2023-DSE
CHEM
PAPER 2

HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2023

CHEMISTRY PAPER 2

11:45 am – 12:45 pm (1 hour)
This paper must be answered in English

INSTRUCTIONS

(1) This paper consists of **THREE** sections, Section A, Section B and Section C. Attempt **ALL** questions in any **TWO** sections.

(2) Write your answers in the **DSE(D)** Answer Book provided. Start each question (not part of a question) on a new page.

(3) A Periodic Table is printed on page 8 of this Question Paper. Atomic numbers and relative atomic masses of elements can be obtained from the Periodic Table.

Not to be taken away before the end of the examination session

Section A Industrial Chemistry

Answer **ALL** parts of the question.

1. (a) (i) In industry, sorbitol can be used to synthesise vitamin C by the following steps :

$$\text{sorbitol} \xrightarrow{\text{fermentation}} \text{sorbose} \xrightarrow[\text{2. } Cl_2\text{, NaOH}]{\text{1. } CH_3COCH_3\text{, conc.}H_2SO_4} \cdots\cdots \xrightarrow[\text{(several steps)}]{} \text{vitamin C}$$

(1) Explain why it is necessary to synthesise vitamin C in industry. (1 mark)

(2) Explain why this process of synthesising vitamin C is NOT considered to be 'green' according to the principles of green chemistry. (1 mark)

(ii) Methane can be used to form syngas.

(1) Suggest a source of methane. (1 mark)

(2) Write the chemical equation for the formation of syngas from methane. (1 mark)

(iii) State TWO chemicals manufactured by the chloroalkali industry. (1 mark)

(b) The Haber process is an important industrial process to produce ammonia. The chemical equation for the reaction involved is shown below :

$$N_2(g) + 3H_2(g) \overset{Fe(s)}{\rightleftharpoons} 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

Under the optimal operation conditions and in the presence of iron catalyst, the yield of $NH_3(g)$ at equilibrium is about 20%. The activation energy of the forward reaction of the Haber process is 20 kJ mol^{-1}.

(i) What is meant by the term 'activation energy' ? (1 mark)

(ii) Draw an energy profile for the reaction of the Haber process. Label the axes and the activation energy (E_a) of the forward reaction. (2 marks)

(iii) Find the activation energy, in kJ mol^{-1}, of the backward reaction of the Haber process under the same operation conditions. (1 mark)

(iv) State the optimal operation temperature and pressure used in the Haber process. Explain why such conditions are used. (3 marks)

(v) Comment on the following statement :

'Using more iron catalyst can increase the yield of ammonia in the Haber process.' (1 mark)

1. (c) (i) Hydrogen gas and oxygen gas are the feedstocks for the industrial synthesis of hydrogen peroxide (H_2O_2). The synthesis involves the following two steps :

Reaction in Step (1) : $H_2 + \mathbf{Y} \xrightarrow{Pd} H_2\mathbf{Y}$

Y is an organic compound. Hydrogen gas is passed into **Y** (dissolved in an organic solvent). Palladium (Pd) metal is used as a catalyst. At the end of Step (1), the palladium catalyst is removed.

Reaction in Step (2) : $H_2\mathbf{Y} + O_2 \longrightarrow H_2O_2 + \mathbf{Y}$

Air is blown into $H_2\mathbf{Y}$ (dissolved in an organic solvent). At the end of Step (2), H_2O_2 is collected and **Y** is recovered.

(1) Suggest a way to increase the effectiveness of the palladium catalyst. (1 mark)

(2) Explain why **Y** is recovered at the end of Step (2). (1 mark)

(3) Apart from the potential danger of explosion, explain why hydrogen peroxide is NOT synthesised from hydrogen gas and oxygen gas in a single step. (1 mark)

(ii) Under the same experimental conditions, three trials of an experiment were performed to determine the rate equation of the following reaction :

$$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

The table below shows the data obtained :

