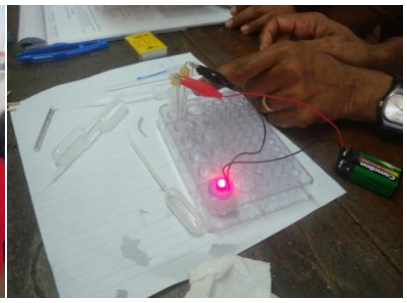
Microscience Manual

Chemistry Students' Manual

(DRAFT)

First Guyana Version Adaptation of Teaching and Learning Materials on Microscience Experiments

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Educational, Scientific and
Cultural Organization

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The Ministry of Education wishes to acknowledge the team of participants in the consultations for the selection of the Microscience Experiments relevant to the national curriculum for Biology, Chemistry and Physics.

Participants

Name	Institution
Mr. Gregory Blyden	Faculty of Natural Sciences - University of Guyana
Mr. Mohandatt Goolsarran	Ministry of Education - NCERD
Mr. Navindra Hardyal	Queens College
Mr. Sirpaul Jaikishun	Faculty of Natural Sciences - University of Guyana
Ms. Petal Jetoo	Ministry of Education - NCERD
Ms. Noella Joseph	Cyril Potter College of Education
Ms. Samantha Joseph	Faculty of Natural Sciences - University of Guyana
Mr. Azad Khan	School of Education and Humanities - University of Guyana
Mr. Patrick Ketwaru	Faculty of Natural Sciences - University of Guyana
Professor Lloyd Kunar	Physics Department - University of Guyana
Mr. Marvin Lee	Queens College
Mr. Andrew Mancey	School of the Nations
Mr. Gary Mendonca	Faculty of Natural Sciences – University of Guyana
M. Kamini Ramrattan	Richard Ishmael Secondary School
Ms. Wendel Roberts	Ministry of Education – NCERD
Ms. Medeba Uzzi	Faculty of Natural Sciences – University of Guyana

Introduction to the first Guyana version adaptation of UNESCO teaching and learning materials on micro science experiments

The contents of this document are recommended by the participants of UNESCO/Kingston/Ministry of Education, NCERD consultations on Micro-Science Experiments held in Georgetown (Guyana) on 27-30 June, 2011. The present materials correspond fully to the existing National Curriculum for teaching basic sciences at the different levels. The materials were selected by the participants of the working consultations. The participants worked with teaching and learning packages on microscience experiments which are available on UNESCO's website and are free for all types of adaptations and modifications. The different types of microscience kits donated by UNESCO/Kingston Office to Guyana can be used in practical classes. The experiments are classified according to grades and some were given first priority (refer to appendix 1). The 'priority one' experiments are recommended for the pilot of the microscience experiments. It is very clear that, new experiments can be developed and tested using the same kit, as proposed by the participants of the working consultations which included curriculum development specialists. Developing new materials can be recommended, as a second stage of the project development. It is noted that the microscience experiments, as a new methodology for hands on laboratory work by students, can work in conjunction with macroscience experiments. Furthermore the microscience kits can be used by teachers for demonstration purposes. We hope, that the Science Teachers in Guyana will find the microscience experiments methodology and teaching and learning materials, interesting and of great value for the enhancement of science education.

Participants of the working consultations

May 2012

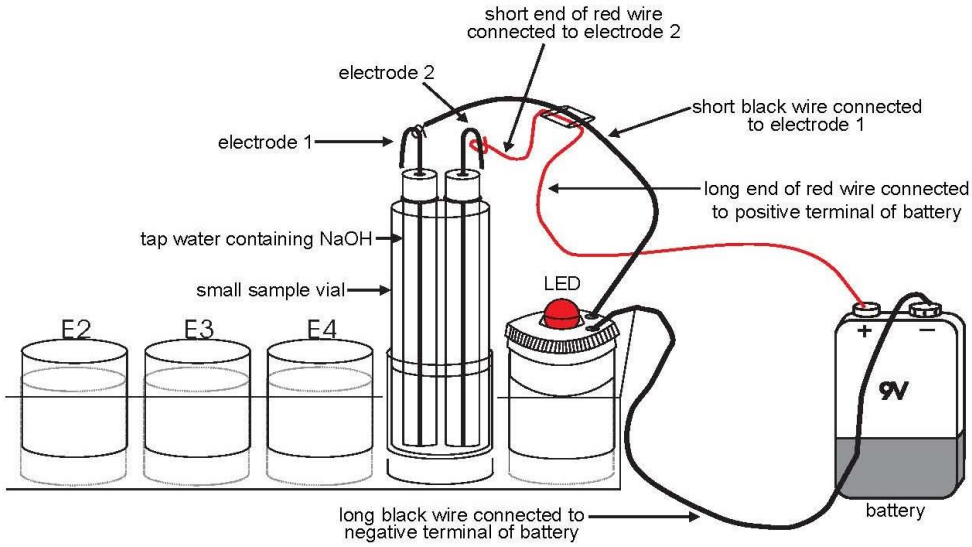
EXPERIMENT 1 – ELECTROYSIS OF WATER

CSEC OBJECTIVE: 6.24 – 6.25

6.24 – Predict the electrode to which an ion will drift

6.25 – Discuss electrolysis of certain substances

Grade Level - 10

Note	**REQUIREMENTS** **Apparatus:** 1 x 9 V heavy duty battery (or 2 x 1.5 V cells); 1 x comboplate®; 1 x current indicator (LED) with wire connections; 2 x drinking straw electrodes; 1 x plastic microspatula; 1 x small sample vial; 1 x microburner; 1 x box of matches; 1 x thin stemmed propette; 2 x red coated copper wires (with exposed ends); 1 x black coated copper wire (with exposed ends). **Chemicals:** Sodium hydroxide pellets (NaOH(s)); Tap water. **Sodium hydroxide will be added to tap water in this experiment to increase the conductivity of the tap water.**
	
	PROCEDURE 1. Push the current indicator into well E6 of the comboplate®. 2. Mark each of the drinking straw electrodes into 1 cm units using a permanent marker pen. Let one of the electrodes be called electrode 1 and the other electrode 2. 3. Remove the lid from the small sample vial and fill half of the vial with tap water. Place the vial into well E5 next to the current indicator in well E6. 4. Use the plastic microspatula to place 1 pellet of sodium hydroxide into the small sample vial and stir until it has dissolved. Use an empty propette to suck up some of the solution from the vial. 5. Hold electrode 1 with the open end upwards and fill the electrode completely with the water from the propette. 6. Quickly turn electrode 1 the other way up and place it into the water in the small

	sample vial. Repeat this procedure for electrode 2. Return any remaining solution in the propette to the small sample vial. **Use tap water to thoroughly rinse your fingers free of the sodium hydroxide solution.** 7. Connect the end of the long black wire from the current indicator to the negative (-) terminal of the battery. Connect the end of the short black wire to electrode 1. *8.* Connect the one end of the red wire to the positive (+) terminal of the battery. Connect the other end of the red wire to electrode 2. *(See Question 1)* *9.* Disconnect the current indicator from the circuit. Reconnect electrode 1 directly to the negative (-) terminal of the battery with the loose red wire supplied. *(See Question 3)* 10. Let the substance produced in electrode 1 be called substance A. Let the substance produced in electrode 2 be called substance B. **(Periodically tap each electrode with your finger, to dislodge substances A and B which may build up in localised areas.)** *11.* When electrode 1 is full of substance A (at the end of the last pen marking on the electrode), disconnect the battery from the circuit. This may take approximately 10 minutes (or longer if you are using two 1.5 V cells). *(See Question 4)* 12. Light the microburner. Carefully remove electrode 1 from the water, sealing the open end with your finger when it is out of the water. Bring electrode 1 very close to the flame of the microburner. **Do not burn yourself or the straw!** *13.* Remove your finger from the opening, allowing substance A to escape. **When you have observed what happens, thoroughly rinse your fingers with tap water.** *(See Question 5)* **Rinse the vial out with clean water.**
	QUESTIONS Q 1. What effect is there on the current indicator when the battery is connected to the electrodes ? Q 2. What is the reason for your observation in question 1 ? Q 3. What do you observe at the different electrodes ? Q 4. When electrode 1 is full of substance A, how much of substance B is there in electrode 2 ? Q 5. What happens when substance A is exposed to the flame ? Q 6. What is the name given to substance A ? Q 7. What is the name of substance B ? Q 8. What test would you do to prove substance B is what you say it is ? Q 9. Why was a greater volume of substance A produced than of substance B ? Q10. Write a summary of what happens when water is electrolysed. Q11. From question 10, would you say that tap water is a compound, an element or a mixture? Explain your answer.

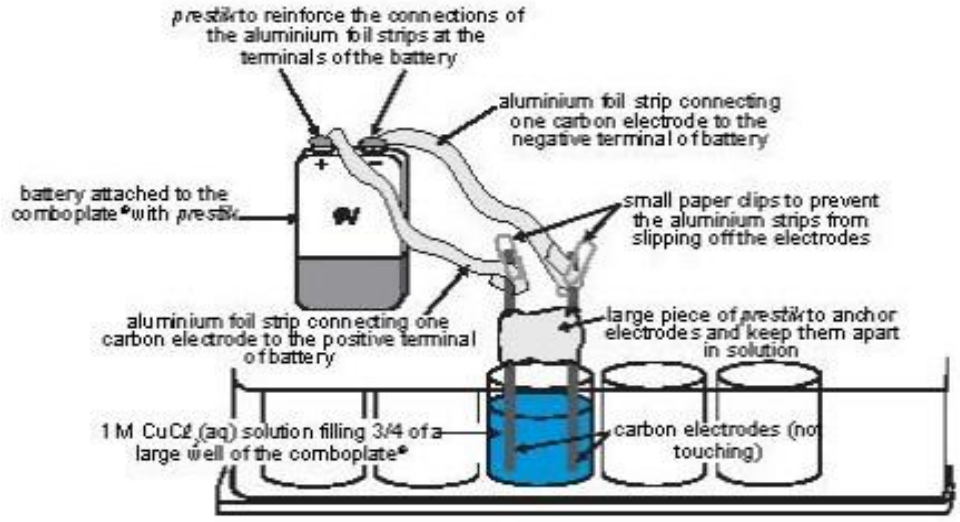
EXPERIMENT 2 - THE ELECTROLYSIS OF A COPPER (II) CHLORIDE SOLUTION

CSEC OBJECTIVE: 6.24 – 6.25

6.24 – Predict the electrode to which an ion will drift

6.25 – Discuss electrolysis of certain substances

Grade Level - 10

...	**REQUIREMENTS** **Apparatus:** 1 x comboplate®; 1 x 9V battery; 2 x strips aluminium foil - 3 cm x 15 cm (or 2 x connecting wires with crocodile clips); 1 x graphite pencil or 2 x graphite rods (approximately 2 mm x 5 cm); 2 x plastic coated paper clips (optional); *prestik*. **Chemicals:** Copper(II) chloride solution ($CuCl_2(aq)$) [1 M]; Indicator paper; Tap water.
	
	PROCEDURE 1. Use a piece of *prestik* to stick the 9V battery to the comboplate®. This will prevent the battery moving around during the experiment so that the aluminium foil connectors are not pulled away from the electrodes. 2. Break open the pencil carefully and remove the graphite/carbon rod. Make two carbon electrodes by breaking or cutting the rod into two shorter pieces of approximately 5 cm each in length. Alternatively, ready-made carbon rods can be used. 3. Push one of the carbon electrodes into a large piece of prestik. Push the other electrode into the same piece of *prestik*. Make sure that the electrodes are far apart from one another so that they do not touch when placed into the copper chloride solution. 4. Use a clean propette to fill about ¾ of one of the large wells of the comboplate® with the 1 M copper(II) chloride solution. 5. Place the carbon electrodes in the solution as shown in the diagram above. The electrodes do not need to be held in the upright position. They can be rested at an angle against the wall of the large well. 6. Fold one of the strips of aluminium foil about three times to form a narrow but

