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Paper 9701/12
Multiple Choice

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

General comments

This examination paper provided a suitable challenge to the candidates. Candidates had sufficient time to complete the paper within the time allowed.

Questions 2, **4**, **5**, **8**, **9**, **16**, **18**, **19**, **27** and **37** were found to be easier. **Questions 10**, **12**, **14**, **23**, **26** and **38** were found to be particularly difficult.

Comments on specific questions

Question 10

The most commonly chosen incorrect answer was **D**.

Each Mn atom is reduced in oxidation state by 3, each sulfur atom is oxidised in oxidation state by 2, so candidates can start with:
$2MnO_4^- + vH_2O + 3SO_3^{2-} \rightarrow 2MnO_2 + 3SO_4^{2-} + zOH^-$.

Balancing for charge, it can be deduced that there must be $2OH^-$. Finally balancing for hydrogen and oxygen gives:
$2MnO_4^- + H_2O + 3SO_3^{2-} \rightarrow 2MnO_2 + 3SO_4^{2-} + 2OH^-$.

Since all three statements are true the answer is **A**.

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Question 12

The most commonly chosen incorrect answer was **D**.
To double the pressure, the temperature must be increased. This favours the endothermic backward reaction, causing a reduction in K_p. The correct answer is therefore **A**.

Question 14

The most commonly chosen incorrect answers were **B** and **C**.
B is not correct for a compound such as MgO or water. **C** would be correct if it ended with 'one atom of the element relative to **1/12** the mass of an atom of carbon-12'. **D** is the correct definition.

Question 23

The most commonly chosen incorrect answer was **C**.
The equation for the reaction that occurs under the conditions described is:
$3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$.
Since there were 0.60 mol of NaOH present at the start, and an excess of chlorine was used, there will be 0.50 mol of NaCl formed in the reaction. The correct answer is **B**.

Question 26

The most commonly chosen incorrect answer was **B**.
The five structural isomers are but-1-ene, but-2-ene, methylpropene, cyclobutane and methylcyclopropane.
The correct answer is **C**.

Question 38

The most commonly chosen incorrect answer was **D**.
The structural formula for 2-hydroxybutanenitrile is $CH_3CH_2CH(OH)CN$. It can be deduced from the question that this was formed by a nucleophilic addition reaction between HCN and CH_3CH_2CHO, which is propanal.
Since propanal forms when compound Y is heated with a mild oxidising agent, compound Y is propan-1-ol and the correct answer is **C**.

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Paper 9701/22
AS Level Structured Questions

Key messages

- Candidates are reminded to read questions carefully and check answers thoroughly, especially in extended answers where more writing is required. The accurate use of chemical terminology is welcomed, as it removes ambiguity from responses. Clear statement of fact is crucial in the presentation of argument, and it is advised that only a narrow range of vocabulary be permitted when assessing understanding.

- Candidates are reminded to address 'explain' questions fully — not merely to state facts or general rules, but also to show how these combine to give reasons for chemical phenomena. For example, a secure understanding of bonding and structure within molecules, in particular for organic species, can then be used to link structural features to mechanistic probabilities.

- Candidates are reminded that their 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

This paper tested candidates' knowledge and understanding of important aspects of AS Level Chemistry. The large majority of questions were single-mark or two-mark items, allowing marks to be awarded across the entire range of questions; candidates were able to score well on both AO1 and AO2 items, though some AO2 questions were answered vaguely.

Candidates need to be clear about the difference between items that ask them to *state* information, and those that ask them to *explain*: in this latter case, it is not sufficient to quote a 'rule' by way of evidence: proper reasoning needs to be incorporated into an answer.

Scripts were generally clear and well presented. As a general point of presentation, answers written in pencil and then overlaid with ink without rubbing out the pencil are difficult to read. Papers should be cleaned of debris from erasers, as this too affects the legibility of responses. Candidates should be able to write all answers in the spaces provided.

Comments on specific questions

Question 1

This short question tested candidates' knowledge and reasoning in the context of ionisation energies. Each of the questions that asked for explanations were reasonably well attempted from the point of factual recall. Candidates are reminded to include all factors involved and to synthesise and compare the competing variables in their answers.

