HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2022

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) Answer the following short questions :

(i) Under certain conditions, ethanoic acid can be manufactured by the following reaction :

$$CH_3OH(l) + CO(g) \xrightarrow{Rh,\ HI} CH_3COOH(l)$$

(1) Suggest one reason why this reaction is considered to be green.

(2) Suggest one reason why this reaction is NOT considered to be green.

(2 marks)

(ii) A factory manufactures catalytic converters with a catalyst coating on a porous structure.

(1) Suggest one advantage of using a porous structure in the catalytic converters.

(2) Explain why the effectiveness of the catalyst may decrease after prolonged use.

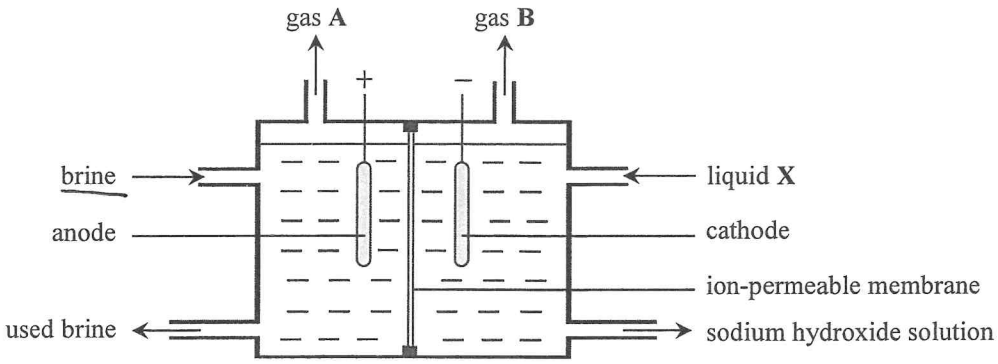
(2 marks)

(iii) Which one of the following items is NOT manufactured from petrochemicals ?

nylon rope, glass bottle, soapless detergent

(1 mark)

(b) The diagram below shows a membrane electrolytic cell used in the chloroalkali industry. Brine and liquid **X** are continuously added into the membrane electrolytic cell to produce gas **A**, gas **B** and sodium hydroxide solution.



(i) What is **X** ?

(1 mark)

(ii) Gas **A** is formed at the anode of the membrane electrolytic cell.

(1) What is **A** ?

(2) Explain why **A** is formed.

(2 marks)

(iii) Gas **B** and sodium hydroxide solution are formed at the cathode of the membrane electrolytic cell.

(1) Write a half equation for the formation of **B**.

(2) Explain why sodium hydroxide solution is formed and why it does not contain sodium chloride.

(3 marks)

