CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY   **8873/02**

Paper 2 Structured Questions   **29 September 2022**
                                                                    1 hour 30 minutes

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THE INSTRUCTIONS FIRST

Write your subject class, registration number and name in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper. You may use a soft pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.

*Answer **all** questions on the Question Paper.*

The use of an approved calculator is expected, where appropriate.

A Data Booklet is provided.

The number of marks is given in brackets [ ] at the end of each question or part question.

Appropriate significant figures and units are expected for final numerical answers.

For Examiner's Use	
1	/17
2	/9
3	/8
4	/15
5	/11
Penalty	
Presentation	
Paper 2	/60
Paper 1	/20
Total	/80
Promo Percentage	/100

This document consists of **16** printed pages

1 Some properties of SCl_2, S_2Cl_2, S_8 and Cl_2 are shown in the table.

property	SCl_2	S_2Cl_2	S_8	Cl_2
density / g cm^{-3}	1.62	1.69	2.07	0.00290
melting point / °C	−78	−80	115	−102
boiling point / °C	decomposes at 59 °C	137	445	−34
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	−49.8	−59.4		

(a) S_2Cl_2 can be made by direct combination of sulfur in its standard state, S_8, and chlorine gas, Cl_2.

(i) Write a thermochemical equation that represents the standard enthalpy change of formation of S_2Cl_2.

.... [2]

(ii) A chemist wishes to prepare 10.0 cm^3 of S_2Cl_2 from its elements.

Use the data in the table to calculate the mass of sulfur required to produce this volume of S_2Cl_2. Give your answer to 4 significant figures.

[2]

(iii) Suggest a reason for the difference in physical state of S_8 and Cl_2 at room temperature and pressure.

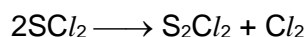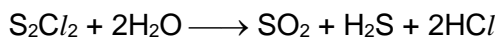...

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.... [2]

(b) S_2Cl_2 can also be formed when SCl_2 decomposes, as shown in the equation below.

$$2SCl_2 \longrightarrow S_2Cl_2 + Cl_2$$

Using the data in the table, calculate the standard enthalpy change, $\Delta H_r^\ominus$, for this reaction.

[1]

(c) S_2Cl_2 reacts with water, as shown in the equation below.

$$S_2Cl_2 + 2H_2O \longrightarrow SO_2 + H_2S + 2HCl$$

By considering the oxidation states of sulfur, state and explain the type of reaction taking place.

....

....

.... [2]

(d) **(i)** Draw a dot-and-cross diagram to show the bonding present in S_2Cl_2. given that the atoms are bonded in the order Cl–S–S–Cl.

[1]

(ii) Predict the shape about the S atom and the Cl–S–S bond angle in S_2Cl_2.

shape: …………………………………...

bond angle: ………………………….. [1]

(e) Chloramine, NH_2Cl, can be used in the treatment of drinking water to kill bacteria.

Draw a labelled diagram to show the interaction formed between NH_2Cl and a H_2O molecule.

[2]

(f) The ionic radii of some ions are shown in the table below.

species	ionic radius / nm
Cl^-	0.181
O^{2-}	0.140
S^{2-}	0.184

Using the data given, explain the difference in ionic radius of the following pairs of elements.
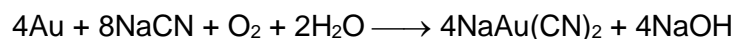
(i) Cl^- and S^{2-}

[2]

(ii) O^{2-} and S^{2-}

[2]

[Total: 17]

2 **(a)** Gold can be extracted from low-grade ore around the world by use of the *Elsner* reaction in which the impure gold ore is reacted with an aqueous solution of sodium cyanide, as shown in the equation below.

$$4Au + 8NaCN + O_2 + 2H_2O \longrightarrow 4NaAu(CN)_2 + 4NaOH$$

The experimental procedure to determine the percentage by mass of gold in the sample of impure gold ore is as follows:

- A sample of 35 g of impure gold ore was added to 250 cm^3 aqueous solution of sodium cyanide.
- 25.0 cm^3 of the resulting solution was neutralised with 15 cm^3 of 0.3 mol dm^{-3} sulfuric acid.
- The excess sulfuric acid was then titrated with 0.06 mol dm^{-3} potassium hydroxide solution. 17.00 cm^3 of KOH (aq) was required to reach the end point.

