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Paper 9701/12
Multiple Choice

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

General comments

This examination paper provided a suitable challenge to the candidates. Candidates appeared to have sufficient time to complete the paper.

Nine questions were found to be less challenging by candidates. The majority of candidates chose the correct response to each of **Questions 1**, **2**, **3**, **4**, **7**, **12**, **20**, **23** and **39**. Six questions were particularly difficult. A minority of candidates chose the correct response to each of **Questions 14**, **27**, **28**, **29**, **34** and **37**. This suggests that candidates find multiple choice questions on organic chemistry topics more difficult than those on physical or inorganic topics. The questions that were found to be particularly difficult will now be examined in greater detail.

Question 14

A minority chose the correct answer, **D**. The most commonly chosen incorrect answer was **B**. Since a water molecule is able to hydrogen bond with both of its lone pairs and with both of its hydrogen atoms, the 'maximum number of hydrogen bonds it can be involved in' is four.

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Question 27

This was found to be a difficult question. The most commonly chosen incorrect answer was **C**. Compound **B** produces only one alkene when treated with hot alcoholic NaOH so it cannot be the answer. Compounds **C** and **D** both produce two alkenes when treated with hot alcoholic NaOH. However, none of the alkenes produced react with Br_2 to form a non-chiral product. Compound **A** reacts with hot alcoholic NaOH to give two products. If the C=C bond forms in the side chain, the product reacts with Br_2 to form a non-chiral product. If the C=C bond forms in the ring, the product reacts with Br_2 to form a mixture of four optical isomers. Therefore, compound **A** matches the description in the question.

Question 28

The most commonly chosen incorrect answer was **C**. This question was probably best approached by drawing out the structure of compound M. To do this correctly, candidates had to know:

- how primary and secondary alcohols react with acidified potassium dichromate(VI)
- that alkenes, ketones and tertiary alcohols do not react with acidified potassium dichromate(VI).

Question 29

The most commonly chosen incorrect answer was **C**. The cyclohexene ring is non-planar. The majority of candidates deduced this, choosing either option **C** or option **D**. The molecular formula of cyclohexene is C_6H_{10}. Any straight-chain alkene with this molecular formula must have two C=C double bonds, so the correct answer is **D**.

Question 34

The most commonly chosen incorrect answers were **B** and **C**. The eight isomers are:

- pentanal
- the two optical isomers of 2-methylbutanal
- 3-methylbutanal
- dimethylpropanal
- pentan-2-one
- pentan-3-one
- 3-methylbutanone.

Question 37

The most commonly chosen incorrect answer was **C**. 380 cm^3 of hydrogen is 380 ÷ 22400 moles at s.t.p. This works out to be 0.01696 moles. Since two carboxylic acid molecules react with magnesium to give one H_2 molecule, there were 0.03393 moles of Q in 4.00 g, giving a relative formula mass of 118. Candidates who incorrectly used the molar volume at room conditions, 24.0 dm^3, will have calculated 0.01583 moles of hydrogen, therefore 0.03167 moles of Q. This then gives a relative formula mass of 126, explaining the choice of answer **C**.

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Paper 9701/22
AS Level Structured Questions

Key Messages

- Structured questions give candidates the opportunity to show their knowledge and understanding over a wide range of syllabus topics. The best answers are concise and precise; there is often little need for full sentences, providing that the sense and balance of answers are clear.
- Candidates are reminded to address 'explain' questions fully – not merely to state facts or rules of thumb, but then to show how they can combine to give reasons for chemical phenomena. This often requires a secure understanding of bonding and structure within molecules, in particular for organic species where linking structural features to mechanisms is important.
- Working in calculations should be shown to ensure that due credit can be awarded. Harsh or early rounding of numbers should be avoided, as it leads to sizable inaccuracies later.

