CHEMISTRY

Paper 9701/12
Multiple Choice

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

The majority of candidates were able to finish the paper within the time allowed.

The mean mark was 20/40, the median mark was 19/40 and the mode was 15/40.

Ten questions can be said to have been found to be easier. 60 per cent or more of candidates chose the correct responses to each of **Questions 1**, **4**, **6**, **8**, **14**, **17**, **24**, **35**, **37** and **40**. Six questions can be said to have been found to be particularly challenging. 35 per cent or less of candidates chose the correct responses to each of **Questions 2**, **3**, **12**, **20**, **28** and **32**. The questions that were found to be particularly challenging will now be looked at in greater detail.

Question 2

32 per cent of candidates chose the correct answer, **A**. The most commonly chosen incorrect option was **B**. The reaction mixture consists of 0.030 moles of $CuCO_3$ and 0.050 moles of HCl. Since 0.030 moles of $CuCO_3$ react with 0.060 moles of HCl, the acid is the limiting reagent. 0.050 moles of HCl react to give 0.025 moles of CO_2, which has a volume of 0.60 dm^3 under room conditions.

Question 3

5 per cent of candidates chose the correct answer, **D**. The most commonly chosen incorrect option was **A**. Option **A** is true of the 3p **subshell**, which can hold a maximum of six electrons, but is not true of a 3p **orbital**, which can hold two electrons. In an isolated phosphorus atom, each 3p orbital is occupied by one electron, so **D** is correct.

Question 12

33 per cent of candidates chose the correct answer, **A**. The most commonly chosen incorrect option was **B**. Aluminium oxide has no reaction with water, so options **C** and **D** are incorrect. To decide between **A** and **B** it is necessary to look at the last column. Al_2O_3 reacts with HCl to form $AlCl_3$. SiO_2 does not react with HCl, so the answer is **A**.

Question 20

30 per cent of candidates chose the correct answer, **C**. The most commonly chosen incorrect option was **B**. The five isomers are 1,1,1-trichloropropane, 1,1,2-trichloropropane, 1,1,3-trichloropropane, 1,2,2-trichloropropane and 1,2,3-trichloropropane. The common choice of **B** shows that many candidates missed out just one of these five isomers.

Question 28

31 per cent of candidates chose the correct answer, **D**. The most commonly chosen incorrect option was **A**, which is incorrect as a ketone cannot be oxidised by hot, acidified dichromate solution, so the solution will not change colour. **D** is correct because:

cyclohexanol is oxidised by hot, acidified dichromate solution to cyclohexanone

cyclohexanone will not affect Tollens' reagent but gives an orange precipitate with 2,4-DNPH reagent.

Question 32

31 per cent of candidates chose the correct answer, **A**. The most commonly chosen incorrect option was **D**. This suggests that these candidates were able to conclude correctly that O and Cl^+ have the same number of unpaired electrons in p orbitals, so statement 1 is true. Statement 2 is also true, F^+ and Ga^- both have two unpaired p electrons. Statement 3 is also true, N and Kr^{3+} both have three unpaired p electrons. Therefore, all three statements are true, and the correct answer is **A**.

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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.

Candidates are reminded to address 'explain' questions fully – merely stating facts or rules of thumb is not sufficient. Candidates need to go on to show how these combine to give reasons for chemical phenomena. This often requires a secure understanding of bonding and structure within molecules, in particular for organic species, linking structural feature to mechanistic probabilities.

Candidates are also 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 recurring AO2 themes continue to be 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, it is difficult for examiners to read scripts where answers written in pencil have been overlaid with ink without rubbing out the pencil. 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 question combined elements of inorganic and physical chemistry, with an organic mechanism at the end. Candidates are reminded to look carefully at the detail of each question and to be precise in their inclusion of detail and vocabulary.

(a) 'Triple bond' appeared very frequently throughout the cohort's answers, but often without the qualification that it was strong or required a lot of energy to break.

