



Oxford Cambridge and RSA

**Thursday 23 June 2022 – Morning**

**A Level Chemistry B (Salters)**

**H433/03** Practical skills in chemistry

**Time allowed: 1 hour 30 minutes**



**You must have:**

- the Practical Insert (inside this document)
- the Data Sheet for Chemistry B

**You can use:**

- a scientific or graphical calculator
- an HB pencil



Please write clearly in black ink. **Do not write in the barcodes.**

Centre number

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Candidate number

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First name(s) \_\_\_\_\_

Last name \_\_\_\_\_

**INSTRUCTIONS**

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

**INFORMATION**

- The total mark for this paper is **60**.
- The marks for each question are shown in brackets [ ].
- Quality of extended response will be assessed in questions marked with an asterisk (\*).
- This document has **16** pages.

**ADVICE**

- Read each question carefully before you start your answer.

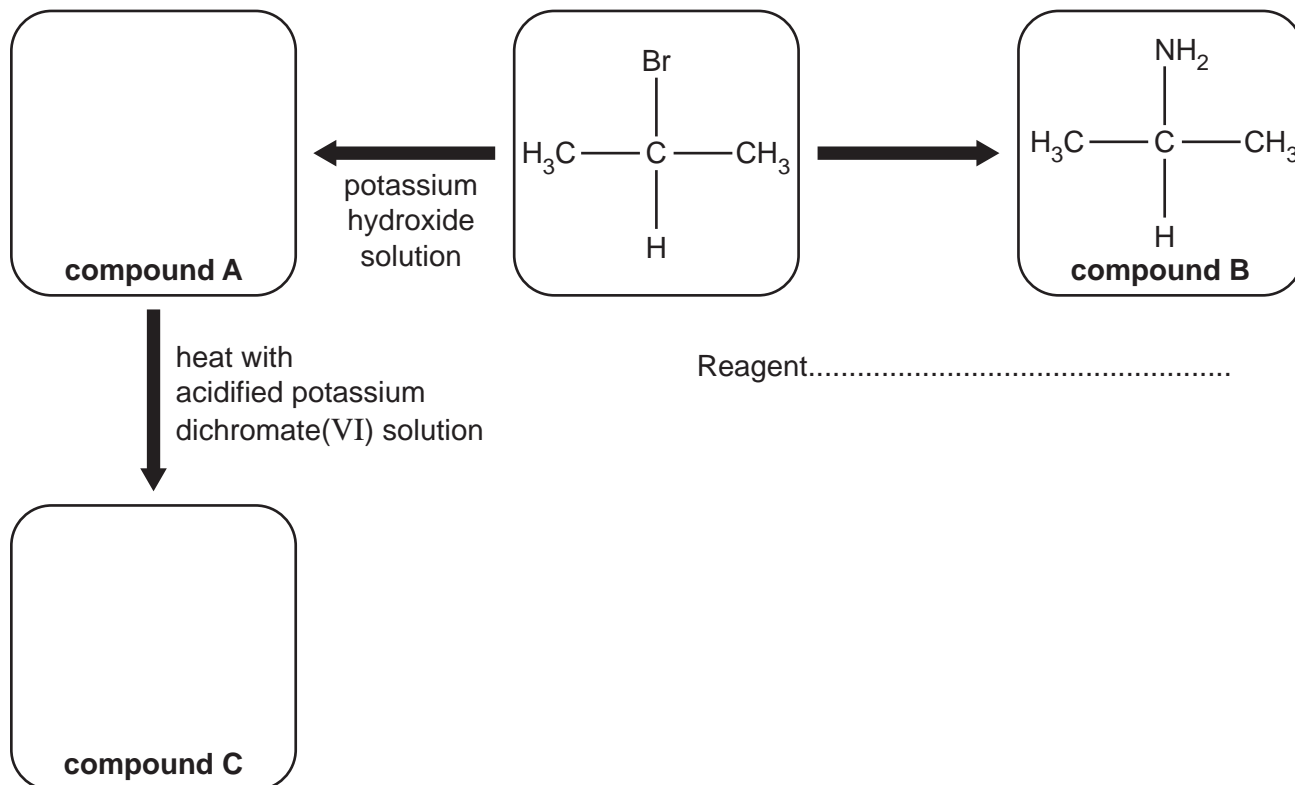
2

Answer **all** the questions.