General Comments

Very few scripts were 'double written' (ink over pencil), which when seen, makes reading difficult. Centres are advised not to supply additional writing material, as there should be sufficient space on the question paper to write all answers in the spaces provided. Where candidates find it necessary to write at greater length, they are requested to give a clear indication of where their continued writing can be found.

Comments on Specific Questions

Question 1

This question tested ideas of atomic structure, periodicity and some quantitative chemistry. Knowledge of electronegativity was less secure and many Period 3 equations were incorrectly presented as redox reactions.

(a) (i) There were some very good answers here, although many candidates tried to answer in terms of ionisation or electron affinity.

(ii) Few candidates were awarded both marks as this required a balance of points to construct an argument. Spin-pair repulsion arguments were unnecessarily presented on a number of occasions. Many mentioned the distance of the outermost electron from the nucleus without any reference to its significance. Other answers included non-justified references to ionic radius or ionisation energy.

(b) (i) A whole array of different diagrams was seen, with only the ionic form (Li^+ and H^-) acceptable. All electrons, only four in total, were required to be shown.

(ii) Linear, trigonal planar and planar were popular incorrect answers.

(c) (i) The most common error here was the omission of state symbols from the elemental species. Many answers suggested that H_2 was being ionised.

(ii) This was well answered by many candidates.

(iii) Most candidates answered this well, although $3p^6$ was commonly seen.

(d) (i) A large number of answers erroneously suggested H_2SO_4 as a product.

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(ii) Both Na_2S and Na_2SO_4 appeared regularly, as did H_2. Candidates are advised to consider whether redox has occurred in these reactions.

(iii) Many incorrect versions for the formula of the carbonate were seen such as $Mg(CO_3)_2$ or $MgCO_2$. Many candidates incorrectly gave H_2 as a product from an acid–base reaction.

(e) (i) Many candidates gave the correct overall dipole for S=C=O but then went on to give the remaining three dipoles incorrectly.

(ii) Candidates frequently found it difficult to convert all of the physical quantities to consistent units. Many answers gave the identity as arsenic or some other element and clearly had not used Table 1.2 to identify the compound.

Question 2

This was an inorganic-chemistry question based around Group 2.

(a) (i) A labelled diagram showing the structure of a metal crystal was required here. Candidates are reminded of the subtle difference between delocalised and free electrons.

(ii) There were many good answers here although some responses continued to use free electrons instead of delocalised.

(b) A large proportion of candidates offered the reaction with steam ($\rightarrow MgO + H_2$) rather than that with cold water, although there were many good answers.

(c) Several answers gave examples of metals which would 'displace' Mg but not Ba. Water was a favourite reagent, with the explanation given as either difference in solubility or a hydrolysis type reaction. Such answers were not sufficiently creditworthy.

(d) (i) This question was answered quite well by candidates.

(ii) A good proportion of candidates understood what was needed, but many spoilt a good answer by stating that X = Ba. The most common error was not to include the stoichiometric factor of ½: such answers tended to have further inconsistency in the subtraction of the A_r of $1\times$ or $2\times$ C*l*.

Question 3

This question was largely framed around organic chemistry, with the inclusion of some physical and stoichiometric work. It was well attempted on the whole, although knowledge of some key definitions was seen to be weaker.

(a) (i) Many candidates appreciated that a single product was the outcome of an addition reaction, but many others described/attempted to describe an addition reaction without indicating that only one product was formed.

(ii) This was well answered by most candidates.

(iii) The major errors here were butan-1-one, butan-1-ol/butanol or propanal/propan-1-al. Candidates are reminded that there is no need to offer a locational number for the aldehyde group.

(iv) Very few candidates converted the quantities to moles, so simply offered 96% of 5000 kg as the answer.

(b) (i) Candidates seemed largely unaware of the nucleophilic addition mechanism. Common errors and omissions included:

- incorrect placement of the lone pair of electrons on the N of the CN^- ion.
- giving the intermediate a positive charge which was subsequently attacked by the CN^- nucleophile.
- mechanisms involving the H (of HCN) / H^+ attacking the intermediate negative ions.

