A MANUAL OF SUGGESTED CSEC CHEMISTRY LABORATORY EXPERIMENTS

The 2016 Chemistry Lab Manual contains samples of tried and tested Chemistry Labs and accompanying mark schemes. Each Chemistry teacher contributed two labs per topic, mark schemes and a few Planning and Designing labs to a pool. The labs and mark schemes were vetted by a CSEC moderator. Use of these labs was not mandatory.

COMPILED BY:

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St. Vincent and the Grenadines

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Separation Techniques

Contributed by L. Harry

Lab 1. PAPER CHROMATOGRAPHY-ORR/MM/AI

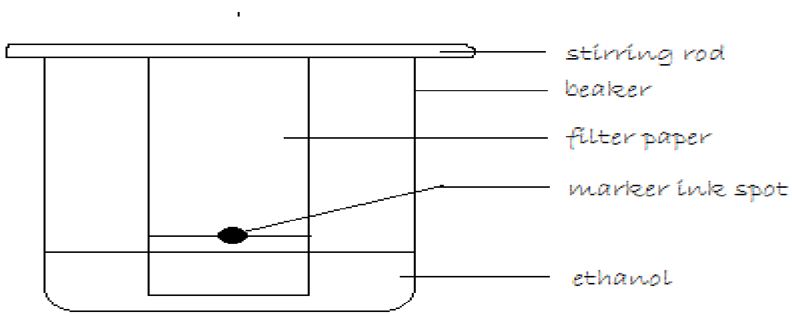
TITLE: Paper chromatography

AIM: To determine whether the ink/dye in three different brands of red permanent markers are the same

APPARATUS: three stirring rods, ruler, scissors, 2 pieces of filter paper, 70 mls ethanol, 25ml measuring cylinder, three 150ml beakers, tape, three different brands of red permanent markers

METHOD:

- Cut three strips of filter paper with the dimensions of 9 cm x 1.5 cm.
- On one strip, mark a line 1 cm away from one end and place a dot of one permanent marker ink in the center of the line. Repeat with the remaining strips, using the other markers.
- Measure out 20 mls of ethanol and pour it into each beaker.
- Tape the unmarked end of each filter paper to a stirring rod and gently place the filter paper into the ethanol. Make sure that the dot does not touch the ethanol and then allow the experiment to run until the dyes are separated. Mark the furthest point on the paper the ethanol rises to.
- Allow the paper to dry and then mark the points at which all the dyes separated. Label each separated component using letters, starting with A being the ink component which separated closest to starting point..



TITLE: DIAGRAM SHOWING SEPARATION OF MARKER INK USING PAPER CHROMATOGRAPHY

OBSERVATION:

Stick the chromatograms into your book and label the chromatogram belonging to each marker. Also, note the distances travelled by the components of each chromatogram

DISCUSSION:

Background:

- Define paper chromatography and describe how paper chromatography is used as a separation technique.
- Outline how paper chromatography is useful in this particular experiment.

Explanation:

- Compare the separated ink components of each marker. (Note similarities and differences observed of distance travelled and colour where applicable.)
- Account for the differences observed among the separated components of the markers' inks.

Limitation, assumption, source of error or precaution:

- Give one of each.(Where applicable)

CONCLUSION:

- Answer aim using relevant observational data.

Lab 2. FILTRATION-ORR/MM/AI

TITLE: Filtration

AIM: To separate chalk (powdered calcium carbonate) from a chalk and water suspension.

APPARATUS: One stick of white chalk, mortar and pestle, one 25 ml measuring cylinder, two 100 ml beakers, one filter paper, one filter funnel, one retort stand and clamp, one stirring rod, one spatula

METHOD:

- Place the clamp on the retort stand.
- Fold the filter paper into a quarter circle and insert into the filter funnel, dampening the paper to adhere it to the funnel.
- Place the filter funnel into the clamp to secure it to the retort stand.
- Place an empty beaker under the funnel.
- Break the chalk into small pieces and pulverize using the mortar and pestle.
- Place the chalk powder into an empty beaker, then fill the beaker with 30 mls of water using the measuring cylinder.
- Mix the contents vigorously, carefully noting the appearance of the mixture.
- Carefully pour all of the contents into the filter funnel.
- Leave to filter then collect the filtrate and dried residue and note the appearance of both.

OBSERVATION:

Note observations of the physical aspects of the original components, the resultant mixture and the filtrate and residue.

DISCUSSION:

Background:

- Define filtration and describe how filtration is used as a separation technique.

Explanation:

- Explain why filtration is a suitable technique for the separation of the chalk suspension as opposed to another named separation technique.
- Account for the differences observed with the original components before mixing, when mixed and after separation.

Limitation, assumption, source of error or precaution:

- Give one of each.(Where applicable)

CONCLUSION:

Answer aim using relevant observational data.

Lab 3. PLANNING AND DESIGN

OBSERVATION:

While organizing his work station, Mark, a student, accidentally caused some sodium chloride to fall into some zinc powder. Design an experiment that would allow Mark to separate the mixture back to its original contents.

Acid, Bases and Salts

Contributed by S. Abbott

Lab 4:

Title: Acids, Bases and salts

Aim: To identify acids and alkali by using indicators

Apparatus and **Materials**: Solution of A,B, C and D, phenolphthalein, methyl orange, screened methyl orange, bromothymol blue, blue litmus paper, red litmus paper, test tube, beakers.

Method:

1. Collect 30ml of each solution in separate beakers.

2. Divide solution A into five portions in separate test tubes.

3. From the first portion, pour a small amount on the red litmus paper and observe any colour change.

4. To the first portion pour a small amount of the solution onto blue litmus paper and observe any colour change.

5. To the second portion add 3-4 drops of phenolthalein and observe any colour change.

6. To the third portion add 3-4 drops of methyl orange and observe any colour change.

7. To the fourth portion add 3-4 drops of screened methyl orange and observe any colour change.

8. To the fifth portion a 3-4 drops of bromothymol blue and observe any colour change.

9. Repeat steps 2-8 using solutions B, C and D. Ensure to rinse the test tubes with tap water followed by distilled water.

10. Record the results in a table.

Results:

Test	Observation	Inference

Discussion:

Identify which solution is an acid and which is a base. Support your answer using the observations obtained above.

Lab 5:

Aim: To investigate the action of dilute sulphuric acid on metals, carbonates, hydrogen carbonates and bases.

Apparatus and Materials: Test tubes, test tube rack, delivery tube, splint, magnesium strip, sodium hydrogen carbonate, copper oxide, copper, sulphuric acid, lime water.

