Marking Schemes

This document was prepared for markers' reference. It should not be regarded as a set of model answers. Candidates and teachers who were not involved in the marking process are advised to interpret its content with care.

Chemistry
Paper 1

SECTION A

Question No. Part I	Key	Question No. Part II	Key
1.	C (92%)	25.	C (66%)
2.	A (68%)	26.	B (69%)
3.	B (40%)	27.	D (78%)
4.	B (83%)	28.	D (66%)
5.	A (59%)	29.	B (50%)
6.	C (69%)	30.	A (75%)
7.	B (83%)	31.	C (58%)
8.	B (82%)	32.	C (74%)
9.	C (76%)	33.	A (81%)
10.	C (83%)	34.	D (64%)
11.	A (69%)	35.	B (86%)
12.	D (43%)	36.	A (72%)
13.	D (70%)		
14.	A (78%)		
15.	B (24%)		
16.	D (67%)		
17.	C (81%)		
18.	B (84%)		
19.	A (70%)		
20.	D (49%)		
21.	D (53%)		
22.	C (72%)		
23.	D (80%)		
24.	A (78%)		

Note: Figures in brackets indicate the percentages of candidates choosing the correct answers.

General Marking Instructions

1. In order to maintain a uniform standard in marking, markers should adhere to the marking scheme agreed at the markers' meeting.

2. The marking scheme may not exhaust all possible answers for each question. Markers should exercise their professional discretion and judgment in accepting alternative answers that are not in the marking scheme but are correct and well reasoned.

3. In questions asking for a specified number of reasons or examples etc. and a candidate gives more than the required number, the extra answers should not be marked. For instance, in a question asking candidates to provide two examples, and if a candidate gives three answers, only the first two should be marked.

4. In cases where a candidate answers more questions than required, the answers to all questions should be marked. However, the excess answer(s) receiving the lowest score(s) will be disregarded in the calculation of the final mark.

5. Award zero marks for answers which are contradictory.

6. Chemical equations should be balanced except those in reaction schemes for organic synthesis. For energetics, the chemical equations given should include the correct state symbols of the chemical species involved.

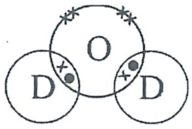
7. In the question paper, questions which assess candidates' communication skills are marked with an asterisk (*). For these questions, the mark for effective communication (1 mark per question) will be awarded if candidates can produce answers which are easily understandable. No marks for effective communication will be awarded if the answers produced by candidates contain a lot of irrelevant materials and/or wrong concepts in chemistry.

SECTION B

Part I

Marks

1. (a) Protium and deuterium have same number of protons but different numbers of neutrons. / Protium and deuterium have same atomic number but different mass numbers. 1

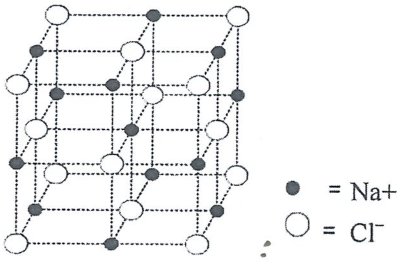
(b) 

1

(c) (i) Any TWO of the following (1 mark for each point) : 2

- Colourless gas evolves.
- Sodium metal dissolves. / Sodium drags / moves on the surface of $D_2O(l)$.
- Sparks are observed. / Flame is observed. / Sodium burns. / Heat evolves. / White fume evolves. / Hissing sound is heard.

(ii) $2Na + 2D_2O \rightarrow 2NaOD + D_2$ 1

2. (a) 

1

(b) (i) Total mass of 4 Na^+ ions and 4 Cl^- ions
$= (23.0 + 35.5) \times 4 / L = 234 / L$ (g) 1

(ii) $234 / L = 2.17 \times 1.80 \times 10^{-22}$
$L = 5.99 \times 10^{23}$ (mol^{-1}) 2

3. (a) (i) bromine in organic solvent 1

(ii)
- $CH_3–CH=CH–CH_3 + Br_2 \rightarrow CH_3–(CHBr)_2–CH_3$ 1
- But-2-ene / An alkene reacts with Br_2, and Br_2 is decolourised / all Br_2 is consumed / a colourless product is formed. 1

(b)
- Gas **X** may be ammonia / NH_3. 1
- $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$ 1
- $OH^-(aq)$ turns phenolphthalein pink. / Ammonia / The gas / The solution is alkaline, and it turns phenolphthalein pink. 1

Marks

4. (a) (i) • Dissolve the solid by adding deionised / distilled water to the solid in a beaker. 1
• Transfer the solution with rinsing with deionised / distilled water into a 250.0 cm^3 volumetric flask and add deionised / distilled water to the graduation mark of the flask and shake thoroughly. 1

(ii) molarity of the standard solution = (1.12 / 204.1) ÷ 0.2500 2
= 0.022 (M)

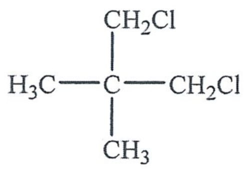
(b) • If it ionises completely in water, $[H^+(aq)]$ = 0.060 M then the pH will be 1.22. 1
• However, the actual pH (3.30) is higher than 1.22, therefore the –COOH group in potassium hydrogenphthalate only ionises partly in water. 1

5. (a) chlorine / Cl_2 1

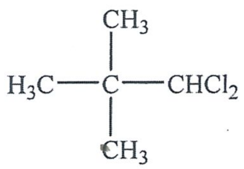
(b) light / *hυ* / ultra-violet / UV / radical initiator 1

