OCR
Oxford Cambridge and RSA

A Level Chemistry A
H432/03 Unified Chemistry

Practice paper – Set 2
Time allowed: 1 hour 30 minutes

You must have:
• the Data Sheet for Chemistry A

You may use:
• a scientific or graphical calculator
• a ruler (cm/mm)

First name	
Last name	

Centre number					Candidate number				

INSTRUCTIONS
• Use black ink. You may use an HB pencil for graphs and diagrams.
• Complete the boxes above with your name, centre number and candidate number.
• Answer **all** the questions.
• Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
• Do **not** write in the barcodes.

INFORMATION
• The total mark for this paper is **70**.
• The marks for each question are shown in brackets **[ ]**.
• Quality of extended responses will be assessed in questions marked with an asterisk (*).
• This document consists of **20** pages.

Answer **all** the questions.

1 Acid rain is caused by the reaction of acid gases with water and oxygen in the air.

Coal often contains traces of iron(II) disulfide, FeS_2.

(a) FeS_2 is an ionic compound of Fe^{2+} ions and S_2^{2-} ions.

(i) Write the electron configuration, in terms of sub-shells, of an Fe^{2+} ion.

.... **[1]**

(ii) Draw a '*dot-and-cross*' diagram for FeS_2.

Show outer electrons only.

[2]

(b) Combustion of coal, containing traces of FeS_2, produces the acid gas, sulfur dioxide, SO_2.

$$4FeS_2(s) + 11O_2(g) \rightarrow 2Fe_2O_3(s) + 8SO_2(g)$$
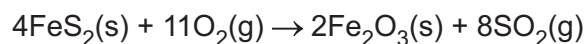
A batch of coal contains 3.00% by mass of FeS_2.

Calculate the volume of SO_2 gas, in m^3, produced by combustion of 1.00 tonne of this coal at 50.0 °C and a pressure of 100 kPa.

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

volume = ... m^3 **[5]**

(c) Dimethylsulfide, $(CH_3)_2S$, produced by marine organisms, is a natural cause of acid rain.

$(CH_3)_2S$ has a boiling point of 37 °C and is insoluble in water.

(i) The displayed formula of a molecule of $(CH_3)_2S$ is shown below.

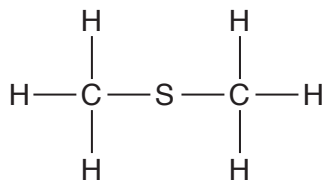$$H—\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}—S—\underset{\underset{H}{|}}{\overset{\overset{H}{|}}{C}}—H$$

Predict the C–S–C bond angle in a $(CH_3)_2S$ molecule.

Explain your answer.

Bond angle ....

Explanation ....

....

....

.... **[3]**

(ii) Explain why $(CH_3)_2S$ has a low boiling point and is insoluble in water.

....

....

....

....

....

.... **[3]**

2 This question is about chemicals used by gardeners.

(a) A garden product contains hydrated ammonium iron(II) sulfate, $(NH_4)_2Fe(SO_4)_2 \cdot xH_2O$. $(NH_4)_2Fe(SO_4)_2 \cdot xH_2O$ contains 27.55% by mass of water of crystallisation.

Calculate the value of x in the formula $(NH_4)_2Fe(SO_4)_2 \cdot xH_2O$.

Show your working.

x = ... **[3]**

(b) The garden product in **(a)** is a solid mixture of the following ingredients:

• Hydrated ammonium iron(II) sulfate, $(NH_4)_2Fe(SO_4)_2 \cdot xH_2O$, which is soluble in water

• Crushed limestone (calcium carbonate)

• Sand.

(i) Suggest why crushed limestone has been included in this garden product.

....

.... **[1]**

(ii)* Plan a procedure on a test tube scale to show that the solid mixture contains the following ions:

- NH_4^+, Fe^{2+} and SO_4^{2-} present in $(NH_4)_2Fe(SO_4)_2 \cdot xH_2O$

- CO_3^{2-} present in crushed limestone.

Show your reasoning, including relevant equations.

....

....

....

....

....

....

....

....

....

....

.... **[6]**

(c) Some gardeners spray crops with 'Bordeaux mixture' which contains several compounds.

One of the compounds in Bordeaux mixture is prepared by a student. The student added aqueous sodium hydroxide to aqueous copper(II) sulfate.

