PERIODIC TABLE 周期表

GROUP 族

atomic number 原子序 / relative atomic mass 相對原子質量 (key: 1 H 1.0)

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)

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.	B (42%)	25.	C (84%)
2.	D (68%)	26.	B (65%)
3.	C (82%)	27.	D (79%)
4.	A (65%)	28.	B (76%)
5.	B (64%)	29.	C (40%)
6.	B (71%)	30.	B (73%)
7.	D (54%)	31.	D (65%)
8.	D (93%)	32.	A (44%)
9.	A (79%)	33.	D (29%)
10.	A (71%)	34.	A (61%)
11.	D (80%)	35.	A (39%)
12.	B (74%)	36.	A (86%)
13.	C (82%)		
14.	C (74%)		
15.	D (54%)		
16.	C (86%)		
17.	B (85%)		
18.	A (59%)		
19.	C (68%)		
20.	A (59%)		
21.	C (50%)		
22.	A (53%)		
23.	C (62%)		
24.	D (62%)		

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.

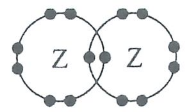
SECTION B

Part I

Marks

1. (a) 2, 8, 18, 7 — 1

(b) — 1



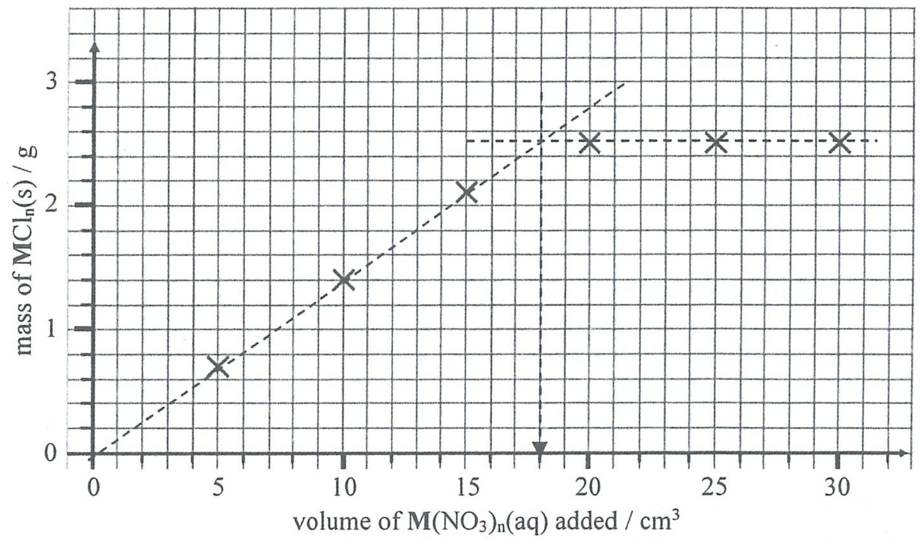
(c) (i) $K_2SO_3(s) + 2HCl(aq) \rightarrow 2KCl(aq) + H_2O(l) + SO_2(g)$ /
$K_2SO_3(s) + 2H^+(aq) \rightarrow 2K^+(aq) + H_2O(l) + SO_2(g)$ — 2

(ii) Reddish brown changes to colourless. — 1
$Br_2 + SO_2 + 2H_2O \rightarrow 2Br^- + SO_4^{2-} + 4H^+$ — 1
OR $\mathbf{Y}_2 + SO_2 + 2H_2O \rightarrow 2\mathbf{Y}^- + SO_4^{2-} + 4H^+$

(iii) **Y** and **Z** have the same number of electrons in the outermost shells, hence they have similar chemical properties. — 1

2. (a) It is because for the last three points in the graph, the amount of $\mathbf{M}(NO_3)_n$ / M^{n+} added is in excess. — 1

(b) (i) — 1



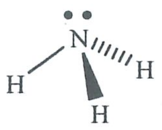
volume of $\mathbf{M}(NO_3)_n(aq)$ = 18 cm^3 — 1

(ii) (18 / 1000) x 0.5 = 0.009 mol — 1

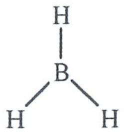
(c) No. of moles of Cl^- : (50 / 1000) x 0.36 = 0.018 mol — 3
Ratio of metal ions to chloride ions = 0.009 : 0.018 = 1 : 2. The empirical formula of the metal chloride is $\mathbf{M}Cl_2$.
M would be lead because the ratio of Pb to Cl in its empirical formula is 1:2 while the ratio of Ag to Cl is 1:1.

