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IAL Chemistry WCH13 01

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Introduction

Many candidates seemed well prepared for this paper and were able to demonstrate their knowledge and understanding of practical techniques in both familiar and unfamiliar contexts. This was particularly noticeable on questions about chemical testing and on calculations. Unfortunately, others seemed ill-prepared and appeared unfamiliar with even common practical activities and so struggled to show their knowledge and understanding. There was no evidence, however, that candidates had insufficient time to complete the paper.

Question 1 (a-b)

This set of items proved more challenging than expected, with some candidates unclear as to how and why this practical technique was used. Initial graph plotting was generally very accurate and many candidates scored the mark for point plotting in (a)(i). Some candidates, however, used points for their graphs which are so small that they cannot be seen, particularly if covered with lines of best fit. Under these circumstances small dots for points are not the best markers to use and candidates would do better to use a cross. Where marks are available for graph plotting these cannot be awarded where points cannot be seen. In (a)(ii) was either well understood or proved challenging. Most candidates were able to draw a line of best fit using the final 5 points on the graph, though some continue to 'join the dots' which in chemistry graph work rarely, if ever, to score marks. Many candidates did not recognise that the maximum temperature change would be found at 3.5 minutes using extrapolated lines and instead used maximum temperature – minimum temperature. Temperature changes were also commonly found at either 3 minutes or 4 minutes rather than when the zinc was added at 3.5 minutes.

(a)(iii) proved the least well answered of this set of items. Whilst many candidates knew that they should use lines of best fit, and were able to do so, very few understood the reason for doing this, with most referring to blanket ideas such as removing anomalies or finding averages.

In (b)(i) many candidates were able to secure full marks either using the method in the mark scheme or by calculation of the theoretical mass of zinc required to react with the copper(II) sulfate solution, and thus demonstrating that it was in excess. As is quite common, in (b)(ii) a relatively high number of candidates used the mass of zinc in the expression for heat transfer instead of the mass of the copper(II) sulfate solution so did not score this mark. The additional assumptions in (b)(iii) were quite well understood and candidates were able to score well on this mark. The final calculation was also well understood and so (b)(iv) often scored 2 marks.

(a)(i) The points are accurate, though not all easily seen, and scored 1 mark.

(a)(ii) The line of best fit joining the top points is good and is extended past 3.5 minutes giving access to all the marks. Unfortunately the candidate goes no further and gives a temperature change value of 45°C which is not made clear the origin of. From their graph the correct value would be 44°C.

(a)(iii) is a typical example of the 'catch all's' of spotting anomalies and averaging values. Neither of those scored here.

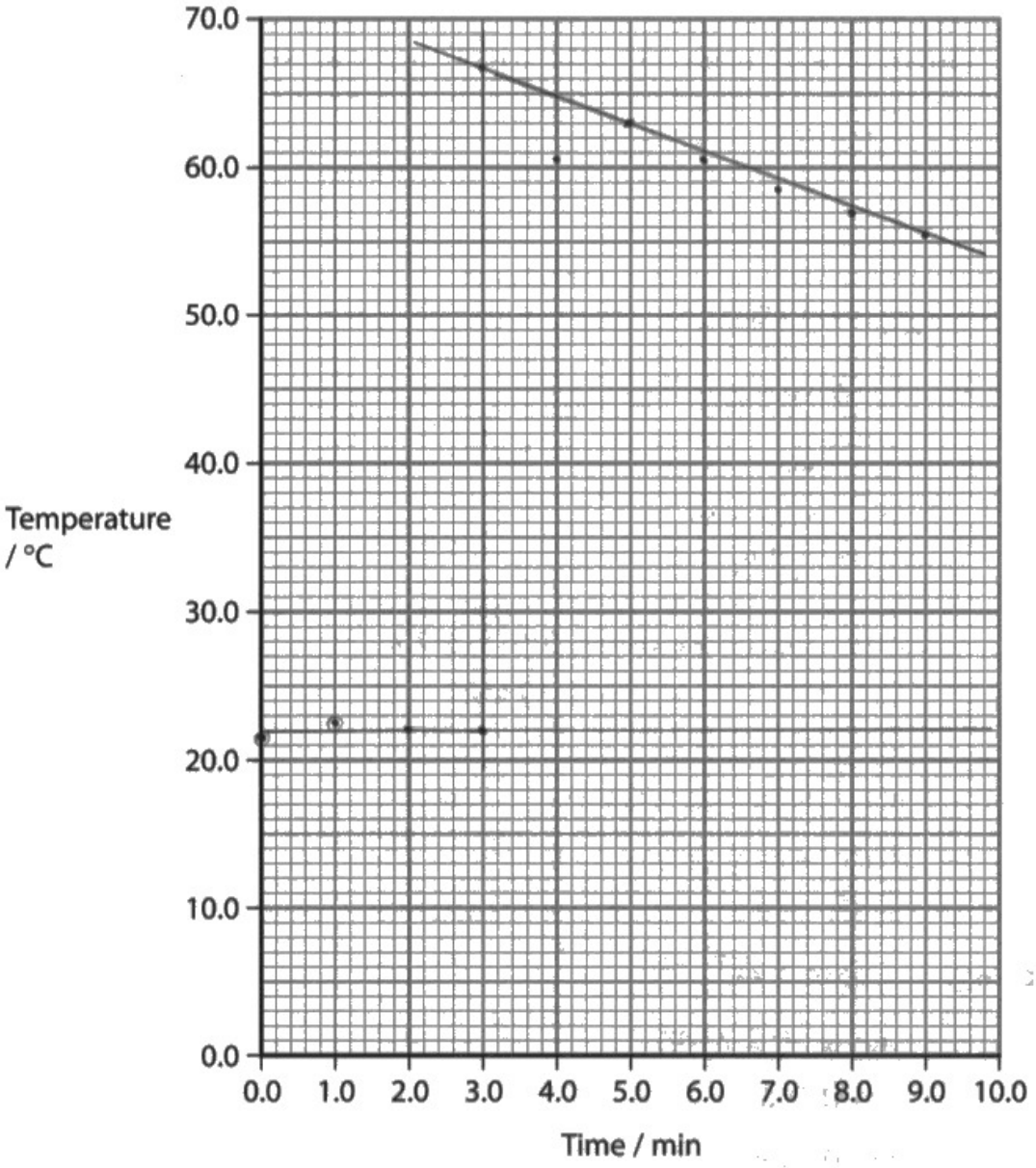
The calculations in (b)(i) and (b)(ii) are both fully correct. This answer uses the alternative route on the MS of finding the theoretical mass of zinc required in (b)(i).

