Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UPES

End Semester Examination, May 2024

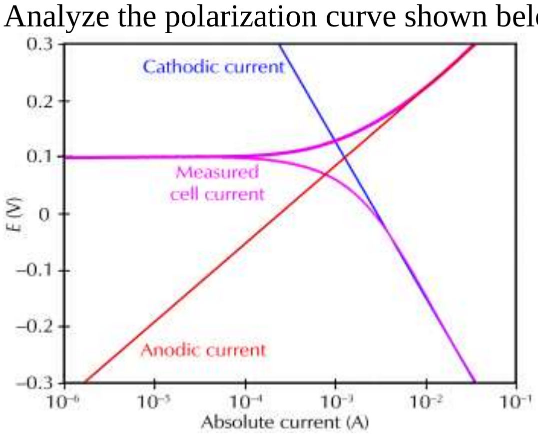
Course: Environmental Degradation of Materials **Semester: VI**
Program: B.Tech AM&NT **Time : 03 hrs.**
Course Code: MEMA 3010 **Max. Marks: 100**

Instructions: ***Instructions: All questions are compulsory. The question paper consists of 11 questions divided into 3 sections A, B and C. Section A comprises 5 questions of 4 marks each, Section B comprises 4 questions of 10 marks each and Section C comprises 2 questions of 20 marks each.***

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Discuss (a) Fretting Corrosion (b) Fatigue Corrosion	**4**	**CO1**
Q 2	Discuss Ist and 2nd Gibb's Duhem Equation and explain its importance.	**4**	**CO1**
Q 3	Explain Tafel's theory of hydrogen overvoltage.	**4**	**CO1**
Q 4	Explain concentration polarization.	**4**	**CO1**
Q 5	Compute the corrosion penetration rate, in mpy, for iron corrosion in HCI (to form Fe^{2+} ions) if the corrosion current density is 8 x 10^{-5} A/cm^2. For iron A = 55.85 g/mol and ρ=7.9 g/cm^3.	**4**	**CO2**

SECTION B
(4Qx10M= 40 Marks)

Q 6	Ni corroded in deaerated water with P_H = 8 and K_{sp} (Solubility product) = 1.6 x 10^{-16}. Ni → Ni $(OH)_2$ and $E^o_{Ni^{+2}/Ni}$ = -0.25 V. Analyze the feasibility of the reaction.	**10**	**CO3**
Q 7	Analyze the polarization curve shown below:  	**10**	**CO3**

Q 8	The limiting current density i_L, associated with concentration polarization is given by: $i_l = DnF\frac{C}{\delta}$ (i)State what each of the parameters in the above equation means. (ii) Derive the above equation using Fick's first and Faraday's laws. State clearly any assumptions you make	**10**	**CO2**
Q 9	Calculate the corrosion rate for AISI 316 alloy using the table given below: ($i = 1\ \mu A/cm^2$)	**10**	**CO3**

Elements	Wt%	N (electrons)	Density (gm/cm^3)	Molecular Weight
Cr	18	1	8.9	52.01
Ni	8	2	10.2	58.68
Mo	3	1	95.95	95.95
fe	70	2	55.85	55.85

SECTION-C
(2Qx20M=40 Marks)

Q 10	Construct a pourbaix diagram using the following reactions: (1) $Ni^{+2} + 2e \rightarrow \mathrm{Ni}$ (2) $Ni + H_2O \rightarrow \mathrm{NiO} + 2H^+ + 2e$ or $NiO + 2H^+ + 2e \rightarrow \mathrm{Ni} + H_2O$ (3) $Ni^{+2} + 2H_2O \rightarrow \mathrm{Ni(OH)_2} + 2H^+$ (4) $NiO + H_2O \rightarrow \mathrm{Ni(OH)_2}$ (5) $H^+ + e \rightarrow 0.5\ H_2$ (6) $O_2 + 4H^+ + 4e \rightarrow 2H_2O$ (7) $2H_2O + 2e \rightarrow 2\mathrm{(OH)}^- + H_2$ Thermodynamic data:	**20**	**CO3**

$\mu^o_{Ni} = 0$	$\mu^o_{H_2} = 0$
$\mu^o_{Ni^{+2}} = -46398\ J/mol$	$\mu^o_{O_2} = 0$
$\mu^o_{Nio} = -215729.8\ J/mol$	$\mu^o_{H_2O} = -235964.2\ J/mol$
$\mu^o_{Ni(OH)_2} = -452690\ J/mol$	$\mu^o_{OH-} = -157147.1\ J/mol$
$\mu^o_{H^+} = 0$	

Q 11	Zinc is being deposited from a 1M $ZnCl_2$ electrolyte whose pH is 3. The electrolytic cell consists of a pair of planar electrodes. The submerged area of each electrode is 1 m^2, the anode-cathode distance (ACD) is 0.02 m, and the solution conductivity (σ) is 4 Ω^{-1} m^{-1}. At 25 °C both zinc deposition and hydrogen evolution are possible. Assume that the reactions follow Tafel behaviour. For the zinc reaction β_{Zn} = 0.5 and $i_{o,Zn}$= 10^{-3} A/m^2 . For hydrogen β_{H_2}= 0.5 and $io,H2$ = 10-5 A/m2 . The voltage at the cathode with respect to the SCE (Vc) is – 1.2 V. Ignore activation overpotential at the anode concentration overpotential. a) Calculate the rate of Zn deposition and Vcell, assuming H_2 evolution is suppressed. Neglect activation overpotential at the anode. ***OR*** Discuss concentration overvoltage using a polarization curve. Also, explain the effect of current on overvoltage using a polarization curve.	**20**	**CO2**