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- curly arrows inaccurately coming from the C (in the C=O group).
- the H (of HCN) shown attacking the O (in the C=O group) to form an intermediate hydroxyl derivative with a positive charge.

(ii) The first and third marks of this question gave the largest number of variants, with Fehling's reagent or DNPH offered for experiment 1. For experiment 3, many answers erroneously gave a change or loss of colour rather than a method of noting that no reaction had occurred.

(iii) There were some very good answers here, although some increased the number of H atoms in the product and/or H_2 appeared as a product.

(iv) This was generally very well answered, with occasionally some candidates circling two C atoms or the entirety of HOCHCN.

(c) It appeared that many candidates did not understand the term molecular formula and gave structural formulae throughout.

(d) (i) Some answers referred to a change in position of the equilibrium/yield, which was not credited.

(ii) Many answers excluded the word gas and just stated 'less/fewer (number of) moles'. Although the reaction in question was entirely in the gas phase, precision in an answer is crucial. A few candidates gave the incorrect direction of the equilibrium shift.

(iii) Many candidates used a value of 436 in their answers, which suggests the use of a Data Booklet. Centres are reminded that Data Booklets are **not** to be issued to candidates for these papers.

(iv) Any mention of hydrogen bonding was not credited, in accordance with the convention and definition used by this qualification.

Question 4

This was a second organic chemistry question, which included some analytical work. This was generally answered well by many candidates, though later parts on IR and MS appeared less familiar to some.

(a) (i) 'Heat' or equivalent was often missing. H_2SO_4 was a popular answer despite the conditions suggested in the syllabus.

(ii) Many repeat units were shown containing four carbon atoms, as if the CH_3 groups had been incorporated into the backbone. Some candidates showed an ethene structure with missing CH_3 side groups.

(iii) Candidates very often showed the reverse equation with C_4H_8 and H_2O. Quite a few answers contained Al_2O_3 as a reactant and several answers omitted H_2O as a product.

(b) (i) This was well answered.

(ii) There were many correct structures/names for iodoform but very few correct propanoate ions.

(c) (i) There were many correct answers to this item.

(ii) Catalyst and oxidising agent were the common errors here, but otherwise there were many correct answers.

(d) (i) Compound **F** was commonly given incorrectly as the unknown compound, referring to an O–H absorption in the range 2850–3000 cm^{-1}. Candidates are reminded that C–H stretches appear in all organic spectra. Where absorptions are referenced, candidates need to identify which bond is stretching: 'nitrile', for example, is insufficient.

(ii) There were many null responses to this. Where attempted, candidates' answers were evenly split between correct identification of an identical abundance and some complicated (erroneous) mathematics.

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Paper 9701/33
Advanced Practical Skills 1

Key messages

- Candidates should be reminded to read the questions carefully to ensure they are providing appropriate answers.
- Candidate should be given the opportunity to discuss reasons for variations in results such as precision of apparatus and accuracy of procedure.

General comments

Better performing candidates had clearly spent a good amount of time practicing practical techniques. Comments on specific questions

Question 1

The candidates who do not regularly complete practical work were more likely to have difficulties with how some of the calculation parts of this question related to the practical task. The accuracy of their practical work was generally good.

(a) The most common error was to designate the residue as '**FA 1** after heating' instead of 'residue' or 'contents after heating'. **FA 1** is the hydrated basic oxide whereas the residue should be anhydrous. When recording the mass of **FA 1** used, a number of candidates incorrectly calculated the mass lost. There was evidence that some candidates did not heat the solid with a sufficiently hot flame for the full 4 minutes, as there was a significant decrease in mass after the second heating. However, most candidates gained at least some credit for accuracy.

(b) (i) Almost all candidates correctly calculated the amount of zinc oxide formed and most of these then divided by 3 as expected.

