times \frac{56}{1.18}$$
$$= 54.6\ kJ$$
$$\text{Hence } \Delta H_{2b} = -54.6\ kJ\ mol^{-1}$$

Enthalpy change for route 1 = ΔH_1 = $-110\ kJ\ mol^{-1}$

Enthalpy change for route 2 = $\Delta H_{2a} + \Delta H_{2b} = -49.6 - 54.6 = -104\ kJ\ mol^{-1}$

Since ΔH_1 is approximately equal to $\Delta H_{2a} + \Delta H_{2b}$, Hess's Law has been confirmed.

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

potassium hydroxide (~ 3 g) — **potassium hydroxide**


corrosive

1.0 mol l^{-1} hydrochloric acid (50 cm^3)
(86 cm^3 concentrated hydrochloric acid per litre)

1.0 mol l^{-1} hydrochloric acid


irritant

concentrated hydrochloric acid


corrosive

Apparatus

25 cm^3 (or 50 cm^3) measuring cylinders (2)
100 cm^3 plastic beakers (2) or polystyrene cups (2)
0 - 50 °C thermometer (1)
access to balance (0.01 g readability)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
solid potassium hydroxide	Nil if small stock bottle sent to lab.	Wear goggles and pvc gloves if dispensing into smaller containers.
1 mol l^{-1} hydrochloric acid from concentrated acid	Fumes and solution of concentrated acid are corrosive to eyes, skin and respiratory system.	Wear goggles and carry out dilution to 1 mol l^{-1} in a fume cupboard.

Notes

It is important that the hydrochloric acid be in excess. Provided that the concentrations and volumes of acid used are as stated a mass of just less than 1.4 g (0.025 mol) potassium hydroxide will ensure this.
Sodium hydroxide is more deliquescent than potassium hydroxide but could be used as a substitute.

- Quantitative Electrolysis -

INTRODUCTION

On electrolysing dilute sulphuric acid the hydrogen ions are reduced to hydrogen gas at the negatively charged electrode:

$$2H^+(aq) + 2e \longrightarrow H_2(g)$$

The ion-electron equation shows that two moles of electrons are needed to liberate one mole of the element. Since 96 500 C is the charge associated with one mole of electrons, then 2 x 96 500 C will, in theory, be required to produce one mole of hydrogen.

The aim of the experiment is to confirm this i.e. to determine the quantity of electricity required to produce one mole of hydrogen by electrolysing dilute sulphuric acid.

Requirements

- electrolytic cell fitted with carbon electrodes
- low voltage source of electricity
- ammeter
- variable resistor
- connecting wires
- 50 cm^3 graduated tube or measuring cylinder
- timer
- clamp stand and clamp
- 0.1 $mol\,l^{-1}$ sulphuric acid

Hazards

0.1 $mol\,l^{-1}$ sulphuric acid irritates the eyes.
There is a very small risk of explosion from the hydrogen and oxygen released in the electrolysis.

Care

Wear eye protection.
When filling the graduated tube (or measuring cylinder) with dilute sulphuric acid and when placing it into the electrolyte, wear gloves. If any acid splashes on your skin wash it off immediately.
If you use a power pack do not plug it into the mains until you have had the circuit checked by your teacher/lecturer.
The electrolysis should be carried out in a well-ventilated room and make sure flames are absent when the hydrogen is released from the graduated tube (or measuring cylinder) at the end of the experiment.

Procedure

1. As directed by your teacher/lecturer, set up a circuit containing an electrolytic cell, an ammeter and a variable resistor but **do not switch** on the voltage source at the moment.
2. Add dilute sulphuric acid to the electrolytic cell making sure the electrodes are well covered.
3. Fill the graduated tube or measuring cylinder with dilute sulphuric acid. Making sure no acid falls out of the tube (or cylinder) invert it and carefully place the open end underneath the surface of the acid in the cell.
4. Clamp the graduated tube (or measuring cylinder) in a vertical position but do not place it over the negatively charged electrode as yet.
5. Switch on the source of electricity and adjust the variable resistor to set the current to 0.5 A. Leave the current passing through the solution for a few minutes. This allows the porous carbon electrodes to become saturated with gas.
6. Switch off and position the graduated tube (or measuring cylinder) over the negatively charged electrode. Make sure the tube (or cylinder) is not resting on the bottom of the cell.

