National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Exemplar for Internal Achievement Standard

Chemistry Level 3

This exemplar supports assessment against:

Achievement Standard 91387

Carry out an investigation in chemistry involving quantitative analysis

An annotated exemplar is an extract of student evidence, with a commentary, to explain key aspects of the standard. It assists teachers to make assessment judgements at the grade boundaries.

New Zealand Qualifications Authority

To support internal assessment

	Grade Boundary: Low Excellence

1.	For Excellence, the student needs to carry out a comprehensive investigation in chemistry involving quantitative analysis.
	
	This involves:
	
	• accurate processing of the data using appropriate significant figures and units
	• presenting a report that shows evidence of justifying the steps used in the procedure in relation to the reaction(s) occurring and to the nature of the samples being analysed
	• a comprehensive evaluation of the investigation that includes a selection from:
	  ◦ evaluation of the reliability of the data by considering the procedure used and possible sources of error
	  ◦ justification of how the processed data supports the conclusion(s)
	  ◦ linking the conclusion(s) to chemical principles and/or real life applications.
	
	This student has accurately processed data using appropriate significant figures and units (1), evaluated the reliability of the data by considering the procedure (2) and possible sources of error (3), and attempted to justify how the processed data supports the conclusion(s) (4).
	
	For a more secure Excellence, the student could link the conclusion(s) to chemical principles and/or real life applications.

Student 1: Low Excellence

NZQA Intended for teacher use only

Purpose:

To investigate by quantitative analysis, the variation in the concentration of Vitamin C (in gL^{-1}) of "Just Juice Orange and Mango" juice when heated to 20, 40, 60, 70 and 80 degrees Celsius for 10 minutes.

Calculations:

These are sample calculations, all calculations done are in log book.

Actual concentration of $S_2O_3^{2-}$

Using: $IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

$n(IO_3^-) = c \times V = 0.0100 \times (25/1000) = 2.5 \times 10^{-4}$

$n(I_2) = 2.5 \times 10^{-4} \times 3 = 7.5 \times 10^{-4}$ mol

Using: $2S_2O_3^{2-} + I_2 \rightarrow 2I^- + S_4O_6^{2-}$

$n(S_2O_3^{2-}) = 2 \times 7.5 \times 10^{-4} = 1.5 \times 10^{-3}$ mol

$c(S_2O_3^{2-}) = n/V = (1.5 \times 10^{-3}) / 0.0293333 = 0.051136364$ $molL^{-1} = 0.0511$ $molL^{-1}$ (3sf)

This concentration will be used for further calculations

Part A – calculation of blank titration:

$V(S_2O_3^{2-}) = 0.02925$

n = c/V therefore $n(S_2O_3^{2-}) = 0.0511 \times 0.02925 = 1.494675 \times 10^{-3}$

$n(I_2$ total$) = ½ \times 1.494675 \times 10^{-3} = 7.47335 \times 10^{-4}$ mol

This represents the maximum number of moles of iodine formed when no vitamin C is present.

Part B – calculation of back titration:

20°C

$n(I_2) = 7.47335 \times 10^{-4}$

$n(S_2O_3^{2-}) = 0.0511 \times 0.018167$ (average at this temperature)

$n(S_2O_3^{2-}) = 9.283337 \times 10^{-4}$ mol

$n(I_2$ remaining$) = ½ \times 9.283337 \times 10^{-4} = 4.6416685 \times 10^{-4}$

Vitamin C reacts with iodine at a 1:1 mole ratio. This means that calculating the number of I_2 moles that reacted with vitamin C, the number of moles of vitamin C can be calculated.

So:

$n(I_2$ reacted with vit C$) = n(I_2$ remaining$) = 7.47335 \times 10^{-4} - 4.6416685 \times 10^{-4} = 2.8317065 \times 10^{-4}$ mol = n(vitamin C)

c(vitamin C$) = n/V = 2.8317065 \times 10^{-4} / 0.1 = 2.8317065 \times 10^{-3}$ $molL^{-1}$

c(vitamin C in $gL^{-1}$$) = 176 \times 2.8317065 \times 10^{-3}$ (where 176 is the molar mass of vitamin C in g $mol^{-1}$$) = 0.498$ gL^{-1}

1

Final Evaluation:

From the data obtained in the experiment and from the graphs of the data we can see that there is quite a strong negative relationship between the temperature of the juice and the vitamin C content of the juice. The lowest temperature of 20°C had a vitamin C concentration of 0.498 gL^{-1}, and the highest temperature of 80°C had a concentration of 0.275 gL^{-1}.

