All things AOS3

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VCE STAV, 2019

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Resources can be found at
www.mychemhub.com

Why?

Big Ideas

World of work is changing

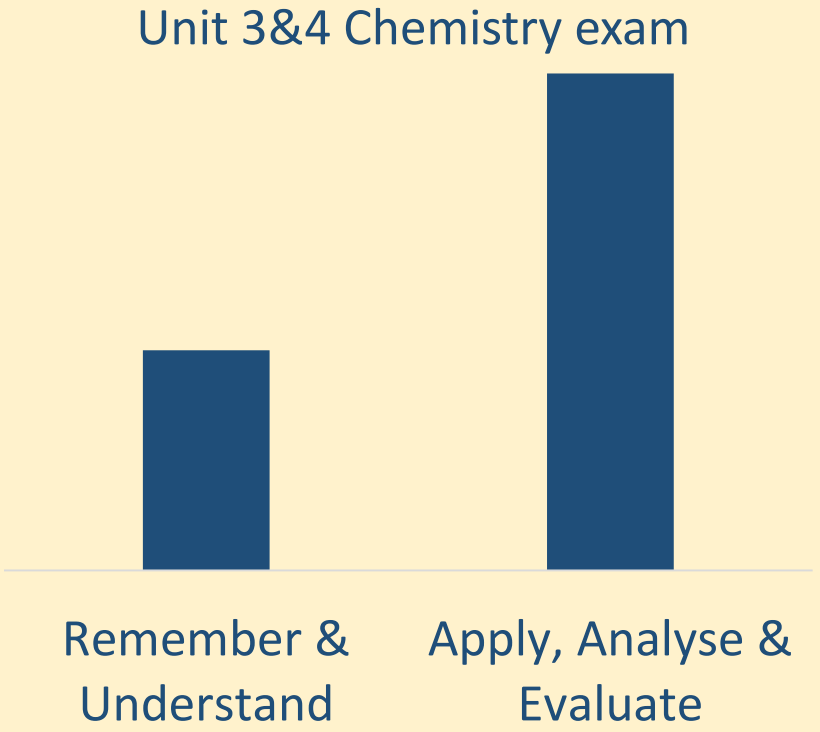
Broaden appeal of science

Ignite student learning

Improve student results

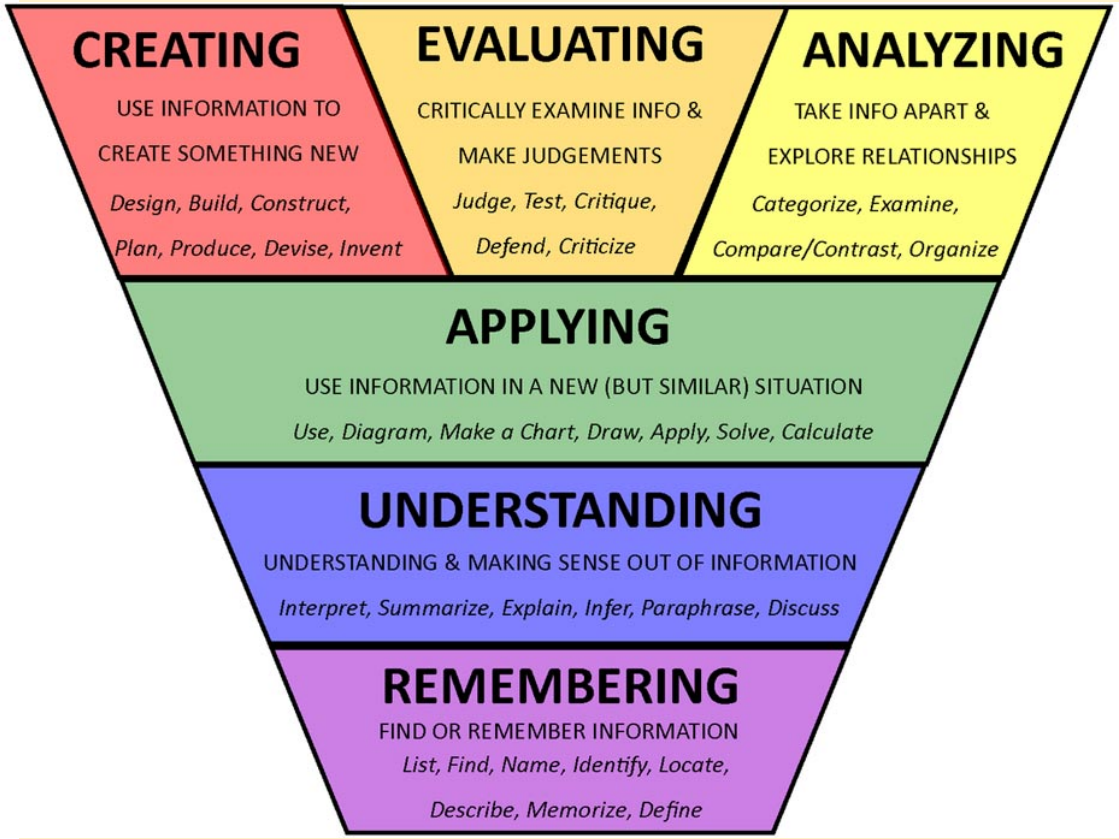
Effect?

