**Water Analysis**

Student Guide





**Researching Chemistry**

**Higher**

Photo: Wikipedia, GDFL

Higher Physics Topical Investigation Skin Cancer—Prevention and Cure

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**Investigation Brief**

Suntan creams stop harmful UV radiation reaching the skin. Manufacturers’ products are rated with a Sun Protection Factor (SPF). Suntan creams can have SPF values from 6 to over 50.

UV radiation monitors normally measure irradiance in output intensity per unit area. Thus, a typical low intensity UV lamp may emit approximately 10 mWcm-2.

The aim of this investigation is to determine the effect of various suntan creams on the transmission of UV radiation. In particular, the relationship between SPF and absorption should be found.

**Investigation Notes**

UV lamps can be harmful. Make sure that you read the safety leaflet which is supplied with the UV lamp. Some cheap UV monitors do not measure the irradiance of UV radiation. Rather, they give an indication of UV index. It is possible to undertake this investigation with such a monitor, but results will be less reliable and accurate. UV radiation does not pass through many transparent materials (including glass). However, UV transparent acrylics are readily available.

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**Overview of the assignemnt 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 of various substances that can enter our water supply. The practical experiments include titrations that are similar to some done at advanced higher level and are sometimes 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?

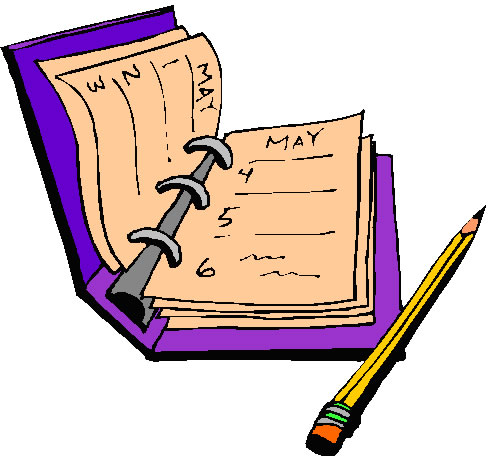
There are three types of activities in the unit.

**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**

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.

How will I organise

my 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?

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.

What about teamwork?

The web allows you to access a huge amount of information.

Using the internet for background research

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**

As you work on this unit, you will carry out activities which develop your skills in undertaking research in physics.

What do I have to do to pass this unit?

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/.](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. |

Access to clean water is of huge importance worldwide. While it is commonly thought to be a problem affecting poorer nations, pollution from industry and agriculture cause problems in richer countries as well. In the summer of 2014, pollution in Lake Erie caused an algal bloom resulting in the citizens of Toledo and surrounding regions to have to boil their water before drinking it.

Why is this topical?

In order to determine the safety of a water supply, it is necessary to analyse the water to determine what substances are in it and what remedial measures might be needed to make it potable (drinkable).

**Investigation A**

*“How hard is the water? How does the concentration of Calcium and Magnesium ions affect hardness of water?”*

**Introduction**

Water makes up around 66.7% of the surface of the Earth. It is essential for all forms of life on Earth. In Scotland, drinking water is available on tap but depending on the area and the supply of water there are many dissolved ions. Water is used for washing and has a foaming capacity depending on the hardness or softness of the water. The foaming capacity of water depends on the concentration of calcium and magnesium ions.

**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 below, 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 What ions are present in water and how does this vary in different areas?

A2 How does tap water compare to bottled mineral water in term of the ions present?

A3 What ions are responsible for making water hard and how can the hardness of water be tested for.

A4 Give details of chemical reactions and formulae equations involved.

A5 How does the hardness of water affect the foaming capacity of soaps?

A6 Many countries add fluoride ions to drinking water. Why are fluoride ions added to water and why do some countries not allow fluoride to be added to drinking water.

A7 Why are chloride ions added to water?

**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. Ensure sites are credible. For more advice on effective web-based research see the Education Scotland resource on <http://www.educationscotland.gov.uk>

**Planning your investigation**

The next stage in your investigation is to plan and carry out an appropriate experimental procedure that will allow you to find out quantitatively the mass of calcium and magnesium ions in water.

**The Chemistry**

Permanent hardness of water is due to the presence of the ions Ca2+, Mg 2+,Fe 3+ and SO4 2- This type of hardness cannot be eliminated by boiling. The water with this type of hardness is said to be *permanently hard*.