(ii) Many candidates correctly divided the mass of **FA 1** they used in **(a)** by their final answer to **(b)(i)**. However, not all candidates gave their answer to the expected 2 to 4 significant figures. As candidates are expected to use a 2-decimal place balance giving an answer to 5 or more significant figures is not creditable.

(iii) Candidates generally found it difficult to keep track of the numbers involved in this addition so only a minority gave the correct answer.

(iv) The majority of candidates were aware that they needed to use the difference between their answers to **(b)(ii)** and **(b)(iii)** in some way. Many candidates carried out the calculation correctly but their value of **x** was not given as an integer. However, when **(b)(iii)** was greater than **(b)(ii)** candidates frequently incorrectly subtracted **(b)(ii)**, the M_r of hydrated solid, from **(b)(iii)**, the M_r of anhydrous solid.

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Question 2

It was evident that most candidates were experienced in titrations, although candidates in a few centres showed widely differing titres. It is important to read the questions carefully so that numerical answers are calculated correctly and that candidates understand how to process their results.

(a) Some candidates did not record their burette readings for the rough titration. These did not need to be shown to #.#0 or #.#5 (unlike the readings for the accurate titres) but had to be written either in the space given or correctly labelled in the accurate titration table. Some candidates did not give their accurate readings to 2 decimal places and some did not give acceptable headings for their tables of results. The majority of candidates recognised that the final titre needed to be concordant (within 0.10 cm^3 of each other). Many gained full credit for accuracy.

(b) Candidates should ensure they only use titres within 0.20 cm^3 when calculating the mean. Some did not give their answer correct to 2 decimal places.

(c) (i) Owing to the concentrations of reactants in **(a)** being given to 3 significant figures and the precision of the apparatus used, all numerical answers should have been given to 3 or 4 significant figures. Many candidates gave at least one answer to only 2 significant figures.

(ii) Almost all candidates correctly calculated the moles of sodium hydroxide.

(iii) A common error was to omit the $\times 40$, which indicated that candidates had not read the question sufficiently carefully.

(iv) Almost all candidates attempting this part calculated the original amount of acid correctly. Many of these then correctly subtracted their value from **(c)(iii)**.

(v) While many candidates recognised $3ZnCl_2$ and CO_2 would be formed in the reaction, far fewer balanced the equation with $(5 + \mathbf{x})H_2O$. There was some help with the equation, as **(b)** showed the stoichiometry of the zinc compound and the carbon dioxide after heating.

(vi) Candidates were able to gain credit by using the stoichiometry shown for the reactants in the equation. Some mistakenly used the mass of 3.52 g in the first part of the question.

(d) This part tested the candidates' understanding of the preceding method and calculation. Careful reading of the question would have helped. Only the better performing candidate were able to gain full credit. A common error was stating that the number of moles of sodium hydroxide present in the titre was higher. While a number of candidates did start correctly, they did not develop their answers sufficiently.

Question 3

The Qualitative analysis information at the start of the question states that all observations should be recorded. Many candidates only gave one observation in a part question, which was insufficient to gain credit. A wide range of marks was seen.

(a) The most often seen correct observation was that the solid turned black. Some candidates reported the condensation forming at the mouth of the hard-glass test-tube on gentle heating. Only a few noted the colour and the powdered state of **FA 5** initially. Candidates should be encouraged to report the colours and state of the unknown before and after heating when there is a change in appearance. Very few candidates tested for evolution of carbon dioxide and the majority of these reported that the limewater went milky which is no longer awarded credit.

(b) (i) The most common answers were that there was rapid effervescence and that the contents of the test-tube became hot. Many candidates who attempted a gas test were unable to gain credit as they omitted that the splint used to test the gas was lighted.

(ii) Some candidates wrote a half-equation for Mg. Others wrote a full equation even though they had yet to identify the anion. Some omitted the state symbols.

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(c) (i) Most candidates noted the effervescence though fewer described the colour and state of the product. Some tested the gas but did not employ the correct terminology: 'the gas forms a white precipitate with limewater'.