	sturdy connector as shown in the diagram above. Fold the other aluminium foil strip in the same way. 7. Attach each one of the aluminium foil connectors to separate terminals of the battery. *Prestik* can be used to reinforce the connections to the battery. Alternatively, small crocodile clips can be used to make sure that the foil strips are properly connected to the battery terminals. 8. Connect the battery to the electrodes by attaching the aluminium foil strips from the terminals of the battery to separate carbon electrodes, as shown in the diagram. (*See Question 1*)
Note	Small, plastic-coated paper clips can be used to attach the ends of each foil strip to the electrodes. This helps to prevent the foil from slipping off the electrodes during electrolysis.
	9. After about one or two minutes, lift the comboplate® gently upwards towards your chin. (*See Question 2*)
CAUTION	**Do not inhale the fumes directly!**
	10. Moisten a small piece of indicator paper (either litmus or universal indicator paper in the kit) with tap water. 11. Hold one corner of the paper at the electrode where there is bubbling taking place. (*See Question 3*) 12. Look closely at the other electrode in the solution and observe any changes taking place. (*See Question 4*) 13. Allow the electrolysis to continue for another 5 to 10 minutes. Disconnect the foil from the electrode where no bubbling was observed. 14. Lift the electrode out of the copper (II) chloride solution and examine its appearance. (*See Question 5*) **Clean all apparatus thoroughly.**
	QUESTIONS Q1. What do you notice as soon as the battery has been connected to the electrodes? Q2. Describe the odour coming from the well. Q3. What happens to the section of the litmus paper that is held close to the electrode at which bubbling takes place? Is this electrode connected to the positive or negative terminal of the battery? Q4. Describe the change in appearance of the other electrode (i.e the electrode where no bubbling occurs). Is this electrode connected to the positive or negative terminal of the battery? Q5. What has happened to the electrode after the electrolysis of the copper(II) chloride solution has been allowed to continue for 5 to 10 more minutes? Q6. What was happening at the electrode where you saw bubbling taking place? Use your answers to Questions 2 and 3 to support your explanation. Q7. What was happening at the electrode where no bubbles were observed? Q8. Describe the appearance of the copper(II) chloride solution before electrolysis took place. Do the products formed at each electrode have the same properties as the original solution? Explain your answer by referring to observations made during the experiment. Q9. From your answer to Question 8, describe the effect of an electric current on a copper(II) chloride solution. Q10. The carbon rods or electrodes are required for carrying current into and out of the copper(II) chloride solution. Each electrode has a special name. The electrode

	connected to the positive terminal of the battery is called the anode, while the electrode connected to the negative terminal of the battery is called the cathode. i. At which electrode did chlorine gas form? (See your answer to Question 3) ii. At which electrode did copper metal deposit? (See your answer to Question 4) Q11. An electric current can only flow if the solution contains charged particles that are able to move through the solution. Write down the formulae of the charged particles which exist in a copper(II) chloride solution. Name the charged particles. Q12. Recall what you observed at the anode. Which charged particles in the copper(II) chloride solution moved towards the anode? Q13. Which charged particles moved towards the cathode? Explain by referring to the product you observed at this electrode. Q14. Write down a balanced equation to show the reaction taking place in the well during electrolysis. What type of reaction is this? Explain your answer with reference to the observations made at each electrode. Q15. What kind of half-reaction occurs at the anode? Write an equation for this half-reaction. (See your answers to Q10i and Q14) Q16. What kind of half-reaction occurs at the cathode? Write an equation for this half-reaction. (See your answers to Q10ii and Q14)

EXPERIMENT 3 - THE REACTION OF COPPER WITH OXYGEN

CSEC OBJECTIVE: Section B2. - 4.1
4.1 Discuss the reactivity of metals
Grade Level - 10

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 ml syringe; 1 x thin stemmed propette; 2 x plastic microspatulas; 1 x lid 1; 1 x lid 2; 1 x glass tube; 2 x silicone tubes (4 cm x 4 mm); 1 x microburner; 1 x box of matches.

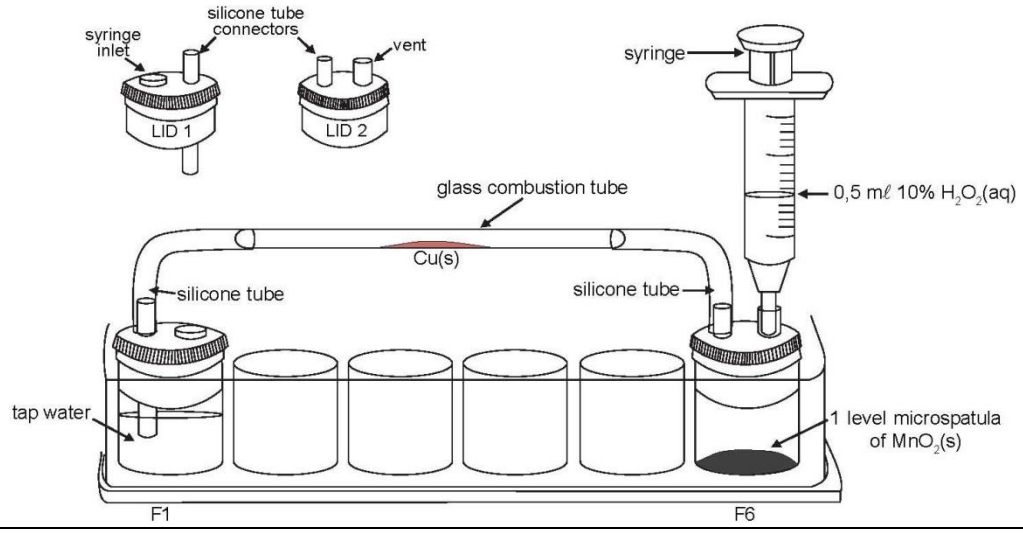
Chemicals: Manganese dioxide powder ($MnO_2(s)$); Fresh hydrogen peroxide solution ($H_2O_2(aq)$) [10 %]; Methylated spirits; Copper powder (Cu(s)); Tap water.

Note

The hydrogen peroxide solution should be fresh, otherwise the results will not be as described below.

CAUTION

The methylated spirits used in the microburner is poisonous. Do not inhale the vapour or drink the liquid. If any hydrogen peroxide is spilt on the skin, thoroughly rinse the affected area with water.



PROCEDURE

1. Add 1 level spatula of manganese dioxide powder into well F6, using the spooned end of a microspatula.
2. Fill ¾ of well F1 with tap water. Seal well F1 with lid 2, making sure the vent hole faces inwards. Seal well F6 with lid 1.
3. Connect one silicone tube to the tube connector on lid 1. Connect the other silicone tube to the tube connector on lid 2.
4. Hold the glass tube in a horizontal position. Use the narrow end of a clean microspatula to place a small quantity of copper powder in the centre of the glass tube. *(See Question 1)*
5. Keep the glass tube in a horizontal position and attach one end to the silicone tube on lid 1. Connect the other end to the silicone tube on lid 2.

Note	**Keep the glass tube horizontal at all times otherwise the copper powder might spill into well F6.** 6. Fill the syringe with 0,5 ml of 10% H_2O_2(aq). Fit the nozzle of the syringe into the syringe inlet on lid 1 in well F6. 7. Light the microburner and place it on one side away from the comboplate®. *8.* Add the 0,5 ml of H_2O_2(aq) very slowly from the syringe into well F6. *(See Question 2)* *9.* When a few bubbles have come through the water in well F1, bring the flame of the microburner to the middle of the glass tube where the copper powder has been placed. Observe what happens in the glass tube while heating. *(See Question 4)*
Note	**Keep the flame of the microburner directly beneath the copper in the tube. Do not move the microburner from side to side.** 10. Stop heating the copper after 5 minutes, or after the copper has changed in appearance. Blow out the microburner flame. 11. If you see water being sucked back from well F1 into the glass tube, disconnect lid 2 from well F1. **Thoroughly clean the comboplate® as manganese dioxide leaves a residue in the well.**
	QUESTIONS Q1. Describe the appearance of the copper powder. Q2. What happens when 10% hydrogen peroxide solution is added to well F6 ? Q3. Why was it necessary to wait for the first few bubbles to come through before heating the glass tube ? Q4. What is happening to the copper powder during heating ? Describe any other changes in the glass tube. Q5. From your observations of the powder in the glass tube, would you say a chemical reaction occurred ? Explain your answer. Q6. What product is formed when copper burns in oxygen ? Q7. Write a word equation for the combustion of copper in oxygen. Q8. Write a balanced chemical equation for the combustion of copper in oxygen. Q9. How would you try to prove that the product formed in this experiment is indeed copper(II) oxide ? Suggest an experimental set-up to perform this experiment.

EXPERIMENT 4 – THE REACTION OF SULPUR WITH OXYGEN

CSEC OBJECTIVE: Section B2. - 3.1

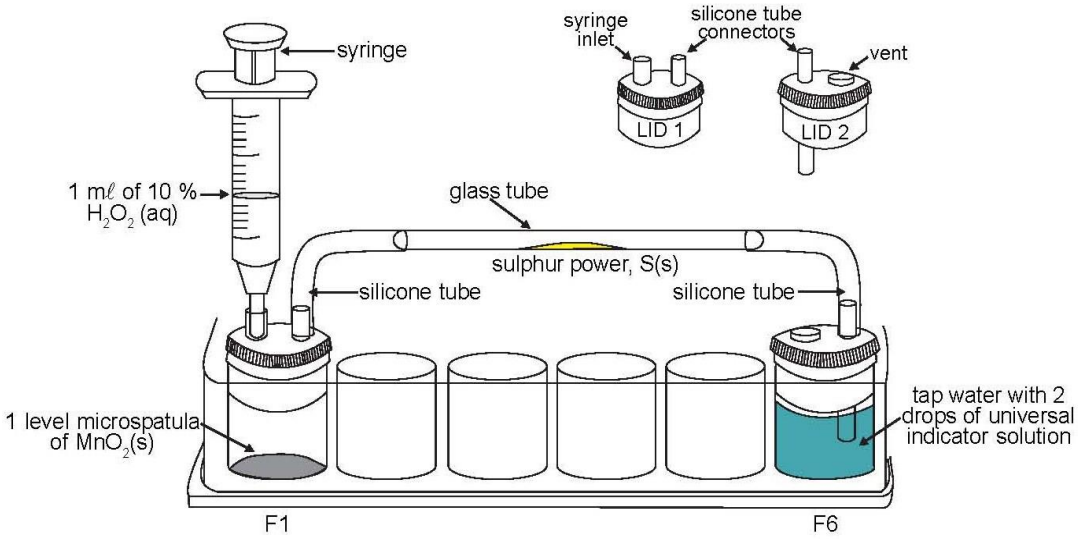
3.1 Describe the physical and chemical properties of non-metals

Grade Level - 10

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x syringe; 1 x lid 1; 1 x lid 2; 2 x plastic microspatulas; 2 x silicone tubes (4 cm x 4 mm); 1 x glass combustion tube; 2 x propettes; 1 x microburner.

Chemicals: Manganese dioxide powder ($MnO_2(s)$); Fresh hydrogen peroxide solution ($H_2O_2(aq)$)[10 %]; Universal indicator solution; Sulphur powder (S(s)); Methylated spirits; Tap water.



PROCEDURE

1. Use the spooned end of a plastic microspatula to place one level spatula of manganese dioxide powder into well F1.
2. Fill ¾ of well F6 with tap water using a propette.
3. Use another propette to place 2 drops of the universal indicator solution into the tap water in F6. (*See Question 1*)
4. Push lid 1 securely into well F1. Attach one of the silicone tubes to the tube connector on the lid as shown in the diagram.
5. Push lid 2 securely into well F6. Make sure that the vent in the lid faces inwards.
6. Attach the other silicone tube to the tube connector on lid 2 as shown in the diagram.
7. Fill the syringe with 1 ml of the 10% hydrogen peroxide solution.
8. Fit the syringe into the syringe inlet on lid 1 in well F1.
9. Hold the glass tube in a horizontal position. Use the narrow end of a clean

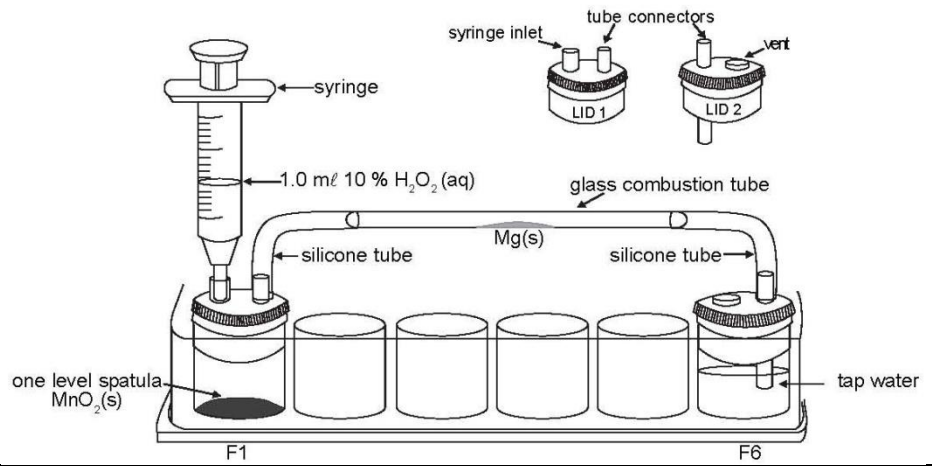
	microspatula to place a small quantity of sulphur powder in the centre of the glass tube. 10. Keep the glass tube in a horizontal position and attach one end of the glass tube to the silicone tube on lid 1. Connect the other end of the glass tube to the silicone tube on lid 2.
Note	**Do not move well F1.** 11. Light the microburner and move it away from the comboplate®. 12. Slowly add about 0,4 ml of the 10% H_2O_2(aq) from the syringe into well F1. Wait for a steady stream of bubbles to appear in the water in well F6, then begin heating the sulphur powder in the glass tube with the microburner. (*See Question 2*)
Note	**Keep the flame of the microburner directly beneath the sulphur in the tube. Do not move the flame from side to side.** 13. If the bubbles stop flowing in F6, add more of the H_2O_2(aq) dropwise to F1 while continuing to heat the sulphur. 14. After all the sulphur has burned, blow out the microburner flame. Hold the comboplate® up and wave your hand over well F6 towards your nose.
CAUTION	**Do not inhale the fumes directly!** (*See Question 3*) 15. If you see water being sucked back from F6 into the glass tube, disconnect lid 2 from F6. **Clean all apparatus thoroughly.**
	QUESTIONS Q1 Write down the colour of the indicator in the tap water. Describe the water as acidic, basic or neutral. Q2. What do you observe in the glass tube while heating the sulphur ? Q3. Describe the smell that comes from the vent in well F6. Q4. What is the colour of the indicator solution in well F6 after the experiment ? Q5. Why did the indicator change colour ? Q6. Write a word equation for the combustion of sulphur in oxygen. Q7. Some carbon fuels, such as coal, contain sulphur as an impurity. When these fuels burn they form sulphur dioxide. Using the observations in the above experiment with the universal indicator, explain how the burning of sulphur in the environment can contribute to the problem of acid rain.

