Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER 2
SESSION 2018/2019

COURSE NAME	:	CORROSION AND PREVENTION
COURSE CODE	:	BDB 40403
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JUNE/JULY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **FIVE (5)** QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) Explain corrosion on steel under drop of water with an appropriate sketch.
(5 marks)

(b) An electrochemical cell is constructed as shown in **Figure Q1 (b).** A strip of Sn and a strip of unknown metal Y are used as electrodes. When the switch is closed, the mass of the Sn electrode increases. If the standard cell potential E^{o}_{cell} is +0.60 V, what is the standard potential (in volts) for *Y* electrode? Identify your metal *Y*.
(5 marks)

(c) Clearly differentiate between activation polarization and concentration polarization by using an appropriate diagram.
(5 marks)

(d) The concrete roof of swimming pool at Universiti Tun Hussein Onn collapsed. The roof was supported by stainless steel rods. Scene investigation identified that chloride-based disinfectants were used in the pool. The temperature was maintained at ambient and high humidity were observed. Predict what form of corrosion caused the roof to collapse give your suggestion for prevention.
(5 marks)

Q2 (a) Write the possible oxidation and reduction half-reactions that occur when magnesium is immersed in each of the following solutions;
(i) HCl
(ii) HCl solution containing dissolved oxygen
(iii) HCl solution containing dissolved oxygen and, in addition, Fe^{2+} ions.
(5 marks)

(b) Analyze the cell potential of a galvanic cell consists of an electrode of magnesium in a 0.05 M solution of $MgSO_4$ and an electrode of copper in a 0.09 M solution of $CuSO_4$ at 25°C. The two electrodes are separated by a porous wall.
(5 marks)

(c) Justify the differences between anodic and cathodic protection.
(5 marks)

(d) Two admiralty brass (71% Cu, 28% Zn, 1% Sn) heat exchanger tubes from a cooler in a refinery unit showed cracks. Results from inspection found both tubes showed cracks extending circumferentially above 180°C on the tension side of the U-bend. Tube 1 showed a relatively smooth surface, whereas Tube 2 showed buildup of corrosion products. Tube 1 showed cracking with minimum branching propagating from inside the tube. By EDX-ray analysis, the presence of copper and zinc ions and some small amounts of chloride, sulfur, silicon and tin were observed. Give your

judgement the form of corrosion caused the heat exchanger to fail and suggest your corrosion prevention.

(5 marks)

Q3 (a) Explain the application of volatile corrosion inhibitor.

(5 marks)

(b) A voltaic cell is created under standard conditions with the cell notation;
$Cu_{(s)} \mid Cu^{2+}{}_{(aq)} \parallel Ag^{+}{}_{(aq)} \mid Ag_{(s)}$
Calculate the value for standard cell potential, $E^{o}{}_{cell}$.

(5 marks)

(c) Select an appropriate approach to control corrosion during design stage

(5 marks)

(d) Construct FIVE (5) common atmospheric classifications for atmospheric corrosion.

(5 marks)

Q4 (a) Cylic polarization potential of stainless steel 316L and unknown metal X are shown in **Figure Q4 (a)**. Discuss the corrosion properties between these two metals.

(5 marks)

(b) Calculate the ratio of the oxide volume-to-metal volume (Pilling-Bedworth ratio) for the oxidation of aluminium-to-aluminium oxide, Al_2O_3. The density of aluminium is 2.70 g/cm^3 and that of aluminium oxide is 3.70 g/cm^3. Given molarity of aluminium and oxygen are 26.98 g/mol and 16.0 g/mol respectively.

$$PB\ ratio = \frac{volume\ of\ oxide\ produced\ by\ oxidation}{volume\ of\ metal\ consumed\ by\ oxidation}$$

(5 marks)

(c) What are the advantages of using impressed current cathodic protection (ICCP) to protect metal from corrosion.

(5 marks)

(d) Select the major factors affecting atmospheric corrosion

(5marks)

Q5 (a) What is the voltage (E_{cell}) of a cell comprising a zinc plate in zinc sulphate and a copper plate in copper sulphate. The concentration of $ZnSO_4$ and $CuSO_4$ are 1.0 and 0.01 respectively.

(5 marks)

(b) A steel screw was attached to a steel body, with time, the area at the bottom of the screw start to corrode. Suggest THREE (3) suitable solutions to prevent this corrosion from happen.

(5 marks)

(c) With an appropriate ONE (1) type of cathodic protection installation system in infrastructure, evaluate its mechanism to protect parent structure.

