CHEMISTRY

Paper 5070/11
Multiple Choice

Question Number	*Key*	*Question Number*	*Key*
1	**A**	21	**C**
2	**C**	22	**D**
3	**A**	23	**C**
4	**B**	24	**A**
5	**C**	25	**D**
6	**A**	26	**C**
7	**B**	27	**B**
8	**C**	28	**D**
9	**C**	29	**A**
10	**B**	30	**C**
11	**B**	31	**A**
12	**A**	32	**D**
13	**C**	33	**B**
14	**A**	34	**B**
15	**D**	35	**C**
16	**C**	36	**D**
17	**D**	37	**C**
18	**C**	38	**C**
19	**D**	39	**C**
20	**D**	40	**D**

General comments

Questions 1, **6**, **12**, **16**, **29**, **31** and **40** proved the most accessible to candidates.

Questions 4, **13**, **22**, **23**, **26** and **35** proved the most challenging. In some cases, the incorrect responses covered all or most of the alternatives. In other cases, the predominance of one incorrect answer perhaps showed a widespread misconception.

Comments on specific questions

Question 4

Each distractor was chosen with equal probability, indicating that candidates were not confident with this area of the syllabus.

Question 13

Distractors **B** and **D** were common incorrect answers.

Question 22

Some candidates chose **A**. These candidates may not have realised the need for the electrolyte to be a liquid.

Question 23

A significant number of candidates chose distractor **A**, thus suggesting that three soluble salts were possible. These candidates perhaps did not know the solubilities of the salts, or they did not realise that both the carbonates could potentially react with all the acids.

Question 26

A number of candidates selected **A** and thought that atmospheric oxygen reacted with aqueous copper(II) sulfate to give black copper(II) oxide.

Question 35

Candidates who selected **D** realised that ethene generally reacts by addition across the double bond but did not know that, whichever way steam is added, the same product would be formed.

CHEMISTRY

Paper 5070/12
Multiple Choice

Question Number	*Key*	*Question Number*	*Key*
1	**B**	21	**C**
2	**B**	22	**D**
3	**D**	23	**D**
4	**C**	24	**B**
5	**B**	25	**D**
6	**C**	26	**D**
7	**A**	27	**A**
8	**D**	28	**C**
9	**D**	29	**A**
10	**A**	30	**B**
11	**D**	31	**C**
12	**C**	32	**C**
13	**B**	33	**B**
14	**D**	34	**B**
15	**A**	35	**D**
16	**C**	36	**B**
17	**A**	37	**C**
18	**A**	38	**D**
19	**D**	39	**A**
20	**D**	40	**C**

General comments

Questions 4, **8**, **10**, **24** and **29** proved to be the most accessible to candidates. **Questions 2**, **5**, **9**, **12**, **27**, **28** and **30** were found to be the most challenging. In some cases, the incorrect responses covered all or most of the alternatives. In other cases, the predominance of one incorrect answer perhaps showed a widespread misconception.

Comments on specific questions

Question 2

The correct response was selected by the majority of candidates. However, **C** and **D** were also popular responses. This indicates that although candidates were familiar with following the rate of a reaction by measuring the volume of gas produced, the use of loss of mass was not appreciated.

Question 5

Distractors **C** and **D** were popular options. Some candidates focused on the eutectic point which is lower than the melting point of both tin and lead, hence giving the response **C.** It is difficult to explain the number who suggested **D** and indicates that candidates were not familiar with this area of the syllabus.

Question 9

The majority selected **A**, presumably as the diagram showed the presence of covalent bonds, and missed that **A** states a compound. Candidates thus ignored the formula of C_{60} in the stem of the question.

Question 12

Distractors **B** and **D** were common incorrect answers.

Question 27

Distractors **B** and **C** were popular incorrect options. Since elements were present in the equations for **B** and **C** it appears that candidates did not recognise the significance of their oxidation.

Question 28

Some candidates thought that atmospheric oxygen reacted with aqueous copper(II) sulfate to give black copper(II) oxide.

Question 30

The majority gave distractor **D**. It seems likely that candidates did not realise that oxygen is used in making steel.

CHEMISTRY

Paper 5070/21
Theory

Key messages

When describing tends or patterns from data provided either in a table or graphically, candidates must make the descriptions comparative e.g. as factor A increases factor B decreases.

Candidates need to draw diagrams carefully and make sure they are fully labelled.

Candidates need to organise their answers to quantitative questions so that all the working out is shown.

General comments

Most of the candidates followed the rubric of the examination paper and attempted just three questions from ***Section B***.

Candidates often confused rate and position of equilibrium, giving answers about rate when the question was about Le Chatelier's principle.

Comments on specific questions

Section A

Question 1

This question involved the selection of the most appropriate compound from the list provided in the examination paper. Most candidates followed the rubric and gave the formula of the compound rather than the name.

(a) Many candidates selected NO; a common incorrect answer was SO_2.

(b) Many candidates selected CH_4; the most common incorrect answers were C_3H_8, NO and SO_2.

(c) Some candidates selected $Ba(NO_3)_2$; a common incorrect answer was $Zn(NO_3)_2$.

(d) The catalyst for the contact process was well known although some candidates did select SO_2.

(e) Many candidates recognised calcium oxide as one of the products of the thermal decomposition of limestone.

Question 2

This question focused on the properties of acids and acidic soils.

(a) (i) Candidates were often able to give a clear definition of a strong acid referring to either an acid that was completely ionised or was fully dissociated. A common misconception was to refer to an acid that completely dissolves in water; another common misconception was that it was an acid with a low pH value.

(ii) Candidates often described the use of Universal Indicator to find the pH of a solution but often neglected to mention the comparison with a pH colour chart. Other candidates just referred to the use of a pH meter.

(b) Although candidates often appreciated that a base or alkali had to be added to an acidic soil to neutralise the soil, the candidates frequently gave inappropriate bases such as sodium hydroxide rather than lime or limestone. Some candidates thought that fertilisers would neutralise acidic soils.

