EGN 3365
Review on Corrosion

Expectations on Chapter 17

❑Chapter 17

- Understand corrosion reaction for metal is electrochemical in nature and the oxidation or anodic half-cell reaction involves metal giving out electrons and getting oxidized and the reduction or cathodic half-cell reaction involves another species (e.g., proton, oxygen gas, other cations, etc.) receiving electron and getting reduced.
- Be able to describe physical meaning of standard electrode potential and understand galvanic series.
- Be able to use standard electrode potential for different electrode half-cell reactions to determine the appropriate electrochemical reaction. Be able to write the basic anodic (oxidation) and cathodic (reduction) half cell reactions and the overall reaction and calculate the total cell voltage
- Understand passivation for metals involves formation of corrosion product that are often dense and insoluble that prevents further corrosion from happening
- Understand the common corrosion protection techniques such as choosing the different materials, cathodic protection, protective coating, adding corrosion inhibitors.

Expectations on Chapter 17

Chapter 17 (continued)

- Understand the oxidation of metals and Ellinghma diagram. Be able to use Ellingham diagram to determine the equilibrium partial pressure of oxygen for different metals, and, for a given condition (certain temperature) be able to determine if a metal will oxidize at a given oxygen partial pressure pO_2.
- Understand the degradation for polymers include physical degradation such as dissolution and bond rupturing.

Class Exercise

Knowing standard electrode potential E^o for the following electrode reactions are: $Cu^{2+} + 2e^- = Cu$, $E^o(Cu/Cu^{2+}) = 0.340$ V;

In addition, for $O_2 + 4H^+ + 4e^- = 2H_2O$, $E^o(H_2O/O_2) = 1.229$ V, and for $2H^+ + 2e- = H_2$, $E^o(H_2/H^+) = 0.000$ V

Determine, when copper metal is immersed in acidic aqueous solution <u>without</u> dissolved oxygen, corrosion will happen or not? What if the acidic aqueous solution contains significant dissolved oxygen, will copper corrode? Explain your answer and write reactions, if applicable

Copper standard electrode potential E^o (Cu/Cu^{2+})=0.34V, which is more positive than $E^o(H_2/H^+) = 0.000$ V, corrosion of Cu in acidic solution without oxygen will NOT happen. E^o (Cu/Cu^{2+})=0.34V is more negative than $E^o(O_2/H_2O) = 1.229$ V, therefore, oxidation (anodic) reaction happens for Cu/Cu^{2+} half cell (pair) while reduction (cathodic) reaction happens for oxygen reduction.

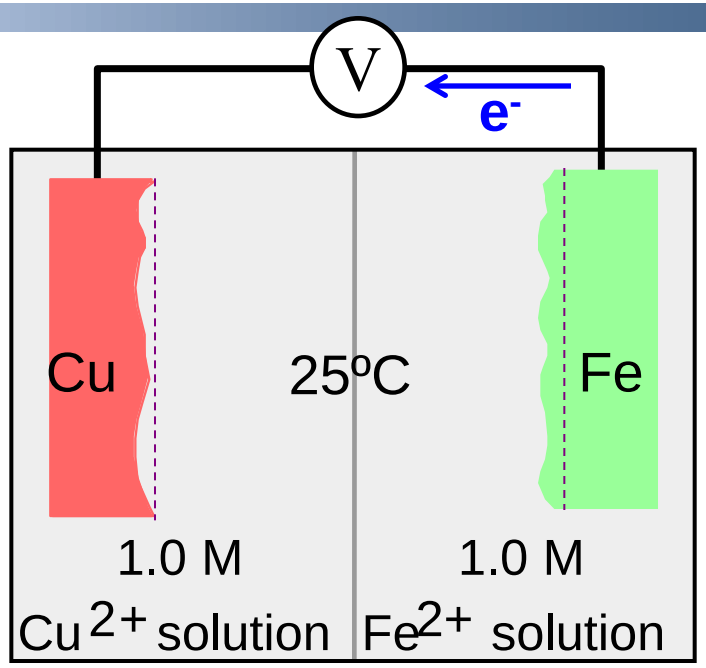
Anodic/oxidation half cell reaction: $Cu \rightarrow Cu^{2+} + 2e^-$

Cathodic/reduction half cell reaction: $O_2 + 4H^+ + 4e^- = 2H_2O$

Overall reaction: $2Cu + 4H^+ + O_2 = 2Cu^{2+} + 2H_2O$

Class Exercise

For an electrochemical cell connecting Cu/Cu^{2+} (1 M, $E^o(Cu/Cu^{2+})$=0.34V) electrode with Fe/Fe^{2+} (1 M, $E^o(Fe/Fe^{2+})$=-0.44V) electrode through a membrane



Q1: ***On which electrode does oxidation reaction and reduction reaction happen, respectively? Write half cell and overall reactions and mark the direction of electron flow on the schematic***

$E^o(Fe/Fe^{2+})$= -0.440V, which is more negative than $E^o(Cu/Cu^{2+})$= +0.340V, therefore, Fe oxidizes

