

CHEMISTRY

Paper 5070/11
Multiple Choice

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

General Comments

Candidates should be aware that a number of the questions require a simple recall of the information specifically mentioned on the syllabus.

Comments on Specific Questions

Question 7

Carbon atoms always form four covalent bonds, oxygen atoms form two covalent bonds and hydrogen atoms form one covalent bond. Using the above knowledge the safest method of tackling **Question 7** is to draw the structure of each compound.

Question 13

The syllabus requires a good knowledge of the electrolysis of aqueous copper(II) sulfate with copper electrodes as a means of purifying copper. This knowledge leads to the choice of alternative **A** as the correct answer.

Question 16

Curve 2 showed that in the second experiment more oxygen was produced. The only method of obtaining more product from a reaction which is not reversible is to use more of the starting reagents.

Question 18

Most candidates appreciated that aluminium oxide is amphoteric, though many did not realise that magnesium oxide is a basic oxide.

Question 24

In the blast furnace, iron(III) oxide is reduced by either carbon or carbon monoxide neither of which is a metal, thus statement 3 is not correct.

Question 26

The metals used in the sacrificial protection of iron are always more reactive than iron. Magnesium is higher than iron and copper is lower than iron in the reactivity series. Therefore alternative **D** was the correct answer.

Question 30

Nitrogen dioxide is an acidic gas and reacts with the oxygen and water in the atmosphere to form nitric acid which is a constituent of acid rain. Buildings made from limestone will as a consequence be damaged when nitrogen dioxide is present in the atmosphere, eliminating alternatives **B** and **C**.

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Paper 5070/12
Multiple Choice

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

General Comments

Candidates should be aware that a number of the questions require a simple recall of the information specifically mentioned on the syllabus.

Comments on Specific Questions

Question 2

In a titration it is essential to have a flask in which the solutions involved can react together. The only alternative in the question which had a flask as one of the essential pieces of apparatus was **C**.

Question 7

Most candidates realised that the salt was a chloride. The fact that zinc hydroxide is amphoteric and dissolves in excess sodium hydroxide was the essential piece of knowledge required to eliminate zinc chloride.

Question 26

Nitrogen dioxide is an acidic gas and reacts with the oxygen and water in the atmosphere to form nitric acid which is a constituent of acid rain. Buildings made from limestone will therefore be damaged when nitrogen dioxide is present in the atmosphere, eliminating alternatives **B** and **C**.

Question 28

Sodium is too high in the reactivity series to have its ions easily reduced to sodium atoms by another reagent and so electrolysis is the method used.

Question 39

The candidates who did not choose alternative **D** as their answer were possibly confusing the terms general formula and empirical formula.

CHEMISTRY

Paper 5070/21

Theory

Key Messages

To be successful in calculations candidates must organise their answers in a clear and coherent way making certain that the working out is clearly shown. Candidates are advised not to round their answers in the middle of the problem but to wait until the end.

Candidates often found questions involving structure and bonding quite challenging and would have benefitted from using chemical terminology with greater precision and clarity.

Candidates did not show a clear understanding of the kinetic theory of matter and often used collision theory where it was not appropriate.

General Comments

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

Candidates did not always organise their answers to quantitative questions which made it difficult to award marks for errors carried forward. Candidates should be advised to show all the steps in a calculation so that examiners can easily credit the working out when an answer is incorrect.

Comments on Specific Questions

Section A

Question A1

This question was about different organic compounds.

- (a) Many candidates recognised that any one of the organic acids listed would react with magnesium to give hydrogen. A common mistake was to give one of the alcohols from the list.
- (b) Many candidates appreciated that propanol can be oxidised to give propanoic acid; however, some candidates gave propane instead.
- (c) The concept that carboxylic acids react with alcohols to make esters was well known.
- (d) Many candidates recognised the displayed formula as an ester but did not always choose the correct ester, ethyl butanoate. The most common error was to give the isomeric ester butyl ethanoate instead.
- (e) Candidates often chose propane but some recognised that a molecule of propanoic acid also had 11 atoms.

Question A2

This question was about calcium compounds.

- (a) Candidates did not always know the formula for calcium hydroxide and/or calcium carbonate and as a result could not construct the correct equation.
- (b) Only the best answers specifically referred to the presence of hydroxide ions in calcium hydroxide and then wrote the equation between hydrogen ions and hydroxide ions.
- (c) The best answers gave an equation showing the formation of gaseous ammonia. Many other candidates appreciated that nitrogen would be lost from the soil but implied it was nitrogen gas rather than ammonia gas.
- (d) The best answers showed all the working out to calculate the empirical formula $\text{CaH}_4\text{P}_2\text{O}_8$. Some candidates gave this as $\text{CaH}_4(\text{PO}_4)_2$ and others as $\text{Ca}(\text{H}_2\text{PO}_4)_2$. Candidates found deducing the formula of the anion very demanding and often either left it blank or gave formulae that did not relate to the empirical formula they had calculated. Correct answers included PO_4^{3-} and H_2PO_4^- .

Centres should advise candidates not to round up their answers to calculations in the middle of the problem but wait until the end when it is more appropriate. Some candidates inverted the expression for moles, using $\text{moles} = A_r/m_{\text{mass}}$. These candidates were only able to access the mark for the formula of the anion.

Question A3

This question focused on the conversion of oxygen, O_2 , into ozone, O_3 .

