
UNIVERSITI SAINS MALAYSIA

KSCP Examination
Academic Session 2006/2007
Peperiksaan KSCP
Sidang Akademik 2006/2007

June/Jun 2007

EBB 316/3 - Corrosions & Degradation *EBB 316/3 - Kakisan & Degradasi*

Time : 3 hours
Masa : 3 jam

Please check that this examination paper consists of NINE pages of printed material and TWO pages APPENDIX before you begin the examination.

This paper contains SEVEN questions. Translations in English are enclosed together with this script.

Answer any FIVE questions. If a candidate answers more than five questions, only the first five answers will be examined and awarded marks.

Answer to any question must start on a new page.

All questions must be answered in Bahasa Malaysia.

Sila pastikan bahawa kertas peperiksaan ini mengandungi SEMBILAN muka surat beserta DUA muka surat (Lampiran) yang bercetak sebelum anda memulakan peperiksaan.

Kertas soalan ini mengandungi TUJUH soalan. Terjemahan dalam Bahasa Inggeris ada disertakan.

Jawab LIMA soalan. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.

Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.

Semua soalan mesti dijawab dalam Bahasa Malaysia.

1. [a] Briefly describe the usefulness and limitations of thermodynamics in the study of corrosion phenomena.

Perihalkan dengan ringkas kegunaan dan had-had termodinamik dalam kajian fenomena kakisan.

(20 marks/markah)

- [b] Write electrochemical equations for the oxidation and reduction processes which occur during:

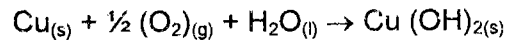
- (i) the corrosion of aluminium by air-free sulphuric acid.
- (ii) corrosion of iron in aerated sulphuric acid containing ferric sulphate.
- (iii) corrosion of copper in aerated sulphuric acid containing ferric sulphate.

Tuliskan persamaan elektrokimia untuk proses-proses pengoksidaan dan penurunan yang berlaku semasa:

- (i) *kakisan aluminium dalam asid sulfurik bebas-udara.*
- (ii) *kakisan besi dalam asid sulfurik berudara mengandungi ferik sulfat.*
- (iii) *kakisan kuprum dalam asid sulfurik berudara mengandungi ferik sulfat.*

(30 marks/markah)

- [c] Consider the possibility of corrosion of copper in aerated water at pH 7 given by the equation

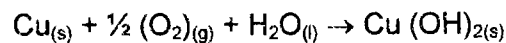


Estimate the electromotive force associated with this reaction by considering the reaction of two half-cell electrode process

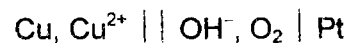


The potentials of oxygen electrode at pH 7 is +0.815V, and the solubility product of $\text{Cu} (\text{OH})_2$, $K_s = a_{\text{Cu}^{2+}} \times (a_{\text{OH}^-})^2 = 1.6 \times 10^{-19}$.

Pertimbangkan kemungkinan kakisian kuprum dalam air berudara pada pH 7 diberikan oleh persamaan



Anggarkan daya elektromotif berkaitan dengan tindakbalas ini dengan mempertimbangkan tindakbalas proses elektrod dua sel-setengah



Keupayaan elektrod oksigen pada pH 7 ialah +0.815V dan produk keterlarutan $\text{Cu}(\text{OH})_2$, $K_s = a_{\text{Cu}^{2+}} \times (a_{\text{OH}^-})^2 = 1.6 \times 10^{-19}$.

(50 marks/markah)

2. [a] List the factors affecting the choice of an engineering material and elaborate on factors affecting the corrosion properties.

Senaraikan faktor-faktor mempengaruhi pemilihan bahan kejuruteraan dan huraikan faktor-faktor yang mempengaruhi sifat kakisan.

(20 marks/markah)

- [b] What effect does oxidizer concentration have on corrosion rate of a metal with active-passive behaviour. Carefully explain your answer.

Apakah kesan kepekatan pengoksida ke atas kadar kakisan logam dengan sifat aktif-pasif. Terangkan jawapan anda dengan jelas.

(40 marks/markah)

- [c] If anodic dissolution curves were available for two active-passive metals, how would you use them to determine the relative corrosion resistance of the metals in contact with powerful oxidizers. Use hypothetical curves to illustrate your explanation.

Jika keluk pelarutan anod untuk dua logam aktif-pasif diberikan, bagaimana anda menggunakannya untuk menentukan kerintangan kakisan relatif logam di dalam larutan mengoksida yang kuat. Gunakan keluk hipotetikal untuk menerangkan jawapan anda.

(40 marks/markah)

3. [a] In corrosion kinetic, what do you understand by metal corroding in solution under activation control. Explain.

Dalam kinetik kakisan, apakah yang anda faham dengan logam terkakis dalam larutan di bawah kawalan pengaktifan. Terangkan.

