

Forms of Corrosion

① General (Uniform): with uniform corrosion, anodic dissolution is uniformly distributed over the entire metallic surface. The corrosion rate is nearly constant at all locations. Microscopic anodes and cathodes are continuously changing their electrochemical behaviour from anode to cathode cells for uniform attack. Uniform

② Galvanic corrosion: corrosion leads the higher destruction of metals, particularly steels. But, it is relatively easy to control by (i) Protective coatings (ii) inhibitors and (iii) Cathodic Protection.

② Galvanic corrosion: Galvanic corrosion (dissimilar metals) occurs when two electrochemically dissimilar metals are

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Connected and exposed to a corrosive environment. The less noble metal (anode) suffers accelerated attack and the more noble metal (cathode) is cathodically protected by the galvanic current. Electrochemical series does not account for the corrosion of all metals and alloys.

Consequently, a more practical series, called galvanic series have been prepared by studying the corrosion of metals and alloys in a given environment like sea-water. Galvanic series give real and useful information for studying the corrosion of metals and alloys.

A galvanic corrosion cell occurs when copper lines are connected to galvanized steel. In this example, the soil is electrolyte, the copper line is the cathode, and the water main is the anode.

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Concentration cell corrosion : concentration cell

corrosion occurs because of differences in the environment surrounding the metal. This form of corrosion is referred to as "crevice corrosion", "gasket corrosion", and "deposit corrosion"

because it commonly occurs in localized areas where small volumes stagnant solution exist. The most common concentration cells are the "oxygen" and "metal ion" cells.

Areas on a surface in contact with an electrolyte having a high oxygen concentration generally will be cathodic relative to those areas where less oxygen is present (oxygen cell). Areas on surface where the electrolyte contains an appreciable

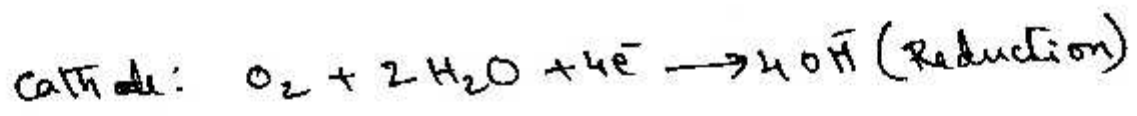
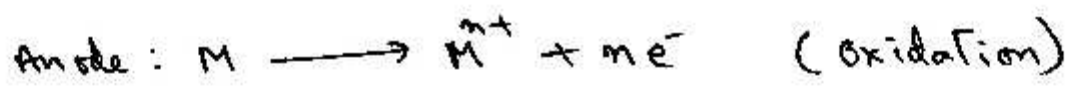
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quantity of the metal's ions will be cathodic compared to locations where the metal ion concentration is lower (metal ion cell).

Pitting Corrosion : Pitting corrosion is a randomly occurring, highly localized form of attack on a metal surface. It is one of the most destructive forms of corrosion. Steel and galvanized steel pipes and storage tanks are susceptible to pitting corrosion when exposed to saline environments.

When a small dust particle gets deposited on a steel surface, the region below the dust particle is exposed to less oxygen compared to the remaining part. As a result, the region below the dust particle acts as anode and undergoes corrosion and forms a pit. The remaining region of metal acts as cathode and is unaffected.

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Formation of a small anodic area and large cathodic area results in intense corrosion below the dust particle.

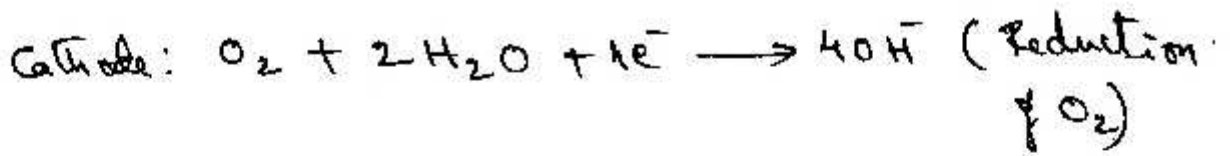
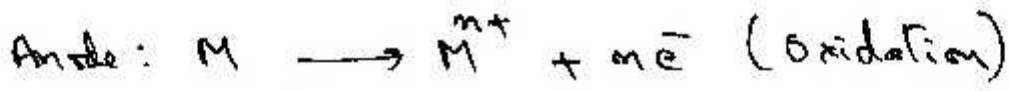


Differential metal corrosion

Differential metal corrosion occurs when two dissimilar metals are in contact with each other and are exposed to corrosive environment. The two metals differ in their electrode potentials. The metal with lower electrode potential acts as anode and the other metal with higher electrode potential acts as cathode. A galvanic cell develops between the two metals. The anionic metal undergoes oxidation and

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gets corroded.