(c) substitution reaction 1

(d) (i) 1



or

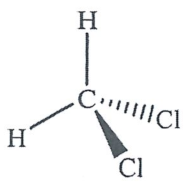


1,3-dichloro-2,2-dimethylpropane 1,1-dichloro-2,2-dimethylpropane 1

(ii) The structure other to the answer in (i) 1

(iii) structural isomer 1

6. (a) 1



(b) (i) The polarities of bonds in CCl_4 cancel out each other while those in CH_2Cl_2 do not. 1

(ii) • CCl_4 has a larger molecular size than that of CH_2Cl_2. 1
• Therefore, it has stronger van der Waals' forces between molecules / intermolecular forces, and hence a higher boiling point. 1

Marks

7. (a) (i) Separate the $CuSO_4(aq)$ and $MgSO_4(aq)$. / Allow ions to pass through. / Complete the circuit. 1

(ii) Yes. The multimeter reading is positive showing electrons flowing from Mg to Cu through the external circuit as Mg loses electrons more readily than Cu. 1

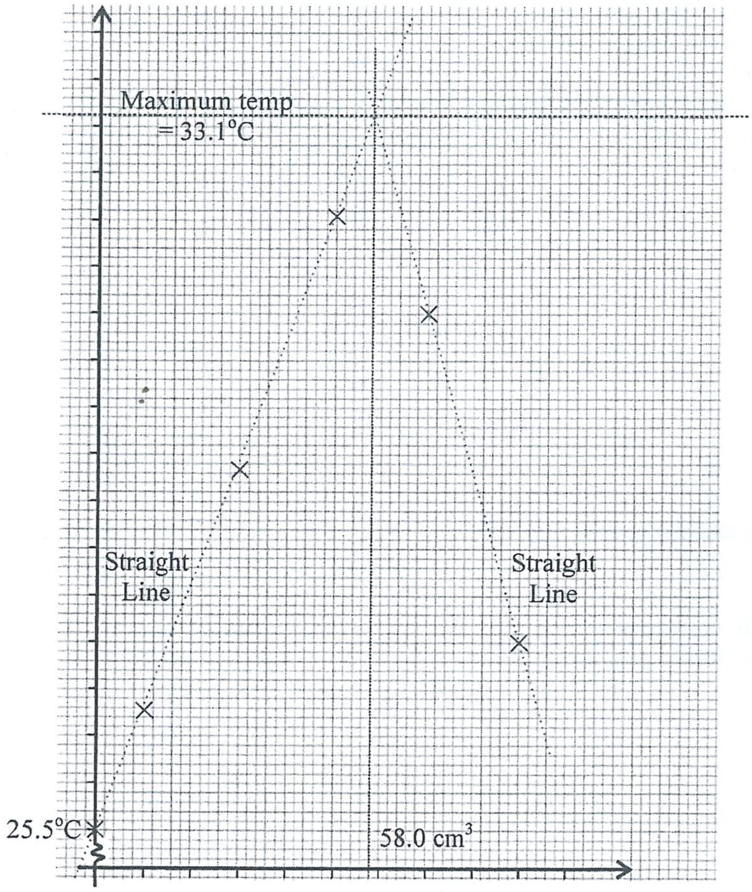
(iii) $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ 1

(b) (i) $Br_2(aq) + 2e^- \rightarrow 2Br^-(aq)$ 1

(ii) The size of the electrode decreases. / Colour around the electrode deepens. 1

(iii)
- less negative 1
- Iodine gains electrons less readily than bromine. 1

8. (a) 1



(b) (i) No. of moles of NaOH(aq) used = 1.0 × (58.0 ÷ 1000) = 0.058 2

∵ At equivalent point, no. of moles of NaOH(aq) used = No. of moles of HCl(aq) reacted

∴ No. of moles of HCl(aq) reacted = 0.058

Concentration of HCl(aq) = 0.058 ÷ (42.0 ÷ 1000) = 1.38 mol dm^{-3}

(ii) Energy released during the reaction = 100.0 × 1.0 × 4.18 × (33.1 – 25.5) = 3176.8 J 2

Enthalpy change of neutralisation = –3176.8 ÷ (0.058 × 1000) = –54.77 (kJ mol^{-1})

(c) The term means the enthalpy change when an acid solution and a base / an alkali solution react together under standard conditions to produce 1 mole of water. 1

				Marks
9.	(a)	(i)	Prevents the iron from contacting with air / oxygen / water.	1
		(ii)	Yes. These iron cans corrode more readily as tin is less reactive than iron.	1
		(iii)	Zinc ions are toxic and may contaminate the food.	1
	(b)	(i)	Aluminium has an impervious / impermeable layer of oxide / aluminium oxide on the surface.	1
		(ii)	anodisation	1
		(iii)	It has a low density / is malleable / is easy to mould / recycle / dye.	1

10. Chemical knowledge — 4

- Dissolve the sample in distilled water.
- Add excess $Zn(s)$ to the sample solution.
- Filter to collect $ZnSO_4(aq)$.
- Evaporate the filtrate, allow $ZnSO_4$ solid to crystallise out / collect crystals and then dry with filter paper / in a desiccator.

Communication mark — 1

Part II

Marks

11. (a) $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$ / 1
$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$

(b) (i) $(82.8 - 82.0)$ g / $(12 - 2)$ min 2
$= 0.08$ g min^{-1}
OR
$(82.8-82.0)$g / $[(12-2)\times 60]$s
$= 1.33\times 10^{-3}$ g s^{-1}

(ii)
- The slope / curvature of the tangent of the curve at t=0 for Trial 2 is larger than that for Trial 1. 1
- It shows a higher initial rate of reaction as the concentration of HNO_3 / H^+ in Trial 2 is higher than that in Trial 1. 1

OR
- The decrease in mass for Trial 1 is smaller than that for Trial 2.
- Less CO_2 is given out in Trial 1 because the number of moles of HNO_3 / H^+ used in Trial 1 is less than that in Trial 2.