In (b)(iii), whilst we do ignore the mass of zinc as this candidate suggests, to score the mark we are looking for an explanation of why this is so. A statement such as 'the heat capacity of zinc is zero', would score the mark.

The final answer starts well and produces a value of the correct magnitude, but the sign is wrong as the reaction is exothermic and the units are not correct, so this scores 1 of the two marks for dividing the energy transfer by the number of moles.

(a) (i) Plot a graph of temperature against time on the grid.

(1)



(ii) Use the graph to determine the maximum temperature change, ΔT, in this experiment. You **must** show your working on the graph.

(3)

$\Delta T =$ 45 °C

(iii) State why using a series of measurements gives a more accurate temperature change than taking the initial and highest temperatures.

(1)

more values helps us to identify the anomaly and emit it, and take an average.

(b) (i) Show by calculation that the zinc powder is in excess.

(2)

$n = \frac{1 \times 50}{1000}$

$= 0.05$ mol

$n = g/Mr$

$g = 0.05 \times 65.4$

$= 3.27$ g

∴ excess zinc powder = $4.50 - 3.27$

$= 1.23$ g

(ii) Calculate the energy transferred in the reaction, in joules.

Assume that the specific heat capacity of the solution is 4.2 $J g^{-1} °C^{-1}$.

(1)

$E = mc\Delta T$

$= 50 \times 4.2 \times 45$

$= 9450$ J

$= 9.45$ kJ

(iii) State a second assumption, other than the specific heat capacity of the solution, that you have made in your calculation in (b)(ii).

(1)

The mass of the solid in the solution is negligible.

(iv) Calculate the enthalpy change of the reaction, using your answers to (b)(i) and (b)(ii).

(2)

$\Delta H = \frac{q}{n}$

$= \frac{9.45}{0.05}$

$= +189 \text{ kJ}.$

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Examiner Comments

This is an example of a candidate using dots as graph marker points. Though these are easily seen many were not and these would better be replaced with crosses.

The temperature of the solution rises during the reaction, so the reaction is exothermic. Consequently the final answer should be negative.

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Examiner Tip

Use crosses as marker points on graphs.

Show working on your graphs when the graphs are used to provide answers such as gradients or temperature changes.

Think carefully about the sign of energy changes. If the temperature of the solution rises, then the reaction is releasing energy and so is exothermic.

Question 1 (c)

There were a number of questions in this paper looking at different aspects of errors and uncertainty. Some candidates were very familiar with this type of work and were able to deal with the subtle differences in the various questions, whilst others were less confident and tended to rely on general 'human error' type answers. This question asks for improvements to the procedure to improve the accuracy of the result. Candidates were asked to justify their answers which some chose not to do. Answers which suggested an improvement would increase the accuracy of the result were very unlikely to score the justification mark as that was what the question asked.

This example scored 1 for the use of the digital thermometer and the justification that this would decrease the uncertainty of the temperature.

The use of a copper beaker was often suggested, along with the idea that this would reduce heat loss. Copper is a good conductor of heat and so heat loss would be higher than with a polystyrene cup.

(c) Identify **two** improvements in the experimental procedure that would improve the accuracy of the result, other than repeating the experiment. Justify your answers.

(2)

using a digital thermometer to decrease the uncertainty of the temperature

using a copper beaker so none of the heat energy is lost to the apparatus

ResultsPlus
Examiner Comments

For 2 marks you should expect to make two points, as this candidate has done.

ResultsPlus
Examiner Tip

Questions asking for justification, such as this one, will need some explanation of why the improvement will work as suggested.

Question 2 (a)

This question provided a good number of marks for very many candidates, who dealt with the requirements of this calculation very well. The most common mistake was not to remember to multiply by 10 in step 2 of the calculation. Many candidates realised that if they did this their answer was too large, and there was considerable evidence of candidates realising this and going back through their calculation to correct themselves, which is, of course, to be encouraged!

This was quite a common answer, with a single mistake.

2 The hydrogencarbonate of an unknown Group 1 metal, $MHCO_3$, is a white solid. Two students carried out a titration experiment using hydrochloric acid.

The results were used to determine a value for the relative formula mass, M_r, of $MHCO_3$ and thus obtain a value for the relative atomic mass, A_r, of M.

Both students made solutions containing 2.00 g of $MHCO_3$.

The **first** student made a 250.0 cm^3 standard solution.

The **second** student made a solution by placing the $MHCO_3$ in a beaker, dissolving the solid in a little deionised water, and then filling the beaker to the 250 cm^3 mark.

Both students titrated 25.0 cm^3 portions of their solution using hydrochloric acid with a concentration of 0.150 mol dm^{-3}. They used the same method and equipment.

The students repeated their titrations until they achieved concordant titres.

The **first** student obtained a mean titre of 13.35 cm^3.

(a) Calculate the value for the A_r of the metal M from the data of the **first** student.

$MHCO_3$ and HCl react in a 1 : 1 ratio.

You must show your working. Give your answer to **two** decimal places.