Marks

3. (a) (i) 1



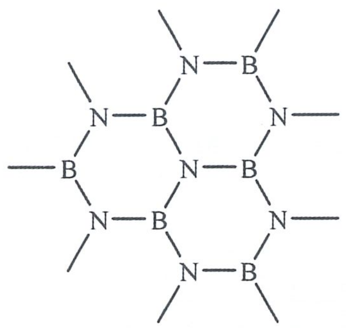
(ii) 1



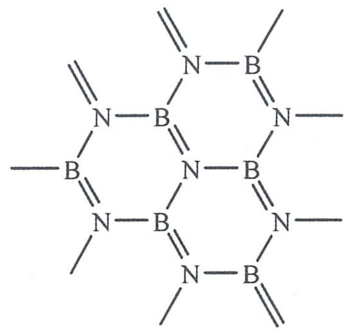
(b) (i)
- B–N would be the dative covalent bond. 1
- The lone electron pair on nitrogen atom of NH_3 is donated to form a dative covalent bond with the boron atom of BH_3. 1

(ii)
- Both are van der Waals' forces between their respective molecules. 1
- As H_3NBH_3 is polar but ethane is not, the van der Waals' forces between H_3NBH_3 molecules are stronger than those between ethane molecules. 1

(iii) 2



or



4. (a) To increase the surface area of eggshell for increasing the reaction rate. 1

(b) To dissolve organic substances in eggshell. 1

(c) Speed up the reaction between the calcium carbonate in the sample with HCl(aq). / To make sure that the reaction is complete. 1

(d) phenolphthalein 1

(e) Number of moles of $CaCO_3$ in the sample
$= (0.200 \times 25.00 - 0.102 \times 16.85) \times 10^{-3} \times ½$ 3
$= 1.64 \times 10^{-3}$
Percentage by mass of $CaCO_3$ in the sample
$= 1.64 \times 10^{-3} \times 100.1 \div 0.204 \times 100\ \%$
$= 80.5\ \%$

Marks

5. (a) Carboxyl group / –COOH group 1

(b) (i) Any two : $HO_2CCH_2CH_2CO_2H$ / $HO_2CCH(CH_3)CO_2H$ / $HO_2CCH_2COOCH_3$ 2

(ii)
- The enthalpy change when solutions of an acid and an alkali / a base react together under standard conditions to produce 1 mole of water. 1
- As indicated in the equation, the reaction produces 2 moles of water, hence **y** / 2 represents the standard enthalpy change of neutralisation for that reaction. 1

(iii)
- Less negative than -57.3 kJ mol^{-1}. 1
- **W** is a weak acid when compared with HCl(aq), energy is needed to ionise the hydrogen in the carboxyl group. 1

6. (a)
- To provide an aqueous medium so as to produce mobile ions. 1
- Magnesium is higher than copper in the electrochemical series / ECS and release electrons. The electrons pass from the negative pole of the voltmeter to the positive pole, producing to a positive reading. 1

(b) (i) $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$ 1

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

(c) The position of the pointer is higher than 0 and lower than the reading in **Diagram (1)**. 1

(d) (i) $Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$ 1

(ii) Displacement 1

7. (a)
- Put a moist red litmus paper near the mouth of the conical flask. 1
- Ammonia gas dissolves in water to give OH^- ions which turn red litmus paper to blue. 1

(b) Alkali is a water soluble substance reacting with an acid to give salt and water only. 1

(c) (i) $Ba(s) + 9H_2(g) + 5O_2(g) \rightarrow Ba(OH)_2 \bullet 8H_2O(s)$ $\Delta H_f^\circ = -3345$ kJ mol^{-1} 1

(ii) $\Delta H^\circ = (-859) + 10 \times (-286) + 2 \times (-46) - (-3345) - 2 \times (-314)$ 2
$= +162$ kJ mol^{-1}

(iii) As the reaction is endothermic, the temperature of the mixture would decrease. 1

Marks

8. Chemical knowledge (1 mark for each point, a maximum of 5 marks) 5
- Separation of crude oil by oil refinery / fractional distillation gives heavy oil or fuel oil, etc.
- Cracking gives a mixture of small molecules with ethene.
- $C_7H_{16} \rightarrow CH_2{=}CH_2 + C_5H_{12}$
- Fractional distillation of the above mixture gives ethene.
- Addition reaction of ethene and bromine gives 1,2-dibromoethane.
- $CH_2{=}CH_2 + Br_2 \rightarrow BrCH_2CH_2Br$

Communication mark 1

Part II

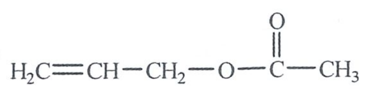
9. (a) $K_c = [N_2O_4(g)]_{eqm} / [NO_2(g)]_{eqm}^2$ 3
$[NO_2(g)]_{eqm} = 0.0323\ mol\ dm^{-3}$
$a = [N_2O_4(g)]_{eqm} = 0.001 + (0.04 - 0.0323) / 2 = 0.00485\ mol\ dm^{-3}$
$K_c = 0.00485 / (0.0323)^2 = 4.649\ mol^{-1}dm^3$

(b)
- More NO_2 is formed and the equilibrium position shifts to the left / shifts to the reactant side when the temperature increases. 1
- Increasing temperature shifts the equilibrium position to endothermic direction. Therefore, the forward reaction is exothermic. 1

