

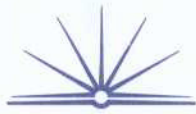


29 (a) (i) Steel (~~iron with carbon~~) Iron (steel \rightarrow with carbon)

(ii) Aluminium is a passivating metal. This means that as the aluminium oxidises, it forms an impermeable ~~the~~ non-porous layer of Al_2O_3 (oxide). This prevents further corrosion and thus aluminium can be exposed to oxidising conditions without risk of huge corrosion.

(b) (i) Magnesium

(ii) Sacrificial anodes are more reactive and ~~make~~ the hull of the ship the cathode, ~~and~~ so only reduction happens ~~at the~~ on the hull of the ship. Thus any newly created Fe^{3+} ~~at~~ is reduced back to $\text{Fe}_{(s)}$ again. This protects the ship from corrosion but blocks of anode for protection need to be replaced often and also put in regular places as they protect a small area only. A galvanic cell is essentially created, opposing the natural cell of rusting.



(c) Adding other elements to iron can ~~be~~ be both beneficial and detrimental. Carbon added to iron can help make the iron structurally stronger, but aids corrosion, as the oxidation of Fe can take place near the carbon impurity.

If a metal such as Chromium is added, the resistance to corrosion is much stronger and the metal is stronger as well.

The addition of other metals can lead to ~~the~~ more corrosion resistance, but more brittle ~~compounds~~ compounds. The opposite can also happen. Compounds can also change properties such as malleability.

The addition of more ^{diverse/} expensive elements ~~usually~~ generally leads to ~~both~~ improvement in both qualities, but in ^{common/} cheaper elements, ~~it also creates a problem~~ ^{problems are also created.} Pure iron is too soft ~~and~~ however, ^{it} corrodes very slowly.

The addition of different elements can be done based on the conditions to which it is to be exposed. If structural integrity is needed but is not in a corrosive environment, ~~the~~ an additive such as carbon can be added, however if it is an object near the sea, such as a street sign, ~~other~~ something such as Chromium might be needed.



(d) (i) Corrosion - the oxidation of a metal to produce other complex ~~metallic~~ compounds (such as oxide).

(ii) ~~Method~~

A Set of conditions ~~are~~ ^{is} set out to ensure ^{constant} environments. ^A Controls ~~are~~ also used. ~~Some variables include amount of~~ Variables need to be controlled. Test tubes are used and the same amount of different metals (cleaned) are put in ^{separate} test tubes. ~~are~~ monitored for corrosion over a period of time.

(iii) - Controlling all variables, inc: O_2 , H_2O , heat/cold, light, closed environment, ~~the~~ surface area of metals, oxidation of metals, same type of water, size ^{of} test tube, amounts of different variables, etc.

- Conduct several different ~~sets~~ sets of environments to ascertain complete / conclusive results.

- Make sure controls are monitored also for discrepancies \rightarrow could indicate problems with prac.

- Several groups doing same conditions, so similarities and differences can be recorded and analysed.



(c) For silver:

Silver coins, such as those found on Dutch ~~ships~~ sailing ships have been found to be encrusted with CaCO_3 (limestone deposits) and also oxidised (Ag_2S).

The first procedure is the removal of the carbonate deposits.

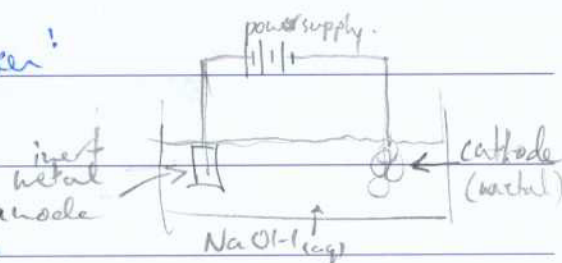
This involves soaking in dilute acid (usually sulfuric acid)

to dissolve deposits. $\text{H}_2\text{SO}_4(\text{aq}) + \text{CaCO}_3(\text{s}) \rightarrow \text{CaSO}_4(\text{aq}) + \text{H}_2\text{CO}_3(\text{aq})$

Thus the carbonate is soluble and is removed from the surface of the metal.

The metal is then electrolysed to reduce silver ions (Ag^+) back to solid silver. This means that the original cuttings of the coin can be saved, whereas just polishing the Ag_2S would wear away the silver. The electrolysis places the metal at the cathode and an inert electrode as the anode, in a NaOH solution:

This gives eqn:



For heavily encrusted ~~metal~~ silver objects, the electrolyte may need changing one or more times to ensure ^{that} a constant ^{flow} of electrons is possible and



thus electrolysis is completely conducted.

After this, the ^{silver} ~~metal~~ should be back, ~~the~~ close to its original state. This means that the wires can be rinsed ~~and~~ with distilled water, ready for preservation.

The silver ~~is~~ is usually ~~protected with~~ sometimes coated with a thin wax, but ~~so~~ this is usually not necessary. The metal is usually kept in a sealed off container with a constant air supply. This air needs to be ~~for~~ free from lots of ~~assumed~~ H_2O ~~exposure~~, but the air must not contain any sulfides at all. ~~the~~ Even small amounts of S^{2-} in the air can lead to re-oxidation of the metal.

(As the $Ag^+ + e^- \rightarrow Ag$ $E_{eq} = 0.80V$, ~~the~~ the $Ag \rightarrow Ag^+ + e^-$ does not readily occur, and so re-oxidation is not much of a problem ~~is~~. As such, H_2O in the air is not a large problem).