1 This question is about haloalkanes and their reactivity.

(a) Haloalkanes are useful intermediates for preparing a range of organic compounds.

A flowchart showing the synthesis of three organic compounds is shown below.

(i) Complete the flowchart showing the structures of compounds **A** and **C**.On the dotted line show the reagent needed to form compound **B**.

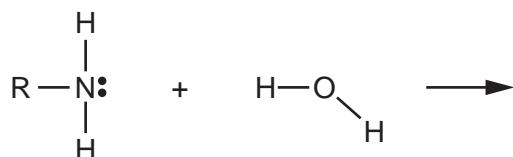
[3]

(ii) Which homologous series does compound **B** belong to?

..... [1]

(b) Compound **B** behaves as a base.Complete the diagram of a mechanism that shows how a molecule of compound **B** reacts with water to give a basic solution.

Show 'curly arrows'.



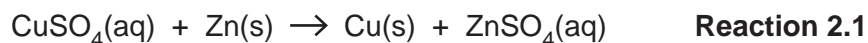
[2]



## 4

2 This question is about the enthalpy change of the reaction of zinc with copper(II) sulfate solution.

(a) A student investigates the temperature change when **Reaction 2.1** occurs.

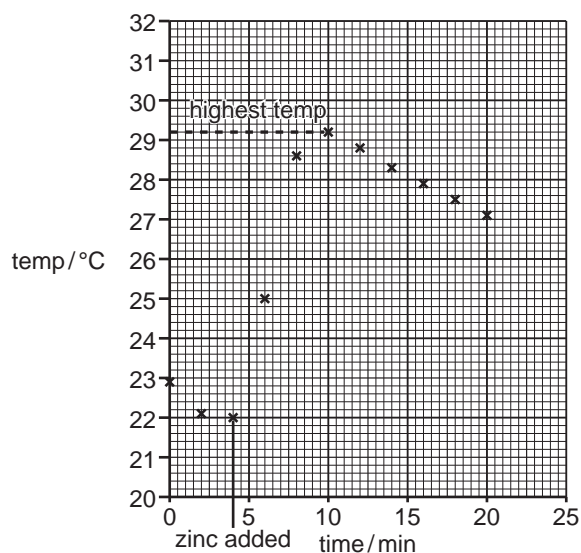


(i) The student adds 1.20 g of powdered zinc to 50.0 cm<sup>3</sup> of 0.200 mol dm<sup>-3</sup> copper(II) sulfate solution in a glass beaker.

Use calculations to show which is the limiting reagent.

limiting reagent is ..... [2]

(ii) The student measures the temperature of the contents of the beaker over a period of 20 minutes and plots the data on the graph below.



The student uses the graph to determine the highest temperature as shown.

The student uses this temperature to calculate the heat energy given to the solution per mole of limiting reagent.

Show the student's calculation, giving the answer in kJ mol<sup>-1</sup>.

Give your answer to an **appropriate** number of significant figures.

heat energy given to the solution = ..... kJ mol<sup>-1</sup> [3]



6

Additional answer space if required for part 2(c).

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**Turn over for the next question**

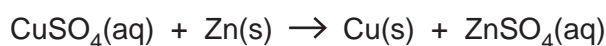
3 This question is about redox and electrochemical cells.