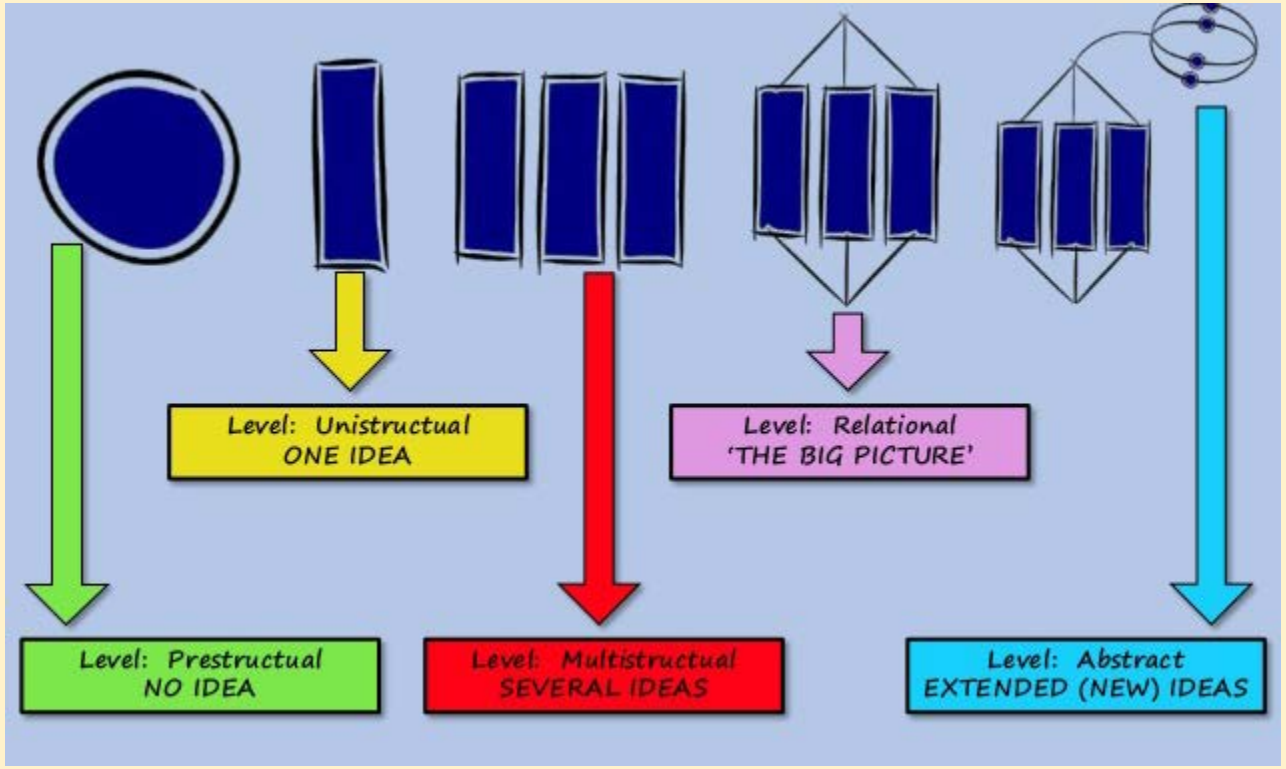
Flow on effect



AOS3 questions comprise 20% of the exam

Flow on effect





Effect?

Psychology Chief examiner

"The examination reflected changes to the study design, particularly in relation to a greater focus on scientific literacy and on experimental design. Examination questions also reflected the interconnectedness of different Areas of Study as well as the relationship between key knowledge and key science skills in the study design."

Chemistry Chief examiner

"Students should be aware that there is a fundamental requirement to be able to apply their learned knowledge and understanding to any context that appears on an examination."

Biology Chief examiner

"Many Section B questions required students to develop answers from the situations provided; this required a thoughtful approach. Unit 4, Area of Study 3 was an important part of the examination, where students could draw on the knowledge gained in their school-assessed coursework."

Response?

Change my teaching

Less step by step teaching

More linking of ideas

Greater student choice

More targeted teaching

Less step by step teaching

More linking of ideas

Ch 2 Energy from fuels

Review

Reactions can be exothermic or endothermic where

ΔH = Hproducts – Hreactants

Thermochemical Equations

A thermochemical equation shows the amount of heat produced or absorbed by a reaction.

Example

Octane is a major component of petrol:

C_8H_8 (g) + 12 ½ O_2 (g) ⇒ 8CO_2 (g) + 9H_2O (g) **ΔH = -5054 kJ mol^{-1}**

This means_____

Writing Thermochemical Equations

The ***ΔH*** value must be positive or negative to indicate an endothermic or exothermic reaction. If an enthalpy change was given as ***ΔH*** = 345 kJ.mol^{-1}, this does not mean it is an endothermic reaction.

Rules

2. The physical state of matter must be shown;

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$ ***ΔH*** = - 572 kJ.mol^{-1}

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$ ***ΔH*** = - 484 kJ.mol^{-1}

There is a difference in ***ΔH*** between the products being a liquid and a gas.

So, the condensation of 2 moles of water vapour to 2 moles of liquid water at 25°C produces 88 kJ of energy.

3. If the coefficients are doubled, the **Δ** *H* value must be doubled:

$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$ ***ΔH*** = - 572 kJ.mol^{-1}

$4H_{2(g)} + 2O_{2(g)} \rightarrow 4H_2O_{(l)}$ ***ΔH*** = - 1144 kJ.mol^{-1}

The amount of energy produced is directly proportional to the amount of substance initially present.

If twice as much reactant is used, then twice as much energy can be produced.

4. If a reaction is reversed, ***ΔH*** is equal to, but opposite in sign, to that of the forward reaction:

$2H_2O_{(l)} \rightarrow 2H_{2(g)} + O_{2(g)}$ ***ΔH*** = + 572 kJ.mol^{-1}

Less step by step teaching

More linking of ideas

	Fossil Fuels	**Biofuels**
Types of fuels		
Electricity production	**Coal 35% efficient** Chemical equation: Energy transformations **Natural Gas 40%** Chemical equation: Energy transformations	**Biogas 40% efficient** Chemical equation: Energy transformations:
Transport fuels	**Petrol 25% efficiency** Chemical equation: 1 mol releases: _____ kJ of energy **LPG**	**Bioethanol** Chemical equation: 1 mol releases: _____ kJ of energy

Greater student choice

Chemistry Personal Learning Plan – High 2019 Hein = textbook

Term 1 Unit 3 AOS1, AOS2

Wk 2	**Edrolo**	Mon 4/02	Wed 6/02	Fri 8/02
	Fuels	Chp MC Fuels	Chp MC Ener Fuels	Chp MC Calc fuels
Wk 3		Mon 11/02	Wed 13/02	Fri 15/02
	Exo/ Endo	Chp ER Energy Q8-14	Chp ER Ener Q15-19	Chp Energy test
Wk 4		Mon 18/02	Wed 20/02	Fri 22/02
	Chem rxn Colln Theory Rxn rates	Hein Ch 7 p174 Q1-4	Hein Ch 7 p178 Q1-4	Hein Ch 7 p188 Q1-4
Wk 5		Mon 25/02	Wed 27/02	Fri 1/03
	Equilibrium	Chp MC Gal Cells Hein Ch 8.2 Q1-4	Chp ER Gal Cells Hein Ch 8.3 Q1-5	Chp ER Gal Cells Hein Ch 8.4 Q1-7
Wk 6		Mon 4/03	Wed 6/03	Fri 8/03
	Energy supply fuel cells	Chp Gal cell & Fuel cells test Section A	Chp Gal cell & Fuel cells test Section B	Chp Gal cell & Fuel cells test Section B
Wk 7		Mon 11/03	Wed 13/03	Fri 15/03
	Calcs for Equilibrium Le Chatliers	Chp MC Rate Q1-8	Hein Ch 8.7 Q1-4	Hein Ch 8.7 Q5,6

Chemistry Personal Learning Plan – Medium 2019 Hein = textbook

Term 1 Unit 3 AOS1, AOS2

Wk 2	**Edrolo**	Mon 4/02	Wed 6/02	Fri 8/02
	Galvanic Cells	Hein Ch5.1 Q1-5	Hein Ch5.2 Q1-4	Hein Ch5.3 Q1-5
Wk 3		Mon 11/02	Wed 13/02	Fri 15/02
	Galvanic Cells	Hein Ch5 Rev Q1-5	Hein Ch5 Rev Q6-12	Hein Ch5 Rev Q12-20
Wk 4		Mon 18/02	Wed 20/02	Fri 22/02
	Fuel Cells vs Gal cells Unit 3 AOS1 exam	Hein Ch6.1 Q1-5	Hein Ch6 Rev Q1-7	Hein Ch6 Rev Q8-14
		Celebrate! You have completed the chapter questions for U3 AOS1		
Wk 5		Mon 25/02	Wed 27/02	Fri 1/03
		Chp ER Energy Q8-14	Chp ER Ener Q15-19	Chp Energy test
Wk 6		Mon 4/03	Wed 6/03	Fri 8/03
	Galvanic Cells	Chp MC Gal Cells	Chp ER Gal Cells	Chp ER Gal Cells
Wk 7		Mon 11/03	Wed 13/03	Fri 15/03
	Chem rxn Colln Theory Rxn rates	Hein Ch 7 p174 Q1-4	Hein Ch 7 p178 Q1-4	Hein Ch 7 p188 Q1-4

