CONTENTS

CHEMISTRY (962/1)

OVERALL PERFORMANCE

For Semester 1, 4605 candidates sat examination for this subject and 63.35% of them obtained a full pass.

The percentage of the candidates for each grade are as following:

Grade	**A**	**A–**	**B+**	**B**	**B–**	**C+**	**C**	**C–**	**D+**	**D**	**F**
Percentage	9.53	5.88	11.42	9.71	9.92	6.62	10.27	6.51	5.73	5.58	18.81

CANDIDATES' RESPONSES

SECTION A: *Multiple-Choice*

Answer Keys

Question number	**Key**	**Question number**	**Key**	**Question number**	**Key**
1	**C**	6	**D**	11	**C**
2	**D**	7	**D**	12	**B**
3	**C**	8	**D**	13	**B**
4	**C**	9	**A**	14	**A**
5	**A**	10	**B**	15	**D**

General comments

The performance of the candidates were good. Question 8 was very difficult to answer with less than 30% of the candidates obtained the correct answers. The rest of the questions were in the medium range with 30% to 70% of the candidates obtaining the correct answers.

SECTIONS B AND C: *Structure and Essay*

General comments

The performance of the candidates depends on test centres. It was found that the candidates from big centres performed better than the candidates from smaller centres.

Comments on the individual question

Question 16

In part (*a*), many candidates only explained the general concept of nucleon number and relative atomic mass but failed to relate the above terms and the values given with reference to boron as required by the question. For example, the candidates did not state the number of protons as 5 and neutron as 6 in their definition of nucleon number of boron. A few candidates stated relative atomic mass refers to the average mass of the isotopes of boron.

In part (*b*)(i), most candidates were able to determine the relative molecular mass of boron trifluoride as 67.8. However, a few candidates did not round up the relative molecular mass to three significant figures and a few even used units, g or g mol^{-1} in the answer.

In part (*b*)(ii), most candidates were able to give the fragmented ions at m/e 48, 49 and 68. However, many candidates did not show the positive charge on the fragment ions. For example, $^{10}BF_2$, $^{11}BF_2$, $^{11}BF_3$ instead of $^{10}BF_2^+$, $^{11}BF_2^+$, $^{11}BF_3^+$. They also included both the nucleon and proton number of the atoms in the formula of the fragment ions such as $[^{10}_{5}B^{19}_{9}F_2]^+$.

Question 17

In part (*a*), most candidates were able to determine the order of reaction using the data given in the question. However, there were some candidates who did not write out the general rate equation for the reaction. Some left out the rate constant, *k*, when comparing and substituting the experimental data in the rate equations.

In part (*b*), many candidates were able to write the rate equation for the reaction.

In part (*c*), most candidates were able to calculate the value of the rate constant, *k*. Some candidates gave incorrect significant figures, wrong unit and no unit for the rate constant.

In part (*d*), most candidates were able to calculate the initial rate when concentrations of NO and H_2 were given but many of them did not round up the final answer to two significant figures.

Question 18

In part (*a*), many candidates were able to draw the Lewis structures of SO_2, SO_3 and SO_3^{2-} with octet and/or expanded octet configuration. Common mistakes made by some candidates are as follows:

- did not show the valence electrons of oxygen atoms or lone pair electrons of sulphur atom
- did not put the negative formal charge in the Lewis structure of SO_3^{2-}
- did not show the lone pair electrons of S in Lewis structure of SO_3^{2-}
- did not state the bond angles of the molecules or ion
- stated the wrong number of bond pairs and lone pairs around the central atom
- did not spell the structures correctly. For example, bent was spelt as bend, trigonal planar as triangular planar or trigonal planer / planner, trigonal pyramidal as trigonal / trigolar / trigona pyimidal.

In part (*b*), many candidates were able to give the ascending order of polarity of the oxides, $SO_3 > SO_2 > SO_3^{2-}$. However, most candidates were unable to compare the polarity of these oxides. They failed to give the reason why SO_3^{2-} is more polar than SO_2 due to having more S-O bonds and failed to relate polarity of the oxides with electronegativity of the atoms, dipole moment and symmetrical factors.