(b) (i) This was answered well by many; a number of answers gave the correct formula for magnesium nitride and then neglected to balance the equation. Common incorrect answers also included MgN_3, MgN and various forms of nitrate compound.

(ii) Many answers referred to the colour change of litmus paper, without referencing observations from the experiment itself. Candidates are reminded that 'a gas was given off' is a conclusion, not an observation; fizzing, bubbling and effervescence are taken as synonymous.

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

(ii) This item was assessing a specific syllabus point, yet many candidates seemed to struggle with the question and how to phrase their answers.

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

(ii) The first equation was generally given correctly. Many candidates could not identify the products of the second reaction correctly; answers frequently included $MgNO_3$ or Mg.

(iii) Most candidates were able to score at least one mark in this question. However, a significant number of responses included data for N–N (160 kJ mol^{-1}) and O–O (150) rather than N ≡ N and O = O. Other errors were not using 82 in calculations, or to switch products and reactants.

(e) Some candidates were able to answer this accurately and fully. It was clear that many did not appreciate the meaning and use of a curly (double-headed) arrow. Candidates are reminded that arrows originating from negative charge centres need to lead from a lone pair of electrons or from a bond.

Question 2

The main focus of this question was structure and bonding, with the emphasis in assessment on clear and careful answers and argument. Candidates should be careful to make comparisons in their answers where such are required by the question.

(a) (i) It was clear that candidates were aware of the definition of relative formula mass, but there was some confusion in answers when looking to define 'relative' – mixing a molar scale with that of the ^{12}C base unit.

(ii) There were many answers here which focused entirely on the intermolecular forces in one of the species, with no reference or comparison to the other. Candidates are reminded to be careful not to suggest that (covalent) bonds are broken when intermolecular forces are overcome.

(iii) Many candidates simply gave the answer of 'ionic bonding' with no further explanation. Others linked ionic bonding incorrectly to intermolecular forces, or wrote of giant covalent structures.

(iv) This item was answered well by many. For some, missing state symbols or use of $H_2O(aq)$ prevented the award of full marks.

(b) (i) Many answers incorrectly gave …$3p^5$ as the electronic configuration.

(ii) There were many vague answers given to this question, with little reference to the behaviour of either I_2 or Cl_2. Candidates are reminded not to use electronegativity as an explanation of reactivity.

(iii) This question was generally well answered. The use of NaOH was a common error.

(iv) This question was well answered.

(c) (i) Most candidates answered this question well, though several attempts omitted lone pairs of electrons and there were occasional answers employing ionic diagrams.

(ii) Many candidates answered this well. It was a common error to see the formation of O_2 or H_2 in balanced equations.

(iii) This item was well answered by most, with few instances of endothermic profiles or Boltzmann-type curves.

(iv) Many candidates showed themselves quite proficient at this question. For some, the lone pair was often missing from the F atom, or not linked to the hydrogen bond.

(d) (i) Once candidates had set up a correct mathematical expression, most were able to evaluate the answer correctly. Many answers incorrectly mixed units, or gave incorrect values for *R* (e.g. 4.18 or 8.14) or *T* (e.g. 0).

(ii) Many candidates treated this as an empirical formula calculation and chose answers that gave a nearest value without cross-checking other values.

Question 3

This short question based on organic chemistry was well answered by many. A thorough knowledge and identification of functional groups and their chemical properties was necessary to gain most credit.

(a) There were many varied answers to the observations required in this question, with some candidates clearly resorting to guesswork. Candidates are reminded of the difference between *observations* and *conclusions*, most notably that 'gas given off' is the latter, not the former.

(b) Many answers gave $C_5H_{10}OH$ as the product, i.e. with only 1H having been added. Answers that tried to include $NaBH_4$ in a balanced *equation* did not gain credit, as there were uniformly incorrect.

(c) This question was well answered by many candidates.

(d) Most answers correctly referenced the absorption ranges; fewer were able to represent the bonds involved correctly.

Question 4

A longer question based in organic chemistry was well answered by many candidates, demonstrating good understanding of halogenoalkanes, alkenes and carboxyl compounds. Markownikoff's rule was tested in the final item. Candidates are reminded to be clear with their wording and reference in their written arguments.