Stoichiometry

VCE U3&4 Chem exam facts
- approx. 20% marks allocated to calculations
- most calculations require stoichiometry skills

Limiting Reagents
- Limiting reagent worksheets — The Cavalcade o' Chemistry
- Limiting reagent and percentage yield — Kahn Academy
- Limiting reagent — Kahn Academy

Practice problems
- Example Problem 1 — Kahn Academy
- Example Problem 2 — Kahn Academy
- Simple stoichiometry worksheets — The Cavalcade o' Chemistry

Stoichiometry introduction
- Introduction to Stoichiometry — SparkNotes, uses conversion factors
- Introduction to Stoichiometry — Kahn Academy
- Introduction to Stoichiometry — Kahn Academy

Foundations
- Balancing Chemical Equations — SMARTERTEACHER, YouTube
- Balancing more complex chemical equations — Kahn Academy
- Determining the mol ratio — SMARTERTEACHER, YouTube

References:
All quizzes from PreTests/PostTests
All Khan Academy content is available for free at www.khanacademy.org
SparkNotes Editors. "SparkNotes on Stoichiometric Calculations." SparkNotes.com. SparkNotes LLC. n.d. Web. 6 Feb. 2019.
Cavalcade 1 (2018) The Cavalcade o' Chemistry, https://chemfiesta.org/, date accessed 7th Feb 2018.

CHEM TopUp Tools

PreTests
Quiz 1
Quiz 2

PostTests
Quiz 1
Quiz 2

KEY
Video
Notes
Worksheet

Further resources can be found at MyChemHub

Feb 2019
Resources curated by Adele Hudson
www.mychemhub.com

More targeted teaching

PreTests
Quiz 1
Quiz 2

PostTests
Quiz 1
Quiz 2

Foundations

Balancing Chemical Equations
SMARTERTEACHER, YouTube

Balancing more complex chemical equations
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Determining the mol ratio
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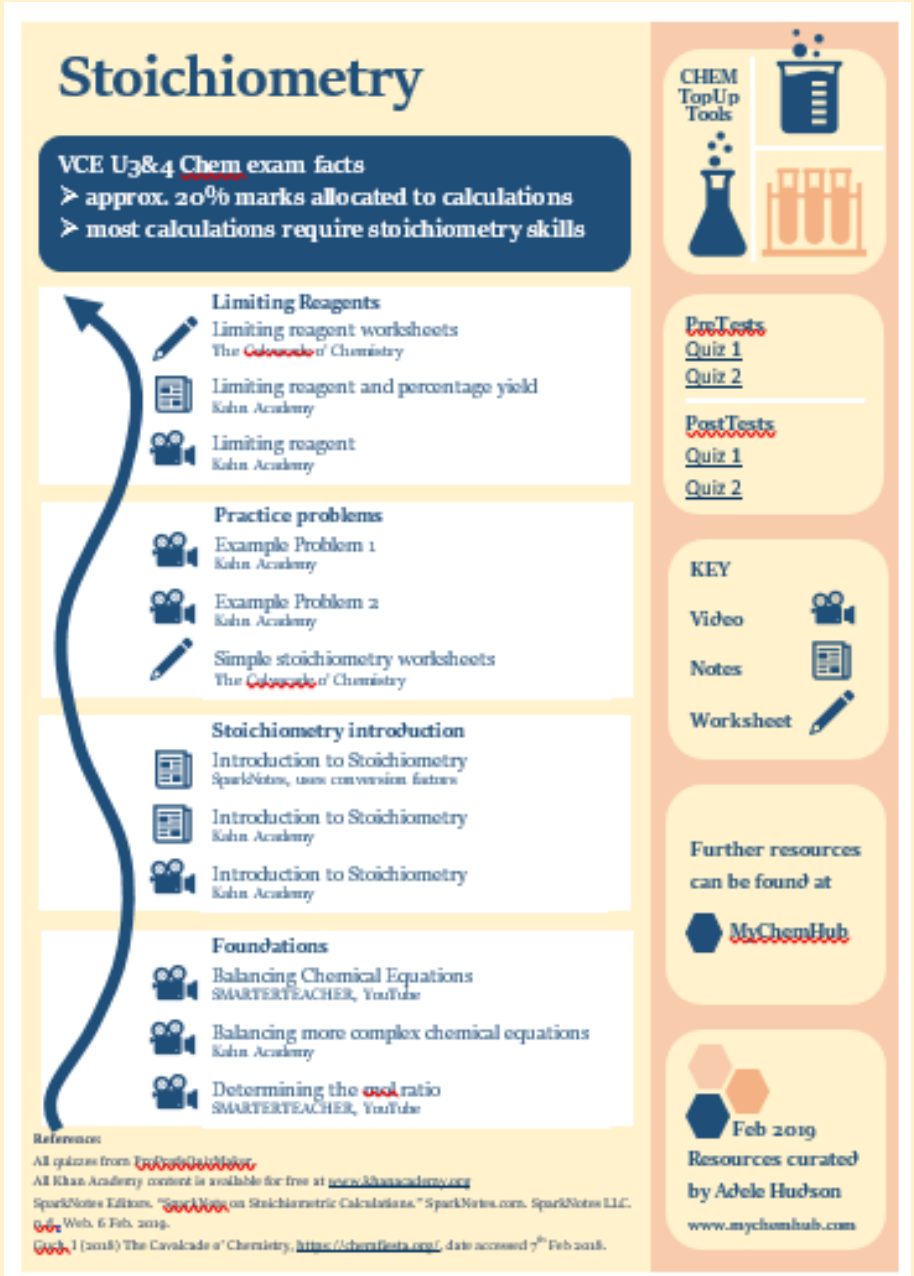

More targeted teaching

Practice problems

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AOS3?

Learn key science skills Yr 7 -12

Integrate AOS3 into content

Target more challenging ideas

Use research groups in practical investigation

Learn key science skills Yr 7 -12

Year 7	Year 8	Year 9	Year 10
Question Hypothesis	Question Hypothesis	Question Hypothesis	Question Hypothesis
Variables Procedure Safety	Variables Method Safety	Variables Method Safety	Variables Method Safety
Observations Tables Graphs	Observations Tables Graphs	Observations Tables Graphs	Observations Tables Graphs
Evaluates data Errors Links to theory Conclusion	Evaluates data Errors Links to theory Conclusion	Evaluates data Errors Modifications Links to theory Conclusions	Evaluates data Errors Modifications Links to theory Conclusions
	Scientific terminology	Scientific terminology	Scientific terminology

			links key findings		
		identifies trends and patterns	explains key findings with scientific theory	explains errors in method	identifies limitations
asks questions that can be tested	makes predictions based on theory	summarises data	explains key findings with own theory	identifies errors in method	summarises key findings
states what will be done	makes predictions	includes data	Identifies key findings	includes errors	includes findings
identifies purpose	**makes predictions**	**evaluates data**	**analyses data**	**evaluates method**	**makes conclusions**

Integrate AOS3 into content

Making predictions

Unit 3 AOS1: Predicting melting point of fuel samples based on their physical states

U1 AOS1: Predicting the melting point of an element from patterns in the periodic table

Skill session: Predicting the melting (or sublimation) point of fuel samples based on their physical states

Adapted from VCAA VCE Advice for Teachers Chemistry, digital resource, http://www.vcaa.vic.edu.au, date accessed 9th Feb 2018.