Question 19

In part (*a*), many candidates were unable to state crystalline solids and their types of bonding involved. Instead of giving the four types of crystalline solids, the candidates gave specific examples of solid substances and stated the types of bonds present in the solid. Most candidates tried to explain the bonding by giving the example of all the allotropes of carbon (diamond, graphite, fullerene), silicon or compounds (iodine and sodium chloride). Thus, they did not answer the question. Some candidates were also unable to spell the van der Waals forces correctly and also stated crystalline solids as ionic molecule, metallic compound, simple molecule and giant molecule.

In part (*b*), many candidates were unable to calculate the partial pressure of each component in the mixture. The candidates were able to use the expression of $pV = nRT$ but they made a mistake as they assumed the volume 300 dm^3 was solely the volume of nitrogen gas. Thus, they calculated it as the number of moles of nitrogen gas and not as total number of moles of gases. Nevertheless, most candidates were able to calculate the number of moles of water vapour and carbon dioxide. Hence they managed to calculate the partial pressure of water vapour and carbon dioxide. However, some candidates did not give the final answer to three significant figures. Some candidates calculated the number of moles of sulphuric acid or sodium hydroxide instead of the number of moles of water or carbon dioxide.

Question 20

In part (*a*), most of the candidates were unable to explain acids and bases by using BrØnsted-Lowry theory and did not use the term conjugate base in explaining the strength of bases. Candidates were unable to indicate H_2 as an acid. However, they managed to indicate that OH^- is the conjugate base of H_2O but did not relate H^- as the conjugate base of H_2. Thus, they did not explain that H_2O is a stronger acid than H_2 therefore OH^- is a stronger conjugate base than H^-. Many candidates were able to calculate the volume of hydrogen gas evolved. The candidates were aware that they need to calculate the number of moles of CaH_2 first before calculating the volume of H_2. However, some candidates failed to relate the number of moles of CaH_2 with the number of moles of H_2. Most of the candidates were able to use the expression of $pV = nRT$ to calculate the volume of hydrogen gas. Some candidates failed to give the final answers to correct significant figures and/or the correct unit of volume, m^3 or dm^3.

In part (*b*), many candidates were unable to sketch the titration curves with the correct shape, labeling of the correct x-axis and the important pH values before and after titration including the equivalence point and the volume of the titration at the end point. Most candidates sketched the titration curve with volume of alkali as the x-axis. Hence, the shape of the curve was wrong and labeling of the important pH value points on the curve were also incorrect.

In part (*c*), many candidates were able to name the indicator for the titration as methyl orange or methyl red. Some candidates gave the correct answer but wrongly spelt the name of the indicator.

CHEMISTRY (962/2)

OVERALL PERFORMANCE

For Semester 2, 4461 candidates sat the examination and 63.48 % of them obtained a full pass.

The percentage of the candidates for each grade are as following:

Grade	**A**	**A–**	**B+**	**B**	**B–**	**C+**	**C**	**C–**	**D+**	**D**	**F**
Percentage	3.12	6.11	5.06	10.75	11.93	13.98	14.15	7.35	3.42	3.01	21.13

CANDIDATES' RESPONSES

SECTION A: *Multiple-Choice*

Answer Keys

Question number	**Key**	**Question number**	**Key**	**Question number**	**Key**
1	**C**	6	**A**	11	**A**
2	**D**	7	**B**	12	**D**
3	**D**	8	**C**	13	**D**
4	**A**	9	**C**	14	**C**
5	**B**	10	**C**	15	**A**

General comments

The performance of the candidates were good. Questions 2, 5, 7 and 11 were easy for the candidates to answer with 70.1%, 80.7%, 80.8% and 73.9% of the candidates managed to obtain the correct answers respectively. Meanwhile, Question 3 and 14 were difficult for the candidates to answer with 33.5% and 34.3% of candidates managed to obtain the correct answers respectively.

SECTION B AND C: *Structure and Essay*

General comments

The performance of the candidates depends on the test centres. It was discovered that the candidates from big centres performed better than the candidates from smaller centres.

Comments on the individual questions

Question 16

In part (*a*), the question was about the seven ionisation energies of element *X*. Candidates should analyse the data given in the table. They were able to explain the biggest difference in successive ionisation energies with a deduction of 5 electrons in the valence shell, the valence electronic configuration, $ns^2\ np^3$. Thus *X* was in Group 15. Many candidates were able to deduce the group for element *X* and gave the reason for their deduction. However, a few candidates failed to mention that *X* had five valence electrons. Also, some candidates failed to mention the largest difference between 5th and 6th ionisation energies as the reason for the group deduction. Candidates wrote their answer as there is a large energy gap between the fifth and sixth ionisation energies. The word gap was wrong as it implied a space.

