Oxford Cambridge and RSA

Friday 23 June 2023 – 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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1 Ozone, O_3, is a serious pollutant when present in the troposphere.

(a) Give **one** polluting effect of ozone in the troposphere.

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

(b) Tropospheric ozone is produced by the reactions of nitrogen oxides, NO_x, and hydrocarbons. These, together with carbon monoxide, CO, are pollutants produced by motor vehicles.

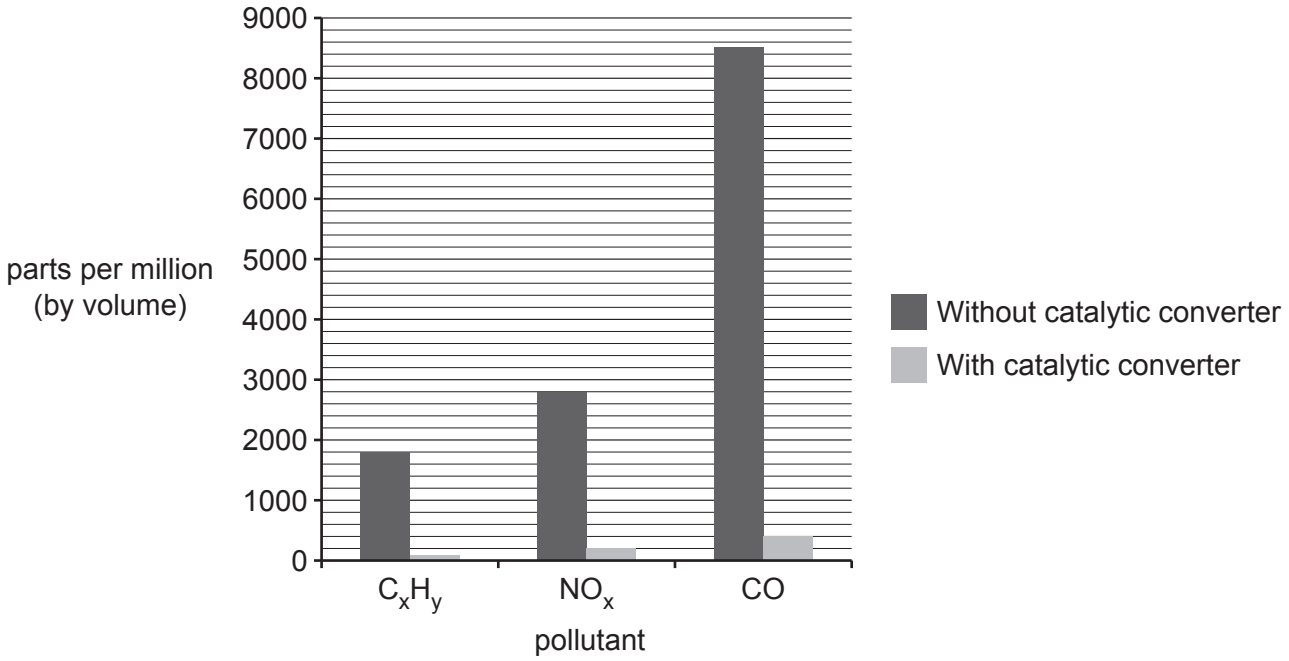
Catalytic converters in vehicle exhausts catalyse the reaction in **Equation 1.1** and also the oxidation of hydrocarbons to carbon dioxide and water.

$2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$ **Equation 1.1**

(i) The bar chart below shows the reduction in the various pollutant levels when a suitable catalytic converter is fitted.

Calculate the percentage reduction in **NO_x** levels when a catalytic converter is fitted.

Give your answer to **2** significant figures.



percentage reduction ..... % **[2]**

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(ii) A student says that the reactions in a catalytic converter decrease car pollution to zero.

Comment on this statement.

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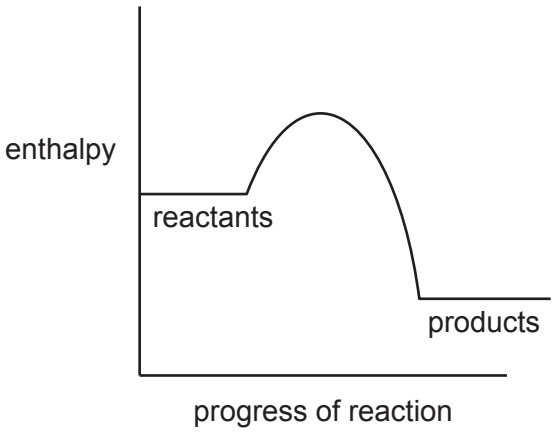
..... **[3]**

(iii) The diagram below represents an energy profile for the catalysed reaction in **Equation 1.1**.



