ROYAL SOCIETY OF CHEMISTRY | SECONDARY AND FURTHER EDUCATION GROUP

Proceedings of the 3rd Secondary and Further Education National Conference

School of Chemistry
Birmingham University
July 4th 2017

RSC Secondary and Further Education Group – (SaFE)
National Chemistry Teachers and Educators Conference 2017
Transitions - Chemistry from 8-18 and beyond

School of Chemistry - The University of Birmingham 4 July 2017 09:30-16:00

PROGRAMME

09:30 – 10:00 Arrival and registration in the Foyer

10:00 – 10:55 OPENING SESSION (Room 203)

10:00 – 10:05 **Professor Jon Preece** - welcome on behalf of the School of Chemistry

10:05 – 10:10 **Dr. Julie Hyde -** Welcome and introduction by the chair of the SaFE group

10:10 – 10:55 Keynote address: **Edmund Walsh - From Controlled Assessment to Required Practical – progress or retrograde step?’**

10:55 – 11:10 MORNING BREAK & NETWORKING

INTRODUCTION TO THE AFTERNOON BREAKOUT SESSIONS (Room 203)

11:10 – 11:25 **Dr. Andy Markwick -** Evolution Educational Consultancy – KS2 KS3 interphase

11:25 – 11:40 **Simon Jukes -** Director CSR scientific training. Apprenticeships and Industry

11:40 - 11:55 **Dr. David Paterson -** OCR Chemistry subject advisor. Beyond the recipe.

11:55 – 12:10 **Heidi Dobbs –** RSC Educational Coordinator Midlands region

12:10 – 13:00 LUNCH & NETWORKING

13:00 – 16:00 BREAKOUT SESSIONS (Various rooms)

13:00 – 13:55 *Breakout sessions - session 1*

14:00 – 14:55 *Breakout sessions - session 2*

15:00 – 15:10 **REFRESHMENTS AVAILABLE**

15:10 – 16:00 CLOSING SESSION (Room 203)

15:10 – 15:50 **Lorelly Wilson** – **SUPER STARTERS - Demonstrations giving you loads of ideas using household items and kitchen chemicals.**

15:50 – 16:00 **Dr Julie Hyde** - Closing comments & date for conference 2018

16:00 – 16:30 **REFRESHMENTS AVAILABLE**

BREAKOUT SESSIONS – TO BE RUN TWICE

Simon Jukes	**Apprenticeships - Understanding industrial options.**
Dr. Andy Markwick	**The Curriculum - What is needed at KS2 and how it interphases with KS3 - a quantum leap ?**
Dr. David Paterson	**Beyond the recipe – Some ideas on making practical work more effective.**
Dr. Sandy Wilkinson	**Using ICT to enhance the Teaching, Learning and Assessment in Chemistry.**
Bob Worley	**Suggested GCSE chemistry practical procedures in miniature.**

DISPLAY BOARDS IN THE FOYER

Simon Rees - RSC Educational Techniques Group

ASE – Gaynor Sharp ASE West Midlands

Peter Hoare – Free post-16 chemistry learning and teaching resources using online worldwide databases

David Paterson – Ideas for effective practicals ?

West Midlands Chemistry Teachers Centre

Birmingham University School of Chemistry

SciChem – Glassware

Participants wishing to attend the ICT session should bring along their own laptop/ipad etc.

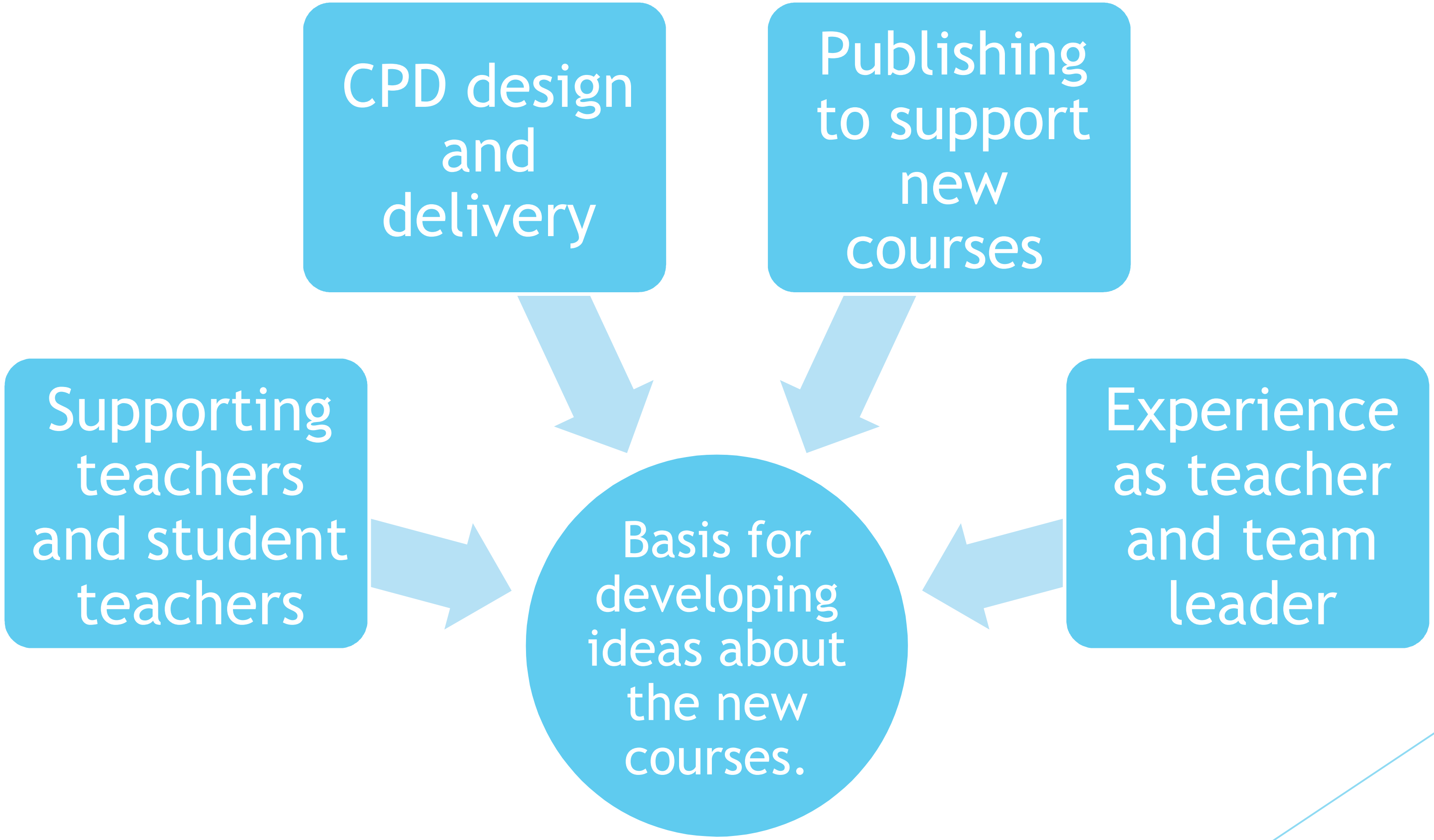
Divining the algorithm

Ed Walsh

ed walsh consulting

Specialising in Science

Intro: Ed Walsh



CPD design and delivery

Publishing to support new courses

Supporting teachers and student teachers

Experience as teacher and team leader

Basis for developing ideas about the new courses.

How can practical work produce better scientists?

Thinking about practical work

- “Science without practical work is like swimming without water.”

  SCORE report ‘Practical work in science’ 2008

- Whenever the equipment comes out, my heart sinks. Either the experiment will show what we already know, or else it won’t, in which case there’s hell up.”

  GCSE student, quoted in National Strategies SLDP presentation

- “I can’t understand why my students didn’t do well on that question (in the exam). After all, *they’d done the experiment*.”

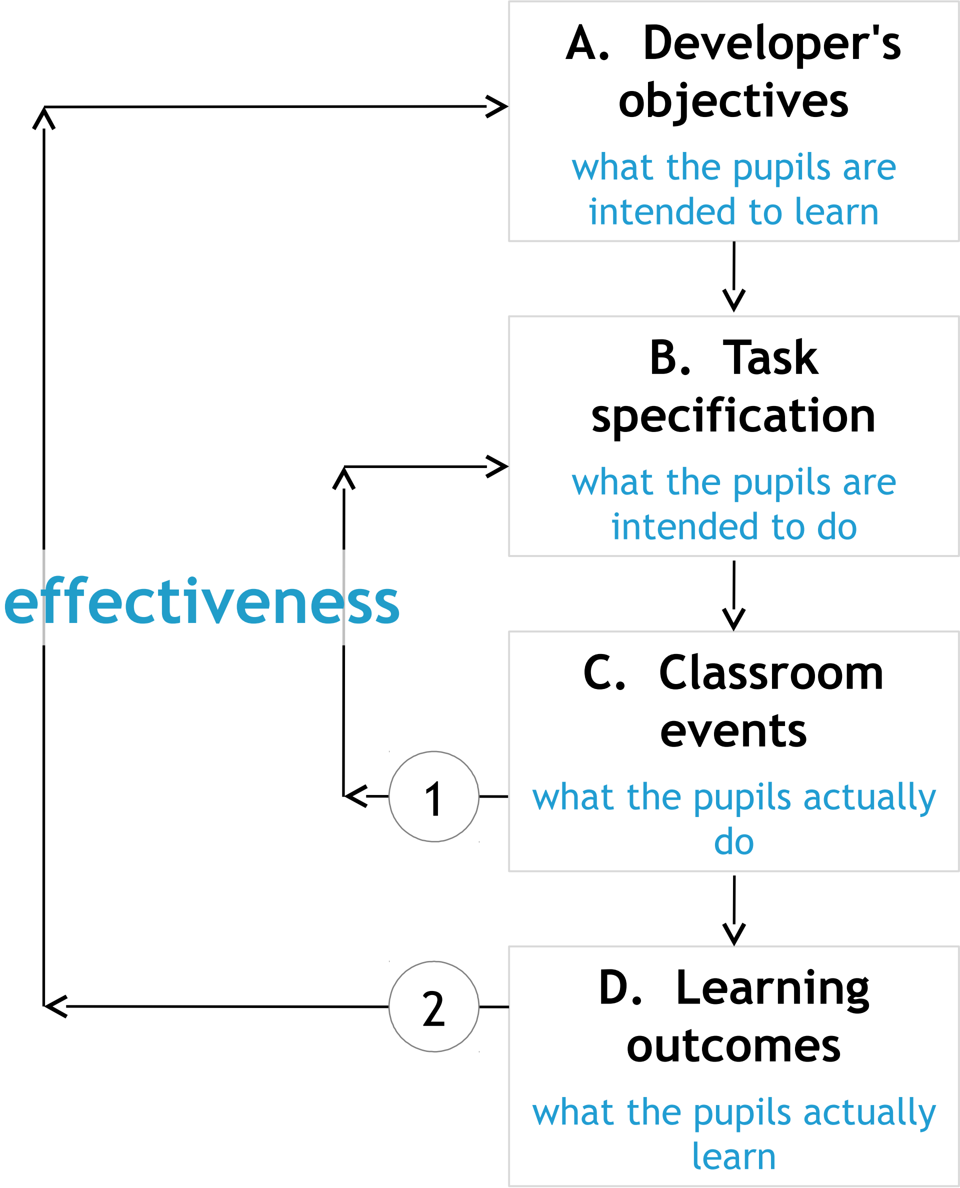
  Head of (not very successful) Science department

- (First question to students doing practical work) “Can you tell me what you’re doing?” (Second question) “Can you tell me why you’re doing it?” (Responses – much better on first than second).

Does practical work lead to a better understanding of science?

- Does practical work lead to students developing a better understanding of scientific ideas and processes?
- How should we plan, structure, deliver and assess practical work in science?
- How will examiners approach the challenge of assessing proficiency in scientific enquiry?

Reflecting on practical work



A. Developer's objectives

what the pupils are intended to learn

B. Task specification

what the pupils are intended to do

C. Classroom events

what the pupils actually do

D. Learning outcomes

what the pupils actually learn

effectiveness

1

2

Effectiveness at Level 1

Did pupils do what they were intended to do (and see the things they were meant to see)?

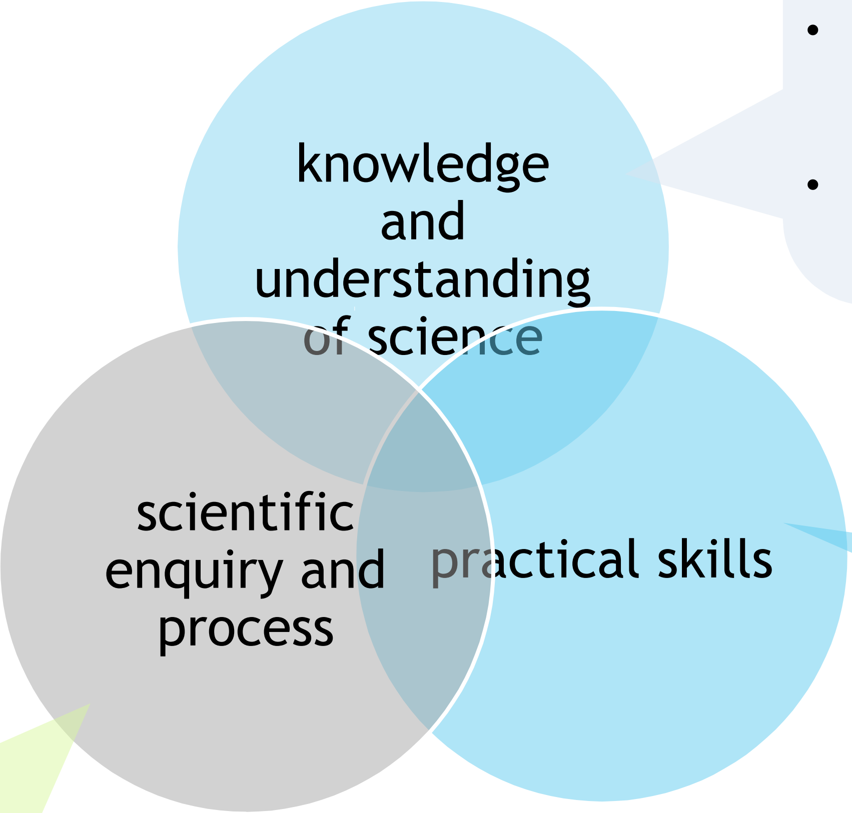
Effectiveness at Level 2

Did pupils learn (and can later show understanding of) what they were intended to learn?

From: ‘Analysing practical science activities’, Millar, ASE, 2010

Why do we do practical work?

- the key learning outcomes



- Make observations
- Identify or classify
- Describe a link between variables
- Show understanding of scientific ideas

- Identify equipment
- Use equipment

- Propose a question
- Plan a strategy
- Evaluate risk
- Collect relevant data
- Present data effectively
- Interpret data
- State a conclusion
- Evaluate a conclusion

From: ‘Analysing practical science activities’, Millar, ASE, 2010

What drives the design of assessment items?

- There are multiple factors that drive the design of exam papers – understanding this enables us to see why questions will be written in particular ways.
- Once this algorithm is understood it can not only be used to support progress towards better outcomes but also harnessed to developing the quality of provision.

Assessment objectives

	Assessment Objectives	Weighting
AO1	Demonstrate knowledge and understanding of: • scientific ideas • scientific techniques and procedures.	40%
AO2	Apply knowledge and understanding of: • scientific ideas • scientific enquiry, techniques and procedures.	40%
AO3	Analyse information and ideas to: • interpret and evaluate • make judgements and draw conclusions • develop and improve experimental procedures.	20%

Apparatus & techniques

AT 1	Use of appropriate apparatus to make and record a range of measurements accurately, including mass, time, temperature, and volume of liquids and gases (links to A-level AT a).
AT 2	Safe use of appropriate heating devices and techniques including use of a Bunsen burner and a water bath or electric heater (links to A-level AT b).
AT 3	Use of appropriate apparatus and techniques for conducting and monitoring chemical reactions, including appropriate reagents and/or techniques for the measurement of pH in different situations (links to A-level AT a and d).
AT 4	Safe use of a range of equipment to purify and/or separate chemical mixtures including evaporation, filtration, crystallisation, chromatography and distillation (links to A-level AT d and g).
AT 5	Making and recording of appropriate observations during chemical reactions including changes in temperature and the measurement of rates of reaction by a variety of methods such as production of gas and colour change (links to A-level AT a and l).
AT 6	Safe use and careful handling of gases, liquids and solids, including careful mixing of reagents under controlled conditions, using appropriate apparatus to explore chemical changes and/or products (links to A-level AT a and k).
AT 7	Use of appropriate apparatus and techniques to draw, set up and use electrochemical cells for separation and production of elements and compounds (links to A-level AT d and j).
AT8	Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including gas tests, flame tests, precipitation reactions, and the determination of concentrations of strong acids and strong alkalis (links to A-level AT d).

Furthermore…

- Items based on practical aspects will need to represent not less than 15% of the marks …
- … this will be interpreted tightly, so that an item relating to, say, investigating rates of reaction will contribute to this but a following item on, say, analysing the data from the investigation won't.
- Furthermore, every part of the specification needs to be visited over a period of time; there can't be any 'dusty corners' that are not featured …
- … it might be advisable to assume that this is no more than, say, three years.

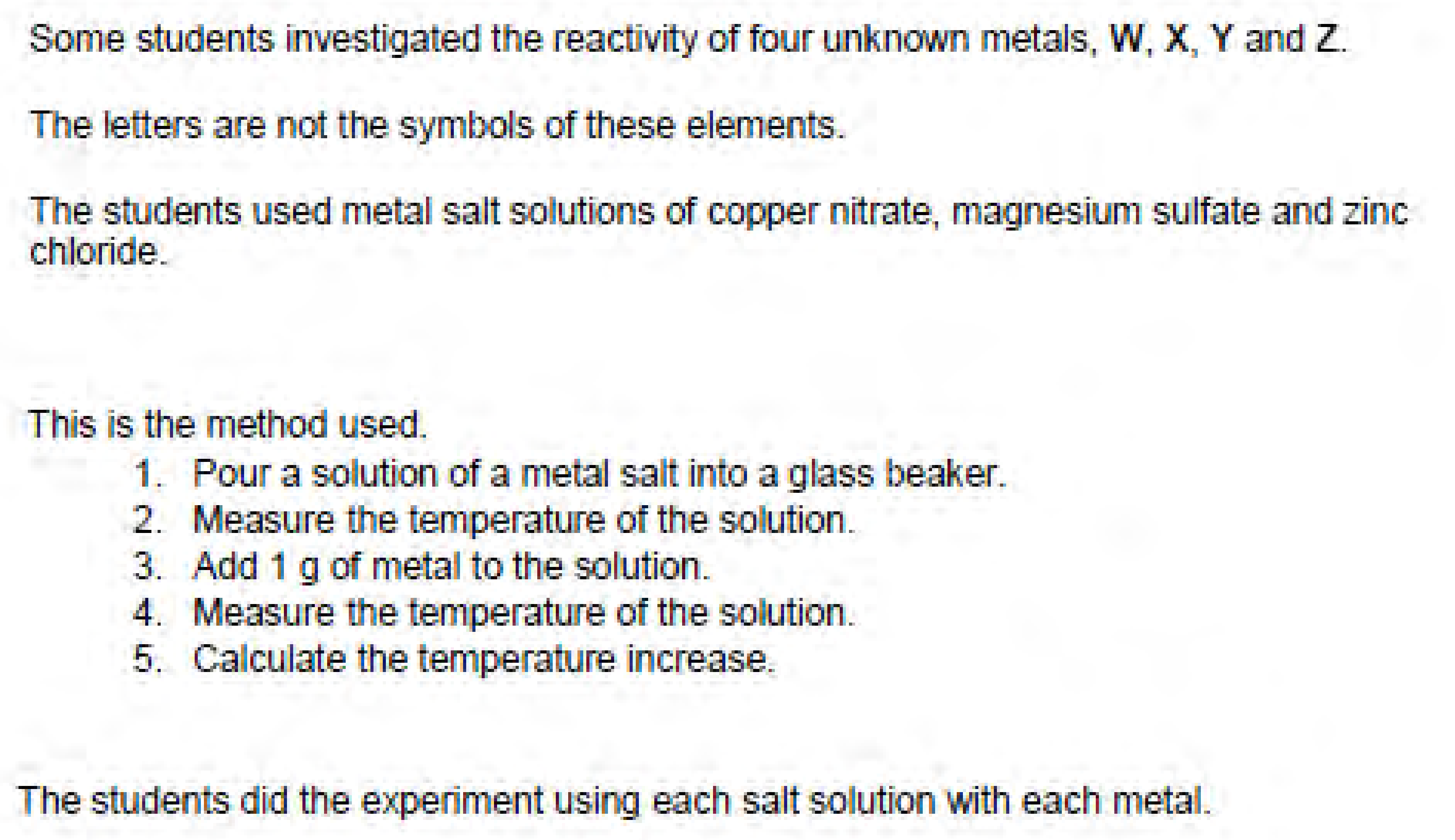
What will the result of this be?

- Significant number of items relating to practical work in each paper.
- Different types of items, drawing on different skills
- Associated with explanations, data analysis, supporting concepts and calculations
- Not all based on required practicals

Assessing application

- Chymosin is an enzyme that makes milk clot. A student wanted to test the effect of pH on the ability of chymosin to clot milk at room temperature.
- The following was available to the student:
  - Five test tubes
  - Buffer solutions at pH 4, pH 5, pH 6, pH 7 and pH 8.
  - Chymosin solution
  - Milk at room temperature
  - 5 cm^3 syringes
- Devise an experiment to test the effect of pH on the ability of chymosin to clot milk at room temperature. [3 marks]
- Stipulated practical: *Investigate the factors that affect enzyme activity*

What questions might the examiner ask?



Some students investigated the reactivity of four unknown metals, **W**, **X**, **Y** and **Z**.

The letters are not the symbols of these elements.

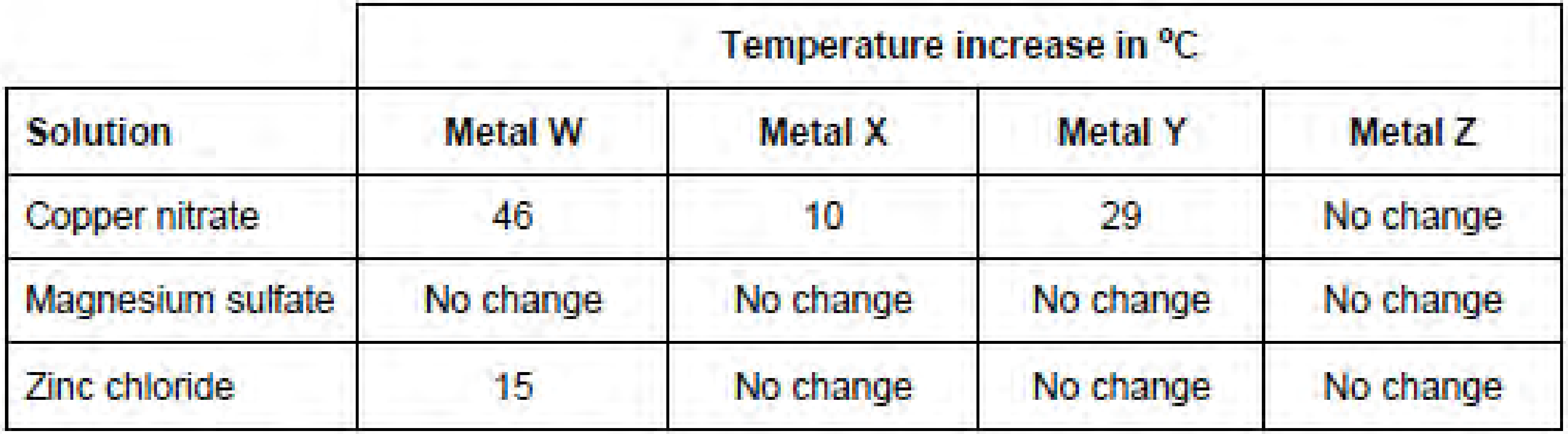
The students used metal salt solutions of copper nitrate, magnesium sulfate and zinc chloride.

This is the method used.

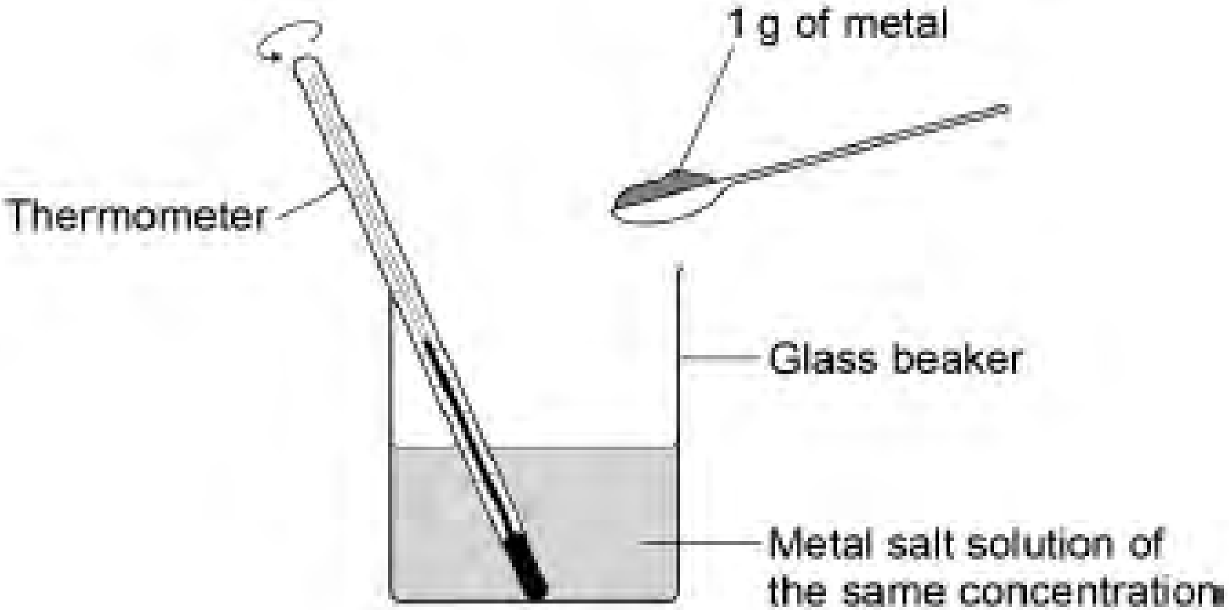
1. Pour a solution of a metal salt into a glass beaker.
2. Measure the temperature of the solution.
3. Add 1 g of metal to the solution.
4. Measure the temperature of the solution.
5. Calculate the temperature increase.

The students did the experiment using each salt solution with each metal.

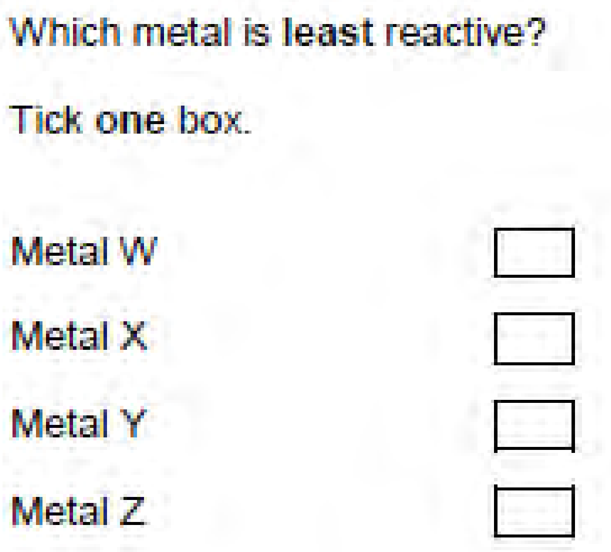
What questions might the examiner ask?



	Temperature increase in °C			
Solution	**Metal W**	**Metal X**	**Metal Y**	**Metal Z**
Copper nitrate	46	10	29	No change
Magnesium sulfate	No change	No change	No change	No change
Zinc chloride	15	No change	No change	No change



What questions did the examiner ask?



Which metal is least reactive?

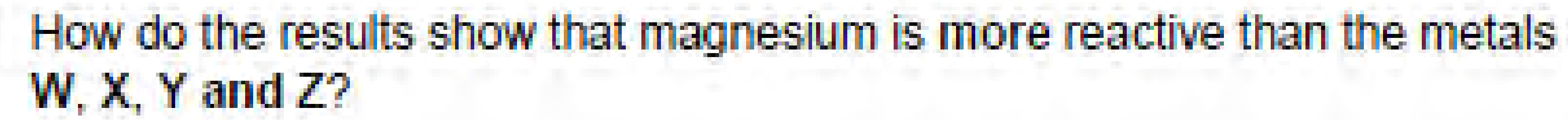
Tick one box.

Metal W ☐

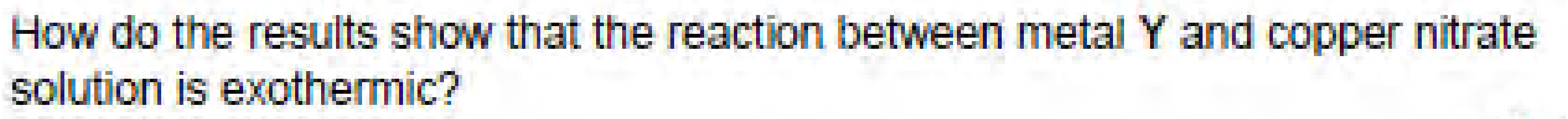
Metal X ☐

Metal Y ☐

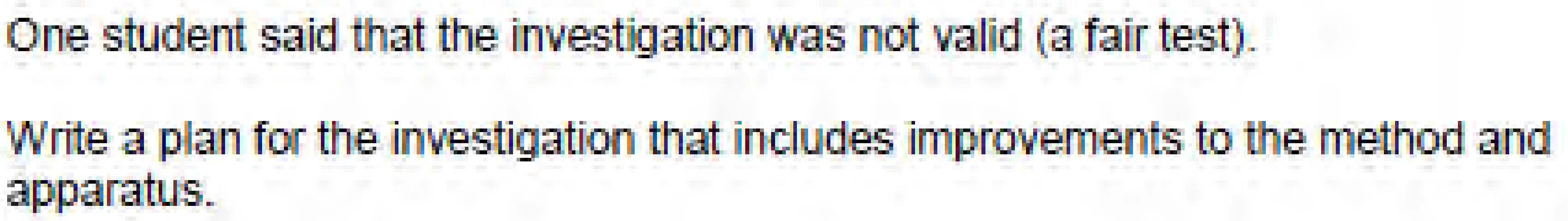
Metal Z ☐



How do the results show that magnesium is more reactive than the metals **W, X, Y and Z?**



How do the results show that the reaction between metal Y and copper nitrate solution is exothermic?



One student said that the investigation was not valid (a fair test).

Write a plan for the investigation that includes improvements to the method and apparatus.

What questions might the examiner ask?

Investigate how paper chromatography can be used to separate and tell the difference between coloured substances. Students should calculate Rf values.

Apparatus and techniques

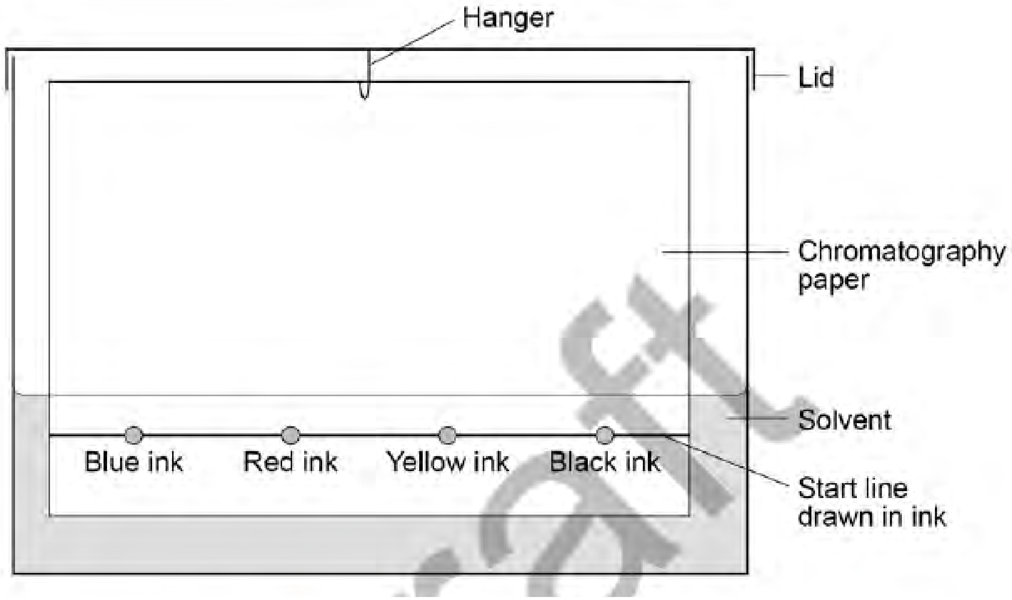
- AT 1 – use of appropriate apparatus to make and record a range of measurements accurately.
- AT 4 – safe use of a range of equipment to purify and/or separate chemical mixtures including chromatography.

Key opportunities for skills development

- WS 2.4 – carry out experiments appropriately having due regard for the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.
- WS 2.6 – make and record observations and measurements using a range of apparatus and methods.

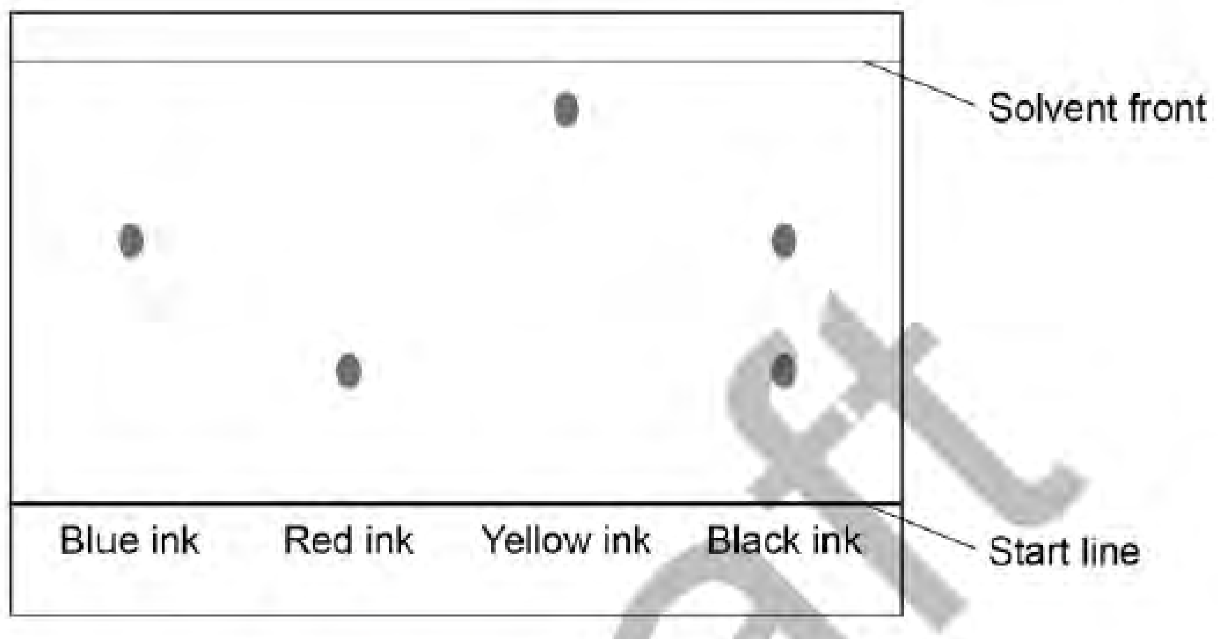
What questions did the examiner ask?

- A student used paper chromatography to investigate the colours in different inks.



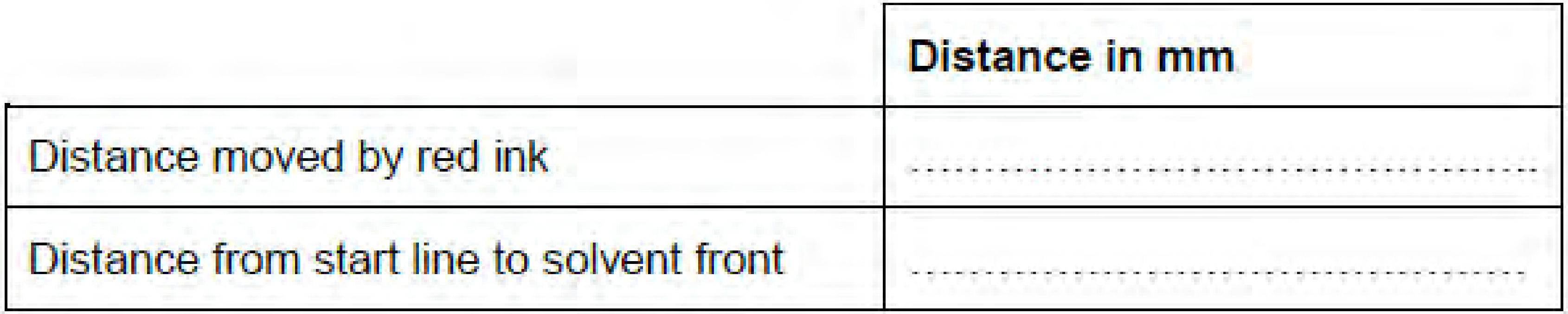
- a) The student made two mistakes in setting up the apparatus. Identify the two mistakes. Describe the problem each mistake would cause. [4 marks]

- The student then set up the apparatus without making any mistakes. His results are shown here:



- b) What colours are in the black ink? [1 mark]
- c) Which of the inks is the most soluble in the solvent? Give a reason for your answer. [2 marks]

- d) Use the results to complete the table below, then calculate the R_f value for red ink. [5 marks]



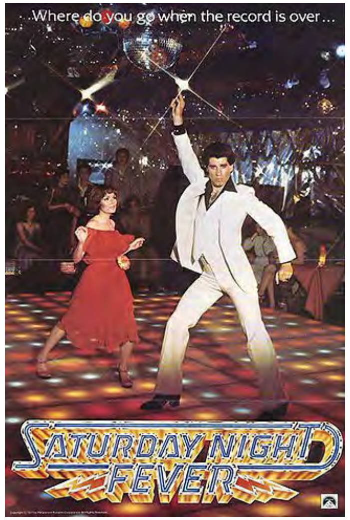
	Distance in mm
Distance moved by red ink	....
Distance from start line to solvent front	....

- The R_f value for red ink is calculated using the equation.
- $R_f = \dfrac{\text{distance moved by red ink from the start line}}{\text{distance moved by solvent from the start line}}$

- Give your answer to 2 significant figures.

What’s the role of KS3?

- KS3 needs to have a strong functional role in developing ideas, processes and skills so that students are ‘GCSE ready’ when they get to the start of KS4.
- This doesn’t mean starting to teach GCSE material in Y7. However …
- … it is appropriate to identify what can be done to build effective foundations.



GCSE
Science

So … what do we know?

- Doing practical work is necessary but not sufficient. If students do the same practical as we've done it doesn't mean they've thought the same thoughts. The activities are essential but not sufficient.
- Practical work needs to be placed in a broader context than sometimes happens. Its role needs to go well beyond familiarity with set procedures. As well as knowing how to do it, students need to understand other things too, such as:
  - Why is it done this way?
  - What can this be applied to?
  - How can this procedure be improved?
- Working scientifically has a strong role in the new GCSE specifications and will be assessed with a variety of types of questions. There is a journey from doing the experiment to answering exam questions.
- Working scientifically needs a set of habits and familiarity with a language; this needs to start in KS3.

