UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
MAY 2024 SEMESTER

COURSE	:	BBM5323 – OILFIELD AND PROCESS-RELATED CORROSION
DATE	:	10 AUGUST 2024 (SATURDAY)
TIME	:	2:30 PM – 5:30 PM (3 HOURS)

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.

2. Begin **EACH** answer on a new page in the Answer Booklet.

3. Indicate clearly answers that are cancelled, if any.

4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.

5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **SIX (6)** printed pages in this **double-sided** Question Booklet including the cover page and appendix.

1. **FIGURE Q1** depicts a schematic process flow for a petroleum refinery in downstream industry. The refining units and equipment are faced with a multitude of corrosion mechanisms and material failures.
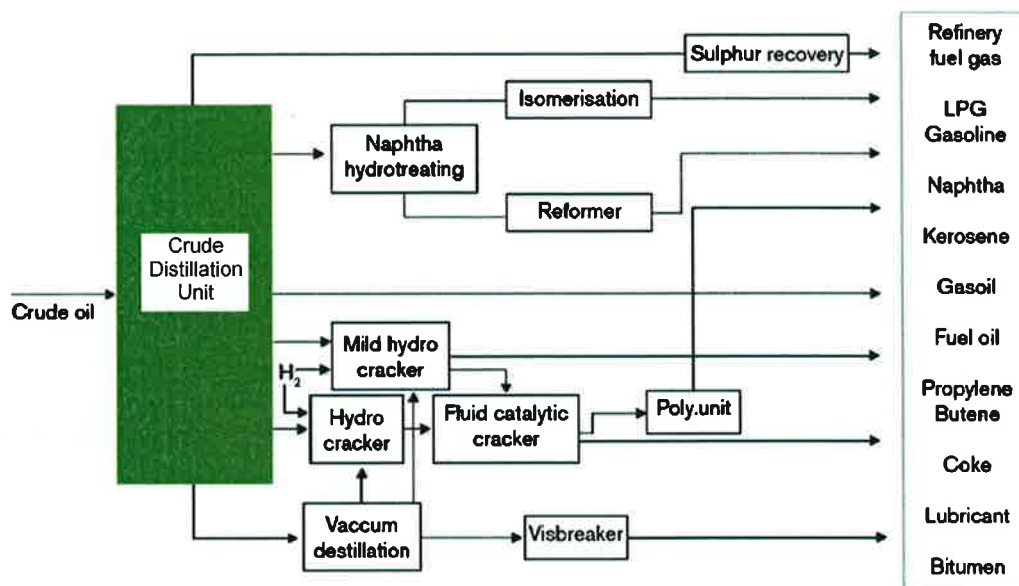

FIGURE Q1

Assess the following process units covering the forms of corrosion, affected equipment, damage appearance and influencing factors.

a. Crude Distillation Unit.

[10 marks]

b. Amine Treating Unit.

[10 marks]

c. Propose **TWO (2)** preventive measures for **part (a)** and **(b)**, respectively.

[4 marks]

2. Carbon dioxide corrosion refers to the wall thinning of steel surface, due to the presence of dissolved CO_2 in water. This type of corrosion is prevalent in the production pipelines in the oilfield.

a. Express all possible chemical and electrochemical reactions that would occur in an aqueous CO_2 corrosion process.

[10 marks]

b. Assuming condensed water, prove that the hydrogen ion, H^+ concentration can be derived by the following CO_2-water chemistry model:

$$(C_{H^+})^3 - (K_{ca}.K_{Hyd}.K_{sol}.p_{CO_2}.C_{H^+}) - (2K_{bi}.K_{ca}.K_{Hyd}.K_{sol}.p_{CO_2}) - (C_{H^+}.K_{wa}) = 0$$

[10 marks]

c. Comment what happens to the changes of bicarbonate and carbonic species concentrations when the solution pH is varied from acidic to neutral then alkaline level.

[6 marks]

3. Wet H_2S damage is a damage mechanism associated with the equipment operating in wet sour service environment. **FIGURE Q3** shows the schematics of four major types of H_2S damage.
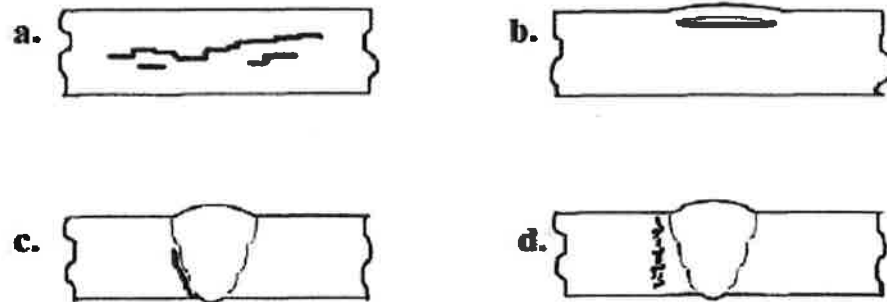

FIGURE Q3

a. Identify the types of H_2S damage in **FIGURE Q3** and describe the damage appearances of each.

[8 marks]

b. Assess the severity level, mechanisms, and influencing factors for each case in **part (a)**.

[12 marks]

c. Given a natural gas feed stream at a total pressure of 100 psi contains 0.06% mol. H_2S and 6% mol. CO_2, evaluate if there is any risk of wet H_2S damage.

[6 marks]

4. Environmental-Assisted Cracking (EAC) is a broad term for Stress Corrosion Cracking (SCC) that occur on a susceptible material when exposed to critical environment above a threshold tensile stress value.

    a. "This type of EAC typically occurs in the Fluid Catalytic Cracking Unit (FCCU) where the equipment is exposed to carbonates, ammonia, and sour water." Assess this type of EAC by justifying your answer with the mechanism, damage appearance and critical parameters that promote such EAC under the FCCU's environment.

    [12 marks]

    b. "This type of EAC occurs rather quickly during shutdowns and startups of hydrotreating unit when exposed to sulfur, moisture and oxygen. It rarely causes failure during operation". Assess this type of EAC by justifying your answer with the mechanism, damage appearance and critical parameters that promote such EAC.

    [12 marks]

– END OF PAPER –

APPENDIX

Pressure unit: 1000 psi = 6895 kPa

List of Equilibrium Constants

$$K_{sol} = c_{CO_2}/p_{CO_2}$$

$$K_{wa} = c_{H^+} c_{OH^-}$$

$$K_{hy} = c_{H_2CO_3}/c_{CO_2}$$

$$K_{ca} = c_{H^+} c_{HCO_3^-}/c_{H_2CO_3}$$

$$K_{bi} = c_{H^+} c_{CO_3^{2-}}/c_{HCO_3^-}$$