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ADVANCED TEACHING & LEARNING PACKAGES MICROCHEMISTRY EXPERIENCES

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The UNESCO-Associated Centre for Microscience Experiments
RADMASTE Centre
University of the Witwatersrand, Johannesburg

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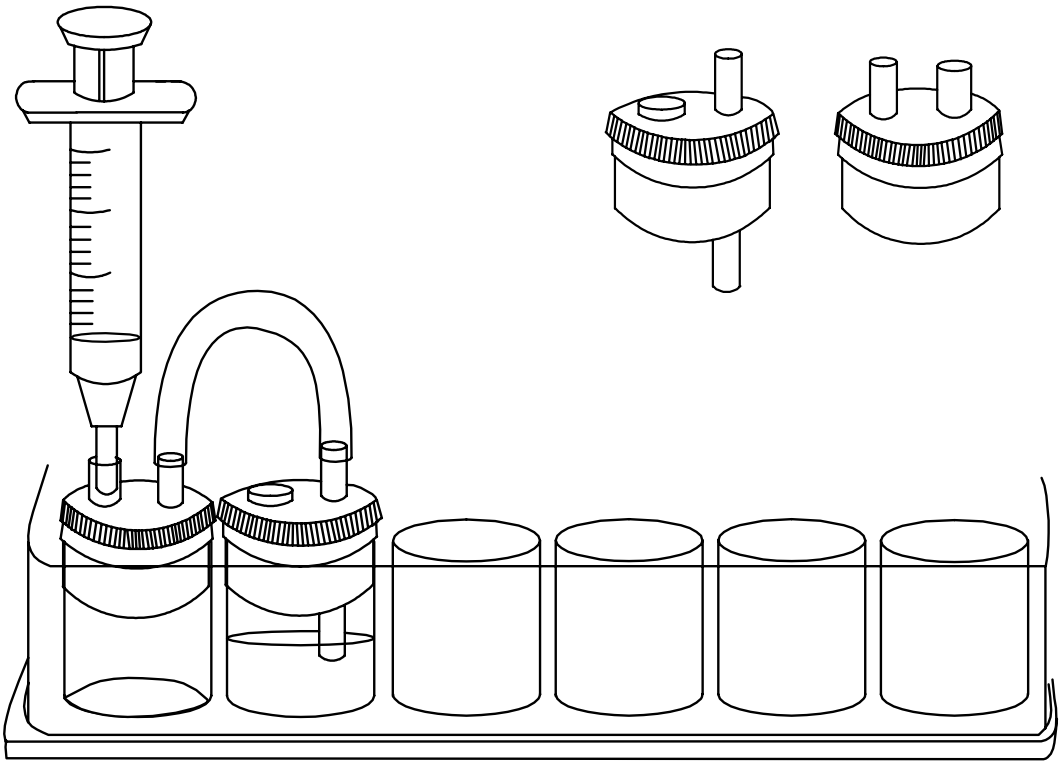
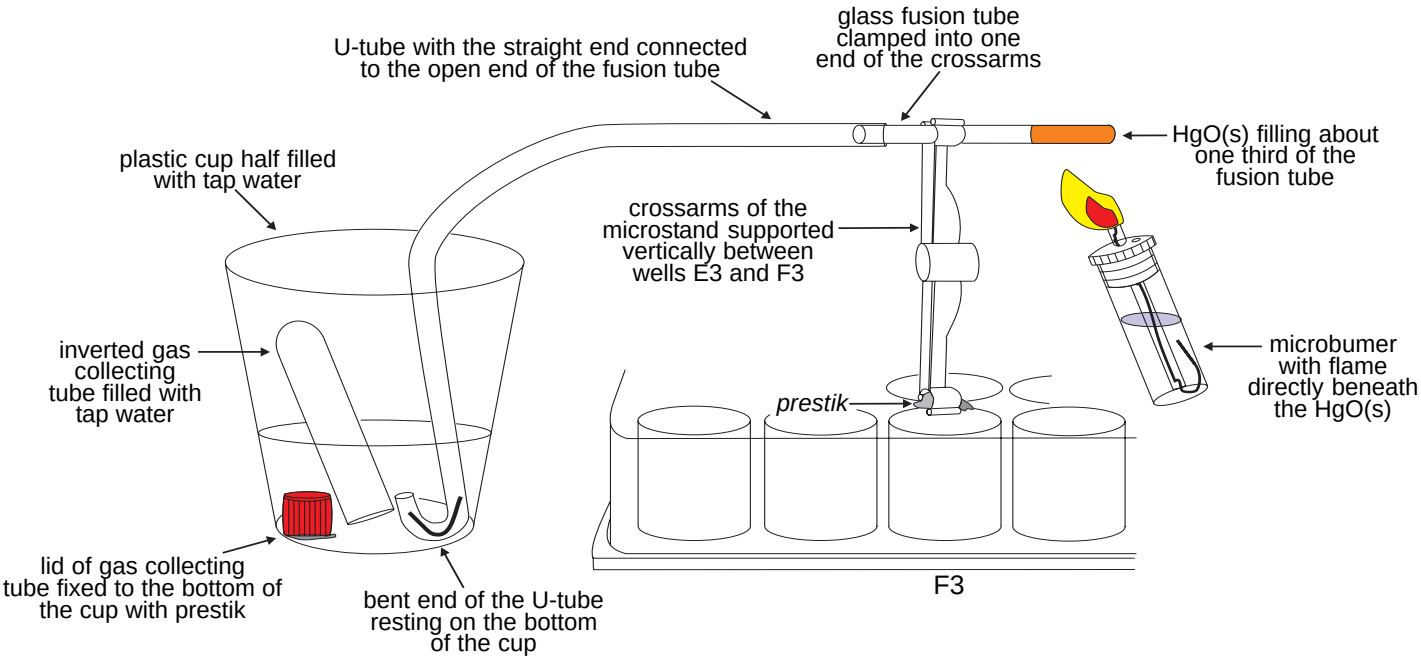


DECOMPOSITION OF MERCURY(II) OXIDE

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x glass fusion tube; 1 x silicone tube with U-bend (U-tube); 1 x crossarms for the microstand; 1 x plastic microspatula; 1 x propette; 1 x gas collecting tube with lid; 1 x microburner; Matches or toothpick splints; 1 x plastic cup; *Prestik*.

Chemicals: Mercury(II) oxide powder (HgO(s)); Tap water.



PROCEDURE

1. Hold the fusion tube in a horizontal position. Use the narrow end of a plastic microspatula to fill about ⅓ to ¼ of the fusion tube with mercury(II) oxide powder. Tap the sealed end of the tube gently to compact the powder at the bottom of the tube.
2. Examine the diagram above carefully and set up all the apparatus except for the gas collecting tube, the plastic cup and the microburner.
3. Remove the lid from the gas collecting tube. Attach a small piece of prestik to the end of the lid and stick the lid inside the bottom of a plastic cup or similar container.
4. Fill half of the plastic cup with tap water. Fill the gas collecting tube to the brim with water.
5. Place the tip of one of your fingers over the mouth of the gas collecting tube and invert it (turn it upside down), making sure that no air bubbles remain in the tube.
6. Keeping your finger in place, lower the inverted tube into the water in the plastic cup.

Note **Do not remove your finger until the mouth of the tube is below the level of the water in the cup.**

7. Lower the U-tube into the plastic cup. The bent end must be on the bottom of the cup next to the mouth of the gas collecting tube.

Note **If you have followed steps 3 to 7 correctly, then your set-up should look like that in the diagram above.**

8. Light the microburner. Hold the flame directly beneath the HgO(s) in the fusion tube. Continue heating the HgO(s) during the next steps. *(See Questions 1, 2, 3)*
9. Wait for a few bubbles to appear in the water from the bent end of the U-tube in the plastic cup. Carefully place the gas collecting tube over the bent end of the U-tube. *(See Question 4)*
10. Leave the gas collecting tube in this position until it has filled with the gas escaping from the U-tube. Now, lift the gas collecting tube away from the U-tube and push it into the lid in the plastic cup. **Never lift the gas collecting tube above the water level in the cup.**
11. Carefully twist the tube so that the tube and its lid are dislodged from the prestik. Remove the gas collecting tube from the cup.
12. Light a match or toothpick splint in the microburner flame. Wait until the burning end begins to glow, then quickly remove the lid from the gas collecting tube and hold the glowing end inside the mouth of the tube. *(See Question 5)*
13. Blow out the flame of the microburner.

Place any mercury into a container for mercury waste. Clean the fusion tube after it has cooled.

DECOMPOSITION OF MERCURY(II) OXIDE

QUESTIONS

Q 1. What happens to the mercury(II) oxide powder as it is heated ?

Q 2. What do you observe on the wall of the fusion tube ?

Q 3. What is the name of the substance formed on the wall of the fusion tube ?

Q 4. Why is it necessary to let a few bubbles emerge from the U-tube before putting the gas collecting tube in place?

Q 5. What do you observe when the glowing end of the match or splint is held inside the mouth of the gas collecting tube?

Q 6. What is the name of the gas that you collected ?

Q 7. How do you know that it was this gas that you collected ?

Q 8. What has happened to the mercury(II) oxide ? Try to write down a word equation or chemical equation to show what happened.

Q 9. From your answer to Question 8, would you say that mercury(II) oxide is a compound, an element or a mixture?

Q10. What do you observe in the fusion tube after it has cooled ?

Q11. Why do you think that the mercury(II) oxide has changed in appearance again ?

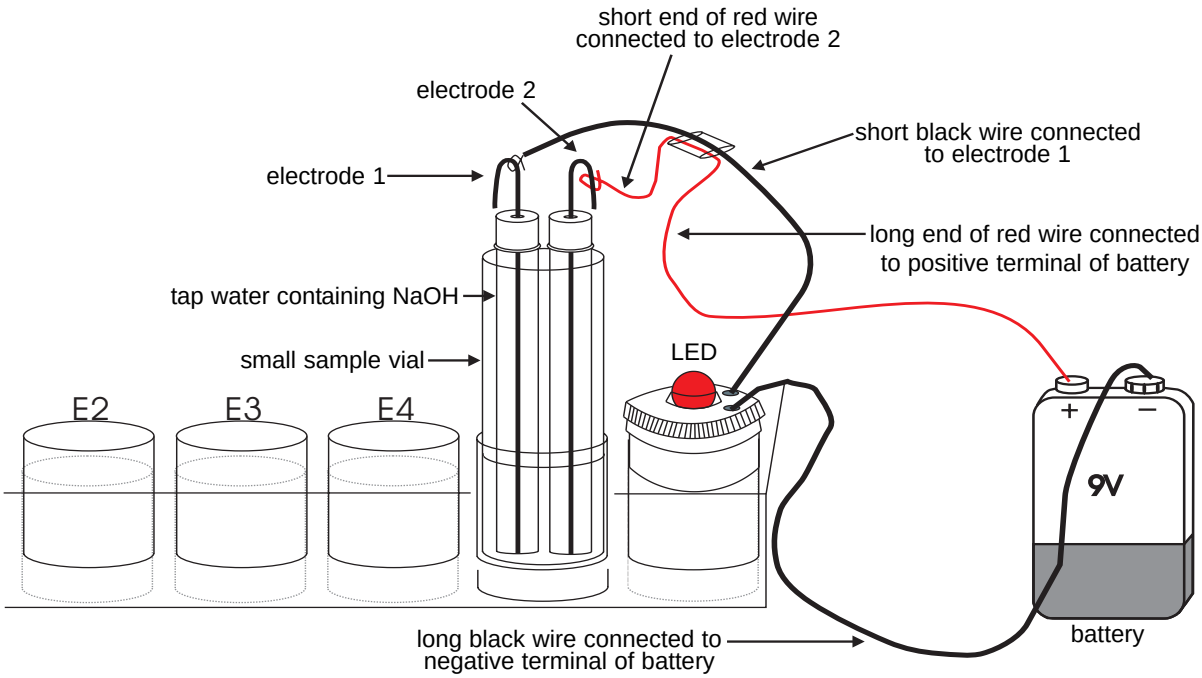
ELECTROLYSIS OF WATER

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.

Note **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.

ELECTROLYSIS OF 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 ?

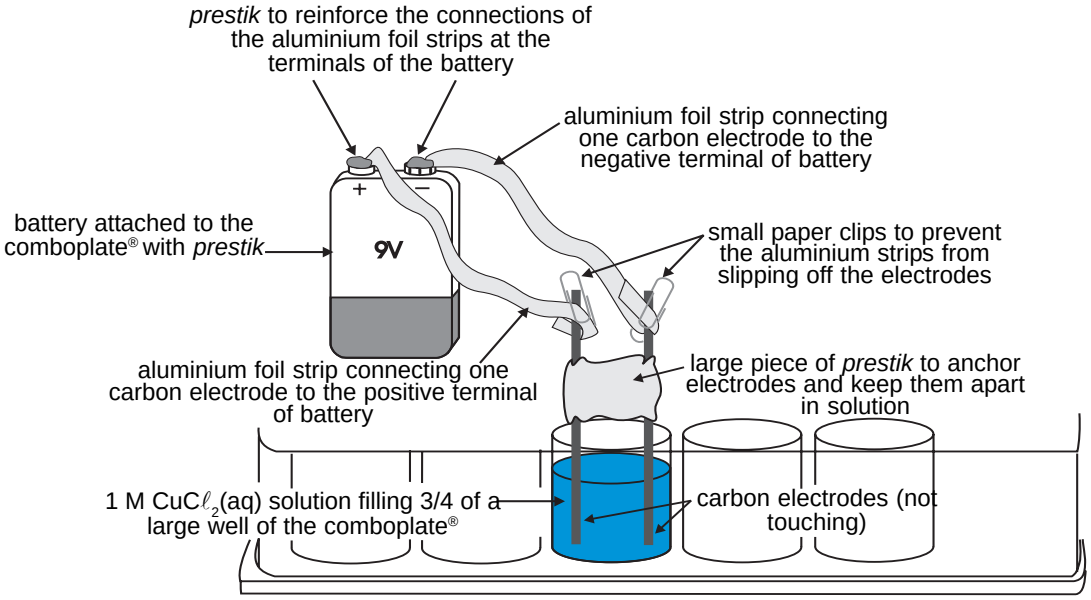
Q10. Write a summary of what happens when water is electrolysed.

Q11. From question 10, would you say that tap water is a compound, an element or a mixture ? Explain your answer.

THE ELECTROLYSIS OF A COPPER(II) CHLORIDE SOLUTION

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 ($CuC\ell_2$(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.

THE ELECTROLYSIS OF A COPPER(II) CHLORIDE SOLUTION

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)

SEPARATION TECHNIQUES – PAPER CHROMATOGRAPHY

PART 1: Is the ink of a black permanent marking pen a mixture or a pure substance ?

REQUIREMENTS

Apparatus: 1 x sample vial (size 1); 1 x strip of filter paper – 6 cm x 10 mm; 1 x thin stemmed propette; 1 x black permanent marking pen; 1 x measuring ruler.
Chemicals: Methanol ($CH_3OH(\ell)$).

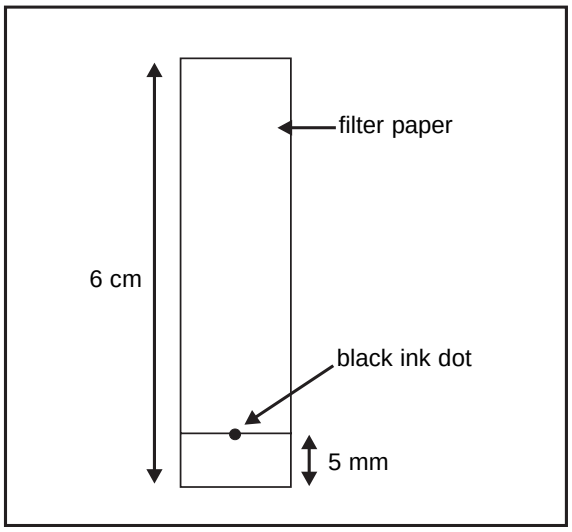


FIGURE 1

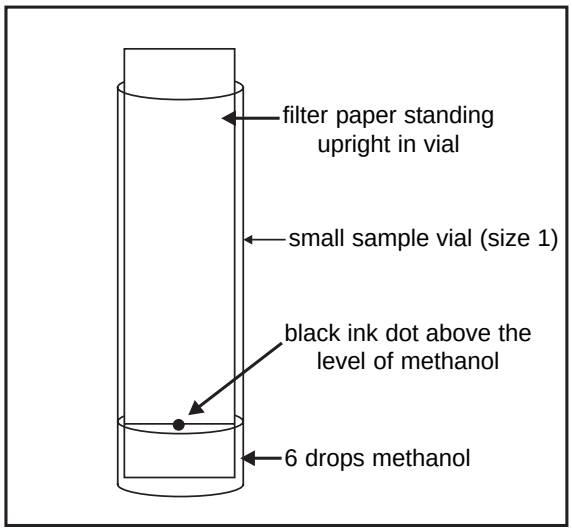


FIGURE 2

PROCEDURE

1. Use the black permanent marking pen and the ruler to make a small ink dot about 5 mm away from one edge of the 6 cm long strip of filter paper (see fig.1). Try to use a pen with a fine tip. If you only have a broad tipped pen, try to make the dot as small as possible otherwise the ink may spread too much during the separation.
2. Use a propette to put 6 drops of methanol into the sample vial. Place the drops directly into the vial without spilling any methanol on the sides, as this will affect the separation.
3. Carefully insert the filter paper into the sample vial so that the small ink dot on the filter paper is just above the methanol in the vial (see figure 2). *(See Questions 1, 2)*

Note **Place the filter paper as upright as possible in the vial, otherwise the methanol may travel unevenly up the filter paper and cause the ink to run off the side of the filter paper.**

4. Wait for about 10 to 15 minutes. *(See Question 3)*

Clean the sample vial thoroughly before starting Part 2.

PART 2: Can water be used as a solvent to separate black permanent ink into its components by paper chromatography ?

REQUIREMENTS

Apparatus: As for Part 1.
Chemicals: Tap water ($H_2O(\ell)$).

PROCEDURE

1. Repeat steps 1 to 3 as in part 1, using a new strip of filter paper and water as the solvent. *(See Questions 1, 2)*
2. Wait for about 10 minutes. *(See Question 3)*

Clean the sample vial thoroughly.

SEPARATION TECHNIQUES – PAPER CHROMATOGRAPHY

QUESTIONS – PART 1

Q1. What happens to the filter paper the moment it is inserted into the methanol in the sample vial ?

Q2. Does the black ink dot remain 5 mm from the edge of the strip of filter paper after 2 minutes ?

Q3. What can you see on the filter paper after about 10 – 15 minutes ?

Note **Black ink is made up of different colours. Depending upon the manufacturer of the pen used, varying colours may be seen. Blue and red are particularly common.**

Q4. Is the ink a mixture or a pure substance ?

Q5. Give a reason for your answer to question 4.

Q6. Which component in the black ink is most soluble in methanol ? Explain your answer.

Q7. Which component in the black ink is least soluble in methanol ? Explain your answer.

Q8. Is the black ink a homogeneous or heterogeneous mixture ? Explain your answer.

QUESTIONS – PART 2

Q1. Does the black ink on the filter paper remain 5 mm from the edge of the filter paper after 2 minutes ?

Q2. What happens to the dot of black ink after 10 minutes ?

Q3. Has the black ink dot separated into different components as in Part 1 (with methanol as the solvent) ?

Q4. Can water be used to separate the components of black ink ?

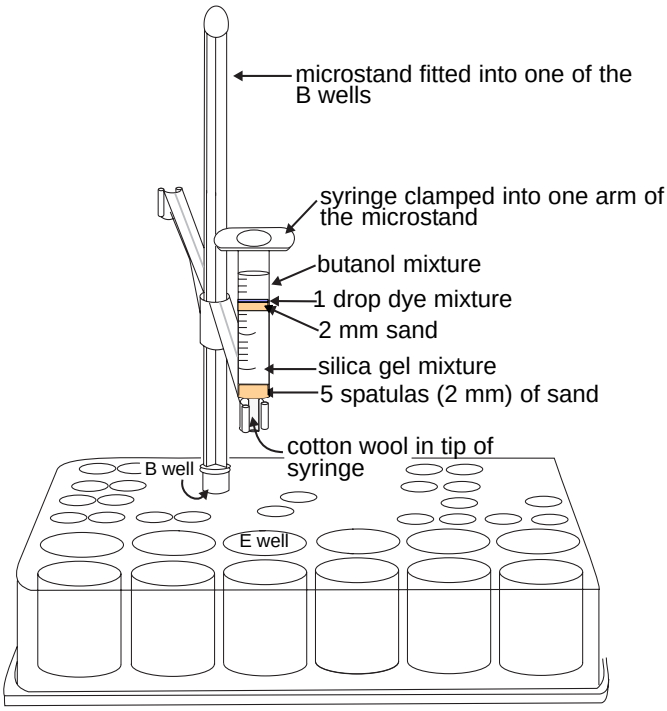
Q5. Give a reason for your answer to question 4.

Q6. Why is this black ink described as “permanent” ?

SEPARATION OF TWO DYES BY COLUMN CHROMATOGRAPHY

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 mℓ syringe; cotton wool; 1 x microstand; 2 x propettes; 1 x microspatula; 1 x glass rod; 1 x small sample vial; 1 x large sample vial with lid.
Chemicals: 1-butanol ($C_4H_{10}O(\ell)$); Ethanol ($C_2H_6O(\ell)$); Silica gel; Tap water; Food dyes mixture; Sand.



PROCEDURE

1. Prepare a solution of 10:1:1 of 1-butanol : ethanol : water in the large sample vial. Use 10 mℓ of 1-butanol. Close the lid tightly and shake the mixture thoroughly. This mixture is later referred to as the butanol mixture.
2. Take a comboplate® and put a microstand into well B1 (or any of the B wells).
3. Push a little cotton wool into the tip of the 2 mℓ syringe and keep the tip facing downwards.
4. Clamp the nozzle of the syringe into one arm of the microstand so that the tip is directly above one of the large wells.
5. Add 5 spatulas of sand on top of the cotton wool so that your sand layer is about 2 mm high.
6. In a small sample vial put 10 heaped spatulas of silica gel, and add about half a propette of the butanol mixture. Stir with a glass rod. Add the silica gel mixture to the syringe.
7. Keep the syringe in the clamp so that the butanol mixture coming through the nozzle is collected in well E1 (or any of the E wells in line with the B well you have used). Allow the silica gel-butanol mixture to settle.
8. Add another 3 heaped spatulas of sand on top of the silica gel so that it is about 2 mm high as well. *(See Question 1)*
9. Use a clean propette to put one drop of the dye mixture on top of the sand in the syringe. *(See Question 2)*
10. Add more butanol mixture to the syringe, making sure that the top of the sand never dries out. You can use the butanol mixture collected from the syringe in well E1 to refill the syringe.
11. Keep adding the butanol mixture until you observe the different dye components separate (or move at different speeds) down the silica gel column. *(See Question 3)*

EXTENSION

This can be done if one wishes to collect separate samples of the two dyes. It takes a much longer time.

1. Follow instructions 1 to 11 above, but add four drops of the dye mixture on top of the sand instead of one drop.
2. Keep the butanol mixture to the brim of the syringe at all times.
3. Observe the different colours separate down the silica gel column.
4. When some dye first emerges from the column, collect the coloured solution in a well.
5. When a different colour starts to emerge, collect this solution in a different well.

Note **Once the dyes start to emerge you must not use the solution to refill the syringe.**

SEPARATION OF TWO DYES BY COLUMN CHROMATOGRAPHY

QUESTIONS

Q1. What is the function of the sand in the column ?

Q2. What colour is the dye mixture ?

Q3. What colour(s) substances can be seen on the silica gel ?

Q4. Why do the different food dyes travel at different speeds down the silica gel column ?

Q5. Suggest why the dye mixture cannot be separated using filtration.

Q6. Suggest an alternative method that can be used to separate the dye mixture. Explain the basis of this separation method.

COMPOUNDS, ELEMENTS, PURE SUBSTANCES AND MIXTURES - MODELLING THE ATOMS AND MOLECULES

REQUIREMENTS

Apparatus: Modelling clay (or suitable substitute) with at least two different colours; 1 x piece of lined paper.

ASSUMPTION

All modelling clay balls produced represent atoms. The different kinds of atoms are represented by the different colours used.

Note Although these model clay balls represent the atoms greatly magnified in size, this does not mean that the real, microscopic atoms have the colour or any of the other properties that the modelling clay has.

ACTIVITY 1 - PROCEDURE

1. Take a small piece of the modelling clay (one colour) and break this into 10 equal sized pieces. Take these pieces and by placing them one at a time between your thumb and forefinger, roll each of them into balls. Let these balls represent atoms of a substance A. Place these balls on the piece of paper. *(See Question 1)*
2. Take two atoms of substance A and gently press them together so that the modelling clay balls just stick to one another. Repeat this process until there are five sets of two atoms combined. *(See Question 4)*
3. Save the paired clay balls for Activity 2.

ACTIVITY 2 - PROCEDURE

1. Repeat the process of making 10 equal-sized balls of modelling clay (as in Activity 1, procedure 1)) using a different colour than was used before. Let these balls represent atoms of substance B.

   HINT **See Figure 3.**

2. Once again take two atoms of substance B and combine them (as in Activity 1, procedure 2)), repeating this process until five sets of two atoms combined are produced. Place this combination on the paper away from the first combination.

   (See Question 1)

3. Bring the two different collections of paired atoms together in such a way that the two collections, one of one colour and one of the other, touch each other, but are not intermingled.

   HINT **See Figure 5.**

   Let this arrangement of the two collections of paired atoms together be called substance C. *(See Question 3)*

4. Now thoroughly intermingle the two different collections of paired atoms. Let this new arrangement be called substance D

   HINT **See Figure 6.** *(See Question 6)*

ACTIVITY 3 - PROCEDURE

1. Separate the paired atoms of A and B so that there are only individual atoms left. For every atom of substance A, gently stick it together with one atom of substance B. Let this new arrangement be called substance E. *(See Question 1)*

ACTIVITY 1 - QUESTIONS

Q1. Is substance A a compound, a homogeneous or a heterogeneous mixture, or an element? Give a reason for your answer (See Figure 1).

Q2. What criterion at the microscopic level is used to decide if a substance X is a pure substance?

Q3. Using the criterion in Question 2 above, is substance A a pure substance?

Q4. What is the name given to the combination of the two atoms of substance A (See Figure 2)?

Q5. Is substance A now a compound, a homogeneous or a heterogeneous mixture, or an element? Explain your answer.

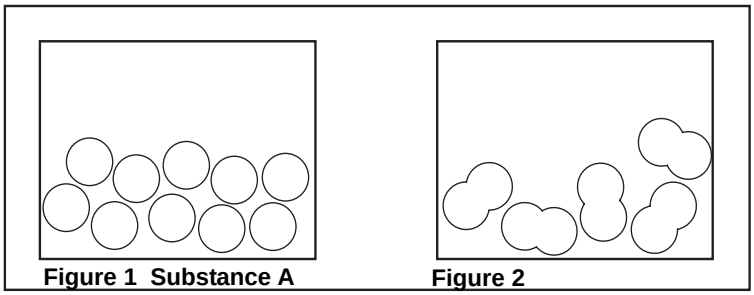


Figure 1 Substance A **Figure 2**

ACTIVITY 2 - QUESTIONS

Q1. Is substance B a compound, a homogeneous or a heterogeneous mixture, or an element? Give a reason for your answer (See Figure 4).

Q2. What is the name given to the combination of the two atoms of substance B ?

Q3. Is substance C a compound, a homogeneous or a heterogeneous mixture, or an element? Give a reason for your answer.

Q4. If the two collections of paired atoms in substance C, were to be moved apart from each other, would this represent a physical or a chemical change? Give a reason for your answer.

Q5. What is the name given to the process in Question 4 ?

Q6. Is substance D a compound, a homogeneous or a heterogeneous mixture, or an element? Give a reason for your answer.

Q7. If the two collections of paired atoms in substance D were to be moved apart from each other, would this represent a physical or a chemical change? Give a reason for your answer.

Q8. What is the name given to the process in Question 7 ?

Q9. Propose a method to perform the process mentioned in Question 8 above, with real substances.

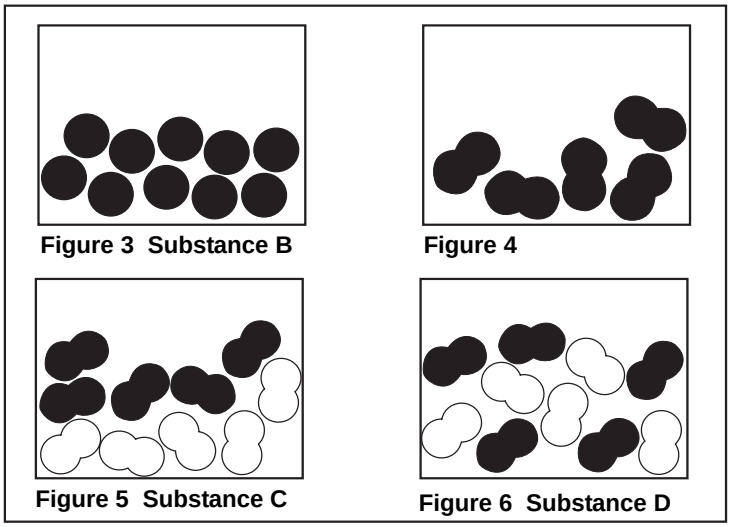


Figure 3 Substance B **Figure 4**

Figure 5 Substance C **Figure 6 Substance D**

ACTIVITY 3 - QUESTIONS

Q1. Is substance E a compound, a homogeneous or a heterogeneous mixture or an element? Give a reason for your answer (See Figure 7).

Q2. How does substance E differ from substance D ?

Q3. If the paired atoms in substance E were to be rearranged into paired atoms as in substance D would this represent a physical or a chemical change? Give a reason for your answer.

Q4. What is the name of the process in Question 3 ?

Q5. How does the energy required to change substance E into substance D compare with the energy required to change substance D to substance C ?

Q6. Propose a method to perform the change mentioned previously in Question 4.

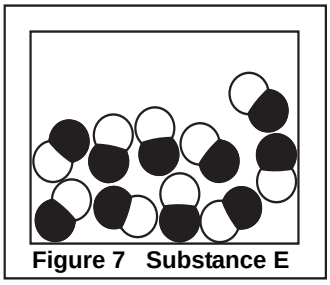
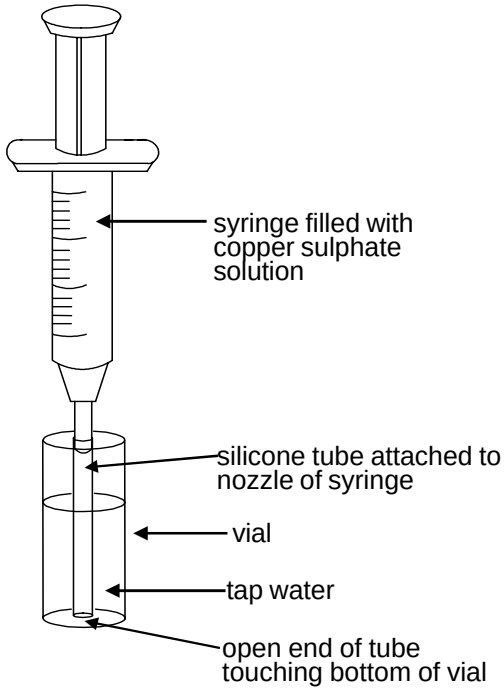


Figure 7 Substance E

DO DISSOLVED SUBSTANCES SPREAD ?

REQUIREMENTS

Apparatus: 1 x vial with lid; 1 x syringe; 1 x silicone tube; *Prestik*.
Chemicals: Saturated copper sulphate solution; Tap water**.**



PROCEDURE

1. Fill ¾ of the microburner vial with water.
2. Fill a syringe with copper sulphate solution.
3. Attach the silicone tube to the nozzle of the syringe.
4. Carefully insert the silicone tube into the water in the vial, until the open end touches the bottom.
5. Press the plunger of the syringe slowly so that the copper sulphate solution moves down the tube into the water at the bottom of the vial.
6. Carefully remove the tube and syringe.
7. Put the lid onto the vial and seal the hole in the lid with a piece of *prestik*. *(See Question 1)*

DO DISSOLVED SUBSTANCES SPREAD ?

QUESTIONS

Q1. Make a drawing to show the appearance of the vial. Use a blue crayon if possible to colour in, to make your drawing easier to understand.

Q2. Put the vial in a safe place and observe its contents each day for a whole week if possible. Each day make a drawing.

Q3. Why do you think that the vial containing the layer of copper sulphate solution and the water should be closed ?