(a) Candidates are advised to count the number of carbons in a given structure carefully and be consistent in their counting from one end of a molecule.

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

(ii) There were many correct answers to this item. Occasional answers gave chloropropene as a reactant.

(iii) Not many answers appreciated that free-radical reactions are ill-controlled and can give a multitude of products by further substitution.

(iv) Candidates are reminded to specify reagents carefully, including concentration where applicable.

(c) (i) Creditable answers were those with specific conditions included.

(ii) Many candidates answered this correctly. 'Reducing agent' was frequently given incorrectly as the role of H_2SO_4.

(iii) This was generally well answered.

(iv) There were some good answers to this question. Fewer candidates spotted the hydrolysis of both the ester and the nitrile groups.

(d) Answers tended to be confused about what the pertinent stable species was – answers referencing the 2-bromo compound in this context were not creditable.

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Paper 9701/33
Advanced Practical Skills

Key messages

- Candidates should be advised to read the instructions given in the paper carefully. Underlining or highlighting key words would help some candidates provide appropriate answers.
- Candidates should take care to use the styles of displaying and abbreviation for units as given in the syllabus.
- Candidates should be reminded that if a solid, when added to a solution does not dissolve, then the solid should not be described as a precipitate.
- Candidates are expected to spend 20 per cent (or more) contact time with teachers in the laboratory. This is to carry out or observe practical work to illustrate or to develop the understanding of the theory.

General comments

It is important that every candidate can be linked to a particular session/laboratory and to a corresponding set of Supervisor's results. Invigilators/Supervisors at centres running more than one session, and/or using more than one laboratory, should instruct their candidates to complete the Session/Laboratory boxes on the front of the examination paper.

This paper proved accessible to all candidates and it generated a wide range of marks. Almost all candidates completed the paper, indicating that there were no time constraints.

Comments on specific questions

Question 1

The degree of success in manipulating the apparatus appeared to vary considerably. In general, candidates were able to use their results correctly in the calculation. Correct responses were seen to all parts of the question; many ignored the information given at the start of **(d)** and so could not access this mark.

(a) Many candidates gained both marks in this part. The most common errors were either to omit one of the items stipulated in the method or to use incorrect units. Some candidates wrote 'gm' instead of 'g', or 'ml' instead of 'cm^3'. The volumes of gas collected tended to be centre dependent (approximately 30–180 cm^3). Generally, the candidates and relevant supervisor obtained similar results.

(b) Correct answers were seen from the majority of candidates to **(ii)**, **(iii)** and **(iv)**. Some candidates used a mass ratio in **(v)** and many gave their answer to a single integer thus losing the mark for **(i)**. Candidates should note that answers to one significant figure are rarely acceptable. Rounding errors were also seen and candidates should be reminded that, for example, 0.8947 rounded to two significant figures is 0.89 but 0.8952 rounds to 0.90.

(c) Candidates found this question challenging. Many answers involved the change of rate of reaction, which was not relevant. These answers did not address the difference in volume of gas collected at lower temperature and hence the apparent decrease in moles if using the same molar gas volume of 24 dm^3.

(d) A substantial minority of candidates did not read the question so suggested ways of reducing the loss of gas prior to the bung being replaced. Other incorrect responses included the carbon dioxide being stuck in the tube or that the delivery tube was not sufficiently far up the measuring cylinder. Successful candidates produced answers covering the whole range of possible ways of reducing the solubility of carbon dioxide in water.

Question 2

Candidates achieved a wide range of marks in this question, with the majority gaining over half the marks available. Correct responses were seen to all parts of the question.