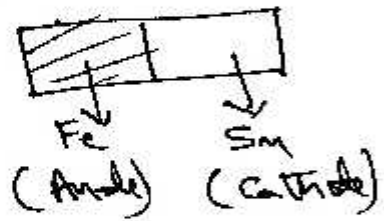
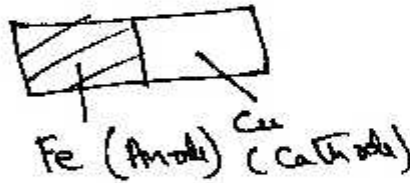
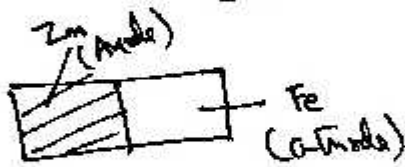


Higher the potential difference between the anodic and cathodic metals, higher is the rate of corrosion.

E.g. steel screws in copper sheet

steel screws with copper washer

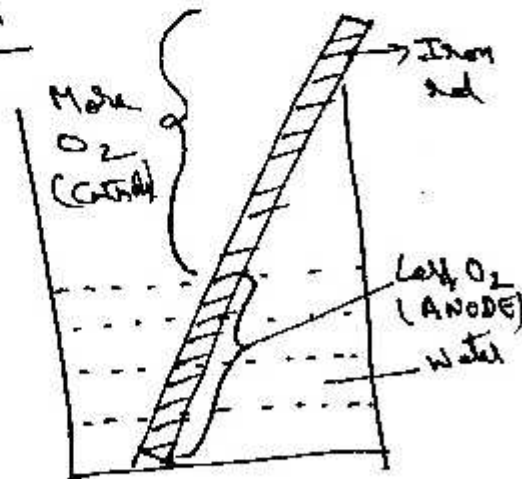
Bolt and nut made up of different metals.



Differential aeration corrosion

When two different areas of the same metal are exposed to different oxygen concentrations, differential aeration corrosion occurs.

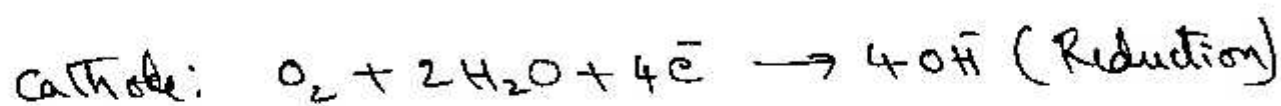
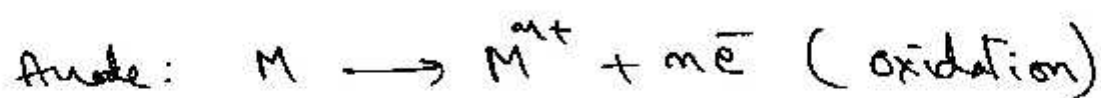
E.g. An iron rod partially dipped in water. The part of the metal exposed to less oxygen concentration acts as anode.



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The Part which is exposed to more oxygen concⁿ. acts as Cathode. The anodic region undergoes corrosion and the Cathodic region is unaffected.

Cell reactions:



Example: \rightarrow Partially filled iron tank undergoes

corrosion inside water

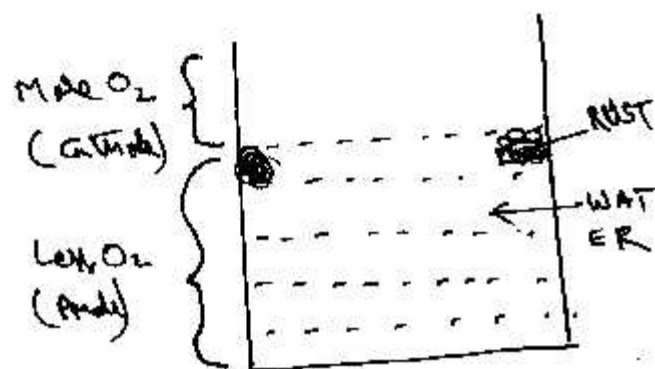
\rightarrow Part of the nail inside the wall undergoes corrosion

\rightarrow when a dirt ~~is~~ particle sits on a metal bed, the part under the dirt undergoes the corrosion.