(a) Some candidates gave ionisation incorrectly to be a reductive process. Most candidates were able to provide the correct state symbols.

(b) (i) The best responses were clear in their use of terminology, citing the increased attraction of the nucleus for the outer electrons despite the mitigating factor of shielding.

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(ii) Many candidates wrote well about spin-pair repulsion but neglected the increased nuclear charge that, although outweighed, still contributes to the effect.

(c) This was well answered by many candidates. Some candidates saw the largest jump between energies as after the first ionisation.

Question 2

This inorganic and physical chemistry question had a bias towards AO1, which candidates were able to tackle well. Later questions about sulfur / nitrogen and equilibria seemed less familiar topics.

(a) (i) Candidates are pointed to the syllabus definitions which cite the gain of electrons or the change of oxidation state.

(ii) This was answered well by many candidates; the inclusion of H_2 as a product was frequently seen.

(b) (i) This was answered well by most candidates.

(ii) Fewer candidates were able to answer this question correctly. Both $NaAlO_2$ and $NaAl(OH)_4$ were accepted as products in suitably balanced equations.

(iii) Candidates are advised to use diagrams where possible to help their answers, as these tend to be less ambiguous. Reference to the increase *frequency* of successful collisions, rather than just a statement of 'more' successful collisions was seen in better responses.

(c) (i) Many candidates were able to identify structure and bonding correctly but without justification. Good responses included reference to the low melting point (simple) and hydrolysis (covalent). Simple repetition of wording in the stem was not credited as an explanation.

(ii) This was answered well by most candidates.

(iii) This was answered well by many candidates. Common omissions / errors were the lack of a negative sign or the summation of –1372 and –3012 rather than the difference.

(iv) Candidates are advised to remember that such hydrolysis reactions are not redox processes.

(d) (i) Some candidates erroneously reversed equation 1, ignoring the catalytic role of NO_2 in the overall process $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$.

(ii) Many varied incorrect answers were given here, including VOCs and commonly CO.

(iii) Candidates who could interpret the graph were able to answer this question comprehensively. Others struggled first to note that the temperature at 50 km is higher than that at 20 km, and then to apply that to the equilibrium system.

Question 3

This question looked at the chemistry of halides within both an inorganic and organic context. Candidates confused halogens and hydrogen halides in their earlier answers; knowledge of relative oxidising and reducing strengths was not secure. The titration curves in **(d)(ii)** were the weakest answers of the paper.

(a) Most candidates could identify the trend correctly but then tried incorrectly to explain it in terms of the thermal stability of the hydrogen halides.

(b) (i) This was well answered by many candidates.

(ii) This proved challenging to candidates and this is an area where practice of this type of question would benefit candidates. Concentrated H_2SO_4 with $NaCl$ is deemed to be an acid / base reaction only, whereas the same with NaBr (or indeed NaI) is acid / base and then redox. Explanations needed to relay the differing reducing strength of the halides.

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(c) This was well answered by many candidates.

(d) (i) Candidates are advised to be careful in their explanation of 'strong', as references to dissolution rather than dissociation were often seen.

(ii) This question was not answered well by candidates, such that most were not able to recall the typical sigmoid shape of a titration curve. Credit was given for the starting pH values, the steep gradient at 25 cm^3 and a reasonable final pH in each diagram.

(e) (i) Credit was available for accurate recall of a standard asymmetric electrophilic addition reaction. Candidates needed to depict curly arrows carefully, with the tail emanating from a lone pair or the middle of a bond and the head pointing clearly to its target (single atoms in this case). The carbon backbone of the intermediate and the product needed to be consistently correct.

(ii) Candidates were expected to explain Markovnikoff's rule, with reference to the structure of the carbon backbone and a *comparison* of the inductive effects in both intermediates. There seemed to be some confusion over secondary and tertiary structures.

(iii) Whereas many candidates were able to identify the products in water, those in ethanol were less often correctly given. HBr was frequently given as the single inorganic product.