In part (*b*), candidates had to determine the structures of Al_2O_3, SiO_2 and SO_3. The expected answer by the candidates should be Al_2O_3 is ionic with covalent characteristics, SiO_2 has a giant covalent structure while SO_3 is a simple covalent molecule. In explaining the higher melting point of MgO compared to Na_2O, candidates should know that both are ionic compounds, thus both have ionic bonds. Therefore they should answer that the ionic bond in MgO is stronger than in Na_2O as Mg^{2+} has a higher charge density than Na^+.

In part (*b*)(i), most candidates were able to determine the type of structures for SiO_2 and SO_3 while most of them failed to correctly determine the type of structure for Al_2O_3. Many candidates instead only wrote giant ionic compound without including ‘with covalent character’.

In part (*b*)(ii), a few candidates answered using charge density of the metal ions but many candidates only mentioned charge and not the size of Mg^{2+}. Many candidates were also confused between ionic and metallic bond. Candidates answered that MgO has stronger metallic bond than Na_2O instead of ionic bond.

Question 17

The question asked about the reaction of halide ion with concentrated sulphuric acid. In part (*a*), most candidates were able to identify the halide ions *X*, *Y* and *Z* based on the observations of the halide ions when the halide ions reacted with concentrated sulphuric acid. Some candidates incorrectly spelt chloride ion as cloride ion.

In part (*b*), some candidates were able to write two equations involved but most of the candidates managed to write the first equation only correctly.

Some candidates did not balance the chemical equations. A few candidates wrote in the form of salt, NaBr not Br^-.

In part (*c*), most candidates were able to arrange the halogen halide in ascending order of acidity, H*X*, H*Y*, HZ.

In part (*d*), many candidates were unable to identify the oxidising agent and reducing agent, so they did not give the correct reason why *X* forms only white fumes. Some candidates stated that X^- is a stronger oxidising agent than concentrated H_2SO_4. The candidates answered *X* as the oxidising agent instead of X_2.

Question 18

This question was about the energy cycle for AgCl. In part (*a*)(i), most candidates were able to construct the energy cycle for AgCl. Some of the candidates managed to find the lattice energy of AgCl and by using the formula to calculate the enthalpy of solution for AgCl.

Some candidates also constructed another energy cycle using the lattice energy obtained from the first energy cycle and enthalpy of hydration to find the enthalpy of solution for AgCl. Some candidates did not include the enthalpy of hydration in their energy cycles. Many candidates did not label the bond energy of Cl–Cl as half of +243 kJ mol^{-1}. Some candidates did not label the first electron affinity of Cl correctly. Many candidates were able to calculate the enthalpy of solution but some of them did not include the positive sign.

In part (*a*)(ii), most candidates were able to calculate the enthalpy of solution of AgBr and AgCl but failed to compare their enthalpies. Instead, the candidates compared the solubility of AgCl and AgBr. Most candidates did not use the term endothermic or exothermic in the comparison but used positive or negative sign.

In part (*b*), candidates were expected to write balanced thermochemical and complete equations. Most candidates were able to write the correct equation for reaction between an acid and a base. Some candidates were unable to write balanced equations and used the wrong expression, $Q = mc\Delta T$ instead of $q = mc\Delta T$

Many candidates were unable to calculate the final temperature. Many did not get the correct limiting reagent, which is HCl to calculate the heat change. Some other mistakes were incorrect significant figure for the final answer and substitutions.

Question 19

In part (*a*), the candidates were expected to explain the trend in melting points of Group 2 elements based on the data given in the table. Based on the data, the atomic radii of the elements increases going down the group, the melting points in general decreases, the metallic bond decreases in strength going down the group. Most candidates did not state that magnesium, calcium, strontium and barium were all metals thus having strong metallic bonds. Many candidates stated that the melting point increases down Group 2 while the atomic size increases. The majority of the candidates did not explain the trend of Group 2 melting point based on the strength of metallic bond but rather the attraction forces between the nucleus and the outermost electrons. Most candidates did not define the concept of metallic bonding. The majority of candidates were able to identify magnesium has the lowest melting point but failed to mention it was due to a different crystal structure.

In part (*b*), many candidates were unable to compare the thermal stability of $Mg(NO_3)_2$ and $Mg(OH)_2$. Only a few candidates wrote the decomposition equations of $Mg(NO_3)_2$ and $Mg(OH)_2$ correctly.