The determination of water hardness is a useful test that provides a measure of quality of water for households and industrial uses.

When hard water is heated, CaCO3 precipitates out, which then clogs pipes and industrial boilers. This leads to malfunction or damage and is expensive to remove.

The ions involved in water hardness, i.e. Ca2+ (aq) and Mg2+ (aq), can be determined by two titrations with a chelating agent, ethylenediaminetetraacetic acid (EDTA), usually in the form of disodium salt. The titration reaction is:

**Ca2++ EDTA4 ------> CaEDTA2-**

Total hardness (calcium and magnesium) is determined by titrating at pH 10 (using an ammonia buffer) with Eriochrome black T as the indicator.

Calcium alone can be determined using the same EDTA solution but this time using sodium bydroxide (to make the solution more alkaline) and Murexide as the indicator.

Whilst planning your experimental work you must consider:

* Which water sample(s) you will investigate?
* how to find out the actual calcium and magnesium ion content in the water?
* which chemicals will be required?
* what apparatus will be required?
* the hazards that might be involved and how you will minimise risk.

**Equipment and Materials Required**

|  |  |
| --- | --- |
| 0.001 M EDTA solution | 0.5% Eriochrome Black T solution  (This has a very short shelf life – prepare fresh each day). |
| 1M NaOH | 0.5% Murexide |
| pH 10 ammonia buffer | Burette |
| Clamp and stand |  |

**Method**

*Experiment 1 – Total Hardness Determination*

1. Fill a 50 cm3 burette with 0.001 mol l‑1 EDTA solution, making sure the tip is full and free of air bubbles..
2. Add 50.00 cm3 of an unknown hard water solution into a 100 cm3 beaker.
3. Add 10 cm3 of Ammonia buffer to the beaker.
4. Add 0.5 cm3 of Eriochrome Black T indicator.
5. Titrate with the 0.001 mol l-1 EDTA until the colour changes from wine red to pure blue. Read burette to +/- 0.10 cm3.
6. Repeat the titration until the final volumes agree to +/- 0.20 cm3.

*Experiment 2 – Calcium Determination*

1. Fill a 50 cm3 burette with 0.001 mol l-1 EDTA solution, making sure the tip is full and free of air bubbles.
2. Add 50.00 cm3 of an unknown hard water solution into a 100 cm3 beaker.
3. Add 4 cm3 of 1.0 mol l-1 Sodium Hydroxide.
4. Add 0.5 cm3 of Murexide indicator.
5. Titrate with the 0.001 mol l-1 EDTA until the colour changes from salmon pink to orchid purple. Read burette to +/- 0.10 cm3.
6. Repeat the titration until the final volumes agree to +/- 0.20 cm3.

**Calculations**

From the equation, 1 mole of calcium complexes with 1 mole of EDTA, so it is easy to work out the concentrations.

Molarity of EDTA solution is 0.001 mol l-1

1cm3 of 0.001 mol l-1 EDTA = 0.1 mg of CaCO3

Calcium– take the figure from experiment 2

Magnesium– subtract the result from experiment 2 (calcium) from the result of experiment 1 (total hardness)

**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
* Background/ Underlying Chemistry including research from at least two different sources.
* a brief explanation of how volumetric titration technique can be used to determine the calcium and magnesium ion concentration in water.
* your experimental observations and results, including the calibration graph
* a comparison of the actual and the calculated ion concentration in bottled mineral water.
* reasons why your experimental results are different from the actual results (if they are different)
* an evaluation 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.

# **Investigation B**

*“How much iron is in water? “*

**Introduction**

Water makes up around 66.7% of the surface of the Earth. It is essential for all forms of life on Earth. In Scotland, drinking water is available on tap but depending on the area and the supply of water there are many dissolved ions.

Your task is to find out the mass of iron in tap water from different areas or from fresh sources of water in the environment, such as rivers or springs. The technique of colorimetry can be used to measure the concentration of iron ions in an unknown sample of water using a calibration graph and comparing the concentration found to the value stated on the label of mineral water.

**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 below, 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**

B1 Why does water contain iron? Where does the iron come from?

B2 What is iron needed for in our diets?

B3 What iron ions are the most common form?

B4 What compounds does iron form in water and in the human body?

B5 What are the effects of high concentrations of iron?

B6 Give details of the reactions involved and formulae equations.