On the diagram:

- Indicate the activation enthalpy of the catalysed reaction.
- Draw a progress curve for the uncatalysed reaction.

[1]

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(c) In the stratosphere, nitrogen monoxide removes ozone molecules by the sequence of reactions below.

$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$ **Reaction 1**

$NO_2(g) + O(g) \rightarrow NO(g) + O_2(g)$ **Reaction 2**

A student suggests that the NO molecule is behaving as a heterogeneous catalyst.

Use your chemical knowledge to comment on the student's suggestion.

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

(d) Chlorine atoms also act as catalysts to remove ozone.

The atoms can be formed by the reaction shown below.

$Cl_2 \rightarrow 2Cl$

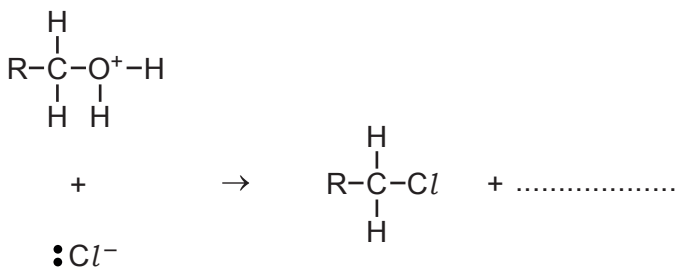
What conditions are needed for this reaction to occur and what **type** of bond fission occurs?

Conditions .....

Type of bond fission ..... **[2]**

(e) By contrast, chloride **ions** react in a different way, for example in the reaction below.

Mark 'curly arrows' on the diagram and give the other product.



[2]

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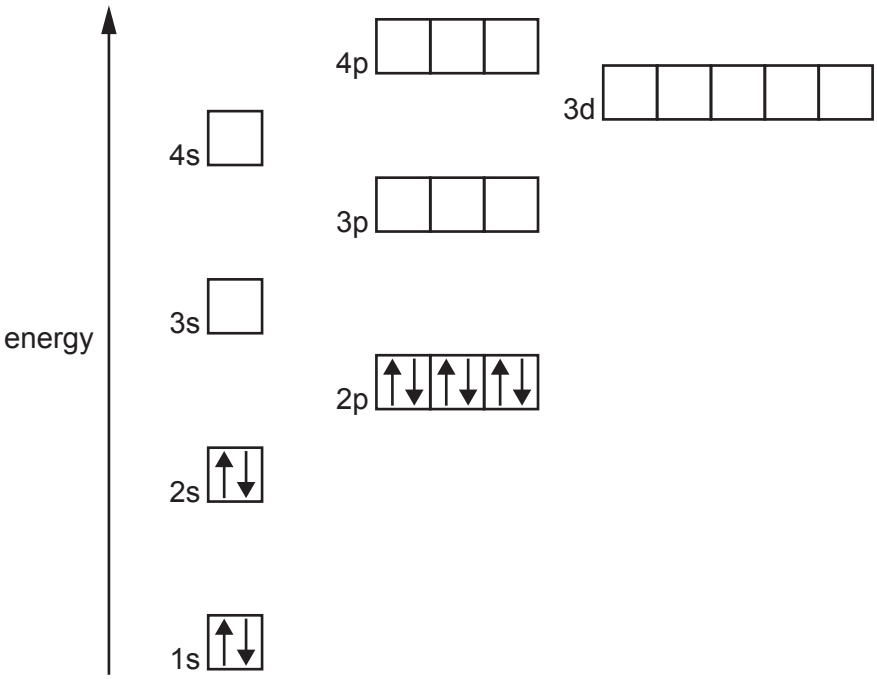
2 Copper is a d-block metal and forms many complexes.

(a) **(i)** Complete the diagram below to show the electronic configuration of a **Cu^{2+} ion**.



[2]

(ii) Explain why copper is classed as a transition metal.

.....

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

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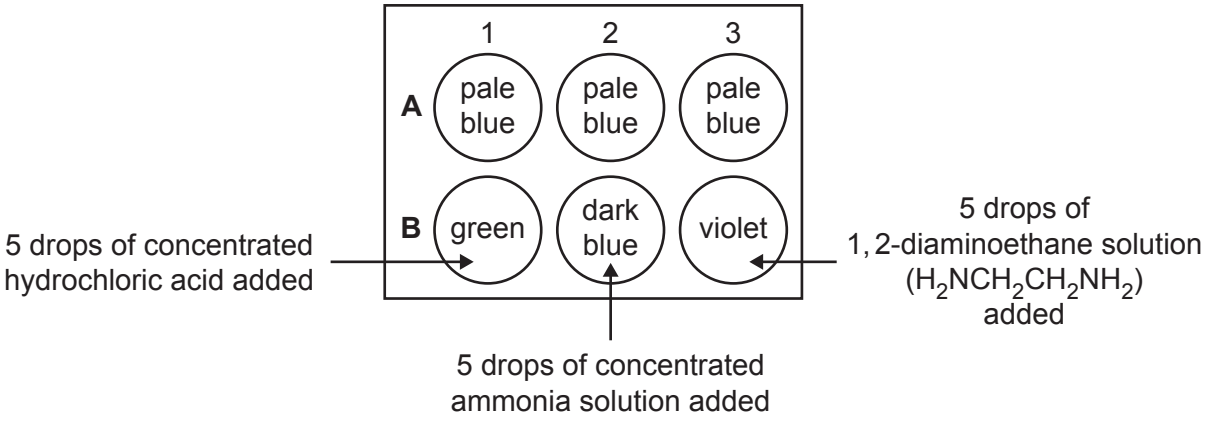
(b)* The Cu^{2+} ion forms several complex ions with different ligands.