- (a) (i) Candidates often gave very good answers explaining that more energy was released during bond making than absorbed during bond breaking. Other candidates only focused on the bond making and implied that there was no bond breaking in this reaction. A common misconception was to refer to more energy used in bond making than bond breaking without clearly explaining whether the energy was released or absorbed.
- (ii) Some candidates gave the correct answer of 588 kJ and showed clearly how this answer had been obtained. A common error was to get an answer of double this because they used the relative atomic mass of oxygen rather than the relative molecular mass for oxygen, O_2 .
- (b) Most candidates were able to name an ozone-depleting pollutant.
- (c) (i) The best answers recognised that the position of equilibrium would shift to the left because there were more moles of gas on the right hand side. A common misconception was that the reaction shifted to the right because the reaction was faster.
- (ii) The best answers recognised that the position of equilibrium would shift to the left because the backward reaction is exothermic. Some candidates referred to rate of reaction rather than position of equilibrium, while others used the decrease in rate of reaction as a reason why the position of equilibrium moves to the left. A small proportion of the candidates referred to an increased or decreased position of equilibrium.
- (iii) Candidates found this question difficult to answer since it was about the reaction becoming slower rather than faster. Only the very best answers referred to the particles having less energy, moving slower and there being fewer successful collisions.

Question A4

This question focused on sulfur and some of its compounds.

- (a) Candidates could often define the term isotopes but a common misconception was to not refer to atoms. Some answers given referred to isotopes as the same element with different numbers of neutrons and did not imply atoms within the answer. The best answers referred to atoms having the same number of protons and different number of neutrons. A common misconception was to refer to isotopes having different relative atomic masses.

- (b) Candidates could often get two of the three entries in the table correct. A common misconception was to give the number of electrons in the isotope rather than the electronic configuration. Some candidates gave the correct orbital notation for the electronic configuration. This was given full credit but is beyond the scope of the syllabus.
- (c) Some candidates showed their working out to get the molecular formula of S_8 . Other candidates gave answers such as $8S$ or ^{256}S . A significant proportion of the candidates did not attempt this question.
- (d) (i) Many answers just referred to weak bonds without specifying the nature or type of bond. The best answers referred to weak intermolecular forces or weak bonds between molecules. Some candidates referred to van der Waals forces and this was given credit. The most common misconceptions were to refer to weak covalent bonds or intermolecular forces between atoms.
- (ii) The idea of the lack of free electrons, no sea of electrons or no delocalised electrons was well known by the candidates.
- (e) The formulae for the potassium ion and sulfide ion were well known. Some candidates gave the electronic configurations for the elements rather than the ions and others used orbital notation.
- (f) Many candidates could draw the correct 'dot-and-cross' diagram. Some candidates drew the complete diagram including the inner shells even though these were not required by the question. The most common errors were not drawing the two lone pairs on sulfur and adding an extra electron to the outer shell of the hydrogen atom. A few Lewis diagrams were drawn and if correct gained full credit.
- (g) Some candidates could construct the balanced equation but other candidates used the incorrect formulae or added incorrect products.

Question A5

This question focused on some of the reactions of copper(II) nitrate.

- (a) (i) Many candidates recognised that **B** was oxygen and gave the correct formula.
- (ii) Candidates found the construction of the equation to show the decomposition of copper(II) nitrate very demanding. Many candidates did not write down the correct formulae for the products and even if correct could not balance the equation. Many different formulae for oxides of nitrogen were given rather than the NO_2 that was needed.
- (b) Candidates were often unable to deduce the identities of the unknown compounds **C** and **D**. Ammonium or ammonium hydroxide was a common wrong answer for **C**.
- (c) Candidates found this question very challenging and rarely gave the name of a soluble carbonate. The most common answer was calcium carbonate. In terms of the ionic equation the formula for the carbonate ion was not well known and it was often given as CO_3 or CO_3^- . The state symbols were often missing and if shown often showed the precipitate as (aq) rather than (s).

Section B

Question B6

This question was about ammonium nitrite and ammonium nitrate.

- (a) Many candidates could give the test for ammonia gas, typically using moist red litmus paper, but the candidates did not always link their answer to the formation of ammonia from the ammonium ion. A common mistake was to heat the ammonium nitrite with sodium hydroxide and aluminium and then test for ammonia. A common misconception was that the solution of ammonium nitrite itself would contain ammonia.
- (b) The best answers showed the calculation in stages calculating the moles of ammonium nitrite, the moles of nitrogen and then the volume of nitrogen at room temperature and pressure. This

approach made the award of 'error carried forward' marks very straightforward. Many candidates did not use this approach and showed little or no working. A common error was to quote the final answer of 0.3 dm^3 or 300 cm^3 without units or to use the wrong conversion from dm^3 to cm^3 . Other candidates used a molar volume at room temperature and pressure of 22.4 dm^3 rather than 24 dm^3 .

- (c) The candidates found this question very challenging and most did not spot that the formula for ammonium nitrate had one more oxygen atom than that for ammonium nitrite and so N_2O was produced instead of N_2 . Answers often included different oxides of nitrogen such as NO_2 and NO .
- (d) Many candidates misread the question and gave descriptions of how to make crystals of ammonium nitrate rather than aqueous ammonium nitrate. Some candidates did not appreciate that a titration method had to be used and instead described the use of ammonium oxide or ammonium hydroxide as an insoluble base. Only the very best answers described a method involving titration and clearly mentioned doing the titration twice once with the indicator to determine the volume at the end-point and once without the indicator.

Question B7

This question focused on some aspects of the chemistry of molybdenum.

- (a) Candidates were often able to construct the equation for the reaction between molybdenum(VI) oxide and aluminium.
- (b) Candidates who used oxidation number normally quoted the correct values. Some candidates used the gain or loss of oxygen to explain their answers. Only a small number of candidates confused the definitions of oxidation and reduction.
- (c) Good answers were exemplified by organised working out that if necessary allowed the award of 'error carried forward' marks. The most common error was to calculate the incorrect relative formula mass for molybdenum(VI) oxide.
- (d) Candidates often realised that molybdenum was less reactive but sometimes did not offer an adequate explanation and merely stated that molybdenum was lower in the reactivity series. Good answers referred to the ability of aluminium to displace molybdenum from its oxide.
- (e) (i) Good answers included a labelled diagram showing clearly the close packing of the positive metal ions. Candidates often mentioned the presence of the delocalised electrons.
(ii) Many candidates failed to appreciate the significance of the attraction between the delocalised electrons and the positive metal ions. As a result they did not mention that the positive ion was more highly charged or that there were more electrons when explaining the high melting point of molybdenum. Often candidates just referred to stronger metallic bonding.