(a) Most candidates tabulated the data clearly. A significant minority did not include all the data stipulated in the question. Candidates should be reminded to read instructions carefully and to construct a table for their results before starting their practical work. Many incorrectly labelled 'mass of crucible (+ lid) + residue' as 'mass of crucible (+ lid) + **FA 3** after heating'. As **FA 3** denotes the reactant and this undergoes thermal decomposition, the solid remaining is no longer **FA 3**. Some candidates and supervisors gave mass ratios (mass of **FA 3** ÷ mass loss) well above the theoretical range. This suggests that insufficient heating had taken place. Less easily explained is the fact that a few supervisors and candidates produced a ratio considerably below the theoretical range.

(b) This section was a good discriminator as most candidates successfully answered **(i)** but the number of candidates getting marks for each part decreased through the question. Some candidates had trouble with **(iii)** because they had miscalculated either **(i)** or **(ii)** and so performing the correct calculation resulted in a negative answer. Part **(iv)** was answered correctly by a majority of candidates. In **(v)**, some candidates confused which value to use for the number of moles of water. Some tried to find the water by some form of subtraction (ignoring the 'thermal decomposition' in the question). A minority of candidates answered **(vi)** correctly.

(c) There were many correct answers to **(i)**. A significant number of candidates suggested incorrectly that replacing the lid stopped water and/or carbon dioxide from escaping. Some of those correctly stating that water would not be absorbed did not specify that this would come from the atmosphere. A large majority of candidates gained the mark in **(ii)** with 'heat to constant mass' being the acceptable answer most commonly seen. In **(iii)**, some candidates ignored either 'chemical test' or 'observations'. 'Test with limewater' was only acceptable if it was clear that the gas evolved was being tested. Candidates needed to suggest the observation of 'effervescence' or that 'the gas formed a white precipitate with limewater'. Those suggesting heating the solid and testing any gas evolved with limewater needed to make clear that it was the residue being heated.

Question 3

There was a wide range of marks seen but with fewer candidates gaining over half marks compared to **Question 2**. Candidates need to be more precise in their descriptions of observations. Correct responses were seen to all parts of the question.

(a) Most candidates observed the blue filtrate in **(i)**; fewer described the solid correctly, with the majority suggesting it was a precipitate. There were correct observations listed for all tests in **(ii)** but it was rare for all five marks to be awarded. The most common error was describing the colour of the mix of copper(I) iodide and aqueous iodine as yellow. In the test with aqueous silver nitrate, it was not enough for candidates to write 'blue solution' as this could have been before adding the reagents to a portion of the filtrate. An acceptable alternative to 'no visible reaction' was 'remains a blue solution'. In the test with an aqueous barium compound, many candidates described the precipitate as (pale) blue instead of noting that the precipitate was white (in a blue solution). Very few candidates scored both marks in **(iii)**. The marks most commonly awarded were for 'effervescence' on adding **FA 6** to the dilute nitric acid or for 'blue precipitate' with aqueous sodium hydroxide.

(b) A large majority of candidates scored the mark in **(i)**. Some candidates lost the mark by describing the cation as 'copper' and not as 'copper(II)'. Candidates should be encouraged to write correct formulae in this type of question. Part **(ii)** caused problems for many, with common errors being a lack of state symbols and incorrect balancing. Some candidates wrote a full equation and did not attempt to cancel it down to an ionic equation. There were few correct responses in **(iii)** with 'neutralisation' and 'displacement' being common incorrect responses. Candidates should be reminded that oxidation always takes place with reduction; if only one part is specified then the species undergoing the oxidation or reduction must be given.

(c) Many correct responses were seen. Some ignored the question and suggested using an indicator. Some candidates used aqueous barium chloride or nitrate, which were not appropriate for testing for H^+ ions. The majority of candidates suggested a correct chemical test. It was not clear from some answers that the test had been carried out; some missed out a conclusion. A conclusion of 'hydrogen gas evolved' on adding magnesium ribbon and observing effervescence should have been that the test and result showed **FA 6** was an acid.

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Paper 9701/42
A Level Structured Questions

Key messages

Candidates should write clearly in dark blue or black pen.
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.

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 of the questions. There was no evidence of candidates being short of time.

Comments on specific questions

Question 1

(a) This was well known by many candidates. Some candidates misunderstood the rubric and simply stated two gases, which scored no credit.