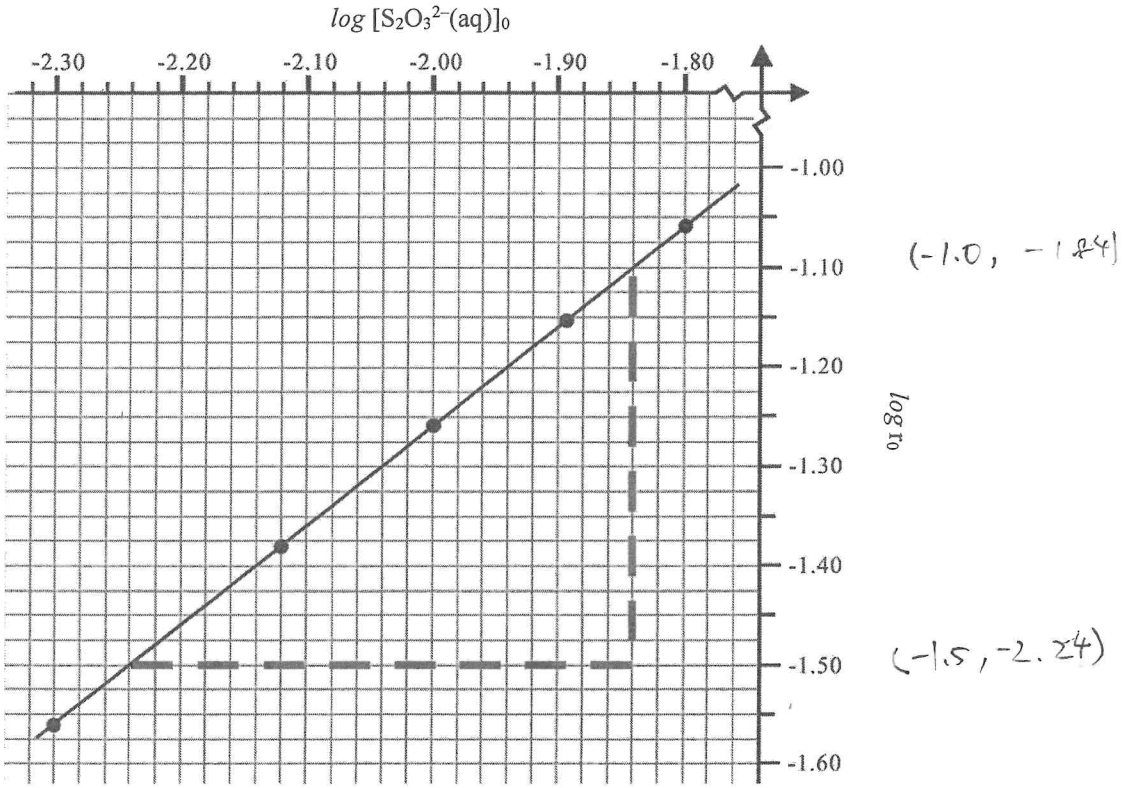
(iv) Suggest a chemical that can be manufactured from the reaction between **A** and sodium hydroxide solution.

(1 mark)

1. (c) The chemical kinetics of the following reaction at a certain temperature was studied :

$$S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow SO_2(g) + S(s) + H_2O(l)$$

Several trials of an experiment were performed under the same experimental conditions, except varying the initial concentration of $S_2O_3^{2-}(aq)$ (represented by $[S_2O_3^{2-}(aq)]_0$), to measure the initial rate of formation of S(s) (represented by r_0). The following graph shows the experimental results obtained from these trials :



(i) What is meant by the term 'initial rate' ?

(1 mark)

(ii) The rate equation for the reaction is shown below :

$$\text{Rate} = k\,[S_2O_3^{2-}(aq)]^a\,[H^+(aq)]^b$$

where k is the rate constant,
a is the order of reaction with respect to $S_2O_3^{2-}(aq)$
and ***b*** is the order of reaction with respect to $H^+(aq)$.

Given that the concentration of $H^+(aq)$ used was much higher than that of $S_2O_3^{2-}(aq)$ in each trial, explain why the above rate equation can be modified as shown below :

$$\text{Rate} = k'\,[S_2O_3^{2-}(aq)]^a$$

where k′ is regarded as a constant.

(2 marks)

(iii) By using the dotted lines in the graph above, deduce the order of reaction with respect to $S_2O_3^{2-}(aq)$.

(3 marks)

(iv) The experiment was repeated at 25 °C and 35 °C separately, while other experimental conditions were the same. The rate constant of the reaction at 25 °C is k_1 and the rate constant of the reaction at 35 °C is k_2. The ratio of k_2 to k_1 is 1.9 : 1.0. Calculate the activation energy of the reaction, in kJ mol^{-1}.

(Gas constant R = 8.31 J K^{-1} mol^{-1}; Arrhenius equation : $\log k = constant - \frac{E_a}{2.3RT}$)

(2 marks)

END OF SECTION A

Go on to the next page

Section B Materials Chemistry

Answer **ALL** parts of the question.

2. (a) Answer the following short questions :

(i) Gold nanoparticles of various size exhibit different colours.

(1) State the meaning of the term 'nanoparticles'.

(2) Suggest an application of gold nanoparticles in buildings.

(2 marks)

(ii) The following diagrams show three different phases of liquid crystal molecules :

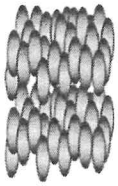


Diagram **A**

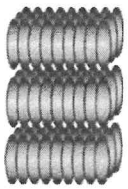


Diagram **B**

Diagram **C**

(1) Which diagram represents the expected phase of liquid crystal molecules when no voltage is applied to the liquid crystal layers in liquid crystal displays ?