Question B8

This question was about the manufacture of poly(chloroethene).

- (a) The two processes used to make ethene from crude oil were well known.
- (b) Some candidates could write the correct electrode reaction but often the equation involved electrons being gained by chloride ions rather than being lost.
- (c) Many candidates could draw the structure of dichloroethane and most realised that the isomer made was 1,2-dichloroethane rather than 1,1-dichloroethane.
- (d) Many candidates appreciated that HCl was made in the reaction. The mark scheme allowed both hydrogen chloride and hydrochloric acid as the name of the compound formed.
- (e) The structure of poly(chloroethene) was often well drawn with candidates either drawing the repeat unit with free bonds at the end or a section involving at least three repeat units again with the free

bonds. A common misconception was to draw the polymer with double bonds between carbon atoms.

- (f) (i) Some candidates appreciated that in addition polymerisation the mass of polymer made is the same as the mass of monomer used.
- (ii) Providing the candidates got part (i) correct they were normally able to calculate the percentage yield as 96.7%.

Question B9

This question focused on the homologous series of alkanes.

- (a) Many candidates just restated the information in the question and did not specifically explain why dodecane was a liquid. The best answers stated that 25 °C was between the boiling point and the melting point.
- (b) Candidates did not always specifically mention particles in their answer. Candidates often stated that butane had more energy rather than the particles had more energy. Some candidates referred to overcoming intermolecular forces but others mentioned breaking covalent bonds. A common misconception was to give some reference to collision theory.
- (c) Many candidates appreciated that the volume would decrease as the pressure increases but were not able to explain why this happens in terms of particles. Candidates rarely mentioned that the particles were more crowded or had moved closer together; however, answers often referred to an increased collision frequency.
- (d) Candidates often explained that fractional distillation could be used since the alkanes had different boiling points.
- (e) Many candidates could draw the two isomers but some drew the same isomer twice.
- (f) Candidates gave a wide range of different answers ranging from monosubstituted to fully substituted products. All these answers were given marks.

CHEMISTRY

Paper 5070/22
Theory

Key Messages

- Many candidates need more practice in deducing the formulae of compounds such as P_2O_5 and $(NH_4)_3PO_4$ from first principles.
- The construction of ionic equations needs more practice.

General comments

Many candidates tackled this paper well and gained good marks in both **Section A** and **Section B**. Most candidates gave answers of the appropriate length to questions involving free response. Others gave answers which were too vague or not related to what was expected from the stem of the question e.g. in **Question B6(c)** many candidates did not realise that they had to select a compound that would react with ammonium carbonate. Very few candidates left parts of questions unanswered.

Some candidates' knowledge of structure and bonding was good. Others got confused between ionic and covalent structures, often calling the particles in an ionic structure, atoms or molecules and vice versa. Many referred to intermolecular forces between ions and atoms in a covalent bond.

Many aspects of organic chemistry were well answered e.g. **Question A1(a)** and parts of **Questions B8** and **B9**. The writing of balanced equations was not always successful, a major obstacle for some candidates being to work out how to construct ionic equations. **Questions A2(d)(iii)**, **A4(b)** and **A5(a)** caused particular problems in terms of identifying the ions and, in **A5(a)**, in terms of balancing with electrons.

Many candidates answered equilibrium questions in terms of rate of reaction and referred to equilibrium in questions involving rate of reaction. Many candidates need more practice in interpreting whether the question relates to one or the other of these topics. Many candidates also need practice at answering questions involving the rate of reaction especially on the effect of temperature on rate of reaction (**Question 8(b)**)

Practical aspects of chemistry as in **Question B6(c)** on salt purification, pose a challenge for many candidates. Candidates could improve their marks if they considered carefully the different states of the components in each system. Many candidates did not appear to understand that the term *observations* applies to what you can see, hear or smell since in **Question B6(a)** many candidates stated the names of substances rather than explaining what happens during the reaction.

Some candidates performed well in questions involving calculations, showing appropriate working, clear progression in each step of the calculation and clear indications about to what each number refers e.g. moles $TiCl_4 = 0.658$ mol. Candidates should be encouraged to follow this method. Some candidates gave no explanation of what they were doing or the relevant units: g or mol or $mol\ cm^{-3}$. This often makes it difficult to award marks for 'error carried forward'.

Comments on specific questions

Section A

Question A1

This question was the best answered in the Paper. Candidates generally scored well in most parts. The exception being part **(a)(iii)** where many confused propyl ethanoate with ethyl propanoate. A minority of candidates disadvantaged themselves by writing multiple answers to some parts of the question.

- (a) (i) Most candidates recognised **C** as being a CFC. The most common incorrect answer was **E**.
- (ii) Nearly all the candidates recognised **A** as propanoic acid.
- (iii) Some candidates correctly identified propyl ethanoate as **F**. The most common error was to suggest the ester **H**.
- (iv) Most candidates gave **G** as the alcohol which can be oxidised to ethanoic acid. A few put the other alcohol, **B**.
- (b) Most candidates recognised that an ester is made from an alcohol and a carboxylic acid. The most common error was to suggest a combination of two alcohols or two esters.

Question A2

This proved to be the most challenging question on the Paper. Some candidates gave good answers to parts (a) and (b) and many scored at least one mark in the calculation in part (b)(ii). Some candidates gave good answers to part (c) and clearly had a good grasp of equilibrium. Others gave answers to the equilibrium questions which related to rate of reaction or confused the effects of temperature and pressure on equilibrium reactions. Many candidates need more practice in constructing ionic equations such as those in part (d).