(c) Many candidates could interpret the data in the graph; many of these candidates did not describe the pattern with sufficient clarity. Better performing candidates stated that the rate of uptake of potassium ions increases as the pH increased until pH 7 and then the rate did not change. Some other candidates did not mention pH at all and referred to a high rate of uptake when the soil became less acid.

Question 3

This question focused on the homologous series of alcohols.

(a) Only a very small proportion of the candidates gave the correct molecular formula of $C_8H_{18}O$.

(b)(i) Candidates often gave imprecise answers referring to the boiling point increasing without making any reference to the number of carbon atoms increasing.

(ii) Almost all the candidates could estimate the density of butanol, giving values between 0.806 and 0.813 g/cm^3.

(iii) Better performing candidates explained that pentanol was a liquid because the melting point was below room temperature and the boiling point being above room temperature. Many candidates only referred to either the melting point or the boiling point and often did not refer to room temperature at all.

(c) A significant proportion of the candidates did not understand the meaning of the term viscosity and as a result gave the wrong trend and/or could not explain their trend. Candidates did not mention about the molecules having stronger intermolecular forces or being more tangled as the number of carbon atoms increased. Some candidates tried to explain viscosity in terms of the change in boiling point or density.

(d) Candidates that recognised the formation of carbon dioxide and water could often write the balanced equation, with many giving an equation that involved a fraction. Other candidates gave oxidation products such as propanoic acid rather than combustion products. A small proportion of the candidates gave answers that involved pentanol rather than propanol.

(e)(i) The most common answer given by candidates was atmospheric oxygen. In contrast, the use of potassium manganate(VII) (or potassium dichromate(VI)) or was not well known. The conditions used for the oxidation was poorly answered and often the conditions for the hydration of an alkene were given.

(ii) Many candidates could not recall the structure of propanoic acid. A common error was not to show the hydroxyl group as O—H; the question stated that all the atoms and all the bonds had to be shown.

Question 4

This question focused on the chemistry of the peroxodisulfate ion.

(a) Some candidates could interpret the quantitative data given in the table to deduce that the rate of reaction increases with both peroxodisulfate ion and iodide ion concentration.

(b) Many candidates appreciated that with a catalyst the activation energy for the reaction was lower.

(c)(i) Candidates found this question quite challenging and many candidates confused oxidising agent with oxidation. The idea that iron(III) ions gain electrons was not well understood. Better performing candidates stated that the iron(III) ions were reduced in the reaction by gaining electrons.

(ii) Candidates found the description of the colour change very difficult since both reagents changed colour.

(iii) Most candidates used aqueous sodium hydroxide as a test for iron(III) ions with others using aqueous ammonia. A small proportion of the candidates did not attempt this question.

(d) Candidates found the ionic equation very challenging and only the better performing candidates could give the correct equation. The most common error was to balance the change of the Fe^{2+} with that of the Fe^{3+} by having an equation showing $3Fe^{2+}$ and $2Fe^{3+}$. Other candidates did not balance the $S_2O_8^{2-}$ with $2SO_4^{2-}$.

Question 5

This question focused on the decomposition of potassium chlorate to make potassium chloride and oxygen.

(a) In this question the candidates had to ensure that the answer was correctly rounded up or down as appropriate providing that the answer had at least two significant figures. The correct answer was 39.2%. A common misconception was to quote the relative formula mass of $KClO_3$ as 245 rather than 122.5.

(b) Better performing candidates showed all the working out by calculating the amount in moles of $KClO_3$, using the stoichiometry of the equation to deduce the amount in moles of oxygen and finally used the molar volume at room temperature and pressure to calculate the volume of oxygen produced. Error carried forward marks were awarded in this question but only if it was clear where the error had been made. A common error was not to give the units for the volume quoted. A small proportion of the candidates did not attempt this question.

(c)(i) Better performing candidates described the loss of electrons from potassium to give a full valence shell and the gain of electrons by chlorine to give a full valence shell. Some candidates did not refer to the formation of the stable electron configurations. Only a small proportion of the candidates described the wrong electron transfer.

(ii) The physical properties of potassium chloride were well known and the most common answers were high melting and boiling point and conducts electricity when molten or in aqueous solution.

Question 6

This question focused on the gases in the air.

(a) The correct percentages were not well known by candidates.

(b)(i) The 'dot-and-cross' diagram for oxygen was often correct; a common misconception was to show only one shared pair between the oxygen atoms rather than two shared pairs.

(ii) Better performing candidates showed argon as monoatomic and often gave the atomic (proton) number and the mass (nucleon) number, which was not required. A significant proportion of the candidates gave the formula as Ar_2.

(c) Candidates often appreciated that argon was unreactive; they were less likely to explain that if air was present oxygen would react with either the sodium or titanium.

(d) Most candidates recalled that argon was used to make light bulbs.

Section B

Question 7

This question was about ethenyl ethanoate and polymerisation.

(a) Many candidates could draw an energy profile diagram. Better performing candidates drew these diagrams carefully to ensure that the activation energy and enthalpy change were correctly shown. A common misconception was to show the activation energy from the product level rather than the reactant energy level.

(b) The test for unsaturation was well known.

(c) Some candidates could balance the equation. Other candidates found this to be quite a challenging question and a significant proportion of candidates did not attempt the question.

(d) Many candidates could draw the structure of the polymer; some candidates neglected to include the free bonds at both ends of the structure. A common misconception was to include a double bond in the structure.

(e) Many candidates just mentioned air pollution, water pollution or land pollution but this was not sufficiently detailed. Better performing candidates referred to litter, the use of land-fill sites or the production of toxic gases during incineration.

Question 8

This question focused on the manufacture of ethanol by the hydration of ethene.

(a) The conditions for the hydration of ethene were well known and better performing candidates gave correct values for the temperature and pressure used as well as the name of the catalyst used.

(b)(i) Candidates were often able to interpret the graph and state that as the temperature increases the percentage yield decreases, however they were not able to explain this trend. Many candidates did not appreciate that Le Chatelier's principle had to be applied to the equilibrium and explain that with an exothermic reaction the backward reaction was favoured when the temperature increases. Some candidates gave answers based on rate rather than equilibrium.

(ii) The idea of a compromise temperature that balances yield and rate was not often mentioned by candidates. Many candidates appreciated that 200 °C gave a reaction that was too slow.

