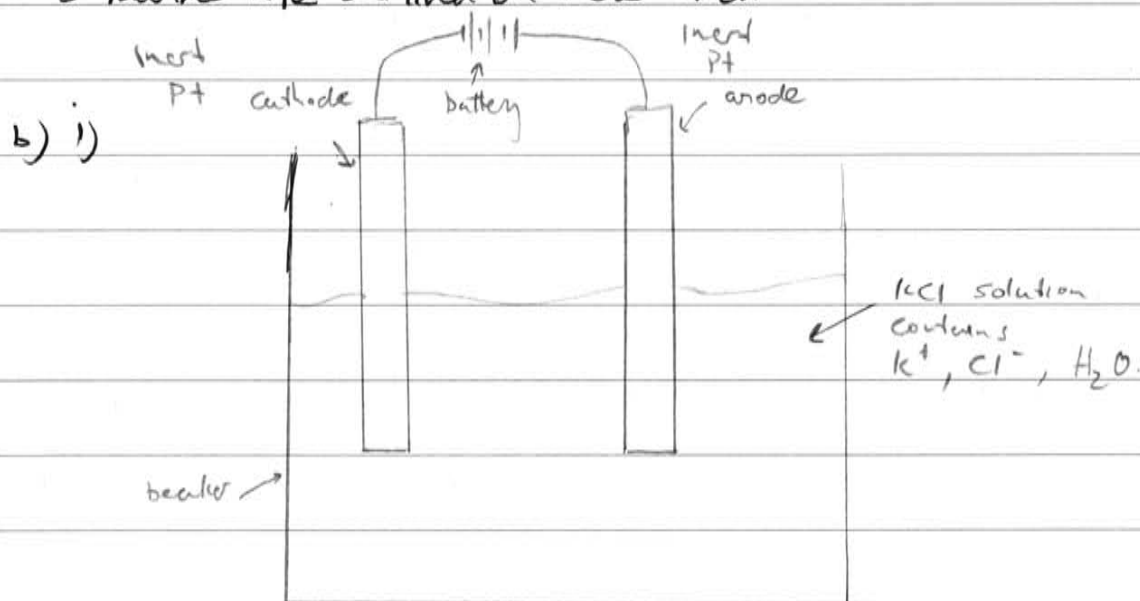
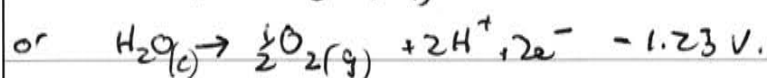
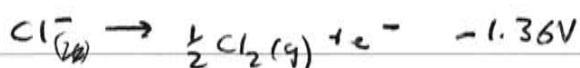


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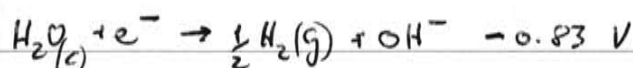
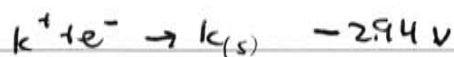
a) The artefact is predominantly composed of wood and this would have been seriously affected by bacteria in this time. The bacteria would have broken down the cellulose providing support to the timber and the water inside the cells would have been replaced by salt water. The metal supports around the artefact would have likely corroded as well. ~~As~~ Concretions would have likely also formed on the artefact as marine life ~~has~~ lived on the artefact.



At anode - oxidation.



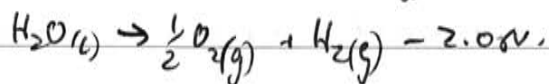
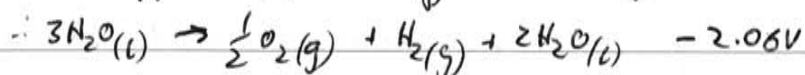
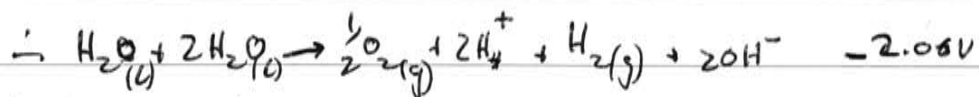
At cathode - reduction



At the anode H<sub>2</sub>O is more likely to oxidise than Cl<sup>-</sup> as it has a lower voltage.

However there is not much difference so some chlorine could be oxidised.

At the cathode water is again more likely to be reduced as it has a voltage requirement of 0.83 to potassium's 2.94.



ii) The cathode would be identified by the production of  $\text{H}_2$  gas. To find this you could use the pop test. Place a test tube upside down over the cathode to collect the gas it releases and place a lit taper to the test tube. If it makes a popping sound it was hydrogen and therefore the cathode.

c) As the percentage of carbon in steel increases, so does its hardness, strength and brittleness. At the same time it becomes less malleable, ductile and becomes more susceptible to corrosion.

As a result of this steel 1 would be <sup>moderately</sup> malleable, soft and not susceptible to corrosion, <sup>whilst still having strength and moderate hardness.</sup> Thus it would be used in cars and fittings for boats as these should not corrode but still require some strength.

In steel 2, its higher percentage of carbon would make it hard and strong as well as brittle. It would be used for building materials since these require it to be under a lot of pressure and be strong.

In steel 3 the high percentage of carbon is offset by the manganese and silicon which would make it more resistant to corrosion and ~~more~~ less brittle whilst still being hard. This would make it useful for kitchen appliances as they are often in contact with moisture and should not corrode.

In steel 4 the lack of carbon is made up for by the high levels of Chromium and Nickel which provide strength whilst preventing corrosion. This would be used for boats as they are constantly in contact with the water and so require metals which do not corrode a great deal and

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that have strength.