(c) Use same mass of calcium carbonate of different sizes to perform the experiment, all other conditions of the experiment should be kept unchanged. 1

12. (a) $[Fe(SCN)^{2+}(aq)] / [Fe^{3+}(aq)][SCN^-(aq)]$ 1

(b) 3

$$\begin{array}{ccccc} Fe^{3+}(aq) & + & SCN^-(aq) & \rightleftharpoons & Fe(SCN)^{2+}(aq) \\ 0.020 - x & & 0.010 - x & & x \end{array}$$

$x / (0.020 - x)(0.010 - x) = 1.08 \times 10^3$
$x = 0.0217$ mol dm^{-3} (rejected since larger than both 0.020 and 0.010)
$x = 9.21 \times 10^{-3}$ mol dm^{-3}

(c) Increasing of K_c means that the equilibrium position shifts to the right / product side, hence the ΔH should be positive. 1

(d)
- $Na_2SO_3(s)$ added reacts with $Fe^{3+}(aq)$ so as to decrease the concentration of $Fe^{3+}(aq)$. 1
- The equilibrium position shifts to the left / reactant side. The concentration of $Fe(SCN)^{2+}$ decreases, so the colour of the mixture becomes paler. 1

Marks

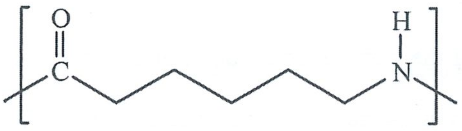
13. (a) (i) ethanal / acetaldehyde / CH_3CHO — 1

(ii) It is because ethanal has a low boiling point / is volatile, so was easily distilled off / vaporised out and cannot be further oxidised to give ethanoic acid. — 1

(b) (i) ethanamide — 1

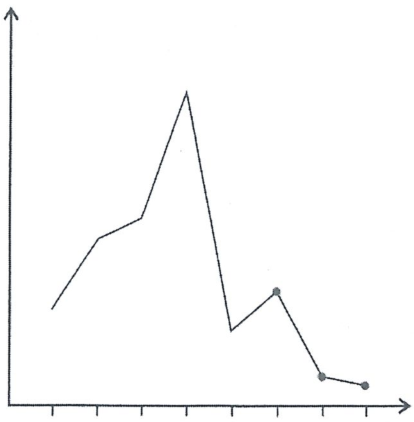
(ii) 1. PCl_3 2. NH_3 — 1

(c) (i) — 1



(ii) As there is no losing of small molecules during the polymerisation, it can be regarded as no condensation is involved. — 1

14. (a) — 1



(b) The metallic bond in Mg is stronger than that in Na as Mg has more delocalised electrons / more outermost shell electrons than Na. OR
The metallic bond in Mg is stronger than that in Na as Mg has two outermost shell delocalised electrons while Na has one only. — 1

(c)
- Melting of Si needs high energy to break the strong covalent bonds between Si atoms in the giant covalent structure. — 1
- Melting of P only needs smaller energy to break the weak intermolecular forces. / P has a simple molecular structure, there are weak van der Waals' forces between molecules. — 1

15. Chemical knowledge (1 mark for each point, a maximum of 4 marks) — 4
- It reduces the water surface tension so that water can spread and wet the surfaces.
- The hydrocarbon tails of the detergent particles dissolve in oil (hydrophobic).
- The ionic heads of the detergent particles dissolve in water (hydrophilic).
- Water molecules attract the hydrophilic ionic heads and bring the oil into water.
- By stirring, the oil breaks up into tiny droplets and these droplets cannot come together again due to the repulsion between ionic heads / negative charges.

Communication mark — 1

Paper 2

Marks

1. (a) (i) The Haber process produces ammonia / NH_3 which can make fertilisers to increase crop yield. 1

(ii) (1) $CH_4 + H_2O \rightarrow CO + 3H_2$ 1

(2) It is because biomass is a renewable energy resource. 1

(iii)
- Comparing Trial 3 with Trial 2 (both same in [**B**(aq)], doubling the [**A**(aq)] leads to a double of the initial rate. Hence, the order of reaction with respect to **A**(aq) = 1. 1
- Comparing Trial 1 with Trial 2 (both same in [**A**(aq)], doubling the [**B**(aq)] leads to four times of the initial rate. Hence, the order of reaction with respect to **B**(aq) = 2. 1

(b) (i)
- Use concentrated sodium chloride solution / brine as electrolyte. 1
- Anode : $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ 1
- Cathode : $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ 1
- The membrane is permeable to cations but not anions. 1

(ii) $Cl_2(g) + 2NaOH(aq) \rightarrow NaOCl(aq) + NaCl(aq) + H_2O(l)$ 1

(iii) Atom economy for Reaction (I) = 32 / 108.5 = 29.5 % 2
Atom economy for Reaction (II) =32 / 68 = 47.1 %
Reaction (II) is greener as it has a higher atom economy.