Question 4

Some recall and application of basic organic chemistry was well attempted by many, though precise recall of reagents and identification of reaction types was not secure. Weaker responses included long lists which often contained contradictory responses which cancelled out any credit initially gained.

(a) (i) The reactions of 2,4-DNPH and Tollens' reagent were seemingly well known to candidates; fewer were able to suggest what would happen with sodium metal.

(ii) Candidates mostly seemed to know that the structures needed to be mirror images of one another. However, fewer answers were able to give sufficient correct detail to show non-superimposable three-dimensional renditions. Structures were often represented as flat cross-shaped molecules, or with an impossible arrangement of wedges and dashes.

(b) (i) Methanol was often identified correctly as the reactant, though the conditions were often left incomplete.

(ii) This was answered well by most candidates.

(iii) Candidates are advised always to cite both the absorption frequency range and the bond / functional group responsible for the absorption.

(iv) The reagents were well identified by candidates; the types of reaction were less well known. Terminology was not well applied here.

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Paper 9701/33
Advanced Practical Skills

Key messages

- It is essential that candidates and supervisors enter the information regarding session and laboratory on the front cover of the paper so that candidates' results can be matched with the relevant supervisor values.
- Candidates should be encouraged to reflect on the precision of apparatus used when providing numerical answers.
- Candidates should be given opportunities to calculate percentage errors and suggest why their results are different from theoretical values.
- Candidates should be given the opportunity to carry out practical exercises which lead to the graphical representation of results so that the plotting of points and construction of lines of best fit is to the required standard.
- Candidates should be given opportunities to discuss the reasons for carrying out practical procedures in a particular way.
- Candidates should be given opportunities to select reagents and tests to identify unknown ions and to record their observations using correct terminology, making use of the Qualitative analysis notes provided at the end of every practical examination paper.

General comments

There appeared to be no time constraints with almost all candidates completing the paper.

During the exam, the supervisor must carry out all the experiments and record the results on a spare copy of the question paper, clearly labelled 'supervisor's results'. Results for all three questions should be recorded. Problems with results arising from faulty chemicals or apparatus should be noted in the supervisor's report and are taken into consideration by the principal examiner.

Centres are reminded that the identities of chemicals labelled with letter codes may be different from their descriptions in the question paper. This is stated on page 5 of the *Confidential Instructions*.

Comments on specific questions

Question 1

(a) Candidates should be reminded that thermometers calibrated at 1 °C should be read to the nearest 0.5 °C. Most candidates performed the practical work well and gained credit for accuracy.

(b) (i) Centres should ensure candidates have learned graphing skills. Few candidates gained more than 3 of the 4 marks available. Almost all candidates assigned the correct variable to each axis. Candidates were less confident in selecting a suitable scale (so the points and any extension used at least half the grid) and in drawing a suitable line of best fit. Candidates should be encouraged to use a simple scale such as 1, 2, 4 or 5 to a 20 mm square. Use of, for example, 3 or 7 to a 20 mm square usually led to plotting errors. When plotting their results, candidates need to be precise. They should be encouraged to use a sharp pencil and be reminded that any point that should be on a line has its centre on that line.

Each line of best fit may be straight or a smooth curve. Candidates are instructed to label anomalous points and should either circle or otherwise label these points. A line of best fit should have points balanced either side of the line and not be capable of rotation.

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(ii) Candidates needed to use the scales on their graph to give the volume of acid required. Integer answers were insufficiently accurate to gain credit. In many cases an answer to two decimal places could not be supported from the position of the intercept of the lines of best fit.

(iii) Not all candidates realised that they should be using the stoichiometry shown in the equation at the start of the question.

(c) (i) It was uncommon for candidates to refer to their graph as required in the question. Many responses were vague and did not state how the two thermometer readings would be processed. A typical answer which was not awarded credit was '*subtract the lowest temperature from the highest*'.

(ii) The question asks for the error to be compared with the theoretical value. Some candidates divided by –55.2 instead of the textbook value.

(iii) Only better performing candidates answered this part at the level expected. Candidates needed to state that a less negative ΔH results from a smaller ΔT, as well as giving reasons for this. Many answers referred to heat loss to the surroundings without any further explanation. Many candidates appear unaware of the difference between heat and temperature.