- (a) Many candidates gave fluorine as the most reactive halogen. The most common incorrect answers were astatine and chlorine.
- (b) (i) Some candidates answered this question well. Others did not gain the second mark because they wrote further statements such as 'the energy released in bond forming is greater than that in bond breaking', implying that energy is released in both.
- (ii) Some candidates scored both marks for the correct answer but a significant proportion scored a single mark because they calculated moles of *Cl* atoms not moles of Cl_2 molecules as their first step. Some candidates were not able to work out the relative molecular mass of chlorine, giving 70 instead of 71. Weaker answers tended to use the figures 105.5 and 185 incorrectly, multiplying them or subtracting them.
- (c) (i) Some candidates realised that the position of equilibrium was related to the number of moles of reactants and products. Others suggested that position of equilibrium would move to the left or to the right, thinking that they had used the equation to back up their answer. In reality many candidates counted the number of moles on either side of the equation incorrectly, often quoting more moles on the left and ignoring the 2HI on the right. A small proportion of the candidates focused on rate of reaction rather than the position of equilibrium. Others used the idea that the reaction was endothermic to deduce, incorrectly, the change in the position of equilibrium.
- (ii) Some candidates linked the shift in equilibrium to the left to the forward reaction being endothermic or the backward reaction exothermic. Others did not specify that the exothermic reaction was the backward reaction.
- (d) (i) Some candidates gave the correct equation for the dissociation of hydroiodic acid. A few gave a correct equation involving H_3O^+ ions. Many wrote the equation for the thermal decomposition of hydrogen iodide. Other common errors were: the inclusion of water in the equation; giving incorrect products such as HOI; the equation reversed with HI as a product.
- (ii) Many candidates did not know the formula for calcium iodide, CaI often being preferred to CaI_2 . Even when the formula of calcium iodide was correct, many did not balance the HI on the left. A significant minority of candidates wrote calcium hydride and iodine as the products.
- (iii) Few candidates gave an ionic equation and many gave equations which were mixtures of ions and molecules. Many candidates wrote the reaction of hydrogen ions with hydroxide ions to form water. Many of the candidates who realised that the reaction was between carbonate ions and hydrogen ions, gave the incorrect formula for the carbonate ion, CO_3^- .

Question A3

Many candidates gave good answers to many parts of this question, especially to parts **(a)** (isotopes), **(c)(ii)** (lack of electrical conduction), **(d)** (numbers of subatomic particles) and **(e)** ('dot-and-cross' diagram). Some gave incorrect answers relating to forces between molecules (part **(c)(i)**). Many candidates would benefit from more practice in working out formulae from combining powers or oxidation numbers (part **(f)**).

- (a)** Nearly all candidates were able to describe one difference and one similarity of the two isotopes. The most common error was to suggest that isotopes have different relative atomic masses.
- (b)** Some candidates gave the correct formula of phosphorus as P_4 . Common errors included $2P_4$, $4P$, P_2 and ^{124}P . A significant number of candidates suggested PNb , which could not be given credit even though it does have a relative mass of 124.
- (c) (i)** The best answers referred to van der Waals' forces or weak forces between molecules. A common misconception was to suggest weak forces between covalent bonds.
 - (ii)** Most candidates recognised that phosphorus does not conduct electricity because it has no mobile electrons. The idea of free electrons was the commonest correct answer. A minority of candidates mentioned ions or atoms which were not free to move.
- (d)** Most candidates gained at least two of the three marks available. The commonest error was to give the number of electrons (18) instead of the electronic configuration (2,8,8). Others did not consider that P^{3-} is an ion not an atom and gave the incorrect configuration 2,8,5. A few candidates gave electronic orbital configuration, which was acceptable.
- (e)** A majority of the candidates drew good 'dot-and-cross' diagrams for PH_3 . Very few wrote ionic structures. The commonest errors were related to the outer shell of the phosphorus or hydrogen atoms rather than the bonding pairs of electrons.
- (f)** The formula for phosphorus(V) oxide was not well known. Many candidates wrote PO_5 , P_5O_2 or P_2O_3 . Those who did write the correct formula, P_2O_5 , often obtained the mark for balancing as well.

Question A4

Many candidates gave full working and obtained the correct answer for the empirical formula of SO_3 in part **(a)(ii)** as well as deducing the correct formula of SO_2 in part **(a)(i)**. Few gained marks for constructing a balanced equation including state symbols for the precipitation of iron(II) hydroxide in part **(b)** because the formula of the iron(II) hydroxide was incorrect.

- (a) (i)** Many candidates deduced correctly that the formula should be SO_2 . The most common errors were CO_2 , O_2 and H_2 . A significant number of candidates wrote the name rather than the formula.
 - (ii)** Good answers gave full working and gave the name as sulfur trioxide. A common misconception was to name SO_3 as sulfite. Common errors included: using atomic number as a divisor instead of atomic mass to calculate the mole ratio; using 32 for oxygen; inverting the expression to calculate the amount in moles. A number of candidates rounded up the ratios incorrectly to form SO_2 .
 - (iii)** Common errors were: Fe, FeO, FeO_2 or iron ions.
- (b)** Many candidates realised that the precipitate was iron(II) hydroxide, but few wrote the correct formula, the most common errors being FeOH or $FeOH_2$. Others did not balance the ionic equation. A common error in the use of state symbols was to suggest that iron(II) hydroxide was aqueous. Many candidates did not include the state symbols. Many candidates wrote molecular equations or a combination of molecular and ionic.
- (c)** The most common correct answers involved the use of barium chloride or barium nitrate. Some candidates gave the name of the precipitate and not the formula. Common errors include the addition of barium, barium sulfate or sulfuric acid (together with barium chloride).

Question A5

Many candidates performed well on this question. The calculation in part (c) was generally well set out and often correct and the copper purification question in part (b) was answered well. In part (a) many candidates made simple errors in writing the equations for the reactions at the anode and cathode for the electrolysis of magnesium chloride.

