# Chemistry

## Report on Student Performance in the Practice Papers

The practice papers were piloted in seven schools with more than 300 students participating in the pilot exercise. Despite the sample size being a bit small, students' performance in this exercise should still reflect some weaknesses of students. Readers are advised to study this report together with the selected samples of student performance so that they can get a better understanding of the high, mid and low performance of students in this pilot exercise.

**Paper 1**

**Section A** (multiple-choice questions)

There were 24 questions in Part I and 12 questions in Part II. Students' performance was good in general. The mean percentage score was 61.89, and the standard deviation was 17.16. Some misconceptions of students were revealed from their performance in the following items:

1. Q.5 is a straightforward question. However, only about half of the students chose the correct answer, which is option C. Some students failed to draw from their experience that freezing involves liberation of heat and melting involves absorption of heat, and hence they wrongly chose option A.

Q.5 Which of the following processes is endothermic ?

| | | |
|---|---|---|
| A. | $H_2O(\ell) \rightarrow H_2O(s)$ | (23%) |
| B. | $CuSO_4(s) + 5H_2O(\ell) \rightarrow CuSO_4 \cdot 5H_2O(s)$ | (14%) |
| C.* | $2H_2O(\ell) \rightarrow 2H_2(g) + O_2(g)$ | (53%) |
| D. | $Ca(s) + 2H_2O(\ell) \rightarrow Ca(OH)_2(aq) + H_2(g)$ | (10%) |

2. Q.7 is a question set on the nature of science and is about the discovery of argon Students' performance was unsatisfactory. Their failure in choosing the correct answer, which is option B, was probably because they were not familiar with the historical development of chemistry, or they had a poor understanding of the information given. Extensive reading can help students perform well in questions of this type.

Q.7 A scientist extracted a sample of 'nitrogen' from air by removing the oxygen and carbon dioxide. The scientist then compared the mass of a known volume of the 'nitrogen' sample ($m_1$) with that of the same volume of pure nitrogen ($m_2$) under the same set of conditions. The experiment was repeated a number of times. It was found that $m_1$ was consistently greater than $m_2$ .

Which of the following gases is likely to be present in the 'nitrogen' obtained to account for the result that $m_1$ is greater than $m_2$ ?

| | | |
|---|---|---|
| A. | neon | (12%) |
| B.* | argon | (31%) |
| C. | methane | (13%) |
| D. | water vapour | (44%) |

3. In general, students did not perform well in questions involving calculations. In Q.9, less than 40% of s were able to choose the right option for this question. These students probably had a weak understandi the concept of morality.

Q.9 When 25 $cm^3$ of 1.00 mol $dm^{-3}$ NaOH(aq) is mixed with 25 $cm^3$ of 1.00 mol $dm^{-3}$ HCl(aq), the temperature of the mixture rises by 6°C. Which of the following reactants, when mixed under the same conditions, would give a similar temperature rise ?

| | | | |
|---|---|---|---|
| A. | 25 $cm^3$ of 2.00 mol $dm^{-3}$ NaOH(aq) | and 25 $cm^3$ of 2.00 mol $dm^{-3}$ HCl(aq) | (11%) |
| B.* | 50 $cm^3$ of 1.00 mol $dm^{-3}$ NaOH(aq) | and 50 $cm^3$ of 1.00 mol $dm^{-3}$ HCl(aq) | (37%) |
| C. | 50 $cm^3$ of 0.50 mol $dm^{-3}$ NaOH(aq) | and 50 $cm^3$ of 0.50 mol $dm^{-3}$ HCl(aq) | (44%) |
| D. | 100 $cm^3$ of 0.25 mol $dm^{-3}$ NaOH(aq) | and 100 $cm^3$ of 0.25 mol $dm^{-3}$ HCl(aq) | ( 8%) |

4. Some students were weak in correlating chemistry to environmental issues. They did not know that cadmium and its compounds are toxic, and thus the disposal of nickel-cadmium batteries could pose harm to life.

Q.23 Which of the following statements about lithium-ion batteries is/are correct ?

(1) In lithium-ion batteries, the electrolyte is a lithium salt in water.
(2) Lithium-ion batteries are rechargeable.
(3) The disposal of lithium-ion batteries causes less harm to the environment than that of nickel-cadmium batteries.