Question 2

(a) Most candidates presented their data in the manner required and a large majority of candidates gained credit for accuracy. Candidates were less successful in recording the burette readings for the rough titre. Some candidates read burettes only to 0.1 cm^3. Centres should remind candidates that the boxes labelled I to VII on the right of the page are for the examiner's use.

(b) Most candidates clearly showed how they obtained the mean value. However, some selected titres with a wider range than 0.20 cm^3. Some did not give the answer correct to two decimal places and a small number did not indicate which titre values they used to calculate the mean value.

(c) (i) Candidates should give final answers that reflect the precision of the apparatus and concentrations of solutions used. Some candidates correctly wrote that their answers should be to three or four significant figures but then did not do so.

(ii) Almost all candidates correctly calculated the amount of sodium thiosulfate reacting with the remaining iodine. Some candidates did not use the stoichiometry of the equation so could not be awarded credit.

(iii) Almost all candidates correctly calculated the initial amount of iodine. However, not all subtracted **(c)(ii)** for the amount of iodine that reacted with the sodium sulfite.

(iv) Answering this question required candidates to look at the information given at the start of the question. As 10.0 cm^3 of **FA 3** was pipetted and the stoichiometry in the sulfite : iodine equation is 1 : 1 the answer to **(c)(iii)** should have been multiplied by 100.

(v) Many candidates found this part challenging. However, there was a significant minority who performed well. Candidates should be reminded to use relative atomic masses to one decimal place as given in the Periodic Table at the back of the examination paper. Some candidates confused the moles of hydrated with moles of anhydrous sodium sulfite. It is important that candidates are reminded to read information given in the questions carefully. Although candidates were told at the start of the question that *x* is an integer, a minority of candidates gave *x* to one or more decimal places.

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(d) Few candidates gained credit for this part. The least common correct response involved the slow rate of reaction of thiosulfate and hydrogen ions. A number of candidates stated they either agreed or disagreed with the student without any explanation. Others gave an incomplete explanation such as '*the sodium carbonate would react*.'

Question 3

(a) (i) Many candidates gained credit for their observations. Some candidates appeared unaware of the correct terminology. A '*white solution*' is a contradiction in terms. A solution may be coloured or colourless; it cannot be opaque so cannot appear white. Candidates should be reminded to give the initial colour of a reagent such as acidified aqueous potassium manganate(VII) as it is the change in colour of such a reagent that shows whether a reaction has taken place.

(ii) Some candidates gave the names instead of the formulae of the ions.

(b) (i) Almost all candidates correctly selected aqueous sodium hydroxide and aqueous ammonia as their reagents and most used these reagents to excess. The most common omissions were warming the unknowns with aqueous sodium hydroxide or not using (red) litmus paper to test any gas evolved. Some candidates incorrectly detected ammonia after warming **FA 7** with sodium hydroxide and then did not warm the **FA 8** and sodium hydroxide mixture. A small number of candidates incorrectly reported 'soluble white precipitate' for **FA 8** reacting with sodium hydroxide. Candidates should be reminded to make use of the Qualitative analysis notes.

(ii) A conclusion, even if a correct identity of an ion, cannot be accepted unless there is supporting evidence: some candidates reported **FA 8** contained Al^{3+} ions with either incomplete or incorrect evidence. A few candidates suggested **FA 7** contained Na^{+} ions, rather than the expected answer of '*unknown*', with no indication that they had carried out a flame test. (Flame tests for cations are not specified on the current syllabus.)

(iii) The equations involving the precipitation of aluminium hydroxide or the production of ammonia were most commonly seen. However, some candidates did not balance their equations. Others either omitted or gave incorrect state symbols.

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Paper 9701/42
A Level Structured Questions

Key messages

- 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 generally well answered, many candidates identified H_2O_2 as an oxidising agent. The ionic equation was found to be more challenging. Common errors included omission of H^+ or having O_2 and H_2 as products.

(ii) A minority of candidates were able to successfully calculate the correct mass of iodine. Some errors included:
- 0.396 g (from $93.8 = (0.390 / 15) \div (x - 0.390 / 20)$) or
- 0.384 g (from $93.8 = (0.390 / 15) \div (0.390 - x / 20)$).