Q4. Direction of movement of the dissolved copper sulphate particles in the vial

a Draw an arrow on one of your diagrams to show the direction in which the dissolved copper sulphate spreads in the vial.

b Describe the direction in which the dissolved copper sulphate in the vial spreads after a few days.

c Where is the concentration of the copper sulphate solution in the vial highest at the beginning of the activity ?

d Where is the concentration of the copper sulphate solution in the vial lowest at the beginning of the activity ?

e Describe the direction in which the dissolved copper sulphate spreads in the vial. Use concentration in your description.

Q5. We call the spreading and mixing of substances diffusion. Use your findings from this activity to write a sentence or two to explain clearly what diffusion is.

Q6. This activity shows that dissolved copper sulphate particles spread throughout the water in the vial. Explain this spreading using the Particle Theory.

Q7. Why do you think diffusion takes place more slowly through water than through air at the same temperature ? Use your knowledge of particles to answer.

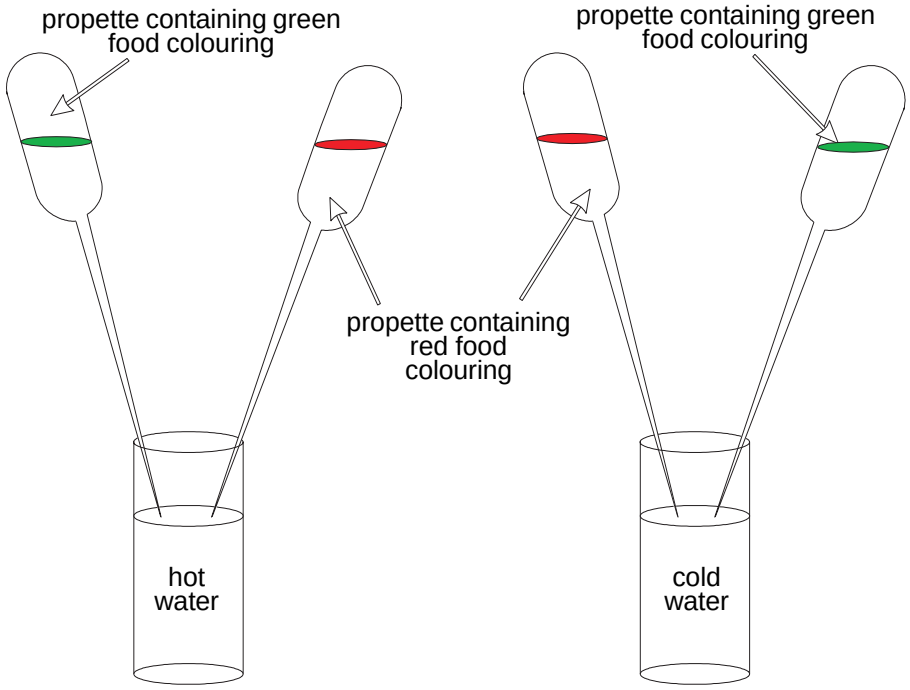
Q8. What difference would you expect to observe if you use hot copper sulphate solution in the syringe and hot water in the vial ?

COLLIDING CLOUDS OF COLOUR

REQUIREMENTS

Apparatus: 2 x vials; 4 x propettes; 1 x pen to write on the vials.

Chemicals: Red food colouring; Green food colouring; Hot and cold water (from the refrigerator).



PROCEDURE

1. Work in pairs.
2. Label one vial HOT WATER and the other vial COLD WATER.
3. Fill one vial with hot water, and the other vial with cold water. The water in both vials must be at the same level.
4. Put red food colouring into two propettes.
5. Put green food colouring into two propettes.
6. Gently put one drop each of red and green food colouring onto the surface of the **hot** water. Ask your partner to put one drop each of red and green food colouring onto the surface of the **cold** water AT EXACTLY THE SAME TIME.

Note **The drops must be on opposite sides of the water but must not be put on the walls of the vials.**
(See Question 1)

Rinse the propettes and vials thoroughly with water.

QUESTIONS

Q1. Why does the food colouring sink to the bottom of the water in both vials ?

Q2. How do you think the temperature of the drops of food colouring changes when they are put into the hot and cold water ?

Q3. What difference do you see when the food colouring sinks in the hot and the cold water ?

Q4. What happens to the food colouring when it settles on the bottom of the vials ?

Q5. Describe any differences in appearance of the mixture in the two vials after about 10 minutes.

Q6. What substances do you see diffusing in this activity ?

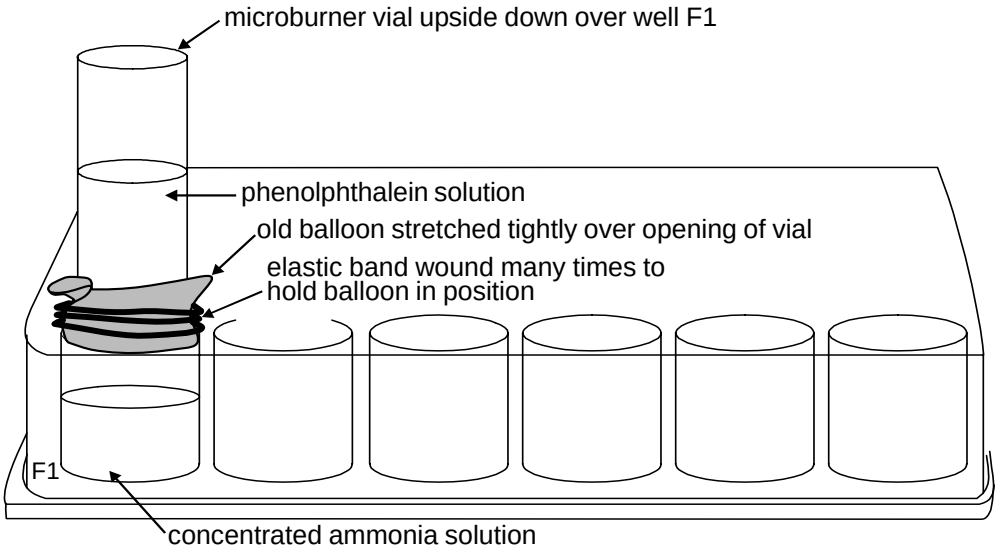
Q7. In this activity, you saw the effect of temperature on the speed at which liquids diffuse. What is this effect ?

LEAKING BALLOONS ? ? ?

REQUIREMENTS

Apparatus: 1 x comboplate®; 2 x propettes; 1 x microburner vial; 1 x elastic band; 1 x pair of scissors; An old balloon – preferably white (or blow up a new balloon and leave it for a few days); *Prestik*; A piece of white paper.

Chemicals: Phenolphthalein solution; Concentrated ammonia solution**.**



PROCEDURE

1. Mix a drop of phenolphthalein solution with a few drops of ammonia solution in well A12. *(See Question 1)*
2. Use a propette to half fill the microburner vial with water. Add 2 drops phenolphthalein solution and stir.
3. Stretch a piece of rubber cut from the balloon tightly over the opening of the microburner vial.
4. Wind the elastic band many times over the balloon to hold it securely in place.
5. Turn the vial upside down and make sure that the phenolphthalein solution does not leak out of the vial.
6. Use a clean propette to ½ fill well F1 with concentrated ammonia solution. Do not spill any ammonia solution around the perimeter of the well.
7. Place the vial with the phenolphthalein solution upside down over well F1. Push its end into well F1 as in the diagram. If necessary use Prestik to hold the vial in position in well F1.
8. Observe what happens in the vial. *(See Question 2)*

Rinse the comboplate®, vial and propettes with water.

QUESTIONS

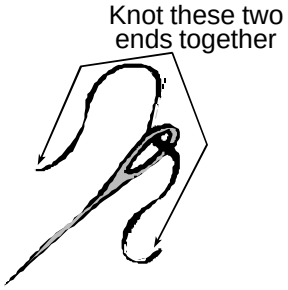
1. What do you observe when the phenolphthalein and ammonia solutions mix ?
2. Describe what happens to the phenolphthalein solution in the vial. In your description include
   - colour changes
   - where these colour changes happen
   - how long it takes the colour changes to happen.
3. What do your observations in Question 2 above tell you about the way the rubber particles are arranged in the piece of rubber ?
4. Describe the direction of diffusion of ammonia gas in this activity.
5. Ivy complains bitterly to her friends that she saw nothing happening in her vial. Phoka is sure that she didn't stretch the rubber enough. Explain the difference between the way the particles are arranged in stretched and unstretched rubber.

HOW FAST DOES GASEOUS AMMONIA DIFFUSE ?

REQUIREMENTS

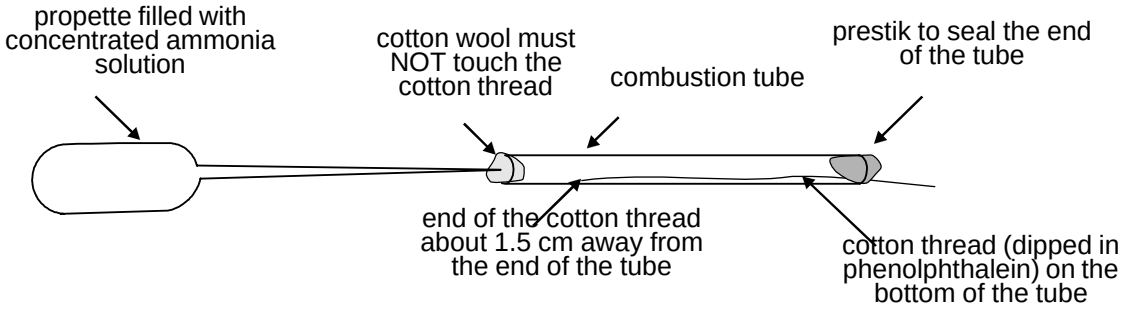
Apparatus: 1 x comboplate®; 1 x sewing needle; 1 x piece of white cotton thread about 15 cm long; 1 x propette; 1 x combustion tube; 1 x ruler; 1 x piece of white paper; cotton wool; Prestik; 1 x pair of scissors; 1 x stopwatch/watch.

Chemicals: Phenolphthalein solution; Concentrated ammonia solution.



PROCEDURE

1. Mix a drop of phenolphthalein solution with a few drops of ammonia solution in well A12. *(See Question 1)*
2. Thread the needle with the cotton as in the diagram above.
3. Dip the cotton thread into the bottle containing the phenolphthalein solution.
4. Use the needle to thread the cotton through the combustion tube. Cut the thread.
5. Pull the thread back through the tube so that only its one end sticks out of the glass tube. The other end of the cotton thread must be about 1½ cm away from the other end of the tube. See the diagram below.



6. Push a tiny piece of Prestik into the end of the tube from which the end of the thread hangs.
7. Use a microspatula to push a tiny piece of cotton wool into the other end of the tube.

Note **The cotton wool must NOT touch the thread.**

8. Put the glass tube onto the table. It must lie flat (horizontal).
9. Put a little concentrated ammonia solution into the propette.
10. Put the propette on the table. Push its tip into the tube so that the tip just touches the cotton wool.
11. Gently press the bulb of the propette so that ONE or TWO drops (no more) of ammonia solution moisten the cotton wool. *(See Question 2)*
12. Start timing when you can see that the ammonia reaches the end of the cotton thread nearer the tip of the propette.
13. Stop timing when you can see that the ammonia reaches the other end of the cotton thread at the piece of prestik. *(See Question 3)*
14. Measure the length of the cotton thread inside the tube. *(See Question 4)*

Rinse the comboplate®, propette and combustion tube with water.

QUESTIONS

Q1. What do you observe when the phenolphthalein and ammonia solutions mix ?

Q2. Describe what happens in the combustion tube.

Q3. What was the time from start to stop ?

Q4. What is the length of thread inside the tube ?

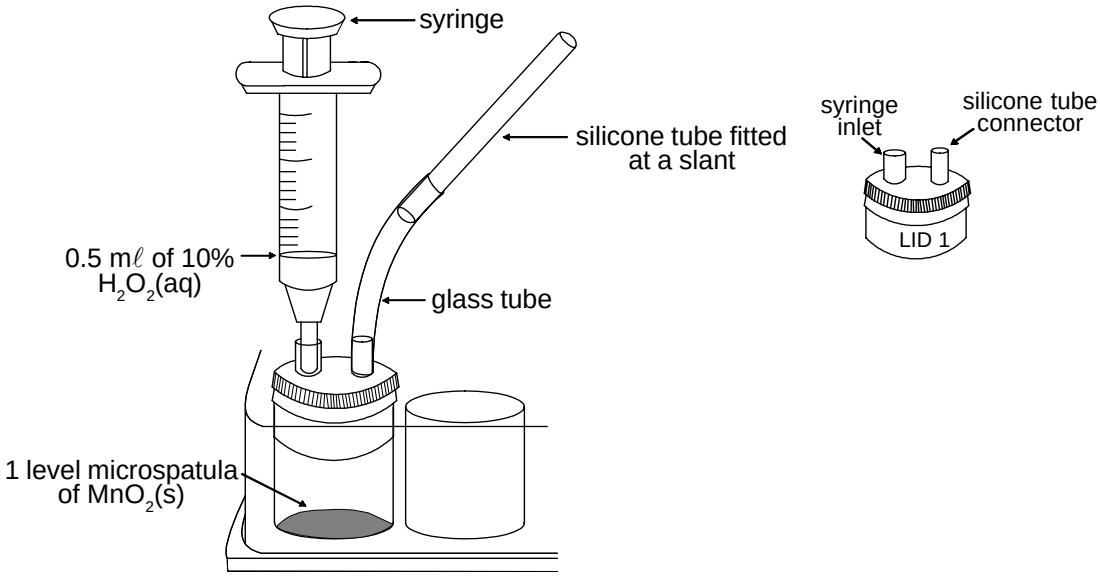
Q5. Work out the speed at which ammonia diffuses in air at room temperature. Show your working.

THE PREPARATION AND TESTING OF OXYGEN

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x microspatula; 1 x syringe; 1 x lid 1; 1 x silicone tube (4 cm x 4 mm); 1 x glass combustion tube; 1 x microburner; 1 x box of matches; 1 x toothpick splint.

Chemicals: Manganese dioxide powder ($MnO_2(s)$); Fresh hydrogen peroxide solution ($H_2O_2(aq)$)[10 %]; Methylated spirits for the microburner.

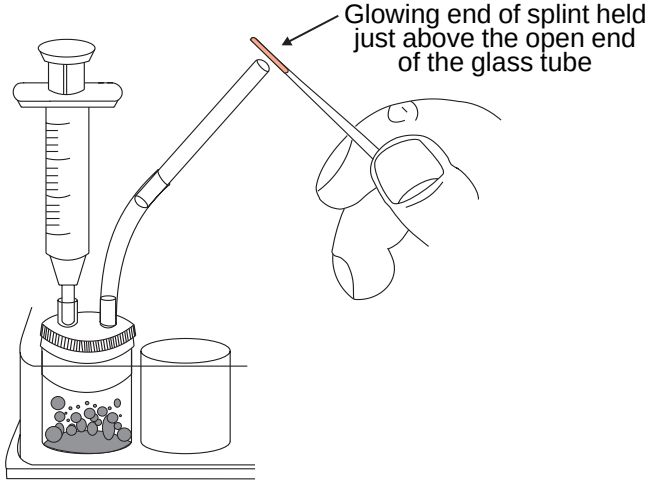


PROCEDURE

1. Use the spooned end of a plastic microspatula to place one level spatula of manganese dioxide powder into one of the large wells of the comboplate®.
2. Seal the well securely with lid 1.
3. Attach a piece of silicone tubing to the tube connector on lid 1 so that it slants away from the syringe inlet. (See the diagram)
4. Connect the free end of the silicone tube to the glass combustion tube as shown in the diagram.
5. Fill the syringe with 0,5 mℓ of ***fresh*** 10% hydrogen peroxide solution.

Note **If the hydrogen peroxide solution is not fresh, the rate of gas production may be too low.**

6. Fit the syringe into the syringe inlet on lid 1, but do not add the hydrogen peroxide to the well yet.
7. Light the microburner and put it down away from the comboplate®.
8. Remove a toothpick splint from your kit. Hold the narrow end of the splint in the flame of the microburner until it begins to burn.
9. While the top 1 to 2 cm of the splint is burning, slowly add the hydrogen peroxide to the manganese dioxide in the well.
10. When the end of the splint is glowing red, put out the flame by either blowing softly on the splint or shaking it gently.
11. Hold the glowing portion of the splint just above the open end of the glass tube and observe what happens. (*See Question 1*)



Note **If the end of the splint is not glowing red or has already burned to an ash, it will not ignite in the gas escaping from the glass tube. The splint will have to be quickly relit in the flame of the microburner until it is glowing red again.**

12. Once the glowing splint has ignited in the gas from the tube, allow it to burn a little longer. Extinguish the flame and hold the glowing portion at the open end of the glass tube again.

Put out the flame of the microburner and clean all apparatus thoroughly.

THE PREPARATION AND TESTING OF OXYGEN

QUESTIONS

Q1. What do you observe each time that the glowing splint is held above the open end of the glass tube ?

Q2. What do you conclude from your observation of the glowing splint ?

Q3. What do you see happening in the well containing the hydrogen peroxide ?

Q4. What do you conclude from your observation of the well ?

Q5. Write a balanced chemical equation to represent the reaction occurring in the well.

Q6. What is the role of the manganese dioxide in this experiment ?

Q7. Suggest an alternative method (using the kit) for collecting the gas formed by the decomposition of hydrogen peroxide.

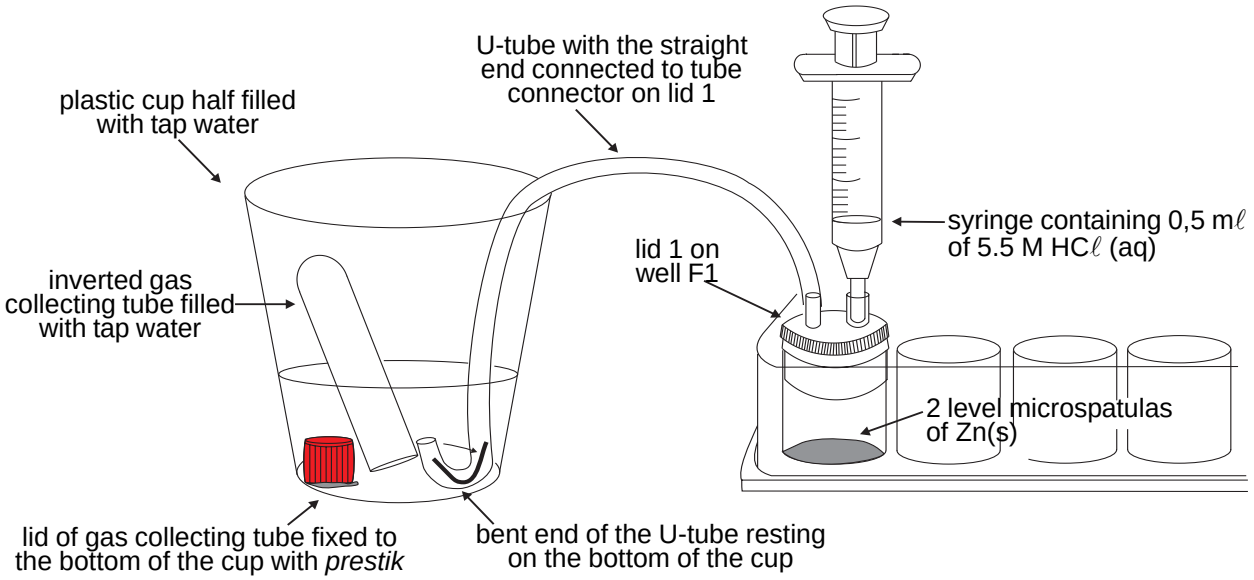
Q8. Oxygen is often stored in large tanks for use in places like laboratories and hospitals. Why do you think these tanks have warnings for people not to smoke near them ?

PREPARATION AND TESTING FOR HYDROGEN

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x silicone tube with U-bend (U-tube); 2 x plastic microspatulas; 1 x propette; 1 x lid 1; 1 x gas collecting tube with lid; 1 x 2 mℓ syringe; Matches or toothpick splints; 1 x plastic cup; *Prestik*.

Chemicals: Zinc powder (Zn(s)); Hydrochloric acid (HCℓ(aq)) [5.5 M]; Anhydrous copper(II) sulphate powder ($CuSO_4$(s)); Tap water.



PROCEDURE

1. Use the spooned end of a plastic microspatula to place 2 level spatulas of zinc powder into well F1. Seal well F1 with lid 1.
2. Connect the straight end of the U-tube to the tube connector on lid 1.
3. Remove the lid from the gas collecting tube. Attach a small piece of prestik to the outer end of the lid and stick the lid inside the bottom of a plastic cup or similar container.
4. Fill half of the plastic cup with tap water.
5. Fill the gas collecting tube to the brim with water.
6. Place the tip of one of your fingers over the mouth of the gas collecting tube and invert it (turn it upside down), making sure that no air bubbles remain in the tube.
7. Keeping your finger in place, lower the inverted tube into the water in the plastic cup.

Note **Do not remove your finger until the mouth of the tube is below the level of the water in the cup.**

8. Lower the U-tube into the plastic cup. The bent end must be on the bottom of the cup next to the mouth of the gas collecting tube.
9. Fill the syringe with 0.5 mℓ of 5.5 M hydrochloric acid. Fit the nozzle of the syringe into the inlet on lid 1.

Note **If you have followed steps 3 to 9 correctly, then your set-up should look like that in the diagram above.**

10. Slowly add about half of the acid dropwise to the zinc powder in well F1. *(See Question 1)*
11. Wait for a few bubbles to appear in the water in the plastic cup. Carefully place the gas collecting tube over the bent end of the U-tube. *(See Question 2)*
12. Add the remainder of the acid to the zinc and collect the gas in the gas collecting tube. *(See Question 3)*
13. When there is no more water left in the gas collecting tube, carefully lift the tube away from the U-tube. Push it firmly into the lid at the bottom of the plastic cup. **Never lift the gas collecting tube above the water level in the cup.**
14. Carefully twist the tube so that the tube and its lid are dislodged from the prestik. Remove the sealed gas collecting tube from the cup and put it upside down on the desk next to you.
15. Light a match. Wait until the flame is small, then quickly remove the lid from the gas collecting tube.
16. Hold the tube horizontally and quickly place the flame just inside the mouth of the tube. *(See Questions 5 and 6)*
17. Use the narrow end of a clean microspatula to add a few grains of white anhydrous copper sulphate into the clear liquid formed at the mouth of the gas collecting tube. *(See Question 7)*

Rinse the comboplate® thoroughly with water.

PREPARATION AND TESTING FOR HYDROGEN

QUESTIONS

Q1. What do you observe in well F1 when the hydrochloric acid is added to the zinc powder ?

Q2. Why is it necessary to let a few bubbles emerge from the U-tube before collecting the gas in the gas collecting tube?

Q3. What happens to the water in the gas collecting tube as the bubbles of gas enter the tube ?

Q4. What is the term used to describe what happens to the water in Question 3 ?

Q5. What happens when the flame of the match is held inside the mouth of the gas collecting tube ?

Q6. Can you see anything on the inner rim of the gas collecting tube where the reaction occurred ?

Q7. Is there a change in the appearance of the white copper sulphate ?

Q8. Write down a word equation for the chemical reaction in well F1 between hydrochloric acid and zinc.

Q9. What property of the gas collected made it necessary to hold the gas collecting tube upside down ?

Q10. Why was there a “pop” sound when the lighted match was brought to the mouth of the gas collecting tube ?

Q11. What product was formed by the chemical reaction mentioned in Question 10 ? Give a reason for your answer.

Q12. Write down a word equation for the chemical reaction referred to in Questions 10 and 11.

Q13. What does the term “anhydrous” mean ?

Q14. Why did the white copper sulphate change colour and what is the name of the product formed ?

Q15. Write down the balanced chemical equation for the reaction occurring in well F1 between zinc and hydrochloric acid.

Q16. Write down the balanced chemical equation for the reaction occurring in the gas collecting tube when the gas produced was tested with the lighted match.

Q17. Write down the balanced chemical equation for the reaction of the anhydrous copper sulphate with the clear liquid produced in the gas collecting tube.

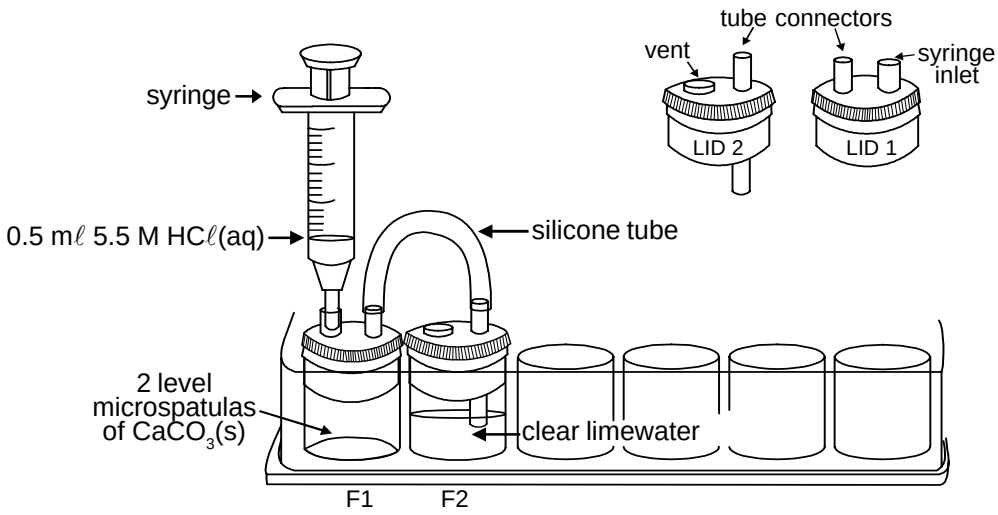
Q18. Write down the name of the other product formed when zinc reacts with hydrochloric acid.

PREPARATION AND PROPERTIES OF CARBON DIOXIDE

PART 1: The Preparation of Carbon Dioxide

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x lid 1; 1 x lid 2; 1 x plastic microspatula; 1 x 2 mℓ syringe; 1 x thin stemmed propette; 1 x silicone tube (4 cm x 4 mm).
Chemicals: Hydrochloric acid (HCℓ(aq)) [5.5 M]; Calcium carbonate powder ($CaCO_3$(s)); Clear limewater ($Ca(OH)_2$(aq)).



PROCEDURE

1. Using the spooned end of the plastic microspatula, place 2 level spatulas of calcium carbonate powder into well F1.
2. Cover well F1 with lid 1.
3. Using a clean propette, fill ¾ of well F2 with the limewater. Cover well F2 with lid 2.
4. Join well F1 to well F2 by attaching the silicone tube to the tube connectors on the lids of wells F1 and F2.
5. Fill the syringe with 0,5 mℓ of 5.5 M hydrochloric acid. Fit the syringe into lid 1 on well F1.
6. Add the acid dropwise to the calcium carbonate in well F1. *(See Questions 1–3)*

Rinse the comboplate® and syringe thoroughly with tap water and dry with paper towel.

PART 2: The Production of Carbon Dioxide During Respiration

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x drinking straw.
Chemicals: Clear limewater ($Ca(OH)_2$(aq)).

PROCEDURE

1. Fill ⅓ of well F3 and well F5 with the clear limewater.
2. Place a clean drinking straw inside the limewater in well F3. Gently blow through the drinking straw into the clear limewater. *(See Question 1)*
3. With a propette, bubble air through the clear limewater in well F5. (Do this by squeezing the air out of the propette whilst the tip is immersed in the lime water. Repeat by removing the propette, letting it fill with air, and then squeezing it out through the limewater. Do this several times.) *(See Question 3)*

Rinse the comboplate® thoroughly with tap water and dry with paper towel.

PREPARATION AND PROPERTIES OF CARBON DIOXIDE

QUESTIONS – PART 1

Q1. What do you observe in well F1 when hydrochloric acid is added to the calcium carbonate ?

Q2. What do you see in well F2 that shows you a gas is being produced ?

Q3. What happens to the clear limewater in well F2 after the gas from well F1 has been bubbled through it ?

Q4. What must the gas be that was produced by the chemical reaction in well F1 ?

Q5. Write down a word equation for the reaction that occurred between the hydrochloric acid and calcium carbonate.

Q6. Write down the chemical equation for the reaction occurring in well F1, but this time use chemical formulae. Balance the chemical equation.

Q7. Clear limewater is an aqueous solution of calcium hydroxide ($Ca(OH)_2(aq)$). When carbon dioxide reacts with the limewater, insoluble calcium carbonate and water are formed. Write down a word equation for the reaction of carbon dioxide with limewater.

Q8. Write down the balanced chemical equation for the reaction described in question 7.

Q9. From your answer to question 8, identify the substance that caused the milkiness when carbon dioxide was tested with clear limewater. Explain why the limewater became milky.

QUESTIONS – PART 2

Q1. What happens to the clear limewater when you blow into it ?

Q2. Explain why there is a change in the appearance of the limewater.

Q3. What happens to the clear limewater when air is bubbled through it ?

Q4. Explain how the experiment shows that carbon dioxide is produced when you respire (“breathe”).

PREPARATION AND PROPERTIES OF CARBON DIOXIDE

PART 3: Dissolving Carbon Dioxide in Water

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x lid 1; 1 x lid 2; 1 x plastic microspatula; 2 x thin stemmed propettes; 1 x 2 mℓ syringe; 1 x silicone tube (4 cm x 4 mm).
Chemicals: Hydrochloric acid (HCℓ(aq)) [5.5 M]; Calcium carbonate powder ($CaCO_3$(s)); Universal indicator solution; Tap water.

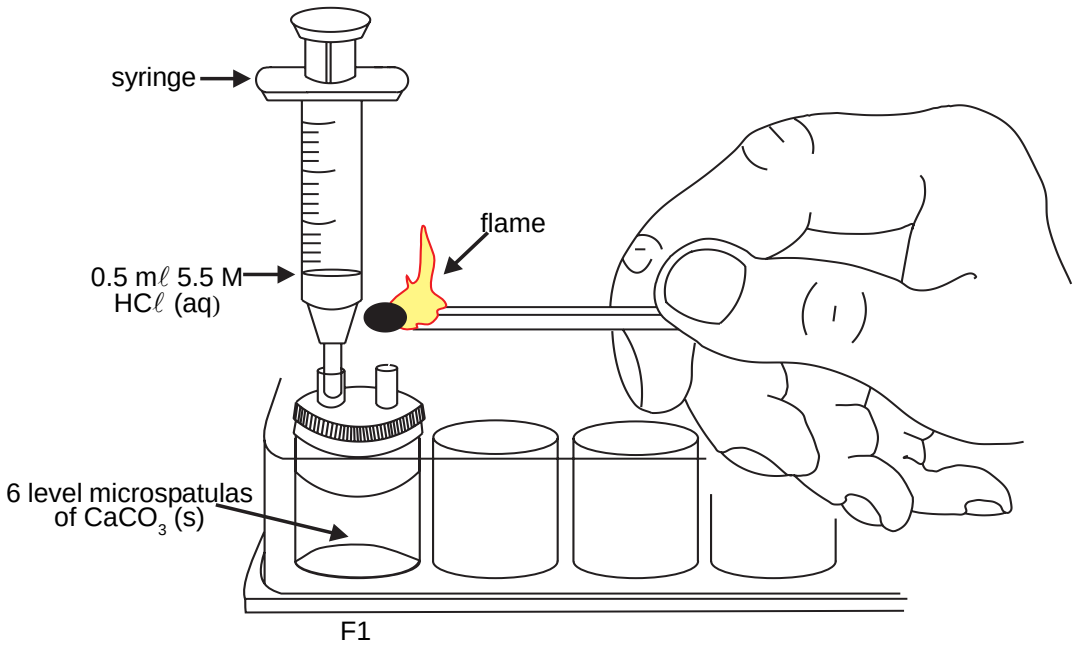
PROCEDURE

Hint: Use the diagram from Part 1 as a guide, but replace the limewater in well F2 with tap water.

1. Using the spoon of the plastic microspatula, place 5 level spatulas of calcium carbonate powder into well F1.
2. Cover well F1 with lid 1.
3. Fill ¾ of well F2 with tap water, using a propette.
4. Using another clean propette, place one drop of the universal indicator solution into the water in well F2. Cover well F2 with lid 2. *(See Question 1)*
5. Join well F1 to well F2 by attaching the silicone tube to the tube connectors on the lids of wells F1 and F2.
6. Fill the syringe with 0,5 mℓ of 5.5 M hydrochloric acid (HCℓ(aq)). Fit the syringe into the inlet of lid 1 on well F1.
7. Add the acid dropwise to the calcium carbonate in well F1. *(See Question 2)*

Rinse the comboplate® and syringe thoroughly with tap water and dry with paper towel.