(b) (i) Candidates generally performed well on this question.

(ii) Most candidates answered this well.

(iii) The correct answer was given by many candidates; a significant number gave the incorrect units.

(iv) Candidates found this challenging. Some did not give an adequate explanation in terms of moles of gaseous particles.

(c) (i) Many candidates gave a correct expression for K_p, with suitable units. Common errors were use of square brackets for partial pressures or expressing units in terms of $mol\,dm^{-3}$.

(ii) Some candidates had difficulty calculating $p(NO)$ and $p(N_2O_3)$ and a common error was 1.92 Pa.

(d) (i) Most candidates answered this well, giving clear reasoning linked to the data in the table.

(ii) Many fully correct answers were seen.

(e) (i) Many candidates understood the idea of a co-ordination number; definitions often lacked precision. A common error was the number of bonds to a ligand.

(ii) This question was usually answered correctly.

(iii) Many candidates incorrectly stated square planar.

(f) (i) Most candidates could draw two correct isomers; some could draw three.

(ii) Most candidates recognised geometrical isomerism. Optical was a common error.

Question 2

(a) (i) The trend and its explanation were well understood by candidates. Some candidates stated why lattice and hydration energies decreased (due to increasing ionic radius); many did not relate the relative decreases in these values.

(ii) This proved challenging for many candidates. Only a few candidates gave a suitable explanation. Most gave an explanation in terms of decomposition rather than solubility.

(iii) Some very good answers were seen. Many candidates identified that $Sr(OH)_2$ and $Ba(OH)_2$ could also be used; only a small number gave a suitable explanation in terms of the solubilities of the hydroxides and carbonates.

(b) (i) Many candidates correctly calculated a value for K_{sp}. A common error was to omit the 2^2 (= 4) in the calculation, for the $[OH^-]^2$. –

(ii) This was usually well known. A common error was stating that bubbles would be produced.

(c) Most candidates found this challenging. Many candidates used incorrect data such as the bond energy for O=O and H–H, did not divide their final answer by 2 or evaluated their expression incorrectly using incorrect signs for energy changes.

Question 3

(a) (i) Most candidates gave the correct pH expression. K_a was rather more problematic and was often given incorrectly as $[H^+]^2/[HA]$.

(ii) Many candidates answered this well. A common error seen was $NaA + OH^- \rightarrow NaOH + A^-$.

(b) This was a challenging question. Some good answers were seen. Many did not correctly calculate the remaining [HOC*l*] and $[H^+]$, and often used 0.17 for HOC*l*.

Question 4

(a) (i) Many candidates answered this question correctly; quite a number of candidates thought the copper atom (in its ground state) was a $3d^94s^2$ system.

(ii) This proved challenging for many candidates and answers often lacked clarity in the explanation. Some candidates stated that light energy is emitted, did not mention that d-orbitals are split or omitted Cu(I) was $3d^{10}$ or had a full d-subshell.

(b) Many fully correct answers were seen. Common errors were 30% (2:1 ratio used) and 59.3% (rounding error).

(c) (i) This proved challenging for some candidates. Many used incorrect $E^\ominus$ data (Cu^{2+}/Cu +0.34 V).

(ii) Candidates who had answered **(c)(i)** correctly usually gave a correct explanation.

(iii) The Nernst equation was not well known. A common error was use of an incorrect $E^\ominus$ in their equation.

(iv) Most candidates found this challenging. Some very good answers were seen; some gave an incomplete answer with no reference to $E^\ominus$ data.

(d) (i) Many fully correct answers were seen. A common error was stating $[CuCl_4]^{2-}$ as dark blue.

(ii) This question was usually fully credited.

(iii) This was often answered well. Common errors included putting ionic charges outside the final set of square brackets, e.g. $[[CuCl_4]]^{2-}$ instead of $[[CuCl_4]^{2-}]$, or $K_{stab} = [Cu^{2+}][Cl^-]^4/[[CuCl_4]^{2-}]$.