(2) State the phase of liquid crystal molecules shown by Diagram **A**.

(2 marks)

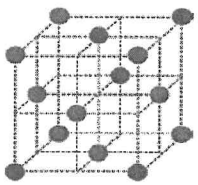
(iii) Consider the following reaction :

$$2NaOH + Cl_2 + 2NH_3 \longrightarrow N_2H_4 + 2NaCl + 2H_2O$$

Calculate the atom economy of this reaction for producing hydrazine (N_2H_4).
(Formula masses : NaOH = 40.0, Cl_2 = 71.0, NH_3 = 17.0,
N_2H_4 = 32.0, NaCl = 58.5, H_2O = 18.0)

(1 mark)

(b) The diagram below shows a unit cell of aluminium crystal. All of the edge lengths of the unit cell are 4.05×10^{-8} cm.



(i) Name this type of crystal structure.

(1 mark)

(ii) Deduce the number of aluminium atoms in the unit cell.

(1 mark)

(iii) Calculate the density of aluminium, in g cm^{-3}.
(Relative atomic mass : Al = 27.0; Avogadro's constant = 6.02×10^{23} mol^{-1})

(2 marks)

2. (b) (iv) A duralumin sample is an alloy of aluminium mixed with a small amount of copper, magnesium and manganese. Consider the following information :

- The melting point of the duralumin sample is lower than that of pure aluminium.
- The tensile strength of the duralumin sample is greater than that of pure aluminium.
- The density of the duralumin sample is 2.78 g cm^{-3}.

(1) In terms of bonding and structure, explain why the duralumin sample has a lower melting point than pure aluminium.

(2) Comment on the following statement :

'This kind of duralumin is more suitable than pure aluminium for making aircraft bodies.'

(3 marks)

(c) Both low density polyethene (LDPE) and high density polyethene (HDPE) are made from the polymerisation of ethene.

(i) Write a chemical equation for the polymerisation of ethene.

(1 mark)

(ii) Name the type of polymerisation for manufacturing polyethene.

(1 mark)

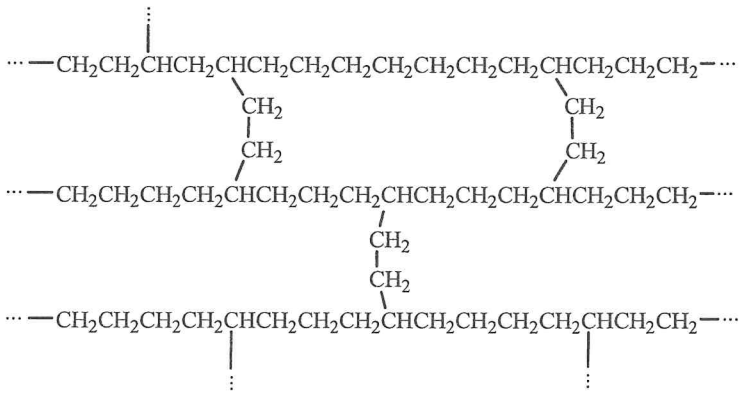
(iii) HDPE can be used to make rigid plastic bottles.

(1) From molecular level, explain why HDPE is more suitable than LDPE for making rigid plastic bottles.

(2) Suggest a moulding method for making HDPE rigid plastic bottles.

(3 marks)

(iv) Polymer **X** is another type of polyethene. It can be used to make hot water pipes. The following diagram shows a part of the structure of polymer **X** :



(1) Comment on the thermal property of **X**.

(2) Explain the thermal property of **X** in terms of bonding and structure.

(3) Besides thermal property, suggest another property of **X** rendering it suitable for making hot water pipes.

(3 marks)

END OF SECTION B

Go on to the next page

Section C Analytical Chemistry

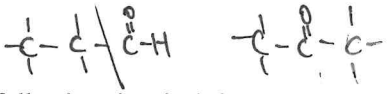
Answer **ALL** parts of the question.

3. (a) Answer the following short questions :

(i) Suggest a chemical test to show how $SO_2(g)$ and $CO_2(g)$ can be distinguished.