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

**Section B** (conventional questions)

Section B consists of two parts, Part I and Part II. Part I contained questions set mainly on Topics I to VIII of the curriculum, while Part II contained those mainly on Topics IX to XII. All questions were compulsory. Students' performance is summarised in the tables below:

**Part I**

| Question Number | Performance in General |
|---|---|
| 1 | Part (a) was generally well answered, indicating that students had a good understanding of the principles underlying the preparation.<br><br>Performance was fair in part (b). Some students were not aware that undissolved solute could be seen when a hot saturated solution of the salt is allowed to cool.<br><br>Parts (c), (d) and (e) were generally well answered. In (d), some students suggested heating the crystals in an oven so as to dry them. They did not realise that dehydration might occur. |
| 2 | Part (a) was well answered. The word 'unpalatable' was unfamiliar to some students. However, most of them could guess that the taste of the wine had turned bad and were able to produce reasonable explanations based on oxidation of the ingredients in wine by atmospheric oxygen. |

| | |
|---|---|
| 2 | Part (b) (i) was well answered. Some students confused the words 'denser' and 'heavi They stated wrongly that 'argon is heavier than air' or 'helium is lighter than air' in parts (b) (ii) and (iii).<br><br>Part (c) was poorly answered. Most students did not realise that pumping air out from the bottle could also remove the volatile organic substances which give the wine its pleasant odour. |
| 3 | Most students were able to draw the correct electron diagrams in parts (a) (i) and (b) (i), and to recognise that the reaction in (a) (ii) is not a redox.<br><br>Students' performance in part (b) (ii) was poor. Some students failed to recognise that the repulsion between the electron pairs in the valence shell of nitrogen could account for the similar shapes of the $NCl_3$ and $NH_3$ molecules. |
| 4 | Performance was fair. In part (a), most students knew the procedures for preparing standard solutions in volumetric analysis, such as the use of a volumetric flask and the need to add deionised water to the volumetric flask up to the graduation mark. However, some students failed to mention that the beaker which was used to contain the carbonate solution needed to be washed a few times, and all of the washings had to be transferred to the volumetric flask before adding deionised water.<br><br>Part (b) was well answered, except that some students wrongly included the unit 'g' in the formula mass of $\mathbf{M}_2CO_3$ , which should bear no units. |
| 5 | In part (a), most students knew the correct method for working out the empirical formula of **X**. However, many did not use the general formula of alkanes, i.e. $C_nH_{2n+2}$ , to deduce the molecular formula of **X**. Part (b) was well answered. In part (c), most students recognised the advantage of using **X** as a fuel, while some did not know that burning kerosene produces a luminous flame. |
| 6 | Parts (a) and (b) were well answered. In (c), some students were not aware that the shape of propan-1-ol molecules allows them to have greater area of contact as compared with the case of propan-2-ol molecules, and hence the density of propan-1-ol is greater than that of propan-2-ol. Students' performance in part (d) was fair. The weaker students were unable to correlate the rate at which steel balls fall to the viscosity of the liquids. |
| 7 | Part (a) was satisfactorily answered. Most students knew how to calculate $\Delta H$ of the reaction. However, some students did not include a negative sign in their final answers for this exothermic reaction.<br><br>Students' performance in part (b) (i), which is a question set to test the rationale behind the choice of materials for particular purposes, was good. In part (b) (ii), some students failed to mention that the reaction of CaO(s) with water is *highly* exothermic or CaO(s) is an *inexpensive* material. |
| 8 | Part (a) was set to test students' ability in writing balanced half-equations. Students' performance was unsatisfactory, especially in writing the half-equation for the oxidation of $CH_3OH(\ell)$ to $CO_2(g)$.<br><br>Students' performance in part (b) (i) was fair. Students should recognise that mobile ions have to be present in order for an electrochemical reaction to occur. In part (b) (ii), most students knew that concentrated methanol solutions are toxic and flammable. Students' performance in part (c), which is an open-ended question, was fair. |

**Part II**

| Question Number | Performance in General |
|---|---|
| 9 | Part (a) was satisfactorily answered. In part (b), some students were not aware that the acidic property of oxides increases with covalent character. Part (c) was poorly answered. Most students were unable to suggest a systematic way to show the acidic, basic and amphoteric properties of the oxides. |
| 10 | Part (b) was set to test students' ability to interpret the experimental results presented in a graphical form, and their understanding of 'controlled experiments'. Students' performance was fair. Some did not realise in (i) that the rate of the reaction increases when the concentration of the catalyst, $Mn^{2+}(aq)$ in this case, builds up. Some failed to suggest in (ii) that a small amount of $Mn^{2+}(aq)$ should be added to the reaction mixture before the start of the repeated experiment. |
| 11 | This was well answered. Most students were able to suggest correct reagent(s) and reaction conditions for each step of the conversion. |
| 12 | Performance was fair. Most students correctly pointed out in (a) (ii) that a pair of enantiomers exhibit different optical properties. Some students produced poor drawings for the three-dimensional structures for the enantiomers in (a) (i), and for the structure of the repeating unit of the polymer in (b). |
| 13 | Parts (a) and (b) were well answered. In (b), many students were unable to give the correct units of $K_c$.<br><br>Performance in part (c) was fair. Most students failed to provide an explanation based on shifting of equilibrium position to account for the colour changes. Some weaker students did not realise that the blue precipitate formed is $Cu(OH)_2(s)$ and the blue colour of the solution subsequently formed is due to presence of $Cu^{2+}(aq)$ ions. |

