UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
MAY 2012 SEMESTER

COURSE	**:**	**MBB4423 – CORROSION ENGINEERING**
DATE	**:**	**2ND SEPTEMBER 2012 (SUNDAY)**
TIME	**:**	**9.00 AM – 12.00 NOON (3 hours)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions from the Question 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.
5. Do not open this Question Booklet until instructed.

Note : There are **SEVEN (7)** pages in this Question Booklet including the cover page.

1. a. In an electrochemical corrosion experiment, an iron sample is immersed in an aqueous de-aerated acid solution and held at a potential of -0.3 V with respect to Standard Hydrogen Electrode (SHE) and pH 3. The Pourbaix diagram for Iron- Water system at 25°C is shown in **FIGURE Q1a**.

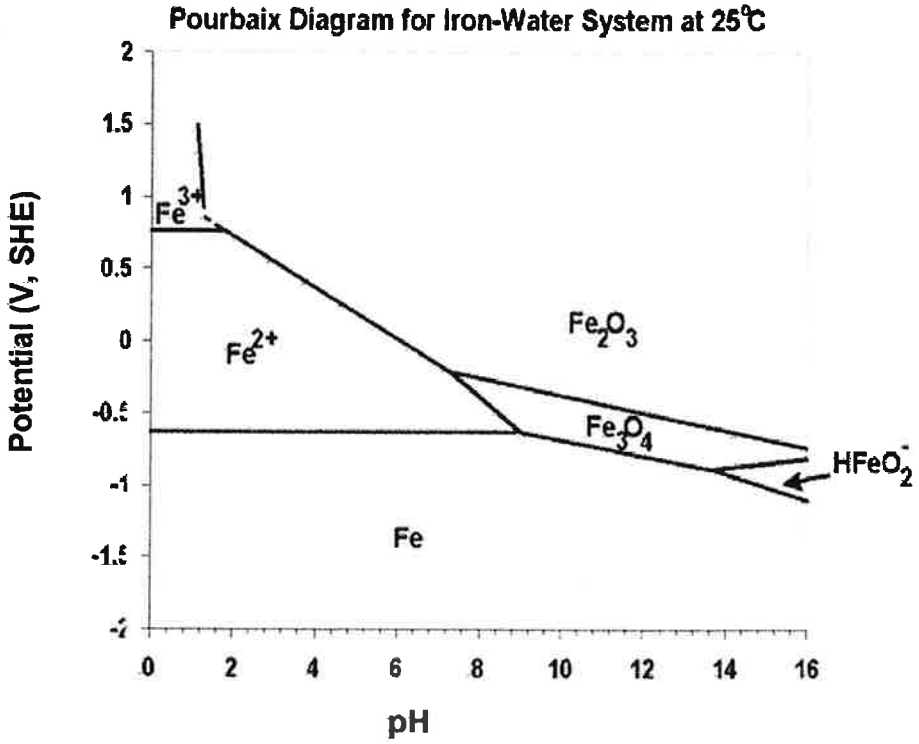

FIGURE Q1a

i. Evaluate whether the iron sample will corrode in this de-aerated acid solution.

[5 marks]

ii. Analyse whether the iron sample will corrode in alkaline solution, pH = 9.

[5 marks]

b. The reaction of iron corroding in an aerated acid at 25°C is given as

$$Fe + 2HCl(aq) + \frac{1}{2}O_2 \rightarrow FeCl_2(aq) + H_2O$$

where:

$E^o(Fe^{2+}/Fe) = -0.440$ V;

$E^o(H^+/H_2) = 0$ V;

$F = 96500$ C/mol; and

$R = 8.314$ J/mol.K .

i. Evaluate the thermodynamics of the corrosion if the concentration of Fe^{2+} is 1 and H^+ is 1.

[6 marks]

ii. Determine the concentration of Fe^{2+} that no more corrosion is possible.

[4 marks]

2. The corrosion of iron in neutral water (pH 7) in equilibrium with air involves two cathodic reactions of hydrogen evolution and oxygen reduction. Corrosion potential (E_{corr}) in aerated water at pH 7 is measured as -0.45 V.

The rates of both oxidation and reduction half-reactions are controlled by activation polarization and the data are given in **TABLE Q2.**

TABLE Q2

	Iron	Hydrogen
Density	7.14 g/cm^3	-
Atomic weight	65.37 g/mole	-
Reduction Potential	E (Fe^{2+}/Fe)= –0.44 V	E (H^+/ H_2) = 0 V
Exchange Current Density	i_o = 10^{-11} A/cm^2	i_o = 10^{-10} A/cm^2
Tafel Slope	β= +0.06 V/decade	β= –0.12 V/decade

a. Determine anodic current density of the corrosion process.

[6 marks]

b. Analyse cathodic current density contributed by hydrogen evolution and oxygen reduction.

[10 marks]

c. Evaluate the dominant cathodic current of the corrosion of iron in neutral water.

[4 marks]

3. a. Corrosion monitoring is an important aspect of design and operation in chemical process plant. There are numerous corrosion monitoring methods and devices available such as linear polarization resistance and corrosion coupon testing. The selection of the methods and locations depends on many factors such as plant maintenance and operating philosophy of a particular plant.

i. Propose and discuss **TWO (2)** objectives of corrosion monitoring.

[4 marks]

ii. Evaluate the application of linear polarization resistance and weight loss coupons in corrosion monitoring.

[8 marks]

b. Onshore buried pipelines are exposed to both internal and external corrosion. The integrity of the pipelines depends on the accurate assessment of the condition of the pipelines. Propose possible methods for corrosion monitoring of typical onshore buried pipelines. Justify.

[8 marks]

4. a. Insulated above-ground storage tanks are susceptible to corrosion under insulation (CUI) especially along the stiffener rings due to water ingression from damaged cladding and poor design of the insulation jacket.

i. Evaluate the type and mechanism of the corrosion on the shell plates along the stiffener rings.

[8 marks]

ii. Propose **TWO (2)** design considerations to prevent the occurrence of the corrosion under insulation of the storage tanks. Justify.

[4 marks]

b. One common corrosion prevention method is coating. However, the degree of the prevention depends strongly on the quality of the coating application and inspection. Formulate the requirements for surface preparation, paint application and inspection of such work.

[8 marks]

5. a. CO_2 corrosion is the main corrosion threat in upstream oil and gas production. There are many parameters influencing CO_2 corrosion which pose challenges to an accurate prediction of the corrosion.

i. Discuss the corrosion mechanism of carbon steel pipeline in the CO_2 environment.

[6 marks]

ii. Evaluate the effect of temperature and CO_2 partial pressure in the prediction of CO_2 corrosion

[8 marks]

b. Inhibitors are commonly used as a corrosion prevention method in oil and gas industry. Propose **TWO (2)** possible mechanisms that contribute to their effectiveness. Justify.

[6 marks]

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