Vitamin C

Student Guide

Researching Chemistry

Higher

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Overview of the assignment and activities.

What is involved in the unit Researching Chemistry?

Studying chemistry involves learning chemistry facts and concepts. It also involves developing particular skills. These include research skills, which may involve you in doing investigative experiments or researching information, perhaps from the internet. The aim of this unit is to help you develop these chemistry skills. You will learn some chemistry facts, probably in some depth, however it is the development of skills which is the focus of the unit.

What chemistry content will I be learning?

In this unit learners will find out through experimentation, the concentration vitamin C in particular foods or drinks. The practical experiment includes a titration that is similar to that done at advanced higher level and is often chosen by students as part of their investigation at advanced higher. Experimental procedures are included in the pupil support pack.

What activities will I be doing?

There are three types of activities in the unit.

Undertaking literature based research is a hugely important skill. In this unit, this is best carried out as web-based research. It is easy to simply look up a single fact on the internet, but undertaking a more structured project is more complex. Sifting through what is often a large amount of data is demanding. Keeping track of what you are trying to find out is one of the most difficult parts of this type of research, and summarising what you have found, without merely cutting and pasting someone else's work is also challenging. There are several research briefs which can be used in preparation for your investigation.

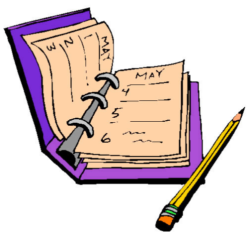
Investigative practical work can be fun and challenging. Planning and designing experiments is often the hardest part of this work. Actually carrying out the experiment may be straightforward. The experiments you are likely to carry out in your investigation are not the kind where you can simply look up the results beforehand. There may be no right or wrong answers. What you find is what you find and your way of doing the experiment may not be similar to others in your class.

Scientific communication is hugely important. It does not matter how interesting or ground breaking your work is; if you cannot communicate your results then you have not completed your work. Information from your web research and data from your practical work will contribute to an assignment that you will complete under supervised conditions. This assignment is assessed externally by the SQA. You can pass this unit without completing the assignment, but you cannot get an overall course award in Higher Chemistry without doing so.

Organising your work and carrying out the activities

How will I organise my work?

Some of the work you carry out in this unit will be in preparation for your research into biodiesel. When you carry out the research activities themselves, it is likely that you will be responsible for organising your work.



You are required to produce a report on the results of a piece of web-based research, and you may produce a report of your practical investigation. You are strongly advised not to produce these "as you go along". Rather, it is very good practice to maintain a diary, or record of work. This should record all your experimental results, ideas, problems you met, references and all the other day to day observations and data that you want recorded. The record of work is your record and as such it should be in a format that suits you. However, experience shows that students who organise their work for ease of reference are likely to be able to extract the information more easily and the resulting reports are likely to be easier to produce.

Will I do the same work as everyone else in my class?

What about teamwork?

This material includes a number of web-based research and practical investigation briefs. It is likely that students within the same class will be allocated different activities, depending on resources available and other classroom management issues.
It is probable that you will undertake some of the work as part of a group. Sometimes, within your team, you will be undertaking the same task and other times you will each focus on a different part of the task. In either case, it is important that discussion takes place. Agree the part that each member of the team will play and ensure that there is time to share the results of the work.

Using the internet for background research

The web allows you to access a huge amount of information.
Make sure that you remain focussed as you carry out your research. It is very easy to get side-tracked. Keep reminding yourself what you are trying to find out as you surf.
Interesting, but not relevant, sites can be visited later. Sites that seem to be promising can be bookmarked so that they can be returned to later.
Tables, graphs and pictures can be copied into a folder. It is likely that some will be used and some will not.
It is worthwhile spending a few moments considering what keywords may best be entered into your search engine.
The web contains many sites containing reliable information – but inevitably some data is unreliable. How can we know what is reliable? As a general rule, information that is not attributed to a source is likely to be unreliable. Professional and government sites are useful. Online encyclopaedias and chat forums are likely to be less reliable. Often it is quite easy to access the same data from a number of sites. This doesn't guarantee the reliability of the information, but it does help.
For more advice on effective web-based research see the Education Scotland resource on
http://www.educationscotland.gov.uk/resources/nq/r/nqresource_tcm4629006.asp?strReferringChannel=nationalqualifications&strReferringPageID=tcm:4-672951-64.

Assessment issues

What do I have to do to pass this unit?

As you work on this unit, you will carry out activities which develop your skills in undertaking research in physics.
Two of the activities contribute to the unit assessment. To be awarded the unit, you need to demonstrate that your work is of at least the required standard in each of the two types of activity.
The two types of activities are:

- Undertaking web based research
- Carrying out investigative practical work - you need to take an active part in planning and carrying out an investigation.

Do I need evidence?

For the web based research, you should ensure that you retain evidence that your work is of the required standard. Each year SQA will ask to see the evidence from a number of candidates. This process is easiest to manage if your evidence is stored in an e-portfolio. You can store text based work, together with pictures, web pages, and any other material which you wish to present as evidence. If you do not use an e-portfolio, you should ensure that your evidence can be easily accessed.
Make sure you:
1) Record at least two sources of information relevant to your focus question. Sufficient detail should be given to allow someone else to find your sources easily. For a website, the URL shown here is perfectly adequate http://www.biodieselfillingstations.co.uk/.
2) Write a brief summary of the information of relevance contained in each of the sources you have identified.

What about assessment in the Higher Chemistry exam?

The Higher unit - Researching Chemistry is available as a free standing unit. It is also a required unit for a course award in Higher Chemistry. There will not be any questions in the Higher Chemistry course assessment which specifically relate to the topic of this unit. However, there will be questions in the course assessment which relate to the skills that you have developed in the unit. The following are the skills which may be assessed in the course assessment:

- Selecting information from texts, tables, charts, graphs and diagrams,
- Presenting information in a variety of forms,
- Processing information,
- Planning and designing an experiment,
- Evaluating experimental procedures,
- Drawing conclusions and making predictions based on evidence provided.

Communication Stage

This will be conducted under a high degree of supervision. This means that:

- You will be in the direct sight of the assessor/teacher
- You must not discuss your work with each other.

During the communication stage you will have access to the following resources:

The material collected during the research stage. This may include, for example, statistical, graphical, numerical or experimental data; data/information from the internet; published articles or extracts; notes taken from a visit or talk; notes taken from a written or audio-visual source.

