UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session 2012/2013

January 2013

EBB 522/3 – Corrosion and Protection

Duration : 3 hours

Please ensure that this examination paper contains NINE printed pages and ONE page APPENDIX before you begin the examination.

This paper consists of SEVEN questions.

Instruction: Answer **FIVE** questions. If a candidate answers more than five questions only the first five questions answered in the answer script would be examined.

The answers to all questions must start on a new page.

All questions must be answered in English.

PART A

1. [a] Figure 1 shows Pourbaix diagram for iron at 25°C (Note: answer the questions with appropriate sketch or electrochemical equation):

(i) What is the line labeled “a”?

(20 marks)

(ii) What is the line labeled “b”?

(20 marks)

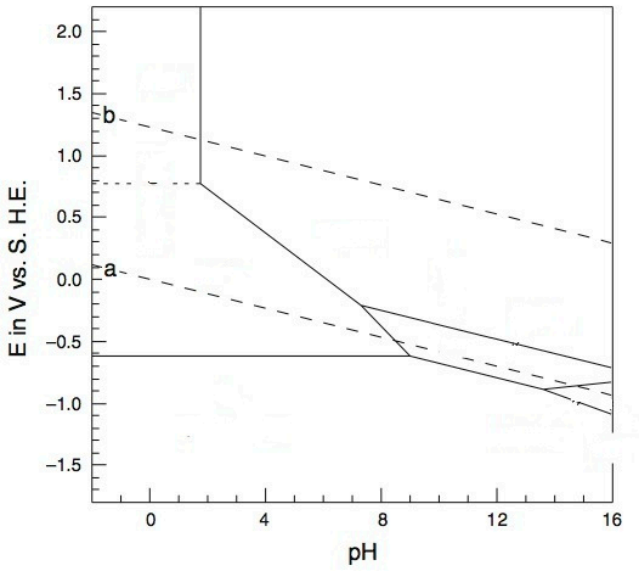

Figure 1

[b] The following electrode potentials were observed after a 1-year immersion period in natural seawater of pH 8.0:

Mild steel	–0.65 V vs. SCE
Zinc	–1.02 V vs. SCE
Mild steel/zinc couple	–0.95 V vs. SCE

(i) Refer to the appropriate Pourbaix diagram and indicate what behavior is expected for each of the two uncoupled electrodes.

(30 marks)

(ii) Based on the Pourbaix diagram, what behavior is expected for the mild steel and zinc components in the short-circuited couple?

(30 marks)

2. [a] Explain, with appropriate drawings, the meaning of relaxation time (τ) in electrochemical impedance spectroscopy?

(30 marks)

[b] Show that the product of RC has a unit of seconds. R is the resistance and C is the capacitance.

(30 marks)

[c] Figure 2 shows the impedance spectra of coated mild steel by paint when exposed to corrosive environment for one day. Calculate the double layer capacitance (C_{dl}) for this system.

(40 marks)

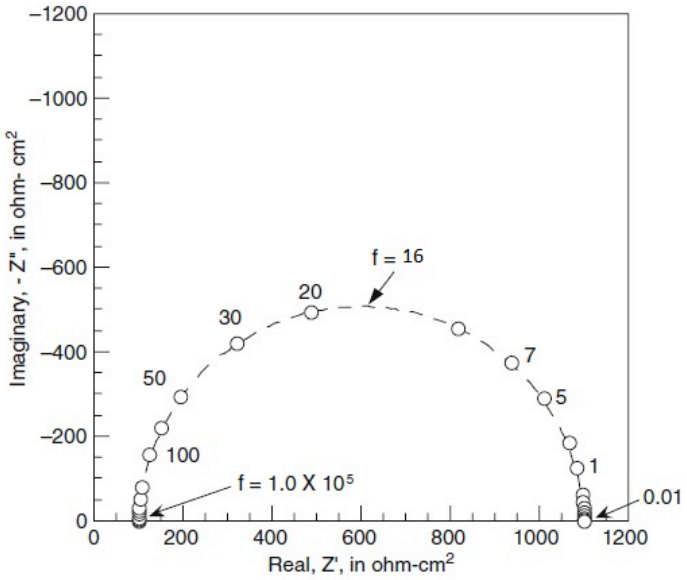

Figure 2

3. [a] Explain basic concept of sacrifly anodic protection (SACP) using a block of zinc and and a block of iron.

(40 marks)

[b] Figure 3 shows a basic explanation of corrosion protection using Pourbaix diagram for iron. Suggest there different means of corrosion protection so as to remove iron from the region of corrosion. Give your explanation based on;

(i) direction X

(20 marks)

(ii) direction Y

(20 marks)

(iii) direction Z

(20 marks)

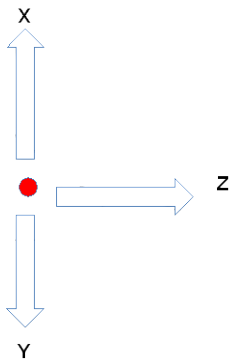

Figure 3

PART B

4. [a] What is pitting?

(20 marks)

[b] Explain how pitting is related to passive film?

(20 marks)

[c] Explain the 'critical pitting potential' (Note: use log I vs. E to help your explanation).

(60 marks)

5. A sample (diameter 50 mm and length 150 mm) was sent by AAM Metal Sdn Bhd to you for open circuit potential measurement. Explain to them what are the measurement and procedures that you are going to use;

(a) Your experimental setup (label and explain each components)

(30 marks)

(b) The expected results

(20 marks)

(c) An electrode potential was measured to be -0.500 V vs. $Cu/CuSO_4$. What is this electrode potential on the SCE scale?

(20 marks)

(d) Table 1 shows data the potential vs. SCE for open circuit measurement

(i) Using a graph paper, plot the graph potential vs. SHE for these data.

