



CANDIDATE  
NAME

CENTRE  
NUMBER

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CANDIDATE  
NUMBER

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**0971/62**

May/June 2023

**1 hour**

No additional materials are needed.

- 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.

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].
- Notes for use in qualitative analysis are provided in the question paper.

This document has **12** pages. Any blank pages are indicated.

- 1 Hot powdered lead(II) oxide is reduced by methane, a flammable gas. The products are lead, steam and carbon dioxide gas.

Fig. 1.1 shows the apparatus used to reduce lead(II) oxide using excess methane.

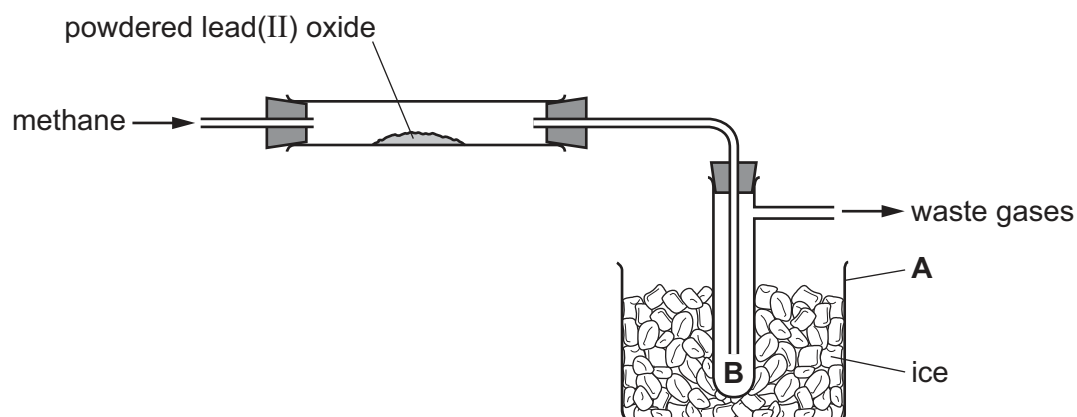


Fig. 1.1

- (a) Name the item of apparatus labelled A.

..... [1]

- (b) Draw an arrow on Fig. 1.1 to show where the apparatus should be heated.

[1]

- (c) Explain why powdered lead(II) oxide is used and **not** a large lump of lead(II) oxide.

.....  
 ..... [1]

- (d) Explain what happens at the point labelled B, on Fig. 1.1.

.....  
 .....  
 ..... [2]

- (e) The waste gases contain methane.

State why the waste gases should **not** be released into the laboratory.

.....  
 ..... [1]

[Total: 6]

- 2 A student investigates how the rate of the reaction between aqueous iron(III) nitrate and aqueous sodium thiosulfate changes with temperature.

The student does five experiments using the apparatus shown in Fig. 2.1.