Once you have agreed the format of your scientific communication with your teacher, you should produce a report on your investigation containing the following key features:

Criteria	Mark	Expected response
Aim	1	The aim must be clearly stated and appropriate to the investigation undertaken.
Apply knowledge and understanding of chemistry	4	Provide correct explanations of the topic researched using chemistry terms/ideas which are at a depth appropriate to Higher Chemistry. The response might include: a statement of the principles involved, formulae, chemical equations, calculations, chemical properties related to bonding present.
Risk assessment	1	State the majority of appropriate safety measures taken during the experimental

		work.
Select information	2	The data/information selected by the candidate for presentation/processing/analysis is both relevant and sufficient.
Process and present	4	Processing can include, for example; performing calculations; manipulating data, summarising referenced text. It must be clear where the raw or extracted data/information came from. Presenting processed data/information can include for example appropriate formats from; summary, graph, table,chart or diagram (one must be a graph, table ,chart or diagram) In each case, sufficient detail should be included to convey the data/information. The source of the original data must be clearly referenced.
Analyse data/information	2	Analysis will include interpreting data/information included in the report(which may or may not have been processed by the student) to identify relationships. This may include further calculations.
Conclusion	1	State a valid conclusion that relates to the aim(s) and is supported by evidence from the students research.
Evaluation	3	Students must make judgements based on criteria. The criteria, upon which judgements of the investigation are made, may include the following • Robustness of findings • Validity of sources • Reliability of data/information • Evaluation of experimental procedure.
Presentation	2	An appropriate title and structure must be given. The references to at least two sources used in the report are given in sufficient detail to allow them to be retrieved by a third party. If one of the sources is an experiment/practical activity, then the title and the aim should be recorded.

Why is this topical?

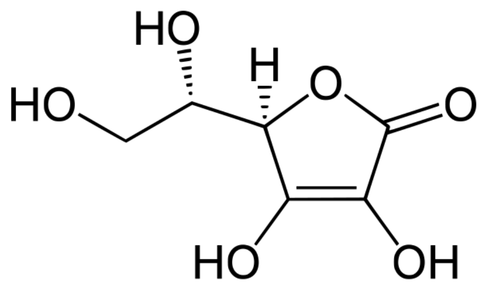
Scurvy, the symptoms of which are haemorrhages, diarrhoea, exhaustion and the tell-tale “scurvy” ulcerated gums, killed many seamen during long sea voyages until, in 1795, the British Navy ordered a daily ration of lime juice for every sailor. This practice earned them the nickname “limeys”, but all but eradicated the disease. The component of the lime juice that prevented scurvy is the reduced form of ascorbic acid, now called vitamin C.

While scurvy is no longer a major health issue, poor nutrition means it has not completely gone away even in wealthy countries like Scotland.

Vitamin C also has a whole variety of other claims made for it: from curing, or at least delaying the onset , of the common cold to protection from cancer.

The Chemistry

Vitamin C is a water-soluble vitamin found in fruits and vegetables, including oranges, strawberries, broccoli, tomatoes and green peppers. Chemically speaking it is the compound ascorbic acid $C_6H_8O_6$.



The body uses ascorbic acid when making collagen, a protein which helps skin, bone, hair and blood vessels stick together. Ascorbic acid also helps the body absorb iron.

We need to take in about 90 mg each day. We can store up to one month's supply of vitamin C, but no more. As we cannot make it in the body, we need to keep ingesting a constant.

Anyone under stress needs extra vitamin C, because the body will use it up more quickly than in a non-stressed state. Smokers need more vitamin C, because smoking is a 'stress' on the body.

Lots of claims are made about vitamin C, for example, taking large amounts is supposed to stop us getting colds and it may help us stop getting some types of cancer.

Ascorbic acid is found in many fruit juices and some vegetables such as broccoli and potatoes.

Cooking can reduce the vitamin content of food because some vitamins are sensitive to heat, water and air. Water-soluble vitamins are most vulnerable to heat, particularly vitamin C and the B vitamins. The type of food preparation influences the loss of vitamins. Choose cooking methods that use minimal heat and water to preserve the vitamin contents of food.

Vitamin C is easily destroyed by excessive heat and water, as well as exposure to air. In studies, boiling caused the most loss, while steaming retained the most vitamin C. An earlier Danish study showed that boiling for just five minutes caused 45 to 64 percent of vitamin C to be lost.

Steaming, microwaving or using a pan or wok with a small amount of water are the preferred cooking methods. The most vitamins are retained when there is less contact with water and a shorter cooking time. In the Danish study, steaming broccoli for five minutes retained almost 100 percent of the water-soluble vitamins. Microwaving and stir-frying reduce vitamin loss because they cook food quickly. Avoid deep-frying. The high heat required for frying destroys heat-sensitive vitamins.

Fresh v Frozen

And as winter approaches, fresh produce is limited (or expensive)in much of the country, which forces many of us to turn to canned or frozen options. While canned vegetables tend to lose a lot of nutrients during the preservation process (notable exceptions include tomatoes and pumpkin), frozen vegetables may be even more healthful than some of the fresh produce sold in supermarkets. Why? Fruits and vegetables chosen for freezing tend to be processed at their peak ripeness, a time when—as a general rule—they are most nutrient-packed.

While the first step of freezing vegetables—blanching them in hot water or steam to kill bacteria and arrest the action of food-degrading enzymes—causes some water-soluble nutrients like vitamin C and the B vitamins to break down or leach out, the subsequent flash-freeze locks the vegetables in a relatively nutrient-rich state.

On the other hand, fruits and vegetables destined to be shipped to the fresh-produce aisles around the country typically are picked before they are ripe, which gives them less time to develop a full spectrum of vitamins and minerals. Outward signs of ripening may still occur, but these vegetables will never have the same nutritive value as if they had been allowed to fully ripen on the vine. In addition, during the long haul from farm to fork, fresh fruits and vegetables are exposed to lots of heat and light, which degrade some nutrients, especially delicate vitamins like C and the B vitamin thiamin.

Testing for Vitamin C Content

2,6-dichlorophenolindophenol (DCPIP) can be used to estimate the concentration of vitamin C in food.

DCPIP is blue when dissolved in water, is red in acid conditions, and is reduced by ascorbic acid (vitamin C) to a colourless compound. However, in this titration, the end point colour change will be from blue to pink due to the presence of the phosphoric(V) acid used to prepare the vegetable extract.

Media Items

1. How biodiesel is made – Methes energy - https://www.youtube.com/watch?v=xLa83KIaEyw

2. A page from Strathclyde university summarising biodiesel production. http://www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/what_biodiesel.htm

3. An Oxfam report highlighting some problems with biofuel production - http://www.oxfam.org/en/grow/policy/hunger-grains

4. A comparison from Oregon of pollution from biodiesel and conventional diesel. http://www.deq.state.or.us/aq/diesel/reducepollution.htm

5. Item from Penn State in the USA with a review of biodiesel including facts about engine performance. http://pubs.cas.psu.edu/FreePubs/pdfs/uc204.pdf

Some more resources

Healthy Eating Diamond Media

http://healthyeating.sfgate.com/cooking-food-reduce-vitamin-content-5164.html

livestrong.com

http://www.livestrong.com/article/547867-what-does-cooking-do-to-vitamin-c/

whfoods.com

http://www.whfoods.com/genpage.php?tname=nutrient&dbid=109

http://www.whfoods.com/genpage.php?tname=nutrient&dbid=109

Eating well.com

http://www.eatingwell.com/nutrition_health/nutrition_news_information/fresh_vs_frozen_vegetables_are_we_giving_up_nutrition_fo

food preservation.about.com

http://foodpreservation.about.com/od/Freezing/a/Fresh-Vs-Frozen-Vegetables.htm

daily mail

http://www.dailymail.co.uk/health/article-2449843/Frozen-food-IS-better-Higher-levels-vitamins-antioxidants.html