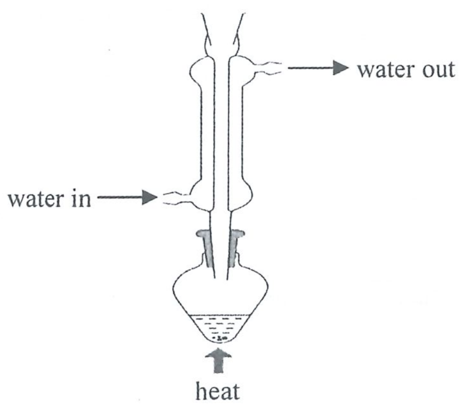
10. (a) (i) $H_2C{=}CH{-}CH_2{-}Cl + NaOH \rightarrow H_2C{=}CH{-}CH_2{-}OH + NaCl$ / 1
$H_2C{=}CH{-}CH_2{-}Cl + OH^- \rightarrow H_2C{=}CH{-}CH_2{-}OH + Cl^-$

(ii) substitution reaction 1

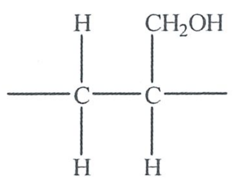
(b) (i) 1



(ii) 2



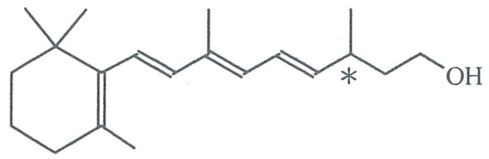
(c) 1



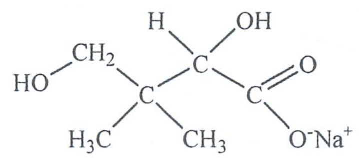
Marks

11. (a) **Z** 1

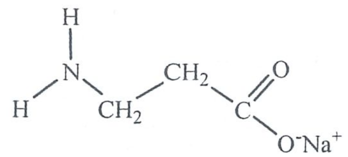
(b) 1



(c) **U** : $HOCH_2C(CH_3)_2CH(OH)CO_2^-Na^+$ / 1
$HOCH_2C(CH_3)_2CH(OH)CO_2Na$ /



V : $H_2NCH_2CH_2CO_2^-Na^+$ / 1
$H_2NCH_2CH_2CO_2Na$ /



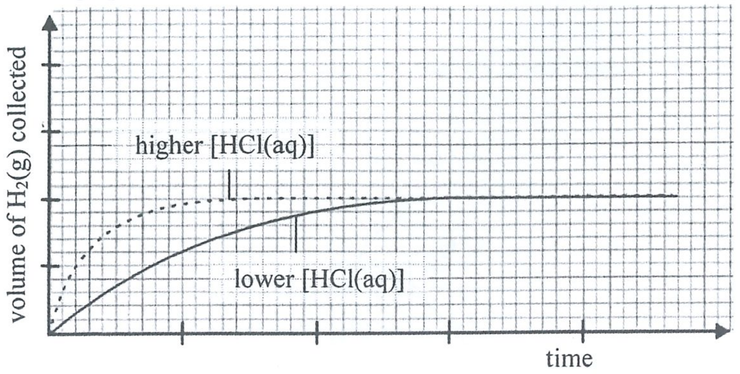
(d) (i) $Na_2CO_3(aq)$ 1

(ii)
- Colourless gas evolves when $Na_2CO_3(aq)$ is put into **X**, but not **W**, **Y** nor **Z**. 1
- Only **X** has a carboxyl group but **W**, **Y** and **Z** do not. 1

12.
- Cobalt / Co^{2+} acts as a catalyst: The rate of formation of gas bubbles (CO_2) increases / rate of reaction increases when Co^{2+} ions are added, 1
- and the pink Co^{2+} ions regenerate / remain chemically unchanged / do not consume at the end of reaction. 1
- Coloured ion / formation of coloured compound: $Co^{2+}(aq)$ is pink / the cobalt(III) compound formed is green. 1
- Variable oxidation states: Cobalt has cobalt(II) and cobalt(III) compounds / can exist as Co^{2+} and Co^{3+}. 1

Marks

13. Chemical knowledge
Labelled graph 2



(1 mark for each point from below, a maximum of 3 marks) 3

- Measure the volume of H_2(g) formed at different time intervals and plot a curve.
- The slope of the curve represents the rate of reaction.
- Repeat the experiment with different concentrations of HCl(aq).
- Fair comparison - other than concentration of HCl(aq), all other conditions should be the same.

Communication mark 1

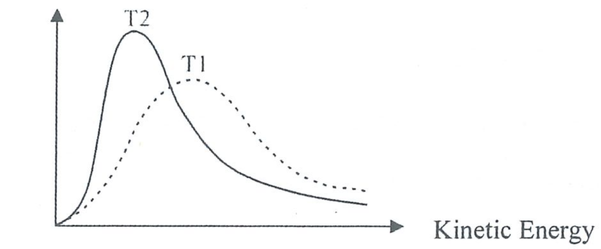
Paper 2

Marks

1. (a) (i)
- No toxic mercury will be produced by membrane electrolytic cell but toxic mercury may leak out from flowing mercury cell. 1
- Energy required for a membrane electrolytic cell is less than that for a flowing mercury cell. 1

(ii) iron / iron(III) oxide 1

(iii) 2



(b) (i) (1) No solvent will be emitted to the environment for Reaction (I) but Reaction (II) will. / The side product ethanol of Reaction (I) is less toxic than the side product methanol of Reaction (II). 1