PART 4: The Effect of Carbon Dioxide on Combustion



REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x lid 1; 1 x plastic microspatula; 1 x 2 mℓ syringe; 1 x box of matches.
Chemicals: Hydrochloric acid (HCℓ(aq)) [5.5 M]; Calcium carbonate powder ($CaCO_3$(s)).

PROCEDURE

1. Using the spoon of the plastic microspatula, place 6 level spatulas of calcium carbonate powder into well F1.
2. Cover well F1 with lid 1.
3. Fill the syringe with 0,5 mℓ of 5.5 M hydrochloric acid. Fit the syringe into lid 1 on well F1.
4. Light a match and hold the burning end over the opening in lid 1. With your free hand, add the hydrochloric acid dropwise from the syringe to the calcium carbonate in well F1. *(See Question 1)*

Rinse the comboplate® and syringe thoroughly with tap water and dry with paper towel.

PREPARATION AND PROPERTIES OF CARBON DIOXIDE

QUESTIONS – PART 3

Q1. What is the colour of the universal indicator in the tap water in well F2 ?

Q2. What does this tell you about the pH of the water ? (Look at the pH colour strip in your kit if you are unsure.)

Q3. What happens in well F2 when the carbon dioxide is bubbled through the water ?

Q4. What does the colour of the indicator in well F2 tell you about the pH of the water after the $CO_2(g)$ has been bubbled through it ?

Q5. What has the $CO_2(g)$ done to make the indicator change colour ?

Q6. When carbon dioxide dissolves in water, some of it reacts with water to form an acid. Write down the word equation for the reaction.

Q7. Write down the balanced chemical equation for this reaction.

Q8. Under pressure, more carbon dioxide dissolves in water to produce a solution called soda water. Can you explain why small gas bubbles are seen and a “fizzing” sound is heard when a bottle of soda water is opened ?

QUESTIONS – PART 4

Q1. What happens to the flame of the match when it is held above the opening of the lid on well F1 ?

Q2. Explain your observations in question 1.

Q3. Write a statement describing the effect of carbon dioxide on combustion.

Q4. Carbon dioxide ($CO_2(g)$) is a more dense gas than oxygen ($O_2(g)$). Describe how this property of CO_2, together with the results of this experiment can be used to fight fires. Name one example of fire-fighting apparatus where these two properties of CO_2 have been put to use.

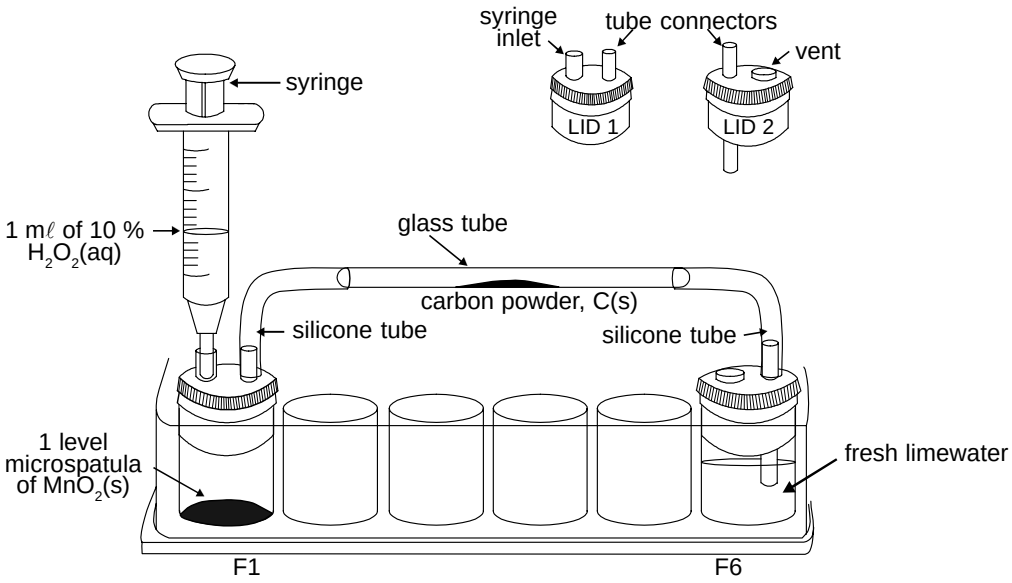
THE REACTION OF CARBON WITH OXYGEN

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 toothpick; 1 x box of matches; 1 x microburner; Cotton wool.

Chemicals: Manganese dioxide powder (MnO_2(s)); Fresh hydrogen peroxide solution (H_2O_2(aq)) [10 %]; Fresh limewater ($Ca(OH)_2$(aq)); Carbon powder (C(s)); Tap water.

Note **The hydrogen peroxide and limewater solutions should be fresh, otherwise the results will not be as described below.**



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 fresh limewater and close the well securely with lid 2. Make sure that the vent in the lid faces inwards. Attach the other silicone tube to the tube connector on lid 2. *(See Question 1)*
4. Fill the syringe with 1 mℓ of the 10% hydrogen peroxide solution, and fit it into the syringe inlet on lid 1 in well F1.
5. Twirl a small piece of cotton wool around the pointed end of a toothpick. Dip the end with the cotton wool into a little water to moisten the cotton wool and push it through the glass tube. This will wet the inner wall of the tube so that the carbon powder adheres to the inside of the tube, and prevents it from moving along the tube during heating.
6. Hold the glass tube in a horizontal position and use the narrow end of a clean microspatula to place a small quantity of carbon powder in the centre of it. 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 **Do not move the glass tube from the horizontal position as some of the carbon powder may fall into well F1, and the experiment will have to be restarted.**

7. Light the microburner and place it on one side.
8. 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 limewater in well F6, then begin heating the carbon powder in the glass tube with the microburner.

Note **Keep the flame of the microburner directly beneath the carbon in the tube. Do not move the microburner from side to side.**

9. If the bubbles stop flowing in well F6, add more of the H_2O_2(aq) dropwise to well F1 while continuing to heat the carbon.
10. Heat the carbon for another ± 2 minutes. *(See Question 2)*
11. After a change has been noted in the limewater, continue to heat the carbon in the glass tube for another 2–3 minutes.
12. Blow out the microburner flame. Disconnect lid 2 from well F6 to avoid limewater being sucked back into the glass tube. *(See Question 3)*

Rinse the comboplate® out with water and shake dry.

Rinse the glass tube with water and scrape out any remaining residue with a toothpick.

THE REACTION OF CARBON WITH OXYGEN

QUESTIONS

Q1. Describe the appearance of the limewater.

Q2. Describe the appearance of the limewater in well F6 after about 2 minutes.

Q3. What difference is there between the quantity of carbon powder added at the beginning of the experiment, and that left in the tube after heating ?

Q4. What do you think has happened to the carbon powder in the glass tube during heating ?

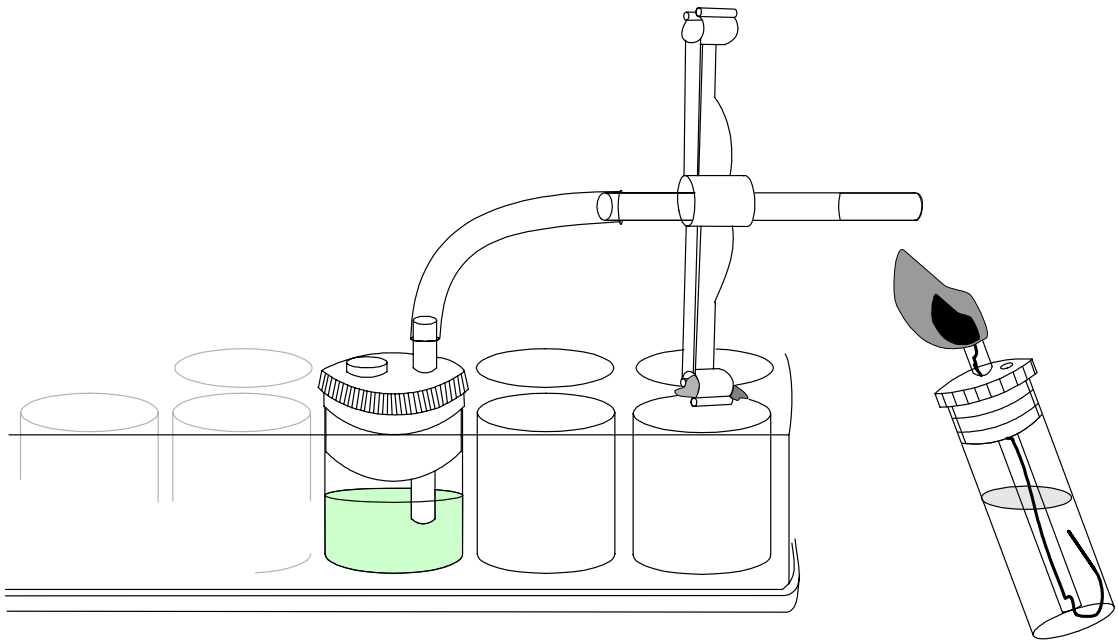
Q5. What caused the change in appearance of the limewater ?

Q6. How do you know that the gas bubbles that caused the limewater to change were not oxygen bubbles formed in well F1 ?

Q7. Write a word equation for the combustion of carbon in oxygen.

Q8. Write a balanced chemical equation for the combustion of carbon in oxygen.

MICROCHEMISTRY
CHAPTER II



THE REACTION OF COPPER WITH OXYGEN

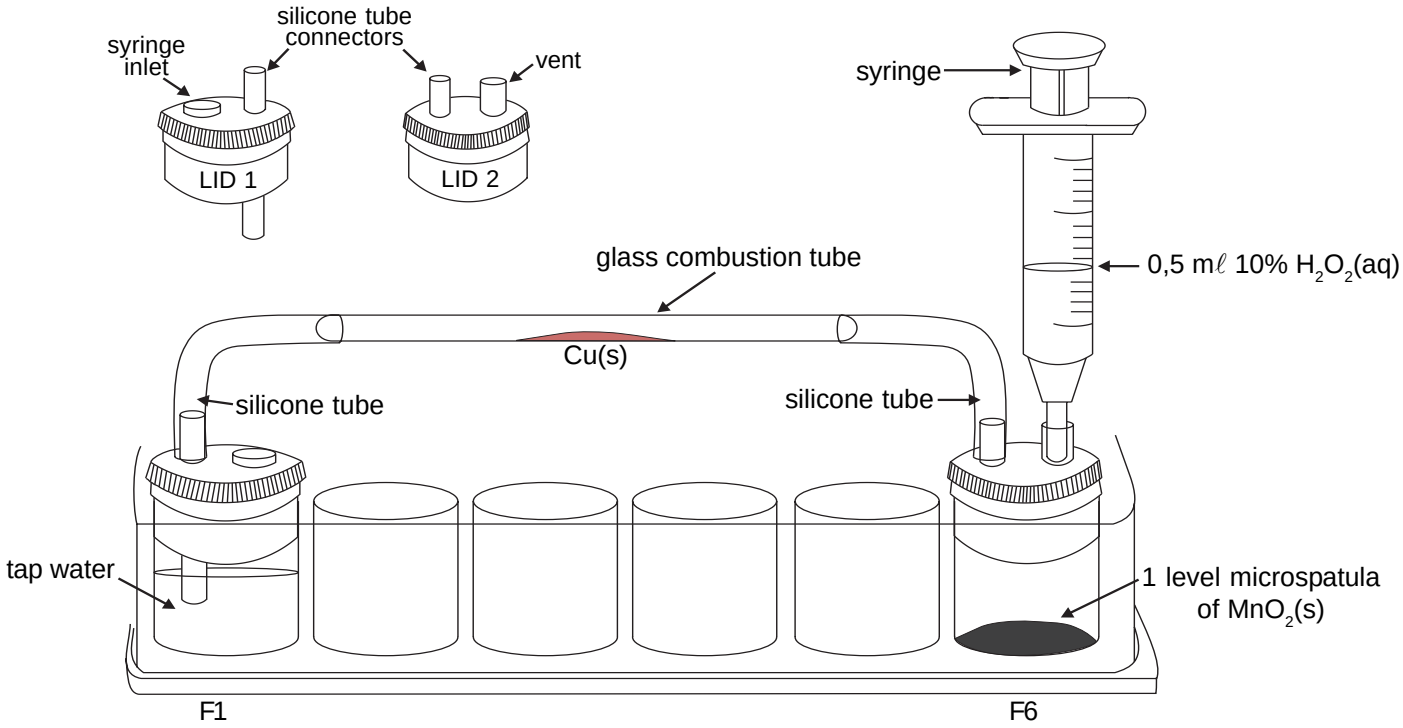
REQUIREMENTS

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.

THE REACTION OF COPPER WITH OXYGEN

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.

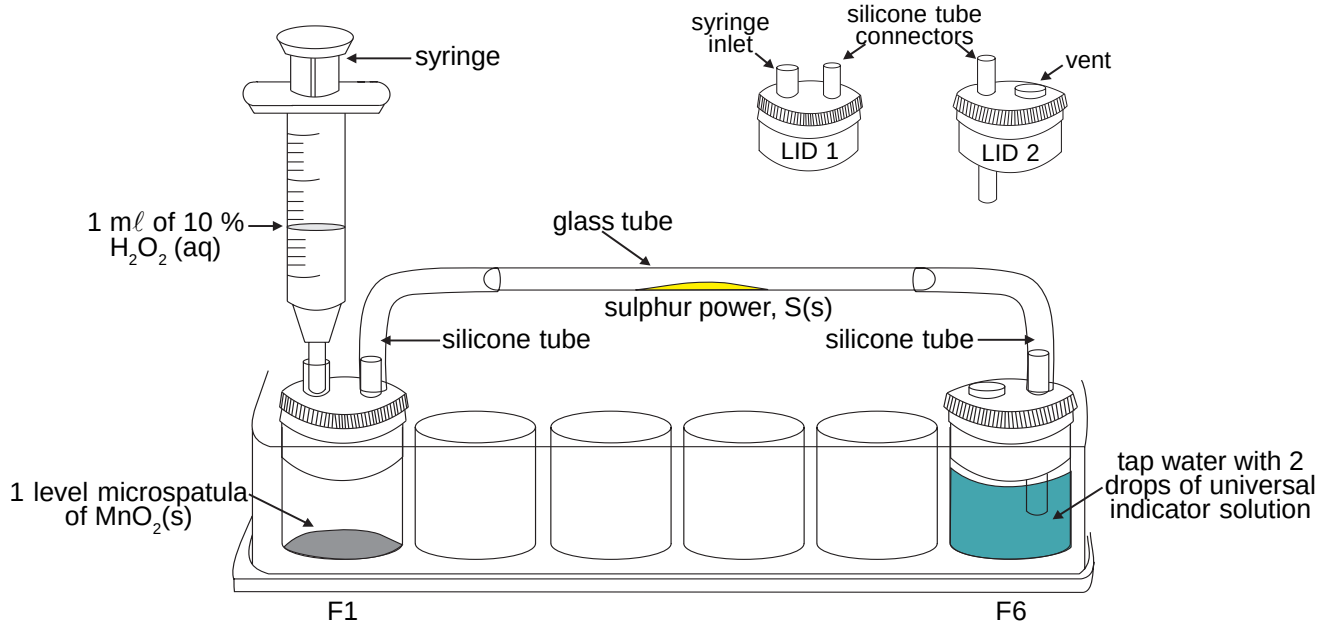
Q9. How would you try to prove that the product formed in this experiment is indeed copper(II) oxide ? Suggest an experimental set-up to perform this experiment.

THE REACTION OF SULPHUR WITH OXYGEN

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 the glass tube from the horizontal position as some of the sulphur powder may fall into 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.

THE REACTION OF SULPHUR WITH OXYGEN

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.

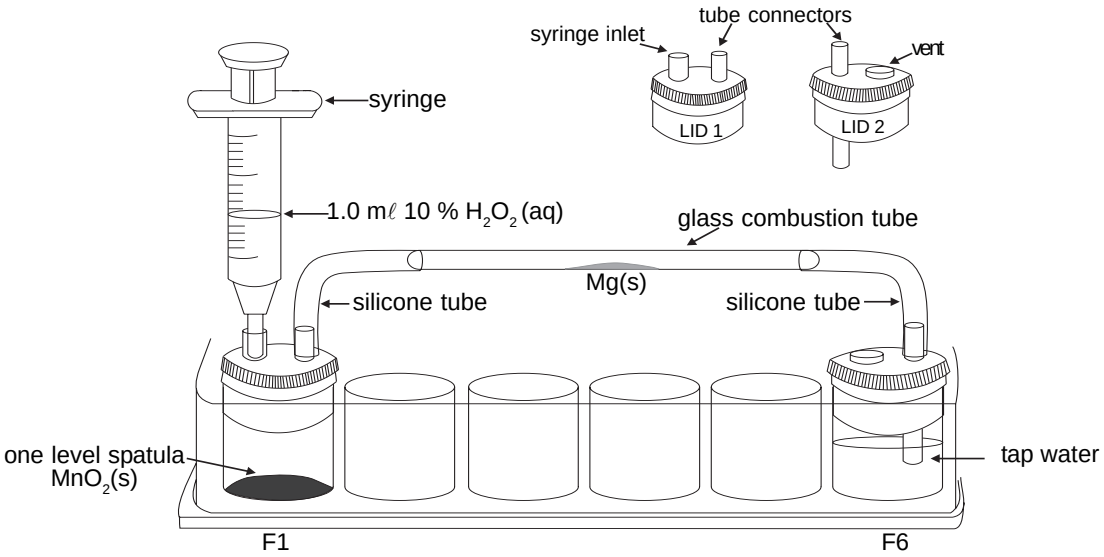
THE REACTION OF MAGNESIUM WITH OXYGEN

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.

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



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)*

Note **Do not move the glass tube from the horizontal position as some of the magnesium powder may fall into well F1.**

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.

Note **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.

THE REACTION OF MAGNESIUM WITH OXYGEN

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.

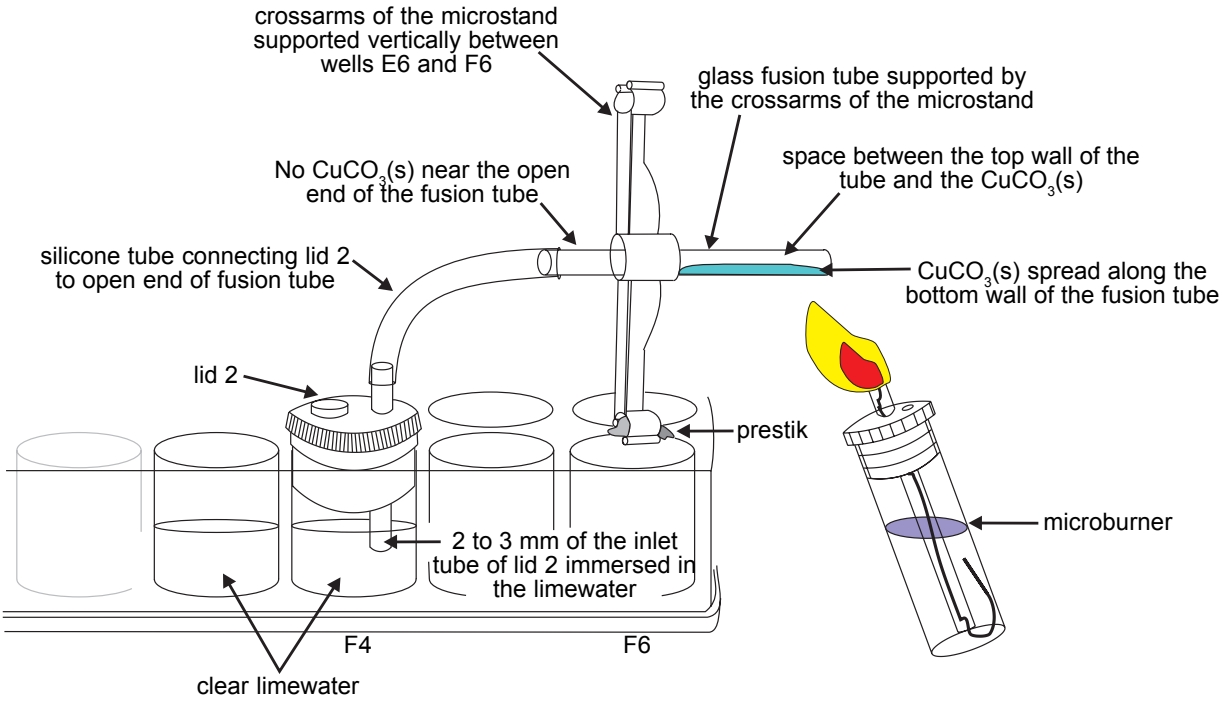
Q10. Write a balanced chemical equation for the combustion of magnesium in oxygen.

DECOMPOSITION OF COPPER CARBONATE

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 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 microburner.
7. Light the microburner. Hold the flame beneath the fusion tube and start heating, waving the flame gently below the $CuCO_3(s)$.

Note **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.

Note **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.

DECOMPOSITION OF COPPER CARBONATE

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.

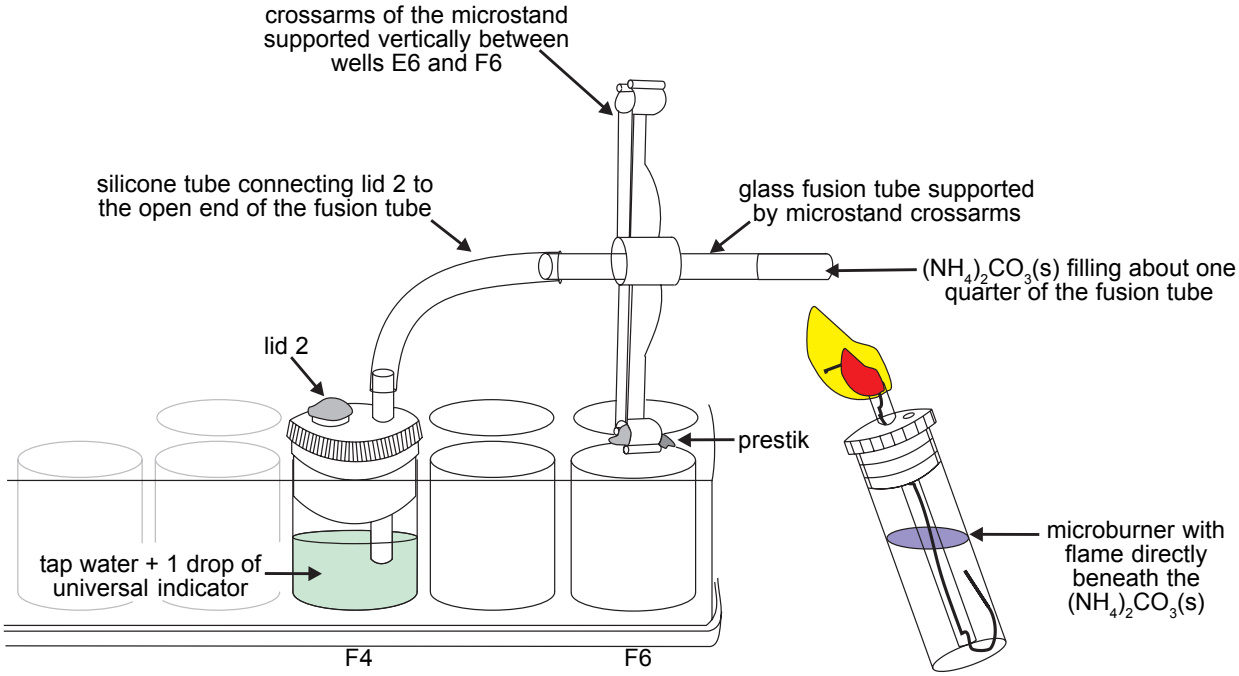
Q11. Write a chemical formula equation for the reaction in Q10 above.

DECOMPOSITION OF AMMONIUM CARBONATE

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.



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.

Note **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.

DECOMPOSITION OF AMMONIUM CARBONATE

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.

REDUCTION OF COPPER(II) OXIDE

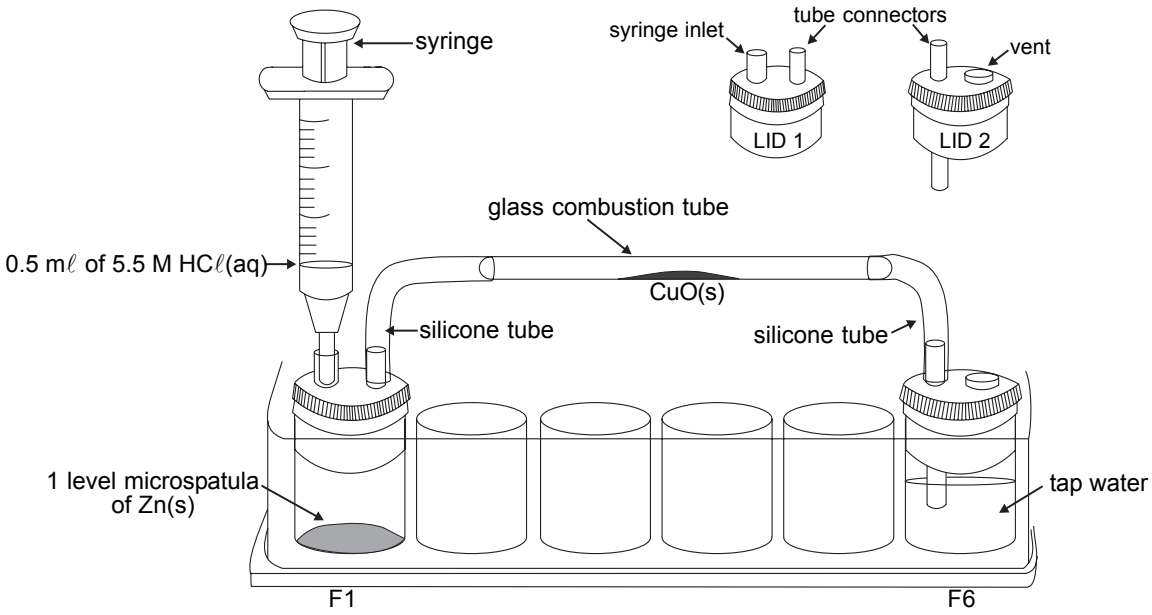
REQUIREMENTS

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.

CAUTION

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. Fill ⅔ of 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.

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

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.

CAUTION **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.

REDUCTION OF COPPER(II) OXIDE

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 (H_2(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.

ACID/BASE TITRATION - AN INTRODUCTION

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.

Note **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 A2 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.

ACID/BASE TITRATION - AN INTRODUCTION

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?

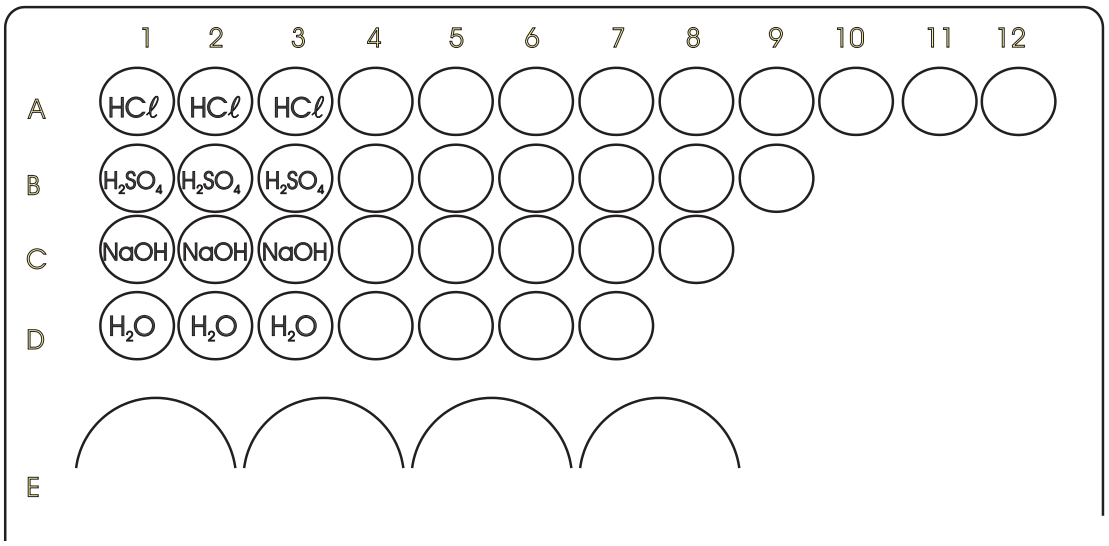
Q6. What is the volume ratio of NaOH/acid B in the titration of 0.10 M acid B?

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

THE EFFECT OF DILUTE ACIDS AND ALKALIS ON INDICATORS

REQUIREMENTS

Apparatus: 1 x comboplate®; 6 x thin stemmed propettes; a sheet of white paper; pH indicator strip.
Chemicals: Hydrochloric acid ($HC\ell$(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.

THE EFFECT OF DILUTE ACIDS AND ALKALIS ON INDICATORS

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.

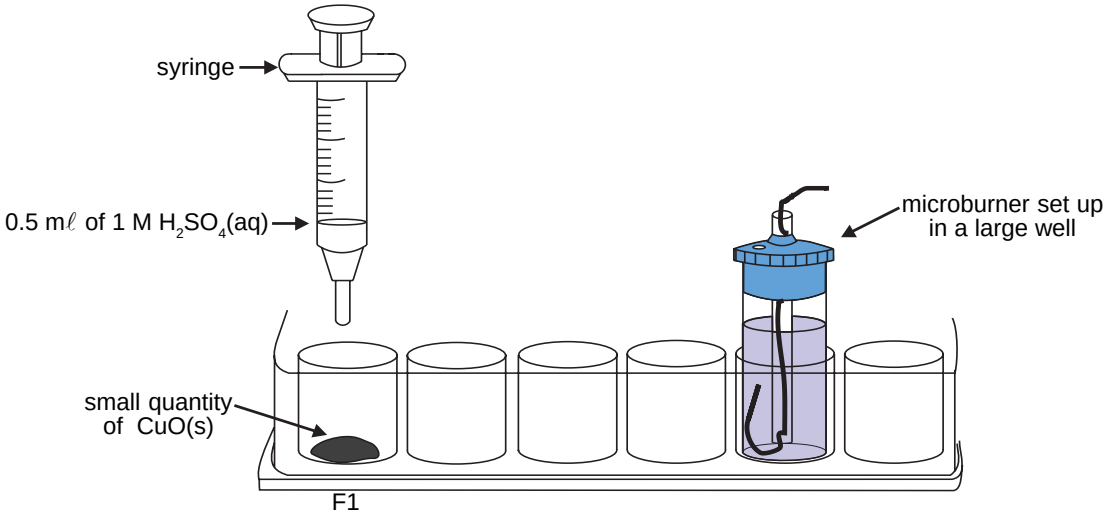
Q6. Discuss in your group: Based on the experiment you have completed, formulate a definition for an indicator.

An indicator is .....

THE REACTION OF SULPHURIC ACID WITH COPPER(II) OXIDE

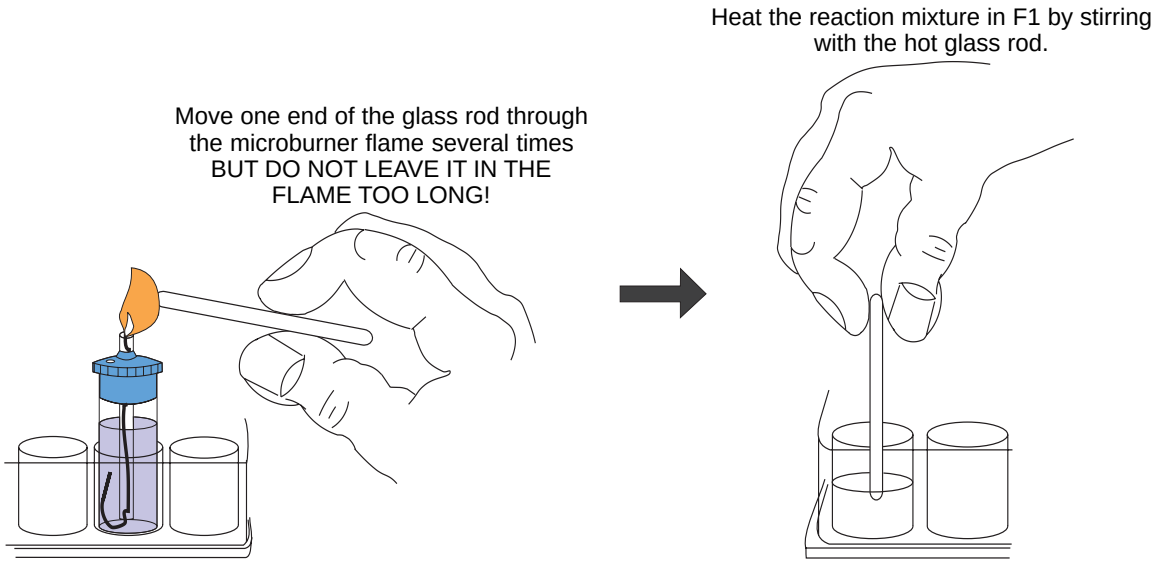
REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x syringe; 1 x microspatula; 1 x microburner; 1 x glass rod; 1 x box of matches.
Chemicals: Copper(II) oxide (CuO(s)); Sulphuric acid (H_2SO_4(aq)) [1 M]; Methylated spirits; Tap water.