7. Switch on the voltage source and at the same time start the timer. If necessary adjust the current to 0.5 A using the variable resistor. Constantly check that the current stays at 0.5 A as the solution is electrolysed.
8. Allow the current to pass until slightly less than 50 cm^3 of hydrogen is produced. At this point switch off the voltage source and record the time for which the current has passed. Also record the current.
9. Measure and record the exact volume of hydrogen produced.

Calculation

(a) From the current (**I**) in amps and the time (**t**) in seconds, the electric charge (**Q**) in coulombs can be calculated using the relationship:

$$\mathbf{Q = I\,t}$$

(b) Let us suppose **x** litres of hydrogen were collected during the electrolysis and let us assume that the molar volume of hydrogen is 24.1 litres mol^{-1}.

Knowing how many coulombs were needed to give us **x** litres of hydrogen, we can calculate the quantity of electricity required to produce 24.1 litres of hydrogen i.e. one mole of hydrogen.

HIGHER CHEMISTRY	- Quantitative Electrolysis -	UNIT 3 PPA 2

Name:	PC(a)	PC(b)	PC(c)	PC(d)	PC(e)	Teacher's/Lecturer's Initials	
Date:							

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

Procedure

* *Draw a labelled diagram of the circuit.*
PC(b)

* *List all the measurements that were made during the experiment.*
PC(b)

Results

* *Present your results in an appropriate manner.*
PC(c)

Calculation / Conclusion

* *Carry out a calculation to determine the quantity of electricity required to produce one mole of hydrogen. Assume the molar volume of hydrogen to be 24.1 litres* mol^{-1}.

(Ask your teacher/lecturer for a HELP SHEET if you are unsure about how to complete the calculation)

PC(d), PC(e)

In theory, 193 000 C are required to produce one mole of hydrogen by electrolysis.

* *Suggest sources of error which could account for any difference between your result and the theoretical one.*

- HELP SHEET –

CALCULATION

Suppose 48.8 cm^3 (0.0488 litre) of hydrogen had been collected using a current of 0.50 A for 790 s.

From the current (I) in amps and the time (t) in seconds we can work out the electric charge (Q) in coulombs using the relationship, Q = It:

$$Q = 0.50 \times 790$$
$$= 395\,C$$

Under the conditions of temperature and pressure of the experiment the molar volume of hydrogen is assumed to be
24.1 litres mol^{-1}. This means that one mole of hydrogen occupies 24.1 litres.
Knowing that 395 C are required to produce 0.0488 litres of hydrogen we can calculate the quantity of electricity needed to produce 24.1 litres of hydrogen i.e. 1 mol of hydrogen:

$$0.0488\,\text{litre} \longleftrightarrow 395\,C$$
$$24.1\,\text{litres (1 mol)} \longleftrightarrow 395 \times \frac{24.1}{0.0488}$$

$$= 1.95 \times 10^5\,C$$

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

~ 0.1 mol l^{-1} sulphuric acid
(5.5 cm^3 concentrated sulphuric acid per litre)

concentrated sulphuric acid

corrosive

Apparatus

electrolytic cell fitted with carbon electrodes (1)
low voltage source of electricity
ammeter (1)
variable resistor (1)
connecting wires (4)
50 cm^3 graduated tube or measuring cylinder (1)
timer (1)
clamp stand and clamp (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
0.1 mol l^{-1} sulphuric acid from concentrated acid	Concentrated acid causes severe burns to eyes and skin.	Wear goggles or faceshield and pvc gloves. Add concentrated acid slowly with stirring to chilled water of volume equal to about half the final volume.

Notes

The sulphuric acid is reusable.

24.1 litres mol^{-1} is the molar volume of hydrogen at 20 °C and 101 kPa.

To reduce the risk of splashes of acid on the hands when placing the filled graduated tube in the acid, the tube could be stoppered, placed in the acid and the stopper removed by using tongs.

