Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2021

Program Name : B.Tech (CE+RP) **Semester: VI**
Course Name : Corrosion Engineering **Time: 03 hrs.**
Course Code : CHCE3025P **Max. Marks: 100**
Nos. of page(s) : 3

Instructions: *The question paper consists of two sections. Answer the questions section wise in the answer booklet.*

Note: *Assume suitable data wherever necessary*

SECTION-A
(Answer all questions)

S. No.		Marks	CO
Q1	Criticize corrosion of metals/alloys in soil environment	**10**	**CO4**
Q2	Discuss about galvanic corrosion, microbiologically induced corrosion, pitting corrosion, erosion corrosion, stress corrosion cracking and their preventions.	**10**	**CO1**
Q3	Describe corrosion and justify how the corrosion rate of a metal/alloy varies with different environments.	**10**	**CO1**
Q4	Determine whether iron is stable in aqueous solution at pH = 3, 5, and 7. Plot the driving EMF and the Gibbs free-energy as a function of pH. Assume P_{H_2} = 1 atm. and $[Fe^{2+}] = 10^{-6}$ M.	**10**	**CO2**
Q5	Illustrate stainless steel alloys and its corrosion behavior.	**10**	**CO4**
Q6	A new heat exchanger is required in conjunction with a rearrangement of existing facilities. Because of corrosion, the expected life of a carbon steel heat exchanger is 5 years. The installed cost is $9500. An alternative to the heat exchanger is a unit fabricated of AISI type 316 stainless steel, with an Installed cost of $26,500 and an estimated life of 15 years, to be written off in 11 years. The minimum acceptable interest rate is 10 percent, the tax rate is 48 percent, and the depreciation method is straight line. **Justify** which unit would be more economical based on annual costs.	**10**	**CO5**

SECTION-B
(Answer all questions and question 7 has internal choice)

Q7	A. Define polarization and discuss about anodic and cathodic polarization. B. Derive Butler-Volmer equation. **OR** Construct an Evans diagram (E vs. log i) for the corrosion of silver in a hydrogen saturated 0.1M HCl solution where the activity of Ag^{2+} is 10^{-18}M. The corrosion reaction data is as follows: $[Ag^+] = 10^{-18}$ M, $[H^+] = 0.1$ M Tafel slopes: $\beta_a = 0.1$ V/decade, $\beta_b = -0.1$ V/decade Tafel constant: $a_c = -0.0824$ V vs SHE (cathode)	**(5+15)** **OR** **(6+9+5)**	**CO2**

	Exchange current densities: $i^{o}_{Ag} = 0.8\frac{A}{cm^2}, i^{o}_{H_2} = 0.15\frac{A}{cm^2}$ Calculate: (a) Equilibrium potentials of the hydrogen and Ag redox reaction. (b) Corrosion current and corrosion potential. (c) Protection current to prevent corrosion.		
Q8	Discuss the following corrosion prevention methods I. Corrosion inhibitors II. Cathodic protection method.	**20**	**CO3**

Table: Standard Electrode Potentials at 25 $^{\circ}$C and Their Isothermal Temperature Coefficients