PROCEDURE

1. Fill the microburner with methylated spirits and set it up in one of the large wells of the comboplate®.
2. Use the narrow end of a clean microspatula to place a small quantity of copper(II) oxide into well F1. (*See Question 1)*
3. Use a clean dry syringe and add 0,5 mℓ of 1 M sulphuric acid into well F1.
4. Light the microburner and carefully heat the one end of the glass rod in the flame. DO NOT KEEP THE ROD IN THE FLAME FOR A LONG PERIOD.
5. Heat the reaction mixture in F1 by stirring with the heated glass rod. Rinse and dry the rod, and repeat the heating process a few times until you notice a change in colour in F1. *(See Question 2)*



6. Leave the mixture in well F1 in the comboplate® overnight. *(See Questions 4, 5)*

Clean all apparatus thoroughly.

THE REACTION OF SULPHURIC ACID WITH COPPER(II) OXIDE

QUESTIONS

Q1. What is the colour of the copper(II) oxide?

Q2. What happens in well F1 after some time?

Q3. What ions give this colour to the solution?

Q4. What do you notice in well F1 after leaving the comboplate® overnight?

Q5. What is this substance in F1?

Q6. The other product of the reaction in F1 evaporated when you heated the solution and left the comboplate® overnight. What could this possibly be?

Q7. Write a word equation for the chemical reaction that took place.

Q8. 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 oxide. What part of the name of the salt comes from the metal oxide?

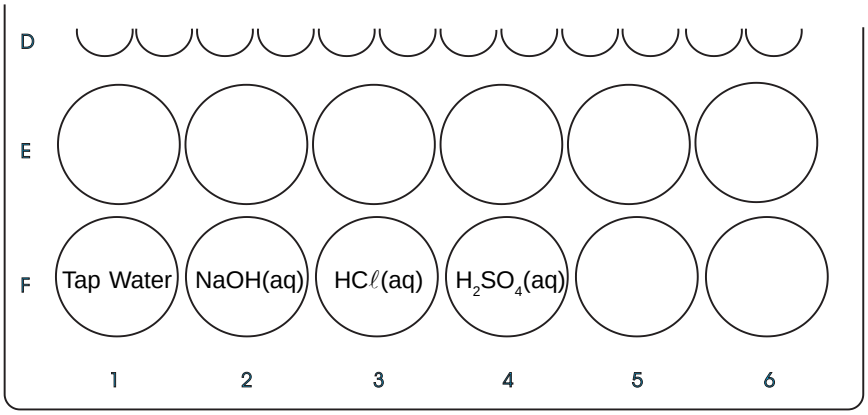
Q9. What part of the name of the salt comes from the acid used in the reaction?

Q10. What difference would it make if you used hydrochloric acid instead of sulphuric acid in the reaction?

THE REACTION OF ACIDS WITH SODIUM HYDROXIDE

REQUIREMENTS

Apparatus: 1 x comboplate®; 4 x propettes; 2 x plastic microspatulas; 1 x syringe; a sheet of white paper.
Chemicals: Hydrochloric acid ($HC\ell(aq)$) [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.

THE REACTION OF ACIDS WITH SODIUM HYDROXIDE

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?

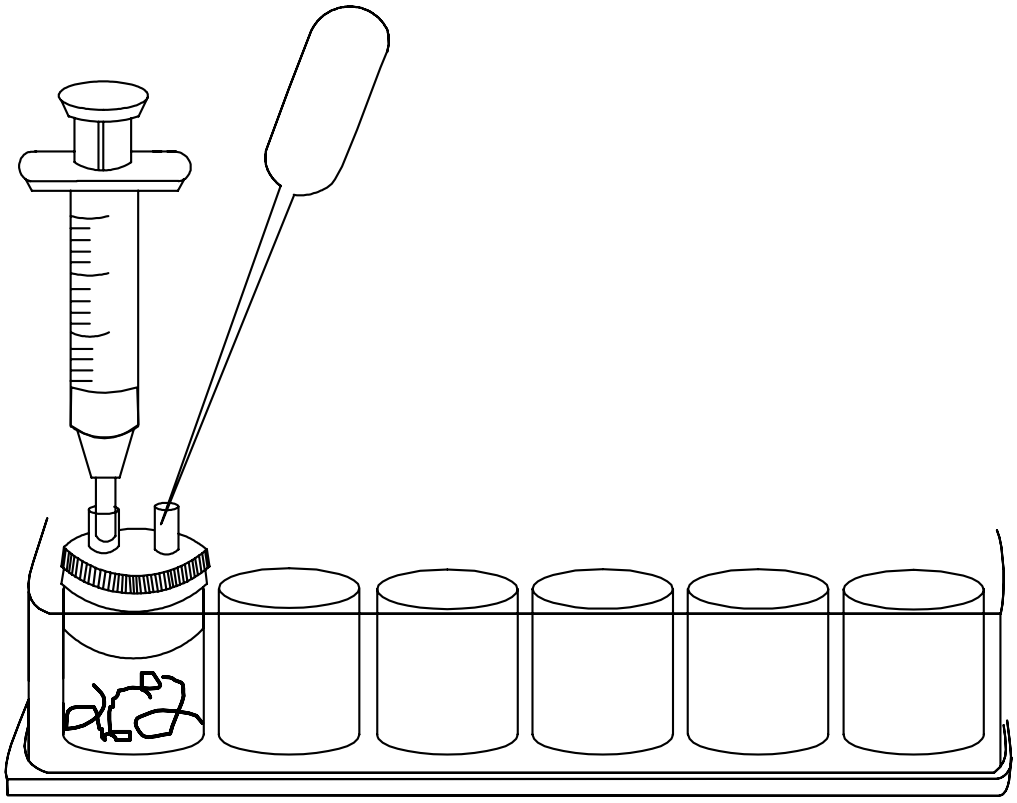
Q7. Explain in your own words what this means.

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?

MICROCHEMISTRY
CHAPTER III



THE REACTION OF GROUP 1 AND 2 METALS WITH WATER

PART 1: The Reaction of the Group 1 Metals – Sodium and Potassium – with Water

REQUIREMENTS

Apparatus: 1 x comboplate®; 2 x thin stemmed propettes; 1 x knife; 1 x unfolded paper clip.
Chemicals: Universal indicator solution; Potassium (K(s)); Sodium (Na(s)); Tap water.

PROCEDURE

1. Half fill wells F1 and F2 with tap water.
2. Add 1 drop of universal indicator solution to each well and observe the colours. *(See Question 1)*
3. Remove a piece of sodium from the storage bottle and place it on a flat surface e.g. an old tile. Press down gently on the metal with an unfolded paper clip, so as to hold it firmly without touching it with your fingers.
4. Scrape off any white oxide coating from the metal with a knife. Use the knife to cut a small piece of Na(s) (about 2 mm x 2 mm). Add this small piece to well F1 and observe. *(See Question 2)*

Note **If the piece of sodium is too big, the comboplate® might crack.**

5. Clean the knife and paper clip, and then use these as before to cut a piece of potassium metal about the same size as the previous piece of sodium. Make sure that you scrape away any of the oxide coating with the knife.
6. Add the small piece of metal to well F2. **(See NOTE above.)** *(See Question 5)*

Rinse the comboplate® thoroughly with water and pat dry using paper towel.

QUESTIONS

Q 1. What is the colour of the solution in each well ? What is their pH ?
Q 2. What happens to the sodium when it is added to the water ?
Q 3. Does the pH of the solution in well F1 change ? Explain.
Q 4. Write a balanced chemical equation which represents the reaction which took place in well F1.
Q 5. What happens to the potassium when it is added to water ?
Q 6. Does the pH of the solution in well F2 change ? Explain.
Q 7. Write a balanced chemical equation which represents the reaction which took place in well F2.
Q 8. Compare the rates of reaction of sodium and potassium with water.

THE REACTION OF GROUP 1 AND 2 METALS WITH WATER

Part 2: The Reaction of the Group 2 Metals - Magnesium and Calcium - with Water

REQUIREMENTS

Apparatus: 1 x comboplate®; 2 x thin stemmed propettes; 1 x plastic microspatula; 1 x piece of sandpaper.
Chemicals: Universal indicator solution; Calcium granules (Ca(s)); Magnesium ribbon (Mg(s)); Tap water.

PROCEDURE

1. Half fill wells F1 and F2 with tap water.
2. Add 1 drop of universal indicator solution to each well. *(See Question 1)*
3. Cut a strip of magnesium ribbon (Mg(s)) about 5 mm long. If the ribbon is dull, rub it with a piece of sandpaper until it is shiny.
4. Add the magnesium ribbon to well F1. *(See Questions 2, 3)*
5. Use a plastic microspatula to add one granule of calcium to well F2. *(See Questions 5, 6)*

Rinse the comboplate® thoroughly with water and pat dry using paper towel.

Part 3: What Gas is Produced when a Group 1 or Group 2 Metal Reacts with Water ?

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x thin stemmed propette; 1 x plastic microspatula; 1 x box of matches.
Chemicals: Calcium granules (Ca(s)); Tap water.

PROCEDURE

1. Fill ¾ of well F1 with tap water.
2. Remove a match from the box and keep these close to you.
3. Using the plastic microspatula, place one granule of calcium into the water in well F1.
4. Quickly light the match and when the flame is small, hold the burning match over well F1. *(See Question 1)*

Rinse the comboplate® thoroughly with water and pat dry using paper towel.

THE REACTION OF GROUP 1 AND 2 METALS WITH WATER

QUESTIONS - PART 2

Q 1. Observe the colour of the solutions in each well and deduce their pH values.

Q 2. What happens to the magnesium when it is added to water ?

Q 3. Does the pH of the solution in well F1 change? (Explain).

Q 4. Write a balanced chemical equation which represents the reaction which took place in well F1.

Q 5. What happens to the calcium when it is added to the water ?

Q 6. Does the pH of the solution in well F2 change? (Explain).

Q 7. Write a balanced chemical equation which represents the reaction which took place in well F2.

Q 8. Compare the rates of reaction of calcium and magnesium with water.

Q 9. Recall your observations from parts 1 and 2 for the reactions of sodium and magnesium with water. Which metal reacts faster with water: sodium or magnesium ?

Q10. Recall your observations from parts 1 and 2 for the reactions of potassium and calcium with water. Which metal reacts faster with water: potassium or calcium ?

Q11. Does the reactivity of Group 1 and 2 metals increase or decrease with increasing atomic number in the group ?

Q12. Does the reactivity of Group 1 and 2 metals increase or decrease with increasing atomic number in a period ?

Q13. Predict whether aluminium would react faster or slower than magnesium with water.

Q14. Predict whether beryllium would react faster or slower than magnesium with water.

Q15. What gas was produced when each of the Group 1 and 2 metals investigated, reacted with water ?

Q16. How would you test for this gas without collecting it ?

QUESTIONS - PART 3

Q 1. What happens while the match is being held over well F1 ?

Q 2. What is the name of the gas produced ?

Q 3. Use your knowledge of the reactivity of the Group 1 and 2 metals with water to explain why sodium, potassium and magnesium were not used in the test for hydrogen.

REACTIONS OF METALS WITH METAL SALT SOLUTIONS

REQUIREMENTS

Apparatus: 1 x comboplate®; 3 x thin stemmed propettes; 3 x plastic microspatulas.
Chemicals: Copper powder (Cu(s)); Iron filings (Fe(s)); Zinc powder (Zn(s));
Copper sulphate solution ($CuSO_4$(aq)) [1 M]; Iron(II) sulphate solution ($FeSO_4$(aq)) [1 M];
Zinc sulphate solution ($ZnSO_4$(aq)) [1 M].

Note **If the iron(II) sulphate solution appears brown or brown/green in colour, it cannot be used. A fresh solution must be prepared.**

PROCEDURE

1. Add 10 drops of aqueous copper sulphate solution into each of wells A1 to A3 with a propette.
2. Use the spooned end of a plastic microspatula to add 1 level microspatula of each of the metals indicated as follows:

   copper powder into well A1,

   iron filings into well A2,

   zinc powder into well A3.

   Use a clean microspatula for each metal.

Note **When adding the metals to the small wells, make sure that you do not spill any powder into adjacent wells as this will cause confusion.**

3. Stir the contents of each well with the thin end of a clean microspatula where necessary.
4. Observe what happens in each well. Wait for 2-3 minutes to confirm your observations. View the comboplate® from above and from the side when making your observations. *(See Question 1)*
5. Repeat steps 1 to 4 above using wells A5 to A7, this time using the iron(II) sulphate solution.
6. Repeat steps 1 to 4 above using wells A9 to A11, this time using the zinc sulphate solution.

Rinse the comboplate® thoroughly with water.

REACTIONS OF METALS WITH METAL SALT SOLUTIONS

QUESTIONS

Q 1. Record your observations in a table like Table 1 below. Describe what you see; if no change is detected, indicate this also.

TABLE 1

	$CuSO_4(aq)$	$FeSO_4(aq)$	$ZnSO_4(aq)$
Cu(s)			
Fe(s)			
Zn(s)			

Q 2. Of the three metals investigated, which metal showed the greatest tendency to react with the aqueous solutions of metal salts?

Give a reason for your answer.

Q 3. Which metal showed the least tendency to react with the aqueous solutions of metal salts?

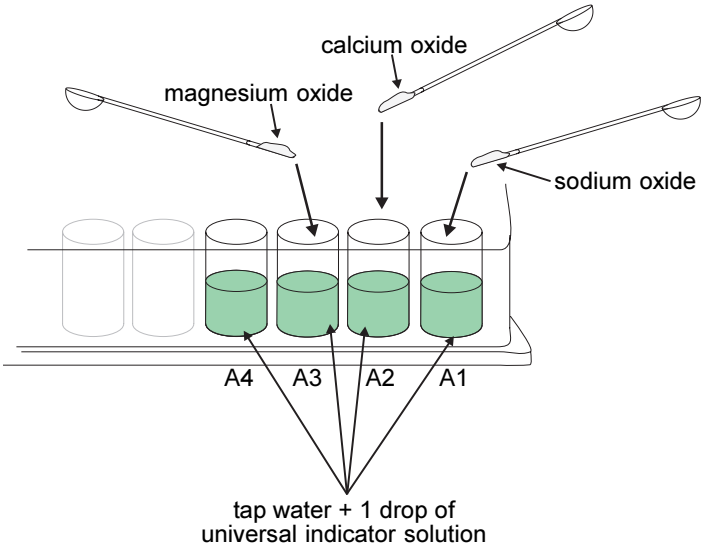
Give a reason for your answer.

Q 4. Write down a reactivity series for the metals, from the most reactive to the least reactive.

ARE METAL OXIDES ACIDIC OR BASIC OXIDES?

REQUIREMENTS

Apparatus: 1 x comboplate®; 3 x microspatulas; 2 x propettes.
Chemicals: Sodium oxide powder (Na_2O_2(s)); Calcium oxide powder (CaO(s)); Magnesium oxide powder (MgO(s)); Universal indicator solution; Tap water.



PROCEDURE

1. Use a clean propette to fill half of wells A1 to A4 with water.
2. Use another clean propette to add one drop of universal indicator solution to each of the four wells. *(See Questions 1, 2)*
3. Use the clean thin ends of three microspatulas to add sodium oxide, calcium oxide and magnesium oxide powders to wells A1, A2 and A3 respectively. In each case use the thin end of the microspatula to stir the solution. *(See Question 3)*

Rinse the comboplate®, propettes and microspatulas with water.

ARE METAL OXIDES ACIDIC OR BASIC OXIDES?

QUESTIONS

Q1. Prepare a table like Table 1 below in your workbook.

Table 1

Well	Colour of Indicator	pH	Acid/Base	Substance Added	Colour of Mixture	pH	Acid/Base
A1							
A2							
A3							
A4							

Q2. Observe and record the colour of the indicator in the water in each well in the second column of Table 1.

Q3. Observe and record the colour of the indicator in the mixture in wells A1, A2 and A3 in the sixth column of Table 1.

Q4. Use the universal indicator colour chart in the kit to deduce the pH corresponding to each colour recorded in your table.

Q5. From the pH values, record whether each solution is acid, base or neutral.

Q6. Are metal oxides acidic or basic oxides?

REACTIVITY OF GROUP 7 ELEMENTS

REQUIREMENTS

Apparatus: 1 x comboplate®; 6 x thin stemmed propettes; 3 x plastic microspatulas.
Chemicals: Sodium chloride solution (NaCℓ(aq)) [0.1 M]; Sodium bromide solution (NaBr(aq)) [0.1 M]; Sodium iodide solution (NaI(aq)) [0.1 M]; Chlorine solution ($C\ell_2$(aq)); Bromine solution (Br_2(aq)); Iodine solution (I_2(aq)).

PROCEDURE

1. Add 3 drops of sodium chloride solution into wells B1, B4 and B7.
2. Add 3 drops of sodium bromide solution into wells B2, B5 and B8.
3. Add 3 drops of sodium iodide solution into wells B3, B6 and B9.
4. Add 5 drops of chlorine solution into wells B1 to B3 with a propette. Stir each solution with a clean spatula and observe what happens. *(See Question 1)*
5. Add 5 drops of bromine solution into wells B4 to B6 with a clean propette. Stir each solution with a clean spatula and observe what happens. *(See Question 3)*
6. Add 5 drops of iodine solution into wells B7 to B9 using a clean propette. Stir each solution with a clean spatula and observe what happens. *(See Question 5)*

Rinse the comboplate® thoroughly with running water.

QUESTIONS

Q 1. Did the colours of the solutions in wells B1 to B3 change ? If so, what are the colour changes ?

Well B1:
Well B2:
Well B3:

Q 2. Explain your answers to question 1, with chemical equations.

Well B1:
Well B2:
Well B3:

Q 3. Did the colours of the solutions in wells B4 to B6 change ? If so, what are the colour changes ?

Well B4:
Well B5:
Well B6:

Q 4. Explain your answers to question 3 with chemical equations.

Well B4:
Well B5:
Well B6:

Q 5. Did the colours of the solutions in wells B7 to B9 change ? If so what are the colour changes ?

Q 6. Explain your answers to question 5 with chemical equations.

Well B7:
Well B8:
Well B9:

Q 7. Which halogen was the most reactive towards halide ions ?

Q 8. Which halogen was the least reactive towards halide ions ?

Q 9. Examine a periodic table. How does the order of the halogens in Group 7 compare with the reactivity of these halogens ?

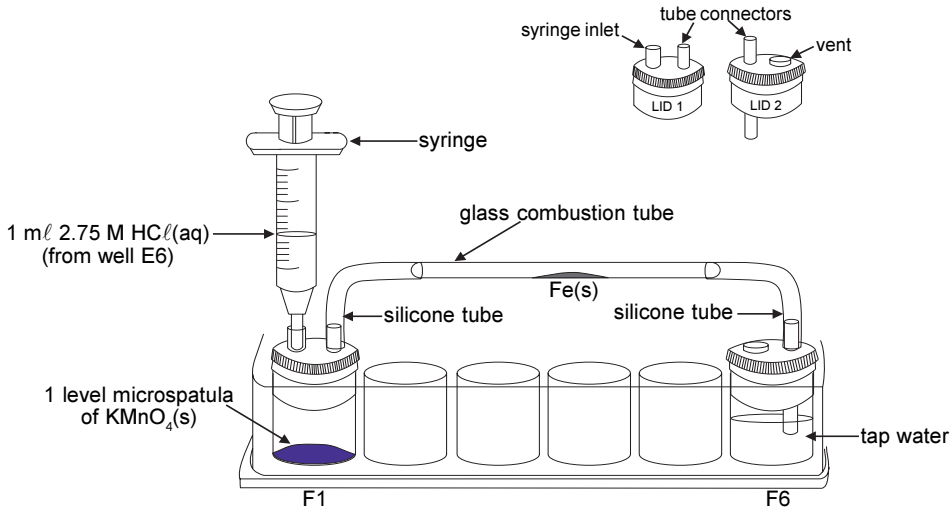
Q10. Predict the reactivity of F_2(g) and give reasons.

PREPARATION OF IRON(III) CHLORIDE

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 mℓ syringe; 1 x lid 1; 1 x lid 2; 2 x plastic microspatulas; 2 x silicone tubing (4 cm x 4 mm); 1 x glass tube; 1 x microburner; 4 x thin stemmed propettes.

Chemicals: Hydrochloric acid (HCℓ(aq)) [5.5 M]; Potassium permanganate powder ($KMnO_4$(s)); Fine iron powder (Fe(s)); Ammonia solution (NH_3(aq)) [1 M]; Nitric acid (HNO_3(aq)) [2 M]; Silver nitrate solution ($AgNO_3$(aq)) [0.1 M]; Tap water.



PROCEDURE

1. Using the spooned end of the plastic microspatula, add 1 level spatula of $KMnO_4$(s) into well F1. Close it with lid 1.
2. With the syringe, add 0.5 mℓ of tap water into well E6. Use the syringe again to add 0.5 mℓ of 5.5 M hydrochloric acid to the water in well E6.
3. Fill the syringe with 1.0 mℓ of the 2.75 M HCℓ(aq) now in well E6, and fit the syringe into lid 1 on well F1.
4. Using a propette, fill ¾ of well F6 with tap water. Place lid 2 on well F6 so that the tube extension on the inside of the lid is immersed in the water. The vent hole in lid 2 must face inwards.
5. Attach one piece of silicone tubing to lid 1 on well F1, and the second piece of silicone tubing to lid 2 on well F6.
6. Using the narrow end of a clean microspatula, place a small amount of fine iron powder in the middle of the glass tube.
7. Hold the glass tube in a horizontal position and attach it to the silicone tubing on lids 1 and 2. **Do not tilt the glass tube.**
8. Light the microburner and place it on one side away from the comboplate®.
9. Add 1.0 mℓ of the 2.75 M HCℓ(aq) dropwise from the syringe into well F1. **Do not add the acid all at once.**
10. Wait for 3 - 4 bubbles to appear in well F6. The rate at which the bubbles appear should be quite rapid.
11. Begin heating the iron powder in the glass tube by holding the flame of the microburner directly beneath the powder. **Do not bring the microburner flame near the silicone tubes as they will melt.**
12. Continue to heat the iron in this manner for about 1 - 1½ minutes. Note what happens in the glass tube. *(See Question 1)*
13. Remove the microburner and allow the glass tube to cool slightly. If you see water being sucked back from well F6 into the glass tube, then quickly disconnect the tube from the apparatus. **Do not let the tube move from the horizontal position.**
14. When the tube is cool, remove it from the silicone tubing and tap it on paper towel to dislodge any of the unreacted iron.
15. Hold the tube vertically above well A1. Flush the tube out with drops of water from a propette. Fill well A1 with the solution from the tube. Note the colour of the solution obtained from the tube. *(See Question 2)*
16. Use a clean propette to transfer half of the solution in well A1 to well A3.
17. Add 1 drop of 1 M NH_3(aq) into well A1. Observe. *(See Question 3)*
18. Add 2 drops of 2 M HNO_3(aq) into well A3 and then add 3 - 4 drops of 0.1 M $AgNO_3$(aq). Observe. *(See Question 4)*

Note **CLEAN THE COMBOPLATE® AS SOON AS POSSIBLE AFTER THE EXPERIMENT AS THE BROWN SOLUTION IN WELL F1 MAY STAIN THE PLASTIC. IF THIS OCCURS, RINSE THE WELL WITH A LITTLE 10% H_2O_2(aq) AND SCRAPE CLEAN WITH A MATCHSTICK. RINSE THE GLASS TUBE WITH WATER AND SCRAPE OUT SOLID WITH A MATCHSTICK. STUBBORN STAINS ON THE GLASS CAN BE REMOVED WITH A SOLUTION OF 2 PARTS CONC. HCℓ(aq) : 1 PART CONC. HNO_3(aq) (i.e. aqua regia).**

PREPARATION OF IRON(III) CHLORIDE

QUESTIONS

Q 1. What happens inside the glass tube?

Q 2. What is the colour of the solution in well A1?

Q 3. What happens in well A1 when the ammonia solution is added?

Q 4. What happens in well A3 when the silver nitrate solution is added?

Q 5. What do you deduce from testing the solution in well A1 with 2 M ammonia solution? Justify your answer.

Q 6. What do you deduce from testing the solution in well A3 with nitric acid and silver nitrate solution? Justify your answer.

Q 7. Explain how your answers to questions 5 and 6 suggest that iron(III) chloride was produced by the reaction of iron and chlorine.

Q 8. Write down the balanced chemical equation for the reaction occurring in the glass tube between the Fe(s) and $C\ell_2$(g).

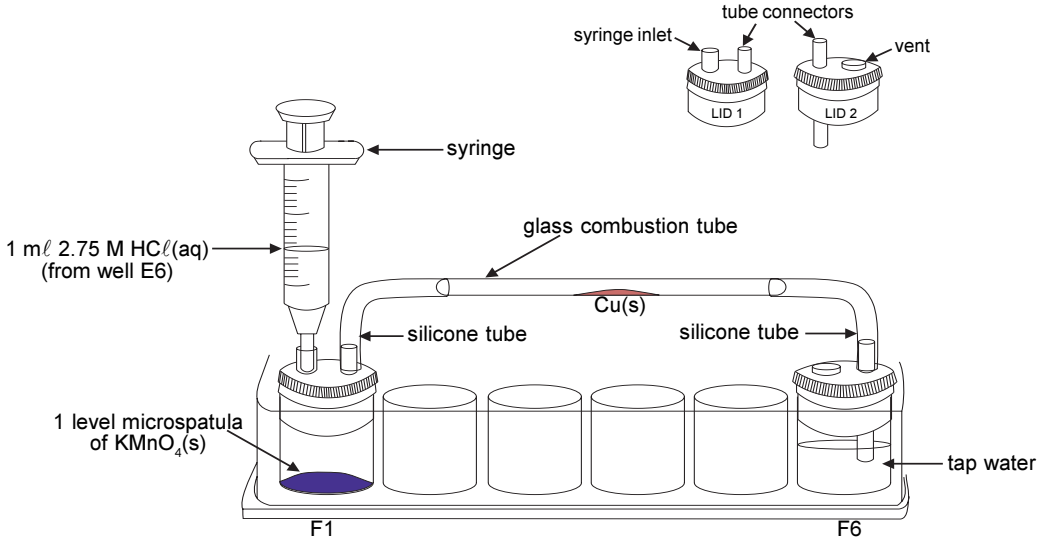
Q 9. What type of reaction is this? Justify your answer by using suitable chemical equations.

PREPARATION OF COPPER(II) CHLORIDE

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 mℓ syringe; 1 x lid 1; 1 x lid 2 ; 2 x plastic microspatulas; 2 x silicone tubing (4 cm x 4 mm); 1 x glass tube; 1 x microburner; 4 x thin stemmed propettes.

Chemicals: Hydrochloric acid (HCℓ(aq)) [5.5 M]; Potassium permanganate powder ($KMnO_4$(s)); Fine copper powder (Cu(s)); Ammonia solution (NH_3(aq)) [1 M]; Nitric acid (HNO_3(aq)) [2 M]; Silver nitrate solution ($AgNO_3$(aq)) [0.1 M]; Tap water.



PROCEDURE

1. Using the spooned end of the plastic microspatula, place 1 level spatula of $KMnO_4$(s) in well F1. Close with lid 1.
2. Fill the syringe with 0.5 mℓ of tap water and add it into well E6. Now fill the syringe with 0.5 mℓ of 5.5 M hydrochloric acid and add this dropwise to the water in well E6. You now have 2.75 M HCℓ(aq).
3. Fill the syringe with 1.0 mℓ of the 2.75 M HCℓ(aq) from well E6 and fit the syringe into the inlet in lid 1 on well F1.
4. Using a propette, fill ¾ of well F6 with tap water. Close with lid 2. Be sure that the tube extension is immersed in the water.
5. Attach one piece of silicone tubing to the lid on well F1 and the second piece of silicone tubing to the lid on well F6.
6. Use the narrow end of a clean microspatula to place a small quantity of fine copper powder in the middle of the glass tube.
7. Hold the glass tube in a horizontal position and attach one end to the silicone tubing on lid 1. Attach the other end to the silicone tubing on lid 2. Make sure that you do not tilt the glass tube, or the copper powder will fall into one of the wells.
8. Light the microburner and place it on one side away from the comboplate®.
9. Add 1.0 mℓ of the 2.75 M HCℓ(aq) dropwise from the syringe into well F1. Do not add the acid all at once, or the solution in well F1 will shoot up the silicone tubing into the glass tube and ruin the experiment.
10. Wait for 3 - 4 bubbles to appear from the end of the tube in the water in well F6. Begin heating the copper powder in the glass tube by holding the flame of the microburner directly beneath the copper powder.
11. Continue to heat the copper in this manner for about 2 - 3 minutes and observe. *(See Question 1)*
12. Remove the microburner and allow the glass tube to cool slightly. If you see water being sucked back from well F6 into the glass tube then quickly disconnect the tube from the apparatus, still keeping it horizontal. *(See Question 2)*
13. When the tube is cool, remove it from the set-up. Hold the tube vertically above well A1.
14. Flush the tube out with water by adding drops of water from a propette into the tube. Fill well A1 with the solution from the tube. Observe. *(See Question 4)*
15. Use the propette to transfer half the solution in well A1 to well A3.
16. Use a clean propette to add 2 drops of 1 M ammonia solution into well A1. Observe. *(See Question 5)*
17. Add 2 drops of 2 M nitric acid and 3 - 4 drops of 0.1 M silver nitrate solution into well A3. *(See Question 6)*

Note **CLEAN THE COMBOPLATE® AS SOON AS POSSIBLE AFTER THE EXPERIMENT AS THE BROWN SOLUTION IN WELL F1 MAY STAIN THE PLASTIC. IF THIS OCCURS, RINSE THE WELL WITH A LITTLE 10% H_2O_2 AND SCRAPE CLEAN WITH A MATCHSTICK. CLEAN THE GLASS TUBE WITH WATER. IF THE SOLID ADHERES TO THE GLASS IN THE TUBE, TRY TO SCRAPE IT OFF WITH A MATCHSTICK. STUBBORN STAINS IN THE GLASS TUBE MAY NEED TO BE REMOVED WITH A SOLUTION OF 2 PARTS CONC. HCℓ(aq) : 1 PART CONC. HNO_3(aq) (i.e. aqua regia).**

PREPARATION OF COPPER(II) CHLORIDE

QUESTIONS

Q 1. Note what happens inside the glass tube.

Q 2. What remains in the glass tube after cooling?

Q 3. What do you think this compound could be? Give a reason for your answer.

Q 4. What is the colour of the solution?

Q 5. What happens in well A1?

Q 6. What happens in well A3?

Q 7. What do you deduce from testing the solution in well A1 with aqueous ammonia solution? Justify your answer and write a balanced chemical equation for the reaction you observed.

Q 8. What do you deduce from testing the solution in well A3 with nitric acid and silver nitrate solution? Justify your answer.

Q 9. What compound has been formed by reaction of copper with chlorine?

Q10. Write a balanced chemical equation for the reaction which you think occurred between chlorine and copper.

ACID-BASE INDICATORS

Part 1: In what pH range do Methyl Orange and Phenolphthalein change colour?

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x plastic microspatula; 6 x thin stemmed propettes.
Chemicals: Hydrochloric acid (HCℓ(aq)) [0.10 M]; Sodium hydroxide (NaOH(aq)) [0.10 M]; Methyl orange solution; Universal indicator solution; Phenolphthalein solution; Tap water.

If any acid or base is spilt on the skin, thoroughly rinse the affected area with water.

PROCEDURE

1. Add 10 drops of HCℓ (0.10 M) into well A1.
2. Add 1 drop of HCℓ (0.10 M) into well A2. Add 9 drops of tap water to well A2.
3. Suck up all of the solution in well A2 with an empty propette.

☞ **For this experiment, we shall refer to this propette as the mixing propette.**

Add 2 drops of this solution into well A3, then return the rest of the solution in the mixing propette to well A2. Add 8 drops of tap water to well A3.