- (a) Some candidates got one of the equations correct but few got both correct. Common errors included: electrons on the wrong side of the equation; electrons with a positive sign; lack of balance of the Cl ; writing $2Mg$ on the right hand side; giving the magnesium ion as Mg^+ . A small number of candidates gave the reaction between magnesium and chlorine or the decomposition of magnesium chloride.
- (b) (i) Many candidates gave the correct answer 'impure copper' but a considerable number just wrote 'copper'. The most common error was to suggest graphite.
- (ii) 'Pure copper' or 'copper' were often seen as correct answers. Incorrect answers included, graphite, impure copper or the names of objects to be plated. A small proportion of candidates gave the electrode reaction as an equation rather than name a substance.
- (c) The calculation was generally well done, most candidates giving full and clear working. A common error was to calculate the wrong number of moles of sodium chloride, assuming that the volume was in cm^3 rather than dm^3 . A significant proportion of the candidates did not use the mole ratio of $NaCl:Cl_2$.

Section B

Question B6

In part (a) some candidates did not write observations but stated names of substances formed. In part (b) most candidates could remember the tests for carbon dioxide and ammonia. In part (c) many candidates were unsure of how to produce a pure dry sample of an insoluble salt with many implying that a soluble salt was being formed and crystallised. In part (d) many candidates could not deduce the formula for ammonium phosphate.

- (a) Many candidates did not use the state symbols to suggest an appropriate observation. The most common correct answers were 'pungent gas formed' and 'mass of solid decreases'. The most common error was to suggest that bubbling or effervescence takes place. A considerable number of candidates did not refer to observations but wrote statements about the products given off e.g. ammonia is formed or water is given off.
- (b) Most candidates could recall the tests for ammonia and carbon dioxide. Some, however, did not link the tests to the names of the gases.
- (c) Few candidates scored all three marks. Many could not name a suitable reagent to add to the ammonium carbonate. The commonest error was to add zinc. Many assumed that the question was about the separation of zinc carbonate from a mixture of zinc carbonate and ammonium carbonate. Although candidates often mentioned filtering in their answers, this was frequently associated with getting the filtrate rather than the residue. Some answers suggested that candidates did not know the difference between the filtrate and the residue. Many did not gain marks because they referred to crystallisation of the salt. Many candidates did not appreciate the need to wash the residue, although many mentioned the drying stage. A few suggested that strong heating was required, which was not acceptable because the carbonate would decompose.
- (d) Many candidates could not deduce the formula for ammonium phosphate and as a result could not balance the equation. Common errors included $(NH_4)_2PO_4$ and $(NH_3)_3PO_4$.

Question B7

Many candidates gave good answers to parts (a) (equation), (c) (mole calculation) and (f) (explanation of electrical conductivity). In part (b) many candidates wrote statements which were not exact enough, whilst in part (d) many candidates did not refer to the displacement of titanium by magnesium. In part (e) many

candidates did not make their answers clear enough and confused covalent bonding with intermolecular bonding.

- (a) Many candidates wrote a correct equation. Common errors included the incorrect formulae for magnesium chloride (often $MgCl$) or titanium (often Ti_4).
- (b) Only a small number of candidates confused the definitions of oxidation and reduction but many suggested that chlorine was associated with oxidation and reduction processes. Candidates who used oxidation number change normally quoted the correct oxidation states. The commonest error was not to specify titanium ions or titanium salt gaining electrons, many candidates being imprecise by referring to titanium gaining electrons.
- (c) Many good answers were seen with the working shown clearly. Some candidates did not work out the molar mass of $TiCl_4$ correctly.
- (d) Candidates were often able to state that titanium is less reactive than magnesium but fewer offered an explanation in terms of displacement or ease of release of electrons. Many candidates just restated their answer in terms of 'titanium is lower than magnesium in the reactivity series'. A significant minority of candidates referred to transition elements being less reactive than Group II elements.
- (e) Few candidates could link the properties of titanium(IV) chloride to its structure and bonding. Many candidates referred to ions or ionic bonding rather than suggesting that that low boiling point indicates weak attraction between the molecules.
- (f) The concept of mobile electrons was well known. Only a minority of candidates suggested that it was the ions that move.

Question B8

In part (a) many candidates completed the equation for cracking and knew the test for unsaturation in part (c)(ii). The correct percentage yield in part (e) was often obtained. Fewer candidates could explain fully why chemical reactions are faster at a higher temperature in part (b) or could draw a section of the polymer in part (c)(i).

- (a) A wide variety of correct equations for the cracking of heptadecane to form propene was given.
- (b) Most candidates appreciated that the rate of the reaction increases as the temperature increases although a few referred to equilibrium increase in kinetic energy. Many candidates referred to collision frequency rather than more successful or energetic collisions. Few referred to an increased number of particles with energy above the activation energy. Some thought that activation energy increased when the temperature increased.
- (c) (i) Candidates often gave a generalised definition of unsaturation rather than address why propenenitrile is unsaturated. Others were imprecise with their answers and only referred to 'double bonds' rather than stating that the double bonds were between carbon atoms, or mentioned the $C\equiv N$ bond which was not relevant to the question.
(ii) The bromine test for unsaturation was well known.
- (d) The best answers either showed a repeat unit with the free bonds or a section of the polymer showing a number of repeat units with the free bonds. Some answers were imprecise, showing the wrong bonding between the C and N of the nitrile group. A considerable minority wrote the CN group as CN_3 . Another common error was to retain the $C=C$ double bond in the drawing representing the polymer.
- (e) Many candidates obtained the correct answer for the calculation, often without showing relevant working. The most common errors led to the incorrect answer 1842 tonnes through inversion of the ratio actual mass:predicted mass. Some candidates converted tonnes into grams and this sometimes led to errors in the number of zeros in the answer.

Question B9

Few candidates wrote accurate enough answers in parts **(a)**, **(b)** and **(c)**. In part **(e)** some candidates drew the isomers of C_4H_8 correctly but others drew the same compound in a different orientation.

