Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9101215028

CHEMISTRY **0620/61**

Paper 6 Alternative to Practical **May/June 2020**

1 hour

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

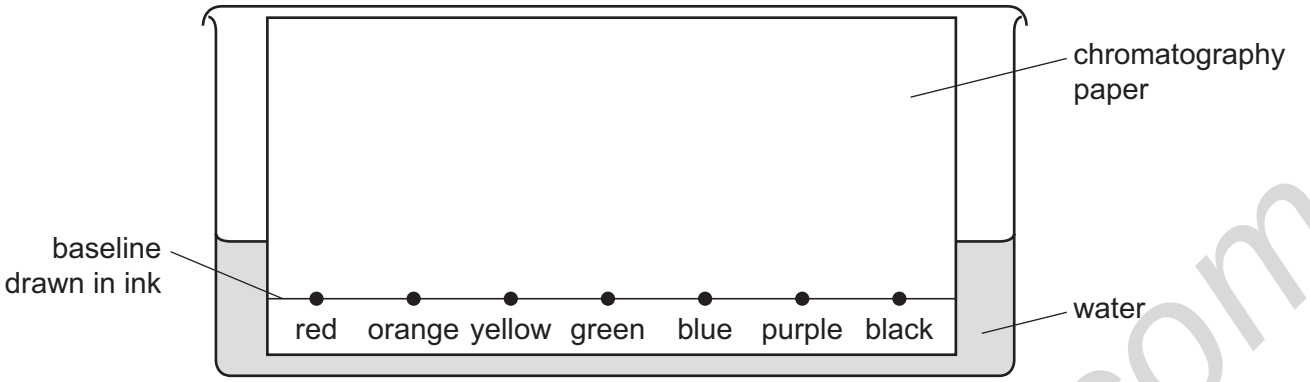
INFORMATION

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **8** pages. Blank pages are indicated.

[Turn over

1 A student investigated the dyes contained in different coloured inks using chromatography. Water was the solvent. The diagram shows how the student set up the apparatus.



(a) Identify **two** errors in the way the student set up the apparatus.

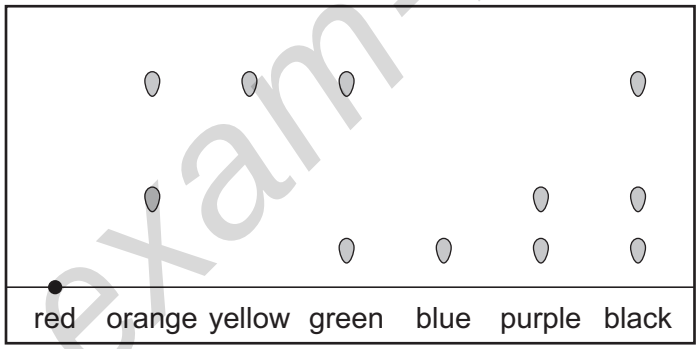
1 .....

2 .....

[2]

(b) The student then carried out the chromatography correctly.

The diagram shows the results.



(i) Which ink contains the greatest number of soluble dyes?

..... [1]

(ii) Which **two** inks are made of a single soluble dye?

..... and .....

[1]

(iii) From the chromatogram it is **not** possible to tell if the red ink contains different dyes.

Suggest how the experiment could be changed to find out if the red ink contains different dyes.

..... [1]

[Total: 5]

Question no. 1

(a) Identify two errors in the way the student set up the apparatus

In paper chromatography, the position of the baseline and the choice of material used to draw it are both crucial for obtaining valid results.

First error:
The **baseline and the ink spots are below the solvent (water) level**. This is incorrect because the inks will **dissolve directly into the solvent** instead of being carried up the chromatography paper by capillary action. As a result, the dyes will not separate properly and the chromatogram will be unreliable.

Second error:
The **baseline has been drawn in ink**. This is an error because ink itself is a mixture of dyes, which will **dissolve in the solvent and travel up the paper**, interfering with the results. The baseline should be drawn in **pencil**, as graphite is insoluble and will not move with the solvent.

(b) The student then carried out the chromatography correctly

The diagram now shows a correct chromatogram, where each separated spot represents a **different soluble dye**.

(i) Which ink contains the greatest number of soluble dyes?

The ink that contains the greatest number of soluble dyes is **black**.

This is because the black ink produces the **largest number of separate spots** on the chromatogram. Each spot corresponds to a different dye that has dissolved in the solvent and travelled a different distance up the paper.

(ii) Which two inks are made of a single soluble dye?

The two inks made of a single soluble dye are **yellow** and **blue**.