(20 marks)

(ii) Which sample is having a better corrosion resistance?

(10 marks)

Table 1

Time (days)	Potential (mV vs. SCE)	
	Sample A	Sample B
0	-442	-42
1	-542	-22
2	-642	-42
3	-692	-92
4	-792	-142
5	-792	-242
6	-842	-442
7	-842	-742
8	-842	-842
9	-842	-842
10	-842	-842

6. AAM Oil Explorer Sdn. Bhd., an oil company has sent two samples (Metal X and Metal Y) to USM in order to analyze their corrosion properties. These samples will be used in seawater application. Figure 4 shows the laboratory monitoring results of the samples.

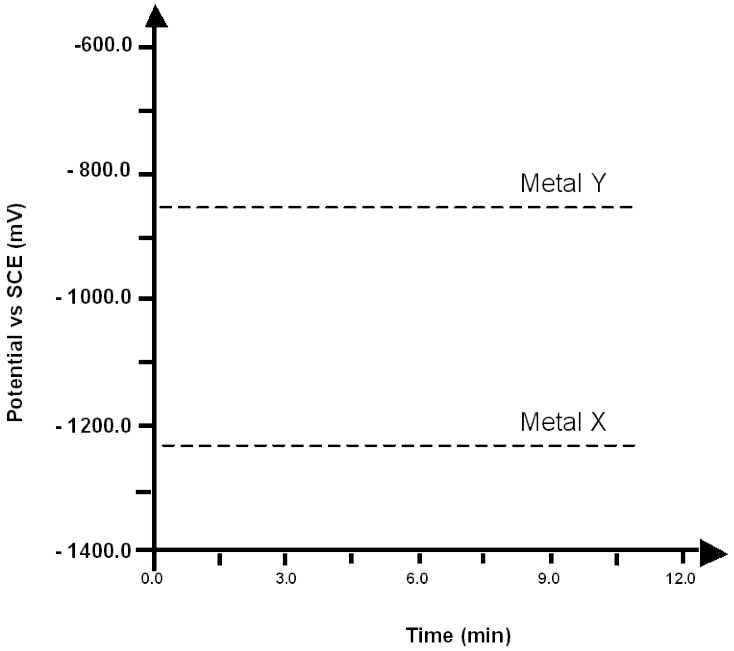

Figure 4

(a) What is the name of this measurement?

(20 marks)

(b) Design and label the basic equipment/component for this measurement.

(20 marks)

(c) Analyze and explain the result for Metal X.

(20 marks)

(d) Analyze and explain the result for Metal Y.

(20 marks)

(e) Predict and explain the result if the Metal is XY alloy?

(20 marks)

7. Figure 5 shows the results from polarization behavior of Sn-8.5Zn-0.25Ag-0.1Al-0.5Ga solders. The sample was tested in de-aerated 3.5% NaCl solution. A Pt wire and Ag/AgCl electrode were used as the counter and reference electrodes, respectively. The potential was scanned from −2000 to +100 mV at a scan rate of 1 mV/s. Based on Figure 5. Describe the reaction that occurred:

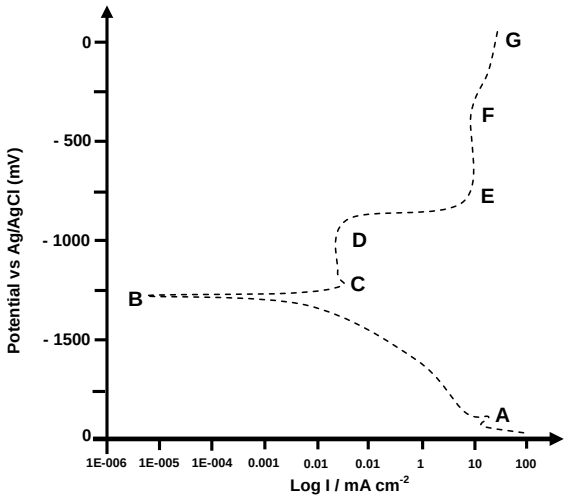

Figure 5

(i) at A-B region

(20 marks)

(ii) at B

(20 marks)

(iii) at C-D region

(20 marks)

(iv) at E-F region

(20 marks)

(v) at F-G region

(20 marks)

…9/-

Hints: Electrochemistry reactions

1. $2H_2O + 2e- \leftrightarrow 2(OH)^- + H_2$
2. $Zn + 2OH- = Zn(OH)_2 + 2e-$ $E^0_{SCE} = -1208$ mV
3. $Zn + 2OH- = ZnO + H_2O + 2e-$ $E^0_{SCE} = -1211$ mV

SCE differs from Ag/AgCl by 0.052 V

- oooOooo -

APPENDIX

Constant Value

Avogadro's constant (N_A)	6.02×10^{23} mol^{-1}
Boltzmann constant (k)	1.38×10^{-23} JK^{-1} 8.62×10^{-5} eV/atom-K
Coulomb constant (k)	$9.0 \times 10^{9} N.m^2/C^2$
Electron charge (e)	$1.60 \times 10^{-19} C$
Electron Mass (m_e)	9.11×10^{-31} kg
Faraday's constant	96500 C/mole (i.e. amp.sec/mole)
Gas constant (R)	8.3I $JK^{-1}mol^{-1}$
Gravity (g)	$9.81 ms^{-2}$
Permeability of a vacuum (μ_0)	$4\pi \times 10^{-7}$ ms^{-1}
Permittivity of a vacuum (ε_0)	8.85 x 10-12 Fm-I
Planck constant (h)	6.63×10^{-34} Js
Velocity of light in a vacuum (c)	3.00×10^{8} ms^{-1}

Periodic Table