- (a)** Many candidates just restated the question and did not specifically explain why decene is a liquid at $25^{\circ}C$. The best answers stated that $25^{\circ}C$ is between the melting point and boiling point.
- (b)** Candidates did not always specifically mention particles in their answer. They were more likely to mention that 'particles have more energy' than to state that 'the particles move further apart'. A significant proportion of the candidates referred to intermolecular forces being overcome when the liquid changes to vapour.
- (c)** Many candidates gave similar answers to part **(b)** but fewer stated that the particles spread out. A common misconception was that the volume of gas only changes when the pressure changes and as a result they stated that the volume did not change.
- (d)** Candidates sometimes compared the density or the boiling point rather than focus on the relative molecular mass. Others did not mention particles and referred to ethene as being 'lighter than butene' rather than referring to lower molecular mass.
- (e)** Many candidates drew two isomers although a proportion of these drew the same isomer twice by bending the chain or rotating the isomer. Common errors included: drawing saturated compounds; omitting one or more hydrogen atoms or bonds; joining carbon atoms with five bonds.
- (f)** Many candidates drew the correct structure of the alcohol. The most common error was to omit a hydrogen atom or a bond line. A few candidates drew a carbon chain having five carbon atoms rather than six.

CHEMISTRY

Paper 5070/31
Practical Test

Key messages

Centres should encourage candidates to be careful in their use of data and to be thorough and consistent in their recording of observations.

General comments

The overall standard was again good. Many candidates proficiently executed the various tasks but there were some whose performance differed notably between the **Questions 1** and **2** e.g. they capably met the demands of the quantitative question but were less assured with the qualitative one. Supervisors are thanked for supplying the experimental results needed to enable the assessment. Whilst the majority of Centres ensured that they are well prepared for the practical test, it is vital that the advice issued in the Confidential Instructions, including checking the requirements, is followed so that candidates can make the most of the examination.

Comments on specific questions

Question 1

It was good to find with the calculations that candidates were generally prepared to persist and provided clear working to accompany their answers. However, care is needed when copying values from calculators or from one part of the question to the next. There were a number of examples of digits being missed or mixed up, which caused particular difficulty when calculating the mole ratio of alkali to acid in **(e)**.

- (a)** Many candidates were clearly competent in carrying out an acid-alkali titration and scored highly with their accurate titres. Nevertheless, there were instances where the necessary volumetric skills were insufficiently developed, as revealed by the wide range of titres recorded. Candidates generally carried out three or four titrations. Two titrations were sufficient to obtain full marks providing the following requirements were met. The initial and final burette readings were given to at least 1 d.p., there were two titres within 0.2 cm^3 of the Supervisor's value, and the average was correctly calculated using two or more results that did not differ by more than 0.2 cm^3 .

Most candidates completed the table of results properly, identified concordant titres and averaged them.

- (b)** While most candidates could calculate the number of moles of solute in a volume of solution of known concentration, there were some who did not recognise the mismatch in volume units and multiplied concentration in mol/dm^3 by the volume in cm^3 . Repeating this calculation mistake in **(d)** generally meant a sensible answer was obtained in **(e)** but there were candidates who were not consistent in their error making. A few candidates mistakenly chose to use the average volume of **Q** or used 20 cm^3 as the volume of **P** despite using a 25 cm^3 pipette.
- (c)** This was the most successfully completed calculation. Nevertheless, in processing the data there were some who increased their chances of error by carrying out more steps than necessary, often determining the mass of acid in the average titre before dividing this mass by 82 and then working out the moles of **Q** in 1 dm^3 .
- (d)** Most candidates used their answer from **(c)** and the average titre to obtain the moles of alkali.
- (e)** As long as the answer from **(b)** was divided by that from **(d)**, the mark was awarded. However, there were some candidates who inverted the ratio and others who subtracted the two numbers.

- (f) Few candidates obtained both marks but there were many who scored one. Writing the reactants formulae in the proportions consistent with the answer to (e) was usually how the mark was secured. Candidates either found it difficult to write the formulae of the salt or balance the equation. Those who chose not to use their answer from (e) but wrote a balanced acid-base reaction also obtained some credit.

Question 2

Candidates used their examination time effectively and it was unusual to find a paper where all the tests had not been attempted. All the scoring points listed in the mark scheme were awarded in the assessment of examination scripts. The most successful candidates carefully followed the instructions and recorded observations clearly using appropriate terminology. While others displayed competence, they were at times inconsistent in their approach. Consequently, marks were lost for incomplete answers and inaccurate recording.

When a gas is observed e.g. by the bubbling of a liquid, the gas should be tested and identified. There is no credit to be gained by simply naming a gas. The instruction in a test to add a reagent until no further change occurs means the written observation must record clearly what happens e.g. precipitate insoluble in excess. Teachers should continue to encourage candidates to make full use of the qualitative analysis notes supplied on the last page of the exam paper. The terminology and method of reporting provided are a model for the successful recording of observations. It was not necessary to make all the observations to obtain full marks for this question.

R contained ammonia **S** contained iron(II) sulfate

- Test 1** Most candidates reported a gas was produced that turned damp red litmus blue and correctly identified it as ammonia. Just reporting the gas as alkaline or pungent gained no credit for the test.
- Test 2** With the exception of those who used descriptions such as the liquid turns milky or cloudy, candidates recorded a white precipitate or solid on addition of **R** and so gained 1 mark. Unfortunately, there were a significant number who did not add **R** to excess and so missed the dissolving of the solid and the colourless solution. It is important to cover both the dissolving and the description of the solution.
- Test 3** The white precipitate formed in (a) was generally found to dissolve in (b).
- Test 4** This proved to be a challenging test. Candidates need to organise their observations so it is clear which refer to (a) and which to (b). No reaction results from the mixing of aqueous hydrogen peroxide and ammonia in (a). Bubbling occurs when copper(I) oxide is added to the mixture. Not all candidates who noted bubbles tried to identify the gas but in general those who did correctly described the test for oxygen and named the gas. Nevertheless, a few believed hydrogen was evolved instead or as well as oxygen, presumably because of the rapid lighting of the glowing splint. Those who followed the instruction 'Leave to stand' noted that the final liquid was blue.
- Test 5** Virtually all candidates reported the white solid formed in (a) remained when acid was added.
- Test 6** A green precipitate formed on adding **R** to **S** was recorded by many but its insolubility in excess was not so frequently noted. Those who allowed the precipitate to stand generally indicated the solid turned brown or yellow.
- Test 7** Providing the instructions are followed in (a) the iron(II) ions in **S** are oxidised to iron(III) ions by the oxidant manganese(IV) oxide and the filtrate obtained as a result is yellow. There were a number of candidates who spent time trying to identify a gas evolved in (a) and oxygen, chlorine, sulfur dioxide were among the suggestions made. A black filtrate made a number of appearances suggesting poor filtration technique or perhaps the confusion of residue and filtrate. In (b) the importance of following instructions was evident in that some did not produce any precipitate and others produced a precipitate that disappeared. Those who added sufficient aqueous ammonia with thorough mixing, firstly neutralised the acid present and then precipitated the iron(III) ions as a brown solid. The precipitate remained in an excess of **R**.