(2) Lower temperature is needed / Higher atom economy for Reaction (II) than Reaction (I). 1

(ii) 3.00 ÷ 136 = 0.022 mol 2
2.23 ÷ 101 = 0.022 mol
(3.89 ÷ 205) ÷ 0.022 × 100%
= 86%

(iii) (1) Because increasing the pressure can shift the equilibrium position to the right. 1

(2)
- Higher temperature will have a higher rate of reaction. But the forward reaction is exothermic, increasing the temperature will shift the equilibrium position to the left. 1
- Higher pressure will shift the equilibrium position to the right but extra cost is needed. 1

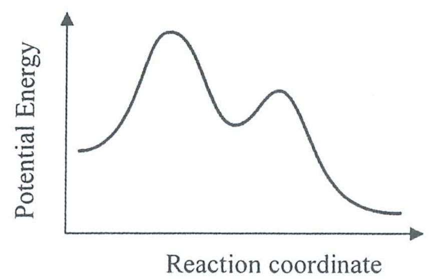
(c) (i) The absorbance is directly proportional to the concentration of I_2(aq) as I_2(aq) is brown while the other species are colourless. 1

(ii)
- The absorbance decreases with time linearly so the rate is independent of [I_2(aq)]. 1
- The order of reaction with respect to I_2(aq) = w = 0 1

(iii) Trial 2 : slope of the plot = –0.7 ÷ 8 = –0.0875 2
Trial 1 : slope of the plot = –0.7 ÷ 16 = –0.04375
(–0.0875) ÷ (–0.04375) = $(2.0 / 1.0)^x$
Order of reaction with respect to propanone = x = 1

(iv) $dm^3\ mol^{-1}\ s^{-1}$ 1

(v) 2



Marks

2. (a) (i) (1) face-centred cubic / cubic close-packed — 1

(2) Pt : $8 \times \frac{1}{8} + 4 \times \frac{1}{2} = 3$ — 1

Mn : $2 \times \frac{1}{2} = 1$ — 1

(ii) (1) Material with particle sizes between 1–100 nm — 1

(2) antibacterial / killing germs / sterilising — 1

(b) (i)
- The metallic bonds between iron ions and delocalised electrons are non-directional. — 1
- When an external force is applied, iron ions will shift and form new metallic bonds, the shape of iron metal changes but the metal will not break. — 1

(ii) (1) hardness — 1

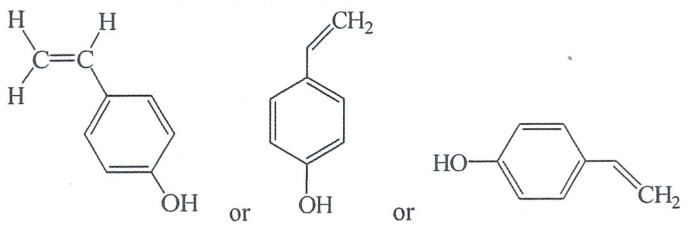
(2) Size of carbon atoms differ from that of iron atoms so that they are not easy to slide over one another, making the alloy become harder. — 1

(iii) (1)
- There are many benzene rings. — 1
- There are many N, O and H atoms to form polar bonds, and there are many strong intermolecular hydrogen bonds formed between chains. — 1

(2) hydrolysis — 1

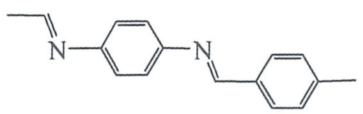
(c) (i) (1 mark for each point, a maximum of 2 marks) — 2
- The structure contains benzene rings.
- The structure contains a polar C≡N group.
- The structure contains a long carbon chain.

(ii) (1) — 1



(2) extrusion moulding / calendering — 1

(iii) (1) — 1



(2) The formation of polymer **C** from its monomers involves the elimination of small molecules. — 1

(3)
- High atom economy — 1
- Formation of non-toxic product — 1

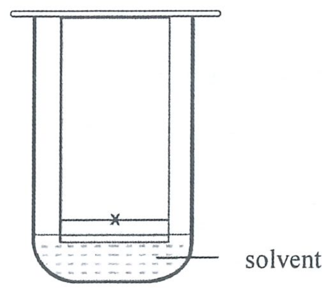
Marks

3. (a) (i)
- Heat the solid samples in a test tube and place a piece of anhydrous / dry cobalt chloride paper near the mouth of the tube. — 1
- If the anhydrous / dry cobalt chloride paper turns from blue to pink, the solid is $Na_2CO_3 \cdot 10H_2O(s)$. The colour of cobalt chloride paper does not change for $Na_2CO_3(s)$. — 1

(ii) Blue changes to colourless. — 1

(iii) Warm hexanal with Tollen's reagent. — 1
It gives a silver mirror but hex-1-ene does not. — 1

(b) (i) — 2



(ii) $R_f = 45 / (130–10–20) = 0.45$ — 1

(iii) aspirin and caffeine — 1

(iv) (1) IR spectrum of aspirin shows a strong absorption peak at 2500 cm^{-1} to 3300 cm^{-1} corresponding to O–H group of carboxylic acid while that of caffeine does not. — 1