The procedure used for this investigation was the analysis of the amount of vitamin C in juice using an iodine-thiosulfate back titration. The iodine used was produced by reacting KIO_3 with KI as it would have been too difficult to handle an iodine solution.

$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

Using this method of indirectly producing iodine the known number of moles in the solution is more accurate.

In the original method, the concentration of sodium thiosulfate was 0.100 $molL^{-1}$. However it was determined that this concentration of thiosulfate meant that the range that the number of moles of iodine would decrease was too small to determine an accurate difference, therefore it was decided to use a concentration of approximately 0.0500 $molL^{-1}$.

2

Quite a few uncertainties were removed from the experiment. We did this by always using the same equipment in each titration which meant that no other solutions could contaminate the equipment. We made sure we used the same solutions for sodium thiosulfate and potassium iodate because of the risk of slightly different solutions if we made batches. We made sure to use the same bottle of juice for the first set of titrations to make sure there was no variance in the amount of vitamin C before even heating it, and then we used a different bottle of juice for the second titration to make sure the first bottle of juice was an appropriate representation of that brand of juice. One thing that could have possibly affected the results was the fact that it was very hard to hold the juice at a consistent temperature for 10 minutes; however the temperature never fluctuated more than about 2 degrees from the target temperature, therefore probably did not affect the trend of the data. We also made sure to carry out the titration as immediately after all solutions and juice were set up so that the vitamin C would not oxidise in the conical flask before titrating possibly giving us a bad result.

3

From research we expected that vitamin C will oxidise faster under heated conditions. This is due to it being one of the least stable vitamins in solution. As time and temperature increase the concentration of vitamin C decreases. Temperature increases the rate of oxidation. The conclusion of this report is valid as we got a constant trend in the data in the direction that we were expecting, and the concordance of all titres being very close to each other's values. The graphs show a negative relationship between the two variables, showing that as temperature increases, the concentration of vitamin C decreases.

4

	Grade Boundary: High Merit

2.	For Merit, the student needs to carry out an in-depth investigation in chemistry involving quantitative analysis.
	
	This involves:
	
	• collection of quality data which includes standardising the standard solution(s) and control of significant variables
	• accurate processing of the data to reach a valid conclusion
	• providing evidence of the mathematical steps used to process the experimental data
	• presenting a report that contains:
	  • a description of the procedure in sufficient detail for the investigation to be duplicated
	  • a conclusion that links the processed data to the purpose of the investigation
	  • an explanation of how the procedure used contributed to the collection of quality data.
	
	This student has accurately processed data (1), given a conclusion that links the processed data to the purpose of the investigation (2), and given an explanation of how the procedure used contributed to the collection of quality data (3).
	
	To reach Excellence, the student could use appropriate significant figures and give a more comprehensive evaluation.

Student 2: High Merit

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Purpose:

To investigate by quantitative analysis, the variation in the concentration of Vitamin C (in gL^{-1}) of "Just Juice Orange and Mango" juice when heated to 20, 40, 60, 70 and 80 degrees Celsius for 10 minutes.

Calculations:

These are sample calculations, all calculations done are in log book.

Actual concentration of $S_2O_3^{2-}$

Using: $IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

$n(IO_3^-) = c \times V = 0.0100 \times (25/1000) = 2.5 \times 10^{-4}$

$n(I_2) = 2.5 \times 10^{-4} \times 3 = 7.5 \times 10^{-4}$ mol

Using: $2S_2O_3^{2-} + I_2 \rightarrow 2I^- + S_4O_6^{2-}$

$n(S_2O_3^{2-}) = 2 \times 7.5 \times 10^{-4} = 1.5 \times 10^{-3}$ mol

$c(S_2O_3^{2-}) = n/V = (1.5 \times 10^{-3}) / 0.0293333 = 0.051136364$ $molL^{-1}$

This concentration will be used for further calculations

Part A – calculation of blank titration:

$V(S_2O_3^{2-}) = 0.02925$

$n = c/V$ therefore $n(S_2O_3^{2-}) = 0.0511 \times 0.02925 = 1.494675 \times 10^{-3}$

$n(I_2$ total$) = ½ \times 1.494675 \times 10^{-3} = 7.47335 \times 10^{-4}$ mol

This represents the maximum number of moles of iodine formed when no vitamin C is present.