Each of these inks produces **only one spot** on the chromatogram, showing that they contain **just one dye** rather than a mixture.

(iii) From the chromatogram it is not possible to tell if the red ink contains different dyes

Suggest how the experiment could be changed to find out if the red ink contains different dyes.

To determine whether the red ink contains more than one dye, the experiment could be changed by **using a different solvent**, such as an **organic solvent** instead of water.

Different dyes have different solubilities in different solvents. Using a different solvent may allow the dyes in the red ink to **separate into more than one spot**, revealing whether it is a mixture.

2 A student investigated the reaction between dilute hydrochloric acid and two different aqueous solutions of sodium carbonate, solution **E** and solution **F**.

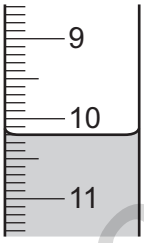
Three experiments were done.

(a) *Experiment 1*

- A burette was filled up to the 0.0 cm^3 mark with dilute hydrochloric acid.
- Using a measuring cylinder, 25 cm^3 of solution **E** was poured into a conical flask.
- Five drops of thymolphthalein indicator were added to the conical flask.
- Dilute hydrochloric acid was slowly added from the burette to the conical flask, while the flask was swirled, until the solution just changed colour.

Use the burette diagrams to complete the table for Experiment 1.

initial reading



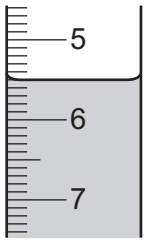
final reading

final burette reading / cm^3	
initial burette reading / cm^3	
volume of dilute hydrochloric acid added / cm^3	

Experiment 2

- The conical flask was emptied and rinsed with distilled water.
- The burette was refilled with dilute hydrochloric acid.
- Experiment 1 was repeated using five drops of methyl orange indicator instead of thymolphthalein indicator.

Use the burette diagrams to complete the table for Experiment 2.



initial reading

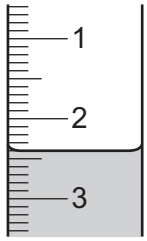
final reading

final burette reading / cm^3	
initial burette reading / cm^3	
volume of dilute hydrochloric acid added / cm^3	

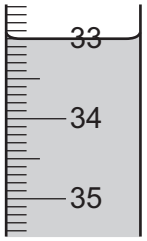
Experiment 3

- The conical flask was emptied and rinsed with distilled water.
- The burette was refilled with dilute hydrochloric acid.
- Using a measuring cylinder, 25 cm^3 of solution **F** was poured into the conical flask.
- Five drops of methyl orange indicator were added to the conical flask.
- Dilute hydrochloric acid was slowly added from the burette to the conical flask, while the flask was swirled, until the solution just changed colour.

Use the burette diagrams to complete the table for Experiment 3.



initial reading



final reading

final burette reading / cm^3	
initial burette reading / cm^3	
volume of dilute hydrochloric acid added / cm^3	

[5]

(b) What colour change was observed in the conical flask in Experiment 2?

from ..... to .....

[2]

(c) Compare the volumes of dilute hydrochloric acid added in Experiment 2 and Experiment 3. Explain any difference.

.....

..... [2]

(d) Determine the simplest whole number ratio of volumes of dilute hydrochloric acid used in Experiments 1 and 2.

ratio Experiment 1 : Experiment 2 = ... [1]

(e) What volume of dilute hydrochloric acid would be required if Experiment 3 was repeated using thymolphthalein indicator instead of methyl orange indicator?

volume = ... [2]

(f) The conical flask was rinsed with distilled water between each experiment.

(i) Why was the conical flask rinsed?

.....

..... [1]

(ii) Why does it **not** matter if a little distilled water is left in the flask after it has been rinsed?

.....

..... [1]

(g) State **two** sources of error in the experiments. For each error suggest an improvement that would reduce the error.

source of error 1 .....

improvement 1 .....

.....

source of error 2 .....

improvement 2 .....

.....