(2) m/z = 43 corresponds to a CH_3CO^+ ion. — 1
As both aspirin and acetaminophen have this fragment, only this information cannot help confirm which one of the three chemicals the sample is. — 1

(c) (i) (1) Orange changes to green. — 1
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$ — 1

(2) Driver **B** has a higher ethanol intake because the breath can also change the colour of the gel in position **c** while Driver **A** cannot. — 1

(3) Exhale the same amount of breath into the tube. — 1

(ii) No. of mole of ethanol = $0.025 \times 4.38 \times 10^{-3} \times 3 = 0.0003285$ mol — 4
Mass of the ethanol = 0.0003285×46
= 0.01511 g = 15.11 mg
The mass of ethanol in 100 cm^3 of serum sample = 15.11 mg ÷ 10 × 100
= 151.1 mg
The mass is 151.1 mg which exceeds 55 mg. The driver would be found guilty.

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 23.8. Candidates' performance was generally good. Some misconceptions of candidates were revealed from their performance in the following items:

1. For Q.1, reacting quicklime with sulphur dioxide will form calcium sulphite instead of calcium sulphate.

Q.1 Which of the following statements concerning quicklime is INCORRECT ?

A.	Heating marble strongly can form quicklime.	(21%)
B.*	Reacting quicklime with sulphur dioxide can form calcium sulphate.	(42%)
C.	Reacting quicklime with carbon dioxide can form calcium carbonate.	(21%)
D.	A large amount of heat evolves when quicklime is put into water.	(16%)

2. For Q.21, statement (1) is wrong while statements (2) and (3) are correct. It is difficult to determine the standard enthalpy change of formation of $NH_3(g)$ directly from experiment because it is impossible for nitrogen and hydrogen to react under normal experimental conditions to form ammonia. That is why the statement (1) is wrong. For statement (2), it should be noted that all combustions are exothermic, and that is why the standard enthalpy change of combustion of $H_2NNH_2(l)$ is negative. Lastly, by definition, the standard enthalpy changes of formation of all elements are zero, hence statement (3) is also correct.

Q.21 Which of the following statements are correct ?

(1) The standard enthalpy change of formation of $NH_3(g)$ can be determined directly from experiment.
(2) The standard enthalpy change of combustion of $H_2NNH_2(l)$ is negative.
(3) The standard enthalpy change of formation of $N_2(g)$ is zero.

A.	(1) and (2)only	(17%)
B.	(1) and (3) only	(8%)
C.*	(2) and (3) only	(50%)
D.	(1), (2) and (3)	(25%)

3. For Q.33, most of the candidates have the misconception that the pH of a pure water sample is always equal to 7.0 and the concentration of aqueous hydroxide ions in it is always equal to 1.0×10^{-7} mol dm^{-3}. In fact, both figures are only true when the temperature of the sample is at 25 °C. It should be noted that the ionisation of liquid water molecules into aqueous hydrogen ions and aqueous hydroxide ions are reversible and endothermic. Higher temperature (50 °C in comparing with 25 °C) would shift the relevant equilibrium position to the product side, therefore more aqueous hydrogen ions and aqueous hydroxide ions would be formed. Increasing the concentration of aqueous hydrogen ions would result in a pH smaller than 7.0. That is why statement (2) is correct. Moreover, according to the stoichiometry of the reaction, the number of moles of aqueous hydrogen ions increased should be the same as the number of moles of aqueous hydroxide ions increased, hence the sample remains neutral. That is why statement (3) is also correct.

Q.33 Refer to the following chemical reaction :

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq) \qquad \Delta H > 0$$

The pH of a pure water sample is 7.0 at 25 °C. Which of the following statements is / are correct when the sample has been heated to 50 °C ?

(1) The $[OH^-(aq)]$ of the sample is 1.0×10^{-7} mol dm^{-3}.
(2) The pH of the sample is smaller than 7.0.
(3) The sample remains neutral.