Method:

1. Add dilute sulphuric acid to a small strip of magnesium, and then insert a lit splint into the test tube to test for gas.

2. Repeat the test for Sodium Hydrogen Carbonate and Copper Carbonate. Test for any gas formed by attaching a delivery tube to the test tube and running it through lime water.

3. Repeat the test for copper oxide and copper.

4. Record all observations in a table

Results:

Discussion: In your inference ensure to explain your observation and write an appropriate balanced equation for the reaction taking place.

Lab 6:

Title: Acid, Bases and Salts

Aim: To make Hydrated Copper (ii) Sulphate crystals.

Apparatus and Materials: 250 mL beaker, spatula, filter funnel, filter paper, conical flask, evaporating dish, 1M Sulphuric acid, Copper (ii) Carbonate.

Method:

1. Add 20 cm^3 of 1M sulphuric acid to beaker.

2. Add a spatula at a time of Copper (ii) carbonate to the test tube until no more can be dissolved.

3. Filter the solution, then pour it into an evaporating dish and allow to evaporate slowly and gently.

4. When crystals start to appear on the sides of the dish, stop evaporating.

5. Place a filter paper over the dish and leave it to cool.

6. After the crystals have formed, put off the excess liquid and dry the crystals by blotting them between filter paper.

7. Ensure to collect your crystals and show them to the instructor.

Discussion:

1. Explain how a soluble carbonate salt is made.

2. Explain the reason why excess carbonate was added to the acid.

3. Why was the mixture filtered and heated?

4. Write a balanced equation for the reaction taking place.

Lab 7:

Title: Acids, Bases and Salts.

Aim: To prepare the salt PbI_2.

Apparatus and Materials: Potassium iodide solution, lead nitrate solution, beaker, measuring cylinder, stirring rod, filter paper, filter funnel.

Method:

1. Add 15 mL of lead nitrate into a beaker followed by 20 mL of potassium iodide and stir the mixture.

2. Filter the mixture and allow the residue to dry in air.

3. Collect the dried sample and exhibit the sample in your report.

Discussion:

1. What is the color of the sample obtained?

2. Is the compound formed soluble or insoluble?

3. Write the equation for the reaction taking place and the ionic equation.

4. What type of reaction is it?

Redox reactions and electrolysis

Contributed by A. Bowman

Lab 8

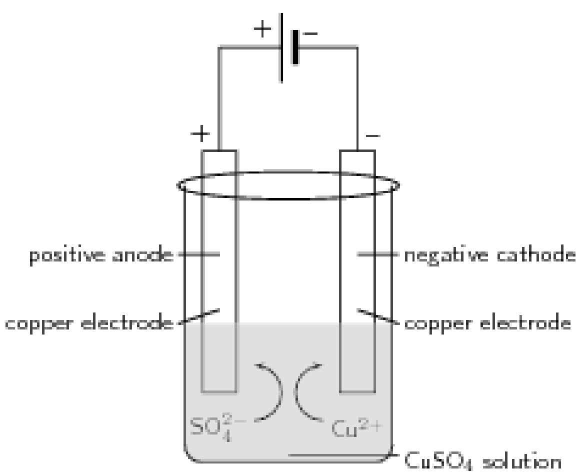
Skills that can be assessed: AI, ORR

Title: Electrolysis

Aim: To investigate electroplating using copper electrodes and copper(ii) sulfate solution.

Materials/Apparatus: $100cm^3$ beaker, 6V battery, Connecting wires (crocodile clips), 1mol dm^3 copper(ii) sulfate solution, pure copper wires (wrap these wires around a pencil to form coils to be used as the electrodes), ammeter, balance, scotch tape, Stop watch

Diagram of Apparatus:



Method:

1. Label the copper coils anode and cathode.
2. Using the balance find the mass of the two copper coils and record their masses.

3. Connect the coils using the connecting wires to the battery so that the anode is connected to the positive terminal end of the battery and the cathode to the negative end.
4. Using the scotch tape fix the coils inside the beaker opposite each other. Ensure they are pointing downwards and are not touching each other and the sides of the beaker.
5. Pour approximately $80cm^3$ of the copper(ii) sulfate solution into the beaker containing the coils. Ensure that the coils are covered with the solution.
6. Close the circuit by connecting the two ends of the connecting wires to the battery terminals using scotch tape and start the stopwatch. Ensure the ammeter is placed in series in the circuit. Measure and record the current in the circuit
7. After ten (10) minutes remove the coils from the solution and turn the circuit off. Measure and record the mass of the coils .Record all other observations.

Observation/Results

Electrodes	Mass before placed in the cell (g)	Mass after placed in the cell (g)	Observations of the electrodes
Anode			
Cathode			

Treatment of Results:

1. What are the ions in the electrolyte?
2. Which ions would be discharged? Explain
3. Explain the process that took place at the cathode
4. Write half ionic equations for the reactions occurring at the anode and cathode
5. Calculate the difference in masses of the anode and cathode before and after it was placed in the solution with the circuit turned on.
6. Using the current and time calculate the mass of copper expected to be deposited. Compare this mass to the actual mass of copper that was deposited. Account for the differences.
7. Give all limitations and errors in the lab

Lab 9

Skills that can be assessed: ORR, MM

Title: Electrolysis

Aim: To investigate the electrical conductivity of various substances.

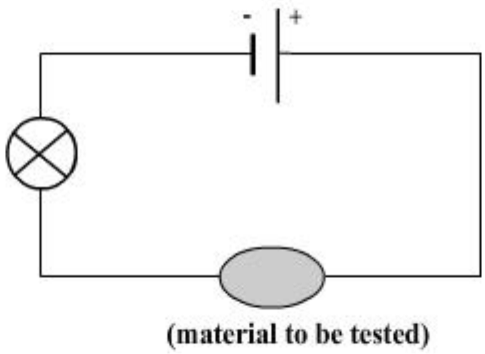
Materials/Apparatus:

Substances to be tested: copper wire, magnesium ribbon, aluminum foil, zinc rods, iron rods, wooden ruler, plastic ruler, copper(ii) sulfate salt, copper(ii) sulfate solution, sodium chloride salt, sodium chloride solution, ethanol, kerosene, sugar and sugar solution.