(i) Write an ionic equation, including state symbols, for the reaction in this preparation.

What would be observed?

Equation ....

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

(ii) It is believed that Cu^{2+} ions in the Bordeaux mixture interact with protein molecules in fungi, preventing growth. Proteins are polyamides.
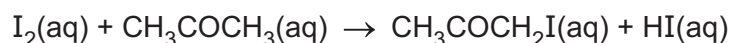
Suggest the interactions which occur between Cu^{2+} ions and protein molecules in fungi.

....

....

....

....

.... **[2]**

7

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

3 A student investigates the rate of reaction between iodine, I_2, and propanone, CH_3COCH_3, in the presence of H^+ ions. The student uses $HCl(aq)$ to supply H^+ ions.

$$I_2(aq) + CH_3COCH_3(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

The student follows the method outlined below.

1. The student starts the reaction by mixing the following solutions.

   $1.00\,cm^3$ of $1.00\,mol\,dm^{-3}$ $I_2(aq)$

   $49.5\,cm^3$ of $1.00\,mol\,dm^{-3}$ $CH_3COCH_3(aq)$

   $49.5\,cm^3$ of $1.00\,mol\,dm^{-3}$ $HCl(aq)$

2. The student places a sample of the reaction mixture in a colorimeter, immediately starts a stopwatch, and records the absorbance.

3. The student records the absorbance every 100 s. The results are shown below.

Time/s	Absorbance
0	0.80
100	0.67
200	0.51
300	0.44
400	0.28
500	0.18
600	0.05

(a) Explain why absorbance decreases during the experiment.

....

....

.... **[1]**
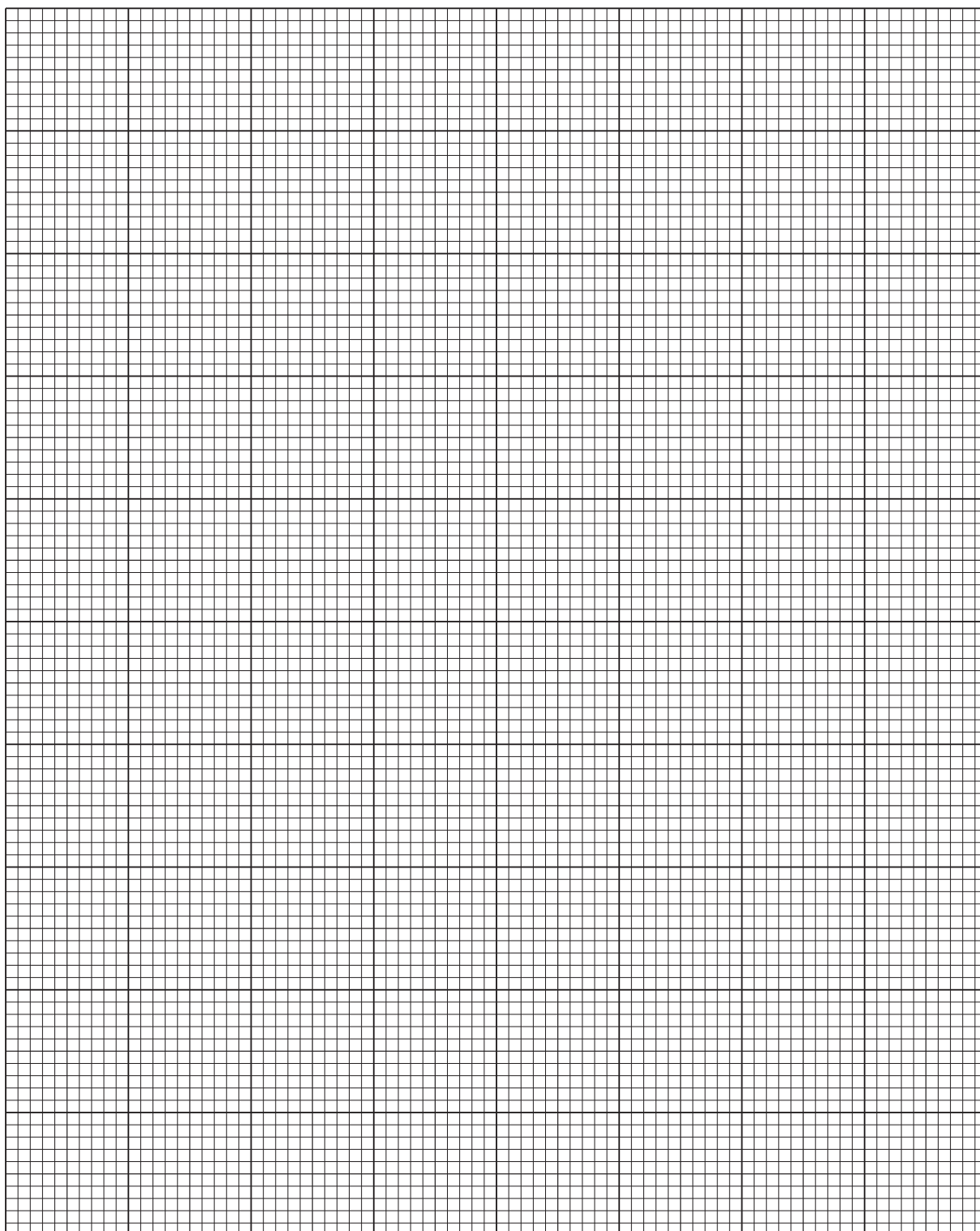
(b) Absorbance is proportional to the concentration of I_2.

