Commentary on candidate 1 evidence

Determination of Calcium Carbonate Content of various eggshells using Back Titration

The evidence for this candidate has achieved the following marks for each section of this course assessment component.

Section	Mark available	Mark awarded	Comments
1 Abstract	1	1	The aim and findings have been given and these are consistent with the conclusion. The results are quoted as % purity, which is not what the candidate determined, but as the conclusion given in the abstract is consistent with that given in the conclusion section, the mark was awarded.
2 Underlying chemistry	3	2	Overall, the candidate has demonstrated a **reasonable** understanding of the underlying chemistry of the project. Relevant underlying chemistry includes: ♦ A good description of back titration, with an exemplar calculation and relevant balanced equations included. ♦ A description of making a standard solution and of primary standards is included. On page 6, the candidate correctly states that due to the insolubility of calcium carbonate a back titration must be carried out, but in relation to standard solutions, they state that it is a primary standard, that was made into a standard solution. ♦ Indicator chemistry – however, this could have been further expanded to explain why phenolphthalein is a suitable indicator. How the colours of phenolphthalein arise could also have been included.

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				♦ A definition of Bronsted-Lowry is given and it correctly describes the reaction involved in the project as an acid-base reaction, but the example given is for water. The candidate included additional information that was not relevant. This irrelevant information was not considered when awarding the marks for this section: ♦ resonance structures for carbonate ion are given and an attempt to explain these using sigma and pi bonding ♦ orbital box notation ♦ rules for electronic configuration ♦ quantum number information ♦ weak acid and pH of weak acid % purity is an incorrect term and it is used throughout the project.
3 Data collection and handling	2	a	1	There is only one procedure given. The procedure does not contain the details of the titration end point colour changes which are required to follow the procedure, and so two marks could not be awarded. The titration colour changes are included in the results section. There is no indication given as to what the 25 cm^3 samples were pipetted into or whether all four samples were pipetted into the same flask. However, an Advanced Higher candidate could repeat the procedure and this information is clear when you look at the results section, and so one mark was awarded.

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	1	b	1	One mark was awarded as all the chemicals requiring additional safety measures have been included with justification. 1 M HCl and phenolphthalein have been included in the risk assessment, however, as these would not require additional safety measures, these did not need to be included.
	1	c	1	A modification with evidence (titration results were too small, they were less than 5·0 cm^3) was carried out and so one mark was awarded. A control experiment was carried out. Although the control was discussed in the evaluation it was not used to give an explanation as to whether the egg shell values would have had lower or higher values based on these results. The results of the control experiment could also have been used to calculate the final % values. The control experiment on its own would not have been awarded this mark.
	1	d	1	All three egg types were duplicated. The control experiment has not been duplicated but this was not required.
	1	e	0	Although masses have been measured to an appropriate level of accuracy for this procedure, the candidate has not detailed what the 1·00 g of calcium carbonate or egg shell was weighed into and there is no mention of how it was transferred. The procedure does not mention how the 25 cm^3 HCl was measured and so this mark was not awarded. From this information it was not possible to award the accuracy mark as there is no evidence that the methods used are accurate.
	1	f	1	Raw data has been recorded for titrations with initial and final burette readings. Although the colour change for the titration has not been given in the procedures section, this was dealt with in section 3(a). Colour changes for the titrations have been given on page 14 and so the mark for raw data was awarded.

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	1	g	0	Numerical data is appropriately presented; however, the table on page 20 has an incorrect heading. % purity is not the correct term (see conclusion section); however, the mark was not awarded as the heading % purity is an incomplete heading.
	1	h	0	The cited references given on pages 4, 5, 6 and 8 are listed correctly at the end of the report, but the citations have been given as full URLs and this is not a relevant referencing system.
4 Data analysis	4	a	3	The data analysis section is marked holistically. Only one type of chemical calculation is used, however, this is a back titration and uses two different mole ratios and concentrations, and these were carried out on three separate samples (x2 for duplicates) as well as a control. There is also a graph plotted. This is acceptable as an Advanced Higher level of analysis. The average titre volumes have been rounded to 1 decimal place, which is an acceptable number of significant figures and the rounding has been carried out correctly. There are a number of small errors in the data analysis. ♦ There are two small errors in calculating titre volumes: – Free range 1 titre 1 should be 10·5 and if this was disregarded the average titre would be 11·3 not 11·4. This would give a final % of 96·8 rather than the 96·6% quoted, however, this was regarded as being a small error in the final calculated value.

