# HSC Chemistry Assessment Task 4: Research Task

## Topics: "Chemical Monitoring and Management" and "Shipwrecks"

**Part A:** Research Content

1. **Discuss the problems associated with the use of CFC's and assess the effectiveness of steps taken to alleviate these problems.**

There are various problems which are associated with the use of CFC's in our atmosphere, the main problem being that the release of CFC's is the cause of **ozone destruction in our stratosphere.** This occurs due to the chemical composition of CFC's which contain the element chlorine where in the presence of sunlight, causes the process of photo dissociation to occur.

$CCl_3F(g) + UV \rightarrow CCl_2F(g) + \cdot Cl(g)$

This reaction causes the CFC's to decompose, forming reactive chlorine free radicals which are unstable. These radicals then escape and act as catalysts for the destruction of ozone.

$.Cl + O_3 \rightarrow ClO + O_2$

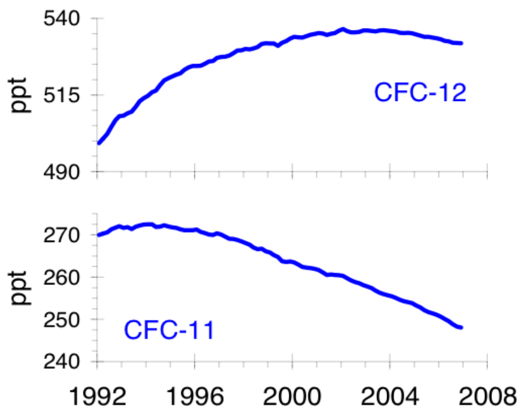
$.ClO +. O \rightarrow .Cl + O_2$

$O_3 +. O \rightarrow 2O_2$

The destruction of ozone or stratospheric ozone depletion is a major concern as the ozone layer in the stratosphere helps to keep approximately 95-99% of the sun's UV radiation from damaging the Earth. Ozone depletion can cause many problems as UV radiation reaches the Earth including: sunburn, eye damage, increased amounts of photochemical smog and damage to aquatic life. Another problem associated with the use of CFC's is global warming where increasing concentrations of CFC's enhances the greenhouse effect.

To alleviate and reduce the harmful effects of problems associated with CFC usage, we have actively tried to decrease ozone depletion by introducing new protocols. For example, in 1987, a protocol called the **Montreal Protocol** was introduced and signed by over 70 countries worldwide, agreeing to reduce CFC production by 50% by 1998, which was effective in preventing CFC overuse as various alternatives have been developed for CFC replacement. Furthermore, the most recent agreement proposed in 1992 was to stop using halogens by the end of 1994, cease the manufacture and use of CFCs and 1,1,1-trichloroethane by 1996 and phase out HCFCs by the early 21st Century.

As a result of the above protocols, legal CFC production has ended in developed countries in 1995 while developing countries were allowed a further 15 years to stop using CFC's by year 2010. Thus, these protocols and our actions have increased the effectiveness of stopping CFC usage and are continuing to successfully alleviate ozone depletion in the future where recent research shows that these international agreements have been successfully effective in solving the problem of ozone depletion.




2. **Identify one alternative chemical used to replace CFC's and evaluate the effectiveness of their use as a replacement for CFC's.**

Because CFC's damage the ozone layer it is necessary to find replacements for these chemicals. An alternative form of chlorofluorocarbons are compounds called hydrochlorofluorocarbons (HCFC's). HCFC's are alternative compounds which contain additional hydrogen atoms and fewer chlorine atoms than CFC's. HCFC's can undergo reactions with free hydroxyl radicals in the troposphere where it is then removed from the atmosphere before finally reaching the stratosphere, where they may damage the ozone layer by the release of chlorine atoms. However, HCFC's cause much less damage to the ozone layer compared to the use of CFC's as they are more reactive and thus react with other particles before it reaches the stratosphere where the remaining radicals are then diffused into the atmosphere.