(50 marks/markah)

- [b] Draw a kinetic diagram (E vs $\log i$) for metal corroding in an acid solution under activation control. Label carefully and indicate, the corrosion rate of metal, i_{corr} . What will be the effect on corrosion rate of metal by the following changes:

- (i) increase i_0 of the metal dissolution reaction?
- (ii) increase i_0 of hydrogen gas evolution reaction?
- (iii) shifting the reversible potential of metal dissolution to more noble (+ve) value?
- (iv) increase the value of β for the oxidation reaction?

Lukis gambarajah kinetik (E lwn $\log i$) untuk logam terkakis dalam larutan asid di bawah kawalan pengaktifan. Labelkan dengan jelas dan tunjukkan kadar kakisan logam, i_{kak} . Apakah kesan ke atas kadar kakisan logam berikutan perubahan-perubahan berikut:

- (i) *peningkatan i_0 tindakbalas pelarutan logam?*
- (ii) *peningkatan i_0 tindakbalas pembebasan gas hidrogen?*
- (iii) *anjakan keupayaan berbalik pelarutan logam ke suatu nilai lebih unggul (+ve)?*
- (iv) *peningkatan nilai β untuk tindakbalas pengoksidaan?*

(50 marks/markah)

4. An active-passive metal in a particular corrosion media has a primary passive potential (E_{pp}) of 0.100V (SHE), a critical anodic current density i_c of 1 mA cm^{-2} and passive current of 1 $\mu A cm^{-2}$. Sketch the appropriate diagram schematically.
- (i) what applied current is necessary to cause passivation?
 - (ii) what applied current is necessary to maintain passivity?
 - (iii) if anodic protection is applied, what is the corrosion rate?
 - (iv) if the metal is couple to a more noble metal (high i_o) what will be the influence on the corrosion resistance of this metal? Explain carefully.

Suatu logam aktif-pasif di dalam media hakis tertentu mempunyai kemampuan pasif primer (E_{pp}) 0.10V (SHE), ketumpatan arus anod kritikal, i_c 1 mA cm^{-2} dan arus pasif 1 $\mu A cm^{-2}$. Lakarkan gambarajah berkaitan secara skematik.

- (i) berapakah arus perlu dikenakan untuk menyebabkan kepasifan?*
- (ii) berapakah arus perlu dikenakan untuk mengekalkan kepasifan?*
- (iii) jika perlindungan anod dikenakan, apakah kadar kakisan logam?*
- (iv) jika logam digandingkan dengan logam yang lebih unggul (i_o tinggi), apakah kesan ke atas kerintangan kakisan logam ini. Terangkan dengan jelas.*

(100 marks/markah)

5. The corrosion potential of iron immersed in deaerated acidic solution of pH 3 is -0.720V (vs. normal calomel electrode). Calculate the corrosion rate in $\text{mg}/(\text{m}^2.\text{s})$. Assume the Tafel slope of the cathodic polarisation curve $\beta_c -0.1\text{V}/\text{decade}$, and hydrogen ion exchange current i_0 equal $1 \text{ mA}/\text{m}^2$. The potential of the normal calomel electrode is $+0.280\text{V}$ in respect to the standard hydrogen electrode. Faraday's constant equal to $96490 \text{ C}/\text{mol}$.

Keupayaan kakisan suatu besi terendam di dalam larutan asid dinyahudara pada pH 3 adalah -0.720V (lawan elektrod kalomel normal). Hitungkan kadar kakisan dalam $\text{mg}/(\text{m}^2.\text{s})$. Andaikan bahawa cerun Tafel untuk pengutuban katod $\beta_c -0.1\text{V}/\text{dekad}$, dan arus pertukaran ion untuk hidrogen i_0 adalah $1 \text{ mA}/\text{m}^2$. Keupayaan elektrod kalomel normal adalah $+0.280\text{V}$ melawan elektrod hidrogen piawai. Angkatap Faraday $96490 \text{ C}/\text{mol}$.

(100 marks/markah)

6. Refer to the Pourbaix diagram for iron in Appendix 1.
- Label the various area of corrosion, passivation, immunity.
 - Suggest how the immunity of iron can be achieved.
 - Write the equilibrium reaction corresponding to line separating Fe and Fe_3O_4 and calculate the slope dE/dpH .
 - What is line (a)?

Rujuk kepada gambajarah Pourbaix untuk besi pada Lampiran 1.

- Labelkan pelbagai kawasan kakisan, kepasifan dan imuniti.*
- Cadangkan bagaimana kemanglian besi dapat dicapai.*
- Tulis tindakbalas keseimbangan merujuk kepada garisan memisahkan Fe dan Fe_3O_4 dan hitung cerun dE/dpH garisan ini.*
- Apakah garisan (a)?*

(100 marks/markah)

7. [a] List 5 general ways to prevent corrosion.

Senaraikan 5 cara umum untuk mengelakkan kakisan.

(20 marks/markah)

- [b] What three conditions are necessary for galvanic corrosion?

Apakah tiga keadaan yang perlu dan mesti wujud untuk kakisan galvanik berlaku?

(20 marks/markah)

- [c] Interpret and explain the significance of the corrosion data as shown below:

- (i) Galvanic corrosion of a couple in 1% NaCl solution.