EXPERIMENT 5 – THE REACTION OF MAGNESIUM WITH OXYGEN

CSEC OBJECTIVE - Section B.2 , 1.1

1.1 Describe the physical and chemical properties of metals

Grade Level - 10

Note	**REQUIREMENTS** **Apparatus:** 1 x comboplate®; 1 x 2 ml syringe; 1 x thin stemmed propette; 2 x plastic microspatulas; 1 x lid 1; 1 x lid 2; 1 x glass tube; 2 x silicone tubes (4 cm x 4 mm); 1 x microburner; 1 x box of matches. **Chemicals:** Manganese dioxide powder ($MnO_2(s)$); Fresh hydrogen peroxide solution ($H_2O_2(aq)$) [10 %]; Methylated spirits; Universal indicator solution; Magnesium powder (Mg(s)); Tap water. **The hydrogen peroxide solution should be fresh, otherwise the results will not be as described below.**
	
Note	**PROCEDURE** 1. Use the spooned end of a plastic microspatula to place one level spatula of manganese dioxide powder into well F1. 2. Push lid 1 securely into well F1. Attach one of the silicone tubes to the tube connector on the lid. 3. Fill ¾ of well F6 with tap water using a propette. 4. Push lid 2 securely into well F6. Make sure that the vent in the lid faces inwards. Attach the other silicone tube to the tube connector on lid 2. 5. Fill the syringe with 1 ml of the 10% hydrogen peroxide solution. Fit the syringe into the syringe inlet on lid 1 in well F1. 6. Hold the glass tube in a horizontal position. Use the narrow end of a clean microspatula to place a small quantity of magnesium powder in the centre of the glass tube. *7.* Keep the glass tube in a horizontal position and attach one end to the silicone tube on lid 1. Connect the other end to the silicone tube on lid 2. *(See Question 1)* **Do not move the glass tube from the horizontal position as some of the magnesium powder may fall into well F1.**

Note	8. Light the microburner and place it on one side. 9. Slowly add about 0,4 ml of the 10% H_2O_2(aq) from the syringe into well F1. Wait for a steady stream of bubbles to appear in the water in well F6, then begin heating the magnesium powder in the glass tube with the microburner. **Keep the flame of the microburner directly beneath the magnesium in the tube. Do not move the microburner from side to side.** *10.* When the bubbles stop flowing in well F6, add the rest of the H_2O_2(aq) very slowly to well F1 while continuing to heat the magnesium. Observe what happens in the glass tube while heating. *(See Question 2)* 11. After the magnesium has changed in appearance, blow out the microburner flame. 12. If you see water being sucked back from well F6 into the glass tube, disconnect lid 2 from well F6. 13. When the glass tube has cooled, remove it from the set-up. Tap the tube gently in well E3 to dislodge as much of the solid product in the tube as possible. 14. Add 10 drops of water to well E3 and stir the solid vigorously in the water. *15.* Use a clean propette to add one drop of universal indicator solution to well E3. *(See Question 4)* 16. Leave the comboplate® to stand for about 5 – 7 minutes. Observe the colour of the indicator in well E3 after this time. **Rinse the comboplate® and shake dry.** **Rinse the glass tube and scrape out any remaining residue with a toothpick.**
	QUESTIONS Q1. Describe the appearance of the magnesium powder. Q2. What did you observe in the glass tube while heating the magnesium in oxygen ? Q3. What do you see inside the glass tube after heating ? (Note: it is usual for a black residue to form at the bottom of the glass tube where the microburner was held, but this is not part of the product.) Q4. What is the colour of the universal indicator solution in well E3 ? Q5. What is the colour of the indicator solution in well E3 after about 5 minutes ? Q6. Is the solution of the product acidic or basic ? Q7. What product is formed when magnesium burns in oxygen ? Q8. Why did the indicator in well E3 change colour ? Q9. Write a word equation for the combustion of magnesium in oxygen. Q10. Write a balanced chemical equation for the combustion of magnesium in oxygen.

EXPERIMENT 6 – DECOMPOSITION OF COPPER CARBONATE

CSEC OBJECTIVE Section B.2 - 1.2

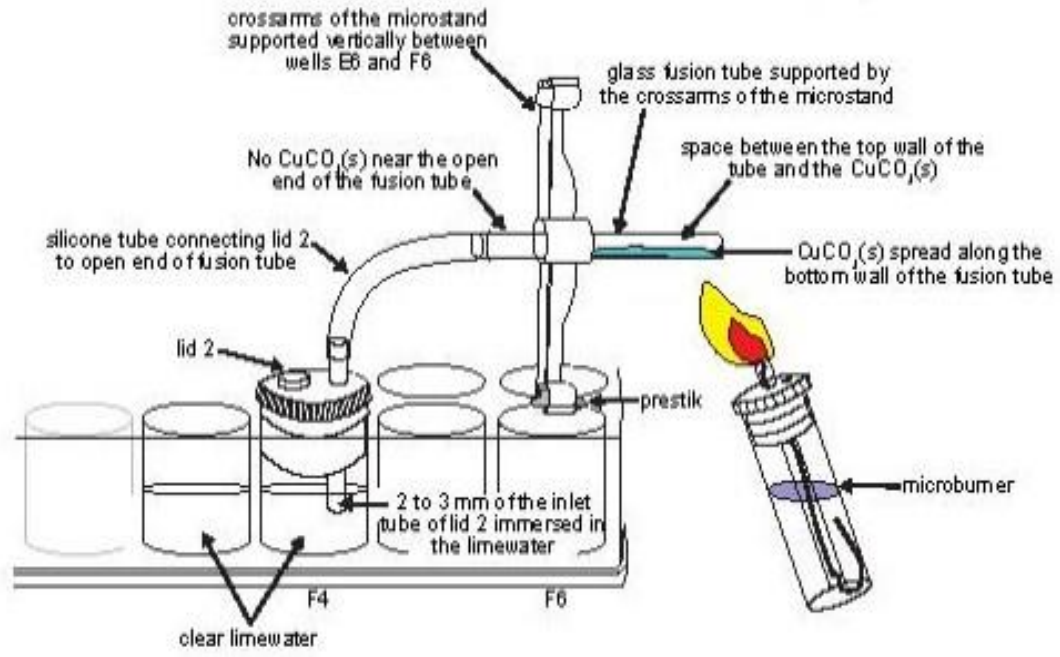
1.2 Describe the reactions of metal oxides, hydroxides, nitrates and carbonates

Grade Level - 10

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x glass fusion tube; 1 x silicone tube; 1 x crossarms for the microstand; 1 x plastic microspatula; 2 x propette; 1 x lid 2; 1 x microburner; small piece of prestik.

Chemicals: Copper(II) carbonate powder ($CuCO_3(s)$); Clear limewater; Sulphuric acid $H_2SO_4(aq)$) [1 M].



PROCEDURE

1. Hold the fusion tube in a horizontal position. Use the narrow end of a plastic microspatula to fill about ½ of the fusion tube with copper(II) carbonate powder.
2. Keep the tube in the horizontal position and gently tap the sealed end of the fusion tube so as to spread the powder on the floor of the tube, taking care not to spread the powder all the way to the open end of the fusion tube.
   Leave about 5 mm from the open end of the tube free of copper carbonate powder as shown in the diagram above. *(See Question 1)*
3. Place a level microspatula of the $CuCO_3(s)$ powder into well A1. Add 1 drop of 1 M sulphuric acid to the powder. *(See Question 2)*
4. Use a clean propette to half fill well F4 of the comboplate® with limewater. Make sure that the limewater is clear.
5. Fit lid 2 into well F4. Make sure that about 2 to 3 mm of the tip of the inlet tube of the lid is immersed in the limewater in well F4. (If not, add more limewater.)
6. Examine the diagram above carefully and set up all apparatus as shown, except the

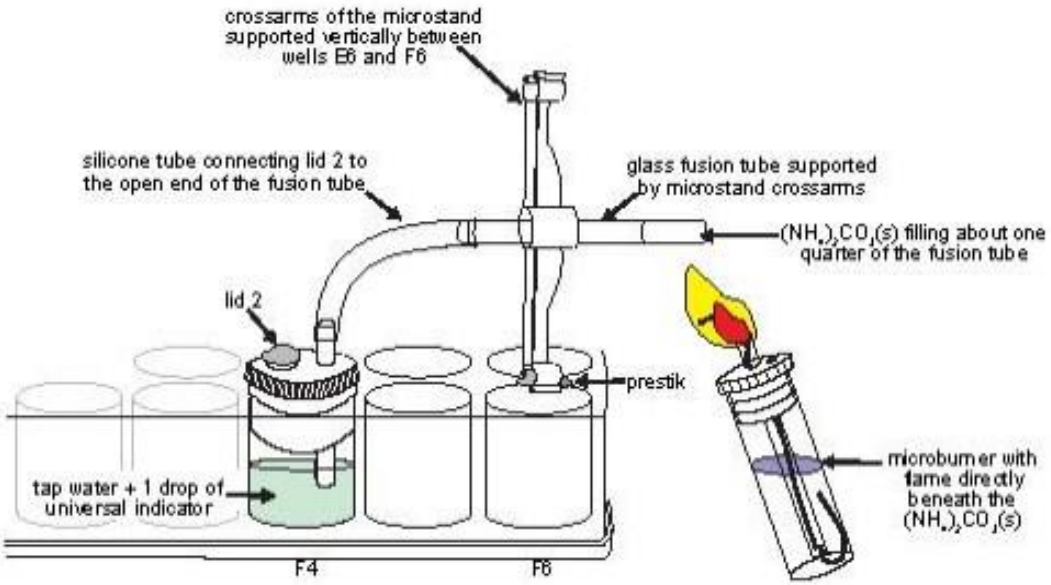
Note Note	microburner. 7. Light the microburner. Hold the flame beneath the fusion tube and start heating, waving the flame gently below the CuCO3(s). **Avoid the $CuCO_3$ moving into the silicone tube by ensuring that there is space between the top wall of the fusion tube and the $CuCO_3$(s) powder (as shown in the diagram). Be careful when heating and stop heating if $CuCO_3$(s) powder moves towards the mouth of the fusion tube. Tap the $CuCO_3$(s) back towards the closed end gently.** 8. Continue heating this way during the next steps. *(See Question 3)* 9. Continue heating until there are no more bubbles coming out in well F4. *(See Question 4)* 10. Discontinue heating and wait for the fusion tube to cool. **The limewater will rise up the silicone tube as cooling takes place. Allow this to happen. However, make sure that the liquid does not get into the fusion tube by disconnecting the fusion tube from the silicone tube as soon as the liquid is close to the mouth of the fusion tube.** 11. Allow the liquid in the silicone tube to go back into well F4. *(See Question 5)* 12. When the fusion tube has cooled, tap some of the remaining solid into well A2 and add a drop of 1 M sulphuric acid. *(See Question 7)* **Clean all apparatus thoroughly.**
	QUESTIONS Q1. What colour is $CuCO_3$(s)? Q2. What happens in well A1? Explain your observation. Q3. What do you observe in well F4? Q4. What colour is the solid remaining in the fusion tube? Q5. What happens in well F4? Q6. What is responsible for your observation in well F4? Q7. What happens in well A2? Q8. What is the name of the solid remaining in the fusion tube after heating? Q9. Explain why your observation in Q7 is different from your observation in Q2. Q10. Write a word equation for the reaction that took place in this experiment. Beneath each substance write the colour. Q11. Write a chemical formula equation for the reaction in Q10 above.

EXPERIMENT 7 – DECOMPOSITION OF AMMONIUM CARBONATE

CSEC OBJECTIVE Section B.2 - 1.2

1.2 Describe the reactions of metal oxides, hydroxides, nitrates and carbonates

Grade Level - 10

	REQUIREMENTS **Apparatus:** 1 x comboplate®; 1 x glass fusion tube; 1 x silicone tube; 1 x crossarms for the microstand; 1 x plastic microspatula; 1 x propette; 1 x lid 2; 1 x microburner; small piece of prestik. **Chemicals:** Ammonium carbonate crystals ($(NH_4)_2CO_3(s)$); Universal indicator solution; Tap water.
	
