STAGE 2 Chemistry⏐Deconstruction and design investigation

###### https://img.aws.livestrongcdn.com/ls-article-image-673/ds-photo/getty/article/99/178/519386251.jpg Investigations Folio: Evaluation of mineral loss in cooking.

#### Background Information

Calcium, magnesium, and other metal ions (often called minerals in the health sciences) such as iron and zinc are important nutrients, and if we don’t get enough of them through our diet we can get a deficiency in these minerals, which can have serious health consequences. On the other hand, other metal ions such as aluminium and arsenic can be quite harmful (poisonous) above certain concentrations. How food is prepared can affect its nutritional value, cooking in an aluminium pot can introduce aluminium ions into the food, which over a prolonged time period can cause aluminium poisoning, for example. Conversely, boiling nutrient rich foods may under certain circumstances reduce its nutritional value, as some of the metal ions could be lost into the cooking water.

Previously you investigated water hardness by determining calcium and magnesium concentrations in several water samples from around South Australia using complexometric titration. There are many techniques that could be used to determine calcium and magnesium (and other mineral) concentrations in solution, each with advantages and disadvantages. For example, calcium and o-cresolphthalein (also called o-cresol red indicator, but not to be confused with o-cresol) form a chromogenic complex that can be quantified by UV-vis colorimetry. O-cresol red indicator, when in alkaline conditions, will bind to calcium forming a coloured (chromogenic) complex. The intensity of this colour can be quantified by spectrometry, and then converted into a concentration by using a standard curve. A standard curve is constructed by producing a series of standardised solutions with a known concentration of calcium, and measuring the intensity of the colour when these are mixed with o-cresol red indicator under alkaline conditions.

In this investigation you will compare and contrast different methods to quantify calcium and magnesium ions in solution, and use one of these methods to evaluate the loss of minerals from food during cooking.

Assessment Conditions

* You will have one 110-minute tutorial session to research and explore concepts surrounding the loss of metal ions into water during cooking, to come up with a hypothesis or investigable question, and deconstruct the problem of investigating it.
* You will have one 110-minute tutorial to trial and develop a procedure based on one of the general procedures that has been supplied or a procedure that has been developed and confirmed by your teacher (note: one procedure may be selected for the entire group to pursue).
* You will have one homework session to finalise the procedure, undertake a risk assessment during the ordering of equipment, and respond to safety requirements for the procedure, apparatus and reagents.
* You will have one 110-minute tutorial to undertake the final developed procedure for the investigation.

#### You will be required to use the spaces provided to record annotated evidence of your understanding – verified during each stage of the investigation under direct supervision.

#### You will then be required to elaborate upon this evidence in the construction of a final formal report. No new evidence may be introduced. You will be given an additional week to complete the final report.

#### You will work collaboratively during the investigation, but each student must demonstrate evidence of original thought in the deconstruction phase and in the construction and submission of an individual report.

*(Word limit for the investigation is* ***1500*** *excluding, apparatus and reagents, procedure, safety and results)*

Report Requirements

* Introduction with relevant chemistry concepts, and either a **hypothesis and variables**, or an **investigable question**
* Reagents and apparatus
* Identification and management of safety
* Procedure that outlines trials and steps taken
* Results
* Analysis of results, identifying trends, and linking results to concepts
* Evaluation of procedures and data, and identifying sources of uncertainty (errors)
* Conclusion, with justification.

Investigation

Key requirements

*Deconstructing the parts of a problem to determine the most appropriate method for investigation*

*Formulating investigable questions and hypotheses identifying variables*

How should we cook mineral rich foods such as spinach, so as to minimise the loss of minerals and maximise the nutritional value of the food we eat?

**Investigate the loss of minerals such as calcium and magnesium from foods during cooking.**

Your investigation could consider:

* The factors that influence how much calcium or magnesium is lost to the cooking water;
* The amount of calcium or magnesium that is present in the foods;
* The nutritional availability of the calcium or magnesium in the foods;
* Varying the approach to cooking to result in more nutritious foods.