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ROYAL SOCIETY OF CHEMISTRY

Chemistry at primary school

Dr Andy Markwick CChem FRSC

Evolution Educational Consultancy

07930282010

Chemistry at KS2

Activity 1 Dissolving, Suspension and absorption

You have been given small amounts of 3 white solids, each in a small container.

1. Using a 3ml pipette, carefully add some water to the first solid drop-by-drop. Record your observations. Keep adding water until you see no further changes.

2. Repeat this for each solid.

Solid	Observation	Explanation
A		
B		
C		

Example of a results table.

The following vocabulary may help you: solute, solvent, soluble, solution, insoluble, suspension, absorb, swell, expand.

Teacher notes

Responses will vary and depend on children's prior knowledge and experiences. However, children should notice that the salt (A) dissolves, flour (B) is insoluble and forms a suspension and 'fake snow' (C) absorbs the water and increases dramatically in volume (Figure 1).

'Fake snow' is a polymer called sodium polyacrylate. This substance is used in baby's nappies. It can absorb up to 300 times its mass in water. To help children visualise dissolving and absorption the following activities can be useful.

Modelling dissolving

Materials

6 x A4 white card (you can write NaCl on each) – this represents the salt crystal. For greater challenge, cards can be labelled Na and Cl to represent the individual sodium and chloride ions.

12 x A4 blue card (you can write H_2O on each) – this represents water molecules. For greater challenge, the cards can be labelled H_2O.

Method

Ask six children to hold a white card and stand close together in a formation of two rows of three. This represents the salt crystals.

Ask six children with blue cards to remove one of the children with a white card from the salt crystal. They must circle the crystal and hold their blue cards outwards.

Children will be familiar with the change in taste of water when salt is added. This model helps children to visualise where the salt is, i.e., surrounded by water molecules (Figure 2).

Modelling absorption

Ask six children to hold a white card and stand shoulder-to-shoulder in a straight line – they represent molecules of 'fake snow'.

Invite someone to be a water molecule (blue card) and squeeze in between the 'fake snow' (line of children). Repeat this with a further three water molecules. They should notice that the line gets longer – this represents the increase in volume of the 'fake snow' (Figure 3).

With both of the above activities, ask children to suggest how the water molecules could be removed, recovering the solids. Children will be able to suggest heating to drive off the water. This can be demonstrated by asking water molecule children to sit down. The activity can be repeated to demonstrate the reversibility of these processes

Links to KS3

Concept of a pure substance, mixtures and dissolving

Separating mixtures

Changes in state

Chemical reactions

Reactants $\longrightarrow$ Products

The following activities provide opportunities for pupils to discover different types of chemical reaction and to learn how chemists use symbols to write chemical formulae.

Children enjoy writing like scientists and being exposed to chemical formulae at KS2 will support their science learning later in secondary school. To begin introducing chemical formulae, it is important to show pupils the symbols used by chemists. A key of symbols is provided for pupils to refer to when asked about the possible names of the chemicals being used (Table 1).

Method

1. Provide children with a list of symbols with their meanings.
2. Use symbols to label chemicals being used, e.g., $NaHCO_3$ rather than sodium hydrogen carbonate or baking powder.
3. Ask children to work out the name of the chemical using the information in the table.
4. Introduce state symbols to show that scientists always distinguish between solid, liquid, gas and solutions.

Abbreviation/symbol	**Meaning**
Na	This symbol stands for the element sodium. Its name is derived from the Latin Natrium.
H	This symbol stands for the element hydrogen.
CO_3	This stands for carbonate. It is a cluster of 1 carbon atom and 3 oxygen atoms.
aq	This symbol is used to show something is dissolved in water. It is short for aqueous, which means water in Latin.
s	This symbol shows that the chemical is in its solid phase.
l	This symbol shows that the chemical is a liquid (pure, nothing is dissolved in it).
CH_3COOH	This is the chemical formula for ethanoic acid. This acid is found in vinegar and gives vinegar its familiar smell.
PVA*	This stands for Poly Vinyl Acetate. It is a polymer.
Borax	Borax is a chemical often used in washing. Borax is a complex molecule containing sodium (Na), boron (B) and oxygen (O). It has the formula $Na_2B_4O_7$.

Table 1. A key showing the meaning of symbols used in the activities.

*Poly means many, so PVA has many vinyl acetate monomers (single) joined together.

For each of the reactions below, pupils are asked to sketch and/or record their observations and provide a possible explanation.

Activity 2 *Making calcium carbonate (limestone)*

1. Place your straw into the test tube containing limewater.
2. **VERY** carefully blow into the test tube. **DO NOT** suck!
3. Record your observations and explain what happened.

Teacher notes

You can obtain lime water (calcium hydroxide solution) from a friendly secondary school. It is advisable that children wear eye protection. Place no more than 5ml of limewater in a test tube.

Demonstrate how to gently blow through the straw into the limewater.

What's the science?

Exhaled air contains enough carbon dioxide to react with the lime water and produce calcium carbonate. Calcium carbonate is insoluble in water and therefore forms a solid, referred to as a precipitate (Figure 4). When a solid is formed in a solution in this way it is called a precipitation reaction.

$$Ca(OH)_{2(aq)} + CO_{2(g)} \rightarrow CaCO_{3(s)} + H_2O_{(l)}$$

This reaction is used to test for carbon dioxide gas.

Links to KS3

Chemical reactions as the rearrangement of atoms

Representing chemical reactions (introducing formulae and word equations)

Formation of limestone

Activity 3 *Reacting an acid with a dissolved carbonate*

(BEFORE YOU DO THIS REACTION MAKE UP YOUR RED CABBAGE INDICATOR)**

The dissolved carbonate is sodium hydrogen carbonate (try to obtain pure $NaHCO_3$ as baking powder also contains other ingredients).

1. Using the syringe, place 10ml of $NaHCO_{3(aq)}$ into a test tube.
2. Pipette in 3ml of red cabbage indicator and note what happens.
3. Using a fresh pipette, very slowly add 10ml of $CH_3COOH_{(aq).}$
4. Record your observations and explain what happened.

**Making red cabbage indicator

Method

1. Using scissors, cut up a small amount of red cabbage into small pieces. Place these into a beaker.
2. Add 5 mls of water and stir (before water is added, ask children to predict the colour of the water).

Teacher notes

Use distilled vinegar for CH_3COOH. If children get vinegar in their eyes, wash out with plenty of water.

What's the science?

Red cabbage juice contains a group of coloured chemicals called anthocyanins. These chemicals change their colour depending on whether they are in acidic, alkaline or neutral environments.

For red cabbage

Red = Acidic

Blue = Neutral

Green/blue = Alkaline

The red cabbage juice is made in water (neutral) and will be a blue colour (Figure 5). When added to the $NaHCO_3$ (alkaline) it will change to a green or green-blue colour. Addition of CH_3COOH (acidic) produces a red colour and carbon dioxide gas is evolved (Figure 6). Ask pupils to suggest what gas they think has been formed (the clue is in the name carbonate).

$$NaHCO_{3(aq)} + CH_3COOH_{(aq)} \longrightarrow CH_3COONa_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

Note: g = gas and l = liquid

If children add the vinegar carefully they may be able to produce red, blue and green layers (acid, neutral and alkaline).

Andy Markwick/RSC/2017

Links to KS3

Chemical reactions as the rearrangement of atoms

Representing chemical reactions (introducing formulae and word equations)

Defining acids and alkalis in terms of neutralisation

pH scale, indicators

Activity 4 *Reacting an acid with a solid carbonate*

1. Add 4 heaped spatulas of baking powder ($NaHCO_3$) into a beaker.
2. Pipette in 3ml of red cabbage indicator. Note what happens.
3. Using the same pipette as in the last experiment, add 3ml of $CH_3COOH_{(aq).}$
4. Record your observations. Add more acid if you want to.

Teacher notes

The reaction is the same as above, yet instead of using a solution of $NaHCO_3$ the solid is used.

The production of carbon dioxide gas from baking powder ($NaHCO_3$) is used in baking. Baking powder thermally decomposes when heated and releases CO_2. It is the CO_2 gas that produces the holes in breads and cakes.

Links to KS3

Chemical reactions as the rearrangement of atoms

Representing chemical reactions (introducing formulae and word equations)

Defining acids and alkalis in terms of neutralisation

pH scale, indicators

Activity 5 *Making a polymer*

1. You have been given a plastic cup containing 10ml PVA glue. Using a measuring cylinder add an equal volume of water and stir it well.
2. Using a 3ml pipette, transfer 9mls of borax solution to the PVA solution and stir.
3. Record your results.
4. Add 6 drops of food dye and mix.
5. You may handle with care! (wear gloves)

Teacher notes

Borax will need to be obtained from a chemical supplier. It is now thought to have a very low risk to pregnant women, and is safe to use (CLEAPSS).

The best results are given if the food dye is added after the borax.

What's the science?

PVA is a polymer containing extremely long chains of vinyl acetate molecules joined together. When borax is added they join the poly vinyl acetate molecules together forming a structure that looks like a ladder or netting. These additional cross-linking bonds changes the properties of the PVA from a viscous liquid into a rubbery solid (Figure 7).

Polymers are everywhere, from plastic bags, to chairs we sit on in school to even our clothes. Children may be familiar with names such as polythene, polyvinyl chloride (PVC) and polyester.

A writing challenge

Imagine visiting another planet. The only life that exists is made of slime. What would it look like? How would it move, feed, reproduce and communicate?

Links to KS3

Chemical reactions as the rearrangement of atoms

Representing chemical reactions (introducing formulae and word equations)

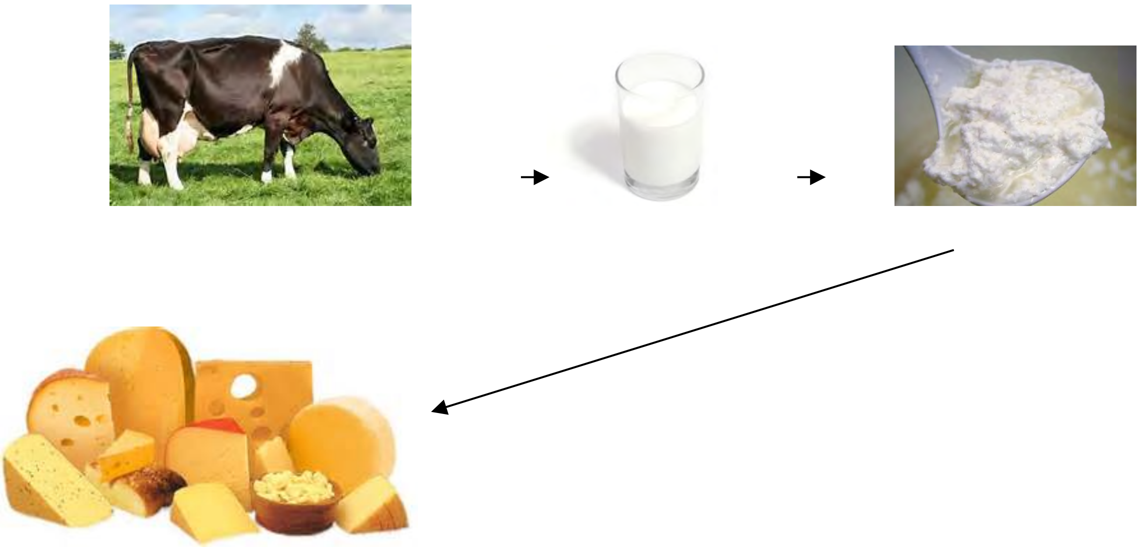
Properties of polymers

Notes

Working Scientifically with chemistry

Investigation 1 *Say cheese!*

Cheese is a dairy product and is made from milk. Milk is composed mostly water, yet also contains proteins, fats and sugars. To make cheese the proteins (polymer molecules) in milk must be made to curdle, or clump together. This can be done by adding an acid.



The investigation

1. Plan an investigation that will allow you to decide whether the acids vinegar, lemon juice or cola curdle cheese best.
2. Check your planning with your teacher before you start your investigation.
3. Remember to record all observations and if you decide to alter your plan, explain why.

Teacher notes

Full fat milk works best, although you may like to suggest investigating different compositions or brands of milk.

What's the science?

Milk contains the proteins casein and whey. The casein protein in milk forms a colloidal suspension. When an acid is added it makes the proteins clump together and eventually they get too large to remain in colloidal suspension and so they precipitate out forming curds. The whey protein remains in solution.

Investigation 2 Egg white

Egg white is predominantly composed of a protein polymer called albumen. As with casein, the polymer chains can be altered by the addition of an acid. In this investigation children can be asked to plan and investigate what happens to albumen when a variety of different acids are added to it.

Albumen can either be obtained directly from eggs or purchasing liquid albumen from a supermarket.

Acids might include vinegar, fruit juices, fizzy drinks and lemon juice.

Encourage children to record their observations carefully, to consider fair testing and whether repeats might be necessary.

Investigation 3 Fermentation

Fermentation is an example of a biochemical reaction involving yeast. When yeast is exposed to water, warmth and a food source such as sugar, it will respire and in doing so produce waste products CO_2 and alcohol. People have used the process of fermentation over millennia to make bread rise (CO_2) and to make alcoholic drinks.

Method

1. Add 1 spatula (1/2 tsp) yeast into a test tube or boiling tube.
2. Dissolve 1/4tsp of sugar in 10mls water.
3. Add the solution to the yeast.
4. Place a balloon over the top of the tube and observe over 2 days.

As the yeast begins to respire, CO_2 is produced and this will enter the balloon and make it rise. Alcohol will also be produced and so care is needed when handling the tubes. Children should observe, rather than handle the tubes once fermentation has started.

Possible investigation

Plan an investigation to observe what happens when the concentration of sugar solution is changed. Alternatively, investigate how changing the temperature affects the rate of fermentation of yeast.

Chemistry at KS2

Activity 1 Dissolving, Suspension and absorption

You have been given small amounts of 3 white solids, each in a small container.

1. Using a 3ml pipette, carefully add some water to the first solid drop-by-drop. Record your observations. Keep adding water until you see no further changes.

2. Repeat this for each solid.

Solid	Observation	Explanation
A		
B		
C		

Example of a results table.

The following vocabulary may help you: solute, solvent, soluble, solution, insoluble, suspension, absorb, swell, expand.

Teacher notes

Responses will vary and depend on children's prior knowledge and experiences. However, children should notice that the salt (A) dissolves, flour (B) is insoluble and forms a suspension and 'fake snow' (C) absorbs the water and increases dramatically in volume (Figure 1).

'Fake snow' is a polymer called sodium polyacrylate. This substance is used in baby's nappies. It can absorb up to 300 times its mass in water. To help children visualise dissolving and absorption the following activities can be useful.

Modelling dissolving

Materials

6 x A4 white card (you can write NaCl on each) – this represents the salt crystal. For greater challenge, cards can be labelled Na and Cl to represent the individual sodium and chloride ions.

12 x A4 blue card (you can write H_2O on each) – this represents water molecules. For greater challenge, the cards can be labelled H_2O.

Method

Ask six children to hold a white card and stand close together in a formation of two rows of three. This represents the salt crystals.

Ask six children with blue cards to remove one of the children with a white card from the salt crystal. They must circle the crystal and hold their blue cards outwards.

Children will be familiar with the change in taste of water when salt is added. This model helps children to visualise where the salt is, i.e., surrounded by water molecules (Figure 2).

Modelling absorption

Ask six children to hold a white card and stand shoulder-to-shoulder in a straight line – they represent molecules of ‘fake snow’.

Invite someone to be a water molecule (blue card) and squeeze in between the ‘fake snow’ (line of children). Repeat this with a further three water molecules. They should notice that the line gets longer – this represents the increase in volume of the ‘fake snow’ (Figure 3).

With both of the above activities, ask children to suggest how the water molecules could be removed, recovering the solids. Children will be able to suggest heating to drive off the water. This can be demonstrated by asking water molecule children to sit down. The activity can be repeated to demonstrate the reversibility of these processes

Links to KS3

Concept of a pure substance, mixtures and dissolving

Separating mixtures

Changes in state

Chemical reactions

Reactants ⟶ Products

The following activities provide opportunities for pupils to discover different types of chemical reaction and to learn how chemists use symbols to write chemical formulae.

Children enjoy writing like scientists and being exposed to chemical formulae at KS2 will support their science learning later in secondary school. To begin introducing chemical formulae, it is important to show pupils the symbols used by chemists. A key of symbols is provided for pupils to refer to when asked about the possible names of the chemicals being used (Table 1).

Method

1. Provide children with a list of symbols with their meanings.
2. Use symbols to label chemicals being used, e.g., $NaHCO_3$ rather than sodium hydrogen carbonate or baking powder.
3. Ask children to work out the name of the chemical using the information in the table.
4. Introduce state symbols to show that scientists always distinguish between solid, liquid, gas and solutions.

Abbreviation/symbol	**Meaning**
Na	This symbol stands for the element sodium. Its name is derived from the Latin Natrium.
H	This symbol stands for the element hydrogen.
CO_3	This stands for carbonate. It is a cluster of 1 carbon atom and 3 oxygen atoms.
aq	This symbol is used to show something is dissolved in water. It is short for aqueous, which means water in Latin.
s	This symbol shows that the chemical is in its solid phase.
l	This symbol shows that the chemical is a liquid (pure, nothing is dissolved in it).
CH_3COOH	This is the chemical formula for ethanoic acid. This acid is found in vinegar and gives vinegar its familiar smell.
PVA*	This stands for Poly Vinyl Acetate. It is a polymer.
Borax	Borax is a chemical often used in washing. Borax is a complex molecule containing sodium (Na), boron (B) and oxygen (O). It has the formula $Na_2B_4O_7$.

Table 1. A key showing the meaning of symbols used in the activities.

*Poly means many, so PVA has many vinyl acetate monomers (single) joined together.

For each of the reactions below, pupils are asked to sketch and/or record their observations and provide a possible explanation.

Activity 2 *Making calcium carbonate (limestone)*

1. Place your straw into the test tube containing limewater.
2. **VERY** carefully blow into the test tube. **DO NOT** suck!
3. Record your observations and explain what happened.

Teacher notes

You can obtain lime water (calcium hydroxide solution) from a friendly secondary school. It is advisable that children wear eye protection. Place no more than 5ml of limewater in a test tube.

Demonstrate how to gently blow through the straw into the limewater.

What's the science?

Exhaled air contains enough carbon dioxide to react with the lime water and produce calcium carbonate. Calcium carbonate is insoluble in water and therefore forms a solid, referred to as a precipitate (Figure 4). When a solid is formed in a solution in this way it is called a precipitation reaction.

$$Ca(OH)_{2(aq)} + CO_{2(g)} \rightarrow CaCO_{3(s)} + H_2O_{(l)}$$

This reaction is used to test for carbon dioxide gas.

Links to KS3

Chemical reactions as the rearrangement of atoms

Representing chemical reactions (introducing formulae and word equations)

Formation of limestone

Activity 3 *Reacting an acid with a dissolved carbonate*

(BEFORE YOU DO THIS REACTION MAKE UP YOUR RED CABBAGE INDICATOR)**

The dissolved carbonate is sodium hydrogen carbonate (try to obtain pure $NaHCO_3$ as baking powder also contains other ingredients).

1. Using the syringe, place 10ml of $NaHCO_{3(aq)}$ into a test tube.
2. Pipette in 3ml of red cabbage indicator and note what happens.
3. Using a fresh pipette, very slowly add 10ml of $CH_3COOH_{(aq).}$
4. Record your observations and explain what happened.

**Making red cabbage indicator

Method

1. Using scissors, cut up a small amount of red cabbage into small pieces. Place these into a beaker.
2. Add 5 mls of water and stir (before water is added, ask children to predict the colour of the water).

Teacher notes

Use distilled vinegar for CH_3COOH. If children get vinegar in their eyes, wash out with plenty of water.

What's the science?

Red cabbage juice contains a group of coloured chemicals called anthocyanins. These chemicals change their colour depending on whether they are in acidic, alkaline or neutral environments.

For red cabbage

Red = Acidic

Blue = Neutral

Green/blue = Alkaline

The red cabbage juice is made in water (neutral) and will be a blue colour (Figure 5). When added to the $NaHCO_3$ (alkaline) it will change to a green or green-blue colour. Addition of CH_3COOH (acidic) produces a red colour and carbon dioxide gas is evolved (Figure 6). Ask pupils to suggest what gas they think has been formed (the clue is in the name carbonate).

$$NaHCO_{3(aq)} + CH_3COOH_{(aq)} \longrightarrow CH_3COONa_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

Note: g = gas and l = liquid

If children add the vinegar carefully they may be able to produce red, blue and green layers (acid, neutral and alkaline).

Andy Markwick/RSC/2017

Links to KS3

Chemical reactions as the rearrangement of atoms

Representing chemical reactions (introducing formulae and word equations)

Defining acids and alkalis in terms of neutralisation

pH scale, indicators

Activity 4 *Reacting an acid with a solid carbonate*

1. Add 4 heaped spatulas of baking powder ($NaHCO_3$) into a beaker.
2. Pipette in 3ml of red cabbage indicator. Note what happens.
3. Using the same pipette as in the last experiment, add 3ml of $CH_3COOH_{(aq).}$
4. Record your observations. Add more acid if you want to.

Teacher notes

The reaction is the same as above, yet instead of using a solution of $NaHCO_3$ the solid is used.

The production of carbon dioxide gas from baking powder ($NaHCO_3$) is used in baking. Baking powder thermally decomposes when heated and releases CO_2. It is the CO_2 gas that produces the holes in breads and cakes.

Links to KS3

Chemical reactions as the rearrangement of atoms

Representing chemical reactions (introducing formulae and word equations)

Defining acids and alkalis in terms of neutralisation

pH scale, indicators

Activity 5 *Making a polymer*

1. You have been given a plastic cup containing 10ml PVA glue. Using a measuring cylinder add an equal volume of water and stir it well.
2. Using a 3ml pipette, transfer 9mls of borax solution to the PVA solution and stir.
3. Record your results.
4. Add 6 drops of food dye and mix.
5. You may handle with care! (wear gloves)

Teacher notes

Borax will need to be obtained from a chemical supplier. It is now thought to have a very low risk to pregnant women, and is safe to use (CLEAPSS).

The best results are given if the food dye is added after the borax.

What's the science?

PVA is a polymer containing extremely long chains of vinyl acetate molecules joined together. When borax is added they join the poly vinyl acetate molecules together forming a structure that looks like a ladder or netting. These additional cross-linking bonds changes the properties of the PVA from a viscous liquid into a rubbery solid (Figure 7).

Polymers are everywhere, from plastic bags, to chairs we sit on in school to even our clothes. Children may be familiar with names such as polythene, polyvinyl chloride (PVC) and polyester.

A writing challenge

Imagine visiting another planet. The only life that exists is made of slime. What would it look like? How would it move, feed, reproduce and communicate?

Links to KS3

Chemical reactions as the rearrangement of atoms

Representing chemical reactions (introducing formulae and word equations)

Properties of polymers

Notes

Working Scientifically with chemistry

Investigation 1 *Say cheese!*

Cheese is a dairy product and is made from milk. Milk is composed mostly water, yet also contains proteins, fats and sugars. To make cheese the proteins (polymer molecules) in milk must be made to curdle, or clump together. This can be done by adding an acid.

The investigation

1. Plan an investigation that will allow you to decide whether the acids vinegar, lemon juice or cola curdle cheese best.
2. Check your planning with your teacher before you start your investigation.
3. Remember to record all observations and if you decide to alter your plan, explain why.

Teacher notes

Full fat milk works best, although you may like to suggest investigating different compositions or brands of milk.

What’s the science?

Milk contains the proteins casein and whey. The casein protein in milk forms a colloidal suspension. When an acid is added it makes the proteins clump together and eventually they get too large to remain in colloidal suspension and so they precipitate out forming curds. The whey protein remains in solution.

Investigation 2 Egg white

Egg white is predominantly composed of a protein polymer called albumen. As with casein, the polymer chains can be altered by the addition of an acid. In this investigation children can be asked to plan and investigate what happens to albumen when a variety of different acids are added to it.

Albumen can either be obtained directly from eggs or purchasing liquid albumen from a supermarket.

Acids might include vinegar, fruit juices, fizzy drinks and lemon juice.

Encourage children to record their observations carefully, to consider fair testing and whether repeats might be necessary.

Investigation 3 Fermentation

Fermentation is an example of a biochemical reaction involving yeast. When yeast is exposed to water, warmth and a food source such as sugar, it will respire and in doing so produce waste products CO_2 and alcohol. People have used the process of fermentation over millennia to make bread rise (CO_2) and to make alcoholic drinks.

Method

1. Add 1 spatula (1/2 tsp) yeast into a test tube or boiling tube.
2. Dissolve 1/4tsp of sugar in 10mls water.
3. Add the solution to the yeast.
4. Place a balloon over the top of the tube and observe over 2 days.

As the yeast begins to respire, CO_2 is produced and this will enter the balloon and make it rise. Alcohol will also be produced and so care is needed when handling the tubes. Children should observe, rather than handle the tubes once fermentation has started.

Possible investigation

Plan an investigation to observe what happens when the concentration of sugar solution is changed. Alternatively, investigate how changing the temperature affects the rate of fermentation of yeast.

The science curriculum KS2 to KS3 - a quantum leap?

Dr Andy Markwick
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07930282010

Maintaining curiosity (OFSTED, 2013)

- A high-quality science education provides the foundations for **understanding the world** through the specific disciplines of **biology, chemistry and physics**.
- Science has changed our lives and is vital to the **world's future prosperity**, and all pupils should be taught essential aspects of the **knowledge, methods, processes and uses of science**.

Is science important?

“Science is more essential for our prosperity, our security, our health, our environment, and our quality of life than it has ever been before” … Barack Obama

“We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology”... Carl Sagan

Engaging young minds – the research – the barriers?

- By year 5 many children have already decided whether science will be part of their career choices.
- Pupils entering year 7 have poorer science skills and knowledge than they used to have.
- Limited science knowledge of teachers results in lower confidence to teach science.
- Science is poorly resourced in primary schools.

How can secondary colleagues support primary schools?

- Offer CPD that focuses upon the KS1 and KS2 science curriculum
- Concentrate less on the one-off spectaculars and more on the requirements of the primary curriculum
- Demonstrate science learning using ONLY equipment that primary schools can access.
- Help to develop a primary science curriculum that provides pupils with a secure foundation for KS3.

KS3 – why should secondary schools invest in supporting primary colleagues?

- Many schools have opted for a 2 year KS3, starting GCSE in year 9
- KS3 curriculum not only delivers a large knowledge base, it introduces some key science ideas
- Limited time in KS1/2 = limited coverage and shallow learning of science and ultimately, poorer baseline knowledge and skills of science when entering KS3.

Workshop

- **Introduces a range of chemistry practicals that can be used at KS2 and uses equipment that primary schools have or can easily and cheaply obtain.**
- *Considers how learning can be extended to support better preparation for year 7 – can key concepts be introduced in KS2 and will this result in better informed year 7 students?*
- *Will increased science learning and challenge at KS2 result in more students who want to*

Apprenticeships – Understanding Industrial Options

Simon Jukes
CSR Scientific Training
Director

CSR Scientific Training

Linked in says - I am the co-founder and Director of a national scientific training company specialising in the delivery of apprenticeships.

Hugely passionate about helping people to find work in the science sector and matching them to the right employer.

200 apprentices across England

csr group scientific training

Scientific Apprenticeships

Recent changes to Apprenticeships in England are wide ranging.

Education & Skills
Funding Agency

Apprenticeship Frameworks V Apprenticeship Standards

INSTITUTE FOR
APPRENTICESHIPS

Science Apprenticeships

- Laboratory Science Technician at Levels 2, 3
- Laboratory Scientist at level 5 and there are Level 6 options!

BTEC Approved Centre

PEARSON

- **Units include;**

Chemical Laboratory Techniques

Industrial Chemical Reactions

Organic and Inorganic Chemistry

Biochemistry and Biochemical Techniques

Quality Assurance and Quality Control

csr group
scientific training

Standard Apprenticeships

- 3 Gateways throughout the programme

Gateway One

Health and Safety Training or Qualification

Gateway Two

Completion of;

1. BTEC Qualification
2. Behaviours Log
3. Vocational Competency log

Gateway Three

End-Point Assessment;

1. Observation
2. Competence Discussion
3. Scenario Case Study

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scientific training

End Point Assessment

- Third party assessment and evaluation of apprentices skills knowledge and ability
- Split into 3 sections –
  - Observation
  - Professional Discussion
  - Scenario Based Case Study
- Results -

FAIL

PASS

distinction

Industry Uptake

- Small numbers by comparison but growing…
- 2014 – 360
- 2015 – 330
- 2016 - 420

2017 will see a large spike in the number of apprentices taken on by the science sector…

Who are the companies taking on apprentices?

LGC

NPL
National Physical Laboratory

NHS

SEVERN
TRENT
WATER

UNIVERSITY OF
OXFORD

Science & Technology
Facilities Council

SOCOTEC

DUNLOP
AIRCRAFT TYRES

WEST MIDLANDS
POLICE

Awareness

- Science industry is increasing the engagement it is making with apprenticeships and more opportunities are being made for young people to gain great transferable science skills and develop academically.
- Current vacancies include
  - Forensic apprentices in Drugs, DNA, Fingerprint Development Unit
  - Environmental Science Apprenticeships
  - Immunological Assay Junior Scientists
  - School Science Technicians
  - Colour Specialists for paste/paints company

High Quality Apprenticeships

- There are numerous of examples across the country of high quality apprenticeship opportunities in various scientific fields.
- Demand is high and is increasing…

Awareness

- Issues such as low application numbers, poor applicants and lack of awareness have led to companies being left with no one to fill apprenticeship positions.

Workshop Questions

- Is enough information being put forward to students?
- Do parents understand that there is a viable alternative to Uni?
- Have teachers got the right information to help students decide?
- Do companies do enough? What could they do better?
- How can training providers help?

Apprenticeships – Understanding Industrial Options

Simon Jukes
CSR Scientific Training
Director

BEYOND THE RECIPE – SOME IDEAS ON MAKING PRACTICAL WORK MORE EFFECTIVE

Dr David Paterson
Subject Advisor, Chemistry
OCR

- OCR Subject Specialist for GCSE/GCE Chemistry
- With OCR since September 2015
- Former Head of Chemistry/Physics and Science at schools in Hertfordshire
- Involved in development of resources, training and support for GCSE and A Level Chemistry

BACKGROUND QUESTIONS

- What is practical work?
- Why do practical work?
- What practical work do I need to do?
- How will practical work be assessed?
- Why can practical work be ineffective?

WHAT IS PRACTICAL WORK?

WHAT IS PRACTICAL WORK?

Learning activities to

- **observe, investigate and develop an understanding** of the world
- **direct**, often hands-on, **experience of phenomena or manipulating real objects and materials**

SCORE, 2013

Science Community Representing Education (SCORE) (2013)
Resourcing practical science at secondary level.
http://www.score-education.org/media/11805/score%20resourcing%20secondary.pdf

CLASSIFYING PRACTICAL WORK

- illustration and demonstration of physical phenomena;
- familiarisation with basic apparatus and techniques;
- data gathering and analysis;
- introducing scientific methods;
- designing a scientific investigation;
- reporting an investigation.

Thinking like a physicist: design criteria for a physics curriculum, Main, P., (2014), *School Science Review*, 95(352), 46
https://www.ase.org.uk/journals/school-science-review/2014/03/352/3570/ssr-march-2014-046-052-main.pdf

TYPES OF PRACTICAL WORK

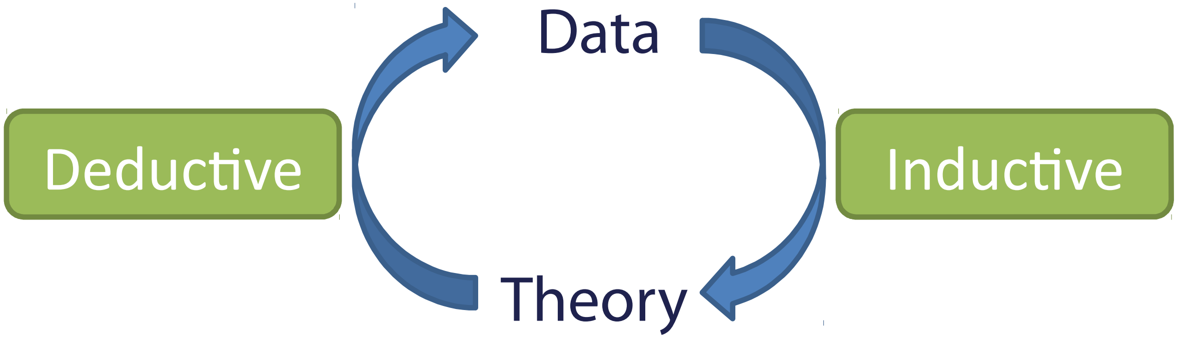
Outcome

- Predetermined
- Undetermined

Procedures

- Teacher generated
- Student generated

Approach



Data

Deductive

Inductive

Theory

A review of laboratory instruction styles, Domin, D., (1999), *J. Chem. Educ.*, 1999, **76(4)**, 543

WHY DO PRACTICAL WORK?

FUNDAMENTAL TO TEACHING

- …essential aspects of knowledge, methods, processes and uses of science…
- …curiosity about natural phenomena…
- … explain what is occurring, predict how things will behave, and analyse causes

National Curriculum for Science in England, (2014)

https://www.gov.uk/government/publications/national-curriculum-in-england-science-programmes-of-study

MAINTAINING CURIOSITY

- In the best schools visited, teachers ensured that pupils understood the 'big ideas' of science. They made sure that pupils **mastered the investigative and practical skills** that underpin the **development of scientific knowledge** and could discover for themselves the relevance and usefulness of those ideas.

Ofsted (2013), Maintaining curiosity - a survey into science education in schools

https://www.gov.uk/government/publications/maintaining-curiosity-a-survey-into-science-education-in-schools

Oxford Cambridge and RSA

WHY DO YOU USE PRACTICAL WORK?

- On separate post-it notes, **write down** 3-5 ideas about why you use practical work in your lessons.
- On your table / all together, **discuss and group** these into common areas.
- **Decide** which were the **dominant reason(s)** for doing practical work?

TOP FIVE REASONS AT GCSE

- To encourage **accurate observation and description**
- To develop **conceptual understanding**
- To develop **reporting, presenting, data analysis and discussion skills**
- To experience the process of finding facts by **investigation**
- To develop **manipulative skills and techniques**

Data collected as part of 'Impact of changes to practical assessment at GCSE and A-level: the start of a longitudinal study by OCR', Wilson, F., *et al*, *School Science Review*, 2016, **362**, 119 - http://www.ase.org.uk/journals/school-science-review/2016/09/362/4200/lssr-september-2016-11

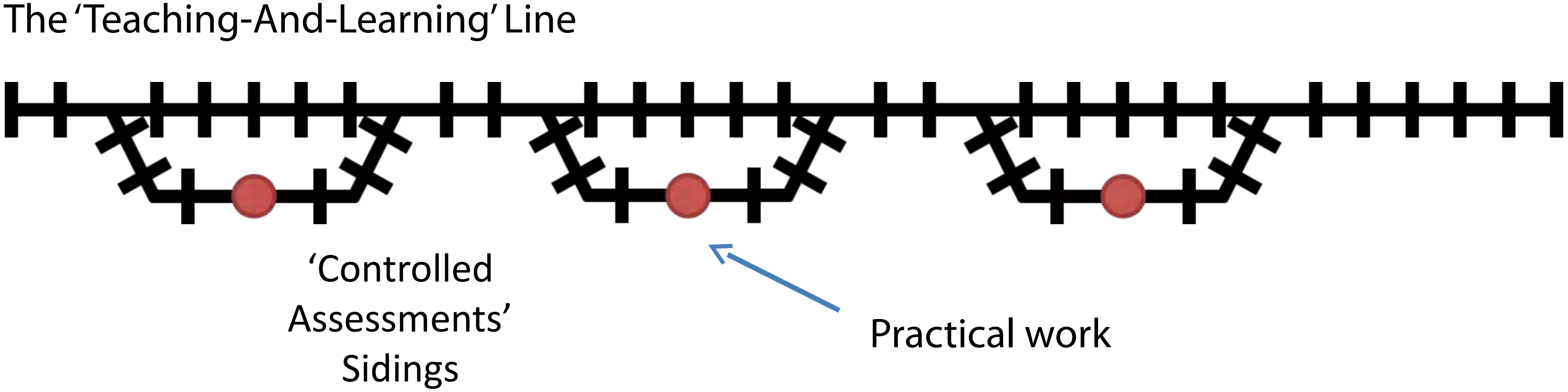
LITERATURE

- Motivation
- Teaching laboratory skills
- Enhancing learning of scientific knowledge
- Insight into and developing scientific method
- Developing ‘scientific attitudes’

Hodson, D. (1990) A critical look at practical work in school science, *School Science Review*, **70**(256), 33-40

EMBEDDING PRACTICAL WORK

The old model



The new model

Practical work integrated into teaching and learning.

WHAT PRACTICAL WORK DO I NEED TO DO?

NEW GCSE REQUIREMENTS

All schools should

- Provide a **broad and balanced practical experience** for all learners
- Take account of the **practical requirements** AND **learning outcomes** detailing practical work
- Provide an annual written ‘practical science statement’ to the exam board

MONITORING

- No monitoring visits are carried out by the exam boards.

- Head of centre declaration – part of the annual update sent to exams officers every year. (Some exam boards have an additional form to complete.)

NEW GCSE REQUIREMENTS

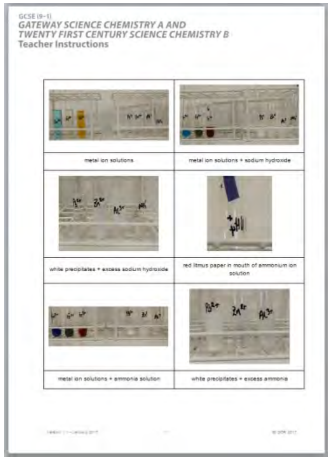
All learners should

- Complete a *minimum* of eight or sixteen (CS) practical activities.

- Have the opportunity to cover all required Apparatus and Techniques.

- Keep up-to-date records of their practical activities (e.g. write-ups)

FLEXIBILITY AND TEACHER PROFESSIONALISM



GCSE (9–1)
GATEWAY SCIENCE CHEMISTRY A AND
TWENTY FIRST CENTURY SCIENCE CHEMISTRY B
Teacher Instructions

metal ion solutions	metal ion solutions + sodium hydroxide
white precipitates + excess sodium hydroxide	red litmus paper in mouth of ammonium ion solution
metal ion solutions + ammonia solution	white precipitates + excess ammonia

Traditional bench chemistry – adapted from **RSC resources**

GCSE (9–1)
GATEWAY SCIENCE CHEMISTRY A AND
TWENTY FIRST CENTURY SCIENCE CHEMISTRY B
Teacher Instructions

Notes

55 mm OR 90 mm polystyrene petri dishes both work, and are widely available (e.g Timstar PE12035) for about 10p each. Drill two holes 1mm wider than the electrodes being used on opposite sides of the petri-dish base. Alternatively, carefully remove sections of the petri-dish side with a small pair of wire cutters. Alternatively, heat a large nail in a Bunsen flame and use this to melt holes through the petri dish. See http://science.cleapss.org.uk/Resource-Info/GL163-Make-a-guide-microscale-electrolysis-apparatus.aspx for further details.

4-6 stock bottles of the solutions with pipettes or dropper bottles will speed up the setting up of the electrochemical cells.

Health and Safety

Eye protection should be worn at all times.

Ensure the petri-dish is covered when the circuit is connected to the power source- this will help contain the chlorine gas while the learners are looking closely at set-up to make their observations.

Ensure the laboratory is well ventilated. Take particular care if you have any asthmatic members of the group.

