UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	CORROSION AND PREVENTION
COURSE CODE	:	BDB 40403
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JULY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **FIVE (5)** QUESTIONS **ONLY**

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

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Q1 (a) A voltaic cell is constructed using electrode magnesium in a solution of magnesium sulphate and copper electrode in a solution of copper sulphate. By referring to standard cell potential value (**Table Q1(a)**), give your prediction whether the reactions are spontaneous or non-spontaneous in aqueous solutions?

(5 marks)

(b) Construct a mathematical equation to relate the cell potential, E_{cell} and free energy, ΔG.

(5 marks)

(c) Referring to **Figure Q1 (c),** sketch the graphs if the temperature is increasing. Support your decision of corrosion rate which relates to the passive range and dissolution kinetics when the temperature of the electrolyte is increasing

(10 marks)

Q2 (a) How the solution resistance affects the electrochemical corrosion data?

(5 marks)

(b) List types of the reference electrode and discuss the differences between them.

(5 marks)

(c) A fire-tube boiler made from carbon steel in which fuel gas flows within the tube while the boiler feed-water along with condensate from the plant flows on the shell-side. Visual inspection revealed heavily localized tubercles were seen on the outside surface of several tubes. After about 11 months of operation, the pipe was leaked and visual inspection found pinholes outside surface contain loose brownish rust. The rust contained chloride and was acidic in nature. Select appropriate corrosion prevention that needs to be applied and identify types of corrosion happen.

(10 marks)

Q3 (a) List FIVE (5) common classification for atmospheric corrosion

(5 marks)

(b) With referring to **Figure Q3(b),** the Pourbaix diagram of copper,

(i) Write the half-cell reactions happen at line 1 and 2.

(5 marks)

(ii) Identify the cell potential between the line 1 and 2.

(5 marks)

(c) Sketch the activation polarization and concentration polarization.

(5 marks)

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Q4 (a) Describe how to control corrosion during the design stage.
(5 marks)

(b) Compare the differences between anodic and cathodic protection
(5 marks)

(c) What are the disadvantages of using sacrificial anode in protecting buried pipe
(5 marks)

(d) **Figure Q4(d)** illustrates a pipeline is buried in soil sacrificial anode. Explain the advantages of using sacrificial anode in protecting the pipe.
(5 marks)

Q5 (a) Sketch the basic components for cathodic protection systems?
(5 marks)

(b) Give your justification the differences between the anodic inhibitor and anodic protection.
(10 marks)

(c) Identify the advantages of using impressed current cathodic protection (ICCP) to protect the metal from corrosion against other methods.
(5 marks)

Q6 (a) Illustrate the electron flow and anodic/cathodic area for threads and welded steel
(5 marks)

(b) List types of corrosion inhibitors.
(5 marks)

(c) (i) Identify types of stray current
(5 marks)

(ii) Illustrate how stray current will disrupt cathodic protection for the buried pipe.
(5 marks)

-END OF QUESTION –

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Table Q1 (a): EMF Series of standard electrode potential at 25 °C

Half-Cell Reaction	E^o (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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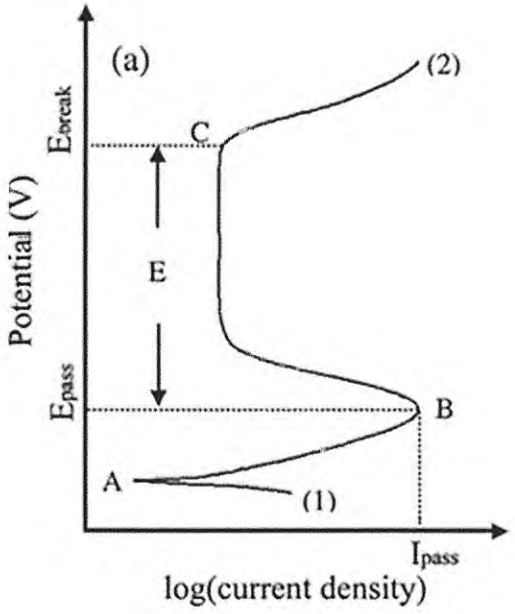

Figure Q1(c)

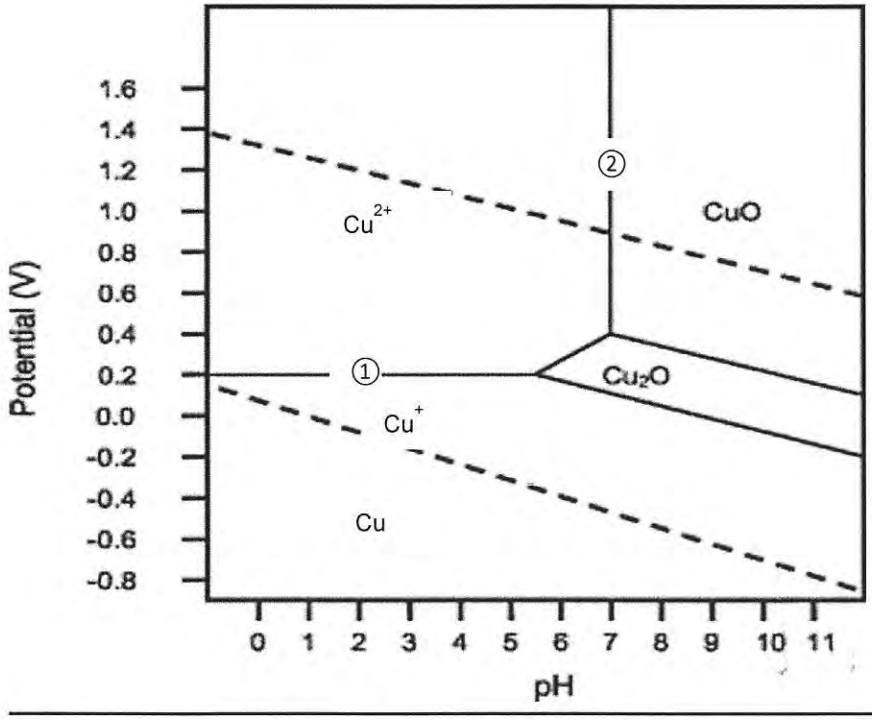

Figure Q3(b)

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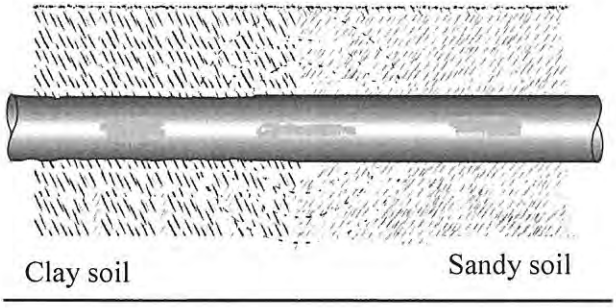

Figure Q4 (d).

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