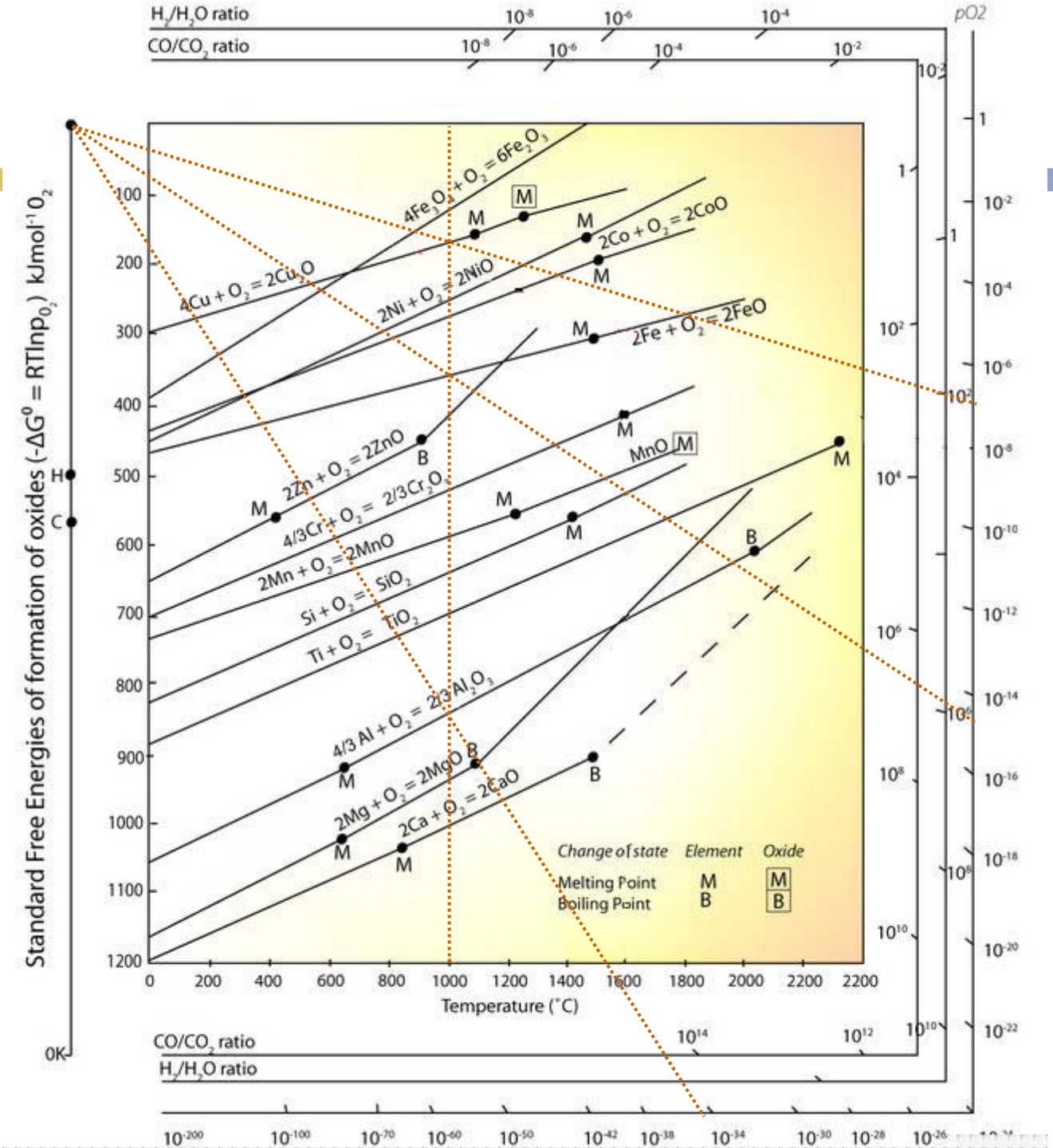
Fe/Fe^{2+} electrode: anodic/oxidation half cell reaction: $Fe \rightarrow Fe^{2+}+2e^-$

Cu/Cu^{2+} electrode: cathodic/reduction half cell reaction: $Cu^{2+}+2e^- \rightarrow Cu$

Overall reaction: $Fe + Cu^{2+} \rightarrow Fe^{2+} + Cu$

Q2 Determine the standard potential for such a cell under equilibrium?

$E_{cell} = E_{cat} – E_{an} = E^o(Cu/Cu^{2+}) - E^o(Fe/Fe^{2+}) =$ 0.340V – (-0.440V) =0.780V



Determine, at 1000 ^{o}C in gas atmosphere with pO_2 of 10^{-12} atm, if Cu and Fe will oxidize thermodynamically

For Cu

pO_2^{eq} (Cu/CuO)~10^{-7}

$pO_2 = 10^{-12} << pO_2^{eq}$

Cu will NOT oxidize

For Fe

pO_2^{eq} (Fe/FeO)~10^{-14}

$pO_2 = 10^{-12} >> pO_2^{eq}$

Fe will oxidize

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