Part B – calculation of back titration:

20°C

$n(I_2) = 7.47335 \times 10^{-4}$

$n(S_2O_3^{2-}) = 0.0511 \times 0.018167$ (average at this temperature)

$n(S_2O_3^{2-}) = 9.283337 \times 10^{-4}$ mol

$n(I_2$ remaining$) = ½ \times 9.283337 \times 10^{-4} = 4.6416685 \times 10^{-4}$

Vitamin C reacts with iodine at a 1:1 mole ratio. This means that calculating the number of I_2 moles that reacted with vitamin C, the number of moles of vitamin C can be calculated.

So:

$n(I_2$ reacted with vit C$) = n(I_2$ remaining$) = 7.47335 \times 10^{-4} - 4.6416685 \times 10^{-4} = 2.8317065 \times 10^{-4}$ mol $= n$(vitamin C)

c(vitamin C) $= n/V = 2.8317065 \times 10^{-4} / 0.1 = 2.8317065 \times 10^{-3}$ $molL^{-1}$

c(vitamin C in gL^{-1}) $= 176 \times 2.8317065 \times 10^{-3}$ (where 176 is the molar mass of vitamin C in g mol^{-1}) $= 0.498380344$ gL^{-1}

1

Final Evaluation:

From the data obtained in the experiment and from the graphs of the data we can see that there is quite a strong negative relationship between the temperature of the juice and the vitamin C content of the juice. The lowest temperature of 20°C had a vitamin C concentration of 0.498380344 gL^{-1}, and the highest temperature of 80°C had a concentration of 0.27456 gL^{-1}. 2

The procedure used for this investigation was the analysis of the amount of vitamin C in juice using an iodine-thiosulfate back titration. The iodine used was produced by reacting KIO_3 with KI as it would have been too difficult to handle an iodine solution.

$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

Using this method of indirectly producing iodine the known number of moles in the solution is more accurate. 3

In the original method, the concentration of sodium thiosulfate was 0.1 $molL^{-1}$. However it was determined that this concentration of thiosulfate meant that the range that the number of moles of iodine would decrease was too small to determine an accurate difference, therefore it was decided to use a concentration of approximately 0.05 $molL^{-1}$.

Quite a few uncertainties were removed from the experiment. We did this by always using the same equipment in each titration which meant that no other solutions could contaminate the equipment. We made sure we used the same solutions for sodium thiosulfate and potassium iodate because of the risk of slightly different solutions if we made batches.

	Grade Boundary: Low Merit

3.	For Merit, the student needs to carry out an in-depth investigation in chemistry involving quantitative analysis.
	
	This involves:
	
	• collection of quality data which includes standardising the standard solution(s) and control of significant variables
	• accurate processing of the data to reach a valid conclusion
	• providing evidence of the mathematical steps used to process the experimental data
	• presenting a report that contains:
	  • a description of the procedure in sufficient detail for the investigation to be duplicated
	  • a conclusion that links the processed data to the purpose of the investigation
	  • an explanation of how the procedure used contributed to the collection of quality data.
	
	This student has accurately processed data (1), given a conclusion that links the processed data to the purpose of the investigation (2), and given an explanation of how the procedure used contributed to the collection of quality data (3).
	
	For a more secure Merit, the student could provide evidence of the mathematic steps used to determine the concentration of $S_2O_3^{2-}$, use appropriate significant figures and units, and give a more comprehensive evaluation.

Student 3: Low Merit

NZQA Intended for teacher use only

Purpose:

To investigate by quantitative analysis, the variation in the concentration of Vitamin C (in gL^{-1}) of "Just Juice Orange and Mango" juice when heated to 20, 40, 60, and 80 degrees Celsius for 10 minutes.