This task addresses the following Key knowledge and key science skills:

- U3 AOS1 KK - the comparison of fossil fuels (coal, petroleum gas, coal seam gas) and biofuels (biogas, bioethanol, biodiesel) with reference to energy content, renewability and environmental impacts related to sourcing and combustion
- U4 AOS3 KK - limitations of data and methodologies
- Key Science skill – making a prediction

Outline

In this task, you will predict the melting (or sublimation) point fuels from their physical state at room temperature.

Materials

- coal
- coconut oil
- bioethanol
- kerosene
- paraffin wax
- methane

Review: How do I make a scientific prediction?

1. Make observations and collect data using your senses or equipment.
2. Look for patterns in the data and link this with any relevant background knowledge that you may have or can find in literature.
3. Develop a statement about future expected results.
4. Test your prediction.

Skill session: Predicting the melting point of an element from patterns in the periodic table

Adapted from GCEBitesize, Making predictions, http://www.bbc.co.uk/schools/gcsebitesize/science, date accessed 9th Feb 2018.

This task addresses the following key knowledge and key science skills:

- U1 AOS1 KK - the periodic table as an organisational tool to identify patterns and trends in, and relationships between, the structures (including electronic configurations and atomic radii) and properties (including electronegativity, first ionisation energy, metallic/non-metallic character and reactivity) of elements.
- U4 AOS3 KK - limitations of data and methodologies
- Key science skill – making a prediction

Outline

In this task, you will predict the melting point of elements using only the patterns in the periodic table.

Method

Examine the table below of the melting point of some of the group 1 elements.

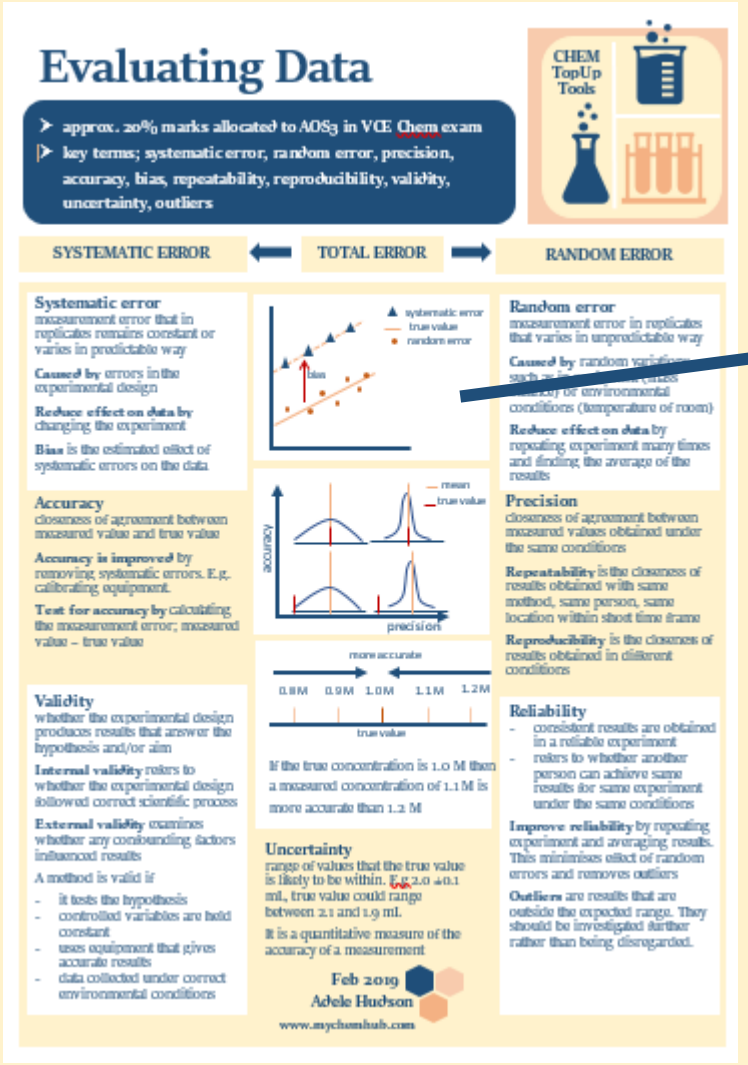
Group 1 Elements	Melting point (°C)
lithium	181

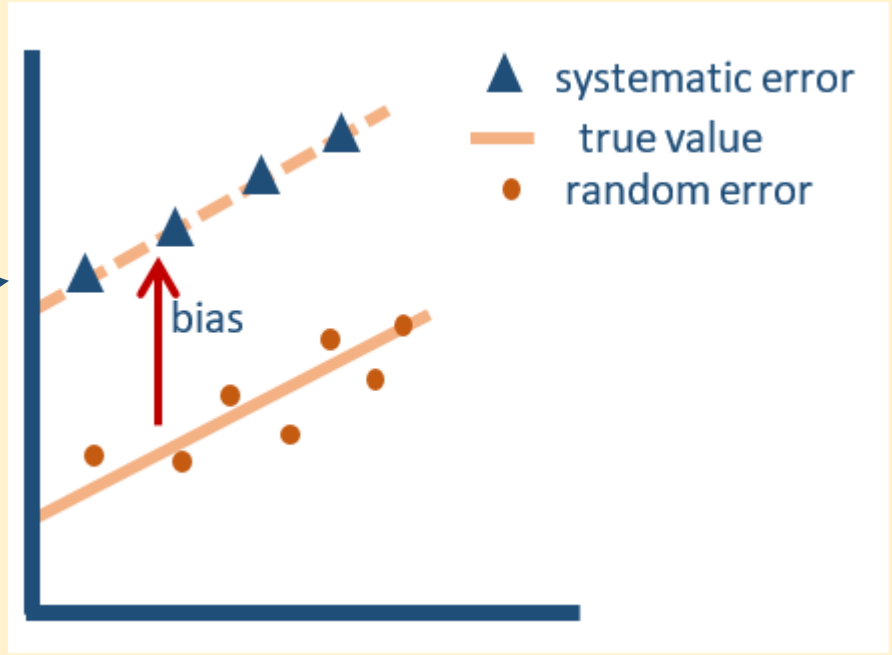
Review: How do I make a scientific prediction?