**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. Ensure sites are credible. For more advice on effective web-based research see the Education Scotland resource on <http://www.educationscotland.gov.uk>

**Planning your investigation**

The next stage in your investigation is to plan and carry out an appropriate experimental procedure that will allow you to find out quantitatively the concentration of iron ions in the water samples.

**The Chemistry**

This experiment allows for the analysis of iron content in water samples. The iron is present in a solution containing Fe3+ (ferric) ions. To make the presence of these ions in solution visible, thiocyanate ions (SCN−) are added. These react with the Fe3+ ions to form a blood-red coloured complex:

Fe3+ (aq) + SCN−(aq) → [FeSCN]2+(aq)

By comparing the intensity of the colour of this solution with the colours of a series of standard solutions, with known Fe3+ concentrations, the concentration of water sample may be determined. This technique is called colorimetry.

Whilst planning your experimental work you must consider:

* Which water sample(s) you will investigate?
* What is the source of the water supply?
* How will the iron concentration be determined?
* If the iron concentration is too low it cannot be determined so how can the concentration be increased?
* Which chemicals will be required?
* What apparatus will be required?
* The hazards that might be involved and how you will minimise risk.

**Equipment and Materials Required**

|  |  |
| --- | --- |
| ferric ammonium sulphate FeNH4(SO4)2•12H2O standard solutions: | 2, 4, 6, 8 and 10 × 10−5 mol l-1  (see below for preparation) |
| 1 mol l-1 ammonium thiocyanate solution (see below for preparation) | 1 mol l-1 sulphuric acid |
| 1 mol l-1  hydrochloric acid | 100 cm3 beaker |
| 200 and 500 cm3 volumetric flasks | 5 cm3 pipette |
| 100 cm3 conical flask | Test tubes (5 for the references plus however many samples you are doing) |
| Colorimeter & cuvettes | distilled water |

**Method**

*Experiment 1 - Preparation of 1 mol l-1 ammonium thiocyanate solution*

1. Weigh 38 g of solid ammonium thiocyanate into a 500 cm3 volumetric flask and make up to the mark with distilled water.

*Experiment 2 - Preparation of Fe3+ standard solutions*

NB: It may take several days to dissolve the Fe3+ salt used here, so carry out this preparation well in advance of the rest of the experiment.

1. Weigh out about 3.0 g of ferric ammonium sulphate (FeNH4(SO4)2•12H2O). Use a mortar and pestle to grind the salt to a fine powder. Accurately weigh 2.41 g of the powder into a 100 cm3 beaker and add 20 cm3 of concentrated sulphuric acid [corrosive]. Leave powder to soak in acid overnight.
2. The next day, carefully pour the acid/powder slurry into a 500 cm3 volumetric flask, rinsing the beaker into the flask a few times with water, then make up to the mark with distilled water. Let this solution stand for several days until the ferric ammonium sulphate powder has fully dissolved. If possible, insert a magnetic stirrer bar and stir the solution to speed up this dissolving process.
3. Use a pipette to transfer 20 cm3 of ferric ion solution to a 200 cm3 volumetric flask and make up to the mark with distilled water. This gives a solution with [Fe3+] = 0.001 mol l-1.
4. To prepare a 2 × 10−5 mol l−1 standard solution pipette 10 cm3 of the 0.001 mol l−1 solution into a 500 cm3 volumetric flask, add 10 cm3 of 1 mol l-1 sulphuric acid, and then make up to the mark with distilled water.
5. Repeat this procedure in separate 500 cm3 volumetric flasks\*, pipetting in 20, 30, 40 and 50

cm3 of 0.001 mol l-1 Fe3+ solution in turn, to obtain 4, 6, 8 and 10 × 10−5 mol l-1 solutions respectively.

(\* if you do not have five 500 cm3 volumetric flasks you can use one flask to prepare each standard in turn. After preparing each standard, pour the solution into a labelled glass vessel which has a lid (eg: a glass bottle). Then rinse your 500 cm3 volumetric flask thoroughly with distilled water before using it to prepare your next standard solution.)

*Experiment 3 – Analysis of Water*

**Colorimetric analysis**

1. Accurately measure 2 cm3 of your sample solution into a clean, dry test tube\*.

2. Next, measure 2 cm3 of each Fe3+ standard solution into separate test tubes

(one standard per tube) in order of increasing concentration, beginning with the

2 × 10−5 mol l-1 standard. It is a good idea to first rinse your pipette or measuring cylinder with

a few cm3 of the 2 × 10−5 mol l-1 standard.

