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

CSEC OBJECTIVES – Section A 7– 7.7 Section C1 - 1.2

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

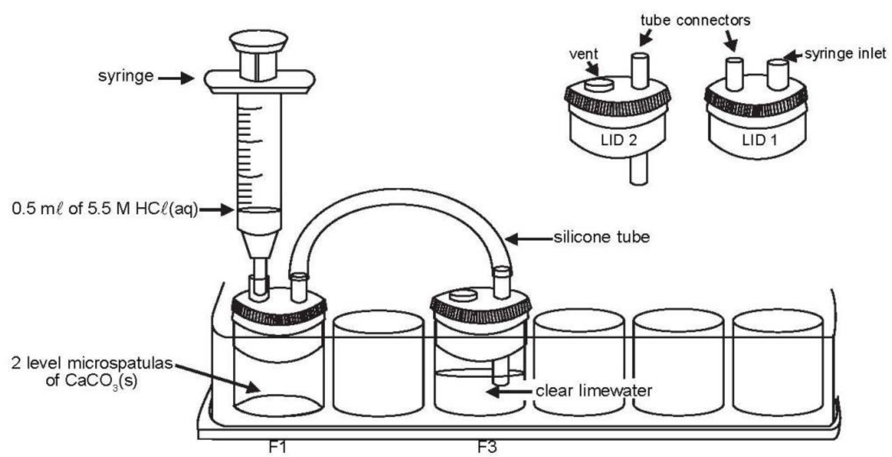
1.2 Describe the reactions of metallic oxides, hydroxides, nitrates and carbonates

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.

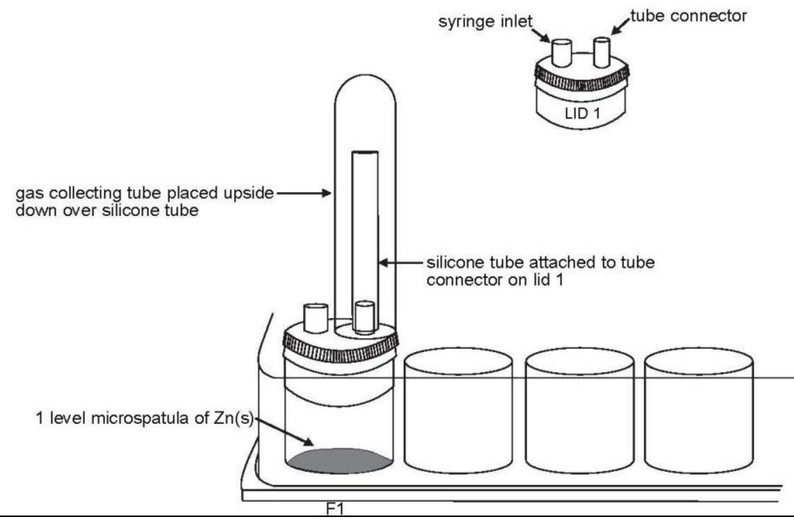


PROCEDURE

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.

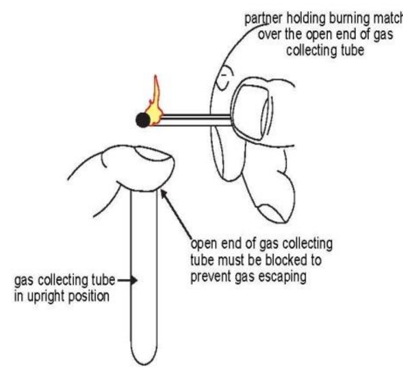
	14. Leave the mixture in well F1 overnight. *(See Question 7)* **Clean all apparatus thoroughly.**
	QUESTIONS Q1. What do you see happening in well F1 when you add the acid? Q2. What do you see in happening in well F3 after a short while? Q3. What does this tell us about the gas that formed in the reaction 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 A7 – 7.7 **7.7 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 A10, 10.2

10.2 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: Na2S2O3(aq) + 2HCl(aq) 6 2NaCl(aq) + S(s) + SO2(g) + H2O(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 (Na2S2O3(aq)) [0.15 M]; Hydrochloric acid (HCl(aq)) [11 M]; Tap water.