(4)

$HCl \quad n = \frac{ms}{Mr} \quad m \times V = \frac{25}{1000} \times 0.15 = 3.75 \times 10^{-3}$

$HCl \; n = 2.0025 \times 10^{-3}$ mol $\quad \frac{13.35}{1000} \times 0.15 = 2.0025 \times 10^{-3}$

$MHCO_3 : HCl$

$1 : 1$

$2.0025 \times 10^{-3} : 2.0025 \times 10^{-3}$

$Mr \; MHCO_3 = \frac{ms}{n} = \frac{2}{2.0025 \times 10^{-3}} = 998.75 \; g\,mol^{-1}$

$Mr \; HCO_3 = 1 + 12 + (16 \times 3) = 61$

$998.8 - 61 = 937.75 \; g\,mol^{-1}$

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Examiner Comments

This candidate has not multiplied the moles of $MHCO_3$ by 10 after the first step in the calculation and so ends with an answer prior to the subtraction of the hydrogen carbonate ion's mass which is 10 times too large.

This scores the first marking point and the third and fourth by transferred error. One mistake so 3 marks scored.

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Examiner Tip

When a sample is taken from a solution in a titration it is often necessary to allow a factor, usually of 10, to be used in the calculation.

This candidate did everything right, here, except for providing an answer which is not to 2 decimal places as required by the question.

2 The hydrogencarbonate of an unknown Group 1 metal, $MHCO_3$, is a white solid. Two students carried out a titration experiment using hydrochloric acid.

The results were used to determine a value for the relative formula mass, M_r, of $MHCO_3$ and thus obtain a value for the relative atomic mass, A_r, of M.

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- **Both** students titrated 25.0 cm^3 portions of their solution using hydrochloric acid with a concentration of 0.150 mol dm^{-3}. They used the same method and equipment.

The students repeated their titrations until they achieved concordant titres.

The **first** student obtained a mean titre of 13.35 cm^3.

(a) Calculate the value for the A_r of the metal M from the data of the **first** student.

$MHCO_3$ and HCl react in a 1 : 1 ratio.

You must show your working. Give your answer to **two** decimal places.

(4)

$MHCO_3 + HCl \longrightarrow MCl + CO_2 + H_2O$

Mean titre = 13.35 cm^3

n
c | v

→ Mole of HCl = Conc. x volume, Mole in 25 cm^3 = $0.150 \times \frac{13.35}{1000} = 2.00 \times 10^{-3}$ mol

→ Mole in 250 cm^3 = $0.150 \times \frac{250}{25} \times \frac{13.35}{1000}$

Mass
mole | Mr

Mole = 0.02 mole HCl

$MHCO_3$	HCl
1	1
x	0.02

X = 0.02 mole of $MHCO_3$

Mr of $MHCO_3$ = $\frac{2.00}{0.02}$ = 99.875 ≈ 99.9

$MHCO_3$ Ar = 99.9 ≈ 100 | M = 100 − 1 − 12 − (16 × 3)
M = 39

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Examiner Comments

Calculations often require a particular number of decimal places or significant figures, and candidates should be aware of the differences between these. This candidate rounded to 100 too soon, which made the final answer naturally by one of only two significant figures rather than 2 decimal places. Subtraction of 61 from 99.875 and then rounding the answer to 2 decimal places would have been correct.

ResultsPlus
Examiner Tip

During calculations use the number given for each calculation in the calculator, rounding your answer to the required number of significant figures or decimal places at the end.

Question 2 (b)(i)

This proved to be a well understood question and scored well. It was anticipated that candidates would calculate the percentage error, but many chose simply to calculate the difference between the experimental and actual values, which answered the question and so was awarded the mark.

Some candidates used a method of dividing the experiment value by the actual value and then subtracting this from 1 to give the percentage error.

(b) **Both** students calculated values of the relative atomic mass of M.
Using their calculations and the total percentage uncertainty of their experiments, they deduced that M was potassium.

The value for A_r calculated by the second student was 37.52.

(i) Calculate the experimental error for the **second** student.

[A_r of potassium = 39.1]

(1)

$\frac{37.52}{39.1} \times 100 = 95.96\%$

so percentage uncertainty = 4.04 %

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Examiner Comments

This is an example of this method

Question 2 (b)(ii)

This calculation to find the possible values from the experimental data was generally quite well done, with most candidates having a good idea of the calculations required even if small mistakes were made. This meant at least some marks were scored by most candidates. Other than those shown in the examples, other common errors included dividing the experimental difference by 2 before subtraction. Some candidates very cleverly recognised they need only focus on the maximum possible value from the experimental data (39.208) and comparing the A_r of potassium with that, saving themselves a small calculation and demonstrating a good understanding of the process.

This item required the candidates to find the range of possible values for the A_r of M from the students experiment value and the percentage uncertainty of their readings.

(ii) The **second** student calculated the A_r value of M to be 37.52 with a total percentage uncertainty of 4.5 %.

Comment on the value of 37.52 obtained by this student by calculating the range of values of A_r.

(3)

$= 37.52 \times \frac{4.5}{100}$

$= 1.6884$

$= 37.52 \pm 1.6884$

$= 37.52 - 1.6884 \quad , \quad 37.52 + 1.6884$

$\therefore = 35.8316 \text{ to } 39.2084$

$= 35.83 \text{ to } 39.21$

37.52 is within the range and hence student's value is consistent.

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Examiner Comments

This candidate was one who made quite a common mistake, which was to calculate the range of possible values for the A_r of M very effectively, but then relate the experimental value to this range, stating that it was within it. It will be, of course, as this was the value used as the centre of the range! A comment such as '39.1 lies within this range' would have scored the third mark.

This was a second common type of mistake. The final comment is the correct one and fits nicely with the mark scheme, but the value used (39.1) for the calculation is not correct.

(ii) The **second** student calculated the A_r value of M to be 37.52 with a total percentage uncertainty of 4.5%.

Comment on the value of 37.52 obtained by this student by calculating the range of values of A_r.

(3)

39.1 39.1
Range = 37.52 + 4.5% × 37.52

= 39.21 40.86

39.1 39.1
∴ 37.52 − 4.5% × 37.52

= 35.83 37.34

Range = 39.21 − 35.83 40.86 − 37.34

The ~~students~~ student's value is within the range. So the calculated value is accepted

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Examiner Comments

The candidate has used the range around the actual A_r of potassium rather than of the student's value. Most unfortunately the correct values and hence answers have been crossed out and replaced!

The method is correct so scores the first two marks.