1. Make observations and collect data using your senses or equipment.
2. Look for patterns in the data and link this with any relevant background knowledge that you may have or

Target more challenging ideas

systematic error, random error, precision, accuracy, bias, repeatability, reproducibility, validity, uncertainty, outliers





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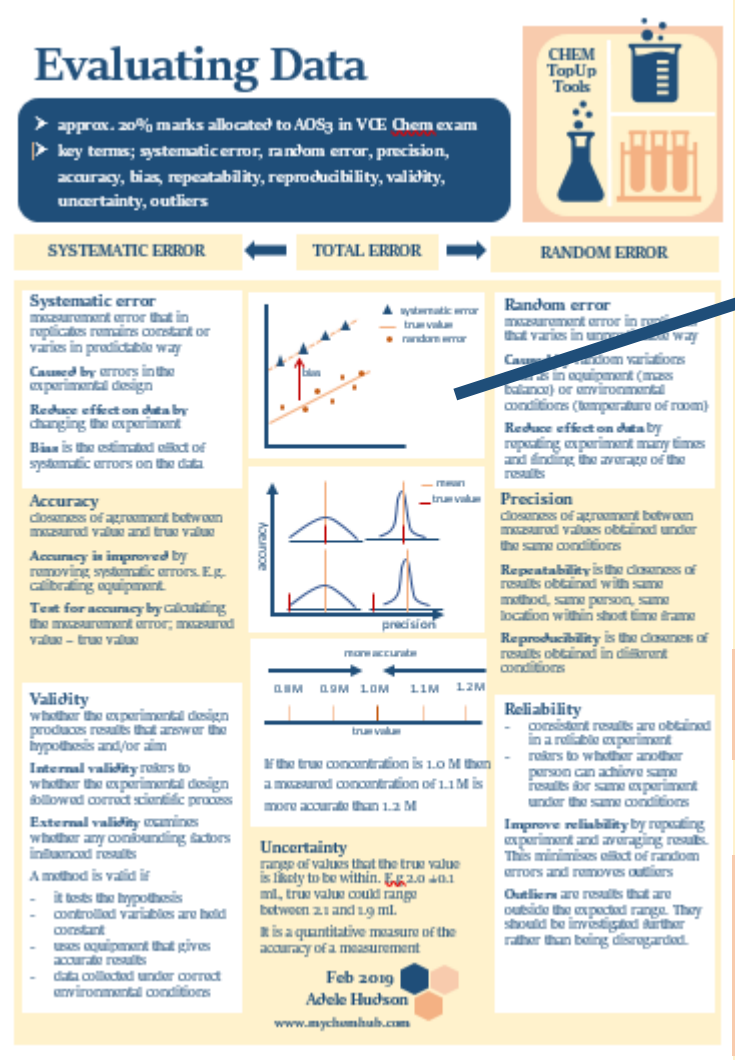

Evaluating Data

- approx. 20% marks allocated to AOS3 in VCE Chem exam
- key terms; systematic error, random error, precision, accuracy, bias, repeatability, reproducibility, validity, uncertainty, outliers

CHEM TopUp Tools

SYSTEMATIC ERROR ⟵ TOTAL ERROR ⟶ RANDOM ERROR

Systematic error
measurement error that in replicates remains constant or varies in predictable way

Caused by errors in the experimental design

Reduce effect on data by changing the experiment

Bias is the estimated effect of systematic errors on the data

Accuracy
closeness of agreement between measured value and true value

Accuracy is improved by removing systematic errors. E.g. calibrating equipment.

Test for accuracy by calculating the measurement error; measured value – true value

Validity
whether the experimental design produces results that answer the hypothesis and/or aim

Internal validity refers to whether the experimental design followed correct scientific process

External validity examines whether any confounding factors influenced results

A method is valid if
- it tests the hypothesis
- controlled variables are held constant
- uses equipment that gives accurate results
- data collected under correct environmental conditions

systematic error
true value
random error
bias

mean
true value
accuracy
precision

more accurate
0.8M 0.9M 1.0M 1.1M 1.2M
true value

If the true concentration is 1.0 M then a measured concentration of 1.1 M is more accurate than 1.2 M

Uncertainty
range of values that the true value is likely to be within. E.g. 2.0 ±0.1 mL, true value could range between 2.1 and 1.9 mL

It is a quantitative measure of the accuracy of a measurement

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Random error
measurement error in [illegible] that varies in unpredictable way

Caused by random variations in [illegible] as in equipment (mass balance) or environmental conditions (temperature of room)

Reduce effect on data by repeating experiment many times and finding the average of the results

Precision
closeness of agreement between measured values obtained under the same conditions

Repeatability is the closeness of results obtained with same method, same person, same location within short time frame

Reproducibility is the closeness of results obtained in different conditions

Reliability
- consistent results are obtained in a reliable experiment
- refers to whether another person can achieve same results for same experiment under the same conditions

Improve reliability by repeating experiment and averaging results. This minimises effect of random errors and removes outliers

Outliers are results that are outside the expected range. They should be investigated further rather than being disregarded.

Accuracy
closeness of agreement between measured value and true value

Accuracy is improved by removing systematic errors. E.g. calibrating equipment.

Test for accuracy by calculating the measurement error; measured value – true value

BIPM – change
- kilogram
- Ampere
- kelvin
- mole

BIPM – international standards for measurement

ISO standard 5725
Accuracy = trueness and precision

Target more challenging ideas

Diagnostic Tests

Systematic error, random error, accuracy and precision

Quiz Level 1

Multiple Choice

1. Accuracy is the
   A. closeness of agreement between replicate values obtained under the same conditions
   B. closeness of agreement between measured value and true value
   C. the measurement error in replicates that varies in unpredictable way
   D. measurement error that in replicates remains constant or varies in a predictable way

2. Precision is the
   A. closeness of agreement between replicate values obtained under the same conditions
   B. closeness of agreement between measured value and true value
   C. the measurement error in replicates that varies in unpredictable way
   D. measurement error that in replicates remains constant or varies in a predictable way

3. Systematic errors refer to
   A. closeness of agreement between replicate values obtained under the same conditions

6. Precision in measurements can be improved by
   A. reducing the number of steps in the method
   B. calibrating the instrument with a new set of standards
   C. repeating the experiment many times and finding the average of the re
   D. reducing the bias in the data by changing the experimental design

7. Systematic errors affect
   A. precision
   B. accuracy
   C. reliability
   D. repeatability

8. The effect of random errors on measurements can be minimised by
   A. changing the experimental design
   B. repeating the experiment many times and averaging the results
   C. removing systematic errors
   D. ensuring the correct scientific process is followed.

9. The accepted value is 2.56. Which set of experimental data is most precise least accurate?
   A. 2.56, 2.73, 2.37
   B. 2.56, 2.52, 2.59
   C. 2.36, 2.35, 2.37
   D. 2.57, 2.92, 2.34

Target more challenging ideas

Apply knowledge tasks

Skill session: Accuracy and precision

This task addresses the following key science skills:

- U2 AOS3 KS, U4 AOS3 KS - the characteristics of scientific research methodologies and techniques of primary qualitative and quantitative data collection relevant to the selected investigation: volumetric analysis, instrumental analysis, calorimetry and/or construction of electrochemical cells; **precision, accuracy**, reliability and validity of data; and minimisation of experimental bias

Introduction

All measurements vary in some way from the true value. It is therefore important to always evaluate the accuracy and precision of experimental results.

