

**M.E. Metallurgical and Material Engineering - First Year - Second Semester 2019****SUBJECT: Environmental Degradation of Materials**

Time: Three Hours

Full marks 100

Answer any five questions, all question carry equal marks

1 Draw a proper polarization diagram to explain how corrosion rate of steel in aqueous environment is dependent on activation and concentration polarization. Explain why activation and concentration polarization occur. Write an equation containing all thermodynamic and kinetic parameters influencing  $E_{corr}$  and  $I_{corr}$ . Explain exchange current density and limiting current density. How to determine corrosion rate by linear polarization method.

20

2. Distinguish between the followings

a. Crevice corrosion and pitting corrosion b Intergranular Corrosion and Weld decay c. EMF series and Galvanic series d. Erosion corrosion and cavitation damage

7+5+3+5

3.Explain the phenomena occurring at metal-electrolyte interface with diagram indicating outer - Helmholtz plane, inner Helmholtz plane, charge separation, occurrence of double layer capacitance and contact adsorption. Draw Randle circuit. In the study of electrochemical impedance spectroscopy, how Nyquist and Bode plots are plotted. Explain how the polarization resistance and capacitance of the randle circuit can be estimated from these plots. What is Warburge impedance? When does it occur?

6+2+4+4+2+2

4a. Discuss why and how metallic structures under tensile stress, well below yield stress, may crack in presence of corrosive environment. What is the source of stress. Can diffusion of Hydrogen into the metal induce stress and cause failure? Give a comparative explanation of Hydrogen induced cracking, Hydrogen blistering and hydrogen embrittlement.

12

4.b. Explain the testing of SCC by Linear Elastic fracture mechanics. How sample geometry is related to  $K_{I}$  (fracture toughness).

8

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5a. Explain the principle of cathodic protection by drawing a polarization diagram for aqueous corrosion of steel. How to find out required potential and current to be applied ? What happens if excess potential is applied ? Draw PSP ( pipe to soil potential) vs distance curve for an underground pipe line before and after cathodic protection. What changes to the curve will occur for a stay current effect? Write down the steps that will follow for sacrificial cathodic protection of a hull of a ship with fixed holidays

10

5.b Explain how an inhibitor functions to decrease corrosion rate. Explain with diagrams anodic , cathodic and mixed inhibitors. Why a scavenger does not work in mitigating acid corrosion of steel ? Why inhibitor works best at PZC. State which type of organic compound form good inhibitor. Name right inhibitors for the following  
i. Automobile engine coolant ii. Sulphuric acid pickling tank iii. Oil refinery

10

6 a Discuss how atmospheric corrosion is influenced by relative humidity, pollutants, temperature and wind flow.

7

6 b. What is microbial corrosion ? Explain Why presence of aerobic and anaerobic micro organisms accelerate material degradation.

7

6c Explain the functions of various constituents of organic paint. Name 2 organic paints for mast of a ship and hull of a ship

4+2

7.Explain the followings

5X4

a. Anodic Protection and Anodizing b. E-Ph diagram c. Compare corrosion rates of steel pile embedded in sea bed and some portion over water surface with polarization diagram. d Deposition of dust ( Carbon soot) on steel structure accelerate atmospheric corrosion of steel., a coat of red primer (alkyd based paint) reduces the corrosion rate