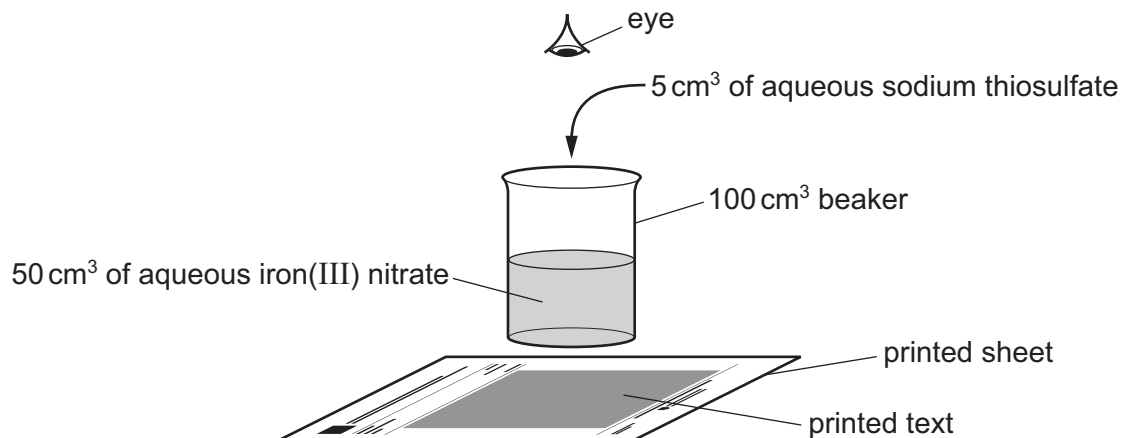


Fig. 2.1

(a) Experiment 1

- Use a 50 cm<sup>3</sup> measuring cylinder to pour 50 cm<sup>3</sup> of aqueous iron(III) nitrate into a 100 cm<sup>3</sup> beaker.
- Stand the beaker on a printed sheet as shown in Fig. 2.1.
- Use a 10 cm<sup>3</sup> measuring cylinder to pour 5 cm<sup>3</sup> of aqueous sodium thiosulfate into the beaker and at the same time start a stop-clock.
- Use a thermometer to stir the contents of the beaker.
- Look down from above the beaker and when the text on the printed sheet becomes visible, stop the stop-clock.
- Use the thermometer to measure the temperature of the solution when the text becomes visible.
- Rinse the beaker and thermometer with water.

Experiment 2

- Use the 50 cm<sup>3</sup> measuring cylinder to pour 50 cm<sup>3</sup> of aqueous iron(III) nitrate into the 100 cm<sup>3</sup> beaker.
- Heat the beaker on a gauze over a Bunsen burner until the temperature of the iron(III) nitrate has increased by about 5 °C.
- Stand the beaker on the printed sheet as shown in Fig. 2.1.
- Use the 10 cm<sup>3</sup> measuring cylinder to pour 5 cm<sup>3</sup> of aqueous sodium thiosulfate into the beaker and at the same time start a stop-clock.
- Use the thermometer to stir the contents of the beaker.
- Look down from above the beaker and when the text on the printed sheet becomes visible, stop the stop-clock.
- Use the thermometer to measure the temperature of the solution when the text becomes visible.
- Rinse the beaker and thermometer with water.

Experiment 3

- Repeat Experiment 2, this time heating the aqueous iron(III) nitrate until the temperature has increased by about 10 °C.

Experiment 4

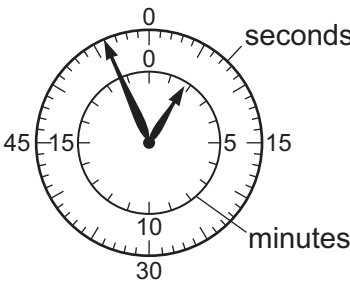
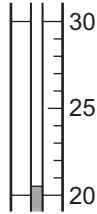
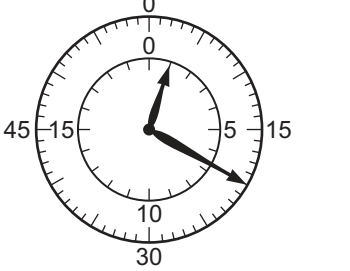
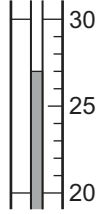
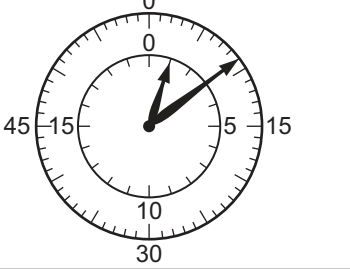
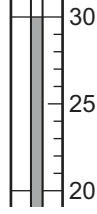
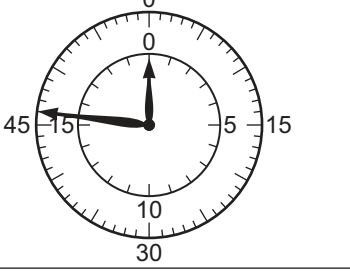
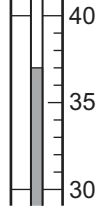
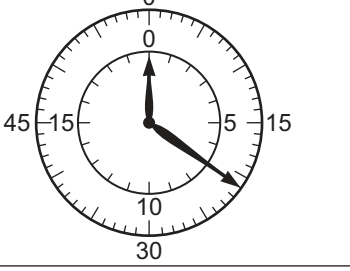
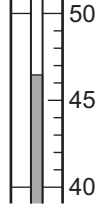
- Repeat Experiment 2, this time heating the aqueous iron(III) nitrate until the temperature has increased by about 15 °C.