Industrially, HCFC's have replaced CFC's as aerosol propellants and have been further developed for use in refrigeration and air-conditioning systems as well as a current use as solvents. Additionally, further technologies that use air have been created to replace the use of CFC's as foaming agents in the production of plastic foams, including a commonly known foam such as Styrofoam. The ultimate futuristic goal is to remove all substances that may damage the ozone layer.

Therefore, due to the higher reactivity of its hydrogen radicals, HCFC's have a greater potential to become increasingly effective as a replacement for CFC's in the short term. However, in the long term, detrimental environmental effects of this compound result in the need for their phasing out as soon as possible as it still instills damaging effects on ozone depletion as well as environmental damage, thus decreasing its effectiveness however overall, HCFC's have less concerning problems compared to CFC usage. Thus, further research into the ecological consequences of HCFC usage is required to ensure their evaluated sustainability and valued effectiveness as a potential replacement for CFC's.

**3. Gather, process and present information on the range and chemistry of the tests use to:**
- **Identify heavy metal pollution of water**
- **Monitor possible eutrophication of waterways**

A wide range of tests can be used to both identify heavy metal pollution in water as well as monitor the possible eutrophication of waterways. Predominantly, a sodium sulfide solution can be used to detect the presence of heavy metal ions in a sample of water. The ion hydrogen sulfide produced is a very weak acid, meaning that it will only exist in small amounts in an acidic solution however it can be more noticeably present in an alkaline solution.

$S^{2-}(aq) + 2H_3O^+(aq) \rightleftharpoons H_2S(aq) + 2H_2O(l)$

This test is effective and is a successful method in determining the presence of heavy metal ions in water. Other tests include: Flame tests and Atomic Absorption Spectroscopy, where a light source is used to measure the specific absorption concentration (in ppm) of the heavy metal being tested, where its accuracy increases its methodical effectiveness.

Procedure:

1. The water sample is acidified and drops of sodium sulfide are added. A precipitate may form if it is reacted with an insoluble ion e.g. $Pb^{2+}$, $Ag^+$ or $Cu^{2+}$, producing a precipitate e.g. $Pb^{2+}(aq) + S^{2-}(aq) \rightleftharpoons PbS(s)$
2. If a precipitate is formed when the sample is basified, then one or more of the following is present: chromium, zinc, iron (III), nickel, cobalt, manganese etc., where it is then centrifuged/filtered off and made basic to test for any of the second group of cations.
3. If no precipitate forms, the solution is made to be slightly basic.

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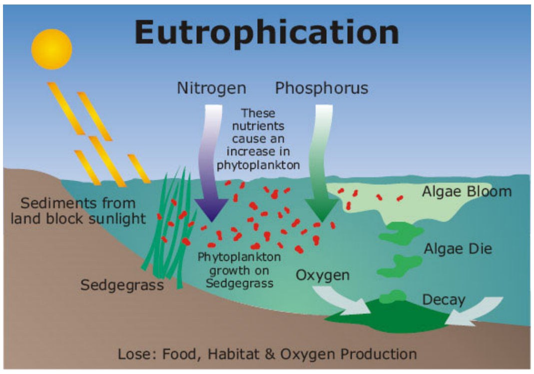
Eutrophication occurs when a body of water becomes enriched with nutrients e.g. nitrates and phosphates to allow for algal blooms to grow. Algal blooms in water use up oxygen and block the sunlight. However, the oxygen molecules when used up will eventually diminish, killing algae. Decomposers such as bacteria and cyanobacteria consume the dead algae, which releases unwanted toxins into waterways. These polluted waterways are left inhabitable by plants, animals and unusable by humans.




Measuring the phosphate concentration of the water can help monitor limiting plant growth which is measured by using **UV-Vis Spectroscopy.**

1. Ammonium molybdite and potassium tartrate react in an acid medium with $PO_4^{2-}$ ions producing phosphomolybdic acid.
2. This acid is then reduced using ascorbic acid producing phosphorus molybdenum $(MoO_2.4MoO_3)_2.H_3PO_4$.
3. The final intensity of phosphate concentration can be measured by absorbance at 880nm for further determination.

