2025-2026
MOCK EXAM
S.6 CHEM

PAPER 2

Good Hope School
Mock Examination 2025-2026

S.6 CHEMISTRY PAPER 2

1 hour
This paper must be answered in English

Name	
Class	
Class Number	
Block Number	

INSTRUCTIONS

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

(2) Write your answers in the 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.

Section A Industrial Chemistry

Answer **ALL** parts of the question.

1. (a) A chemical manufacturer plans to produce large quantities of ethanol (C_2H_5OH). Details of two different methods are shown in the table below:

	Method 1	**Method 2**
Reaction	$C_6H_{12}O_6(aq) \xrightarrow{\text{zymase}} 2C_2H_5OH(aq) + 2CO_2(g)$ glucose	$C_2H_4(g) + H_2O(g) \underset{}{\overset{\text{Conc. } H_3PO_4}{\rightleftharpoons}} C_2H_5OH(g)$
Reaction Conditions	• 35 – 40 °C • 1 atm	• 300 °C • 60 – 70 atm

(i) Calculate the percentage atom economy for the formation of ethanol in Method 1. (1 mark)
(Relative molecular masses: $C_6H_{12}O_6$ = 180.0, C_2H_5OH = 46.0, CO_2 = 44.0)
Percentage atom economy = [(2 x 46.0) / 180.0] x 100% = 51.1% [1]
Excellent performance.

(ii) Suggest two reasons, based on the principles of green chemistry, why Method 1 might be considered 'greener' than Method 2. (2 marks)

[Any two of the following. 1 mark each]
- Method 1 uses glucose from renewable feedstock whereas Method 2 uses non-renewable crude oil.
- Method 1 operates at a lower temperature (35-40 °C) / pressure (1 atm), requiring less energy input (lower carbon footprint from energy use).
- Method 1 does not use corrosive chemicals while method 2 uses corrosive H_3PO_4.

Good performance.

- Some students falsely stated H_3PO_4 is toxic.
- Some students only stated the conditions without comparing or associating them with the energy input.
- NOT accept "using biodegradable glucose" as answer. Biodegradable refers to how a substance breaks down in the environment. While glucose is biodegradable, however, we aren't throwing the glucose away; we are converting it into ethanol.

(iii) Apart from higher atom economy, suggest ONE advantage of manufacturing ethanol using method 2 over method 1. (1 mark)

[Any one of the following. 1 mark each]
- Method 2 does not consume food but method 1 does.
- The rate of reaction of method 2 is faster than method 1.
- Method 2 produces ethanol in higher purity than method 1.

Fair performance.
- Some students suggested that there would be no by-products formed. However, this idea is too similar to the concept of atom economy.
- During fermentation (Method 1), yeast produces side products like carbon dioxide, glycerol, and various esters. Dead yeast cells and leftover sugar also remain in the mix. The resulting "broth" is mostly water and requires extensive, energy-heavy distillation to reach high purity.
- Enzymes are biological catalysts that are highly efficient but have a "speed limit" and can become denatured (break down) if the temperature rises too high

(iv) The reaction in Method 2 is reversible and exothermic.

(1) Explain why a temperature of 300 °C is used. (1 mark)

Although a lower temperature favours the forward exothermic reaction shifting the equilibrium position to the right, increasing the product yield. However, the rate at lower temperature would be too slow to be economical. 300 °C is a compromise temperature. [1]

Fair performance.

- Many students would only mention how the temperature affects the rate / yield, without mentioning the **compromise** between the two.

(2) Without changing the operation conditions, suggest how Method 2 can be implemented in a more economical way. (1 mark)

installing heat exchanger/ recycling unreacted reactants [1]

Good performance.

(v) The catalyst in Method 1 (zymase) and Method 2 (H_3PO_4) both increase the rate of reaction. Explain how a catalyst works. (2 marks)

Catalyst provides an alternative pathway of lower activation energy. [1] In the presence of catalyst, there will be a high proportion of reactant particles having energy higher than equal to activation energy, hence the frequence of effective collision increases. [1] Rate of reaction thus increases.

Fair performance. Some students only mentioned the first point, while some mentioned that a catalyst would increase the forward and backward rate by the same extent, which is describing the effect of catalyst but not explaining how it works.