A.	(1) only	(6%)
B.	(2) only	(26%)
C.	(1) and (3) only	(39%)
D.*	(2) and (3) only	(29%)

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 percentage of the candidates were able to give the correct electronic arrangement of an atom of **Y**. In part (b), about two thirds of the candidates were able to give the correct electron diagram for a molecule of **Z**. A small number of the candidates did not read the question carefully and wrongly gave the electron diagram for an atom of **Z**. In part (c)(i), about two thirds of the candidates were able to give a chemical equation with correct state symbols for the reaction between K_2SO_3 crystals and dilute hydrochloric acid. In part (c)(ii), about a third of the candidates were able to state the expected observation in container (1) and write the correct ionic equation for the reaction involved. Some candidates wrongly considered Br^- was oxidised to Br_2 in container (1) and stated that a brown fume was released. Some candidates only gave a half equation for the reduction of Br_2. In part (c)(iii), about two thirds of the candidates were able to correctly state that **Y** and **Z** have the same numbers of electrons in the outermost shell. A small number of the candidates only stated that **Y** and **Z** belong to the same group of the periodic table without referring to their electronic arrangements in the answer.
2	The performance of candidates in this question was satisfactory. In part (a), about half of the candidates were able to state that HCl(aq) is the limiting reagent in the reaction. A small number of the candidates only stated that the reaction was complete without any elaboration. In part (b)(i), just below half of the candidates were able to deduce the correct volume of $M(NO_3)_n$ by correctly extrapolating the data points shown on the graph. About a third of the candidates wrongly stated the volume of $\mathbf{M}(NO_3)_n$ that reacted was 20 cm^3. In part (b)(ii), about half of the candidates were able to correctly calculate the number of moles of $\mathbf{M}(NO_3)_n$ needed. In part (c), only about a quarter of the candidates were able to give the correct empirical formula for $\mathbf{M}Cl_n$, but failed to specifically state the comparison of the charges of a silver ion and a lead ion.
3	The performance of candidates in this question was good. In part (a), a very high percentage of the candidates were able to give the correct three-dimensional diagram for the shapes of a NH_3 molecule and a BH_3 molecule. In part (b)(i), a very high percentage of the candidates were able to correctly state the B—N bond as the dative covalent bond in the molecule, and about half of them were able to give a correct explanation. However, some candidates wrongly stated that both of the electrons in the B—N bond are contributed by the boron atom. In part (b)(ii), only a very small number of the candidates were able to correctly explain why H_3NBH_3 is a solid but ethane is a gas at room conditions. Many candidates wrongly stated that H_3NBH_3 molecules are held by strong hydrogen bonds while the ethane molecules are held by weak van der Waals' forces. About a quarter of the candidates were able to state H_3NBH_3 molecules and C_2H_6 molecules are both held by weak van der Waals' forces, but they wrongly stated that the forces between H_3NBH_3 molecules are stronger because the molecular size of H_3NBH_3 is larger than that of C_2H_6. In part (b)(iii), nearly half of the candidates were able to draw the structure of one layer of solid boron nitride and label the atoms correctly.
4	The performance of candidates in this question was satisfactory. In part (a), a very high percentage of the candidates were able to state that the sample was ground into powder to increase the surface area of the eggshell for increasing the reaction rate. In part (b), just below half of the candidates were able to state that the reason for adding ethanol is to dissolve the organic substances in the eggshells. In part (c), about half of the candidates were able to suggest an explanation for heating the mixture for 15 minutes. Some candidates wrongly stated that heating the mixture is to evaporate the volatile organic substances. In part (d), about two thirds of the candidates gave the correct answer. A small number of the candidates misspelt the word 'phenolphthalein'. In part (e), just below half of the candidates were able to calculate the percentage by mass of $CaCO_3$ in the sample.

Question Number	Performance in General
5	The performance of candidates in this question was satisfactory. In part (a), about two thirds of the candidates were able to suggest the functional group of **W**. In part (b)(i), about two thirds of the candidates were able to draw the possible structures of **W**, using skeletal structural formula, expanded structural formula, etc. In part (b)(ii), less than a third of the candidates were able to state the exact meaning of the 'standard enthalpy of neutralisation', and even fewer candidates were able to deduce its value. In part (b)(iii), more than a third of the candidates were able to predict the enthalpy change as 'less negative than', but most of the candidates were not able to provide a good explanation.
6	The performance of candidates in this question was satisfactory. In part (a), less than a third of the candidates used 'mobile ions' and 'the reactivity of magnesium is higher than that of copper' in their answers. Some candidates considered water could provide hydrogen ions and hydroxide ions for conducting electricity, and some candidates considered 'delocalised electrons'. In part (b), about two thirds of the candidates wrote the correct half equations. In part (c), only about half of the candidates were able to draw the expected position of the pointer. In part (d), only about half of the candidates were able to write the relevant chemical equation / ionic equation, and the name of the type of reaction.
7	The performance of candidates in this question was fair. In part (a), about a third of the candidates were able to suggest the correct way to test for ammonia gas, but most of the candidates did not provide a good explanation. In part (b), only a very small number of the candidates were able to describe accurately the meaning of the term 'alkali'. Many of the candidates did not include 'soluble in water', 'hydroxide ions as the only anions', etc. in their answers. In part (c)(i), most of the candidates failed to write the correct thermochemical equation. Many of the candidates did not include the correct state symbols and the correct ΔH term. In part (c)(ii) & (iii), about half of the candidates completed the calculation as required and explained the expected temperature change.
8	The performance of candidates in this question was fair. About a third of the candidates were able to describe how to produce 1,2-dibromoethane from crude oil according to the correct sequence of the production processes. Some candidates erroneously considered the use of 'substitution reaction', and mixed up the chemical properties of ethane and ethene. Only a small number of the candidates were able to use correct chemical equations to represent 'cracking' and 'addition reaction'.
9	The performance of candidates in this question was satisfactory. In part (a), just below half of the candidates were able to calculate the equilibrium constant correctly. About a third of the candidates failed to calculate the correct equilibrium concentration of N_2O_4. A small number of the candidates gave an incorrect unit in their answers. In part (b), only a small number of candidates were able to give a correct and complete deduction. A very small number of candidates wrongly stated that the equilibrium position is shifted to the product side upon increasing the temperature.