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Examiner Tip

Clearly show what you are doing in your calculations by labelling the calculations (e.g. range = ...). This makes it much more likely that you will be awarded marks for your calculation processes if the numbers used are not quite correct.

Question 2 (b)(iii)

This question focussed on percentage uncertainty. Most candidates who had a good understanding of what percentage uncertainty is will have scored both marks here. The best candidates were able to justify the change in percentage uncertainty when the titre volume increased, even though this was a step further than was required by the mark scheme.

This item requires an understanding of percentage uncertainty. It is related to, but not the same as, the idea of improving accuracy in Q01(c). As an 'explain' question, an element of explanation is required for the marks to be scored.

This example exemplifies candidates relying on experiment error rather than percentage uncertainty. The first results from mistakes made during the practical, whilst the second comes about due to the uncertainty of values obtained due to the manufacturing of equipment, such as glassware.

(iii) The **first** student suggested that the burette was the biggest source of experimental uncertainty.

Explain how the percentage uncertainty of the burette reading could be reduced without changing the apparatus or simply repeating the experiment.

(2)

Making sure the HCl reaches the tip of the burette by opening the tap until the solution reaches the tip. (Accurate reading of starting volume).

Reading volume from bottom of meniscus (ensures correct initial and final volume of the burette are read ~~out~~ correctly)

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Examiner Comments

This candidate has correctly identified two sources of error in the titration readings. Experimental errors are not, however, experiment uncertainties.

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Examiner Tip

Learn the differences in the key terminology associated with error and uncertainty in practicals.

(iii) The **first** student suggested that the burette was the biggest source of experimental uncertainty.

Explain how the percentage uncertainty of the burette reading could be reduced without changing the apparatus or simply repeating the experiment.

(2)

increasing the mass of ~~XX~~ increase the size or mass decrease the amount of acid, which gives more $MHCO_3$, which decreases the percentage uncertainty

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Examiner Comments

This candidate seems to have recognised that the volumes recorded are the significant factor, but the answer given lacks clarity and precision. No marks are scored.

(iii) The **first** student suggested that the burette was the biggest source of experimental uncertainty.

Explain how the percentage uncertainty of the burette reading could be reduced without changing the apparatus or simply repeating the experiment.

(2)

Using more volume of the hydrogen carbonate increases the value of the mean titre. A larger mean titre reduces the percentage uncertainity.

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Examiner Comments

This candidate clearly recognises that it is the percentage uncertainty of the reading of volume, which is reduced as the volume read becomes larger, which is key. Their suggested improvement, increasing the volume of the $MHCO_3$ solution, was allowed, though not the best. Nevertheless, both marks were scored.

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Examiner Tip

On 'explain' questions you must do just that. The second sentence explains why the first sentence results in reduced percentage uncertainty.

Question 2 (b)(iv)

The construction of a standard solution is a question very commonly asked at this level, and many candidates had clearly prepared well and knew how to approach their answers.

This example was the expected type of response and scored full marks.

(iv) The **second** student was told that using a beaker to prepare their standard solution was incorrect.

Describe the steps the student should take to make a standard solution as accurately as possible.
Assume that the student is supplied with 2.00 g of $MHCO_3$ in a weighing bottle and the usual laboratory glassware.

(4)

1. transfer 2.00 g of $MHCO_3$ to a beaker and reweigh
2. add 100 cm^3 of deionised water to the beaker and dissolve $MHCO_3$ while stirring it with a stirring rod
3. transfer the solution to a 250 cm^3 volumetric flask
4. rinse the beaker with a washing bottle and transfer the washings to the volumetric flask
5. fill the volumetric flask up to the 250 cm^3 mark
6. invert the flask mutiple times to ensure uniform solution

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Examiner Comments

Details are important. The most commonly omitted are the need to rinse the glassware to ensure all the solution, and hence all the $MHCO_3$, is transferred to the volumetric flask and the final mixing of the solution.

Learn the common processes which are commonly asked about in examinations. This is one, recrystallisation is another.

This candidate has a good idea of the required steps in this process, but the answer lacks the necessary precision.

(iv) The **second** student was told that using a beaker to prepare their standard solution was incorrect.

Describe the steps the student should take to make a standard solution as accurately as possible.
Assume that the student is supplied with 2.00 g of $MHCO_3$ in a weighing bottle and the usual laboratory glassware.

(4)

The salt acid $MHCO_3$ should be placed in a beaker and filled with still water until $150cm^3$ then mix to make sure its dissolved. Transfer it to a measuring cylinder and add the remaining $100cm^3$ and mix. The However the weighted bottle should be weighted alone first then with the salt to see how much salt there is.

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Examiner Comments

Firstly, the glassware needed is the volumetric flask. Secondly the volume of water required to make the solution is unlikely to be 250 cm^3. The addition of water should be to make the solution volume to 250 cm^3. The candidate has, however, dissolved the solid prior to preparing the standard solution and so was able to score 1 mark.

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Examiner Tip

Use a volumetric flask for preparing standard solutions. The steps involved ensure all the measured mass of solid ends up in a solution of exactly 250 cm^3.

(iv) The **second** student was told that using a beaker to prepare their standard solution was incorrect.

Describe the steps the student should take to make a standard solution as accurately as possible.
Assume that the student is supplied with 2.00 g of $MHCO_3$ in a weighing bottle and the usual laboratory glassware.

(4)

1) The student should Rinse glass ware with distilled or deionized water
2) student should fill ~~beaker~~ ~~pipette~~ beaker 250cm3 with 2.00g of MHCO3 ~~solution~~ and make rest up with water
3) student should then use pipette to obtain 25cm3 of solution filling to ganulated mark (diluted solution)
4) student moves solution into burette.

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Examiner Comments

There were no marks given for this example

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Examiner Tip

Help students to understand problem solving.

Question 2 (c)(i)

This item was a straightforward one, requiring the identification of the flame test as the way to check the identity of M. The flame test is first encountered at GCSE and is enjoyed as a practical activity by most students, as a result this type of question is often answered very well.