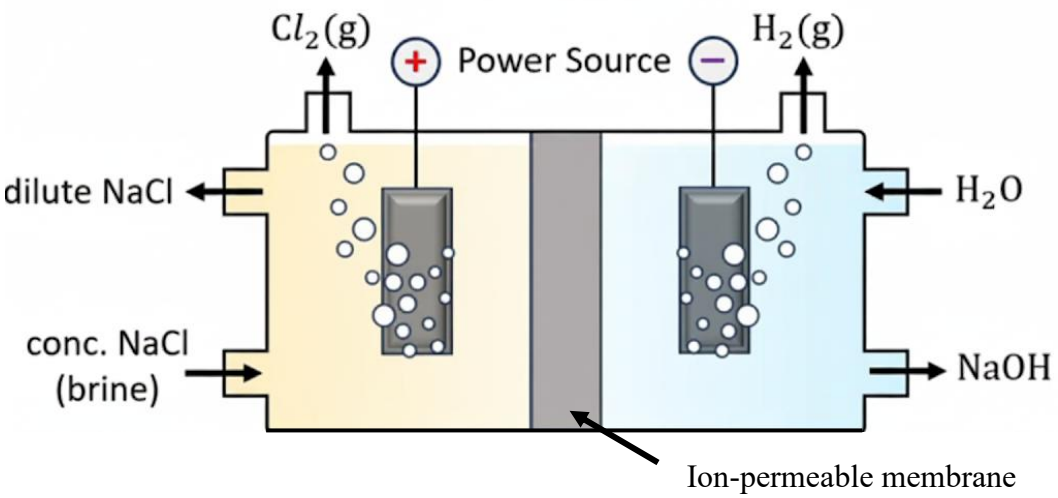
[8 marks]

1. (b) (i) Write a chemical equation to show how hydrogen can be synthesized from natural gas. (1 mark)

$CH_4 + H_2O \rightleftharpoons CO + 3H_2$ [1]

Fair performance. Some students wrote the equation for water gas shift reaction instead. Some students did not balance the equation correctly. Some students did not use a reversible arrow.

(ii) The diagram below shows a membrane electrolytic cell used in the chloroalkali industry.



(1) Explain the working principle of membrane cell to produce hydrogen and sodium hydroxide. Equations are NOT required. (2 marks)

$H^+(aq)$ ions are discharged to give H_2 at the cathode as H^+ occupies a lower position than $Na^+(aq)$. [1]

The membrane is permeable to cations only. As there is a higher concentration of Na^+ at the anodic compartment, $Na^+(aq)$ ions flow to the cathodic compartment. [1] Hence, together with $OH^-(aq)$ remained, concentrated NaOH(aq) is formed.

Poor performance. Many students were able to tell H^+ would be discharged but could not explain why. They also failed to mention in detail why Na^+ ions are able to flow to the cathodic compartment.

(2) A chemical engineering intern proposes substituting the standard highly purified brine with filtered sea water to reduce raw material costs.
Explain the undesirable chemical consequence of using filtered sea water to replace brine in the membrane cell. (1 mark)

- Filtered sea water contains Ca^{2+}/ Mg^{2+} which may pass through the ion-membrane and contaminates the NaOH in the cathodic compartment/ forms insoluble $Ca(OH)_2$/ $Mg(OH)_2$ which may clog the membrane, reducing its efficiency. OR
- Sea water contains a lower concentration of NaCl than brine, hence OH^- may be discharged give O_2 instead.

Poor performance. Some students thought the impurities would poison the catalyst. Some students did not mention in detailed what would be formed instead.

[4 marks]

1. (c) A blue food dye (**B**) reacts with hypochlorite ions (OCl^-) to form a colourless product (**Q**). The reaction can be represented as follows:

$$\mathbf{B}(aq) + OCl^-(aq) \rightarrow \mathbf{Q}(aq)$$

An experiment was conducted to determine the order of reaction with respect to $OCl^-(aq)$. In each trial of experiment, different volumes of NaOCl(aq), water were mixed with a fixed volume of **B**(aq) at 298 K. The time taken (t) for the disappearance of blue colour was determined. The results are shown below:

Trial	Volume of 1.0 M NaOCl(aq) / cm^3	Volume of 0.03 M **B**(aq) / cm^3	Volume of water / cm^3	Time taken (t) /s
1	2.5	5.0	7.5	120
2	5.0	5.0	5.0	30
3	6.0	5.0	4.0	x

(i) Explain why the experiment would be considered unfair if water is not added to make the total volume of the mixture the same. (1 mark)

If the total volume of the mixture is different in each trial, the initial concentration of **B**(aq) would also change from one trial to the next, in addition to the concentration of $OCl^-(aq)$. This would not be a fair test, as there are two variables. [1]

Poor performance. Some students could not mention the concentration of B(aq) would also be changed. The reason why it should be mentioned is because rate = $k[NaOCl]^m[B]^n$. That means the rate also depends on the concentration of B(aq). Though same volume of 0.03 M **B**(aq) is used, however, when the total volume of the mixture varies, the concentration of concentration of **B**(aq) change too.