Question 5

(a) (i) Many candidates gained credit; a significant number missed out part of the structure.

(ii) Most candidates gave a correct answer.

(iii) Many candidates could name two types of intermolecular force but did not refer to atoms/groups that are present in the *Super Glue* polymer.

(b) (i) Better performing candidates correctly identified both **Y** and **Z**. The identity of **Y** was more frequently known than **Z**.

(ii) This was not well known. Many candidates identified methanol in the esterification step but omitted the conditions. The reagents for steps 2 and 3 were less commonly awarded.

Question 6

(a) Most candidates gave the correct answer.

(b) (i) Many candidates stated that ketamine is a base. Common errors included as a catalyst and oxidising agent.

(ii) Most candidates answered this question correctly.

(iii) This question was well answered. The use of the ^{13}C:^{12}C ratio of 1.1% was required for this calculation.

(iv) This question discriminated well.

(v) This was not well known. Only a few candidates calculated this correctly.

(vi) Many candidates did not attempt this question. Some good answers were seen; some did not follow the guidance in the stem that 'ketamine contains one atom of each of three different elements' (in addition to carbon and hydrogen).

(c) (i) Many candidates gained full credit here. Common errors were four and seven peaks.

(ii) Many candidates answered this question well; quite a number had difficulty with identifying the splitting pattern or the number of protons present for each peak.

(iii) This was generally well answered.

(iv) Most candidates gave the correct answer here.

Question 7

(a) (i) Most candidates correctly identified HO_2CCO_2H.

(ii) Many correct answers were seen. The most common error was $HCl(g)$.

(b) (i) Most candidates correctly drew the structures of **B** and **D**. The identity of **C** was more frequently known than **E**. A common error was a positional error of the –COCOC*l* group in **C**.

(ii) This was not well known. The common errors were to:

include water in step 1, e.g.'Cl_2(aq) + $AlCl_3$' did not receive credit as $AlCl_3$ would be hydrolysed

use reflux for step 2, which would lead to multi nitration of the benzene

omit concentrated in step 2 or step 3

use $NaBH_4$ for step 4.

(iii) Many candidates gave a correct answer.

(iv) This was well answered.

(c) Some very good answers were seen. Most candidates correctly identified the oxidation product from the reaction with acidified $Cr_2O_7^{2-}$. The other reactions were less well known. Common errors included:

the formation of an alkoxide salt with NaOH

the substitution of C*l* with Br or H in the chlorobenzene ring with Br

the substitution of OH by C*l* with HC*l*(aq).

CHEMISTRY

Paper 9701/52
Planning, Analysis and Evaluation

Key messages

Centres should include as much practical work as possible in their course, so that candidates are familiar with common experimental techniques and apparatus. It was apparent that many candidates did not recognise the simple techniques needed in **Questions 1(a)(iii)** and **2(b)(i)**.

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 this level.

Candidates should be dissuaded from offering lists of answers beyond the number of responses asked for.

Candidates should be aware that lines of best fit need to split the plotted points in such a way as to have an approximately equal number of points (excluding anomalies) either side of the line.

General comments

Question 1 involved graph work. Candidates are advised to clearly show their points by using a diagonal cross, 'x', with the intersect of the lines being the exact co-ordinates on the grid. Alternatively, a point within a circle, ⊙, would be suitable with the point being the exact co-ordinates 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.

Comments on specific questions

Question 1

(a) (i) Most candidates answered this question correctly.

(ii) Some candidates did not realise that additional measurements were needed to ensure that the exact mass transferred is known.

Knowledge of 'weighing by difference' was the expected answer in which candidates would reweigh the 'empty' weighing boat *after* transfer of the solid and determine the exact mass transferred.

An acceptable alternative was to record the mass of the empty beaker then record the mass of the beaker + solid.

(iii) This question asked about two steps to make a standard solution: how to transfer all the KI solution into the volumetric flask and how to fill the volumetric flask to the 250 cm^3 mark.

This should have cued candidates into rinsing the beaker with distilled water as part of the transfer process and then on to the need to add distilled water drop-wise (using a dropper) as the level approached the mark.