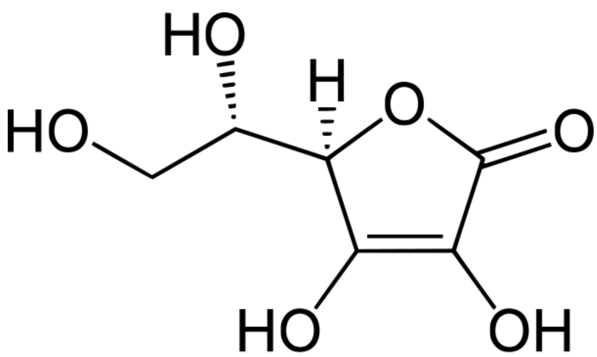
the grocer

http://www.thegrocer.co.uk/fmcg/fresh/frozen-food-makers-hit-back-at-fruit-and-veg-health-study/356096.article

Investigation A

"Which vegetables contain the most vitamin C?"

Vitamin C is the compound ascorbic acid with the molecular formula $C_6H_8O_6$.



The body uses ascorbic acid when making collagen, a protein which helps skin, bone, hair and blood vessels stick together. Ascorbic acid also helps the body absorb iron.

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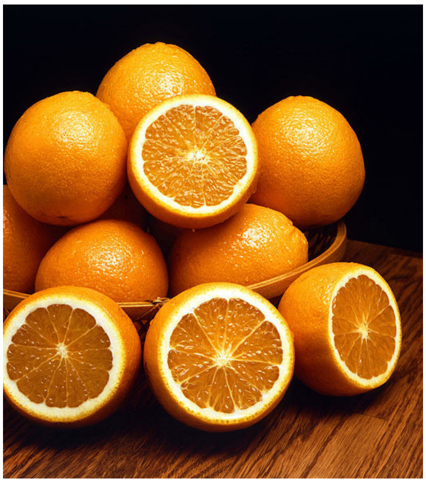
As we cannot make it in the body, we need a regular source in our diet



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Cooking Methods

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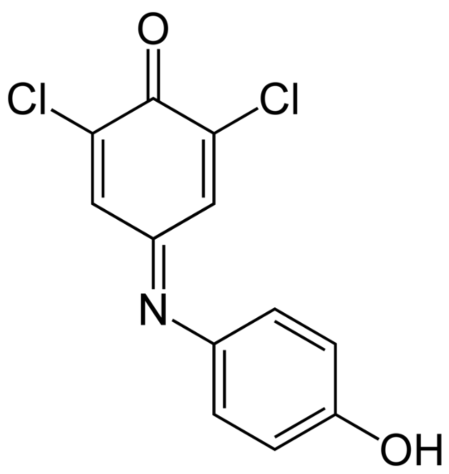

Background research

The first stage of carrying out research in chemistry is to review what is already known about the topic of interest. Chemists use books, scientific papers, journals and the internet to carry out background research.

Your first task in the Researching Chemistry unit is to *independently* carry out background research into one of the focus questions listed, which will be assigned to you by your teacher. In school it is likely that you will carry out your background research on the internet.

Once you have completed your background research, you must then complete the unit assessment tasks and store your research evidence in a safe place.

Assessment tasks

1. **Record at least two sources of information relevant to your focus question**. Sufficient detail should be given to allow someone else to find your sources easily. For a website, the URL shown here is perfectly adequate: http://www.biodieselfillingstations.co.uk/.
2. **Write a brief summary** of the information of relevance contained in each of the sources you have identified.

Focus Questions

A1 Explain why the human body requires Vitamin C.

A2 Many foods and drinks which contain Vitamin C are known as ‘superfoods’. What requirements must be met for a food to be labelled as a superfood?

A3 What evidence is there to suggest that eating superfoods is good for human health?

A4 Many people make fruit/vegetable smoothies to get their daily allowance of vitamins. It is thought that smoothies can be harmful to health. What evidence is there to support this?

A5 Vitamin C is a powerful antioxidant. State some sources of vitamin C and briefly explain the role it plays in the human body.

A6 The concentration of Vitamin C in food and drink can be affected by storage conditions. How should food be stored to maintain the maximum concentration of Vitamin C?

A7 How do different methods of cooking affect the vitamin C levels in vegetables?

Advice on using the internet for background research

The web allows you to access a huge amount of information – don't get side-tracked! Promising sites should be bookmarked so that you can return to them later. Tables, graphs and pictures can be copied into a folder. It is worthwhile spending a few moments considering which keywords may be the best to enter into your search engine. For more advice on effective web-based research see the LTS resource on http://www.ltscotland.org.uk/nationalqualifications/resources/r/nqresource_tcm4629006.asp.

Planning your investigation

The next stage in your investigation is to plan and carry out an appropriate experimental procedure that will allow you to determine how much vitamin C is contained in a range of fruits.

Whilst planning your experimental work you may wish to consider:

- which fruits/vegetables or fruit/vegetable juices will you use?
- how to find out the expected vitamin C concentration by reading labels and/or carrying out internet research
- what apparatus will be required?
- which chemicals will be required?
- the hazards that might be involved and how you will minimise risk?

Procedure

This experiment uses 2,6-dichlorophenolindophenol (DCPIP) in a titration, to estimate the concentration of vitamin C in food. DCPIP is blue when dissolved in water and is red in acid conditions, and is reduced by ascorbic acid (vitamin C) to a colourless compound. However, in this titration, the end point colour change will be from blue to pink due to the presence of the phosphoric(V) acid used to prepare the vegetable extract.

You will need:

Apparatus for titration, 25 cm^3 pipette, 50 cm^3 burette, 250 cm^3 conical flask, pipette filler	Measuring cylinders, 500 cm^3 and 250 cm^3
Beaker, 250 cm^3	Liquidiser
Filter funnel and muslin for filtration	Vegetables to test, 100 g
5% phosphoric(V) acid solution	A solution of 2,6-dichlorophenolindophenol (DCPIP)

What you do:

- Accurately weigh out about 50 g of your vegetable and put it in a liquidiser with 250 cm^3 of 5.0% phosphoric(V) acid.
- Ensure the lid is securely fitted and liquidise at high speed.

  (The purpose of the 5% phosphoric(V) acid solution is to provide acid conditions to inactivate the enzyme ascorbic acid oxidase and to extract the ascorbic acid from the food).
- Filter off using a muslin filter.
- Make up the volume of extract plus washings to 300 cm^3 with deionised (not distilled) water.
- Set up the burette filled with DCPIP.
- Using a pipette filler, pipette 25 cm^3 of the vegetable extract into a conical flask.
- Titrate with the DCPIP indicator solution until a pink end point is reached.

  Note: If the vegetable extract solution is a greenish colour, the colour change to pink at the end point may be very difficult to see. The pink colour may appear as a brownish tinge!

  Stop when you think you have reached the end point and ask your teacher.