(iii) Most candidates found this question difficult. Some thought iodine is polar and more soluble in hexan-2-one.

(b) (i) This was well known. A few candidates gave the definition for the enthalpy change of hydration instead of solution.

(ii) This answer was usually correct.

(iii) Candidates performed well on this question. A common error was stating that the lattice energy became less negative due to the decreasing electrostatic attraction between the nucleus and the outer electrons.

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

(ii) This was not well known. Common errors included methyl orange and phenolphthalein.

(iii) Most candidates gave a correct answer.

(d) Many candidates found this question challenging, often leaving their equations unbalanced.

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(e) This question discriminated well. Most candidates gave correct units; some did not work in mol dm^{-3} (omission of ($[Hg^{2+}]$) = $1.00 \times 10^{-7} \div 454.4 = 2.20 \times 10^{-10}$ (mol dm^{-3})). Candidates were able to gain partial credit (error carried forward) for $K_{sp} = 4.00 \times 10^{-21}$.

Question 2

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

(ii) Many correct answers were seen. A common error was discussing the effect of temperature of an endothermic reaction in terms of le Chatelier's principle.

(b) (i) Most candidates calculated the correct entropy change of reaction. Common errors were +239 (omission of $\times$ 3) and +135 (sign error).

(ii) This was generally well answered. Common errors were not recognising reaction 3 is the reverse reaction of reaction 2 and using $\Delta S = -135\ J\ K^{-1}\ mol^{-1}$, or not changing ΔS to kJ for their calculation.

(c) This was often correct. Common errors included:
- 572.6 (omission of $\times$ 4)
- use of the incorrect A_r for Si, for example 14 or 32.1.

Question 3

(a) (i) This was generally answered well. Some definitions lacked precision.

(ii) This answer was usually correct.

(b) (i) Some candidates mistakenly stated that the d subshell was full.

(ii) Most candidates gave a correct answer.

(iii) This question was found to be difficult. Common errors included omission of H^+ and unbalanced equations.

(c) (i) Many candidates found this question challenging. Most candidates were able to recall the equation $\Delta G = -nE^{\ominus}_{cell}F$; many were unable to complete the calculation successfully. Common errors seen were +1.13 V (E_{cell} calculated only) and +2.36 V (sign error).

(ii) Few correct answers were seen. Expected answers included:
- Ti^{3+} vacant d orbitals can form dative bonds or
- Ti^{3+} has vacant (d) orbitals which are energetically accessible.

(iii) This question was found to be difficult.

(d) (i) This answer was usually correct.

(ii) Some good answers were seen but many gave equations that were unbalanced with charge, stating H_2 was formed instead of $2H^+$.

(iii) This definition was well known. Some candidates did not specify that **two** lone pairs from the ligand formed a dative covalent bond to the central metal ion.

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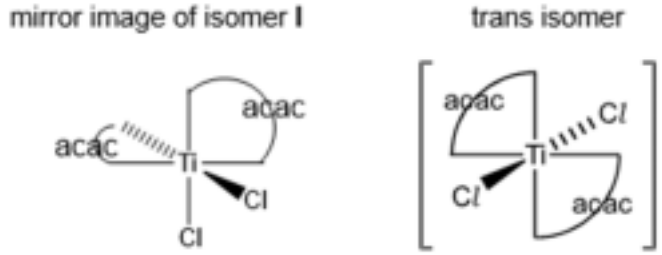
(iv) This was generally well answered. Some candidates had difficulty with drawing three-dimensional diagrams of the other two isomers.



Some structures suggested were repeats of either stereoisomer 1 or one of those already credited.

(v) Many candidates found it difficult to identify the polar stereoisomers and provide a suitable explanation. It was expected that the cis isomers were identified and stated that their dipoles did not cancel. Some candidates just stated that polarity does not cancel, or the cis isomers are non-symmetrical.

Question 4

(a) (i) Most candidates could identify the other functional groups in either **F** or **J** but not both. Alcohol was a common error.