Most candidates, including this one, were able to score both marks on this item.

(c) The solution formed from the reaction between $MHCO_3$ and HCl can be evaporated to give a white solid, MCl.

(i) State the test the students might use on the white solid to show that M was potassium. Include the expected result.

(2)

use of flame test and the expected result is a lilac ~~purple~~ flame

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Examiner Comments

This candidate answered correctly with lilac as the flame colour for potassium. Purple is not acceptable and does not score the second mark as a description of potassium's flame colour.

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Examiner Tip

Learn the expected flame colours for the Group 1 and Group 2 ions.

Question 2 (c)(ii)

This question required care. The candidates were asked to describe the test and the expected result, on the white solid. Most described the test they would perform on a solution of the white solid, and failed to recognise that they needed to dissolve the solid first for the test to work effectively. Nevertheless, two marks, for the use of silver nitrate and the resulting white precipitate, were very commonly scored.

This example was typical of the most common response and scored 2 out of 3 marks. The use of ammonia as a confirmatory test was ignored. The use of concentrated sulfuric acid present in the mark scheme was rarely used by candidates.

(ii) Describe a test and the expected result to confirm the presence of the chloride ion in the white solid.

(3)

- add acidified Silver nitrate ($AgNO_3$) to a solution of the white solid
- white precipitate forms
- add dilute ammonia (few drops), precipitate dissolves in ammonia so solution goes clear

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Examiner Comments

Think carefully about the tests on ions. The tests must be applied in the right way to ensure an effective test and result to score full marks. This candidate has recognised the need for a solution of the white solid but does not say how this is formed. This prevents scoring the first mark. There is no mention of the use of nitric acid, which also prevents the first mark from scoring.

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Examiner Tip

Practice application of tests in different circumstances to ensure full marks are scored.

Question 3 (a)

The first item in Q3 was to identify the most appropriate piece of glassware to measure cyclohexanol volume for the experiment. The procedure says 'approximately 12 cm^{3}'. This should prompt the candidates that the volume is not particularly precise, being only 2 significant figures, and the word approximately is used. This suggests that glassware with relatively large uncertainty, such as a measuring cylinder, will be sufficient to measure this volume. A pipette has a low uncertainty, and a 12.0 cm3 pipette is rare, so is not the most appropriate. A burette will measure 12.0 cm3 with low uncertainty, so we allowed this, even though it requires setting up, rinsing, filling etc. so is not the most appropriate.

This candidate had the right idea.

(a) Give the most suitable piece of apparatus for measuring the cyclohexanol in Step **1**.

(1)

measuring tube

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Examiner Comments

The piece of glassware is called a measuring cylinder, so measuring tube is not sufficient and does not score.

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Examiner Tip

Learn the proper names for equipment, when they should be used and how to draw them.

Beakers were a common answer.

(a) Give the most suitable piece of apparatus for measuring the cyclohexanol in Step **1**.

(1)

25 cm^3 beaker

A 25cm3 beaker will probably not have a graduation at 12.0 cm3, so measuring will be very approximate. The uncertainty on a beaker is extremely large, so it is very rarely appropriate to measure a volume using a beaker.

Question 3 (b)

Since this paper focusses on practical work, understanding why we take the steps we do in a procedure is an important part of this process. This item looks at the mixing of two reagents which result in an exothermic reaction and so required cooling. This is a common step in AS and A-level chemistry practicals. Candidates often focussed on the mixing of the reagents and reaction rates without identifying how the step would affect the yield of cyclohexene. Those that recognised that the exothermic nature of the reaction was important then often focussed on the effect on the reactant, cyclohexanol, which has a relatively high boiling point and low volatility compared to cyclohexene, the product of the reaction. Cyclohexene is therefore the substance likely to evaporate and be lost.

This candidate provided the expected answer and scored both marks.

(b) Explain why adding phosphoric(V) acid slowly, with cooling and swirling, in Step **2** results in a higher yield of cyclohexene.

(2)

The reaction is exothermic, some of cyclohexene may be lost due to evaporation due to high temperatures. To avoid high temperatures which lead to loss of product we add it drop by drop with cooling and swirling to minimise temperature increase hence this increases the yield of cyclohexene.

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Examiner Comments

This is an excellent answer which has identified the main feature of this mixing and the effect on the yield of product.

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Examiner Tip

Think carefully about the contents of reaction mixtures. In practical situations you will often not be familiar with the procedure that is happening and must apply your knowledge and skills to the situation presented to you.

Any situation which identifies whether a reaction is exo or endothermic is likely to trigger answers which focus on the shift in the position of an equilibrium. If a reaction has not been identified as an equilibrium in the question or in an answer this is unlikely to score marks.

(b) Explain why adding phosphoric(V) acid slowly, with cooling and swirling, in Step **2** results in a higher yield of cyclohexene.

(2)

As it is an exothermic reaction, lower temperature would favour the exothermic reaction leading to a higher yield of cyclohexene.

ResultsPlus
Examiner Comments

This candidate scores a mark for recognising the reaction is exothermic and has then answered in terms of equilibrium. Though there is some good logic being used here, the subsequent distillation of the reaction mixture would counter this argument. Equilibrium has not been mentioned and so this does not score.

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Examiner Tip

Use equilibrium type arguments only if a reaction is clearly identified as an equilibrium.

Question 3 (c)

This question focusses on the use of anti-bumping granules, but asks about why bumping should be avoided. It is therefore looking at the effect of bumping not on what bumping is. Answers describing bumping as uneven boiling or similar therefore would not score on their own but required how this would effect the process.

This candidate, presumably a little unsure of the way forward, has provided a list of possible reasons for adding anti-bumping granules.

(c) In Step **3** anti-bumping granules are present to promote smooth boiling in the mixture.

Give a reason, other than damage to equipment, why bumping should be avoided.

(1)

- To avoid build up of pressure
- To avoid large gas bubbles
- To avoid electrons from colliding and releasing energy
- To get more yield

ResultsPlus
Examiner Comments

This item asks about the reason to avoid bumping. Consequently, these suggestions do not score as they do not consider the effect of bumping happening.