  All titrations should be carried out in duplicate and concordant titres obtained.

Average your titres.

- Repeat the experiment with other fruit/vegetables.

Results Tables:

Vegetable 1:..Mass of vegetable used .... g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
Titre	cm^3	cm^3	cm^3
Average of the First and Second Run titres		cm^3	

Vegetable 2: ....Mass of vegetable used .... g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
DCPIP Titre	cm^3	cm^3	cm^3
Average of the First and Second Run titres		cm^3	

Vegetable 3: ....Mass of vegetable used .... g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
DCPIP Titre	cm^3	cm^3	cm^3

Average of the First and Second Run titres	[redacted]	cm^3

You may, of course, do more than 3

Calculating the Vitamin C Content of a Fruit / Vegatable.

This depends on the fact that one mole of DCPIP will react with one mole of vitamin C.

One mole of DCPIP = 290.08g

One mole of vitamin C (ascorbic acid) = 176.13g

Specimen calculation:

Suppose the DCPIP was made by dissolving exactly 0.4g in 1 litre of solution.

This means the concentration of DCPIP = $\frac{0.4}{290.06} = 1.3789 \times 10^{-3}$ *mol* l^{-1}

Assuming 50g of the vegetable was used

Assuming the total volume of vegetable extract was 300 cm^3

Assuming that the volume of vegetable extract used in the titration was 25 cm^3

Assuming the average titre of DCPIP used in the experiment was 32 cm^3

Then the calculation will be as follows:

Number of moles of DCPIP used in the titration = Concentration of DCPIP x the titre (litres)

$= 1.3789 \times 10^{-3} \times \frac{32}{1000}$

$= 4.41 \times 10^{-5}$ *moles*

The number of moles of DCPIP used = The number of moles of Vitamin C

*25*cm^3 *of the vegetable extract contained* 4.41×10^{-5} *moles of vitamin C*

*Therefore 300*cm^3 *of the vegetable extract contained* $4.41 \times 10^{-5} \times \frac{300}{25}$ *moles of vitamin C*

$= 5.292 \times 10^{-4}$ *moles of vitamin C*

The mass of vitamin C in 50g of the vegetable = Number of moles x Mass of 1 mole

$= 5.292 \times 10^{-4} \times 176.13$

= 9.3208 x 10^{-2} g

= 93.208 mg

So the mass of vitamin C in 100g of the vegetable = 2 x 93.208 mg

= 186.416 mg

Concentration of vitamin C in the vegetable = 186.416 mg/100 g

Record your answers on the table provided below.

Concentration of DCPIP solution =

Name of fresh vegetable	Average DCPIP titre	Concentration of vitamin C (mg/100 g)
	cm^3	
	cm^3	
	cm^3	
	cm^3	
	cm^3	
	cm^3	

Reporting Your Results

The final stage of any scientific investigation involves reporting the results. Scientists use a wide range of communication methods to report their results, including scientific papers, laboratory reports, blogs, videos, scientific posters, podcasts, PowerPoints, web pages, etc.

Assessment task

Once you have agreed the format of your scientific communication with your teacher, you should produce a report on your investigation containing the following key features:

- a clear statement of the aim of your investigation
- a description of why vitamin C is and why it is required in our diet.
- a brief explanation of how the Briggs–Rauscher reaction can be used to measure the level of vitamin C in a food/drink
- your experimental observations and results, including bar graphs
- a comparison of the actual and theoretical vitamin C concentrations in your fruits/vegetables.
- reasons why the experimental results are different from the actual results (if they are different)
- a description of any ways in which the results could be improved
- a valid conclusion, based on the evidence in your report, which relates to your aim.

Communication Stage

You will need to complete the communication stage of the assignment. As a guide, evidence which meets the requirements of this Component of Course assessment is likely to be 800-1500 words, excluding tables, charts and diagrams. You will complete the controlled assessment stage in no more than 1 hour and 30 minutes and under open book supervised conditions.

The following information should help you communicate you assignment:

Devise an appropriate aim for an investigation

The aim(s) must be clearly stated and appropriate to the investigation undertaken.

Apply knowledge and understanding of chemistry

Correct explanations of the topic researched using chemistry terms/ideas which are at a depth appropriate to Higher Chemistry (this **does not** mean the answer has to be 'excellent' or 'complete')

The response might include: a statement of the principles involved, formulae, chemical equations, calculations, chemical properties related to the bonding present.

Risk assessment

Candidate states the majority of appropriate safety measures taken during their experimental work.

Select information

The data/information selected by the candidate for presentation/processing/analysis is both relevant **and** sufficient. This could include raw data from an experiment/practical activity, extracted tables, graphs, diagrams and text. It might include, for example, statistical, graphical, numerical or experimental data; data/information from the internet; published articles or extracts; notes taken from a visit or talk; notes taken from a written or audio-visual source.

Process and present

Processing can include, for example: performing calculations, manipulating data, summarising referenced text (although the marks are awarded for processing, it must be clear where the raw or extracted data/information came from)

Presenting processed data/information can include for example appropriate formats from: summary, graph, table, chart or diagram (one must be graph, table, chart or diagram). In each case, sufficient detail should be included to convey the data/information. In all cases the candidate must clearly reference the source of the original data.

Analyse data/information

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Conclusion(s)

State a conclusion that relate(s) to the aim(s) and is supported by evidence from the candidate's research.

Evaluation

For marks to be awarded for evaluation, candidates must make judgements based on criteria. The criteria, upon which judgements of the investigation are made, may include the following (not an exhaustive list):

- robustness of findings
- validity of sources
- reliability of data/information
- evaluation of experimental procedure

One mark for each valid, evaluative comment based on relevant criteria, to a maximum of three marks.

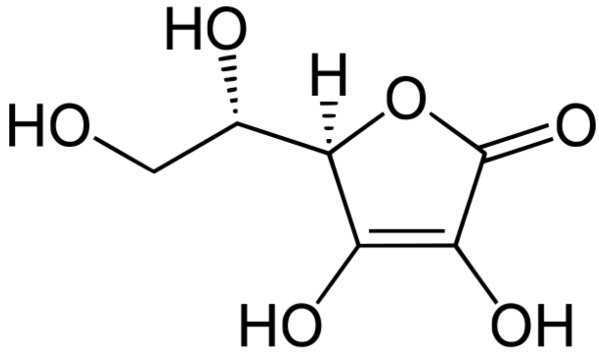
Presentation

- Appropriate title and structure
- The references to at least two sources used in the report are given in sufficient detail to allow them to be retrieved by a third party. If one of the sources is an experiment/practical activity, then the title and the aim should be recorded.

Investigation B

"Does Cooking affect the concentration of vitamin C in vegetables?"

Vitamin C is the compound ascorbic acid with the molecular formula $C_6H_8O_6$.

