

**Exam of corrosion**

**Exercise 1** (9 pts)

- Define the following terms:  
Corrosion - Uniform corrosion - Pitting corrosion - Galvanic corrosion - Hydrogen corrosion.
- Mention five factors that affect corrosion.
- Mention the types of corrosion, then explain one of these types in two or three lines.
- Mention four forms of corrosion, other than those mentioned previously.
- Define a corrosion inhibitor.
- Mention the methods of corrosion protection.
- The H<sub>2</sub>O molecule is amphiprotic, meaning it can act as both an acid and a base. As an acid, it can donate a proton (H<sup>+</sup>), and as a base, it can accept a proton. Draw the Pourbaix diagram for water, defined by the boundary lines corresponding to the O<sub>2</sub>/H<sub>2</sub>O and H<sup>+</sup>/H<sub>2</sub> redox couples.

Given:  $E_{H^+/H_2}^\circ = 0 \text{ V/ENH}$  and  $E_{O_2/H_2O}^\circ = 1.23 \text{ V/ENH}$

**Exercise 2** (9 pts)

Consider the species Mn(s), Mn<sup>2+</sup>, Mn<sup>3+</sup>, Mn(OH)<sub>2</sub>(s), and Mn(OH)<sub>3</sub>(s) with an ion concentration  $C_0 = 0,01 \text{ mol/L}$ . The constants and standard potentials are as follows:

$$K_s(Mn(OH)_2) = 2 \cdot 10^{-13}$$

$$K_s(Mn(OH)_3) = 2 \cdot 10^{-36}$$

$$E_{Mn^{2+}/Mn}^\circ = -1.18 \text{ V/ENH}$$

$$E_{Mn^{3+}/Mn^{2+}}^\circ = +1.51 \text{ V/ENH}$$

1. Calculate the oxidation number of Mn in the given species.
2. Calculate the pH at which Mn<sup>2+</sup> precipitates as Mn(OH)<sub>2</sub>.
3. Calculate the pH at which Mn<sup>3+</sup> precipitates as Mn(OH)<sub>3</sub>.
4. Write the equations corresponding to each boundary between the species.
5. Annotate the E-pH diagram.

# Corrosion

M<sup>o</sup> = 9 pts

## Corrosion:

(91)

Natural phenomena that affects metals or alloys resulting in deterioration of their properties.

\* Uniform corrosion (92)  
it is a general attack and it occurs on the all surface metal, because of this the surface looks mottled.

\* Pitting corrosion (93)  
It is localized corrosion, its occurs in specific areas due to the presence of small defects in the surface.

\* Galvanic corrosion (94)  
It arises when two dissimilar metals are in electrical contact.

\* Hydrogen corrosion, is the deterioration of structural properties, it

occurs in the presence of H<sub>2</sub> leading to degradation of mechanical properties.

(2) Factor that affect rate of corrosion - (95)  
Environmental - Humidity, T<sup>o</sup>, pH, pollution.

- Material property
- Corrosion type
- Electrochemical process (conductivity)
- Microbial activity

(3) Types of corrosion  
chemical, electrochemical, biologic (96)

Definition of the (97)

- (1) four forms of corrosion: stress corrosion, crevice corrosion, Intergranular, filiform, Fretting (98)
- Erosion corrosion (99)
- selective

$$pH = 14 + \log [OH^-]$$



$$K_{s2} = [Mn^{3+}] [OH^-]^3$$

$$[OH^-] = \sqrt[3]{\frac{K_{s2}}{[Mn^{3+}]}} = \sqrt[3]{\frac{2 \cdot 10^{-26}}{0,01}}$$

