UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2014/2015 Academic Session

June 2015

EBB 160/3 – Physical Chemistry of Engineering Materials
[Kimia Fizikal Bahan Kejuruteraan]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains TEN printed pages before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEPULUH muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

This paper consists of SEVEN questions.
[Kertas soalan ini mengandungi TUJUH soalan.]

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

The answers to all questions must start on a new page.
[Mulakan jawapan anda untuk semua soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

In the event of any discrepancies in the examination questions, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

...2/-

1. [a] A sheet of magnesium metal weighing 15kg was placed into a beaker containing hydrochloric acid. What is the work done on the environment (1 atm, 298K) due to the reaction between Mg and the acid? (Rel.atomic mass Mg : 24.31 g/mol).

Satu kepingan logam magnesium beratnya 15kg diletakkan di dalam sebuah bikar mengandungi asid hidroklorik. Apakah kerja yang dijalankan terhadap persekitaran (1 atm, 298K) apabila Mg dan asid bertindak balas? (Jisim atom relatif Mg: 24.31 g/mol).

(40 marks/*markah*)

[b] The transformation in Manganese can be represented as:

Penjelmaan Mangan boleh diwakili seperti berikut:

$$\text{Mn}(\alpha) \xrightarrow{720^{\circ}C} \text{Mn}(\beta) \xrightarrow{1100^{\circ}C} \text{Mn}(\gamma) \xrightarrow{1136^{\circ}C} \text{Mn}(\delta)$$

Calculate the heat of reaction when Mn (δ) is oxidised by pure oxygen to form MnO at 1200°C.

Hitungkan haba tindak balas apabila Mn(δ) dioksidakan oleh oksigen tulin membentuk MnO pada suhu 1200°C.

Given:

Diberi:

$$Mn(\alpha) + \frac{1}{2}(O_2) \rightarrow MnO;$$

$$\Delta H^{0}_{298} = -384{,}928 J/mol$$

$$Mn(\alpha) \rightarrow Mn(\beta);$$

$$\Delta H_f = 2.0 kJ/mol$$

$$Mn(\beta) \rightarrow Mn(\gamma);$$

$$\Delta H_f = 2.30 kJ/mol$$

$$Mn(\gamma) \rightarrow Mn(\delta);$$

$$\Delta H_f = 1.80 kJ/mol$$

$$C_p Mn(\alpha) = 21.59 + 15.94x10^{-3}T \ J/K/mol$$

$$C_p Mn(\beta) = 34.85 + 2.76x10^{-3}T \ J/K/mol$$

$$C_p Mn(\gamma) = 44.77 J/K/mol$$

$$C_p Mn(\delta) = 47.28 J/K/mol$$

$$C_p MnO = 46.44 + 8.12x10^{-3}T - 3.68x10^{5}T^{-2} \ J/K/mol$$

$$C_p O_2 = 29.96 + 4.184x10^{-3}T - 1.67x10^{5}T^{-2} \ J/K/mol$$

(60 marks/*markah*)

...4/-

2. [a] The normal melting point of aluminium is 931.7K with heat of fusion of 10.76 kJmol^{-1}. Calculate the entropy change for the solidification of aluminium at 931.7K.

Takat lebur normal aluminium ialah 931.7K dan haba pelakuran pula ialah 10.76 kJmol^{-1}. Hitungkan perubahan entropi bagi pemejalan aluminium pada suhu 931.7K.

(25 marks/*markah*)

[b] If super-cooled aluminium solidifies at 930K, find the entropy change in aluminium. Given:

Jika penyejukan lampau aluminium memejal pada suhu 930K, cari perubahan entropi dalam aluminium. Diberi:

Al (s) : $C_p = 20.7 + 12.4 \times 10^{-3}$ T J K^{-1} mol^{-1}

Al (l) : $C_p = 29.3$ J K^{-1} mol^{-1}

(45 marks/*markah*)

[c] If the surrounding for the aluminium in (b) is at a temperature slightly less than 903K, calculate the entropy change in the surrounding and that of the isolated system.

Jika persekitaran aluminium pada (b) adalah pada suhu kurang sedikit daripada 903K, hitungkan perubahan entropi pada persekitaran tersebut dan sistem terpencil.

