Chemistry (962)

OVERALL PERFORMANCE

The number of candidates for this subject was 8504. The percentage of candidates who obtained a full pass was 72.24%, an increase of 2.23% compared with the previous year.

The achievement of candidates for this subject according to grades is as follows:

Grade	A	A–	B+	B	B–	C+	C	C–	D+	D	F
Percentage	6.34	6.72	7.73	10.62	11.80	14.63	14.40	5.10	6.26	5.36	11.04

RESPONSES OF CANDIDATES

PAPER 962/1 (MULTIPLE-CHOICE)

Keys

Question number	Key	Question number	Key	Question number	Key
1	**C**	18	**C**	35	**B**
2	**B**	19	**B**	36	**A**
3	**C**	20	**B**	37	**B**
4	**B**	21	**D**	38	**C**
5	**D**	22	**B**	39	**D**
6	**A**	23	**D**	40	**A**
7	**B**	24	**C**	41	**A**
8	**B**	25	**C**	42	**B**
9	**D**	26	**C**	43	**D**
10	**C**	27	**D**	44	**C**
11	**B**	28	**B**	45	**A**
12	**A**	29	**A**	46	**B**
13	**D**	30	**A**	47	**B**
14	**A**	31	**B**	48	**D**
15	**D**	32	**C**	49	**B**
16	**C**	33	**C**	50	**A**
17	**C**	34	**C**		

General comments

The mean square was 26.74 (44.64%) and there was a very good spread of scores with a standard deviation of 8.66. Questions 4, 7, 15, 16, 17, 20, 23, 26, 31, 42 and 46 were very difficult for candidates with less than 30% of candidates obtaining the correct answers. Questions 2, 6, 8, 10, 11, 24, 28, 34, 35, 38, 41 and 47 were answered correctly by at least 60% of candidates.

PAPER 962/2 (STRUCTURE AND ESSAY)

General comments

There were many candidates who attempted to answer all the questions, demonstrating sound knowledge and a good understanding of the chemistry examined in this paper. On the other hand, there are still a significant number of candidates whose knowledge of inorganic chemistry is poor. Generally, candidates' knowledge of organic chemistry continues to improve. Overall, the answers given showed a continuing improvement in the quality of candidates' performance with most candidates being able to demonstrate some positive achievement with a mean of 29.70 and a standard deviation of 18.12.

Comments on the individual question

Question 1

In part (*a*)(i), most candidates were able to write the definition for pH as negative logarithm of the concentration of hydrogen ions.

In part (*b*), most candidates were able to calculate the concentration of hydrogen ions in the sample of the yoghurt drink. A small number of candidates failed to give their final answers to appropriate significant figures. Some candidates lost marks because they "rounded off" their answers in the early stage of their calculation.

In part (*c*), almost all candidates started by using the formula $M_1V_1 = M_2V_2$; which was acceptable. However, a significant number of candidates failed to understand the question correctly. They did not substitute the numerical values of the volume and the concentration given in the question.

In part (*d*), most candidates were able to state that lactic acid is a weak acid, but they failed to state that lactic acid reacts completely with potassium hydroxide.

In part (*e*), the majority of candidates failed to state that $K_a = \frac{[H]^2}{c}$ to solve the calculation.

In part (*f*), most candidates were unable to sketch the titration curve correctly. They failed to label the initial pH of the lactic acid as 3.52 cm^3 and the volume of KOH for complete neutralisation as 27.85 cm^3 on the titration curve that they had drawn.

Answers: (*b*) $[H^+] = 3.02 \times 10^{-4}$ mol dm^{-3}; (*c*) [Lactic acid] = 0.1114 mol dm^{-3};
(*e*) $K_a = 8.19 \times 10^{-7}$ mol dm^{-3}

Question 2

In part (*a*), very few candidates were able to give a complete answer as silver chloride dissolves to give a colourless solution. A few candidates confused the term *dissolve* with *soluble*. The correct term to state an observation should be *dissolve*. Only good candidates were able to get the second mark allocated in this part by stating the formation of complex ion, $[Ag(NH_3)_2]^+$.

In part (*b*)(i), most candidates were able to state Hess's law.

