HONG KONG EXAMINATIONS AND ASSESSMENT AUTHORITY
HONG KONG DIPLOMA OF SECONDARY EDUCATION EXAMINATION 2019

# 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) Explain why the Haber process significantly contributes to crop yield increase.

(1 mark)

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

(2) Syngas can be obtained from the conversion of biomass. Suggest why it is considered as an advancement of the methanol production technology.

(2 marks)

(iii) Three trials of an experiment were performed under the same experimental conditions to study the kinetics of the following reaction :

$$2\mathbf{A}(aq) + \mathbf{B}(aq) \rightarrow 2\mathbf{C}(aq) + 2\mathbf{D}(aq) + \mathbf{E}(s)$$

The table below shows the data obtained :

| Trial | Initial concentration of **A**(aq) / mol $dm^{-3}$ | Initial concentration of **B**(aq) / mol $dm^{-3}$ | Initial rate of formation of **D**(aq) / mol $dm^{-3}$ $s^{-1}$ |
|---|---|---|---|
| 1 | 0.0836 | 0.202 | $0.26 \times 10^{-4}$ |
| 2 | 0.0836 | 0.404 | $1.04 \times 10^{-4}$ |
| 3 | 0.0418 | 0.404 | $0.52 \times 10^{-4}$ |

Deduce the order of reaction with respect to **A**(aq) and that with respect to **B**(aq).

(2 marks)

(b) A chloroalkaline chemical plant uses membrane electrolytic cells to produce hydrogen, chlorine and sodium hydroxide.

(i) With the help of chemical equations, briefly describe how hydrogen, chlorine and sodium hydroxide are produced in a membrane electrolytic cell.

(4 marks)

(ii) Sodium hypochlorite (NaOCl) can be made from the products obtained in the membrane electrolytic cell. Write a chemical equation for its formation.

(1 mark)

(iii) By using NaOCl, this chemical plant can produce hydrazine ($H_2NNH_2$), a propellant used in space vehicles :

$$NaOCl + 2NH_3 \rightarrow H_2NNH_2 + NaCl + H_2O \qquad \text{Reaction (I)}$$

However, instead of using NaOCl, $H_2O_2$ can also be used to produce hydrazine :

$$H_2O_2 + 2NH_3 \rightarrow H_2NNH_2 + 2H_2O \qquad \text{Reaction (II)}$$

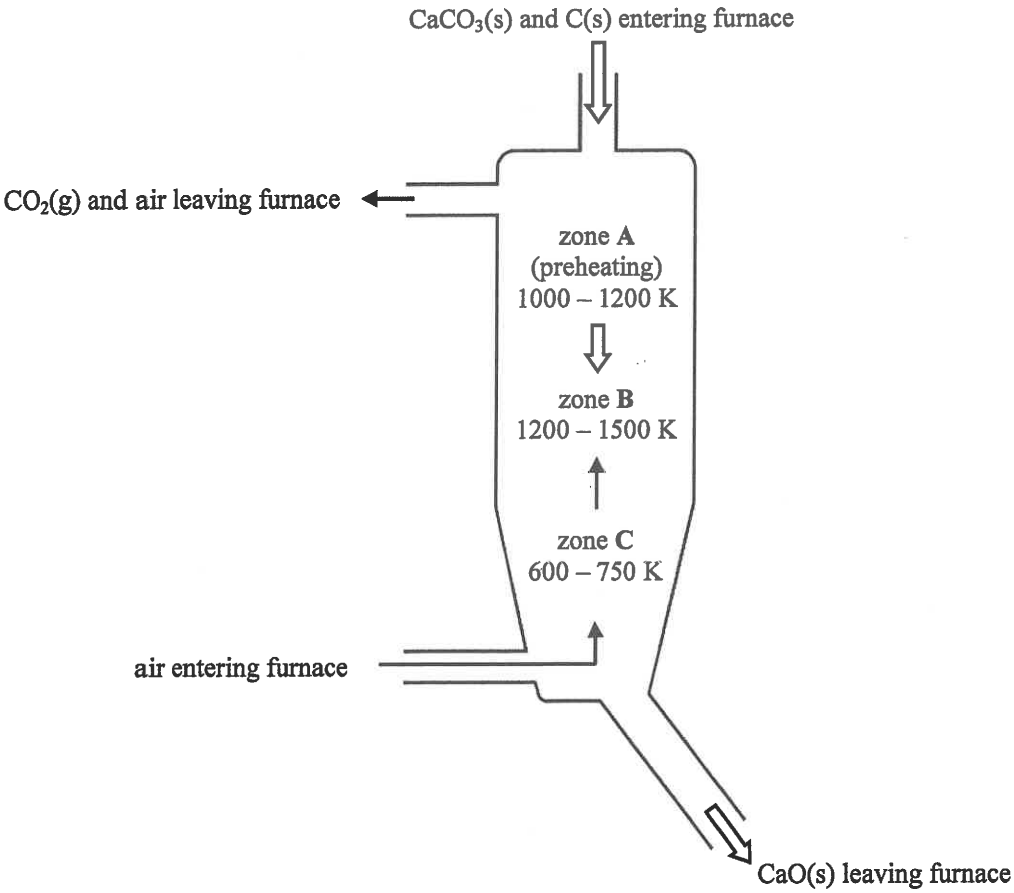
By calculating the respective atom economy of Reaction (I) and Reaction (II), compare which of them can be considered as greener.
(Formula masses : NaOCl = 74.5, $NH_3$ = 17.0, $H_2O_2$ = 34.0, $H_2NNH_2$ = 32.0, NaCl = 58.5, $H_2O$ = 18.0)