Calculate the percentage by mass of gold in the sample of impure gold ore.

[3]

(b) Gold can also be found in the sea water. It is believed that gold has a concentration of 11 parts per trillion by mass in sea water. Calculate the concentration of gold present in mol dm^{-3}, given that the density of sea water is 1.03 g cm^{-3}.

[1 trillion = 10^{12}]

[2]

(c) Explain why gold is commonly used in electrical wiring in terms of its structure.

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.... [1]

(d) In a biochemical laboratory, a plasma torch is often used to ionise a variety of samples during analysis. A sample of gold, Au, was allowed to pass through the plasma torch and the particles that emerged were routed through an electromagnet.

It was observed that a beam of $^{197}Au^{2+}$ gives an angle of deflection of $+4°$.
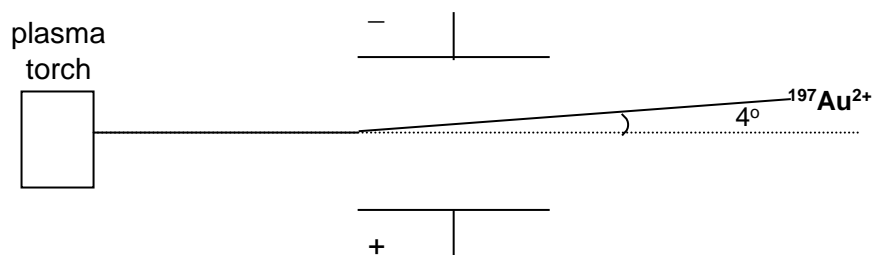
(i) Calculate the angle of deflection for a sample of $^{52}Cr^{3+}$ ions.

[1]

(ii) Write the full electronic configuration of Cr^{3+}.

.... [1]

(iii) In alkaline medium, Cr^{3+} can be oxidized to CrO_4^{2-}.

Construct the oxidation half equation.

.... [1]

[Total: 9]

3 **(a)** 0.03 moles of but-1-ene, $CH_2=CHCH_2CH_3$, are completely burnt in a 2 dm^3 sealed vessel containing 0.30 moles of oxygen gas at 450 °C. The vessel walls can withstand a maximum pressure of 2000 kPa.

(i) Construct a chemical equation, including state symbols, for the combustion of but-1-ene gas with oxygen in the 2 dm^3 sealed vessel at 450 °C.

.... [2]

(ii) Calculate the total amount of gas present in the vessel when the combustion is completed at 450 °C.

[1]

(iii) At 450 °C, 1 mol of gas in a 2 dm^3 container would exert a total pressure of 3×10^6 Pa.

Suggest if the vessel will remain intact throughout the reaction.

[1]

(b) Compound **W** can undergo the following reaction.

W → step 1 → **X** + H_2O
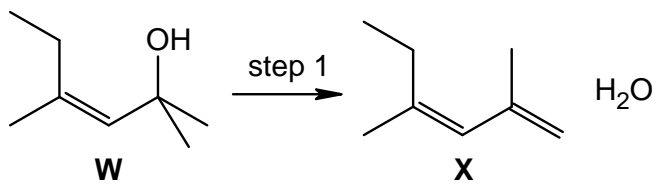
(i) Suggest the reagents and conditions for step 1.

.... [1]

(ii) Using relevant information from the *Data Booklet*, calculate ΔH_r for step 1.

[2]

(iii) Draw the structure of the stereoisomer of **X**.

[1]

[Total: 8]

4 **(a)** In an experiment, 40 cm^3 of 1.00 mol dm^{-3} sodium hydroxide is added to 10 cm^3 of 1.00 mol dm^{-3} sulfuric acid. The temperature of the mixture rises by 5.4 °C.

$$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

(i) Calculate the enthalpy change of neutralisation.

[2]

(ii) The above reaction is repeated using H_2CO_3, a weak acid, in place of sulfuric acid.

Suggest the effect on the temperature rise of the reaction mixture.

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.... [2]

(b) A student investigated the rate of reaction between 2-chloropropanoic acid and aqueous sodium carbonate by measuring how long it takes for 10.0 cm^3 of gas to be collected.