NB: Make sure you label each boiling tube appropriately with the name of the sample or standard it contains.

1. Add 2 cm3of 1 mol l-1 ammonium thiocyanate solution to each iron solution in sequence,

with 2 minutes between each addition\*\*. These additions must be carefully timed so that all samples react for the same period of time.

4. Mix the solutions by swirling. A stable red colour will appear over the next few minutes.

5. As near as possible to 15 minutes after adding thiocyanate\*\*\*, pour your samples into a

cuvette and measure the absorbance at a wavelength of 490 nm for each coloured solution

using your colorimeter. These measurements will be made in sequence − one sample every

two minutes − reflecting the timing of the thiocyanate additions above. The measured

absorbance of light is a direct measure of the intensity of the solution’s colour.

*\* You can, if you wish, simply add the solutions and mix in a cuvette.*

*\*\* If you have a colorimeter to hand, you should be able to do it faster than this. 1 sample per minute is easily achievable and with practice, one every 30s is quite possible.*

*\*\*\* As long as you are reasonably close to the time, all should be well. When left for another 5 minutes, the darkest of the reference samples only dropped from a reading of 0.44 to 0.42. An extra 10 minutes caused a further drop to 0.40.*

**Calculations**

1. Using only the absorbance results obtained for your Fe3+ standard solutions (not your unknown iron sample), prepare a graph with [Fe3+ ] (in 10-5 mol l-1) as the horizontal axis and absorbance (at 490 nm) as the vertical axis.
2. Draw a line of best fit for your data points that goes through the origin (because absorbance must be zero when Fe3+ concentration is zero).
3. You can use this graph to determine the iron content of your water samples.

The concentration of substances in drinking water is usually given as parts per million (ppm). 1ppm = 1 mg per l (for low concentrations at least).

To work out the concentration in ppm:

1. Multiply the figure in mol l-1l by the Atomic mass of Iron - 55.845
2. This gives the number of g l-1
3. Divide by 1000
4. This gives the value in mg l-1 = ppm

The concentrations in ppm Fe3+ of your standard solutions are:

|  |  |
| --- | --- |
| x10-5 mol l-1 | [Iron] ppm |
| 10 | 5.68 |
| 8 | 4.55 |
| 6 | 3.41 |
| 4 | 2.27 |
| 2 | 1.14 |

**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
* Background/ Underlying Chemistry including research from at least two different sources.
* a brief explanation of the techniques involved, e.g. colorimetry, and how the technique is used to determine the mass of iron in water samples.
* your experimental observations and results, including the calibration graph
* a comparison of the actual and the calculated ion concentration of known samples.
* reasons why your experimental results are different from the actual results (if they are different)
* an evaluation 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.
* A further investigation could be carried out to find the effect of iron concentration on the hardness of water.

# **Investigation C**

*“What is the concentration of phosphates in water?”*

**Introduction**

Water makes up around 66.7% of the surface of the Earth. It is essential for all forms of life on Earth. In Scotland, drinking water is available on tap but depending on the area and the supply of water there are many dissolved ions. Water is used for washing and has a foaming capacity depending on the hardness or softness of the water. Phosphate ions are often present in water samples.

**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 below, 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**

C1 How do phosphates enter the water supply?

C2 What are the effects of phosphates on the water treatments plants?

C3 What is the limit in ppm of phosphates in the discharge from sewage treatment plants, according to the Environment Agency for Scotland.

C4 How can phosphate levels be controlled?

**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. Ensure sites are credible. For more advice on effective web-based research see the Education Scotland resource on <http://www.educationscotland.gov.uk>

**Planning your investigation**

The next stage in your investigation is to plan and carry out an appropriate experimental procedure that will allow you to find out quantitatively the concentration of phosphate ions in the water samples.

This experiment allows for the analysis of phosphate content in water samples. Firstly a series of dilutions is made from a standard phosphate solution. The solutions will have different colour intensities which will give reference absorbance values.

By comparing the intensity of the colour of the water samples solution with the colours of a series of standard dilutions, with known phosphate concentrations, the concentration of water sample may be determined. This technique is called colorimetry.

