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

1. For Q.15, less than half of the candidates correctly chose the key B. It should be noted that reduction would occur at the negative electrode when the cell is being recharged. Moreover, the reaction during recharge is in the opposite direction of the one during discharge. Hence, option B is then the half equation involved.

Q15. The following equation shows the reaction when a secondary cell is discharging :

$$2NiO(OH)(s) + Cd(s) + 2H_2O(l) \rightarrow 2Ni(OH)_2(s) + Cd(OH)_2(s)$$

Which of the following half equations shows the change at the negative electrode when the cell is being recharged ?

A.	$Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2(s) + 2e^-$	(29%)
B.*	$Cd(OH)_2(s) + 2e^- \rightarrow Cd(s) + 2OH^-(aq)$	(36%)
C.	$Ni(OH)_2(s) + OH^-(aq) \rightarrow NiO(OH)(s) + H_2O(l) + e^-$	(20%)
D.	$NiO(OH)(s) + H_2O(l) + e^- \rightarrow Ni(OH)_2(s) + OH^-(aq)$	(15%)

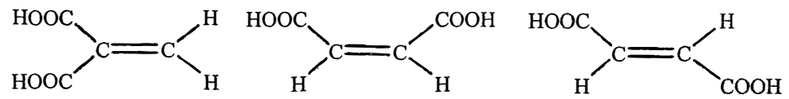
2. For Q.20, nearly half of the candidates wrongly chose option A. It indicates that they did not know that both Pb atom and Pb^{2+} ion have the same number of occupied electron shells. Pb has 14 electrons in its outermost shell. After losing 2 electrons to become Pb^{2+} ion, it still has 12 electrons in the original outermost shell. It is why both Pb atom and Pb^{2+} ion have the same number of occupied electron shells.

Q20. Pb is an element in Group IV of the Periodic Table and can form Pb^{2+} ion. Which of the following statements are correct ?

(1) The change from Pb^{2+} ion to Pb atom is a reduction.
(2) Both Pb atom and Pb^{2+} ion have the same number of protons.
(3) Both Pb atom and Pb^{2+} ion have the same number of occupied electron shells.

A.	(1) and (2) only	(47%)
B.	(1) and (3) only	(9%)
C.	(2) and (3) only	(6%)
D.*	(1), (2) and (3)	(38%)

3. For Q.29, around sixty percent of the candidates wrongly chose option D. It indicates that they might probably miss one of the following isomers that **X** may have :



Q29. The molecular formula of compound **X** is $C_4H_4O_4$. It has two $-COOH$ groups. How many isomers may **X** have ?

A.	5	(3%)
B.	4	(12%)
C.*	3	(26%)
D.	2	(59%)

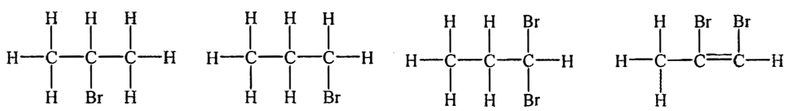
4. For Q.31, most of the candidates correctly chose option (1). It indicates that they knew that nylon-6,6 can be used to make ropes. However, quite a large number of them at the same time wrongly chose option (3). In fact, there are only four, instead of six, $-CH_2$ groups between the two C=O bonds in the repeating unit of nylon-6,6.

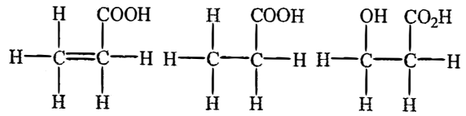
Q31. Which of the following statements concerning nylon-6,6 is / are correct ?

(1) It can be used to make ropes.
(2) The polymerisation in forming it is a hydrolysis process.
(3) Its repeating unit is $-\left[\overset{H}{\overset{|}{N}}(CH_2)_6\overset{H}{\overset{|}{N}}\overset{O}{\overset{\|}{C}}(CH_2)_6\underset{\underset{O}{\|}}{C}\right]-$.

