Question 29

a) i a galvanic cell

ii $Cu^{2+} + 2e^- \rightarrow Cu_{(s)}$ 0.34V

$Fe^{2+} + 2e^- \rightarrow Fe_{(s)}$ −0.44V

$\therefore Fe_{(s)} \rightarrow Fe^{2+} + 2e^-$ 0.44V

$\therefore$ voltage required = 0.34 + 0.44

= 0.78 V

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b) Galvani applied 2 different metal wires to a frogs leg, and noticed it jump. He thought that this electricity came from the animal, it was Volta who realised that it was the different types of metal causing electrons to flow. He discovered that stacks of copper and zinc plates alternated, with brine soaked cardboard between the plates produced electricity showing it was the metals, and not the animal causing the current. Voltas pile allowed scientists to perform experiments with the electricity, and discover the principles of electron transfer which cause it to operate. Two scientists who were experts in this field were Sir Humphrey Davy and Michael Faraday. Davy performed many electrolysis experiments and developed theories on ionic compounds. Faraday gained a greater understanding of electron transfer, and compounded his laws of electrolysis.

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c) i leaching by fresh water

ii Crusty deposits of coral and calcium carbonate can be removed by soaking in acid, or from sharp taps from a hammer. Once these are removed, electrolysis is a key procedure in restoring artefacts. It can be used to remove chloride salts, convert corroded iron back to metal and clean silver. Underwater, silver is often corroded to silver sulphide Ag_2S. This protects the metal underneath, but if manually removed, will sacrifice details on the silverware (often coins) Thus electrolysis is used converting Ag_2S.

~~$Ag_2S \rightarrow 2Ag + S^{2-}$~~ $Ag_2S + 2e^- \rightarrow 2Ag + S^{2-}$

restoring the silver without sacrificing the details of the coin. It can then be coated in a clear laquer to protect it from furthur corrosion.

d) i Iron nails were placed in test tubes containing various solutions - tap water, distilled water, weak acid and left open to the air for 3 days. The amounts of rust on the nails was then compared.

ii In the experiment, the nail in the weak solution of acid did corrode more than the others. This is because the hydrogen ions in solution of the acid ~~aid~~ increase the conductivity of the water. With the electron transfer reaction, ions migrate to conserve charge. The extra conductivity allowed this migration to happen faster, thus the acidic solution caused faster corrosion. The tap water, being slightly more acidic than the distilled variety also ~~corroded a little more than~~ had a faster corrosion rate of its nail than the distilled water. The increased corrosion of the nail in the acidic solution supports the hypothesis that acid environments accelerate corrosion of shipwrecks.

e) At great depths, the ocean is very cold, and under high pressures. The low temperature should slow the rate of reactions, thus slowing the corrosion process down. However, low temperatures also make gases more soluble. This could mean more oxygen dissolved in the water, oxygen being an essential component of corrosion of iron, but, due to the demands of ocean life for oxygen, there is actually very little oxygen at great depths. There are bacteria that don't require oxygen though, and these anaerobic bacteria can produce sulphides and CO_2 that react with metals, as well as eating away at some metals themselves.

This combination of factors means that corrosion at great depths occurs faster than might be expected. Even though there is little oxygen and the low temperature slows down the rate of reactions, anaerobic bacteria produce sulphides that react with metals such as silver and CO_2 that can form solid calcium carbonate crusts on objects. These

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factors speed corrosion of metals, even ~~at~~ in the deep ocean.