CAUTION

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 11.3

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)

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].

Note

It is better to use a thermometer graduated in 0.1 oC intervals, to make recording of the temperature change more accurate.

INTRODUCTION

The magnitude of the enthalpy change)**H** 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 0.1oC. *(See Question 4)* **Wash the comboplate® thoroughly with water and shake dry.**
	PART 2: The enthalpy change ()H) for the reaction between acetic acid (CH3COOH(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 (CH3COOH(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 ?

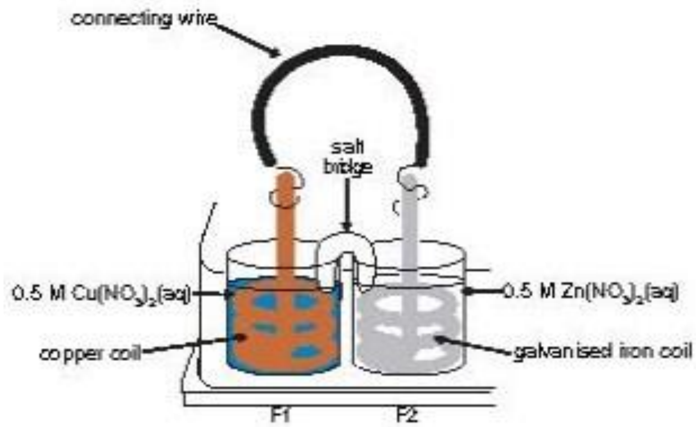
EXPERIMENT 16 - THE ZINC/COPPER CELL

CSEC OBJECTIVE – Section A9; 9.8

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 (KNO3(aq)); Copper nitrate solution (Cu(NO3)2(aq)) [0.5 M]; Zinc nitrate solution (Zn(NO3)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 (KNO3(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

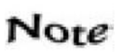
CSEC OBJECTIVE – Section A 7; 7.11

Grade Level – 10/11 and 12

REQUIREMENTS

Apparatus: 1 x 2 ml syringe; 1 x plastic microspatula; 1 x comboplate®.

Chemicals: Copper nitrate (Cu(NO3)2.3H2O(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(NO3)2.3H2O 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 Cu2+(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 Cu2+(aq) ions?
Give a reason for your answer.

Q 3. Which well, comparing wells F1 and F2, has the greater amount of Cu2+(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.

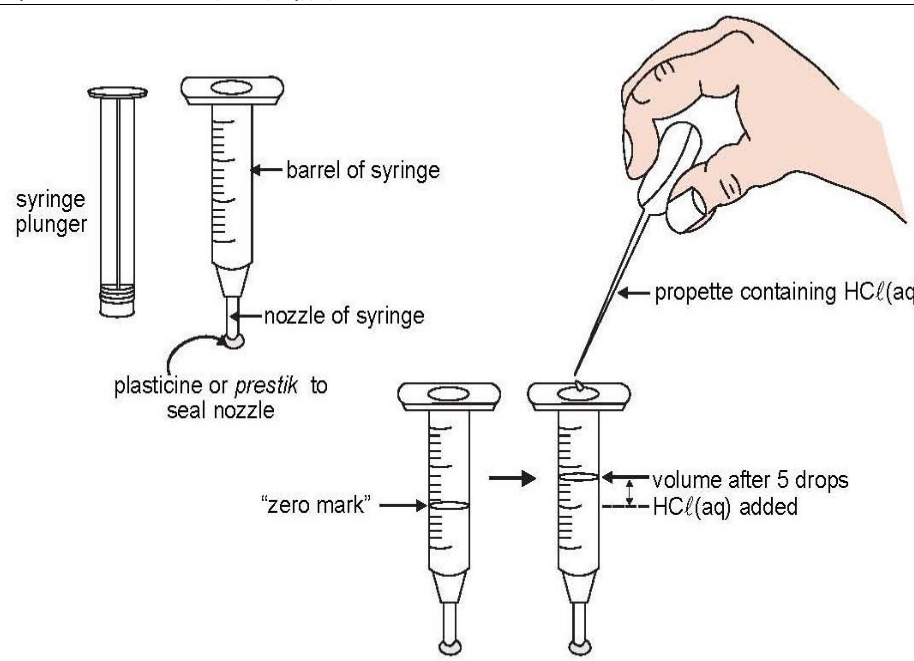
EXPERIMENT 18 - ACID BASE TITRATION – DETERMINING THE CONCENTRATION OF AN ACID

CSEC OBJECTIVE – Section A7; 7.11
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 (H2SO4(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