## Experiment 5

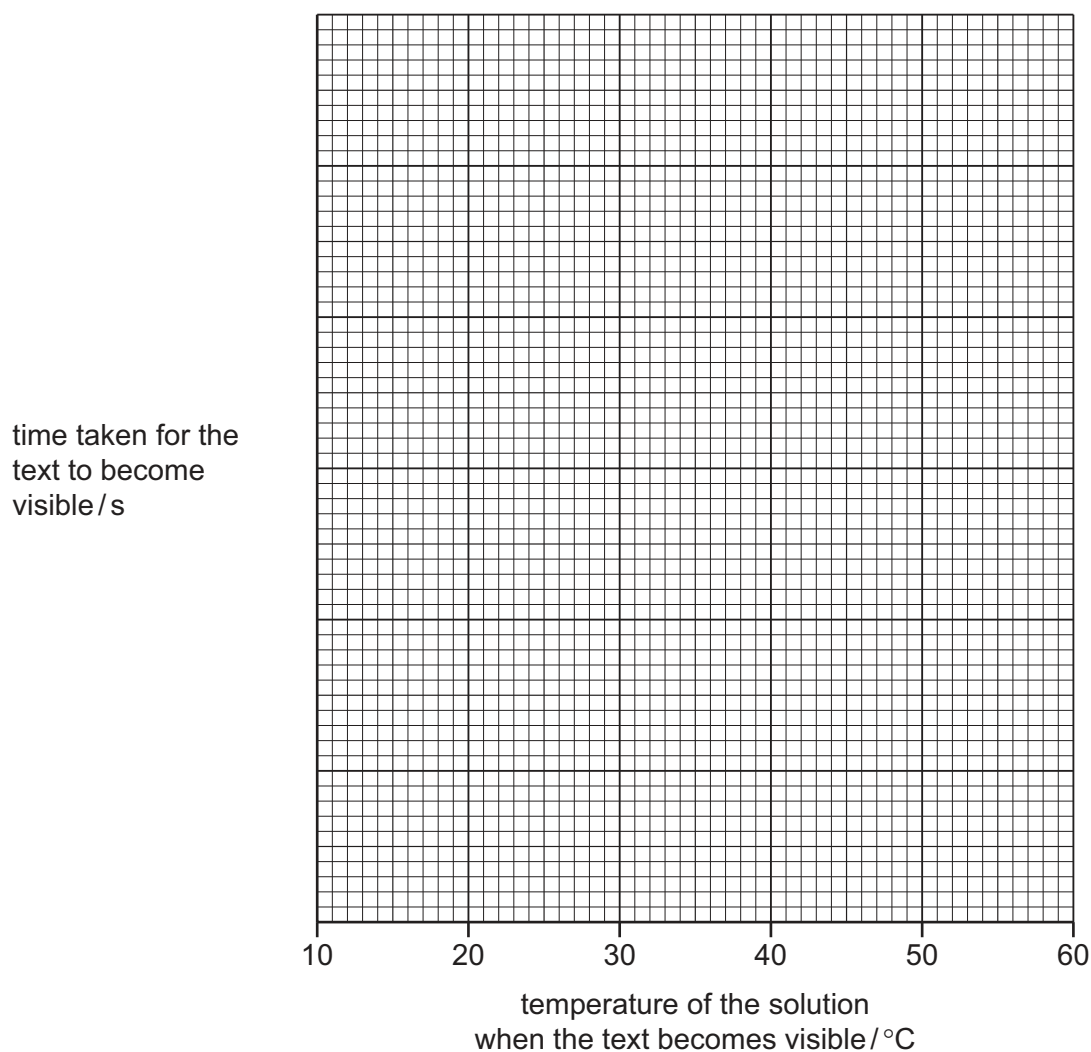
- Repeat Experiment 2, this time heating the aqueous iron(III) nitrate until the temperature has increased by about 25 °C.