**Table 3.1** shows standard electrode potentials, some of which will be needed for the rest of this question.

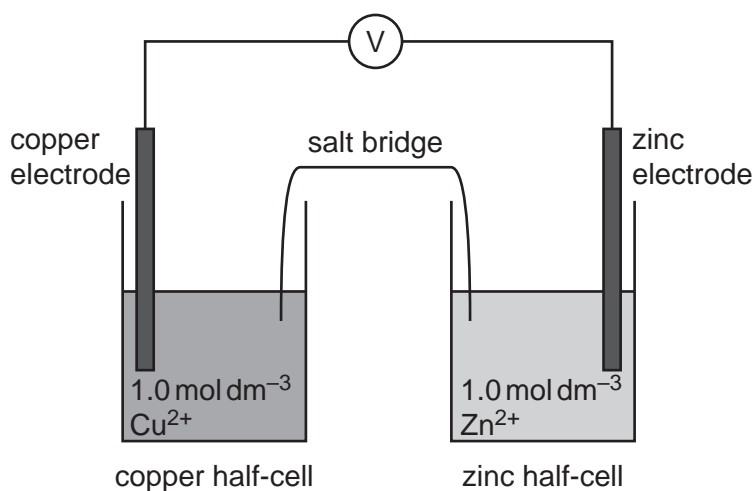
Half reaction	Standard electrode potential, $E^\ominus / \text{V}$
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Zn}(\text{s})$	-0.76
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Fe}(\text{s})$	-0.44
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g})$	0.00
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Cu}(\text{s})$	+0.34
$\frac{1}{2}\text{O}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightleftharpoons 2\text{OH}^-(\text{aq})$	+0.40
$\frac{1}{2}\text{I}_2(\text{aq}) + \text{e}^- \rightleftharpoons \text{I}^-(\text{aq})$	+0.54
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightleftharpoons \text{Fe}^{2+}(\text{aq})$	+0.77
$\text{Ag}^+(\text{aq}) + \text{e}^- \rightleftharpoons \text{Ag}(\text{s})$	+0.80
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-(\text{aq})$	+1.36
$\text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \rightleftharpoons \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	+1.51

**Table 3.1**

(a) The reaction between zinc metal and aqueous  $\text{Cu}^{2+}$  ions can be arranged in a cell to produce electrical energy.



A diagram of a copper/zinc cell is shown in **Fig. 3.1**.



**Fig. 3.1**

When the cell delivers a current, oxidation takes place in one half-cell and reduction in the other.



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- (i) Write half-equations for the reactions that take place in each half-cell.

Show state symbols.

oxidation reaction:

reduction reaction:

[2]

- (ii) Explain the purpose of the salt bridge.

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

- (iii) Calculate  $E^{\ominus}_{\text{cell}}$  for the copper/zinc cell in **Fig. 3.1**.

$$E^{\ominus}_{\text{cell}} = \dots\dots\dots \text{ V [1]}$$

- (b) Standard electrode potentials can be used to decide whether a reaction is feasible.

Predict, with reasons, if any reaction could take place in each of the following situations.

Use the data in **Table 3.1**.

- (i) Metallic silver is added to aqueous iron(II) sulfate.

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

- (ii) Aqueous potassium chloride is added to acidified potassium manganate(VII) solution.

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

## 10

- (c) The relationship between the ion concentration and the electrode potential for a metal/ion electrode is given (at 298 K) by **Equation 3.1**, where  $n$  is the number of electrons transferred in the half reaction.

$$E = E^\ominus + \frac{0.059 \times \log_{10}[\text{ion}]}{n} \quad \text{Equation 3.1}$$

- (i) Explain how **Equation 3.1** shows that  $E = E^\ominus$  under standard conditions.

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

- (ii) Calculate the electrode potential of a  $\text{Zn}^{2+}(\text{aq})/\text{Zn}(\text{s})$  half-cell when  $[\text{Zn}^{2+}(\text{aq})] = 0.20 \text{ mol dm}^{-3}$ .

$E = \dots\dots\dots \text{ V [2]}$

Half reaction	Standard electrode potential, $E^\ominus / \text{V}$
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Zn}(\text{s})$	-0.76
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Fe}(\text{s})$	-0.44
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g})$	0.00
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Cu}(\text{s})$	+0.34
$\frac{1}{2}\text{O}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + 2\text{e}^- \rightleftharpoons 2\text{OH}^-(\text{aq})$	+0.40
$\frac{1}{2}\text{I}_2(\text{aq}) + \text{e}^- \rightleftharpoons \text{I}^-(\text{aq})$	+0.54
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$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightleftharpoons 2\text{Cl}^-(\text{aq})$	+1.36
$\text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \rightleftharpoons \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	+1.51