(5 marks)

(d) A voltaic cell is constructed using electrode magnesium in solution of magnesium sulphate and copper electrode in solution of copper sulphate. By referring to standard cell potential value, give your prediction whether the reactions are spontaneous or non-spontaneous in aqueous solutions?

(5 marks)

Q6 (a) Explain the effects of corrosion to environment and economy.

(5 marks)

(b) Illustrate the internal corrosion of waste water system that is dominated by formation of sulphuric acid.

(5 marks)

(c) What are drawbacks of cathodic protection system?

(5 marks)

(d) A leak was detected at pipe joint between rolled and bottom pipe of heat exchanger unit. The heat exchanger was made from austenitic stainless steel. The temperature involved is 90°C to 170°C at 8-10 atm. A physical examination of the pipe showed that the surface was pitted all around the rolled joint very close to the steam chamber and grooves were noticeable in the vicinity of this spot. The rolled joint was not very tight due to grooves surface. Give your evaluation about forms of corrosion and prevention can be made.

(5 marks)

-END OF QUESTION –

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Table : emf Series of standard electrode potential at 25 °C

Half-Cell Reaction	E^0 (volts)
$F_2 + 2e \longrightarrow 2F^-$	2.87
$Au^+ + e \longrightarrow Au^+$	1.68
$Cl_2 + 2e \longrightarrow 2Cl^-$	1.36
$O_2 + 4H^+ + 4e \longrightarrow 2H_2O$	1.229
$O_2 + 4H^+ (10^{-7}\ M) + 4e \longrightarrow 2H_2O$	0.82
$Ag^+ + e \longrightarrow Ag$	0.799
$Fe^{3+} + e \longrightarrow Fe^{2+}$	0.771
$O_2 + 2H_2O + 4e \longrightarrow 4OH^-$	0.48
$Cu^{2+} + 2e \longrightarrow Cu$	0.337
$2H^+ + 2e \longrightarrow H_2$	0.0000
$Pb^{2+} + 2e \longrightarrow Pb$	-0.126
$Sn^{2+} + 2e \longrightarrow Sn$	-0.14
$Ni^{2+} + 2e \longrightarrow Ni$	-0.25
$Co^{2+} + 2e \longrightarrow Co$	-0.28
$Fe^{2+} + 2e \longrightarrow Fe$	-0.44
$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$	-0.74
$Zn^{2+} + 2e \longrightarrow Zn$	-0.763
$Al^{3+} + 3e \longrightarrow Al$	-1.66
$Mg^{2+} + 2e \longrightarrow Mg$	-2.34
$Na^+ + e \longrightarrow Na$	-2.714
$Ca^{2+} + 2e \longrightarrow Ca$	-2.87
$K^+ + e \longrightarrow K$	-2.925

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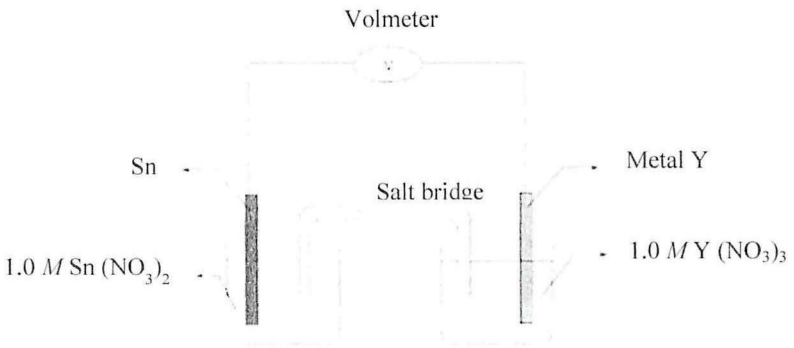

Figure Q1 (b).

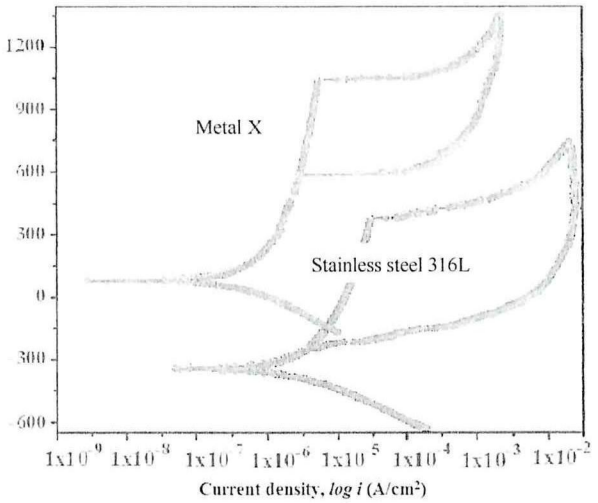

Figure Q4 (a)