[4]

[Total: 18]

Question no. 2

(a) Completing the tables using the burette diagrams

Experiment 1 (solution E with thymolphthalein)

From the burette diagrams:

- **Initial burette reading = 0.0 cm^3**
- **Final burette reading = 10.2 cm^3**

The **volume of dilute hydrochloric acid added** is calculated by subtracting the initial reading from the final reading:

- **Volume added = 10.2 − 0.0 = 10.2 cm^3**

So, for Experiment 1:

- **Final reading: 10.2 cm^3**
- **Initial reading: 0.0 cm^3**
- **Volume added: 10.2 cm^3**

Experiment 2 (solution E with methyl orange)

From the burette diagrams:

- **Initial burette reading = 5.5 cm^3**
- **Final burette reading = 25.9 cm^3**

The volume of acid added is:

- **Volume added = 25.9 − 5.5 = 20.4 cm^3**

So, for Experiment 2:

- **Final reading: 25.9 cm^3**
- **Initial reading: 5.5 cm^3**
- **Volume added: 20.4 cm^3**

Experiment 3 (solution F with methyl orange)

From the burette diagrams:

- **Initial burette reading = 2.4 cm^3**
- **Final burette reading = 33.0 cm^3**

The volume of acid added is:

- **Volume added = 33.0 − 2.4 = 30.6 cm^3**

So, for Experiment 3:

- **Final reading: 33.0 cm^3**
- **Initial reading: 2.4 cm^3**
- **Volume added: 30.6 cm^3**

(b) Colour change observed in Experiment 2

Methyl orange is **yellow in alkaline solution** and **red in acidic solution**.

Since sodium carbonate solution is alkaline and hydrochloric acid is added until the endpoint:

- **Colour change: from yellow to red (or orange/pink)**

(c) Comparison of volumes of acid used in Experiments 2 and 3

- Volume used in Experiment 2 = **20.4 cm^3**
- Volume used in Experiment 3 = **30.6 cm^3**

More dilute hydrochloric acid was required in Experiment 3 than in Experiment 2.

This is because **solution F is more concentrated than solution E**, so it contains **more moles of sodium carbonate** in the same 25 cm^3 volume. Therefore, **more acid is needed to completely neutralise solution F**.

Numerically:

- **30.6 ÷ 20.4 = 1.5**

So, **solution F is 1.5 times more concentrated than solution E**.

(d) Ratio of volumes of acid used in Experiments 1 and 2

- Experiment 1 volume = **10.2 cm^3**
- Experiment 2 volume = **20.4 cm^3**

Forming the simplest whole-number ratio:

- **10.2 : 20.4 = 1 : 2**

So,

- **Ratio (Experiment 1 : Experiment 2) = 1 : 2**

(e) Volume of acid required if Experiment 3 used thymolphthalein instead of methyl orange

From Experiments 1 and 2, thymolphthalein requires **half the volume of acid** compared with methyl orange for the same solution.

In Experiment 3 (with methyl orange):

- Acid used = **30.6 cm^3**

So, with thymolphthalein:

- **30.6 ÷ 2 = 15.3 cm^3**

Therefore:

- **Required volume = 15.3 cm^3**

(f) Rinsing the conical flask

(i) Why was the conical flask rinsed?

The conical flask was rinsed to **remove any residues from the previous experiment**, such as leftover acid, alkali, or indicator, which could **affect the accuracy of the next titration**.

(ii) Why does it not matter if a little distilled water is left in the flask?

A small amount of distilled water **does not change the number of moles of solution E or F added**, because the volume of sodium carbonate solution is **measured separately using a measuring cylinder**. The water only dilutes the solution slightly and **does not affect the titration result**.

(g) Sources of error and improvements

Source of error 1

Using a **measuring cylinder** to measure 25 cm^3 of solution, which is less accurate.

Improvement 1
Use a **pipette** to measure the volume more precisely.

Source of error 2

The **endpoint colour change may be misjudged**, especially if acid is added too quickly.

Improvement 2
Add the acid **more slowly near the endpoint**, or **repeat the titration and calculate a mean value**.

3 Two solids, solid **G** and solid **H**, were analysed. Solid **G** was copper(II) carbonate.
Tests were done on each solid.

tests on solid G

Complete the expected observations.

(a) Solid **G** was placed in a boiling tube. An excess of dilute sulfuric acid was added to the boiling tube. Any gas produced was tested.

observations .....

.....

..... [3]

(b) Identify the gas produced in **(a)**.

..... [1]

(c) Aqueous ammonia was added slowly until in excess to the solution produced in **(a)**.

observations .....

.....

.....

..... [3]

tests on solid H

Tests were done and the following observations were made.

tests on solid **H**	observations
test 1 Flame test	yellow flame
test 2 Some of solid **H** was placed in a boiling tube. The boiling tube was heated strongly.	condensation appeared near the mouth of the boiling tube
Solid **H** was dissolved in distilled water. The solution was divided into two equal portions. **test 3** About 1 cm^3 of dilute nitric acid followed by a few drops of aqueous silver nitrate were added to the first portion of the solution.	the solution remained colourless
test 4 About 1 cm^3 of dilute nitric acid followed by a few drops of aqueous barium nitrate were added to the second portion of the solution.	white precipitate

(d) What conclusion can be made from the result of **test 3**?