A group of students performs a simple microscale experiment to investigate some copper(II) complexes.

They use a plate with small wells into which drops of solutions can be placed.

Their method and the results are shown below.

- **All** wells have 5 drops of copper(II) sulfate solution added to them.
- Wells **B**1, 2 and 3 have drops of other solutions added as identified in the diagram.



Use the student results to explain the meaning of the term **ligand** and suggest formulae and shapes for the complexes formed.

Use diagrams in your answer. **[6]**

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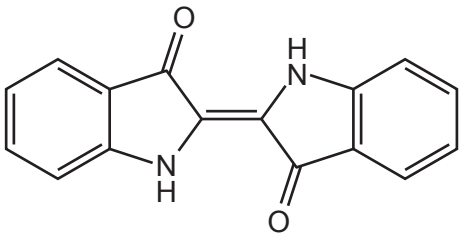
3 Indigo is a natural blue dye that can be extracted from various plants.



Indigo

(a) **(i)** The IR spectrum of indigo has a significant absorption around 3300 cm^{-1}.

Suggest the most likely bond in indigo responsible for this absorption.

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

(ii) Indigo is used to dye cotton. The cotton structure has many –OH groups.

Suggest the strongest type of intermolecular bond that binds indigo to cotton.

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

(b) A frequency of yellow light has a wavelength of 5.90×10^{-7} m.

(i) Calculate the energy (in kJ) associated with one mole of photons of this wavelength.

energy = ... kJ **[3]**

(ii) Explain why indigo has a blue colour.

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..... **[3]**

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(c)* Benzene rings in dyes are usually represented as shown in **Fig. 3.1**. However, benzene rings in other organic molecules are often represented as shown in **Fig. 3.2**.

Fig. 3.1

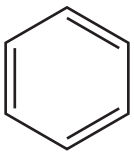

Fig. 3.2

Explain why **Fig. 3.2** is a better match for the actual **structure** and **reactions** of benzene molecules.

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..... **[6]**

Additional answer space if required.

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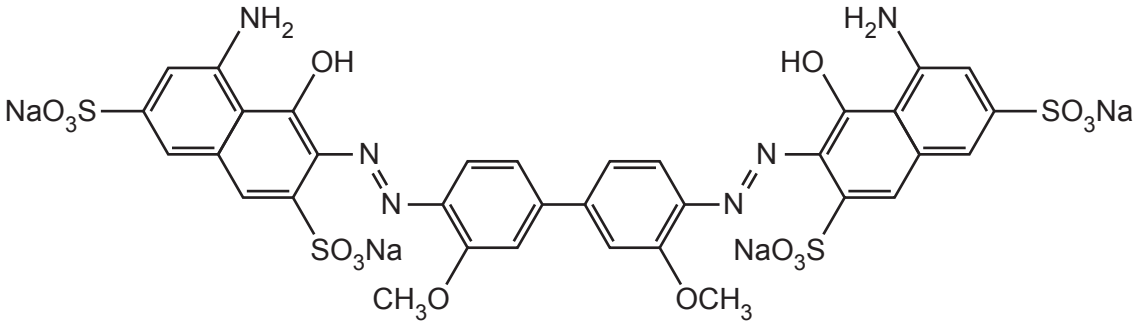
(d) **(i)** The dye **direct blue 15** does not fade, whereas indigo does.



Direct blue 15

This dye is made by sulfonation.

Give the reagents and conditions used in the sulfonation of **benzene**, the name of the mechanism of the reaction and a property of **direct blue 15** that is caused by the sulfonation.

Reagents and conditions .....

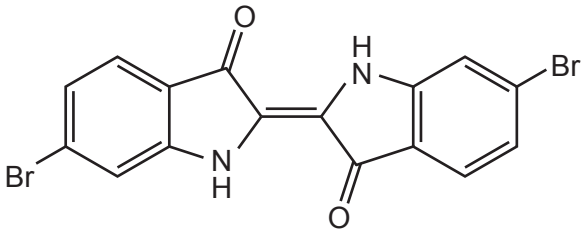
.....