In part (*b*)(ii), most candidates were able to draw Born-Haber cycle for silver chloride. However, some candidates lost their marks when they failed to write the correct physical state for the element or species involved in the chemical equations.

Question 3

In part (*a*), while the majority of candidates knew how to draw the structure of dimer aluminium chloride, Al_2Cl_6, there were significant numbers of candidates who gave incorrect answers. A common error was failing to show the arrows of the dative bonds in Al_2Cl_6 molecule. The candidates wrongly stated that the type of bonding was ionic with a covalent character or dative bond instead of covalent bond.

In part (*b*), many candidates found this part difficult because they were unable to deduce, in the beginning, the correct structure of aluminium chloride. Only good candidates were able to calculate the volume of aqueous silver nitrate with the correct unit and significant figures.

In part (*c*), most candidates were able to write the equation for the reaction of aluminium chloride with ethoxyethane as:

$$(CH_3CH_2)_2O + AlCl_3 \rightarrow [(CH_3CH_2)_2O \rightarrow AlCl_3]$$

However, the majority of candidates were unable to explain that in order to react with ethoxyethane, the dimer had to dissociate to a monomer which had a vacant orbital for the formation of dative bond. For the reaction of aluminium chloride with water, most candidates were unable to explain the highly exothermic reaction between aluminium chloride and water which was due to the hydration of a highly positively charged aluminium ion. Instead, they explained it as hydrolysis occurring. The word *hydrolysis* should have been used to explain the acidity of an acid or a base. Candidates were also unable to write the equation for the reaction between aluminium chloride and water as shown below.

$$Al_2Cl_6 + 12H_2O \rightarrow 2[Al(H_2O)_6]^{3+} + 6Cl^-$$

Answer: (*b*) 112 cm^3

Question 4

In part (*a*), most candidates were able to give the correct pK_a value for each compound.

In part (*b*), most candidates were able to arrange the compound in ascending order of their boiling point as shown below.

$$CH_3COCH_3 < CH_3CH(OH)CH_3 < CH_3COOH$$

Many candidates correctly explained that the trend of melting point was due to the fact that CH_3COCH_3 and $CH_3CH(OH)CH_3$ had an intermolecular hydrogen bonding whereas CH_3COOH had van der Waals' forces. Almost all candidates did not state that CH_3COOH had the highest boiling point because the molecule existed as a dimer.

In part (*c*)(i), most candidates were able to draw the structural formulae of the monomers of the polymers *X* and *Y* .

In part (*c*)(ii), the majority of candidates were able to state the type of polymerisation of polymer *X* as a condensation polymerisation, while polymer *Y* as an addition polymerisation.

Question 5

In part (*a*)(i), many candidates failed to correctly define the relative molecular mass of *X* as follows.

$$\text{Relative molecular mass of } X = \frac{12 \times \text{Mass of one molecule of } X}{\text{Mass one atom of carbon-12}}$$

However, most candidates correctly identified *X* as methane, CH_4.

Part (*a*)(ii) was generally well answered. Those candidates who were penalised usually failed to give the answer to the correct significant figures and unit.

In part (*b*)(i), relatively fewer candidates answer this part correctly. However, many candidates did not state that both elements were metals. They explained the difference in melting point between potassium and copper in terms of atomic size or ionisation energy, and not due to the different strength of metallic bonds. There were fewer candidates who wrongly stated that potassium was an ionic element.

Part (*b*)(ii) was poorly answered. Most candidates were not able to distinguish between hexagonal and cubic closed-packed structures.

Answer: (*a*)(ii) 0.022 mol

Question 6

In part (*a*), there were many good answers to this part with good description of lithium and beryllium. Candidates were able to state the electronic configuration of the compounds and state that beryllium is a better electrical conductor than lithium. However, many candidates omitted the keywords *delocalised* or *free mobile electrons* of the valence electrons. Some candidates lost their marks when they used *valence ion* for *valence electrons.*

In part (*b*)(i), most candidates were able to state that lithium oxidised, but failed to recognise that the species reduced was argentum ions and not $AgCrO_4$. They were also able to get the overall equation for the reactions correctly.