☞☞ **Rinse the mixing propette with tap water 2 to 3 times before using it in step 7.**

4. Add 10 drops of tap water into well A4.
5. Add 10 drops of NaOH (0.10 M) into well A7.
6. Add 1 drop of NaOH (0.10 M) into well A6. Add 9 drops of tap water to well A6.
7. Suck up all of the solution in well A6 with the cleaned mixing propette. Dispense 1 drop of this solution into well A5, then return the rest of the solution in the mixing propette to well A6. Add 9 drops of tap water to well A5.
8. Add 1 drop of universal indicator solution into each of the wells A1 to A7. *(See Question 1)*
9. Repeat steps 1 to 7 in wells B1 to B7.
10. Add one drop of methyl orange to each of the wells B1 to B7.

    Stir the solution in each well with a cleaned plastic microspatula if you are uncertain of the colour change.
11. Repeat steps 1 to 7 in wells C1 to C7. Add one drop of phenolphthalein to each of the wells C1 to C7.

    Stir the solution in each well with a cleaned plastic microspatula if you are uncertain of the colour change.

Rinse the wells with tap water, and then shake them dry.

Part 2: What is the pH of vinegar, Sprite and soapy water?

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x plastic microspatula; 4 x thin stemmed propettes.
Chemicals: White vinegar; Sprite; Soapy water; Universal indicator solution.

PROCEDURE

1. Add 10 drops of white vinegar into well A1.
2. Add 10 drops of Sprite into well A2.
3. Add 10 drops of soapy water into well A3.
4. Add 1 drop of universal indicator solution into each of the wells A1 to A3.

   Stir the solution in each well with a cleaned plastic microspatula if you are uncertain of the colour change.

   (See Question 1)

Rinse the wells with tap water, and then shake them dry.

ACID-BASE INDICATORS

QUESTIONS - PART 1

Q1. Note the colour of the solution in each well and write this down in a table like Table 2. Use Table 1 to determine the pH from the colour of each solution in wells A1 to A7. Write down each pH value in your table.

Table 1. pH universal indicator table

Colour	pH	Colour	pH
Dark Red	1	Dark Green	8
Light Red	2	Green/Blue	9
Dark Orange	3	Light Blue	10
Orange	4	Dark Blue	11
Light Orange	5	Light Purple	12
Yellow	6	Dark Purple	13
Light Green	7		

Note **Due to the different concentrations of universal indicator solutions available, and the differences in water samples obtained, the colours observed with the indicator solution at the pH's prepared may vary slightly.**

Table 2.

Well Number	Colour of solution	proposed pH
A1		
A2		
A3		
A4		
A5		
A6		
A7		

Q2. When a hypothetical indicator HX is placed in a colourless solution of pH 2 the colour of the solution appears red. When the same quantity of indicator HX is added to a colourless solution of pH 10 the solution appears green. Why were the colours different for the same indicator?

Q3. At which pH values was the colour of methyl orange in solution red?

Q4. At which pH values was the colour of methyl orange in solution yellow/orange?

Q5. At which pH values was phenolphthalein colourless in solution?

Q6. At which pH values was phenolphthalein pink in solution?

Q7. What is the pH range in which (a) methyl orange, and (b) phenolphthalein change colour?

QUESTIONS - PART 2

Q1. Note the colour of the solution in each well and write this down in a table like Table 2 in Part 1.

Q2. Use Table 1 (Part 1) to determine the pH from the colour of each solution in wells A1 to A3.
Write down the pH of each solution in your table.

PROPERTIES OF ACIDS AND ALKALIS

REQUIREMENTS

Apparatus: 1 x comboplate®; 6 x propettes; 1 x sheet of white paper; pH indicator strip; 1 x microspatula.
Chemicals: Hydrochloric acid (HCℓ(aq)) [1 M]; Vinegar; Lemon juice; Universal indicator paper; Universal indicator solution; Methyl orange indicator solution; Sodium hydroxide solution (NaOH(aq) [1 M]; Bicarbonate of soda; Tap water.

PROCEDURE

As part of this experiment you will be tasting some household chemicals. Many chemicals are highly toxic: DO NOT TASTE ANY CHEMICAL SUBSTANCE IN THE LABORATORY UNLESS SPECIFICALLY INSTRUCTED TO DO SO.

1. Place the comboplate® on the sheet of white paper.
2. Use a clean dry propette and place one drop of vinegar on your finger. Taste it.
3. Place 5 drops of the vinegar in each of wells A1, A2 and A3.
4. Use a clean dry propette and place one drop of lemon juice on your finger. Taste it. Wash your hands. *(See Question 1)*
5. Place 5 drops of the lemon juice in each of wells B1, B2 and B3.
6. Place 5 drops of 1 M hydrochloric acid in each of wells C1, C2 and C3.
7. Take a level microspatula of bicarbonate of soda powder and taste the powder. *(See Question 2)*
8. Place one level microspatula of bicarbonate of soda in well F1. Use a clean dry propette to place 25 drops of tap water in well F1. Stir with the microspatula.
9. Use a clean dry propette to suck up some of the solution of bicarbonate of soda in well F1. Place 5 drops of this solution into each of wells D1, D2 and D3.
10. Use a clean dry propette and place one drop of 1 M sodium hydroxide on your forefinger. Rub your forefinger and thumb together. Wash your hands. *(See Question 3)*
11. Place 5 drops of 1 M sodium hydroxide in wells A10, A11 and A12. *(See Question 5)*
12. Use a clean dry propette and add 1 drop of universal indicator solution to wells A1, B1, C1, D1 and A10.
13. Use a clean dry propette and add 1 drop of methyl orange solution to wells A2, B2, C2, D2 and A11.
14. Tear strips of universal indicator paper into smaller pieces. Fold each piece in half lengthwise.
15. Place a piece of indicator paper in wells A3, B3, C3, D3 and A12. *(See Questions 6 to 8)*

Clean all apparatus thoroughly.

PROPERTIES OF ACIDS AND ALKALIS

QUESTIONS

Q1. What did you notice about the taste of lemon juice and vinegar?

Q2. Describe the taste of the bicarbonate of soda.

Q3. What did you notice when you rubbed the sodium hydroxide between your fingers?

Q4. Do you think taste is an effective way to distinguish between different chemicals? Explain your answer.

Q5. Prepare a table like the one shown below.

	In Vinegar	In Lemon Juice	In HCℓ(aq)	In Bicarbonate of Soda	In NaOH(aq)
Colour of Universal Indicator					
Colour of Methyl Orange					
Colour of Universal Indicator Paper					

Q6. Enter your observations in your table.

Q7. Use the information on the pH indicator strip to classify the substances as "acidic, "neutral" or "alkaline".

Q8. Design a table and use the results of this experiment to summarise some of the properties of acids and alkalis.

STOICHIOMETRY - A THERMOCHEMICAL DETERMINATION OF THE STOICHIOMETRY OF ACID-BASE REACTIONS

The reaction of hydrochloric acid (HCℓ(aq)) and sodium hydroxide (NaOH(aq))

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 mℓ syringe; 1 x thermometer.
Chemicals: Hydrochloric acid (HCℓ(aq)) [1.0 M]; Sodium hydroxide solution (NaOH(aq)) [1.0 M].

Note **It is better to use a thermometer graduated in 0.1 °C intervals so that the temperature can be recorded accurately.**

If any acid is spilt on the skin or eyes, thoroughly rinse the affected area with water.

PROCEDURE

Well	E1	E2	E3	E4	E5	E6	F1	F2
Volume of NaOH(aq)/ mℓ	1.6	1.4	1.2	1.1	1.0	0.9	0.7	0.4

1. Add the volumes of 1.0 M sodium hydroxide into the wells as indicated above. Use a clean 2 mℓ syringe to do this. Rinse the syringe a few times with tap water to clean it before using it again in step 5.
2. Use the thermometer to read the initial temperature of the sodium hydroxide solution in two or three wells. They should all be the same. When you place the thermometer into a well, wait a few seconds before recording the temperature and make sure the bulb of the thermometer is adequately covered with solution. *(See Question 1)*
3. After you have completed step 2, rinse the thermometer with water and dry it. Insert the thermometer into the bottle of 1 M hydrochloric acid. Wait a few seconds, then record the temperature of the acid.

   It will be assumed that this initial temperature of HCℓ(aq) will be the same for all the wells. *(See Question 2)*
4. Rinse the thermometer with water and dry it again.
5. Use the syringe to suck up 0.4 mℓ of the hydrochloric acid. **Make sure the syringe is completely dry inside, otherwise the water in the syringe will dilute the acid.**
6. Hold the thermometer in well E1 with one hand. Use your free hand to add 0.4 mℓ of 1.0 M hydrochloric acid into well E1. Stir the reaction mixture with the tip of the thermometer, then observe the maximum temperature. *(See Question 5)*

Well	E1	E2	E3	E4	E5	E6	F1	F2
Volume of HCℓ(aq)/ mℓ	0.4	0.6	0.8	0.9	1.0	1.1	1.3	1.6

7. Repeat this process by adding the volumes of 1.0 M hydrochloric acid as indicated above, remembering to always observe the maximum temperature of the reaction mixture. *(See Question 6)*

Rinse the wells in the comboplate® with running tap water then shake them dry.

STOICHIOMETRY - A THERMOCHEMICAL DETERMINATION OF THE STOICHIOMETRY OF ACID-BASE REACTIONS

QUESTIONS

Q 1. What is the initial temperature of the sodium hydroxide solution ?
Q 2. What is the initial temperature of HCℓ(aq) ?
Q 3. What is the average initial temperature of the two reactants ?*
Q 4. Prepare a table like Table 1 below.

Table 1

Well	Volume of NaOH(aq) /mℓ	Volume of HCℓ(aq) /mℓ	Maximum Temperature/ °C	Change in Temp.** of mixture/ °C
	2.0	0.0		**0.00**
E1	1.6	0.4		
E2	1.4	0.6		
E3	1.2	0.8		
E4	1.1	0.9		
E5	1.0	1.0		
E6	0.9	1.1		
F1	0.7	1.3		
F2	0.4	1.6		
	0.0	2.0		**0.00**

* **Average initial temp. = (initial temp. of NaOH(aq) + initial temp of HCℓ(aq)) ÷ 2**
** **Change in temperature = Maximum temp. - Average initial temp.**

Q 5. Record the maximum temperature for the mixture in well E1 in your table.
Q 6. Record the maximum temperature for each mixture in your table.
Q 7. Calculate the change in temperature of the reaction mixture in each well and record the values in your table.
Q 8. Prepare a graph with the change in temperature on the Y axis. On the X axis put the volume of sodium hydroxide solution (from 0.0 mℓ to 2.0 mℓ at 0.2 mℓ intervals), as well as the volume of hydrochloric acid (from 2.0 mℓ to 0.0 mℓ at intervals of 0.2 mℓ).
On the X axis, let 0,5 cm represent 0.1 mℓ of solution. On the Y axis, let 1,0 cm represent a 1.0 °C temperature change.

Note **From Table 1, it can be seen that the total volume of solutions added to each well is 2 mℓ. Therefore the X axis can serve as an axis for the volumes of both NaOH(aq) and HCℓ(aq). At each volume of NaOH(aq), the volume of HCℓ(aq) is (2 mℓ - V(NaOH)). For example, on the X axis a scale mark could be 1.7 mℓ sodium hydroxide solution and 0.3 mℓ hydrochloric acid.**

Q 9. The scientific method used for finding the volume ratio with a graph like that which you have prepared, is to draw the best straight line through the set of points showing a positive slope, and another straight line through the set of points which displays a negative slope.
Therefore, draw the best straight line through the set of points between 0.0 mℓ and the volume of sodium hydroxide at which the maximum change of temperature was observed. Now, draw the best straight line through the set of points between this volume that gave the maximum temperature change and 2.0 mℓ sodium hydroxide. Where the two lines intersect is the true maximum point on the curve (i.e where the highest change in temperature occurs). Drop a perpendicular from this point onto the X axis and record the volumes of NaOH(aq) and HCℓ(aq) where the perpendicular touches the axis.
Q10. Why is there a temperature change when hydrochloric acid and sodium hydroxide solution are mixed?
Q11. In Table 1, you should notice that a temperature change of 0 °C has been recorded for the sodium hydroxide volumes of 2.0 mℓ and 0.0 mℓ. Although you have not tested these volumes, why do you think the temperature change is 0 °C?
Q12. Why is the temperature change different when different volume ratios of hydrochloric acid and sodium hydroxide solution are used?
Q13. Use the volumes of hydrochloric acid and sodium hydroxide solution from your graph to calculate the volume ratio of HCℓ:NaOH that corresponds to the maximum temperature increase.
Q14. What do you deduce from your answer to question 13 about the mole ratio in which hydrochloric acid and sodium hydroxide react?
Q15. Justify your answer to question 14.
Q16. Write down a balanced chemical equation to represent the chemical reaction between hydrochloric acid and sodium hydroxide solution.

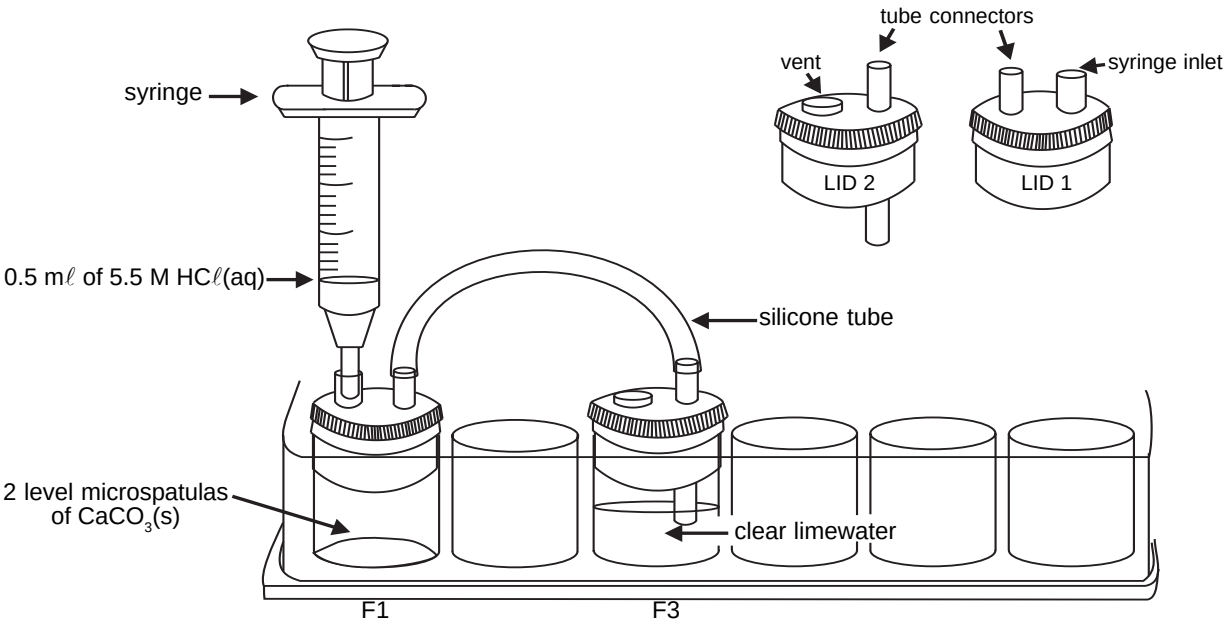
PREPARATION OF A SALT:

THE REACTION BETWEEN AN ACID AND A METAL CARBONATE

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.

PREPARATION OF A SALT:
THE REACTION BETWEEN AN ACID AND A METAL CARBONATE

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:

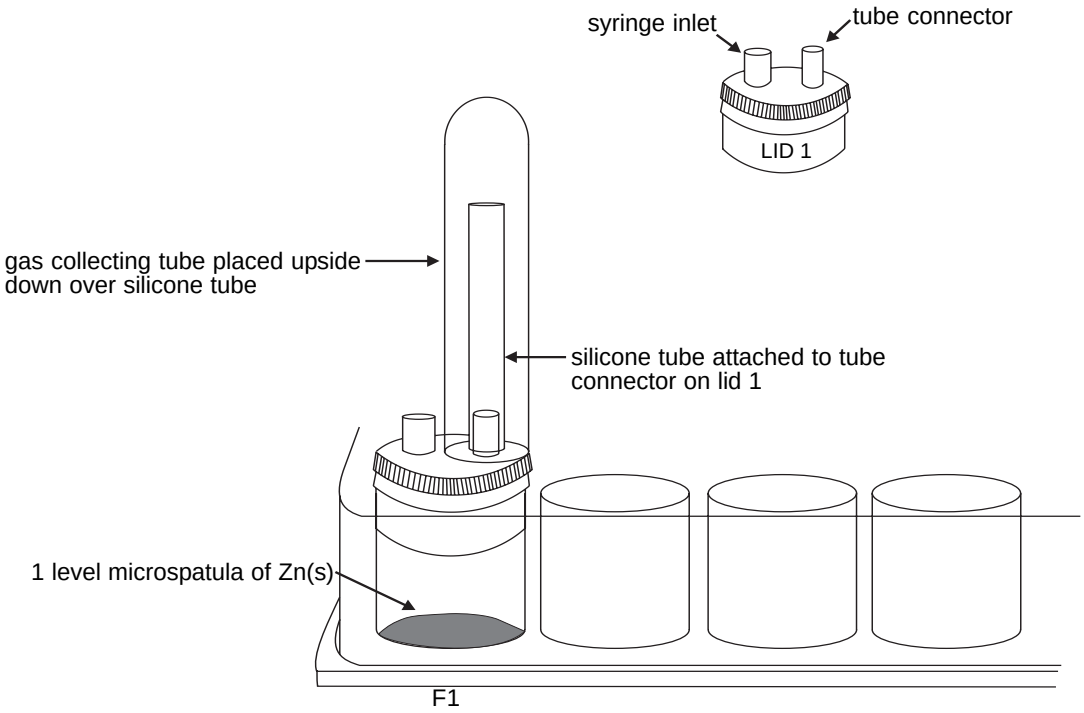
acid + metal carbonate →

PREPARATION OF A SALT:
THE REACTION OF AN ACID WITH A METAL

REQUIREMENTS

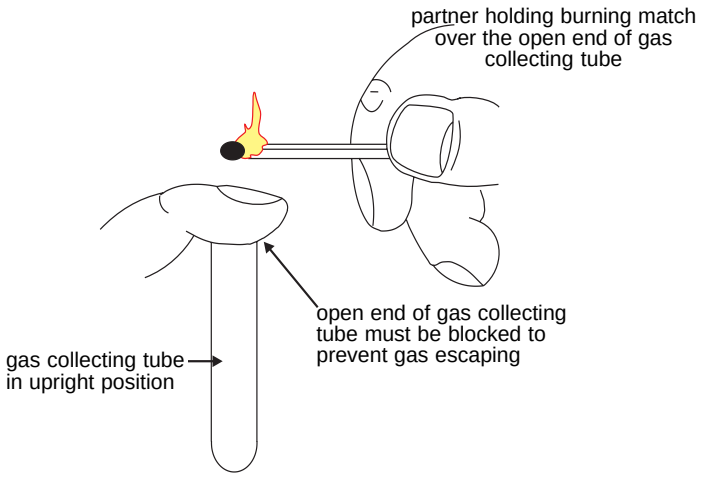
Apparatus: 1 x comboplate®; 1 x lid 1; 1 x 2 mℓ syringe; 1 x gas collecting tube; 1 x silicone tube; 1 x plastic microspatula; 1 x box of matches.

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.

PREPARATION OF A SALT:
THE REACTION OF AN ACID WITH A METAL

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.

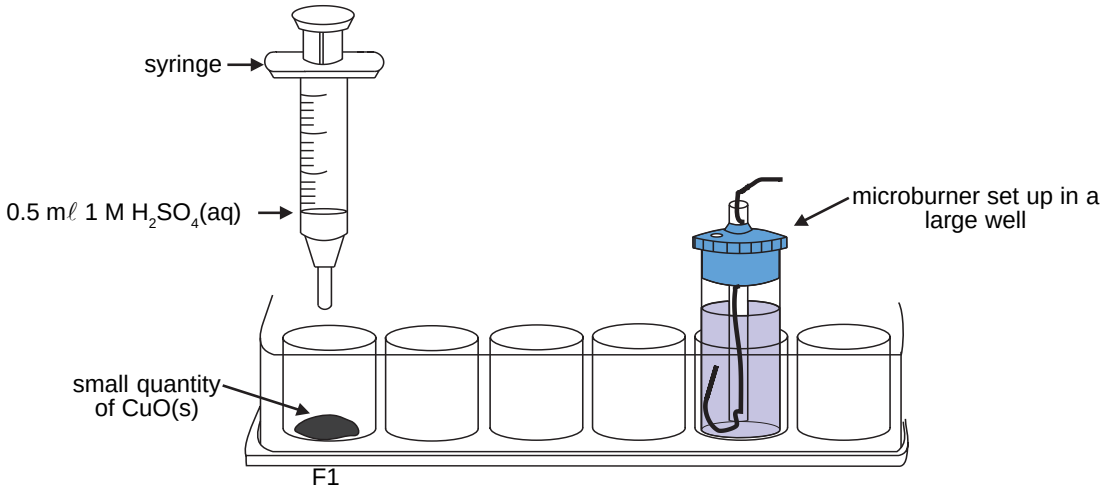
Q16. What chemicals would you use to prepare magnesium sulphate using a similar procedure?

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

PREPARATION OF A SALT:
THE REACTION BETWEEN AN ACID AND A METAL OXIDE

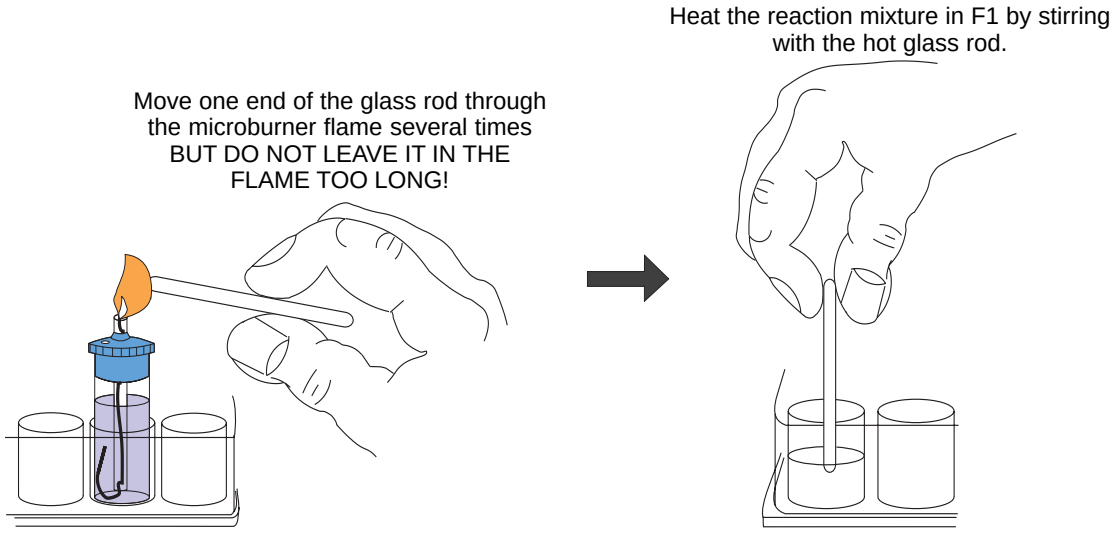
REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x syringe; 1 x microspatula; 1 x microburner; 1 x box matches; 1 x glass rod.
Chemicals: Copper(II) oxide (CuO(s)); Sulphuric acid (H_2SO_4 (aq)) [1 M]; Methylated spirits; Tap water.



PROCEDURE

1. Fill the microburner with methylated spirits and set it up in one of the large wells of the comboplate®.
2. Use the narrow end of a clean microspatula to place a small quantity of copper(II) oxide into well F1. *(See Question 1)*
3. Use a clean dry syringe and add 0,5 mℓ of 1 M sulphuric acid into well F1.
4. Light the microburner and carefully heat the one end of the glass rod in the flame. DO NOT KEEP THE ROD IN THE FLAME FOR A LONG PERIOD.
5. Heat the reaction mixture in F1 by stirring with the heated glass rod. Rinse and dry the rod, and repeat the heating process a few times until you notice a change in colour in F1. *(See Question 2)*



6. Leave the mixture in well F1 in the comboplate® overnight. *(See Questions 4, 5)*

Clean all apparatus thoroughly.

PREPARATION OF A SALT:
THE REACTION BETWEEN AN ACID AND A METAL OXIDE

QUESTIONS

Q1. What is the colour of the copper(II) oxide?

Q2. What happens in well F1 after some time?

Q3. What ions give this colour to the solution?

Q4. What do you notice in well F1 after leaving the comboplate® overnight?

Q5. What is this substance in F1?

Q6. The other product in this reaction evaporated when you heated the solution and left the comboplate® overnight. What could this possibly be?

Q7. Write a word equation for the chemical reaction that took place.

Q8. Write a balanced chemical equation for this reaction.

Q9. 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 oxide. What part of the name of the salt comes from the metal oxide?

Q10. What part of the name of the salt comes from the acid used in the reaction?

Q11. What difference would it make if you used hydrochloric acid instead of sulphuric acid in the reaction?

Q12. What chemicals would you use to prepare magnesium sulphate using the reaction between an acid and a metal oxide?

THE CONDUCTIVITY AND pH OF SOLUTIONS OF ACIDS AND BASES

PART 1: What is the effect of the concentration of a basic or acidic solution on its conductivity and pH?

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 mℓ syringe; 1 x thin stemmed propette; 1 x plastic microspatula; 1 x current indicator with connections; 1 x 9V battery; 2 x carbon rods (pencil leads).

Chemicals: Sodium hydroxide (NaOH(aq)) [0.10 M]; Hydrochloric acid (HCℓ(aq)) [0.10 M]; Universal indicator solution; Tap water.

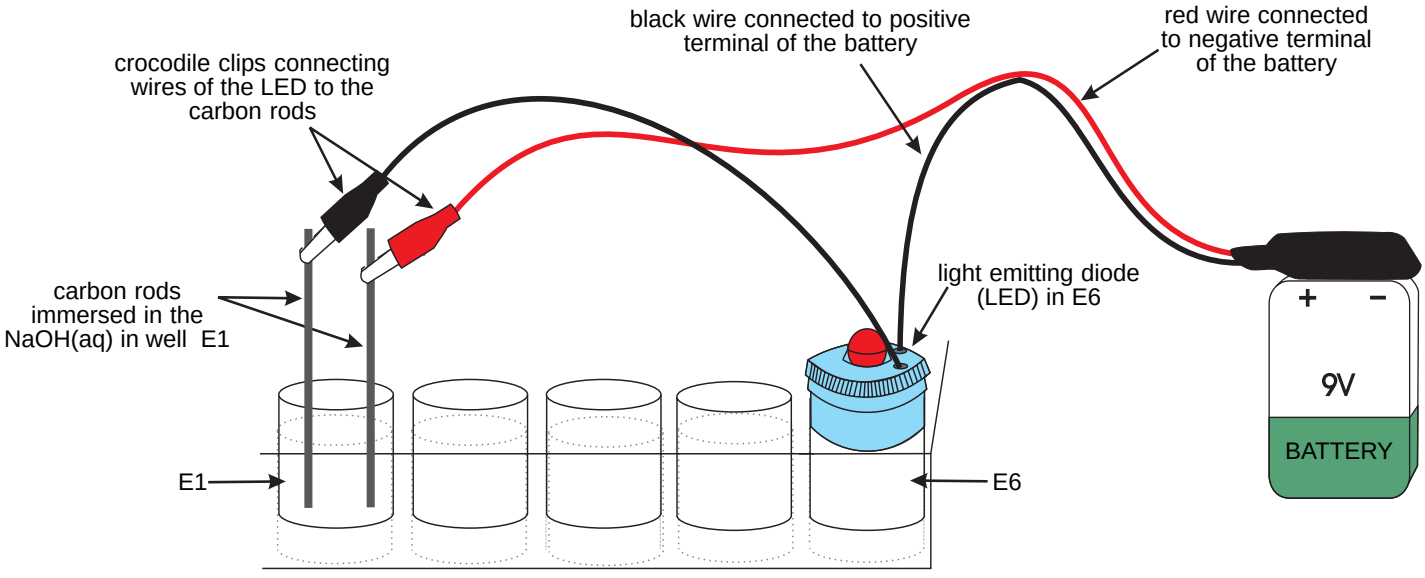
Note **The experiment should be performed in a room with subdued lighting so that the 'brightness' of the light emitting diode (LED) can be observed better. If this is not possible, the students may cup one of their hands around the current indicator to show up the glowing LED.**

INTRODUCTION

In this experiment hydrochloric acid and a solution of sodium hydroxide will be diluted. The aim of this experiment is to determine what effect diluting these solutions has on their conductivities and their pH's. What would you expect ?

PROCEDURE

1. Use the syringe to add 0.1 mℓ of sodium hydroxide (0.10 M) into well E1.
2. Rinse the syringe with tap water to clean it. Add 1.9 mℓ of tap water into well E1.
3. Stir the solution in well E1 with the spooned end of the microspatula to mix the contents.
4. Make sure that the syringe is dry inside, then suck up 0.1 mℓ of the solution in well E1 with the syringe. Place this into well E2. Rinse the syringe with tap water to clean it. Dispense 1.9 mℓ of tap water into well E2.
5. Stir the solution in well E2 with the spooned end of the microspatula to mix the contents.
6. Push the lid with the current indicator into well E6.
7. Connect the battery clip of the current indicator to the terminals of the 9 V battery.
8. Connect each of the crocodile clips to a carbon rod (pencil lead) as shown in the diagram.
9. Insert the carbon rod connected to the long black wire into the solution in well E1. Insert the carbon rod connected to the long end of the red wire into the same solution in well E1. Take care that the carbon rods do not touch in the solution.
10. Observe what happens to the red light emitting diode (LED) in the current indicator. *(See Question 1)*



11. Wipe the carbon rods clean and then test the conductivity of the solution in well E2 in the same way. *(See Question 3)*
12. Repeat steps 1 to 11 as before, using hydrochloric acid (0.10 M) instead of sodium hydroxide. Use wells F1 and F2. *(See Question 5)*
13. Dispense 1 drop of universal indicator solution into wells E1, E2, F1 and F2. Use an indicator colour strip or colour chart to deduce the pH of each of these solutions. *(See Question 6)*

Clean the comboplate® and syringe before proceeding with part 2.

THE CONDUCTIVITY AND pH OF SOLUTIONS OF ACIDS AND BASES

QUESTIONS

Q 1. Prepare a table like Table 1 below.

Table 1. Experimental observations

Well	Concentration NaOH(aq)/M	LED glow: dull, bright?	pH of solution
E1			
E2			
Well	Concentration HCℓ(aq)/M	LED glow: dull, bright?	pH of solution
F1			
F2			

Q 2. Enter your observations from step 9.

Q 3. Enter your observations from step 10.

Q 4. Calculate the concentration of each of the sodium hydroxide solutions. Write these down in Table 1.

Q 5. Record all your results for hydrochloric acid in your table.

Q 6. Record the pH of each solution in your table.

Q 7. Which wells had the higher concentration of sodium hydroxide solution and hydrochloric acid and what were the pH values of the solutions in these wells ?

Q 8. Which wells had the lower concentration of sodium hydroxide solution and hydrochloric acid and what were the pH values of the solutions in these wells ?

Q 9. What causes the current indicator to glow ?

Q10. The current indicator used in this experiment will not glow if the wires are immersed in pure (deionised) water. If pure water contains $H_3O^+(aq)$ and $OH^-(aq)$ ions, why will the current indicator not glow?

Q11. In which wells did the current indicator glow more brightly for the sodium hydroxide solution and hydrochloric acid and what were the pH values of the solutions in these wells ?

Q12. In which wells did the current indicator glow less brightly for the sodium hydroxide solution and hydrochloric acid and what were the pH values of the solutions in these wells?

Q13. What is the effect of the concentration of a basic or acidic solution on its conductivity and pH ?

THE CONDUCTIVITY AND pH OF SOLUTIONS OF ACIDS AND BASES

PART 2: Does the nature of a base or acid affect the conductivity and pH of its solution?

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 mℓ syringe; 1 x thin stemmed propette; 1 x plastic microspatula; 1 x current indicator with connections; 1 x 9V battery; 2 x carbon rods (pencil leads).

Chemicals: Sodium hydroxide (NaOH(aq)) [0.10 M]; Ammonia (NH_3(aq)) [1.0 M]; Hydrochloric acid (HCℓ(aq)) [0.10 M]; Acetic acid (CH_3COOH(aq)) [1.0 M]; Universal indicator solution; Tap water.