Tafsirkan dan terangkan signifikan data kakisan yang berikut:

- (i) Kakisan galvanik suatu gandingan dalam larutan 1% NaCl.

First Metal Logam Pertama	Corrosion Rate mg/(dm ² -d) Kadar kakisan mg/(dm ² -d)	Second Metal Logam Kedua	Corrosion Rate mg/(dm ² -d) Kadar Kakisan mg/(dm ² -d)
Iron (mild steel) Keluli lembut	183	Copper Kuprum	0
Iron (mild steel) Keluli lembut	176.1	Tungsten Tungsten	5.2
Iron (mild steel) Keluli lembut	9.8	Aluminum Aluminium	105.9
Iron (mild steel) Keluli lembut	0.4	Zinc Zink	688

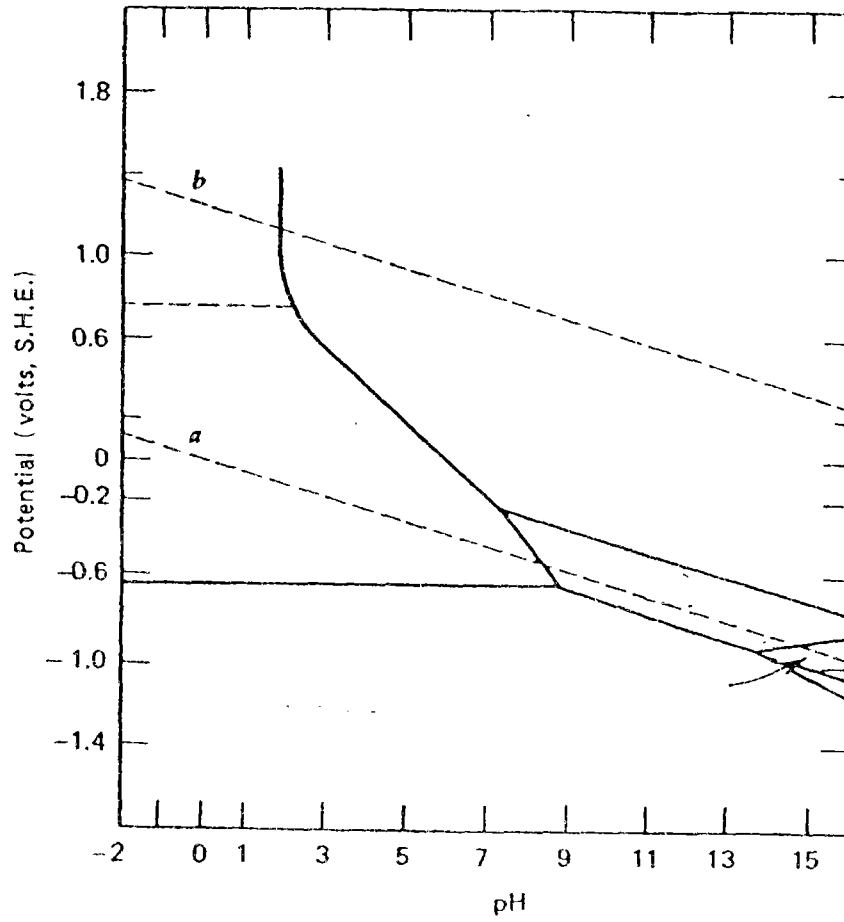
- (ii) Corrosion in 5% sulfuric acid, room temperature.

Kakisan dalam larutan asid larutan asid sulfurik 5%, pada suhu bilik.

	Air - Standard <i>Tertepu - udara</i>	Air Free <i>Tanpa udara</i>
Stainless steel <i>Keluli nirkarat</i>	0.4 mg/(dm ² -d)	54.4 mg/(dm ² -d)
67% Ni - 33% Cu (Monel)	39.0 mg/(dm ² -d)	6.5 mg/(dm ² -d)

(60 marks/markah)

LAMPIRAN 1



Pourbaix diagram for iron.

LAMPIRAN 2

Standard emf series of metals

	Metal-metal ion equilibrium (unit activity)	Electrode potential vs. normal hydrogen electrode at 25°C, volts
↑ Noble or cathodic	Au-Au ⁺³	+1.498
	Pt-Pt ⁺²	+1.2
	Pd-Pd ⁺²	+0.987
	Ag-Ag ⁺	+0.799
	Hg-Hg ₂ ⁺²	+0.788
	Cu-Cu ⁺²	+0.337
	H ₂ -H ⁺	0.000
↓ Active or anodic	Pb-Pb ⁺²	-0.126
	Sn-Sn ⁺²	-0.136
	Ni-Ni ⁺²	-0.250
	Co-Co ⁺²	-0.277
	Cd-Cd ⁺²	-0.403
	Fe-Fe ⁺²	-0.440
	Cr-Cr ⁺³	-0.744
	Zn-Zn ⁺²	-0.763
	Al-Al ⁺³	-1.662
	Mg-Mg ⁺²	-2.363
	Na-Na ⁺	-2.714
	K-K ⁺	-2.925