Method

Learners will set up and run the electrochemical cell, producing copper at the cathode and chlorine at the anode. They will make a variety of observations including of the production of these substances and their chemical reactions.

Images from trials

After the electrolysis is completed	Showing the formation of copper at the cathode

Microscale chemistry – adapted from **CLEAPSS resources**

GCSE (9–1)
GATEWAY SCIENCE CHEMISTRY A AND
TWENTY FIRST CENTURY SCIENCE CHEMISTRY B
Teacher Instructions

Notes

Most homes contain common solvents in a variety of forms. For example, isopropyl alcohol (isopropanol) can be found in rubbing alcohol, or cleaning liquids in nail varnish kits. Ethanol is the major component of surgical spirit, used for cleaning and disinfecting skin. Acetone is the major component of some nail varnish removers.

Health and Safety

All organic solvents will be flammable and should be used away from naked flames.

Eye protection should be worn.

Method

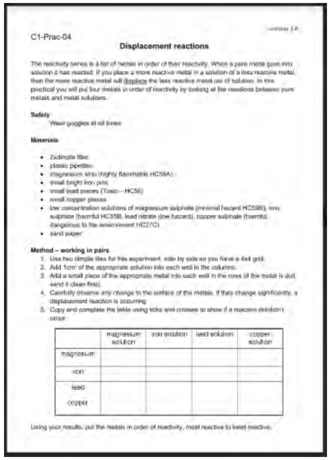
This method makes use of apparatus and reagents likely to be available in the home / alternative provision establishments. Despite this, the separation of mixtures by chromatography can be readily demonstrated, and provides a useful stepping stone to higher quality chromatography and measurement of Rf values.

Learner should be aware of the equipment that would be used in a standard laboratory chromatography practical – see questions.

Images from trials

Figure 1: Images from the trial

Kitchen/home chemistry – simple practicals using **readily available equipment/ reagents**



version 1.0

C1-Prac-04

Displacement reactions

The reactivity series is a list of metals in order of their reactivity. When a pure metal goes into solution it has reacted. If you place a more reactive metal in a solution of a less reactive metal, then the more reactive metal will displace the less reactive metal out of solution. In this practical you will put four metals in order of reactivity by looking at the reactions between pure metals and metal solutions.

Safety

Wear goggles at all times

Materials

- 2xdimple tiles
- plastic pipettes
- magnesium strip (highly flammable HC59A)
- small bright iron pins
- small lead pieces (Toxic – HC56)
- small copper pieces
- low concentration solutions of magnesium sulphate (minimal hazard HC59B), iron sulphate (harmful HC55B, lead nitrate (low hazard), copper sulphate (harmful, dangerous to the environment HC27C)
- sand paper

Method – working in pairs

1. Use two dimple tiles for this experiment, side by side so you have a 4x4 grid.
2. Add 1cm³ of the appropriate solution into each well in the columns.
3. Add a small piece of the appropriate metal into each well in the rows (if the metal is dull, sand it clean first).
4. Carefully observe any change to the surface of the metals. If they change significantly, a displacement reaction is occurring.
5. Copy and complete the table using ticks and crosses to show if a reaction did/didn't occur.

	magnesium solution	iron solution	lead solution	copper solution
magnesium				
iron				
lead				
copper				

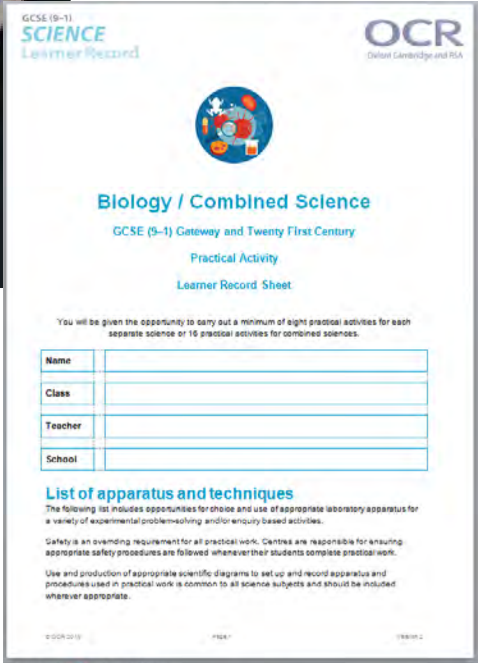
Using your results, put the metals in order of reactivity, most reactive to least reactive.

Your own practical, OUP, other from publishers, RSC, IoP, RSB, ASE, CLEAPSS….

LEARNER RECORDS

Learner science books
These MUST be kept up to date.

OCR Learner Record Sheets can help learners track their learning.
These are NOT compulsory.



GCSE (9–1)
SCIENCE
Learner Record

OCR
Oxford Cambridge and RSA

Biology / Combined Science

GCSE (9–1) Gateway and Twenty First Century

Practical Activity

Learner Record Sheet

You will be given the opportunity to carry out a minimum of eight practical activities for each separate science or 16 practical activities for combined sciences.

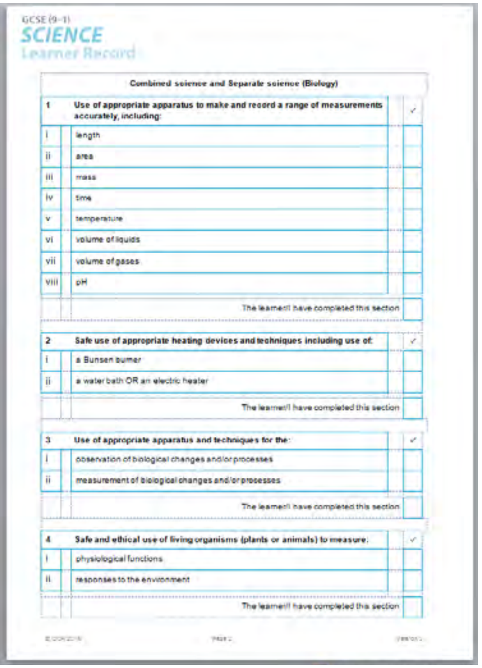
Name	
Class	
Teacher	
School	

List of apparatus and techniques

The following list includes opportunities for choice and use of appropriate laboratory apparatus for a variety of experimental problem-solving and/or enquiry based activities.

Safety is an overriding requirement for all practical work. Centres are responsible for ensuring appropriate safety procedures are followed whenever their students complete practical work.

Use and production of appropriate scientific diagrams to set up and record apparatus and procedures used in practical work is common to all science subjects and should be included wherever appropriate.



GCSE (9–1)
SCIENCE
Learner Record

	Combined science and Separate science (Biology)	
1	**Use of appropriate apparatus to make and record a range of measurements accurately, including:**	✓
i	length	☐
ii	area	☐
iii	mass	☐
iv	time	☐
v	temperature	☐
vi	volume of liquids	☐
vii	volume of gases	☐
viii	pH	☐
	The learner/I have completed this section	☐
2	**Safe use of appropriate heating devices and techniques including use of:**	✓
i	a Bunsen burner	☐
ii	a water bath OR an electric heater	☐
	The learner/I have completed this section	☐
3	**Use of appropriate apparatus and techniques for the:**	✓
i	observation of biological changes and/or processes	☐
ii	measurement of biological changes and/or processes	☐
	The learner/I have completed this section	☐
4	**Safe and ethical use of living organisms (plants or animals) to measure:**	✓
i	physiological functions	☐
ii	responses to the environment	☐
	The learner/I have completed this section	☐

HOW WILL PRACTICAL WORK BE ASSESSED?

ASSESSMENT OBJECTIVES

- AO1 : **Demonstrate** knowledge and understanding of scientific techniques and procedures.
- AO2: **Apply** knowledge and understanding of scientific enquiry, techniques and procedures.
- AO3: **Analyse** information and ideas to develop and improve experimental procedures.

http://www.ocr.org.uk/Images/234598-specification-accredited-gcse-gateway-science-suite-chemistry-a-j248.p

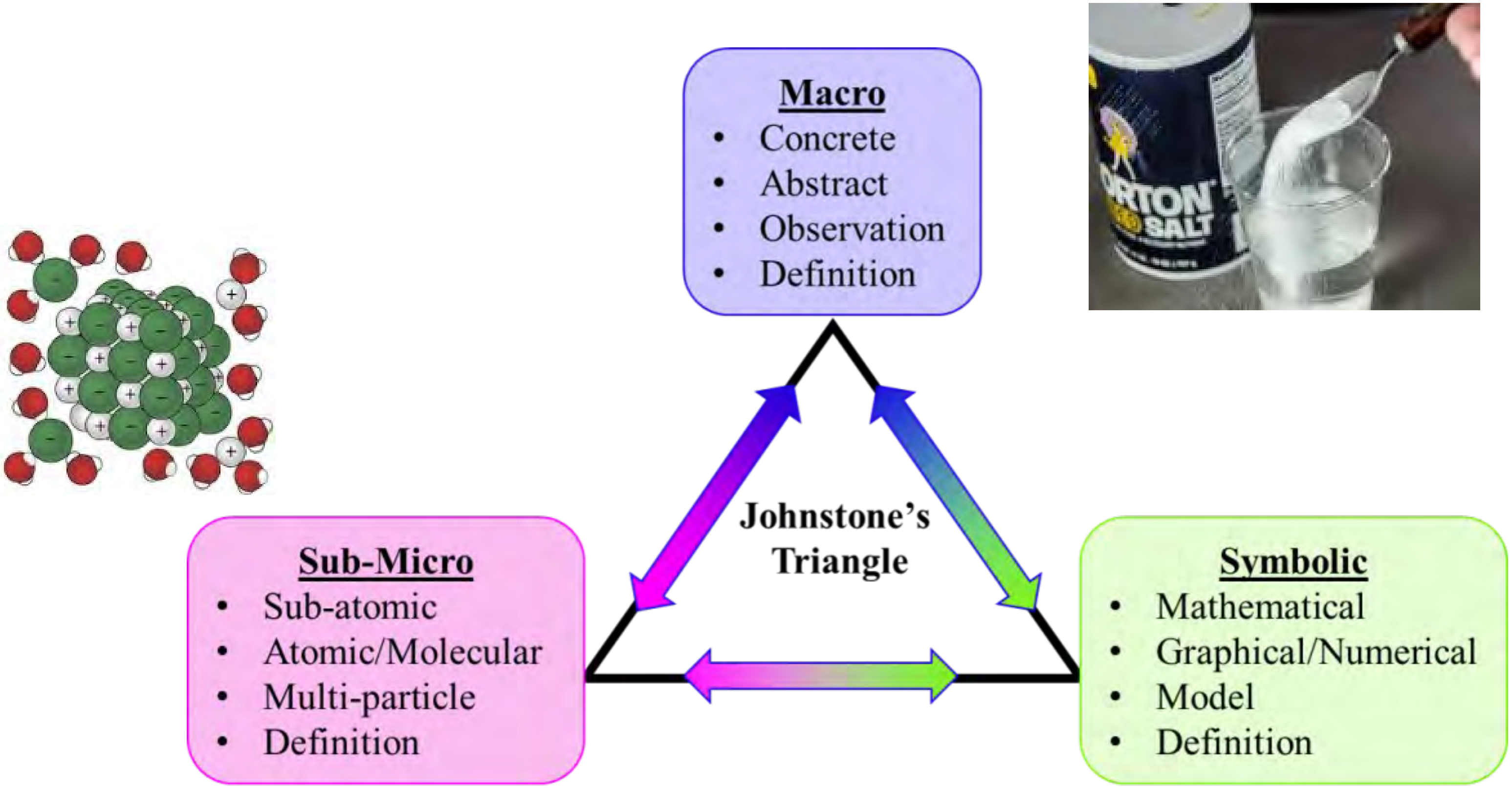
WHY CAN PRACTICAL WORK BE INEFFECTIVE?

ONE VIEW…

- Although practical work is commonly considered to be invaluable in scientific ***teaching***, research shows that it is not necessarily so valuable in scientific ***learning***. The evidence points to the uncomfortable conclusion that much laboratory work has been of little benefit in helping pupils and students ***understand concepts.***

Clackson, S.G. and Wright, D.K., An appraisal of practical work in science education, *School Science Review*, 1992, **74**(266), 39-42

THE JOHNSTONE TRIANGLE



Macro
- Concrete
- Abstract
- Observation
- Definition

Johnstone's Triangle

Sub-Micro
- Sub-atomic
- Atomic/Molecular
- Multi-particle
- Definition

Symbolic
- Mathematical
- Graphical/Numerical
- Model
- Definition

$NaC\mathit{l}\,(s) \rightarrow Na^{+}(aq) + C\mathit{l}^{-}(aq)$

http://michaelseery.com/home/index.php/tag/cognitive-load-theory/

For wider review: Taber, K.S., Revisiting the chemistry triplet, *Chem. Educ. Res. Pract*. 2013, **14**, 156 - http://pubs.rsc.org/en/Content/ArticleLanding/2013/RP/c3rp00012e

COGNITIVE LOAD

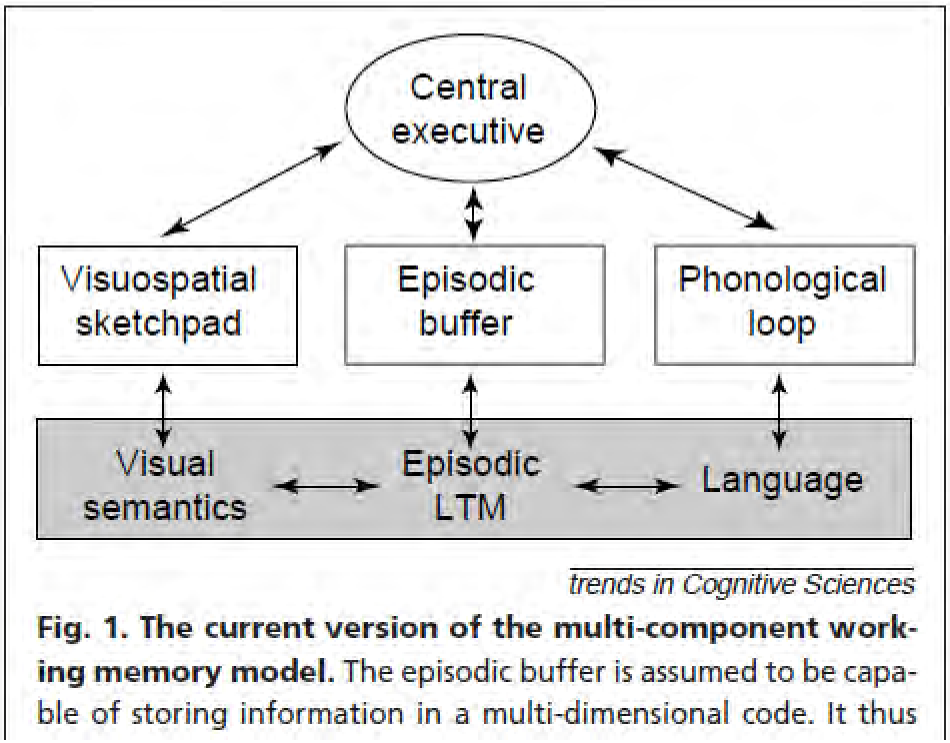


Fig. 1. The current version of the multi-component working memory model. The episodic buffer is assumed to be capable of storing information in a multi-dimensional code. It thus

Working memory – ‘Fluid systems’

Long term memory – ‘Crystallised systems’

Baddeley. A., The episodic buffer: a new component of working memory?, *Trends in Cognitive Science*, 2000, 4(11), 417-23 - http://www.sciencedirect.com/science/article/pii/S1364661300015382

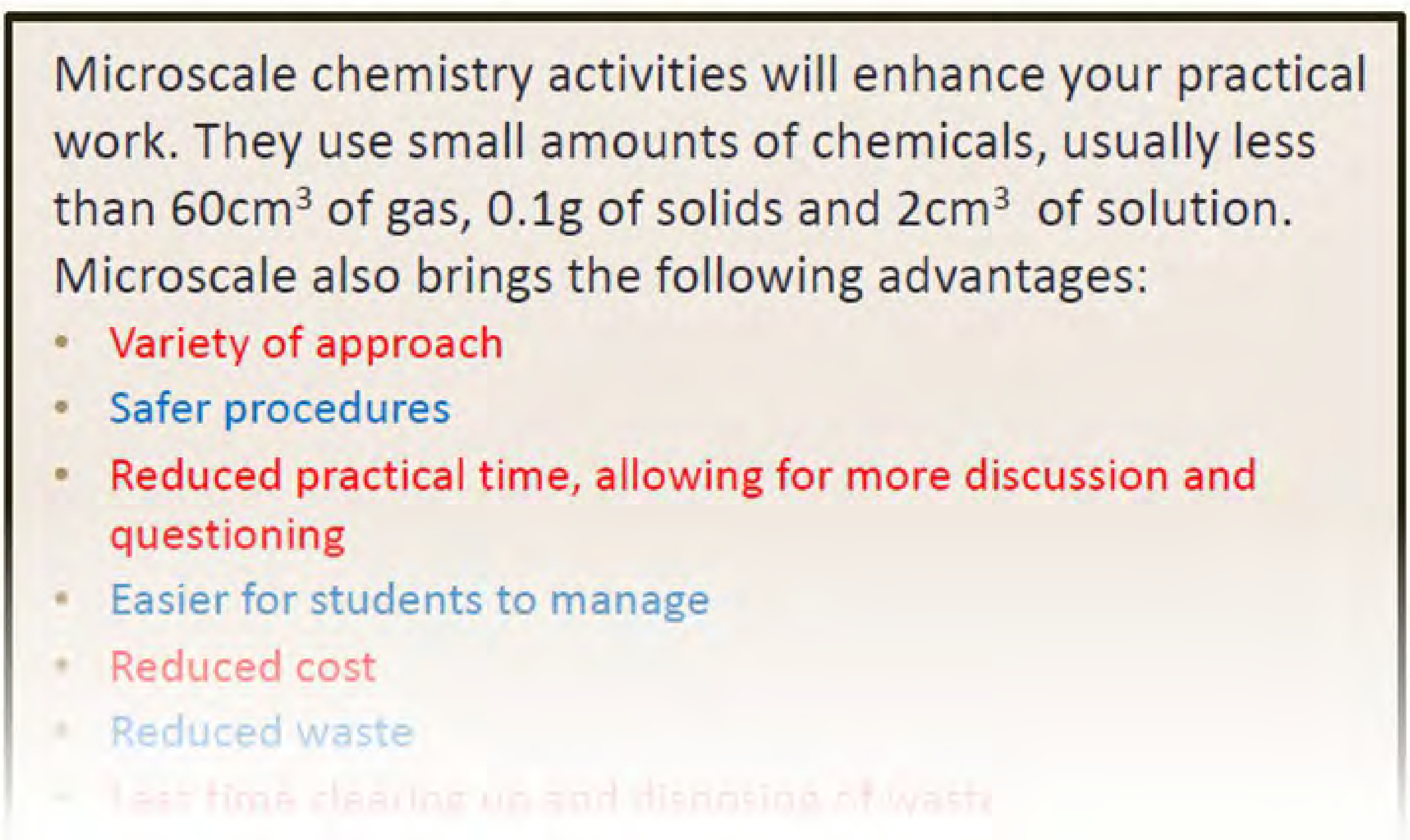
KEY QUESTIONS

- How do we get beyond them just ‘following the recipe’?
- How do we reduce the cognitive load inherent in some practical work?
- How do we maximise the benefit of practical work for our students in our classrooms?

KEY IDEAS

- Ensure practicals have a clear goal
  - Don’t overload them/students
- Use of microscale activities
  - e.g. electrolysis
- Working up to complex practical tasks
  - e.g. titration

MICROSCALE CHEMISTRY



Microscale chemistry activities will enhance your practical work. They use small amounts of chemicals, usually less than 60cm^3 of gas, 0.1g of solids and 2cm^3 of solution. Microscale also brings the following advantages:

- Variety of approach
- Safer procedures
- Reduced practical time, allowing for more discussion and questioning
- Easier for students to manage
- Reduced cost
- Reduced waste
- Less time clearing up and disposing of waste

http://science.cleapss.org.uk/, Bob Worley (CLEAPSS Chemistry Adviser – bob.worley@cleapss.org.uk)
http://microchemuk.weebly.com/uploads/2/8/3/7/28377873/microscale_chemistry_poster_ppt3_ptb.pdf

MICROSCALE $CuCl_2$ ELECTROLYSIS

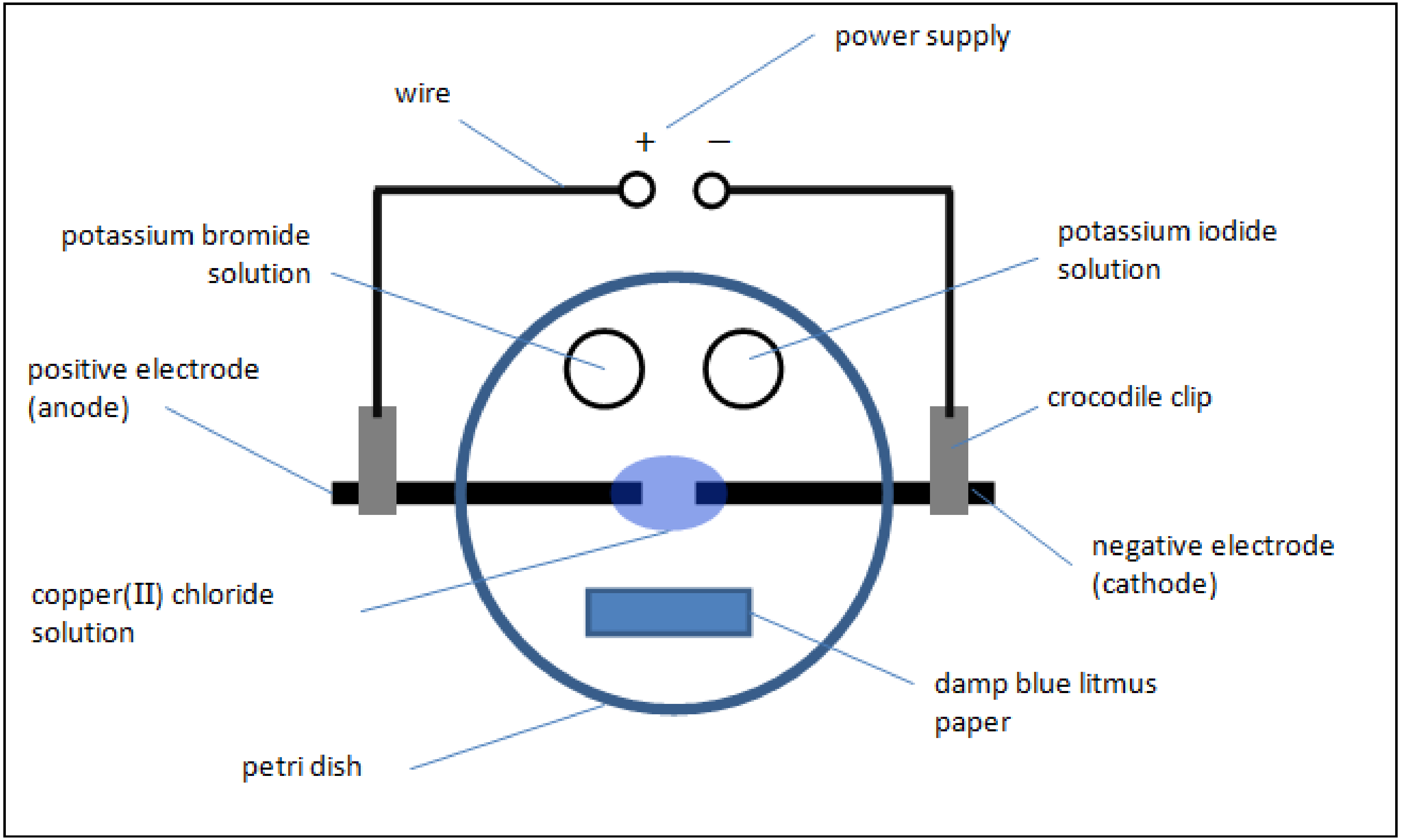
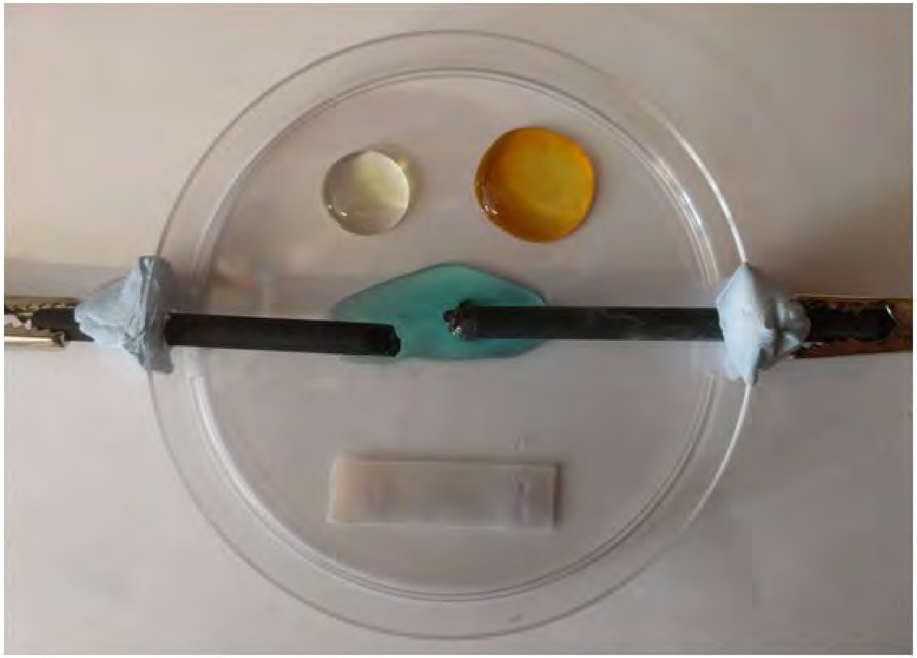


Figure 1: The electrochemical cell setup

http://www.ocr.org.uk/Images/311750-pag-activity-chemistry-electrolysis-suggestion-2.docx

MICROSCALE $CuCl_2$ ELECTROLYSIS



After the electrolysis is completed

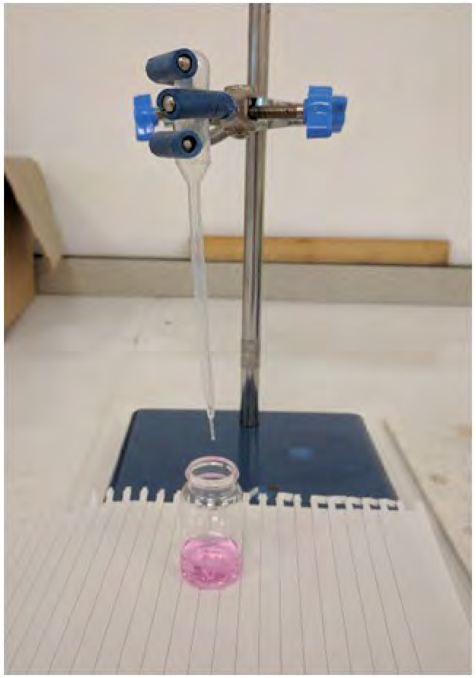
http://www.ocr.org.uk/Images/311750-pag-activity-chemistry-electrolysis-suggestion-2.docx

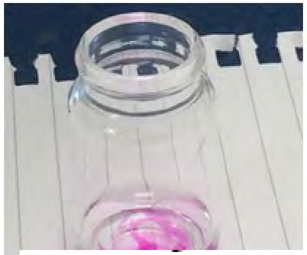
BREAKING DOWN TITRATION

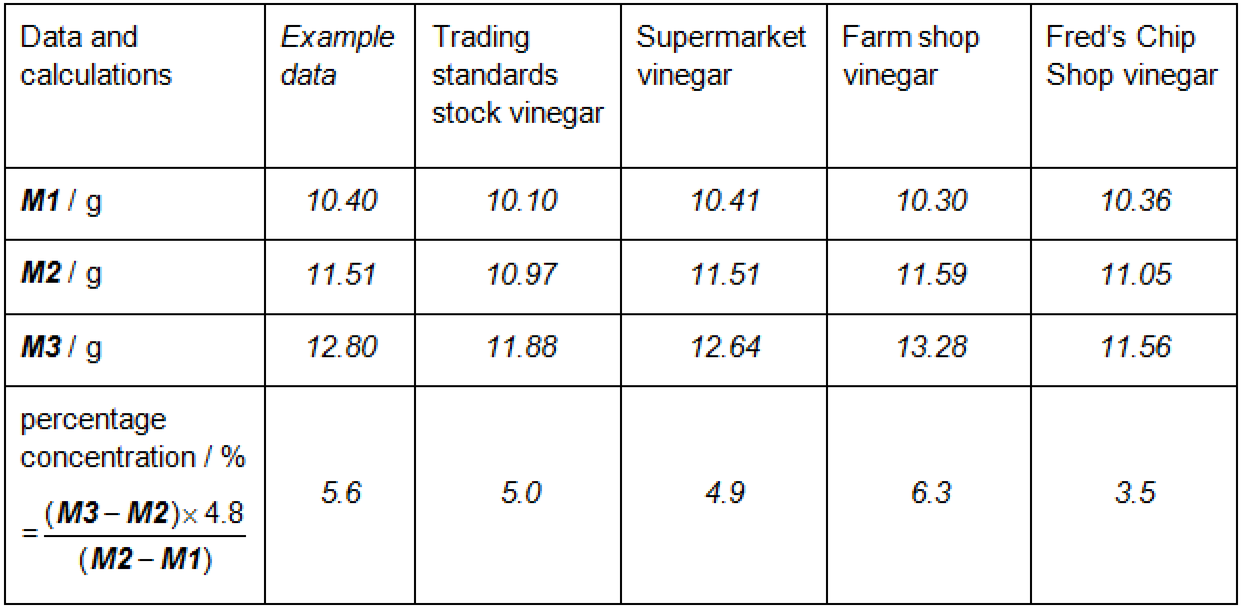
Recap	• Neutralisation and indicators (RSC LC)
Simplified Titration	• ‘The Vinegar Dilemma’ (OCR PAG 5.2)
New Equipment	• Pipette and burette
Interactive Titration	• Low stakes e-learning (RSC LC)
Standard Tiration	• $\mathrm{HC}l$/NaOH titration (OCR PAG 5.1)
Acid Strength	• ‘Chemical Misconceptions’ resources (RSC LC)
Investigation	• Planning and problem solving
Consolidation	• Calculations practice

http://www.ocr.org.uk/qualifications/by-subject/science/science-news/practical-work-and-cognitive-load/

THE VINEGAR DILEMMA







Data and calculations	*Example data*	Trading standards stock vinegar	Supermarket vinegar	Farm shop vinegar	Fred's Chip Shop vinegar
M1 / g	10.40	10.10	10.41	10.30	10.36
M2 / g	11.51	10.97	11.51	11.59	11.05
M3 / g	12.80	11.88	12.64	13.28	11.56
percentage concentration / % $= \frac{(\mathbf{M3} - \mathbf{M2}) \times 4.8}{(\mathbf{M2} - \mathbf{M1})}$	5.6	5.0	4.9	6.3	3.5

http://www.ocr.org.uk/Images/323620-pag-activity-chemistry-titration-suggestion-2.docx

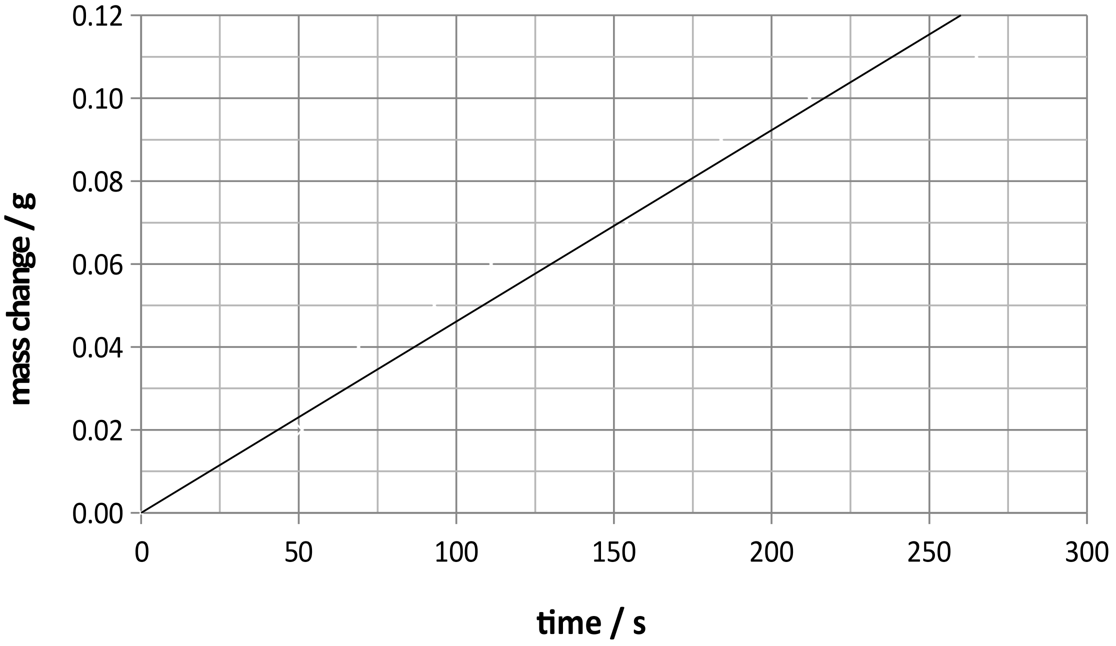
RATE OF REACTION

- Introduction to rates using simplified equipment:

https://www.youtube.com/watch?v=NzsHfzMlBUU

RATE OF REACTION

time / s	mass change / g
0	0.00
51	0.02
69	0.04
93	0.05
111	0.06
154	0.07
184	0.09
212	0.10
265	0.11



Change in mass over time of the reaction between vinegar and chalk

https://www.youtube.com/watch?v=NzsHfzMlBUU

RATE OF REACTION

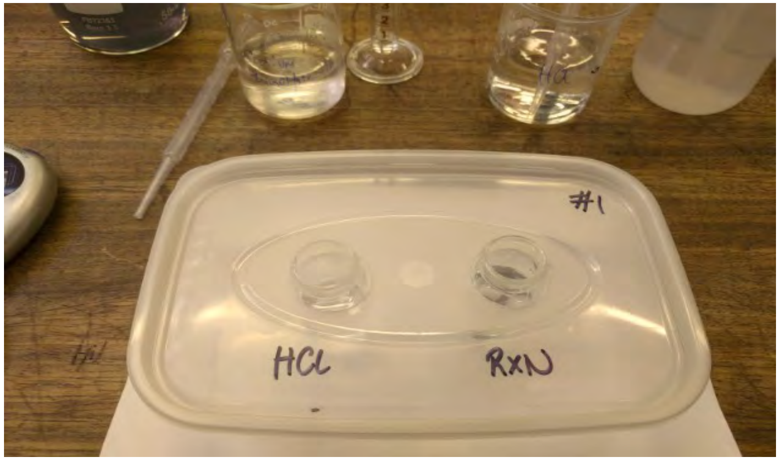
Advantages

- Rapid collection of data – no waiting for the balances
- Students can pause video to collect accurate data
- Low cost of balance (c. £10) makes class set possible
- Using more familiar apparatus / substances – reducing cognitive load

https://www.youtube.com/watch?v=NzsHfzMlBUU

OTHER CHEMISTRY PAG ACTIVITIES

The experimental setup.



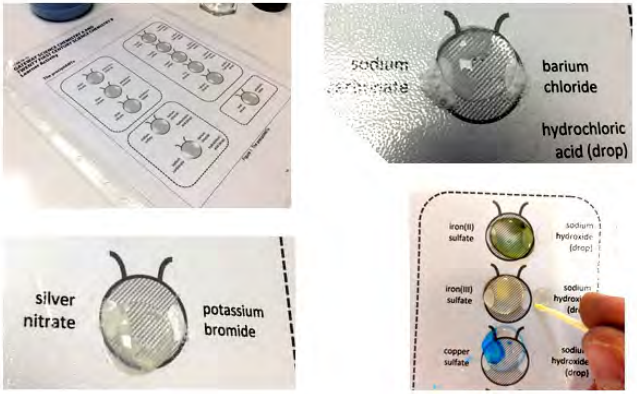
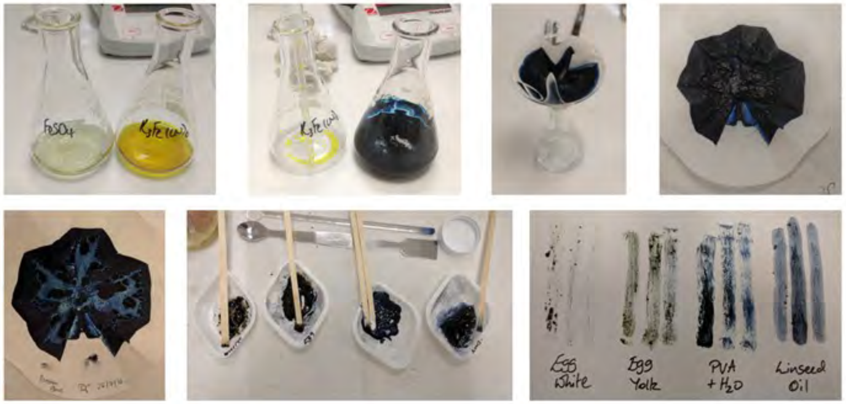


Figure 1 – Images from the trial



http://www.ocr.org.uk/Images/324585-gcse-chemistry-practical-activities-general-teacher-notes.docx

SUMMARY

- Have a clear idea of what is to be achieved through the practical work.
- Plan series of activities that allow for progressive accumulation of understanding and skills.
- Consider the use of micro-scale to replace/supplement 'standard' practical work.
- Continually discuss and refine practice in your department/wider community (today!).

Chemistry PAG 2: Electrolysis
Combined Science PAG C1: Electrolysis

Suggested Activity 2: Microscale electrolysis of copper(II) chloride

Instructions and answers for teachers & technicians

These instructions cover the learner activity section which can be found on page 11. This Practical activity supports OCR GCSE Chemistry and Combined Science.

When distributing the activity section to the learners either as a printed copy or as a Word file you will need to remove the teacher instructions section.

This is a **suggested** practical activity that can be used as part of teaching the GCSE (9-1) Gateway Science (A) and Twenty First Century Science (B) specifications.

These are **not controlled assessment tasks**, and there is **no requirement to use these particular activities**.

You may modify these activities to suit your learners and centre. Alternative activities are available from, for example, Royal Society of Biology, Royal Society of Chemistry, Institute of Physics, CLEAPSS and publishing companies, or of your own devising.

Further details are available in the specifications (Practical Skills Topics), and in these videos.

OCR recommendations:

Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer's requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.

CLEAPSS resources are useful for carrying out risk-assessments: (http://science.cleapss.org.uk).

Centres should trial experiments in advance of giving them to learners. Centres may choose to make adaptations to this practical activity, but should be aware that this may affect the Apparatus and Techniques covered by the learner.

Introduction

In this activity, learners carry out a micro-scale electrolysis of copper(II) chloride solution in a petri-dish, producing copper solid and chlorine gas. Within the petri dish, the chlorine gas reacts with the potassium bromide and potassium chloride solutions via displacement reactions, and with damp blue litmus paper demonstrating the acid and bleaching nature of the chlorine gas in water.

This activity can be modified to reduce the number of observations the learners are making, allowing them to focus on less chemistry. For example, the set-up could be used without the potassium salt solutions, and just focus on the reaction of chlorine gas with the blue litmus paper. Such changes will affect the Apparatus and Techniques covered, so modification of the learner sheet may be appropriate.