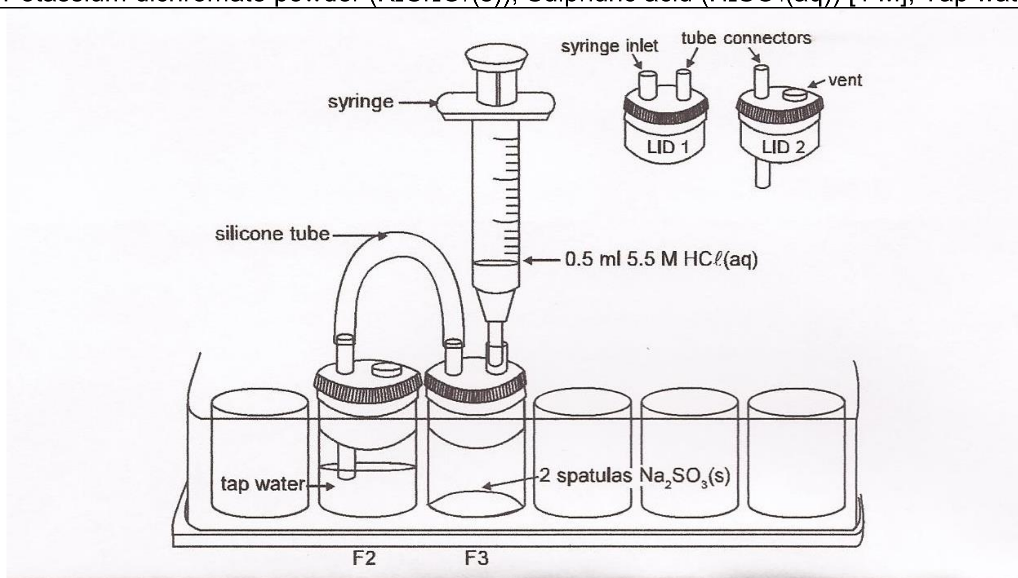
CSEC OBJECTIVE – Section C 6 Objective 6.3

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 3/4 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 6 Objective 6.3

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.

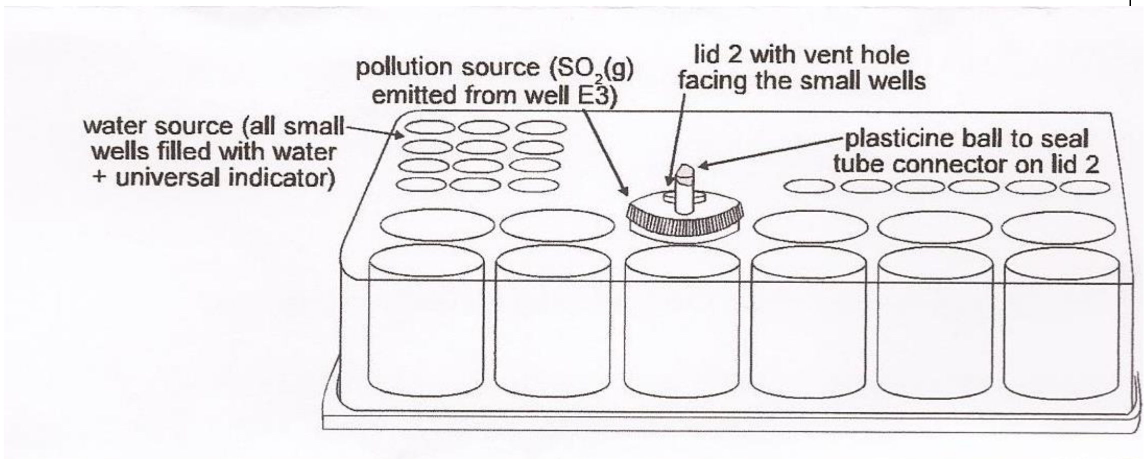
PROCEDURE

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).