Question Number	Performance in General
10	The performance of candidates in this question was fair. In part (a)(i), only about a quarter of the candidates were able to give a balanced chemical equation for the reaction. Some candidates did not read the question carefully, and gave an equation of the reaction for preparing 3-chloropropene from **Y**. In part (a)(ii), about two thirds of the candidates were able to name the type of the reaction correctly. Some candidates entering the English version misspelt the word 'substitution'. In part (b)(i), just below half of the candidates were able to give the correct structural formula of **L**. In part (b)(ii), about a quarter of the candidates were able to draw a correct labelled diagram for the set-up. Some candidates wrongly drew the set-up as a closed system, while some wrongly drew a distillation set-up in the answer. In part (c), just below half of the candidates were able to give the correct repeating unit of the polymer. Some candidates wrongly included 'n' in the answer and gave a structural formula for the polymer.
11	The performance of candidates in this question was satisfactory. In part (a), about three quarters of the candidates were able to identify compound **Z** as a tertiary alcohol. In part (b), about two thirds of the candidates were able to correctly identify the chiral centre in compound **W**. In part (c), only a small number of candidates were able to give the correct structures for both compounds **U** and **V**. About a third of the candidates failed to recognise that the amide group in the compound undergoes alkaline hydrolysis in the reaction. Some candidates failed to show an awareness that the products were formed in alkaline conditions and did not give the structures of **U** and **V** as sodium carboxylates. In part (d)(i), about two thirds of the candidates were able to state that Na_2CO_3(aq) can be used to distinguish **X** from the other three compounds. A small number of the candidates wrongly gave acidified $K_2Cr_2O_7$(aq) as the answer. In part (d)(ii), about half of the candidates were able to state that colourless gas is formed when Na_2CO_3(aq) is added to **X**, but only about a quarter of the candidates were able to give a complete explanation in the answer.
12	The performance of candidates in this question was satisfactory. Even though only a small number of candidates were able to give a correct and complete answer, more than half of the candidates were able to correctly state at least two characteristics of transition metals and illustrate their answers by using the observations described in the question. Some candidates failed to answer using precise terminology. For example, they wrote 'transition metals have different colours' instead of 'transition metals form coloured ions and compounds'. More than a third of the candidates failed to state that Co^{2+} was regenerated or it was not consumed upon the completion of the reaction.
13	The performance of candidates in this question was satisfactory. Even though only a small number of the candidates were able to give a correct and complete answer, the majority of the candidates were able to give a partially correct answer. About half of the candidates were able to give two correct labelled curves on the graph. Some candidates wrongly gave 'reaction coordinate' for the label of the x-axis. Some candidates failed to state that the two trials have to be carried out under the same conditions except the concentration of HCl(aq). Some candidates did not read the question carefully and failed to recognise that they were asked to describe how the effect of concentration of HCl(aq) on the rate of the reaction can be studied experimentally. They wrongly gave their answers in terms of the collision theory.

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 satisfactory. In part (a)(i), about a third of the candidates were able to suggest two advantages of a membrane electrolytic cell over a flowing mercury cell in chloroalkali industry. Many candidates wrongly suggested that the sodium hydroxide obtained in a membrane electrolytic cell would be purer. In part (a)(ii), a very high proportion of the candidates were able to state iron as the catalyst in the Haber process. In part (a)(iii), about half of the candidates were able to sketch the Maxwell-Boltzmann distribution curves for the two different temperatures. The performance of candidates in part (b) was satisfactory. In part (b)(i)(1), about a quarter of the candidates were able to suggest one reason for Reaction (I) to be considered as greener than Reaction (II). However, many candidates answered this question without a comparative sense. In part (b)(i)(2), about two thirds of the candidates were able to suggest one reason for Reaction (II) to be considered as greener than Reaction (I). Some candidates stated 'the use of a solvent in Reaction (II) while the lack of a solvent in Reaction (I)' as the reason for Reaction (II) being greener than Reaction (I) which was incorrect. In part (b)(ii), about half of the candidates were able to calculate the yield of the product. Some candidates calculated the mass of the product obtained without further expressing their answers in terms of yield. In part (b)(iii)(1), about three quarters of the candidates were able to explain why the operation pressure would be set as 30 atm but not at atmospheric pressure with reference to the yield of the reaction. In part (b)(iii)(2), below half of the candidates were able to explain why the optimum conditions would be set at 180°C and 30 atm with reference to the rate and yield of the reaction, and the maintenance cost respectively. The performance of candidates in part (c) was fair. In part (c)(i), below half of the candidates were able to suggest 'the absorbance is directly proportional to the concentration of brown I_2' as the reason for 'the rate of change of the absorbance can represent the rate of reaction'. In part (c)(ii), below half of the candidates were able to deduce 'w' with reference to the linear plot in Line 1. In part (c)(iii), just below half of the candidates were able to deduce 'x' with reference to Line 1 and Line 2. In part (c)(iv), about a quarter of the candidates were able to give the unit of the rate constant as $dm^3\ mol^{-1}\ s^{-1}$. In part (c)(v), about half of the candidates were able to draw an energy profile for the given reaction. Some candidates wrongly drew two energy profiles to represent one with a catalyst and the other one without.