This resource is adapted from the CLEAPSS experiment ‘The microelectrolysis of copper(II) chloride – https://www.youtube.com/watch?v=KvW-g1FQV9E

Further information and instructions for making the electrolysis cell can be found at:

- http://science.cleapss.org.uk/Resource-Info/GL163-Make-it-guide-microscale-electrolysis-apparatus.aspx
- http://www.cleapss.org.uk/attachments/article/0/Small_scale_Hoffman_ASE2014.pdf?Conferences/ASE%202014/

Another micro-scale electrolysis experiment is available from the Royal Society of Chemistry Microscale Chemistry publication http://www.rsc.org/learn-chemistry/resource/res00000541/electrolysis-using-a-microscale-hoffman-apparatus.

DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet (**Chemistry** / *Combined Science*) and Trackers (**Chemistry** / *Combined Science*) available online. **There is no requirement to use these resources.**

By doing this experiment, learners have an opportunity to develop the following skills:

3 [*8*]: Use of appropriate apparatus and techniques for: i) conducting and monitoring chemical reactions

6 [*11*]: Safe use and careful handling of gases, liquids and solids, including: ii) using appropriate apparatus to explore chemical changes and/or products

7 [*12*]: Use of appropriate apparatus and techniques to: i) draw electrochemical cells for separation and production of elements and compounds; ii) set up and use electrochemical cells for separation and production of elements and compounds

8: Use of appropriate qualitative reagents and techniques to analyse and identify unknown samples or products including: i) gas tests

Aims

To set-up a micro-scale electrolysis reaction of copper(II) chloride, and to analyse the products formed.

Intended class time

20-25 minutes

Links to Specifications:

Gateway Science (Suite A) – including Working Scientifically (WS)

C3.4a recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes

C3.4d describe electrolysis in terms of the ions present and reactions at the electrodes

C3.4e describe the technique of electrolysis using inter and non-inert electrodes

C4.1a recall the simple properties of Groups 1, 7 and 0

C4.1b explain how observed simple properties of Group 1, 7 and 0 depend on the outer shell of electrons of the atoms and predict properties from given trends down the groups

C4.2a describe tests to identify selected gases

C6.1b explain why and how electrolysis is used to extract some metals from ores

W1.3a presenting observations and other data using appropriate methods

W1.3e interpreting observations and other data

W1.3f presenting reasoned explanations

W1.4a use scientific vocabulary, terminology and definitions

WS2a carry out experiments

WS2b make and record observations and measurements using a range of apparatus and methods

WS2c presenting observations using appropriate methods

Twenty First Century Science (Suite B) – including Ideas about Science (IaS)

C1.4.2 describe a test to identify chlorine (using blue litmus paper)

C2.2.6 recall the simple properties of Group 7 elements including their states and colours at room temperature and pressure, their colours as gases, their reactions with Group 1 elements and their displacement reactions with other metal halides

C2.2.7 describe experiments to identify the reactivity pattern of Group 7 elements including displacement reactions

C3.2.5 explain why electrolysis is used to extract some metals from their ores

C3.3.1 describe electrolysis in terms of the ions present and reactions at the electrodes

C3.3.3 recall that metals (or hydrogen) are formed at the cathode and non-metals are formed at the anode in electrolysis using inert electrodes

C3.3.4 use the names and symbols of common elements and compounds and the principle of conversation of mass to write half equations

C3.3.5 explain reduction and oxidation in terms of gain or loss of electrons, identifying which species is oxidised and which are reduced

C3.3.8 describe the technique of electrolysis of an aqueous solution of a salt

IaS2.1 present observations and other data using appropriate formats

IaS2.11 in a given context interpret observations and other data (presented in diagrammatic, graphical, symbolic or numerical form) to make inferences and to draw reasoned conclusions, using appropriate scientific vocabulary and terminology to communicate the scientific rationale for findings and conclusions

Mathematical Skills covered

No defined mathematical skill is covered in this experiment.

Technical Requirements – PER GROUP

Chemicals

Identity	Approximate quantity required or produced PER GROUP	Hazard information
0.5 mol dm^{-3} aqueous copper(II) chloride solution, $CuCl_2$(aq)	0.5 cm^3	Currently not classified as hazardous at this concentration
0.5 mol dm^{-3} aqueous potassium bromide solution, KBr(aq)	0.2 cm^3	Currently not classified as hazardous at this concentration
0.2 mol dm^{-3} aqueous potassium iodide solution, KI(aq)	0.2 cm^3	Currently not classified as hazardous at this concentration
chlorine	1 cm^3 produced (per group)	 DANGER May cause or intensity fire; oxidiser. Causes skin irritation. Causes serious eye irritation. Toxic if inhaled. May cause respiratory irritation. Very toxic to aquatic organisms.

Equipment

- pre-prepared petri-dish with two small holes on opposite sides, and lid (see note below)
- two graphite or carbon-fibre (e.g. kite rods) electrodes
- 2 crocodile clips and wires
- power-pack/9 V battery
- blue litmus paper
- dropping pipettes
- blu-tack

Notes

55 mm OR 90 mm polystyrene petri dishes both work, and are widely available (e.g Timstar PE12035) for about 10p each. Drill two holes 1mm wider than the electrodes being used on opposite sides of the petri-dish base. Alternatively, carefully remove sections of the petri-dish side with a small pair of wire cutters. Alternatively, heat a large nail in a Bunsen flame and use this to melt holes through the petri dish. See http://science.cleapss.org.uk/Resource-Info/GL163-Make-it-guide-microscale-electrolysis-apparatus.aspx for further details.

4-6 stock bottles of the solutions with pipettes or dropper bottles will speed up the setting up of the electrochemical (electrolysis) cells.

Health and Safety

Eye protection should be worn at all times.

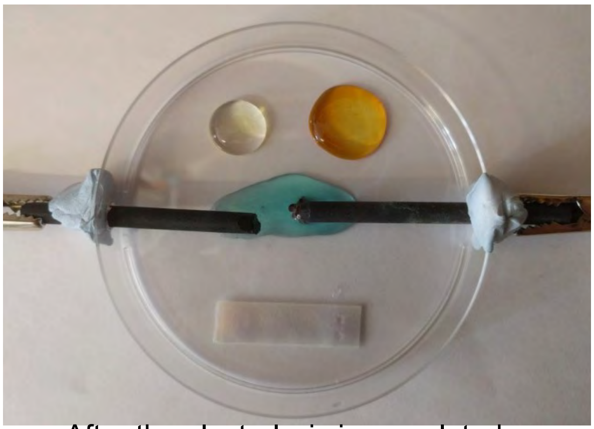
Ensure the petri-dish is covered when the circuit is connected to the power source- this will help contain the chlorine gas while the learners are looking closely at set-up to make their observations.

Ensure the laboratory is well ventilated. Take particular care if you have any asthmatic members of the group.

Method

Learners will set up and run the electrochemical (electrolysis) cell, producing copper at the cathode and chlorine at the anode. They will make a variety of observations including of the production of these substances and their chemical reactions.

Images from trials

 After the electrolysis is completed	 Showing the formation of copper at the cathode

Analysis of results – Trial results

You can draw your own table, or copy the one below:

Where?	Observation
potassium bromide drop	turned from colourless to light orange/brown
potassium iodide drop	turned from colourless to orange/brown
positive electrode (anode)	bubbles formed
negative electrode (cathode)	brown/black substance formed
damp blue litmus paper	turned pink then white
copper(II) chloride drop	slowly turned from pale blue to colourless

The questions you set your learners will depend on what the focus of the experiment is.

1. Chlorine is an acidic and bleaching gas in solution. Describe and explain the evidence you have for the production of chlorine gas. **[4 marks]**

Blue litmus paper turns red in the presence of acids, and turns white in the presence of a bleach. The chlorine gas dissolved in the water forming hydrochloric acid which turned the litmus paper pink/red, and a bleach which turned the paper white.

2. Chlorine is a reactive gas and will displace less reactive Group 7 elements from solution. Describe and explain the evidence that you have for the production of chlorine gas. **[6 marks]**

A gas is formed at the anode, where chloride ions can discharge. The reactivity of the halogens decreases down Group 7, therefore chlorine is more reactive than bromine and iodine. When chlorine dissolves in the colourless potassium bromide solution, the solution turns pale orange/brown as bromine forms. When chlorine dissolves in the colourless potassium iodide solution, the solution turn dark brown as iodine forms.

3. In solution, copper is present as Cu^{2+} ions and forms a blue substance (called a complex) with water. Describe and explain the evidence you have for the production of copper metal. **[4 marks]**

A brown/black substance forms at the negative electrode (cathode) where the positive copper ions discharge during electrolysis. The copper chloride solution slowly decolourised during the electrolysis as the copper ions come out of solution.

4. Draw a diagram to show how you would carry out the electrolysis of a larger volume (e.g. 20 cm^3) of copper(II) chloride. **[4 marks]**

Extension opportunities

1. Write word and symbol equations for the different reactions that have occurred:

(a) Copper(II) chloride drop: Two half equations and full redox equation [**6 marks**]

copper ions + electrons -------> copper ⍰

Cu^{2+}(aq) + $2e^{- -}$ ------> Cu(s) ⍰

chloride ions -----> chlorine + electrons ⍰

$2Cl^{-}$(aq) -----> Cl_2(g) + $2e^{-}$ ⍰

copper ions + chloride ions -----> copper + chlorine ions ⍰

Cu^{2+}(aq) + $2Cl^{-}$(aq)-----> Cu(s) + Cl_2(g) ⍰

(b) Displacement reaction in the potassium bromide drop **[2 marks]**

chlorine + bromide -----> chloride + bromine ⍰

Cl_2(g) + $2Br^{-}$(aq) -----> $2Cl^{-}$(aq) + Br_2(aq) ⍰

(c) Displacement reaction in the potassium iodide drop **[2 marks]**

chlorine + iodide-----> chloride +iodine ⍰

Cl_2(g) + $2I^{-}$(aq) -----> $2Cl^{-}$(aq) + I_2(aq) ⍰

2. Predict, with explanation, what will happen to the rate of electrolysis over time.
[2 marks]

As the concentration of the copper(II) ions decreases, the solution becomes less conductive so the rate of electrolysis decreases. (In some observations, the discharged copper 'grows' from the cathode towards the anode, and an increase in the rate of bubble formation is seen, presumably as the effective size of the electrode is increased).

3. Explain why the colour of the copper(II) chloride solution changes over time.

[2 marks]

The copper(II) ion forms a complex in solution (with six water molecules) which is blue. As the copper ions discharge at the cathode, the concentration of this complex decreases, hence the solution becomes less blue.

Document updates

v1		Published on the qualification pages
v1.1	January 2017	Consolidated labelling and formatting of activities
V1.2	February 2017	Correction of Combined Science labelling

Chemistry PAG 2: Electrolysis

Combined Science PAG C1: Electrolysis

Suggested Activity 2: Microscale electrolysis of copper(II) chloride

Learner Activity

Introduction

In this activity, you will pass an electrical current through copper(II) chloride solution to form two electrolysis products, copper and chlorine. The reaction will be carried out as a microscale experiment, which allows multiple experiments to be conducted at the same time, while minimising the amount of reagents used and the risks associated with chlorine gas.

Aims

To set-up a microscale electrolysis reaction of copper(II) chloride, and to analyse the products formed.

Figure 1: The electrochemical (electrolysis) cell setup

Intended class time

20-25 minutes

Equipment (per group)

- pre-prepared petri-dish with two small holes on opposite sides, and a lid
- two graphite/carbon-fibre electrodes
- 2 crocodile clips and wires
- power-pack/9V battery
- 0.5 mol dm^{-3} aqueous copper chloride solution (low hazard)
- 0.5 mol dm^{-3} aqueous potassium bromide solution (low hazard)
- 0.2 mol dm^{-3} aqueous potassium iodide solution (low hazard)
- dropping pipettes
- blue litmus paper
- blu-tack

Health and Safety

- Eye protection should be worn at all times.
- Ensure the laboratory is well ventilated – chlorine gas (DANGER: Toxic and irritant) is produced. Your teacher will discuss this with you before the practical is carried out.
- Ensure the petri-dish is covered when the circuit is connected to the power source.

Method

1. Set up the apparatus as shown in Figure 1. Slide the electrodes through the pre-drilled holes in the side of the petri-dish – the gap between the ends should be about 1cm – and connect the crocodile clips to electrodes.. **Do not turn on the power supply yet**.
   You may need to use blu-tack to prevent the ends of the electrodes from 'tipping-up' – see Figure 2 below.

2. Pipette about 10 drops of the copper(II) chloride solution between the ends of the electrodes
   Both electrodes need to be within the drop so that the circuit is complete and the current can flow.

3. Pipette about five drops each of potassium bromide and potassium iodide separately onto the petri-dish.
   These solutions will both react with one of the products of electrolysis of copper(II) chloride – you will be looking for a colour change.

4. Dampen a 2-3 cm piece of blue litmus paper and place in the petri dish.
   The indicator paper is usually used to test for acidic substances, but can also be used to test for substances that bleach – again you will be looking for a colour change.

5. Turn on the power supply to about 3V for up to two minutes and record your observations in a table. If you are using a battery, the reactions should be complete within about one minute.
   Your observations will be in all three solution drops and the litmus paper. Do not run the electrolysis for more than two minutes.

6. Dismantle your experimental set up. Place the indicator paper in the bin, and rinse the petri-dish and electrodes in a sink.

Analysis of results

You can draw your own table, or use the one below:

Where?	Observation
potassium bromide drop	
potassium iodide drop	
positive electrode (anode)	
negative electrode (cathode)	
damp blue litmus paper	
copper(II) chloride drop	

Your ability to analyse your observations may depend on how much of the GCSE Chemistry/Combined Science course you have studied. Your teacher will let you know which questions you should focus on:

1. Chlorine is an acidic and bleaching gas in solution. Describe and explain the evidence you have for the production of chlorine gas. **[4 marks]**

2 Chlorine is a reactive gas and will displace less reactive Group 7 elements from solution. Describe and explain the evidence that you have for the production of chlorine gas.**[6 marks]**

3. In solution, copper is present as Cu^{2+} ions and forms a blue substance (called a complex) with water. Describe and explain the evidence you have for the production of copper metal. **[4 marks]**

4. Draw a diagram to show how you would carry out the electrolysis of a larger volume (e.g. 20 cm^3) of copper(II) chloride. **[4 marks]**

Extension opportunities

1. Write word and symbol equations for the different reactions that have occurred:

(a) Copper(II) chloride drop: Two half equations and full redox equation **[6 marks]**

(b) Displacement reaction in the potassium bromide drop **[2 marks]**

(c) Displacement reaction in the potassium iodide drop **[2 marks]**

2. Predict, with explanation, what will happen to the rate of electrolysis over time. **[2 marks]**

3. Explain why the colour of the copper(II) chloride solution changes over time. **[2 marks]**

DfE Apparatus and Techniques covered

If you are using the OCR Practical Activity Learner Record Sheet (**Chemistry** / *Combined Science*) you may be able to tick off the following skills:

Chemistry					***Combined Science***		
3-i	6-ii	7-i	7-ii		*8-i*	*11-ii*	*12-i*
8-i							

THE ROLE OF AN RSC EDUCATION COORDINATOR

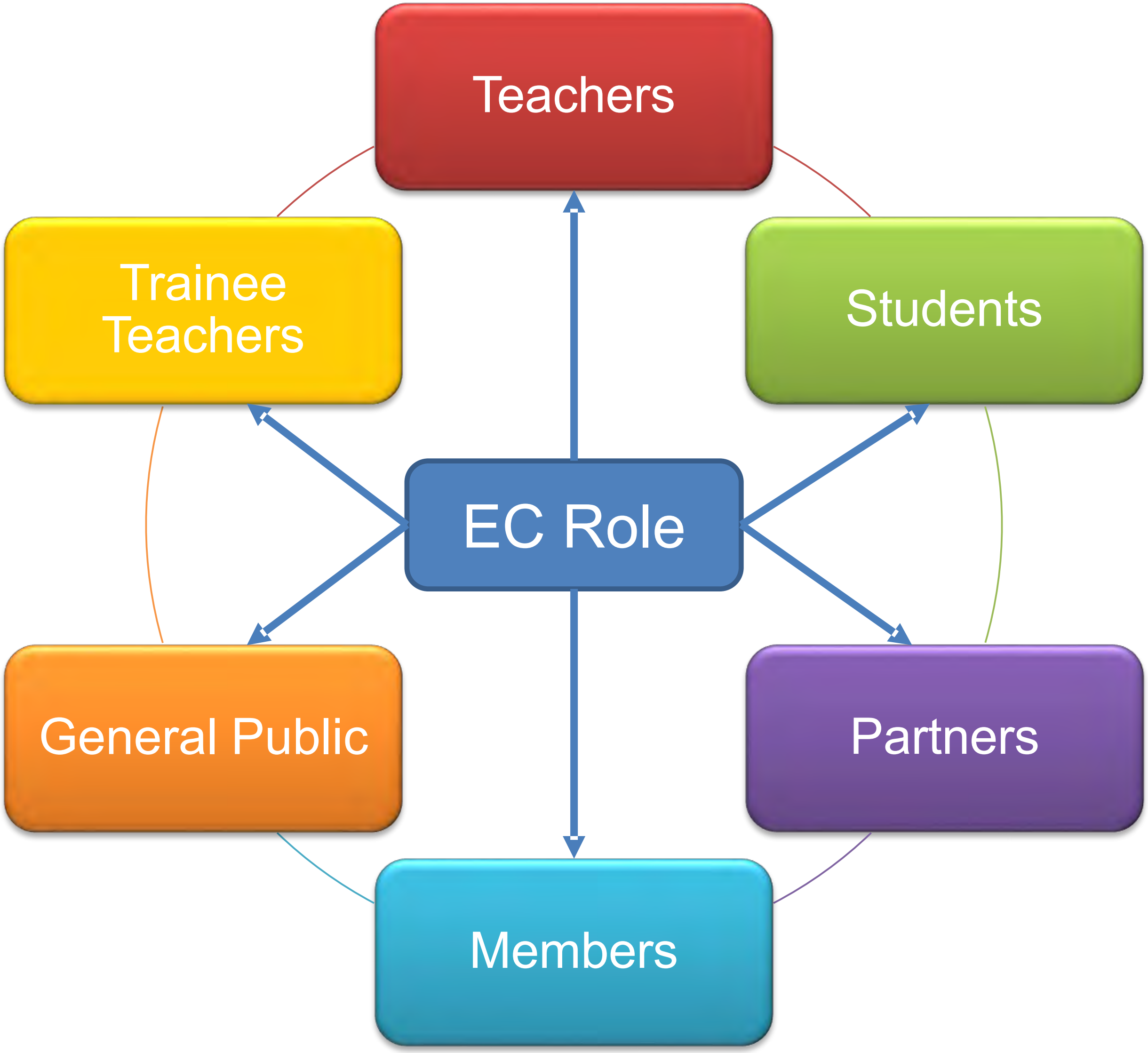
Heidi Dobbs

RSC Education Coordinator: Midlands

Education Coordinators (ECs)

- 2 ECs per region
    - – Based at universities, RSC offices, colleges, a science centre and a STEM Ambassador hub
    - – Non-RSC based staff work 1 day a week for host
- Range of backgrounds, experience and expertise
    - – Close-knit team!

Engage, enthuse, inform, support



Teachers

Trainee Teachers

Students

EC Role

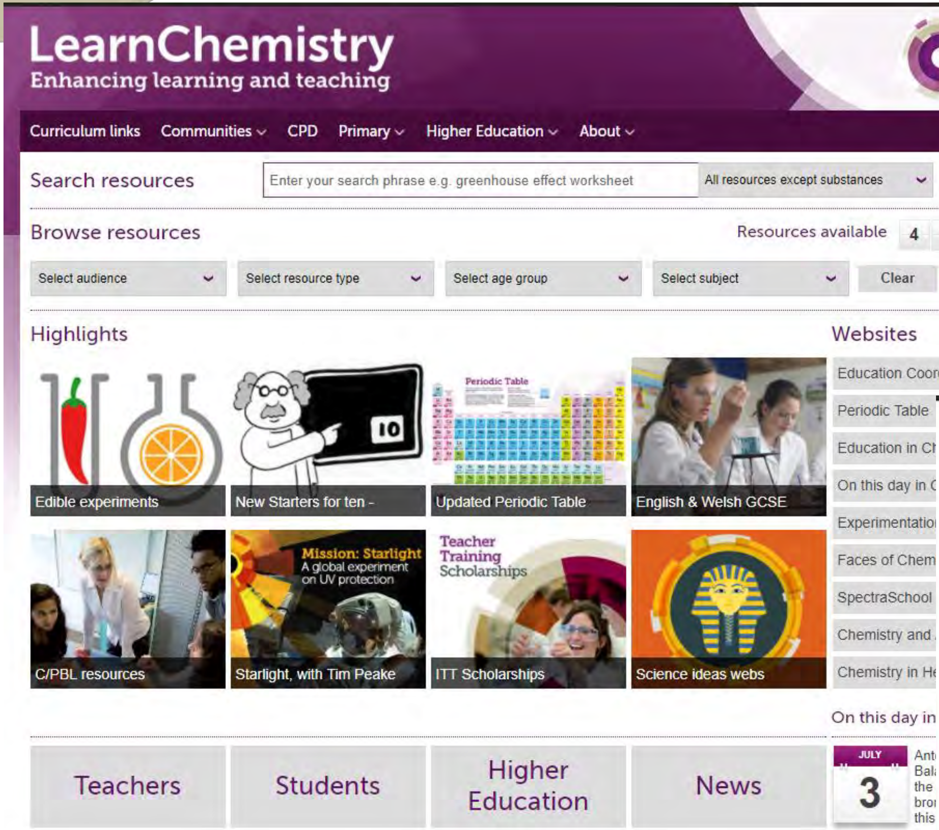
General Public

Partners

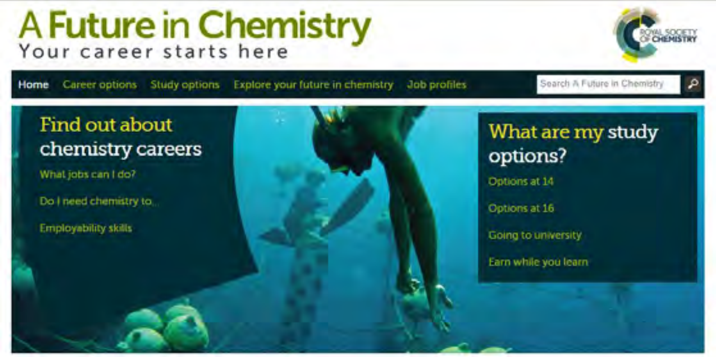
Members

School support from the RSC

- Resources
- Partnerships
- Contacts



www.rsc.org/learn-chemistry



My job is linked to sales and marketing even though I work in a lab.

I help maintain the welfare of the environment through analysing riverways and bathing waters.

www.rsc.org/careers/future

Primary science events (teachers)

Secondary science events (teachers)

Working with partners

Education organisations

Museums/Visitor attractions

Networks

Industry

Schools

Universities/Colleges

…

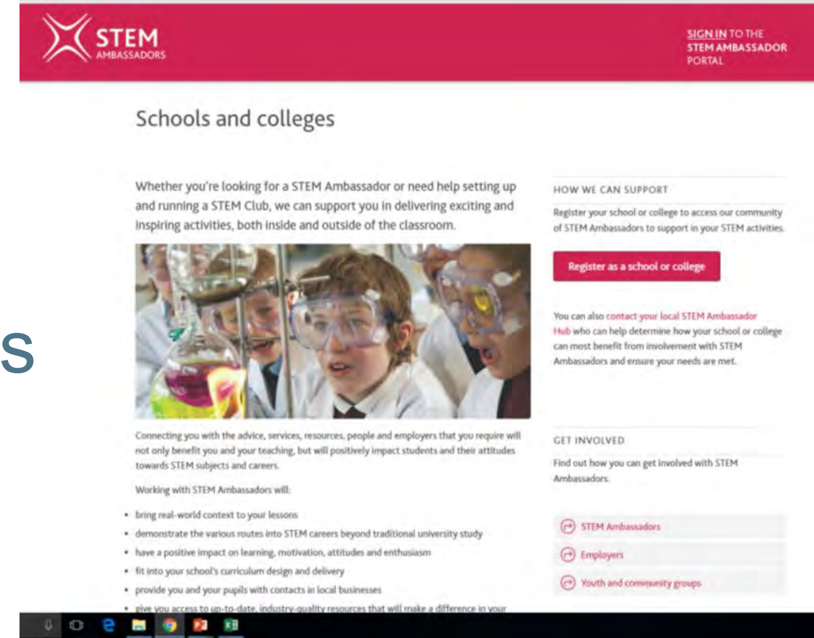
Working with RSC members

What we don’t do….

- Is run workshops for students in schools. BUT…

Spectroscopy in a Suitcase (SIAS)

- AND…many of our members are STEM Ambassadors!



Schools and colleges

Whether you're looking for a STEM Ambassador or need help setting up and running a STEM Club, we can support you in delivering exciting and inspiring activities, both inside and outside of the classroom.

Connecting you with the advice, services, resources, people and employers that you require will not only benefit you and your teaching, but will positively impact students and their attitudes towards STEM subjects and careers.

Working with STEM Ambassadors will:

- bring real-world context to your lessons
- demonstrate the various routes into STEM careers beyond traditional university study
- have a positive impact on learning, motivation, attitudes and enthusiasm
- fit into your school's curriculum design and delivery
- provide you and your pupils with contacts in local businesses
- give you access to up-to-date, industry-quality resources that will make a difference in your

HOW WE CAN SUPPORT

Register your school or college to access our community of STEM Ambassadors to support in your STEM activities.

You can also contact your local STEM Ambassador Hub who can help determine how your school or college can most benefit from involvement with STEM Ambassadors and ensure your needs are met.

GET INVOLVED

Find out how you can get involved with STEM Ambassadors.

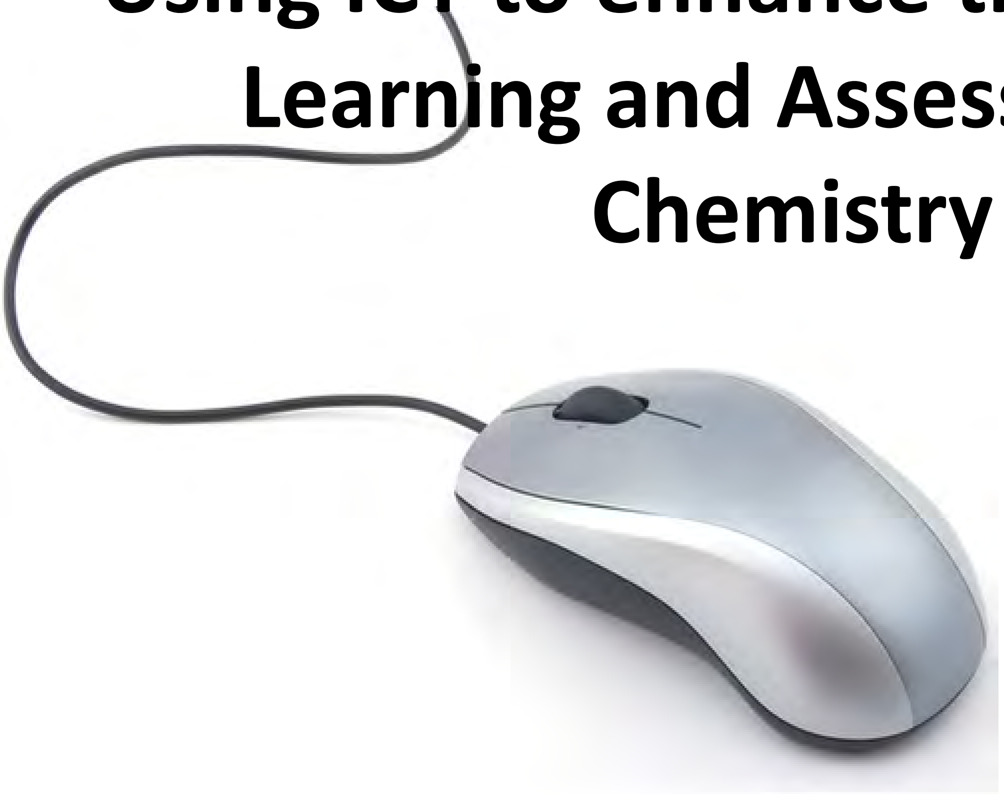
So… get to know your Education Coordinators

- Education Coordinators can:
  - Point you in the right direction
  - Put you in touch with the right people
  - Keep you in touch with what is happening in your area
  - Support you in any way they can (resources, CPD, events etc.)

- RSC Education Coordinators: Midlands
  - heidi.dobbs@nottingham.ac.uk
  - R.Patchett.1@warwick.ac.uk
  - Twitter: @RSC_MidsEd

Thank you!

www.rsc.org



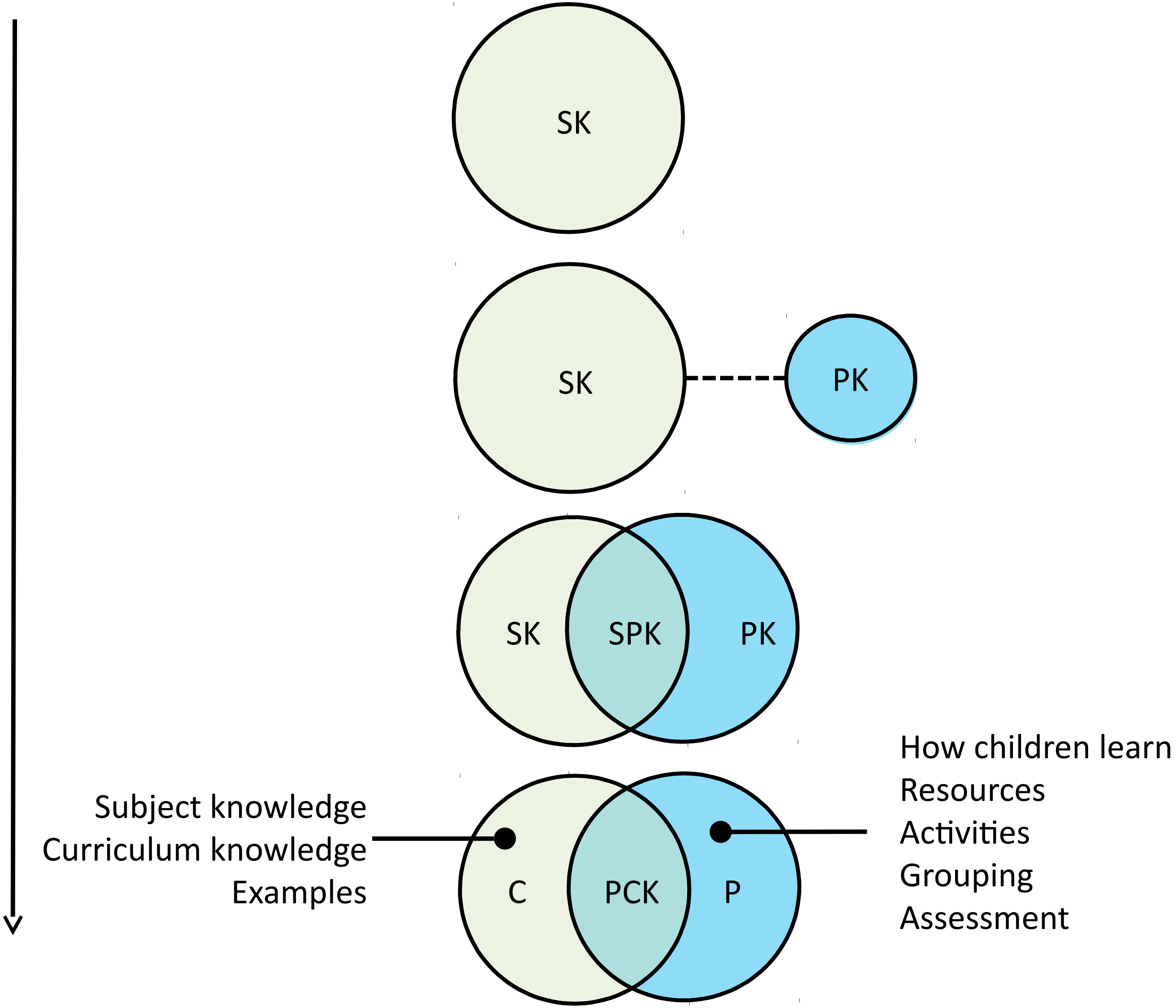
Using ICT to enhance the Teaching, Learning and Assessment in Chemistry

Sandy Wilkinson School of Education

UNIVERSITY OF BIRMINGHAM

Effective teaching depends on flexible access to rich, well organised and integrated knowledge from different domains.

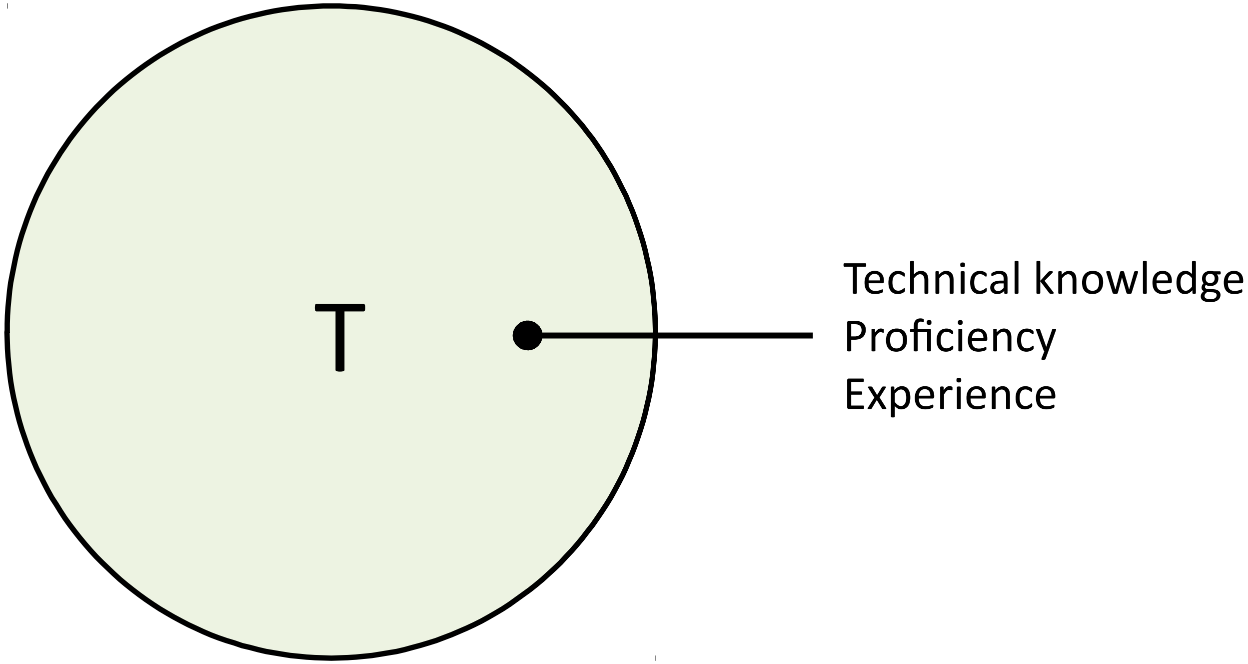
Shulman (1986)



Subject knowledge
Curriculum knowledge
Examples

How children learn
Resources
Activities
Grouping
Assessment

Based on a model by Wellington and Ireson (2012)



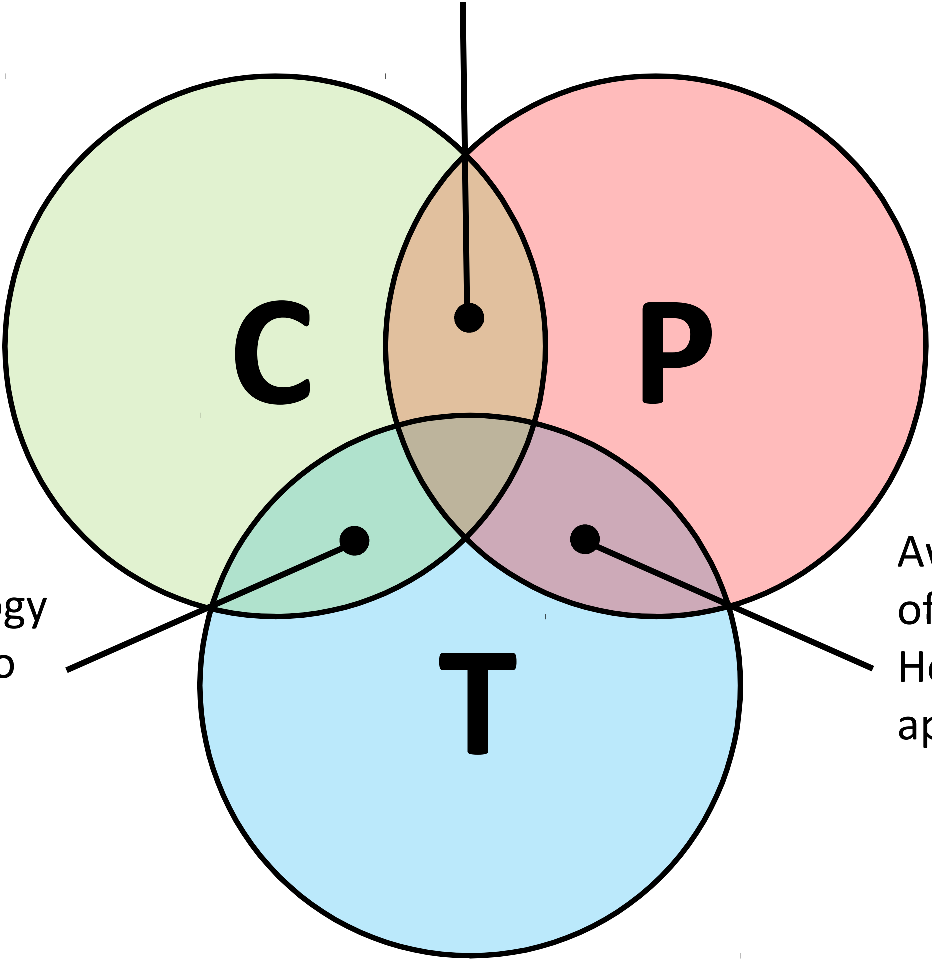
T

Technical knowledge
Proficiency
Experience

(Koehler et al., 2007)

…newer digital technologies are protean, unstable and opaque…

Koehler and Mishra (2009)



Representation of concepts
Cognitive challenge
Barriers to learning

How technology can be used to represent the subject

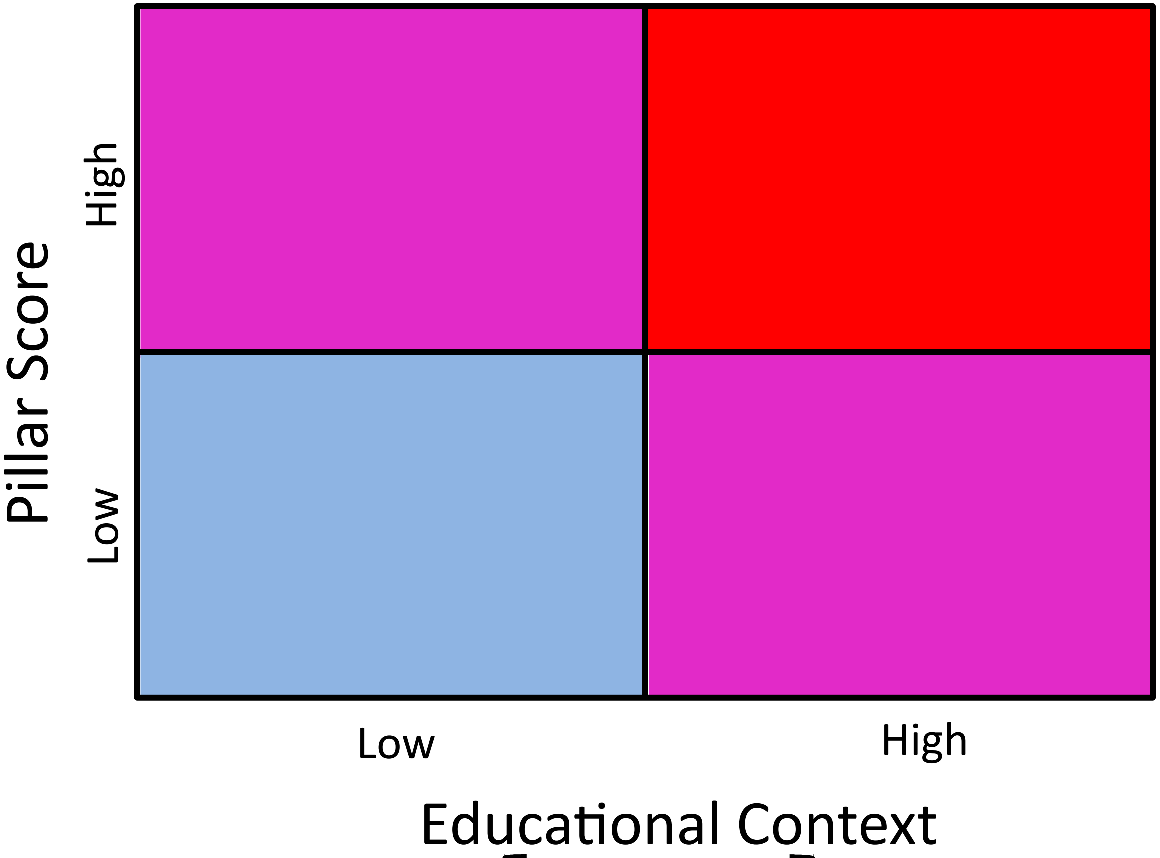
Awareness of the range of ICT applications
How to select appropriate applications

Based on The interaction of Technological Pedagogical Content Knowledge (TPCK)
(Koehler et al., 2007)

A way of thinking about the educational value of an app.