(ii) This proved difficult for some candidates. Most managed to state the correct number of chiral centres in one of the molecules.

(b) (i) Many good answers were seen; most correctly identified the organic product **D**. However, some omitted one of the conditions for step 1 ($AlCl_3$) or step 4 ('concentrated' with HCl).

(ii) This was generally answered well. Most candidates were able to give the correct structure of **G**. However, some omitted the directing effect of COOH in their explanation.

(c) (i) Many candidates found this difficult. The most common errors were $C_9H_{17}O$ or $C_9H_{17}OH$.

(ii) This was generally well answered. Common errors included electrophilic substitution and reduction.

(d) (i) Many candidates found this difficult. The most common error was forming H^+ instead of H_2.

(ii) This answer was usually correct.

(iii) Many candidates were able to describe that the electronegative oxygen in the C=O weakens the O–H bond further. However, some omitted that this will also stabilise the carboxylate anion.

(e) This proved difficult for many candidates and some answers lacked precision and sufficient detail, for example stating that the OH group activates the benzene ring without explaining how, in terms of the lone pair on the oxygen overlapping with the p-ring system and increasing the electron density in the ring.

Question 5

(a) (i) Candidates performed well on this question. The most common error was writing an equation for the hydrolysis of the chloroalkane.
$CH_3CHClCOOH + H_2O \rightleftharpoons CH_3CHOHCOOH + HCl$

(ii) This was generally answered well.

(iii) Most candidates were able to identify that the electronegative chlorine weakens the O–H bond. However, many did not link to the difference in the pH of the solutions in terms of acid strength, for example, some stating $CH_3CHClCOOH$ is more acidic than CH_3CH_2COOH.

(b) (i) This was generally answered well. However, some definitions omitted a reference to pH.

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(ii) This question was usually correctly answered.

(iii) This answer was usually correct.

(iv) Common errors for this questions included:
- an incorrect linkage bond such as –COO–NH–
- inclusion of a trivalent carbon or omitting a carbon atom.

(v) This was usually well known. A common error was addition.

(vi) This was well known.

(c) (i) Candidates performed well on this question.

(ii) Many candidates were able to determine the half-life from the graph. Some showed that it was first order as it has a constant half-life.

(iii) This was rarely credited. Candidates had to state that $[NH_3]$ stays constant and does not affect the rate.

(iv) Many candidates found this question challenging. Some were able to use the information clearly to show the rate was first order with respect to $[NH_3]$. However, it was less common for candidates to deduce that the reaction was S_N2 due to the reaction being first order with respect to the $[NH_3]$ and to [2-chloropropanoate].

(v) This question was generally answered well. Candidates often omitted that increasing temperature leads to greater proportion of particles have $E \geqslant E_A$.

(vi) Candidates were not confident in answering this question. This was only credited occasionally.

Question 6

(a) Most candidates found this question difficult. The most common error was the equation.
$HOCH_2COOH + SOCl_2 \rightarrow ClCH_2COCl + SO_2 + H_2O$

(b) Many candidates found this question challenging. Common errors were to act as a buffer solution or to remove the chloride ions.

(c) Many candidates found this question challenging. Common errors included:
- omitting the dipole for the C=O bond
- omitting the lone pair on the N on the amine or on the O^- in the intermediate
- omitting a curly arrow on the C=O bond
- directing the curly arrow from the N lone pair to an incorrect atom
- an incorrect intermediate structure.

(d) This proved difficult for many candidates. Many just stated that the N atom had a lone pair but omitted that it would be ‘donated’.

(e) (i) Candidates found this difficult. Many identified the mobile phase as ethyl ethanoate; the stationary phase was less well known.

(ii) Most candidates answered this correctly.

(iii) This was found to be challenging. Many candidates did not give an adequate explanation. For example, ‘**X** is less soluble in the mobile phase’.

(f) (i) Candidates performed well on this question.

(ii) This was generally well answered. Most candidates were able to identify that $\delta = 7.1$ were H–Ar protons; amide was a common error. Many got the type of proton for $\delta = 3.0$ and 2.3 reversed.

(iii) This question discriminated well. Common errors were stating either 6 peaks or 8 peaks.