(2 marks)

1. (c) In industry, CaO(s) is produced from the decomposition of $CaCO_3(s)$ :

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g) \qquad \Delta H = +180 \text{ kJ mol}^{-1}$$

The diagram below shows an operating furnace for producing CaO(s) in an industrial plant. $CaCO_3(s)$ and C(s) enter the furnace from the top while air enters the furnace near the bottom.




(i) State one feedstock for $CaCO_3(s)$.

(1 mark)

(ii) Explain why the injection of C(s) and air can result in a higher average temperature in zone **B** than in zone **A**.

(1 mark)

(iii) The operation pressure is set at about 1 atm. Give TWO reasons why a higher operation pressure is not preferred.

(2 marks)

(iv) The activation energy of the above decomposition of $CaCO_3(s)$ is 160 kJ $mol^{-1}$. Calculate the ratio of the rate constant at 1500 K to the rate constant at 1200 K for the decomposition of $CaCO_3(s)$.
(Gas constant $R = 8.31$ J $K^{-1}$ $mol^{-1}$)

(3 marks)

(v) According to chemical equilibrium, suggest why the decomposition of $CaCO_3(s)$ mainly occurs in zone **B**.

(1 mark)

**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 :

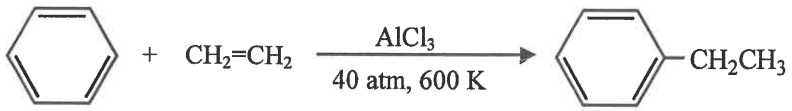
(i) From molecular level, explain why cotton (mainly containing cellulose) absorbs water easily.

(2 marks)

(ii) Draw a diagram to show the arrangement of molecules in the nematic phase of liquid crystals.

(1 mark)

(iii) Based on the given information, suggest TWO reasons why the reaction below can be considered as green.




(2 marks)

(b) Iron and copper are metals widely used in daily life.

(i) Iron crystal has an open structure at room conditions. Name this structure and draw a diagram to represent a unit cell of it.

(2 marks)

(ii) To replace iron-made drinking water pipes with pipes made of copper, the copper pipes may be needed to join together using suitable solder. State which of the alloys **A**, **B** and **C** listed below you would choose to use as the suitable solder and give TWO reasons to support your choice.

| Alloy | Metals contained | Density / g $cm^{-3}$ | Melting point / °C |
|---|---|---|---|
| **A** | Pb, Sn | 8.8 | 183 |
| **B** | Ag, Cu, Sn | 7.4 | 217 |
| **C** | Al, Sn, Ti | 4.5 | 1590 |

(2 marks)

(iii) Suggest why water taps are commonly made of brass instead of copper.

(1 mark)