Question Number	Popularity (%)	Performance in General
Section B: 2	6	The performance of candidates in part (a) was poor. In part (a)(i)(1), only a small number of the candidates were able to name the type of the crystal structure for Pt. In part (a)(i)(2), only a small number of the candidates were able to deduce the respective numbers of Pt atoms and Mn atoms in the given unit cell. In part (a)(ii), only a small number of the candidates were able to state the meaning of the term 'nanomaterials' and the use of silver nanomaterials in daily life. The performance of candidates in part (b) was poor. In part (b)(i), only a very small number of the candidates were able to give a complete explanation as to why iron is malleable and ductile. Many candidates did not explain the changes at the atomic level when an external force is applied. In part (b)(ii)(1), about half of the candidates were able to suggest the physical properties required, i.e. hardness. In part (b)(ii)(2), only a small number of the candidates were able to explain why the strength would improve using the difference in size of carbon and iron atoms. In part (b)(iii), only a small number of the candidates were able to give the explanation for the rigidity of Kevlar and state that Kevlar would undergo acid hydrolysis. The performance of candidates in part (c) was poor. In part (c)(i), only a small number of the candidates were able to state the structural characteristics of **A**. In part (c)(ii)(1), only a third of the candidates were able to draw the structure of the monomer of **B**. In part (c)(ii)(2), only a very small number of the candidates were able to suggest the suitable moulding method for making a thin film of **B**. In part (c)(iii)(1), only a very small number of the candidates were able to draw the structure of the repeating unit of **C**. In part (c)(iii)(2), only a small number of the candidates were able to include 'elimination of water molecules' in their answers. In part (c)(iii)(3), only a small number of the candidates were able to give the reasons why the polymerisation can be considered as green. Some candidates erroneous considered the atom economy of the reaction as 100%, and some candidates mixed up the meaning of 'yield' and 'atom economy'.

Question Number	Popularity (%)	Performance in General
Section C: 3	96	The performance of candidates in part (a) was good. In part (a)(i), just below half of the candidates were able to suggest how to distinguish $Na_2CO_3(s)$ and $Na_2CO_3 \cdot 10H_2O(s)$. Many candidates were able to suggest the use of dry cobalt(II) chloride paper but some candidates did not mention heating the sample in order to test the water given out. In part (a)(ii), about half of the candidates were able to suggest that the colour change for the titration between $I_2(aq)$ and $Na_2SO_3(aq)$ would be from blue to colourless. In part (a)(iii), about three quarters of the candidates were able to describe a chemical test to distinguish between hex-1-ene and hexanal. Some candidates wrongly used acidified potassium permanganate solution to distinguish the two compounds despite both giving similar observable changes. The performance of candidates in part (b) was satisfactory. In part (b)(i), about a third of the candidates were able to draw a labelled diagram for the set-up in performing a TLC experiment. However, many candidates did not label the solvent in the diagram and some candidates wrongly labelled it as drug **Y**. In part (b)(ii), about three quarters of the candidates were able to calculate the R_f value for aspirin. In part (b)(iii), a high proportion of the candidates were able to suggest the drug would contain aspirin and caffeine. In part (b)(iv)(1), about a third of the candidates were able to state that only the IR spectrum of aspirin would contain a strong IR absorption peak from 2500 cm^{-1} to 3300 cm^{-1} corresponding to the O-H group of carboxylic acid. Some candidates stated that only caffeine would have a strong absorption peak from 3350 cm^{-1} to 3500 cm^{-1} without recognising that caffeine does not have a N-H group. In part (b)(iv)(2), below half of the candidates were able to suggest the major peak m/z = 43 in the mass spectrum of the sample would represent CH_3CO^+ ion. Some candidates did not recognise that both aspirin and acetaminophen would have this fragment so that this information cannot be used to confirm which one of the three chemicals would the sample be. The performance of candidates in part (c) was good. In part (c)(i)(1), a high proportion of the candidates were able to give the colour change and a half equation for the colour change involved. In part (c)(i)(2), a high proportion of the candidates were able to state which driver would have a higher ethanol intake. In part (c)(i)(3), about a quarter of the candidates were able to suggest the same amount of breath would allow the checking to be performed in a fair manner. In part (c)(ii), about half of the candidates were able to calculate the mass of C_2H_5OH in the serum sample and determine whether the driver would be found guilty. Some candidates did not make use of the mole ratio of $C_2H_5OH(aq)$ to $K_2Cr_2O_7(aq)$ in their calculations.

School-based Assessment

All school candidates have to participate in School-based Assessment (SBA). There were 11848 students from 431 schools submitted their SBA marks this year. This is the ninth 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, an 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 55.1 % of schools fall into the 'within the expected range' category, while the marks of 27.8 % of schools are higher than expected, and 17.1 % 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. It is noted that a very small number of schools did not include 'titration' exercise in their volumetric analysis experiments, which may not be beneficial to the development of the holistic laboratory-based learning experience. 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. It is encouraging to observe that some schools, with sufficient lesson time and other resources, arranged 'preparative experiments' for their students.

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 are 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 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 2020 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.