(c) (i) limestone / marble 1

(ii) Carbon burns in air to produce heat. 1

(iii)
- High operation pressure needs high construction cost. 1
- High operation pressure shifts the equilibrium position to the left, decreasing the yield. 1

(iv) 3

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

$$\log\left(\frac{k_2}{k_1}\right) = \frac{160 \times 10^3}{2.3 \times 8.31}\left(\frac{1}{1200} - \frac{1}{1500}\right)$$

$$\frac{k_2}{k_1} = 24.8$$

(v) Higher temperature shifts the equilibrium position to the right, increasing the yield. 1

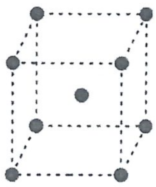
Marks

2. (a) (i)
- Cellulose consists of many polar hydroxyl groups. 1
- The hydroxyl groups attract water molecules by hydrogen bonds. 1

(ii)  1

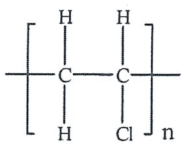
(iii)
- Catalyst is used. 1
- High atom economy (100%) 1

(b) (i) body-centred cubic 1

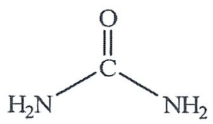
 1

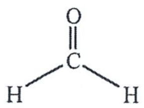
(ii) Alloy **B**
- It does not contain poisonous lead compounds. 1
- Its melting point is relatively low. 1

(iii) Brass is harder / is more corrosion resistant / has a more appealing appearance than copper. 1

(iv) (1)  1

(2) extrusion moulding 1

(c) (i) (1)  1

 1

(2) condensation polymerisation 1

(ii) (1) sulphur 1

(2) vulcanisation 1

(iii) (1) **Z** is elastic whereas **X** is rigid. 1

(2)
- **Z** has a cross-linking structure whereas **Y** has a linear structure. 1
- Hence, **Z** is more heat-resistant / abrasion-resistant than **Y**. 1

Marks

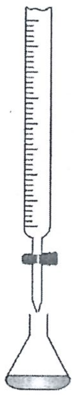
3. (a) (i) • IR Peak at 2070 – 2250 cm^{-1} corresponds to C≡C. 1
• Relative molecular mass of 40.0 confirms it to be $HC \equiv CCH_3$. 1

(ii) immiscible with water / low boiling point / easily evaporate 1

(iii) • Heat with Tollen's reagent. 1
• Only **A** gives silver mirror. 1

(b) (i) It is to prevent the formation of solid Ag_2CO_3 etc. 1

(ii) 1



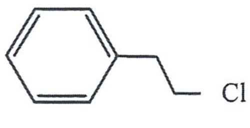
Correct labelling :
Burette, conical flask, KSCN(aq), acidified bacon sample with $AgNO_3$(aq) 1

(iii) No. of mole of KSCN(aq) = No. of mole of Ag^+(aq) left in the mixture = No. of mole of Ag^+(aq) reacted with KSCN(aq) = 0.1 × 0.00942 4
No. of mole of AgCl formed
= 1.0 × 0.0025 – 0.1 × 0.00942 = 0.001558
Percentage by mass of sodium = (0.001558 × 23.0 / 2.0) × 100%
= 1.79%

(c) (i) (1) • Different substances have different adsorptivity to the stationary phase. 1
• They have different solubility in mobile phase. 1

(2) column chromatography 1

(ii) The chemical species for the peak at m/z = 91 may be $C_6H_5CH_2^+$. 1
The chemical species for the peak at m/z = 140 may be $C_6H_5CH_2CH_2{}^{35}Cl^+$. 1
(or m/z = 142 may be $C_6H_5CH_2CH_2{}^{37}Cl^+$)
Possible structure :



1

(iii) (1) High levels of dioxins may cause cancer. 1

(2) Modern instrumentation is accurate and sensitive enough to measure very low levels of dioxins. 1

Candidates' Performance

Paper 1

Paper 1 consisted of two sections, Section A (multiple-choice questions) and Section B (conventional questions). Sections A and B each comprised two parts, Part I and Part II. Part I contained questions mainly on Topics I to VIII of the curriculum, while Part II mainly on Topics IX to XII. All questions in both sections were compulsory.

Section A (multiple-choice questions)

This section consists of 36 multiple-choice questions. The mean score was 24.9. Candidates' performance was generally good. Some misconceptions of candidates were revealed from their performance in the following items:

1. For Q.3, in option A, red wine turning sour involves the oxidation of ethanol to ethanoic acid. In option C, combusting natural gas involves the oxidation of fuels to carbon dioxide and water. In option D, removing nitrogen oxides in the catalytic converter involves the reduction of nitrogen oxides to nitrogen. All the above three options do involve oxidation and reduction. However, for option B, removing rust using white vinegar only involves the neutralisation of rust (an iron oxide) with ethanoic acid and that does not involve oxidation and reduction. Therefore, B is the correct answer.

   Q.3 Which of the following processes does NOT involve oxidation and reduction ?

A.	red wine turning sour	(17%)
B.*	removing rust using white vinegar	(40%)
C.	combusting natural gas in a power station	(35%)
D.	removing nitrogen oxides in the catalytic converter of a car	(8%)

2. For Q.15, it should be noted that in order to slow down the corrosion of an iron-made object, the object should be made as the cathode of a chemical cell, namely cathodic protection. However, many candidates wrongly thought that the object should be connected to the cathode of a chemical cell. This may explain why so many candidates chose option D over B.

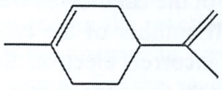
   Q.15 Which of the following methods can slow down the corrosion of an iron-made object ?

   (1) Connect it to a piece of lead.
   (2) Plate a layer of copper coating completely onto its surface.
   (3) Connect it to the cathode of a chemical cell.

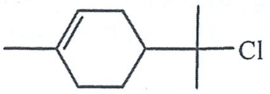
A.	(1) only	(4%)
B.*	(2) only	(24%)
C.	(1) and (3) only	(9%)
D.	(2) and (3) only	(63%)

3. For Q.29, many candidates did not apply the Markovnikov's rule to predict the major product in the addition reaction of HCl(g) to limonene. According to Markovnikov's rule, the hydrogen atom is added to the carbon with the greatest number of hydrogen atoms while the Cl component is added to the carbon with the least number of hydrogen atoms. Based on the rule, B is the correct answer.