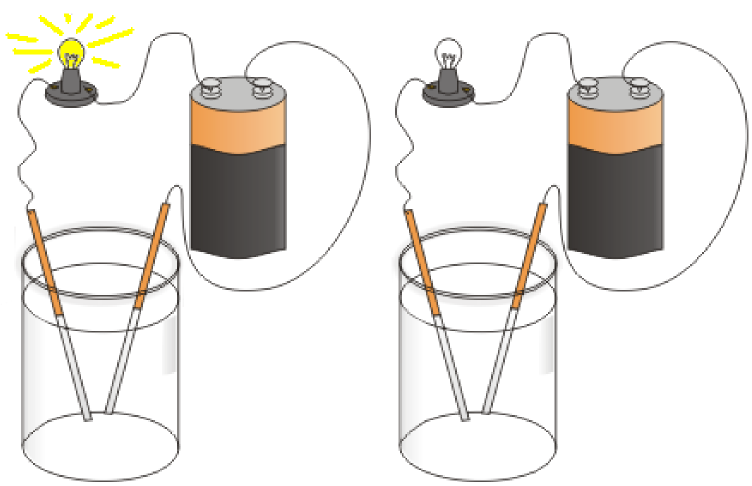
Materials to make the circuit: 6V battery, connecting wire, ammeter, beaker, graphite rods, bulb

Diagram of Apparatus:

Apparatus 1: Used to Test Solid Substances



Apparatus 2: Used to Test Liquid Substances



Method:

1. Make a table with four (4) columns headed ‘Substances Tested’, ‘Type of Bonding’, ‘Prediction of Electrical Conductivity’ and ‘Electrical Conductivity’
2. Set up two circuits as shown in the diagram above. Use apparatus 1 for the solid substances and apparatus 2 for the liquid substances

3. Test the substances using the appropriate circuit an record the observations

Observations/Results

Substances Tested	Type of Bonding	Prediction of Electrical Conductivity	Electrical Conductivity X If bulb did not light √ If bulb light

Questions:

1. Compare your results with your predictions
2. Define metallic and electrolytic conduction
3. Classify the substances tested as having metallic conduction or electrolytic conduction. Explain your answer

Qualitative Analysis

Contributed by K. Lynch

Lab 10

SKILLS: ORR

AIM: To identify cations

APPARATUS/MATERIALS: salts containing calcium, aluminium, zinc, lead (II), iron (II), iron (III), copper (II) and ammonia ions, sodium hydroxide solution, aqueous ammonia, potassium iodide solution, a piece of red litmus paper and test tubes

METHOD:

- Carefully place a very small spatula of each salt into a separate test tube. Add 2cm3 of distilled water to each tube and shake to dissolve the salt.
- Label the tube with the symbol of the cation it contains.
- Add a few drops of sodium hydroxide solution to each tube. Observe the colour of the precipitate.
- Add excess sodium hydroxide solution to each tube and see if the precipitate dissolves.
- If no precipitate forms, gently heat the contents of the test tube and test for ammonia gas by placing a piece of red litmus paper across the mouth of the test tube.
- Record your results in a table using the following headings for columns: cation, colour of precipitate on addition of sodium hydroxide dropwise, ionic equation for the reaction occurring, solubility of the precipitate on adding excess sodium hydroxide solution.
- Repeat the steps replacing sodium hydroxide with aqueous ammonia.

- Place small spatulas of the salts containing aluminium and lead (II) ions in two separate test tubes. Add 2cm3 of distilled water to each and shake to make solutions.
- Add a few drops of potassium iodide solution to each and look for a precipitate forming. Record the colour of the precipitate.

QUESTIONS:

1. Explain why some of the cations' precipitate dissolved when excess sodium hydroxide added while others did not.
2. Explain why the precipitates dissolved when excess aqueous ammonia was added.
3. State which cation(s) do not form a precipitate with sodium hydroxide then state if ammonia is given off and why.

Lab 11

SKILLS: ORR, A/I

AIM: To identify common anions in solution using simple qualitative chemical tests

APPARATUS/MATERIALS: clean, dry test tubes, test tube holder and rack, unknown salts (A, B, C, D), reagents

METHOD:

- You are required to carry out the appropriate tests to find out the identity of each salt. Use the information you learned to decide on the tests you will use. You may carry out more than one test on each salt.
- Once you have decided on the tests to use, proceed to carry them out to confirm the identity of each salt.
- For each salt:

a) record the method used for each test you carried out and the results of the test.

b) explain the results of each test

c) write ionic equations where appropriate.

Lab 12

SKILL: ORR, MM, A/I

AIM: To identify gases

APPARATUS/MATERIALS: ammonium carbonate, magnesium nitrate, lime water, red and blue litmus, dry cobalt paper, tweezers, wooden splint, test tubes, test tube with cork and delivery tube

METHOD:

- Place a spatula full of ammonium carbonate into a dry test tube and place the cork with the delivery tube into the test tube. Place about 2cm3 of lime water into another test tube.
- Heat the test tube gently using a Bunsen flame. While heating, hold a piece of moist red litmus paper across the end of the delivery tube using the tweezers. Observe the change in colour of the paper.
- While still heating the tube, place a piece of dry cobalt chloride paper across the end of the delivery tube. Observe the change in colour of the paper.
- While still heating the tube, bubble the gas into the lime water. Observe what happens in the lime water.
- As you are heating, observe what happens to the ammonium carbonate in the test tube.
- Identify the three gases that are produced when ammonium carbonate is heated. Hence, write an equation for the decomposition of ammonium carbonate.

- Place a small spatula full of magnesium nitrate into another dry test tube.
- Heat the test tube gently using a Bunsen flame and as soon as a brown gas is seen, slowly insert a glowing splint into the tube. Observe what happens to the splint.
- While still heating, place a piece of moist blue litmus paper into the brown gas. Observe the change in the colour of the paper.

QUESTIONS:

1. Explain why the quantity of ammonium carbonate decreased as it was heated and possibly disappeared completely.
2. Identify the two gases produced when magnesium nitrate is heated. Given that the solid remaining is magnesium oxide, write a balanced equation for the reaction.

Volumetric Analysis
Contributed by R. Frederick

Lab 13

Title: Volumetric Analysis 1

Aim : To find the concentration of a solution of sodium hydroxide by a titration method, using hydrochloric acid.

Apparatus and materials:

- Solution containing approximately 4 g dm^{-3} sodium hydroxide
- 0.1 mol dm^{-3} hydrochloric acid, accurately standardized
- Methyl orange or screened methyl orange indicator
- Conical flasks
- 50 cm^3 burette
- 25 cm^3 pipette

Procedure :

(a) Wash the burette thoroughly with a liquid detergent. Wash it with tap water, then with distilled water and finally rinse it with the hydrochloric acid solution. Fill the burette to a convenient graduation mark with hydrochloric acid. Record this reading.

(b) Pipette 25.0 cm^3 of the sodium hydroxide solution into a conical flask, add 1 – 2 drops of indicator, and add hydrochloric acid from the burette until the end-point is reached. Record the burette reading.

