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						Candidate number				

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.

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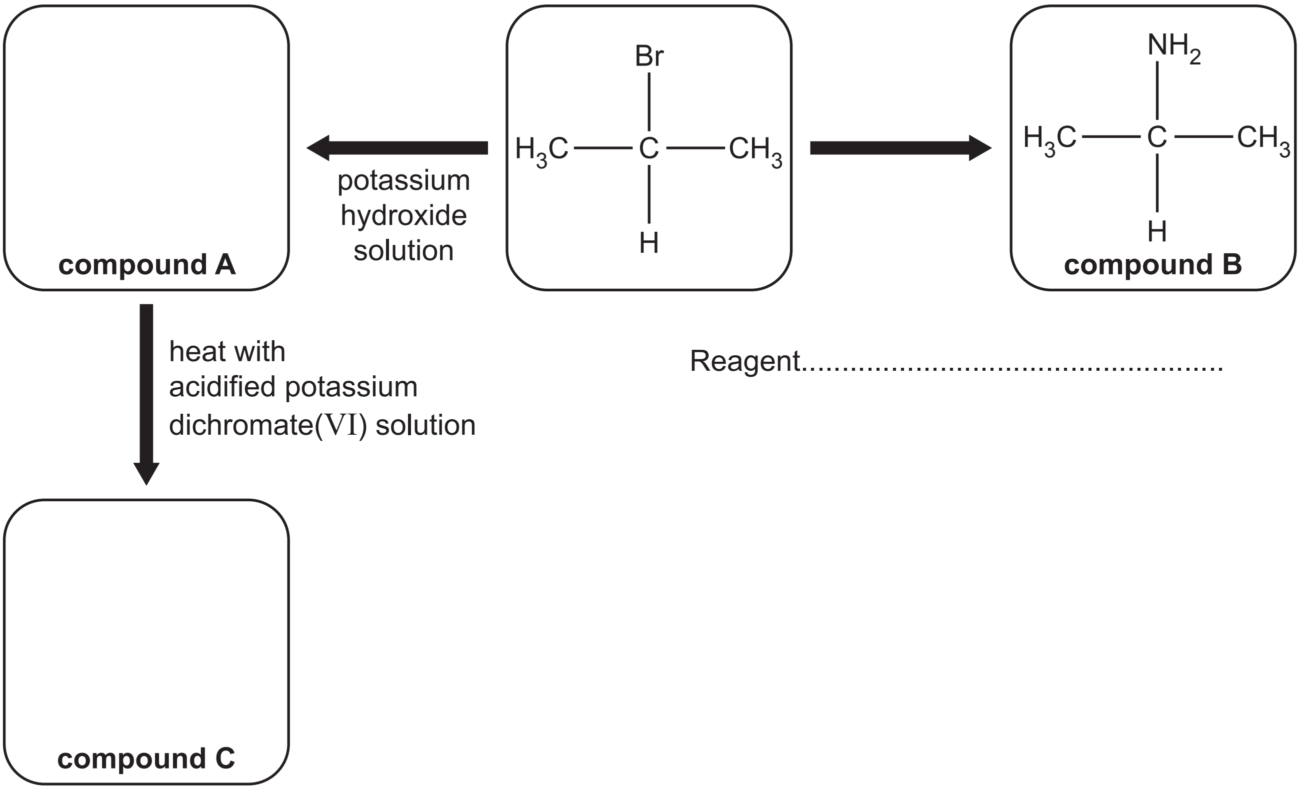
Answer **all** the questions.

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]**

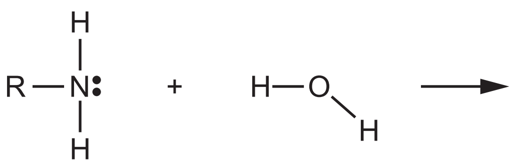
(ii) Which homologous series does compound **B** belong to?

.... **[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]

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(c) Some haloalkanes act as greenhouse gases that absorb infrared radiation in the troposphere.

Give the source of this infrared radiation.

.... **[1]**

(d)* A student wishes to compare the relative reactivities of haloalkanes.

The student investigates the rates of hydrolysis of 1-chlorobutane, 1-bromobutane and 1-iodobutane by following the reaction in the presence of aqueous silver ions.

Design a suitable procedure that the student should follow.

Give the expected results and how they can be interpreted.

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Additional answer space if required.

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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.