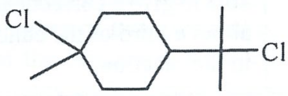
Q.29 The structure of limonene is shown below :



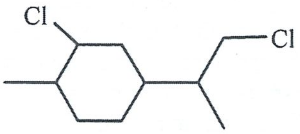
It reacts with excess HCl(g) to give **Z** as the major product. Which of the following is **Z** ?

A. 

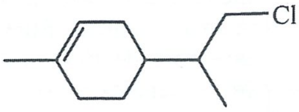
(12%)

B.* 

(50%)

C. 

(25%)

D. 

(13%)

Section B (conventional questions)

Question Number	Performance in General
1	The performance of candidates in this question was good. In part (a), a very high proportion of the candidates were able to correctly explain why protium and deuterium are isotopes. In part (b), about three quarters of the candidates were able to give the correct electron diagram for a D_2O molecule. A small number of the candidates wrongly considered D_2O to be an ionic compound and gave an incorrect electron diagram. In part (c)(i), about three quarters of the candidates were able to state the correct expected observations for the reaction between sodium metal and liquid D_2O. A small number of the candidates wrongly stated that white precipitate was formed in the reaction. In part (c)(ii), about a third of the candidates were able to give a correct chemical equation for the reaction between sodium and D_2O. However, about a third of the candidates wrongly considered that Na_2O, instead of NaOD, was formed in the reaction.
2	The performance of candidates in this question was fair. In part (a), about three quarters of the candidates were able to complete the diagram of the structure of sodium chloride crystal. A small number of the candidates wrongly thought that the particle positions in the three layers are identical, or missed 1 or 2 particles from the diagram. In part (b)(i), about a quarter of the candidates were able to correctly express the total mass of 4 Na^+ and 4 Cl^- ions in terms of the Avogadro's constant. In part (b)(ii), about a third of the candidates were able to calculate the Avogadro's constant correctly.
3	The performance of candidates in this question was satisfactory. In part (a)(i), about two thirds of the candidates were able to correctly give bromine as the answer. A small number of the candidates possibly did not read the question carefully and mistakenly gave aqueous bromine as the answer. There was also a small number of the candidates who wrongly identified the orange solution as potassium dichromate solution. In part (a)(ii), about a third of the candidates were able to give the correct chemical equation for the reaction. A small number of the candidates gave incorrect structures of but-2-ene or the reaction product. A small number of the candidates only wrote down the chemical equation without giving an explanation for the colour change. In part (b), about two thirds of the candidates were able to give a correct and complete answer. A small number of the candidates just stated that the gas is NH_3, or wrote down a chemical equation, without further elaboration. A small number of the candidates wrongly gave NaOH as the answer, not realising that NaOH is a solid at room temperature. A very small number of the candidates wrongly stated that NH_4^+ is alkaline.
4	The performance of candidates in this question was good. In part (a)(i), about two thirds of the candidates were able to correctly and completely described how a standard solution of potassium hydrogenphthalate can be prepared in a laboratory. Some candidates failed to state the use of distilled water or deionised water to dissolve the solid when preparing the solution. A small number of the candidates wrongly suggested dissolving the solid directly in the volumetric flask. A few candidates wrongly suggested using a pipette to transfer 250.0 cm^3 of the solution from the beaker to a volumetric flask. In part (a)(ii), about three quarters of the candidates were able to calculate the molarity of the standard solution. In part (b), about two thirds of the candidates were able to correctly state and explain that the –COOH group in potassium hydrogenphthalate is not completely ionised.

Question Number	Performance in General
5	The performance of candidates in this question was good. In part (a), about two thirds of the candidates were able to give a correct reagent for the reaction. Some candidates wrongly gave Cl_2(aq) or HCl as the answers. In part (b), about three quarters of the candidates were able to state that light is required for the reaction. Some candidates did not read the question carefully, and gave 'heat' as the answer. In part (c), about three quarters of the candidates were able to name 'substitution' for the reaction type. Some candidates wrongly gave 'addition reaction' as the answer, or wrongly spelt 'substitution'. In part (d)(i) and (ii), about half of the candidates were able to give the correct structures of the compounds, and just under half of the candidates were able to give the correct systematic name of one of the compounds. However, some candidates gave the structures of two identical compounds for part (i) & (ii). In part (d)(iii), about three quarters of the candidates were able to state the correct type of isomerism exhibited by the two compounds. Some candidates wrongly stated that the two compounds are enantiomers.
6	The performance of candidates in this question was good. In part (a), a very high proportion of the candidates were able to draw the required three-dimensional structure. In part (b), just less than half of the candidates were able to explain why CH_2Cl_2 is a polar molecule but CCl_4 is not. In addition, about half of the candidates were able to explain fully why CCl_4 has a higher boiling point than that of CH_2Cl_2. Some candidates wrongly explained the difference in boiling points using erroneous answers like 'CCl_4 is already a liquid' and 'CCl_4 has strong covalent bonds in its molecule while CH_2Cl_2 has weak van der Waals' forces between molecules'.
7	The performance of candidates in this question was satisfactory. In part (a), about three quarters of the candidates were able to state the use of the porous pot and write the half equation to represent the change that occurs at the cathode. However, only a small number of the candidates were able to deduce the correct direction of how electrons flow through the external circuit. In part (b)(i), just under half of the candidates were able to write the half equation required. In part (b)(ii), about two thirds of the candidates were able to state the expected observation. In part (b)(iii), about a third of the candidates were able to select the correct change in the multimeter reading and give an explanation.
8	The performance of candidates in this question was satisfactory. In part (a), about three quarters of the candidates were able to show how to estimate the maximum temperature using the graph provided. Some candidates wrongly linked up all the data points instead of using two straight lines. In part (b)(i), about three quarters of the candidates were able to calculate the number of mole of NaOH(aq) and the concentration of HCl(aq). However, in part (b)(ii), only about a third of the candidates were able to determine the exact enthalpy change of neutralisation. A common mistake was the omission of the negative sign. In part (c), only about a third of the candidates were able to include all the key terms like '1 mole of water', 'acid', 'base' and 'standard conditions' in their answers.
9	The performance of candidates in this question was satisfactory. In part (a)(i), about three quarters of the candidates were able to describe the principle of this kind of corrosion prevention. In part (a)(ii), about half of the candidates were able to give the correct explanation. Some candidates incorrectly suggested that 'iron is the sacrificial metal'. In part (a)(iii), about two thirds of the candidates were able to state that zinc ions are poisonous, but some candidates suggested wrong answers like 'lead is poisonous'. In part (b)(i), about half of the candidates were able to explain the phenomenon using the appropriate chemistry principle. However, in part (b)(ii), some candidates wrongly used the same principle to explain how aluminium and tin can prevent iron from corrosion. In part (b)(iii), only about a quarter of the candidates were able to suggest the advantage of using aluminium to make cans.