(c) Candidates often gave answers that related to an increase of rate rather than the position of equilibrium shifting as the pressure increased. Some candidates appreciated that the position of equilibrium shifted to the side, which had the lowest number of moles but did not apply this to the actual reaction in the question.

(d) Some candidates could give the correct equation but many candidates were not able to give the correct formula for the ester product.

Question 9

This question was about tin and silver.

(a) Many candidates could give the two properties characteristic of metals. The most popular correct responses were good thermal or electrical conductors, malleable or ductile. Candidates that referred to high density and high melting or boiling points were not given credit since there are examples of metals with low density and low melting and boiling points.

(b) Candidates often drew poor diagrams and missed out the cell or battery required. Most candidates did not give the correct electrolyte and even if they realised it needed a soluble silver salt, they did not then name aqueous silver nitrate. Candidates often did not label the electrodes so it was not possible to tell if the silver was the cathode or the anode.

(c) The correct empirical formula was $SnCl_2$ obtained by calculating the amount in moles of both elements and then deducing the simplest whole number ratio of moles. Candidates often did not calculate the mass of chlorine in the compound and used the mass of tin chloride instead.

(d) Candidates found the calculation very demanding and often did not calculate the predicted or expected yield of tin(IV) oxide. Instead, many candidates used the mass of tin(II) oxide and mass of tin(IV) oxide to calculate a percentage yield. Those candidates who did calculate the correct expected mass got the correct percentage yield of 84%.

Question 10

This question was about the preparation of hydrated lithium nitrate and the electrolysis of lithium oxide.

(a) Only the better performing candidates could describe the preparation of hydrated lithium nitrate. Most of these candidates described a method involving doing the titration twice; one with the indicator and one without. Many candidates did not appreciate that a titration method had to be used and instead used the method of insoluble base and acid. These candidates sometimes obtained the marks for crystallising lithium nitrate hydrate for its aqueous solution.

(b) Better performing candidates showed the working out clearly, calculating the moles of lithium nitrate, the relative formula mass of hydrated lithium nitrate and finally the mass of crystals prepared. Many candidates found the second step very challenging and did not seem very familiar with the use of the dot in the formula $LiNO_3.3H_2O$.

(c) Candidates were not able to use the equation to deduce an observation and often just gave the name of the product formed. Better performing candidates referred to the formation of a brown gas or of a white solid.

(d) Many candidates appreciated that ions were free to move in molten lithium oxide and only a small proportion of candidates referred to mobile electrons.

(e) Candidates often gave the correct products of the electrolysis of molten lithium oxide. Some candidate gave equations instead and these were often incorrect.

CHEMISTRY

Paper 5070/22
Theory

Key messages

- Many candidates need more practice in questions involving the practical aspects of chemistry.
- The construction of ionic equations needs more practice.
- Candidates are encouraged to read the stem of questions carefully to ascertain what is required.

General comments

Some candidates tackled this paper well in both ***Section A*** and ***Section B***. Most candidates gave responses of the appropriate length to questions involving free response. Others gave responses that were too vague or not related to what was expected from the stem of the question e.g. in **Question A5(c)** many candidates did not heed the word 'molecule' in the stem of the question and wrote about the structure of nickel carbonyl as if it were a metal. In addition, many wrote about chemical properties instead of the physical properties requested by the stem. In **Question A6(b)** many candidates did not refer to a trend and just gave a list of properties of the alkali metals.

Some candidates' knowledge of how chemical properties are related to structure was good. Others need more practice in relating the strength of metals and alloys to their structure and knowing how molecular structures are distinguished from ionic or other giant structures in terms of their characteristic properties.

Many candidates need to revise essential terms related to organic compounds such as the characteristics of homologous series and the nature of isomers.

Candidates need more practice in writing balanced equations. A major obstacle for many candidates was to work out how to construct ionic equations. **Questions A2(c)** and especially **A4(d)** caused particular problems in terms of identifying the ions. More practice is also needed in balancing 'molecular' equations e.g. in **Questions A3(d)(i)** and **B7(e)**.

Many candidates also need more practice in interpreting graphs and the data in tables. The rate question, **A4(a)** was answered by many candidates without reference to the difference in concentrations of each of the three substances involved in the reaction. Other candidates gave rather imprecise answers when interpreting the graph in **Question A3(c)(i)**, as well as incorrectly extrapolating a figure for the melting point of the unbranched alkane with ten carbon atoms.

Many candidates could improve their performance by further revision of practical aspects of chemistry e.g. in **Question B10(a)** on salt purification. Many candidates also need more revision on qualitative tests such as seen in **Questions A2(b)** and **B10(c)**.

Many candidates need more revision in learning, understanding and applying definitions such as *isotopes*, *homologous series* and *relative atomic mass*.

Some candidates performed well in questions involving calculations, showing appropriate working, clear progression in each step of the calculation and clear indications about what each number refers to. Candidates should be encouraged to follow this method.

Comments on specific questions

Section A

Question A1

This was the best answered of the ***Section A*** questions. Candidates generally performed well in most parts. The exception was part **(d)** where many did not recognise that carbon monoxide reduces iron(III) oxide to iron in the blast furnace.

(a) Many candidates correctly identified sulfur dioxide as an acidic atmospheric pollutant arising from volcanic activity. There was no common incorrect response.

(b) Many candidates identified C_3H_8 as a saturated hydrocarbon. The commonest error was to suggest the unsaturated C_2H_4. Other common errors were C_3H_4 or CO_2.

(c) Many candidates correctly identified zinc sulfate. Potassium sulfate or sodium phosphate were common errors. A considerable minority suggested one of the organic compounds from the list instead of an ionic compound.

(d) Some candidates recognised that carbon monoxide reduces iron(III) oxide to iron in the blast furnace. A considerable minority suggested that carbon dioxide was the reducing agent.

(e) The involvement of phosphate ions in eutrophication was fairly well known. Many candidates suggested potassium sulfate. The commonest incorrect answer was to suggest zinc sulfate.