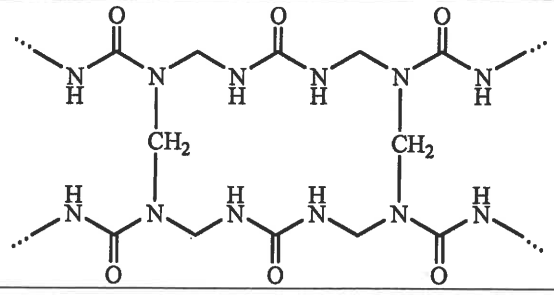
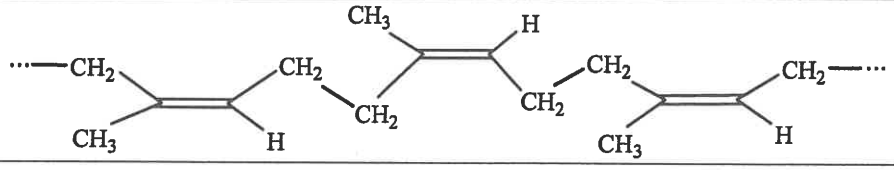
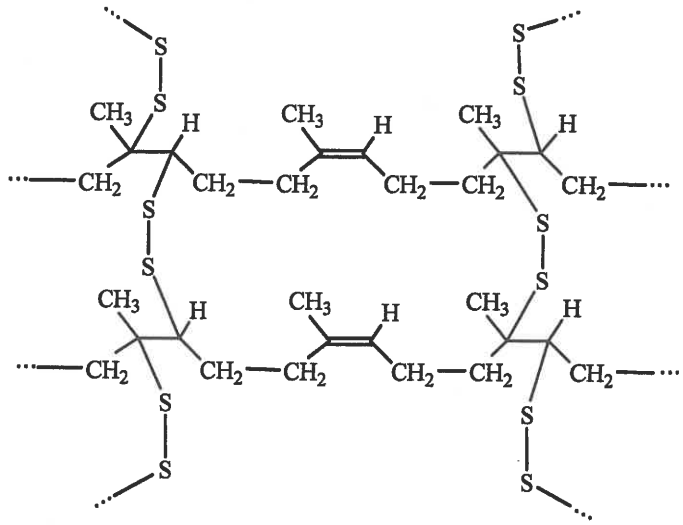
(iv) Iron-made drainage pipes can be replaced with pipes made of polyvinyl chloride (PVC).

(1) Draw the structural formula of polyvinyl chloride.

(2) Suggest a moulding method for making PVC pipes.

(2 marks)

2. (c) **X**, **Y** and **Z** are polymeric materials. Part of their structures are shown below :

| | Part of the structure |
|---|---|
| **X** |  |
| **Y** |  |
| **Z** |  |

(i) **X** is a thermosetting polymer.

(1) Draw the structures of the monomers of **X**.

(2) Name the type of polymerisation in the formation of **X**.

(3 marks)

(ii) In industry, heating **Y** with a substance **W** gives **Z**.

(1) What is **W** ?

(2) Name the process involved.

(2 marks)

(iii) Among these three materials, **Z** is the best in making car tyres.

(1) By considering their physical properties, suggest a reason why **Z** is more suitable than **X** in making car tyres.

(2) Explain, from molecular level, why **Z** is more suitable than **Y** in making car tyres.

(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) The infra-red spectrum of a hydrocarbon (relative molecular mass = 40.0) shows an absorption peak at around 2150 $cm^{-1}$. According to the table below, deduce the possible structural formula of this hydrocarbon.
(Relative atomic masses : H = 1.0, C = 12.0)

**Characteristic Infra-red Absorption Wavenumber Ranges (Stretching modes)**

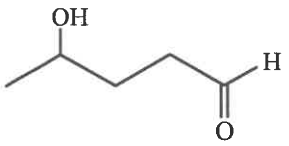
| Bond | Compound type | Wavenumber range / $cm^{-1}$ |
|---|---|---|
| C=C | Alkenes | 1610 to 1680 |
| C=O | Aldehydes, ketones, carboxylic acids and derivatives | 1680 to 1800 |
| C≡C | Alkynes | 2070 to 2250 |
| C≡N | Nitriles | 2200 to 2280 |
| O–H | Acids (hydrogen-bonded) | 2500 to 3300 |
| C–H | Alkanes, alkenes, arenes | 2840 to 3095 |
| O–H | Alcohols (hydrogen-bonded) | 3230 to 3670 |
| N–H | Amines | 3350 to 3500 |

(2 marks)

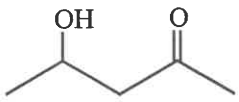
(ii) Organic compounds can be extracted by suitable solvents from their aqueous solutions. The solvents should dissolve the organic compounds to be extracted without reacting with them. State one other property these solvents should have.