Whilst planning your experimental work you must consider:

* Which water sample(s) you will investigate?
* What is the source of the water supply?
* How will the phosphate concentration be determined?
* Which chemicals will be required?
* What apparatus will be required?
* The hazards that might be involved and how you will minimise risk.

**Equipment and Materials Required**

|  |  |
| --- | --- |
| 0.00844 mol l-1 potassium antimonyl tartrate | Dissolve 1.3715 g K(SbO)C4H4O6.0.5H2O in 400 cm3 distilled water in a 500 cm3 volumetric flask and dilute to volume.) |
| 0.0162 mol l-1 | Dissolve 20 g (NH4)6Mo7O24.4H2O in 500 cm3 distilled water. |
| 0.1 mol l-1 Ascorbic acid | Dissolve 1.76 g ascorbic acid in 100 cm3 distilled water |
| Cuvettes |  |
| Colorimeter |  |

**Method**

*Experiment 1 – determination of phosphate concentration*

1. Make up your combined reagent: Mix the above reagents in the following proportions for 100 cm3 of the combined reagent: (Mix after the addition of each reagent)
   1. 50 cm3 2.5 mol l-1 H2SO4
   2. 5 cm3 potassium antimonyl tartrate solution
   3. 15 cm3 ammonium Molybdate solution
   4. 30 cm3 ascorbic acid solution.

Let all reagents reach room temperature fefore they are mixed and mix them in the order given. If turbidity forms in the combined reagent, shake and let stand for a frew minutes until turbidity disappears before proceeding. The reagent is stable for 4 hours.

1. Make a series of dilutions of your phosphate solution as follows: 0.5 cm3 of solution with 9.5 cm3 distilled water; 1 cm3 with 9 cm3 of distilled water and so on.
2. Place 5 cm3 of each dilution of the reference solution of your samples in a series of test tubes.
3. Add 1 cm3 of the combined reagent to each and mix thoroughly.
4. Leave the solutions for between 10 and 15 minutes.
5. Transfer some of the coloured solutions to cuvettes and read the absorbance at 590nm.
6. Plot the absorbance of your diluted reference solutions on a graph. This is your reference graph.
7. Read off the results for your water samples from the standard graph you obtained in 7.

**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
* Background/ Underlying Chemistry including research from at least two different sources.
* a brief explanation of the techniques involved e.g. colorimetry, and how this technique is used determine the phosphate concentrations in water.
* your experimental observations and results, including the calibration graph
* a comparison of the actual and the calculated ion concentration in bottled mineral water.
* reasons why your experimental results are different from the actual results (if they are different)
* an evaluation 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.

# 

# **Investigation D**

*“Making and testing Soap and Detergent “*

**Introduction**

Solid soaps are a widely used commercial product and are the sodium salts of fatty acids. Soaps can be made using naturally occurring fats by hydrolysing the large ester molecules using sodium hydroxide to produce the sodium salt of the fatty acid and glycerol. If the glycerol is not removed then the soap will also contain moisturising properties. Soaps are surfactants and reduce the surface tension of water.

<http://www.nuffieldfoundation.org/practical-chemistry/detergents-soaps-and-surface-tension>

Soaps need to be safe to use so chemical tests need to be done to ensure the soap will not cause damage to the user.

**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 below, 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**

D1 What chemicals are the active ingredients in commercial soaps?

D2 What are the traditional methods and two processes used to make soap?

D3 How do soaps remove grease and oil? What is the action of soaps?

D4 What types of fats can be used in making natural soap?

D5 How are synthetic soaps made?

D6 How are soaps scented?

D7 When making soap, How is it possible to test when the soap is neutralised?

D8 Give details of chemical equations and formulae for making soap.

D9 Why is it necessary to test soap?

D10 What tests will be carried out on the soap and how does this compare to commercial soaps.

D11 What affects the foaming capacity of soap ?

D12 How can the foaming capacity of soap be determined?

D13 What is the expected pH of the soap?

D14 How can water dispersal be tested?

**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. Ensure sites are credible. For more advice on effective web-based research see the Education Scotland resource on <http://www.educationscotland.gov.uk>

**Planning your investigation**

The next stage in your investigation is to plan and carry out an appropriate experimental procedure that will allow you to make a soap product. You will then carry out a series of tests on the soap to ensure its safety for use. The tests can then be compared to the same test results from commercial soaps.