	Initial concentration of $H_2O_2(aq)$ / mol dm^{-3}	Initial concentration of $I^-(aq)$ / mol dm^{-3}	Initial concentration of $H^+(aq)$ / mol dm^{-3}	Initial rate of formation of $I_2(aq)$ / mol dm^{-3} s^{-1}
Trial 1	0.0010	0.10	0.10	2.8×10^{-6}
Trial 2	0.0020	0.10	0.0010	5.6×10^{-6}
Trial 3	0.0020	0.50	0.10	2.8×10^{-5}

(1) Given that the order of reaction with respect to $H_2O_2(aq)$ is 1, deduce the order of reaction with respect to $I^-(aq)$ and that with respect to $H^+(aq)$. (2 marks)

(2) Based on the data in Trial 1, calculate the rate constant of the reaction under the same experimental conditions. (2 marks)

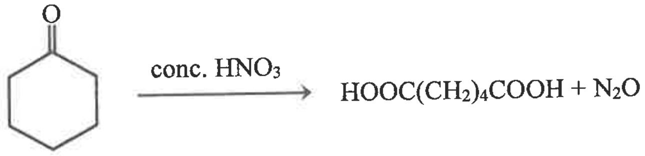
END OF SECTION A

Section B **Materials Chemistry**

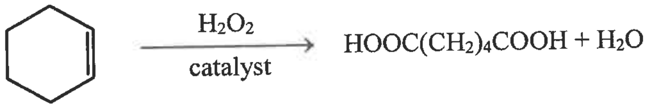
Answer **ALL** parts of the question.

2. (a) (i) Hexanedioic acid ($HOOC(CH_2)_4COOH$) is one of the monomers for making nylon-6,6. The following two methods can be used to prepare hexanedioic acid :

Method (I) :

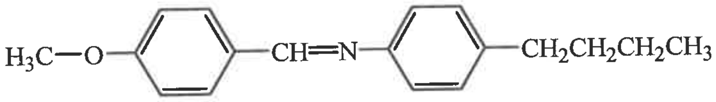


Method (II) :



Suggest TWO reasons why **Method (II)** is considered to be 'greener' than **Method (I)** according to the principles of green chemistry. (2 marks)

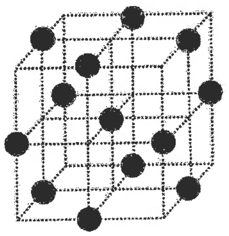
(ii) State TWO structural features of the following molecule of a substance that make the substance exhibit liquid-crystalline behaviour.



(2 marks)

(iii) Urea-methanal is a polymer commonly used in making electric sockets. Draw the repeating unit of urea-methanal. (1 mark)

(b) The diagram below shows a unit cell of silver crystal :



(i) Name this type of crystal structure. (1 mark)

(ii) Deduce the number of silver atoms in the above unit cell. (2 marks)

2. (b) (iii) Sterling silver is an alloy. A sample of sterling silver is composed of 92.5% silver and 7.5% copper.

(1) In terms of bonding and structure, explain why the melting point of sterling silver is lower than that of pure silver. (2 marks)

(2) Apart from price, suggest one advantage of using sterling silver over pure silver in making jewellery. (1 mark)

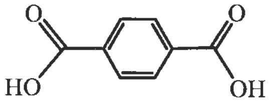
(iv) A spherical cluster consists of many silver atoms. The diameter of this spherical cluster is 80 times the diameter of a silver atom. Is this spherical cluster a nanoparticle ? Explain your answer.
(Given: the diameter of a silver atom = 0.288 nm) (2 marks)

(c) A 'cooling towel' is made from poly(ethylene terephthalate) (PET) which is a condensation polymer. In comparison with a wet cotton towel of the same size, water evaporates more easily from a wet 'cooling towel'.

(i) What is meant by the term 'condensation polymer' ? (1 mark)

(ii) PET can be made from the two monomers below :

$HOCH_2CH_2OH$



Write the chemical equation for the formation of PET. (1 mark)

(iii) In terms of molecular structure, explain whether PET is a thermoplastic or a thermosetting plastic. (1 mark)

(iv) Cellulose is the major component of cotton. In terms of bonding and structure, explain why water evaporates more easily from a wet 'cooling towel' than a wet cotton towel of the same size. (2 marks)

(v) The 'cooling towel' is woven from PET fibres. Suggest a moulding method for making PET fibres. (1 mark)

(vi) Suggest one problem of recycling the 'cooling towel'. (1 mark)

END OF SECTION B

Go on to the next page

Section C Analytical Chemistry

Answer **ALL** parts of the question.