Question A2

This was the least well answered of the ***Section A*** questions. Many candidates knew the formulae for at least one of the ions in part **(a)** but few knew the qualitative analysis test for ammonium ions in part **(b)**. The standard ionic equation for a neutralisation reaction was not well known.

(a) Some candidates gave the correct formulae for the ammonium and sulfate ions. A greater proportion of the candidates only answered one of these correctly. Common errors in writing the ammonium ion were NH_4, without a charge, NH_3^+ or NH_3. The commonest error in writing the sulfate ion was to suggest that it had only a single charge.

(b) Few candidates knew the test for ammonium ions. The majority either gave an incorrect test reagent e.g. silver nitrate, or just warmed the mixture without adding sodium hydroxide. Those who suggested adding sodium hydroxide often forgot about warming the mixture. Many suggested that red litmus would turn blue and some went on to mention that a gas was given off, but few mentioned that a gas was evolved. Many just suggested that the litmus paper be added to a solution.

(c) A minority of the candidates realised that the reaction was a neutralisation reaction between the hydroxide ions in aqueous ammonia and the hydrogen ions in the acid. A wide variety of incorrect equations, involving nitrogen gas, ammonium ions and hydrogen ions or hydrogen gas were seen. These were often unbalanced.

Question A3

Some candidates performed well on this question. Others need more revision in organic chemistry or interpreting information from a graph. In part **(a)** some candidates were able to give two characteristics of a homologous series. Others appeared not to know these characteristics. In part **(b)** many candidates could draw the structure of butane but in part **(c)** some either interpreted information from a graph incorrectly or did not give sufficient information. In part **(d)(i)** some candidates were able to balance the equation correctly. In part **(d)(ii)** a significant number of candidates gave a single product for the incomplete combustion of pentane.

(a) Many candidates gave one correct property. Common errors were 'the same empirical formula', 'the same physical properties' and 'different physical properties', rather than suggesting a trend. Candidates most commonly correct gave 'same chemical properties' or 'have a general formula'.

(b) This was the best answered part of **Question 3**. Most candidates drew the correct structure of butane. Fewer were able to draw a correct structure for the isomer 2-methylpropane. Many drew two versions of butane one with a straight chain and another with a chain of four carbon atoms bent at one end or at both ends. A minority of candidates omitted one or more bonds or one or more hydrogen atoms.

(c) (i) Most candidates recognised that the melting point was increasing with the increase in number of carbon atoms but others thought that it was decreasing. Few commented on the irregular shape of the graph or gave imprecise answers such as 'it goes up and down'. Many did not offer a description and tried to give an explanation in terms of bonding.

(ii) The negative values appeared to pose problems for some candidates. Many offered a lower value than –50 °C. A significant number of candidates gave a positive value or simply omitted the negative sign.

(d) (i) Many candidates balanced the equation correctly. Others gave incorrect products such as hydrogen or hydrocarbons, through muddling combustion with cracking.

(ii) Many candidates incorrectly suggested that carbon monoxide is the only product formed. Where additional products were given, hydrogen and unburned hydrocarbons were the commonest incorrect suggestions. Most candidates were aware that carbon monoxide is poisonous. A minority gave vague answers such as 'it affects the blood system' or 'causes breathing difficulties'.

Question A4

This question was generally fairly well answered except for part **(c)** where candidates often gave an imprecise definition of an isotope and part **(d)** where candidates muddled the ions and atoms of iodine and astatine or wrote combination molecules such as IAt.

(a) Some candidates correctly identified which species to compare, keeping two of the concentrations constant. Others did not know which pieces of information in the table to select and wrote confusing statements such as 'the rate goes up then down again'. Many candidates suggested that the rate of reaction would increase when the concentration of iodine increased. Others suggested decreases in rate of reaction especially when the concentration of the hydrochloric acid was increased.

(b) Many candidates correctly stated that particles gain kinetic energy. Fewer went on to suggest an increase in the number or rate of successful collisions. Even fewer mentioned activation energy. Many candidates only referred to increased collision frequency.

(c) The definition of *isotopes* was not well known. Many candidates left out the key word 'atoms'. Others suggested that isotopes are elements but with the same number of protons but omitted the presence of neutrons. Incorrect reference to electrons, relative atomic mass or different numbers of protons was not uncommon.

(d) Most candidates ignored the basic rules of balancing both atoms and charges in ionic equations. A major problem was that many candidates did not know the products of the reaction of halogens with halides. It was not uncommon to see incorrect products such as IAt or monatomic halogens. Other common errors were the inclusion of the same negative ion on both sides of the equation or the addition of extra products unrelated to the halogens e.g. hydrogen.

(e) Many candidates focussed incorrectly on hydrogen and oxygen rather than the iodide and iodine. A considerable number of candidates referred to oxidation numbers but few seemed to have a sound grasp of the concept. Many stated that iodide ions were gaining electrons.

Question A5

This question was one of the least well answered in ***Section A***. Parts **(a)** and **(e)** were generally well answered but few candidates answered the calculation in part **(b)** fully correctly or were able to identify two suitable physical properties of a molecular compound in part **(c)**. In part **(d)** very few candidates could suggest a suitable reason why the relative atomic mass of nickel is smaller than the relative atomic mass of cobalt.

(a) Many candidates calculated the percentage correctly. Some had the calculation upside down with the relative molecular mass divided by 59. Many candidates did not calculate the relative molecular mass of nickel carbonyl correctly.

(b) Many candidates made the common error of not realising that there were 5 moles of gas produced per mole of nickel carbonyl decomposed. Others mistakenly calculated the volume of the hydrogen iodide used rather than the volume of the gaseous products. A considerable proportion of candidates did not respond to this question.

(c) Most candidates did not recognise that nickel carbonyl is a simple molecule. Many appeared to think that the presence of nickel made the whole structure metallic despite the presence of the word 'molecule' in the stem of the question. Therefore, many candidates incorrectly suggested that the compound had high melting point, high density and conducted electricity. Many of those candidates who suggested that nickel carbonyl was either a liquid or a gas did not then refer to room temperature. A significant number of candidates suggested chemical properties rather than physical properties.