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Paper 9701/52
Planning, Analysis and Evaluation

Key messages

- Candidates need to show full working when calculating percentage errors. It is key that they use 2×0.5 the graduation in certain apparatus as a basis for the percentage calculation rather than the interval itself.
- Candidates need to be aware of the difference in the command to use three significant figures and 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

In general, candidates seemed well-prepared for this exam, but it was noticeable that some of the basic A Level practical techniques needed in **Question 1** were not known.

Candidates need to read a question carefully. Many candidates did not include the origin in their line of best fit in **Question 2(d)**.

Comments on specific questions

Question 1

(a) The majority of candidates correctly identified that the crucible should be left to cool before being reweighed.

(b) Candidates found this question more challenging; relatively few realised that initial gentle heating should be done to prevent the crystals spitting out.

(c) Very few candidates knew a crucible should be held in a crucible holder during heating. The most common error was to use a pair of tongs.

(d) A significant number of candidates knew that the sample needed to be heated to constant mass to complete the method. Weaker responses tended to try to explain the calculations involved in processing data.

(e) (i) Better performing candidates were able to complete this straightforward calculation; others struggled to cope with the data given. Weaker responses did not score as they were unable to deduce which subtractions resulted in the mass of water removed or the mass of anhydrous solid remaining.

(ii) Most candidates were unable to state why the experimental value of *x* was greater than the theoretical value. Many simply assumed not all the water of crystallisation had been driven off. Better responses suggested the initial crystals may have been wet but very few spotted the obvious answer that decomposition of the anhydrous copper(II) sulfate formed took place. Mass loss through spitting was also credited.

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(f) Candidates need to clearly show how they derive answers. If the mass was 13.60 g, then the balance must have intervals of 0.01 g and the reading of half this graduation could be made (i.e. to the nearest 0.005 g). Furthermore, there needs to be two readings made. The expected working was:

$$\frac{(0.005 \times 2)}{13.60} \times 100$$

$\frac{0.01}{13.60} \times 100$ was not accepted.

Question 2

(a) (i) Better performing candidates knew a standard solution was one of known concentration. Most candidates suggested it was a solution made up under standard conditions.

(ii) Some good descriptions of how to produce stated volumes of standard solutions were seen. Many determined that the true volume of pure ethanoic acid was 28.57 cm^3 and realised that this volume cannot be measured using standard laboratory volumetric apparatus so therefore 28.60 cm^3 should be used. Some candidates stated that this volume should be delivered straight from a burette but went onto incorrectly suggest that the burette should be rinsed into the volumetric flask. In this preparation, there was no need to transfer the pure ethanoic acid into an intermediate beaker but candidates who chose this route could have still obtained full credit provided correct rinsing of the beaker occurred.

(b) Most candidates knew that pure ethanoic acid was corrosive (or an irritant), although quite a few did not actually say so, instead simply referring only to its effects.

(c) (i) Weaker responses confused three significant figures with three decimal places and sometimes the rounding was incorrect.

(ii) The experimental dependent variable (i.e. the one directly measured in the experiment) was conductivity. Many incorrectly opted for 'molar conductivity' which is processed rather than recorded data.

(iii) Many candidates found it very difficult to express exactly what they meant. The conductivity of distilled water is measured so that it can be subtracted from the conductivity of the solutions of ethanoic acid - although, in practice, it will be two low to be significant. Answers in terms of a control or calibration were accepted.

(iv) Most candidates realised that temperature should be controlled.

(d) The quality of point plotting was high as was, in general, the position of the line of best fit. A significant number of candidates did not follow the instruction to include the origin in the line of best fit.

(e) The anomaly was easily spotted, as was its probable cause due to incorrect dilution.

(f) (i) The most common error was selecting points on the line which were too close together. A separation of at least 15 units on the *y*-axis was expected.

(ii) This was a challenging calculation and the units even more so. However, it caused few problems for the better performing candidates.

(g) Many candidates had the correct idea that the experiment was valid because the experimental result was within the range allowed by a 6.5 percentage error in the theoretical result; many found difficulty in showing this using the numbers given.

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