Accuracy is the closeness of agreement between the measured value and the true value. Accuracy is affected by the systematic errors in the design of the experiment. For example, a mass balance may read 1.00g but if it is not calibrated the mass could in fact be 0.98g. Therefore, eliminating systematic errors can improve accuracy such as specifying that pipettes be used rather than beakers to deliver volumes in a titration. It is possible to test for accuracy by calculating the measurement error which is the measured error minus the true value. At times, there is no accepted true value for an experiment. In these occasions, the accuracy can be determined from examining the errors and comparing the value to an estimate of the true value.

Accuracy
closeness of agreement between measured value and true value

Accuracy is improved by removing systematic errors. e.g. calibrating equipment.

Test for accuracy by calculating the measurement error; measured value – true value

Precision
closeness of agreement between replicate values obtained under the same conditions

Target more challenging ideas

Apply knowledge tasks

Skill session: Accuracy an

This task addresses the follc

- U2 AOS3 KS, U4 AOS3 and quantitative data calorimetry and/or cc minimisation of exper

Introduction

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Accuracy is the closeness c true value. Accuracy is affe experiment. For example, a the mass could in fact be improve accuracy such as sp deliver volumes in a titratio measurement error which i there is no accepted true accuracy can be determinec to an estimate of the true v

same conditions

Precision is the closeness of agreement between replicate values obtained under the same conditions. The precision of experimental data is limited by random errors. For example, measurements that require greater estimation will be less precise. A 50 mL burette, which has graduations of 0.1 mL, will deliver a far more precise volume than a 50 mL measuring cylinder which has graduations of 1 mL. Repeating experiments will reduce the effect of random errors and improve precision. Selecting equipment suitable for the experiment will also improve precision. For example, titrations often require grade A glassware while a measuring cylinder can be used to deliver volumes in an organic synthesis reaction.

Apply your knowledge

Accuracy and precision can be represented graphically (Figure 1.) \

a) Why is greater precision represented by a narrower graph?

b) Why is there more overlap between the mean or the average of experimental result for more accurate data sets?

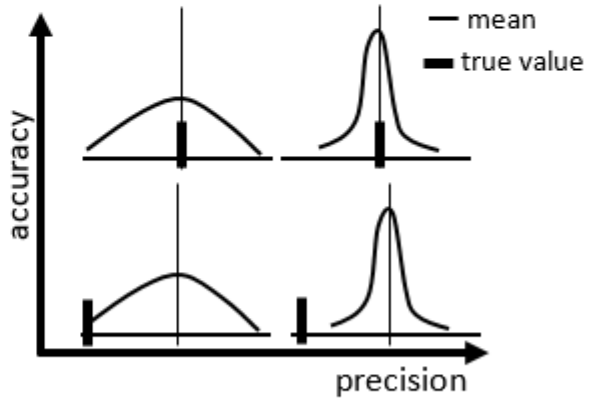


Figure 1. Graphical representation of accuracy and precision.

Target more challenging ideas

Apply knowledge tasks

Skill session: The three R's -repeatability, reproducibility and reliability

This task addresses the following key science skills:

- U2 AOS3 KS, U4 AOS3 KS - the characteristics of scientific research methodologies and techniques of primary qualitative and quantitative data collection relevant to the selected investigation: volumetric analysis, instrumental analysis, calorimetry and/or construction of electrochemical cells; precision, accuracy, **reliability** and validity of data; and minimisation of experimental bias

Introduction

Repeatability, reproducibility and reliability refers to the precision of an experiment under different conditions.

Repeatability is the closeness of results obtained with same method, same person, same location within short time frame. For example, results are said to be repeatable when three or more concordant results are obtained by one person, using the same equipment, in the same laboratory on one day. Repeatability can be improved by using more precise equipment and increasing the number of replicates.

Reproducibility is the closeness of results obtained in different conditions. These different conditions can include different operators, different laboratories, different equipment, different environmental conditions.

Repeatability is the closeness of results obtained with same method, same person, same location within short time frame

Reproducibility is the closeness of results obtained in different conditions

Reliability

- consistent results are obtained in a reliable experiment
- refers to whether another person can achieve same results for same experiment

Target more challenging ideas

Apply knowledge tasks

Skill session: The three R's -repeatability, reproducibility and reliability

This task addresses the following inquiry skill:

- U2 AOS3 KS, and quantita calorimetry a minimisation

Introduction

Repeatability, reprc experiment under d **Repeatability** is the person, same locati to be repeatable wh person, using the s Repeatability can l increasing the numb **Reproducibility** is th These different cc laboratories, differ

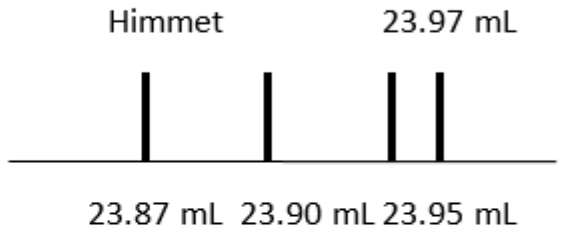
using more precise equipment and increasing the number of replicates.

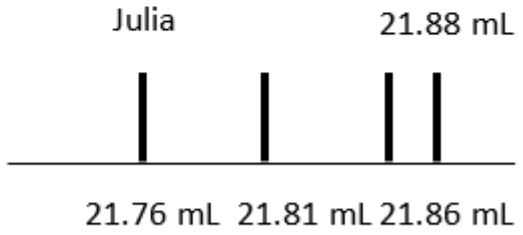
Reliability refers to whether the experiment will produce consistent results for a range of conditions with minimal variation in the data. An experiment is said to be reliable when another person can achieve the same results for same experiment. Greater reliability can be achieved by repeating the experiment and averaging the results. This minimises effect of random errors and removes outliers.

This minimises effect of random errors and removes outliers

Application of knowledge

a) Himmet determined four titre values for a ethanoic acid/sodium hydroxide titration. The results were recorded during one lesson using the same equipment and in the same laboratory. Were the results concordant? Were they repeatable? Give reasons to support your answer.





b) Julia repeated the same experiment the following day using new equipment, new unstandardised sodium hydroxide and in a different laboratory. The results were concordant, but there were differences in the overall titre value. Suggest changes to the method which could improve the reproducibility of the technique.

Use research groups in practical investigation

Research Groups

You will complete an individual research task within a research group. In your research group you will be able to support each other by collaborating on the background theory and even measurement techniques. However, you will have individual research questions. For example, a research group is looking at Vitamin C with one person in the group studying the degradation of Vitamin C under different types of lights while another may look at the effect of temperature on the degradation of Vitamin C.

- Bioplastics
- Catalase
- Starch
- Vitamin C

Keys to success

- 30 -40 min training session prior to practical lessons in using the analytical technique.
- students support each other during practical lessons e.g. share calibration data

Use research groups in practical investigation

Catalase

Catalase is an enzyme that is useful in breaking down toxins such as hydrogen peroxide. It is found in the liver and kidney's in humans and is also present in high concentrations in plants and fungus products such as potatoes and yeast.