Calculate the concentration of I_2 at the start of the experiment and after 500 s.

Time/s	Absorbance	$[I_2(aq)]/mol\,dm^{-3}$
0	0.80	
500	0.18	

[2]

(c) (i) Plot a graph of absorbance against time and draw a line of best fit.

[3]

 Turn over

(ii) Use your graph to find the order of reaction with respect to iodine.
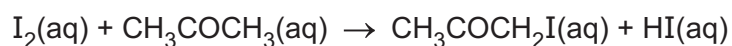
Explain your reasoning.

Order ....

Explanation ....

....

.... **[2]**

(d) A three step mechanism has been proposed for this reaction.

$$I_2(aq) + CH_3COCH_3(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

Complete the mechanism by adding equations for **Step 1** and **Step 3** in the boxes below.

|	
Step 1 (slow)	
Step 2 (fast)	
Step 3 (fast)	

[2]

4 This question is about properties of sulfuric acid, H_2SO_4.

(a) Concentrated sulfuric acid has a boiling point of 270 °C. The high boiling point is thought to be caused by hydrogen bonding between H_2SO_4 molecules.

The diagram below shows the structure of a sulfuric acid molecule.

Add a molecule of H_2SO_4 to show hydrogen bonding between two molecules of H_2SO_4. Include relevant dipoles and lone pairs.
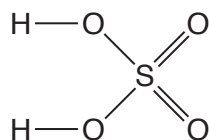
[2]

(b) Concentrated sulfuric acid is a powerful oxidising agent. Concentrated sulfuric acid oxidises hydrogen iodide, HI, to form iodine, hydrogen sulfide and one other product.

Construct an equation for this reaction.

.... [2]

(c) Concentrated sulfuric acid is often used to catalyse organic reactions.

An insecticide, **B**, can be made by the reaction below, using H_2SO_4 as a catalyst.

Insecticide **B**
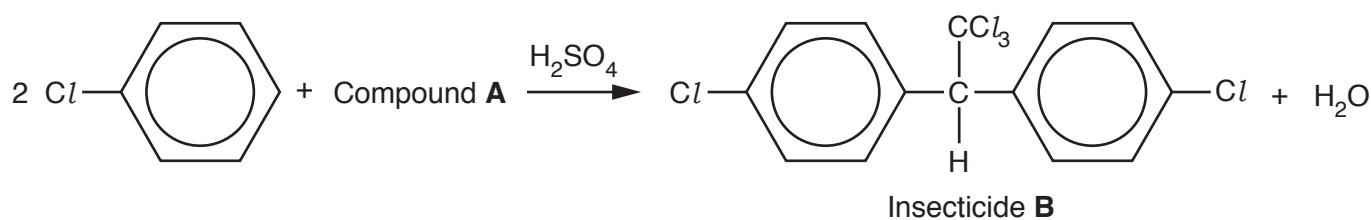
(i) Draw the structure for compound **A**.

[1]

(ii) Sulfuric acid is a catalyst in many reactions.

State **one** other example of an organic reaction in which sulfuric acid is a catalyst.

.... [1]

(d) A student carries out an experiment to find the enthalpy change of solution, $\Delta_{sol}H$, of sulfuric acid using the following method.