(d) Very few candidates understood the concept of relative atomic mass in terms of the averages of the isotopic masses. A few included the word 'isotope' in their answers but hardly any commented on the idea that the relative atomic mass is an average mass of all the isotopes. The commonest incorrect answers just referred to different numbers of neutrons.

(e) Many candidates gave a suitable definition of a strong acid in terms of degree of dissociation or ionisation. Some answers lacked precision or did not include reference to the acid, sometimes making the response read as if an ionic compound were being discussed e.g. 'a substance that dissolves to form positive and negative ions in solution'. A few candidates did not understand that acids cannot have a high pH e.g. above pH 7, whether they are strong or weak. Others only referred to pH values, corrosiveness or reactivity.

Question A6

Many candidates gave good answers to parts **(a)**, metallic conduction and **(c)**, reaction of rubidium with water. Part **(b)** was less well answered, with many candidates not focussing on the word 'trend' in the stem of the question. In part **(d)** many candidates did not compare the reactivity of the two metals.

(a) Most candidates stated the movement of electrons. A few wrote, incorrectly, about moving ions or mentioned electrons without the idea of movement.

(b) Many candidates did not take note of the word 'trend' in the stem of the question and wrote about the general properties of the alkali metals. Apart from this, the commonest error was to suggest that melting or boiling point increases down the Group.

(c) Many candidates gave hydrogen as a product of the reaction of rubidium with water. Fewer quoted rubidium hydroxide, with rubidium oxide being a common error. Another common error was to suggest two gases e.g. oxygen and carbon dioxide.

(d) Many candidates compared the reactivity of sodium to titanium chloride rather than titanium itself. There were many references to electrons but usually these were incorrect or irrelevant.

Section B

Question B7

This was the least well answered of the ***Section B*** questions although it was often chosen. Parts **(a)** and **(b)** were reasonably well done but in part **(c)** few candidates described in sufficient detail how the yield changed as the temperature increased or gave a convincing explanation of why the reaction is carried out at 450 ºC. In part **(d)** many candidates gave imprecise answers without referring the direction of equilibrium change to the moles of gases in the equation. In part **(e)** many candidates did not realise that bromine is diatomic.

(a) Many candidates gave the correct answer vanadium(V) oxide. Others gave the wrong oxidation state of vanadium or suggested elements such as iron, nickel or oxygen.

(b) Many candidates drew a correct 'dot-and-cross' diagram for an oxygen molecule. The commonest errors were to give an ionic structure, to draw a single oxygen atom, to draw one pair of shared electrons or to add extra pairs of electrons on the outer shells.

(c) (i) Few candidates answered this fully correctly. Many ignored the nearly horizontal part of the graph. Others did not explain why the yield was decreasing with increasing temperature. Many did not realise that the yield was decreasing at all and a considerable proportion of the candidates suggested that it was increasing.

(ii) Some candidates correctly stated that the reaction was too slow at 250 ºC but only a few made any kind of reference regarding the yield at 450 ºC or to the concept of a compromise between rate and yield. A common error was to state that there is a 'compromise temperature'. Others suggested that there is no reaction at all at 250 ºC. A considerable number of candidates referred to enzymes even though they had given the correct catalyst as an answer to **(a)**.

(d) Many candidates linked answer to change in temperature. Others stated a change in the number of moles but did not state what this meant in terms of the direction in which the equilibrium would shift. Many candidates gave vague answers mentioning moles but appearing to relate to how change in concentration affects equilibrium rather than addressing the numbers of moles in the equation given. Others wrote vague statements about lower pressure or trying to equalise pressure.

(e) A minority of the candidates constructed a correctly-balanced equation. The main error was to write 2Br instead of Br_2. Other common errors were to write the formula of hydrogen bromide as H_2Br or H_2Br_2 or to try to balance the right hand side with $2SO_2$.

Question B8

This was the best answered of the ***Section B*** questions. Many candidates gave good answers to most parts. The exception was part **(d)(ii)** where the candidates were asked to construct the balanced equation for the reaction of molybdenum with chlorine.

(a) Most candidates drew well-labelled diagrams. Common errors included: drawing an endothermic energy change; mislabelling the enthalpy change or activation energy; positioning the activation energy arrow so that the full extent of the activation energy was unclear; incorrect positioning of the enthalpy change from the *x*-axis to the product level.

(b) Many candidates referred correctly to the C=C bond or unsaturation. The commonest incorrect answer was to suggest that some type of redox reaction was taking place.

(c) Many candidates drew a clear structure of a portion of the polymer chain. The commonest errors were either not including the continuation bonds or the presence of a double bond between the C atoms of the backbone.

(d) (i) Some candidates gave two suitable properties of molybdenum. Others chose chemical properties instead of physical properties or properties that related to compounds of molybdenum e.g. 'it is coloured'; 'it has variable oxidation states'; 'compounds are soluble in water'.

(ii) A minority of candidates balanced the equation and gave the correct state symbols. Common errors included $6Cl$ instead of $3Cl_2$ and Mo_6 as the product. Some were able to write the correct state symbols but 'aq' often appeared incorrectly after $MoCl_6$, or chlorine was thought to be a liquid.

Question B9

A minority of candidates answered parts **(b)** to **(e)** well. Few candidates took account of the hydrogen in **(a)**. Many could extract the information from the table in part **(b)** but fewer could describe the structure of metals in terms of layers of atoms/ions in part **(c)**. Parts **(d)**, diagram of apparatus for electroplating and part **(e)**, calculation of empirical formula, were reasonably well done by some candidates. Others omitted essential detail in part **(d)** or an essential mathematical step in part **(e)**.

(a) Most candidates were content to write a simple statement without reference to hydrogen e.g. 'magnesium is more reactive than copper'. The most often seen acceptable answer referred to magnesium being more reactive than hydrogen and copper being less reactive than hydrogen. Hardly any candidates mentioned ease of electron loss or gain.

(b) This was generally well answered. The commonest errors were to reverse the trend or make a non-comparative statement e.g. 'when there is zinc present, it is strong'.

(c) Most candidates stated the idea of the atoms/ions being different sizes in the alloy. The commonest error was to not refer to layers of atoms sliding. Some candidates did not refer to what happens in the pure copper and only concentrated on the brass. Many referred to weaker forces when different elements are present.