Also, there is also a calorimetric method available for estimating nitrate concentration, however both this method and UV-Vis Spectroscopy are very effective in monitoring eutrophication in waterways.

**4. Gather, process and present information on the features of the local town water supply in terms of:**
- **Catchment area**
- **Possible sources of contamination**
- **Chemical tests available to determine levels and types of contaminants**
- **Physical and chemical processes used to purify water**
- **Chemical additives in the water and the reasons for the presence of these additives**

The main catchment area in Sydney is Warragamba Dam where approximately 80% of Sydney's Water is obtained from this area which is over 9000 square kilometers in size, stretching out from the south of Goulburn to the north of Lithgow. Warragamba Dam is located one hour from Sydney's CBD and is Australia's largest urban water supply dam.

Some possible sources of contamination at Warragamba Dam includes:

1. **Agriculture:** where fertilizers and animal waste can pollute the waterways, especially as 60 percent of Sydney's drinking water is owned privately. Fertilizer and chemical runoffs from the soil can poison the water and kill aquatic life, becoming contaminated and unsafe to drink.
2. **Eutrophication:** this can definitely cause water contamination and poison as the unwanted growth of

   $$106CO_2 + 16NO_3^- + HPO_4^{2-} + 122H_2O + 18H^+ \xrightarrow{\text{Energy + microelement}} C_{106}H_{263}O_{110}N_{16}P(\text{boiplasm of algae} + 138O_2)$$ algae,

   microorganisms and bacteria can grow and feed on the nutrients obtained from agricultural runoffs e.g. fertilizers. This causes water to be infected with microorganisms which may cause sickness and infections when consumed e.g. Protozoa Cryptosporidium and Giardia can potentially result in outbreaks of infectious diseases.
3. Current and **abandoned mining sites** also have the potential to contaminate water from the source of heavy metal ions, which can be toxic to marine organisms and humans.
4. **Land clearing:** increased erosion of land can also lead to sediment runoff into waterways, resulting in increased turbidity of the water, making it dangerous to drink.

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Some chemical tests are conducted by Water NSW who monitors the water quality at Warragamba dam where samples of the water are either taken by hand or with special equipment linked by a satellite at routine times and during wet weather. Some tests are done on-site for rapid identification of any major problems e.g. a sudden increase in heavy metal ions. Sydney Water also takes samples back to the laboratories for more detailed analysis to determine levels and types of contaminants e.g. algae, metal ions, animal faeces etc. After the purification process, drinking water is also tested at NATA accredited Laboratories by Sydney water.

Water must be purified to meet Australia's Drinking Water Guidelines. Some physical and chemical processes used to purify water include filtration (physical), where fine screens act as filters to remove large materials such as leaves, twigs and other particles. Flocculants (chemical) are then added to cause the coagulation of particles, allowing an easier filtration process through the sand, or layers of sand and anthracite. Chlorine (chemical) is then added to kill any remaining microbes. If water is to travel a long distance in pipes, ammonia (chemical) is added to form monochloramine, which lasts longer than chlorine alone.

Chemical additives added to the water include fluoride, a chemical added to drinking water to help prevent tooth decay. By the law of the Fluoridation of Public Water Supplies Act 1957, drinking water now contains 1mg/L of fluoride. Another chemical additive in water is lime and some carbon dioxide, which is added to correct the pH level in order to minimalize the corrosion of water pipes.

**5. Outline and analyse the impact of the work of Galvani, Volta, Davy and Faraday in understanding electron transfer reactions.**

Luigi Galvani is an Italian physiologist, born in 1737 in Bologna, Italy. After he published the results of his series of experiments in 1791 on the electrical stimulation of frog legs, Galvani observed and discovered that muscles will contract after an electrical shock was emitted when two different metals formed a circuit with the muscle tissue. From his experiments, Galvani suggested that animal tissue contained an electrical fluid known as "animal electricity." Galvani's discoveries of what he conceived to be electricity in animal tissue has a large impact in unintentionally discovering electron transfer reactions and initiated electrophysiology as a scientific field, greatly contributing to our understanding of electrical connections in biological systems.

