Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER II
## SESSION 2023/2024

| | | |
|---|---|---|
| COURSE NAME | : | CORROSION AND PREVENTION |
| COURSE CODE | : | BDB 40403 |
| PROGRAMME CODE | : | BDD |
| EXAMINATION DATE | : | JULY 2024 |
| DURATION | : | 3 HOURS |
| INSTRUCTIONS | : | 1. ANSWER ALL QUESTIONS<br>2. THIS FINAL EXAMINATION IS CONDUCTED VIA<br>☐ Open book<br>☒ Closed book<br>3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK |

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

**Q1** (a) Explain the major ingredients which cause of an atmospheric corrosion.

(5 marks)

(b) The aluminium can of pasteurizer brewery was destroyed as shown in **Figure Q1.1**. After 2 months of production, one-half of the can is completely corroded. The beer ingredient is softened water with 0.1%-1.0% sodium hypochlorite (0.1%–1.0%) at 60°C with pH 8-9. Determine the damage mechanism and how to prevent the attack.

(7 marks)

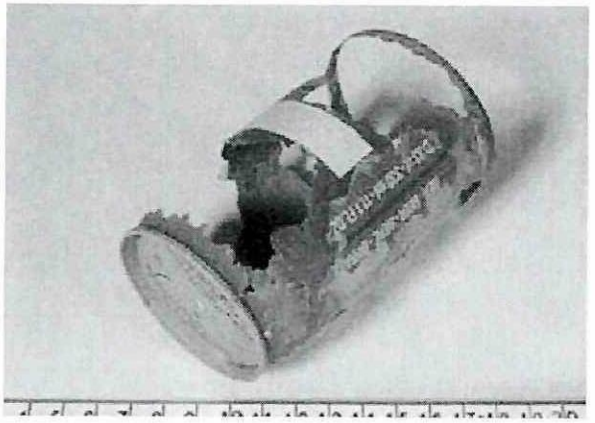

**Figure Q1.1** Aluminium beer can

(c) Evaluate a cathodic protection system with the support of the Pourbaix Diagram.

(8 marks)

**Q2** (a) The Johor Offshore company having a problem when their piping and umbilicals are cracks in subsea. The pipeline is transporting crude extracted to midstream. The pipe as shown in **Figure Q2.1** is support by concrete to avoid mechanical damage due to vibration. Explain briefly;

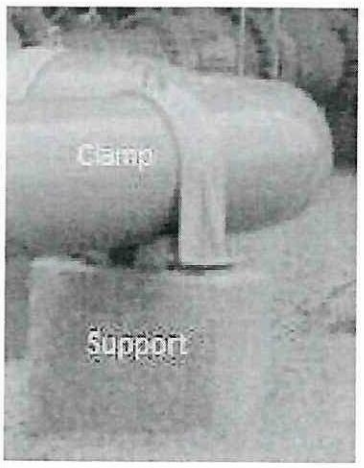


**Figure Q2.1** Subsea pipeline

(i) Justify, what is possible corrosion attack if the pipe support is splash away.

(5 marks)

(ii) As a corrosion engineer, what is your recommendation to solve this problem?

(7 marks)

(b) Syarikat Air Johor (SAJ) in Parit Raja uses cathodic protection along the pipeline from water treatment to residential areas. During the monsoon season, Parit Raja was hit by floods. Do you think this disaster affected the voltage reading at the test point? Give your comment.

(8 marks)

**Q3** (a) Construct a chemical reaction on how sulfate-reducing bacteria (SRB) initiate Microbial Induced Corrosion (MIC).

(5 marks)

(b) **Figure Q3.1** shows cracks along the weldment of carbon steel. Give your comment about this damage mechanism.

(7 marks)

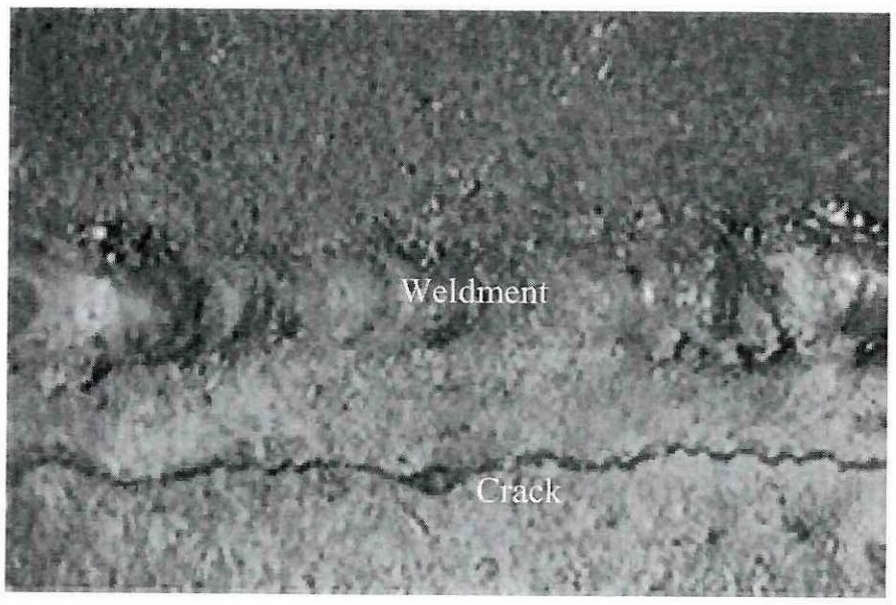


**Figure Q3.2** Crack along the weldment

(c) With an appropriate sketch of a storage tank, give your comment how faulty design may cause corrosion attack.

(8 marks)

**Q4** (a) Kedah Bitumen is producing bitumen at operation temperature mostly more than 200°C. In the existing piping, they used stainless steel 304 which had severe cracks. They planned to change the material to Incoloy 825. Identify;

(i) Comparing these two material candidates, identify the possible corrosion attack on stainless steel 304 and Incoloy 825.

(7 marks)

(ii) Does changing the material really solve the problem for corrosion in their process?

(5 marks)

(b) With an appropriate sketch, explain the stages of hydrogen attack in carbon steel at high temperatures ended with hydrogen embrittlement.

(8 marks)

**Q5** (a) Differentiate how inhibitors protect carbon steel from corrosion attacks.

(5 marks)

(b) What are the differences between stress corrosion cracking (SCC) and hydrogen embrittlement (HE).

(7 marks)

(c) Give your justification for selecting a corrosion inhibitor

(8 marks)

**- END OF QUESTIONS -**

**APPENDIX A**

| 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 |
| $AgCl(s) + e^- \rightarrow Ag(s) + Cl^-(aq)$ | 0.22 |
| $2H^+ + 2e \longrightarrow H_2$ | 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 |