(ii) Using the data in the table, deduce the order of reaction with respect to OCl^-(aq). (1 mark)

$1/t = k\,[NaOCl]^m[B]^n$
$1/120 = k\,[2.5]^m[5]^n$ -------(1)
$1/30 = k\,[5.0]^m[5]^n$ --------(2)
(1)/(2) $(1/120) / (1/30) = (2.5/5)^m$
$m = 2$ [1]

Good performance.

(iii) Deduce the time taken, *x*, for the disappearance of blue colour in Trial 3. (1 mark)

$(1/120) / (1/x) = (2.5/6)^2$

$x = 20.8$ [1]

Good performance. Note that *x* should not carry any unit.

(iv) Describe how you would conduct an experiment and use a suitable graph to show that the reaction is first order with respect to **B**(aq). (3 marks)

Repeat the experiment by mixing different volume of **B** and water used, but using fixed volume of NaOCl while keeping the total volume of the mixture the same. [1] Measure the time taken for the disappearance of blue colour in each trial.

Plot a graph of 1/t against volume of B used. [1] A straight line passing through the origin is obtained [1] which shows that the rate is directly proportional to concentration of [B(aq)].

Poor performance. Many students would miss out the controlled variables e.g. volume of the total mixture. Some students plotted a wrong graph. Note that we need like to show the reaction is first order with respect to B(aq) i.e. rate = k'[B]. The rate depends on 1/t while the concentration of B(aq) depends on the volume of B used. The line would be a straight line through the origin.

(v) Trial 1 was repeated at 323 K. The time taken for the blue colour to disappear was 18 s. Calculate the activation energy of the reaction.

(Gas constant, R = 8.31 J K^{-1} mol^{-1}) (2 marks)

$$\log\frac{k_1}{k_2} = -\frac{Ea}{2.3R}\left(\frac{1}{T_1}-\frac{1}{T_2}\right)$$

$$\log\frac{1/t_1}{1/t_2} = -\frac{Ea}{2.3R}\left(\frac{1}{T_1}-\frac{1}{T_2}\right)$$ [1]

$$\log\frac{1/120}{1/18} = -\frac{Ea}{2.3\,(8.31)}\left(\frac{1}{298}-\frac{1}{323}\right)$$

$Ea = 60630$ J mol^{-1} = 60600 J mol^{-1} or 60.6 kJ mol^{-1} [1]

Good performance. Some students did not round the value to 3 sig figs. Some students gave a wrong unit for E_a.

[8 marks]

Section B Material Chemistry

Answer **ALL** parts of the question.

2. (a) (i) Cellulose is a condensation polymer of glucose.

(1) What is the meaning of the term "condensation polymer"? (1 mark)

(2) Draw the structure of a molecule of glucose. (1 mark)

(ii) The relative molecular mass of cellulose generally ranges from 2.5×10^5 to 1.0×10^6. Suggest why the relative molecular mass of cellulose falls into a wide range. (1 mark)

(iii) Explain why there is a significant difference in the solubility of glucose and cellulose in water. (3 marks)

(b) (i) Methyl cellulose is a polymer synthesized from cellulose. It is commonly used as the active ingredient of wallpaper glue.

Methyl cellulose glue, when dried, is a white solid. State and explain the behaviour of the white solid when it is gradually heated up to a very high temperature. (3 marks)

(ii) Poly(methyl 2-cyanoacrylate) is commonly used as the active ingredient of superglue.