Most of Galvani's scientific colleagues believed his views however his friend Allessandro Volta, the professor of physics at the University of Pavia was not convinced by Galvani's analogy. This lead to the Galvani-Volta controversy, where both scientists both examined the same specimen and the interaction of electricity and muscle contractions in frog's legs but both concluded with opposing theories of the phenomenon. Volta repeated Galvani's experiments and established that it was the wires in the solution that generated the electric current called "metallic electricity" and not the animal tissue itself. Volta thus constructed the first Galvanic cell and later created the "Voltaic Pile" as he stacked various cells together, forming the first direct current battery, becoming the first man to generate electricity from a chemical reaction.

Sir Humphry Davy was an English chemist who worked in many fields of study. In the early 19$^{th}$ century, Davy worked on a created a new powerful battery for further electrolytic research after he heard of the existence of the voltaic pile and its ability to decompose water. To do this, Davy isolated several various metals using electrolytic cells e.g. potassium, sodium and calcium using electrolysis and from his results obtained the conclusion that the electrical currents in the voltaic pile were generated by chemical changes. Thus, Davy's contribution to electron transfer reactions greatly improved our knowledge and use of electricity in batteries and the effects of electricity on chemical compounds while demonstrating the importance of free ions during electrolysis.

During the early-mid 19th century, Michael Faraday who was originally Davy's assistant conducted research across many different physical science fields. Principally, Faraday is well known for his successful work in the discovery of the electric motor, electromagnetism and electrochemistry. Faraday's work included firstly repeating Davy's experiments to develop the quantitative laws of electrolysis, where he saw a correlation between the charge transferred in decomposition to the mass deposited on the cathode. Faraday eventually presented the electrochemical nomenclature that is still currently used in our society, including the terms: anion, cation, electrode and electrolyte.

**6. Compare the composition, properties and uses of a range of steels.**

There are many different varieties of steel compositions, with each one having different and unique properties and uses. 7 types of steels include:

| Steel: | Composition: | Properties: | Uses: |
|---|---|---|---|
| Mild | • < 0.2% Carbon.<br>• One of the largest groups of carbon steel. | • Malleable and soft.<br>• Inexpensive and easy to work with.<br>• Not very resistant to corrosion. | It has many uses including:<br>• Pipes<br>• Machinery<br>• Ship building<br>• Nuts and bolts<br>• Roofing<br>• Nails, chains and cables<br> |
| Stainless | • Contains 10-25% chromium<br>• Contains 4-22% Nickel | • It has a high polish and is shiny<br>• Hard<br>• It unlike the mild steel is very resistant to corrosion and rust | • It is used in machinery that are used for processing food<br>• Kitchen sinks and appliances<br>• Razor blades<br>• Cutlery<br>• Surgical Instruments and hospital items<br> |
| Structural | • Contains 0.2-0.5% Carbon content | • It is hard and strong | • Girders and vehicles<br>• Beams<br>• Railways |

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| | | • Also like Mild steel tends to corrode fairly rapidly<br>• Has high tensile strength | • Reinforcements for buildings<br>• Ships |
| High Carbon Steel | • Carbon content between 0.6-1.4% | • Having a high carbon content provides tempered hardness and strength<br>• Not very ductile<br>• Sometimes, strong carbide formers e.g. Chromium are added as alloying elements to form carbides of these metals. | • It can be used as a tool and die steels as it has a strong and hard metallic property as well as resistance to wearing and corrosion. |
| Alloy Steel-Manganese | • 0.15-0.3% of carbon<br>• 10-15% of Manganese | • The presence of Manganese contributes to an increased strength and hardness of metal. However, the degree to which manages increases hardness is dependent on the carbon content of the steel.<br>• Adding Manganese results in a reduce in risk | • Used in cables<br>• Filters and wire mesh for the petrochemical and chemical industries<br>• This allow steel can also be used as a reducing agent in ferromanganese production.<br>• Used in safes, crushers and mechanical shovels.<br>• Manganese as an alloy is used in the construction of ships and boats as is has excellent strength and is lightweight.<br> |