Hirsch-Pasek et al. (2015)

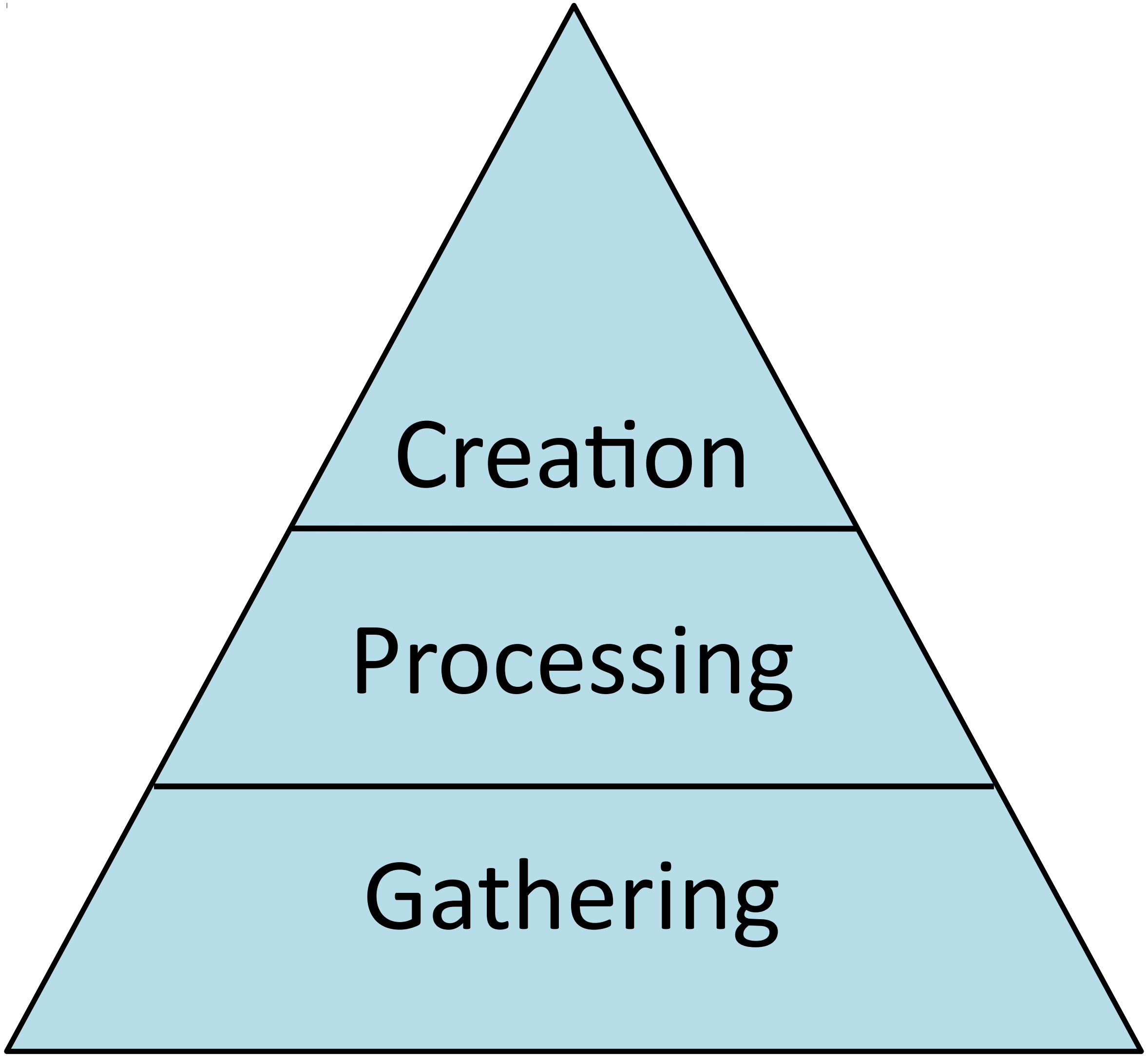
- Active involvement
- Engagement
- Meaningful experiences
- Social interactions



- Purpose
- Challenge
- Learning goals
- Links
- Coherence

Considerations…

Personal	Technical knowledge Technical confidence
Situational	Resource management Accessibility Location Contingency
Education (Teaching)	Facilitation Explanation Exemplification Delivery modes Information (AfL, AoL)
Education (Learning)	Authentic need Active learning Linked to outcomes Enabling Needs for alternatives

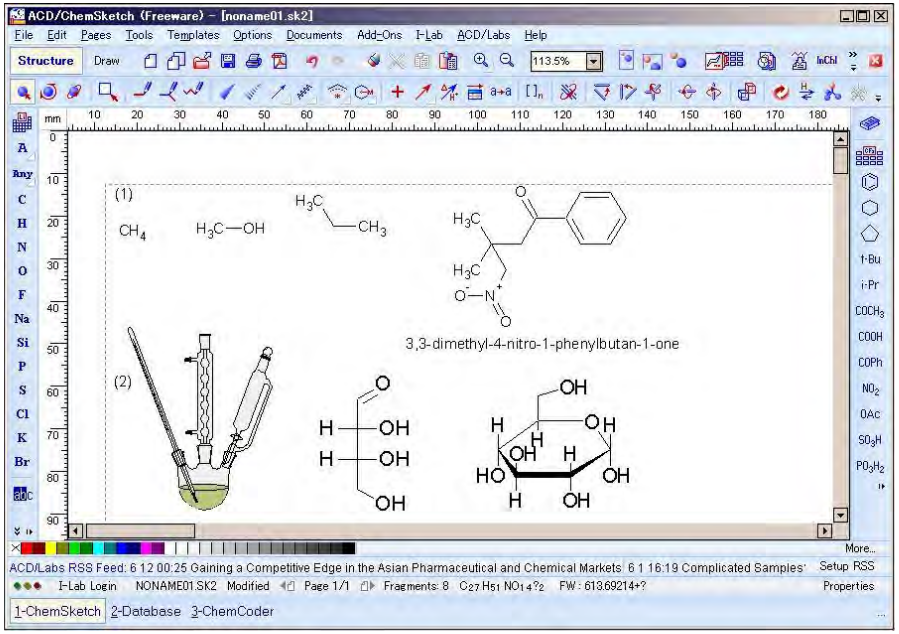


Creation

Processing

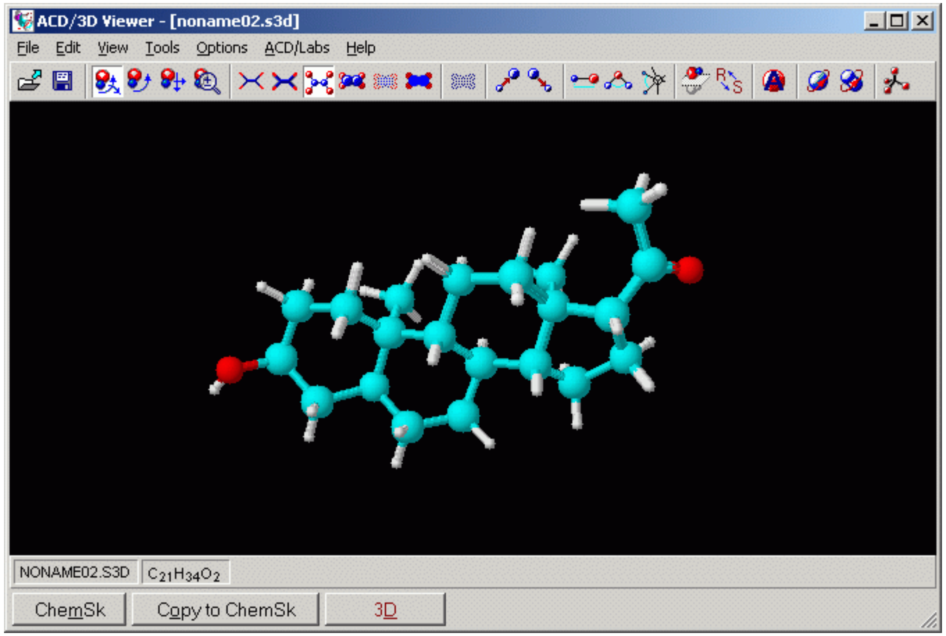
Gathering

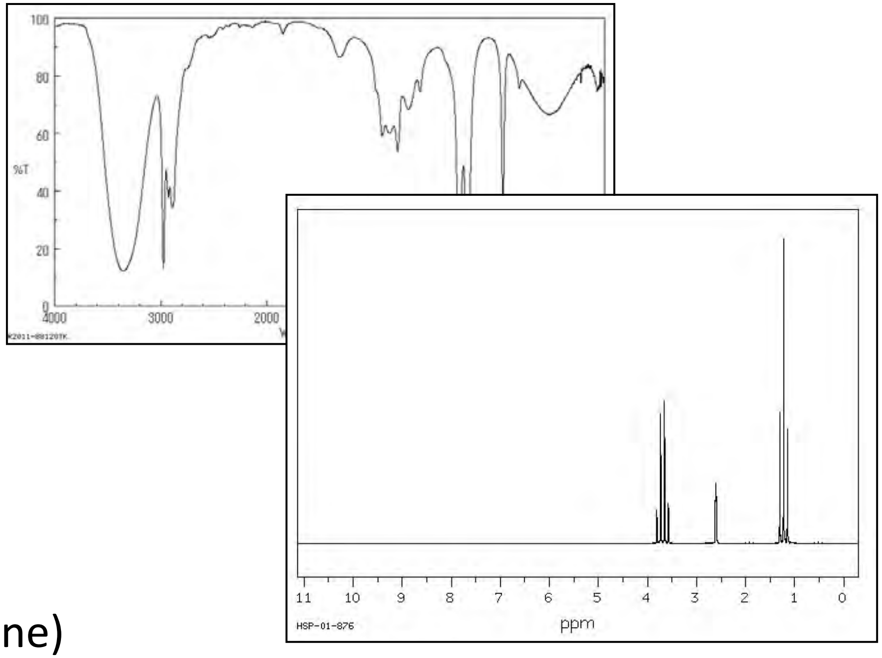
ChemSketch (freeware)

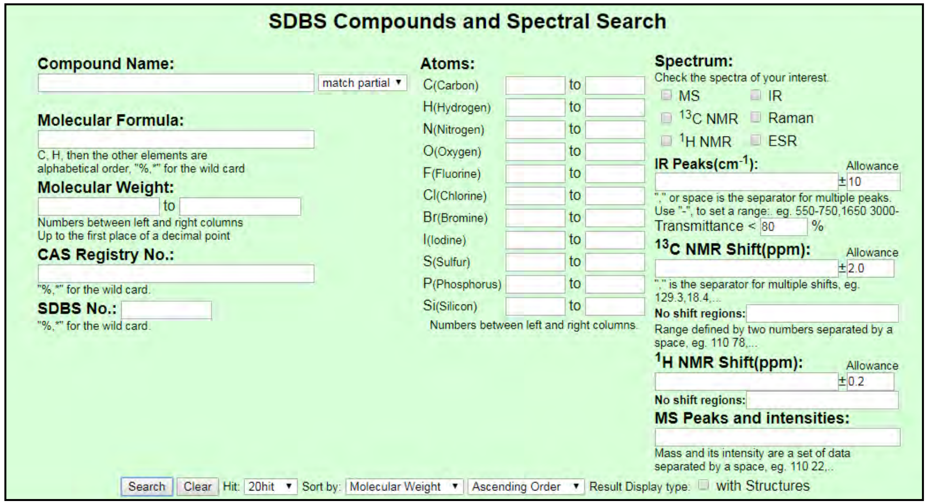


ACD/Labs RSS Feed: 6 12 00:25 Gaining a Competitive Edge in the Asian Pharmaceutical and Chemical Markets 6 1 16:19 Complicated Samples' Setup RSS

I-Lab Login NONAME01.SK2 Modified Page 1/1 Fragments: 8 C27H51 NO14?2 FW: 613.69214+? Properties







SDBS Compounds and Spectral Search

Compound Name: ☐ match partial ▾

Molecular Formula: ☐

C, H, then the other elements are alphabetical order, "%,*" for the wild card

Molecular Weight: ☐ to ☐

Numbers between left and right columns
Up to the first place of a decimal point

CAS Registry No.: ☐

"%,*" for the wild card.

SDBS No.: ☐

"%,*" for the wild card.

Atoms:

C(Carbon) ☐ to ☐
H(Hydrogen) ☐ to ☐
N(Nitrogen) ☐ to ☐
O(Oxygen) ☐ to ☐
F(Fluorine) ☐ to ☐
Cl(Chlorine) ☐ to ☐
Br(Bromine) ☐ to ☐
I(Iodine) ☐ to ☐
S(Sulfur) ☐ to ☐
P(Phosphorus) ☐ to ☐
Si(Silicon) ☐ to ☐

Numbers between left and right columns.

Spectrum:

Check the spectra of your interest.

☐ MS ☐ IR
☐ ^{13}C NMR ☐ Raman
☐ ^{1}H NMR ☐ ESR

IR Peaks(cm^{-1}): ☐ Allowance ±10

"," or space is the separator for multiple peaks. Use "-", to set a range:. eg. 550-750,1650 3000-

Transmittance < 80 %

^{13}C NMR Shift(ppm): ☐ Allowance ±2.0

"," is the separator for multiple shifts, eg. 129.3,18.4,...

No shift regions: ☐

Range defined by two numbers separated by a space, eg. 110 78,...

^{1}H NMR Shift(ppm): ☐ Allowance ±0.2

No shift regions: ☐

MS Peaks and intensities: ☐

Mass and its intensity are a set of data separated by a space, eg. 110 22,...

Search Clear Hit: 20hit ▾ Sort by: Molecular Weight ▾ Ascending Order ▾ Result Display type: ☐ with Structures

Spectral Database for Organic Compounds (online)

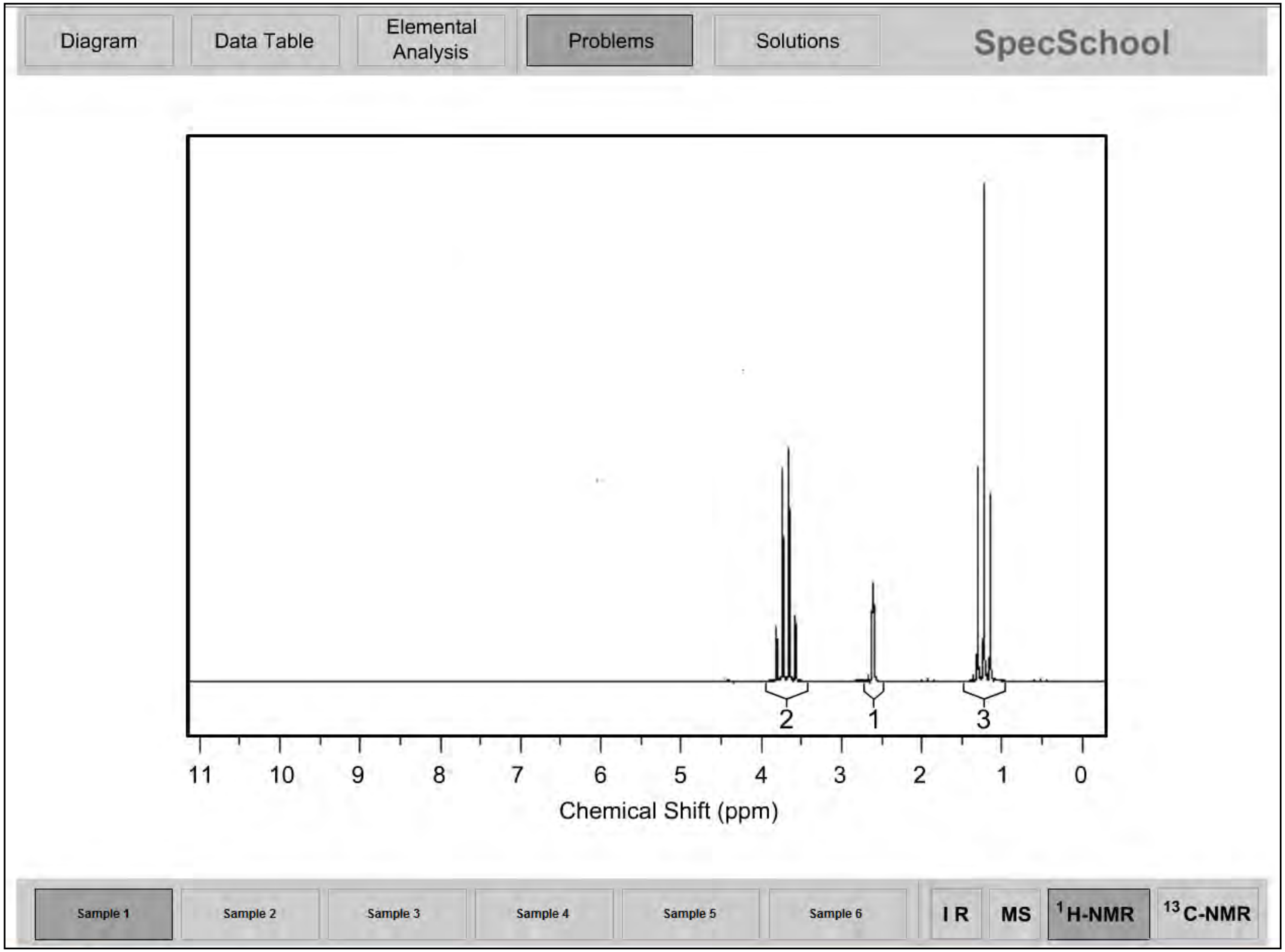
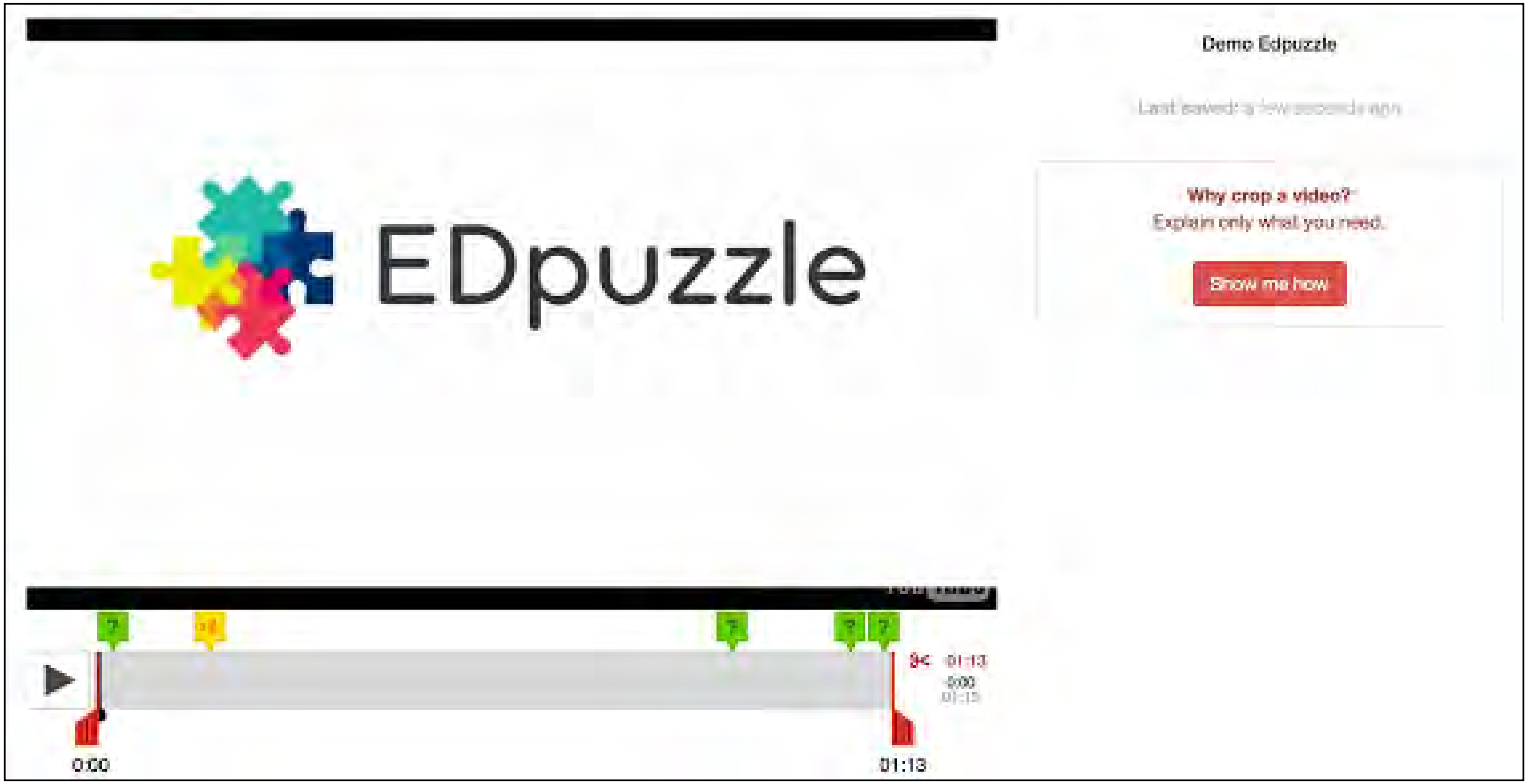


Diagram
Data Table
Elemental Analysis
Problems
Solutions
SpecSchool
2
1
3
11
10
9
8
7
6
5
4
3
2
1
0
Chemical Shift (ppm)
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5
Sample 6
I R
MS
^{1}H-NMR
^{13}C-NMR

Balancing Equations for GCSE Chemistry

- Reactions of Acids Go
- Alkali Metals and Water Go
- Reactions with Oxygen Go
- Reactions of Halogens Go
- The Haber Process Go
- Decomposition Reactions Go
- Metal Extraction Go
- Combustion of Hydrocarbons Go



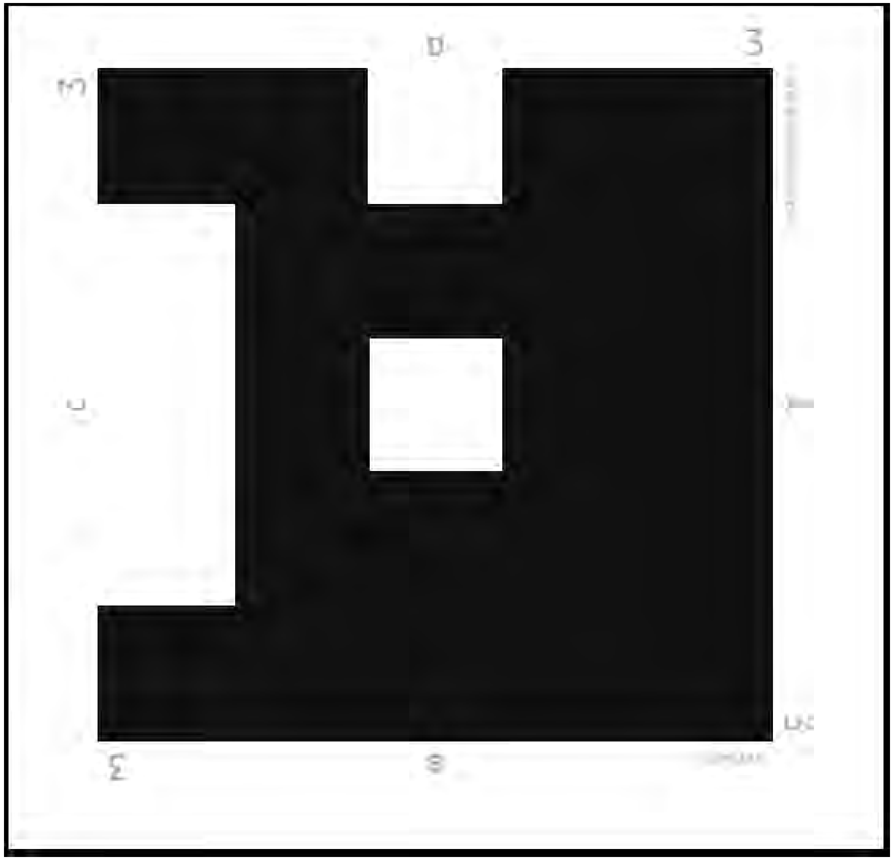
Demo Edpuzzle

Last saved: a few seconds ago

Why crop a video?
Explain only what you need.

plickers

clickers, simplified




ELEMENTS
4D
Pu
PuBr3
Bromine
Plutonium
Plutonium(III) Bromide
2Pu + 3Br2 → 2PuBr3

Suggested GCSE chemistry practical procedures in miniature (Lab Chem West B)

Robert Worley, FRSC, MSc Semi-Retired Chemistry Adviser with CLEAPSS bob.worley@cleapss.org.uk, www.microchemuk.weebly.com

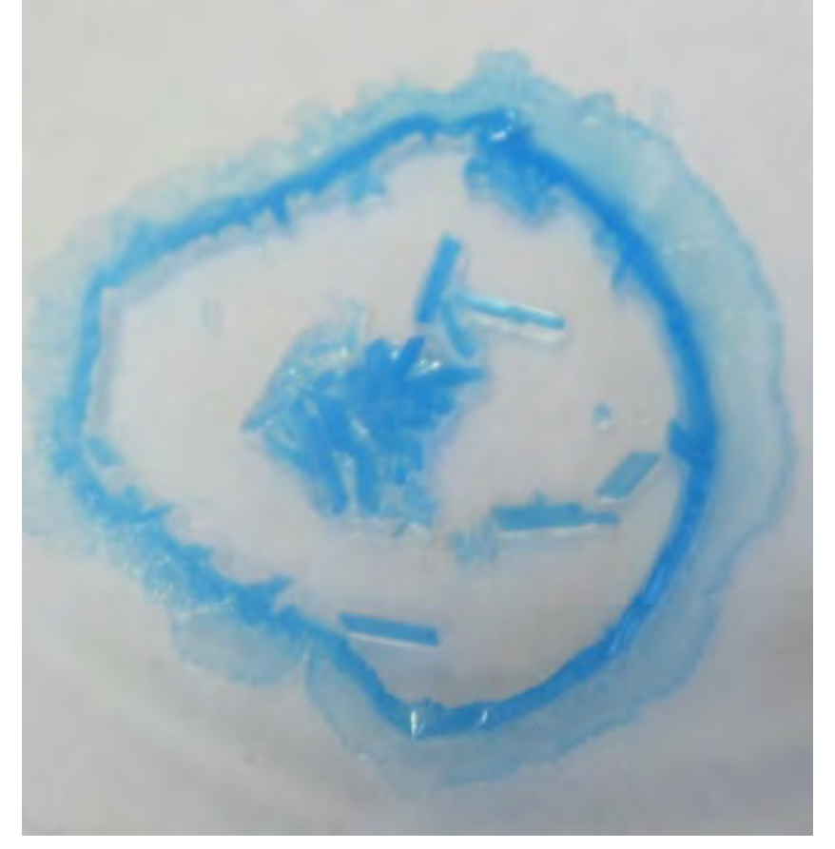
Why do this?

CLEAPSS receives calls daily about “exemplar” experiments published by the examination Boards. There are many reasons, shortage and unavailability of chemicals and equipment, the knock-on effect on changes in safety legislation, waste and disposal of chemicals by the technicians, suitability to students and some even do not seem to work very well. The hour workshop will focus on the 8 experiments required for the new GCSEs and looks at the problems encountered with some microscale solutions.

It is now becoming evident that miniaturised procedures save time in lessons for the teacher to teach and place less stress on the short-term working memory of students so they are hopefully less confused. In addition there are the well known advantages on increased safety and savings on expense. In the time allowed, there will be a workshop where you will prepare copper sulfate crystals, analyse for ions and carry out micro-electrolysis. Demonstrations will include distillation, an introduction to titration without the paraphernalia. Exhibits will include chromatography, thermochemistry and the thiosulfate /acid rate experiment

Making Salts

Preparation of a pure, dry sample of a soluble salt from an insoluble oxide or carbonate, using a Bunsen burner to heat dilute acid and a water bath or electric heater to evaporate the solution.



In fact Bunsen burners are not required to heat the acid. The method provides crystals in less than 30 minutes

Neutralization

Determination of the reacting volumes of solutions of a strong acid and a strong alkali by titration.

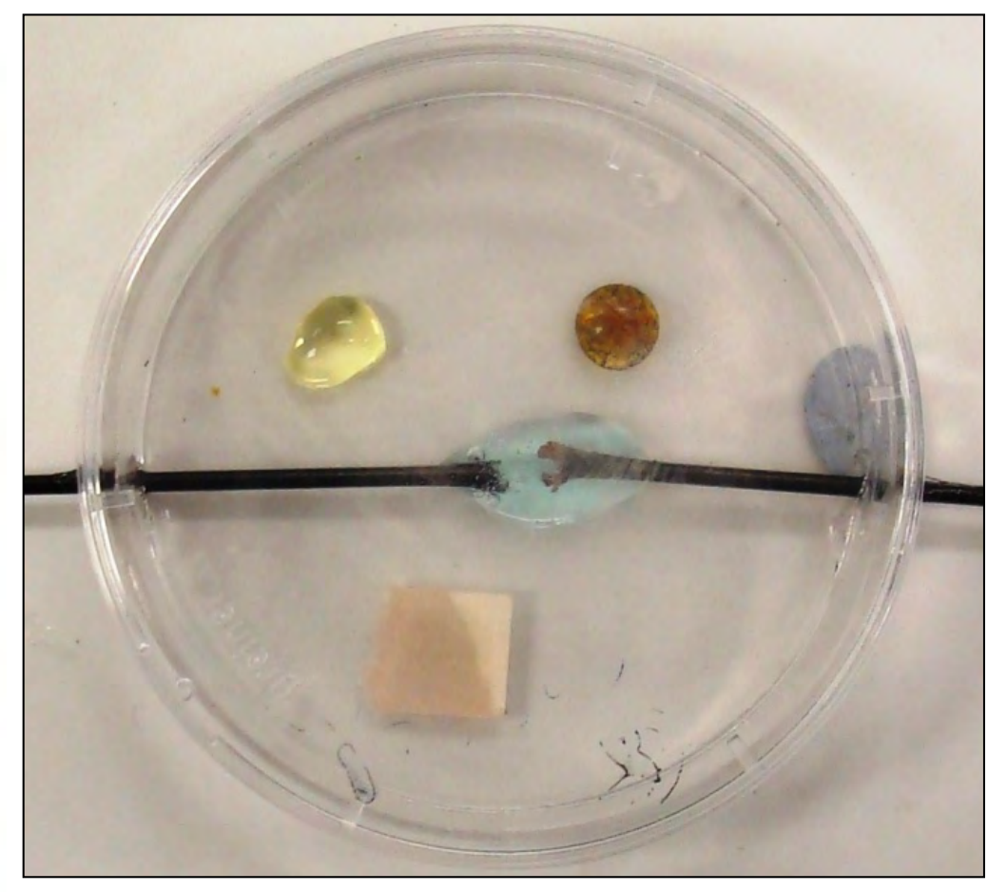
Determination of the concentration of one of the solutions in mol/dm³ and g/dm³ from the reacting volumes and the known concentration of the other solution.

This mass-weighing method with inexpensive, yet accurate balances, provides an introduction to titration without all the paraphernalia which detracts from the chemistry. It can be introduced later.

Electrolysis

Investigate what happens when aqueous solutions are electrolysed using inert electrodes.

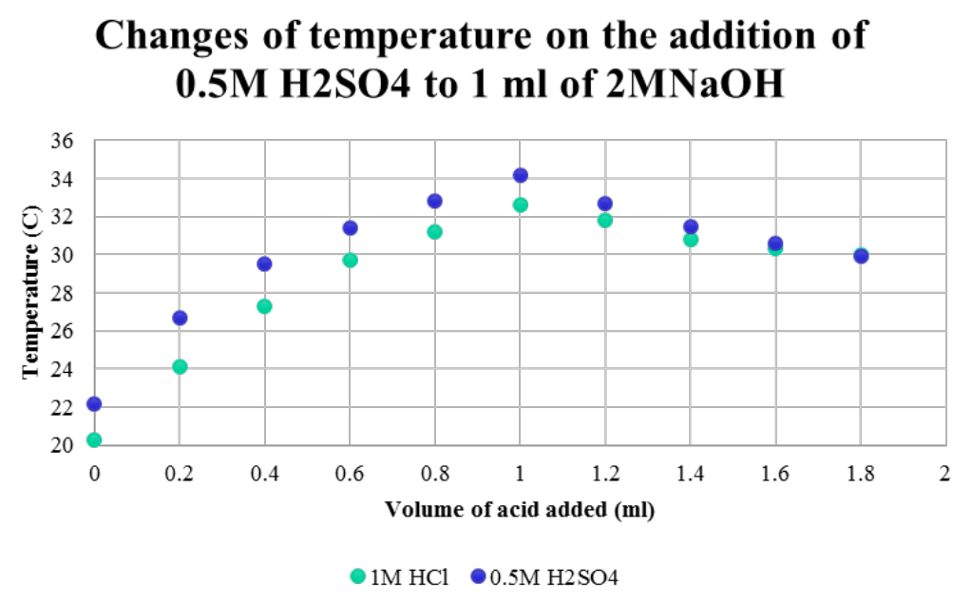
This should be an investigation involving developing a hypothesis.



Safety issues have arose with the use of chloride and collecting gases. In measuring the mass changes of copper, measure mass loss on the anode rather than mass gain on the cathode.

Temperature changes

Investigate the variables that affect temperature changes in reacting solutions, eg acid plus metals, acid plus carbonates, neutralisations, displacement of metals.



The experiment can be scaled down to a few ml and the reagents. Mercury thermometers cannot now be purchased. Inexpensive digital thermometers to one dec place are readily available or is the scale reading important?

Rates of reaction

Investigate how changes in concentration affect the rates of reactions by a method involving measuring the volume of a gas produced and a method involving a change in colour or turbidity. This should be an investigation involving developing a hypothesis.

Sulfur dioxide is produced in the thiosulfate/acid reaction. Safety can be improved by scaling down and using a stop bath of 0.5M sodium carbonate (with indicator), into which the reactants are poured

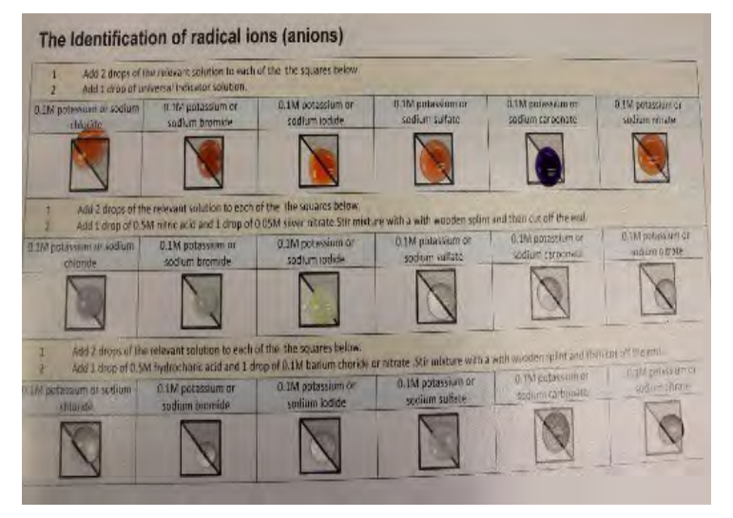
Chromatography

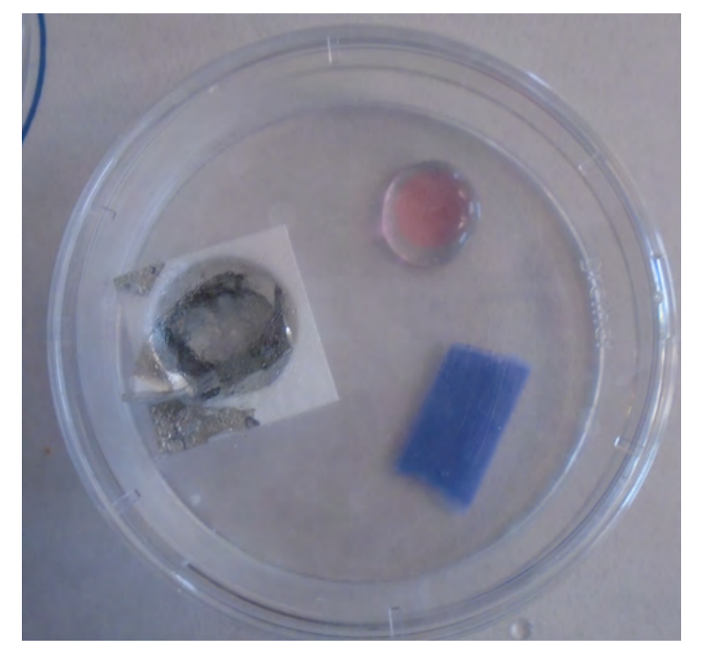
Investigate how paper chromatography can be used to separate and tell the difference between coloured substances. Students should calculate Rf values.

Paper chromatography is slow and never provides the same pictures as depicted in text books. This means that Rf values are not easy to calculate. This article http://tinyurl.com/lv4ydwp discusses progression of the subject even toTLC that is possible to GCSE.

Identifying ions

Use of chemical tests to identify the ions in unknown single ionic compounds covering the ions from sections aluminium, calcium and magnesium, copper(II), iron(II) and iron(III) ion, carbonates, halides and sulfates.


The Identification of radical ions (anions)



Using drops of reagents on plastic sheets provides results without the used of lots of test tubes. There will be a novel test for carbonates and nitrates as well.

Water purification

Analysis and purification of water samples from different sources, including pH, dissolved solids and distillation.

Conductivity is the criteria for water purification, not pH. The new CLEAPSS micro-heater will be on show along with larger equipment and the CLEAPSS conductivity indicator. Picture shows micro distillation of orange peel.