(1) Draw the structure of the monomer of poly(methyl 2-cyanoacrylate). (1 mark)

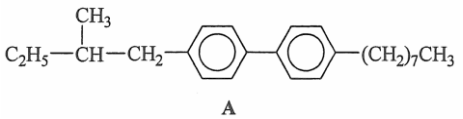
(2) Propanone is a commonly used solvent for removing hardened superglue. Explain why propanone can dissolve poly(methyl 2-cyanoacrylate). (2 marks)

(iii) Which of methyl cellulose or poly(methyl 2-cyanoacrylate) degrades more readily in the environment? Explain your answer. (2 marks)

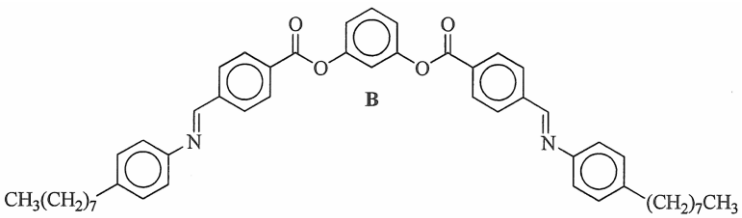
(c) Liquid crystals are widely used in making visual displays. Liquid crystals can have various phases in their structures.

(i) Compare the nematic phase and the smectic phase of liquid crystals. (2 marks)

(ii) Explain which of the following compounds, **A** or **B**, would form cholesteric phase liquid crystals. (1 mark)



A



B

(iii) Suggest why liquid crystal would lose liquid crystal properties at very low temperatures. (1 mark)

(iv) Organic Light Emitting Diode (OLED) can emit light when an electric current passes through. OLED can also be used in making visual displays. Explain why the power efficiency of liquid crystal displays is considered to be lower than that of OLED displays. (2 marks)

END OF SECTION B

Section C Analytical Chemistry

Answer **ALL** parts of the question.

3. (a) Suggest a chemical test to distinguish between

(i) propanone and propanal; (2 marks)

Warm the two liquids with Tollen's reagent. [1]
Only propanal will give a silver mirror on the wall of the test tube. [1]
Good performance.

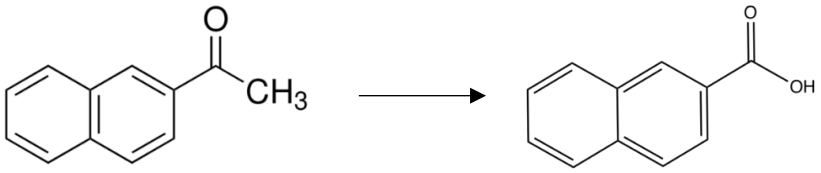
(ii) zinc nitrate solution and aluminium nitrate solution. (2 marks)

Add $NH_3(aq)$/ NH_3 solution dropwise until excess. [1] [0 for missing the physical state]
Zinc nitrate gives white precipitate which redissolve in excess $NH_3(aq)$ while aluminium nitrate gives white precipitate which does not redissolve. [1]

Fair performance.
Common mistakes:

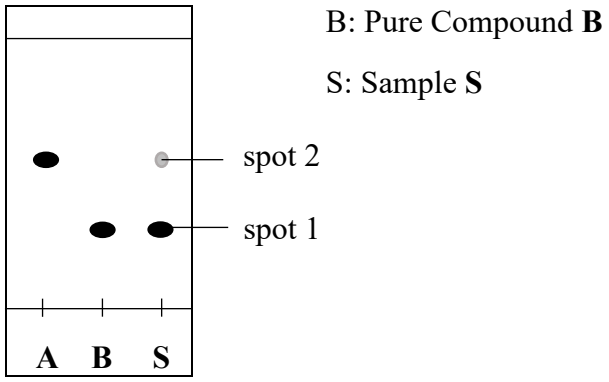
- Missing physical states
- Some students only gave the observation of one of the solutions.
- Some students wrong describe the observation as "In excess ammonia, zinc nitrate redissolves" instead of referring to the "precipitate" which redissolves.

(b) A chemist synthesized the following organic compound **B** using the following synthetic route:



compound **A** compound **B**

(i) After the synthesis, the solid product obtained, sample **S**, is dissolved in diethyl ether and analyzed by thin-layer chromatography using a suitable organic solvent. The chromatogram obtained is shown below:



(ii) (1) Explain why compound **B** has a smaller R_f value than compound **A**. (1 mark)
Compound **B** is more strongly adsorbed to the stationary phase / less soluble in the mobile phase. [1]

Fair performance. Some students could not mention the stationary phase / the mobile phase.