INTRODUCTION

In this experiment two different bases (sodium hydroxide and ammonia) and two different acids (hydrochloric acid and acetic acid) will be compared. The aim of this experiment is to determine what effect the different natures of these acids and bases has on the conductivities and pH's of their solutions. Before starting the experiment, compare the concentrations of the acids and bases listed in the chemicals requirements table and try to predict what you would expect.

PROCEDURE

1. Use a clean, dry syringe to dispense 1,0 mℓ of a solution of ammonia (1.0 M) into well E1. Rinse the syringe thoroughly with tap water and dry it before proceeding with step 2.

2. Use the syringe to add 1,0 mℓ of a solution of sodium hydroxide (0.10 M) to well E2. Clean and dry the syringe as before.

3. Use the syringe to place 1,0 mℓ of acetic acid (1.0 M) into well F1. Clean and dry the syringe as before.

4. Use the syringe to place 1,0 mℓ of hydrochloric acid (0.10 M) into well F2.

5. Test the conductivity of the solutions in wells E1, E2, F1 and F2. *(See Question 1)*

6. Add one drop of universal indicator solution to each of wells E1, E2, F1 and F2. *(See Question 3)*

Clean the comboplate® with water and shake dry.

THE CONDUCTIVITY AND pH OF SOLUTIONS OF ACIDS AND BASES

QUESTIONS

Q 1. Prepare a table like Table 2 below.

Table 2. Experimental observations

Well	Concentration /M	Solution Type	pH	LED glow: very dull, dull, bright, very bright ?
E1	1.0	Ammonia		
E2	0.1	Sodium Hydroxide		
F1	1.0	Acetic Acid		
F2	0.1	Hydrochloric Acid		

Q 2. Record your conductivity observations in your table.

Q 3. Record your pH observations in your table.

Q 4. Which of the solutions in wells E1 and E2 has the higher pH ?

Q 5. Which of the solutions in wells E1 and E2 caused the current indicator to glow brighter ?

Q 6. Which is a stronger base: ammonia or sodium hydroxide ? Explain.

Q 7. Which of the solutions in wells F1 and F2 has the lower pH ?

Q 8. Which of the solutions in wells F1 and F2 caused the current indicator to glow brighter ?

Q 9. Which is a stronger acid: acetic acid or hydrochloric acid ? Explain.

Q10. How does the nature of a base or acid affect the conductivity and pH of its solutions ?

THE STOICHIOMETRY OF PRECIPITATION REACTIONS

Part 1 The Reaction of Potassium Chromate ($(K_2CrO_4(aq))$) and Barium Chloride ($BaC\ell_2(aq)$)

REQUIREMENTS

Apparatus: 1 x comboplate®; 2 x thin stemmed propettes; 1 x plastic microspatula; 1 x measuring ruler; 1 x plastic container.

Chemicals: Potassium chromate solution ($K_2CrO_4(aq)$) [0.50 M]; Barium chloride solution ($BaC\ell_2(aq)$) [0.50 M]; Boiling water.

Note **The plastic container must be large enough to hold the comboplate® e.g a 2 litre ice cream tub.**

PROCEDURE

1. Add 9 drops of the barium chloride solution into well A1 with a thin stemmed propette. Use Table 1 below to add the required number of drops of $BaC\ell_2(aq)$ to wells A2, A3, A4 and A5. *(See Question 1)*

Table 1

Well	A1	A2	A3	A4	A5
Drops of $BaC\ell_2(aq)$ [0.50 M] to add	9	7	5	3	1

2. Choose a second thin stemmed propette identical to the one used to dispense the barium chloride solution. Use the second propette to add 1 drop of the potassium chromate solution into well A1, to make a total of 10 drops. *(See Questions 2 and 3)*
3. Use Table 2 to dispense the required number of drops of $K_2CrO_4(aq)$ into the other wells.
4. Stir the contents of each well with the plastic microspatula.

Table 2

Well	A1	A2	A3	A4	A5
Drops of $K_2CrO_4(aq)$ [0.50 M] to add	1	3	5	7	9

5. Pour boiling water into the plastic container to a depth of about 1.5 cm. Float the comboplate® in the water for five minutes. (**The water must not cover the comboplate®.**)

Note **If boiling water is not available, the experiment will still work. After stirring the solutions in each well, allow the precipitates to settle for about 10 minutes. Proceed from step 6 onwards and complete the experiment.**

6. Remove the comboplate® and leave it to stand for another 5 minutes.
7. After 5 minutes, use the ruler to measure the approximate height of the precipitate that has formed in each well. Lift the comboplate® to the light to observe the precipitates more carefully. *(See Question 5)*

Rinse the wells in the comboplate® with running tap water into a waste jar, then shake them dry before Part 2.

THE STOICHIOMETRY OF PRECIPITATION REACTIONS

QUESTIONS

Q 1. What is the colour of the barium chloride solution?
Q 2. What is the colour of the potassium chromate solution?
Q 3. What happens in well A1 after adding the drop of potassium chromate solution?
Q 4. Prepare a table like Table 3 below.
Q 5. Complete your table.

Table 3.

Well	Drops of $BaC\ell_2$(aq) [0.50 M] / (V_1)	Drops of K_2CrO_4(aq) [0.50 M] / (V_2)	Height of precipitate / mm
	10	0	**0.0**
A1	9	1	
A2	7	3	
A3	5	5	
A4	3	7	
A5	1	9	
	0	10	**0.0**

Q 6. Prepare a graph with the height of precipitate (mm) on the Y axis. On the X axis put the volume of barium chloride solution (from 0 drops to 10 drops at one drop intervals), as well as the volume of potassium chromate solution (from 10 drops to 0 drops at intervals of one drop).

Note **From Table 3, it can be seen that the total volume of solutions added to each well is 10 drops. Therefore the X axis can serve as an axis for the volumes of both $BaC\ell_2$(aq) and K_2CrO_4(aq). At each volume of $BaC\ell_2$(aq), the volume of K_2CrO_4(aq) is (10 drops - drops of $BaC\ell_2$(aq)). For example, on the X axis a scale mark could be 3 drops of barium chloride solution and 7 drops of potassium chromate solution.**

Q 7. The scientific method used for finding the volume ratio with a graph like that which you have prepared, is to draw the best straight line through the set of points showing a positive slope, and another straight line through the set of points which displays a negative slope.

Therefore, draw the best straight line through the set of points between 0 and the number of drops of barium chloride giving the maximum height of the precipitate. Now, draw the best straight line through the set of points between the number of drops for the maximum height and 10. The two lines will intersect at the true maximum point on the curve (i.e where the highest precipitate occurs).

Drop a perpendicular from this point onto the X axis and record the drops of $BaC\ell_2$(aq) and K_2CrO_4(aq) where the perpendicular touches the axis.

Volume (V_1) of $BaC\ell_2$(aq) in drops: _____
Volume (V_2) of K_2CrO_4(aq) in drops: _____

Q 8. What causes a precipitate to form, when barium chloride and potassium chromate solutions are mixed?
Q 9. You will notice in Table 3 that the height of the precipitate at 0 drops and 10 drops of barium chloride is given as 0 mm. Explain this.
Q10. Why does the height of the precipitate change as the ratio of barium chloride:potassium chromate changes?
Q11. Calculate the volume ratio (V_1/V_2) corresponding to the maximum height of precipitate.
Q12. What do you deduce from the volume ratio in question 11 about the mole ratio in which barium chloride and potassium chromate react?
Q13. Justify your answer to question 12.
Q14. Write down a balanced chemical equation to represent the chemical reaction between barium chloride and potassium chromate.
Q15. What would be the mole ratio (see question 11) if the concentrations of both the barium chloride and the potassium chromate solutions were doubled? Give reasons for your answer.
Q16. What do you notice about the appearance of the solutions above the precipitates in wells A1 and A2?
Q17. What do you notice about the appearance of the solutions above the precipitates in wells A4 and A5?
Q18. Explain the observations made in questions 16 and 17. (Recall your observations of the colours of the $BaC\ell_2$(aq) and the K_2CrO_4(aq) at the beginning of the experiment.)

THE STOICHIOMETRY OF PRECIPITATION REACTIONS

Part 2 The Reaction of Lead Nitrate ($Pb(NO_3)_2$(aq)) and Sodium Iodide (NaI(aq))

REQUIREMENTS

Apparatus: 1 x comboplate®; 2 x thin stemmed propettes; 1 x plastic microspatula; 1 x measuring ruler; 1 x plastic container.

Chemicals: Lead nitrate ($Pb(NO_3)_2$(aq)) [0.50 M]; Sodium iodide (NaI(aq)) [0.50 M]; Boiling water.

PROCEDURE

1. Add 2 drops of the lead nitrate solution into well A1 with a thin stemmed propette. Similarly add the number of drops of the lead nitrate solution into the other wells as indicated in Table 1 below.

Table 1

Well	A1	A2	A3	A4	A5
Drops of $Pb(NO_3)_2$ [0.50 M] to add	2	4	7	8	10

2. Choose a second thin stemmed propette identical to the one used to add the lead nitrate solution. Use the second propette to add 10 drops of the sodium iodide solution into well A1, to make a total volume of 12 drops. Similarly add the drops of the sodium iodide solution into the other wells as indicated in Table 2 below.

3. Use the plastic microspatula to stir the contents of each well.

Table 2

Well	A1	A2	A3	A4	A5
Drops of NaI(aq) [0.50 M] to add	10	8	5	4	2

4. Pour boiling water into the plastic container to a depth of about 1.5 cm. Float the comboplate® in the water for five minutes. (**The water must not cover the comboplate®.**)

5. Remove the comboplate® and leave it to stand for about another 5 minutes. *(See Question 1)*

6. After 5 minutes, use the ruler to measure the approximate height of the precipitate that has formed in each well. Lift the comboplate® to the light to observe the precipitates more carefully. *(See Question 2)*

Note **If boiling water is not available, the experiment will still work. After stirring the solutions in each well, allow the precipitates to settle for about 10 minutes. Proceed from step 6 onwards and complete the experiment.**

Rinse the wells in the comboplate® with running tap water into a waste jar, then shake them dry.
Thoroughly wash your hands after this experiment.

THE STOICHIOMETRY OF PRECIPITATION REACTIONS

QUESTIONS

Q 1. Prepare a table like Table 3.

Table 3.

Well	Drops of $Pb(NO_3)_2$(aq) [0.50 M] / (V_1)	Drops of NaI(aq) [0.50 M] / (V_2)	Height of Precipitate / mm
	0	12	**0.0**
A1	2	10	
A2	4	8	
A3	7	5	
A4	8	4	
A5	10	2	
	12	0	**0.0**

Q 2. Record the heights of the precipitates in your table.

Q 3. Prepare a graph with the height of precipitate (mm) on the Y axis. On the X axis put the volume of lead nitrate solution (from 0 drops to 12 drops at one drop intervals), as well as the volume of sodium iodide solution (from 12 drops to 0 drops at intervals of one drop).

Note **From Table 3, it can be seen that the total volume of solutions added to each well is 12 drops. Therefore the X axis can serve as an axis for the volumes of both $Pb(NO_3)_2$(aq) and NaI(aq). At each volume of $Pb(NO_3)_2$(aq), the volume of NaI(aq) is (12 drops - drops of $Pb(NO_3)_2$(aq)). For example, on the X axis a scale mark could be 3 drops of lead nitrate solution and 9 drops of sodium iodide solution.**

Q 4. Draw the best straight line through the set of points between 0 and the number of drops of lead nitrate which gave the most precipitate. Now, draw the best straight line between the most precipitate and 12 drops of lead nitrate (i.e 0 drops of NaI(aq) and no reaction). The two lines will intersect at the true maximum point on the curve (i.e where the highest precipitate occurs). Drop a perpendicular from this point onto the X axis and record the volume (V_1) of $Pb(NO_3)_2$(aq) and volume (V_2) of NaI(aq) in drops, where the perpendicular touches the axis.

Q 5. What causes a precipitate to form, when lead nitrate and sodium iodide solutions are mixed?

Q 6. Calculate the volume ratio (V_1/V_2) corresponding to the maximum height of precipitate.

Q 7. What do you deduce from the volume ratio in question 6 about the mole ratio in which lead nitrate and sodium iodide react?

Q 8. Justify your answer to question 7.

Q 9. Write down a balanced chemical equation to represent the chemical reaction between lead nitrate and sodium iodide.

TESTING FOR IONS IN AQUEOUS SOLUTIONS

PART 1: Testing for the Presence of Sulphate Ions

REQUIREMENTS

Apparatus: 1 x comboplate®; 6 x thin stemmed propettes.
Chemicals: Sulphuric acid ($H_2SO_4(aq)$) [1.0 M]; Sodium hydrogencarbonate solution ($NaHCO_3(aq)$) [0.5 M]; Zinc nitrate solution ($Zn(NO_3)_2(aq)$) [0.5 M]; Hydrochloric acid ($HC\ell(aq)$) [11 M]; Barium chloride solution ($BaC\ell_2(aq)$) [0.5 M]; Tap water.

If any acid is spilt on the skin thoroughly rinse the affected area with water.

PROCEDURE

1. Use a clean propette to add 5 drops of tap water into well A1.
2. Add 5 drops of the following solutions: sulphuric acid (1.0 M) into well A2, sodium hydrogencarbonate (0.5 M) into well A3 and zinc nitrate (0.5 M) into well A4. Use a clean propette for each solution.
3. Add 3 drops of barium chloride solution into each of wells A1 to A4. *(See Question 1)*
4. Use a clean propette to add 1 drop of 11 M hydrochloric acid into each of wells A1 to A4. *(See Question 5)*

Rinse the wells of the comboplate® with tap water and shake them dry before proceeding with part 2.

PART 2: Testing for the Presence of Halide Ions

REQUIREMENTS

Apparatus: 1 x comboplate®; 5 x thin stemmed propettes.
Chemicals: Sodium chloride solution ($NaC\ell(aq)$) [0.1 M]; Sodium bromide solution ($NaBr(aq)$) [0.1 M]; Sodium iodide solution ($NaI(aq)$) [0.1 M]; Silver nitrate solution ($AgNO_3(aq)$) [0.1 M]; Nitric acid ($HNO_3(aq)$) [2.0 M].

PROCEDURE

1. Add 5 drops of sodium chloride solution into well A1, 5 drops of sodium bromide solution into well A2 and 5 drops of sodium iodide solution into well A3.
2. Add 2 drops of nitric acid (2.0 M) and 3 drops of silver nitrate solution into each of wells A1 to A3.
3. Observe what happens. *(See Questions 1, 2)*

Wash the comboplate® with tap water and shake dry.

TESTING FOR IONS IN AQUEOUS SOLUTIONS

QUESTIONS - PART 1

Q 1. What do you observe when a solution of barium chloride is added to wells A1 to A4?

Q 2. In which well/s do you observe a precipitate?

Q 3. Write the chemical formula to represent any precipitate/s observed in wells A1 to A4.

Sodium chloride and zinc chloride are both soluble in water.

Q 4. Can the addition of a solution of barium chloride (as in the above procedure) serve as a test for the presence of sulphates in aqueous solutions? Give a reason for your answer.

Q 5. What do you observe when 11 M hydrochloric acid is added to wells A1 to A4?

Q 6. In which well/s do you now observe a precipitate?

Q 7. Write a chemical formula to represent any precipitate/s observed in the above wells, after the addition of HCℓ(aq).

Q 8. Explain any change observed in wells A1 to A4 on adding the HCℓ(aq).

Q 9. On the basis of your observations, state how you would test for sulphate ions in solution.

Q10. How would you show by experiment that a solution contained both carbonate and sulphate ?

QUESTIONS - PART 2

Q 1. Prepare a table like Table 1 below.

Table 1

Well	Halide Solution	Initial Appearance	Final Appearance
A1			
A2			
A3			

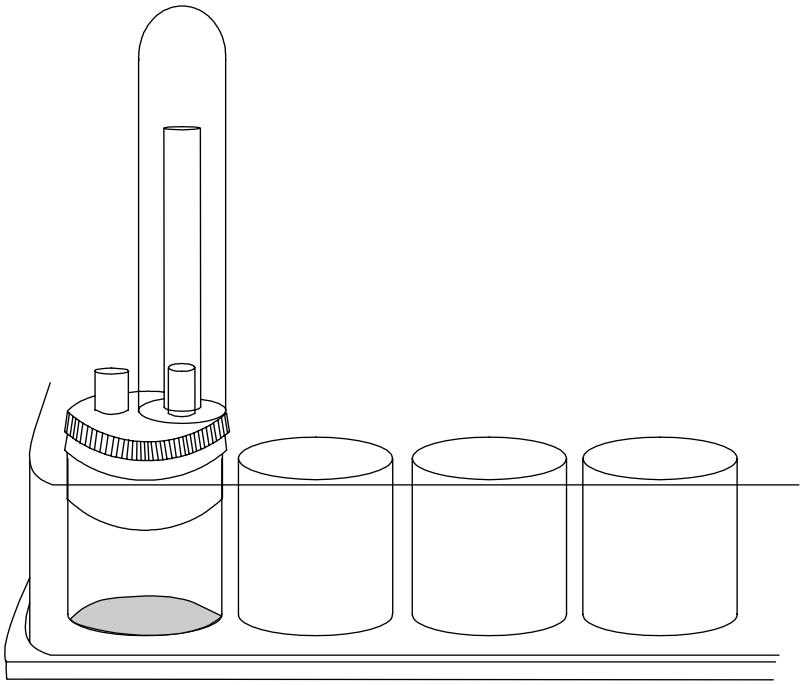
Q 2. Record your observations in the table.

Q 3. Did a chemical reaction occur in any of wells A1 to A3? Explain your answer.

Q 4. Write a balanced chemical equation to represent any reaction which occurred in wells A1 to A3.

Q 5. From your observations is it possible to distinguish which halide is present in solution by adding silver nitrate? Explain your answer.

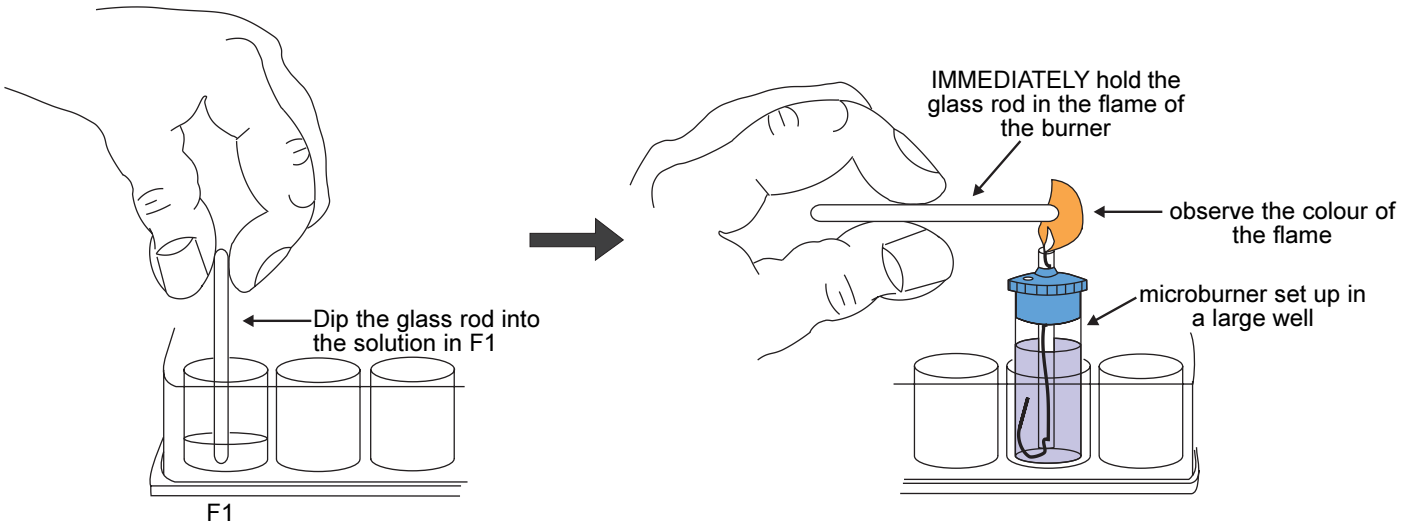
MICROCHEMISTRY
CHAPTER IV



FLAME COLOURS

REQUIREMENTS

Apparatus: 1 x microburner; 1 x box of matches; 1 x glass rod; 1 x comboplate®; 5 x propettes; towelling paper.
Chemicals: Methylated spirits; Copper nitrate solution ($Cu(NO_3)_2(aq)$) [0,5 M];
Saturated sodium chloride solution ($NaC\ell(aq)$); Potassium nitrate solution ($KNO_3(aq)$) [1.3 M];
Calcium oxide powder ($CaO(s)$); Nitric acid ($HNO_3(aq)$) [6 M]; Tap water.



PROCEDURE

The flame colours are more easily observed if the experiment is carried out in dim light, such as a room with drawn curtains.

1. Place 2 level spatulas of calcium oxide powder in well F1 of the comboplate®.
2. Use a clean dry propette and add nitric acid drop-by drop to well F1. Keep adding the nitric acid until the reaction in the well subsides.
3. Set up the microburner in one of the empty big wells. Light the burner. *(See Question 1)*
4. Dip the glass rod in well F1, and immediately hold the glass rod in the flame of the microburner. Take note of the flame colour.
5. Rinse the glass rod in the tap water and dry it with the towelling paper.
6. Use a clean, dry propette to add 5 drops of copper nitrate solution to well A1. Use another propette to add 5 drops of sodium chloride solution to well A3. Add 5 drops of potassium nitrate solution to well A5 with another clean propette.
7. Dip the glass rod into the copper nitrate solution in well A1, and hold the rod in the flame. Take note of the colour of the flame.
8. Rinse the glass rod in the tap water and dry it with the towelling paper.
9. Repeat steps 7 and 8 with the sodium chloride and potassium nitrate solutions in wells A3 and A5. *(See Question 3)*

Clean all apparatus thoroughly.

QUESTIONS

Q1. Draw up a table to summarise your observations in this experiment. Include in it the salt solution you used, the metal ions present in the solution and the flame colours.

Q2. Write a word equation for the reaction that took place in well F1.

Q3. Write a balanced chemical equation for the reaction that took place in well F1.

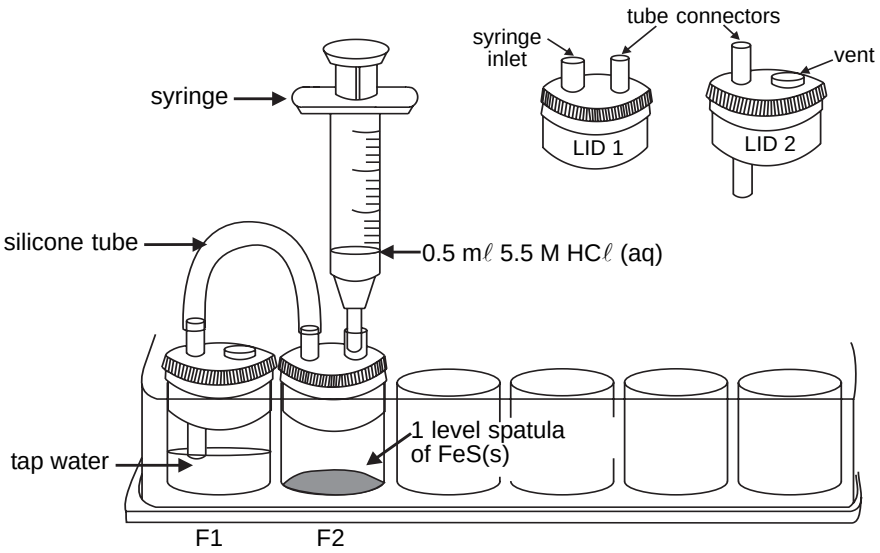
PREPARATION AND PROPERTIES OF HYDROGEN SULPHIDE

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x lid 1; 1 x lid 2; 1 x silicone tube; 1 x 2 ml syringe; 3 x plastic microspatulas; 3 x thin stemmed propettes.

Chemicals: Hydrochloric acid (HCℓ(aq)) [5.5 M]; Hydrochloric acid HCℓ(aq) [11 M]; Iron sulphide granules (FeS(s)); Universal indicator solution; Copper nitrate $Cu(NO_3)_2.3H_2O(s)$; Zinc nitrate $(Zn(NO_3)_2.4H_2O(s))$; Lead nitrate $(Pb(NO_3)_2(s))$; Potassium dichromate $(K_2Cr_2O_7(s))$; Tap water.

CAUTION **If any acid is spilt on the skin, thoroughly rinse the affected area with water.**



PROCEDURE

1. Use a propette to fill ¾ of well F1 with tap water. Use the same propette to add 5 drops of the water into well A1.
2. Test the pH of the water by adding 1 drop of universal indicator to well A1. Note the colour of the indicator.
3. Place 1 level microspatula of solid iron sulphide (FeS(s)) into well F2, using the spooned end of the microspatula.
4. Seal well F1 with lid 2. Make sure the vent hole faces inwards (see the figure). Seal well F2 with lid 1.
5. Connect one end of the silicone tube to lid 1 and the other end to lid 2.
6. Fill the syringe with 0.5 mℓ of 5.5 M HCℓ(aq) and fit the nozzle of the syringe into the syringe inlet on lid 1.
7. Inject the 0.5 mℓ of 5.5 M HCℓ very slowly into well F2. Note what happens in well F2 when the acid is injected. *(See Questions 1, 2)*
8. After 3 minutes, remove the lid from well F1. Suck up all of the solution in well F1 with an empty propette.
9. Add 1 drop of the solution in the propette into well A2. Add a drop of universal indicator to well A2. *(See Question 4)*
10. Add 5 drops of the solution in the propette into wells A4, A6, A8 and A10.
11. Add 5 drops of tap water into each of wells A3, A5, A7 and A9 with a clean propette.
12. Add 2 drops of 11 M HCℓ(aq) into wells A3 and A4 using another propette. Use the narrow end of a plastic microspatula to add a few grains of $K_2Cr_2O_7(s)$ into each of these wells and stir. *(See Question 6)*
13. Add a few grains of $Cu(NO_3)_2.3H_2O(s)$ into wells A5 and A6 with the narrow end of a plastic microspatula. Stir. *(See Question 9)*
14. Add a few grains of $Pb(NO_3)_2(s)$ into wells A7 and A8 with the narrow end of a clean microspatula. Stir. *(See Question 10)*
15. Add a few grains of $Zn(NO_3)_2.4H_2O(s)$ into wells A9 and A10 with the narrow end of a clean microspatula. Stir.

Note **You may need to add a few more grains of zinc nitrate before any changes are seen.** *(See Question 11)*

Discard the mixture of FeS with dilute HCℓ in well F2 into a waste jar.
Rinse the comboplate® well with tap water and shake dry.

PREPARATION AND PROPERTIES OF HYDROGEN SULPHIDE

QUESTIONS

Q 1. What do you observe happening in well F1 ?

Q 2. Can you smell anything from the vent in well F1 ?
If so, what do you think this smell is due to ?

Q 3. Write down a chemical formula for the gas formed in well F2.

Q 4. Having observed the change in the indicator colour, what can you say about the solution ?

Q 5. Give a chemical equation to represent the reaction of hydrochloric acid ($HC\ell(aq)$) with iron sulphide (FeS(s)).

Q 6. What is the colour of the solution in wells A3 and A4 ?

Q 7. What evidence do you have that aqueous hydrogen sulphide $H_2S(aq)$ reacts with $K_2Cr_2O_7(aq)$?

Q 8. If the equation for the reaction is $\mathbf{3H_2S + 8HC\ell + K_2Cr_2O_7 \rightarrow 2CrC\ell 3 + 7H_2O + 3S + 2KC\ell}$, is the reaction a redox one ? Give a reason for your answer.

Q 9. What is the colour of the mixture in wells A5 and A6 ?

Q10. What is the colour of the mixture in wells A7 and A8 ?

Q11. What is the colour of the mixture in wells A9 and A10 ?

Q12. Have the solutions in wells A6, A8 and A10 reacted with the metal salts that were added to them ?

Q13. Give the reason for your answer to question 12 and illustrate what you think has happened in each of these wells with a chemical equation.

Q14. Is aqueous hydrogen sulphide ($H_2S(aq)$) oxidised by any of the metal salts which have been used in wells A6, A8 and A10 ?

Q15. Is aqueous hydrogen sulphide ($H_2S(aq)$) reduced by any of the metal salts which have been used in wells A6, A8 and A10 ?

Q16. Give the reason for your answers to questions 14 and 15 above.

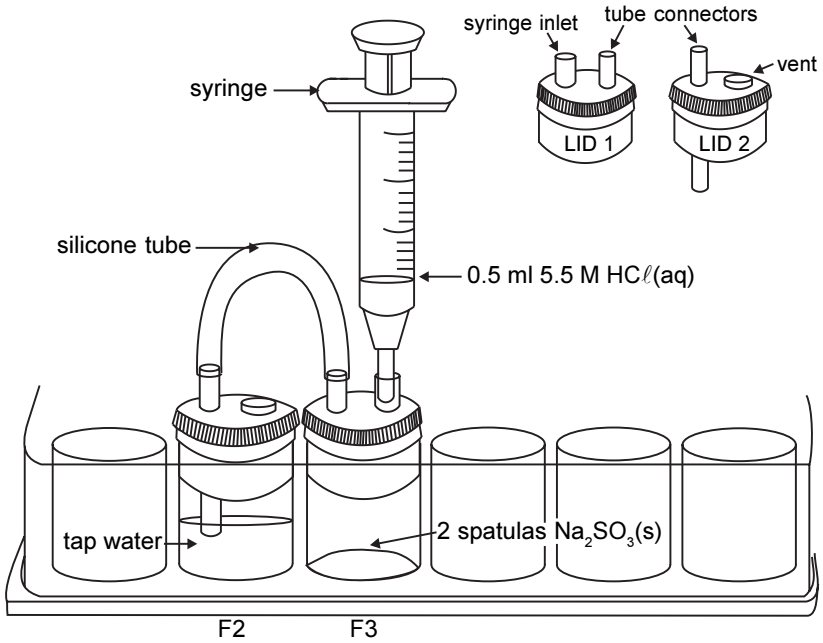
Q17. Write a statement describing the two different kinds of reaction that may occur when hydrogen sulphide reacts with metal salts in aqueous solution.

PREPARATION AND PROPERTIES OF SULPHUR DIOXIDE

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.

PREPARATION AND PROPERTIES OF SULPHUR DIOXIDE

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 ($HC\ell(aq)$) 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 ?

THE REACTION OF SULPHUR DIOXIDE AND HYDROGEN SULPHIDE

REQUIREMENTS

Apparatus: 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; 2 x microspatulas.

Chemicals: Hydrochloric acid (HCℓ(aq)) [5.5 M]; Sodium sulphite powder (Na_2SO_3(s)); Iron(II) sulphide powder (FeS(s)); Tap water.

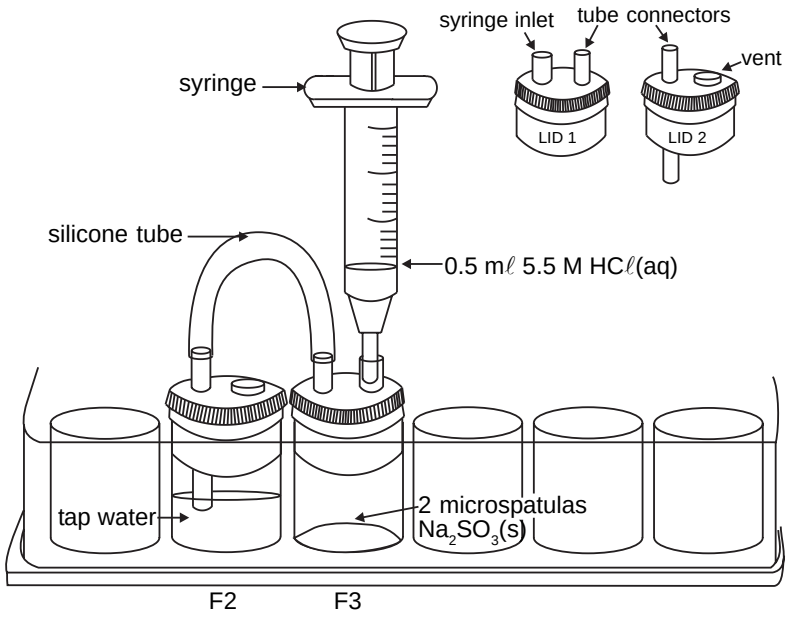


Figure 1

PROCEDURE

1. Fill $^3/_4$ of well F2 with tap water.
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.1). 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.
7. Wait about 1 to 2 minutes. Shake the comboplate® gently to prevent suck-back from F2 into F3.
8. Disconnect the one end of the silicone tube that was connected to lid 2 on well F2.
9. Remove lid 1 from well F3 together with the tube and the syringe.
10. Place 2 spatulas of FeS(s) into well F1 using the spooned end of the microspatula.
11. Refill the syringe with 0.5 mℓ of 5.5 M HCℓ(aq). Seal well F1 with lid 1.
12. Connect wells F1 and F2 as shown in Figure 2.
13. Insert the syringe into the inlet on lid 1 and slowly inject the 0.5 mℓ of 5.5 M HCℓ(aq) into well F1. *(See Question 1)*

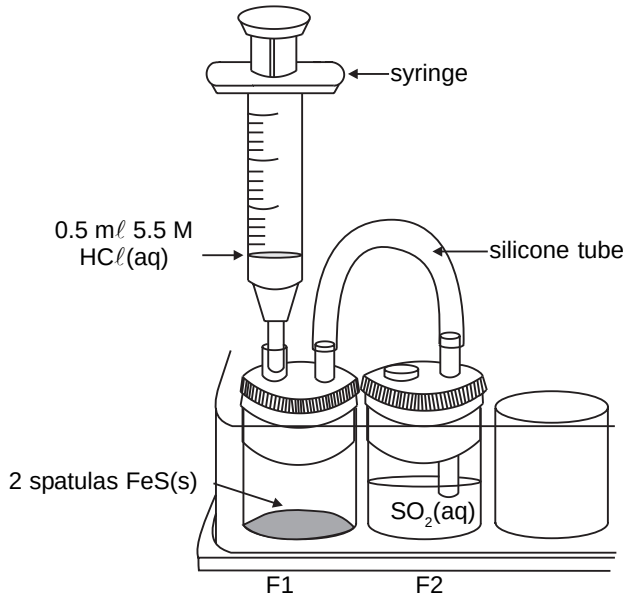


Figure 2

Rinse the comboplate® with water and shake dry.