(ii) As **FA 6** is an acid and was likely to have been used in excess in **(c)(i)** it was necessary to add a large volume of aqueous ammonia for it to be in excess and thus obtain all the expected observations. Most candidates noted the blue precipitate, although not all added sufficient aqueous ammonia for the precipitate to dissolve. Some described the precipitate as dark blue, which is the colour of the solution formed with excess. Others only described observing a dark blue solution with no mention of precipitate.

(d) (i) Some candidates ignored the rubric in **(b)** and tested the solution with an aqueous barium salt. However, the majority suggested using aqueous silver nitrate in one of their tests. This should have been accompanied by aqueous ammonia to distinguish between any halide precipitates formed.

(ii) Candidates should ensure their tests and resulting observations are shown clearly. The correct results for both tests were needed. Those mistakenly reporting a gas turning red litmus blue on warming **FA 6** with aqueous sodium hydroxide and aluminium foil showed the litmus paper must have been in contact with liquid droplets. A small number of candidates tested **FA 7** instead of **FA 6** so were unable to see the white precipitate with aqueous silver nitrate dissolving in aqueous ammonia.

(e) Most candidates obtained sufficient results to gain some credit in this part.

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Paper 9701/42
A Level Structured Questions

Key messages

- Candidates must ensure their handwriting is legible.
- Candidates need to ensure that corrected work is clear to read; work that is crossed out should be very clearly crossed out and never overwritten with the new answer.
- Chemical equations, ionic equations and half-equations should always be balanced for substances and charge.
- In organic reaction mechanisms, the starting and finishing points of curly arrows is a key part in the description of the mechanisms.

General comments

This paper gave candidates of all abilities the opportunity to demonstrate their knowledge and understanding of a wide range of chemistry topics. Candidates who had prepared well for the examination were able to attempt all the questions. Many candidates were able to work through to the end of the paper.

Comments on specific questions

Question 1

(a) (i) This was answered well. A common error was $3d^8 4s^2$.

(ii) Many candidates found this question challenging. Common errors included use of $S_2(g)$ or omitting an electron from IE1.

(iii) Some candidates used ambiguous language, stating the first electron affinity 'decreases' instead of becoming less exothermic.

(iv) This was generally well answered. Some candidates incorrectly suggested that this was due to stronger nuclear attraction instead of stronger attraction between the ions.

(b) (i) Candidates performed well on this question. A common error was omitting any reference to the gaseous state.

(ii) This answer was usually correct.

(iii) Candidates often gave the correct answer here. Common errors included +558.6 (use of T = 800) and 2.33×10^5 (omission of $\Delta S \div 1000$).

(c) (i) This was often correct. The most common error was $Zn(NO_3)_2 \rightarrow Zn + 2NO_2 + O_2$.

(ii) This explanation was well known and clearly described by many candidates.

(iii) Most candidates gave the correct answer.

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Question 2

(a) Candidates performed well on this question. H_3PO_4 was a common error.

(b) (i) Many candidates found this question challenging. It was necessary to use Le Chatelier's Principle to predict the electrode potential would become more positive as a lower $[H_2PO_2^-]$ is used which shifts the equilibrium to the right. An alternative acceptable approach was using the Nernst equation.

(ii) Candidates performed well on this question. Common errors included –2.31 and –0.83.

(iii) This was generally answered well. Some excellent clear, labelled diagrams were seen. Common errors included:
- omitting Pt electrode label
- labelling the Cr electrode as Pt and
- labelling the electrolyte as Cr^{3+} / Cr in the other half-cell.

(iv) Many candidates found this question difficult.

(v) This equation required precise and careful work. Often the equations suggested were unbalanced for atoms and charges, for example: $H_2PO_2^- + Ni^{2+} \rightarrow HPO_3^{2-} + Ni$.