In part (*b*)(ii), many candidates lost a mark when they failed to state the final answer with the correct significant figures or unit or positive sign.

Part (*c*)(i) was very poorly answered by the majority of candidates. They were not able to draw a complete labelled diagram of the fuel-cell.

In part (*c*)(ii), only a few candidates were able to write both the half-cell equations for the reactions involved as follows
At the cathode: $O_2(g) + H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$
At the anode: $H_2(g) + 2OH^-(aq) \rightarrow 4OH^-(l) + 4e^-$

Answer: (*b*)(ii) +3.50 V

Question 7

In part (*a*), most candidates knew that nitrogen gas was less reactive than ammonia because of the presence of triple bonds in the molecule. Although they knew that the inertness of nitrogen molecule was due to its triple bonds, many candidates failed to state that triple bonds was strong and required a lot of energy to break the bond. Only a few candidates stated that the lone pair of electrons of ammonia contributed to its reactivity rather than its polar nature. The majority of candidates failed to state that the N–H bond in ammonia was weaker than the N–N bond, and therefore less energy was required to break the N–H bond.

In part (*b*), most candidates were able to compare the melting points of elements in Period 3, but unable to explain the melting points of elements for the first row of the *d*-block elements. There were many good answers to this part with a good description and explanation. Many candidates knew that the melting point increased from sodium to silicon, and decreased from silicon to argon. Sodium, magnesium and aluminium were metals with high melting points, silicon had a giant covalent structure while phosphorus, sulphur and chlorine existed as simple molecules. However, only a few candidates stated that argon had the lowest melting point because it was a monoatomic element. For the explanation of the melting points of *d*-block elements, most candidates failed to state that the *d*-block elements had almost the same value of melting point with similar metallic bond strength. Candidates mistakenly thought that the melting point increased because of increasing atomic mass.

Question 8

Part (*a*) was very poorly answered by the majority of the candidates. Examiner expected candidates to compare the relative stability of +2 and +4 oxidation states rather than explaining the trend on going up or down the group. Better candidates further discussed that the stability of PbO_2 and PbO was due to the inert pair effect in Pb^{2+} ions. However, most candidates failed to discuss the bonding in the monoxides and dioxides of Group 14 elements. In +4 oxidation state, the Group 14 elements were bonded to oxygen by covalent bond while in +2 oxidation state, the bonding changed to ionic. Candidates also lost their marks when they failed to state that the strength of the covalent bonds became weaker as the atomic size increased down the group.

In part (*b*)(i), most candidates gave the correct balanced equations as follows.

$$Cl_2 + H_2O \rightarrow HCl + HOCl$$
$$2HOCl \rightarrow O_2 + 2HCl$$

The overall equation was $2Cl_2 + 2H_2O \rightarrow Cl_2 + 4HCl$. Better candidates were able to discuss the role of chlorine as both oxidising and reducing agents in this disproportionate reaction. Part (*b*)(i) was correctly answered by the majority of candidates.

Question 9

In part (*a*)(i), most candidates were able to name the mechanism of the reaction as S_N1. However, those who failed to obtain full marks made the mistake when they did not state which were the slow or fast steps in the mechanism and also they did not draw the arrow to show the attack of the CN^- ion on the carbocation.

In part (*a*)(ii), most candidates knew that the rate decreased because C–Br bond was stronger than C–I bond.

In part (*b*)(i), the majority of candidates were able to state that the reagent was alcoholic or ethanolic KOH or NaOH. The reaction condition involved in the conversion was heating, boiling or refluxing.

In part (*b*)(ii), most candidates were able to write the structural formulae of unsaturated hydrocarbons.

In part (*b*)(iii), the majority of candidates knew the unsaturated hydrocarbon in (*b*)(ii) as $CH_3C(CH_3){=}CH_2$.

In part (*b*)(iv), most candidates were able to write the equation for the conversion of haloalkane *X* to the monomer stated in (*b*)(iii).

Question 10

In part (*a*)(i) most candidates were able to give the reagents, reaction condition, and the intermediate product formed for the formation of cyclohexanone from phenol.