THE REACTION OF SULPHUR DIOXIDE AND HYDROGEN SULPHIDE

QUESTIONS

Q1. What do you observe in well F2 where the two gases generated in wells F1 and F3 mix in aqueous solution?

Q2. Why do you think this has happened? What is the substance observed in well F2?

Q3. Write a chemical equation to represent the reaction between the two gases in aqueous solution.

Q4. Is hydrogen sulphide oxidised or reduced when the two gases in aqueous solution mix? Give a reason for your answer.

Q5. Is sulphur dioxide reduced or oxidised when the two gases in aqueous solution mix? Give reasons for your answer.

AIR POLLUTION BY SULPHUR DIOXIDE

PART 1: Uncontrolled Emission of Sulphur Dioxide

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.

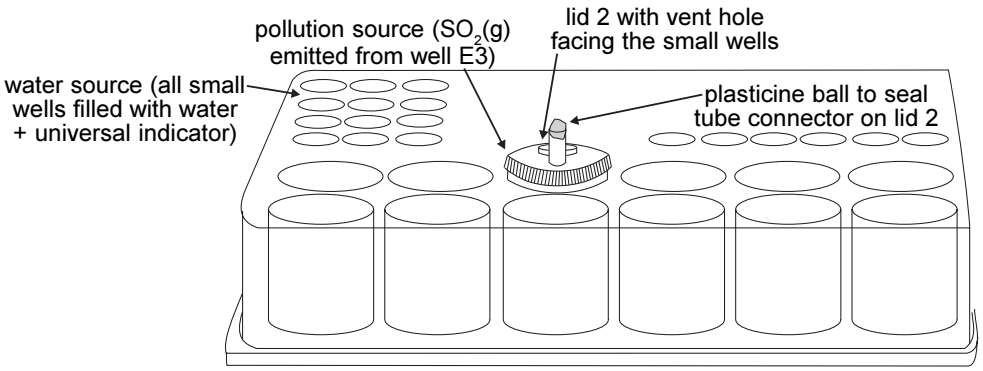
PROCEDURE

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 the 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.**

. 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.

AIR POLLUTION BY SULPHUR DIOXIDE

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.

AIR POLLUTION BY SULPHUR DIOXIDE

Part 2: The Function of a Chimney in Dispersing Air Pollutants

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.

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.

Note **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.

Part 3: The Elimination of Emission by an Absorbing Substance

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)*

Clean the comboplate® thoroughly.

AIR POLLUTION BY SULPHUR DIOXIDE

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.

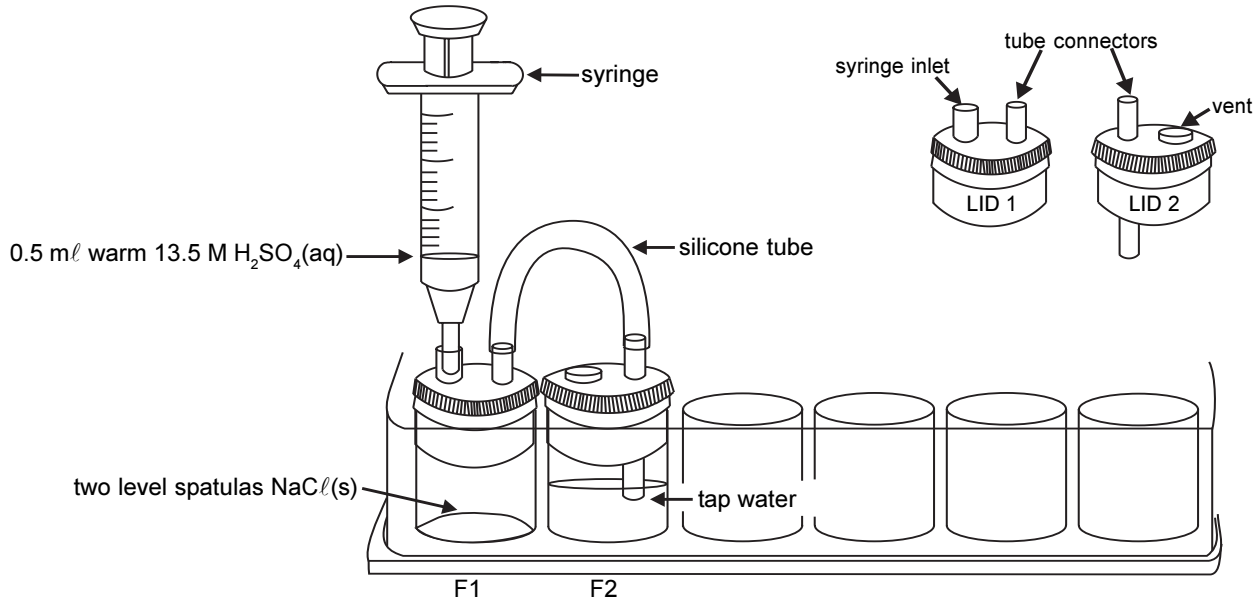
Q 3. Write a statement describing the effect of calcium oxide on SO_2 emission.

PREPARATION AND TESTING FOR HYDROCHLORIC ACID

REQUIREMENTS

Apparatus: 1 x comboplate®; 4 x thin stemmed propettes; 1 x 2 mℓ syringe; 1 x lid 1; 1 x lid 2; 1 x plastic microspatula; 1 x silicone tube (4 cm x 4 mm).

Chemicals: Concentrated sulphuric acid (H_2SO_4(aq)) [13.5 M]; Sodium chloride (NaCℓ(s)); Silver nitrate solution ($AgNO_3$(aq)) [0.1 M]; Universal indicator solution; Tap water.



PROCEDURE

1. Before you begin this experiment, heat the bottle containing the 13.5 M sulphuric acid in a little hot water.
2. Using the spooned end of the microspatula, place two level spatulas of sodium chloride into well F1.
3. Place lid 1 onto well F1.
4. Fill ¾ of well F2 with tap water.
5. Add 5 drops of tap water into well A1 with a clean propette. Add 1 drop of universal indicator solution to the water in well A1, using a different propette. *(See Question 1)*
6. Add 5 drops of the same tap water into well A4. Using a clean propette, add 1 drop of silver nitrate solution to the tap water. *(See Question 3)*
7. Cover well F2 with lid 2.
8. Connect well F2 to well F1 by means of silicone tubing fitted to the tube connectors on the lids of these wells.
9. Fill the syringe with 0,5 mℓ of **warm**, concentrated H_2SO_4(aq) and fit it into the syringe inlet of the lid on well F1.
10. Inject the concentrated H_2SO_4(aq) dropwise into well F1 containing NaCℓ(s). **Perform this step carefully, otherwise the solution in well F1 may bubble through the tube into well F2.** *(See Questions 4 and 5)*
11. When no more bubbles can be seen in well F2, remove the lid from well F2.
12. Using a clean propette, draw up the solution from well F2. Dispense 5 drops of the solution into well A2. Add one drop of universal indicator to well A2. *(See Questions 6 and 7)*
13. Add 5 drops of the solution from well F2 into well A5.
14. Add 1 drop of 0.1 M silver nitrate solution into well A5. *(See Question 8)*

Rinse the comboplate® with water and shake dry.

PREPARATION AND TESTING FOR HYDROCHLORIC ACID

QUESTIONS

Q 1. Note the colour of the indicator in the sample of tap water.

Q 2. What is the pH of the water ?

Q 3. What do you observe in well A4 ?

Q 4. What do you observe happening in well F1 ?

Q 5. What happens in well F2 ?

Q 6. What is the colour of the indicator in well A2 ?

Q 7. Is this solution acidic, basic or neutral ?

Q 8. What happens in well A5 ?

Q 9. Write a balanced chemical equation to represent the reaction occurring in well F1.

Q10. What is the name of the gas that produced the bubbles in the water in well F2 ?

Q11. Explain why the water in well F2 has changed in pH. What does this tell you about the gas produced in well F1 ?

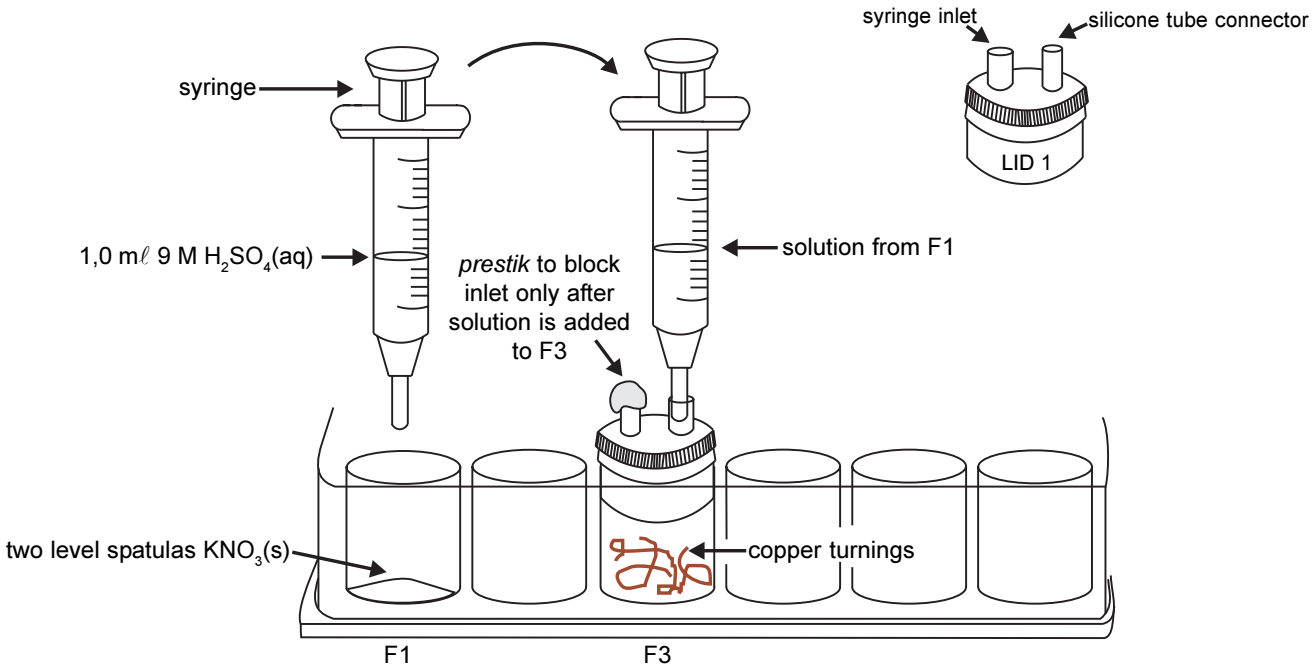
Q12. Write a balanced chemical equation to represent the reaction of the gas with the water in well F2. From the equation, identify the ions that caused the universal indicator to change colour.

Q13. What further evidence is there for your answers to questions 10 and 11 ? Write down the chemical equation of the precipitation reaction in well A5.

PREPARATION AND TESTING FOR NITRIC ACID

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 mℓ syringe; 1 x lid 1; 1 x plastic microspatula; 1 x piece of plasticine or *prestik*.
Chemicals: Tap water; Sulphuric acid (H_2SO_4(aq)) [~ 9 M]; Potassium nitrate powder (KNO_3(s)); Copper turnings (Cu(s)).



PROCEDURE

1. Using the spooned end of the microspatula, place 2 level spatulas of potassium nitrate powder into well F1.
2. Fill the syringe with 1 mℓ of 9 M sulphuric acid.
3. Inject the 9 M sulphuric acid dropwise into well F1. *(See Questions 1 and 2)*

To test the product formed in well F1, proceed as follows:

4. Rinse the 2 mℓ syringe with tap water. Shake the syringe dry and use it to draw up all of the solution from well F1 (about 1.0 mℓ).
5. Half fill well F3 with copper turnings. Place lid 1 onto well F3.
6. Fit the syringe containing the solution from well F1 into the syringe inlet on lid 1.

Note **The figure shows a piece of *prestik* blocking the tube connector on lid 1. DO NOT place the *prestik* over the outlet until after steps 7 and 8 have been completed.**

7. Inject the solution dropwise from the syringe into well F3. *(See Question 3)*
8. Look carefully at the area above the copper turnings in well F3. (You may have to lift the comboplate® against a white background to view this.) *(See Question 4)*
9. Very quickly block the silicone tube connector on the lid by gently pushing a piece of plasticine or *prestik* over the top of the connector.
10. Wait for 3 – 5 minutes to pass and then examine the contents of well F3 again. *(See Question 5)*

Discard the contents in wells F1 and F3 and clean these wells with tap water.
Thoroughly clean the syringe.

PREPARATION AND TESTING FOR NITRIC ACID

QUESTIONS

Q 1. What are the names of the aqueous products formed in the reaction ?

Q 2. Write a balanced chemical equation to represent the reaction occurring in well F1 between sulphuric acid ($H_2SO_4(aq)$) and potassium nitrate ($KNO_3(s)$)).

Q 3. What happens in well F3 ?

Q 4. Do you notice any coloured gaseous products forming ?

Q 5. What is the colour of the solution in well F3 after 3 – 5 minutes ?

Q 6. What is the colour of the gas formed in well F3 ?

Q 7. Identify the products and their respective colours that you observed in well F3.

Q 8. Write a balanced chemical equation to represent the reaction occurring in well F3.

Q 9. The gaseous product, nitrogen monoxide (NO), is colourless and cannot be seen. Why did the gas in well F3 appear brown after the well was blocked with plasticine for 5 minutes ? (*Hint: think of the reaction of NO(g) with the air in well F3.)

Q10. How does the chemical reaction in well F3 provide evidence for the production of nitric acid in well F1?

SOLUBILITY OF GROUP 2 METAL SULPHATES IN WATER

REQUIREMENTS

Apparatus: 1 x comboplate®; 5 x thin stemmed propettes; 1 x white paper.
Chemicals: Magnesium nitrate solution ($Mg(NO_3)_2(aq)$) [0.1 M]; Calcium nitrate solution ($Ca(NO_3)_2(aq)$) [0.1 M]; Barium nitrate solution ($Ba(NO_3)_2(aq)$) [0.1 M]; Strontium nitrate solution ($Sr(NO_3)_2(aq)$) [0.1 M]; Sodium sulphate solution ($Na_2SO_4(aq)$) [0.1 M].

PROCEDURE

1. Place the comboplate® on a piece of white paper.
2. Add 5 drops of the following solutions:

   magnesium nitrate (0.1 M) into well A1,
   calcium nitrate (0.1 M) into well A2,
   strontium nitrate (0.1 M) into well A3,
   barium nitrate (0.1 M) into well A4.
3. Add 5 drops of sodium sulphate solution (0.1 M) into wells A1 to A4.
4. Observe what happens. *(See Questions 1, 2)*

Thoroughly clean the propettes and comboplate® with water.

QUESTIONS

Q 1. Prepare a table like Table 1 below.

Table 1. Experimental observations

	Most Precipitate	Second Most Precipitate	Third Most Precipitate	Least Precipitate
WELL				
PRODUCT				

Q 2. Observe the heights of the precipitates formed in each well and record in your table which wells had the most through to the least precipitate.

Q 3. Give the name and formula of the product which formed in each well. Record this in your table.

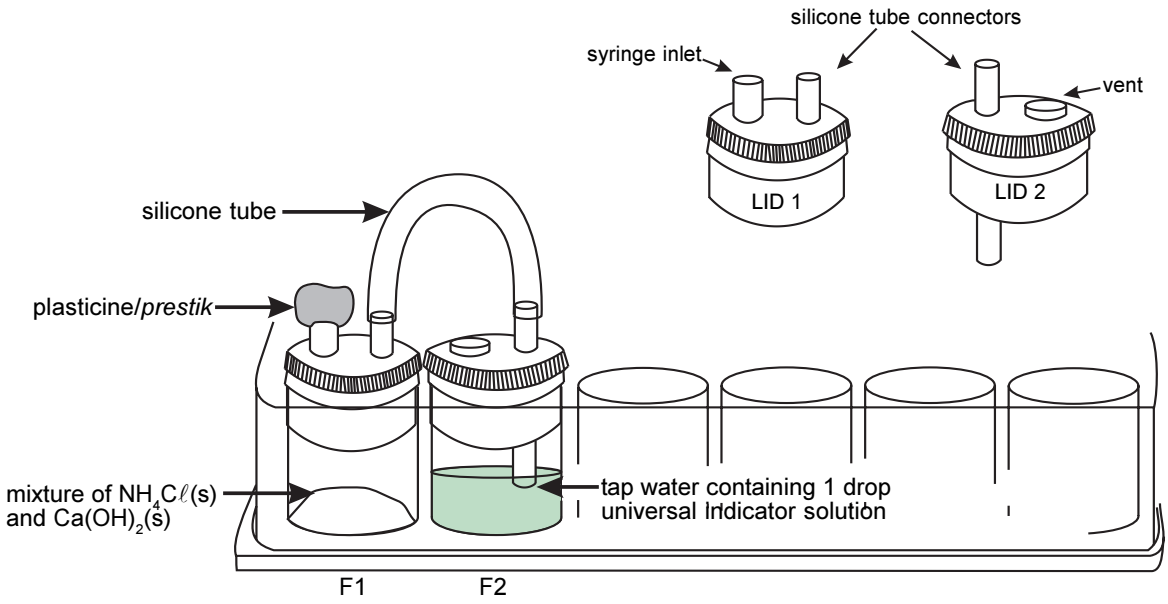
Q 4. What is the order of solubility of the sulphates of the Group 2 elements – Mg, Ca, Sr and Ba ?

PREPARATION OF AMMONIA

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x lid 1; 1 x lid 2; 2 x plastic microspatulas; 1 x silicone tubing (4 cm x 4 mm); 2 x propettes; 1 x large plastic container (eg. a 2 litre ice-cream tub, or similar); Plasticine or *prestik*.

Chemicals: Ammonium chloride ($NH_4C\ell(s)$); Calcium hydroxide ($Ca(OH)_2(s)$); Universal indicator solution; Tap water; Hot water.



PROCEDURE

1. Use a clean propette to fill ¾ of well F2 with tap water.
2. Place 1 drop of universal indicator solution into the tap water in well F2.

   What do you observe ? *(See Question 1)*
3. Using the spooned end of a plastic microspatula, add 3 spatulas of ammonium chloride powder into well F1.
4. Add 3 spatulas of calcium hydroxide powder into well F1, using the spooned end of another microspatula.
5. Stir the contents of well F1 with the microspatula to mix them thoroughly.
6. Place lid 1 on well F1. Seal the syringe inlet of lid 1 by pushing a piece of *prestik* or plasticine over the inlet.
7. Place lid 2 on well F2 so that the vent faces towards well F1. Connect well F1 to well F2 by attaching the silicone tube to the tube outlets on lids 1 and 2.
8. Fill a container with a little hot water (preferably near boiling).
9. Place the comboplate® carefully in the hot water. It should float on the surface of the water. **Do not force the comboplate® to the bottom of the container.**
10. Leave the comboplate® in the hot water for about 1 – 2 minutes. (**The hotter the water, the shorter the time needed for any observations to be made**.)
11. After 1 – 2 minutes, remove the comboplate® from the water. Disconnect the silicone tubing from lids 1 and 2 to prevent suck-back of the water from well F2 into well F1.
12. Remove lid 1 from well F1 and observe the contents. *(See Question 2)*
13. Wave your hand across well F1 towards your nose. What do you smell ? *(See Question 3)*
14. Remove lid 2 from well F2 and observe the contents. *(See Question 4)*

Rinse the comboplate® thoroughly with water.

PREPARATION OF AMMONIA

QUESTIONS

Q 1. What is the colour of the universal indicator in tap water ? What does this imply about tap water ?

Q 2. What has happened to the mixture of ammonium chloride and calcium hydroxide in well F1 ?

Q 3. Describe the smell from well F1.

Q 4. What has happened to the colour of the universal indicator in well F2 ?

What does this imply about the solution in well F2 ?

Q 5. What evidence is there that a gas was produced from the reaction between ammonium chloride and calcium hydroxide, even if it appeared as if nothing was happening to the mixture in well F1 ?

Q 6. What do your results with the universal indicator solution tell you about the gas produced in well F1 ? Give a reason for your answer.

Q 7. What is the name of the gas produced in well F1 ?

Q 8. Why was calcium hydroxide ($Ca(OH)_2(s)$) used in the mixture with ammonium chloride ($NH_4C\ell(s)$) ?

Q 9. Write a balanced chemical equation to represent the reaction that occurred in well F1.

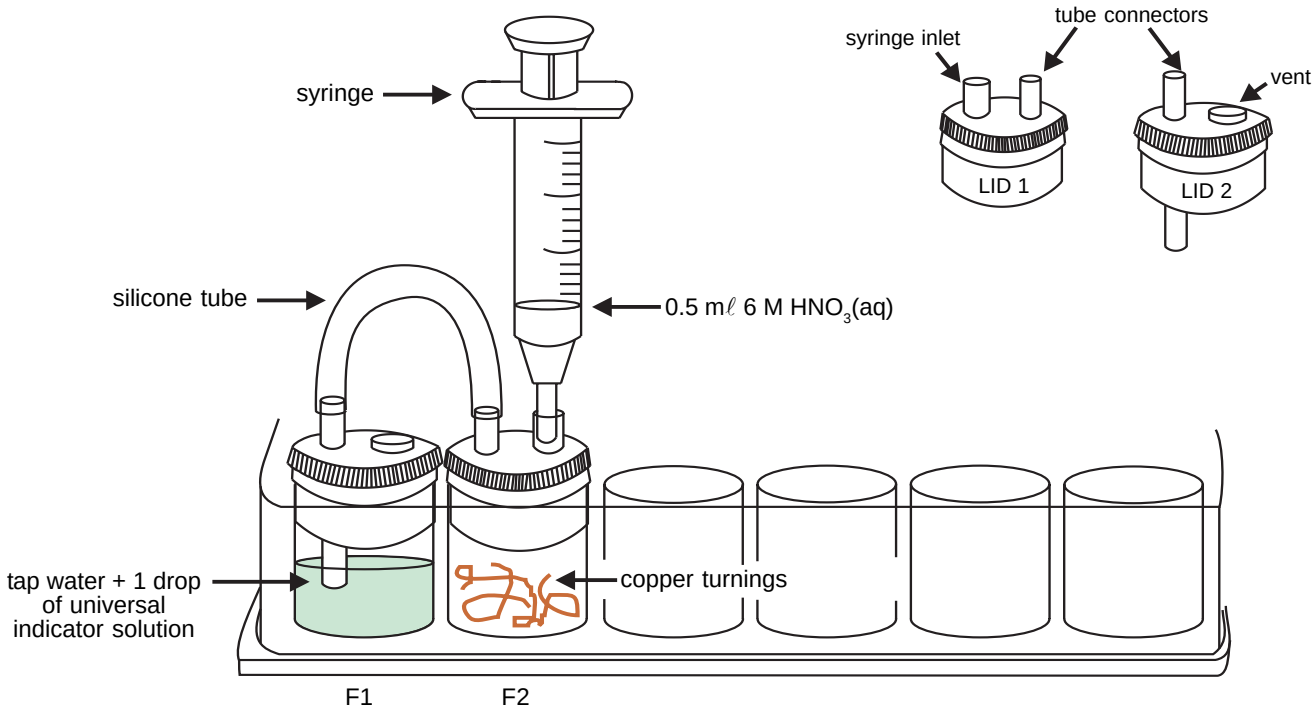
Q10. Write a balanced chemical equation to represent the reaction that occurred in well F2.

PREPARATION AND PROPERTIES OF NITROGEN DIOXIDE

PART 1: Preparation of Nitrogen Dioxide

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 mℓ syringe; 1 x lid 1; 1 x lid 2; 1 x thin stemmed propette; 1 x silicone tube (4 cm x 4 mm).
Chemicals: Copper turnings (Cu(s)); Nitric acid (HNO_3(aq)) [6 M]; Universal indicator solution; Tap water.



PROCEDURE

1. Fill $^3/_4$ of well F1 with tap water. Add one drop of universal indicator solution into well F1.
2. Add 5 copper turnings into well F2.
3. Seal well F1 with lid 2. Make sure the vent hole is nearest to well F2 (see the figure). Seal well F2 with lid 1.
4. Connect one end of the plastic tube to the connector on lid 2. Connect the remaining end of the plastic tube to the connector on lid 1.
5. Fill the syringe with 0.5 mℓ of 6 M nitric acid and insert the nozzle of the syringe into the syringe inlet on lid 1 (see the figure for the complete set-up).
6. Inject all the nitric acid into well F2 very slowly.
7. Wait about 2 minutes from the time you finished adding the nitric acid. *(See Questions 1 to 4)*
8. After 2 minutes examine the solution in well F1. *(See Question 5)*

Clean the comboplate® thoroughly before you start Part 2.

PREPARATION AND PROPERTIES OF NITROGEN DIOXIDE

QUESTIONS

Q1. Note the pH of the water in well F1. (Hint: Use the pH indicator colour strip)

Q2. What do you observe happening in well F2 ?

Q3. Can you smell anything from the vent in well F1 ? (Describe what you smell.)

Q4. What is the colour of the gas produced in well F2 ?

Q5. What is the pH of the solution in well F1 ?

Q6. What is the name of the gas formed in well F2 ?

Q7. What is the chemical formula of the gas formed in well F2 ?

Q8. What is the name of the aqueous product in well F2 ?

Q9. Give a balanced chemical equation for the reaction of 6 M nitric acid and copper.

PREPARATION AND PROPERTIES OF NITROGEN DIOXIDE

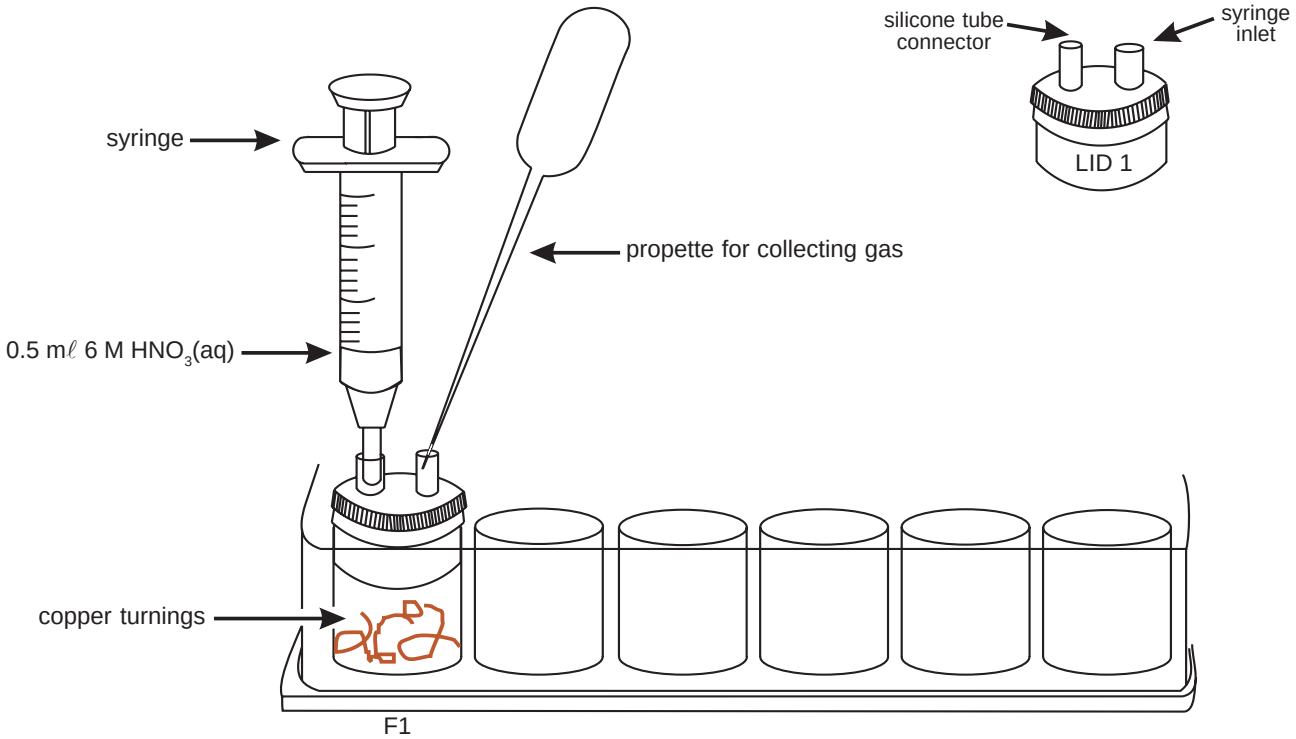
Part 2: The Effect of Temperature on the Equilibrium:

$$2NO_2(g)\ \text{(brown)} \rightleftharpoons N_2O_4(g)\ \text{(colourless)}$$

Nitrogen Dioxide	Dinitrogen Tetroxide

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 mℓ syringe; 1 x lid 1; 1 x thin stemmed propette; 2 x plastic cups.
Chemicals: Copper turnings (Cu(s)); Nitric acid (HNO_3(aq)) [6 M]; Hot water; Cold water (ice water).



PROCEDURE

1. Place two plastic cups on a flat surface (a table). Fill the one with cold water (ice water) and the other with hot water.
2. Fill ½ of well F1 with copper turnings. Cover well F1 with lid 1.
3. Suck up 0.5 mℓ of 6 M nitric acid with the syringe. Insert the nozzle of the syringe into the syringe inlet in lid 1.
4. Inject the 0.5 mℓ of nitric acid into well F1 slowly.
5. Quickly press the bulb of the propette to release the air. Keeping the bulb tightly squeezed, place the stem of the propette into the tube outlet on lid 1 covering well F1.
6. Release the pressure on the bulb of the propette and suck up the gas generated in well F1.
7. Remove the stem of the propette when the bulb is full. Invert the propette and pinch the tip closed.

Note **Keep the tip of the stem pinched closed at all times to prevent the gas from escaping.**

8. Place the bulb of the propette into the cup of hot water for approximately 30 seconds. *(See Question 1)*
9. Place the bulb of the propette into the cup of cold water for approximately 30 seconds. *(See Question 2)*

Wash the comboplate® thoroughly with clean water and pat it dry using a paper towel.

PREPARATION AND PROPERTIES OF NITROGEN DIOXIDE

QUESTIONS

Q1. Note the colour of the gas in the bulb of the propette.

Q2. Note the colour of the gas in the bulb of the propette.

Q3 Using the given chemical equation, explain the colour difference between the gaseous mixture in the propette at a high temperature and at a low temperature.

Q4. Write a statement describing the effect of temperature on the equilibrium between NO_2 and N_2O_4.

Q5. Which molecules are the higher energy molecules – NO_2 or N_2O_4 ? Justify your answer.