Conclusions

As a result of identifying ammonia in **Test 1**, there were many who correctly suggested **R** contained ammonia, or sometimes ammonium hydroxide. The most popular incorrect answer was ammonium chloride.

A positive sulfate ion test in **Test 5** and a green precipitate in **Test 6** generally led many to identify **S** as containing iron(II) sulfate but some lost the mark by being imprecise and writing iron sulfate or supplying an incorrect formula such as Fe_2SO_4 or $\text{Fe}(\text{SO}_4)_2$.

CHEMISTRY

Paper 5070/32

Practical Test

Key messages

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General comments

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Comments on specific questions

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Conclusions

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CHEMISTRY

Paper 5070/41
Alternative to Practical

Key Messages

In answering calculations candidates should always show all of their working. Most questions involve a one stage calculation and are worth one mark. When the number of marks allocated to a calculation is greater than one, it is an indication of its difficulty. In such cases one or more of the marks will be for the working. If no working is shown and the answer is incorrect all the allocated marks for that calculation are lost.

General comments

The Alternative to Practical Chemistry paper is designed to test the candidates' 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. The standard continues to be maintained and the majority of candidates show evidence of possessing many of the aforementioned skills.

Most candidates show competency of plotting points accurately on graphs and joining the points 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) (i) The colour alone was insufficient to score the mark.
- (ii) Most candidates gave the correct equation.
- (iii) Nitric acid is used to convert zinc oxide into zinc nitrate. Some candidates gave more complex names than was necessary for the acid.
- (b) (i) The evolution of harmful gases was insufficient to score the mark.
- (ii) Most candidates correctly calculated the number of moles of zinc nitrate.
- (iii) This was well answered. An incorrect answer in (ii) could be carried forward to score the marks in (iii).

Question 2

- (a) Many candidates deduced the correct value of n in the formula but lost the name mark by giving the name of the acid with this number of carbon atoms, forgetting to include the carbon atom of the COOH group.
- (b) The identity of the gas was well known but some confused the test for hydrogen using a lighted splint with that for oxygen where a glowing splint is used.

- (c) (i) Alkanoate was not accepted as this term also includes salts.
- (ii) Many candidates were unfamiliar with the structure of the ester linkage.
- (iii) The compounds needed to produce ethyl ethanoate were well known but candidates should take care with the spelling of organic compounds and ensure their handwriting is sufficiently clear.
- (iv) An ester containing four carbon atoms was required.

Question 3

The use of a safety bulb was well known.

Question 4

A common error was to give sodium as the product at the negative electrode.

Question 5

Most candidates knew that a more reactive metal displaces a less reactive metal from a solution of its ions and were able to deduce the order of reactivity.

Question 6

In this reaction copper(II) sulfate is reduced to copper and zinc is oxidized.

Question 7

Most candidates were able to calculate correctly the mass of sodium hydroxide.

Question 8

- (a) Many candidates gave a test for the presence of ammonia. This was insufficient as it was necessary to state what would happen in the test if ammonia was absent.
- (b) Most candidates gave the correct colours as stated in the question.
- (c) The titration results were generally correct. The mean should be calculated from the closest two titres. A common error was to use all three titres in calculating the mean.
- (d) - (i) In the calculations, errors are carried forward so that candidates are given credit for correct chemistry even if an error has been made in an earlier part. Candidates were penalised once if answers were given to less than three significant figures except when the third figure was zero.

Question 9

The observations in all of the tests were generally correct. Most candidates knew the test for nitrate ions using sodium hydroxide and aluminium, but even if no test marks were scored, the observation mark could still be obtained.

Question 10

- (a) The thermometers were generally read correctly.
- (b) Many candidates realised that the problem concerned the low temperature but most suggested that this was due to the type of thermometer used, rather than the difficulty of reaching the temperature which is well below room temperature. This could be achieved by, for example, placing the tube in a beaker containing ice.
- (c) The points were generally plotted accurately and joined with smooth curves extended to the y-axis.
- (d) The candidates needed to read from their graph the masses of each compound where the curves crossed the y-axis.
- (e) Most candidates correctly read the temperature at which the solubility of each compound was the same but many gave the mass reading at that temperature as the solubility, failing to realise that this mass needed to be multiplied by 10 to give the solubility in 100g of water.
- (f) From the curves it can be deduced that the ammonium chloride would not completely dissolve at this temperature resulting in a solution containing undissolved solid whereas the potassium nitrate would completely dissolve resulting in a (colourless) solution.

CHEMISTRY

Paper 5070/42
Alternative to Practical

Key Messages

In answering calculations candidates should always show all of their working. Most questions involve a one stage calculation and are worth one mark. When the number of marks allocated to a calculation is greater than one, it is an indication of its difficulty. In such cases one or more of the marks will be for the working. If no working is shown and the answer is incorrect all the allocated marks for that calculation are lost.