Water - line Corrosion (An example of differential

aeration corrosion)

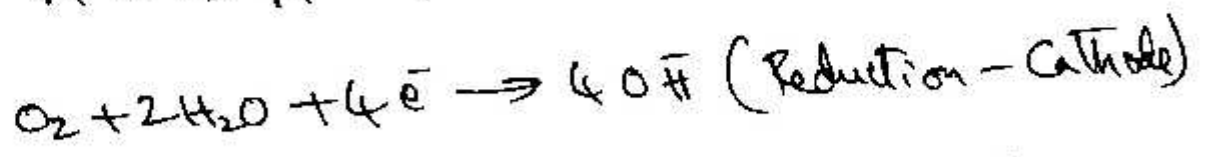
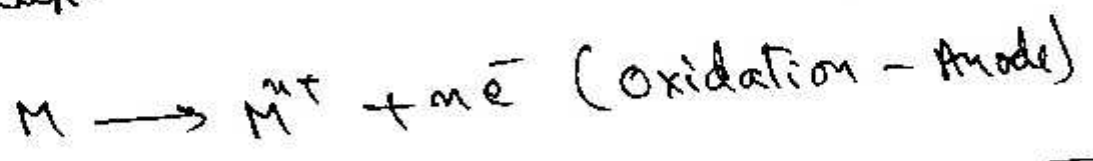
when a steel tank is partially filled with water for a long time, the



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immersed portion of the tank below the water line is exposed only to dissolved oxygen, whereas, the ~~portion~~ portion above the water line is exposed to more oxygen. Thus the portion below the water line acts as anode and undergoes corrosion.

The upper portion acts as cathode and is unaffected. A distinct brown line is formed just below the water line due to the deposition of rust.



Ships which remain partially immersed in sea water for a long time undergo water-line corrosion.

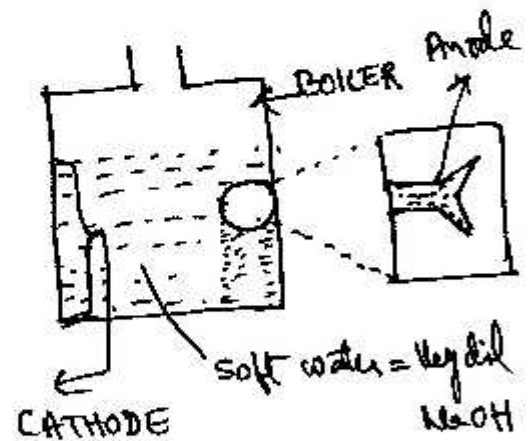
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Stress Corrosion

Stress corrosion can occur when alloys are subjected to static, surface tensile stresses and are exposed to certain corrosive environments. Cracks are initiated and propagated by the combined effect of a surface tensile stress and the environment.

The portion which is under stress, acts as anode and the rest part acts as Cathode.

It is now a galvanic system and hence anodic part which is small in area will corrode



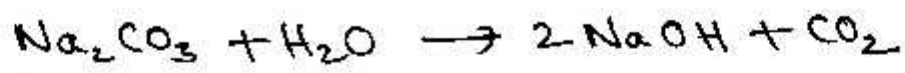
more.

Example: Caustic embrittlement in Boilers.

This is caused by using highly alkaline water in the boiler, mostly in high pressure boiler. During lime-soda process, free Na_2CO_3 is usually present in small proportion in the softened

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water. Na_2CO_3 in high pressure boilers decomposes to give NaOH and CO_2 . This makes boiler ^{water} caustic.



It causes embrittlement of boiler parts like bends, joints etc.

The water containing NaOH flows into the minute hair-cracks ⁱⁿ the inner wall of the boiler, by capillary action. Here, water evaporates and the $[\text{NaOH}]$ increases progressively. When the concentration of NaOH increases to 10%, caustic soda attacks the ~~water~~ surrounding areas, thereby dissolving iron of boiler wall as sodium-ferrate. This causes embrittlement of boiler wall at stressed parts like bends, joints etc.

$$3\text{Na}_2\text{FeO}_4 + 3\text{H}_2\text{O} \rightarrow \text{Fe}_3\text{O}_4 + \text{H}_2 + 6\text{NaOH}$$

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Addition of Na_2SO_4 and phosphates to boiler water prevents caustic cracking.

Erosion Corrosion: ~~Erosion~~ Erosion corrosion refers to the repetitive formation and destruction of the metal's protective surface film. This typically occurs in a moving liquid. Erosion may be impinging or sliding (pipe wall) when it occurs. An example is the erosion corrosion of copper water tubes in a hot, high velocity, soft water environment. Cavitation is a special form of erosion corrosion.

Intergranular corrosion: Intergranular corrosion is a localized condition that occurs at, or in narrow zones immediately adjacent to, the grain boundaries of an alloy. Welding,

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Stress relief annealing, improper heat treating, or overheating in service generally establish the microscopic, compositional inhomogeneities that make a material susceptible to intergranular corrosion.