A.*	(1) only	(34%)
B.	(2) only	(6%)
C.	(1) and (3) only	(51%)
D.	(2) and (3) only	(9%)

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 give the correct electronic arrangement of a phosphorus atom, but some of them gave the electron diagram of a phosphorus atom, and a small number of them wrongly gave the electronic arrangement of a chlorine atom. In part (b), a very high proportion of the candidates were able to state that some chlorine atoms have different mass numbers because chlorine atoms have isotopes, or some chlorine atoms have different number of neutrons. Some candidates wrongly stated that some chlorine atoms have different numbers of protons or electrons. In part (c)(i), just less than half of the candidates were able to give the correct molecular formula of the compound with correct deduction. A small number of candidates gave only the molecular formula without showing any deduction. In part (c)(ii), about three quarters of the candidates were able to give the correct electron diagram for PCl_3. Some candidates gave electron diagrams with an incorrect number of electrons in the outermost shells, or without showing the lone pairs in the diagrams.
2	The performance of candidates in this question was satisfactory. In part (a), about two thirds of the candidates were able to give the correct explanation. Some candidates wrongly stated that $K_2SO_4(aq)$ can provide mobile electrons to conduct electricity, or it allows mobile electrons to pass through, or $K_2SO_4(aq)$ would not react with $K^+(aq)$ or $Fe(CN)_6^{3-}(aq)$ but water would react with them. In part (b), a very high percentage of the candidates were able to give the correct colour of $FeSO_4(aq)$, but some of them wrongly stated that the colour of $FeSO_4(aq)$ is dark green, dirty green, or bluish green. In part (c), only about one third of the candidates were able to state the correct observation; about a quarter were able to give the correct explanation. In part (d), about one third of the candidates were able to state that there would be no observable change around the middle of the filter paper; a quarter were able to fully state that after the two poles of the cell have been reversed, the $K^+(aq)$ and $SO_4^{2-}(aq)$ that migrate to the middle of the filter paper do not show any colour on the filter paper.
3	The performance of candidates in this question was fair. In part (a), nearly all candidates were able to write the correct name of the reaction type, and about two thirds of the candidates were able to suggest a correct importance of this type of reaction in industry. A few candidates were confused about catalytic cracking and fractional distillation, and wrongly stated that this reaction can separate useful fractions from petroleum. In part (b), about two thirds of the candidates were able to correctly state the advantage of using broken unglazed porcelain in the experiment. Some candidates wrongly stated that smaller pieces of porcelain can be heated more efficiently. In part (c)(i), about three quarters of the candidates were able to give the correct balanced equation for the reaction. Some candidates failed to give the correct molecular formula of octane, and some failed to give the correct stoichiometric coefficients for the equation. In part (c)(ii)(1), about three quarters of the candidates were able to give the correct answer. Some candidates failed to give the correct colour of bromine solution, and a few candidates wrongly stated the colour change is from colourless to brown. In part (c)(ii)(2), about three quarters of the candidates were able to give the correct structure of the reaction product. However, some candidates gave the following incorrect structures:  In part (d), about two thirds of the candidates were able to state that something had to be done to prevent sucking back of water into the hot boiling tube, and about one third of the candidates were able to give the correct procedure to prevent sucking back of water. Some candidates wrongly stated that the hot boiling tube should be cooled down slowly, or the gaseous products should be taken into a fume cupboard.