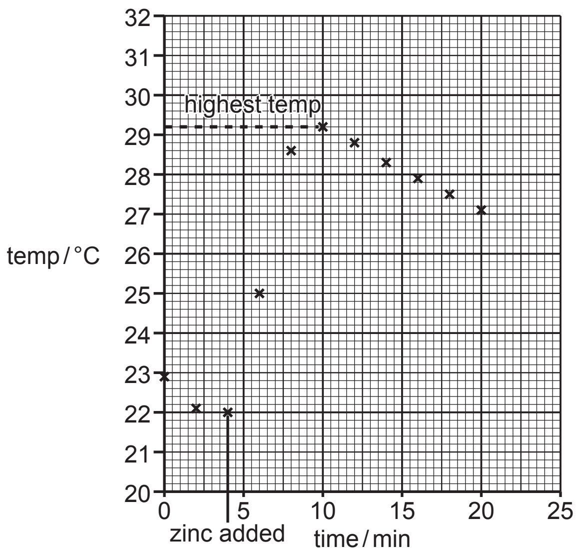
$CuSO_4(aq) + Zn(s) \rightarrow Cu(s) + ZnSO_4(aq)$ **Reaction 2.1**

(i) The student adds 1.20 g of powdered zinc to 50.0 cm^3 of 0.200 mol dm^{-3} 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^{-1}.

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

heat energy given to the solution = ... kJ mol^{-1} **[3]**

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(b) Calculate $\Delta_r H^{\ominus}$ for **Reaction 2.1** using the data shown below.

	$\Delta_f H^{\ominus}$ / kJ mol^{-1}
Cu^{2+}(aq)	+ 64.4
Zn^{2+}(aq)	–152.4

$\Delta_r H^{\ominus}$ = ... kJ mol^{-1} **[1]**

(c)* The value obtained from the student's experiment is considerably less exothermic than the value in part **(b)**.

Evaluate the student's experiment, identifying limitations in both the experimental procedure and the measurements taken. You should also comment on how any of the limitations you have identified will affect the final value.

Suggest possible improvements to the procedure, apparatus and measurements. **[6]**

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You may continue your answer over the page if you need to.

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

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Turn over for the next question

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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, $E^\ominus$ /V**
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	–0.76
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	–0.44
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$\frac{1}{2}O_2(aq) + H_2O(l) + 2e^- \rightleftharpoons 2OH^-(aq)$	+0.40
$\frac{1}{2}I_2(aq) + e^- \rightleftharpoons I^-(aq)$	+0.54
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	+1.51

Table 3.1

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

$CuSO_4(aq) + Zn(s) \rightarrow Cu(s) + ZnSO_4(aq)$

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

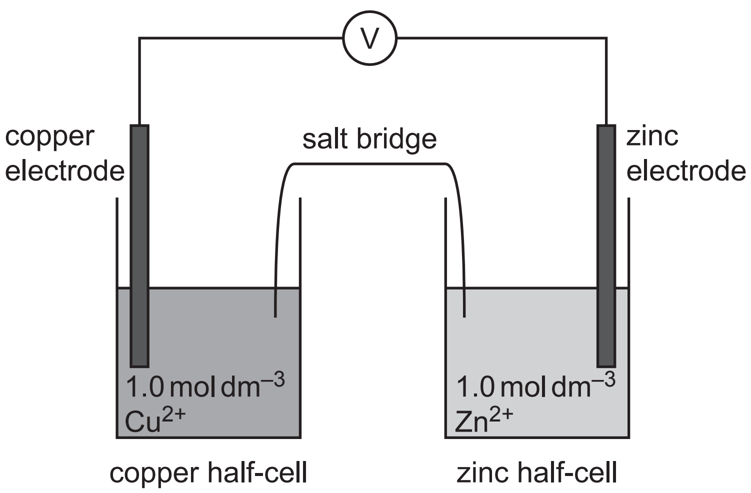

Fig. 3.1

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 $E^{\ominus}_{cell}$ for the copper/zinc cell in **Fig. 3.1**.

$E^{\ominus}_{cell}$ = ... 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.

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.... **[1]**

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

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.... **[2]**

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(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.

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

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

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.... **[2]**

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

E = ... V **[2]**

Half reaction	Standard electrode potential, $E^{\ominus}$ /V
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	–0.76
$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	–0.44
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0.34
$\frac{1}{2}O_2(aq) + H_2O(l) + 2e^- \rightleftharpoons 2OH^-(aq)$	+0.40
$\frac{1}{2}I_2(aq) + e^- \rightleftharpoons I^-(aq)$	+0.54
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	+1.51

Table 3.1

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(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 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.