Calculations:

Part A – calculation of blank titration:

$V(S_2O_3^{2-}) = 0.02925$

$n = c/V$ therefore $n(S_2O_3^{2-}) = 0.0511 \times 0.02925 = 1.494675 \times 10^{-3}$

$n(I_2$ total$) = ½ \times 1.494675 \times 10^{-3} = 7.47335 \times 10^{-4}$

Part B – calculation of back titration:

20°C

$n(I_2) = 7.47335 \times 10^{-4}$

$n(S_2O_3^{2-}) = 0.0511 \times 0.018167$ (average at this temperature)

$n(S_2O_3^{2-}) = 9.283337 \times 10^{-4}$

$n(I_2$ remaining$) = ½ \times 9.283337 \times 10^{-4} = 4.6416685 \times 10^{-4}$

$n(I_2$ reacted with vit C$) = n(I_2$ remaining$) = 7.47335 \times 10^{-4} - 4.6416685 \times 10^{-4} = 2.8317065 \times 10^{-4}$ mol = n(vitamin C)

c(vitamin C$) = n/V = 2.8317065 \times 10^{-4} / 0.1 = 2.8317065 \times 10^{-3}$

c(vitamin C$) = 176 \times 2.8317065 \times 10^{-3} = 0.498380344$

(1)

Final Evaluation:

From the data obtained in the experiment and from the graphs of the data we can see that there is quite a strong negative relationship between the temperature of the juice and the vitamin C content of the juice.

(2)

The procedure used for this investigation was the analysis of the amount of vitamin C in juice using an iodine-thiosulfate back titration. The iodine used was produced by reacting KIO_3 with KI as it would have been too difficult to handle an iodine solution.

$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

Using this method of indirectly producing iodine the known number of moles in the solution is more accurate.

(3)

In the original method, the concentration of sodium thiosulfate was 0.1 $molL^{-1}$. However it was determined that this concentration of thiosulfate meant that the range that the number of moles of iodine would decrease was too small to determine an accurate difference, therefore it was decided to use a concentration of approximately 0.05 $molL^{-1}$.

	Grade Boundary: High Achieved

4.	For Achieved, the student needs to carry out an investigation in chemistry involving quantitative analysis.
	
	This involves:
	
	• exploring a possible trend or pattern in the quantity of substance in a sample
	• developing and carrying out a procedure to collect data about a possible trend or pattern in the quantity of a substance
	• collecting and recording a sufficient quantity of data to enable a conclusion to be reached
	• processing of the data to reach a conclusion
	• presenting a report that contains:
	  ◦ a statement of the purpose of the investigation
	  ◦ a description of the procedure that includes preparation of samples and the analytical technique used
	  ◦ a summary of the collected and processed data
	  ◦ a conclusion based on the processed data.
	
	This student has given a statement of the purpose of the investigation (1), processed data (2) and given a conclusion that is based on processed data (3).
	
	To reach Merit, the student could investigate a minimum of 5 values of the independent variable in order to reach a valid conclusion, give a conclusion that links the processed data to the purpose of the investigation, and give an explanation of how the procedure used contributed to the collection of quality data.

Student 4: High Achieved

NZQA Intended for teacher use only

Purpose:

To investigate by quantitative analysis, the variation in the concentration of Vitamin C of "Just Juice Orange and Mango" juice when heated to 20, 40, 60, and 80 degrees Celsius for 10 minutes. (1)

Calculations:

Part A – calculation of blank titration:

$V(S_2O_3^{2-}) = 0.02925$

$n(S_2O_3^{2-}) = 0.0511 \times 0.02925 = 1.494675 \times 10^{-3}$

$n(I_2 \text{ total}) = ½ \times 1.494675 \times 10^{-3} = 7.47335 \times 10^{-4}$

Part B – calculation of back titration:

20°C

$n(I_2) = 7.47335 \times 10^{-4}$

$n(S_2O_3^{2-}) = 0.0511 \times 0.018167$ $n(S_2O_3^{2-}) = 9.283337 \times 10^{-4}$

$n(I_2 \text{ remaining}) = ½ \times 9.283337 \times 10^{-4} = 4.6416685 \times 10^{-4}$ (2)