Note	**PROCEDURE** 1. Hold the fusion tube in a horizontal position. Use the narrow end of the microspatula to carefully fill about ¼ of the fusion tube with ammonium carbonate crystals. Tap the sealed end of the tube to make the crystals fall to the bottom of the tube. **The ammonium carbonate crystals are big and sticky, handle them with care.** 2. Use a clean propette to fill half of well F4 with tap water. Add a drop of universal indicator solution to the water in well F4. *(See Questions 1, 2)* 3. Examine the diagram above carefully and set up all apparatus, except the microburner. 4. Light the microburner. Hold the flame beneath the $(NH_4)_2CO_3(s)$ in the fusion tube and start heating. *(See Questions 3,4)* 5. Continue heating until no more bubbles are produced in well F4. *(See Questions 5,*

	6) 6. Disconnect the apparatus. Cautiously smell the solution in well F4 and the open fusion tube. *(See Question 8)* **Clean all apparatus thoroughly.**
	QUESTIONS Q1. What colour is the universal indicator before adding it to the water? Q2. What colour is the universal indicator after adding it to the water? Q3. What happens in well F4 as heating is continued? Q4. What happens in the fusion tube as heating is continued? Q5. What colour is the mixture in well F4? Q6. Is the mixture in well F4 acidic or basic after heating? Q7. Why did the mixture in well F4 go basic? Q8. What do you smell? Q9. What remains in the fusion tube? Q10. Write a formula equation for the reaction in this experiment.

EXPERIMENT 8 – REDUCTION OF COPPER (II) OXIDE

Section A. Objective 6.15

6.15 Identify oxidation and reduction reactions including reactions at electrodes

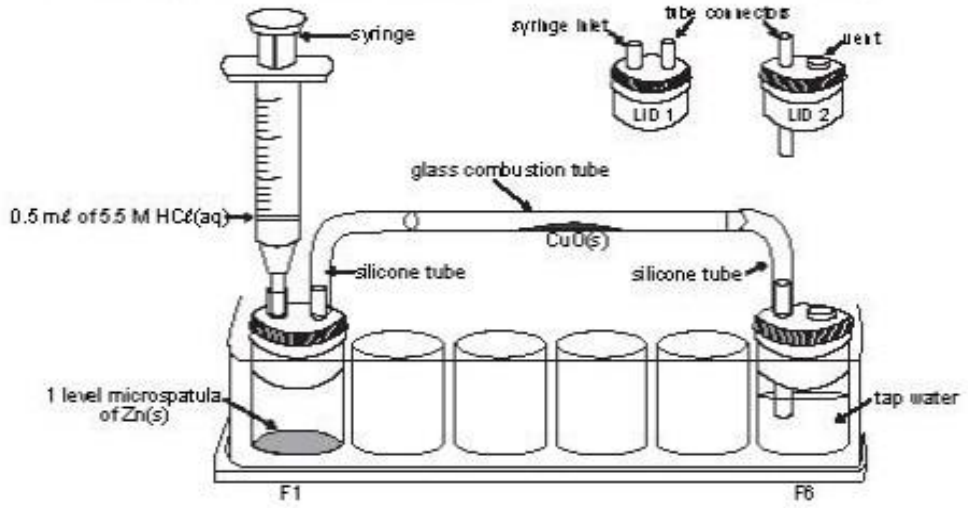
Grade Level - 10

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 ml syringe; 1 x glass tube (6 cm x 4 mm); 1 x lid 1; 1 x lid 2; 2 x plastic microspatulas; 1 x propette; 2 x silicone tubes (4 cm x 4 mm); 1 x microburner;
1 x box of matches.

Chemicals: Hydrochloric acid (HCl(aq)) [5.5 M]; Zinc powder (Zn(s)); Copper(II) oxide powder (CuO(s)); Methylated spirits.

1. **The methylated spirits used in the microburner is poisonous. Do not inhale the vapour or drink the liquid.**
2. **If any acid is spilt on the skin, thoroughly rinse the affected area with water.**



PROCEDURE

1. Use the spooned end of a clean microspatula to add one level spatula of zinc powder to well F1.
2. Half-fill well F6 with tap water from a propette.
3. Seal well F1 with lid 1. Seal well F6 with lid 2 so that the vent hole faces outwards.
4. Connect one end of a silicone tube to the tube connector on lid 1. Connect one end of the other silicone tube to the tube connector on lid 2.
5. Hold the glass tube in a horizontal position. Use the narrow end of a clean microspatula to place a small quantity of copper(II) oxide powder in the centre of the glass tube.
6. Keep the glass tube horizontal and attach one end to the silicone tube on lid 1. Connect the other end to the silicone tube on lid 2.

Keep the glass tube horizontal at all times otherwise the powder might spill into wells F1 or F6.

Note	7. Fill the syringe with 0.5 ml of 5.5 M HCl(aq). Fit the nozzle of the syringe into the syringe inlet on lid 1 in well F1. 8. Light the microburner and place it on one side away from the comboplate®. 9. Add the HCl(aq) very slowly from the syringe into well F1. *(See Question 1)* 10. When a few bubbles have come through the water in well F6, bring the flame of the microburner to the middle of the glass tube where the CuO(s) has been placed. Hold the microburner in this position. **Do not bring the flame of the microburner near the silicone tubes (as they will melt) or the vent of well F1 (as hydrogen is explosive).** 11. Stop heating the CuO(s) after about 2 minutes or after it has changed in appearance. Blow out the microburner flame. *(See Questions 3 and 4)* 12. If you see water being sucked back from well F6 into the glass tube, disconnect lid 2 from well F6. **Remove the glass tube from the set-up when it has cooled.** **Rinse the comboplate® and syringe thoroughly.**
	QUESTIONS Q1. What happens when 5.5 M HCl(aq) is added to well F1? Q2. Why was it necessary to wait for the first few bubbles to come through before heating the glass tube? Q3. What has happened to the CuO(s)? Q4. Describe any other changes in the glass tube. Q5. From your observations of the solid in the glass tube, would you say a chemical reaction occurred? Explain your answer. Q6. What do you think the products of this reaction are? Q7. Write down the equation for the chemical reaction in which hydrogen was formed, starting with Zn(s) and HCl(aq). Q8. How could we test if hydrogen gas (H2(g)) is really being produced? Q9. Write down the chemical equation for the reaction of copper oxide (CuO(s)) which you think occurred. Q10. Suggest how you could prove that water is a product of the reaction.

EXPERIMENT 9 – ACID/BASE TITRATION – AN INTRODUCTION

Section A. Objective 3.7

3.7 Use results from volumetric analysis to calculate:

(I) The number of reacting moles

(ii) the mole ratio in which reactant combine

Grade Level - 10

Note CAUTION	**REQUIREMENTS** **Apparatus:** 1 x plastic microspatula; 5 x thin stemmed propettes. **Chemicals:** Acid A [0.10 M]; Acid B [0.10 M]; Sodium hydroxide solution (NaOH(aq)) [0.10 M]; Methyl orange indicator; Tap water. **The microspatula should be cleaned before each use.** **If any acid or base is spilt on the skin, thoroughly rinse the affected area with water.**
	PROCEDURE 1. Add 5 drops of tap water into well A1. *2.* Add 1 drop of methyl orange indicator into well A1. *(See Question 1)* *3.* Repeat steps 1 and 2 above in well A2 using acid A instead of tap water. *(See Question 2)* 4. Add a sufficient number of drops of sodium hydroxide solution to well A2 to just cause the colour of the solution in well A1 to be the same as that in well A1. **Use the plastic microspatula to stir the solution after each drop of sodium hydroxide added.** Carefully count the number of drops of sodium hydroxide used. *(See Question 3)* *5.* Repeat the titration you did in well A2 two more times, in wells A3 and A4. *(See Question 3)* 6. Repeat steps 3 and 4 above in wells A5, A6 and A7, this time using acid B instead of acid A. *7.* Carefully count the number of drops of sodium hydroxide used. *(See Question 4)* **Rinse the comboplate® with tap water and shake dry.**
	QUESTIONS Q1. Note the colour of the solution in well A1. Q2. Note the colour of the solution in well A2. Q3. Prepare a table like Table 1 below, and enter the number of drops.

TABLE 1.

Acid Used	Number of Drops of Acid A	Number of Drops of NaOH	Average No. of Drops NaOH
A	5 5 5	_____ _____ _____	_____

Q4. Prepare a table like Table 2 below, and enter the number of drops.

TABLE 2.

Acid Used	Number of Drops of Acid B	Number of Drops of NaOH	Average No. of Drops of NaOH
B	5 5 5	_____ _____ _____	_____

Q5. What is the volume ratio of NaOH/acid A in the titration of 0.10 M acid A?

Q6. What is the volume ratio of NaOH/acid B in the titration of 0.10 M acid B?

Q7. Compare your answers to questions 5 and 6 above and then explain these results.

EXPERIMENT 10 – THE EFFECT OF DILUTE ACIDS AND BASES ON INDICATORS

CSEC OBJECTIVE Section A – 6.6

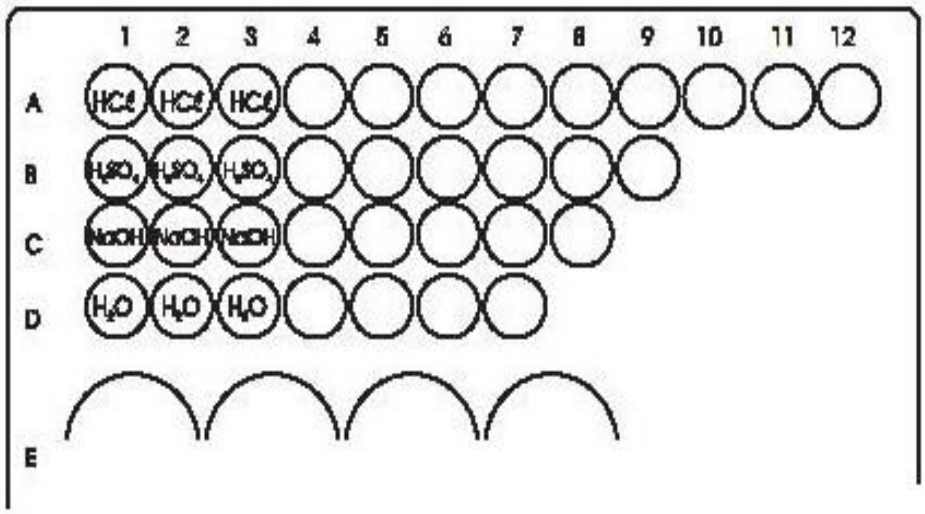
6.6 Relate acidity and alkalinity to the pH scale

Grade Level - 10

REQUIREMENTS

Apparatus: 1 x comboplate®; 6 x thin stemmed propettes; a sheet of white paper; pH indicator strip.

Chemicals: Hydrochloric acid (HCl(aq)) [1 M]; Sulphuric acid (H_2SO_4(aq)) [1 M]; Sodium hydroxide solution (NaOH(aq)) [1 M]; Tap water; Universal indicator solution; Methyl orange solution; Universal indicator paper.



PROCEDURE

1. Place the comboplate® on the sheet of white paper. *(See Question 1)*
2. Use a clean propette to place 10 drops of hydrochloric acid (1 M) in each of the wells A1, A2, and A3.
3. Use a clean propette to place 10 drops of sulphuric acid (1 M) in each of the wells B1, B2 and B3.
4. Use a clean propette to place 10 drops of sodium hydroxide solution (1 M) in each of the wells C1, C2 and C3.
5. Use a clean propette to place 10 drops of tap water in each of the wells D1, D2 and D3.
6. Use a clean propette to place 1 drop of universal indicator solution into each of the wells A1, B1, C1 and D1.*(See Question 2)*
7. Use a clean propette to place 1 drop of methyl orange solution into each of the wells A2, B2, C2 and D2.*(See Question 2)*
8. Tear two strips of universal indicator paper in half. Fold each half lengthwise, and place inside wells A3, B3, C3 and D3. *(See Questions 2, 3)*

Rinse the comboplate® and propettes with water.

QUESTIONS

Q1. Prepare a table like the one shown below.

Q2. Complete the table.

Table 1

	In HCl(aq)	In H_2SO_4 (aq)	In NaOH(aq)	In Tap Water
Colour of Universal Indicator				
Colour of Methyl Orange				
Colour of Universal Indicator Paper				

Q3. What did you see happen in this experiment?

Q4. Use the information on the pH indicator strip to classify the substances as "acidic", "neutral" or "alkaline".

Q5. Discuss in your group: What do the words "indicator" and "to indicate" mean in everyday use? Think of some everyday examples of where we use the words.

Q6. Discuss in your group: Based on the experiment you have completed, formulate a definition for an indicator.
An indicator is .....

