

Internal Assessment Resource

Chemistry Level 2

This resource supports assessment against Achievement Standard 91910

Standard title: Carry out a practical investigation into a substance present in a consumer product using quantitative analysis

**Credits:** 4

Resource title: Analysis of household bleach

**Resource reference:** Chemistry 2.1B

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| This resource:   * Clarifies the requirements of the standard * Supports good assessment practice * Should be subjected to the school’s usual assessment quality assurance process * Should be modified to make the context relevant to students in their school environment and ensure that submitted evidence is authentic |

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| Date version published by Ministry of Education | December 2018 Version 1  To support internal assessment from 2019 |
| Authenticity of evidence | Teachers must manage authenticity for any assessment from a public source, because students may have access to the assessment schedule or student exemplar material.  Using this assessment resource without modification may mean that students’ work is not authentic. The teacher may need to change figures, measurements or data sources or set a different context or topic to be investigated or a different text to read or perform. |

**Internal Assessment Resource**

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Teacher guidelines

The following guidelines are supplied to enable teachers to carry out valid and consistent assessment using this internal assessment resource.

Teachers need to be very familiar with the outcome being assessed by the achievement standard. The achievement criteria and the explanatory notes contain information, definitions, and requirements that are crucial when interpreting the standard and assessing students against it.

Context/setting

This activity requires students to carry out a comprehensive practical investigation into the sodium hypochlorite present in a sample of household bleach using quantitative analysis. Using quantitative analysis means that students will carry out a titrimetric analysis to gather data, followed by carrying out calculations to draw a conclusion. General instructions for the investigation will be provided to students in writing, including a general procedure (method), and the chemicals that the students are to use.

While it is preferable for each student to carry out the practical titration process individually, this may not be feasible where equipment is limited or in a case of disability. In such cases students might share tasks amongst a group but teachers would need to use their school’s procedures to ensure that each student has clear understanding of all criteria involved in the analysis process.

Providing a general procedure means students are to be given guidance about the overall approach they are to take, including the reactions occurring and balanced full equations. Students are required to trial and modify this procedure before carrying it out, which will generally involve identifying significant variables to control, and determining an appropriate dilution of the consumer product to enable quality data to be gathered. Titre results should be at least 5 mL and usually less than 30mL.

Students will use their modified procedure to determine the concentration of sodium hypochlorite in a sample of household bleach. They will use quantitative calculations to determine the concentration of any standard solution used in the investigation, as well as the concentration of the hypochlorite, in units appropriate for the sample being tested (grams per litre).

Students will be provided with the relationships n=cV and n=m/M and must use these formulae, and stoichiometric principles, to independently carry out their quantitative calculations.

The pipette size may be varied depending on what is available, but 20 or 25 mL is preferable. The concentration of the thiosulfate solution provided to the students should be approximately 0.120 mol L-1 and must be accurately known. The household bleach being investigated should be relatively fresh (not expired) and free of any soaps/detergents or thickening/foaming agents which may impact on the ability of the students to gather quality data and/or prepare accurate dilutions.

It is anticipated that this investigation will be introduced at the end of a unit of work that has provided students with knowledge of the preparation of standard solutions, carrying out dilutions, relevant quantitative calculations, the use of titration equipment, and the appropriate use of vocabulary, symbols and conventions

The context for this investigation is the analysis of household bleach. You will need to ensure that students have learned about titrations, the use of observable colour changes to determine an end point of a titration, and in particular the use of starch to observe the starch-iodine complex end point in iodometry.

It may be appropriate to use the iodometry procedure in investigating the concentration of another species (e.g. Cu2+, IO3-, etc) in a formative assessment prior to this investigation.

This activity requires students to present their investigation as a written report. Other suitable presentation formats could include a PowerPoint file or wall poster.

Conditions

Students will need time to develop the skills involved in the type of investigation outlined in the activity. This could take up to five or six weeks.

Students will undertake all work in this assessment individually.