(c) Repeat the titration as many times as convenient, until consecutive burette readings differ by no more than ± 0.10 cm^3.

Treatment of results

(a) Tabulate your results as follows:

Burette readings/ cm³	Rough	1	2
At end of titration			
At start of titration			
Volume of HCl used/cm³			

(b) Using the values for the accurate titration only, find the average volume of hydrochloric acid that just neutralizes 25.0 cm^3 of the sodium hydroxide solution:

Average titration: *V* cm^3 of HCl (aq) = 25.0 cm^3 of NaOH (aq)

(c) Find the number of moles of hydrochloric in the average volume used

No. of mol of HCl = (Vol. of HCl (aq) x Concentration) / 1000

(d) From the equation, one mole of HCl(aq) reacts with one mole of NaOH(aq). Use this information to find the number of moles of NaOH(aq) in 25.0 cm^3 of the solution.

(e) Using your answer to (d), find the concentration of the NaOH(aq) in both mol dm^{-3} and g dm^{-3}.

References:

Norman Lambert, Marine Mohammed. 1987. Practical Chemistry for CXC. England. Heinemann

Lab 14

Title: Volumetric Analysis 2

Aim: To find the concentration of sodium carbonate solution

Apparatus and materials:

- Solution containing approximately 5.3 g dm^{-3} anhydrous sodium carbonate
- 0.1 mol dm^{-3} hydrochloric acid, accurately standardized
- Methyl orange or screened methyl orange
- 250 cm^3 conical flasks
- 50 cm^3 burette
- 25 cm^3 pipette

Procedure

(a) Rinse a clean burette with hydrochloric acid, then fill it with the same solution to a convenient graduation mark. Record the burette reading.

(b) Rinse a clean 25 cm^3 pipette with sodium carbonate solution, then fill it to the mark with the same solution. Transfer the sodium carbonate solution to a 250 cm^3 conical flask and add 1 – 2 drops of indicator.

(c) Titrate the sodium carbonate solution against the hydrochloric acid until the end-point is reached.

(d) Repeat the titration until consecutive burette readings differ by no more than ± 0.10 cm^3.

Treatment of results

(a) Tabulate your results as follows:

Burette readings/ cm^3	Rough	1	2
At end of titration			
At start of titration			
Volume of HCl used/cm^3			

(b) Using the values for the accurate titration only, find the average volume of hydrochloric acid that just neutralizes 25.0 cm^3 of the sodium hydroxide solution:

Average titration: *V* cm^3 of HCl (aq) = 25.0 cm^3 of Na_2CO_3 (aq)

(c) Find the number of moles of hydrochloric in the average volume used

No. of mol of HCl = (Vol. of HCl (aq) x Concentration) / 1000

(d) From the equation it can be deduced that two moles of HCl(aq) reacts with one mole of Na_2CO_3(aq). Use this information to find the number of moles of Na_2CO_3 (aq) in 25.0 cm^3 of the solution.

(e) Using your answer to (d), find the number of moles of Na_2CO_3(aq) in 1000 cm^3 of solution.

References:

Norman Lambert, Marine Mohammed. 1987. Practical Chemistry for CXC. England. Heinemann

Lab 15

Title: Volumetric Analysis 3

Aim: To find the concentration of potassium manganite (VII) solution

Apparatus and materials:

- Solution containing 35.0 g dm^{-3} of ammonium iron (II) sulfate, made by dissolving the salt in 200 cm^3 of 2 mol dm^{-3} sulfuric acid, then making up to 1 dm^3 with distilled water
- Potassium manganite (VII) solution, about 3.2 g dm^{-3}
- 2 mol dm^{-3} sulfuric acid
- Burette

- Pipette
- Conical flasks

Procedure:

(a) Pipette 25.0 cm^3 of ammonium iron (II) sulfate solution into a conical flask. Add an equal volume of 2 mol dm^{-3} sulfuric acid (using a measuring cylinder) and titrate the mixture against the potassium manganate (VII) to the first permanent pink end-point.

Note: Because of the intense colour of the manganate (VII) solution, it may be necessary to read the top of the meniscus in the burette.

(b) Repeat the titration until consecutive burette readings differ by no more than 0.10 cm^3

Treatment of Results

(a) Display your titration results in a table and find the average volume of potassium manganate (VII) required to oxidize 25 cm^3 of the iron (II) solution in the presence of dilute sulfuric acid.

(b) Calculate:

$$1\ mol\ MnO_4^- \equiv 5\ mol\ Fe^{2+}$$

(i) The number of moles of ammonium iron (II) sulfate, $(NH_4)_2Fe(SO_4)_2.6H_2O$, in 1 dm^3 of solution.

(ii) The number of moles of ammonium iron (II) sulfate used in the titration.

(iii) The number of moles of potassium manganate (VII) in the average volume used.

(iv) The number of moles of the potassium manganate (VII) in 1 dm^3 of the solution.

(v) The mass concentration of the potassium manganate (VII) solution,

(vi) The volume in dm^3 of the potassium manganate (VII) solution which contains 15g of $KMnO_4$;

(vii) The number of moles of potassium ions present in the solution of potassium manganate (VII).

References:

Norman Lambert, Marine Mohammed. 1987. Practical Chemistry for CXC. England. Heinemann

Rates of Reaction

Contributed by J. King

Lab 16

Introduction:

Does particle size really affect the rate of a reaction? In this experiment we will explore this by using a 3cm strip of magnesium ribbon versus a 3cm strip of magnesium ribbon cut into several pieces.

Magnesium reacts with hydrochloric acid to produce hydrogen gas. By measuring the volume of gas evolved over regular time intervals we can determine the rate of this chemical reaction.

Note to teachers: The lab below is showing how the experiment can be done using either a gas syringe or measuring cylinder and trough. Choose the set-up which is more feasible based on the equipment available.

Title: Investigating how particle size affects the rate of reaction

Aim: To investigate how the particle size of magnesium affects the rate of its reaction with hydrochloric acid.

Apparatus/Materials for <u>diagram 1</u>: 100cm^3 conical flask, 100cm^3 measuring cylinder, single-holed rubber bung with delivery tube to fit, 100cm^3 gas syringe, two strips of magnesium ribbon (3cm each), dilute hydrochloric acid (1M), retort stand with clamp, stop clock.

Apparatus/Materials for <u>diagram 2</u>: 100cm^3 conical flask, single-holed rubber bung with delivery tube to fit, two 100cm^3 measuring cylinders, trough, two strips of magnesium ribbon (3cm each), dilute hydrochloric acid (1M), retort stand with clamp, stop clock.