Some suggested areas of research for this technique include:

- Comparison of the activity of a range of antioxidants by measuring the rate of decomposition of hydrogen peroxide by potato catalase.
- Investigation of the effect of temperature on the kinetics of the enzyme catalased decomposition of hydrogen peroxide
- Comparing the activity of catalase from different sources such as potatoes and yeast

Additional resources

Catalase: H2O2 oxidoreductase, website providing details of catalase structure

- A simple assay for measuring catalase activity.docx

Catalase and coenzymes

- Can polyvinyl alcohol stabilise the enzyme catalase?
- Is spending hundreds of dollars on coenzyme CoQ10 tablets really worth the money?

Use research groups in practical investigation

Starch

Starch is a polysaccharide that is made by plants to store energy and exists in two forms, amylose and amylopectin. Being able to measure the change in the forms of starch under different conditions and the relative amounts of the two types of starch in different food sources is important as amylose and amylopectin have very different properties and are digested at different rates in the human body.

Monitoring the rate at which carbohydrates are digested is important for managing blood glucose levels. This is particularly important for people who are diabetic or who are pre dibetic with insulin sensitivity. The glycemic index is a relative ranking of foods containing carbohydrates according to their effect on blood glucose levels. Foods that have a high GI value contain carbohydrates that are digested quickly and will quickly increase the amount of blood glucose. Amylose forms tight clumps and is more difficult to digest so it has a lower GI than amylopectin, which due to its branched structure is more open. therefore, monitoring the changes in amylose content due to cooking is important as it can mean a change in the GI value.

This research also informs the bioplastics research as the properties of the bioplastics will change with variations in the two forms of starch content. Greater concentrations of amylose result in a stronger bioplastic, so acids such as vinegar are added to reduce the branching in amylopectin.

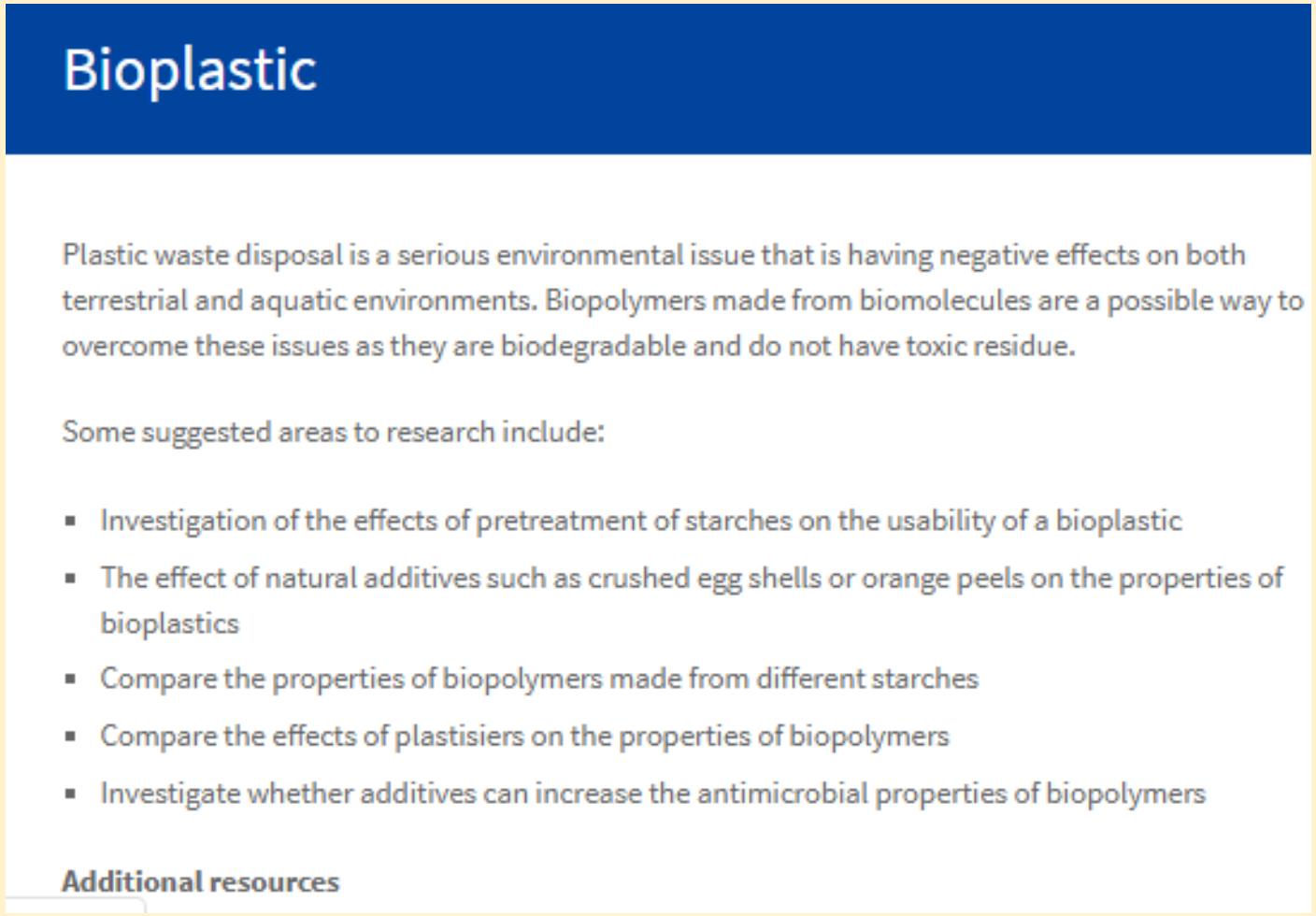
Some suggested areas to research include:

- Comparison of the type starch in 'high' GI potatoes compared to 'low' GI potatoes

Starch

- Can cooking times turn a high GI food into a low GI food?
- Can acid decrease the GI of foods?

Use research groups in practical investigation



Bioplastic

Plastic waste disposal is a serious environmental issue that is having negative effects on both terrestrial and aquatic environments. Biopolymers made from biomolecules are a possible way to overcome these issues as they are biodegradable and do not have toxic residue.

Some suggested areas to research include:

- Investigation of the effects of pretreatment of starches on the usability of a bioplastic
- The effect of natural additives such as crushed egg shells or orange peels on the properties of bioplastics
- Compare the properties of biopolymers made from different starches
- Compare the effects of plastisiers on the properties of biopolymers
- Investigate whether additives can increase the antimicrobial properties of biopolymers

Additional resources

Bioplastics

- Change of tensile strength due to different additives in bioplastic
- Ethylene glycol: The future of bioplastics?

Use research groups in practical investigation

Vitamin C

Vitamin C is an important dietary component as it is required for the biosynthesis of collagen, L-carnitine and some neurotransmitters. Vitamin C is an antioxidant which regenerates other antioxidants in the body and is important in the immune system. Fruits such as citrus is a good source of Vitamin C along with some vegetables such as red and green peppers. Vitamin C is heat sensitive, water soluble and is also light sensitive so cooking, processing and storage of food products can decrease the concentration of vitamin C in foods.

Some suggested areas to research include:

- Investigation of the effect of different types of light on the concentration of vitamin C in juices
- Investigation of heat on the concentration of vitamin C in juices
- The effect of cooking time on the concentration of vitamin C in vegetables

- Colourimetric determination of Vitamin C.pdf
- Vitamin C Research Groups.docx

Vitamin C

- Are you benefiting from Vitamin C in strawberries?
- Are you really sure your orange juice contains Vitamin C?