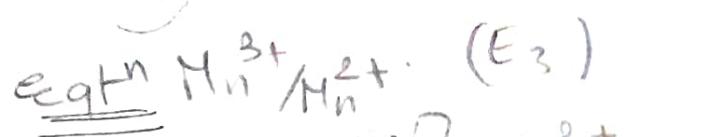
$$[OH^-] = 5,848 \cdot 10^{-10} \text{ mol/l}$$

$$\Rightarrow [H_3O^+] = \frac{K_w}{[OH^-]}$$

$$[H_3O^+] = \frac{10^{-14}}{5,848 \cdot 10^{-10}}$$

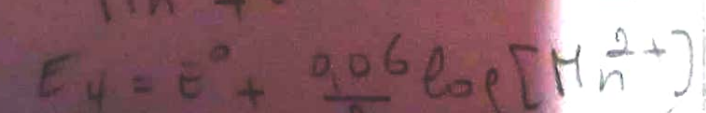
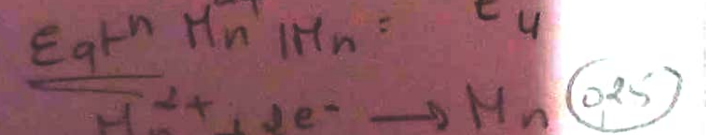
$$[H_3O^+] = 1,709 \cdot 10^{-5} \text{ mol/l}$$

$$pH = 2,76$$



$$E_3 = E_3^0 + 0,06 \log \frac{[Mn^{3+}]}{[Mn^{2+}]}$$

$$E_3 = 1,51 \text{ V/ENH}$$



$$E_4 = E_4^0 + \frac{0,06}{2} \log [Mn^{2+}]$$

$$E_4 = -1,18 + 0,03 \log(0,01)$$

$$E_4 = -1,24 \text{ V/ENH}$$



$$E_5 = E_5^0 + \frac{0,06}{1} \log \frac{[H^+]^3}{[Mn^{2+}]}$$

$$E_5 = E_5^0 + 0,06 \log [H^+] - 0,06 \log [Mn^{2+}]$$

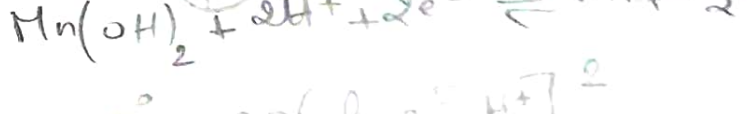
$$E_5^0 = 0,18 \text{ pH} + 1,88 \text{ V/ENH}$$

boundary 3 and 5 at pH = 2,76

We have  $E_3 = E_5$

$$So: 1,51 = E_5^0 - 0,18 \text{ pH} + 1,88$$

$$E_5^0 = 1,51 + 0,18 \text{ pH} - 1,88 = 1,88$$



$$E_6 = E_6^0 + \frac{0,06}{2} \log [H^+]^2$$

$$E_6 = E_6^0 - 0,06 \text{ pH}$$

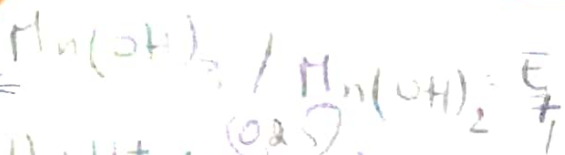
$$At \text{ pH} = 2,76 \Rightarrow E_4 = E_6$$