In part (*c*), candidates were required to state whether the aqueous solution of $BeCl_2$ containing $[Be(H_2O)_4]^{2+}$ and Cl^- is acidic or basic and to explain the properties of the solution. Most of candidates were able to state the solution as acidic due to the high charge density of Be^{2+} that enabled Be^{2+} to undergo hydrolysis producing H_3O^+.

Question 20

The question was about silicon as semiconductor. In part (*a*), the majority of the candidates were unable to relate the semiconductor properties of silicon and diamond in terms of energy band. Most candidates wrote about the differences in structure between silicon and diamond with some writing about general carbon rather than diamond. The candidates were expected to explain the electrical conductivity of silicon and diamond using energy band. Most of the candidates were unable to compare silicon and diamond.

In part (*b*), many candidates were able to explain the differences between carbon dioxide and silicon dioxide in terms of their physical properties but failed to relate it to their structures. They only mentioned the type of structure not their shapes. Many candidates stated solubility of carbon dioxide and silicon dioxide instead of melting point.

CHEMISTRY (962/3)

OVERALL PERFORMANCE

For Semester 3, 4570 candidates sat examination for this subject and 54.57% of them obtained a full pass.

The percentage of the candidates for each grade are as following:

Grade	**A**	**A–**	**B+**	**B**	**B–**	**C+**	**C**	**C–**	**D+**	**D**	**F**
Percentage	7.46	5.14	5.80	4.75	11.33	9.74	10.35	5.08	7.64	4.66	28.05

CANDIDATES' RESPONSES

SECTION A: *Multiple-Choice*

Answer Keys

Question number	**Key**	**Question number**	**Key**	**Question number**	**Key**
1	**B**	6	**A**	11	**D**
2	**D**	7	**C**	12	**A**
3	**D**	8	**C**	13	**C**
4	**C**	9	**A**	14	**B**
5	**D**	10	**D**	15	**B**

General comments

The performance of the candidates were good. Question 11 was difficult for the candidates to answer with 29.9% of the candidates managed to obtain the correct answers. The rest of the questions were in the medium range with 30% to 70% of the candidates obtaining the correct answers.

SECTION B AND C: *Structure and Essay*

General comments

The performance of the candidates depends on the test centre. It was found out that the candidates from big centres performed much better than the candidates from smaller centres.

Comments on the individual questions

Question 16

In part (*a*), most candidates were able to determine the empirical formula of *X*. Some of the candidates did not get the correct answer because the ratio of C:H was calculated as 1:1.2 and rounded up to the wrong ratio of 1:1 instead of 5:6.

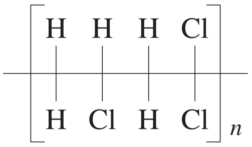
In part (*b*), the majority of candidates were able to give the molecular formula of *X* following the correct answer from part (*a*). The common mistake made was to not change the units of pressure, Pa, and volume, m^3, correctly when using the ideal gas equation.

In part (*c*)(i), the majority of candidates were able to draw the structural formula of *X*.

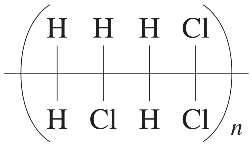
In part (*c*)(ii), the majority of candidates were able to draw structural formula of isomer *X*. The weaker candidates could not correctly draw the optically active isomer of *X*.

Question 17

In part (*a*)(i), most candidates were able to draw the structural formula of the polymer correctly. However, many candidates made a mistake of drawing with a round bracket instead of a square bracket.



Correct answer



Wrong answer

In part (*a*)(ii), most candidates were able to state the type of polymerisation. A few candidates gave the wrong term for the type of polymerisation. For example, additional polymerisation instead of addition polymerisation.

In part (*b*)(i), most candidates were able to state the two monomers correctly either their names or structural formulae. Many candidates made a common mistake when stating the monomer by naming it as 1,6-hexane dicarboxylic acid, 1,6-hexadioic acid, 1,6 hexanedioic acid and 1,6-hexenedioic acid.

In part (*b*)(ii), many candidates were unable to give the complete chemical equation for the formation of the polymer. The candidates did not write the stoichiometry coefficient, *n*, for each monomer even though the polymer was correct.

In part (*c*)(i), many candidates were able to draw the structure of the monomer used in the formation of neoprene correctly. The candidates made a common mistake by drawing one C=C bond instead of two C=C bonds in the structure of the monomer.

