Example 10

Determine the corrosion rate of carbon steel in salt solution from the following laboratory data. Consider the corrosion rate by a)mpy , b)mdd. C) Calculate the current density in µA/cm^2

Δ W (g)	0.0153	0.0290	0.0409	0.055	0.0685
T (h)	48	96	144	192	240

Given: K=3.45*10^6, ρ for carbon steel= 7.86 gm/cm^3, area = 24.96 cm^2, n=2 and atomic mass = 55.8 g/mole.

$$mpy = \frac{K}{A_s\ \rho} * \frac{\Delta\, w}{t}$$

Mpy = corrosion rate
K = constant
A$_s$= surface area cm^2
ρ = density Δw= weight loss (g)
T: time hr

Double layer theory

When a metal is immersed in an electrolyte, a dynamic equilibrium is established across the interface with a potential difference between the metal and electrolyte. The atoms of the metal, M, ionize producing aquo-ions, Mn+(ag), and electrons, ne, according to:

$$\mathrm{M} = \mathrm{M}^{n+}(aq) + ne$$

Where M represents metal atoms. The metal is left with a negative charge and its positively charged metal ions, Mn+(aq), in the electrolyte are attracted back towards the metal surface. Thus, a potential difference and dynamic equilibrium between the metal and the solution is established. The atoms of the metal continue to ionize until the displacement of electrical charges produced balances the tendency of the metallic atoms to ionize into the electrolyte.

Consider, for example, a piece of zinc metal in water. Zinc dissolves producing positively charged zinc ions (cations):

$$\mathrm{Zn} \rightarrow \mathrm{Zn}^{2+} + 2e$$

The zinc ions in the solution remain very close to the metal surface. The zinc metal becomes negatively charged as the positive ions leave its surface. The excess electrons on the zinc surface orient themselves opposite to a layer of zinc ions of equal and opposite charge on the water side of the zinc/water interface. Such a process leads to the formation of an electrical double layer of about 1 nm (10^{-7} cm) thickness along the metal/solution interface (Fig. 2.9). Figure 2.9A shows the metal/solution interface at the moment of immersion and the formation of double layer is shown in Figs 2.9B and C. The double layer shown in Figs 2.9B and C is formed as a result of attraction between the negative ions (anions) and positive ions (cations) on one hand, and repulsion between similarly charged ion, anions or cations on the other hand.

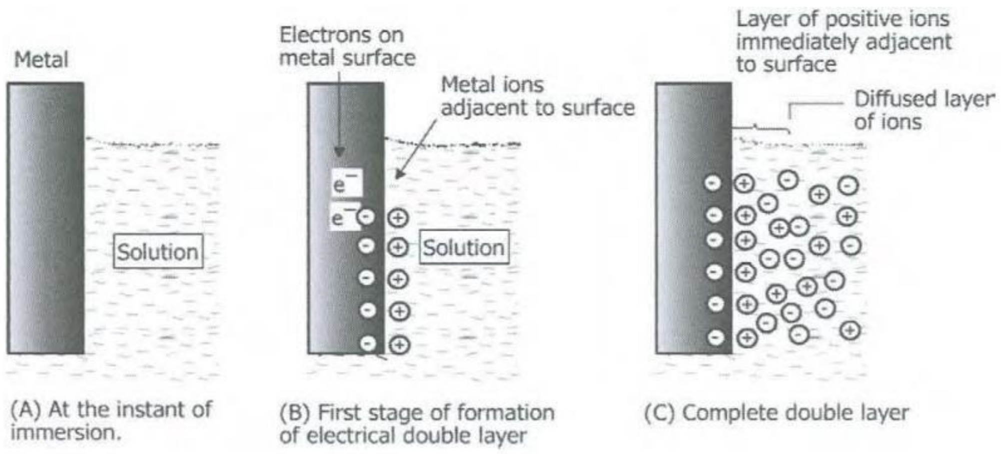

Figure 2.9 Representation of electrical double layer at a metal/solution interface

As a result of the above interactions, cations diffuse amongst the anions until an equilibrium is established between the metal and solution, and between the bulk of the solution and the layer adjacent to the metal surface. The plane passing through the ions absorbed on the metal surface is called the ***Inner Helmholtz plane***, whereas the plane passing through the center of solvated cation is called the ***Outer Helmholtz plane***, which also marks the beginning of a diffuse layer when an excess of charges is neutralized (Fig. 2.9C).

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