$n(I_2 \text{ reacted with vit C}) = n(I_2 \text{ remaining}) = 7.47335 \times 10^{-4} - 4.6416685 \times 10^{-4} = 2.8317065 \times 10^{-4}$ mol = n(vitamin C)

$c(\text{vitamin C}) = n/V = 2.8317065 \times 10^{-4} / 0.1 = 2.8317065 \times 10^{-3}$

Conclusion:

From the data obtained in the experiment and from the graphs of the data we can see that as the temperature is increased the average titre increases. (3)

	Grade Boundary: Low Achieved

5.	For Achieved, the student needs to carry out an investigation in chemistry involving quantitative analysis.
	
	This involves:
	
	• exploring a possible trend or pattern in the quantity of substance in a sample
	• developing and carrying out a procedure to collect data about a possible trend or pattern in the quantity of a substance
	• collecting and recording a sufficient quantity of data to enable a conclusion to be reached
	• processing of the data to reach a conclusion
	• presenting a report that contains:
	  • a statement of the purpose of the investigation
	  • a description of the procedure that includes preparation of samples and the analytical technique used
	  • a summary of the collected and processed data
	  • a conclusion based on the processed data.
	
	This student has explored a possible trend or pattern in the quantity of substance in a sample and collected a sufficient quantity of data to enable a conclusion to be reached (1). They have processed the data, with some errors (2), to reach a conclusion based on the processed data (3).
	
	For a more secure Achieved, the student could more clearly state the purpose and the conclusion.

Student 5: Low Achieved

NZQA Intended for teacher use only

Purpose:

To investigate what happens to the vitamin C in fruit juice when it is heated to 20, 40, 60, and 80 degrees Celsius for 10 minutes. (1)

Calculations:

Part A – calculation of blank titration:

$V(S_2O_3^{2-}) = 0.02925$

$n(S_2O_3^{2-}) = 0.0511 \times 0.02925 = 1.49 \times 10^{-3}$

$n(I_2 \text{ total}) = ½ \times 1.49 \times 10^{-3} = 7.47 \times 10^{-4}$

Part B – calculation of back titration:

20°C

$n(I_2) = 7.47 \times 10^{-4}$

$n(S_2O_3^{2-}) = 0.01 \times 0.0182$ $n(S_2O_3^{2-}) = 1.82 \times 10^{-4}$

$n(I_2 \text{ remaining}) = ½ \times 1.82 \times 10^{-4} = 0.91 \times 10^{-4}$ (2)

$n(I_2 \text{ reacted with vit C}) = n(I_2 \text{ remaining}) = 7.47 \times 10^{-4} - 0.91 \times 10^{-4} = .656 \times 10^{-4}$ mol = n(vitamin C)

$c(\text{vitamin C}) = n/V = .656 \times 10^{-4} / 0.1 = 0.656 \times 10^{-3}$

Conclusion:

As the temperature is increased the volume of thiosulfate needed increases. (3)

	Grade Boundary: High Not Achieved

6.	For Achieved, the student needs to carry out an investigation in chemistry involving quantitative analysis.
	
	This involves:
	
	• exploring a possible trend or pattern in the quantity of substance in a sample
	• developing and carrying out a procedure to collect data about a possible trend or pattern in the quantity of a substance
	• collecting and recording a sufficient quantity of data to enable a conclusion to be reached
	• processing of the data to reach a conclusion
	• presenting a report that contains:
	  • a statement of the purpose of the investigation
	  • a description of the procedure that includes preparation of samples and the analytical technique used
	  • a summary of the collected and processed data
	  • a conclusion based on the processed data.
	
	This student has investigated a possible trend and stated a purpose (1) and made a conclusion based on some of the processed data (2).
	
	To reach Achieved, the student could include a summary of the processed data in the report, and base the conclusion on more than one value of the independent variable.

Student 6: High Not Achieved

NZQA Intended for teacher use only

Purpose:

To investigate what happens to the vitamin C in fruit juice when it is heated to 20, 60, and 80 degrees Celsius. (1)

Calculations:

20°C

c(vitamin C) = n/V = .656 $x10^{-4}$ / 0.1 = 0.656 $x10^{-3}$

Conclusion:

The juice heated to 20°C had 0.656 x 10^{-}3 $molL^{-1}$ of vitamin C. (2)