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				– Free range 2 titre 2 should be 11·5 although average titre would stay 11·4. ♦ The calculation for the control experiment uses 0·05 $moll^{-1}$ NaOH but in the table of raw data on page 11 the concentration is quoted as being 0·1 $moll^{-1}$. The procedure on page 9 also quotes 0·05 $moll^{-1}$. The calculation that has been carried out is correct for the values used (see bullet below), however, the titre volumes obtained as well as the calculated answer all suggest that the concentration was 0·1 $moll^{-1}$ NaOH that was used. This would give a final answer of 98·6% calcium carbonate. ♦ The number of moles $CaCO_3$ for control should be 0·0112 (not 0·01112) but the correct value was used in the calculation. ♦ A bar chart has been presented which is an appropriate graph for this data and it has the minimum number of bars, so is acceptable. The grid lines are appropriate and although the axis label is % purity – this matches with the table of data used to generate the graph given on page 20. There is an issue with the labelling of the bars – incorrect rounding applied – for example, duck egg should be 99·45% to 4 significant figures and not the 99·50% that has been labelled (the plotting is correct for the calculated values).
	1	b	1	The final percentages are 3 significant figures and the lowest data measured was 2 significant figures, and so the final values are within the accepted range.
5 Conclusion	1	0		The conclusion relates to the aim, however, the % purity term is not valid as these values are % by mass of calcium carbonate and do not relate to purity.

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6 Analysis	1	0	There is no comparison to literature values and these are obtainable from the internet.
7 Evaluation	4	3	Uncertainties of pipette, burette, standard flask and balance is given and % uncertainties calculated but not combined – one mark awarded. The following are valid evaluative statements with justification. ♦ Statement: 'This could have altered the volume of acid required to react with the base.' Justification: '…it was not possible to remove all membrane from the eggshell before it was reacted with acid.' ♦ Statement: 'This could mean some Calcium Carbonate went unreacted and therefore is not included in calculations, leading to inaccurate results.' Justification: 'It is possible that not all of the eggshell dissolved in the acid in the first part of the procedure.' The following evaluative statements have been made but an appropriate justification has not been given. ♦ Statement: 'I kept the rough titre to hand so that a direct comparison could be made.' Justification: 'To ensure a similar end point was reached on each titration …' This statement has not been justified in terms of the candidate's results. The candidate could have justified this by saying that the results obtained were concordant and the end point colour was the

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			same for each titration. ♦ Statement: 'My results were valid in that they were close to this (control) value and did not go over 100%.' Justification: 'The control experiment I carried out gave a % purity value of more than 100%.' The candidate has not shown an understanding that if the control experiment gave greater than 100%, then the actual values obtained for the egg shells are likely to be higher than the actual % calcium carbonate present in the egg shells. ♦ Statement: 'A possible reason for gaining a value of more than 100% …' (in the control) Justification: '…more than one base was present in the eggshell.' The justification given is incorrect as is the statement – the egg shell values were not more than 100%. This applies to the control only. The candidate has not appreciated that the presence of another base in the egg shell would lead to a higher than actual % calcium carbonate content. In addition, the following justification has been given but the evaluative statement is not valid. ♦ Statement: '…less than 1·00g was actually reacted with the acid leading to inaccurate results.' Justification: 'It is possible that the eggshell was not completely dry before being weighed.'

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			A valid statement would need to be linked to the results obtained and the candidate's results do not support this statement. If a smaller mass than 1·00g was used in the calculations, the final values would be lower.
8 Structure	1	1	Title, contents page and page numbers are given.
Total	**25**	**16**	