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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020**

COURSE NAME : CORROSION AND PREVENTION
COURSE CODE : BDB 40403
PROGRAMME CODE : BDD
EXAMINATION DATE : DECEMBER 2019/JANUARY 2020
DURATION : 3 HOURS
INSTRUCTION : ANSWER **FIVE (5)** QUESTIONS
ONLY

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

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- Q1**
- (a) Discuss the effects of corrosion to social and environmental. (4 marks)
 - (b) Identify FIVE (5) types of corrosion inhibitors. (5 marks)
 - (c) With a sketch, explain corrosion on steel under drop of water. (3 marks)
 - (d) Select an ideal design for prevention of corrosion under thermal insulation. (8 marks)
- Q2**
- (a) With an appropriate diagram, explain clearly the difference between activation polarization and concentration polarization. (4 marks)
 - (b) List the material selection steps to mitigate corrosion attack (5 marks)
 - (c) Explain how to control corrosion during design stage. (3 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. (8 marks)
- Q3**
- (a) **Figure Q3** illustrates a pipeline is buried in two types of soil; clay and sandy soil. Evaluate which area of the pipe would be the anode and which is the cathode. Sketch the electron flow and justification to your judgement. (8 marks)
 - (b) Name electrochemical points (A, B and C) and regions (D and E) in **Figure Q3 (b)** (5 marks)
 - (c) Suggest FOUR (4) methods to control corrosion. (4 marks)
 - (d) Explain the application of volatile corrosion inhibitor. (3 marks)

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- Q4** (a) 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 pin holes outside surface contain loose brownish rust. The rust contained chloride and was acidic in nature. Select appropriate corrosion prevention to apply and identify types of corrosion happen. (8 marks)
- (b) A voltaic cell is created under standard conditions with the cell notation
$$\text{Cu}_{(s)} \mid \text{Cu}^{2+}_{(aq)} \parallel \text{Ag}^{+}_{(aq)} \mid \text{Ag}_{(s)}$$
Write the anodic and cathodic half-cell reactions and balanced net-ionic equation for the overall chemical reaction occurring in the cell. By referring to **Table Q4(b)**, calculate the value for standard cell potential, E°_{cell} . (4 marks)
- (c) Categorized FIVE (5) common atmospheric for classification of atmospheric corrosion. (5 marks)
- (d) Sketch different regimes of framework for treating atmospheric corrosion. (3 marks)
- Q5** (a) The water pipes leading into Hussein's house are made of lead, while the rest of the plumbing in his house are made from iron. To eliminate the possibility of lead poisoning, a plumber suggests replacing it with stainless steel. Based on your knowledge as an engineer, judge the plumber selection with suitable reason. Given is the galvanic series (**Figure Q5(a)**) (7 marks)
- (b) Analyse the major factors affecting atmospheric corrosion. (4 marks)
- (c) With an appropriate diagram, briefly explain about anodic protection. (5 marks)
- (d) Evaluate the advantages of using impressed current cathodic protection (ICCP) to protect metal from corrosion against other methods. (4 marks)

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- Q6**
- (a) Explain how to measure atmospheric corrosion.
(5 marks)
 - (b) Differentiate between Stress Corrosion Cracking and Hydrogen Embrittlement.
(5 marks)
 - (c) Cyclic polarization potential of stainless steel and unknown metal X are shown in **Figure Q6 (c)**. Compare the corrosion properties between these two metals. Which metal has better corrosion resistance?
(5 marks)
 - (d) A steel screw is attached to a steel body, with time, the area at the bottom of the screw starts to corrode. Suggest **THREE (3)** suitable solutions to prevent this corrosion from happening.
(5 marks)

-END OF QUESTION -

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Table Q4 (b): EMF Series of standard electrode potential at 25 °C

Half-Cell Reaction	E° (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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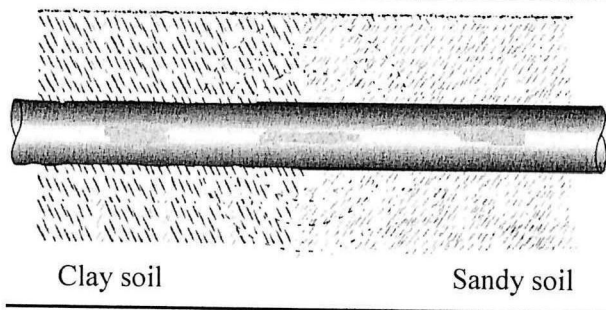


Figure Q1 (d)

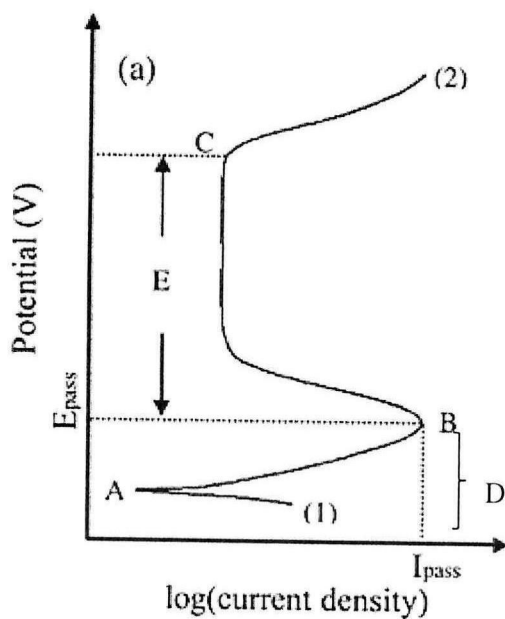


Figure Q3(b)