Note

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 6 Objective 6.3

Grade Level – 10/11 and 12

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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.
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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.
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EXPERIMENT 20 - AIR POLLUTION BY SULPHUR DIOXIDE

PART 3 – The Elimination of Emission by an Absorbing Substance

CSEC OBJECTIVE – Section C 6 Objective 6.3
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.

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.

Note

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

EXPERIMENT 21 - ORGANIC CHEMISTRY – ESTERS

CSEC OBJECTIVE – Section B 3 Objective 3.7
Grade Level –11

	REQUIREMENTS **Apparatus:** 1 x sample vial; 2 x thin stemmed propettes; 1 x microburner; 1 x glass rod. **Chemicals:** Pure ethanoic acid ($CH_3COOH(l)$); Ethanol ($C_2H_5OH(l)$); Sulphuric acid ($H_2SO_4(aq)$) [18 M].
Caution	**18 M sulphuric acid is extremely corrosive. If any acid spills on the skin, rinse the affected area immediately under running water.**
	PROCEDURE 1. Add twenty drops of ethanol from a propette into an empty sample vial. 2. Add twenty drops of ethanoic acid from another propette into the sample vial. 3. Add one drop of concentrated sulphuric acid (18 M) into the sample vial. Lift the vial up and swirl the contents before heating. 4. Heat the contents of the sample vial with a clean glass rod which has been passed through the flame of a microburner 2 or 3 times. Cautiously smell the contents of the sample vial. (See Question 1) 5. Clean the vial thoroughly before commencing with step 6. 6. Repeat steps 1, 2 and 4 above but this time **do not add the sulphuric acid to the contents of the sample vial.** Cautiously smell the contents of the sample vial. (See Question 2)

	QUESTIONS – Q1. Describe the smell of the contents in the sample vial. Q 2. Describe the smell of the contents in the sample vial. Q 3. What is the name of the ester that can be formed when ethanoic acid reacts with ethanol? Q 4. What is the name given to the type of reaction by which esters form from a carboxylic acid and an alcohol? Q 5. Was there such a reaction in the sample vial each time? Q 6. What can you conclude about the role of concentrated sulphuric acid in the esterification reaction?

EXPERIMENT 22 - ORGANIC CHEMISTRY – SATURATED AND UNSATURATED HYDROCARBONS

CSEC OBJECTIVE – Section B 3 Objective 3.3
Grade Level –11

	REQUIREMENTS **Apparatus:** 1 x comboplate®; 3 x thin stemmed propettes; 2 x plastic microspatulas. **Chemicals:** Bromine solution ($Br_2(aq)$); Cyclohexane ($C_6H_{12}(l)$); Hex-1-ene ($C_6H_{12}(l)$).
	PROCEDURE 1. Add 5 drops of cyclohexane with a propette into well A1. 2. Add 5 drops of hex-1-ene with a propette into well A3. 3. Add 5 drops of bromine solution from a propette into each of the wells and observe. (See Question 1) 4. Stir the contents of each well thoroughly using a clean microspatula and observe. (See Question 2) **Thoroughly clean the comboplate® with water.**
	QUESTIONS – Q 1. What happens in each well immediately after adding the bromine? Well A1: Cyclohexane/bromine Well A3: Hex-1-ene/bromine Q 2. What happens in each well after stirring the contents ? Well A1: Cyclohexane/bromine Well A3: Hex-1-ene/bromine

	Q 3. Explain what happened when cyclohexane was in contact with aqueous bromine. Q 4. Is cyclohexane a saturated or unsaturated hydrocarbon? Justify your answer. Q 5. Why was it necessary to stir the contents of each well? Q 6. Explain what happened when hex-1-ene was in contact with aqueous bromine. Q 7. Is hex-1-ene a saturated or unsaturated hydrocarbon? Justify your answer. Q 8. What type of reaction occurs between hex-1-ene and aqueous bromine? Write an equation to represent it. Q 9. How can you test whether a hydrocarbon is saturated or unsaturated ?