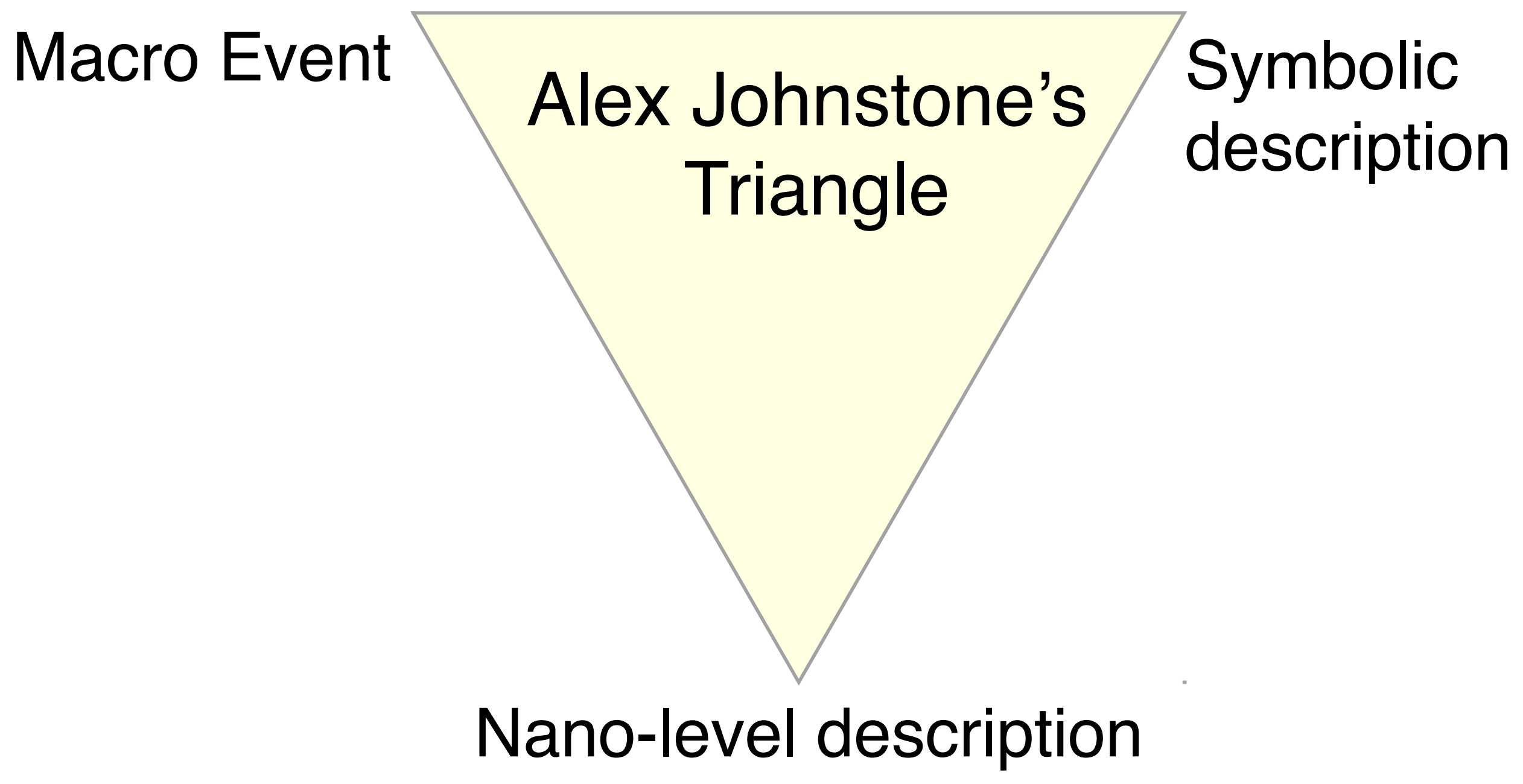
The Johnstone Triangle: Chemical Education Theory Exemplified by Microscale Chemistry with the Diffusing Precipitate

Robert Worley, FRSC, MSc Semi-Retired Chemistry Adviser with CLEAPSS bob.worley@cleapss.org.uk, www.microchemuk.weebly.com

THE JOHNSTONE TRIANGLE

Chemistry never ceases to amaze students, whether it loud bangs, fires and sudden colour changes. ***So why do students find chemistry so difficult?***

Science demands that we go beyond the MACRO event and examine how these events occur at the NANO-LEVEL, how they can be SYMBOLLICALLY represented, which includes how data be collected and used. Can the scientist predict further similar events and if they do not fit the prediction, can they be explained with the present model or do we have to go back to develop a new model? This is where we lose the majority of students. Alex Johnstone encapsulated these thoughts into his famous triangle which can help teachers organise their thoughts and strategies in teaching.



Literature cited

Chaplin: http://www1.lsbu.ac.uk/water/water_molecule.html

Seery: https://eic.rsc.org/opinion/chemical-bonding-confusion/2010015.article , http://michaelseery.com/home/index.php/2016/10/a-tour-around-johnstones-triangle/

Taber: https://eic.rsc.org/section/feature/chemical-bonding/2020113.article

Warren and Stephenson: https://eic.rsc.org/cpd/practical-chromatography/2500327.article

THE MACRO EVENT

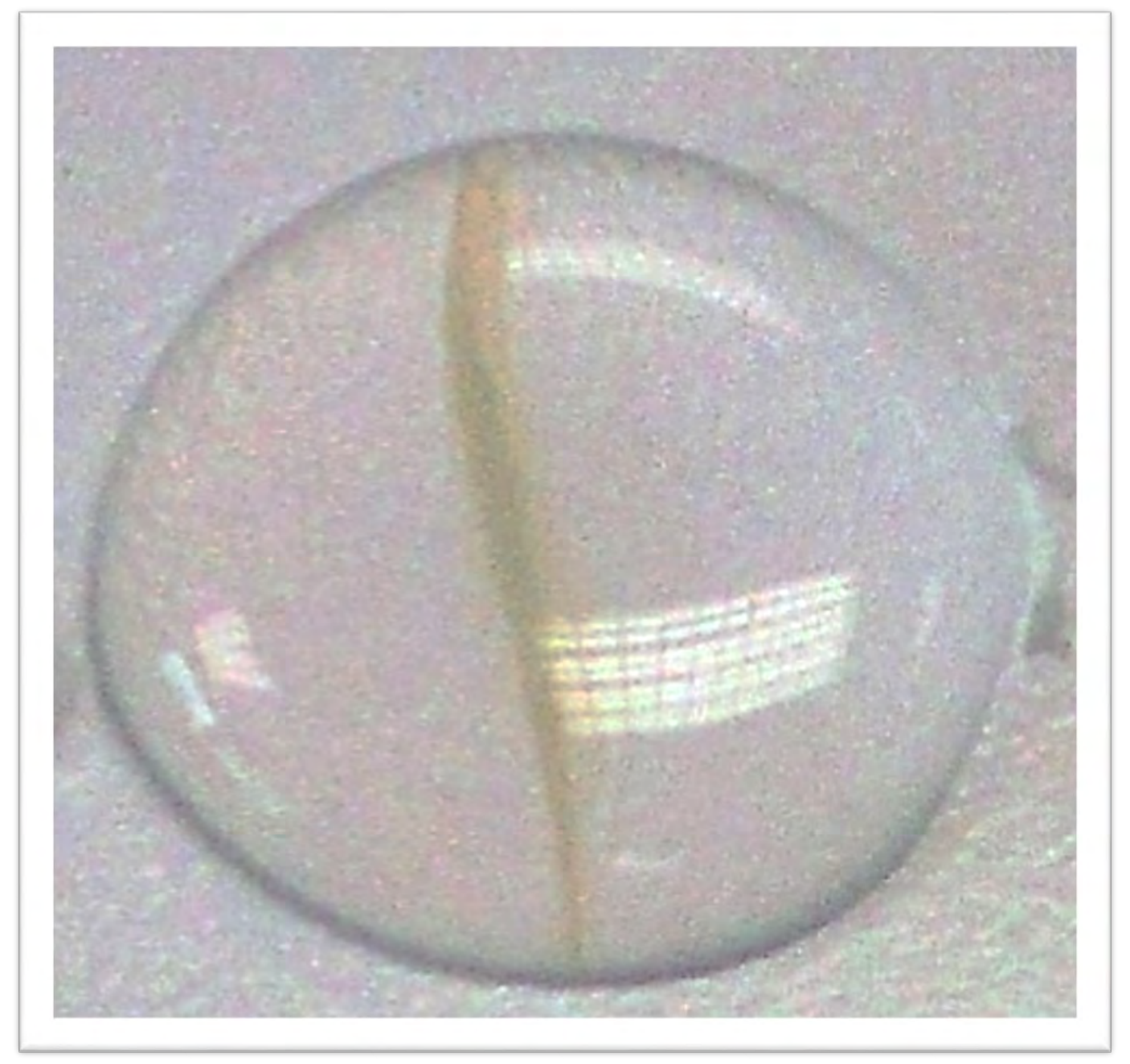
Precipitation is magic to most students. Two clear, possibly coloured liquids, liquids on mixing, produce a solid in the ligquid. Where have the liquids come from? Usually they prepared by a teacher or technician.

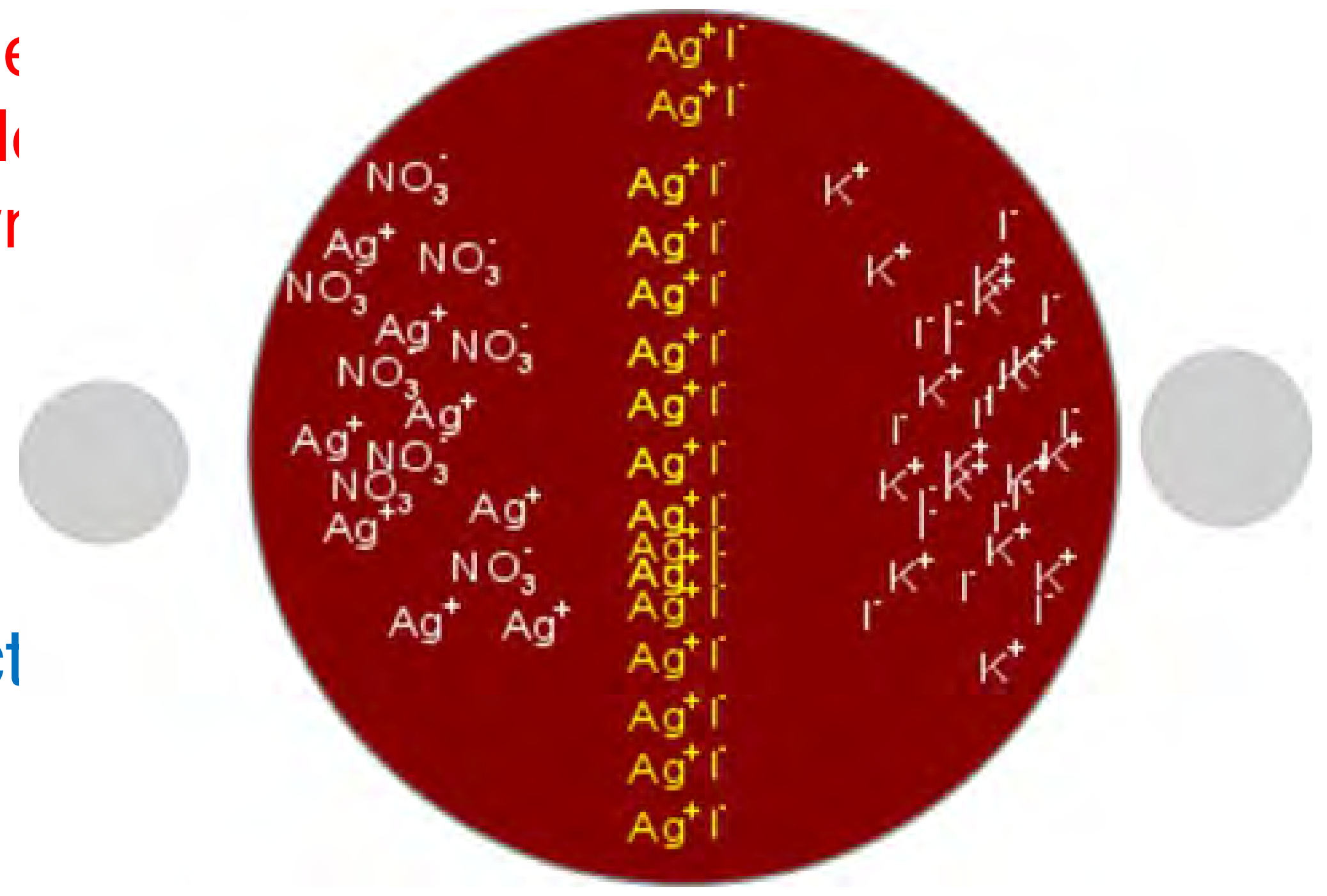
How to make a diffusing precipitate

Push a few crystals of two solids, such as potassium iodide and silver nitrate, placed either side of a 1.5 to 2 cm diameter puddle of pure water on a polypropylene sheet. Observe that the solids dissolve in the outer reaches of the "puddl and then see a precipitate suddenly appear down the centre.

In this example, the yellow precipitate is silver iodide.

Other pairs of solids are available; try copper(II) sulfate and sodium carbonate. You can contact me for a worksheet.





NANO-LEVEL DESCRIPTION

Interpreting these events at the nano-level, requires understanding of electrostatic attraction between particles in chemistry, the process of dilution, via the solvation of ions by water, and the diffusion of solvated ions through water. *(There is a great opportunity for drawing concept cartoons here. I tried (see above) but I had to miss out water because it becomes too complicated. All this information about precipitation cannot be taught to students at the same time. There has to be progression as described by Dorothy Warren and Kay Stephenson with regards to chromatography in school chemistry.)*

SYMBOLIC DESCRIPTION

Chemists represent these particles with symbols. This leads to the describing reactions reactions with chemical "equations". *(Another problem area! I believe that there is huge confusion in students' long term memory with conflicting use of the word "equation", and the use of indices when compared to their experience in school mathematics. Ionic "equations" are more complicated?)*

Acknowledgments

I would like to acknowledge the help of Dr Kay Stephenson and Mary Owen for their help with the chemistry and materials.. Also Steve Jones, Director of CLEAPSS, Dr Kristy Turner, Dr David Paterson and Prof Michael Seery for their encouragement and enthusiasm in this journey into teaching with small scale chemistry.

Discussion

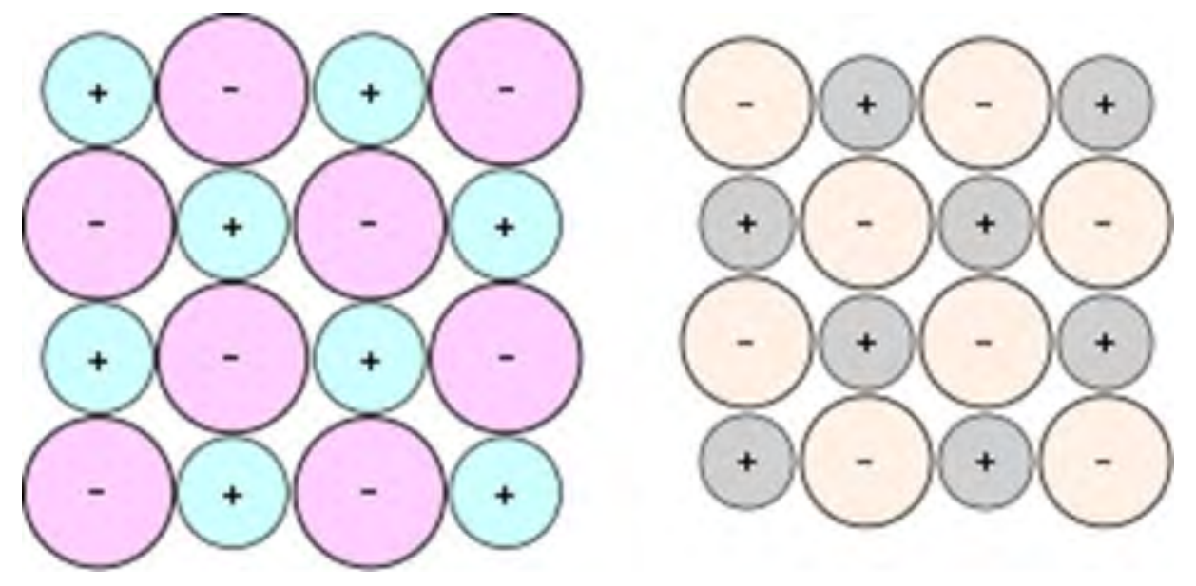
The precipitation reaction is an example of the interplay between electrostatic attractions at the nano-level. (Michael Seery and Keith Taber). This interplay is fundamental in understanding chemistry. It will become more sophisticated, more mathematical but in schools the foundations have to be laid.

Electrostatic attraction is present between sub-atomic particles, covalent, ionic and metallic bonds, solvation, complexes, hydrogen bonds and even between particles in the gases phase.

The structure of water is fundamental to dissolving (Martin Chaplin). The bent structure of the molecule, lone pair of electrons and the electrostatic attraction of electrons towards oxygen in the O-H bonds all come together to make the molecule have a dipole. Evidence for this can be shown in deflecting a narrow stream of water by bringing a rubber balloon close to it after rubbing the balloon on a woollen sleeve to develop an electrostatic charge on the balloon.,

Macro event 1:

The solids are outside the puddle of water



Nano-level

The solids are charged particles called ions. (Evidence; when molten, these salts conduct an electric current).

Symbolic

$KI(s)$, $AgNO_3(s)$

Or is a better representation, $K^+I^-(s)$ and $Ag^+ NO_3^-(s)$?

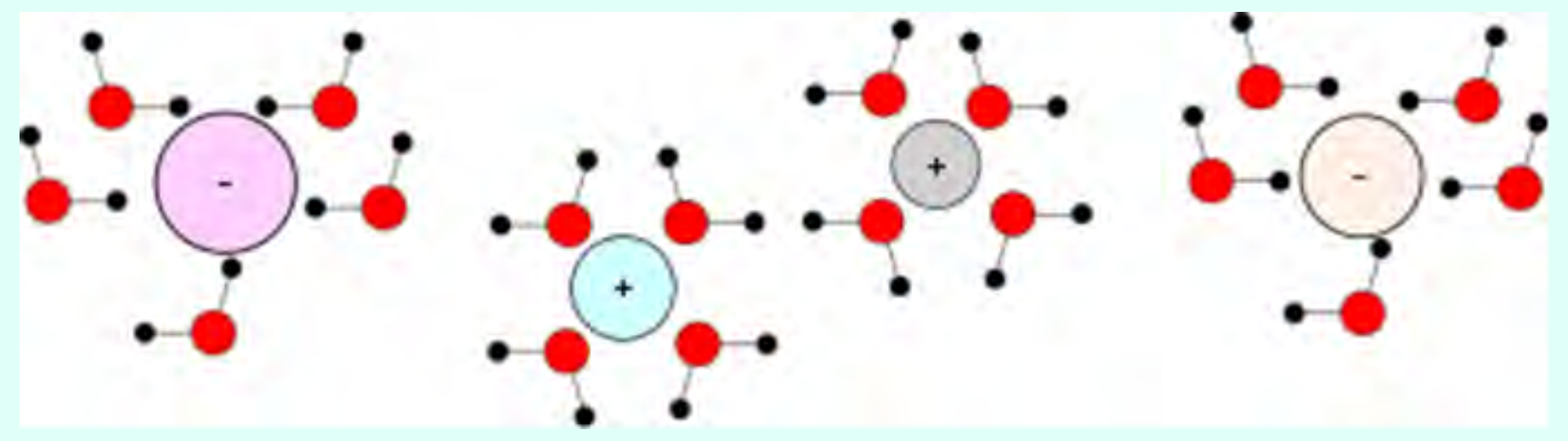
Macro event 2:

The solids are pushed into the puddle from either side and the solids disappear.

Nano-level

No the solids dissolve! There is no magic! The attractive forces between the water particles and the charged particles (ions) overcomes the attractive forces between the ions in the solid.

I think that comes as a big surprise as ionic bonds are often described as strong bonds requiring lots of energy to break them apart.



Symbolic

$K^+(aq)$, $I^-(aq)$, $Ag^+(aq)$, $NO_3^-(aq)$

Macro event 3:

A yellow solid appears down the centre of the puddle.

Nano-level

The charged particles, surrounded by water molecules (solvated ions), MUST move through the water molecules in the puddle. It is called diffusion. (It is the only way one can explain the yellow slash in the centre of the puddle.)

The attractive forces between the silver and iodide ions MUST be stronger than those between the silver and iodide ions and water. (It is the only way can explain the yellow slash.) So it comes out of the solution as a solid. (But why is it yellow? Sorry I don't know)

Symbolic

$$K^+(aq) + I^-(aq) + Ag^+(aq) + NO_3^-(aq) \longrightarrow AgI(s) + K^+(aq) + NO_3^-(aq)$$

Microscale chemistry

Bob Worley BSc, MSc, FRSC
Chemistry Adviser, CLEAPSS
Email: bob.worley@cleapss.org.uk
www.microchemuk.weebly.com

CLEAPSS, Brunel Science Park, Kingston Lane Uxbridge, UB8 3PH, UK; Tel:01895251496; www.cleapss.org.uk; email: science @cleapss.org.uk

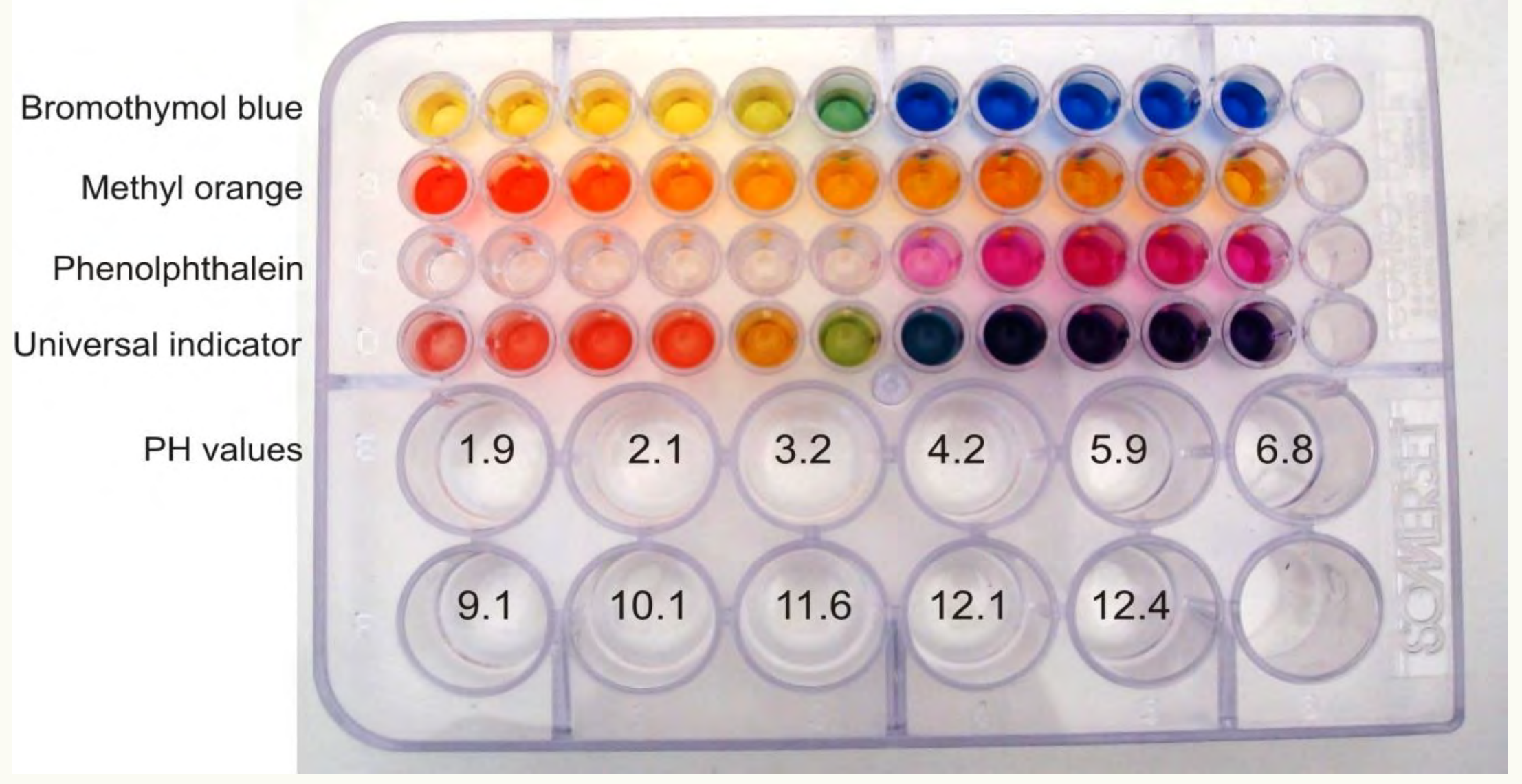
Microscale chemistry activities will enhance your practical work. They use small amounts of chemicals, usually less than 60cm^3 of gas, 0.1g of solids and 2cm^3 of solution. Microscale also brings the following advantages:

- Variety of approach
- Safer procedures
- Reduced practical time, allowing for more discussion and questioning
- Allows students to work on their own
- Easier for students to manage
- Easier to provide students with everything needed on a small tray- reduces movement in the lab
- Quantitative results and data manipulation are possible
- Uses modern materials and equipment
- A laboratory is not always required
- Images can be projected onto a white board using a webcam or video microscope
- Photographs can be taken by students for their Lab Books.
- Makes some hard-to-do preparations possible, or much easier.
- Reduced cost
- Reduced waste
- Less time clearing up and disposing of waste

Courses

Whole and half-day courses are available or can be booked through CLEAPSS or myself by phoning CLEAPSS, emailing myself and you can look for courses on http://courses.cleapss.org.uk/Courses/Courses.aspx

pH AND INDICATORS



VANADIUM OXIDATION STATES

MICROELECTROLYSIS

$CuCl_2$ solution is placed between carbon fibre electrodes.
Cl_2 gas diffuses into, and reacts with the litmus paper KI and KBr solutions.
Only 6cm^3 of chlorine gas is produced.

THE CROWN BOTTLE TOP AS CRUCIBLE

% water in $CuSO_4.5H_2O$

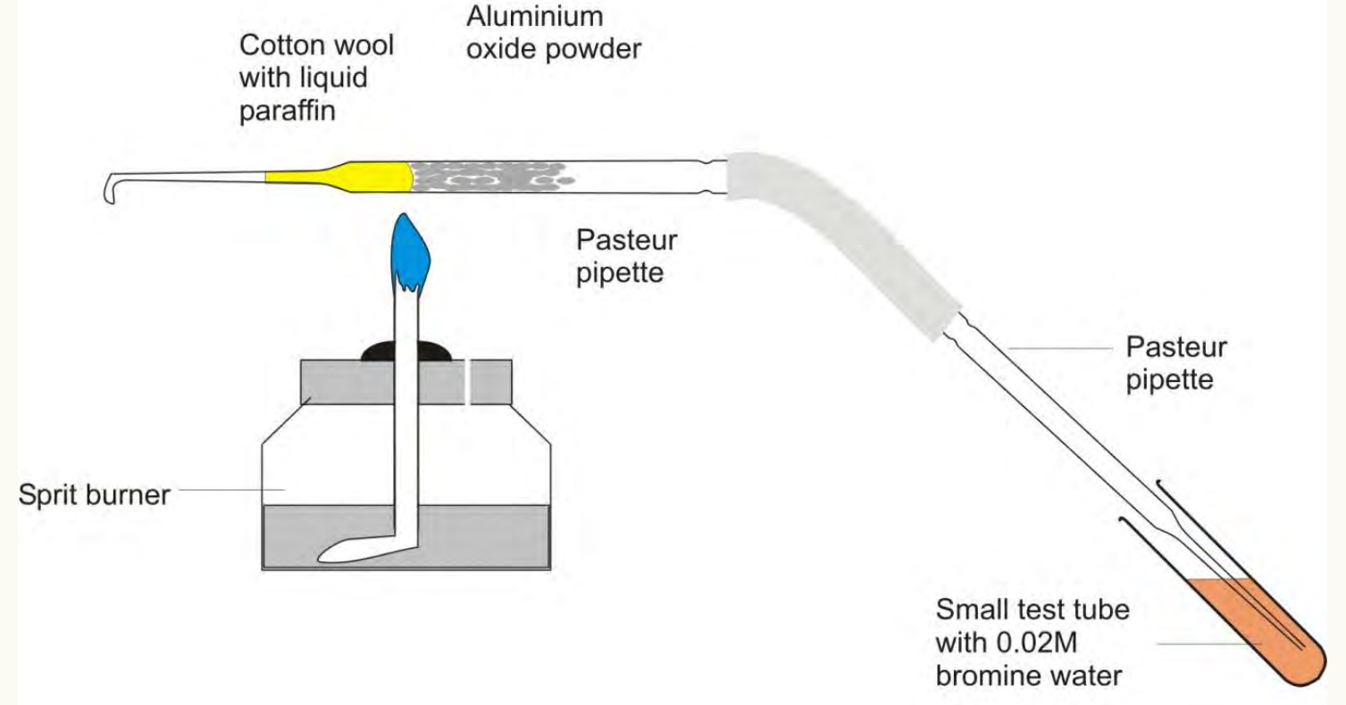
Using this equipment gives superior results to using porcelain crucibles

Determining the increase in mass on burning Mg in air

IONS DIFFUSING

One soluble salt is placed 1.5 cm from another on a plastic sheet.
Water is dripped in between them and the salts are moved into the droplet. Precipitates and complexes can be seen forming down the centre.

CRACKING & PREP OF ALKENES



Cracking liquid paraffin and preparation of propene by dehydration of propan-2-ol can be carried out safely with no risk of suckback. Hydrogenation of propene can be achieved.

HOFMANN VOLTAMETER

The arrangement costs less than £25.
Uses 0.8M Na_2SO_4 as the electrolyte.
Rockets and explosions can be powered by the hydrogen & oxygen produced.

GAS DIFFUSION CHEMISTRY

Uses a single tablet blister pack as the reaction vessel. Only a small volume of gas is generated. The gas diffuses to aqueous solutions of various reagents and into moist indicator paper.

The Chemistry Of Ammonia

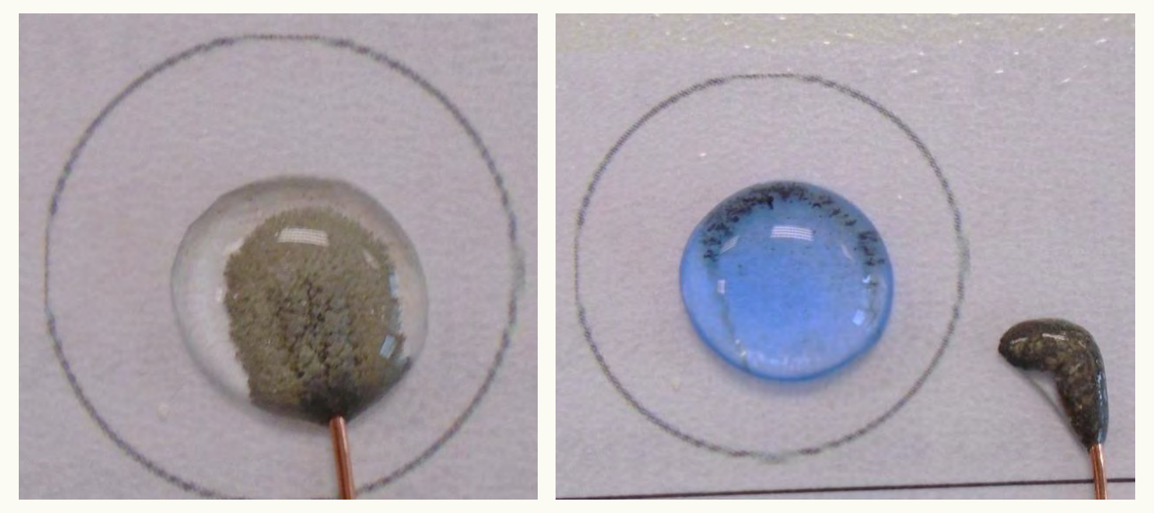
TITRATING

Uses the screw of the clamp or a Hofmann clip to add drops of one reagent from the special pipette to the other reagent in the vial.
Measurements carried out by weighing.

MICROELECTROLYSIS OF MOLTEN SALTS

Molten lead bromide is electrolysed with an iron nail cathode (you can write with this to show the lead) and a nichrome wire anode, which releases bromine

CHEMISTRY IN DROPS



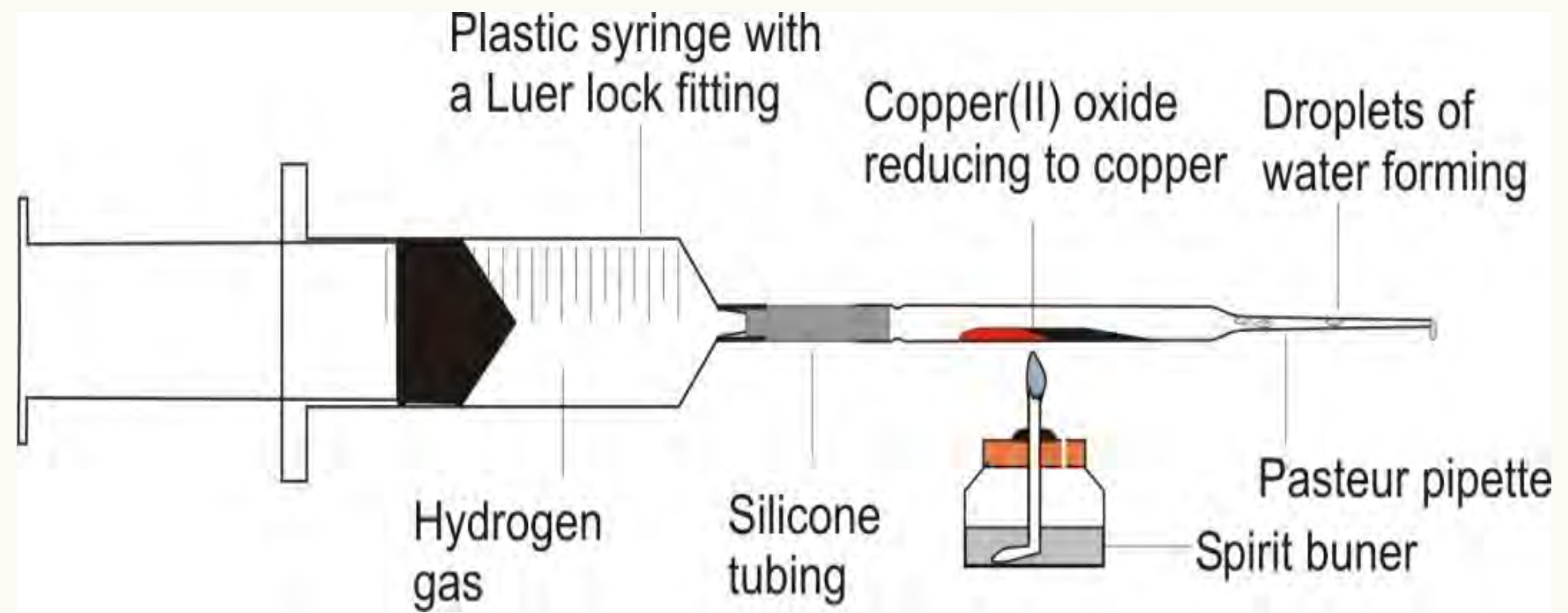
Cu wire in 0.05M AgNO3.
Withdraw wire with attached silver and add 2M ammonia.
Blue colour indicates Cu ions.

An instruction sheet is inserted into a plastic folder. Tiny quantities of aqueous chemicals can be dropped onto the sheet to carry out reaction.
Removes the need for test tubes.

ELECTRODE POTENTIALS

The time taken is substantially reduced with this quick and easy method.

HYDROGEN REDUCTION OF METAL OXIDES



No risk of hydrogen/ air explosions

POLYMERISATION

Methyl methacrylate is mixed with the initiator in a closed glass Pasteur pipette and warmed in hot water. The pipette is broken apart to obtain the plastic in the shape of the pipette.
No smells!

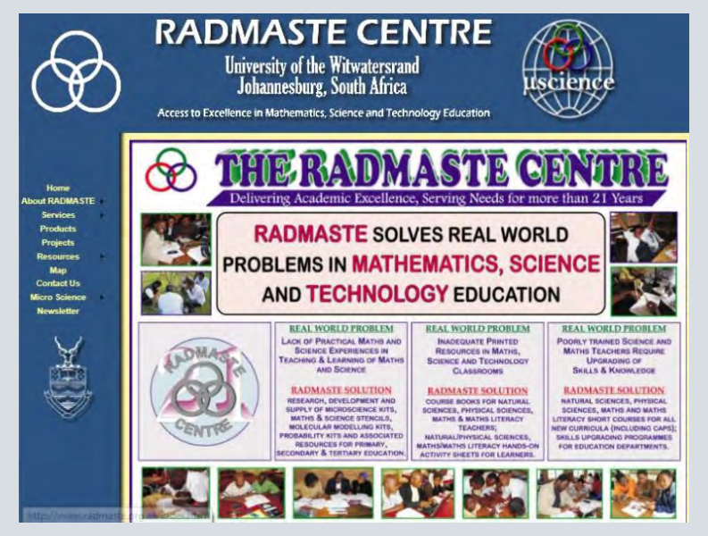
Equipment and further information for microscale chemistry

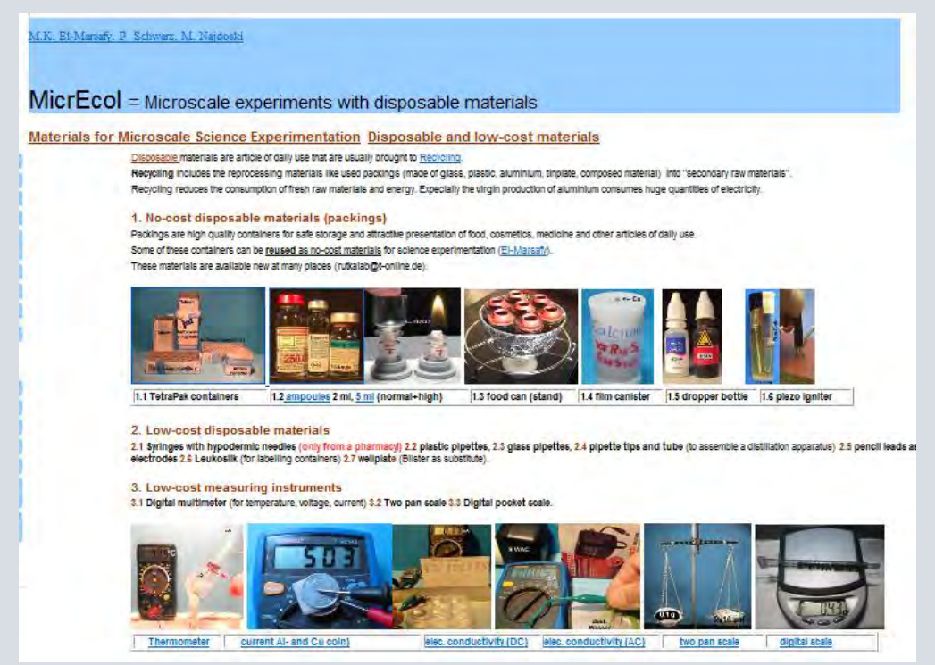
CLEAPSS, Brunel Science Park, Kingston Lane Uxbridge, UB8 3PH, UK; Tel:01895251496; www.cleapss.org.uk; email: science @cleapss.org.uk

Bob Worley BSc, MSc, FRSC
Chemistry Adviser, CLEAPSS
Email: bob.worley@cleapss.org.uk
www.microchemuk.weebly.com

IT'S ALL ROUND THE WORLD

http://www.radmaste.org.za/index.htm


RADMASTE CENTRE
THE RADMASTE CENTRE
RADMASTE SOLVES REAL WORLD PROBLEMS IN MATHEMATICS, SCIENCE AND TECHNOLOGY EDUCATION


MicrEcol – Microscale experiments with disposable materials

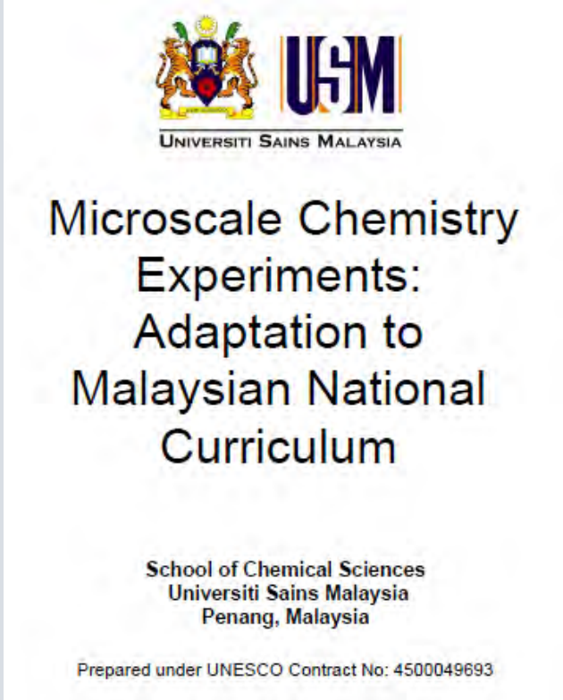
http://micrecol.de/


Microscale Gas Chemistry
Bruce Mattson, Ph.D., Department of Chemistry
Creighton University, Omaha Nebraska, USA

Why Microscale Gas Chemistry?