Question Number	Performance in General
4	The performance of candidates in this question was fair. In part (a)(i), about half of the candidates were able to give the correct three-dimensional structure of a CS_2 molecule. Some candidates wrongly gave a bent structure for this molecule, or gave an electron diagram in the answer. In part (a)(ii), a very high percentage of candidates were able to give the correct three-dimensional, tetrahedral structure of a CH_2Br_2 molecule. In part (b), about two thirds of the candidates were able to correctly identify the polar bonds in a CH_2Br_2 molecule, and below half of the candidates were able to give the correct explanation. Some candidates misinterpreted the question, and discussed whether CH_2Br_2 is a polar molecule. In part (c), about one third of the candidates were able to give the correct answer. Some candidates wrongly stated that CO_2 is a non-polar molecule while CS_2 is polar, and some candidates wrongly stated that CS_2 has a giant covalent structure.
5	The performance of candidates in this question was satisfactory. In part (a), about half of the candidates were able to draw the structure of compound **A**, but most of them failed to write the required systematic name (i.e. propenoic acid). Some candidates gave the following incorrect structures:  In part (b), around three quarters of the candidates were able to state the correct type of polymerisation, but some gave incorrect answers like 'addiction polymerisation' and 'additional polymerisation'. In part (c), about forty percent of the candidates were able to answer the question. In part (d), nearly half of the candidates were not able to write the correct structure of polymer **C**. Mistakes such as 'covalent bond between sodium and carbon', 'presence of hydroxyl group' and 'the omission of n' were common.
6	The performance of candidates in this question was good. In part (a), about seventy percent of the candidates were able to point out the three ionisable hydrogen atoms in the structure of citric acid. In part (b) (i), about seventy percent of the candidates were able to state the apparatus to be used, but some of them gave incorrect answers like 'conical flask', 'beaker', 'burette' and 'pipette', etc. In part (b) (ii), two thirds of the candidates were able to do the required calculation. In part (c) (i), most of the candidates were able to state the correct observation, but in part (c) (ii), quite a number of them wrote the following incorrect ionic equation: $2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$.
7	The performance of candidates in this question was fair. In part (a), the performance of candidates was very poor. Only a very small number of candidates were able to state 'constant pressure' as the required condition. In part (b), about one third of the candidates were able to explain why an indirect method should be needed. In part (c)(i), about seventy percent of the candidates were able to suggest the possible error. In part (c)(ii), only less than half of the candidates were able to correctly explain why the enthalpy change of reaction of $CaCO_3(s)$ with $H_2SO_4(aq)$ could not be determined using the procedure. In part (d), the performance of candidates was fair. The most common mistake was 'the omission of the state symbols'. Furthermore, many candidates were not able to write the balanced chemical equation required, and hence failed to complete the required calculation.

Question Number	Performance in General
8	The performance of candidates in this question was fair. In part (a)(i), about two thirds of the candidates failed to state the observation at electrode **X**, i.e. a reddish brown colour gas will be given out. In part (a)(ii), about half of the candidates got the correct answer. In part (b), about two thirds of the candidates were able to state that bromine is toxic, but some of them put forward incorrect answers like 'harmful' and 'irritant'. In part (c)(i), about half of the candidates were able to deduce the oxidising agent as MnO_2 based on the change in oxidation number of Mn (i.e. +4 decreases to +3). In part (c)(ii), most of them were not able to write the required half equation, and many erroneously included $H^+(aq)$ in the equation. Quite a number of the candidates wro nglysuggested Zn as the oxidising agent and wrongly wrote: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$.
9	The performance of candidates in this question was fair. About forty percent of the candidates were able to give correct tests to distinguish the solids, and predicted the observations correctly. However, most candidates failed to use water to dissolve the solids first. Many candidates incorrectly considered that flame test can be used, and gave incorrect answers like bright white light for $MgSO_4(s)$ or $MgSO_4 \cdot 7H_2O(s)$. Some candidates wrongly stated that when heated strongly, $ZnSO_4(s)$ would show a yellow colour, and when cooled a white colour.
10	The performance of candidates in this question was fair. In part (a), about half of the candidates were able give a correct description about the term 'dynamic equilibrium'. In part (b), about one third of the candidates were able to give the correct calculation. Some candidates were able to obtain the correct numbers of moles of SO_2, O_2 and SO_3 present at equilibrium, and correctly put the corresponding terms into the equilibrium expression, but they failed to correctly solve the corresponding equations. In part (c)(i), just less than half of the candidates were able to give the correct answer. Some candidates failed to recognise the effect of changing the temperature on exothermic/endothermic reactions. In part (c)(ii), just less than half of the candidates were able to give the correct answer. Some candidates only stated that adding a suitable catalyst would not increase the number of moles of $SO_3(g)$ obtained without giving a proper explan at ion.
11	The performance of candidates in this question was poor. In part (a), less than half of the candidates were able to correctly state keeping the total volume of the reaction mixtures the same for conducting fair tests among the trials, so that the concentration of NaOH(aq) would be the only variable. In part (b), only a quarter of the candidates were able to correctly find out the pH of the NaOH(aq) in Trial 2. Some candidates were confused about number of moles of NaOH and concentration of so l ion in the calculation, and some cand idates failed to recognise the meaning of $[H^+(aq)][OH^-(aq)] = 1.0 \times 10^{-14}\ mol^2 dm^{-6}$, nd failed to apply this equation in the calcul ation. Some c andidates w e re confused about $[H^+(aq)]$ and $[OH^-(aq)]$ in the calculation. In part (c), about half of the candidates were able to recognise the rate of the reaction was affected by the concentration of NaOH(aq) in the mixture. Some candidates failed to recognise the focus of this question, and wrongly stated that the rate of the reaction was affected by the volume of NaOH(aq) added. A very small number of the candidates were able to give a complete deduction in their answers. In part (d), a very high percentage of the candidates were able to correctly state the colour change can be more accurately detected by colorimetry. Some candidates gave an incorrect answer such as 'calorimetry'.