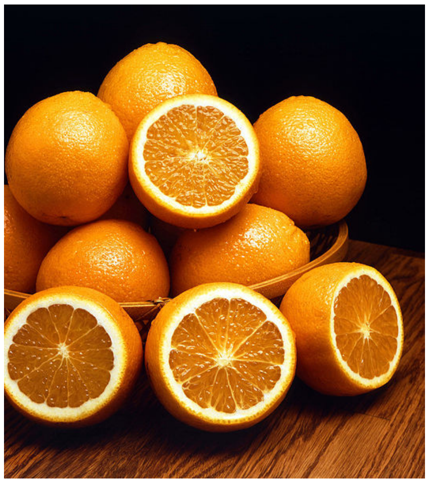


The body uses ascorbic acid when making collagen, a protein which helps skin, bone, hair and blood vessels stick together. Ascorbic acid also helps the body absorb iron.

We need to take in about 90 mg each day. We can store up to one month's supply of vitamin C, but no more.

As we cannot make it in the body, we need a regular source in our diet

Anyone under stress needs extra vitamin C, because the body will use it up more quickly than in a non-stressed state.



Smokers need more vitamin C, because smoking is a 'stress' on the body.

Lots of things are said about vitamin C, for example, taking large amounts is supposed to stop us getting colds and it may help us stop getting some types of cancer.

Ascorbic acid is found in many fruit juices and some vegetables such as broccoli and potatoes.

Cooking Methods

Cooking can reduce the vitamin content of food because some vitamins are sensitive to heat, water and air. Water-soluble vitamins are most vulnerable to heat, particularly vitamin C and the B vitamins. The type of food preparation influences the loss of vitamins. Choose cooking methods that use minimal heat and water to preserve the vitamin contents of food.

Vitamin C, also known as ascorbic acid, is a water-soluble vitamin found in fruits and vegetables, including oranges, strawberries, broccoli, tomatoes and green peppers. Vitamin C is easily destroyed by excessive heat and water, as well as exposure to air. In studies, boiling caused the most loss, while steaming retained the most vitamin C. An earlier Danish study showed that boiling for just five minutes caused 45 to 64 percent of vitamin C to be lost.

Steaming, microwaving or using a pan or wok with a small amount of water are the preferred cooking methods. The most vitamins are retained when there is less contact with water and a shorter cooking time. In a Danish study, steaming broccoli for five minutes retained almost 100 percent of the water-soluble vitamins. Microwaving and stir-frying reduce vitamin loss because they cook food quickly. Avoid deep-frying. The high heat required for frying destroys heat-sensitive vitamins.

Fresh v Frozen

And as winter approaches, fresh produce is limited—or expensive—in much of the country, which forces many of us to turn to canned or frozen options. While canned vegetables tend to lose a lot of nutrients during the preservation process (notable exceptions include tomatoes and pumpkin), frozen vegetables may be even more healthful than some of the fresh produce sold in supermarkets. Why? Fruits and vegetables chosen for freezing tend to be processed at their peak ripeness, a time when—as a general rule—they are most nutrient-packed.

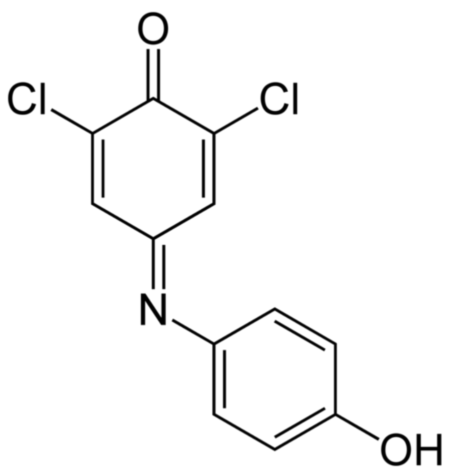
While the first step of freezing vegetables—blanching them in hot water or steam to kill bacteria and arrest the action of food-degrading enzymes—causes some water-soluble nutrients like vitamin C and the B vitamins to break down or leach out, the subsequent flash-freeze locks the vegetables in a relatively nutrient-rich state.

On the other hand, fruits and vegetables destined to be shipped to the fresh-produce aisles around the country typically are picked before they are ripe, which gives them less time to develop a full spectrum of vitamins and minerals. Outward signs of ripening may still occur, but these vegetables will never have the same nutritive value as if they had been allowed to fully ripen on the vine. In addition, during the long haul from farm to fork, fresh fruits and vegetables are exposed to lots of heat and light, which degrade some nutrients, especially delicate vitamins like C and the B vitamin thiamin.

2,6-dichlorophenolindophenol (DCPIP) can be used to estimate the concentration of vitamin C in food.

DCPIP is blue when dissolved in water, is red in acid conditions, and is reduced by ascorbic acid (vitamin C)) to a colourless compound. However, in this titration, the end point colour change will be from blue to pink due to the presence of the phosphoric(V) acid used to prepare the vegetable extract.

DCPIP should be treated as HARMFUL. (*See Risk Assessment*)



Background research

The first stage of carrying out research in chemistry is to review what is already known about the topic of interest. Chemists use books, scientific papers, journals and the internet to carry out background research.

Your first task in the Researching Chemistry unit is to *independently* carry out background research into one of the focus questions listed, which will be assigned to you by your teacher. In school it is likely that you will carry out your background research on the internet.

Once you have completed your background research, you must then complete the unit assessment tasks and store your research evidence in a safe place.

Assessment tasks

3. **Record at least two sources of information relevant to your focus question**. Sufficient detail should be given to allow someone else to find your sources easily. For a website, the URL shown here is perfectly adequate: http://www.biodieselfillingstations.co.uk/.

4. **Write a brief summary** of the information of relevance contained in each of the sources you have identified.

Focus Questions

A1 Explain why the human body requires Vitamin C.

A2 Many foods and drinks which contain Vitamin C are known as 'superfoods'. What requirements must be met for a food to be labelled as a superfood?

A3 What evidence is there to suggest that eating superfoods is good for human health?

A4 Many people make fruit smoothies to get their daily allowance of vitamins from fruits. It is thought that smoothies can be harmful to health. What evidence is there to support this?

A5 Vitamin c is a powerful antioxidant. State some sources of vitamin C briefly explain the role it plays in the human body.

A6 The concentration of Vitamin C in food and drink can be affected by Cooking. What methods of cooking will retain the greatest quantity of vitamin C?

Advice on using the internet for background research

The web allows you to access a huge amount of information – don't get side-tracked! Promising sites should be bookmarked so that you can return to them later. Tables, graphs and pictures can be copied into a folder. It is worthwhile spending a few moments considering which keywords may be the best to enter into your search engine. For more advice on effective web-based research see the LTS resource on http://www.ltscotland.org.uk/nationalqualifications/resources/r/nqresource_tcm4629006.asp.

Planning your investigation

The next stage in your investigation is to plan and carry out an appropriate experimental procedure that will allow you to determine how much antioxidant is contained in a range of fruits.

Whilst planning your experimental work you may wish to consider:

- which fruits/vegetables or fruit/vegetable juices will you use?
- how to find out the expected vitamin C concentration by reading labels and/or carrying out internet research
- what apparatus will be required
- which chemicals will be required
- the hazards that might be involved and how you will minimise risk.