ResultsPlus
Examiner Tip

Read the question carefully and ensure that you answer this question rather than one with which you may be more familiar.

This was a very common type of argument, focussing on the spilling of reaction mixture from the apparatus. Answers like this often also considered the possible safety implications of this happening.

(c) In Step **3** anti-bumping granules are present to promote smooth boiling in the mixture.

Give a reason, other than damage to equipment, why bumping should be avoided.

out of the flask (1)

It may cause the solution to spit, possibly resulting in loss of product.

ResultsPlus
Examiner Comments

This candidate has the right idea, but as this is a distillation process the apparatus is closed to the condenser. Consequently, it is unlikely for the solution to escape from the flask. Instead, the solution will enter the condenser and become part of the collected product.

ResultsPlus
Examiner Tip

If you are unsure about the reason for carrying out a step in a practical procedure, check with your teacher. All the steps are important and any of the processes might be asked about in an examination.

Question 3 (d)

This proved challenging for some candidates. The first marking point required an explanation of how the range related to the evaporation and boiling points of cyclohexene, which it includes, and water and cyclohexanol, which are substantially above. The second marking point is for showing how this would affect the resulting distillate.

This answer focusses on the effect of the range on water, without saying how it relates to the cyclohexene. Remember that the range and boiling temperatures were given in the question so simply quoting these without explanation will not score marks.

(d) Explain why, in Step **4**, the distillate is collected in a temperature range of 80 °C to 90 °C.

(2)

Substance	Boiling temperature / °C
Cyclohexanol	162
Cyclohexene	83
Water	100

because cyclohexene which is distillate boil at temperature 83°C which is within the rang of 80°C to 90°C and at higher temperature than 90°C water will be at distillate also.

ResultsPlus
Examiner Comments

This item scores the second marking point by suggesting that water will distil across above 90°C, but does not score the first as it does not say how the range is related to the boiling point of cyclohexene.

ResultsPlus
Examiner Tip

Remember to use the information provided, not just requote data already given to you.

This candidate just scores both marks.

(d) Explain why, in Step **4**, the distillate is collected in a temperature range of 80 °C to 90 °C.

(2)

Substance	Boiling temperature / °C
Cyclohexanol	162
Cyclohexene	83
Water	100

Boiling temperature of cyclohexene is 83°C, lower than the others. 80° C to 90°C ensures only cyclohexene is boiled, not water or cyclohexanol, since they both have a boiling temperature greater than 90°C.

ResultsPlus
Examiner Comments

The first mark is scored right at the end where the statement that water and cyclohexanol have a boiling point greater than 90°C completes that point. The statement that only cyclohexene is boiled was just allowed as an equivalent to no water or cyclohexanol would distil across.

Question 3 (e)(i)

The substance being removed by sodium carbonate and an equation for the reaction were required here. Ionic is in bold and so an ionic equation was required. Most candidates recognised this.

This was a typical example of a candidate gaining credit with a rather general answer. Unfortunately, this candidate makes no attempt to provide an equation. They possibly did not fully read the question.

(e) (i) State what is removed by washing the mixture with sodium carbonate solution in Step **5**.
Include an **ionic** equation for the reaction.
State symbols are not required.

(2)