General Comments

The Alternative to Practical Chemistry paper is designed to test the candidates' 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. The standard continues to be maintained and the majority of candidates show evidence of possessing many of the aforementioned skills.

Most candidates show competency of plotting points accurately on graphs and joining the points 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) (i) Candidates gave a variety of different colours to describe magnesium ribbon. White was very common, but others such as black or pink were also seen.
- (ii) The equation was often correct. Common errors were MgO_2 as the formula of magnesium oxide, and O as the formula of oxygen. Equations using correct formulae were not always balanced.
- (b) Hydrogen was usually identified correctly. The most common error in the test was to use a glowing splint instead of a burning splint.
- (c) (i) Magnesium oxide is a base, and reacts with an acid to form a salt and water only. Because the salt is magnesium sulfate, which is soluble in water, it would form a solution. Because magnesium is not a transition element, the solution would be colourless. Some candidates suggested effervescence would be seen.
- (ii) The equation was often correct, although Mg was sometimes seen instead of MgO and H_2 seen instead of H_2O (which may explain the reported effervescence in (c)(i)).

Question 2

- (a) (i) This was almost always answered correctly.
- (ii) The majority of candidates were aware that the temperature increase meant that the reactions were exothermic.

- (b) (i) Many candidates were able to manipulate the data correctly. Candidate should be aware that an empirical formula shows the smallest whole number ratio of atoms of each element in a compound, whereas a molecular formula shows the number of atoms of each element in one molecule. In this case the empirical formula and the molecular formula are both the same.
- (ii) The amount of heat given out when alcohols burn is directly related to the number of carbon atoms in the alcohol. Therefore **X** contains fewer carbon atoms than **Y**, and **Z** contains more carbon atoms than **Y**. In some cases **X** and **Z** were reversed by candidates. The formulae of appropriate alcohols were required, although some candidates gave names. The reasons were often not adequately expressed, and some candidates referred to flammability and physical properties rather than amount of heat given out or temperature rise.
- (c) (i) The name of propanoic acid or the formula was often incorrect. Propenoic acid was occasionally seen and could not be credited.
- (ii) The oxidising agents that were accepted were acidified potassium manganate(VII) or acidified potassium dichromate. The colour change was usually correct for the reagent given.
- (d) The name and structure of propyl propanoate were found to be challenging by many candidates. Esters were often drawn with the wrong numbers of carbon atoms and/or the wrong ester linkage.

Question 3

This was answered very well.

Question 4

This was answered well.

Question 5

Candidates found this the most challenging of the multiple choice questions. Many gave (b) as the answer

Question 6

This was answered well.

Question 7

Most candidates were able to work out correctly which combination of volume and concentration was correct, although (d) was often given as the answer.

Question 8

- (a) This was well answered.
- (b) Almost all candidates gave filtration as a correct answer to this response.
- (c) A variety of colours were seen in answer to this question, including the correct colours the wrong way round.
- (d) The table was usually completed correctly. The last two values were occasionally used to calculate the average, (giving a value of 25.5 cm^3) some candidates being of the impression that the first titration was always a rough one and should never be used to calculate the average, as opposed to calculating the average from the two closest titres.
- (e) - (h) The calculations were carried out well by the majority of candidates.

Zeros were sometimes missed out from answers with several zeroes. If a calculator gives an answer in standard form e.g. 5.06×10^{-4} , candidates should consider writing this in the answer space rather than trying to convert to non-standard form, thus avoiding conversion errors.

There were occasional errors in not giving enough significant figures or in rounding incorrectly, but these did not occur very often. Candidates were penalised once if answers were given to less than three significant figures except when the third figure was zero. In the calculations, errors are carried forward so that candidates are given credit for correct chemistry even if an error has been made in an earlier part.

- (i) (i) This was answered very well by the majority of candidates. There were occasional errors of using 14 instead of 28 as the numerator, and the M_r of ammonium sulfate was occasionally calculated incorrectly.
- (ii) This was answered quite well, but salts which did not contain nitrogen, such as potassium sulfate were seen occasionally. Phosphorus was also occasionally seen, as was potassium. Some gave formulae, despite being asked for a name.

Question 9

- (a) The wording of the answer to this part was often unclear. It is preferred that candidates write that **V** is not a compound containing a transition element or **V** does not contain ions of a transition element. Alternatively, **V** does not have to be mentioned and a statement that transition metal ions are absent is sufficient. Wording such as '**V** is not a transition element' implies that **V** is an element rather than a compound and does not score.
- (b), (c) In both parts is that statements such as soluble white precipitate (which suggest that the precipitate may still be there) should be avoided. The precipitate dissolves to form a colourless solution is what should be written in both (b)(ii) and (c)(ii).
- (d) Large numbers of candidates knew how to describe the test for nitrates though heat or warm was not always present.

Question 10

- (a) The table was usually completed correctly.

Occasionally values of 0.15, 0.10, 0.08 and 0.00 plus 0.09, 0.05, 0.00 and 0.00 were seen. These were obtained by subtracting from the previous mass as oppose to the original mass of 87.50.
- (b) This was often answered well. The most common error was to give the formula of calcium chloride as CaCl .
- (c) Those who knew that the loss of mass was due to the formation of a gas had to make it clear that the gas escaped from the apparatus. Other incorrect reasons were given such as decrease in the amount of marble or decrease in concentration of the acid.
- (d) The graph was almost always drawn very well and usually scored all three marks. A small number of candidates did not start both curves from the origin.

In both parts of (e) some candidates had difficulty in locating 45 and 75 seconds, as was evident from lines drawn incorrectly on the graph.
- (e) (i) Many candidates achieved the correct value from their graph.

(ii) This scored less well. Those who found the correct value from the graph usually gave it as the answer instead of subtracting from 87.50.
- (f) This scored quite well. It was necessary to give two comparisons such as larger surface area leads to greater rate of reaction.
- (g) Some candidates were able to work out how much calcium carbonate had reacted. Fewer subtracted their answer from 10.0 g to calculate the mass of marble remaining.