A 50 cm^3 burette could be used as an alternative to the graduated tube as could a graduated plastic pipette (see SSERC Bulletins 156 (p 9) and 166 (p 28)).

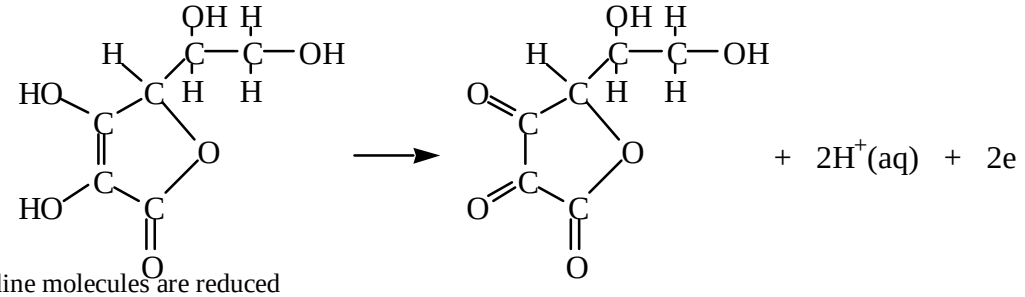
- A Redox Titration -

INTRODUCTION

Vitamin C (ascorbic acid) is an important component of our diet. In its absence the protein, collagen, cannot form fibres properly and this results in skin lesions and blood vessel fragility.

Although vitamin C occurs naturally in many fruits and vegetables many people take vitamin C tablets to supplement their intake.

Vitamin C can undergo a redox reaction with iodine in which the vitamin C is oxidised



$$+ \ 2H^+(aq) \ + \ 2e$$

and the iodine molecules are reduced

$$I_2(aq) + 2e \longrightarrow 2I^-(aq)$$

The aim of this experiment is to determine the mass of vitamin C in a tablet by carrying out a redox titration using a solution of iodine of accurately known concentration and starch solution as an indicator.

Requirements

small beaker
wash bottle
250 cm^3 standard flask
filter funnel
25 cm^3 pipette
50 cm^3 burette
conical flask
pipette filler
white tile
standard solution of iodine
starch solution
vitamin C tablet
deionised water

Hazard

The iodine solution irritates the eyes.

Care

Wear eye protection and wash your hands if any iodine solution spills on them.

Procedure

1. Add a vitamin C tablet to the beaker.
2. Add some deionised water (approximately 50 cm^3) to the beaker and stir the mixture until the tablet has dissolved.
3. Carefully add the resulting solution to the 250 cm^3 standard flask. Rinse out the beaker several times with water and add the washings to the flask.
4. Add water to the standard flask to bring the volume of the solution up to the graduation mark on the neck.
5. Stopper the flask and invert it several times to make sure the solution is thoroughly mixed.

6. After rinsing the pipette with a little of the vitamin C solution, pipette 25 cm^3 of it into the conical flask.
7. Add a few drops of starch solution to the vitamin C solution in the conical flask.
8. After rinsing the burette with a little iodine solution, fill the burette with the iodine solution.
9. Note the initial burette reading. Since the solution has a dark colour, it is difficult to see the bottom of the meniscus. Take the burette reading from the top of the meniscus.
10. Add the iodine solution slowly from the burette whilst gently swirling the solution in the conical flask. Initially you will see a blue/black colour as the iodine reacts with the starch but this will rapidly disappear as the iodine reacts with the vitamin C.
11. Near the end-point of the titration the colour disappears more slowly. At this point add the iodine solution drop by drop until the solution just turns a blue/black colour and remains so.
12. This is the end-point of the titration i.e. all the vitamin C has reacted. Note the final burette reading.
13. Wash out the conical flask.
14. Repeat the titrations until concordant results are obtained.

Calculation

(a) Knowing the average volume and concentration of the iodine solution used in the redox titration, the number of moles of iodine can be calculated.

(b) With the result from step (a) and the balanced equation for the redox reaction, we can work out the number of moles of vitamin C in 25 cm^3 of the vitamin C solution. This can be scaled up to find the number of moles of vitamin C in 250 cm^3 of the vitamin C solution.