A series of experiments were carried out to study the order of reaction with respect to 2-chloropropanoic acid and sodium carbonate. The following results were obtained.

Experiment Number	Volume / cm^3			Time / s
	2-chloropropanoic acid	Na_2CO_3	H_2O	
1	20.0	40.0	40.0	75
2	20.0	30.0	50.0	100
3	10.0	30.0	60.0	100
4	15.0	*x*	*y*	200

(i) State the relationship between rate of reaction and time taken to collect 10.0 cm^3 of gas.

.... [1]

(ii) Determine the order of the reaction with respect to 2-chloropropanoic acid and sodium carbonate.

[2]

(iii) Hence, write the rate equation.

.... [1]

(iv) State the value of *x* and *y* in Experiment 4.

[1]

(v) With the aid of an appropriate diagram, explain how the addition of a catalyst can affect the rate of reaction between 2-chloropropanoic acid and sodium carbonate.

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.... [3]

(c) 2-chloropropanoic acid can be converted into propenoic acid.
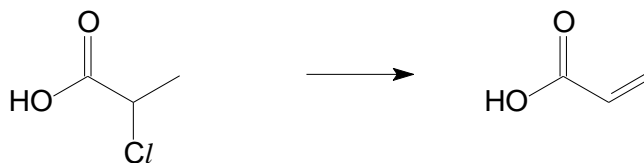
(i) State the type of reaction.

.... [1]

(ii) Suggest a simple chemical test to distinguish between 2-chloropropanoic acid and propenoic acid.

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.... [2]

[Total: 15]

5 **(a)** Ethanoic acid can be made from different classes of compound. Choose two starting organic compounds that have different functional groups that can be converted to ethanoic acid. Describe the reactions to form ethanoic acid including reagents, equations and any observations in your answer.
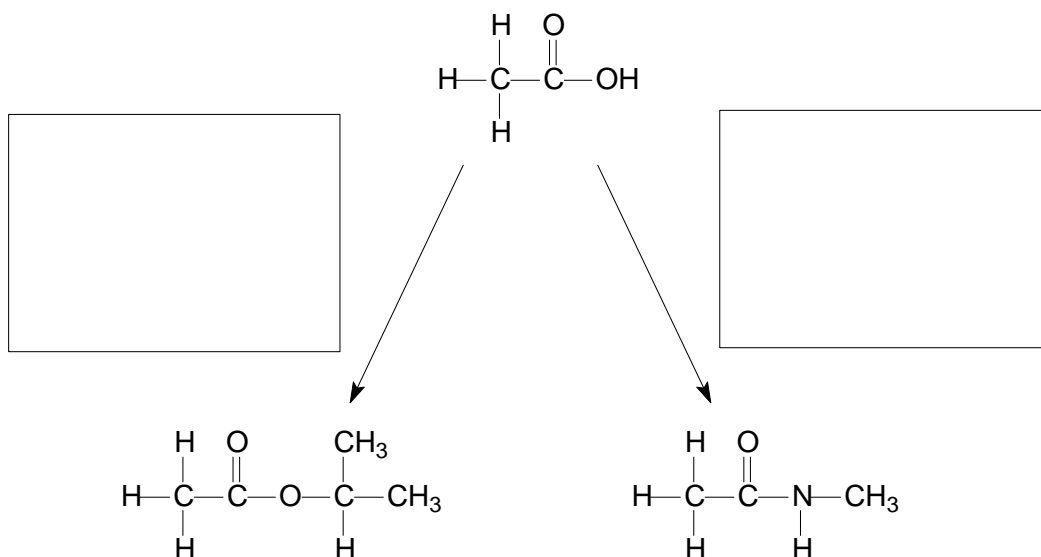
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.... [5]

(b) Ethanoic acid can be converted to ester and amide.

Give the reagents and conditions for the following conversions.

(c) In a sample, one molecule of ethanoic acid has a relative molecular mass of 60 and another molecule of ethanoic acid has a relative molecular mass of 61. Suggest a reason for this difference in relative molecular mass.

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.... [2]

(d) Draw the skeletal structure of a functional group isomer of ethanoic acid. Name the functional groups present in this isomer.

[2]

[Total: 11]