(c) (i) This was found to be challenging. A common error was 2.67×10^{-4} (omission of division by 60).

(ii) Most candidates were able to give a suitable explanation to justify the order with respect to $[H_2PO_2^-]$ from the data for experiments 1 and 2. Fewer correctly used data from experiment 3.

(iii) Candidates often gave the correct answer.

(iv) Most candidates gave a correct answer.

(v) This answer was usually correct.

(d) This was generally well answered. Common errors included:
- describing a heterogeneous catalyst, rather than its mode of action
- suggesting that a heterogeneous catalyst weakens bonds between reactant molecules
- omitting that product molecules are desorbed after the reaction.

Question 3

(a) This was well known.

(b) (i) Candidates performed well on this question. Common errors were giving a physical property such as high densities and high melting points.

(ii) Many candidates were able to give typical chemical properties of transition elements.

(c) (i) Most candidates answered this question well and gave a clear justification to show the results were consistent with the stoichiometry of equation 2.

(ii) Many candidates were able to draw a suitable three-dimensional structure of this complex ion. The charge of the complex ion was often omitted.

(d) (i) Candidates found this challenging. V^{3+} was the most common error.

(ii) Many candidates found this question difficult. The most common error was +7.

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Question 4

(a) (i) This was generally answered well. A common error was:
$CH_3CONH_2 + 2[H] \rightarrow CH_3CH_2NH_2 + ½O_2$.

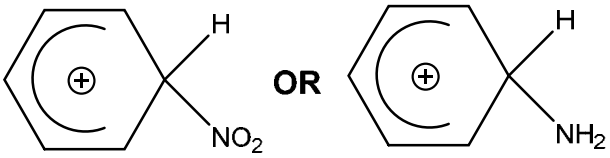
(ii) Most candidates were able to identify the mechanism, however the conditions were less well known.

(iii) Most candidates found this question difficult. Common errors were $H_2NCH_2CH_2NH_2$ and $(CH_3)_2NH$.

(b) Candidates performed reasonably well on this question. Most candidates recognised that the lone pair on the N of NH_2 is delocalised into the benzene ring and the alkyl (ethyl) group is an electron donating group. However, the explanation to their effect on the electron density of N was normally absent.

(c) Many good answers were seen. Some common errors included the omission of 'concentrated', the use of HNO_2 (instead of HNO_3) and drawing an intermediate ion as the intermediate compound.

intermediate ion



(d) (i) This was answered well. The most common error was 3,5-dibromophenylamine.

(ii) This answer was usually correct.

(iii) Candidates often gave the correct answer here.

(iv) Many candidates omitted alkaline conditions and just stated a low temperature which was insufficient.

(v) Most candidates gave a correct answer.

(e) (i) This definition was well known. Some candidates did not specify that the ligand formed a dative covalent bond to the central metal ion.

(ii) This was generally well answered. Some had difficulty with drawing three-dimensional diagrams of the two isomers or drew two identical diagrams. Other errors included use of O_2H for H_2O and NH_3 for CH_3NH_2 in the diagrams.

(iii) This answer was usually correct.

(f) (i) Most candidates gave a correct answer.

(ii) This was generally well answered. Some candidates inverted the expression or had ionic charges written outside the final set of square brackets.

(iii) Most candidates gave a correct answer.

(iv) This was rarely correct.

(v) Most candidates correctly linked the stabilities to the magnitude of K_{stab}. However, only a minority identified $[Cd(H_2O)_6]^{2+}$ as the least stable.

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Question 5

(a) Many candidates found this question difficult. Most were able to correctly to identify that the carbons were sp^2 hybridised; often the planar shape was omitted. The description of how orbital overlap forms σ and π bonds between the carbon atoms was not well known. Diagrams showing orbital overlap were often inadequate and unlabelled.
Good responses explained that:
- sp^2 orbitals overlap head-on to form σ bonds and
- a p orbital overlaps sideways forming π bonds.