(2 marks)

(ii) Illustrate how $CH_3CH_2CHO(l)$ and $CH_3COCH_3(l)$ can be distinguished from their respective mass spectra.



(2 marks)

(iii) Which one of the following chemicals is the most suitable for drying ethyl butanoate ?

concentrated sulphuric acid, solid sodium hydroxide, anhydrous sodium sulphate

(1 mark)

(b) A solid sample consists of a compound **Y** and a small amount of an impurity **Z**. The following steps were performed in an experiment to obtain pure **Y**(s) from this solid sample.
(Given : **Y** is more soluble in deionised water at 80 °C than at 25 °C.)

Step (1) : 1.40 g of this solid sample was added to 50 cm^3 of deionised water and heated to 80 °C.
Step (2) : Water-insoluble activated charcoal was then added to remove **Z**. The mixture obtained was filtered when it was still hot.
Step (3) : The hot filtrate obtained was allowed to cool slowly to 25 °C. **Y**(s) was formed.
Step (4) : The cooled mixture was filtered to collect **Y**(s). After washing and drying, 0.75 g of **Y**(s) was collected.

(i) It is given that no more than 3.04 g of **Y**(s) can dissolve in 100 cm^3 of deionised water at 80 °C. Show, by calculation, that all of **Y** in this solid sample should have dissolved in Step (1).

(1 mark)

(ii) Explain why the mixture was filtered in Step (2).

(1 mark)

(iii) Name the process of the formation of **Y**(s) in Step (3).

(1 mark)

(iv) Suggest one reason why the mass of **Y**(s) collected in Step (4) was smaller than the mass of **Y** in this solid sample.

(1 mark)

(v) **Y** and **Z** can be separated by chromatography. Thin layer chromatography (TLC) and column chromatography were performed separately with this solid sample using the same stationary phase and mobile phase.
(Given : R_f value of **Y** is greater than that of **Z**.)

(1) Sketch a labelled chromatogram of TLC to show the expected result.

(2) Explain whether the first-collected fraction in the column chromatography is **Y** or **Z**.

(3 marks)

3. (c) The major ingredient in a certain brand of iron supplement tablets is $FeSO_4$. Several pieces of these iron supplement tablets were dissolved in deionised water to obtain an aqueous solution **S**. The concentration of $Fe^{2+}(aq)$ ions in solution **S** was determined by using the following two methods :

(i) **Method (I) : using volumetric analysis**

The chemical equation for the reaction involved in the titration is as follows :

$$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$

25.00 cm^3 of solution **S** was acidified and then titrated with 0.0041 M $KMnO_4(aq)$. The mean volume of the $KMnO_4(aq)$ required to reach the end point was 32.35 cm^3.

(1) The colour of the reaction mixture changed from pale yellow to pale pink at the end point of the titration. Explain the colour change.

(2) Calculate the concentration of $Fe^{2+}(aq)$ ions in solution **S**.

(4 marks)

(ii) **Method (II) : using colorimetry**

$Fe^{2+}(aq)$ can completely react with a colourless organic reagent to form an orange-red species **W**(aq).
(Given : number of moles of $Fe^{2+}(aq)$ reacted : number of moles of **W**(aq) formed = 1 : 1)

Step (1) : Several standard $FeSO_4(aq)$ solutions of various concentrations were separately treated with the colourless organic reagent to form the corresponding orange-red solutions of **W**(aq).

Step (2) : The absorbances of these solutions of **W**(aq) were measured using a colorimeter and a calibration curve was plotted.

Step (3) : Solution **S** was diluted 100 times. A sample of this diluted solution was treated in the same way as described in Step (1) to give a solution **T** which contains **W**(aq).

Step (4) : The absorbance of solution **T** was measured.

(1) Sketch the calibration curve in Step (2) and label the axes. On this sketch, show how the concentration of **W**(aq) in solution **T** can be found.

(2) Hence, suggest how the concentration of $Fe^{2+}(aq)$ ions in solution **S** can be determined.

(4 marks)

END OF SECTION C
END OF PAPER

PERIODIC TABLE 周期表

GROUP 族

atomic number 原子序

relative atomic mass 相對原子質量

I	II											III	IV	V	VI	VII	0
				1 **H** 1.0													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)