Whilst planning your experimental work you must consider:

* What fat will be used and how will this be obtained?
* How will the sodium salt of the fatty acid be obtained?
* What are the desirable properties of the soap (moisturising, deep cleaning)
* What scent will the soap have and how will this scent be obtained.
* What tests will be carried out on the soap?
* Which chemicals will be required?
* What apparatus will be required?
* The hazards that might be involved and how you will minimise risk.

**Castor oil** is used as a source of vegetable oils which, on reaction with warm concentrated alkali, form **soaps**. The vegetable oils in castor oil also contain hydroxy-groups (–OH) which will react readily with concentrated sulfuric acid, forming a long chain molecule with an ionic sulfonate group on the end. Such molecules behave as **detergents**.

**Equipment and Materials Required**

|  |  |
| --- | --- |
| Test-tubes, 4 (with corks) | Castor oil, about 5 cm3 |
| Boiling tubes, 3 | Ethanol (IDA, Industrial Denatured Alcohol) (HIGHLY FLAMMABLE, HARMFUL), 5 cm3 |
| Test-tube rack | Sodium hydroxide solution, 5 mol l-1 (CORROSIVE), 10 cm3 |
| Dropping pipette | Sodium chloride, 10 g |
| Measuring cylinders (10 cm3), 2 | Concentrated sulfuric acid (CORROSIVE), 2 cm3 |
| Beakers (100 cm3), 2 | Purified water (distilled or deionised) |
| Beaker (250 cm3) |  |
| Glass rod |  |
| Spatula |  |
| Bunsen burner |  |
| Tripod stand |  |
| Heat resistant mat |  |
| Boiling water from kettle |  |
| Ice bath |  |
| Filter flask, funnel, filter paper and pump |  |

**Method**

*Experiment 1 – Making Soap*

1. Place about 2 cm3 of castor oil in a 100 cm3 beaker using a dropping pipette, followed by 5 cm3 of ethanol. Stir with a glass rod to mix.
2. Add 10 cm3 of sodium hydroxide solution..
3. Prepare a water bath containing near-boiling water from an electric kettle so that you can safely lower the small beaker into it without spillage. A 250 cm3 beaker may be used as the water bath. Do not use too much water, as the small beaker needs to be supported without risk of the water coming over the top.
4. Stir the mixture in the beaker with a glass rod for 5 minutes. If the water bath cools too much, you may need to renew with fresh boiling water.
5. Meanwhile in a boiling tube make a saturated solution of sodium chloride by shaking solid sodium chloride with 10 cm3 of water until no more will dissolve. Allow to settle.
6. After 5 minutes, add the saturated sodium chloride solution to the small beaker and stir.
7. Add desired scent at this point and mix thoroughly.
8. Cool the mixture by changing to a cold water bath (or an ice bath if available).
9. Soft, white lumps of the soap will gradually form in the mixture. Leave for a few minutes to improve the yield. During this time the soap may rise to the surface and form a soft crust on cooling.
10. Using a pump, with a fresh filter paper damped down in the funnel, filter off the soap, breaking up the crust with a glass rod if necessary
11. Allow the soap to drain on a paper towel – do not touch it with your fingers, as it may still contain sodium hydroxide.
12. Use a spatula to transfer a little of the soap to a test-tube, and add a few cm3 of purified water. Shake well! What happens? You have made a soap!

*Experiment 2 – Making Detergent*

1. Add 4 cm3 of concentrated sulfuric acid to a boiling tube (your teacher may do this for you).
2. Using the dropping pipette, add 2 cm3 of castor oil very carefully to the boiling tube, swirling gently to mix. Does the test-tube become hot?
3. Add 10 cm3 of cold water to a boiling tube (about 3 - 4 cm depth), then carefully pour the reaction mixture from the first tube into the water. The liquid may be very slow-flowing (viscous) and contain concentrated acid, so be careful and take your time over this.
4. Stir to remove the excess of acid into the water and then decant (pour off) the water down the sink, leaving a pinkish-grey sludge. Wash the product again with two more portions of water.
5. Use a spatula to transfer a small quantity of the product to a clean test-tube. Add a few cm3 of water, and shake well. What happens? You have made a detergent!