- **It's fun and easy!** Easy to learn how. Gases ready in 5 minutes!
- **Great labs! Great demos!** Students enjoy making gases.
- **It's visual!** Best way to 'see' a gas is to watch it being produced.
- It's microscale in terms of quantities, but large enough to see - 60 mL.
- **It's inexpensive.** A syringe of CO2 costs less than 1 cent to produce.
- **It's green** - little or no chemical wastes.

http://mattson.creighton.edu/Microscale_Gas_Chemistry.html


UNIVERSITI SAINS MALAYSIA
Microscale Chemistry Experiments: Adaptation to Malaysian National Curriculum

School of Chemical Sciences
Universiti Sains Malaysia
Penang, Malaysia

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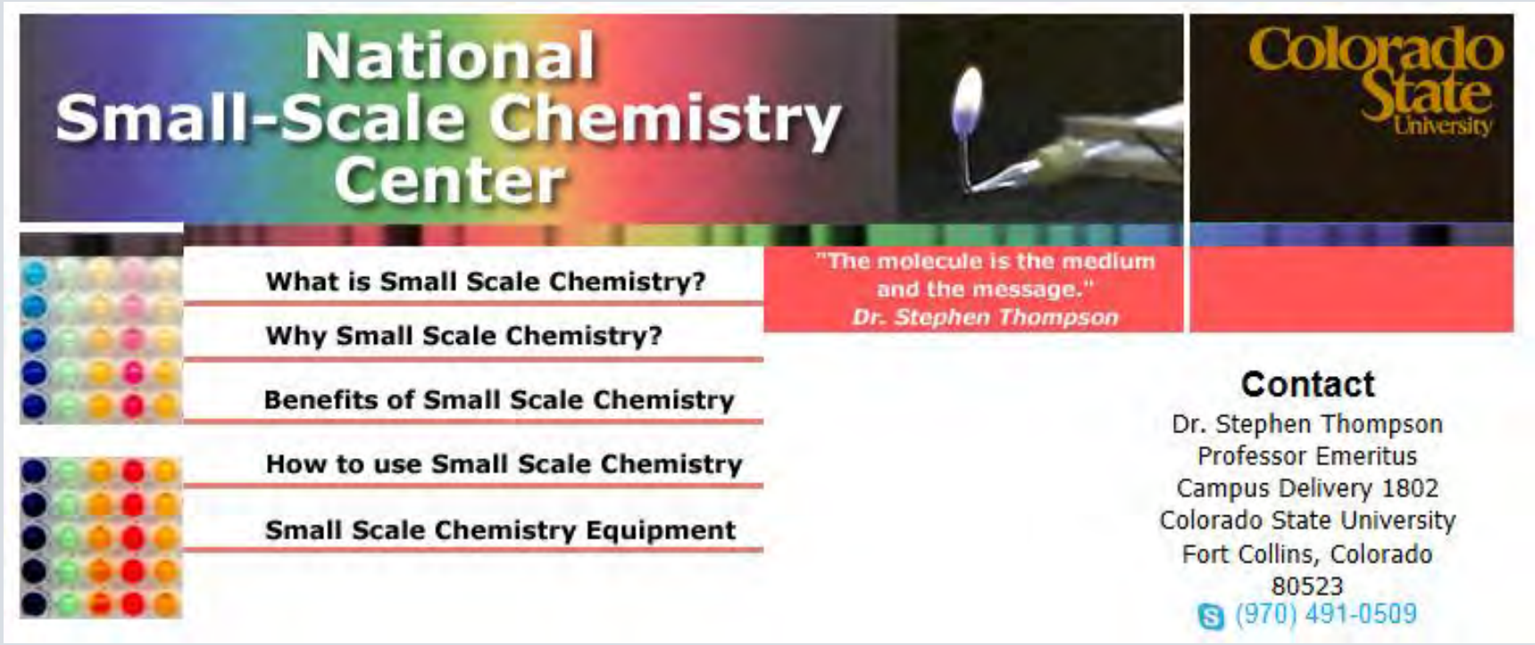
http://www.unesco.org/new/en/natural-sciences/special-themes/science-education/basic-sciences/microscience/


National Small-Scale Chemistry Center
Colorado State University
What is Small Scale Chemistry?
Why Small Scale Chemistry?
Benefits of Small Scale Chemistry
How to use Small Scale Chemistry
Small Scale Chemistry Equipment
"The molecule is the medium and the message."
Dr. Stephen Thompson
Contact
Dr. Stephen Thompson
Professor Emeritus
Campus Delivery 1802
Colorado State University
Fort Collins, Colorado
80523
(970) 491-0509

http://www.smallscalechemistry.colostate.edu/

DESIGNING NEW EQUIPMENT

Microscale distillation with a heated copper coil. Extraction of orange oils is shown on the right.

BALANCES

Insert in an online search engine "Pocket Digital Scale Mini Jewellery"
Cost from £5 to £20

Capacity 100g, reading to 0.01g; Balances even reading to 0.001g available but with lower capacity. On the downside, they are not as robust as school balances and need to be counted back in at the end of an activity.

CROWN BOTTLE TOPS

These are the metal caps found on soda and beer bottles. Try not to distort the teeth too much when removing them from the bottle. They comfortably fit a small pipe clay triangle.

Made of steel with a plastic insert which has to be burned out in the fume cupboard first. Insert small nut and bolt for holding with tongs or pliers.

DROPPING BOTTLES

One supplier is **http://tinyurl.com/ampulla-dropper** and there are others.
Cost about £25 for 100

Using dropping bottle negates the need for pipettes, and reduces cross contamination.

ELECTRODES

These robust yet flexible carbon-fibre electrodes, with a diameter 2mm are obtained from online kite shops and cost about £5 a metre. See **http://tinyurl.com/q4l2e33**.

Unfolded metal paper clips can be used as well

SPIRIT BURNER

These are based on small jam jars (< 50cm^3) which you can obtain online, or from with jam, etc. from shops. You will need to drill a hole to insert the glass tube. Remember to drill a small escape hole as well. The wick is string. The fuel is methylated spirit. More details can obtained from CLEAPSS

PASTEUR PIPETTES

Broken ones from the biology dept are useful. They can be sealed with a flame from a spirit or Bunsen burner, and used as small disposable test tubes.

They are also used for delivery tubes and combustion tubes.

COMBO AND WELL PLATES

Available from most suppliers. Used in place of test tubes or beakers.

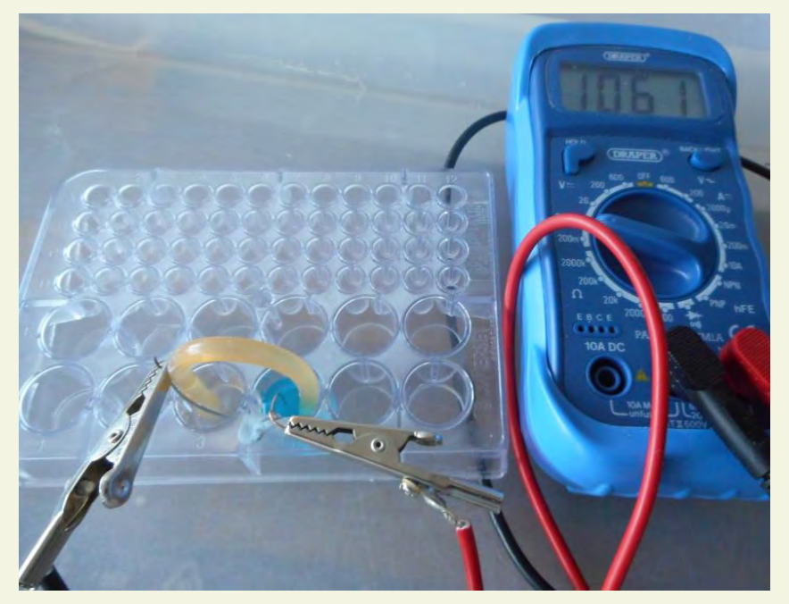
PLASTIC PIPETTES

Used for transferring liquids. 3 ml size delivers 20 drops to the ml. Those used in titrating deliver 50 drops to the ml.
Go to **http://tinyurl.com/q3p4osr**

There are lots of creative uses for the pipette. They can be converted into spatulas, funnels, etc.

SILICONE TUBING

Much easier to use than natural rubber. Inserting small diameter in larger diameter tubing allows objects to be connected together.


Flexible salt bridge

SYRINGES, CAPS & TAPS

Used to collect and store gases and deliver precise quantities of liquid.

Stored hydrogen in a syringe for many days using a cap. Go to http://tinyurl.com/nfkxnl3, Product code: 7015LLPK

Usefulfor adding and removing gases from syringes. See **http://tinyurl.com/q3v88p4**

CORIFLUTE AND SUPPORT

Corriflute

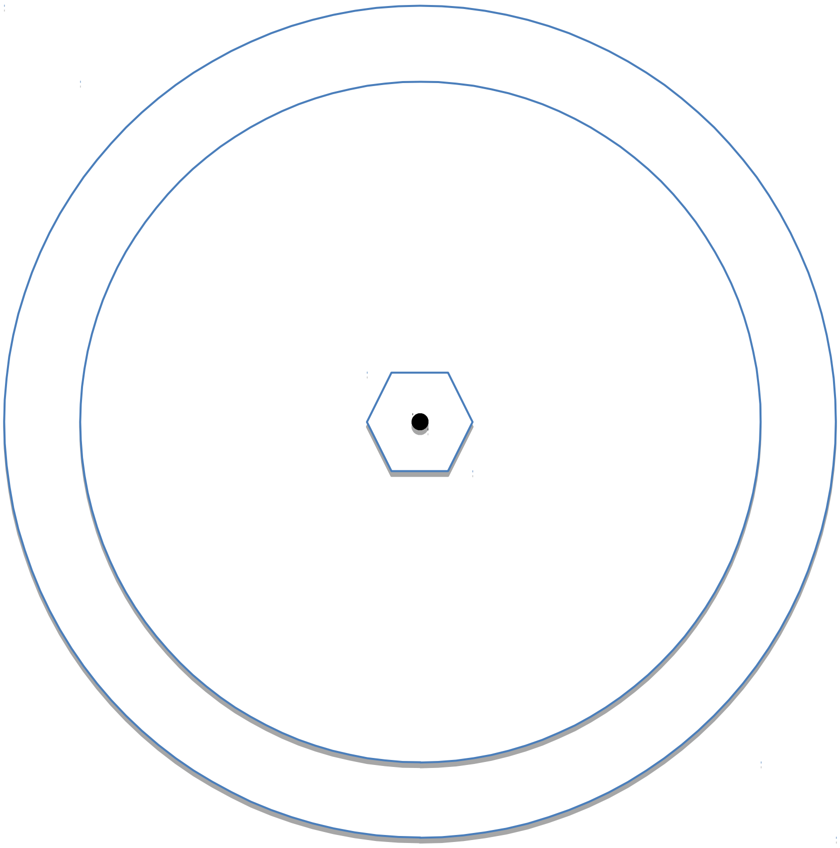
Aluminium sheet

Meccano

Chromatography of felt tip pens

Method 1 (a KS3 investigation)

- Place 9 or 11cm filter paper over the relevant circle below.
- Press hard while you put a colour on each corner of the small hexagon in the centre of the circle.
- Put a small dot of the felt tip pen at each corner of the hexagon. Write down the order you do this
- Now put a pencil dot over the colour (this will be a reference mark).
- With metal scissors or forceps just pierce through the solid dot.
- With the scissors cut a cotton bud off the top. (They can shoot all over the place so do this in a large beaker or box; they may be cut for you)
- Careful push the small amount of stem through the paper so that the cotton sits proud of the paper.
- Fill at 5 or 9cm Petri dish about ¾ full of water.
- Lower the paper with the cotton bud onto into the dish and the water will rise up the cotton wool and spread out along the paper resulting chromatography.

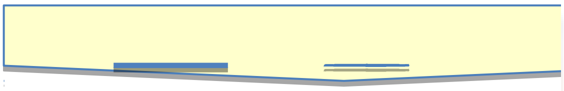


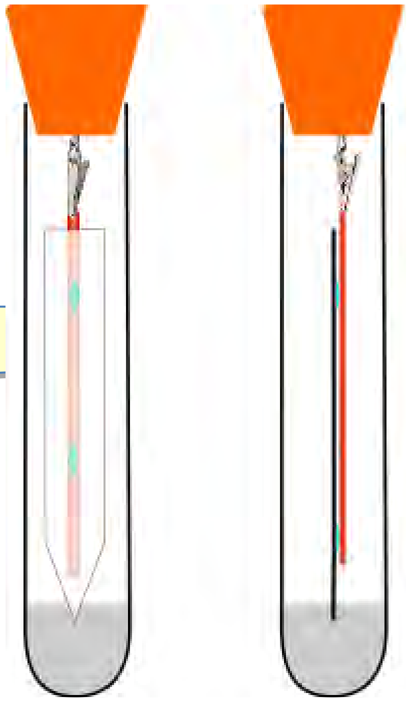
Extension

1. Investigate altering the brand of paper
2. Compare the same colour in different makes of pens
3. Use different solution other than water such as 0.1M ethanoic acid, 0.1M sodium carbonate,0.1M sodium chloride.

Method 2 (Progressing to KS4)

- Cut strips of chromatography paper or any absorbent paper into 90 x 10mm lengths
- Cut a wooden splint to about 8cm long
- Now cut end into a point.
- Press the paper flat on a clean dry bench
- Place a **TINY** spot of the felt tip ink in the centre of the paper and a pencil mark alongside it.
- In pencil write the make of pen, colour and solvent being used at the top of the paper.
- Attach two tiny blobs of Blu-Tac to the wooden splint with the splint rising above the paper so it can be inserted into the crocodile clip. Attach the splint to the crocodile clip.
- Place water in the boiling tube to where you think that point of the paper will enter the water.
- Insert a crocodile clip into a rubber bung with a hole and clip the other of the paper to this.
- Lower the point4ed end so that the point enters the water and you can place the bung lightly on the boiling tube.
- When the solvent front is more than ¾ up the paper, remove it and allow it to dry.





Extension

Paper chromatography is poor. You do not obtain the perfect spots presented in text books. To do that you need Thin Layer Chromatography, which at KS4 level is expensive. But it can be extended to Biro Inks.

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Microscale preparation of copper(II) sulfate(VI)-5- water crystals

Outline Method and Control Measures

Wear eye protection.

Make sure the hot sand trays are on (care required). Dissecting needles wil be sharp.

Note that method B for crystlliazation requirea watch glasses that cover a 100 ml beaker.

The Reaction

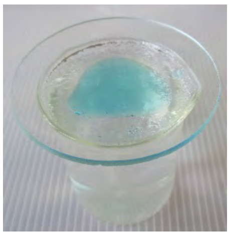
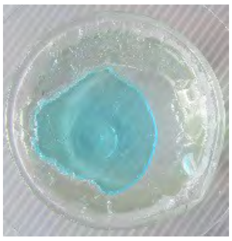
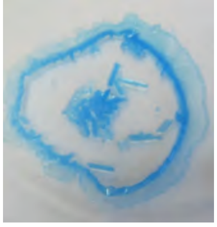
Method 1	Method 2
• Take the plunger out of a 2 ml syringe. • Poke a piece of cotton wool down the barrel and into the tip. This will be the filter. A dissecting needle or nichrome wire is good for this. Make sure the wool is half way down the spout. • Measure out between 0.12 and 0.16g of copper(II) oxide. Put this into the barrel. • Place a cap on the syringe and add 1 cm^3 of 1.4M sulfuric(VI) acid with a plastic pipette. • Fill a 100 ml beaker with boiling water from a kettle and place the syringe in the hot water (Fig 1). • Ensure the mixing by agitating the syringe a few times .After a few minutes the reaction is complete. • Have a suitable watch glass ready. With a pen make an identifying mark. • Hold the syringe above the watch glass. Remove the cap. Insert the plunger gently into the top. Hold the plunger by the stem (it is not a water pistol!), gently push the barrel down so that the liquid is forced through the cotton wool onto the watch glass.	• Measure out between 0.12 and 0.16g of copper(II) oxide. Put this into a glass vial. • Add 1 cm^3 of 1.4M sulfuric(VI) acid with a plastic pipette. • Place this on the sand tray and witness the reaction. • Poke a piece of cotton Into the tip of the syringe. This will be the filter. A dissecting needle or nichrome wire is good for this. Make sure a little wool sticks out. • Place the vial on a edge of a tile of pad and suck up the hot blue liquid into the barrel of the syringe, leaving the black solid behind. • Have suitable watch glass ready. With a pen make an identifying mark • Hold the syringe above a watch glass. Use forceps to remove the cotton wool and let the liquid

Crystallization

Method A	Method A
• Use forceps to move the watch glass to the hot sand bath. • Once you see solids forming around the edge (Fig 3), remove the watch glass to the bench and in about 10 minutes crystals will be appearing as it cools down and the water evaporates (Fig 4).	• Refill the 100ml beaker up to the top with boiling water and carefully put the watch glass on top (Fig 2) • Once you see solids forming around the edge (Fig 3), remove the watch glass to the bench and in about 10 minutes crystals will be appearing as it cools down and the water evaporates (Fig 4).

OR

The watch glass could just be left overnight to form larger crystals.

			
Fig 1	Fig 2	Fig 3	Fig 3

Why should we do this

This experiment is carried out by every school in the UK. CLEAPSS have received reports of several incidents of scalds and inhalation of toxic and corrosive gasses such as sulfur dioxide and trioxide. The latter is caused by the overheating of copper sulfate solution. One text book forgot that the reactions needs heat to occur in the time span of a lesson. This resulted in students heating sulfuric acid!

But the reaction does not need Bunsen burner temperatures, hot water from a kettle does is suitable.

Students add so much copper (II) oxide that filtering is slow as the paper becomes blocked.

One of the aims of this experiment is to complete the whole operation in one lesson.

This is not the method in the text book

No but that method can be demonstrated. Students can compare the methods.

There is another objection to book methods; the evaporation procedure normally required putting a porcelain basin on a steam bath. This can take a very long time to work and boredom hits the students.

Some books suggest boiling the copper sulfate solution on a tripod and gauze. Porcelain basins are liable to crack under heat stress and students heat to dryness and decompose the copper sulfate.

See also https://www.youtube.com/watch?v=L1mI4IHQJsc

https://www.youtube.com/watch?v=PTa8tkJ8rv0

PP027 - Making copper sulfate crystals (this is on a larger scale but still not the method in the book!)

Micro Distillation of Copper(II) chloride solution

Copper(II) sulfate could be used as well

The coloured liquid, such as a copper(II) salt is distilled to produce a colourless solution which gives negative tests for copper(II) ions, anions, and exhibits low conductivity of electricity because there are very few ions present.

Procedure

Distillation

- Wear eye protection.
- Place 2cm^3 of 0.1M copper(II) chloride or sulfate solution in a small Bijoux bottle.
- Add 2 to 4 anti-bumping granules.
- Insert the bottle into the CLEAPSS electrical heating collar.
- Insert the delivery tube so that it leads into a small vial.
- Connect the heater to a low voltage DC supply. The supply should be limited to a 4 to 4.5V supply.
- After 3 to 4 minutes, the liquid that should be colourless should drip into the vial. Collect about 0.5cm^3 of liquid.

Testing the distillate

Insert this sheet into polythene or or polypropylene transparent folder

Place 2 drops of the 0.1M copper(II) salt in each of the circles on the plastic folder.

Add 1 drop of 0.4M sodium hydroxide solution	Add 1 drop of 0.05M silver nitrate solution (chloride) or 0.1M barium chloride (sulfate)	Test the salt for conductivity using a CLEAPSS conductivity indicator
○	●	○

Place 2 drops of the distillate in each of the circles

Add 1 drop of 0.4M sodium hydroxide solution	Add 1 drop of 0.05M silver nitrate solution (chloride) or 0.1M barium chloride (sulfate)	Test the salt for conductivity using a CLEAPSS conductivity indicator
○	●	○

Micro Distillation of aqueous ethanol

- Wear eye protection.
- Place 2cm^3 of 20% ethanol solution in a small Bijoux bottle.
- Add 2 to 4 anti-bumping granules.
- Insert the bottle into the CLEAPSS electrical heating collar.
- Insert the delivery tube so that it leads into a small vial.
- Connect the heater to a low voltage DC supply. The supply should be limited to a 4 to 4.5V supply.
- After 3 to 4 minutes, the liquid that should be colourless should drip into the vial. Collect about 0.2cm^3 of liquid.

Testing the distillate

- Use 2 crown bottle tops with the plastic inserts burnt out as a crucible.
- Place them on a heat proof mat.
- Add a few grains of salt (this is so the pale blue flame of ethanol can be seen)
- Place about 0.2cm^3 of 20% ethanol in on top and the distillate in another. Apply a lighted splint to them to see if the liquid catches fire.

Micro Distillation of orange peel

- Wear eye protection.
- Place orange peel in a mortar with a little water and crush it with the pestle so it can be sucked up with a pipette
- Place 2cm^3 paste in a small Bijoux bottle.
- Add 2 to 4 anti-bumping granules.
- Insert the bottle into the CLEAPSS electrical heating collar.
- Insert the delivery tube so that it leads into a small vial.
- Connect the heater to a low voltage DC supply. The supply should be limited to a 4 to 4.5V supply.
- After 3 to 4 minutes, the liquid that should be colourless should drip into the vial. Collect about 0.5cm^3 of liquid.

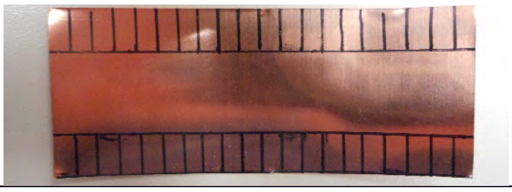
Testing the distillate

- Smell the distillate
- Test a little distillate with one drop of 0.002M acidified potassium manganate(VII) solution.
- Test a little distillate with one drop of 0.002M bromine water.

The Still

Based on an idea from Chris Lloyd of SSERC

More detailed instructions will be posted about this in due course.

A 10 x 4cm piece of copper foil is laid flat as shown in the photograph on the right. The horizontal lines are drawn 1 cm from each edge. Vertical lines are drawn in 0.5cm intervals.	
Cuts are made with heavy duty scissors down the vertical lines. The foil is wrapped loosely around a 7 ml Bijoux Universal Bottle and the bottom flaps are turned under the base of the bottle to hold it in place (two flaps can be left and fold up in order to keep the wire coil in place). 1 metre of 0.45mm (26SWG) enamelled (insulated) copper wire is then wrapped around the copper foil leaving about 8cm of wire free at either end. The upper flaps and two lower flaps are turned over to keeps the wire in place. The ends of the wire are burnt with a flame from a match to remove the enamel insulation and allow contact with a DC source. The DC source should be set to below 5V as higher currents may burn the enamel and cause shorting of the wire.	  
The equipment can be wrapped in mineral and placed in a small jam jar with the loose wire ends showing.	

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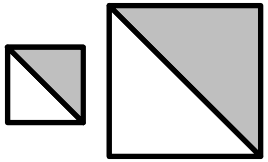
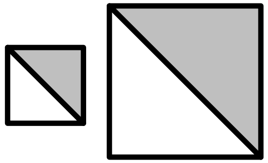
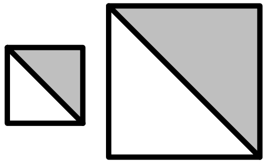
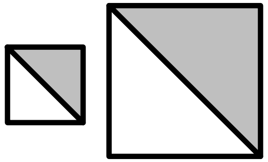
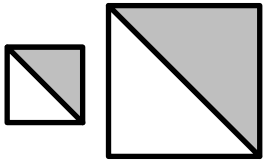
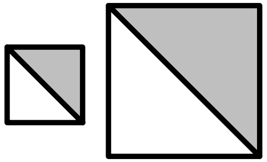
WEAR EYE PROTECTION

The Identification of metal ions (cations)

Place the paper in the plastic envelope

1 Add 2 drops of the relevant metal salt solution to each of the the squares below. For the iron(II) sulfate just place 1 or 2 crystals on each square ant then add 2 drops of pure water.
2 Add 1 drop of 0.4M sodium hydroxide solution to the squares . Stir mixture with a with wooden splint and then cut off the end.
3 Now add 5 more drops of the 0.4M sodium hydroxide solutin to the LARGER Sqares only. Stir mixture with a with wooden splint and then cut off the end.

0.1M aluminum potassium sulfate sol	0.1M calcium chloride	0.1M copper(II) sulfate(VI) sol	0.1M iron(III)nitrate sol	1 or 2 crystals of iron(II) sulfate(VI)into each square with plus 2 drops of water	0.1M magnesium sulfate(VI) sol
					

WEAR EYE PROTECTION

The Identification of radical ions (anions)

1 Add 2 drops of the relevant solution to each of the the squares below.
2 Add 1 drop of universal indicator solution.

0.1M potassium or sodium chloride	0.1M potassium or sodium bromide	0.1M potassium or sodium iodide	0.1M potassium or sodium sulfate	0.1M potassium or sodium carbonate	0.1M potassium or sodium nitrate
◩	◩	◩	◩	◩	◩

1 Add 2 drops of the relevant solution to each of the the squares below.
2 Add 1 drop of 0.5M nitric acid and 1 drop of 0.05M silver nitrate.Stir mixture with a with wooden splint and then cut off the end.

0.1M potassium or sodium chloride	0.1M potassium or sodium bromide	0.1M potassium or sodium iodide	0.1M potassium or sodium sulfate	0.1M potassium or sodium carbonate	0.1M potassium or sodium nitrate
◩	◩	◩	◩	◩	◩

1 Add 2 drops of the relevant solution to each of the the squares below.
2 Add 1 drop of 0.5M hydrochoric acid and 1 drop of 0.1M barium choride or nitrate .Stir mixture with a with wooden splint and then cut off the end.

0.1M potassium or sodium chloride	0.1M potassium or sodium bromide	0.1M potassium or sodium iodide	0.1M potassium or sodium sulfate	0.1M potassium or sodium carbonate	0.1M potassium or sodium nitrate
◩	◩	◩	◩	◩	◩

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WEAR EYE PROTECTION

Confirming the Identification of carbonates and nitrates

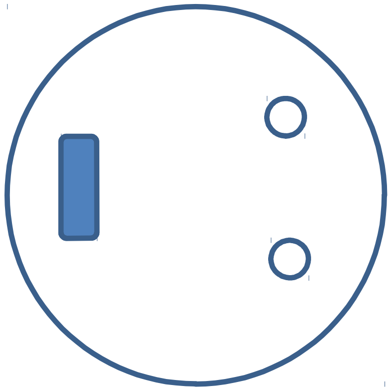
Carbonate

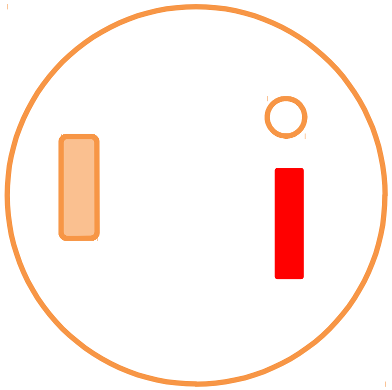
1. Place the Petri dish on the on the blue circle below.
2. Place about 0.1g of the suspected solid carbonate into a blister pack and place this in the dish were the blue shape is positioned.
3. Into the little circles place 2 drops of freshly made calcium hydroxide solution (lime water) and 0.01M sodium hydroxide with one drop of universal indicator to the other.
4. Now add about 0.5ml of 2M hydrochloric acid in the blister pack and immediately put the cover on the dish

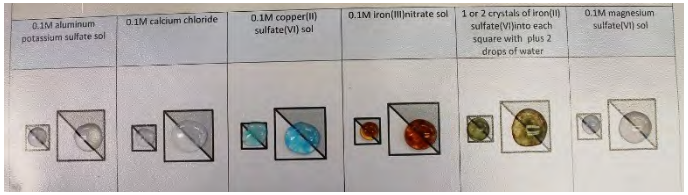
.

Nitrate

1. Place the Petri dish on the on the orange circle below.
2. Place about 0.1g of the suspected solid nitrate into a blister pack and place this in the dish were the blue shape is positioned.
3. Into the little circles place 1 drop of 0.01M hydrochloric acid followed by 1 drop of Universal Indicator.
4. Add a piece of red litmus paper moistened with distilled water.
5. Into the blister pack add a piece of aluminum foil and 0.5 ml of 0.4M sodium nitrate solution. It may take a few minutes for the reaction to take place.



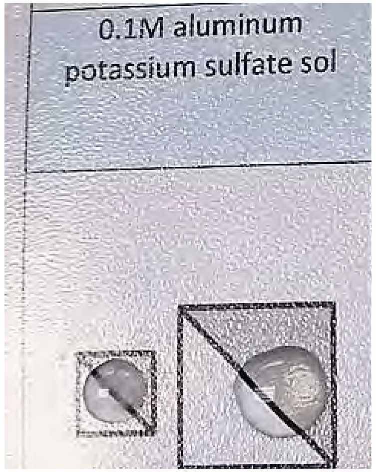




Notes

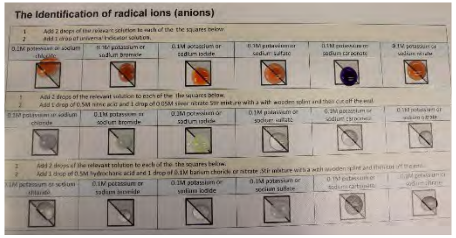
Method

1. The squares are designed so that you can see the faint white precipitates.
2. The folders used are from office supplies and made of polypropylene
3. The paper instructions are inserted into the plastic folder.
4. Dropping bottles or plastic pipettes can be used for the addition.
5. Using a camera, a permanent record can be taken.



Disposal

Wipe the plastic with a paper towel and dispose of the towel in the waste. Very little material is used. If still concerned place the paper towels in 1M hydrochloric acid tio dissolve the hydroxides.

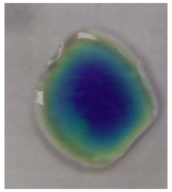


Metal cations

1. There are 2 squares for the reaction so that students can compare the reactions when excess sodium hydroxide is added. Aluminum, zinc and lead hydroxides dissolve in excess sodium hydroxide. If aluminum and zinc are both in the syllabus then you have to do a similar procedure with 2M ammonia (freshly prepared).
2. Copper is also amphoteric with a dark blue solution forming. This can decompose into black copper oxide in time.
3. It is better to use solid iron(II) sulfate and add water as it is often made up in acid to reduce oxidation but it requires more alkali to form the hydroxide. You will also notice the air oxidation of green iron(II) hydroxide to the brown iron(III) hydroxide. Iron(III) nitrate is much easier to prepare as the an example of iron(III) salt than the chlorides as no acid is required.

Anions

The tests for carbonate and nitrate are useful extensions using a diffusing gas in a petri dish approach. Look for halos on the indicators. Such as carbon dioxide on the indicator

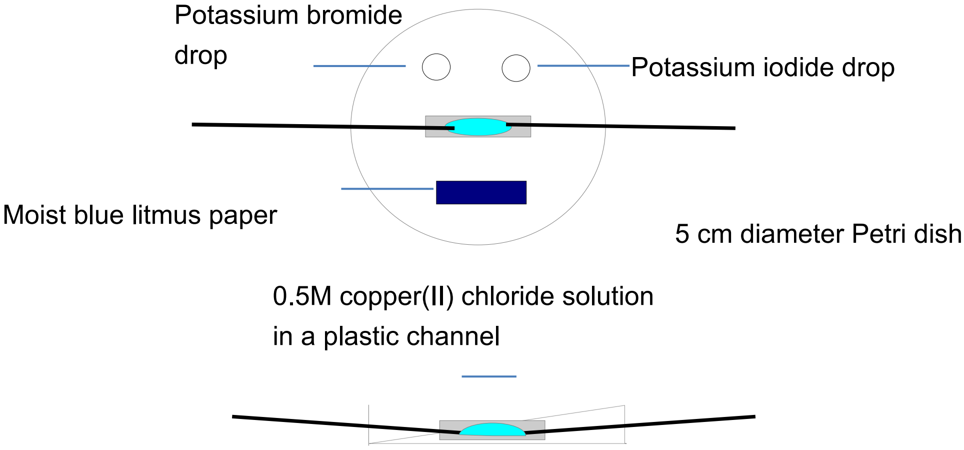


Micro-electrolysis of copper(II) chloride solution

Procedure

Wear eye protection

1. Place the following in the Petri dish (see diagram below) in the following order:
   (i) **1-2 drops** of potassium bromide solution (~ 0.5 M – 2 M);
   (ii) **1-2 drops** of potassium iodide solution (~ 0.1 M – 0.5 M);
   (iii) a piece of *damp* blue litmus paper;
   (iv) a few drops of 0.5 M copper(II) chloride solution … until the 'merged' drop just touches both electrodes.

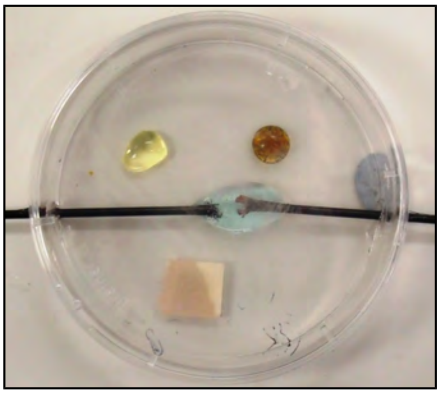


2. Place the lid on the Petri dish and then connect the electrodes to a DC source (~ 6
3. Switch on and observe what happens: (i) at the electrodes, (ii) to the test solutions & indicator.
4. Look carefully at the electrode regions using the digital microscope.

Warning: please disconnect the battery as soon as you have completed your observations.

Note: To avoid inhaling chlorine gas (*which could trigger breathing difficulties in those who are susceptible*), do **not** remove the Petri dish cover **and** at the same time lean close to the dish.
The chlorine can be quickly diffused away with a waft of the hand. The chlorine levels are, on average, well below the workplace exposure levels (see note on reverse).

Results



Notes

During the electrolysis:

- copper, Cu(s), is produced at the cathode (see picture on page 1).
- chlorine, $Cl_2(g)$ formed at the anode reacts with the salt solutions to form bromine, Br_2, and iodine, I_2 (in solution).
- moist blue litmus paper turns red due to formation of hydrochloric acid, HCl(aq), and chloric(I) acid, HClO(aq). The latter then oxidises the litmus dye to give colourless products.
- The results are even more effective if the procedure is viewed via a visualizer/digital microscope.

Equipment and safety notes

- The electrodes are 1mm carbon fibre rods available from suppliers of kite materials.
- In this procedure, 4 drops (i.e. 0.2 cm^3) of 0.5 M copper(II) chloride solution are used. The maximum amount of chlorine that could be produced is ~ 7.1 mg (i.e. ~ 2.4 cm^3 at room temperature).

  If 15 sets of equipment were all working at the same time, the Workplace Exposure Limit (WEL) of 1.5 mg m^{-3} (averaged over the whole room) would not be reached. However, it *would* be exceeded in localised areas, i.e., just above the Petri dish when the lid is removed. Hence, great care must be taken to avoid inhaling the chlorine gas.

Possible extensions

Find out what happens with other salt solutions.

Potassium bromide	Place 1 drop of 2M potassium bromide in a Petri dish and add 9 drops of water. Place this mixture between the electrodes. Based on the experiment with copper(II) chloride solution, design some additional investigations.
Iron(II) sulfate(VI)	Place iron(II) sulfate(VI) solution between the electrodes. If iron is produced at an electrode, it ought to be *magnetic*. Is it?
Zinc sulfate(VI)	Place 0.1M zinc sulfate(VI) solution between the electrodes. Follow the electrolysis using a digital microscope. Further dilution will slow down the rate of electrolysis but will this make the appearance of any metal crystals easier to see? Investigate.
Lead nitrate(V)	Place 0.1 M lead nitrate(V) solution between the electrodes and follow the electrolysis using a digital microscope.
Silver nitrate(V)	Place 0.05M silver nitrate(V)solution between the electrodes and follow the electrolysis using a digital microscope.
Sodium sulfate solution	Does carbon dioxide or oxygen come off at the anode. Addition of bromothymol blue, Universal indicator is interesting. A small Hofmann voltameter is available for testing as well
Alter electrodes	Alternative electrodes include copper wire, steel metal paper clips, iron nails and nichrome wire
Electrode distance	Does altering the distance between electrodes make a difference?

Disposal

All the liquids can be washed down the sink into the foul water drain.

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Acidity of vinegar by micro-titration

Procedure

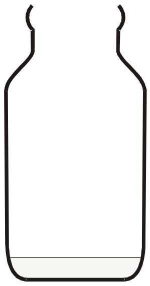
- Wear eye protection.

Part A: Preparing the sample

To enable the endpoint to be more visible, the samples of vinegar can be diluted by 4 in one of two ways:

(i) pipette 25 cm^3 of vinegar into a 100 cm^3 volumetric flask and make up to 100 cm^3 of water, **OR**
(ii) place 25 cm^3 of vinegar into a 100 cm^3 measuring cylinder and make up to 100 cm^3 with water.

Part B: Carrying out the micro-titration



- Place 1 drop of phenolphthalein indicator solution in a glass vial. Weigh the vial (**M1**).
- Now add *about* 1 cm^3 of the diluted vinegar solution and reweigh the vial (**M2**).

M1 =

M2 =

- You now need one of the special thin tipped pipettes ('pastette'). Squeeze the pastette bulb tightly and draw the sodium hydroxide solution (0.2 M) into it.
- Clamp the pastette as shown in **Figure a** (and the picture below right).
- Gently turn the clamp screw to add drops of sodium hydroxide solution to the vial. Agitate the vial between additions. You will see the pink/mauve colour appear more dramatically after a while and then disappear on agitation.

  You must stop the 'titration' when the addition of one drop of alkali results in the pink/mauve colour appearing in the vial but NOT disappearing on agitation.
- Weigh the vial and contents (**M3**).