(c) Your final answer in step (b) will, of course, be equal to the number of moles of vitamin C in the tablet. Using this result and the mass of one mole of vitamin C (176 g) we can finally work out the mass of vitamin C in the tablet.

HIGHER CHEMISTRY	- A Redox Titration -	UNIT 3 PPA 3

Name:	PC(a)	PC(b)		PC(c)	PC(d)	PC(e)	Teacher's/Lecturer's Initials	
Date:								

- ASSESSMENT SHEET -

* *State the aim of the experiment.*
PC(b)

* *Using the molecular formula for vitamin C write equations for the oxidation and reduction half-reactions and hence write a balanced equation for the redox reaction between vitamin C and iodine.*

Procedure

* *Write a **brief** description of the experimental procedure you carried out to determine the mass of vitamin C in a tablet.*
PC(b)

Results

* *Present your results in an appropriate manner.*
PC(c)

Calculation / Conclusion

* *Carry out a calculation to determine the mass of vitamin C in the tablet.*
(Ask your teacher/lecturer for a HELP SHEET if you are unsure about how to complete the calculation)

PC(d), PC(e)

- HELP SHEET –

CALCULATION

Suppose the average titre volume was 22.1 cm^3 and the iodine solution had a concentration of 0.0250 $mol\,l^{-1}$.

From the average titre volume in litres (V) and the concentration of the iodine solution (C), we can calculate the number of moles of iodine (n) used in the titration:

$$n_{(iodine)} = C \times V = 0.0250 \times 0.0221$$
$$= 5.525 \times 10^{-4}\,mol$$

We can now use the balanced redox equation to calculate the number of moles of vitamin C in a 25 cm^3 sample of the vitamin C solution:

$$C_6H_8O_6 + I_2 \longrightarrow C_6H_6O_6 + 2H^+ + 2I^-$$
$$1\,mol \longleftrightarrow 1\,mol$$
$$5.525 \times 10^{-4}\,mol \longleftrightarrow 5.525 \times 10^{-4}\,mol$$

But there were 250 cm^3 of vitamin C in total and so to determine the number of moles of vitamin C in the tablet we have to scale up our last answer:

$$n_{(vitamin\,C)} \text{ per tablet} = 10 \times 5.525 \times 10^{-4}$$
$$= 5.525 \times 10^{-3}\,mol$$

Vitamin C: $C_6H_8O_6$

Mass of 1 mole = 6(12) + 8(1) + 6(16) = 176 g

We can now calculate the mass of vitamin C per tablet:

$$\text{Mass of vitamin C per tablet} = 176 \times 5.525 \times 10^{-3}$$
$$= 0.972\,g$$

- TEACHER/LECTURER/TECHNICIAN SHEET -

Requirements per student (or group)

Reagents

1 g vitamin C tablet (1)

0.025 mol l^{-1} iodine solution (~ 75 cm^3)
(6.35 g iodine and 20 g potassium iodide per litre)

iodine

harmful

1 % fresh starch solution (as indicator)
(Mix 1 g soluble starch to a thin paste with water, then add to 100 cm^3 boiling water)

deionised water (250 cm^3)

Apparatus

250 cm^3 standard flask (1)
25 cm^3 pipette (1)
50 cm^3 burette (1)
100 cm^3 beaker (1)
100 cm^3 conical flask (1)
pipette filler (1)
filter funnel (1)
wash bottle (1)
white tile (1)

Safety Measures

Preparation/provision of:	Main Hazards	Control Measures
0.025 mol l^{-1} iodine from solid or ampoule	Solid burns eyes and skin; harmful if ingested. Vapour irritates eyes.	Wear goggles and pvc gloves. Prepare in ventilated room and keep 1 mol l^{-1} sodium thiosulphate handy to treat any spills on the skin.

Notes

The iodine solution will require to be standardised. This can be done against a standard solution of sodium thiosulphate.

Alternatively, the iodine solution could be prepared from a commercial volumetric standard.

Both lemon and orange-flavoured effervescent vitamin C tablets are suitable. Despite the bright orange colour of the latter the end-point of the titration is distinct.