Question Number	Performance in General
1 2	The performance of candidates in this question was poor. Only a small number of the candidates were able to give a correct synthetic route, and stated the appropriate reagents an reaction conditions in each step. Even though about half of the candidates were able to recognise that this synthetic route involves two key steps, converting an amide into a carboxylic acid in the first step, and intramolecular esterification in the second step, some candidates failed to give complete answers. Common mistakes included omitting the reaction conditions, stating inappropriate reagents for the steps (using dilute H_2SO_4 for esterification), and including inappropriate steps (oxidation with acidified $K_2Cr_2O_7$, reduction with $LiAlH_4$) in the proposed synthetic route.
13	The performance of candidates in this question was fair. In part (a), about two thirds of the candidates were able to give a correct labelled diagram for the set-up for heating the mixture under reflux. Some candidates wrongly gave the drawing of a distillation set-up in their answers. Other common mistakes included missing labels in the diagrams, inappropriate positions of water inlet and outlet on the condenser, and drawing the set-up as a closed system. In part (b), about half of the candidates were able to suggest an appropriate alternative reagent for carrying out the reduction reaction. Some candidates wrongly stated using $LiAlH_4$ in an acidic aqueous medium ($LiAlH_4$ / $H^+(aq)$). In part (c), about half of the candidates were able to give the correct answer. Some candidates gave incorrect answers such as 'positional isomers', 'geometrical isomers', and 'structural isomers'. In part (d), only about one third of the candidates were able to correctly state that the two compounds **P** and **Q** have different optical activity, or they can rotate plane-polarised light to the same extent but opposite directions. Some candidates wrongly stated that the two compounds have different melting points or boiling points. In part (e), less than half of the candidates were able to suggest an appropriate chemical test to distinguish acetophenone and **P**.
14	The performance of candidates in this question was fair. About one third of the candidates were able to give a correct and complete answer. About two thirds of the candidates were able to arrange the four elements in the correct decreasing order of electrical conductivity, but some of them failed to give correct explanations in some places. Some candidates failed to recognise that sodium and aluminium have giant metallic structures or silicon has a giant covalent structure. Some candidates wrongly stated that sodium has a higher electrical conductivity than aluminium because sodium is more reactive, and the outermost shell electron of a sodium atom loses more easily than the outermost shell electrons of an aluminium atom when conducting electricity.

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. However, around three quarters of the candidates were not able to state what the area under a Maxwell-Boltzmann distribution curve represents, while about half of them were not able to give - reasons for choosing 300°C as the operation temperature for the ethanol production; - two major constituent gases in syngas; and - one important chemical made directly from syngas. The performance of candidates in part (b) was fair. About three quarters of the candidates were not able to write a chemical equation for oxidising nitrogen dioxide forming nitric acid or give the reasons for the installation of a heat exchanger in the manufacture of ammonia in the Haber Process. Just below half of the candidates were not able to - suggest nitrogen can be obtained from fractional distillation of liquefied air; - write a chemical equation for oxidising ammonia giving nitrogen monoxide; and - calculate the mass of ammonia produced from the given information. The performance of candidates in part (c) was good. Eighty percent of the candidates were able to point out the effect of enzyme in hydrolysis of sucrose. Moreover, most candidates were able to deduce the order of reaction with respect to HCl(aq) but not many candidates were able to deduce the order of reaction with respect to $C_{12}H_{22}O_{11}$(aq). About half of the candidates were able to write a rate equation for the hydrolysis of sucrose. However, only about one third of the candidates were able to calculate the rate constant with correct unit, of which, about a quarter were able to give reasons based on green chemistry principles to illustrate why starch is considered to be more suitable than sucrose as a source of glucose.
Section B: 2	6	The performance of candidates in part (a) was poor. In part (a)(ii), only about ten percent of the candidates were able to give answers like 'polar nature' and the 'presence of phenyl groups'. In part (a)(iii), less than one third of the candidates were able to describe the presence of intermolecular hydrogen bonds as the reason for the rigidity of Kevlar. The performance of candidates in part (b) was fair. About three quarters of the candidates failed to name the type of crystal structure. Incorrect answers like 'body-centered cubic' were common. In addition, many candidates were not able to deduce the number of gold atoms in the given unit cell and wrongly regarded the coordination number required as 13. The performance of candidates in part (c) was fair. About seventy percent of the candidates were not able to make deduction and hence draw the structures of the two monomers of PBT. Moreover, many candidates wrongly stated the type of polymerisation involved as 'addition polymerisation'. Only a few candidates were able to draw the required structure correctly.