Diagrams:

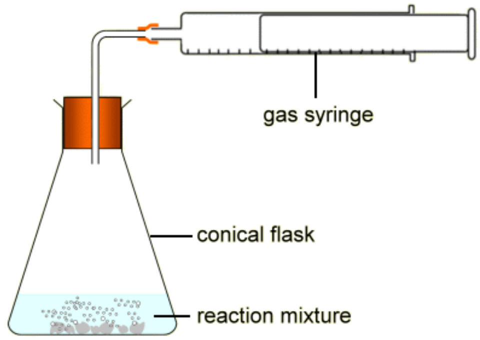


DIAGRAM 1: SHOWING EXPERIMENTAL SET-UP USING A GAS SYRINGE

OR

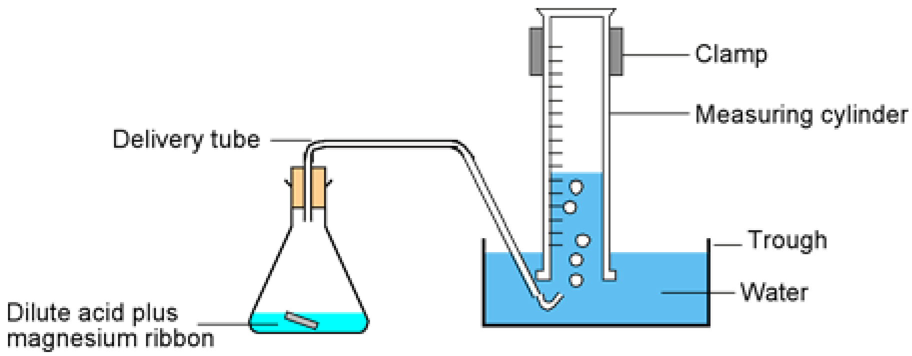


DIAGRAM 2: SHOWING EXPERIMENTAL SET-UP WITH MEASURING CYLINDER

Procedure:

1. Measure 50cm^3 HCl (aq) using the measuring cylinder. Pour the acid into the clean conical flask.

2. Set up the apparatus as shown in the relevant diagram (1 or 2).

3. Add a 3cm strip of magnesium ribbon to the conical flask, quickly stopper the flask and start the stop clock.
4. Record the volume of gas given off at suitable time intervals (e.g. every 30s).
5. Continue timing and recording until no more gas is given off.
6. At the end of the experiment rinse the conical flask and repeat step 1.
7. Cut the second strip of magnesium ribbon into 10 pieces.
8. Repeat from step 3 onwards this time using the magnesium pieces.
9. Tabulate all relevant results.

Observations: Record relevant observations

Results: Show data collected in suitable forms (tables and a graph suggested).

Discussion:

1. Give brief background information on how particle size affects the rate of reaction.
2. Explain your observations briefly, including a suitable equation for the reaction taking place.
3. Interpret the shapes of the curves.
4. State and discuss possible sources of error (if any).

Conclusion: Relate to aim (i.e. How does particle size affect the rate based on your experimental findings?)

SUGGESTED POINTS FOR AN ORR MARK SCHEME (Adjust, omit, add as you see fit)

ORR

Observation (**4mrks**: 1 mk for any of the following or any other relevant observation)

Relevant before observation (max of 1 mk)

A colourless gas evolves

The reaction is vigorous

The magnesium dissolves completely

A colourless solution remains

Recording:

Table

Table is neatly constructed (i.e. completely boxed in with all sections distinct) **(1mk)**

Table has a self-explanatory title **(1mk)**

Table's heading show appropriate units **(1mk)**

Graph

Graph has a self-explanatory title (**1mk**)

Axes lines are drawn (**1 mk**)

Axes are labelled with units (**2mks**)

- Both labelled but without units (1mk)
- Only one labelled with units (1mk)
- No marks awarded for one label without unit or units with labels

Graph has a correct scale (**1mk**)

Graph has a clear key to distinguish the two curves **(1mk)**

Points are correctly plotted for both curves (**4 mks**: 2mks for each curve)

- Deduct 1 mk if over two points are incorrect per curve
- No marks awarded for over two points are incorrect per curve

Student has drawn smooth curves (**2 mks**: 1 mk each)

Curves are neatly drawn (i.e. using a well sharpened pencil) (**1mk**)

Reporting

All sections and headings are included **(1mk)**

The lab format is correct **(1mk)**

Each section is used appropriately **(2mks)**

- Over two sections used inappropriately, no marks
- Only one section used inappropriately (1mk)

The method is recorded in past tense (1mk) and is grammatically correct (1mk) **(2 mks)**

The lab report is concise **(1mk)**

NB to teachers you can scale down/adjust this mark scheme appropriately. These are just some points you could assess when marking an ORR lab.

Lab 17

Note to teacher: The grid provided is incomplete. Prior to experiment, measure the distance between the central dot and each circle in cm, have students write the value in space provided on grid.

Make KI solution of an appropriate concentration that the iodine pellet can be observed dissolving gradually.

Introduction: Diffusion is the movement particles from a region of high concentration to a region of low concentration until evenly distributed. The rate of diffusion may be affected by a number of factors. One such factor is temperature. In this experiment you will be investigating how temperature affects the rate of diffusion of iodine when dissolving in potassium iodide solution.

Title: The Rate of Diffusion

Aim:

Apparatus/Materials: One iodine pellet, dilute KI (aq), 400ml beaker, a straw, a pair of tweezers, thermometer, stop watch, 100ml measuring cylinder, concentric grid (provided below)

Diagram:

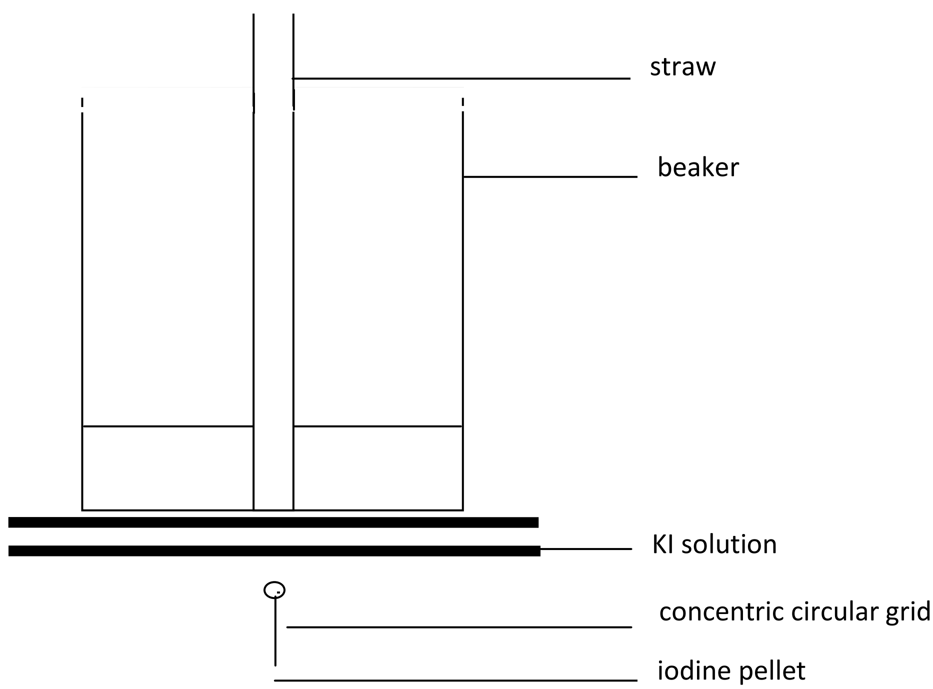


DIAGRAM SHOWING RATE OF DIFFUSION EXPERIMENTAL SET-UP

Method:

1. Measure 25cm^3 of room temperature KI (aq) using a measuring cylinder and use a thermometer to record the temperature of the KI (aq).
2. Place empty beaker over circular grid provided, ensuring that the dot is central.

3. Place the straw into beaker and ensure that the straw's opening surrounds the dot.
4. Using the pair of tweezers add one iodine pellet into the beaker via the straw. DO NOT MOVE THE STRAW.
5. Slowly add the 25 cm^3 of the KI (aq) into the beaker.
6. Slowly remove the straw leaving behind the pellet at the centre. Immediately start the timer.
7. Measure the distance traveled by the iodine every 30s for a maximum of 5 minutes. Record the results in a suitable table.
8. Repeat the experiment using potassium iodide solution which has been heated to 40˚C.
9. Record all observations and results.

Observations: Write a paragraph describing all relevant observations.

Results: Construct TWO tables, each having 3 columns showing the: Time (s); Diffusion distance(cm); Rate of diffusion (cm/s). The first table will show the results using KI (aq) at room temperature and the second table will show the results using KI (aq) at 40˚C.

Use your results to construct a graph of Diffusion Distance vs. Time. Plot the two graphs on the same graph paper. Use a key to differentiate between the two temperatures.

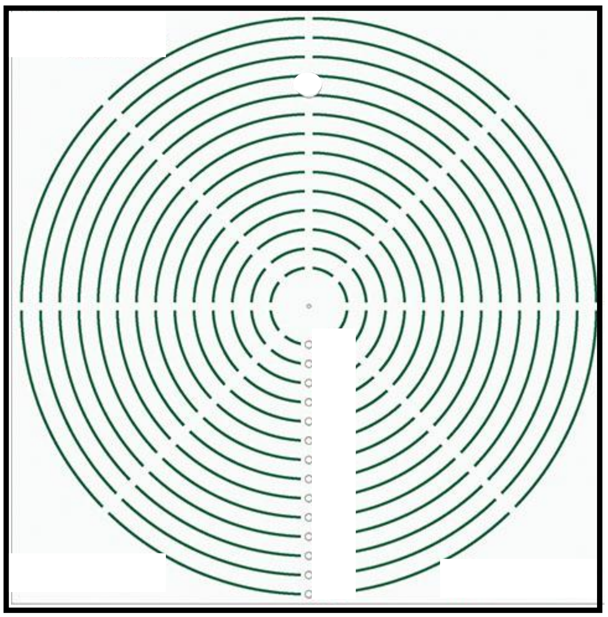
Discussion: Based on your experimental findings (observations, data and graphs), state how increasing the temperature affects the rate of diffusion.

Explain the above using your knowledge of kinetic energy and the movement of particles.

Suggest any possible source of error and how you could prevent this error.

Conclusion: State how increasing the temperature affects the rate of diffusion.

Write in the distance(cm) of each circle from the centre, then PLACE BEAKER OVER THIS GRID to carry out the experiment.



A&I- Analysis & Interpretation

Aim (2mks)

To investigate how increasing the temperature affects the rate of diffusion. (2)

To investigate the rate of diffusion (1/2)

Discussion (7mks)

The movement of the iodine was observed because the particles moved from an area of high conc. to low concentration. **(1)**

The data shows that the rate is higher/less time is taken to reach a particular distance at 40°C than at rt. **(1)**

Graph is steeper at 40°C than graph at room temperature **(1)**

Iodine particles move faster at 40°C than at rt because they have more kinetic energy. **(2)**

Source of error:

Heat loss to the surroundings- use insulation to prevent heat loss

(2mks: 1mk-error; 1mk-prevention)

Any other relevant error and prevention (award the 2mrks)

Conclusion (2 marks)

As temperature increases the rate of diffusion increases. (2)

Temperature affects the rate of diffusion (1/2)

Lab 18

Introduction: When calcium carbonate chips react with hydrochloric acid, CO_2 gas is produced. Decreasing the concentration of the acid affects the rate of this reaction.

In this experiment we will be investigating how decreasing the concentration affects the rate of reaction by measuring the time taken for a specific volume of gas to be produced with different concentrations of hydrochloric acid.

Also consider the following during this experiment:

What are some of the variables that must be controlled during this experiment?

Why is it important to control these variables?

Note to teacher: This lab may be done as a demonstration with student volunteers or in large groups depending on the availability of resources and materials.

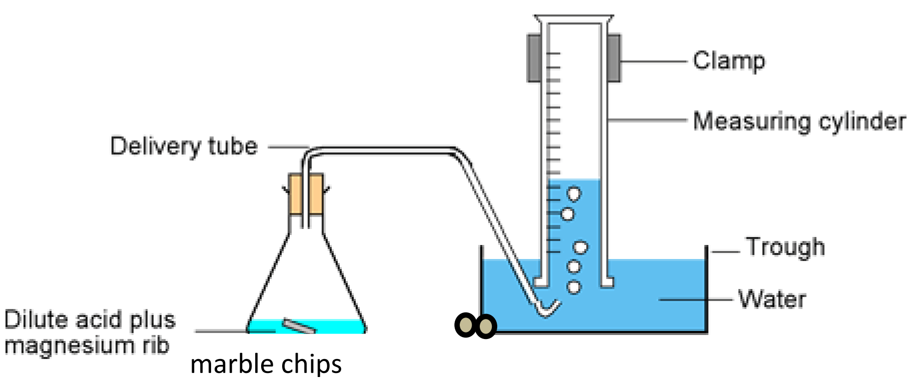
View lab here https://www.youtube.com/watch?v=E0bXd4zOXqA

Title: Investigating how Concentration Affects the Rate of Reaction

Aim:

Apparatus/Materials: Trough, 100cm^3 measuring cylinders (2), rubber tubing or delivery tube, retort stand and clamp, 250 cm^3 conical flask with single-holed rubber bung, marble chips (appr. 35g calcium carbonate in total), hydrochloric acid (2M), water, stop clock, scale or balance , watch glasses or beakers for weighing.