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| | | of cracking because of the reduction in the quenching shock.<br>• Enhances tensile strength<br>• Increased resistance to corrosion<br>• Reduced ductility.<br>• Increases the rate of carbon penetration and thermal expansion.<br>• Manganese is a necessity for the process of hot rolling of steel by its combination with oxygen and sulfur. | |
| Tool Steels | • 0.9-1.5% Carbon content<br>• The composition of tool steels contains tungsten, molybdenum, cobalt and vanadium in varying quantities.<br>• Available in a wide variety of shapes and sizes e.g. round bar, | • Properties of tool steels include increased heat resistance and durability<br>• Very hard and strong and are commonly used to form other metal products.<br>• Resistant to wear<br>• Can be almost brittle | • Having the property of increased heat durability makes tool steels ideal for being used as cutting and drilling equipment.<br>• Long tubular products can be used for rods, rails, pipes and wires.<br>• Flat products can be used for plates, sheets, coils, strips and knives.<br>• Also used in automotive parts e.g. packaging, shipbuilding and construction.<br>• Other products include: valves, fittings, flanges and are used as piping materials.<br>• Can be used for tool blades, cutlery and machinery. |

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| | square bar etc. | | |
| Ultra-High Carbon Steel | • Experimental alloy which contains between 1.0-2.1% carbon content. | • Tempered to possess a great hardness level and strength<br>• Hard to weld or fuse.<br>• Extra brittle<br>• Good tensile ductility. | • Used for special purposes e.g. knives, drills, axles or punches.<br>• Ultra-high carbon steels can also be used to make various cutting tools or masonry nails.<br>• Making press machinery<br>• Woodcutting and metal cutting tools. |

**7. Trace historical developments in the choice of materials used in the construction of ocean-going vessels with a focus on the metals used.**

Back in ancient history, boats, sea-ships and ocean vessels were almost always constructed from wood or other locally available materials e.g. logs, bamboo or animal skins. The wooded construction consisted of wooden planks and beams, which were fastened together with spikes and metal nails, but it had not yet been imagined that man could construct ships from metals and/or alloys. However, in the 1600's it was discovered that when thin copper/lead sheets were secured onto the hull of a ship, it would reduce the growth of weeds and microorganisms and restrict any wood-eating worms on and in its hull. Thus, small sheets of copper, brass and bronze were used as a part of the ship's construction, where later iron dominated as the main metal used to fasten the wooded planks to each other. As man began to experiment with different metallic materials, ocean-vessels and boat-building evolved into being predominantly constructed of iron and steel (most common) and eventually alloys such as aluminum became popular instead of using wooden resources.

Some list of metals/alloys used as boat-building/ocean-vessel materials are assessed below in chronological order:

| Metal/Alloy | Use with relation to its period | Advantage(s) | Disadvantage(s) | Critical assessment/Judgement |
|---|---|---|---|---|
| Pieces of Copper, bronze and brass | Pieces of copper, brass and bronze (alloys of copper) are used in parts of ship-construction, including fastenings of wooden planks while also acting as a barrier to reduce the entry and growth of organisms inside the ship. These metals and alloys were used in the 1600's and were continued to be | Advantages of using copper, bronze and brass was that it was useful in protecting the underwater hull of the ship from the corrosive effects of salt water and copper acts as its own antifouling paint through | Disadvantages of using copper, bronze and steel was that it was can be expensive and heavy, and even though it is highly corrosion resistant, copper is also susceptible to corrode through oxidation, affecting its life expectancy as a metal used in | Thus, from the advantages and disadvantages listed, it can be concluded that copper and its alloys are effective as a construction material for certain parts of boats and ships however, it will not be very effective as the core material in building the main structure of the ship as it is susceptible to corrosion, costly and |