Question Number	Popularity (%)	Performance in General
Section C: 3	96	The performance of candidates in part (a) was satisfactory. About half of the candidates were able to give one property of sodium hydroxide that makes it not suitable for preparing a standard solution and about two thirds of the candidates were able to state the similarity and difference between the infrared spectra of cellulose and chitin. However, most of them were not able to give a chemical test for hypochlorite ions. The performance of candidates in part (b) was satisfactory. As only about half of the candidates were able to write a chemical equation for the reaction between Fe^{2+}(aq) and $Na_2Cr_2O_7$(aq) under acidic conditions, many candidates were not able to calculate the concentration of $Na_2Cr_2O_7$(aq) in **A**. About half of the candidates were also able to state the relationship between absorbance and [$Cr_2O_7^{2-}$(aq)] and calculate the concentration of $Na_2Cr_2O_7$(aq) in **B**. However, only a very small number of the candidates were able to suggest why a blue filter is used and colorimetry is more appropriate than volumetric analysis in the determination of the concentration of a very dilute $Na_2Cr_2O_7$(aq). The performance of candidates in part (c) was fair. Most of the candidates were not able to outline the experimental procedure in separating **Y** from the given mixture and wrongly suggested the use of distillation as the final step in the separation. A high proportion of the candidates were not able to suggest a method to identify the solid obtained as pure **Y**. Moreover, a very high proportion of the candidates were not able to suggest how **X** and **Y** can be differentiated from their mass spectra.

School-based Assessment

All school candidates have to participate in School-based Assessment (SBA). There were 14176 students from 421 schools submitted their SBA marks this year. This is the fifth year of implementation of SBA for the Hong Kong Diploma of Secondary School Education (HKDSE). With the experience acquired over the past four 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 2015. The conference and group meetings provided teachers with general comments and summary about the SBA implementation, and up-to-date adjustments 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 classes. 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 52.5% of schools fall into the 'within the expected range' category, while the marks of 30.0% of schools are higher than expected, and 17.5% 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 24 district coordinators to address enquiries from teachers about SBA implementation, and to ensure that schools were running the scheme within 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 encouraging to see experiments from different topics like 'Chemistry reactions and energy', 'Rate of reaction' and 'Chemical equilibrium' have been commonly used. It was observed, however, that not many schools carried out preparative experiments (in particularly those involving organic reactions) for SBA tasks. Due to the lack of this kind of experience, many students have limited understanding about the correct procedures of carrying out an organic reaction and isolating the product from the reaction mixture. Conducting these types of experiments can strengthen students' abilities on basic laboratory skills.

2. Variety of Written Work
   Worksheets, 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. Previous experience showed that students frequently omitted some essential items (such as date, experimental title, objectives, and reference, etc) in the first few times when they wrote laboratory reports. However, after gaining some experience, students were able to write a laboratory report in a proper manner.

3. Use of 'feedback' to promote learning
   Providing feedback to students through submitted reports is important for facilitating student learning. It also helps students to avoid making the same type of mistakes in the future. Moreover, students are encouraged to discuss with their teachers their own performance in carrying out experiments and related written tasks. Teachers can provide students with written and other forms of feedback to promote learning through School-based Assessment.

4. 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 in these areas.

5. 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 HKDSE 2016, students' performance is 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.