Name of mechanism .....

Property of **direct blue 15** .....

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

(ii) Dibromoindigo can be prepared synthetically by reacting indigo with bromine, using an iron catalyst.



Dibromoindigo

The reaction has the same type of mechanism as sulfonation.

Explain the role of the iron in forming Br^+.

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

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

(a) **(i)** Explain why the results of **Experiment 1** show that the rate of reaction does **not** vary with the iodine concentration.

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

(ii) During **Experiment 1**, the students ensured the concentration of propanone remained virtually constant.

How did they do this?

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

(b) Suggest why the total volume is kept constant in **Experiment 2**.

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

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(c) **(i)** An extended version of **Table 4.1** from the Insert is given below.

Use the data in this table to calculate the rates of reaction (in cm^3 of iodine solution decolorised per second) in **Run B** and **Run C**.

Give your answers to **2** significant figures and write your values in the appropriate blank boxes in the table.

Table 4.1

	Run A	**Run B**	**Run C**
Volume of 2.0 mol dm^{-3} HCl / cm^3	20.0	10.0	20.0
Volume of 2.0 mol dm^{-3} propanone / cm^3	8.0	8.0	4.0
Volume of water / cm^3	0	10.0	4.0
Volume of 0.010 mol dm^{-3} iodine / cm^3	4.0	4.0	4.0
Total volume in flask / cm^3	32.0	32.0	32.0
Time for colour to disappear	115	234	240
Rate of reaction of iodine / $cm^3\,s^{-1}$	0.035		
Rate of reaction of iodine / mol $dm^{-3}\,s^{-1}$	1.1×10^{-5}		

[1]

(ii) The students do a text book search and find that the rate equation for the reaction is:

Rate = k [propanone][H^+]

Explain whether the results of **Experiment 1** and **Experiment 2** support this rate equation.

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..... **[3]**

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(d) **(i)** Show why the rate of reaction of iodine in **Run A** is 1.1×10^{-5} mol dm^{-3} s^{-1}.

[1]

(ii) Using the data in **Table 4.1** for **Experiment 2 Run A**, calculate the initial concentrations of hydrochloric acid and propanone in the flask.

Use these values, along with the rate from **(d)(i)**, to calculate the value of the rate constant, *k*, with its units.

[HC*l*] = ... mol dm^{-3}

[propanone] = ... mol dm^{-3}

k = ... units ..... **[4]**

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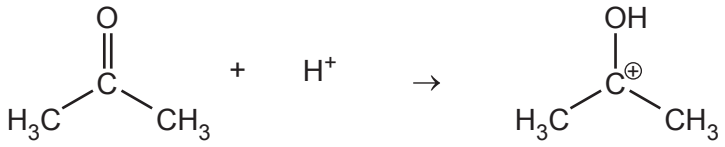
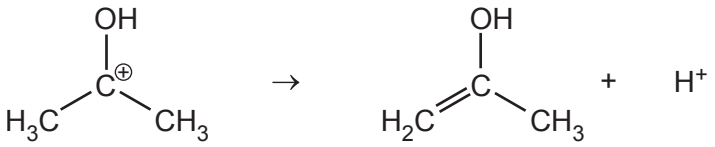
(e) A student proposes the reaction mechanism below for the iodination of propanone.

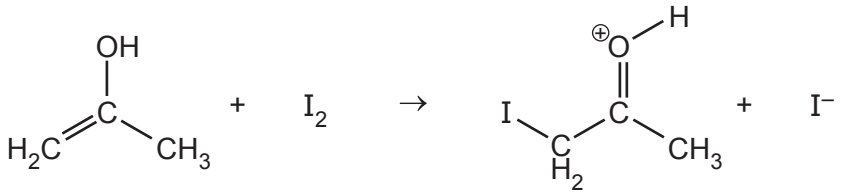
Step 1



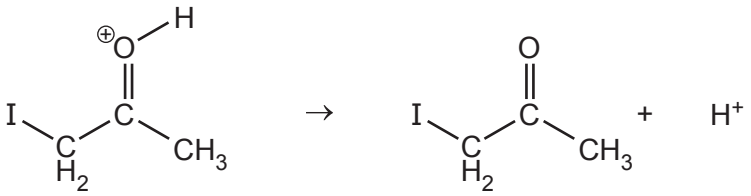
Step 2



Step 3



Step 4



Assuming the rate equation below to be correct, identify and explain the **rate determining step** in the student's mechanism.

Explain why the reactant iodine does not feature in the rate equation.

Rate = k [propanone][H^+]

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

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(f) The students wear safety goggles and protective gloves when carrying out the experiments.

Using the information from the insert, suggest **one other** necessary health and safety measure.

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

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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