**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'. Students were required to attempt all questions in two of these sections.

| Question Number | Performance in General |
|---|---|
| 1 (a) | The question was set to test students' ability to apply their chemical knowledge to an unfamiliar situation. In this case, it is the synthesis of vitamin C by the Reichstein process. Students' performance was fair. Parts (i) and (ii) were well answered. In (iii) (II), some students did not realise that the conversion of D-sorbitol to L-sorbose requires the use of an enzyme catalyst which is *highly selective*, and the conversion cannot be effected by commonly used oxidising agents. Those students who had mastered the principles of green chemistry well were able to produce good answers in (iv). |
| (b) | The weaker students failed to state, in (i), the meaning or the characteristics of a first order reaction. The calculation in (ii) was quite straightforward. Some students demonstrated poor graph-plotting skills and some did not plot the graph on a graph paper. These students obtained results for $E_a$ which deviated from the acceptable range. Some students were not aware that the logarithm of concentration bears *no units*. |

| | |
|---|---|
| 1 (c) | In (i), most students were able to give the correct half-equation for the formation of $H_2(g)$ a that of $Cl_2(g)$. However, the weaker students failed to explain the preferential discharge of $H^+(aq)$ ions by referring to the electrochemical series, and that of $Cl^-(aq)$ ions based on concentration effect. Some students did not realise that the membrane only allows cations to pass through it. They might have confused 'membrane cell' with 'diaphragm cell', both of which are used in the manufacture of chlorine. Part (ii) was well answered. Part (iii) is an open-ended question aiming at testing students' critical thinking skills. Some students failed to recognise that large scale manufacture of $H_2(g)$ by electrolysis of brine would bring about surplus $Cl_2(g)$, the disposal of which could pose other environmental problems. |
| 2 (a) | Part (i) (I) and (II) were well answered. In (III), some students demonstrated weakness in the conversion of length units from 'm' to 'cm', and thus were unable to calculate the density of solid aluminium correctly. Part (ii) was well answered. Part (iii) aimed at testing students' comprehension skills as well as their knowledge of ceramics. Although biotite, one of the many aluminosilicates, is not familiar to them, they should be able to deduce from the layer structure of biotite that it can easily flake off, and its use as an insulator in electronics. |
| (b) | In part (i), most students were able to give the correct structure of styrene and to propose a correct moulding method for making the plastic lid. In part (ii) (I), some students did not realise that SAN does not necessarily contain styrene and acrylonitrile in 1:1 mole ratio, and that the two monomers can distribute themselves randomly in the polymer chain. In part (ii) (II), some students were unable to recognise that the polar -C≡N groups in SAN will cause the molecules to interact with stronger dipole-dipole attraction in addition to the weaker van der Waals forces, which only operate between PS molecules. Part (iii) required students to demonstrate an understanding of the effect of cross-linking on the thermal properties of plastics. Students' performance was fair. Some students produced poor drawings of the cross-linkages in the structure of the thermosetting plastic. |
| 3 (a) | Most students correctly proposed 'carboxylic acid' in (i) and 'separating funnel' in (ii). Students' performance in (iii) was fair. In (iv), most students were able to deduce the presence of C=C bond in **X** and to identify the peak for the molecular-ion in the mass spectrum. Some students, who wrongly perceived **X** to be an ester, were unable to deduce a correct structure for **X.** In (v), some students were unable to propose 'column chromatography' based on the TLC results. |
| (b) | Parts (i) and (iii) were set to test the underlying principles of gravimetric analysis and the techniques involved in performing such type of experiments. Students' performance was fair. Some students were unable to express their ideas clearly using appropriate vocabulary. Those students who were weak in chemical stoichiometry were unable to calculate the percentage by mass of barium in the barium salt in part (ii). |