$$\Rightarrow -1,24 = E_6^0 - 0,06 \text{ pH}$$

$$\Rightarrow E_6^0 = -1,24 + 0,52$$

$$E_6^0 = -0,72 \text{ V/ENH}$$

$$(3) \Rightarrow E_6 = -0,72 - 0,06 \text{ pH}$$



$$E_f = E_f^\circ + 0,06 [\text{H}^+] \\ = E_f^\circ - 0,06 \text{pH}$$

$$\text{at pH} = 8,65 \quad E_f = E_f^\circ \quad (\text{OR})$$

$$1,88 - 0,06 \text{pH} = E_f^\circ - 0,06 \text{pH}$$

$$\therefore E_f^\circ = 0,842 \text{ V/ENH}$$

$$\therefore E_f = 0,842 - 0,06 \text{pH} \quad (\text{OR})$$

1 pt 5

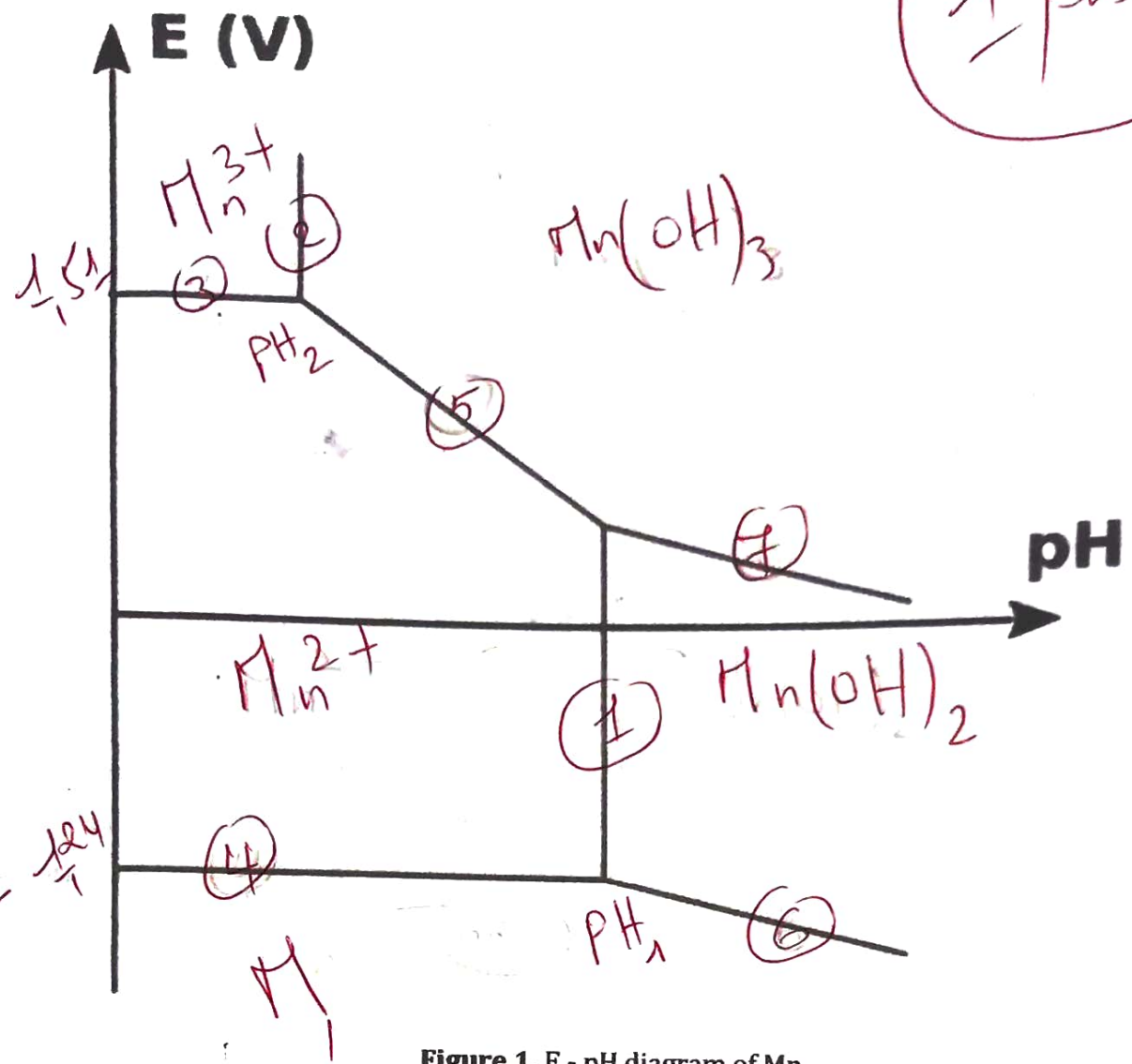


Figure 1. E - pH diagram of Mn