These steels of different percentages carbon, Manganese, Silicon, Nickel and chromium have ~~the~~ <sup>very</sup> different properties and thus are suited to different uses which require these properties.

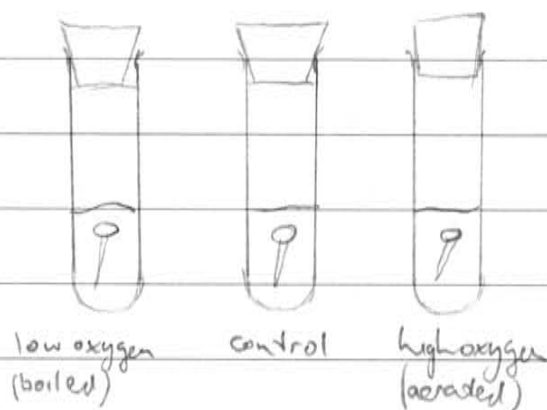
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d) i) To test the environmental factors that affect the rate of corrosion of iron we used the following experiment.

The three factors tested were presence of oxygen, level of salinity and acidity of solution.

To test the corrosion of iron in different levels of oxygen we set up three test tubes, one with tap water, one with boiled water and one with aerated water. In each medium size test tube we placed ~~three~~ an identical iron nail and covered it in 5 mL of water. We then stoppered the test tube to prevent oxygen from making iron rust. To aerate the water we used a fish tank aerator. This was left for 5 days and any changes observed each day.



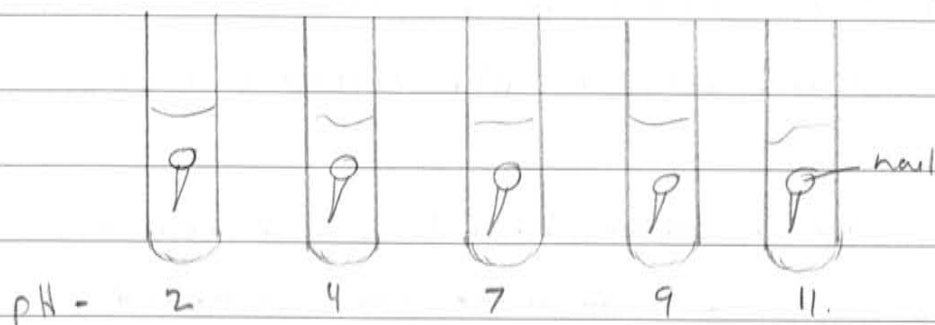
We found that the nail with the highest concentration of oxygen corroded the most quickly and the most.

To test the corrosion ~~rate~~ of iron in different levels of salinity we used <sup>medium</sup> 3 test tubes and first filled one with 5 mL of distilled water, one with 5 mL of tap water and one with 5 mL of 0.05 mol/L NaCl solution.

In these we placed 3 identical nails and left them for 5 days, observing changes daily. We found that the nails in the higher salinity environments had the highest level of corrosion.

To test the corrosion of iron in ~~different~~ solutions of differing

acidity we used  $\frac{5}{n}$  <sup>medium</sup> test tubes and 5 identical iron nails. In each test tube we placed 5ml of a solution ~~one~~ of differing pH's.



These were left for 5 days and changes were observed daily.

We found that at very low pH's the nail corroded greatly but did not rust, instead turning black. Aside from this, the lower pH's corroded much more rapidly than those of a high pH.

ii) to reduce the factor of Oxygen in an marine environment a surface could be painted to prevent contact of the surface with oxygen

e) For wooden artefacts that have been immersed in salt water the cellulose which forms the cell walls has been broken down and the water in the cell replaced with salt water. To dry the artefact out would cause it to warp or the salt crystals grow inside the cells. The artefact would also ~~be cover~~ be likely to be covered in concretions. To remove these picks or dental tools could be used. The wooden artefact would then be soaked in polyethylene glycol (PEG) <sup>solution</sup> to replace the salt <sup>water</sup> in the cells. This would have to happen over a long period of time to allow all the salt to be removed, with the solution being changed regularly. The wooden artefact would then be able to be dried and coated with

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a further layer of PEG. These processes are effective for restoring wooden artefacts or the electrolytic cleaning <sup>and</sup> soaking in bases ~~and soaking in~~ ~~water~~ would be harmful to a natural artefact like wood.

On the other hand a copper artefact could not be soaked in PEG as this would be harmful to a metal.

A copper artefact would also be saturated with salt when retrieved from the ocean. Instead of being soaked in PEG solution it would be soaked in and would also be very likely covered in concretions. To remove the  $\text{CaCO}_3$  concretions it could be soaked in a weak acid eg acetic acid to remove some concretions and the rest removed with hammer a chisel or dental tools. This would then be soaked in water to bath to remove the salt in the metal. Similarly to the wood artefact, the copper one, would be moved to fresh water baths regularly.

Once the salt had been removed, the copper could then be electrolytically cleaned in water of a weak base eg  $\text{Na}_2\text{CO}_3$  <sup>solution</sup>. This is where the artefact is made the cathode in an electrolytic cell and the anode is inert.

eg. at cathode  $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu(s)}$  or +0.43V

at anode  $\text{H}_2\text{O} \rightarrow \frac{1}{2}\text{O}_2 + 2\text{H}^+ + 2\text{e}^-$  -1.23V.

This removes products of corrosion and if the voltage is high enough  $\text{H}_2$  gas can be produced to further lift these products off.

The artefact would then be dried using ~~alcohol~~ ethanol and coated in a layer of wax to prevent further corrosion.

Both the techniques for restoring wooden and copper artefacts are suitable to the artefacts and aim to preserve them without causing any harm to the artefact.

You may ask for an extra Writing Booklet if you need more space.