Resource requirements

Students require access to:

* 20.0 or 25.0 mL pipette (the task and schedule is based on a 25 mL pipette)
* 10.0 or 25.0 mL measuring cylinders
* 100 or 250 mL volumetric flasks
* burette (preferably 50.0 mL)
* 3 conical flasks (100-250 mL)
* undiluted household bleach
* standard sodium thiosulfate solution (approximately 0.120 mol L-1)
* sulfuric acid solution (approximately 2.00 mol L-1)
* solid potassium iodate
* 10% potassium iodide solution
* wash bottle containing distilled (or deionised) water
* starch solution

Teacher note: Students are to be provided with the unmodified bleach, and thiosulfate solution with concentration ~0.120 mol L-1. As part of the development of the student’s investigation, it is expected that they will independently discover that they need to prepare a diluted sample as the volume of thiosulfate solution necessary to completely react the iodine produced will initially exceed the burette capacity. This can be determined by initial trials using a 10.0 (or 25.0) mL measuring cylinder.

A 10% dilution is common but may not be appropriate in some instances. Titres should be at least 5 mL, but no more than the maximum volume of the burette used in the analysis.

The dilution necessary will be based upon the age and concentration of hypochlorite ions in the bleach solution, and the concentration of the sodium thiosulfate solution used in the investigation.

Additional information

The teacher should carry out the procedure prior to the student practical assessment to determine the appropriate dilution factor and expected titre for the bleach sample being analysed.

Cheaper generic brands of household bleach have lower concentrations of hypochlorite but are more likely to be free of any additives that could affect student results, such as surfactants, soaps, detergents, thickening agents, or foaming agents.

Other possible contexts

Other possible contexts for a quantitative investigation include: acid-base, complexometric, precipitation, and other suitable redox reactions.

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Credits: 4

Resource title: Analysis of household bleach

Resource reference: Chemistry 2.1B

Student instructions

Introduction

This assessment activity requires you to carry out a practical investigation into the concentration of sodium hypochlorite present in household bleach.

will have up to five class periods to carry out the investigation and complete the written report.

You will be assessed on the comprehensiveness of your practical investigation, which involves:

* + trialling and modifying the provided procedure and/or bleach product
  + calculating the concentration of the standard solutions used in the investigation
  + using the procedure to collect accurate and valid data
  + processing the data to reach a conclusion
  + justifying the modifications made in terms of the validity and accuracy of the investigation
  + evaluating the outcome of the investigation in relation to the household bleach
  + reporting your investigation in a written report.

Make sure you show all working, give your answers to three significant figures, and use appropriate units.

The following instructions provide you with a structure that will allow you to demonstrate the outcomes required for successful achievement of this standard.

Background information

A common compound which is used as a disinfectant around the home is sodium hypochlorite (NaOCl). It is commonly found in a pale yellow-green dilute solution which is called household bleach. Sodium hypochlorite is an oxidising agent which causes damage to the cellular structure of microorganisms, leading to their death.

Sodium hypochlorite is unstable and starts breaking down shortly after manufacturing due to exposure to the atmosphere and light. Many household bleaches contain between 3 – 8% sodium hypochlorite, along with trace amounts of sodium hydroxide to keep the pH high and slow down the decomposition of the bleach.

Task

Your task is to carry out an investigation into the concentration of sodium hypochlorite in a specific household bleach product. The product label provided by the manufacturer will give an indication of the expected concentration of the hypochlorite in the sample.

The procedure and data you will use in the standardisation of the sodium thiosulfate solution is given in Resource A and the procedure you will use for the titrimetric analysis of hypochlorite ions (OCl–) present in a solution is given in Resource B.

Part A: Preliminary Calculations

Before starting your investigation, you are to carry out quantitative calculations to determine the concentration of the sodium thiosulfate solution used in your titrimetric analysis. The solution has been titrated against a primary standard solution of potassium iodate. The data related to the standardisation is provided to you in Resource A.

You need to use stoichiometric principles and the relationships n=m/M and n=cV, in the determination of the concentrations of these solutions.

Potassium iodate standard solution

Calculate the amount, in moles, of potassium iodate dissolved into the volumetric flask. *M*(KIO3) = 214 g mol­–1

Leave sufficient space for students to write their answers.

Use the known amount of potassium iodate, and the volume of the volumetric flask, to calculate the concentration of the potassium iodate standard solution.

Leave sufficient space for students to write their answers.

Standardisation of sodium thiosulfate solution

Use the known volume and concentration of the potassium iodate solution to calculate the amount, in moles, of potassium iodate used in the standardisation.

