Start here.

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bacteria would have broken down the cellulose providing support to the timber and the water inside the cells would have been replaced by salt water.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. Algae colonies would have likely also formed on the artefact as marine life lived on the artefact.

b) i) Al electrode - oxidation

\[ \text{Cl}^- (aq) \rightarrow \frac{1}{2} \text{Cl}_2 (g) + e^- \quad -1.36 \text{V} \]

or \[ \text{H}_2 \text{O} (l) \rightarrow \frac{1}{2} \text{O}_2 (g) + 2 \text{H}^+ + 2e^- \quad -1.23 \text{V} \]

Al cathode - reduction

\[ \text{K}^+ + e^- \rightarrow \text{K} (s) \quad -2.94 \text{V} \]

\[ \text{H}_2 \text{O} (l) + e^- \rightarrow \frac{1}{2} \text{H}_2 (g) + \text{OH}^- \quad -0.83 \text{V} \]

At the anode, H_2O is more likely to oxidise than Cl^- 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 due to its lower voltage requirement of 0.83 V compared to potassiums 2.94.
\[
\begin{align*}
\text{H}_2\text{O}(l) + 2\text{H}_2\text{O}(l) &\rightarrow \text{H}_2\text{O}(g) + 2\text{H}^+ + \text{H}_2(g) + 2\text{OH}^- \quad -2.08\text{V} \\
3\text{H}_2\text{O}(l) &\rightarrow \frac{3}{2}\text{O}_2(g) + 3\text{H}_2(g) + 2\text{H}_2\text{O}(g) \quad -2.08\text{V} \\
\text{H}_2\text{O}(l) &\rightarrow \frac{1}{2}\text{O}_2(g) + \text{H}_2(g) \quad -2.05\text{V}.
\end{align*}
\]

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. If it bubbles and place a lit taper in the test tube, if it bursts 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 very malleable, soft and not susceptible to corrosion. Thus, it would be used in areas where fitting for boats or there should not corrode but still require some strength.

In steel 2, a higher percentage of carbon would make it hard and strong as well as brittle. It would be used for building materials since they 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 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
They have strength.

Thus steels of different percentages carbon, manganese, silicon, nickel and chromium have very different properties and they are suited to different uses which require these properties.
d) i) To test the environmental factors that affect the rate of corrosion of iron we used the following experiments.

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 tubes we placed three identical iron nails and covered it in 5 ml of water. We then stoppered the test tubes to prevent oxygen from moving in or out. To aerate the water we used a fish tank aerator. This was left for 5 days and any changes observed each day.

![Diagram of test tubes](image.png)

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

To test the corrosion of iron in different levels of salinity we used 3 test tubes and filled one with 5 ml of distilled water, one with 5 ml of tap water and one with 5 ml of 0.05 molar 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 environment had the highest level of corrosion.

To test the corrosion of iron in different solutions of chloruring
medium acidity we used 5 dist tubes and 5 identical iron nails. In each
dist tube we placed 5 ml of a solution 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 a marine environment a surface
could be provided to prevent contact of the surface with oxygen.

(2) for wooden artefacts that have been immersed in salt water.
The cellulose which forms the cell walls has been broken down and
the water within cell replaced with salt water. To dry the artefact
and would cause it to warp or small crystals grow inside the cells.
The artefact would also become more likely to be covered in corrosion. To
remove these picks or dental tools could be used. The wooden artefact would
solution
then be soaked in polyethylene glycol (PEG) to replace the salt 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

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A further layer of PECs. These processes are effective for restoring wooden artifacts by an electrochemical cleaning and sealing. The bases would be harmful to a natural artifact like wood. On the other hand, a copper artifact could not be coated in PECs as it would be harmful to a metal.

A copper artifact would also be saltwater with salt water retrieved from the ocean. Instead of being placed in a PEC solution, it would be cleaned and would also be very likely covered in corrosion. To remove the CaCO₃ concretions, it could be soaked in muriatic acid or oxalic acid to remove some concretions and then rinsed with warm water or detergent. This would then be sealed in water to help remove the salt in the metal. Similarly, the copper artifact would be moved to fresh water, regularly.

Once the salt had been removed, the copper could then be electrolytically cleaned in an environment of a weak borate Na₂CO₃. This is where the artifact is made the cathode in an electrolytic cell and the anode is an inert, e.g., cathode: Cu (s) \rightarrow Cu (s) $$\Delta G = -1043$$kJ

on the anode: Cu + 2H₂O \rightarrow \frac{1}{2}O₂ + 2H⁺ + Cu²⁺ \Delta G = -1.23 $$kJ$$

This removes products of corrosion and if the voltage is high enough, the artifact can be produced to further lift these products off.

The artifact would then be dried by extraction ethanol and placed in a larger or more to prevent further corrosion. Both the techniques for restoring wooden and copper artifacts are available to the conservator to choose from to prevent them without causing any harm to the artifact.

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