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| | used throughout the 17th century. | the use of copper plates pinned onto the outside of the hull. | ship-building before it has to be replaced. | can be heavy/dense in places. Therefore, research and experiments involving other metals should be investigated as a replacement for copper. |
| Cast Iron | Cast Iron and iron ships had first been proposed for military use in the Outbreak of the American Civil War in 1861 during the Reconstruction Period as a metal used in ship-building. During the war, iron-clad ships were used to withstand weapons that could cause damage from great distances. | Advantages in using iron as a boat-building metal is that it has stronger, can be easily worked and long-lasting properties which is favorable in the transport of more cargo where its strength meant that more cargo holds could be built, resulting in faster transport speeds. It is also relatively cheap and abundant. | During the end of the 1840's iron was no longer used for ship construction as iron hulls were more vulnerable to attacks from solid shots, it had brittle properties compared to wood etc. | Thus, from the advantages and disadvantages compared, iron is overall more advantageous as a ship building material in comparison to previous materials such as wood as it allowed larger ships to have a more flexible design and is longer-lasting and faster in speed. Iron hulls are also becoming increasingly cost effective however rusting of iron e.g. $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$ has become an increasing problem in assessing its use as a metal in the construction of ships and ocean-vessels. |
| Steel | Steel has become the main modern metal involved in ship construction, consisting of a large group of alloys containing carbon and iron with varying amounts of a number of other elements. | Advantages of using steel as a construction metal is that easily welded, malleable and well-shaped and machined, which are all useful properties in ship-building. Stainless steels are also used as it has a high resistance to corrosion from containing | Disadvantages of steel includes that it corrodes in very humid areas, coastal regions and various other moist areas. To use steel as a boat-building metal, builders would have to use anti-corrosive coatings to protect its structure. | Thus, steel is a good material to use in ship building as it has many advantageous properties including: it is cost effective and light weight, it is ductile, durable and adaptable. All of these properties help to extend the lifespan of steel ship structures, and thus, steel is a good metallic material for use in boat-building/ocean-vessel construction. |

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| | | 10.5% chromium. | | |
| Aluminum and other alloys | Aluminum is a relatively new addition to the steels used in ship building. It is used currently, in the 21st century and has become a common metal used in the construction of ocean vessels, boats and ships. Other alloys such as titanium and zinc are also being widely used as it possesses advantageous and desirable qualities. | There are many advantages of using aluminum as a metal for building ships as it has light, strong and corrosion resistant properties where the development of aluminum alloys has improved the fatigue resistance of steel and its ability to be welded, making this metal easy to work with. | Some disadvantages of using aluminum is that it is considerably more expensive than steel due to its desirable properties and it is also highly flammable when exposed to flames, but on water these drawbacks do not surpass its advantageous qualities. | Thus, due to the advantages and disadvantages of aluminum, it can be assessed and judged that overall, it serves as a strong and reliable metal to be used in the construction of boats and ships as it is readily weldable, light, strong and corrosion resistant. |

**Bibliography:**


1. Bell, Terrence. The Balance: Steel Grades. (2017). Retrived from: https://www.thebalance.com/steel-grades-2340174 Date accessed: 17/6/2017
2. Dibner, B. (2017). Encyclopedia Britannica. Luigi Galvani. Retrieved from: https://www.britannica.com/biography/Luigi-Galvani Date accessed: 14/6/2017
3. Dux College. (2009). Paramatta, Sydney. Retrieved from: https://dc.edu.au/dot-point-summary-chemical-monitoring-management/ Date accessed: 20/5/2017


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4. Irwin, D. (2006). *Chemistry Contexts 2 Second Edition: HSC.* Australia: Pearson Education. **(Textbook)**


**Validity Evaluation:** This textbook is a primary resource and therefore it has high validity. This source is reliable, accurate and valid due to it having been carefully checked and edited before being published and is a primary resource, written by Debbie Irwin who has had experience in writing and editing Chemistry Textbooks, working for Pearson Education in Australia. It has been published during the last decade and is therefore valid and reliable as a source of current, well researched and accurate information. This textbook is written specifically for educational purposes, covering HSC topics and syllabus dot points and is unbiased, therefore increasing its validity.