Procedure

This experiment uses 2,6-dichlorophenolindophenol (DCPIP) in a titration, to estimate the concentration of vitamin C in food. DCPIP is blue when dissolved in water and is red in acid conditions, and is reduced by ascorbic acid (vitamin C) to a colourless compound. However, in this titration, the end point colour change will be from blue to pink due to the presence of the phosphoric(V) acid used to prepare the vegetable extract.

You will need:

Apparatus for titration, 25 cm^3 pipette, 50 cm^3 burette, 250 cm^3 conical flask, pipette filler	Measuring cylinders, 500 cm^3 and 250 cm^3
Beaker, 250 cm^3	Liquidiser
Filter funnel and muslin for filtration	Vegetables to test, 100 g
5% phosphoric(V) acid solution	A solution of 2,6-dichlorophenolindophenol (DCPIP)

What you do:

- Accurately weigh out about 50 g of your vegetable and put it in a liquidiser with 250 cm^3 of 5.0% phosphoric(V) acid.
- Ensure the lid is securely fitted and liquidise at high speed.

  (The purpose of the 5% phosphoric(V) acid solution is to provide acid conditions to inactivate the enzyme ascorbic acid oxidase and to extract the ascorbic acid from the food).
- Filter off using a muslin filter.
- Make up the volume of extract plus washings to 300 cm^3 with deionised (not distilled) water.
- Set up the burette filled with DCPIP.
- Using a pipette filler, pipette 25 cm^3 of the vegetable extract into a conical flask.
- Titrate with the DCPIP indicator solution until a pink end point is reached.

  Note: If the vegetable extract solution is a greenish colour, the colour change to pink at the end point may be very difficult to see. The pink colour may appear as a brownish tinge!

  Stop when you think you have reached the end point and ask your teacher.

All titrations should be carried out in duplicate and concordant titres obtained.

Average your titres.

- Repeat the experiment with the other ‘cooked’ vegetatables.

Results Tables:

Uncooked Vegetable 1:..Mass of vegetable used ……. g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
Titre	cm^3	cm^3	cm^3
Average of the First and Second Run titres			cm^3

Steamed Vegetable 1: ....Mass of vegetable used ……. g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
DCPIP Titre	cm^3	cm^3	cm^3
Average of the First and Second Run titres			cm^3

Boiled Vegetable 1: ....Mass of vegetable used ……. g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
DCPIP Titre	cm^3	cm^3	cm^3

Average of the First and Second Run titres		cm^3	

Fried Vegetable 1: .... Mass of vegetable used .... g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
Titre	cm^3	cm^3	cm^3
Average of the First and Second Run titres		cm^3	

Calculating the Vitamin C Content of a Fruit/Vegatable.

This depends on the fact that one mole of DCPIP will react with one mole of vitamin C.

One mole of DCPIP = 290.08g

One mole of vitamin C (ascorbic acid) = 176.13g

Specimen calculation:

Suppose the DCPIP was made by dissolving exactly 0.4g in 1 litre of solution.

This means the concentration of DCPIP = $\frac{0.4}{290.06} = 1.3789 \times 10^{-3}$ mol l^{-1}

Assuming 50g of the vegetable was used

Assuming the total volume of vegetable extract was 300 cm^3

Assuming that the volume of vegetable extract used in the titration was 25 cm^3

Assuming the average titre of DCPIP used in the experiment was 32 cm^3

Then the calculation will be as follows:

Number of moles of DCPIP used in the titration = Concentration of DCPIP x the titre (litres)

$= 1.3789 \times 10^{-3} \times \frac{32}{1000}$

$= 4.41 \times 10^{-5}$ *moles*

The number of moles of DCPIP used = The number of moles of Vitamin C

25cm^3 of the vegetable extract contained 4.41×10^{-5} *moles of vitamin C*

Therefore 300cm^3 of the vegetable extract contained $4.41 \times 10^{-5} \times \frac{300}{25}$ *moles of vitamin C*

$= 5.292 \times 10^{-4}$ *moles of vitamin C*

The mass of vitamin C in 50g of the vegetable = Number of moles x Mass of 1 mole

$= 5.292 \times 10^{-4} \times 176.13$

$= 9.3208 \times 10^{-2}$ *g*

= 93.208 mg

So the mass of vitamin C in 100g of the vegetable = 2 x 93.208 mg

= 186.416 mg

Concentration of vitamin C in the vegetable = 186.416 mg/100 g

Concentration of DCPIP solution = ……………..

Method of Cooking	Average Titre (cm^3)	Vitamin C content (mg/100 g)	Vitamin C content of fresh vegetable (mg/100 g)	Percentage loss of vitamin C on processing
Fresh Vegetable				
Boiled Vegetable				
Steamed Vegetable				
Fried vegetable				

Reporting Your Results

The final stage of any scientific investigation involves reporting the results. Scientists use a wide range of communication methods to report their results, including scientific papers, laboratory reports, blogs, videos, scientific posters, podcasts, PowerPoints, web pages, etc.

Assessment task

Once you have agreed the format of your scientific communication with your teacher, you should produce a report on your investigation containing the following key features:

- a clear statement of the aim of your investigation
- a description of why vitamin C is and why it is required in our diet.
- a brief explanation of how the reaction can be used to measure the level of vitamin C in a food/drink
- your experimental observations and results, including bar graphs
- a comparison of the actual and theoretical vitamin C concentrations in your vegetables.
- reasons why the experimental results are different from the actual results (if they are different)
- a description of any ways in which the results could be improved

- a valid conclusion, based on the evidence in your report, which relates to your aim.

Communication Stage

You will need to complete the communication stage of the assignment. As a guide, evidence which meets the requirements of this Component of Course assessment is likely to be 800-1500 words, excluding tables, charts and diagrams. You will complete the controlled assessment stage in no more than 1 hour and 30 minutes and under open book supervised conditions.

The following information should help you communicate you assignment:

Devise an appropriate aim for an investigation

The aim(s) must be clearly stated and appropriate to the investigation undertaken.

Apply knowledge and understanding of chemistry

Correct explanations of the topic researched using chemistry terms/ideas which are at a depth appropriate to Higher Chemistry (this **does not** mean the answer has to be 'excellent' or 'complete')

The response might include: a statement of the principles involved, formulae, chemical equations, calculations, chemical properties related to the bonding present.

Risk assessment

Candidate states the majority of appropriate safety measures taken during their experimental work.

Select information

The data/information selected by the candidate for presentation/processing/analysis is both relevant **and** sufficient. This could include raw data from an experiment/practical activity, extracted tables, graphs, diagrams and text. It might include, for example, statistical, graphical, numerical or experimental data; data/information from the internet; published articles or extracts; notes taken from a visit or talk; notes taken from a written or audio-visual source.

Process and present

Processing can include, for example: performing calculations, manipulating data, summarising referenced text (although the marks are awarded for processing, it must be clear where the raw or extracted data/information came from)

Presenting processed data/information can include for example appropriate formats from: summary, graph, table, chart or diagram (one must be graph, table, chart or diagram). In each case, sufficient detail should be included to convey the data/information. In all cases the candidate must clearly reference the source of the original data.