Hypothesis or Investigable Question

* Develop a hypothesis or investigable question for the investigation. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ [IAE1]
* If a *hypothesis* has been developed, identify the *independent* and *dependent* variables in the investigation and describe how they will be altered measured where necessary. Outline the *factors* that will be *held* *constant*, outline how they will be held constant and why they need to be kept constant.

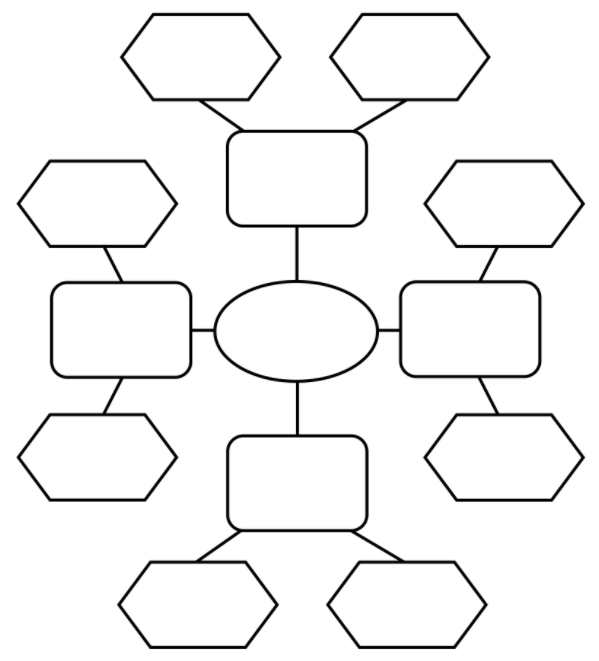
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| --- | --- |
| **Variable** | **How it will be altered or measured** |
| Independent variable |  |
| Dependent variable |  |

|  |  |  |
| --- | --- | --- |
| **Factors held constant**  (controlled variables) | **How it will be controlled** | **Why it is controlled** |
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| **Variables that cannot be controlled**  (Extraneous variables) |  |

[IAE1]

* If an *investigable question* has been pursued, outline the sub-questions and processes that you may investigate.



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Discussion and Comparison of Methods

Key requirements

*Selecting and using appropriate equipment, apparatus, and techniques*

* Briefly explain the advantages and disadvantages of each of the following methods for quantifying calcium/ magnesium ions in solution: complexometric titration, colorimetry (using o-cresol red indicator to form a chromogenic compound), and one other method you would suggest.
* Describe under what circumstances you would choose one method over the others, and
* Explain which method you will use for this investigation, given your hypothesis or investigable question above.

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Introduction

Key requirements

*Communicating knowledge and understanding of concepts*

* Construct an *introduction* to the investigation. The introduction should explain and motivate your hypothesis/ investigable question. It should also explain the physical and chemical processes involved in investigating your hypothesis/ investigable question, and your choice of method given the limitations of these processes. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
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#### General Procedure ➊ Cooking Spinach

#### Apparatus & Reagents

# Volumetric pipettes Measuring Cyclinders Beakers

Hotplate stirrers Distilled waterWater samples

Spinach Glass stirring rod Conical Flasks

Colander

Safety Notes

*Hotplates don’t appear hot when hot. Do not touch, and keep away from electrical cables.*

*Wear a* ***lab coat*** *and* ***safety glasses*** *during this practical. Refer to MSDS supplied for each reagent.*

General Procedure

Neutralising the glycerol

* Add spinach to 100mL water in a conical flask.
* Heat spinach/ water mixture for 10min.
* Filter spinach using a colander, collecting the filtrate.
* Use a method for quantifying calcium/ magnesium on the filtrate to determine how much calcium/ magnesium was extracted from the spinach in the cooking process.