(b) (i) Candidates performed well on this question. The most common error was forming a chloride ion.

(ii) Many good answers were seen. Some difficulties seen included:
- curly arrows going in the wrong direction,
- poorly drawn intermediates and
- the omission of the formation of H^+.

(c) (i) Candidates often gave the correct answer here.

(ii) This was answered well. The most common error was drawing the same structure of **Q**.

(iii) This question discriminated well. Many identified the correct trend. However, the significance of the differing strengths of the C–C*l* bonds was less well understood.

(d) Many candidates were able to suggest a suitable structure for **Z**, however they had difficulty with the reagents and conditions for step 3 and 4.

(e) (i) This definition was not well known; often incomplete answers were given such as 'they have non-superimposable molecules'.

(ii) This answer was usually correct.

(iii) A method of adapting the synthesis to produce a single enantiomer was not well known.

(f) (i) Many candidates found this question difficult. Common errors were stating either 8 peaks or 9 peaks.

(ii) Many candidates found this question challenging. Some missed the significance of D_2O and included the –OH and $–NH_2$ protons in their explanation. Common errors included:
- omission of the number of protons for each of the peaks and
- the application of the n+1 rule for the splitting pattern.

Question 6

(a) (i) This was answered well. A common error was ethanol.

(ii) Candidates often gave the correct answer here.

(b) A minority of the candidates were able to suggest a suitable answer. Some incorrectly thought butan-1-ol was non-polar and or more polar than water.

(c) Many candidates were not able to identify the ligands. A common incorrect answer was H_2O exchanging with $CN^–$.

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(d) (i) Many candidates found this question difficult. The equation was often left incomplete, unbalanced or producing an incorrect product such as K_2O or $C_8H_5O_4K_2$.

(ii) Most candidates were able to calculate the initial moles of KOH and HA and the pH of the buffer from a calculated value of $[H^+]$. The correct moles at equilibrium and a correctly calculated value for $[H^+]$ were awarded less seen. Some common errors included:

- 5.18 incorrect moles at equilibrium
- 5.22 sign error in Henderson-Hasselbalch equation
- 5.40 incorrect moles at equilibrium and an incorrectly calculated value for $[H^+]$.

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Paper 9701/52
Planning, Analysis and Evaluation

Key messages

- Candidates need to clearly read and recognize the difference in the command to use three significant figures and the command to use three decimal places.
- Candidates should be aware of the need to use an appropriate number of significant figures in numerical answers even when a question does not specify an exact number of significant figures. One significant figure will usually be insufficient at A-level.

General comments

Candidates are advised to clearly show their plotted graph points using a diagonal cross, 'x', with the intersect of the lines being the exact coordinates on the grid. Alternatively, a point within a circle, ⊙, would be suitable with the point being the exact coordinates on the grid. Candidates should be aware that a single point (with no circle) will likely not show up if a line of best fit needs to be drawn over it.

In calculation work, candidates should be encouraged to show full working and in multi-step calculations, avoid early rounding as this invariably produces an incorrect final answer.

Comments on specific questions

Question 1

(a) (i)(ii) Many candidates correctly wrote titres to a second decimal place, although a few insisted on writing 9.9 cm^3 for titre 2. Determining the suitable mean titre to be used in subsequent calculations proved more difficult. Many candidates either averaged all four titres or the three accurate titres instead of the two (concordant) titres within 0.10 cm^3 of each other. Of those who averaged titres 1 and 3, many omitted the second decimal place and gave 9.7 cm^3 rather than 9.70 cm^3.

(b) Candidates were more familiar with the term 'standard solution', although a common error was that it referred to 1.00 $mol\,dm^{-3}$.

(c) (i) It was apparent that many candidates did not appreciate that this question was about determining an equilibrium constant. The idea that the mixture needed time to achieve equilibrium, rather than completion, eluded most candidates.

(ii) Most candidates did not appreciate that a solid silver precipitate was produced and that this needed to settle before aliquots could be removed from the supernatant liquid.