Diagram:



Method:

1. Pre-weigh five batches of marble chips, each of approximately 7 grams.
2. Set up the apparatus as shown below ensuring that the measuring cylinder is free of air bubbles.
3. Use a measuring cylinder to measure 50cm^3 of HCl (aq). Pour acid into a clean conical flask.

4. Add the first 7g of marble chips to the acid all at once, then quickly stopper the conical flask. Start the timer. Record how many seconds is taken for 100cm^3 of gas to evolve.

5. Rinse apparatus and repeat the experiment using the dilutions shown in the table below.

6. Tabulate all results.

TABLE SHOWING VOLUMES OF ACID AND WATER USED, INCLUDING THE TIME TAKEN FOR CO_2 GAS TO EVOLVE

Volume of Hydrochloric Acid/ cm^3	Volume of water/cm^3	Time Taken for 100cm^3 of gas to evolve/s
50	0	
40	10	
30	20	
20	30	
10	40	

Observations: state relevant observations here

Results: Construct and complete the above table

A suitable graph may also be constructed.

Discussion:

Give relevant background information. Include an equation for the reaction occurring.

Explain your experimental findings using your knowledge of the particulate theory, concentration and how reactions occur.

Discuss errors (if any).

Conclusion: How does deceasing the concentration affect the rate?

Lab 19

Rates of Reaction- Planning and Designing Lab

Jackie suggests to the teacher that one of the factors that can affect the rate of a reaction is the level of reactivity of a metal. What do you think?

Plan and design an experiment to investigate what effect (if any) the reactivity of metals has on the rate of reaction.

Lab 20

Another possible P and D

The decomposition of hydrogen peroxide occurs more rapidly when a catalyst is used. The decomposition reaction is shown in the equation below:

$$2\,H_2O_2\,(l) \xrightarrow{\text{catalyst}} 2\,H_2O\,(l) + O_2\,(g)$$

One common catalyst used for this decomposition is MnO_2 (manganese (IV) oxide) powder. It has been suggested that yeast will do a better job at catalysing this reaction. What do you think?

Plan and design an experiment to determine which of the two would be the better catalyst.

Energetics

Contributed by G. Bowman

Lab 21

Title: Energy changes

Aim: To determine the type of reaction (endothermic/exothermic) involved in dissolving sodium hydroxide in water.

Material apparatus: Styrofoam cup, measuring cylinder, thermometer, watch glass, spatula, sodium hydroxide, triple beam balance.

Procedure:

1. Measure 50cm^3 of water and pour it into the Styrofoam cup. (Leave this to stand for a few minutes while you go on to the next step.)

2. Measure 2g of sodium hydroxide.

3. Measure and record the temperature (T_1) of the water in the Styrofoam cup.

4. Transfer the 2g of sodium hydroxide (all at once) to the water in the Styrofoam cup; stir the mixture while observing the temperature changes. Record the highest or lowest temperature (T_2) reached.

5. Wash up and put away all apparatus carefully.

Results:

Volume of water used: _________________ cm^3

Mass of sodium hydroxide used: _________ g

Initial temperature of water (T_1): _________ ^{0}C

Highest/lowest temperature (T_2) _________^{0}C

Exercise for AI:

1. Was there an increase or a decrease in temperature?

2. State whether the reaction was an endothermic or an exothermic reaction and give a reason?
3. State whether the ΔH value for this reaction is positive or negative and give a reason?
4. Calculate (a) the heat change for the reaction and (b) the heat change for dissolving 1 mole of sodium hydroxide in water.
5. State at least one assumption and one limitation.
6. Draw a fully labeled energy profile diagram for the reaction.

Skill: MM/AI

MM Criteria

Correct use and reading of thermometer 3

(eye level, submerged, accuracy)

Correct use and reading of measuring cylinder 3

(eye level, cylinder flat, accuracy)

Careful transferring of chemical/water 1

Correct use and reading of balance 3

(zeroing, eye level, accuracy)

Total 10

AI criteria

- Energy profile diagram 2
- Calculation of heat change 2
- Type of change explained 2
- Assumptions/limitations described 2

- Appropriate conclusion 2

Total 10

This exercise may be repeated using ammonium chloride instead of sodium hydroxide for the opposite kind of reaction

Saturated and Unsaturated Hydrocarbons

Lab 22

Planning and designing

Problem Statement: A patient is rushed into your ER having ingested an organic liquid. You need to know the nature of the compound in order to treat your patient effectively. You find a bottle amongst their personal effects but most of the label on the bottle is gone. You can make out the first three letters of the functional group which are ‘ALK’. Plan and design an experiment to accurately determine the functional group of the organic liquid.

Lab 23:

Planning and designing

Margarine vs Butter

Problem

Margarine vs butter? Which is healthier?

Both can be used as spreads on breads or biscuits or even in cooking to improve flavour. In this modern age where obesity and terms such as “good” cholesterol and “bad” cholesterol are “hot” topics, the question **margarine or butter, which is better for your health?** was given as an assignment to CSEC chemistry students. Through research, the students determined that the degree of unsaturation in these products plays a role in the health consequences of using these products. **Plan and design an experiment to determine the degree of unsaturation in samples of margarine and butter.**

Planning and Designing

The following section on planning and designing is taken from the CSEC 2012 Chemistry report. It contains information on planning and designing which you may find helpful.

“Generally, the standard of the laboratory exercises assessed for the Planning and Designing (PD) skill has declined this year as there was a 10 per cent increase in exercises with unsatisfactory PD skills.

This was due mainly to the noticeable increase in the number of standard practical exercises presented this year. Standard practical exercises are those which can be obtained from a chemistry text, and are therefore deemed inappropriate for PD activities, for example:

Plan and design an experiment to determine

The effect of concentration on the rate of a reaction

The products of electrolysis of H2SO4 using inert electrodes

The conditions for rusting

Various formats have been used for the presentation of PD skills, some of which make it very difficult to moderate. Below is a suggested format which may be useful to both teachers and students:

Scenarios

Students should be encouraged to write the scenarios or problem statements at the beginning of each PD exercise. These should also be included in the teachers’ mark scheme.