EXPERIMENT 11 – REACTIONS WITH ACIDS AND SODIUM HYDROXIDE

CSEC OBJECTIVE Section A – 6.8

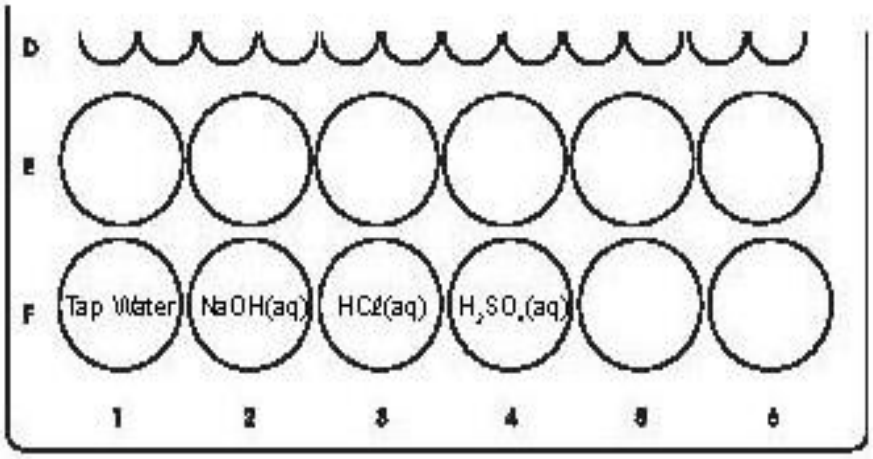
6.8 Investigate the reactions with non-oxidizing acids with:
(i) metals, (ii) carbonates, (iii) hydrogen carbonates (iv) bases

Grade Level - 10

REQUIREMENTS

Apparatus: 1 x comboplate®; 4 x propettes; 2 x plastic microspatulas; 1 x syringe; a sheet of white paper.

Chemicals: Hydrochloric acid (HCl(aq)) [0.1 M]; Sulphuric acid (H_2SO_4(aq)) [0.1 M]); Universal indicator solution;
Tap water; Sodium hydroxide solution (NaOH(aq)) [0.1 M].



PROCEDURE

1. Place the comboplate® on the sheet of white paper.
2. Use a clean dry propette and add tap water to well F1 to half-fill it. *(See Question 1)*
3. Use a clean dry propette and add 10 drops 0.1 M sodium hydroxide solution to F2.
4. Use a clean dry syringe and add 0,5 ml of 0.1 M hydrochloric acid to well F3.
5. Rinse the syringe in clean tap water and shake dry. Use the clean syringe to add 0,5 ml of 0.1 M sulphuric acid to well F4.
6. Use a clean dry propette and add 1 drop of universal indicator solution to wells F1, F2, F3 and F4.
7. Note the colour in the different wells. *(See Questions 2, 3, 4 and 5)*
8. Use a clean dry propette and add 1 drop of the sodium hydroxide (NaOH) solution to well F3. Stir the solution in well F3 with a microspatula. Keep adding the sodium hydroxide drop-by-drop and stirring between adding, until the colour of the solution in well F3 is close to that in well F1.
9. Repeat the same process in well F4: add the sodium hydroxide drop-by-drop to the sulphuric acid in well F4, stirring in between each drop, until the colour in well F4 is close to the colour in well F1. *(See Question 6)*

Clean all apparatus thoroughly.

	QUESTIONS Q1. What chemical substance is in well F1? Q2. What is the colour of the universal indicator in well F1? Q3. Use the pH indicator strip to explain the meaning of the colour of the solution in well F1. Q4. Write down the name of the chemical substance, the colour of the universal indicator, and the meaning of the colour in well F2. Q5. What was the colour of the indicator in the dilute sulphuric acid and hydrochloric acid in wells F3 and F4 before you started adding the sodium hydroxide solution? Use the pH indicator strip to explain the meaning of this colour. Q6. What happens when you add the sodium hydroxide to the acidic solutions? Q7. Explain in your own words what this means. Q8. A wasp sting injects an alkaline chemical into the skin. What household chemical could be used to relieve the pain from the wasp sting? Explain why. Q9. A solution of bicarbonate of soda brings some relief when it is applied to a bee sting on the skin. Explain why this is so. Q10. Why does "Milk of Magnesia" relieve indigestion?

EXPERIMENT 12 – PREPARATION OFA SALT: THE REACTION BETWEEN AN ACID AND A METAL CARBONATE

CSEC OBJECTIVES – Section A – 6.10 Section B 2 - 1.2

6.10 Identify an appropriate method of salt preparation based on the solubility of the salt

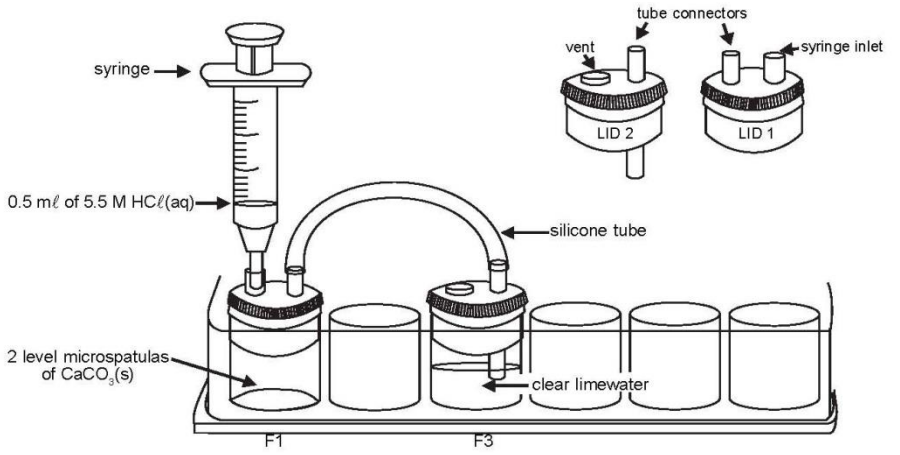
1.2 Describe the reactions of metallic oxides, hydroxides, nitrates and carbonates

Grade Level - 10

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x lid 1; 1 x lid 2; 1 x propette; 1 x plastic microspatula; 1 x 2 ml syringe; 1 x silicone tube (4 cm x 4 mm); 1 x microburner; 1 x glass rod; 1 x box of matches.

Chemicals: Hydrochloric acid (HCl(aq)) [5.5 M]; Calcium carbonate powder ($CaCO_3$(s)); Clear limewater ($Ca(OH)_2$(aq)); Methylated spirits.



PROCEDURE

1. Place 2 level microspatulas of calcium carbonate powder into well F1 of the comboplate®.
2. Cover well F1 with lid 1.
3. Use a clean dry propette and fill ¾ of well F3 with clear limewater.
4. Cover well F3 with lid 2.
5. Join well F1 to well F3 by connecting the silicone tube to the tube connectors on lids 1 and 2.
6. Fill the syringe with 0,5 ml of 5.5 M hydrochloric acid.
7. Fit the syringe into lid 1 on well F1.
8. Add the acid SLOWLY to well F1. *(See Questions 1 to 6)*
9. When the reaction in well F1 seems to have stopped, remove the syringe and silicone tube from lid 1. Remove lid 1 from well F1.
10. Set up the microburner. Light the burner.
11. Carefully heat the tip of the glass rod in the flame - move the tip in and out of the flame for a short while.
12. Heat the contents of well F1 by stirring well F1 with the hot end of the glass rod.
13. Repeat this heating process until the volume of the mixture in well F1 has been reduced by half.

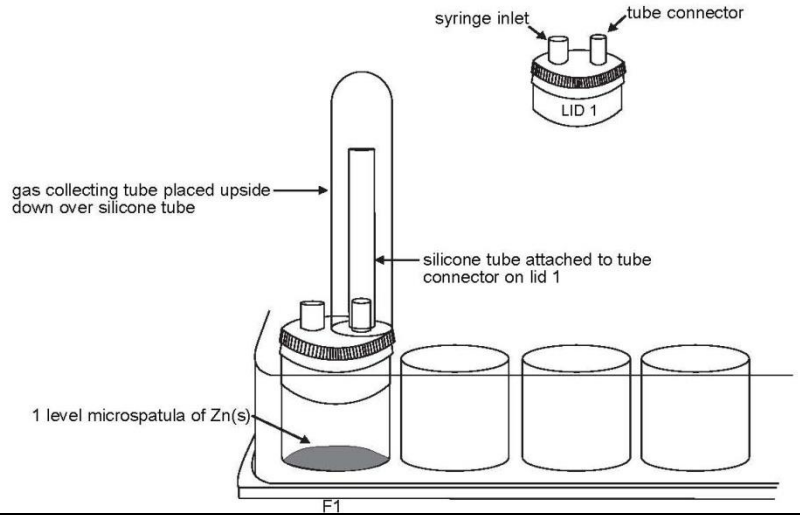
	14. Leave the mixture in well F1 overnight. *(See Question 7)* **Clean all apparatus thoroughly.**
	QUESTIONS Q1. What do you see happening in well F1 when you add the acid? Q2. What do you see happening in well F3 after a short while? Q3. What does this tell us about the gas that formed in the reaction in well F1? Read the following information carefully. Use this to answer Q4 - Q6. **Clear limewater is an aqueous solution of calcium hydroxide. When carbon dioxide reacts with the limewater, insoluble calcium carbonate and water are formed.** Q4. Write down a word equation for the reaction between carbon dioxide and limewater. Q5. Write down a balanced chemical equation for the reaction between carbon dioxide and limewater. Q6. Use the equation above to identify the substance that caused the clear limewater to become milky. Explain your answer. Q7. What do you notice in well F1 after leaving the comboplate® overnight? Q8. What is this substance in F1? Q9. The other product in this reaction evaporated when you heated the solution and left the comboplate® overnight. What could this possibly be? Q10. Write a word equation for the chemical reaction that took place in well F1. Q11. Write a balanced chemical equation for this reaction in well F1. Q12. Look at the name of the crystals that formed in this reaction. It is called a SALT. This salt was prepared by the reaction between an acid and a metal carbonate. What part of the name of the salt comes from the metal carbonate? Q13. What part of the name of the salt comes from the acid used in the reaction? Q14. What difference would it make if you had used nitric acid instead of hydrochloric acid in the reaction? Q15. What chemicals would you use to prepare sodium chloride from the reaction between an acid and a carbonate? Q16. Write a balanced chemical equation for the reaction in your answer to Q15. Q17. In this experiment you looked at the reaction between hydrochloric acid and calcium carbonate. Complete the general chemical equation: acid + metal carbonate →

EXPERIMENT 13 - PREPARATION OF A SALT: THE REACTION OF A METAL WITH AN ACID

CSEC OBJECTIVE – Section A – 6.10

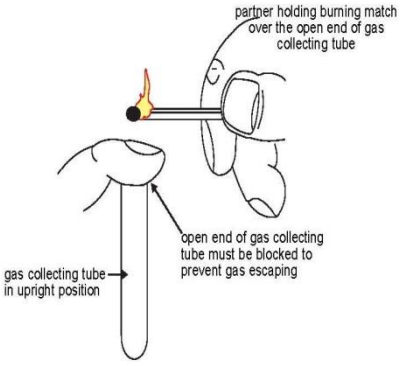
6.10 Identify an appropriate method of salt preparation based on the solubility of the salt

Grade Level - 10

	REQUIREMENTS **Apparatus:** 1 x comboplate®; 1 x lid 1; 1 x 2 ml syringe; 1 x gas collecting tube; 1 x silicone tube; 1 x plastic microspatula; 1 x box of matches. **Chemicals:** Hydrochloric acid (HCl(aq)) [5.5 M]; Zinc powder (Zn (s)); Tap water.
	

PROCEDURE

1. Place one level microspatula of zinc powder into well F1.
2. Place lid 1 on well F1. Make sure that the lid fits tightly onto the well.
3. Attach the silicone tube to the tube connector of lid 1 on well F1.
4. Place the gas collecting tube upside down over the silicone tube.
5. Fill the syringe with 0,5 ml of 5.5 M hydrochloric acid, and fit the syringe to the syringe inlet on lid 1 of well F1.
6. Slowly add 0,2 ml of the acid to the zinc in well F1. Wait for a short while until the reaction in well F1 subsides, and then slowly add the rest of the acid in the syringe. Wait for a few seconds. *(See Questions 1 to 5)*
7. Work with a partner: One person should carefully lift the gas collecting tube from the silicone tube. KEEP THE GAS COLLECTING TUBE UPSIDE DOWN. DO NOT TILT IT. Place the index finger of one hand over the open end of the gas collecting tube to seal it. Now turn the gas collecting tube the right way up, STILL KEEPING YOUR FINGER OVER THE OPEN END. Move the comboplate® well away from you and from any open flames.



8. Let the second person light a match, and hold it above the gas collecting tube (It should be fairly close to the top of the tube, but be careful not to burn your partner's finger!). Remove your finger from the open end of the gas collecting tube when the match is in place above the gas collecting tube. *(See Question 6)*
9. Place the comboplate® in the sun on a window sill and leave the mixture in well F1 overnight. *(See Question 10)*

Clean all apparatus thoroughly.