Use the thermometer diagrams and stop-clock diagrams to complete Table 2.1.

Table 2.1

| experiment | stop-clock diagram                                                                  | time taken for the text to become visible /s | thermometer diagram                                                                   | temperature of the solution when the text becomes visible / °C |
|------------|-------------------------------------------------------------------------------------|----------------------------------------------|---------------------------------------------------------------------------------------|----------------------------------------------------------------|
| 1          |    |                                              |    |                                                                |
| 2          |   |                                              |   |                                                                |
| 3          |  |                                              |  |                                                                |
| 4          |  |                                              |  |                                                                |
| 5          |  |                                              |  |                                                                |

- (b) Write a suitable scale on the y-axis and plot your results from Experiments 1 to 5 on Fig. 2.2. Draw a smooth curve of best fit.



**Fig. 2.2**

[4]

- (c) Deduce the experiment in which the rate of reaction is fastest.

..... [1]

- (d) Use your graph to predict the temperature of the solution when the text becomes visible after 55 seconds.  
Show your working on Fig. 2.2.

temperature = ..... °C [2]

- (e) Explain why wrapping the beaker in cotton wool after it has been heated will improve the accuracy of the results obtained.

.....  
 ..... [2]

- (f) (i) Explain why it would be an improvement to measure the volume of aqueous iron(III) nitrate in a burette rather than a measuring cylinder.

.....  
 ..... [1]

- (ii) Suggest why it would **not** be an improvement to add the aqueous sodium thiosulfate using a pipette.

.....  
 ..... [1]

- (g) Suggest why the aqueous sodium thiosulfate must be added after the aqueous iron(III) nitrate has been heated and **not** before it is heated.

.....  
 ..... [1]

- (h) Describe how the results of the experiment would change when the experiment is repeated using a 250 cm<sup>3</sup> beaker in place of the 100 cm<sup>3</sup> beaker.  
 Explain your answer.

change in results .....

explanation .....

.....  
 ..... [2]

[Total: 18]

- 3 A student tests two substances: solution **F** and solid **G**.

### Tests on solution **F**

Table 3.1 shows the tests and the student's observations for solution **F**. The student divides solution **F** into three portions.

**Table 3.1**

| tests                                                                                                                                                                                            | observations                                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|
| <b>test 1</b><br><br>Do a flame test on the first portion of solution <b>F</b> .                                                                                                                 | light green colour                                                   |
| <b>test 2</b><br><br>To the second portion of solution <b>F</b> , add a 1 cm depth of aqueous sodium hydroxide and a piece of aluminium foil. Warm the mixture gently and test any gas produced. | effervescence was seen;<br>the gas turned damp red litmus paper blue |
| <b>test 3</b><br><br>To the third portion of solution <b>F</b> , add a 1 cm depth of dilute nitric acid followed by a few drops of aqueous silver nitrate.                                       | no change                                                            |

- (a) Describe how to do the flame test used in **test 1**.

.....  
 .....  
 ..... [2]

- (b) Identify the gas given off in **test 2**.

..... [1]

- (c) Identify solution **F**.

.....  
 ..... [2]

- (d) State what would be observed if the student adds dilute sulfuric acid to another portion of solution **F**.

observations .....  
 ..... [1]

**Tests on solid G**

Solid **G** is iron(II) carbonate.

- (e) About 10 cm<sup>3</sup> of dilute sulfuric acid is added to solid **G**.  
Any gas given off is tested.

observations .....  
.....  
..... [2]

- (f) To the product from (e), aqueous sodium hydroxide is added dropwise until in excess.

observations adding dropwise .....  
observations in excess ..... [2]

[Total: 10]

- 4** A metal polish is a mixture of four substances.  
The properties of these substances are shown in Table 4.1.

### Table 4.1

| name of substance | solubility in water | reaction with dilute nitric acid          |
|-------------------|---------------------|-------------------------------------------|
| propanol          | soluble             | dissolves                                 |
| ethanoic acid     | soluble             | dissolves                                 |
| iron(III) oxide   | insoluble           | reacts when warmed to form a soluble salt |
| silicon(IV) oxide | insoluble           | no reaction                               |

Plan an experiment to find the percentage by mass of silicon(IV) oxide in the mixture. Your plan should include how you will calculate the percentage of silicon(IV) oxide in the mixture.