M3 =

Part C: Calculation

Mass of ethanoic (acetic) acid in 100 cm^3 vinegar is (**M3**-**M2**) x 4.8/ (**M2**-**M1**).
This is the % (w/V) value given on the bottle!

Reasoning behind the calculation

Assume that the densities of all the solutions are the same and are equal to that of water (i.e. 1 g cm^{-3}).
From experimental results: Volume of vinegar solution used is **M2** – **M1** cm^3.
Volume of the 0.2 M sodium hydroxide solution is **M3** – **M2** cm^3.
Nº moles of sodium hydroxide used is (**M3** – **M2**) x 0.2/1000
Sodium hydroxide reacts with ethanoic acid in a 1:1 ratio so the number of moles of ethanoic acid reacted (in the ~1 cm^3 sample of diluted vinegar) must also be equal to (**M3** – **M2**) x 0.2/1000.
Hence (**M2** – **M1**) x acid concentration/1000 = (**M3** – **M2**) x 0.2/1000
Rearrange to give concentration of ethanoic acid (in mol dm^{-3}) = (**M3** – **M2**) x 0.2/ (**M2** – **M1**)
M_r of ethanoic acid is 60 g/mol so the *<u>mass</u>* of acid in **1 dm^3** (1 litre) of diluted vinegar
= (**M3** – **M2**) x 0.2 x 60/ (**M2** – **M1**)
So – the *<u>mass</u>* of acid in **1 dm^3** (1 litre) of shop-bought vinegar
= (**M3** – **M2**) x 0.2 x 60 x 4/ (**M2** – **M1**) which is the same as (**M3** – **M2**) x 48/ (**M2** – **M1**)
Mass of ethanoic acid in **100 cm^3** of vinegar = (**M3** – **M2**) x 4.8/ (**M2** – **M1**)
This is the % (w/V) value given on the bottle!
(KS3/4 pupils could work out the % value by just using the last equation.)

Microtitration: why do it?

Reasons quoted for not pursuing titration

- The equipment is expensive and can be quite easily broken by pupils (Y9 is often quoted).
- School science periods are not given the time to carry out such long practicals.
- Pupils do not have the dexterity and/or patience to carry it out.
- Some newly-trained teachers of science and chemistry are not as comfortable with the procedure as "older" chemists are.
- The arithmetic is perceived to be difficult.
- The concepts of stoichiometry and 'the mole' are difficult.

So why look at the microtitration route

This micro-titration activity can provide a useful, low-cost **introduction** to titration technique and the related calculation work. The technique is very quick and students can carry several titrations in the same time as it takes to carry out one titration with burettes and pipettes.

Micro-titration by counting drops

In this technique, two pipettes of the same make are used. The indicator is placed in the vial. 20 drops of one reagent is added to the vial. This is followed by the other reagent until the indicator just changes colour. The drops of the second reagent are counted.

It is very easy to lose count.

Micro-titration by weighing

Most school science departments possess balances weighing to 2 decimal places (a
balances that read to 3 d.p.). Unfortunately schools could only afford 1 balance per l
to long queues and possibly poor behaviour.

It is now possible to buy digital jewellery balances from sites such as Amazons and c
shops. **They cost less than £10.** The cheapest specialised balance from suppliers i
one might get stolen or broken in a year but the loss is trivial compared to the **bene
efficient lessons.**

The pipettes

Plastic Pasteur pipettes are known as "pastettes". They are used extensively in microbiology laboratories.

One supplier, "Alpha Labs" sells 500 non-sterile, extended fine-tip pastettes (which deliver 50 drops per cm^3), for £17.20, i.e., 3.4p each (LW4233).

Using a pastette as a 'burette': To control the drop-wise addition of a solution, the bulb of the pastette is fixed between the claws of the clamp (**Figure a**). Turning the adjusting screw on the clamp (**Figure b**) allows the delivery of one drop at a time, until the endpoint is reached (**Figure c**). If schools do not have the right-shaped clamp, the arrangement in **Figure d** can be set up with Correflute, nylon ties and a Hoffman clip.

(Figure a)

(Figure b)

(Figure c)

(Figure d)

Micro-titration by weighing; is it accurate?

These balances can be calibrated. CLEAPSS have done this to 100g and the application of a 50g mass shows 50.00g.

The downside is that the tare facility does not last long so **do not tare.**

Making the assumption that all the solution densities are the same and then measuring the mass of the vials and solutions appears to work well – experimental results obtained are very similar to those when standard titration equipment is used.

A burette (class B) tolerance is ±0.05ml. For the balance it is ±0.01g.

For an initial and final reading, the overall fractional uncertainty = $\mp\sqrt{(\Delta x^2+\Delta y^2)}$

So for the burette, the fractional uncertainty = $\pm\sqrt{\Delta 0.05^2+\Delta 0.05^2}$ =±0.07ml which is a lot lower than the maximum possible uncertainty which is ±0.10ml. And for weighing the fractional uncertainty is ± 0.014 g.

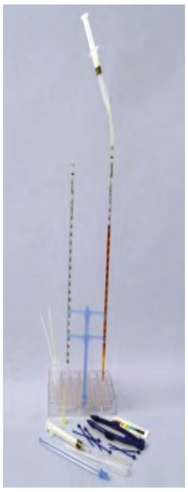
I suspect that volume titrations were the more accurate in the 1850s when these techniques began to be more popular because there were few highly accurate balances available.

Micro-titration by volume

A syringe can be attached to a 1 or 2 ml pipette as shown in the phot on the right..

It takes considerable skill to manipulate the syringe so that only very small volume of reagent are added. (Tolerance is 0.02 ml so the fractional uncertainty is ±0.03ml

Move the syringe by holding the inside of the plunger and not the end. It is not a water pistol!

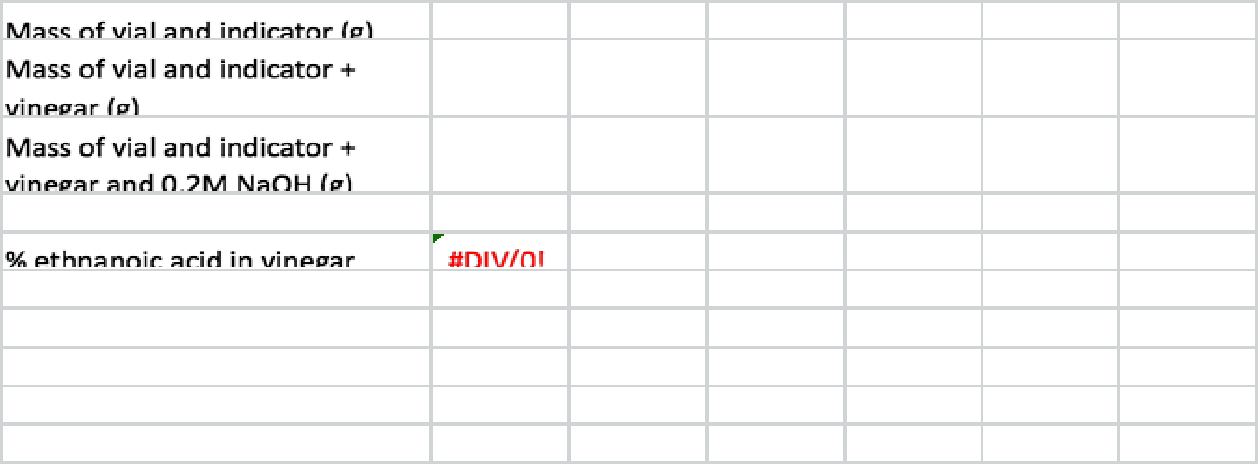


Approach to calculations

The % ethanoic acid in vinegar can be worked out quickly on an excel spreadsheet. The students can then attempt to obtain the same answer using mole calculations

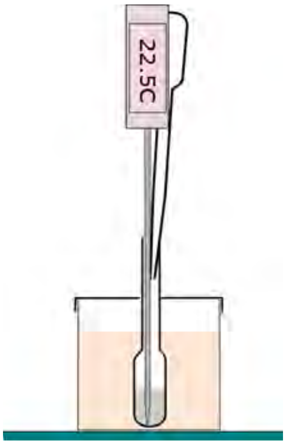
.

The code for the calculation is (the "#DIV/0!") square is "=(B3-B2)*4.8/(B2-B1)".



Mass of vial and indicator (g)						
Mass of vial and indicator + vinegar (g)						
Mass of vial and indicator + vinegar and 0.2M NaOH (g)						
% ethnanoic acid in vinegar	#DIV/0!					

Thermochemistry: Enthalpy of neutralisation



The bulb is cut from the stem at the 2.5 ml mark. This pipette bulb is inserted into a foam or cotton wool support which acts to slow down heat loss. The lid is a 5cm diameter plastic Petri dish lid with a hole melted though.

The beaker is glued to a plastic base to render it more stable.

Very quick method which assumes 1.5ml (1.5g) of each reagent is added

1. Solutions and equipment should be left in the room for at least an hour to allow them to be at the same temperature.
2. Add 1.5 ml of 2M hydrochloric, nitric or 1M sulfuric(VI) acid.
3. Leave the thermometer in the reagent until a steady value is obtained
4. Add 1.5 ml of 2M sodium hydroxide solution
5. Record the highest temperature of the solution with the stem thermometer after stirring gently to ensure mixing.

The expected temperature rise of this system should be 13.7 ^{o}C. The accepted value for the Heaty of neutralization is -57.3 kJmol^{-1} but any school equipment will always provide a lower value because some of the energy is absorbed by the equipment (even if it well insulated), the thermometer and lost to the surrounding atmosphere.

There are many ways of treating the results depending on the ability of the students. The treatment can be continually refined.

Extension 1: Cooling curve correction:

In place of step 5: Record the temperature of the solution every 20 seconds for 5 minutes with mixing.

Extension 2: Using the mass of reagents with cooling correction:

After Step1, 2, and 5, record the mass of the equipment, after adding the first reagent and finally after the temperature measurements have been made, M1, M2 and M3

Extension 3: Using the limiting reagent mass:

The solution with the smaller of the masses added will be the limiting reagent. The amount of water produced in this reaction needs be calculated.

Extension 4: Finding the thermal capacity of the equipment

Leave about 10 ml of water at room temperature and the equipment in the lab for an hour. Find the temperature of this water with the thermometer T_c.

Find the mass of the equipment M_e

Insert 1.5 ml of warm water (about 40 to 50 °C) into the bulb and Find the new mass of the equipment, M1,

Calculate the mass of warm water M_h which is M1-M_e

Insert the thermometer in the warm water and after 3 minutes, record the temperature T_h

Quickly add 1.5ml of the water at room temperature, swirl with the thermometer and record the temperature T_m

Now find the mass of the equipment again M2

Extension 5: Altering the chemicals used:

Use weak acids such as ethanoic acid and weak alkalis such as ammonia and sodium carbonate.

Treating the results

This procedure is quite complicated in the use of mathematics and refinement of results.

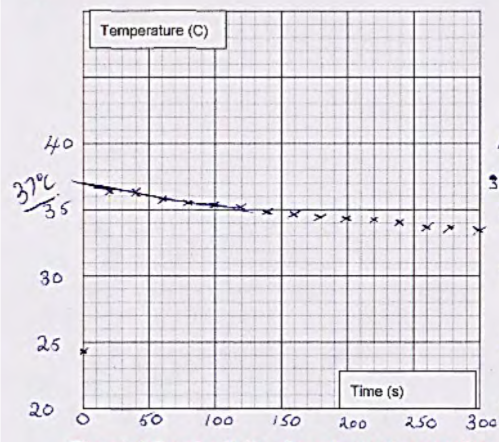
In the reaction of 1.5ml of 2M sodium hydroxide with 1.5ml of 2M nitric acid, the following results were obtained. The amount of water in moles made is 0.003.

Energy evolved per mole of water is 3 x 4.18 x ΔT/0.003 Joules

Enthalpy is -3 x 4.18 x ΔT/3 kJmol^{-1}.

Simplest: Starting temperature was 24.2C Max temperature was 36.3. Temperature rise is 12.1C.
Enthalpy is -50.6 kJmol^{-1}.

Extension 1: Cooling curve correction: See the graph, the highest temperature in now 37.0C. Temperature rise is 12.8C. Enthalpy is -53.5 kJmol^{-1}.



Extension 2: Using the mass of reagents with cooling correction:

With 3.14g of material in the bulb, the
Enthalpy becomes -56.0 kJmol^{-1}

Extension 3: 1.52g of 2M sodium hydroxide solution was reacted with 1.62 of 2M nitric acid, thus the sodium hydroxide solution was the limiting reagent and ie now 0.304 mols of water are formed:

With the cooling correct, the mass of reagents,
the Enthalpy becomes -55.3 kJmol^{-1}

Extension 4: Finding the thermal capacity of the equipment

Leave about 10 ml of water at room temperature and the equipment in the lab for an hour. Find the temperature of this water with the thermometer T_c.

Find the mass of the equipment M_e

Insert 1.5 ml of warm water (about 40 to 50 °C) into the bulb and Find the new mass of the equipment, M1,

Calculate the mass of warm water M_h which is M1-M_e

Insert the thermometer in the warm water and after 3 minutes, record the temperature T_h

Quickly add 1.5ml of the water at room temperature, swirl with the thermometer and record the temperature T_m

Now find the mass of the equipment again M2

Mass of cold water added is M_c is M2-M1

Increase in temperature by the cold water is $T_m - T_c$ (ΔT_c)

Decrease in temperature by the hot water and the equipment is $T_h - T_m$ (ΔT_h)

Thermal capacity of equipment x ΔT_h + (M_h x 4.18 x ΔT_h) = (M_c x 4.18 x ΔT_c)

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The Thiosulfate-Acid Reaction

Why do this?

Many chemical reactions proceed so fast that it is very difficult to measure them. There are, fortunately, a number of slower reactions that can easily be followed in school science laboratories. The reaction between sodium thiosulfate and acid is one such reaction and is mentioned in almost all textbooks.

However, the reaction produces a toxic product, sulfur dioxide, which has caused many schools to stop doing it. In this reduced-scale method, very good results are obtained using only one fifth of the volumes used in traditional methods. The production of sulfur dioxide is reduced by using a ‘stop bath’.

Interestingly, although extensively studied in schools, not a lot is known about this reaction!

Safety

CLEAPSS receives many calls about the thiosulfate/acid reaction.

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + SO_2(g) + S(s)\downarrow + H_2O$$

The main concern is the emission of sulfur dioxide from the thiosulfate/acid reaction causing breathing problems to the pupils when they carry out the procedure and to the technician when they clean the equipment. This is a particular problem when the effect of raised temperatures is studied.

In this reduced-scale method, there are **3 control measures** integral to this procedure, in addition to the usual personal protective equipment (PPE):

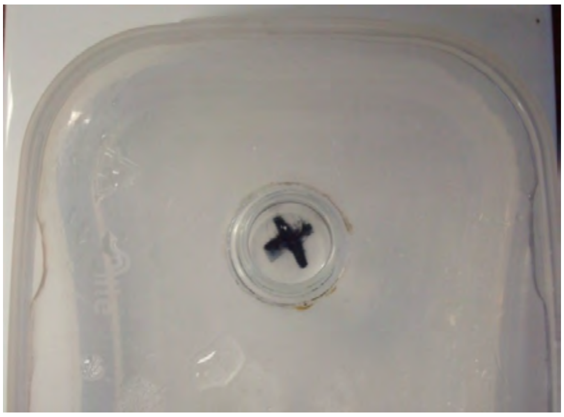
- using smaller volumes,
- using a stated maximum temperature (and minimising heating),
- using a stop bath to neutralise the acid and dissolve sulfur dioxide.

Equipment

The method uses the type of plastic containers typically used for microwaving food. The cross is marked on the base of the container in permanent black ink. The holes in the lid are made by using very hot wide-diameter cork borers or hot 2p coins which have been heated in a Bunsen burner flame (do this in a fume cupboard). The glass vials used hold about 12 to 14 cm ^{3} of liquid. (For example, Timstar sell them for £39.08 for 162 (VI16982), about 24p each.)

Glass vials

The equipment!



Looking over the top!

Investigations

The procedures for two investigations are described.

A: Variation of rate of reaction with concentration of thiosulfate

Wear eye protection.

Make sure you have the sodium carbonate solution with the indicator added to act as a stop bath. Once the colour changes, the carbonate has been used up and you will need to replenish the stop bath.

1. Place about 10 cm^3 of 1M hydrochloric acid (or 0.5M sulfuric(VI) acid) in the 'acid' vial.

2. Place this vial into the correct hole in the plastic container (i.e. the one **without** the cross).

3. Measure 5 cm^3 of 0.1M sodium thiosulfate solution into a 10 cm^3 measuring cylinder.
Add 5 ml of water. Pour the solution into a second vial.
Insert this vial into the correct hole in the plastic container (i.e. the one **with** the cross).

4. With a stopwatch in one hand, use a plastic pipette to add 1 cm^3 of the acid to the thiosulfate solution. Immediately start timing.

5. Look down through the vial from above and record the time for the cross to disappear from view.

6. Now pour the cloudy contents of the vial into the sodium carbonate solution (the 'stop bath').

Repeat the procedure using a different volume of sodium thiosulfate solution and with water added to make a total of 10 ml of solution. Use any value between 3 and 10 ml of sodium thiosulfate solution.

Volume of 0.1M sodium thiosulfate solution (cm^3)	Volume of water (cm^3)	Time (s)	Rate as 1/time (s^{-1})
5	5		
6	4		
7	3		
8	2		
9	1		
10	0		

Plot the time taken or 1/time against volume of sodium thiosulfate (x-axis).

Extension

Does the rate of reaction alter with respect to the hydrogen ion concentration?

We can use 1 cm^3 of 1M sodium thiosulfate solution and vary the concentration of hydrogen ions, H^+ (aq), in a similar way to that described above.

Do not be surprised by the strange results!

B: Variation of rate of reaction with temperature

Wear eye protection.

Make sure you have the sodium carbonate solution with the indicator added to act as a stop bath. Once the colour changes, the carbonate has been used up and you will need to replenish the stop bath.

1. Place about 10 cm^3 of 1M hydrochloric acid (or 0.5M sulfuric(VI) acid) in the 'acid' vial.
2. Place this vial into the correct hole in the plastic container (i.e. the one **without** the cross).
3. Measure 10 cm^3 of 0.05M sodium thiosulfate solution (use a 10 cm^3 measuring cylinder).
   Pour the solution into a second vial.
   Insert this vial into the correct hole in the plastic container (i.e. the one **with** the cross).
4. With a stopwatch in one hand, use a plastic pipette to add 1 cm^3 of the acid to the thiosulfate solution. Immediately start timing.
5. Look down through the vial from above and record the time for the cross to disappear from view.
6. Record the temperature of the reaction mixture.
7. Now pour the cloudy contents of the vial into the sodium carbonate solution (the 'stop bath').
8. Now add water from a very hot water tap (or kettle) to the plastic container.
   The water should be **no hotter than 60 °C**.
9. Measure 10 cm^3 of 0.05M sodium thiosulfate solution into a clean vial.
   Insert this vial into the correct hole in the plastic container (i.e. the one **with** the cross)*.
10. Leave the vial to warm up for 3 minutes*.
11. Repeat **steps 4** to **7** above.
12. Repeat to obtain results for at least 5 different temperatures*.

*The plastic container can be adapted to hold several vials which can each be filled with 10 cm^3 thiosulfate solution (as in **step 3**). As the temperature of the water in the plastic container cools, more readings can be taken. To lower the temperature further, cold water can be added to the container.

The reciprocal of the time in seconds can be used as a measure of the rate of the reaction.

Temperature (°C)	Time (s)	Rate as 1/time (s^{-1})

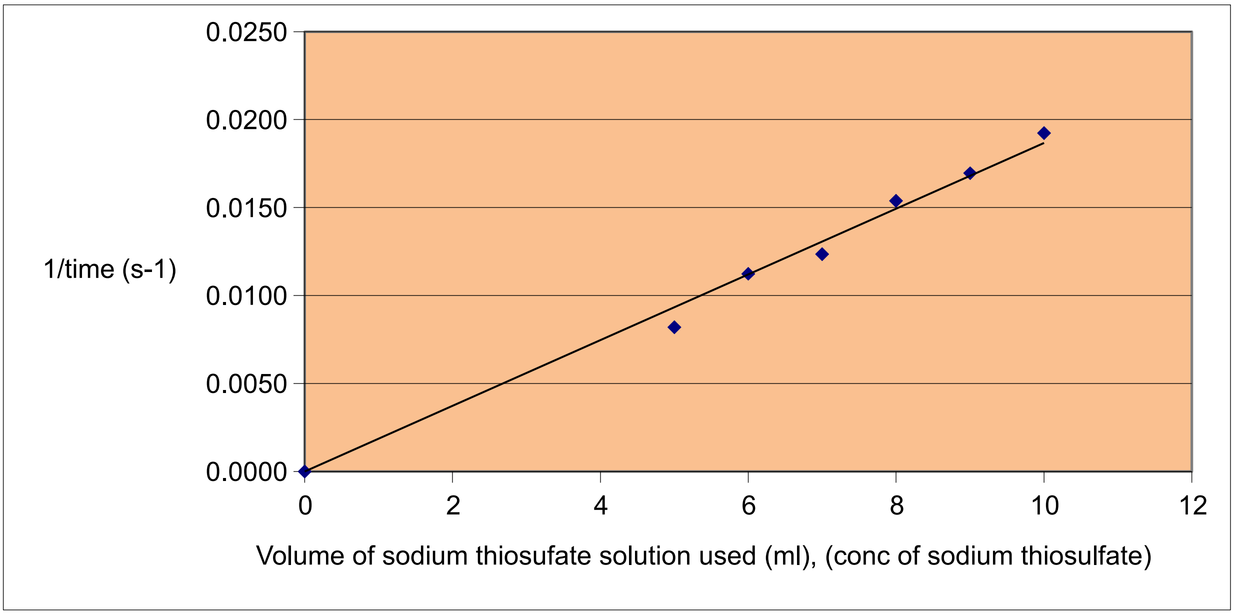
Plot a graph of 1/time against temperature (x-axis).

See also 'Exemplar results' for an extension using the same results.

Exemplar results and extensions

A: Variation of rate of reaction with concentration of thiosulfate

Volume of thiosulfate (cm^3)	Volume of water (cm^3)	Time (s)	1/time (s^{-1})	Temperature (°C)
0	10	0	0.0000	
5	5	122	0.0082	20
6	4	89	0.0112	20
7	3	81	0.0123	20
8	2	65	0.0154	20
9	1	59	0.0169	20
10	0	52	0.0192	20



This shows a direct relationship between the rate of reaction and the concentration of sodium thiosulfate. Although this reaction is often done in school science, it has not been extensively researched.

When the concentration of hydrogen ion is varied, it is clear that the kinetics of the reaction are not at all straightforward. This means that the reaction mechanism is very complex with competing mechanisms and equilibria involved. Think about it! The sulfur atoms are inserted into a chain which then breaks down to give a precipitate of sulfur and sulfur dioxide. This must involve rearrangement reactions!

Many technicians (when clearing up) have stated they can small hydrogen sulfide! *Is* hydrogen sulfide produced?

Another conundrum is "*what percentage of the reaction is completed when the time is taken*?" Is it possible to quench the reaction with sodium carbonate solution and then measure the concentration of sodium thiosulfate left?

Catalysts

There do not appear to be any established catalysts for this reaction. Ammonium molybdate has been mentioned but there is no data on this. Can one be found?

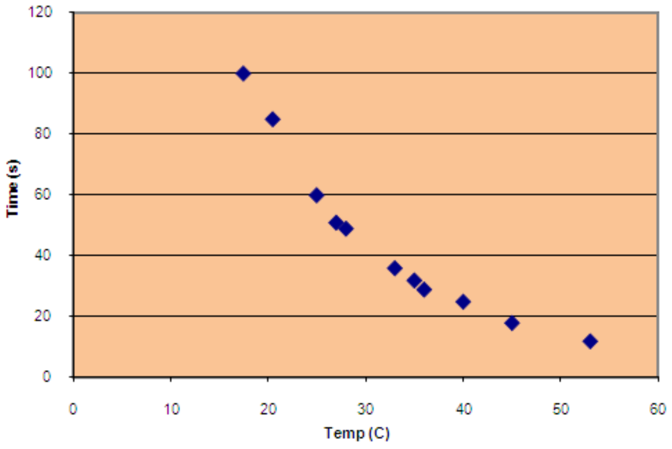
B: Variation of rate of reaction with temperature

Temperature (C)	**Time (s)**	**1/time (s^{-1})**	**Temperature (K)**	**1/T (K^{-1})**	**$\log_e t$**
17.5	100	1.00E-02	290.5	3.44E-03	4.605
20.5	85	1.18E-02	293.5	3.41E-03	4.443
25.0	60	1.67E-02	298.0	3.36E-03	4.094
27.0	51	1.96E-02	300.0	3.33E-03	3.932
28.0	49	2.04E-02	301.0	3.32E-03	3.892
33.0	36	2.78E-02	306.0	3.27E-03	3.584
35.0	32	3.13E-02	308.0	3.25E-03	3.466
36.0	29	3.45E-02	309.0	3.24E-03	3.367
40.0	25	4.00E-02	313.0	3.19E-03	3.219
45.0	18	5.56E-02	318.0	3.14E-03	2.890
53.0	12	8.33E-02	326.0	3.07E-03	2.485

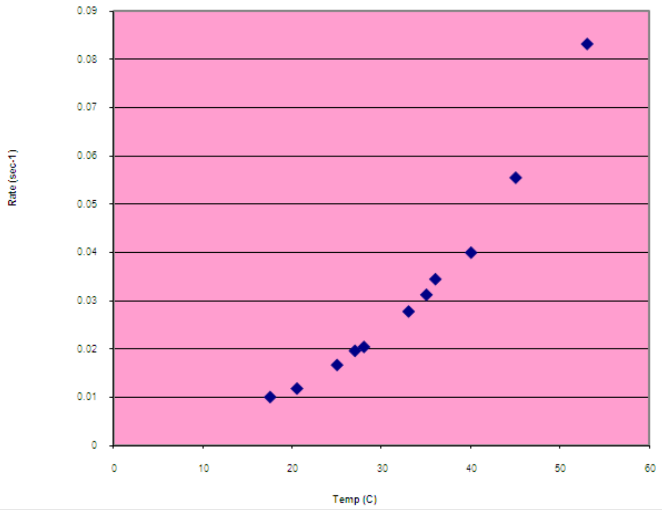
Here are some results taken in the space of 45 minutes!

There are three graphs which can be drawn using these results:

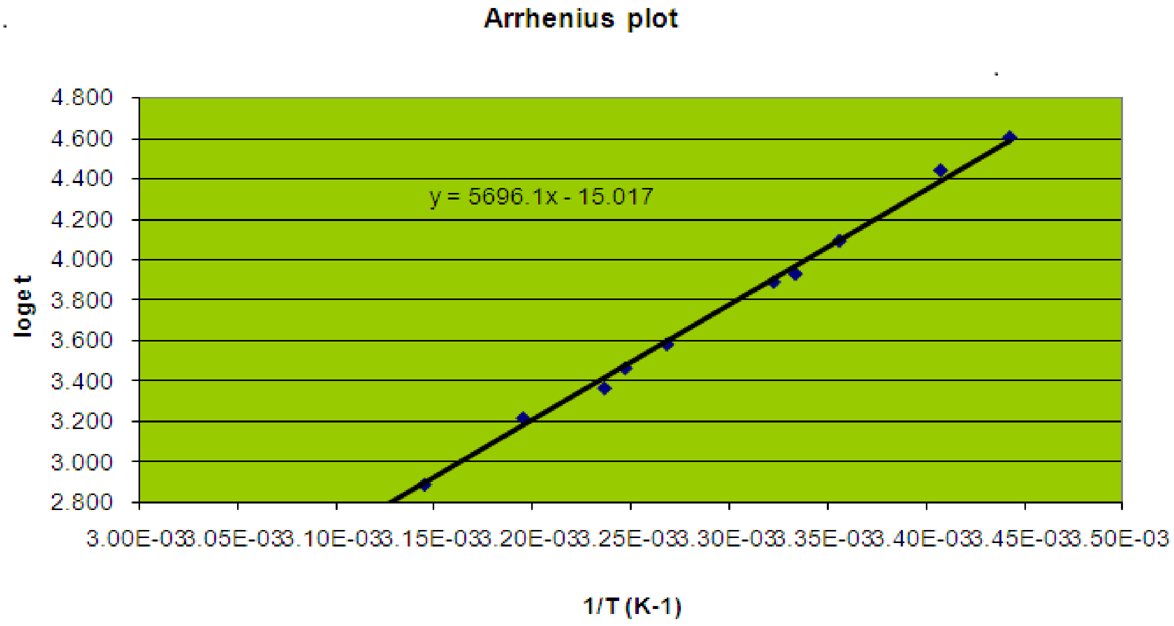
1. Variation of time taken with temperature.

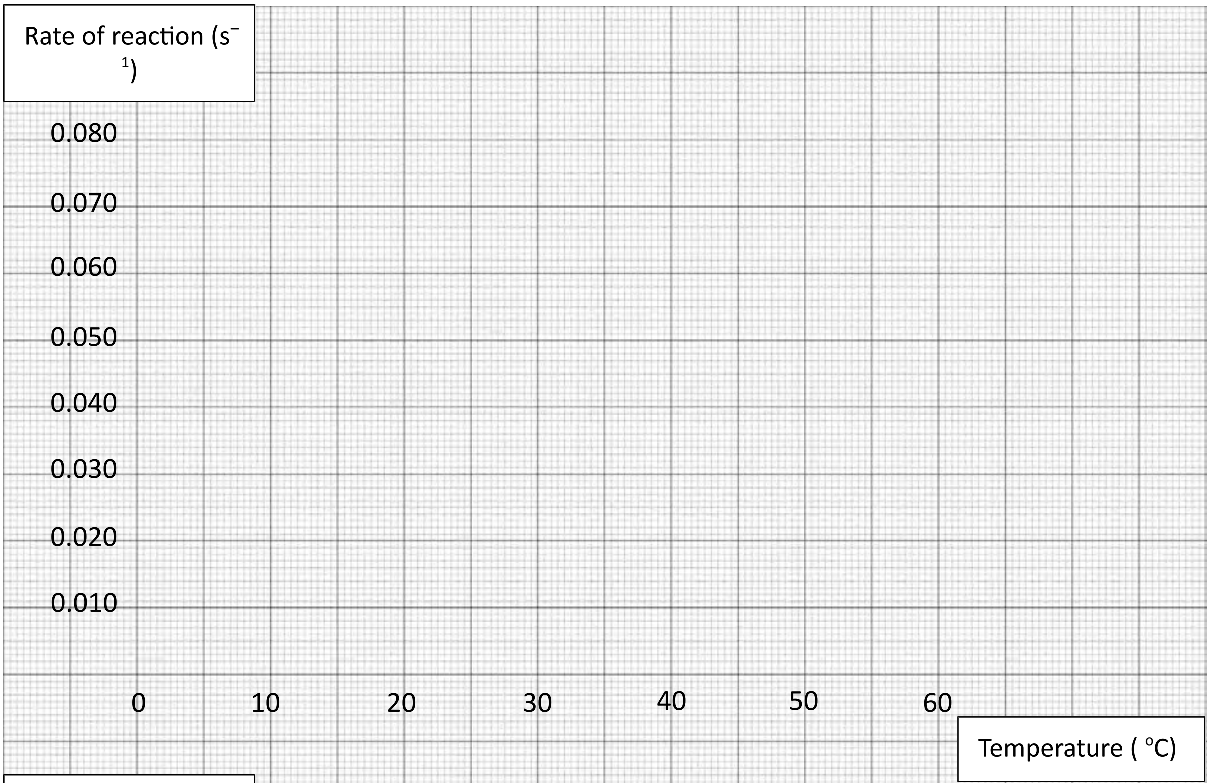


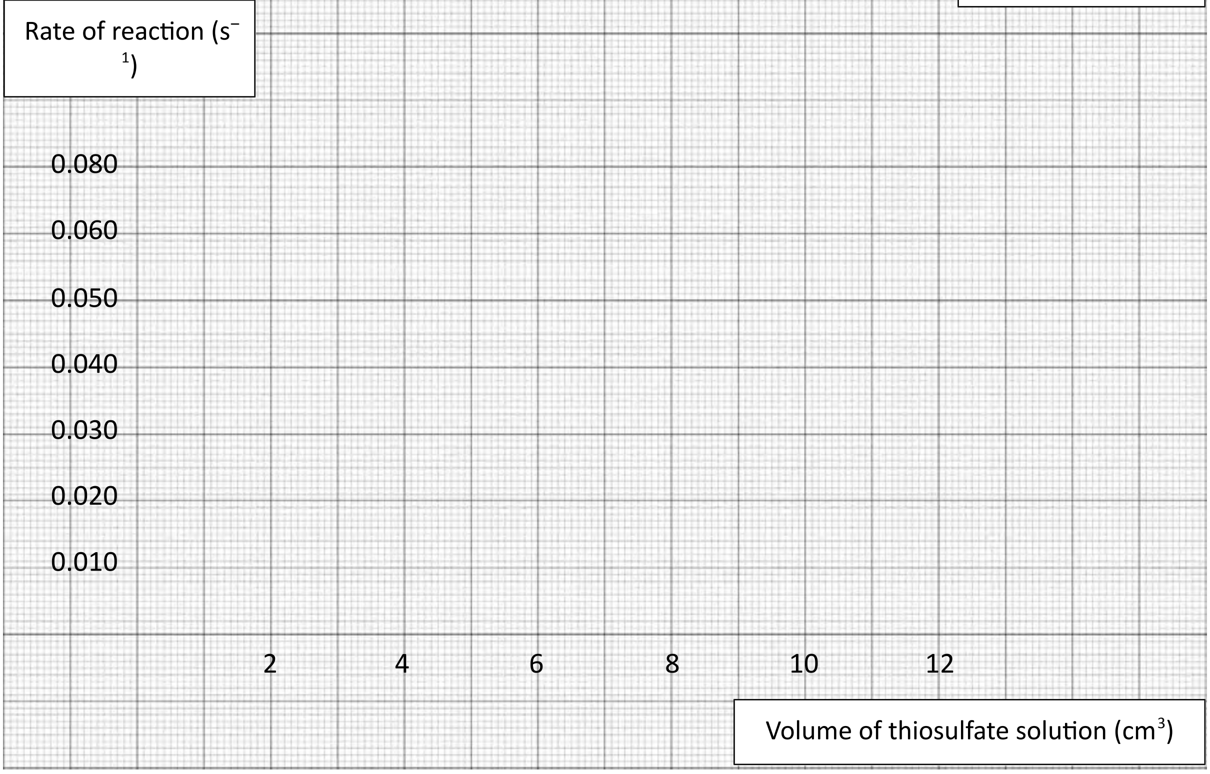
2. Variation of initial rate with temperature



3. An Arrhenius plot (which indicates activation energy of ~ 47 kJ mol^{-1}).

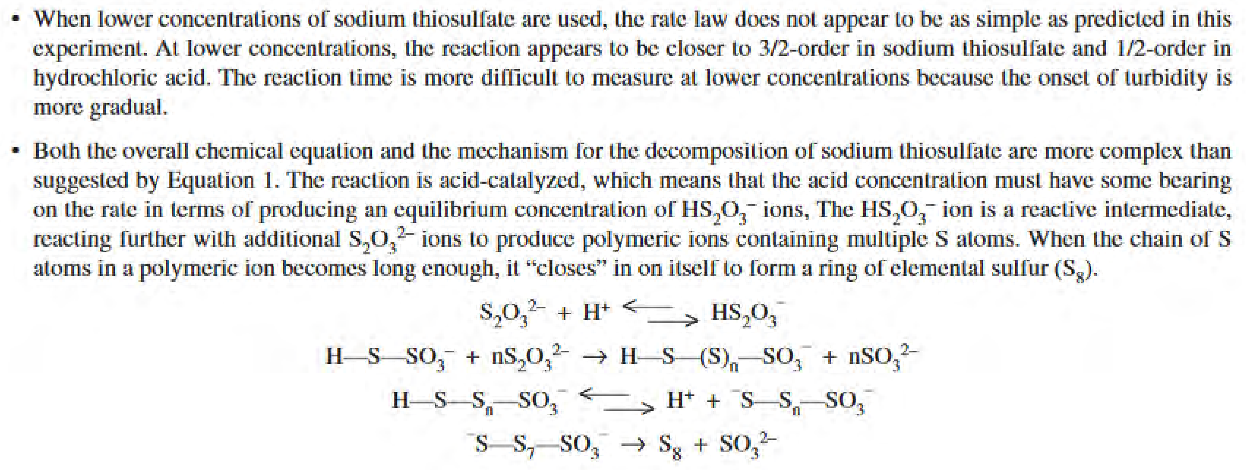



Rate of reaction (s^{-1})
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0
10
20
30
40
50
60
Temperature (°C)


Rate of reaction (s^{-1})
0.080
0.060
0.050
0.040
0.030
0.020
0.010
2
4
6
8
10
12
Volume of thiosulfate solution (cm^3)

Reactions involved

Note from Flinn Scientific on this reaction.



- When lower concentrations of sodium thiosulfate are used, the rate law does not appear to be as simple as predicted in this experiment. At lower concentrations, the reaction appears to be closer to 3/2-order in sodium thiosulfate and 1/2-order in hydrochloric acid. The reaction time is more difficult to measure at lower concentrations because the onset of turbidity is more gradual.
- Both the overall chemical equation and the mechanism for the decomposition of sodium thiosulfate are more complex than suggested by Equation 1. The reaction is acid-catalyzed, which means that the acid concentration must have some bearing on the rate in terms of producing an equilibrium concentration of $HS_2O_3^-$ ions, The $HS_2O_3^-$ ion is a reactive intermediate, reacting further with additional $S_2O_3^{2-}$ ions to produce polymeric ions containing multiple S atoms. When the chain of S atoms in a polymeric ion becomes long enough, it "closes" in on itself to form a ring of elemental sulfur (S_8).

$$S_2O_3^{2-} + H^+ \rightleftharpoons HS_2O_3^-$$

$$H{-}S{-}SO_3^- + nS_2O_3^{2-} \rightarrow H{-}S{-}(S)_n{-}SO_3^- + nSO_3^{2-}$$

$$H{-}S{-}S_n{-}SO_3^- \rightleftharpoons H^+ + {}^-S{-}S_n{-}SO_3^-$$

$${}^-S{-}S_7{-}SO_3^- \rightarrow S_8 + SO_3^{2-}$$

I have never seen an a thoroughly argued mechanism for this reaction. The information above implies at least two mechanisms. There is an enzyme that catalyse the reaction. See below. We could say that the hydrogen ion is a catalyst. But the equation on the first page appears to show it is used up. But the hydrogen ion is really now in equilibrium with the sulfur dioxide. This is quite tricky chemistry.

Detailed structures of relevant sulfur compounds and reactions proposed for sulfur globules production. **(A)** Enzymatically catalyzed reactions. TD, thiosulfate dehydrogenase; TTH, tetrathionate hydrolase.

(B) An oxygenic condensation of disulfane monosulfonic acid that leads to polythionates generation.

(C) Successive condensation reactions of sulfane monosulfonic acids that leads to elemental sulfur production.

TS, thiosulfate; TT, tetrathionate; DSMSA, disulfane monosulfonic acid; SO_4, sulfate; SO_3, sulfite; PT, pentathionate; TSMSA, tetrasulfane monosulfonic acid; OSMSA, octosulfane monosulfonic acid; S_8, elemental sulfur.

Reactions according to Steudel, R., Holdt, G., Göbel, T., and Hazeu, W. (1987). *Chromatographic separation of higher polythionates SnO62- (n = 3…22) and their detection in cultures of Thiobacillus ferrooxidans: molecular composition of bacterial sulfur secretion. Angew. Chem. Int. Ed. Engl. 26, 151–153.*