(2) What does the result of the chromatogram show about sample **S**? (1 mark)

The sample obtained has compound **B** with trace amount of compound **A**. [1]

Fair performance. Some students only mentioned that sample S is a mixture of A and B, without comparing the relative amounts.

(b) (ii) Outline the steps to obtain compound **B** from sample **S** dissolved in diethyl ether using liquid-liquid extraction. (3 marks)

1. $NaHCO_3(aq)$ is added to the sample solution.
   The mixture is shaken in a separating funnel. [1]
2. The mixture in the separating funnel is allowed to settle. The organic layer is discarded.
   Dilute HCl(aq) is added to the aqueous layer. [1]
3. Solid compound *B* can be obtained by filtration. [1]

Fair performance. Compound B is a carboxylic acid. Therefore, it should be reacted with a base first to form a carboxylate ion which readily dissolves in the aqueous layer. In the end, we need to regenerate the acid back. So an acid is required.

Remarks: It is more direct to separate the solid acid formed in the aqueous layer in step 2 by filtration than using ether to extract the acid, which further requires separation of liquids and distillation to distil off ether to isolate the acid.

(c) An experiment was performed to determine the concentration of hypochlorite ions $OCl^-(aq)$ in a commercial brand of bleach.

A 25.0 cm^3 of sample of the bleach was diluted to 250.0 cm^3 with distilled water in a volumetric flask. 25.0 cm^3 of the diluted solution was transferred into a conical flask containing excess potassium iodide solution and excess dilute sulphuric acid. The following reaction occurred:

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

The liberated iodine was titrated against 0.100 mol dm^{-3} sodium thiosulphate solution $Na_2S_2O_3(aq)$ using starch solution as an indicator. 18.50 cm^3 of $Na_2S_2O_3(aq)$ was required to reach the end point. The reaction was:

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

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

From dark blue to colourless [1]

Some students had the colour change in the other way round. Note that the starch and I_2 formed from reaction 1 should be in the conical flask. Therefore, the original colour should be dark blue.

(ii) Calculate the concentration, in mg dm^{-3} of hypochlorite ions in the undiluted commercial bleach.
(Relative atomic masses: O = 16.0; Cl = 35.5) (3 marks)

Number of moles of $Na_2S_2O_3(aq) = 0.100 \times \frac{18.50}{1000} = 1.85 \times 10^{-3}$

Mole ratio of $I_2 : S_2O_3^{2-} = 1 : 2$

Number of moles of $I_2(aq) = 1.85 \times 10^{-3} / 2 = 9.25 \times 10^{-4}$ [1*]

Mole ratio of $OCl^- : I_2 = 1 : 1$

Number of moles of $OCl^-(aq) = 9.25 \times 10^{-4}$

Number of moles of $OCl^-(aq)$ in undiluted bleach $= 9.25 \times 10^{-4} \times (250.0/25.0) = 9.25 \times 10^{-3}$

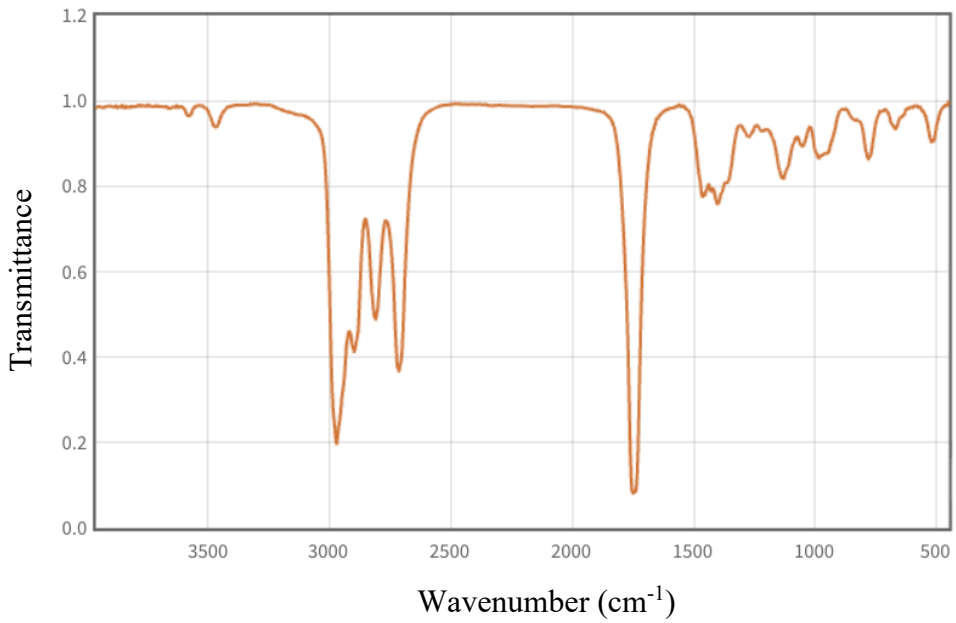
Mass of OCl^- in mg $= 9.25 \times 10^{-3} \times (16+35.5) \times 1000 = 476$ mg [1*]