QUESTIONS

Q1. What happens in well F1 when the acid is added?
Q2. What does this tell us about one of the products of the reaction?
Q3. What, if anything, is in the gas collecting tube at the start of the experiment?
Q4. What, if anything, collects in the gas collecting tube as the reaction takes place in well F1?
Q5. Why does the gas not escape from the upside-down gas collecting tube?
Q6. Describe what happens when you remove your finger from the open end of the gas collecting tube with the burning match in place.
Q7. Explain your answer to Q6.
Q8. What gas was formed during the reaction?
Q9. Explain why it was necessary to move the comboplate® away from any open flames.
Q10. What do you see in the microwell after leaving the comboplate® overnight?
Q11. Explain your observation.
Q12. What were the reactants in well F1?
Q13. What were the products of the reaction in well F1?
Q14. Write a word equation for the reaction that occurred in well F1.
Q15. Write down a balanced chemical equation for the reaction that occurred in well F1.
Q16. What chemicals would you use to prepare magnesium sulphate using a similar procedure?

	Q17.	Write down a balanced chemical equation for the reaction that you propose in question 16.

EXPERIMENT 14 - RATES OF REACTION –THE EFFECT OF CONCENTRATION

CSEC OBJECTIVE – Section A – 7.2

7.2 Identify the factors which affect the rate of a reaction

Grade Level – 10/11

	INTRODUCTION: The rate of reaction can be defined as the rate at which products are formed or reactants are used up. There are a number of factors affecting the rate of reaction. In the following experiment hydrochloric acid reacts with sodium thiosulphate solution and forms sulphur, which makes the solution go milky. The reaction rate can be measured from the length of time when the acid is added until the solution becomes opaque. The reaction equation is: $Na_2S_2O_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$
	Part 1: The Effect of Concentration of Sodium Thiosulphate **REQUIREMENTS** **Apparatus**: 1 x comboplate®; 3 x thin stemmed propettes; 1 x stop watch (or watch with a second hand); Graph paper; White paper. **Chemicals**: Sodium thiosulphate solution ($Na_2S_2O_3(aq)$) [0.15 M]; Hydrochloric acid ($HCl(aq)$) [11 M]; Tap water. **If any acid is spilt on the skin, thoroughly rinse the affected area with water.**
	PROCEDURE 1. Place the comboplate® on white paper with well A1 top left. 2. Using the propette, add 1 drop of sodium thiosulphate solution to well A1, two drops to well A2, three drops to well A3, etc., up to 8 drops in well A8. 3. Return to well A1 and add 7 drops of water to well A1, 6 drops of water to well A2, 5 drops of water to well A3 and so forth up to 1 drop of water to well A7. Each well now has 8 drops of liquid in total. 4. Use a pen or pencil to draw an "X" on the white paper. Place well A8 of the comboplate® over the "X" on the paper before proceeding with the next step. You should be able to see the "X" beneath well A8. (See Question 1) 5. Using the propette, add 5 drops of HCl (11 M) to well A8 and start the stop watch (or note the time on your watch). Take the time when the "X" is no longer visible beneath well A8. (See Question 2) 6. Place well A7 over the "X" on the paper and add 5 drops of HCl (11 M) to well A7. Note the starting time once again and the time when the "X" is no longer visible beneath well A7. (See Question 3) **Repeat the procedure followed above with each well up to well A1.** **Rinse the comboplate® with tap water and shake dry.**
	Part 2: The Effect of Concentration of Hydrochloric Acid **REQUIREMENTS** **Apparatus**: As for Part 1. **Chemicals**: As for Part 1, plus Hydrochloric acid ($HCl(aq)$) [5.5 M].
	PROCEDURE 1. Place the cleaned comboplate® on white paper with well A1 top left. 2. Using the propette, add 3 drops of sodium thiosulphate solution to wells A1 and A2.

3. Add 5 drops of water to wells A1 and A2. Each well now has 8 drops of liquid in total.
4. Use a pen or pencil to draw an "X" on the white paper and place well A1 of the comboplate® over the "X" on the paper before proceeding with the next step.
5. Using the propette, add 5 drops of HCl (5.5 M) to well A1 and start the stop watch (or note the time on your watch). (See Question 1)
6. Repeat step 5 above, but this time use 5 drops of HCl (11 M) and add this to well A2. (See Question 2)

Rinse the comboplate® with tap water and shake dry.

QUESTIONS - PART 1

Q 1. Prepare a table like Table 1 below.

Well	Drops Sodium Thiosulphate Solution	Start time (min:sec)	Finish time (min:sec)	Reaction Time (seconds)	1/Reaction Time (x 10^{-3} s^{-1})
A1					
A2					
A3					
A4					
A5					
A6					
A7					
A8					

Q 2. Note the starting time and the finishing time (when the "X" is no longer visible in well A8) and enter your results in the table.

Q 3. Complete your table.

Q 4. What happened when 11 M hydrochloric acid was added to the sodium thiosulphate solution?

Q 5. Which well has the greatest concentration of sodium thiosulphate solution?

Q 6. In which well has the reaction taken place in the shortest time?

Q 7. In which well has the reaction been the fastest? Explain your answer.

Q 8. Draw the graph: Drops sodium thiosulphate solution (y - axis) vs Reaction Time (x - axis).

Q 9. Draw the graph: Drops sodium thiosulphate solution (y - axis) vs 1/Reaction Time (x -axis).

Q10. What is the relationship between the number of drops of sodium thiosulphate solution and reaction time?

	Q11. Write a statement describing the effect of the concentration of sodium thiosulphate on the rate of its reaction with hydrochloric acid.
	QUESTIONS - PART 2 Q1. Note the time when the "X" is no longer visible beneath well A1. Q2. Note the time when the "X" is no longer visible beneath well A2. Q3. Write a statement describing the effect of the concentration of hydrochloric acid on the rate of its reaction with sodium thiosulphate.

EXPERIMENT 15 - ENTHALPY CHANGE FOR THE REACTIONS OF ACIDS WITH A STRONG BASE

CSEC OBJECTIVE – Section A 8.3
Grade Level – 10/11

	PART 1: The enthalpy change ()H) for the reaction between hydrochloric acid (HCl(aq)) (a strong acid) and sodium hydroxide (NaOH(aq)) (a strong base)
Note	**REQUIREMENTS** **Apparatus:** 1 x comboplate®; 1 x 2 ml syringe; 1 x thermometer. **Chemicals:** Sodium hydroxide solution (NaOH(aq)) [1.0 M]; Hydrochloric acid (HCl(aq)) [1.0 M]. **It is better to use a thermometer graduated in 0.1 °C intervals, to make recording of the temperature change more accurate.**
	INTRODUCTION ***The magnitude of the enthalpy change*** **(ΔH)** for a chemical reaction is related to the heat **(q)** absorbed or released by the surroundings during the reaction at constant pressure. The relationship between these two quantities is: $q = - \Delta H$ By convention, if energy is released to the surroundings as reaction takes place, ΔH is negative (-). If energy is absorbed from the surroundings as reaction takes place, ΔH is positive (+). Hence q in the first case is positive (+) and in the second case is negative (-). • The heat (q) absorbed or released by the surroundings (in this experiment the reaction mixture) is related to the change in temperature of the reaction mixture in the following way: $q = C\Delta T$ • The heat capacity of the mixture, the reaction vessel and the thermometer is given the symbol C. • The change in temperature ΔT represents the final temperature minus the initial temperature ($T_f - T_i$).
	PROCEDURE 1. Insert a clean, dry thermometer into the bottle containing the 1.0 M NaOH(aq). Make sure that the bulb of the thermometer is immersed in the solution. 2. Wait a few seconds, then observe the initial temperature of the sodium hydroxide solution. *(See Question 1)* 3. Rinse the thermometer and dry it thoroughly. Immerse the thermometer in the bottle containing the HCl(aq). The thermometer must be clean and dry, otherwise the hydrochloric acid will be diluted and/or contaminated. 4. Observe the initial temperature of the HCl(aq) then rinse and dry the thermometer before using it again in step 8. (*See Question 2)* 5. Use a clean, dry syringe to add 1,0 ml of the 1.0 M NaOH(aq) into well F1 of the comboplate®. 6. Rinse the syringe and dry it thoroughly inside. Fill the syringe with 1,0 ml of the 1.0 M HCl(aq). 7. Insert the thermometer into well F1 containing the NaOH(aq). Quickly add all of the hydrochloric acid from the syringe into well F1.

	8. Use the thermometer to stir the mixture in well F1. Read the maximum temperature reached by the mixture to 0.1°C. *(See Question 4)* **Wash the comboplate® thoroughly with water and shake dry.**
	PART 2: The enthalpy change ($\triangle$H) for the reaction between acetic acid ($CH_3COOH(aq)$) (a weak acid) and sodium hydroxide (NaOH(aq)) (a strong base)
	REQUIREMENTS **Apparatus:** 1 x comboplate®; 1 x 2 ml syringe; 1 x thermometer. **Chemicals:** Sodium hydroxide solution (NaOH(aq)) [1.0 M]; Acetic acid ($CH_3COOH(aq)$) [1.0 M].
	PROCEDURE 1. Repeat steps 1 to 8 in Part 1 using well F5 and 1.0 ml of 1.0 M acetic acid instead of hydrochloric acid. **Wash the comboplate® thoroughly with water and shake dry.**
	QUESTIONS - PART 1 Q 1. What is the initial temperature of the sodium hydroxide solution ? Q 2. What is the initial temperature of the hydrochloric acid ? Q 3. Calculate the average of the two initial temperatures. This is the average initial temperature, T_i. Q 4. What is the maximum temperature of the mixture ? This is the final temperature, T_f . Q 5. Calculate the change in temperature ΔT. Q 6. Was the final temperature of the reaction mixture higher or lower than the initial average temperature of the reagents ? Q 7. Was energy absorbed or released by the surroundings as this reaction took place ? Q 8. Was energy absorbed or released by the reactants as this reaction took place ? Q 9. Is such a reaction exothermic or endothermic ? Q10. The heat capacity, C, of the comboplate® and contents is approximately 13,03 J $^oC^{-1}$. Calculate q, the energy absorbed or released by the surroundings. Q11. Write down a balanced chemical equation for the reaction between hydrochloric acid and sodium hydroxide. Q12. Calculate the enthalpy change of the reaction in J, and the enthalpy change per mole of reaction in kJ mol^{-1}.
	QUESTIONS - PART 2 Q 1. What is the initial temperature of the sodium hydroxide solution ? Q 2. What is the initial temperature of the acetic acid ? Q 3. Calculate the average of the two initial temperatures. This is the average initial temperature, T_i. Q 4. What is the maximum temperature of the mixture ? This is the final temperature, T_f . Q 5. Calculate the change in temperature, ΔT. Q 6. Was the final temperature of the reaction mixture higher or lower than the initial average temperature of the reagents ? Q 7. Was energy absorbed or released by the surroundings as this reaction took place ? Q 8. Was energy absorbed or released by the reactants as this reaction took place ? Q 9. Is the reaction of acetic acid with sodium hydroxide endothermic or exothermic? Q10. Write down a balanced chemical equation for the reaction between acetic acid and sodium hydroxide. Q11. The heat capacity, C, of the comboplate® and contents is approximately 13,03 J $^oC^{-1}$. Calculate the enthalpy change of the reaction in J, and the enthalpy change per mole

	of reaction in kJ mol^{-1} . Q12. Is the enthalpy change the same as found in Part 1? Q13. What is the explanation for your finding ?

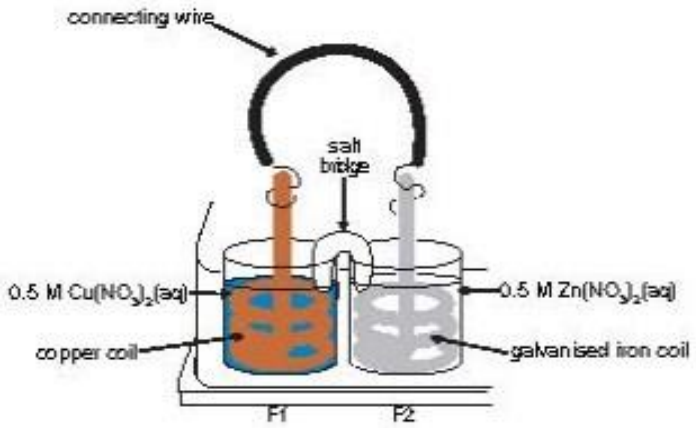
EXPERIMENT 16 - THE ZINC/COPPER CELL

CSEC OBJECTIVE – Section A 6.20

Grade Level – 10/11 and 12

Note CAUTION	**REQUIREMENTS** **Apparatus**: 1 x voltmeter (volts); 1 x 2 ml syringe; 1 x copper wire coil (copper electrode) - 1.5 cm x 1.5 cm; 1 x galvanised iron coil (zinc electrode) - 1.5 cm x 1.5 cm; 1 x comboplate®; 1 x current indicator with wire connections; 1 x connecting copper wire (red coated with exposed wire ends) - 10 cm x 1 mm; 1 x 9 V battery; Connecting wires for voltmeter; 1 x cotton wool ball; 1 x piece of sand paper - 1 cm x 1 cm. **Chemicals**: Saturated potassium nitrate solution ($KNO_3(aq)$); Copper nitrate solution ($Cu(NO_3)_2(aq)$) [0.5 M]; Zinc nitrate solution ($Zn(NO_3)_2(aq)$) [0.5 M]. **Galvanised iron wire is iron wire coated with zinc** **The syringe should be thoroughly cleaned by rinsing with tap water before each new liquid is used. If this is not done the stock solutions will become contaminated and the experiment will be misleading.**
	PROCEDURE 1. Add 2 ml of the copper nitrate solution to well F1 with the 2 ml syringe. Rinse the syringe with tap water 3 or 4 times then use this same syringe to add 2 ml of the zinc nitrate solution to well F2. Rinse the syringe with tap water 3 or 4 times before proceeding with step 2. 2. Clean only the copper wire coil with sand paper until the wire coil looks shiny, and then place it into the copper nitrate solution. Place the galvanized iron wire coil into the zinc nitrate solution. (See the diagram below.) 3. Connect the long end of the black wire on the current indicator to the negative terminal of the 9 V battery. Connect the short end of the black wire to the galvanised iron coil in well F2. 4. Connect the one end of the red wire to the positive terminal of the 9 V battery, and the other end to the copper coil in well F1. (See Question 1) 5. Roll a piece of cotton wool into a strip about 4 cm long and 5 mm thick. Fill the syringe with 1 ml of saturated potassium nitrate ($KNO_3(aq)$) solution and add this to well F6. Place the cotton wool strip into well F6 until it is thoroughly soaked with the potassium nitrate (KNO3(aq)) solution. 6. Remove the soaked strip from well F6 then place the one end of the strip into well F1 and the other end into well F2 as shown in the diagram. (See Question 3) **Disconnect the current indicator entirely from the electrodes before continuing.**

7. Connect the voltmeter to the copper wire coil in well F1 and the galvanised iron wire coil in well F2, using the connecting wires. (See Question 6)
8. Disconnect the voltmeter. Join the separate red coated connecting wire to both electrodes.
9. Wait 10 minutes, then examine the copper electrode by pulling it out of the solution. (See Question 7)



CAUTION

It is essential that the used copper and zinc wire coils are removed from the wells immediately after the experiment is completed to prevent the staining of the wells. Make sure that each well is thoroughly cleaned when the experiment is finished.