You are provided with a sample of the metal polish, dilute nitric acid and common laboratory apparatus.

[6]



## Notes for use in qualitative analysis

### Tests for anions

| anion                                        | test                                                              | test result                                                                             |
|----------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| carbonate, $\text{CO}_3^{2-}$                | add dilute acid, then test for carbon dioxide gas                 | effervescence, carbon dioxide produced                                                  |
| chloride, $\text{Cl}^-$<br>[in solution]     | acidify with dilute nitric acid, then add aqueous silver nitrate  | white ppt.                                                                              |
| bromide, $\text{Br}^-$<br>[in solution]      | acidify with dilute nitric acid, then add aqueous silver nitrate  | cream ppt.                                                                              |
| iodide, $\text{I}^-$<br>[in solution]        | acidify with dilute nitric acid, then add aqueous silver nitrate  | yellow ppt.                                                                             |
| nitrate, $\text{NO}_3^-$<br>[in solution]    | add aqueous sodium hydroxide, then aluminium foil; warm carefully | ammonia produced                                                                        |
| sulfate, $\text{SO}_4^{2-}$<br>[in solution] | acidify with dilute nitric acid, then add aqueous barium nitrate  | white ppt.                                                                              |
| sulfite, $\text{SO}_3^{2-}$                  | add a small volume of acidified aqueous potassium manganate(VII)  | the acidified aqueous potassium manganate(VII) changes colour from purple to colourless |

### Tests for aqueous cations

| cation                          | effect of aqueous sodium hydroxide                                         | effect of aqueous ammonia                                                  |
|---------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------------|
| aluminium, $\text{Al}^{3+}$     | white ppt., soluble in excess, giving a colourless solution                | white ppt., insoluble in excess                                            |
| ammonium, $\text{NH}_4^+$       | ammonia produced on warming                                                | —                                                                          |
| calcium, $\text{Ca}^{2+}$       | white ppt., insoluble in excess                                            | no ppt. or very slight white ppt.                                          |
| chromium(III), $\text{Cr}^{3+}$ | green ppt., soluble in excess                                              | green ppt., insoluble in excess                                            |
| copper(II), $\text{Cu}^{2+}$    | light blue ppt., insoluble in excess                                       | light blue ppt., soluble in excess, giving a dark blue solution            |
| iron(II), $\text{Fe}^{2+}$      | green ppt., insoluble in excess, ppt. turns brown near surface on standing | green ppt., insoluble in excess, ppt. turns brown near surface on standing |
| iron(III), $\text{Fe}^{3+}$     | red-brown ppt., insoluble in excess                                        | red-brown ppt., insoluble in excess                                        |
| zinc, $\text{Zn}^{2+}$          | white ppt., soluble in excess, giving a colourless solution                | white ppt., soluble in excess, giving a colourless solution                |

**Tests for gases**

| gas                           | test and test result                                                       |
|-------------------------------|----------------------------------------------------------------------------|
| ammonia, $\text{NH}_3$        | turns damp red litmus paper blue                                           |
| carbon dioxide, $\text{CO}_2$ | turns limewater milky                                                      |
| chlorine, $\text{Cl}_2$       | bleaches damp litmus paper                                                 |
| hydrogen, $\text{H}_2$        | 'pops' with a lighted splint                                               |
| oxygen, $\text{O}_2$          | relights a glowing splint                                                  |
| sulfur dioxide, $\text{SO}_2$ | turns acidified aqueous potassium manganate(VII) from purple to colourless |

**Flame tests for metal ions**

| metal ion                    | flame colour |
|------------------------------|--------------|
| lithium, $\text{Li}^+$       | red          |
| sodium, $\text{Na}^+$        | yellow       |
| potassium, $\text{K}^+$      | lilac        |
| calcium, $\text{Ca}^{2+}$    | orange-red   |
| barium, $\text{Ba}^{2+}$     | light green  |
| copper(II), $\text{Cu}^{2+}$ | blue-green   |

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