3. (a) (i) Suggest a test to distinguish between $Ca(NO_3)_2(s)$ and $Mg(NO_3)_2(s)$. (2 marks)

(ii) Give one property of solid sodium hydroxide making it NOT suitable to be weighed for preparing a standard solution. (1 mark)

(iii) Outline the steps to obtain hexan-1-ol from a mixture of hexanoic acid and hexan-1-ol by liquid-liquid extraction.
(Given : Both hexanoic acid and hexan-1-ol are immiscible with water.) (2 marks)

(b) The manufacturer of a certain household bleach states that the concentration of sodium hypochlorite (NaOCl) in the bleach is 15.5 g dm^{-3}. In order to determine the actual concentration of NaOCl in the bleach, the following experiment was performed :

Step (1) :	25.00 cm^3 of the bleach was diluted to 250.0 cm^3 to give a solution **X**.
Step (2) :	Excess dilute sulphuric acid and excess potassium iodide solution were added to a conical flask containing 25.00 cm^3 of solution **X**.
Step (3) :	The reaction mixture obtained was titrated with 0.0512 M $Na_2S_2O_3(aq)$. When the colour of solution in the conical flask changed to pale yellow, starch solution was added as an indicator. The titration was continued until the end point was reached.
Step (4) :	The titration was repeated several times, and the mean volume of $Na_2S_2O_3(aq)$ required to reach the end point was 21.02 cm^3.

(i) Name an apparatus that should be used in Step (1). (1 mark)

(ii) The chemical equations for the reactions involved in the experiment are as follows :

$OCl^-(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow I_2(aq) + Cl^-(aq) + H_2O(l)$ (in Step (2))

$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$ (in Step (3))

(1) State the colour change at the end point of the titration. (1 mark)

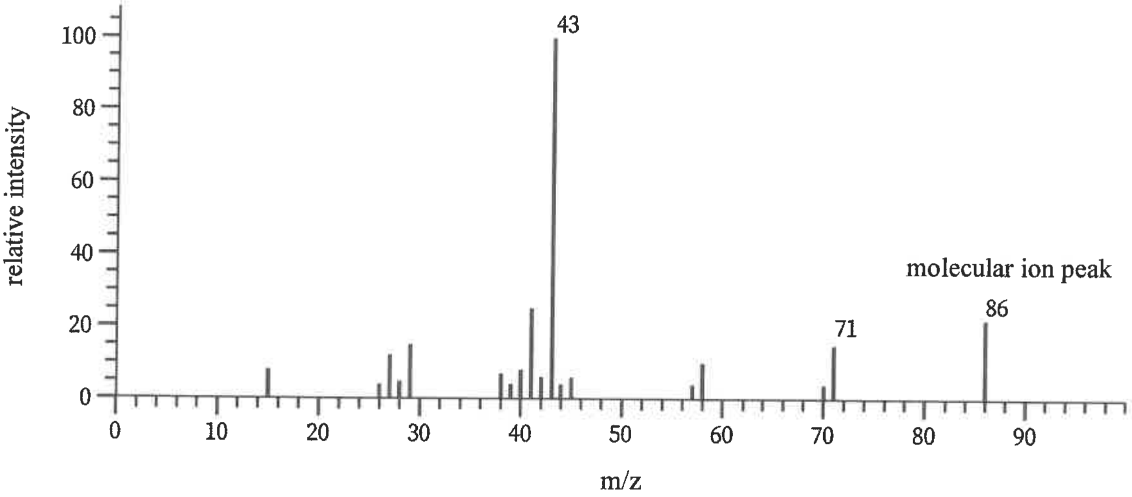
(2) Calculate the actual concentration of NaOCl, in g dm^{-3}, in the bleach.
(Relative atomic masses : O = 16.0, Na = 23.0, Cl = 35.5) (3 marks)