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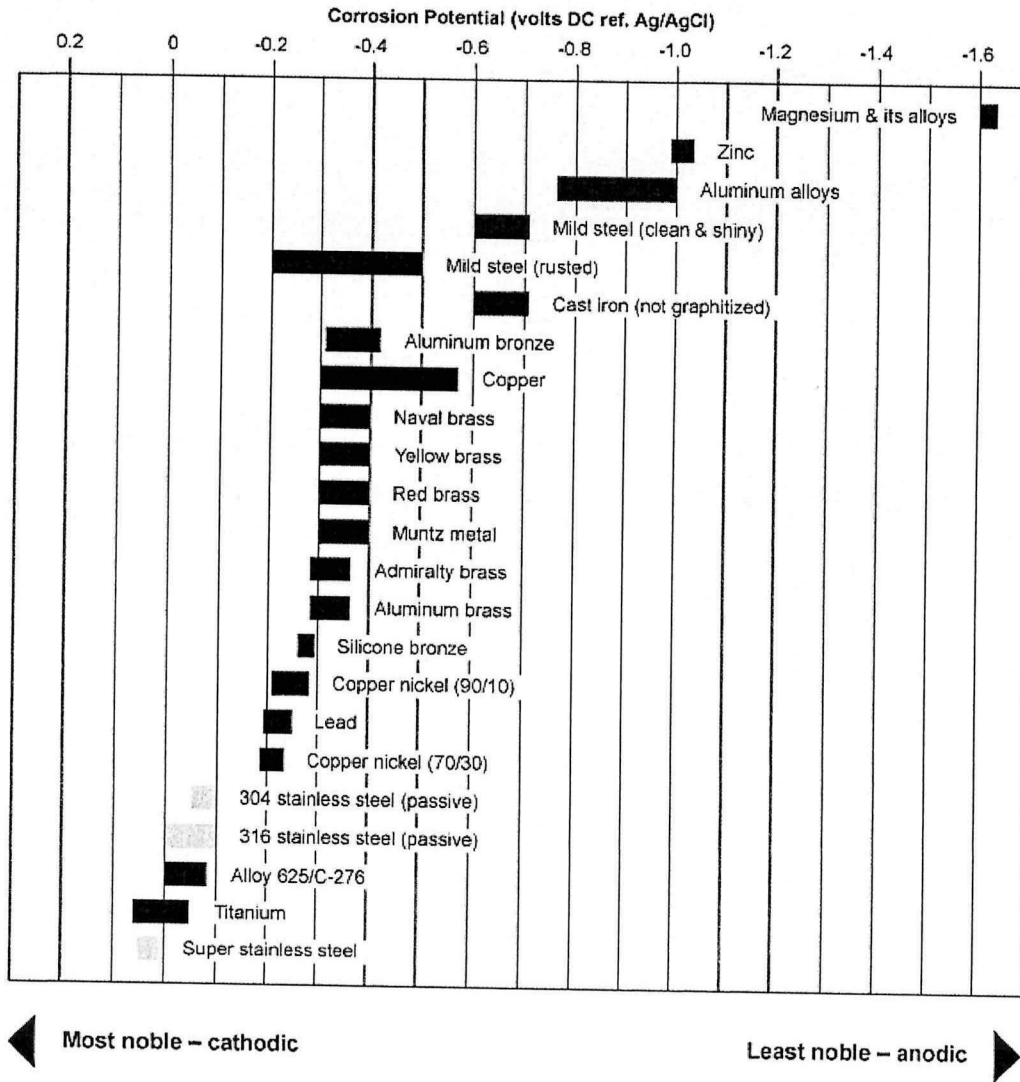


Figure Q5(a) Galvanic series

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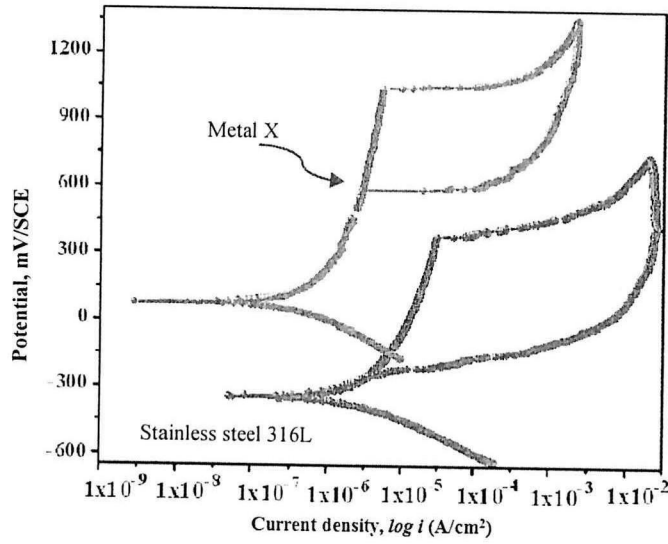


Figure Q6 (c)

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