Leave sufficient space for students to write their answers.

The balanced equation for the overall procedure used in the titration is:

IO3– + 6H+ + 6S2O32– 🡪 I– + 3H2O + 3S4O62–

Calculate the amount, in moles, of sodium thiosulfate reacted in the standardisation.

Leave sufficient space for students to write their answers.

Use the volume, and amount, of sodium thiosulfate reacted in the standardisation to determine the concentration of the sodium thiosulfate solution. Give your answer to three significant figures.

Leave sufficient space for students to write their answers.

Part B: Practical activity

Procedure

Make sure you know the purpose of the investigation. Determine what chemicals and equipment you have been provided with.

Familiarise yourself with the titrimetric analytical method outlined in Resource B.

Plan your practical work and conduct trials, using a 10.0 mL measuring cylinder, to determine how you should modify your procedure and/or bleach product if necessary.

Record significant variables which you have controlled, with a description of what the variables are, and how they have been controlled.

Collect primary data

Using your modified procedure, carry out the titrimetric analysis to collect and record relevant primary data with correct units. The accuracy of your data will contribute to the determination of your grade.

Interpret the data

Carry out quantitative calculations to determine the concentration of sodium hypochlorite in the household bleach. To enable you to evaluate the outcome of your investigation, your final result should be calculated with appropriate units to allow comparison with the concentration given on the label of the household bleach.

You need to make use of stoichiometric principles and the relationships n=m/M and n=cV, in the determination of the concentration.

Record your results

Leave sufficient space for students to write their answers.

Calculations

Calculate the average titre volume for the sodium thiosulfate.

Leave sufficient space for students to write their answers.

Use the known concentration of sodium thiosulfate to calculate the amount, in moles, of sodium thiosulfate.

Leave sufficient space for students to write their answers.

The balanced equation for the overall procedure used in the titration is:

OCl– + 2H+ + 2S2O32– 🡪 Cl– + H2O + S4O62–

Calculate the concentration of sodium hypochlorite in the diluted household bleach sample that you titrated. Give your answer in appropriate units to three significant figures.

Leave sufficient space for students to write their answers.

Use this value and the molar mass of NaOCl of 74.5g mol-1 to calculate this concentration in appropriate units.

Leave sufficient space for students to write their answers.

Use these concentrations and information on how you diluted your sample to calculate the concentration of the original household bleach.

Leave sufficient space for students to write their answers.

Part C: Reporting on your investigation

Produce a comprehensive and detailed report on your investigation.

The report should include:

* + an outline of the purpose of the investigation
  + a description of your modified procedure – this must include a description of:
  + how significant variables were controlled, and
  + any modifications made to the method and/or bleach product during the course of the investigation
  + a record of the data gathered in the investigation
  + a complete account of the quantitative calculations used in the determination of the concentration of all standard solutions, processing of the raw data, and the determination of the concentration of the sodium hypochlorite
  + a conclusion giving the concentration of the hypochlorite in the household bleach
* a discussion of the investigation which includes:
  + justification of the modifications made to the procedure and/or bleach product in relation to the validity of the titration data, and
  + explanation of how your procedure and control of variables improved the quality of the investigation, and
  + evaluation of the outcome of your investigation by comparing the concentration you determined to the concentration stated by the household bleach manufacturer.

Your investigation report should be handed in alongside this investigation booklet.

Resource A – Standard Solutions

Teacher note: This resource sheet may be provided to students completely filled in, or, depending on the task you chose to set students, you may get them to prepare their own primary standard and use it to standardise the thiosulfate.

**Overview**

Sodium thiosulfate cannot be used accurately as a primary standard in your investigation. Prior to carrying out the investigation, the thiosulfate solution must be standardised using a standard solution of potassium iodate.

A standard solution of iodate ions (IO3–) can be prepared in a volumetric flask, then reacted with excess iodide ions (I–) to form iodine (I2). The amount of iodine that is formed is equivalent to the amount of iodate ions present in the sample.

2IO3– + 12H+ + 10I– 🡪 6I2 + 6H2O

The iodine (I2) that has been formed, and therefore the equivalent amount of iodate ions, can be titrated against an unknown solution of sodium thiosulfate (Na2S2O3) to determine the concentration of thiosulfate ions present (S2O32-).