#### General Procedure ➋ Determination of water hardness by complexometric titration (same as in determination of water hardness investigation)

#### Apparatus & Reagents

# Burette Beakers Transfer pipette

Burette stand Measuring cylinders Eriochrome black indicator

Wash bottle Funnel 0.100 molL-1 EDTA (standardised)

Conical flasks White tile Buffer solution (ammonia)

Volumetric pipettes Distilled water

Safety Notes

*Ammonia in the buffer solution may cause irritation to the skin and eyes.*

*Transfer the buffer solution in the fume cupboard.*

*Wear a* ***lab coat*** *and* ***safety glasses*** *during this practical. Refer to MSDS supplied for each reagent.*

General Procedure

* Pipette an aliquot of sample into a clean conical flask.
* Introduce a small amount (0.5mL) of buffer solution.
* Add 10 drops of eriochrome black indicator.
* Fill burette with EDTA solution.
* Titrate with EDTA from the burette.
* Record initial, final, and titre volumes.
* Calculate concentration of ions present in the sample.
* Record results in a reasonable way to be able to combine them with further results when looking for overall trends, etc.

#### General Procedure ➌ Colorimetric analysis of calcium

#### Apparatus & Reagents

# Cuvettes Beakers o-cresol red indicator

Volumetric pipettes Measuring cylinders Ethanol (50%)

Wash bottle Funnel 0.100 molL-1 NaOH

UV-vis spectrometer 500ppm Ca2+ solution (standardised)

Safety Notes

*Sodium hydroxide and ethanol may cause irritation to the skin and eyes. Ethanol is volatile and flammable, transfer it in the fume cupboard and keep it away from ignition sources.*

*Wear a* ***lab coat*** *and* ***safety glasses*** *during this practical. Refer to MSDS supplied for each reagent.*

General Procedure

Making a standard curve

* Serially dilute the Ca2+ solution 1:1, 4 times and then follow the procedure below to make UV-Vis measurements at each of the 5 concentrations.
* Draw a graph of concentration vs UV-Vis absorption for these data.

Making UV-Vis measurements of calcium

* Use volumetric pipettes to aliquot each of: the sample you wish to analyse; o-cresol red indicator; and NaOH solution, into several, labelled, beakers.
* Mix each beaker well.
* Fill a cuvette with solution from each beaker.
* Measure the absorption (575nm) for each cuvette using the UV-vis spectrometer.
* Record the UV-vis absorption (575nm) reading for each in a table.

Converting from UV-vis absorption to concentration

* Use the standard curve constructed using the procedure above to convert UV-vis absorption values to concentration values.
* Record results in a reasonable way to be able to combine them with further results when looking for overall trends, etc.

Procedure

Key requirements

*Selecting and using appropriate equipment, apparatus, and techniques*

* Using one of the general procedures provided above or an investigated procedure, design, construct and describe a final procedure for the investigation, including any necessary reagents and equipment not previously listed.
* Clearly indicate any modifications and improvements that have been made to the original procedure and explain why these changes have been made.
* Complete a Risk Assessment via RiskAssess <https://www.riskassess.com.au/> to place an order for any required apparatus and reagents and to evaluate the safety of the design and associated reagents.

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Results

Key requirements

***Collecting, representing,*** *analysing, and interpreting* ***data***

* Construct suitable table/s for the collation of raw and processed data and observations.

[IAE2]

#### Calculations, Analysis and Discussion

Key requirements

*Collecting, representing,* ***analysing, and interpreting data***

* Undertake any required calculations (you can use additional paper as required, just print it out and attach it to this.

[IAE2]

* Analyse the raw and processed data (if you have constructed and used a calibration curve to analyse your data, you can use software to do this but print out your calibration curve and results and attach them to this).

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Key requirements

*Evaluating procedures and considering their impact on results*

* Identify what limitations that your choice of procedure places on the conclusions that you can reasonably make with respect to your hypothesis or investigable question.

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* Identify sources of *random* and *systematic* error encountered during the investigation, explain their significance, and outline any evidence of the presence of the identified errors in the results obtained.