.....

..... [1]

(e) What conclusions can be made about solid **H** from the results of **test 1**, **test 2** and **test 4**?

.....

.....

..... [3]

[Total: 11]

Question no. 3

Tests on solid G

(Solid G is copper(II) carbonate)

(a) Observations when dilute sulfuric acid is added to solid G and any gas is tested

When solid G is treated with excess dilute sulfuric acid, **vigorous effervescence is observed**, showing that a gas is being produced. The solid gradually dissolves and a **blue solution forms**, indicating the presence of **copper(II) ions in solution**.

The gas produced is passed through limewater, which **turns milky**, confirming that the gas reacts to form a white precipitate of calcium carbonate.

These observations together are consistent with the reaction of a **carbonate with an acid**, producing carbon dioxide.

(b) Identity of the gas produced in (a)

The gas demonstrate by turning limewater milky is **carbon dioxide (CO_2)**.

(c) Observations when aqueous ammonia is added slowly, then in excess, to the solution from (a)

When aqueous ammonia is added **dropwise**, a **pale blue precipitate** first forms. This precipitate is copper(II) hydroxide.

As more ammonia is added and the solution becomes **excess ammonia**, the precipitate **dissolves**, producing a **dark (royal) blue solution**. This is due to the formation of a soluble copper(II) ammine complex.

These colour changes are characteristic of **Cu^{2+} ions**.

Tests on solid H

(d) Conclusion from the result of test 3

In test 3, the solution is acidified with dilute nitric acid and then treated with aqueous silver nitrate. Since **the solution remains colourless and no precipitate forms**, this shows that **no halide ions (chloride, bromide or iodide) are present**.

Therefore, solid H is **not a halide**.

(e) Conclusions from test 1, test 2 and test 4

From **test 1 (flame test)**, the **yellow flame** indicates the presence of **sodium ions (Na^+)**.

From **test 2**, heating solid H produces **condensation near the mouth of the boiling tube**, showing that **water is released on heating**. This means the compound is **hydrated**.

From **test 4**, after acidifying with dilute nitric acid, the addition of aqueous barium nitrate produces a **white precipitate**. This confirms the presence of **sulfate ions (SO_4^{2-})**, as barium sulfate is insoluble.

Final conclusion for solid H

Solid H is a **hydrated sodium sulfate**, and its formula can be written as:

$Na_2SO_4 \cdot xH_2O$

4 Cobalt, manganese and nickel are metals. They react with dilute hydrochloric acid to form hydrogen gas.

Plan an investigation to find the order of reactivity of these three metals.

You are provided with:
- samples of each metal
- dilute hydrochloric acid
- common laboratory apparatus.

Your plan must make it clear how your investigation will be a fair test and how you will use your results to place the metals in order of reactivity.

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..... [6]

Question no. 4

To find the order of reactivity of **cobalt, manganese and nickel**, I would compare how quickly each metal reacts with **dilute hydrochloric acid**, since all three metals produce **hydrogen gas** when they react.

Method

I would place an **equal volume of dilute hydrochloric acid** into **three identical test tubes**. Each test tube would be kept at the **same temperature** and set up in the same way.

I would then prepare **equal masses of cobalt, manganese and nickel**, ensuring that each metal is in the **same physical form** (for example, similar-sized pieces or powder) so that they have the **same surface area**.

Each metal would be added separately to a test tube containing the hydrochloric acid. As soon as the metal is added, I would **start a stopwatch**.

Making it a fair test

To ensure this investigation is a **fair test**, I would keep the following variables the same:

- **Same volume of hydrochloric acid** in each test tube
- **Same concentration of hydrochloric acid**
- **Same temperature** of the acid
- **Same mass (or number of moles) of each metal**
- **Same surface area and physical form of the metals**

The **only variable changed** is the **type of metal**, so any difference in results is due to the metal's reactivity.

Measuring reactivity

I would measure reactivity by **timing the reaction**:

- Start timing when the metal is added to the acid

- Stop timing when **all the solid metal has reacted** and the reaction stops

Alternatively, I could:

- Stop timing when a **fixed volume of hydrogen gas** has been collected
- Or measure the **volume of hydrogen gas produced after a fixed time**

Using the results to determine reactivity

The metal that reacts **in the shortest time** (or produces **hydrogen gas most quickly**) is the **most reactive**.

The metal that reacts **slowest** is the **least reactive**.

Using this comparison, I would place **cobalt, manganese and nickel in order of reactivity**, from **most reactive to least reactive**, based on the speed of hydrogen gas production.