(d) The commonest error was to omit to write that the electrolyte was aqueous; many just wrote copper or copper sulfate. Others suggested steel as the anode or used other substances as electrodes e.g. graphite or occasionally iron or nickel. The construction of the electrolysis cell was usually acceptable. Common errors here were electrodes not dipping in the electrolyte or short-circuiting the external circuit.

(e) Some candidates knew how to do the calculation and showed full working. The commonest error was to forget to calculate the mass of oxygen by subtraction, leading to incorrect answers such as Cu_2O_9. Other errors occurred where candidates used an incorrect value of the relative atomic mass for either Cu or O or inverted the calculation i.e. 64/9.86.

Question B10

This was the least popular of the ***Section B*** questions to be chosen. A wide variety of answers were seen in part **(a)** based on incorrect methods. The calculation in part **(b)** was generally well attempted. The test for copper(II) ions in part **(c)** was not well known. In part **(d)** a considerable number of candidates were able to identify the products when aqueous copper(II) sulfate is electrolysed

(a) Many candidates did not recognise the need to filter off the excess copper oxide. Some suggested filtering later on in the process. Others incorrectly suggested that the copper sulfate solution should be evaporated to dryness. Many suggested methods that would not work using substances other than copper(II) oxide and sulfuric acid or using titration. Most candidates made it clear that it was the solution that they were dealing with and not the residue.

(b) The commonest error was to calculate the relative molecular mass of the hydrated copper(II) sulfate as 160, water of crystallisation not included. Many simple errors in addition, multiplication and division were noted especially in the calculation of the relative molecular mass of the copper(II) sulfate and the calculation of the moles of sulfuric acid. A considerable proportion of the candidates did not respond to this question.

(c) Few candidates included both the observations for the test for copper(II) ions. Some candidates realised that a blue precipitate was formed at first but then did not go on to state that the solution is a deep blue. Others got this in reverse, starting with a deep blue solution and ending up with a light blue precipitate. Many candidates omitted to write that a precipitate was formed when excess ammonia was added.

(d) A greater number of candidates identified the cathode product, copper, than the anode product, oxygen. A small number of candidates suggested that oxygen is formed at the cathode and copper at the anode. A significant number of candidates suggested copper ions or oxide ions being formed rather than the elements. Other common errors included hydrogen instead of Cu and several products at each electrode..

CHEMISTRY

Paper 5070/31
Practical Test

Key messages

While many candidates were proficient in titrating, more candidates need to be secure in handling the demands of the associated calculations.

Candidates should aim to be more careful and consistent in their performing and reporting of qualitative tests.

General comments

In general candidates found **Question 1** more accessible than **Question 2**. Data was properly recorded and processed in the titration and there were many accurate results. Greater variety in the level of success was found in dealing with the volumetric based calculations. Qualitative tests were usually all attempted but the observations were often incomplete and at times incorrect. Supervisors provided the required experimental data to enable the examiner's assessment.

Comments on specific questions

Question 1

(a) The requirements of a volumetric task were well understood by the majority of candidates and consequently, many performed well with their titration results. Very few candidates wasted time carrying out unnecessary extra titrations.

The majority of candidates attempted all the calculations that followed but there was a wide variation in the marks secured. Clear working was generally in evidence.

(b) While the correct volume and concentration of **Q** were chosen, the need to use the same units for volume i.e. cm^3 or dm^3 was not always appreciated.

(c) Some made this a lengthy calculation by determining the concentration of **P** first rather than simply dividing the answer from **(b)** by 5. A few multiplied by 5.

(d) The scaling of the moles of manganate(VII) ions present in the average titre to 250 cm^3 was competently dealt with by a good number of candidates. Those who were unsuccessful usually tried to produce the answer without using the average volume of **P**.

(e) Most of the candidates obtaining an answer in **(d)** rightly sought to multiply it by 55 here.

(f) Masses from **(e)** were generally correctly processed but values in excess of 100% caused a few to alter numbers rather than to examine their previous working.

Question 2

Many candidates found it challenging to be consistent in their carrying out and reporting of the tests. It is important that instructions are carefully followed e.g. a gas when produced should be tested and named. Observations must be recorded correctly and accurately using appropriate terminology. Candidates should be encouraged to make full use of the Qualitative Analysis Notes supplied on the last page of the examination paper. Some candidates gave the wrong formula for the ion e.g. Ca^{+}, CO_3^{-}.

Test 1 Litmus was not always reported to be red or pink in **(a)** and a number of candidates did not record blue in **(b)**. Colourless was a popular alternative.

Test 2 While some responses turned damp red litmus blue with the gas evolved, not all of these named the gas as ammonia.

Test 3 The change in the colour of the liquid to yellow in **(a)** was noted by some candidates but more reported the red-brown precipitate on addition of aqueous alkali to the solution. The insolubility of the solid in excess alkali was seldom stated.

Test 4 There were a number of candidates who noted the bubbling on addition of the magnesium but few who correctly tested and named the gas. Positive tests were described for chlorine and carbon dioxide. The disappearance of the added solid was rarely recorded either here or in **Test 5**.

Test 5 Many missed the bubbling that occurred when the carbonate **S** reacted with the acid.

Test 6 Most of the candidates, who produced a solution in **Test 5**, reported a white precipitate when the aqueous sodium hydroxide was added. More noted the solid to be insoluble in excess than in **Test 3** but there were still many who did not.

Test 7 Some managed to produce a white precipitate with aqueous ammonia. In addition, there were others who described testing for ammonia gas.

Test 8 Only a small number of candidates correctly tested and identified the gas produced.

CHEMISTRY

Paper 5070/32
Practical Test

Key messages

Candidates should aim to be careful and consistent in their performing and reporting of qualitative tests.

General comments

In general, candidates performed better in **Question 1** than **2**. Despite the unfamiliar technique involved in the titration, there were many accurate results. While there was variation in the level of success with the volumetric based calculations, a good number handled the demands and performed well. Qualitative tests were usually all attempted but the observations were often incomplete and at times incorrect.