In part (*c*)(ii), many candidates were unable to explain how vulcanisation resulted in elastic properties of rubber. The candidates made mistakes by explaining the vulcanisation with bond or bridge instead of linkage or cross-linkage. For example, sulphur bond, sulphide bridge and disulphide bond and also incomplete explanation of elasticity. They did not mention the rubber reverted to its original shape when stretching was removed.

Question 18

In part (*a*), most of the candidates were able to give the correct products for nitration of benzene and phenol but could not write the chemical equations properly. For chemical equation, the candidates made a mistake by stating the wrong reagent, they also did not mention concentrated H_2SO_4 and HNO_3. They also wrote only HNO_3 without H_2SO_4. Some candidates gave the wrong product formed from the nitration of phenol. Many candidates were able to draw the mechanisms of nitration of the phenol but did not use Kekule structures in the second step of the mechanism, instead used ring. The candidates also drew the wrong structural formulae of arenium / intermediate ions. Most of them drew hard line in the arenium structure, which means bonding, and the position of semi-circle in the ring was wrong. For the last step, most of the candidates gave the wrong electron movements.

In part (*b*), many candidates were able to describe the solubility of benzene and phenol in water. However, a few candidates used the term dissolve instead of soluble in water. Some candidates wrongly explained solubility using the effect of electron donating groups and electron withdrawing groups.

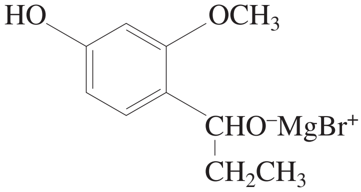
Question 19

In part (*a*), most of the candidates were able to give 4-dinitrophenylhydrazine as a suitable reagent and the correct reaction conditions for the condensation reaction. A few candidates gave primary or secondary amines as a reagent. Most candidates were able to write chemical equations and state the observations. Some candidates gave yellow precipitate as the observation instead of orange precipitate with 2,4-dinitrophenylhydrazine. A few of the candidates were able to give Tollens' reagent as a suitable reagent and reaction condition for the mild oxidation reaction. Many of them gave acidified $KMnO_4$ or $K_2Cr_2O_7$ as a reagent. For esterification reaction, most of the candidates gave acid chloride as a suitable reagent. Some candidates gave wrong reaction conditions such as acid chloride in the presence of H_2SO_4 with heat, NaOH with heat and carboxylic acid in the presence of H_2SO_4 with heat.

In part (*b*), many candidates did not write the intermediate product formed during the reaction of vanillin with C_2H_5MgBr in the chemical equation. Common mistake of writing the equation is shown below.

$$\text{Vanillin} + C_2H_5MgBr \xrightarrow{H_2O/H^+} \text{Product}$$

Some candidates used the intermediate formed and the wrong structural formula of the intermediate as shown below.



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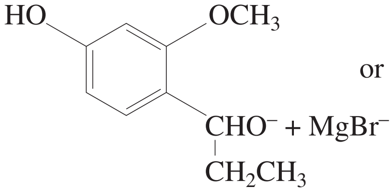

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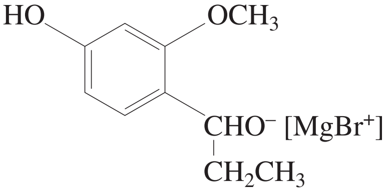
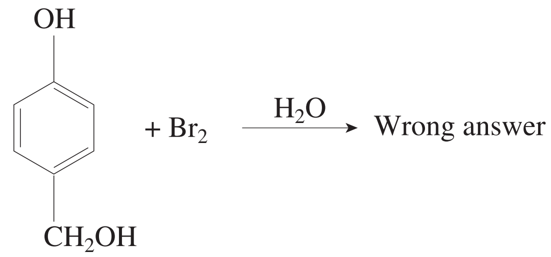


In part (*c*), most candidates were able to state the reagent, the observation and draw the correct structure of the isomer of vanillin. The common mistake was writing the reagent as I_2/ NaOH instead of I_2/ NaOH(aq).

Question 20

In part (*a*), many candidates were able to compare the acidity of compound *Q* with methanol correctly. However, in explaining the answer, many candidates did not use the terms of negative inductive effect, positive inductive effect, resonance-stabilised and not resonance-stabilised. Very few candidates stated phenoxide ion as more stable than methoxide ion due to resonance effect in their answers. Many candidates explained their answer using the alkyl group which increases the electron density or benzene which decreases the electron density and only very few candidates had included the concept of resonance-stabilised for the two compounds.