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Presentation

- Appropriate title and structure
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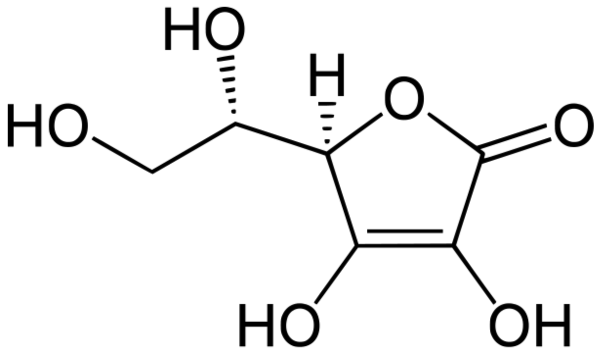
Investigation C:

"Comparing The Vitamin C Content of Fresh with Frozen Vegetables."



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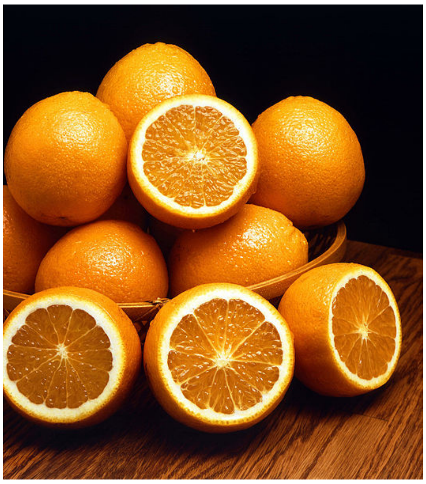
As we cannot make it in the body, we need a constant supply in our diet..



Anyone under stress needs extra vitamin C, because the body will use it up more quickly than in a non-stressed state.

Smokers need more vitamin C, because smoking is a 'stress' on the body.

Lots of things are said about vitamin C, for example, taking large amounts is supposed to stop us getting colds and it may help us stop getting some types of cancer.

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Cooking Methods

Cooking can reduce the vitamin content of food because some vitamins are sensitive to heat, water and air. Water-soluble vitamins are most vulnerable to heat, particularly vitamin C and the B vitamins. The type of food preparation influences the loss of vitamins. Choose cooking methods that use minimal heat and water to preserve the vitamin contents of food.

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C is easily destroyed by excessive heat and water, as well as exposure to air. In studies, boiling caused the most loss, while steaming retained the most vitamin C. An earlier Danish study showed that boiling for just five minutes caused 45 to 64 percent of vitamin C to be lost.

Steaming, microwaving or using a pan or wok with a small amount of water are the preferred cooking methods. The most vitamins are retained when there is less contact with water and a shorter cooking time. In a Danish study, steaming broccoli for five minutes retained almost 100 percent of the water-soluble vitamins. Microwaving and stir-frying reduce vitamin loss because they cook food quickly. Avoid deep-frying. The high heat required for frying destroys heat-sensitive vitamins.

Fresh v Frozen

And as winter approaches, fresh produce is limited—or expensive—in much of the country, which forces many of us to turn to canned or frozen options. While canned vegetables tend to lose a lot of nutrients during the preservation process (notable exceptions include tomatoes and pumpkin), frozen vegetables may be even more healthful than some of the fresh produce sold in supermarkets. Why? Fruits and vegetables chosen for freezing tend to be processed at their peak ripeness, a time when—as a general rule—they are most nutrient-packed.

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On the other hand, fruits and vegetables destined to be shipped to the fresh-produce aisles around the country typically are picked before they are ripe, which gives them less time to develop a full spectrum of vitamins and minerals. Outward signs of ripening may still occur, but these vegetables will never have the same nutritive value as if they had been allowed to fully ripen on the vine. In addition, during the long haul from farm to fork, fresh fruits and vegetables are exposed to lots of heat and light, which degrade some nutrients, especially delicate vitamins like C and the B vitamin thiamin.

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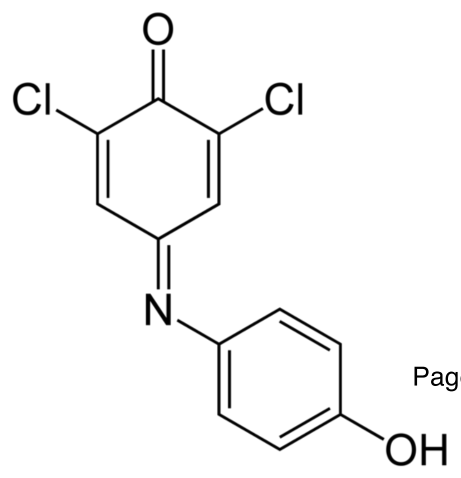

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DCPIP should be treated as HARMFUL. (*See Risk Assessment*)

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1. **Record at least two sources of information relevant to your focus question**. Sufficient detail should be given to allow someone else to find your sources easily. For a website, the URL shown here is perfectly adequate: http://www.biodieselfillingstations.co.uk/.

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Focus Questions

A1 Explain why the human body requires Vitamin C.

A2 Many foods and drinks which contain Vitamin C are known as ‘superfoods’. What requirements must be met for a food to be labelled as a superfood?

A3 What evidence is there to suggest that eating superfoods is good for human health?

A4	Many people make fruit smoothies to get their daily allowance of vitamins from fruits. It is thought that smoothies can be harmful to health. What evidence is there to support this?
A5	Vitamin c is a powerful antioxidant. State some sources of vitamin C and briefly explain the role it plays in the human body.
A6	The concentration of Vitamin C in food can be affected by storage conditions. How should food be stored to maintain the maximum concentration of Vitamin C?

Advice on using the internet for background research

The web allows you to access a huge amount of information – don't get side-tracked! Promising sites should be bookmarked so that you can return to them later. Tables, graphs and pictures can be copied into a folder. It is worthwhile spending a few moments considering which keywords may be the best to enter into your search engine. For more advice on effective web-based research see the LTS resource on http://www.ltscotland.org.uk/nationalqualifications/resources/r/nqresource_tcm4629006.asp.

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The next stage in your investigation is to plan and carry out an appropriate experimental procedure that will allow you to determine how much antioxidant is contained in a range of fruits.

Whilst planning your experimental work you may wish to consider:

- which fruits/vegetables or fruit/vegetable juices will you use?
- how to find out the expected vitamin C concentration by reading labels and/or carrying out internet research
- what apparatus will be required
- which chemicals will be required
- the hazards that might be involved and how you will minimise risk.

Procedure

This experiment uses 2,6-dichlorophenolindophenol (DCPIP) in a titration, to estimate the concentration of vitamin C in food. DCPIP is blue when dissolved in water and is red in acid conditions, and is reduced by ascorbic acid (vitamin C) to a colourless compound. However, in this titration, the end point colour change will be from blue to pink due to the presence of the phosphoric(V) acid used to prepare the vegetable extract.