Question Number	Performance in General
10	The performance of candidates in this question was fair. Only a small number of the candidates provided a comprehensive description on how to obtain the zinc sulphate crystals. A high percentage of the candidates failed to point out that the key step of separation is the use of excess amount of zinc powder, and did not present their answers in a systematic way.
11	The performance of candidates in this question was good. In part (a), about three quarters of the candidates were able to give the correct chemical equation for the reaction between nitric acid and calcium carbonate. Some candidates were not able to balance the equation correctly. In part (b)(i), half of the candidates were able to calculate the average rate of the reaction, and give an answer with a correct unit. However, some candidates wrongly interpreted the data from the graph, made wrong rounding errors or answers using an incorrect unit. In part (b)(ii), just below half of the candidates were able to correctly state and explain the difference in the shape of the curves. Many candidates were not able to explain the difference by using precise concepts and terminology. For example, some candidates explained that the reactions proceeded with different rates because the volumes of HNO_3 used were different, instead of the concentrations of HNO_3 in the reaction mixture were different. In part (c), about two thirds of the candidates were able to suggest an appropriate way to study the effect of surface area of solid reactant on the rate of reaction.
12	The performance of candidates in this question was fair. In part (a), a very high proportion of the candidates were able to give the correct expression for the equilibrium constant. In part (b), about a third of the candidates were able to perform the calculation correctly and give the answer with a correct unit. Some candidates failed to work out the correct initial concentrations for the species in the mixture. In part (c), only about a quarter of the candidates were able to give a correct and complete answer. In part (d), a quarter of the candidates were able to give a correct and complete explanation for the observation. Some candidates wrongly stated that Na_2SO_3 reacts with $Fe(SCN)^{2+}$ to cause a decrease in concentration of $Fe(SCN)^{2+}$, or that this decrease results in the colour of the mixture becoming paler.
13	The performance of candidates in this question was fair. In part (a)(i), about two thirds of the candidates were able to correctly state that the organic product is ethanal. In part (a)(ii), only a small number of the candidates were able to correctly explain why ethanol, instead of ethanoic acid, is collected from the reaction. Some candidates only stated that the boiling point of ethanal is low without giving any further elaboration. A small number of the candidates wrongly stated that $K_2Cr_2O_7$ is only a weak oxidising agent and not strong enough to oxidise ethanol to ethanoic acid. In part (b)(i), about half of the candidates were able to give the correct systematic name of the amide formed. Some candidates misspelt the name of the compound. In part (b)(ii), just below half of the candidates were able to suggest the correct reagent and condition for the reaction. Some candidates failed to state that the reagents PCl_3 and NH_3 should be used in two separate steps. In part (c)(i), only a small number of the candidates were able to draw the correct repeating unit for the polymer. Many candidates failed to recognise that the repeating unit should break between NH and CO in the structure. In part (c)(ii), just below half of the candidates were able to give the correct answer. Some candidates gave vague answers like 'no loss of atoms / substances in the polymerisation'.

Question Number	Performance in General
14	The performance of candidates in this question was satisfactory. In part (a), just below half of the candidates were able to give a correct sketch. Some candidates wrongly considered that the melting point of sulphur is lower than that of phosphorus. In part (b), about a third of the candidates were able to correctly explain why the melting point of Mg is higher than that of Na. Some candidates just stated that Mg has stronger metallic bonds because Mg atoms have more electrons than Na atoms, without mentioning outermost shell electrons or delocalised electrons. In part (c), about half of the candidates were able to give a correct and complete answer. Some candidates only stated that Si and P have different structures (giant covalent structure / simple molecular structure) without mentioning the types of bond breaking involved in the melting process. Some candidates mixed up 'atoms' and 'molecules'.
15	The performance of candidates in this question was fair. Only a small number of the candidates were able to give a complete answer. Some candidates failed to mention that the detergent can reduce the surface tension of water. Some candidates did not mention or describe clearly that the repulsion between the negative charges of ionic heads prevents the oil droplets to come together again. Some candidates wrongly stated Na^+ or ---$SO_4^-Na^+$ as the ionic head. Some candidates did not clearly refer to the structure of the detergent and just gave 'hydrophilic head / hydrophobic tail' without mentioning 'ionic part / hydrocarbon part'.

Paper 2

Paper 2 consisted of three sections. Section A contained questions set on Topic XIII 'Industrial Chemistry', Section B on Topic XIV 'Materials Chemistry' and Section C on Topic XV 'Analytical Chemistry'. Candidates were required to attempt all questions in two of the sections.