5. EasyChem. Matt Schiller. (2010). Retrieved from: http://www.easychem.com.au/monitoring-and-management/water/heavy-metal-pollution-and-eutrophication Date accessed: 25/5/2017

**Validity Evaluation:** This website (secondary source) has a high validity as it has been launched and written by a medicine and philosophy student: Matt Schiller who graduated at UNSW with MBBS (Honors 1), Bachelor of Philosophy and Certificate in Teaching. Since studying chemistry for his HSC, Matt has continued to teach others in this field and self-published his EasyChem website purely for educational purposes. Thus, the information provided is accurate and current to date, easy to understand and well-researched, as information has been referenced from the Chemistry Contexts II Textbook (primary source), therefore heightening the validity of his provided information.

6. Kasten, M. (1997). Metal Boats. Retrieved from: http://www.kastenmarine.com/metalboats.htm Date accessed: 24/6/2017
7. Reliance Foundry. Steel Grading: Carbon and Mild Steel. (2017). Retrived from: http://www.reliance-foundry.com/castings/steel-grades#gref Date accessed: 17/6/2017
8. Water NSW. Maintaining Water Quality. Retrieved from: http://www.waternsw.com.au/water-quality/education/learn/water-quality Date accessed: 1/6/2017

**Images:**

1. Image 1. CFC reduction. Retrieved from: http://www.easychem.com.au/monitoring-and-management/the-atmosphere/problems-associated-with-cfcs (Accessed on: 25/6/2017).
2. Image 2. Eutrophication Process. Retrieved from: http://sachinkbiology11.weebly.com/ (Accessed on: 25/5/2017).
3. Image 3. Luigi Galvani. Retrieved from: https://upload.wikimedia.org/wikipedia/commons/7/7e/Galvani.jpg (Accessed on: 14/6/2017).
4. Image 4. Mild Steel-square bar. Retrieved from: http://www.austenknapman.co.uk/image_resize/crop/mw1000/mh750/products/img_mild-steel-flat-bar.jpg (Accessed on: 17/6/2017).
5. Image 5. Stainless Steel. Retrived from: http://www.searchpointer.com/bangalore/stainless-steel-in-bangalore-sp396cat14c1/ (Accessed on: 17/6/2017).
6. Image 6. Alloy Steel: Manganese. Retrieved from: http://www.tritonalloysinc.com/wp-content/uploads/2014/11/manganese-steel-plate1.png (Accessed on: 17/6/2017).

**PDF's:**

1. Material Science. Seblin, B. (2014). Discuss the effects of each of the different alloying elements in steel. Retrieved from: http://www.uom.ac.mu/faculties/foe/mped/Students_Corner/notes/EnggMaterials/steelbklet.pdf Date accessed: 17/6/2017
2. MIT Department of Civil and Environmental Engineering. Chemical composition of structural steels. (1999). Retrieved from: http://web.mit.edu/1.51/www/pdf/chemical.pdf Date accessed: 17/6/2017
3. Water NSW. Warragamba Dam Facts. Retrieved from: http://www.waternsw.com.au/__data/assets/pdf_file/0003/59907/Fact-sheet-Warragamba-Dam-fact-sheet-Nov15-ScreenRes.pdf Date accessed: 1/6/2017

Extra: **Eutrophication Reaction Equation in Question 4**, retrieved from website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2266883/ written by Xiang Wu.