**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
* Background/ Underlying Chemistry including research from at least two different sources.
* Chemical equations and formulae related to the reactions involved.
* a brief explanation of the chemistry techniques involved.
* your experimental observations and results.
* a brief explanation of how the soap was made
* How was the soap tested for safely
* The expected mass of soap and the percentage yield calculation.
* reasons why your experimental results are different from the actual results (if they are different)
* an evaluation 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.

**Testing Soap**

Quality Control- Testing your soap

# Cosmetic products must go through exhaustive testing prior to launch to ensure that they are effective and safe to use. Manufacturers employ extremely exacting on-going testing to ensure that every bottle of soap produced meets the product specification exactly.

Having produced a soap or detergent, it is now time to test your product against its competitors. You are getting 3 commercial soaps to compare: a cheap one, a mid-price one and an expensive one.

**Preparation**:

A soap solution can be made by dissolving soap flakes (or shavings from bar soap) in ethanol – use IDA (Industrial Denatured Alcohol) (HIGHTLY FLAMMABLE, HARMFUL). Do not dilute with water. An appropriate hazard warning label is required.

**Equipment and Materials Required**

|  |  |
| --- | --- |
| 1 test tube rack | 4 Test tubes |
| 4 petri dishes | 1 10ml measuring cylinder |
| 1 250ml measuring cylinder | 4 large test tubes (with stoppers) |
| 2 1ml Pasteur pipettes | Universal indicator |
| Cooking oil | India ink |
| Distilled water |  |

**Test A - Determination of pH**:

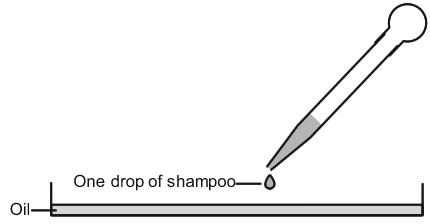
1. Put one drop of the soap in a test-tube.
2. Fill the tube 3/4 full with distilled water.
3. Add two drops of Universal Indicator solution.
4. Find the pH value of the soap solution.
5. Record your results in the table.

**Health and Safety**

* Avoid any skin contact with the Universal indicator.
* Immediately wash any Universal indicator of exposed skin.

*Information: Most soap are neutral or slightly acidic. Acidic solutions cause the cuticle (outer layer) of the hair to shrink and lay flatter on the shaft of the hair. Basic solutions cause the cuticle to swell and open up. Acidic solutions make the hair seem smoother. Basic solutions make hair seem frizzier.*

**Test B - Oil Test**:

1. Pour cooking oil into a petri dish to make a thin film over the base. 
2. Place the dish on the dark paper.
3. Use a dropping pipette to drip one drop of soap onto the oil film (see diagram).
4. Wait until the drop has stopped spreading out, then measure the diameter of the faint iridescent halo formed around the soap drop. This will probably be between 3 and 6 cm in diameter. Write this down in the 'oil test' column of the table.

Test C and Test D are done together make sure you read Test D before you start.

**Test C Shake Test - Determination of Foam Formation**:

1. Put approx 50 ml of the 1% soap solution into a 250ml graduated cylinder and record the volume.
2. Cover the cylinder with your hand and shake 10 times.
3. Record the total volume of the contents after shaking
4. Calculate the volume of the foam only and record your answer
5. Record the size of the bubbles (as small, medium, or large)

*Information: A good soap should have a foam volume of 100 ml or more in the shake test. Bubbles should be small. The smaller the bubbles the longer the foam will persist*.

**Test D Foam Quality and Retention**:

1. Immediately after the Shake Test (Test C), Begin timing.
2. Record the volume of foam at 1-minute intervals for 5 minutes in the table.

*Information: In a good soap, foam retention should remain stable for at least 5 minutes.*

**Test F Dirt Dispersion**:

1. Put two drops of soap in a large test tube
2. Add 10 ml of distilled water
3. Add 1 drop of India Ink
4. Stopper the test tube and shake it ten times.
5. Estimate the amount of ink in the foam (as None, Light, Moderate, or Heavy) and record

*Information: Soaps that cause the ink to concentrate in the foam are considered poor quality. The dirt should stay in the water portion. Dirt that stays in the foam will be difficult to rinse away. It will redeposit on the hair*.

Further Investigations

Further investigations could include:

Testing the foaming capacity of soap with hard and soft water.

How do the ions present affect the foaming capacity.