	Electrode Reaction	$e^{o}\ (V\ vs\ SHE)$	$\left(\frac{dE^{o}}{dT}\right) \times 10^{3} \left(\frac{V}{^{o}C}\right)$
$Li^{+}\|Li$	$Li^{+} + e^{—} = Li$	—3.045	—0.534
$Rb^{+}\|Rb$	$Rb^{+} + e^{—} = Rb$	—2.925	—1.245
$Cs^{+}\|Cs$	$Cs^{+} + e^{—} = Cs$	—2.923	—1.197
$K^{+}\|K$	$K^{+} + e^{—} = K$	—2.925	—1.080
$Ra^{2+}\|Ra$	$Ra^{2+} + 2e^{—} = Ra$	—2.916	—0.59
$Ba^{2+}\|Ba$	$Ba^{2+} + 2e^{—} = Ba$	—2.906	—0.395
$Ca^{2+}\|Ca$	$Ca^{2+} + 2e^{—} = Ca$	—2.866	—0.175
$Na^{+}\|Na$	$Na^{+} + e^{—} = Na$	—2.714	—0.772
$La^{3+}\|La$	$La^{3+} + 3e^{—} = La$	—2.522	+0.085
$Mg^{2+}\|Mg$	$Mg^{2+} + 2e^{—} = Mg$	—2.363	+0.103
$Be^{2+}\|Be$	$Be^{2+} + 2e^{—} = Be$	—1.847	+0.565
$Al^{3+}\|Al$	$Al^{3+} + 3e^{—} = Al$	—1.662	+0.504
$Ti^{2+}\|Ti$	$Ti^{2+} + 2e^{—} = Ti$	—1.628	-
$Zr^{4+}\|Zr$	$Zr^{4+} + 4e^{—} = Zr$	—1.529	-
$V^{2+}\|V$	$V^{2+} + 2e^{—} = V$	—1.186	-
$Mn^{2+}\|Mn$	$Mn^{2+} + 2e^{—} = Mn$	—1.180	—0.08
$Zn^{2+}\|Zn$	$Zn^{2+} + 2e^{—} = Zn$	—0.762	+0.09
$Cr^{3+}\|Cr$	$Cr^{3+} + 3e^{—} = Cr$	—0.744	+0.468
$SbO_2^{-}\|Sb$	$SbO_2^{-} + 2H_2O + 3e^{—} = Sb + 4OH^{—}$	—0.670	-
$Ga^{3+}\|Ga$	$Ga^{3+} + 3e^{—} = Ga$	—0.529	+0.67
$S^{2—}\|S$	$S + 2e^{—} = S^{2—}$	—0.510	-
$Fe^{2+}\|Fe$	$Fe^{2+} + 2e^{—} = Fe$	—0.440	+0.052
$Cr^{3+}, Cr^{2+}\|Pt$	$Cr^{3+} + e^{—} = Cr^{2+}$	—0.408	-
$Cd^{2+}\|Cd$	$Cd^{2+} + 2e^{—} = Cd$	—0.402	—0.093
$Ti^{3+}, Ti^{2+}\|Pt$	$Ti^{3+} + e^{—} = Ti^{2+}$	—0.369	-
$Tl^{+}\|Tl$	$Tl^{+} + e^{—} = Tl$	—0.336	—1.327
$Co^{2+}\|Co$	$Co^{2+} + 2e^{—} = Co$	—0.277	+0.06
$Ni^{2+}\|Ni$	$Ni^{2+} + 2e^{—} = Ni$	—0.250	+0.06
$Mo^{3+}\|Mo$	$Mo^{3+} + 3e^{—} = Mo$	—0.20	-
$Sn^{2+}\|Sn$	$Sn^{2+} + 2e^{—} = Sn$	—0.138	—0.282
$Pb^{2+}\|Pb$	$Pb^{2+} + 2e^{—} = Pb$	—0.126	—0.451
$Ti^{4+}, Ti^{3+}\|Pt$	$Ti^{4+} + e^{—} = Ti^{3+}$	—0.040	-
$H^{+}, H_2\|Pt$	$H^{+} + e^{—} = ½\ H_2$	T0.000	T0.000 (+0.871)^{m}
$Sn^{4+}, Sn^{2+}\|Pt$	$Sn^{4+} + 2e^{—} = Sn^{2+}$	+ 0.015	-
$Cu^{2+}, Cu^{+}\|Pt$	$Cu^{2+} + e^{—} = Cu^{+}$	+ 0.153	+0.073
$Ag^{+}\|Ag$	$Ag^{+} + e^{—} = Ag$	+0.799	
$Cu^{2+}\|Cu$	$Cu^{2+} + 2e^{—} = Cu$	+0.337	+0.008
$Fe(CN)_6^{3—}, Fe(CN)_6^{4—}\|Pt$	$Fe(CN)_6^{3—} + e^{—} = Fe(CN)_6^{4—}$	+0.360	-
$OH^{—}, O_2\|Pt$	$½\ O_2 + H_2O + 2e^{—} = 2OH^{—}$	+0.401	—0.440
$Cu^{+}\|Cu$	$Cu^{+} + e^{—} = Cu$	+0.521	—0.058
$I^{—}\|I_2, Pt$	$I_2 + 2e^{—} = 2I^{—}$	+0.535	—0.148
$MnO_4^{-}, MnO_4^{2-}\|Pt$	$MnO_4^{-} + e^{—} = MnO_4^{2—}$	+0.564	-