• Remove the acid by neutraliging it

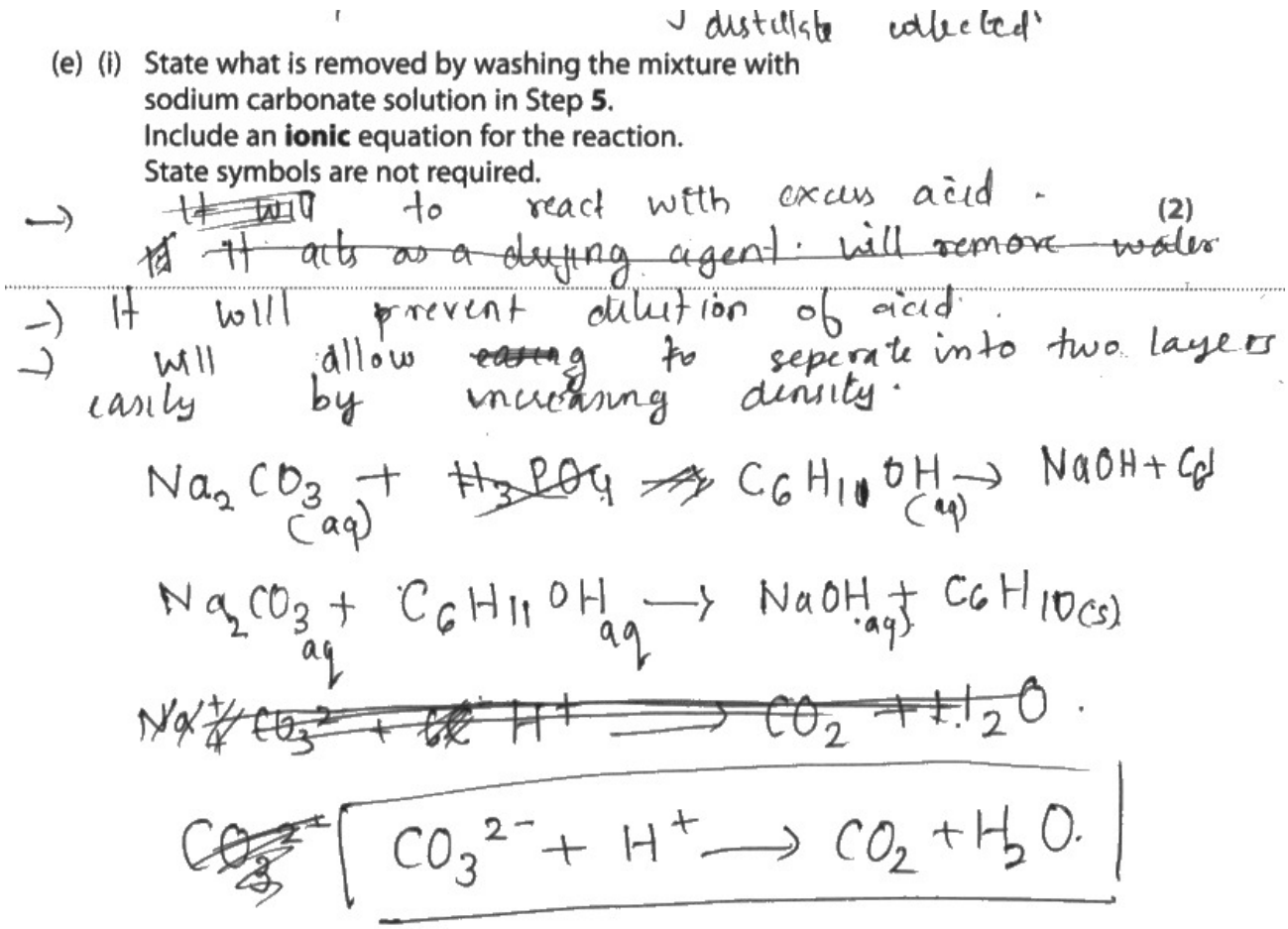
ResultsPlus
Examiner Comments

Candidates were able to score with the word 'acid', even if they were unsure what the acid was. An equation is possible even if the exact nature of the acid is uncertain, using H^+ in the equation.

ResultsPlus
Examiner Tip

Read the question carefully, noting any words in bold. Emboldening is done to help clarify what answer is required.

This answer has multiple parts to it. In general, these will be treated as a list, and any incorrect comments will negate correct ones. Notice that for the final equation, however, the answer is in a box.



ResultsPlus
Examiner Comments

The first sentence (react with excess acid) is correct. The remaining statements seem irrelevant to the question so were ignored. The equations involving cyclohexanol were ignored as the final equation looks like the candidate's final answer because of the box. It is close to being correct but does not balance (it needs a 2 before H^+).
This scored 1.

ResultsPlus
Examiner Tip

Remember that lists of answers will all be marked, and incorrect ones may negate correct answers.

Question 3 (e)(ii)

The diagram in this item is one of the straightforward diagrams which are asked for in this type of paper. Separating funnels are quite variable in their construction, and the candidates answer fully reflected this. Some, however, were clearly drawing other glassware such as filter funnels. Some even drew totally sealed systems. The quality of diagram was quite poor, and this is one area which would benefit from further instruction and exemplification in future sessions.

Separating funnels are often quite cylindrical. This diagram is typical of that type of funnel and is very neatly drawn, with a clear stopper and tap.

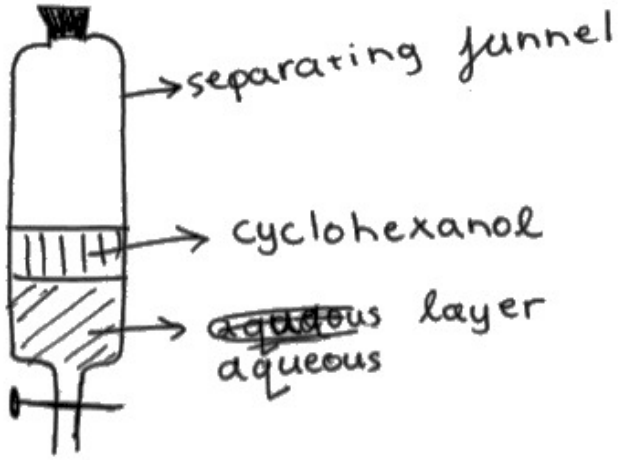
(ii) **After the washing in Step 5, the separating funnel contains two layers.**

Draw a diagram of the separating funnel, labelling its contents.

(2)

Substance	Density / g cm^{-3}
Cyclohexanol	0.96
Cyclohexene	0.81
Water	1.00

* lower density on top



ResultsPlus
Examiner Comments

This scores 1 for the labelled layers. There is no tap on this funnel so the first marking point could not be scored.

ResultsPlus
Examiner Tip

Learn to draw accurately the common practical glassware and set-ups. Use a ruler and labels where appropriate.

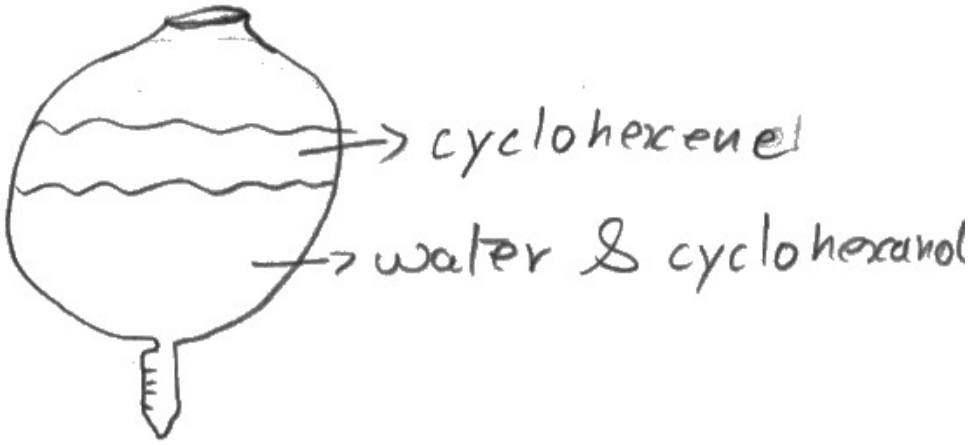
Separating funnels can also look like bulbs, as in this diagram. This is not so realistic as the previous example. The gap at the top might be able to take a bung, so would have been accepted, though it is not the best way to show this aspect. This type of gap, left at the top, was common to many answers. A joint would have been an improvement.

(ii) **After the washing in Step 5, the separating funnel contains two layers.**

Draw a diagram of the separating funnel, labelling its contents.

(2)

Substance	Density / g cm^{-3}
Cyclohexanol	0.96
Cyclohexene	0.81
Water	1.00



ResultsPlus
Examiner Comments

This scores 1 for the labelled layers. There is no tap on this funnel so the first marking point could not be scored.