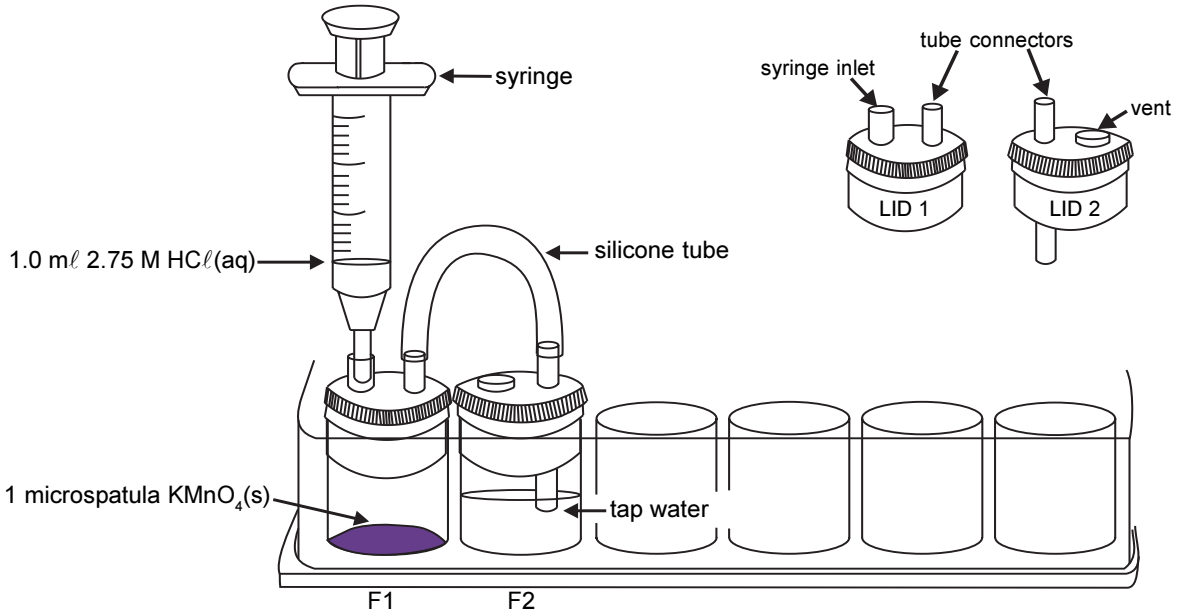
Q6. According to le Chatelier's Principle,and on the basis of your observations, which direction of reaction is exothermic?

PREPARATION AND TESTING FOR CHLORINE

REQUIREMENTS

Apparatus: 1 x comboplate®; 1 x 2 mℓ syringe; 1 x lid 1; 1 x lid 2; 1 x plastic microspatula; 1 x silicone tubing (4 cm x 4 mm); 2 x pieces indicator paper; 1 x strip white paper; 1 x koki pen.

Chemicals: Hydrochloric acid (HCℓ(aq)) [5.5 M]; Potassium permanganate powder ($KMnO_4$(s)); Tap water.



PROCEDURE

1. Using the spooned end of the microspatula, place 1 level spatula of solid potassium permanganate into well F1.
2. Place lid 1 on well F1.
3. Dilute the 5.5 M hydrochloric acid to 2.75 M hydrochloric acid by filling the syringe with 0.5 mℓ of tap water and dispensing it into well F6. Refill the syringe with 0.5 mℓ of 5.5 M HCℓ(aq) and add this dropwise to the water in well F6. You now have 2.75 M HCℓ(aq). Use this acid in step 4.
4. Fill the syringe with 1.0 ml of the 2.75 M HCℓ(aq) from well F6 and fit the syringe into the inlet in lid 1 covering well F1.
5. Fill ¾ of well F2 with tap water. Test the effect of the water on a piece of indicator paper. *(See Question 1)*
6. Cover well F2 with lid 2.
7. Join well F1 to well F2 by means of the silicone tubing.
8. Inject the solution of hydrochloric acid [2.75 M] dropwise into well F1 from the syringe. *(See Questions 2-4)*
9. After about 7 – 8 minutes, remove the lid from well F2. Using another piece of indicator paper, test the effect of the solution in well F2 on the paper. *(See Question 5)*
10. Write your initials on a strip of white paper using a koki pen. Place the paper into the solution in well F2. *(See Question 6)*

Note **As soon as you have completed the test for the effect of the solution on the ink, rinse the comboplate® thoroughly or the brown solution will stain the wells. If this happens, add a few drops of 10% H_2O_2(aq) to the stained wells and scrape the wells clean with a toothpick or matchstick.**

PREPARATION AND TESTING FOR CHLORINE

QUESTIONS

Q 1. Record the colour of the indicator paper with tap water.

Q 2. What happened in well F1 when you added hydrochloric acid to the potassium permanganate?

Q 3. What do you observe in the water in well F2 after $HC\ell(aq)$ is added to the ($KMnO_4(s)$)?

Q 4. Can you smell anything coming from the vent in the lid of well F2? (If you are unsure, wave your hand across the vent towards your nose.) Identify the smell.

Q 5. What is the colour of this second piece of indicator paper?

Q 6. What happens to the ink on the white paper?

Q 7. Explain the observations you made with the indicator paper and the ink writing on the white paper.

Q 8. Name the gas formed in well F1 and write its chemical formula.

Q 9. Write a chemical equation for the reaction occurring between the gas formed in well F1 and the water in well F2.

Q10. What type of reaction occurred in well F1? (Hint: Think about the oxidation states of the different species in the reactants and the products.)

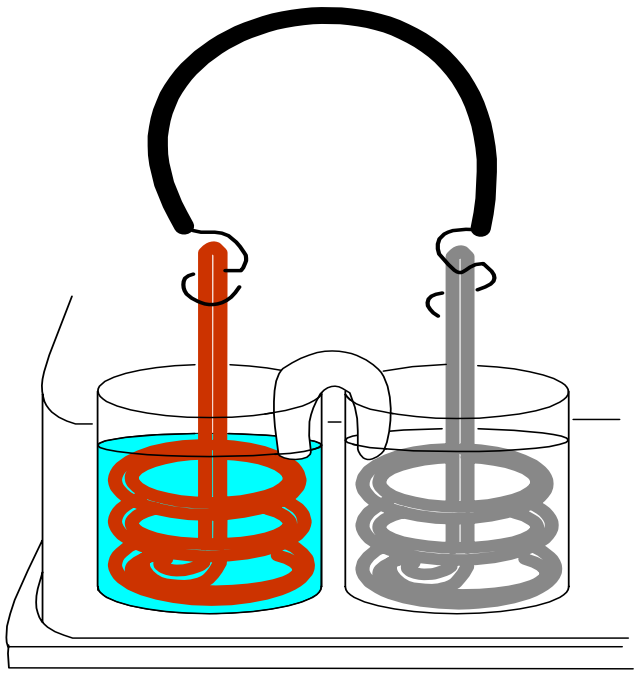
Q11. Justify your answer to question 10.

Q12. From your answers to questions 10 and 11, what kind of substances are required to obtain chlorine from hydrochloric acid?

Q13. Which of the following substances would you use to produce chlorine ($C\ell_2(g)$) from hydrochloric acid ($HC\ell(aq)$)? Explain your choice.

1. Sodium chloride ($NaC\ell(s)$)
2. Manganese dioxide ($MnO_2(s)$)
3. Potassium chloride ($KC\ell(s)$)

MICROCHEMISTRY
CHAPTER V



RATE OF REACTION - FACTORS AFFECTING THE RATE OF A HETEROGENEOUS REACTION

Part 1: The Effect of State of Division of Reactants

REQUIREMENTS

Apparatus: 1 x plastic microspatula; 2 x thin stemmed propettes; 1 x comboplate®.
Chemicals: Hydrochloric acid ($HC\ell(aq)$) [5.5 M]; Calcium carbonate lumps ($CaCO_3(s)$); Calcium carbonate powder ($CaCO_3(s)$); Tap water.

PROCEDURE

1. Remove 1 medium-sized lump of calcium carbonate from the storage bottle with a microspatula. Place the lump into well F1.
2. Add two level spatulas of calcium carbonate powder into well F2, using the spooned end of the plastic microspatula. Spread the powder around so that there are no clumps of powder in one area of the well.
3. Add 15 drops of water into each of wells F1 and F2 with a clean propette. When adding the water to well F1 do not drop the water directly onto the lump of solid, otherwise the lump may break up. Try to keep it in the lump form too when hydrochloric acid is added in the next step.

Note **The lumps of calcium carbonate are not always uniform in size. If you use a small calcium carbonate lump in well F1, you may need only one spatula of calcium carbonate powder in well F2 for a proper comparison to be made. Alternatively, if the calcium carbonate lump is large, you may need to increase the amount of powder used in well F2. A large lump may be broken into smaller pieces with a hard object, but do not try to break the lumps in the comboplate® as they are very hard and will crack the plastic.**

4. Add 5 drops of 5.5 M hydrochloric acid into wells F1 and F2. Add the 5.5 M hydrochloric acid to the water in well F1 and not on top of the lump of solid calcium carbonate. Observe what happens. *(See Questions 1, 2)*

Rinse the comboplate® with water before Part 2.

QUESTIONS

Q1. What can be observed in wells F1 and F2 ?

Q2. In which well would you say the reaction is going faster? Give a reason for your answer.

Q3. Write a statement describing the effect of the state of division of solid calcium carbonate on the rate of its reaction with hydrochloric acid.

RATE OF REACTION - FACTORS AFFECTING THE RATE OF A HETEROGENEOUS REACTION

Part 2: The Effect of Concentration of Reactants

REQUIREMENTS

Apparatus: 1 x plastic microspatula; 4 x thin stemmed propettes; 1 x comboplate®.
Chemicals: Hydrochloric acid (HCℓ(aq)) [0.1 M]; Hydrochloric acid (HCℓ(aq)) [1.0 M]; Hydrochloric acid (HCℓ(aq)) [11 M]; Calcium carbonate powder ($CaCO_3$(s)); Tap water.

PROCEDURE

1. Use the spooned end of the plastic microspatula to add 1 level spatula of calcium carbonate powder into each of wells F3, F4 and F5. Spread the powder around to break up any clumps.
2. Add 15 drops of water with a propette into each of wells F3, F4 and F5.
3. Fill a propette with 0.1 M hydrochloric acid. Fill another propette with 1.0 M hydrochloric acid and a third propette with 11 M hydrochloric acid. Line the propettes up in order from lowest concentration to highest concentration.
4. Add 5 drops of 0.1 M hydrochloric acid into well F3, 5 drops of 1.0 M hydrochloric acid into well F4 and 5 drops of 11 M hydrochloric acid into well F5.

Note **Try to perform this step quickly so that a good comparison of reaction rate can be made from one concentration of HCℓ to the next.**

5. Observe what happens. *(See Question 1)*

Rinse the comboplate® with water before commencing Part 3.

Part 3: The Effect of Temperature

REQUIREMENTS

Apparatus: 1 x plastic microspatula; 2 x thin stemmed propettes; 1 x comboplate®; 1 x microburner; 1 x glass rod.
Chemicals: Hydrochloric acid (HCℓ(aq)) [5.5 M]; Calcium carbonate powder ($CaCO_3$(s)); Tap water.

PROCEDURE

1. Add 1 level spatula of calcium carbonate ($CaCO_3$(s)) powder into each of wells E1 and E2, using the spooned end of the plastic microspatula. Spread the powder around as before.
2. Add 15 drops of tap water into each well.
3. Light the microburner. Hold one end of the glass rod between your fingers, and twirl the other end of the rod three or four times in the flame of the microburner.

CAUTION! **Be careful not to burn yourself!**

4. Dip the hot glass rod into the water in well E2. Stir the water with the rod to distribute the heat.
5. Remove the glass rod from well E2 and wipe it dry. Repeat steps 3 and 4 another two times.

   Blow out the flame of the microburner before continuing with step 6.
6. Add 2 drops of 5.5 M hydrochloric acid into each of wells E1 and E2. Observe what happens. *(See Questions 1 and 2)*

Rinse the comboplate® thoroughly with running water.

RATE OF REACTION - FACTORS AFFECTING THE RATE OF A HETEROGENEOUS REACTION

QUESTIONS - PART 2

Q1. What can be observed in wells F3, F4 and F5 ?

Q2. Place the wells in a sequence, from the well in which the reaction is the fastest to the one in which it is the slowest.

Q3. What is the reason for the difference in reaction rates ?

Q4. Write a statement describing the effect of concentration of hydrochloric acid on the rate of its reaction with solid calcium carbonate.

QUESTIONS - PART 3

Q1. What can be observed in wells E1 and E2?

Q2. In which of these wells would you say the reaction is going faster? Give a reason for your answer.

Q3. What is the reason for your observations in question 1 ?

Q4. Write a statement describing the effect of temperature on the rate of the reaction.

RATES OF REACTION - THE EFFECT OF CATALYSTS

Part 1: Finding a Catalyst for the Decomposition of Hydrogen Peroxide

Introduction: **The substances NaCℓ(s), Cu(s), and MnO_2(s) will be tested as catalysts for the chemical reaction $2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$.**

REQUIREMENTS

Apparatus: 3 x plastic microspatulas; 1 x comboplate®; 1 x thin stemmed propette.
Chemicals: Fresh hydrogen peroxide solution (H_2O_2(aq)) [10%]; Sodium chloride (NaCℓ(s)); Copper powder (Cu(s)); Manganese dioxide powder (MnO_2(s)).

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

PROCEDURE

1. Add 15 drops of the 10% solution of hydrogen peroxide into each of wells F1, F2 and F3.
2. Use the narrow end of a plastic microspatula to add one spatula of sodium chloride into well F1.
3. Use the narrow end of another plastic microspatula to add one spatula of copper powder into well F2.
4. Use the narrow end of another plastic microspatula to add one spatula of manganese dioxide powder into well F3. *(See Question 1)*
5. Wait till the bubbling in well F3 has stopped. Observe what is happening in well F1. *(See Question 2)*
6. Observe what is happening in well F2. *(See Question 3)*
7. Use the propette to add 5 more drops of H_2O_2(aq) to the Cu(s) in well F2. Note what happens in well F2. *(See Question 4)*
8. Observe what is happening in well F3. *(See Question 5)*
9. Use the propette to add 5 more drops of H_2O_2(aq) to the MnO_2(s) in well F3. Note what happens in well F3. *(See Question 6)*

Rinse the wells out with water and shake dry.

Part 2: The Effect of Quantity of Catalyst on the Rate of Decomposition of Hydrogen Peroxide

REQUIREMENTS

Apparatus: 3 x plastic microspatulas; 1 x comboplate®; 1 x thin stemmed propette.
Chemicals: Hydrogen peroxide solution (H_2O_2(aq)) [10%]; Manganese dioxide powder (MnO_2(s)).

PROCEDURE

1. Add 15 drops of the 10% hydrogen peroxide solution into wells F5 and F6.
2. Use the narrow end of a plastic microspatula to add one small spatula of manganese dioxide powder into well F5.
3. Quickly turn the spatula around and use the spooned end to add one level spatula of manganese dioxide powder into well F6.

Note **Try to perform this step quickly so that a proper comparison can be made between wells F5 and F6.** *(See Questions 1 and 2)*

Rinse the comboplate® with water and shake dry.

RATES OF REACTION - THE EFFECT OF CATALYSTS

QUESTIONS - PART 1

Q1. What can be observed in wells F1, F2 and F3?

Q2. Can you still see NaCℓ(s) in well F1? Give a reason for your observation.

Q3. Can you still see Cu(s) in well F2?

Q4. What happens when more H_2O_2(aq) is added to F2?

Q5. Can you still see MnO_2(s) in well F3?

Q6. What happens when more H_2O_2(aq) is added to F3?

Q7. In which well/s is the decomposition reaction of hydrogen peroxide being catalysed? Give reasons for your answer.

Q8. Write a statement describing which of the substances tested, catalyse the decomposition of hydrogen peroxide.

QUESTIONS - PART 2

Q1. What can be observed in wells F5 and F6?

Q2. In which well does the bubbling stop first?

Q3. In which well is the decomposition of hydrogen peroxide proceeding faster? Give reasons for your answer.

Q4. Write a statement describing the effect of quantity of catalyst on the rate of decomposition of hydrogen peroxide.

RATES OF REACTION - THE EFFECT OF CONCENTRATION

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: $Na_2S_2O_3(aq) + 2HC\ell(aq) \rightarrow 2NaC\ell(aq) + S(s) + SO_2(g) + H_2O(\ell)$

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 ($HC\ell(aq)$) [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 $HC\ell$ (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 $HC\ell$ (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 ($HC\ell(aq)$) [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 $HC\ell$ (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 $HC\ell$ (11 M) and add this to well A2. *(See Question 2)*

Rinse the comboplate® with tap water and shake dry.

RATES OF REACTION - THE EFFECT OF CONCENTRATION

QUESTIONS - PART 1

Q 1. Prepare a table like Table 1 below.

Table 1.

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.

ENTHALPY CHANGES FOR REACTIONS OF ACIDS WITH A STRONG BASE

PART 1: The enthalpy change (ΔH) 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 °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 (ΔH) 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.

ENTHALPY CHANGES FOR REACTIONS OF ACIDS WITH A STRONG BASE

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 ?

THE EFFECT OF pH ON THE CHROMATE/DICHROMATE EQUILIBRIUM

$$Cr_2O_7^{2-}(aq) + H_2O(\ell) \rightleftharpoons 2CrO_4^{2-}(aq) + 2H^+(aq)$$

When a dichromate salt is dissolved in water, the dichromate ions react with the water molecules as shown in the above reaction equation. An equilibrium exists such that there are dichromate ($Cr_2O_7^{2-}$) ions, chromate (CrO_4^{2-}) ions and hydrogen (H^+) ions in solution all at the same time. The chromate and dichromate ions become predominant in solution at different pH values. Since the ions have different colours, the colour of the solution at a particular pH will reveal which ion has the greater concentration at that pH.

REQUIREMENTS

Apparatus: 1 x comboplate®; 3 x thin stemmed propettes; 1 x plastic microspatula.
Chemicals: Potassium dichromate powder ($K_2Cr_2O_7(s)$); Nitric acid ($HNO_3(aq)$) [6 M]; Sodium hydroxide ($NaOH(aq)$) [5.5 M]; Tap water.

PROCEDURE

1. Use the narrow end of a plastic microspatula to add a small amount of solid potassium dichromate into each of wells A1 and A2. Do not heap the potassium dichromate onto the microspatula as it will not dissolve completely in the next step. *(See Question 1)*
2. Use a propette to add 5 drops of tap water into wells A1 and A2. Use the plastic microspatula to stir the solutions in wells A1 and A2 until all of the crystals have dissolved. *(See Question 2)*
3. Use a clean propette to add sodium hydroxide solution (5.5 M), drop by drop, into well A2 until the solution changes colour. Stir the solution with the microspatula after each drop is added. *(See Question 4)*
4. Add an equal number of drops of water to well A1. This is to show that the colour change in well A2 is not due to dilution. *(See Question 5)*
5. Wait about 30 seconds, then add a sufficient number of drops of nitric acid into well A2 until the colour of the solution changes again. Stir the solution with the microspatula after each drop is added.
6. Add an equal number of drops of water to well A1 to ensure that the second colour change is not due to dilution.

Rinse the comboplate® thoroughly with running water.

THE EFFECT OF pH ON THE CHROMATE/DICHROMATE EQUILIBRIUM

QUESTIONS

Q 1. What is the colour of solid potassium dichromate?

Q 2. What is the colour of the solutions in wells A1 and A2 ?

Q 3. Which ion in solution is responsible for this colour?

(Refer to the given equation and your former observation.)

Q 4. What number of drops of sodium hydroxide were required to make the solution change colour?

Q 5. Describe the colour change in well A2.

Q 6. Which ion in solution is responsible for the new colour? (Refer to the given equation.)

Q 7. What number of drops of nitric acid (6 M) were required to make the solution change colour?

Q 8. Describe the colour change in well A2.

Q 9. Which ion in solution is responsible for the new colour? (Refer to the given equation.)

Q10. Propose a reason why adding sodium hydroxide to the solution of potassium dichromate caused a colour change.

Q11. Propose a reason why adding nitric acid to the solution containing chromate ions caused a colour change.

Q12. Write down colour indications for the species in the chemical equation:

$Cr_2O_7^{2-}(aq) + H_2O(\ell) \rightleftharpoons 2CrO_4^{2-}(aq) + 2H^+(aq)$

Q13. You are given the following list of reagents:

Nitric acid ($HNO_3(aq)$),

sodium chloride ($NaC\ell(s)$),

potassium hydroxide (KOH(s)).

Which would you choose to add to an orange coloured solution of potassium dichromate to cause it to change to a yellow colour?

Q14. Give the reason for your answer in question 13.

Q15. Write a statement describing the effect of pH on the chromate/dichromate equilibrium.

CHEMICAL EQUILIBRIUM - LE CHATELIER'S PRINCIPLE

PART 1: What is the effect of the concentration of the reactants on the following chemical equilibrium:

$$Cu(H_2O)_4^{2+}(aq) + 4C\ell^-(aq) \rightleftharpoons CuC\ell_4^{2-}(aq) + 4H_2O(\ell)$$

REQUIREMENTS

Apparatus: 2 x thin stemmed propettes; 1 x plastic microspatula; 1 x comboplate®.
Chemicals: Copper nitrate solution ($Cu(NO_3)_2(aq)$) [0.5 M]; Hydrochloric acid ($HC\ell(aq)$) [11 M]; Tap water.

If any acid is spilt on the skin, thoroughly wash the affected area with water.

PROCEDURE

1. Use a clean propette to add 5 drops of 0.5 M $Cu(NO_3)_2(aq)$ into each of wells A1 and A2.

   *Well A1 is the standard for comparison. For every drop of water, or $HC\ell$, placed in well A2, one drop of water should be added to well A1. This is for comparison of the dilution effect. *(See Question 1)*

2. Using another propette, add 3 drops of 11 M $HC\ell$ into well A2. Stir the solution with the narrow end of a plastic microspatula. {**Remember** *}. *(See Question 3)*

3. Add 8 drops of water to well A2. Stir the solution with the narrow end of a plastic microspatula. {**Remember** *}. (**Add a further drop of water if the colour change is not complete**). *(See Question 5)*

4. **KEEP THE CONTENTS OF WELLS A1 AND A2 FOR PART 2.**

PART 2: The effect of temperature on the chemical equilibrium:

$$Cu(H_2O)_4^{2+}(aq) + 4C\ell^-(aq) \rightleftharpoons CuC\ell_4^{2-}(aq) + 4H_2O(\ell)$$

REQUIREMENTS

Apparatus: 1 x glass rod; 1 x microburner; 1 x box of matches.
Chemicals: The solutions in wells A1 and A2 from Part 1; Ice or cold water; Methylated spirits for the microburner.

Methylated spirits is poisonous. Do not inhale the vapour or drink the liquid.
Be careful not to burn your fingers with the hot rod.
Do not touch the surface of the comboplate® with the hot rod. It will melt the plastic.

PROCEDURE

1. Pass the glass rod through the flame of the microburner three or four times. Put the rod into well A2. (If the rod is too hot, the solution boils). Move the rod around in the well to distribute the heat uniformly. *(See Question 1)*

2. Remove the rod, dry it and place it into the container containing ice or cold water (Note: ice works better than cold water). Wait about 1 minute until the rod is cold and insert it into well A2. The colour should change after another 1 minute. *(See Question 3)*

3. Repeat steps 1 and 2, this time placing the hot and then cold rod into well A1. *(See Question 5)*

Rinse the wells with tap water, and then shake them dry as before.

CHEMICAL EQUILIBRIUM - LE CHATELIER'S PRINCIPLE

QUESTIONS - PART 1

Q 1. What is the colour of the solution in each well?

Q 2. Which ion in solution is responsible for this colour? (☺ Refer to the given equation.)

Q 3. Describe the colour change.

Q 4. Which ion in solution is responsible for the new colour? (☺ Refer to the given equation.)

Q 5. Note the colour change in well A2.

Q 6. Propose a reason why adding HCℓ to the solution containing $Cu(NO_3)_2$, turns it yellow/pale green.

Q 7 Write down colour indications for the species in the chemical equation:

$Cu(H_2O)_4^{2+}(aq) + 4C\ell^-(aq) \rightleftharpoons CuC\ell_4^{2-}(aq) + 4H_2O(\ell)$

☺ **Water (H_2O) is colourless.**

Q 8. You are given the following list of reagents:

nitric acid (HNO_3)

sodium chloride (NaCℓ)

sodium hydroxide (NaOH)

Which would you choose to add to a blue copper nitrate solution to cause it to turn yellow/pale green?

Q 9. Give the reason for your answer to Question 8.

Q10. Write a statement describing the effect of concentration of reactants on the equilibrium you have studied.

QUESTIONS - PART 2

Q1. Describe the colour change in well A2. (If the colour change is not convincing, wipe the rod and repeat step 1.)

Q2. Which ion in solution is responsible for the new colour? (☺ Refer to the chemical equation.)

Q3. Describe the colour change in well A2. (If the colour change is not convincing, repeat step 2.)

Q4. Which ion in solution is responsible for the new colour? (☺ Refer to the chemical equation.)

Q5. Do you observe the same colour changes as for well A2?

Q6. Having noted the colour changes in well A2 which species, $Cu(H_2O)_4^{2+}(aq)$ or $CuC\ell_4^{2-}(aq)$, would you say is preferred under the following conditions:

6.1 Hot solution?

6.2 Cold solution?

Q7. Using the given chemical equation, explain why the colour changes when the temperature of the solution in well A2 is:

7.1 increased

7.2 decreased

Q8. Write a statement describing the effect of temperature on the chemical equilibrium you have studied.

Q9. A student says that the temperature affects the colour of all coloured solutions.

9.1 Do you think the student is correct in his view?

9.2 If not, how could you prove that the temperature only changes the colour of a solution when it changes the concentration of one or more of the coloured species in the solution? Suggest an experimental set-up.

CHEMICAL EQUILIBRIUM - THE COMMON ION EFFECT

REQUIREMENTS

Apparatus: 1 x comboplate®; 4 x thin stemmed propettes; 1 x plastic microspatula.
Chemicals: Hydrochloric acid (HCℓ(aq)) [11 M]; Nitric acid (HNO_3(aq)) [~12 M];
Sodium chloride (NaCℓ(aq)) (saturated); Tap water.

PROCEDURE

1. Add 5 drops of the saturated sodium chloride solution from a propette into wells A1 and A2.
2. Use a second propette to add 1 drop of ~12 M nitric acid to well A1. *(See Question 1)*
3. Use a third propette to add 1 drop of 11 M hydrochloric acid to well A2. *(See Question 2)*
4. Add 5 drops of tap water from a clean propette into well A2. Use the spatula to stir the contents of well A2 and observe. *(See Question 7)*

Rinse the comboplate® with running water and shake dry.

QUESTIONS

Q 1. What happens when you add the nitric acid to the saturated sodium chloride solution ?

Q 2. What happens when you add hydrochloric acid to the saturated sodium chloride solution ?

Q 3. Do the solutions added in well A1 have ions in common with one another? If so, state which they are.

Q 4. Do the solutions added in well A2 have ions in common with one another? If so, state which they are.

Q 5. What is the name and chemical formula of the solid formed in well A2 ?

Q 6. In a saturated sodium chloride solution, solid sodium chloride is in equilibrium with the aqueous solution of sodium chloride, as represented in the balanced reaction equation,

$$NaC\ell(s) \rightleftharpoons Na^+(aq) + C\ell^-(aq)$$

Use this information to explain what happened in well A2.

Q 7. What happened to the contents of well A2 on adding water ?

Q 8. Explain what happened in well A2.

Q 9. Explain what is meant by the ‘common ion effect'.

Q10. A student makes a mistake when doing the above experiment and uses 1 M hydrochloric acid instead of 11 M hydrochloric acid in step 3.

Predict what the student will observe.

CONCENTRATION AND AMOUNT OF SUBSTANCE IN SOLUTION

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.

Note **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 F1,
   four level spatulas of copper nitrate into well F2,
   four level spatulas of copper nitrate into well F3.

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.

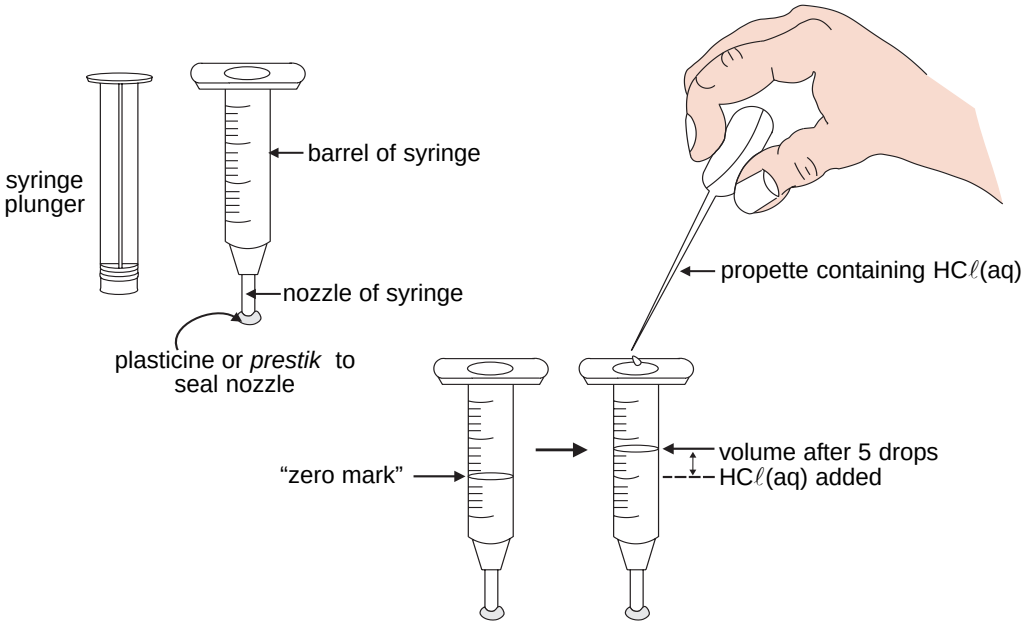
Q 4. Write a statement describing what is meant by the concentration and the amount of a substance in solution.

ACID/BASE TITRATION - DETERMINING THE CONCENTRATION OF AN ACID

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.

ACID/BASE TITRATION - DETERMINING THE CONCENTRATION OF AN ACID

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.

THE ZINC/ COPPER CELL

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].

Note **Galvanised iron wire is iron wire coated with zinc**

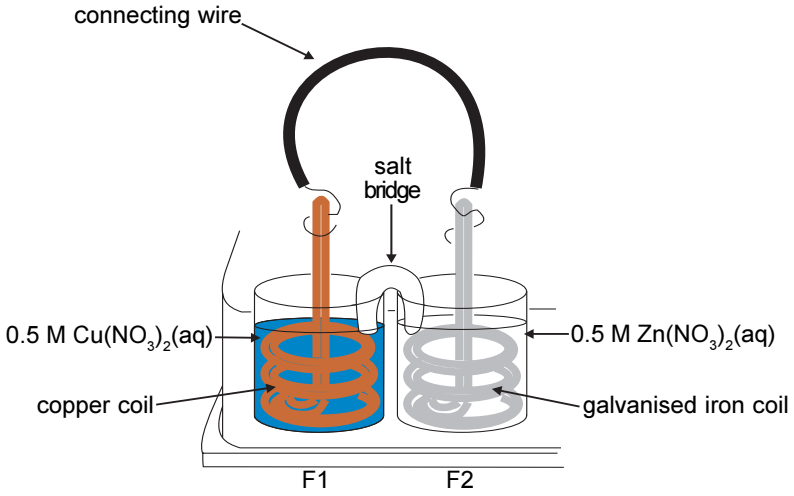
CAUTION **The syringe should be thoroughly cleaned by rinsing with tap water before each new liquid is used. If this is not done the stock solutions will become contaminated and the experiment will be misleading.**

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 ($KNO_3(aq)$) 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.

THE ZINC/ COPPER CELL

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.

ORGANIC CHEMISTRY - ESTERS

REQUIREMENTS

Apparatus: 1 x sample vial; 2 x thin stemmed propettes; 1 x microburner; 1 x glass rod.
Chemicals: Pure ethanoic acid ($CH_3COOH(\ell)$); Ethanol ($C_2H_5OH(\ell)$); Sulphuric acid ($H_2SO_4(aq)$) [18 M].

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)*

Clean the vial thoroughly with water.

QUESTIONS

Q 1. 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 ?

ORGANIC CHEMISTRY -
SATURATED AND UNSATURATED HYDROCARBONS

REQUIREMENTS

Apparatus: 1 x comboplate®; 3 x thin stemmed propettes; 2 x plastic microspatulas.
Chemicals: Bromine solution ($Br_2(aq)$); Cyclohexane ($C_6H_{12}(\ell)$); Hex-1-ene ($C_6H_{12}(\ell)$).

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 ?