(30 marks/*markah*)

3. [a] If FeO is required to be reduced by solid carbon at 600°C,what is the maximum pressure of CO, CO_2 and O_2 necessary for the process to take place, given the following data:

Jika FeO memerlukan karbon pepejal untuk diturunkan pada suhu 600°C, apakah tekanan maksima CO, CO_2 dan O_2 yang diperlukan untuk tindak balas tersebut berlaku, diberikan data berikut:

$FeO (s) = Fe (s) + 1/2O_2 (g)$	$\Delta G^\circ = 259,600 - 62.55$ T Joules
$C (s) + O_2 (g) = CO_2 (g)$	$\Delta G^\circ = -394,100 - 0.84$ T Joules
$2C (s) + O_2 (g) = CO (g)$	$\Delta G^\circ = - 223,400 - 175.3$ T Joules
$2CO (g) + O_2 (g) = 2CO_2 (g)$	$\Delta G^\circ = - 564,800 - 173.6$ T Joules
$C (s) + CO_2 (g) = 2CO(g)$	$\Delta G^\circ = 170,700 - 174.5$ T Joules

(70 marks/*markah*)

[b] What do you understand about the following terms as used in chemical thermodynamics:

(i) Non-state function
(ii) Gibb's Free Energy
(iii) Dissociation temperature

Apakah yang anda fahami mengenai terma berikut yang diguna pakai di dalam termodinamik kimia:

(i) Fungsi bukan keadaan
(ii) Tenaga Bebas Gibbs
(iii) Suhu penceraian

(30 marks/*markah*)

4. [a] Chromium and carbon found in steel formed chromium carbide at 600°C. Based on thermodynamic calculation select which of the following elements Si, Ti and V should be alloyed with steel in order to prevent the formation of chromium carbide.

Kromium dan karbon hadir dalam keluli tahan karat membentuk kromium karbida pada suhu 600°C. Tunjukkan melalui pengiraan termodinamik mana satukah antara logam-logam Si, Ti dan V yang perlu dialoikan kepada keluli tahan karat bagi menghalang pembentukan kromium karbida.

Given:
Diberi:

$3Cr + 2C \rightarrow Cr_3C$	ΔG° = -87,027 – 16.74 T Joules
$Si + C \rightarrow SiC$	ΔG° = -53,430 – 6.95 T Joules
$V + C \rightarrow VC$	ΔG° = - 83,680 + 6.69 T Joules
$Ti + C \rightarrow TiC$	ΔG° = -188,280 + 11.71 Joules

(40 marks/*markah*)

[b] Calculate the standard free energy change for the following reaction Pb (l) + ½ O_2 (g) → PbO (s) at 527°C given the following data:

$$\Delta H^0_{298,PbO(S)=} - 220{,}080 \ J/mol$$

$$\Delta H^0_{800,PbO(l)=} - 220{,}424.4 \ J/mol$$

$$\Delta S^0_{298,PbO(S)} = 68.04 \ J/K/mol$$

$$\Delta S^0_{298,Pb(S)} = 65.1 \ J/K/mol$$

$$\Delta S^0_{298,O2(g)} = 205.88 \ J/K/mol$$

$$C_{P,PbO(S)} = 44.52 + 16.8x10^{-3} \ T \ J/K/mol$$

$$C_{P,Pb(S)} = 23.65 + 9.79x10^{-3} \ T \ J/K/mol$$

$$C_{P,Pb(l)} = 32.55 - 3.108x10^{-3} \ T \ J/K/mol$$

$$C_{P,O2(g)} - 30.07 + 4.2x10^{-3}T - 1.68x10^{5}T^{-2} \ J/K/mol$$

Melting point of Pb, T_m = 327°C

Latent heat of fusion, Pb, L_f = 4830 J/mol

(60 marks/*markah*)

5. [a] Define a catalyst.

Takrifkan pemangkin.

(15 marks/*markah*)

[b] List two examples of first order reactions and prove that $\ln \frac{A_o}{A} = k\ t$ or $[A] = [A]_o e^{-kt}$ for a first order reaction.