It is recommended that the same scenario/problem be given to all students in the group and that other means of encouraging independent work (other than assigning individual PD’s) be found.

It is not recommended that students be left to generate the problems/scenarios of their own; however, in circumstances where this is done these problems/scenarios should be vetted by the teacher to make sure that they are testable and chemistry based.

Hypothesis

The hypothesis should be testable.

As much as possible the manipulated variable should be included in the hypothesis.

The hypothesis should be restricted to one sentence only. Neither the rationale for the position that has been taken nor the method to be used on the experiment should be outlined in the hypothesis.

The language of the hypothesis is also important. It should be stated like an aim.

Aim

Students should be encouraged to specify the method or technique to be employed in the experiment.

The aim must relate to the hypothesis as well as the problem statement.

Apparatus/Materials

Traditionally, most teachers require that the apparatus and materials be placed before the procedure in keeping with the format used for the laboratory exercises. Please note that PD skills in this section may also be written and accepted after the procedure as it is a good practice to identify from the procedure the list of apparatus and materials required.

This is better done while planning the experiment rather than writing a procedure to fit the apparatus and materials. Students should also be encouraged to pay special attention to this section since a mark is deducted for every piece of essential apparatus omitted as determined by the suggested procedure.

Procedure

Special attention must be given to the tense used in the procedure. Students should be taught to write the procedure in the present or future tense; any other tense is unacceptable.

As mentioned before, this section may also be placed before the apparatus and materials section.

Variables

It is recommended that the variables; manipulated, control and responding, be placed immediately after the procedure. Students should be encouraged to list these variables separately as this is an exercise in critical analysis.

Data to be collected

Some students refer to this section as ‘Expected Results’. It is recommended that the term Data to be Collected be used rather than ‘Expected Results’.

In this section, the observations, measurements or qualitative data to be collected that will prove or disprove the hypothesis should be recorded. Please note that actual values should not be recorded in the tables.

The data to be collected may be presented in tabular form or as a description of specific data including units, where appropriate.

Some examples

When doing a titration, the data to be collected will be volumes used rather than concentration. Concentration is actually calculated from the data and hence it will be inappropriate to be used as data collected.

If chromatography is used, then the data collected should included the number of spots or components, their colours and the distance travelled by the components as well as the solvent from the origin. Rf values should never be used as data to be collected since this is also calculated.

Treatment/Interpretation of Data

Again it is recommended that the term data be used rather than ‘results’ in the heading in an attempt to make it clear that this section looks at how the data collected will be used to prove or disprove the hypothesis.

This is the link that shows how the data to be collected answers the aim and validates the hypothesis.

Some examples:

In a scenario where students are trying to find out which brand of vinegar is more concentrated, the Interpretation of Data could be: If Brand Y vinegar uses the least volume (Data to be collected) to neutralize X cm3 of base then Brand Y is the most concentrated vinegar (stated in aim), and therefore the hypothesis is supported.

 In a scenario where students are trying to find out whether two brands of ink contain the same dyes, the Interpretation of Data could be: If both brands of ink contain the same number of components with the same colour and are the same distance from the origin (Data to be Collected), then both brands of ink contain the same dye (stated in the aim) and therefore the hypothesis is supported.

Limitations/Precautions/Assumptions

It is recommended that teachers assist students in distinguishing between these terms.

While they can be related, the way that they are stated can make a significant difference. Please note that Sources of Error should not be presented in a PD lab since it refers to a lab that has been carried out.

In addition, teachers should also be aware of the following:

All PD activities should be based on chemical concepts. Although scenarios may involve Biology, Physics, Food & Nutrition, the focus of the activity must involve chemical concepts related to the Chemistry syllabus.

Students should undertake at least four PD activities over the two-year period. When this is not done, students are at a disadvantage.

Some PD exercises submitted for SBA were assessed for other skills as well. This suggests that the exercise was carried out and so cannot be moderated for PD skills. This places the students at a serious disadvantage.

While a general mark scheme can be written to assess all PD activities, teachers should ensure that it does indeed suit all the PD activities submitted. If not, each PD activity should have a separate mark scheme.

To assist in improving the standard of PD exercises, some ideas for possible PD activities adapted from Jacques (2006) are suggested below.

1. Comparison of homemade vinegar against store-bought vinegar.

2. Best solvent to remove ink stain from a shirt.

3. Comparison of the heat content of alcohols (how the number of carbon atoms in the alcohol affects the heat of combustion)

4. Which water source is best for rusting

5. Vitamin C content in different brands of Vitamin C tablets or fruit juices

6. Electroplating a coin: which would deposit greater amount of metal for a given quantity of electricity — univalent or divalent metal ion. Please note that items like leather belts or sandals should not be used here.

7. Acidity in green-skinned fruits compared to ripened fruits

8. Comparison of different brands of baking powder

9. Comparison to determine if different brands of black marker contain the same ink

10. Comparison of a recently discovered fuel with gasoline (existing fuels)

11. Comparison of hardness of water using soap

12. Comparison of melting point of pure and impure substances, for example, pure stearic acid and stearic acid with a small amount of glucose added

13. Eating peanuts from Brand A makes one thirstier than eating peanuts from Brand B

Please find below more detailed information as examples for number 4 and number11.

4. – Scenario:

Mrs. Jones and Mrs. Thompson both bought steel burglar bars for their homes. Mrs. Jones lives near the beach while Mrs. Thompson lives inland. Three years later Mrs. Jones's bars have more rust than Mrs. Thompson's. Mrs. Jones believes that the rust is due to the exposure of the burglar bars to water from the sea. Plan and design an experiment to determine whether sea water accelerates rusting in steel.

Hypothesis:

Iron rusts faster when exposed to salt water than fresh water.

Aim:

To investigate the effect of salt water as opposed to fresh water on iron by measuring the mass of iron produced.

Variables:

Manipulated – types of water

Controlled – volumes of water used and the time exposed to air

Responding – mass of rust

11. – Scenario

Debbie went in Dominica and while washing clothes she realized that she used less soap than when washing in Barbados. Plan and design an experiment to explain this observation.

Possible hypotheses:

1. The water in Dominica is softer than the water in Barbados

2. The water in Barbados contains more calcium and magnesium ions than the water in Dominica.

Possible Aim:

To determine which water contains more calcium and magnesium by ionic precipitation

Variables:

Manipulated – types of water

Controlled – type of detergent, volume of water

Responding – the mass of precipitate formed”