(1 mark)

(iii) Suggest a chemical test to show how compounds **A** and **B** below can be distinguished :




**A**




**B**

(2 marks)

(b) In order to determine the sodium contents (existing as NaCl) in a bacon sample, its $Cl^-$ contents should first be found. 2.0 g of the bacon sample was added to 2.50 $cm^3$ of 1.0 M $AgNO_3(aq)$. After that, excess dilute $HNO_3(aq)$ was added to the mixture obtained. The AgCl(s) formed was then removed by filtration. The excess $AgNO_3(aq)$ remaining in the filtrate was then titrated with 0.10 M KSCN(aq) to give AgSCN(s) in the presence of a suitable indicator until the end point was reached. All steps were repeated several times and the mean volume of the KSCN(aq) used to reach the end point was 9.42 $cm^3$.

(i) Why was excess dilute $HNO_3(aq)$ added to the mixture ?

(1 mark)

(ii) Draw a diagram for the set-up to be used in the titration, labelling all apparatus and reagents.

(2 marks)

(iii) Assuming that all $Cl^-$ comes from NaCl in the bacon sample, calculate the percentage by mass of sodium in the bacon sample.
(Relative atomic masses: Na = 23.0, Cl = 35.5, Ag = 107.9)

(4 marks)

3. (c) Chlorine reacted with ethylbenzene (  $-CH_2CH_3$) under sunlight to give a mixture of different chlorinated compounds.

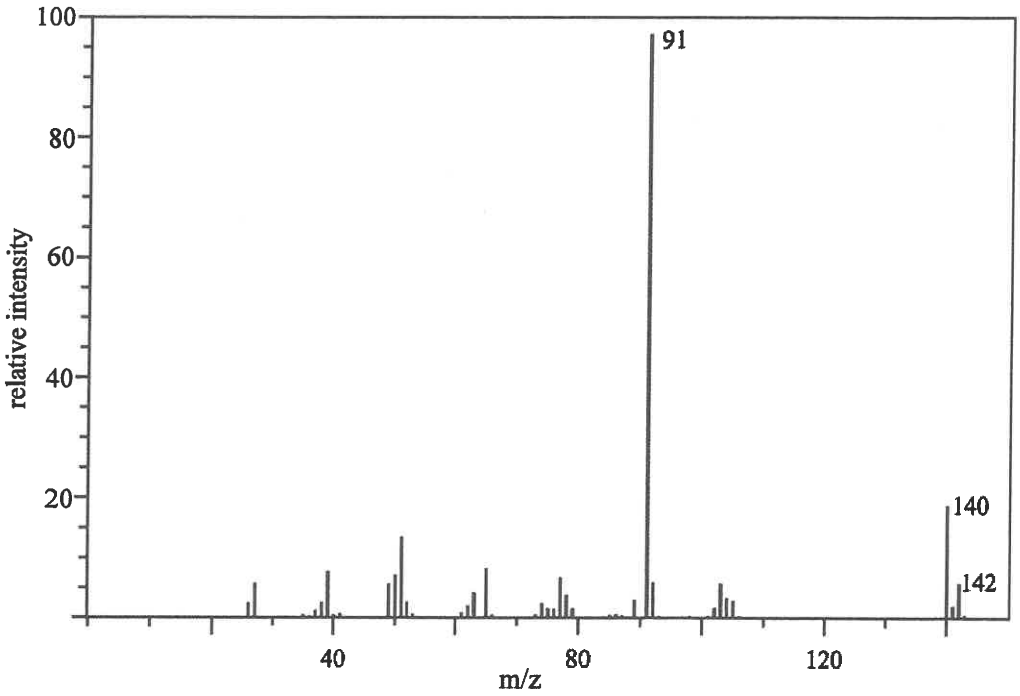
(i) Thin layer chromatography (TLC) was used to separate a small amount of the mixture.

(1) Explain briefly why chromatography can be used to separate a mixture.

(2) Based on the result in TLC, suggest a method to separate a large amount of the mixture.

(3 marks)

(ii) A monochlorinated compound was isolated from the mixture. It is known that chlorine has two isotopes, $^{35}Cl$ and $^{37}Cl$. The mass spectrum of the compound is shown below :




By referring to the labelled peaks, deduce a possible structure of the compound.

(3 marks)

(iii) Pollutants, such as dioxins, can be formed in the manufacturing process of certain chlorine-containing products.

(1) Explain why there is a need to measure dioxin levels.

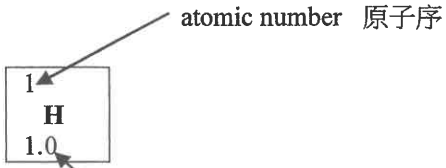
(2) Suggest why dioxin levels are generally measured using modern instrumentation.

(2 marks)

**END OF SECTION C**
**END OF PAPER**

## PERIODIC TABLE 周期表

**GROUP 族**




| 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) |