I2 + 2S2O32– 🡪 2I– + S4O62–

The balanced equation for the overall procedure can be summarised as follows:

IO3– + 6H+ + 6S2O32– 🡪 I– + 3H2O + 3S4O62–

**Preparation of potassium iodate solution**

0.801 g of KIO3 was weighed on a laboratory balance and added to a 200 mL volumetric flask. The flask was then made up to volume using distilled water and shaken until all the solid had fully dissolved.

**Standardisation of sodium thiosulfate solution.**

The sodium thiosulfate solution was titrated against 20 mL samples of the potassium iodate standard solution using the method described above.

The titration data gathered is provided in the table below:

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| --- | --- | --- | --- | --- | --- |
| Titration | Rough | 1 | 2 | 3 | 4 |
| Initial Reading | 1.3 mL | 0.8 mL | 0.5 mL | 0.0 mL | 1.2 mL |
| Final Reading | 20.4 mL | 19.4 mL | 19.2 mL | 18.6 mL | 19.7 mL |
| Titre |  |  |  |  |  |

Teacher note: The data above is provided to give a concentration of sodium thiosulfate solution of approximately 0.120 mol L-1. The sodium thiosulfate solution used in the investigation should be prepared as close to this value as possible. Alternatively, you may wish to standardise the solution yourself and change the data values in the table.

Resource B – Titrimetric Analysis of Hypochlorite

**Overview**

A sample containing hypochlorite ions (OCl–) can be reacted with excess iodide ions (I–) to form iodine (I2) and chloride ions (Cl–). The amount of iodine that is formed is equivalent to the amount of hypochlorite present in the sample.

OCl– + 2H+ + 2I– 🡪 I2 + Cl– + H2O

The iodine (I2) that has been formed, and therefore the equivalent amount of hypochlorite ions, can be quantitatively determined by titrating against a standard solution of sodium thiosulfate (Na2S2O3).

I2 + 2S2O32– 🡪 2I– + S4O62–

The balanced equation for the overall procedure can be summarised as follows:

OCl– + 2H+ + 2S2O32– 🡪 Cl– + H2O + S4O62–

The following solutions and equipment will be provided:

household bleach solution

sodium thiosulfate solution (Concentration = \_\_\_\_\_\_\_\_\_\_\_\_ mol L–1)

sulfuric acid solution (2.00 mol L–1)

potassium iodide solution (10%)

25.0 mL pipettes

10.0 mL measuring cylinders

25.0 mL burette

3 conical flasks

wash bottle containing distilled water

starch solution

**Procedure**

1. Measure a 20 mL aliquot of the diluted bleach solution into a conical flask.
2. Add 10 mL of 10% potassium iodide (KI) solution to the sample, resulting in the formation of a brown iodine (I2) solution.
3. Add 10 mL of 2.00 mol L–1 sulfuric acid (H2SO4) to the flask to acidify the reaction mixture. Begin the titration promptly after acidification.
4. Titrate the iodine mixture in the flask with the sodium thiosulfate solution provided until the brown colour has faded to a pale-yellow colour.
5. Add 2-3 drops of starch solution to the reaction flask, resulting in the formation of a blue-black starch-iodine complex.
6. Continue titrating the solution in the flask with the sodium thiosulfate solution until the reaction mixture turns colourless.
7. Repeat the procedure until three concordant results are obtained.