ResultsPlus
Examiner Tip

Most glassware in organic synthesis procedures will have joints. Learn to draw these as it makes your diagrams easier to understand and more accurate.

Question 3 (e)(iii)

There were several ways to answer this item correctly. Cyclohexanol and sodium carbonate were the answers most given.

(iii) Suggest what might be removed by washing the product with deionised water in Step **6**.

(1)

Impurities such as [redacted] cyclohexanol

ResultsPlus
Examiner Comments

This scores 1. Many candidates simply answered with 'Impurities' or 'Insoluble impurities'.

Question 3 (f)

Questions about drying agents are common, but this was a slightly unusual approach. Many candidates were able to identify MgSO4 as the best reagent, but fewer were able to say why it was good. The very best candidates were able to list both the correct answer (that it was anhydrous) and that it would not react with organic compounds and that it was insoluble in them, all of which were necessary features but were not expected in this item. Calcium hydroxide, $Ca(OH)_2$, was probably the most common incorrect answer.

Typical of a fully correct answer.

(f) Identify from the list shown **one** substance that could be used as a drying agent in Step **7** of this procedure. Justify your choice.

(2)

$C_2H_5OH(l)$	$Ca(OH)_2(s)$	$CuSO_4.5H_2O(s)$
$H_2SO_4(l)$	$MgSO_4(s)$	$Na_2SO_4.10H_2O(s)$

MgSO4 as it is an anhydrous ionic salt.

ResultsPlus
Examiner Comments

The fact that it is an ionic solid is not relevant but correct so can be ignored.

An example quoting $Ca(OH)_2$.

(f) Identify from the list shown **one** substance that could be used as a drying agent in Step **7** of this procedure. Justify your choice.

(2)

$C_2H_5OH(l)$	$Ca(OH)_2(s)$	$CuSO_4.5H_2O(s)$
$H_2SO_4(l)$	$MgSO_4(s)$	$Na_2SO_4.10H_2O(s)$

Ca(OH)2 it won't react with the organic layer.

ResultsPlus
Examiner Comments

This example quite correctly says that it won't react with the organic layer, which though correct would not have scored the mark anyway. In any case, as the incorrect reagent has been chosen the second mark is not accessible.

Question 3 (g)(i)

This proved to be a very straightforward item for most candidates towards the end of the paper. Most knew that bromine water was the reagent and that it would decolourise. The most common colour change given was brown to colourless. This is not correct but is acceptable. Bromine water is never brown, it is the element bromine which is. Bromine water is orange or yellow, depending on the concentration. The second alternative using potassium manganate(VII) was rarely seen.

The most common answer was bromine water turns from brown to colourless.

(g) Chemical tests may be used to show whether or not reactants and products are present during the course of the procedure.

(i) State a chemical test and the expected observation for a C=C double bond.

(2)

bromine water, the colour will change from brown to colourless.

ResultsPlus
Examiner Comments

This scores 2 as an allow as the correct answer is orange to colourless.

ResultsPlus
Examiner Tip

Learn all the tests and expected results in the specification.

Where bromine or Br_2 were given as the test instead of bromine water only brown to colourless was the acceptable observation.

(g) Chemical tests may be used to show whether or not reactants and products are present during the course of the procedure.

(i) State a chemical test and the expected observation for a C=C double bond.

(2)

[redacted] Bromine test where Br_2 is added and if there is a C=C present the color change will be from brown to colorless.

ResultsPlus
Examiner Comments

This scores 2. The colour change is correct for the stated reagent.

Question 3 (g)(ii-iii)

In (g)(ii) the use of phosphorus pentachloride was commonly recognised. Potassium dichromate was the most common incorrect answer given. Sodium was seen on occasion as the reagent, and the formation of esters was sometimes used as a test and could score full marks.

The second part of this section, (g)(iii), was less well understood, with few candidates recognising the presence of water would cause a positive result with the PCl_5 and thus negate the test.

This example gives a list of possible tests in (g)(ii) and (g)(iii) is not an answer which can score a mark.

(ii) State a chemical test and the expected observation for an –OH group.

(2)

Potassium dichromate would turn green to orange in presence of hydroxide ions.

PCl5 will be added and white misty fumes would be shown.

(iii) State whether or not the test in (g)(ii) could be used on the organic product to show if cyclohexanol remains when Step **5** is complete.
Justify your answer.

(1)

it could but it might react with the sodium carbonate.

ResultsPlus
Examiner Comments

Though the PCl_5 test would have scored 2 marks, the second test is included, and the list principle means that this cannot score. (g)(iii) is not worth a mark.

ResultsPlus
Examiner Tip

If a question asks for a chemical test, only one should be given. Additional tests, if incorrect, may negate marks scored in the correct one.

This is perhaps the most common set of answers for this pair of items.

(ii) State a chemical test and the expected observation for an –OH group.

(2)

PCl_5 misty steamy fumes of HCl

(iii) State whether or not the test in (g)(ii) could be used on the organic product to show if cyclohexanol remains when Step **5** is complete.
Justify your answer.

(1)

Yes because the organic product doesn't contain an OH group so if misty fumes is formed that is due to the presence of cyclohexanol

ResultsPlus
Examiner Comments

Two marks are scored in (g)(ii) but the final answer saying that the test will work, whilst true, is not correct as water will also give a positive result so the test will not work in this situation.

Paper Summary

Based on their performance on this paper, candidates are offered the following advice:

- develop practical skills by completing as wide a range as possible of different experiments requiring a variety of different techniques
- practice diagrams of the techniques used to use past papers as examples of diagrams
- understand the reasons for choosing and using particular techniques
- where information and data are provided it is expected that the data will be used. There is rarely any credit for simply requoting the data unless selecting from a large amount of data
- read each question carefully and double-check that the answer matches the requirements of the question
- endeavour to set out answers to all types of question in a logically structured format including labels on diagrams and in calculations to ensure work is clearly understood.

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