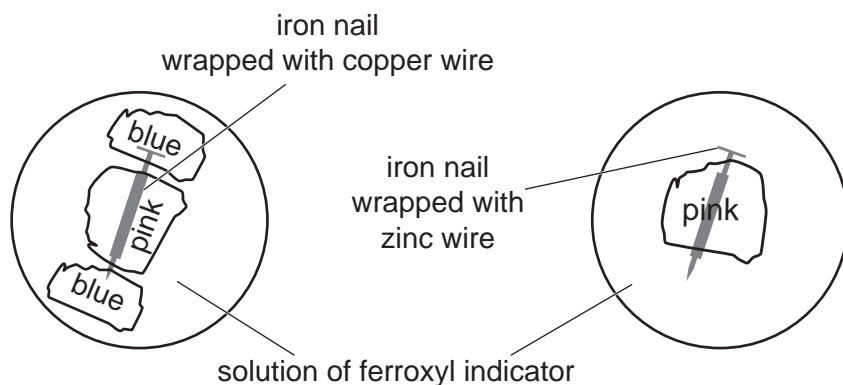
**Table 3.1**

(d) The rusting of iron is an electrochemical process.

A solution of 'ferroxyl' indicator can be used to investigate the reactions taking place in rusting. This indicator turns blue in the presence of  $\text{Fe}^{2+}$  ions and pink in alkaline solution.

In an experiment to investigate rusting, two iron nails are placed in a solution of 'ferroxyl' indicator (containing sodium chloride), in two separate petri dishes. One of the nails has copper wire wrapped around it, the other zinc wire.

The results are shown in **Fig. 3.2** below.



**Fig. 3.2**

A student suggests that the results in **Fig. 3.2** show that the attached zinc wire prevents the iron nail from rusting, but the attached copper wire does not.

Comment on the student's suggestion and use appropriate half-equations from **Table 3.1** to explain the colours in **Fig. 3.2**.

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[4]

4 This question refers to the Practical Insert that is provided as an insert to this paper.

- (a) Suggest how the students accurately made up a solution of  $0.300 \text{ mol dm}^{-3}$  copper(II) nitrate from their standard  $0.400 \text{ mol dm}^{-3}$  solution.

Name the apparatus involved.

.....