Many candidates scored one of the two points, but few scored both.

Many misread the question and assumed the KI in the beaker was in solid form and needed to be dissolved prior to transfer and a large proportion of candidates incorrectly thought that the KI solution (of indeterminate volume) needed to be transferred into the flask using precision volumetric equipment such as burettes or pipettes. This may indicate that the practical skill of making a standard solution had not physically been done by these candidates.

(b) Many candidates did not know the reason behind the technique of rinsing a piece of volumetric apparatus with the same solution that it is to be filled with. There were many descriptions based upon 'removing impurities' but very few stated the expected response based upon the idea of prevention of dilution (by residual distilled water) of the solution in the apparatus.

(c) Most candidates calculated this volume correctly.

(d) (i) The majority of candidates were able to work out that step 4 had been omitted.

(ii) Most candidates realised that the similarity in value of the repeats made the results reliable, but many candidates thought that the process of carrying out repeat experiments was enough to ensure reliability. Others erroneously assumed a trend proved reliability.

(iii) Many candidates were unsure about the calculations regarding percentage error. The degree of uncertainty on a burette is $\pm 0.05\,cm^3$ but because two measurements are needed in order to determine the volume of a titre, the value of the uncertainty is multiplied by two before conversion of the uncertainty to a percentage of the titre volume.

(iv) A significant minority realised the sulfuric acid was in excess so the precision of measurement of its volume was not as important as the volumes of other solutions and therefore a measuring cylinder would be a suitable piece of apparatus. Increased rate of emptying was a common error as was the catalytic activity of sulfuric acid.

(v) Most candidates knew that the dependent variable was the time needed for the indicator to change colour but very few realised that the independent variable was the volume of KI solution within the total volume, in other words, the (relative) concentration of the KI.

(e) (i) This question contained a challenging results table. Many candidates scored both marks.

Some candidates did not know the difference between three significant figures and three decimal places and rounding errors were seen frequently.

(ii) The plotting of the points on the graph was done very well – the exception being the point at (1.00, –2.05) which was often plotted at (1.00, –2.005). Also, the inclusion of negative numbers caused problems for some, e.g. –2.34 was plotted at –2.26 (i.e. 0.04 units above –2.3 rather than below).

Drawing a line of best fit is a difficult skill. Candidates need to remember that if points are not directly on the line then, anomalies apart, there should be an approximately similar number of these points above and below the line.

(iii) Whilst most candidates could correctly read coordinates, a significant number did not use a range that covered at least half of the graph paper. The calculation of the gradient was also well attempted, but the instruction for 3 significant figures was ignored often. The correct deduction of the order (a whole number) was well done.

Question 2

(a) The ionic equation was not well written, with many not knowing what an ionic equation was. Others omitted state symbols or gave an incorrect formula for silver chloride.

(b) (i) Filtration under reduced pressure is a common technique used in the preparation of solid organic substances. It was clear that very few candidates had met this technique. The second mark was awarded for inclusion of a bung to seal the apparatus and this mark was very seldom given.

(ii) Nearly all candidates appreciated that filtration under reduced pressure was a faster technique than filtration under gravity.

Incorrect answers referred to the purity of the product or suggested the residue passed through the filter paper.

(c) (i) Many candidates knew that constant mass would indicate complete dryness.

(ii) Most could calculate the number of moles of silver chloride by deducing the mass formed and dividing this by the molar mass of silver chloride, even if the formula of silver chloride was given as $AgCl_2$ or $AgCl_3$ in **(a)**.

(iii) The calculation was completed correctly by a number of candidates. The common error was not appreciating the ratio of $AgCl$ to XCl_2 was 2:1.

(iv) Some confused answers were seen in response to this question. Some identified that chloride ions were present in tap water yet wrote that this would decrease the number of moles of $AgCl$ precipitated.

Others opted for an increase in the number of moles of $AgCl$ precipitated but gave vague reasons such as 'there are impurities in tap water'.