**Key Information**

M(NaOCl) = 74.5 g mol­–1 n = m/M n = cV

Assessment schedule: Chemistry 91910 – Analysis of household bleach

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| Evidence/Judgements for Achievement | Evidence/Judgements for Achievement with Merit | Evidence/Judgements for Achievement with Excellence |
| The student carries out a practical investigation into a substance present in a consumer product using quantitative analysis.  They do this by using titrimetric analysis and quantitative calculations to gather and process primary data, determine a concentration value for a relevant substance involved in the investigation, and writing a conclusion that is related to the concentration.  In their investigation the student has:   * Trialed and determined if the bleach and/or titration procedure required modification.   Example:  Trials with the original bleach showed that about 2mL of bleach required about 25mL of thiosulfate, so the bleach had to be diluted by a factor of 10 to get reasonable titres from the burette for a 20 mL sample.   * Outlined two or more procedures and controlled variables that helped improve the quality or validity of the primary data.   Examples:  Concentration of the sodium thiosulfate: Kept consistent by ensuring that the solution was extracted from the same stock bottle each time, and all titration tests were carried out on the same day.  Volume measurements: Ensured that all measurements were consistent in being equally recorded from the bottom of the meniscus in all flasks/pipettes/burettes.  Starch use at end point: To prevent excess starch-iodine complex forming, the starch was only added once the titrated solution had changed from brown to a pale-yellow colour.  Hypochlorite concentration: The diluted hypochlorite volumetric flask was stored out of direct sunlight to ensure the solution did not decompose during the course of my investigation.  Cleanliness of flasks: Ensured that the conical flasks used in each test were thoroughly washed prior to carrying out the test to remove all contaminants.  KI purity: Fresh KI solution was used in the titrations to ensure that none of it had reacted with the air to form iodine before being added to the flask.   * Recorded initial and final volumes for the sodium thiosulfate solution used. * Calculated titre volumes, of which at least three fall within an appropriate concordance range. * Calculated an average titre value. * Determined the concentration of either the sodium hypochlorite solution, or sodium thiosulfate solution, with use of stoichiometric principles, and the relationships n=cV and n=m/M.   Example:  *Preliminary Calculations*  *Iodate Solution*  *n(IO3-) = m/M = 0.801 g / 214 g mol-1*  *n(IO3-) = 0.00374 mol*  *c(IO3-) = n/V = 0.00374 mol / 0.200 L*  *c(IO3-) = 0.0187 mol L-1*  *Standardising Na2S2O3*  *Average Titre = 18.6 mL* (using concordant data)  *n(IO3-) = cV = 0.0187 mol L-1 x 0.020 L*  *n(IO3-) = 0.000374 mol*  *n(S2O32-) = n(IO3-) x 6/1*  *n(S2O32-) = 0.000374 mol x 6/1*  *n(S2O32-) = 0.00225 mol*  *c(S2O32-) = n/V = 0.00225 mol / 0.0186 L*  *c(S2O32-) = 0.121 mol L-1*  *Investigation*  *Average titre: 16.50 mL*  *n(S2­­O32-) = cV = 0.121 mol L-1 x 0.01650 L*  *n(S2­­O32-) = 0.00199 mol*  *n(OCl-) = n(S2O32-) x ½*  *n(OCl-) = 0.000996 mol*  *c(OCl-) = n/V = 0.000996 mol / 0.025 L*  *c(OCl-) = 0.0398 mol L-1*   * A minor error in the calculation is allowed but the concentration determined must be a sensible one. * Written a conclusion for their investigation which is related to the calculated concentration of the hypochlorite in the diluted household bleach.   Example:  In my investigation I determined the concentration of sodium hypochlorite in the household bleach was 0.0399 mol L-1 which was different to the concentration given on the manufacturers label.   * There is no penalty for omitting units or inappropriate use of significant figures. * There is no penalty for an error in the calculation of the iodate or thiosulfate being carried through to the hypochlorite calculation.   Example:  *c(S2O32-) = 121 mol L-1*  *c(OCl-) = 0.0398447 mol L-1*  *The examples above are indicative samples only.* | The student carries out an in-depth practical investigation into a substance present in a consumer product using quantitative analysis.  They do this by using results from preliminary trials to independently modify the procedure and/or consumer product, then using titrimetric analysis and quantitative calculations to gather and process quality data to determine the concentration of standard solutions and sodium hypochlorite in household bleach and writing a conclusion that gives the concentration.  In their investigation the student has:   * Trialed and independently modified the provided procedure. * Outlined two or more significant variables and how they have been controlled in the gathering of the primary data. * Carried out their modified procedure involving titrimetric analysis. * Recorded initial and final volumes for the sodium thiosulfate solution used. * Calculated titre volumes, of which at least three fall within a quality concordance range. * Calculated an average titre value using only concordant titre values. * Determined the concentration of the sodium thiosulfate solution and the sodium hypochlorite solution. * Written a valid conclusion for their investigation that relates to the calculated concentration of the hypochlorite in the household bleach.   