In part (*a*)(ii), fewer candidates were able to obtain full marks. However, a common mistake made by candidates was writing the hydrolysis process without heating.

In part (*a*)(iii), many candidates failed to write the correct reagent for the mild oxidation reaction of $CH_3CH_2CH_2OH$ to the aldehyde by using pyridinium chlorochromate, PCC or Cu. Most candidates wrongly gave hot acidified $KMnO_4$ or $K_2Cr_2O_7$ because in this part, the alcohol would be oxidised to the carboxylic acid.

In part (*b*), many candidates could give the correct chemical tests such as Br_2 water, sodium metal or $FeCl_3$ to confirm the presence of –OH group. However, there were few candidates who were unable to draw the structure of the product formed when using Br_2 water and $FeCl_3$. In order to confirm the presence of $–NH_2$ group, candidates should have given the reaction condition or temperature for the nitrous acid and the correct observation for the reaction. The common mistake made by candidates was stating that H_2 was released instead of effervescence was observed. A few candidates found difficulty in writing the equation for the reaction involved.

In part (*c*), most candidates were able to give the correct structural formulae of the products formed such as alcohol and amine, but were not able to draw the structures of the sodium salts of respective carboxylic acids.

PAPER 962/4 (WRITTEN PRACTICAL TEST)

General comments

Overall, the paper proved to be quite challenging with only some part of the questions occasionally getting a correct response. Very high marks were rare while a few candidates failed to get any marks. Greater familiarity with experimental techniques would be of benefit to all candidates.

Comments on the individual question

Question 1

In parts (*a*)(i) and (a)(ii), many candidates were not able to give the values of the burette readings to two decimal places and a few candidates were not able to calculate the average titre value with the correct unit.

In parts (*a*)(iii), (*a*)(iv) and (*a*)(v), only better candidates managed to answer these part correctly.

In part (*b*)(i), the majority of candidates were able to answer this part correctly. Solution *X* was heated before it was titrated with $KMnO_4$ purposely to increase the reaction rate.

In part (*b*)(ii), only a few candidates were able to correctly answer the observation as violet or purple decolourisation. A common weakness of candidates was that they only stated the colour change without mentioning the colour of the solution observed.

Answer: (a)(ii) 21.15 cm^3; (a)(iv) 0.040 mol; (a)(v) 0.78 g.

Question 2

In part (*a*), only a few candidates were able to suggest how the rate of bromine decolourisation could be determined in these experiment, i.e. the time taken for the disappearance of the reddish brown colour in the solution and

$$\text{rate of bromine disappearance} = \frac{[Br_2]}{\text{Time recorded}}$$

In part (*b*), better candidates were able to state that the different volumes of distilled water were used to retain the total volume of the solution.

In part (*c*), only a few candidates were able to state that the temperature of the reaction could be controlled by using water bath.

In part (*d*), very few candidates stated that white paper or tiles could be used to observe the decolourisation of the bromine solution. Candidates also were able to observe the decolourisation of the bromine solution by just looking from the top of the solution.

Part (*e*) was poorly answered by candidates. They were unable to calculate the order of reaction with respect to propanone which was first order, the order of reaction with respect bromine which was zero order, and the order of reaction with respect hydrochloric acid which was also zero order.

In part (*f*), a few candidates were able to write a balanced equation as follows

$$\text{Rate} = [CH_3COCH_3][H+][Br]$$

Question 3

In part (*a*)(i), only a few candidates were able to state that the function of the small pieces of porcelain was to avoid effervescence during boiling process.

In part (a)(ii), only better candidates were able to state the function of the concentrated sulphuric acid as a dry agent.

In part (*a*)(iii), only better candidates were able to state that the distillation could not be carried out using a water bath because the maximum temperature of the water bath was only 100 °C.

Part (*a*)(iv) was poorly answered. Better candidates were able to draw the labelled diagram of the set-up apparatus used.

In part (*b*), a few candidates were able to answer this part correctly as ethanol, ethanoic acid or water.

In part (*c*), a few candidates were able to name the chemicals, which were used to purify ester before it was distilled again, as hydrated potassium chloride or sodium hydrogen carbonate.