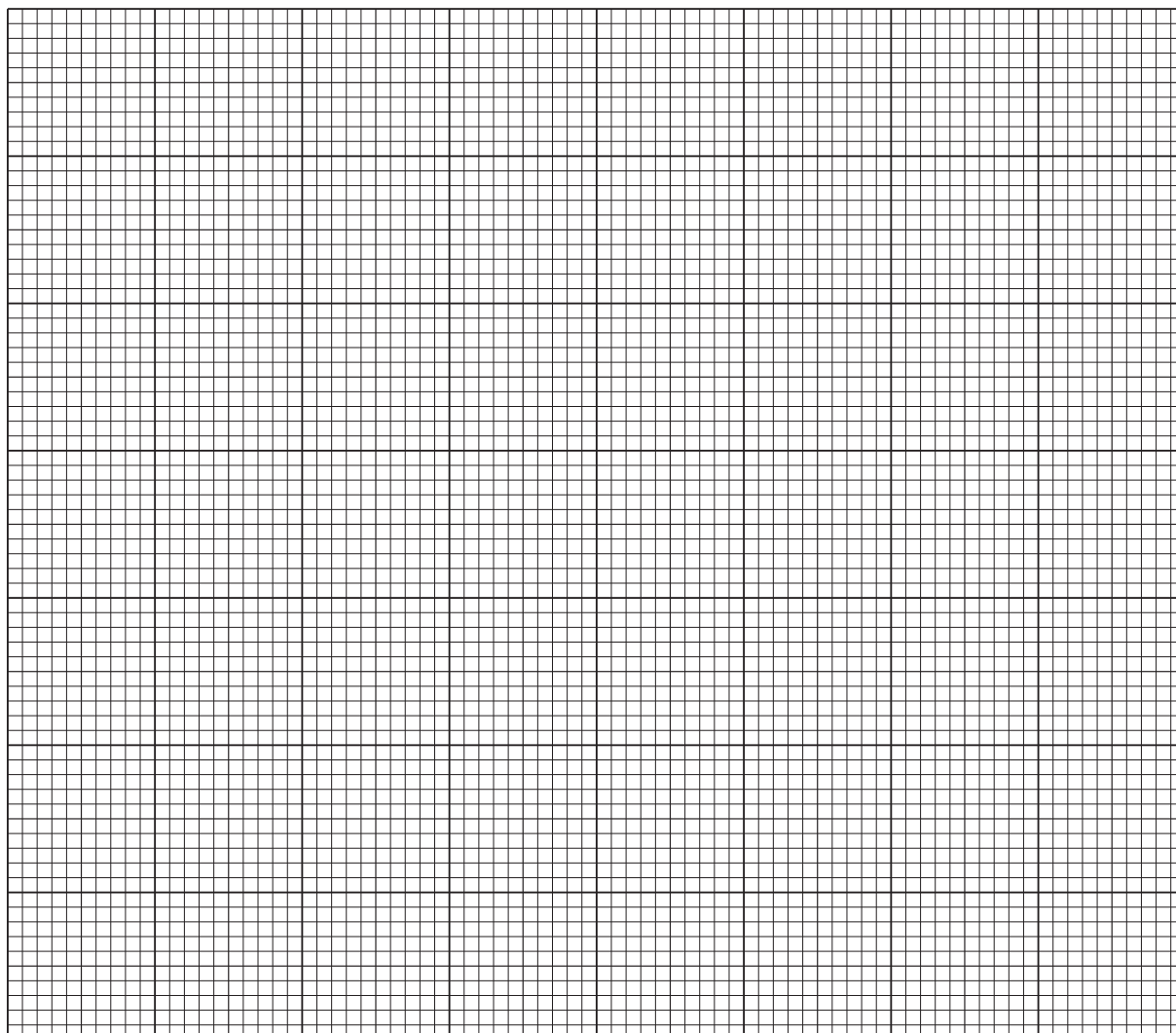
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..... [3]

- (b) (i) Plot a graph of absorbance against concentration on the graph paper below and draw an appropriate line of best fit. Label the axes. [3]



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- (ii) Use your graph on page 12 and data from the insert to calculate the percentage by mass of copper in the brass sample.

percentage by mass of copper in the brass sample = ..... % [3]

- (iii) Explain why an orange filter is placed into the colorimeter before taking the readings.

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..... [2]

Question 4 continues on page 14

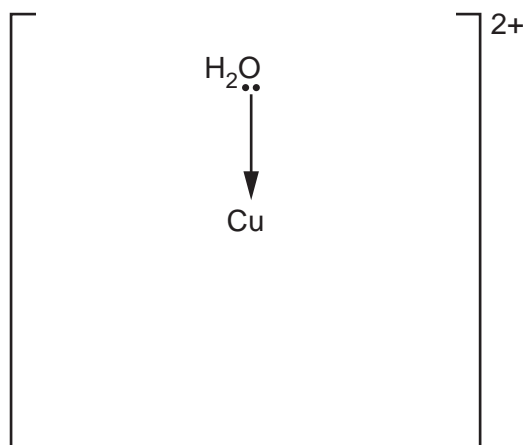
14

(c) A copper(II) ion is said to form an octahedral complex with water ligands.

(i) Explain the term **ligand**.

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

(ii) Complete the diagram below to show the **shape** of the octahedral copper(II) complex ion with water ligands.



[3]

(d) d-block elements form a variety of differently coloured complex ions.

Explain, in terms of electronic structure, why these complex ions are coloured and why different complexes of the same cation have different colours.

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 .....  
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 ..... [4]

**END OF QUESTION PAPER**

**ADDITIONAL ANSWER SPACE**

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

This section of the page is a large, empty area of lined paper. It consists of approximately 25 horizontal dotted lines spaced evenly down the page. A solid vertical line runs down the left side of this area, creating a margin. The rest of the area is open for writing.

A large rectangular area with a solid vertical line on the left side and horizontal dotted lines extending across the page, providing a grid for writing answers.

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