Comments on specific questions

Question 1

(a) The requirements of a volumetric task were well understood by most candidates and consequently, many performed well with their titration results.

The majority of candidates attempted all the calculations that followed and clear working was generally in evidence. Some candidates made careless errors with transcription of numbers. In circumstances where a candidate produces more than one answer to a question, it is important that it is made clear which answer is the intended one i.e. by crossing out the other answers and any associated working. There were examples of the use of 24 dm^3 in producing answers mainly in **(d)** but occasionally in **(b)**.

(b) Many correctly calculated the number of moles of potassium manganate(VII). The major error arose from not appreciating the need to use the same units for volume in the titre and concentration i.e. cm^3 or dm^3. It was common to find 0.2, rather than 0.02, used for the concentration of **Q**.

(c) Virtually all candidates multiplied the answer from **(b)** by 5 but there were the occasional examples of dividing by 5.

(d) Although the scaling of the moles of iron(II) ions present in the pipette volume to 500 cm^3 was competently dealt with by a good number of candidates, this calculation proved to be the most challenging overall. Those who were unsuccessful commonly tried to produce the answer without using the volume of **P**.

(e) Most of the candidates obtaining an answer in **(d)** multiplied it by 56. Unfortunately, a number of these went on to subtract their answer from 3.12 and so obtained the mass of the steel that was not iron.

(f) Masses from **(e)** were generally correctly processed but values in excess of 100% caused some to alter or invert masses rather than examine their previous working.

Question 2

Many candidates found it hard to be consistent in their carrying out and reporting of the tests. It is important that instructions are carefully followed e.g. a gas when produced should be tested and named. Candidates should be encouraged to make full use of the Qualitative Analysis Notes supplied on the last page of the examination paper.

Test 1

The methyl orange turning red or pink in **(a)** was identified by many candidates; there were many who did not report it as being yellow in **(b)**. Colourless or no change was the usual alternative.

Test 2

Having recorded the evolution of a gas, which turned damp red litmus blue, most correctly named the gas. However, a significant number completely missed the production of ammonia.

Test 3

The colour due to the formation of iodine in the mixture of **R** and iodide was less frequently noted than the colour of the complex produced when starch was added.

Test 4

Most candidates reported that the liquid turned blue but few made it clear that copper(II) oxide had disappeared or dissolved in the process. In any test where a solid is added to a liquid, candidates would be well advised to add a little of the solid at first and then more if necessary. Some candidates referred to the added black solid as a precipitate and others described the formation of a black solution. Warming the mixture was believed to result in effervescence and, in a number of cases, positive tests were made for oxygen.

Test 5

Many missed the bubbling that occurred when the carbonate **S** reacted with the acid and some of those who did record the effervescence, made no attempt to identify the gas. As in **test 4**, there was evidence of candidates adding too much solid all at once.

Tests 6 and 7

While some recorded perfectly the formation of a white precipitate, which dissolved in excess producing a colourless solution for each test, there was much variety in other answers. Incomplete observations were given where the appearance of the final solution was omitted. Poor technique resulted in either the precipitate remaining or no precipitate ever appearing. In addition, there were others who described testing for ammonia gas.

Test 8

Only a small proportion of candidates made the correct observation.

Conclusions

Despite candidates having reported sufficient evidence to identify one or more of the ions, candidates found the identification of the ions challenging. Candidates mostly identified NO_3^- in **R**. Only a few candidates suggested H^+, despite recording methyl orange turning red. In some cases, candidates disadvantaged themselves because the wrong formula for the ion was given e.g. Zn^+, CO_3^-, NO_3^{2-}.

CHEMISTRY

Paper 5070/41
Alternative to Practical

Key messages

Candidates are advised that in questions that require them to plan an experiment they should read the question carefully, taking note of all the information provided that is designed to assist them in answering the question.

Candidates should also ensure that all the details requested are included in their responses.

General comments

The Alternative to Practical Chemistry paper is designed to test the candidate's knowledge and experience of practical chemistry.

Skills including recognition and calibration of chemical apparatus and their uses, recall of experimental procedures, handling and interpretation of data, drawing of graphs, analysis of unknown salts and calculations.

Most candidates show competency of plotting points accurately on graphs and drawing lines as instructed.

Calculations are generally completed accurately using the appropriate significant figures, but candidates should be encouraged to show all their working.

Comments on specific questions

Question 1

(a) Most candidates correctly named the fractionating column but often did not state that its purpose is separation. The condenser was also usually named correctly although there were several poor spellings.

(b) Most candidates stated that there should not be a bung in the conical flask. Many candidates stated that the water in and out were wrong but did not state what was wrong. Some candidates incorrectly considered the vertical arrows to represent heat from a flame.

(c) This was well answered.

(d) Most candidates knew that the contents of the flask were flammable and suggested a suitable alternative method of heating. Uniform heating was sometimes given as a reason instead of flammability.

(e) This was answered very well.

Question 2

(a) This was quite well answered. Copper was a common incorrect answer.

(b) Many candidates correctly described the appearance of the solid produced at the cathode but blue was seen quite often.

(c) Many gases were given as answers but those who correctly named oxygen almost always gave a correct test.

Question 3

This question was well answered. The masses are divided by the relative atomic masses and the simplest ratio is then found.

Question 4

Many candidates did not recognise that **(a)**, **(b)** and **(c)** are reactions commonly used in the identification of ions and produce precipitates.

Question 5

A majority of candidates recognised that the rate of reaction in experiment 2 is less than in experiment 1 and that the condition for this is a lower temperature.

Question 6

Some very good responses were seen but many candidates did not read the question carefully and did not take note of what was required in their response. All the information necessary to carry out the separation was given in the question. Distilled water needed for washing at the end was often added at the start. Observations occurring at each stage of the procedure were often omitted and many candidates made copper sulfate crystals rather than producing the pure dry sample of carbon that was required.

Question 7

(a) The mass of limestone was almost always correct.

(b) The use of a volumetric flask to make up solutions was not well known. Candidates should know that these flasks are very important and very accurate pieces of apparatus used in volumetric analysis.

(c) Many incorrect colour changes were seen.