Concentration of OCl^- in mg dm^{-3} = 476 mg / (25/1000) = 19055 mg dm^{-3}

= 19100 mg dm^{-3} [1]

Fair performance. Many students convert g to mg wrongly.

(d) A straight-chain organic compound **X** ($C_xH_yO_z$) has a relative molecular mass of 72.0. It contains 66.7% carbon, 11.1% hydrogen and 22.2% oxygen by mass. The infrared spectrum of the compound is shown below:



(i) Deduce the molecular formula of **X**.
(Relative atomic masses: H = 1.0; C= 12.0; O = 16.0) (2 marks)

Mole ratio of C to H to O $= \frac{66.7}{12.0} : \frac{11.1}{1.0} : \frac{22.2}{16.0} = 4 : 8 : 1$

∴ the empirical formula of Z is C_4H_8O. [1]

Let the molecular formula of **X** be $(C_4H_8O)_n$, where n is an integer.

$n \times (12.0 \times 4 + 1.0 \times 8 + 16.0) = 72.0$

$n = 1$

∴ the molecular formula of **X** is C_4H_8O. [1] Excellent performance.

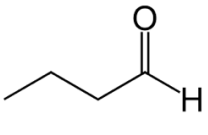
(ii) With reference to the following table, deduce TWO possible structures of **X**. (3 marks)

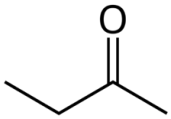
Characteristic Infra-red Absorption Wavenumber Ranges (Stretching modes)

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
O–H	Alcohols, phenols (hydrogen-bonded)	3230 to 3670

In the IR spectrum, a strong absorption peak appears at around 1680 – 1800 cm^{-1}, which shows the presence of C=O bond. [1]

The two possible structures are:



[1] and


[1]

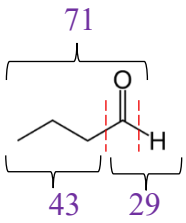
Fair performance. Many students wrongly thought that there is O-H bond in acids. However, there should only be ONE O atom in the molecule, which will eliminate this option.

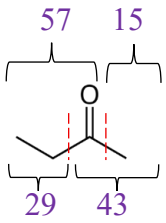
(d) (iii) Suggest how the structure of **X** can be confirmed by using mass spectrometry. (1 mark)

Only butanal will give a prominent peak at m/z = 71, corresponding to $CH_3CH_2CH_2CO^+$ ion. /

Only butanone will give a prominent peak at m/z = 57, corresponding to $CH_3CH_2CO^+$ ion. [1]

Poor performance. Many students did not mention the peaks involved. Some mentioned using m/z = 29, but it would correspond to CHO^+ ion or $CH_3CH_2^+$ ion resulted from fragmentation of butanal and butanone respectively. Some mentioned m/z = 43, but it would correspond to $CH_3CH_2CH_2^+$ ion or CH_3CO^+ ion resulted from fragmentation of butanal and butanone respectively.





(e) Dioxins are toxic air pollutants. Explain why the concentration of dioxins is measured using gas-chromatography-mass spectrometry. (1 mark)

Gas-chromatography-mass spectrometry is accurate and sensitive to low concentration. [1]

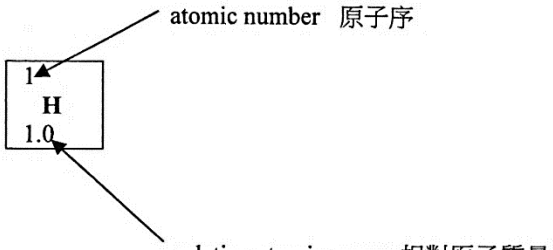
Good performance.

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)