1. A plastic cup is weighed.

2. Approximately $100\,cm^3$ of distilled water is added to the cup.

3. The temperature of the water in the plastic cup is measured.

4. A bottle containing concentrated sulfuric acid is weighed.

5. The sulfuric acid is poured into the plastic cup. The solution formed is stirred with the thermometer.

6. The maximum temperature reached by the solution is recorded.

7. The plastic cup containing the solution is weighed.

8. The empty bottle is weighed.

The student's results are shown in the table below:

Mass readings

Mass of bottle + H_2SO_4/g	25.66
Mass of empty bottle/g	14.38

Mass of plastic cup/g	8.74
Mass of plastic cup + solution formed/g	122.16

Temperature readings

Maximum temperature reached by solution/°C	32.0
Initial temperature of distilled water/°C	21.5

(i) Use the student's results to calculate the enthalpy change of solution of sulfuric acid, in kJ mol⁻¹.

Assume that the specific heat capacity, c, of the solution is the same as for water.

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

enthalpy change of solution, $\Delta_{sol}H$, = ... kJ mol⁻¹ **[4]**

(ii) The student's thermometer has a maximum error of ±0.5 °C.

Calculate the percentage uncertainty in the student's temperature change.

Give your answer to **one** decimal place.

percentage uncertainty = ... % **[1]**

(iii) The student carries out a second experiment using 150 cm³ of distilled water instead of 100 cm³ of distilled water. The mass of concentrated sulfuric acid is the same as in the first experiment.

Predict and explain the effect, if any, of the larger volume of water on the following:

- The temperature change, ΔT

- The calculated value of $\Delta_{sol}H$ for H_2SO_4.

....

....

....

....

....

....

....

.... **[4]**

(e) When concentrated sulfuric acid is added to water, dissociation takes place in two stages.

Stage 1: $H_2SO_4 \rightarrow H^+ + HSO_4^-$

Stage 2: $HSO_4^- \rightleftharpoons H^+ + SO_4^{2-}$
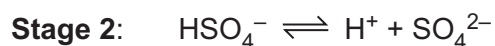
(i) $0.100\,mol\,dm^{-3}$ sulfuric acid has a pH of 0.96.

Explain this observation. Your answer should include a calculation.

....

....

....

....

....

.... **[3]**

(ii) A student adds an excess of aqueous sodium carbonate to dilute sulfuric acid.

- Predict what the student would observe.

- Explain what happens to the equilibrium in **Stage 2** as the aqueous sodium carbonate is added.

Observation ....

Explanation ....

....

....

.... **[2]**

5 Fruit juice contains a mixture of organic acids.

(a)* Acid **C** is an aliphatic organic acid present in fruit juice.

Information about acid **C** is shown below:

- 1.21×10^{-2} mol **C** has a mass of 2.323 g.
- The molecular formula of **C** is $C_xH_yO_7$.
- 1 mol of acid **C** requires 3 mol NaOH for neutralisation.
- Acid **C** contains a hydroxyl group but produces no colour change with hot acidified dichromate(VI).
- The ^{13}C NMR spectrum of **C** has four peaks.

Analyse this information to determine the structure of acid **C**.

Show **all** your reasoning.

....

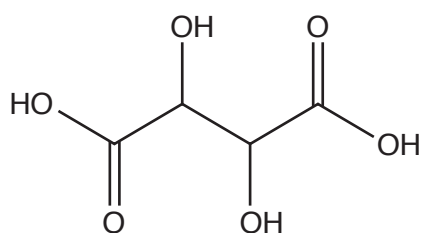...

....

....

....

....

....

....

....

....

....

....

.... **[6]**

(b) Tartaric acid, shown below, is another organic acid present in fruit juice.

(i) What is the empirical formula of tartaric acid?

.... [1]

(ii) Write the systematic name for tartaric acid.

.... [1]

(iii) Tartaric acid reacts with 1,6-diaminohexane, $H_2N(CH_2)_6NH_2$, to form a polymer.

Draw the structure of **one** repeat unit of this polymer.

[2]

(iv) The polymerisation in **(b)(iii)** takes place in two steps.

In the first step, tartaric acid and 1,6-diaminohexane react to form a salt.

Draw the structure of this salt, showing the ions present.

[2]

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).

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....