Senaraikan dua contoh tindakbalas tertib pertama dan buktikan $\ln \frac{A_o}{A} = k\ t$ *atau* $[A] = [A]_o e^{-kt}$ *bagi sesuatu tindakbalas tertib pertama.*

(50 marks/*markah*)

[c] The rate constant of a first-order reaction is 3.5×10^{-2} minute^{-1}. Predict the time taken for half the initial concentration to react.

Pemalar kadar bagi sesuatu tindakbalas tertib pertama adalah 3.5×10^{-2} *minit*$^{-1}$. *Hitungkan masa yang akan diambil supaya tindakbalas mencapai separuh kepekatan asalnya.*

(35 marks/*markah*)

6. [a] List the three rates that an overall reaction rate depend on.
Senaraikan tiga kadar yang menjejaskan kadar tindakbalas am.

(15 marks/*markah*)

[b] Define half-life of a reaction and show that $t_{1/2} = \frac{[A]_0}{2k}$ for a zero order reaction

Takrifkan separuh hayat sesuatu tindak balas dan tunjukkan bahawa $t_{1/2} = \frac{[A]_0}{2k}$ *bagi sesuatu tindakbalas tertib sifar.*

(30 marks/*markah*)

[c] The specific reaction rates of a chemical reaction at 273 K and 303 K are respectively 2.45 x 10^{-5} and 162 x 10^{-5}. Estimate the activation energy of the reaction.

Kadar tindakbalas spesifik sesuatu tindakbalas kimia pada 273 K dan 303 K adalah 2.45 x 10^{-5} dan 162 x 10^{-5} masing-masing. Kirakan tenaga pengaktifan tindak balas tersebut.

(55 marks/*markah*)

7. [a] During the charging of the lead storage cell, the following reaction takes place:

$2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 2H_2SO_4(aq)$

Given n=2, ΔG^o_{298} (kJ mol^{-1}) = -813.14 for $PbSO_4(s)$, -237.129 for $H_2O(l)$, 0 for Pb(s), -217.33 for $PbO_2(s)$, and -744.53 for $H_2SO_4(aq)$. Calculate the change of Gibbs free energy and E^o for this reaction. Predict if this reaction is spontaneous under standard conditions, or if an outside source of energy is required for it to proceed.

Semasa mengecas sel storan plumbum, tindak balas berikut berlaku:

$2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 2H_2SO_4(aq)$

Diberi n=2, ΔG^o_{298} (kJ mol^{-1}) = -813.14 for $PbSO_4$ (s), -237.129 for $H_2O(l)$, 0 for Pb(s), -217.33 for $PbO_2(s)$, dan -744.53 for $H_2SO_4(aq)$. Hitung perubahan tenaga bebas Gibbs dan E^o untuk tindak balas ini. Ramalkan samaada tindakbalas ini adalah spontan di bawah keadaan piawai, atau sumber tenaga luar perlu untuk diteruskan.

(40 marks/*markah*)

[b] Based on the Table 1,

Berdasarkan Jadual 1,

(i) Sketch Λ against $C^{1/2}$ using the graph paper provided.

Lakarkan Λ melawan $C^{1/2}$ menggunakan kertas graf yang disediakan.

(20 marks/*markah*)

(ii) Determine the molar conductivity at infinite dilution, Λ_o for CH_3COOH.

Tentukan kekonduksian molar pada pencairan infiniti, Λ_o untuk CH_3COOH.

(20 marks/*markah*)

(iii) Calculate percentage of ionization in 0.01M solution of CH_3COOH with Λ =14.3 Scm^2mol^{-1}.

Kirakan peratusan pengionan dalam 0.01M larutan CH_3COOH dengan Λ =14.3 Scm^2mol^{-1}.

(20 marks/*markah*)

Table 1: Molar Conductivity of the solutions for various concentration at 25°C

Jadual 1: Kekonduksian Molar bagi larutan untuk kepekatan berlainan pada 25°C

Concentration of the solution, (M) *Kepekatan larutan, (M)*	Molar Conductivity (Scm^2mol^{-1}) *Kekonduksian molar (Scm^2mol^{-1})*		
	HCl	$Na(CH_3COO)$	NaCl
0.005	422.74	89.2	124.50
0.001	421.36	88.5	123.74
0.01	412.00	83.76	118.51
0.1	391.32	72.80	106.74

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