Question Number	Popularity (%)	Performance in General
Section A: 1	98	The performance of candidates in part (a) was good. In part (a)(i), about two thirds of the candidates were able to suggest that the ammonia produced from the Haber process can be used to manufacture fertilisers, contributing to an increase in crop yield. In part (a)(ii)(1), about two thirds of the candidates were able to write the chemical equation for the formation of syngas from methane. In part (a)(ii)(2), about a third of candidates were able to suggest biomass as a renewable energy resource leading to an advancement of methanol production technology. In part (a)(iii), a very high proportion of the candidates were able to deduce the respective order of reaction to **A**(aq) and **B**(aq). The performance of candidates in part (b) was satisfactory. In part (b)(i), about half of the candidates were able to describe the production of hydrogen, chlorine and sodium hydroxide in a membrane electrolytic cell. It would be expected that the answer should include the raw material (i.e. brine), chemical equations and the function of the ion-selective membrane. Some candidates failed to give the raw material and / or the two half equations in the production of hydrogen and chlorine. In part (b)(ii), about a third of the candidates were able to write the chemical equation for the production of sodium hypochlorite. In part (b)(iii), about three quarters of the candidates were able to calculate the respective atom economy of Reactions (I) and (II) and use the result to determine which of them could be considered as greener. The performance of candidates in part (c) was satisfactory. In part (c)(i), about half of the candidates were able to state a feedstock such as limestone for $CaCO_3(s)$. In part (c)(ii), just below half of the candidates were able to state that the exothermic reaction between carbon and air would result in a higher average temperature in zone **B** than in zone **A**. In part (c)(iii), about two thirds of the candidates were able to give two reasons in terms of cost and equilibrium position to account for not using a higher operation pressure. In part (c)(iv), just below half of the candidates were able to calculate the ratio of the rate constant at 1500 K to the rate constant at 1200 K for the decomposition of $CaCO_3(s)$. Some candidates failed to use the Arrhenius equation in their calculations. In part (c)(v), about half of the candidates were able to suggest that why the decomposition of $CaCO_3(s)$ mainly occurs in zone **B**.

Question Number	Popularity (%)	Performance in General
Section B: 2	6	The performance of candidates in part (a) was poor. In part (a)(i), only a small number of the candidates were able to point out the relevant functional group, and to explain the observation using intermolecular hydrogen bonds between cellulose and water molecules. In part (a)(ii), only a small number of the candidates were able to draw a diagram to represent the nematic phase of liquid crystals. In part (a)(iii), just below half of the candidates were able to state one or two reasons to explain why the reaction was considered as green. A few candidates wrongly suggested that the reaction involves 'chlorine' and hence was considered as green. The performance of candidates in part (b) was poor. In part (b)(i) and (ii), only a very small number of the candidates were able to give the correct name of the open structure of iron and to give the two reasons why alloy **B** should be used as solder. Some candidates mixed up lead and zinc, and stated that 'zinc in alloy **A** is poisonous'. In part (b)(iii), about half of the candidates were able to suggest why brass instead of copper should be used to make water taps. In part (b)(iv), about a quarter of the candidates were able to draw the structural formula of PVC. About a third of the candidates were able to suggest a correct moulding method for making PVC pipes. The performance of candidates in part (c) was poor. In part (c)(i)(1), a small number of the candidates were able to draw the structures of the monomers of **X**. In part (c)(i)(2), about half of the candidates were able to give the name of the type of polymerisation involved. In part (c)(ii), about half of the candidates were able to suggest what **W** is, and only about a quarter of the candidates were able to write the exact name of the process involved. In part (c)(iii), only a small number of the candidates were able to show their understanding about the structures and properties of the polymeric materials **X**, **Y** and **Z**.

Question Number	Popularity (%)	Performance in General
Section C: 3	96	The performance of candidates in part (a) was good. In part (a)(i), about three quarters of the candidates were able to make use of the infra-red data and the relative molecular mass to work out the possible structural formula. Some candidates failed to give the structural formula as $HC{\equiv}CCH_3$. In part (a)(ii), about a third of the candidates were able to suggest a property of the solvent, such as its high volatility for it to be used in extracting organic compounds from their aqueous solutions. In part (a)(iii), about two thirds of the candidates were able to describe a chemical test to distinguish compounds **A** and **B**. Some candidates wrongly used acidified sodium dichromate solution to distinguish the two compounds despite both having the oxidisable hydroxyl group. The performance of candidates in part (b) was satisfactory. In part (b)(i), only a small number of the candidates were able to state the function of excess dilute $HNO_3(aq)$ as to prevent the formation of other solid products such as Ag_2CO_3. In part (b)(ii), about two thirds of the candidates were able to draw a labelled diagram to be used in the titration. Some candidates failed to draw the stopcock and some candidates wrongly used a beaker instead of a conical flask to perform the titration. In part (b)(iii), about half of the candidates were able to calculate the percentage by mass of sodium in the bacon sample. The performance of candidates in part (c) was satisfactory. In part (c)(i)(1), just below half of the candidates were able to explain the separation of a mixture by chromatography in terms of different solubility and adsorptivity of the components in the mobile phase and stationary phase. In part (c)(i)(2), just below half of the candidates were able to suggest column chromatography to separate a large amount of the mixture. In part (c)(ii), just below half of the candidates were able to deduce the structure of the compound by making use of the labelled peaks in the mass spectrum provided. Some candidates failed to recognise that the m/z peaks corresponding to 140 and 142 are due to the presence of the two isotopes of chlorine. In part (c)(iii)(1), about two thirds of the candidates were able to suggest that there is a need to measure dioxin levels as dioxin is toxic. In part (c)(iii)(2), about a quarter of the candidates were able to suggest that modern instrumentation is more able to measure low levels of dioxin.

School-based Assessment

All school candidates have to participate in School-based Assessment (SBA). There were 12119 students from 431 schools submitted their SBA marks this year. This is the eighth year of implementation of SBA for the Hong Kong Diploma of Secondary School Education (HKDSE). With the experience acquired over the past years, the implementation was generally smooth in most of the participating schools.