Clean the comboplate® thoroughly with water and pat dry.

QUESTIONS

Q 1. Does the current indicator glow ?
Q 2. Is there a current flowing ?
Q 3. Does the current indicator glow now ?
Q 4. Is there a current flowing ?
Q 5. What is the function of the salt bridge ?
Q 6. Is there a potential difference ?
Q 7. Does it look as shiny as when you put it in the copper nitrate solution ?
Q 8. From your observations of the copper electrode, what would you say is happening?
Suggest a chemical equation for this process.
Is this a reduction or oxidation process ? Give a reason for your answer.
Q 9. What is taking place at the zinc electrode ?
Write down an equation to illustrate this.
Is this a reduction or oxidation process ? Give a reason for your answer.
Q10. What is the direction of the electron flow through the connecting wire ?
Q11. Write down the chemical equation for the overall reaction.

EXPERIMENT 17 - CONCENTRATION AND AMOUNT OF SUBSTANCE IN SOLUTION

CSEC OBJECTIVE – Section A 3.7 (iii)

Grade Level – 10/11 and 12

Note	**REQUIREMENTS** **Apparatus:** 1 x 2 ml syringe; 1 x plastic microspatula; 1 x comboplate®. **Chemicals:** Copper nitrate ($Cu(NO_3)_2.3H_2O(s)$); Tap water. **If the copper nitrate has become hard, the contents of the bottle must be carefully crushed with a sharp object.**
	PROCEDURE 1. Use the spooned end of the plastic microspatula to place: two level spatulas of solid copper nitrate into well F_1, four level spatulas of copper nitrate into well F_2, four level spatulas of copper nitrate into well F_3. 2. Using the syringe, add 1 ml of water into well F1, 1 ml of water into well F2 and 2 ml of water into well F3. 3. Stir the solutions thoroughly with the tip of the spatula until all the solid $Cu(NO_3)_2.3H_2O$ is dissolved. *4.* Lift the comboplate® to the light and observe the colour of the solutions in wells F1 and F2 from the side. *(See Question 1)* *5.* Lift the comboplate® to the light and observe the colour of the solutions in wells F1 and F3 from the side. *(See Question 2)* **Rinse the wells with tap water, and then shake them dry.**
 	**QUESTIONS** Q 1. Which well, comparing wells F1 and F2, has the greater concentration of Cu^{2+}(aq) ions? What is the definition of concentration? Give the reason for your answer. Q 2. Which well, comparing wells F1 and F3, has the greater concentration of Cu^{2+}(aq) ions? Give a reason for your answer. Q 3. Which well, comparing wells F1 and F2, has the greater amount of Cu^{2+}(aq) ions? What is the definition of amount? Give the reason for your answer. Q 4. Write a statement describing what is meant by the concentration and the amount of a substance in solution.

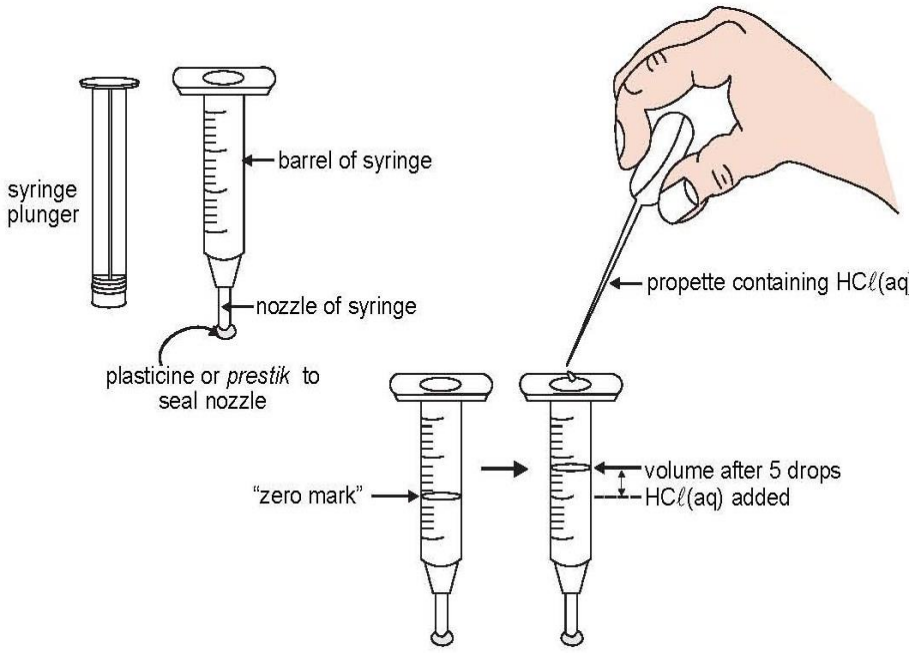
EXPERIMENT 18 - ACID BASE TITRATION – DETERMINING THE CONCENTRATION OF AN ACID

CSEC OBJECTIVE – Section A 3.6
Grade Level – 10/11 and 12

REQUIREMENTS

Apparatus: 4 x thin stemmed propettes; 1 x plastic microspatula; 1 x comboplate®; 1 x 2 ml syringe; 1 x piece of plasticine - 1 cm x 1 cm x 1 cm.

Chemicals: Sodium hydroxide solution (NaOH(aq)) [0.10 M]; Methyl orange indicator solution; Hydrochloric acid (HCl(aq)) (of unknown concentration).



CALIBRATION PROCEDURE

1. Remove the plunger from the 2 ml syringe.
2. Seal the nozzle of the 2 ml syringe with the piece of plasticine.
3. Fill a propette with the hydrochloric acid.
4. Insert the thin stem of the propette containing the hydrochloric acid into the open end of the syringe. Add a sufficient number of drops of hydrochloric acid into the syringe until the volume of the acid just reaches one of the measuring marks on the side of the syringe. Let this mark be the "zero mark". *(See Question 1)*
5. Thereafter count the number of drops of hydrochloric acid you need to add for the volume to reach another measuring mark a few units above the "zero mark" e.g. 0.2

or 0.3 or 0.5 ml. *(See Question 2)*

6. Suck up sufficient of the hydrochloric acid in the syringe back into the propette, until the volume of hydrochloric acid left in the syringe is at the "zero mark". Repeat steps 4 to 5 twice. Be consistent with the volume chosen for calibration. *(See Question 3)*
7. After completing this, remove all the hydrochloric acid from the syringe by sucking it all back into the propette provided for it. Remove the plasticine from the nozzle of the syringe. Rinse the syringe thoroughly with tap water and dry it.
8. Repeat steps 2 to 6 above, but use 0.10 M sodium hydroxide instead of hydrochloric acid. *(See Question 4)*

TITRATION PROCEDURE

1. Add 5 drops of tap water into well A1.
2. Add 1 drop of methyl orange indicator into well A1. *(See Question 5)*
3. Repeat steps 1 and 2 above in well A2 using hydrochloric acid instead of tap water. *(See Question 6)*
4. Add a sufficient number of drops of sodium hydroxide solution to well A2 to just cause the colour of the solution in well A2 to be the same as that in well A1. *(See Question 7)*

   Count the number of drops of sodium hydroxide solution carefully.

   Use the plastic microspatula to stir the contents of the well where necessary. *(See Question 8)*
5. Repeat the titration you did in well A2 two more times, in wells A3 and A4.

   Count the number of drops of sodium hydroxide solution carefully. *(See Question 9)*

Rinse the comboplate® with tap water and shake dry.

QUESTIONS

Q 1. Prepare a table like Table 1 below.

TABLE 1

Solution used	Volume of syringe from "zero mark" /mℓ	No. of dropsof solution needed for set volume	Average No. of drops of solution needed for set volume
HCℓ	_____ _____	_____ _____	_____
NaOH	_____ _____	_____ _____	_____

Q 2. Enter your results into your table.

Q 3. Enter your results into your table.

Q 4. Enter your results into your table.

Complete the procedure for the conversion, that follows.

CONVERSION:

i. Hydrochloric acid:

   _____ (average) drops of HCl occupy _____ ml.

   Therefore 1 drop of HCl occupies _____ ml.

ii. Sodium hydroxide:

   _____ (average) drops of NaOH occupy _____ml.

   Therefore 1 drop of NaOH occupies _____ ml.

Q 5. What is the colour of the solution ?

Q 6. What is the colour of the solution ?

Q 7. Prepare a table like Table 2 below.

TABLE 2

Acid used	No. of drops of HCℓ	No. of drops of NaOH	Average No. of drops of NaOH
HCℓ	5	_____	_____
	5	_____	
	5	_____	

Q 8. What number of drops of NaOH was required ? Enter the result in your table.

Q 9. Enter your result in your table.

Q10. What *average volume* of the 0.10 M sodium hydroxide solution was required to titrate the hydrochloric acid ?

Q11. What amount of sodium hydroxide was this ?

Q12. What amount of HCl reacted with this sodium hydroxide ?

Q13. What *volume* of HCl solution contained this amount of HCl ?

Q14. What is the concentration of the hydrochloric acid ?

Q15. If the 5 drops of hydrochloric acid (HCl(aq)) were replaced with 5 drops of sulphuric acid (H_2SO_4(aq)) of the same concentration, how many drops of 0.10 M sodium hydroxide (NaOH(aq)) solution would be required to reach the end point in this titration ? Explain your answer.

EXPERIMENT 19 - PREPARATION AND PROPERTIES OF SULPHUR DIOXIDE

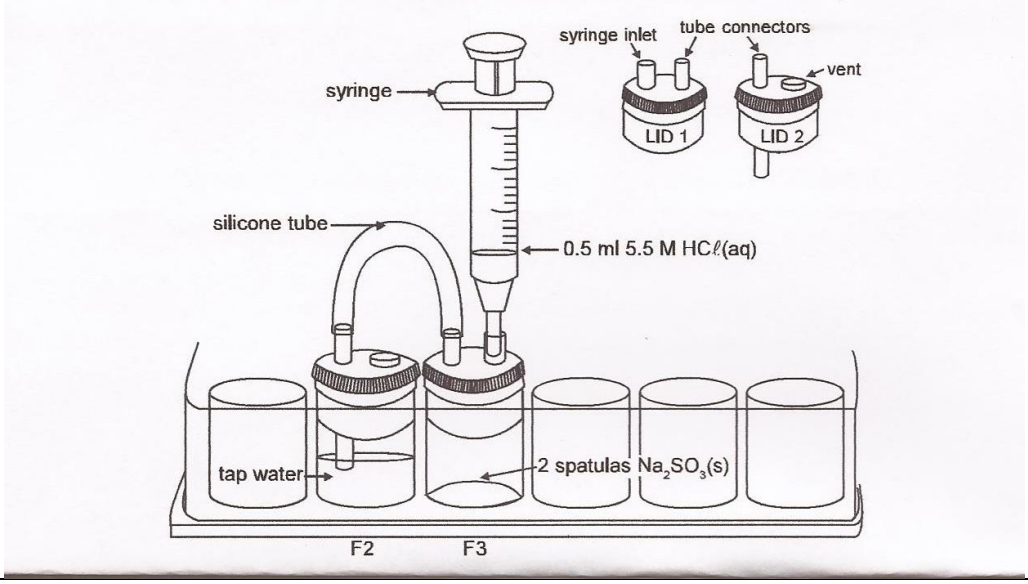
CSEC OBJECTIVE – Section C 2 Objective 3.4

Grade Level – 10/11 and 12

REQUIREMENTS

Apparatus: 2 x pieces universal indicator paper; 1 x comboplate®; 1 x lid 1; 1 x lid 2; 1 x silicone tube (4 cm x 4 mm); 1 x 2 ml syringe; 1 x plastic microspatula.