You will need:

Apparatus for titration, 25 cm^3 pipette, 50 cm^3 burette, 250 cm^3 conical flask, pipette filler	Measuring cylinders, 500 cm^3 and 250 cm^3
Beaker, 250 cm^3	Liquidiser
Filter funnel and muslin for filtration	Vegetables to test, 100 g
5% phosphoric(V) acid solution	A solution of 2,6-dichlorophenolindophenol (DCPIP)

What you do:

- Accurately weigh out about 50 g of your vegetable and put it in a liquidiser with 250 cm^3 of 5.0% phosphoric(V) acid.
- Ensure the lid is securely fitted and liquidise at high speed.

  (The purpose of the 5% phosphoric(V) acid solution is to provide acid conditions to inactivate the enzyme ascorbic acid oxidase and to extract the ascorbic acid from the food).
- Filter off using a muslin filter.
- Make up the volume of extract plus washings to 300 cm^3 with deionised (not distilled) water.

- Set up the burette filled with DCPIP.
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  Note: If the vegetable extract solution is a greenish colour, the colour change to pink at the end point may be very difficult to see. The pink colour may appear as a brownish tinge!

  Stop when you think you have reached the end point and ask your teacher.

  All titrations should be carried out in duplicate and concordant titres obtained.

  Average your titres.
- Repeat the experiment with other fruit/vegetables.

Results Tables:

Fresh Vegetable 1: .... Mass of vegetable used .... g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
Titre	cm^3	cm^3	cm^3
Average of the First and Second Run titres		cm^3	

Frozen Vegetable 1: .... Mass of vegetable used .... g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
DCPIP Titre	cm^3	cm^3	cm^3
Average of the First and Second Run titres		cm^3	

Fresh Vegetable 2: .... Mass of vegetable used ……. g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
DCPIP Titre	cm^3	cm^3	cm^3
Average of the First and Second Run titres		cm^3	

Frozen Vegetable 2: .... Mass of vegetable used ……. g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
Titre	cm^3	cm^3	cm^3
Average of the First and Second Run titres		cm^3	

Fresh Vegetable 3: .... Mass of vegetable used ……. g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
DCPIP Titre	cm^3	cm^3	cm^3
Average of the First and Second Run titres		cm^3	

Frozen Vegetable 3: .... Mass of vegetable used ……. g

	Trial	First Run	Second Run
1st Burette Reading	cm^3	cm^3	cm^3
2nd Burette Reading	cm^3	cm^3	cm^3
DCPIP Titre	cm^3	cm^3	cm^3
Average of the First and Second Run titres		cm^3	

Calculating the Vitamin C Content of a Fruit/Vegatable.

This depends on the fact that one mole of DCPIP will react with one mole of vitamin C.

One mole of DCPIP = 290.08g

One mole of vitamin C (ascorbic acid) = 176.13g

Specimen calculation:

Suppose the DCPIP was made by dissolving exactly 0.4g in 1 litre of solution.

This means the concentration of DCPIP = $\frac{0.4}{290.06} = 1.3789 \times 10^{-3}\ mol\ l^{-1}$

Assuming 50g of the vegetable was used

Assuming the total volume of vegetable extract was 300 cm^3

Assuming that the volume of vegetable extract used in the titration was 25 cm^3

Assuming the average titre of DCPIP used in the experiment was 32 cm^3

Then the calculation will be as follows:

Number of moles of DCPIP used in the titration = Concentration of DCPIP x the titre (litres)

$$= 1.3789 \times 10^{-3} \times \frac{32}{1000}$$

$$= 4.41 \times 10^{-5} \text{ moles}$$

The number of moles of DCPIP used = The number of moles of Vitamin C

*25*cm^3 *of the vegetable extract contained* 4.41×10^{-5} *moles of vitamin C*

Therefore 300cm^3 of the vegetable extract contained $4.41 \times 10^{-5} \times \frac{300}{25}$ *moles of vitamin C*

$= 5.292 \times 10^{-4}$ *moles of vitamin C*

The mass of vitamin C in 50g of the vegetable = Number of moles x Mass of 1 mole

$= 5.292 \times 10^{-4} \times 176.13$

$= 9.3208 \times 10^{-2}$ *g*

= 93.208 mg

So the mass of vitamin C in 100g of the vegetable = 2 x 93.208 mg

= 186.416 mg

Concentration of vitamin C in the vegetable = 186.416 mg/100 g

Concentration of DCPIP solution =

Name of Vegetable	Average DCPIP titre	Concentration of vitamin C (mg/100 g)
Fresh Vegetable 1	cm^3	
Frozen Vegetable 1	cm^3	
Fresh Vegetable 2	cm^3	
Frozen Vegetable 2	cm^3	
Fresh Vegetable 3	cm^3	
Frozen Vegetable 3	cm^3	

Communication Stage

You will need to complete the communication stage of the assignment. As a guide, evidence which meets the requirements of this Component of Course assessment is likely to be 800-1500 words, excluding tables, charts and diagrams. You will complete the controlled assessment stage in no more than 1 hour and 30 minutes and under open book supervised conditions.

The following information should help you communicate you assignment:

Devise an appropriate aim for an investigation

The aim(s) must be clearly stated and appropriate to the investigation undertaken.

Apply knowledge and understanding of chemistry

Correct explanations of the topic researched using chemistry terms/ideas which are at a depth appropriate to Higher Chemistry (this **does not** mean the answer has to be 'excellent' or 'complete')

The response might include: a statement of the principles involved, formulae, chemical equations, calculations, chemical properties related to the bonding present.

Risk assessment

Candidate states the majority of appropriate safety measures taken during their experimental work.

Select information

The data/information selected by the candidate for presentation/processing/analysis is both relevant **and** sufficient. This could include raw data from an experiment/practical activity, extracted tables, graphs, diagrams and text. It might include, for example, statistical, graphical, numerical or experimental data; data/information from the internet; published articles or extracts; notes taken from a visit or talk; notes taken from a written or audio-visual source.

Process and present

Processing can include, for example: performing calculations, manipulating data, summarising referenced text (although the marks are awarded for processing, it must be clear where the raw or extracted data/information came from)

Presenting processed data/information can include for example appropriate formats from: summary, graph, table, chart or diagram (one must be graph, table, chart or diagram). In each case, sufficient detail should be included to convey the data/information. In all cases the candidate must clearly reference the source of the original data.

Analyse data/information

Analysis will include interpreting data/information included in the report (which may/may not have been processed by the candidate) to identify relationships. This may include further calculations.

Conclusion(s)

State a conclusion that relate(s) to the aim(s) and is supported by evidence from the candidate's research.

Evaluation

For marks to be awarded for evaluation, candidates must make judgements based on criteria. The criteria, upon which judgements of the investigation are made, may include the following (not an exhaustive list):

- robustness of findings
- validity of sources
- reliability of data/information
- evaluation of experimental procedure

One mark for each valid, evaluative comment based on relevant criteria, to a maximum of three marks.

Presentation

- Appropriate title and structure
- The references to at least two sources used in the report are given in sufficient detail to allow them to be retrieved by a third party. If one of the sources is an experiment/practical activity, then the title and the aim should be recorded.