To ensure that teachers have a good understanding of the requirements and the principles of the assessment methods of the SBA, a SBA annual conference and group meetings were held in October every year. The conference and group meetings provided teachers with general comments and summary about the SBA implementation, and latest updates of the SBA requirements and administrative operations. The conference also introduced the resources and supports available to help teachers to integrate practical works into chemistry lessons. Furthermore, the Education Bureau and the Hong Kong Examinations and Assessment Authority collaboratively provided training courses and useful resources for teachers, and helped them to enhance knowledge and skill and build up confidence in implementing SBA in their classes.

Based on the assessment data and samples of students' worksheets and reports submitted by participating schools, students' performance was in general satisfactory and within the expectations of the assessment requirements. To address the potential discrepancies in the marking standard among individual teachers and schools, mark moderation based on both statistical methods and professional judgment was performed. We are happy to report that 54.8% of schools fall into the 'within the expected range' category, while the marks of 30.4% of schools are higher than expected, and 14.8% lower than expected. It was observed that the majority of schools with deviations only differed slightly from the expected range. This is encouraging as the data show that the majority of the teachers have a good understanding of SBA implementation, and hence the marking standards are generally appropriate.

To provide continuing support for teachers and to ensure fair implementation of the SBA, two supervisors are assigned to supervise all the schools, and there were a total of 24 district coordinators to address enquiries from teachers about SBA implementation, and to ensure that schools were administering the SBA in accordance with the stipulated guidelines. Phone calls, email correspondences, district group meetings and school visits were conducted to establish close connections between the district coordinators and the teachers. The said communication channels between the supervisors / district coordinators / teachers can enhance mutual understanding. Based on the feedback from various sources, both teachers and students have a better understanding of the essence and the requirements of the SBA. Nonetheless, some comments and recommendations are given below so that further improvement on the implementation of SBA could be made:

1. Variety of Experiments
   Even though there is no strict stipulated requirement on the types of experiments selected for SBA tasks besides including volumetric analysis and qualitative analysis in the task list, it is definitely beneficial to students' learning if they are exposed to a wider variety of experiment types. Experiments from different topics like 'Chemistry reactions and energy', 'Rate of reaction', 'Chemical equilibrium', 'Organic Synthesis' and 'Analytical chemistry' can be used as SBA tasks. Conducting these types of experiments can enrich students' practical experience as well as to strengthen students' practical skills and analytical thinking skills. For qualitative analysis, detection of ions (cations and / or anions) is required, but not the detection of organic species. Moreover, 'Other experiments' refers to experiments suggested in the Curriculum and Assessment Guide, but not volumetric analysis nor detection of ions.

2. Variety of Written Work
   Practical worksheets, experiment-related quizzes and brief / detailed laboratory reports, etc. are all acceptable formats of written work. Teachers generally designed these tasks in a professional manner. Moreover, it is encouraging that most students can follow the instructions given by teachers in accomplishing the written work. Although there is no stipulated requirements in the SBA guidelines regarding the types of written reports to be submitted by a student, writing laboratory reports is definitely an important part of the training for students studying experimental sciences. Organising a laboratory report in the correct format and presenting the data and experimental findings properly are important skills.

3. Assessment Criteria and Mark Scale
   To carry out a valid assessment of students' attainment in practical tasks in SBA, teachers can make use of the most suitable assessment criteria for different types of practical tasks and review them from time to time. In

addition, a systematic mark scale or assessment rubrics can be deployed such that all students are assessed in a reliable way.

4. Use of 'feedback' to promote learning
Providing feedback to students in particular with written remarks and grade / marks through submitted reports is important for facilitating student learning. Students can be encouraged to review their own work and avoid making the same type of mistakes in the future. They can also discuss with their teachers their performance when carrying out experiments and in related written tasks, so as to reinforce their laboratory learning experiences. Teachers can provide students with oral, written and other forms of feedback to promote learning through the SBA.

5. Students' performance in recording and analysing the data obtained from experiments
It was observed that students frequently made mistakes in recording the experimental data, performing calculations, handling graphs and drawing set-up diagrams. These mistakes include using incorrect significant figures in data recording and calculations, using incorrect units for numerical data, and carrying out the calculations incorrectly. As in the previous years, it was observed that quite a number of students incorrectly recorded the burette readings in titrations using numbers with one decimal place. In addition, students showed little attention to the handling of graphs and drawing set-up diagrams, which are essential expected learning outcomes. Students are encouraged to pay more attentions to these areas.

6. Prevention of plagiarism
Students should complete the assessment tasks honestly and responsibly in accordance with the stipulated requirements. They will be subject to severe penalties for proven malpractice, such as plagiarising others' work. The HKDSE Examination Regulations stipulate that a candidate may be liable to disqualification from part or the whole of the examination, or suffer a mark penalty for breaching the regulations. Students can refer to the information leaflet HKDSE Examination - Information on School-based Assessment (http://www.hkeaa.edu.hk/DocLibrary/Media/Leaflets/SBA_pamphlet_E_web.pdf) for guidance on how to properly acknowledge sources of information quoted in their work.

Conclusion

For the implementation of SBA in the 2019 HKDSE, students' performance was generally satisfactory, and teachers have expressed a smooth running of the SBA in their lessons. With the experience acquired in the previous cohorts, most teachers have a clear understanding about the requirements and expected goals of SBA, and have no issues in selecting appropriate practical tasks and assessing the abilities of their students.

PERIODIC TABLE 周期表

GROUP 族

1 **H** 1.0	
1	atomic number 原子序
1.0	relative atomic mass 相對原子質量

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)