Chemicals: Hydrochloric acid (HCl(aq)) [5.5 M]; Sodium sulphite powder ($Na_2SO_3(s)$); Potassium dichromate powder ($K_2Cr_2O_7(s)$); Sulphuric acid ($H_2SO_4(aq)$) [1 M]; Tap water.



PROCEDURE

1. Fill ¾ of well F2 with tap water. Test the pH of the water with a piece of indicator paper. (See Question 1)
2. Using the spooned end of the microspatula, put 2 spatulas of solid $Na_2SO_3(s)$ into well F3.
3. Seal well F2 with lid 2. Make sure the vent hole faces inwards (see fig.). Seal well F3 with lid 1.
4. Connect one end of the silicone tube to the tube connector on lid 2. Connect the remaining end of the silicone tube to the tube connector on lid 1.
5. Fill the syringe with 0.5 ml of 5.5 M HCl(aq) and insert the nozzle of the syringe into the inlet on lid 1.
6. Inject the 0.5 ml of 5.5 M HCl(aq) into well F3 very slowly. Lift the comboplate® up and gently shake it to mix the contents in well F3. (See Question 2)

Note

If you do not shake the comboplate®, water from well F2 will be sucked back through the silicone tube into well F3.

7. Wait about 1 to 2 minutes from the time you finished adding the HCl(aq). Continue to shake the comboplate® if you see suck-back occurring. (See Questions 3, 4)

	8. Remove the lid from well F2 and test the solution with the universal indicator paper. (See Question 5) **9.** Using a clean propette, fill ¾ of well F1 with tap water. **10.** Add 1 to 2 drops of dilute sulphuric acid to both well F1 and well F2. **11.** Use the narrow end of a plastic microspatula to add 1 spatula of solid potassium dichromate ($K_2Cr_2O_7(s)$) into each of wells F1 and F2. Stir each solution with a clean microspatula. (See Question 7) **Rinse the comboplate® with water and shake dry.**
	QUESTIONS Q 1. What is the colour of the indicator paper? What is the pH of the water? Q 2. What do you observe happening in well F3? Q 3. Can you smell anything from the vent in well F2? If so, what do you think the smell is due to? Q 4. What is the chemical formula of the gas formed in well F3? Q 5. What is the colour of the indicator paper? What do you deduce? Q 6. Give a chemical equation for the reaction of hydrochloric acid (HCl(aq)) and sodium sulphite ($Na_2SO_3(s)$). Q 7. What is the colour in each well: F1and F2? Q 8. What ions are responsible for the colour of the solution in well F1? Q 9. Explain any colour difference between the solution in well F1 and well F2. Q10. Is sulphur dioxide oxidised or reduced by potassium dichromate in acid solution?

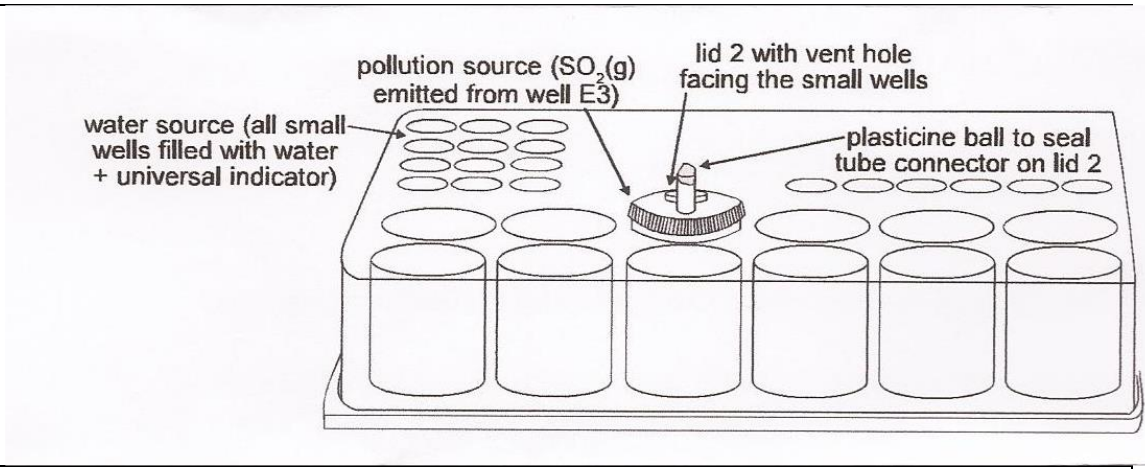
EXPERIMENT 20 - AIR POLLUTION BY SULPHUR DIOXIDE

PART 1 - Uncontrolled Emission of Sulphur Dioxide

CSEC OBJECTIVE – Section C 2 Objective 3.4

Grade Level – 10/11 and 12

	REQUIREMENTS **Apparatus:** 1 x 2 ml syringe; 2 x thin stemmed propettes; 1 x plastic microspatula; 1 x comboplate®;1 x lid 2; 1 x piece of plasticine (5 mm x 5 mm x 5 mm). **Chemicals:** Hydrochloric acid (HCl(aq)) [5.5 M]; Anhydrous sodium sulphite powder (Na_2SO_3(s)); Universal indicator solution; Tap water.
	INTRODUCTION This experiment aims to simulate an industrial plant, which produces gaseous sulphur dioxide, and determine what factors influence the effect of the air-pollution on the water in the vicinity. The small wells of the comboplate®, filled with water, will be used to represent the water supply.
Note	**PROCEDURE** 1. Place the comboplate® under a running water tap and fill all the small wells (wells A1 to D12) with water. 2. Use an empty propette to suck up, and then discard any water that may have got into the large wells. Use a paper towel to gently soak up any water between the small wells on the surface of the comboplate®. 3. Use a propette to add one drop of universal indicator solution into each of the small wells filled with water. (See Question 1) 4. Using the spooned end of a plastic microspatula, add three spatulas of anhydrous sodium sulphite powder into well E3. Insert lid 2 into well E3 in such a way that the vent is closest to the small wells and the tube connector is pointed away from the small wells (see the figure below). 5. Seal the tube connector on lid 2 with a piece of plasticine (see the figure below). **If there are any draughts in the room, the results of the experiment may be affected slightly. If you like, you can use a shallow container such as an empty cardboard box to prevent the effect of any draughts on the experiment. This is, however, not a necessity.** 6. Fill the syringe with 0,2 ml of 5.5 M hydrochloric acid. Hold the nozzle of the syringe just inside the vent in lid 2. Add all of the hydrochloric acid into well E3. Do not push the nozzle of t he syringe all the way into the vent of lid 2, because the syringe will become stuck in the lid. Be careful not to drop any of the hydrochloric acid into the water. 7. Wait about three to five minutes



8. After about 1½ minutes of waiting, briefly lift the comboplate® to the light and observe the colour of the aqueous solutions from underneath the comboplate®. (See Question 2)
9. After about 5 minutes count the number of acidified wells, and hold the comboplate® to the light once again. (See Questions 7, 9).

Clean the comboplate® thoroughly before proceeding with part 2.

QUESTIONS

Q 1. What is the colour and pH of the aqueous solution of universal indicator at the beginning of the experiment?

Q 2. What happens to the colour of the aqueous solution of universal indicator in the wells? What is happening to the pH of this solution?

Q 3. Explain your answer to question 2 using a chemical equation to represent the reaction that could be occurring.

Q 4. Does the colour of the aqueous solution change uniformly:
a) across the surface area of the solution in each well,
b) from top to bottom in each well ?

Q 5. Suggest a reason for your answer to question 4.
Q 6. Is the acidification of the solution the same throughout all the small wells of the comboplate® ? Explain your answer.

Q 7. In how many wells has the water been acidified? (Answer this no longer than 5 minutes from the time you began the experiment.)

Q 8. Would the number of wells showing water acidification be more or less if six microspatulas of sodium sulphite were added to well E3 instead of three, when the experiment began ? Explain your answer.

Q 9. How has the distribution of the acidification changed from the first time you viewed the wells from beneath the comboplate® ? Explain your answer.

EXPERIMENT 20 - AIR POLLUTION BY SULPHUR DIOXIDE

PART 2 – The Function of a Chimney in Dispersing Air Pollutants

CSEC OBJECTIVE – Section C 2 Objective 3.4
Grade Level – 10/11 and 12

	REQUIREMENTS **Apparatus:** 1 x 2 ml syringe; 2 x thin stemmed propettes; 1 x plastic microspatula; 1 x comboplate®; 1 x lid 1; 1 x piece of plasticine (5 mm x 5 mm x 5 mm); 1 x silicone tube (1.5 cm x 4 mm). **Chemicals:** Hydrochloric acid (HCl(aq)) [5.5 M]; Anhydrous sodium sulphite powder (Na_2SO_3(s)); Universal indicator solution; Tap water.
Note	**PROCEDURE** 1. Repeat steps 1 to 3 in part 1. 2. Using the spooned end of a plastic microspatula, add three spatulas of anhydrous sodium sulphite powder into well E3. Insert lid 1 into well E3 in such a way that the tube connector is closest to the small wells and the syringe inlet is pointed away from the small wells. 3. Fit the silicone tube over the tube connector on lid 1. This will model the chimney. **As in part 1, the remainder of the steps may be performed in a draught-free area.** 4. Fill the syringe with 0,2 ml of 5.5 M hydrochloric acid. Fit the syringe into the syringe inlet in lid 1. Add all of the 5.5 M hydrochloric acid gently into well E3. Do not add the acid too quickly as the increase in pressure in the well may force acid out through the silicone tube. Be careful not to drop any of the hydrochloric acid into the water. 5. Immediately after completing step 4, remove the syringe from lid 1 and seal the syringe inlet with a piece of plasticine. Be careful not to drop any of the hydrochloric acid into the water. 6. Wait about 3 to 5 minutes and observe. (See Questions 1, 2) **Clean the comboplate® thoroughly before proceeding with part 3.**

EXPERIMENT 20 - AIR POLLUTION BY SULPHUR DIOXIDE

PART 3 – The Elimination of Emission by an Absorbing Substance

CSEC OBJECTIVE – Section C 2 Objective 3.4
Grade Level – 10/11 and 12

	REQUIREMENTS **Apparatus:** 1 x 2 ml syringe; 3 x thin stemmed propettes; 2 x plastic microspatulas; 1 x comboplate®; 1 x lid 1; 1 x piece of plasticine (5 mm x 5 mm x 5 mm); 1 x silicone tube (1.5 cm x 4 mm); 1 x piece of cotton wool (3 mm x 3 mm) **Chemicals:** Hydrochloric acid (HCl(aq)) [5.5 M]; Anhydrous sodium sulphite powder (Na_2SO_3(s)); Calcium oxide powder (CaO(s)); Universal indicator solution; Tap water.
Note	**PROCEDURE** 1. Repeat steps 1 to 3 in part 1. 2. Using the spooned end of a plastic microspatula, add three spatulas of anhydrous sodium sulphite powder into well E3. Insert lid 1 into well E3 in such a way that the tube connector is closest to the small wells and the syringe inlet is pointed away from the small wells. 3. Insert a small piece of cotton wool into the opening of one end of the silicone tube. Thereafter fit this end of the tube over the tube connector on lid 1. **4.** Use the narrow end of a clean, plastic microspatula to add calcium oxide powder into the other end of the silicone tube. Add sufficient calcium oxide powder to fill the silicone tube up. Try to pack the calcium oxide quite tightly into the tube so that it is not forced out of the tube when the hydrochloric acid is added into the well. This will be the emission absorber. **As in parts 1 and 2, the remaining steps may be performed in a draught-free area.** 5. Fill the syringe with 0,2 ml of hydrochloric acid. Fit the syringe into the syringe inlet in lid 1. Add all of the 5.5 M hydrochloric acid into well E3. Do not add the acid too quickly as the increase in pressure in the well may force all the calcium oxide out of the silicone tube. Be careful not to drop any of the hydrochloric acid into the water. 6. Immediately after completing step 5, remove the syringe from the inlet in lid 1 and seal the inlet with a piece of plasticine. 7. Wait about three to five minutes and observe. (See Question 1)

	QUESTIONS – PART 2 Q 1. Is the acidification of the solution the same throughout all the small wells of the comboplate®? Explain your answer. Q 2. In how many wells has the water been acidified? (Answer this no longer than 5 minutes from the time you began the experiment.) Q 3. Compare your answer to question 2 above with your answer to question 7 in part 1. Is the number of wells showing water acidification greater or smaller when a chimney is present? **QUESTIONS – PART 3** Q 1. In how many wells has the water been acidified? (Answer this no longer than 5 minutes from the time you began the experiment.) Q 2. Write down a balanced chemical equation to show the reaction between the SO_2(g) and the CaO(s) in the chimney. Q 3. Write a statement describing the effect of calcium oxide on SO_2 emission