Example:  *In my investigation I determined the concentration of sodium hypochlorite in the household bleach was 0.0399 mol L-1 which equates to 2.97 g L-1 which is a lot less than the concentration given on the manufacturer's label of 42 g L-1.*   * There is no penalty for omitting units or inappropriate use of significant figures. * Explained how controlling certain variables improved the quality of the investigation.   Example:  *By controlling significant variables in my experiment that were not outlined in the provided method, such as using exact volumes and avoiding changes to the concentrations of the chemicals used, it ensured that the data I gathered was more accurate and reliable. For example, I used a 25 mL pipette when transferring the bleach from the sample bottle into a 250 mL volumetric flask, then carefully diluted this to the exact volume in the flask, which gave me an exact 10% dilution. If the solution was more or less concentrated through mishandling, the data I gathered would not be reliable.*  *The examples above are indicative samples only.* | The student carries out a comprehensive practical investigation into a substance present in a consumer product using quantitative analysis.  They do this by independently modifying a procedure, then using titrimetric analysis and quantitative calculations to gather and process primary data to determine the concentration of sodium hypochlorite in household bleach, writing a conclusion that evaluates the concentration, and a justification of the modifications made in their investigation.  In their investigation the student has:   * Trialed and independently modified the provided procedure. * Outlined two or more significant variables and how they have been controlled in the gathering of the primary data. * Carried out their modified procedure involving titrimetric analysis. * Recorded initial and final volumes for the sodium thiosulfate solution used. * Calculated titre volumes, of which at least three fall within a quality concordance range. * Calculated an average titre value using only concordant titre values. * Determined the concentration of the sodium thiosulfate solution and sodium hypochlorite in the undiluted household bleach in g L-1   Example:  *c(OCl-) = 0.0399 mol L-1*  *c(NaOCl)diluted = nM = 0.0399 mol L-1 x 74.5 g mol-1*  *c(NaOCl)diluted = 2.97 g L-1*  *c(NaOCl)bleach = c(NaOCl)diluted x dilution factor*  *c(NaOCl)bleach = 2.97 g L-1 x 250 mL/25 mL*  *c(NaOCl)bleach = 29.7 g L-1*   * All calculations have been completed with correct units and the final concentration has been given to three significant figures. * Written a valid conclusion for their investigation that relates to the calculated concentration of the hypochlorite in the household bleach. * Justified the modifications made to the procedure in relation to the validity of the titration data and accuracy of the investigation.   Example:  The concentration of the hypochlorite was too high in the household bleach when I trialled the method, and I was unable to get the iodine to completely react, even after 50 mL had been added. By diluting the household bleach down by a factor of 10 I was able to get more realistic titre values in the titration of around 16 mL. If the titre values had been any higher than that there would have been a greater discrepancy between each test and I would not have been able to obtain data values that were within a range of 0.3 mL.  *By carrying out the titration rapidly after the mixing of the chemicals, this ensured that there were no changes to the concentration of any of the reagents in the flask due to exposure to oxygen or the atmosphere, giving me data, which was consistent in each test carried out.*   * Evaluated the outcome of the investigation in relation to the bleach analysed.   Example:  *The concentration of sodium hypochlorite that was determined in the investigation was 29.7 g L-1. This was less than the concentration given on the manufacturer's label of 42 g L-1 and could be due to a number of reasons.*  *As sodium hypochlorite is unstable it could have broken down prior to me carrying out the investigation, either through exposure to light or the atmosphere, which would account for the concentration I determined being lower than expected.*  *The manufacturer may have used a faulty process in the generation of the sodium hypochlorite, mixing of the bleach solution, or the testing of it after manufacture. Or they may have simply not correctly represented the concentration on the label of the bottle in an attempt to sell a product which was substandard.*  Overall, I believe that my modified procedure was followed correctly, and it is more likely that either the household bleach had broken down prior to me testing it, or the manufacturer has reported an incorrect concentration, or the product is past its recommended use by date.  Alternatively, if the student determines that the concentration of sodium hypochlorite is actually greater than that stated on the bottle, then the manufacturer may have allowed for a reduction in concentration over the time period until the use by date.  *The examples above are indicative samples only.* |

Final grades will be decided using professional judgement based on a holistic examination of the evidence provided against the criteria in the Achievement Standard.