In part (*b*), most candidates were able to suggest a chemical test to differentiate compound *Q* from methanol and able to state the observation and write the reaction equation correctly. A few candidates made mistakes by using a wrong test such as Lucas reagent and bromine in carbon tetrachloromethane and also bromine water. For bromine water, the candidates gave inaccurate observation such as compound *Q* decolourised bromine water but no reaction with methanol. Some candidates wrote chemical equation wrongly as shown below.



In part (*c*), many candidates were able to write a synthetic pathway to show how compound *Q* could be prepared from phenol systematically. The most common mistakes, the candidates did not give the physical state of sodium hydroxide and consequently further synthetic pathway became inappropriate and incorrect. They also used incorrect reagents for the preparation of compound *Q*.

PAPER 962/5 (*Written Practical Test*)

General comments

The questions in general were of a good quality.

Comments on the individual questions

Question 1

In part (*a*), most candidates were able to identify burette or conical flask as a suitable apparatus that can be used for titration.

In part (*b*), the majority of the candidates were able to calculate the volume and the mean of HCl used in the titration. However, a few candidates could not differentiate between rough and accurate readings obtained from the titration and could not write the correct significant figure for the readings. Unfortunately, most of the candidates failed to state the colour changes correctly.

In part (*c*), the same mistakes were done in this part as mentioned in part (*b*).

In part (*d*), most of the candidates were unable to calculate the required volume of acid required to complete the neutralisation.

In parts (*e*) and (*f*), most of the candidates were unable to calculate the concentration of K_2CO_3 and KOH and the balanced equation of the reactions involved.

Question 2

In part (*a*), only some candidates mentioned that the colour of the precipitate formed was white, referring to $Ba(OH)_2$. Most of the candidates were unable to write the correct expression of the K_{sp} of $Ba(OH)_2$ although the solubility equilibrium of $Ba(OH)_2$ was given in the question. For the calculation of the concentration of Ba^{2+} and OH^- and determination of the K_{sp} value of $Ba(OH)_2$, most of the candidates were only able to calculate the mole of Ba^{2+}. The candidates wrongly used the volume of solution as $10.00\ cm^3$ instead of $20.80\ cm^3$.

In part (*b*), many candidates were able to plot the exponential graph with correctly labelled axis with unit.

In part (*c*), many candidates were able to determine the temperature as 57.0°C when the value of K_{sp} of $Ba(OH)_2$ was $2.25 \times 10^{-3}\ mol^3\ dm^{-9}$ based on the plotted graph. However, not all candidates were able to state that the dissolution of $Ba(OH)_2$ in the solubility equilibrium as an endothermic process.

In part (*d*), many candidates were unable to give the name of the compound formed and its colour.

Question 3

In part (*a*), most candidate were able to give the correct mass of crystal.

In part (*b*), candidates failed to explain why the mixture was left to cool until room temperature followed by an ice water bath for 15 minutes. Only a few candidates managed to answer that it crystallise the complexes.

In part (*c*), most of the candidates were unable to give the name of the suitable method of filtration to collect the crystals. None of the candidates mentioned the water suction filtration as a method using Buchner funnel.

In part (*d*), some candidates were able to explain the reason of rinsing the crystals with absolute ethanol.

In part (*e*), only a few candidates mentioned that air dried or oven dried at temperature less than 45°C as a suitable method for drying the crystals.

In part (*f*), absolute ethanol could be replaced by propanone or acetone to rinse the crystals during the filtration process. Unfortunately, most of the candidates were unable to give the correct answer.

In part (*g*), most candidates calculated wrongly the percentage yield of $K_3[Cr(C_2O_4)_3.3H_2O$ crystal because they were unable to determine the correct mass of the crystal obtained in the experiment based on the potassium ethanedioate monohydrate, $K_2C_2O_4.H_2O$ in part (*g*)(i).

In part (*h*), many candidates were unable to suggest the reason why the yield of the crystals is less than 100%.

In part (*i*), some candidates were able to calculate the percentage ethanedioate present in the crystal, $K_3[Cr(C_2O_4)_3.3H_2O$ by calculating the correct molecular mass of each entity as the first step for the problem solving.