Use research groups in practical investigation

ARE YOU REALLY SURE THAT YOUR ORANGE JUICE CONTAINS VITAMIN C?

INTRODUCTION

Vitamin C is a strong antioxidant that humans require in order to function properly. It may also reduce the duration of a common cold by 8% in adults and 14% in children (Douglas, 2007). From 2001 to 2002, 31% of Americans were found to be deficient in Vitamin C (USDA, 2005). Inadequate intake of Vitamin C may result in a disease called scurvy inducing in symptoms of fatigue, malaise and/or the inflammation of gums(National Institutes of Health, 2018). The concentration of Vitamin C was investigated regarding the different materials used to package juices. This was conducted to see if there was a correlation between types of package and the levels of ascorbic acid in the juices, and to see which type of packaging would have a juice that is more beneficial to consume. The use of Prussian blue to investigate the absorbances of 709nm by ascorbic acid was also investigated in terms of suitability of acquiring precise results. It was hypothesised that if the packaging is clear, the Vitamin C levels will be more reduced than if it was not transparent. Additionally, the less conductive the packaging is, the less the juice will be heated up and therefore better maintain their Vitamin C levels. The tetra pack is hypothesised to retain its ascorbic acid (Vitamin C) the most as it is both opaque and has low conductivity, followed by the opaque plastic, the metal can, the glass bottle and the clear plastic packaging. This is because ascorbic acid is sensitive to heat and light, reducing its presence the more it is exposed to it as it breaks down in the presence of oxygen through a process called oxidation **[Figure 1]** (Oregon State University, n.d)

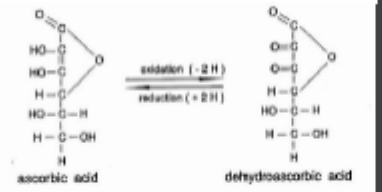
METHOD

A stock solution of 0.01 M ascorbic acid was created and then using 100ml volumetric flasks it was further diluted into concentrations of 0.0001, 0.0002, 0.0003, 0.0004 and 0.0005 using volumetric flasks. Prussian Blue was used for the colorimetric analysis of ascorbic acid and the results were used to create a standard curve **[Figure 2]**. Orange juice (no pulp) was transferred to 5 different containers (clear plastic, opaque plastic, metal can, carton and glass) and left sealed inside them for 24hrs. Each sample was then diluted by a factor of 10, and through Prussian Blue, was analysed using colorimetry.

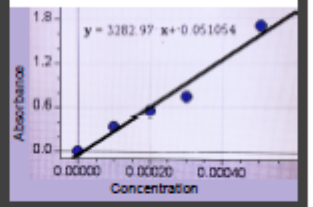
RESULTS

The calibration curve in **[Figure 2]** was created by excluding the absorbance of the 0.0004 M ascorbic acid solution. This was an outlier which had a value of 1.738. Additionally, the absorbances of the different samples should preferably be under 1.00 with higher values indicating the solutions should be further diluted due to the 0.0004 M and 0.0005 M solutions having absorbance values above 1.00. The results **[Figure 3]** are very precise with the largest error bar being only 4.8% of the average value for the Carton trials proving that Prussian Blue is a suitable method for measuring ascorbic acid concentrations in Orange juice. The concentration values resulted to being around double of the stated concentration of ascorbic acid on the orange juice label. It is known that manufacturers are required to have higher concentrations of Vitamin C in their products or else they may be subject to legal proceedings if the concentrations found to be lower than the claimed value (ScienceDaily, 2009). Therefore the results, while they are not accurate to the claimed value, their magnitude is justified. On average, the samples had a concentration of around 0.000417 M with the highest concentration being 0.0004415 (clear plastic trial) and the lowest being 0.000402 M (carton trial).

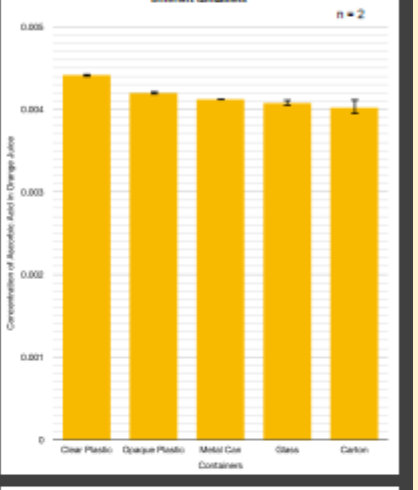
[Figure 1] The oxidation of Vitamin C



[Figure 2] The Concentration of Ascorbic Acid according to Absorbance of 709nm



[Figure 3] The Concentration of Ascorbic Acid from Orange Juice Stored in Different Containers



DISCUSSION

Using Prussian Blue with colorimetry was found to be suitable method for measuring the amount of ascorbic acid in Orange juice as the trials had a very small error range for 95% confidence intervals which indicates how precise the method is. This process works by determining the absorbance of a specific lightwave. As the solution is blue, it reflects the colour blue and absorbs the other colours which the human eye does not perceive it to be. Prussian Blue primarily absorbs the lightwave of 709nm which is the lightwave for orange (Dacarro, G., Taglietti, A. and Pallavinci, P. 2018). The higher the absorbance of the 709nm lightwave, the more blue the solution is and therefore the higher amount of ascorbic acid is in the substance.

It was found that the packaging of orange juice did not affect its ability to maintain ascorbic acid concentrations in a short period of time (24hrs). Although there were slight variances with the results for concentrations of ascorbic acid in different conditions, the sample found with the highest concentration of ascorbic acid (clear plastic sample) should theoretically have the lowest concentration over a period of time. This is because ascorbic acid is very reactive to heat and light causing it to oxidise at a faster rate when in the presence of them. Additionally, higher temperatures increase the rate of reaction due to particles having an increase of kinetic energy which in turn increases the number of particles with the activation energy required to reach the transition stage, allowing them to react (Commons, 2017). This means that there will be more collisions and an increase in successful collisions due to heat energy causing the oxidation of ascorbic acid to be faster. Likewise, light causes a process called photodegradation to occur which essentially is because the photons in light induce oxidation reactions to occur (JustScience, 2017). Therefore, the containers which are clear or conductive are more likely to have lower concentrations in ascorbic acid.

The variances in concentration **[Figure 3]** and the unexpected values for the different containers could be due to orange juice not being uniform and therefore higher concentrations of ascorbic acid maybe be found in one sample compared to another. In order to overcome this, more trials should be conducted to further ensure that the values are more accurate.

CONCLUSION

The container in which orange juice is stored does not affect its Vitamin C values over a short period of time therefore consumers do not have to worry about the effects of its packaging in regards to ascorbic acid if readily consumed. Most people however, don't necessarily consume the Orange juice they purchase within 24hrs, and due to the limited timeframe of the practical investigation, it is unknown whether packaging will affect the ability in maintaining ascorbic acid concentrations in Orange Juice over longer periods of time. Orange juice is also more commonly stored in the fridge unlike the investigation which was conducted at room temperature. In order to improve results, the investigation should span over a longer period of time and in different temperature conditions as this closer mimics the handling of Orange juice by the general public.

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