(d) Most candidates knew that a measuring cylinder was appropriate because the acid was in excess but many simply said that 'it did not need to be measured accurately' but gave no explanation why this should be.

(e) Most candidates were aware that volumetric apparatus such as pipettes and in the case of the question, burettes, needed to be rinsed with the solution they would be measuring the volume of.

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(f) Many candidates did not appreciate that the end-point occurred when the $KMnO_4(aq)$ became marginally in excess. 'Purple to colourless' was frequently seen, suggesting these candidates assumed the end-point occurred when the excess $KMnO_4(aq)$ had reacted. The subtlety of using $KMnO_4(aq)$ as a titrant was missed by many who did get the colour change the correct way around. The end-point occurs when the $KMnO_4(aq)$ is marginally in excess and thus the final colour is a very faint pink rather than a deep purple, which would suggest the $KMnO_4(aq)$ is in a large excess.

(g) Most candidates appreciated that a larger titre had a smaller percentage error.

(h) (i) Most candidates got part way through this two-step calculation and the amount of $KMnO_4(aq)$ was correctly calculated as 4.22×10^{-4} mol. However, relatively few went on to use the stoichiometric ratio and volume of $Fe^{2+}(aq)$.

(ii) Very few candidates appreciated that as the initial amount of Fe^{2+} was equal to the initial amount of Ag^+ then the equilibrium concentrations must be equal, so if $[Fe^{2+}(aq)]_{eqm}$ was determined then this would equal $[Fe^{2+}(aq)]_{eqm}$.

(iii) Despite the question telling them so, relatively few candidates appreciated that the decrease in concentration of $Fe^{2+}(aq)$ was equal to the concentration of $Fe^{3+}(aq)$.

(iv) Despite being given the equation for K_c, most were unable to determine a value for K_c. The units were usually known.

Question 2

(a) The key point that the rate equation, and therefore the order of reaction, can only be determined experimentally was not well known. Many candidates gained credit for suggestions such as 'not all reactants may feature in the rate-determining step'.

(b) Many candidates were able to describe how to prepare stated volumes of standard solutions; others needed to read the question more carefully. The solid given to them was in a 50 cm^3 beaker so dissolving the solid in 100 cm^3 of distilled water would not work.

Once dissolved, many candidates incorrectly transferred the solution to a 250 cm^3 volumetric flask without rinsing the beaker. Some attempted to transfer the solution in the beaker using a burette or volumetric pipette. This mode of transfer would result in some KI being left in the volumetric apparatus and thus the concentration would be below that intended.

(c) (i) Most realised that improving the reliability needed repeats but missed the idea of achieving consistent results or spotting anomalies. 'Repeat and average' is insufficient and did not gain credit.

(ii) Most candidates recognised the volume of KI as the independent variable.

(iii) Most candidates realised that the error in Experiment 5 was due to the omission of **step 4**.

(d) (i) Candidates who performed less well were confused between the significant figures and decimal points and many tables included values to three decimal points rather than three significant figures.

(ii) Both the plotting and drawing of the line of best fit were done well. Some candidates simply drew a line from the first point to the last point. Although this produced a suitable line of best fit in this instance, it will not always be the case and this 'method' of producing a line of best fit should be discouraged.

(iii) Nearly all candidates identified the most anomalous point but relatively few were able to explain that the timing error would have been either starting the timer too early or stopping the timer too late. A significant number did not read the question and suggested that incorrect volumes were used.

(iv) Most candidates were able to read the coordinates correctly, but sometimes they did not cover the sufficient range of at least half the grid. Similarly, the gradient was calculated correctly in most cases but frequently the answer was not given to two decimal places.

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(v) This proved difficult for some candidates but most of the candidates who performed well overall were able to determine their margin of error and went on to realise that as this was greater than the 5.25% error due to measurement errors then other factors must be responsible.

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