(d) The titration results were generally correct. The average volume should be calculated from the closest two titres. Some candidates used all three titres in calculating this volume and others used titres 2 and 3 and assumed that titre 1 should be ignored as it was a trial.

(e) to **(m)** In the calculations, most candidates gained some calculation marks. Candidates are advised to take care not to round to too few significant figures. In calculations based on titrations answers should be given to three significant figures.

Question 8

(a) A coloured solution indicates that a transition metal ion or compound is present in **L**. Most candidates omitted the word ion or compound from their answer.

(b) The reactions of Fe^{2+} ions and NH_4^+ ions with sodium hydroxide were well known. Some candidates did not give a test for the ammonia gas produced in **(iii)**, while others gave the test but did not identify the gas.

(c) This was usually correct.

(d) The test for sulfate ions was well known.

(e) This was well answered.

Question 9

(a) A significant number of candidates confused exothermic and endothermic reactions and others gave answers that were not connected with the temperature rise. Correct observations were rarely given in **(ii)**, with many candidates giving the name of products and not describing what would be seen. The equation was sometimes not balanced correctly or the formula of magnesium chloride was incorrect.

(b) Most candidates completed the graph correctly. A few did not plot the points with sufficient accuracy.

(c) Most candidates correctly read the temperature from their own graph and subtracted 20 from it to determine the temperature rise.

(d) The calculations were usually correct.

CHEMISTRY

Paper 5070/42
Alternative to Practical

Key messages

Greater familiarity with the technique of reflux is required, including the purpose of heating under reflux and how it is carried out practically.

Candidates are advised that in questions that require them to plan an experiment they should read the question carefully, taking note of all the information provided and consider the most appropriate method.

Candidates are expected to know that a volumetric flask is used to make standard solutions for use in volumetric analysis.

Comments on specific questions

Question 1

Many candidates were insufficiently familiar with the technique of heating under reflux.

(a) (i) The majority of candidates could identify the condenser. Small numbers thought the condenser was a fractionating column.

(ii) The majority realised that the condenser turned a vapour or gas into a liquid but only a very small number mentioned that the liquid returned to the distillation flask.

(b) Only a minority of candidates could identify two errors and some confused heating under reflux with distillation. Common incorrect answers were:

a collecting vessel is required
there was no thermometer
there was no fractionating column
water in and out were wrong, without a comment as to what the precise fault was e.g. the water in should be at the bottom and the water out should be at the top.
the arrow was thought to represent a Bunsen burner or some other form of direct heat
the bung which should not be present was not usually specified as the one *at the top of the condenser*.

(c) (i) A large number of candidates realised the danger of flammability.

(ii) Many correct alternatives to a Bunsen burner were given by candidates. Heater, without further information, was seen occasionally.

(d) Distillation or fractional distillation were correctly named by many candidates. Condensation, filtration and even crystallisation were also seen occasionally.

(e) Ethyl ethanoate was named correctly by some candidates. Some used the generic term ester rather than attempt to identify the specific ester.

Question 2

(a) Oxygen was identified often, although other gases such as carbon dioxide, sulfur dioxide and hydrogen were also seen. The test for oxygen was usually correct.

(b) Hydrogen was identified very often, although other gases such as carbon dioxide and sulfur dioxide and oxygen were also seen. The test for hydrogen was usually correct, although 'burns with a pop' was seen occasionally, without reference to a flame being used in the test.

(c) This question was answered fairly well**.** The most common error was the omission of a suitable observation to describe the appearance of gaseous chlorine.

Question 3

This multiple choice question was answered reasonably well by candidates.

Question 4

This multiple choice question was answered very well by candidates.

Question 5

Candidates found this multiple choice question challenging.

Question 6

Candidates found this multiple choice question challenging.

Question 7

There were some extremely good answers to this question. Some candidates did not attempt the question. Others chose inappropriate methods based on techniques such as fractional distillation and chromatography. Experiments were seen in which gases were produced without any other substance being added to the vinegar.

The most suitable method was based on titration with a suitable alkali using a suitable indicator such as methyl orange. Universal Indictor is unsuitable for titrations. Very reactive metals such as sodium would not be added to dilute acids in a school laboratory due to the hazards involved. Any fully successful method should involve using equal volumes of the two samples of vinegar and reacting them with equal quantities of an alkali, metal or carbonate. This is only unnecessary if pH measurements were used to distinguish between the two samples.

Question 8

(a) Almost all the candidates were able to carry out the necessary subtraction.

(b) 'Volumetric flask' was given by a minority of candidates. Conical flasks and measuring cylinders, both of which are inappropriate to make a standard solution, were regularly given in answer to this question.

(c) The table was completed correctly by the majority of candidates. Only a small number read the burettes 'upside down'. A small number of candidates automatically thought that titrations 2 and 3 should be used to determine the average, instead of the titrations that give volumes that are closest together, which includes titration 1 in this case.

(d) to **(j)** The majority of candidates performed calculations based on quantitative analysis very well. Numerical answers should always be given to a minimum of three significant figures.

Question 9

(a) Answers that did not refer to *ions* or *compounds* were not accepted for this question.

(b) This was answered quite well by the majority of candidates. The most common omission was missing out the name of ammonia gas in part **(iii)**. The stem of the question states that 'Any gases produced should be identified by test, result and name'.

(c) This was answered quite well by the majority of candidates. Zinc or calcium ions were common errors.

(d) This was answered quite well by the majority of candidates, although a small number gave another test, used to identify a completely different ion or even a gas. Barium sulfate and silver nitrate were occasionally seen as incorrect reagents.

(e) Ammonium was often seen as a negative ion in combination with aluminium or zinc.

Question 10

(a) Exothermic was seen very often. Endothermic was also fairly common.

(b) Most candidates plotted the points correctly and drew two intersecting straight lines through the points. The left hand line did not always go through the origin. Some lines were obviously without a ruler.

(c) (i) Candidates usually used the graph correctly to determine the required mass.

(ii) Candidates usually used the graph correctly to determine the required temperature rise.

(d) (i) This was answered very well by the majority of candidates.

(ii) This proved to be challenging to candidates.

(iii) This was answered very well by a good number of candidates.