(3) According to the quality control standards, the actual concentration of NaOCl in the bleach is required to lie within ±5% of the concentration stated by the manufacturer (15.5 g dm^{-3}). By calculation, determine whether the bleach fulfills the quality control standards. (1 mark)

(iii) Why was the titration repeated several times in Step (4) ? (1 mark)

3. (c) **A**, **B** and **C** are different straight-chain carbonyl compounds. They have the same general formula $C_nH_{2n}O$. Both **A** and **B** have the same functional group but **C** does not. **D** is a primary alcohol formed from the reduction of **C**.

The mass spectrum of **A** is shown below :



(i) By referring to the mass spectrum of **A**,

(1) deduce the molecular formula of **A**.
(Relative atomic masses : H = 1.0, C = 12.0, O = 16.0) (1 mark)

(2) deduce the structural formula of **A**. (2 marks)

(ii) Draw a possible structure for **B**. (1 mark)

(iii) Suggest a chemical test to distinguish between **B** and **C**. (2 marks)

(iv) With reference to the information given in the table below, suggest TWO expected differences between the infra-red spectra of **C** and **D**. (2 marks)

Characteristic Infra-red Absorption Wavenumber Ranges (Stretching modes)

Bond	Compound type	Wavenumber range / cm^{-1}
C=C	Alkenes	1 610 to 1 680
C=O	Aldehydes, ketones, carboxylic acids and derivatives	1 680 to 1 800
C≡C	Alkynes	2 070 to 2 250
C≡N	Nitriles	2 200 to 2 280
O–H	Acids (hydrogen-bonded)	2 500 to 3 300
C–H	Alkanes, alkenes, arenes	2 840 to 3 095
O–H	Alcohols (hydrogen-bonded)	3 230 to 3 670
N–H	Amines	3 350 to 3 500

END OF SECTION C
END OF PAPER

PERIODIC TABLE 周期表

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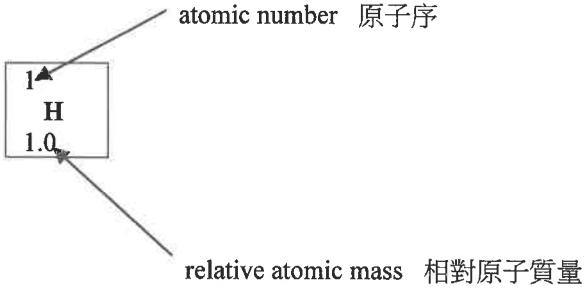

I	II											III	IV	V	VI	VII	0
																	2 **He** 4.0
3 **Li** 6.9	4 **Be** 9.0											5 **B** 10.8	6 **C** 12.0	7 **N** 14.0	8 **O** 16.0	9 **F** 19.0	10 **Ne** 20.2
11 **Na** 23.0	12 **Mg** 24.3											13 **Al** 27.0	14 **Si** 28.1	15 **P** 31.0	16 **S** 32.1	17 **Cl** 35.5	18 **Ar** 40.0
19 **K** 39.1	20 **Ca** 40.1	21 **Sc** 45.0	22 **Ti** 47.9	23 **V** 50.9	24 **Cr** 52.0	25 **Mn** 54.9	26 **Fe** 55.8	27 **Co** 58.9	28 **Ni** 58.7	29 **Cu** 63.5	30 **Zn** 65.4	31 **Ga** 69.7	32 **Ge** 72.6	33 **As** 74.9	34 **Se** 79.0	35 **Br** 79.9	36 **Kr** 83.8
37 **Rb** 85.5	38 **Sr** 87.6	39 **Y** 88.9	40 **Zr** 91.2	41 **Nb** 92.9	42 **Mo** 95.9	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 * **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 ** **Ac** (227)	104 **Rf** (261)	105 **Db** (262)													

*	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
**	90 **Th** 232.0	91 **Pa** (231)	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)