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Evidence for collaboration (Optional)

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| --- | --- | --- | --- | --- | --- | --- |
| Teacher’s Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | **Limited evidence** | **Some evidence** | **Good evidence** | **Strong evidence** | **Exemplary evidence** |
| Skill | Comment | E | D | C | B | A |
| Contribution to the design and investigation |  |  |  |  |  |  |
| Distribution of group roles |  |  |  |  |  |  |
| Confirmation of results |  |  |  |  |  |  |
| Safety and organisation of the workspace |  |  |  |  |  |  |
| Time management |  |  |  |  |  |  |

[IAE1]

* Describe how working collaboratively with your partner during the practical led to greater effectiveness and efficiency. Outline your contribution. Discuss how the collation of results from other groups investigating the tablets, may have increased your understanding of the procedure and confidence in the results obtained.

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Conclusion

Key requirements

*Drawing conclusions*

* Justify suitable conclusions based on your findings and discuss the limitations of these conclusions. Your conclusions should link back to your original hypothesis/ investigable question.

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| --- | --- | --- | --- | --- | --- |
|  | **A** | **B** | **C** | **D** | **E** |
| **Investigation, Analysis, and Evaluation** | Designs a logical, coherent, and detailed chemistry investigation.  Obtains records, and represents data, using appropriate conventions and formats accurately and highly effectively.  Systematically analyses and interprets data and evidence to formulate logical conclusions with detailed justification.  Critically and logically evaluates procedures and discusses their effect on data. | Designs a well-considered and clear chemistry investigation.  Obtains, records, and represents data, using appropriate conventions and formats mostly accurately and effectively.  Logically analyses and interprets data and evidence to formulate suitable conclusions with reasonable justification.  Logically evaluates procedures and their effect on data. | Designs a considered and generally clear chemistry investigation.  Obtains, records, and represents data, using generally appropriate conventions and formats with some errors but generally accurately and effectively.  Undertakes some analysis and interpretation of data and evidence to formulate generally appropriate conclusions with some justification.  Evaluates procedures and some of their effect on data. | Prepares the outline of a chemistry investigation.  Obtains, records, and represents data, using conventions and formats inconsistently, with occasional accuracy and effectiveness.  Describes data and undertakes some basic interpretation to formulate a basic conclusion.  Attempts to evaluate procedures or suggest an effect on data. | Identifies a simple procedure for a chemistry investigation.  Attempts to record and represent some data with limited accuracy or effectiveness.  Attempts to describe results and/or interpret data to formulate a basic conclusion.  Acknowledges that procedures affect data. |
| **Knowledge and Application** | Demonstrates deep and broad knowledge and understanding of a range of chemical concepts.  Develops and applies chemical concepts highly effectively in new and familiar contexts.  Critically explores and understands in depth the interaction between science and society.  Communicates knowledge and understanding of chemistry coherently, with highly effective use of appropriate terms, conventions, and representations. | Demonstrates some depth and breadth of knowledge and understanding of a range of chemical concepts.  Develops and applies chemical concepts mostly effectively in new and familiar contexts.  Logically explores and understands in some depth the interaction between science and society.  Communicates knowledge and understanding of chemistry mostly coherently, with effective use of appropriate terms, conventions, and representations. | Demonstrates knowledge and understanding of a general range of chemical concepts.  Develops and applies chemical concepts generally effectively in new or familiar contexts.  Explores and understands aspects of the interaction between science and society.  Communicates knowledge and understanding of chemistry generally effectively, using some appropriate terms, conventions, and representations. | Demonstrates some basic knowledge and partial understanding of chemical concepts.  Develops and applies some chemical concepts in familiar contexts.  Partially explores and recognises aspects of the interaction between science and society.  Communicates basic chemical information, using some appropriate terms, conventions, and/or representations. | Demonstrates limited recognition and awareness of chemical concepts.  Attempts to develop and apply chemical concepts in familiar contexts.  Attempts to explore and identify an aspect of the interaction between science and society.  Attempts to communicate information about chemistry. |