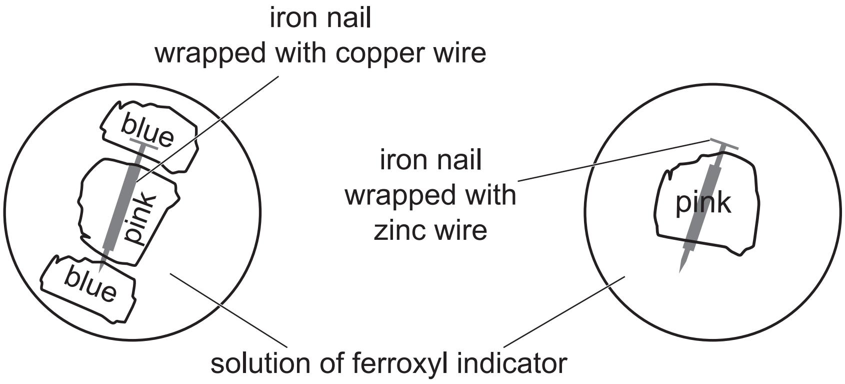

Fig. 3.2

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]**

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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 mol dm^{-3} copper(II) nitrate from their standard 0.400 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

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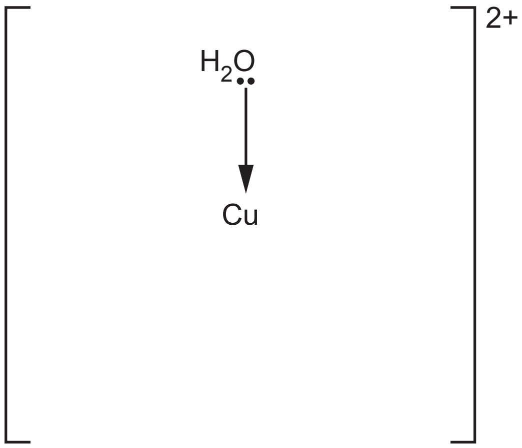
(c) A copper(II) ion is said to form an octahedral complex with water ligands.

(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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.... **[4]**

END OF QUESTION PAPER

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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).

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Thursday 23 June 2022 – Morning

A Level Chemistry B (Salters)

H433/03 Practical skills in chemistry

Practical Insert

Time allowed: 1 hour 30 minutes

INSTRUCTIONS

- Do **not** send this Insert for marking. Keep it in the centre or recycle it.

INFORMATION

- This document has **4** pages.

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Determination of the percentage of copper present in brass.

Brass is an alloy of copper and zinc. The proportions of each metal depend on what the brass is being used for.

A group of students use colorimetry to determine the percentage of copper present in a sample of a brass.

The students' description of their method along with their results is shown below.

Constructing a calibration graph

1. A variety of standard copper(II) nitrate solutions (see results table) were made from an initial standard solution of concentration 0.400 $mol\,dm^{-3}$.

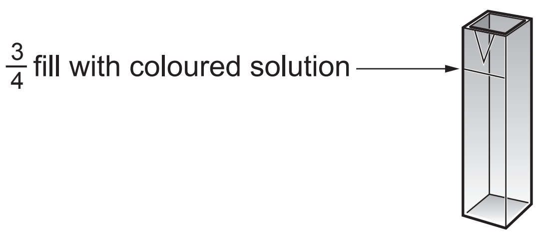
2. An orange filter was placed in the colorimeter.

3. A cuvette was rinsed and $\frac{3}{4}$ filled with deionised water. The outside of the cuvette (see diagram below) was wiped dry with a paper tissue and placed in the colorimeter. The absorbance reading was adjusted until it read zero.

4. The deionised water was discarded and the cuvette $\frac{3}{4}$ filled with the first solution of known concentration (0.025 $mol\,dm^{-3}$). The absorbance was measured and recorded in the results table.

5. The cuvette was again rinsed with deionised water and step 4 repeated for all the standard solutions. Their absorbance values were recorded in the results table.

   A graph of absorbance against concentration can now be constructed.



The cuvette that holds the solution in the colorimeter

Preparation and measurement of the absorbance of a solution of the brass sample

1. Approximately 4 g of the brass sample were weighed accurately.

2. This mass of brass was dissolved in a minimum amount of concentrated nitric acid in a conical flask in a fume cupboard and the solution allowed to cool. The resultant solution was then carefully transferred to a 250 cm^3 volumetric flask and made up to the mark with deionised water.

3. Using a teat pipette, the cuvette used for constructing the calibration graph was rinsed with the brass solution, $\frac{3}{4}$ filled, and its absorbance measured.
   This was compared with the standard solutions to determine the copper concentration.

Results

Concentration of copper(II) nitrate solution / mol dm^{-3}	Absorbance
0.025	0.05
0.050	0.12
0.100	0.25
0.200	0.40
0.300	0.72
0.400	1.03

Mass of brass sample dissolved = 4.04 g

Absorbance of brass solution = 0.44

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