Second Semester Examination
Academic Session 2019/2020

June 2020

EBB 160/3 – Kimia FizikalBahanKejuruteraan
[Physical Chemistry of Engineering Materials]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains ELEVEN (11) printed pages before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEBELAS (11) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions : Answer **FIVE (5)** questions. **Part A is COMPULSORY**. Answer **TWO (2)** questions from PART B. All questions carry the same marks.

*[**Arahan :** Jawab **LIMA (5)** soalan. **Bahagian A WAJIB dijawab**. Jawab **DUA (2)**soalandari BAHAGIAN B. Semua soalan membawa jumlah markah yang sama.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai].

PART A / *BAHAGIAN A*

(1). (a) Using an appropriate diagram, briefly explain the difference between the work done by a system during a multi-stage irreversible and reversible expansion.

Menggunakan diagram yang bersesuaian, terangkan secara ringkas perbezaan antara kerja yang dilakukan oleh suatu system semasa pengembangan berbilang bagi peringkat berbalik dan tidak berbalik

(6 marks / *markah*)

(b) A system moves from state A to state B as shown in Figure 1. When the system takes path 1, 500 J of heat flow into the system and 200 J of work done by the system.

Suatu sistem bergerak dari keadaan A ke keadaan B seperti yang ditunjukkan dalam Rajah 1. Apabila sistem mengambil jalan 1, 500 J haba mengalir ke dalam sistem dan 200 J kerja dilakukan oleh sistem.

(i) Calculate the change of the internal energy.
Kirakan perubahan tenaga dalaman.

(2 marks / *markah*)

(ii) If the system takes path 2, 100 J of work is done by the system. How much heat flows into the system.

Jika sistem tersebut mengambil jalan 2, 100 J kerja dilakukan oleh sistem. Berapa banyak haba mengalir ke dalam sistem.

(2 marks / *markah*)

(iii) Now the system returns from state B to state A via path 3. 100 J of work is done on the system. Calculate the heat flow.

Sekarang sistem tersebut kembali dari keadaan B kepada keadaan A melalui jalan 3. 100 J kerja dilakukan ke atas sistem. Kirakan aliran haba.

(2 marks / *markah*)

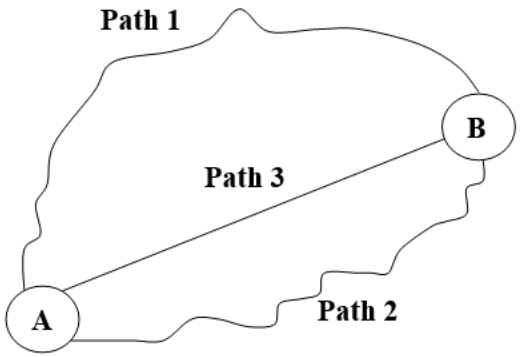

Figure 1 / *Rajah 1*

(c) Calculate the standard heat of formation of PbO from Pb and O_2 at 227°C from the following data:

Kira haba piawai bagi pembentukan PbO dari Pb dan O_2 pada 227°C daripada data berikut:

ΔH^{o}_{298} (PbO) = -219.24 kJ/mol

C_p (PbO) = 44.35 + 16.74 x 10^{-3} T J/K/mol

C_p (Pb) = 23.56 + 9.75 x 10^{-3} T J/K/mol

C_p (O_2) = 29.96 + 4.184 x 10^{-3} T - 1.67 x 10^{5} T^{-2} J/K/mol

(8 marks / *markah*)

(2). (a). Chromium metal can be electroplated from a water solution of potassium dichromate and the reduction half reaction is

Logam Kromium boleh disadurkan daripada larutan air kalium dikromat dan reaksi pengurangan separa adalah

$$Cr_2O_7^{2-}(aq)+14H^+(aq)+ 12e^- \rightarrow 2Cr(s) + 7H_2O$$

(i). Calculate how many grams of chromium will be platted by 1.00 x 10^4 C?
Kira berapa gram kromium yang akan tersadur pada 1.00 x 10^4 C?

(ii). Estimate how long will it take to plate one gram of chromium using a current of 6.00 A?

Anggar berapa lama diperlukan untuk membakar satu gram kromium yang menggunakan arus 6.00 A?

(iii). If the applied voltage is 4.5V, calculate how many kilowatt hours of electric energy are required to plate 1.00 g of Cr? (1kWh=3.60x10^6J)

Jika voltan yang digunakan ialah 4.5V, kira berapa kilowatt jam tenaga elektrik diperlukan untuk menyadur 1.00 g Cr? (1kWh = 3.60x10^6J)

(8 marks/*markah*)

(b). Define molar conductivity of an electrolyte and refer to data in Table 1 to answer the followings:

Tentukan kekonduksian molar elektrolit dan rujuk kepada data dalam Jadual 1 untuk menjawab perkara berikut:

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(i). Sketch Λ against $C^{1/2}$ using the graph paper provided.
Lakarkan Λ terhadap $C^{1/2}$ menggunakan kertas graf yan disediakan.

(ii). Determine the molar conductivity at infinite dilution, Λ_o for CH3COOH.
Tentukan kekonduksian molar pada pencairan tak terhingga, Λ_o untuk CH_3COOH.

(iii). Calculate percentage of ionization in 0.01M solution of CH3COOH with Λ =14.3 Scm^2mol^{-1}.
Kirakan peratusan pengionan dalam penyelesaian 0.01M CH3COOH dengan Λ = 14.3 Scm^2mol^{-1}.

(12 marks/*markah*)

Table 1: Molar conductivity of various substance at different concentration of the solution
Jadual 1: Kekonduksian molar pelbagai bahan pada kepekatan larutan yang berbeza

Concentration of the solution, (M) *Kepekatan larutan (M)*	Molar Conductivity (Scm^2mol^{-1}) *Kekonduksian Molar (Scm^2mol^{-1})*		
	HCl	$Na(CH_3COO)$	NaCl
0.0005	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

(3). (a). If the half-life of a first order reaction is 19.8 minutes, calculate the rate constant, *k*.

Sekiranya separuh hayat sesuatu tindakbalas tertib pertama ialah 19.8 min, kirakan pemalar kadar, k.

(6 marks/*markah*)

(b). The specific reaction rates of a chemical reaction at 273 K and 303 K are respectively 2.45×10^{-5} and 162×10^{-5}. Calculate the activation energy of the reaction.

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

(14 marks/*markah*)

PART B / *BAHAGIAN B*

(4). (a) Briefly explain the importance of Clausius-Clapeyron equation.
Terangkan secara ringkas kepentingan persamaan Clausius-Clapeyron.
(4 marks / *markah*)

(b) Tin (Sn) transforms from grey to white tin at 286 K. The heat of transformation (ΔH_t) has been measured as 2.1 kJ/mol.

Timah (Sn) bertukar dari kelabu ke timah putih pada 286 K. Haba transformasi (ΔH_t) telah diukur iaitu 2.1 kJ / mol.

$$Sn\ (grey, 286\ K) \rightarrow Sn\ (white, 286\ K)$$

(i) Calculate the entropy change of the system (Tin).
Kirakan perubahan entropi dalam system tersebut (Timah).
(3 marks / *markah*)

(ii) Calculate the entropy change of the surroundings.
Kirakan perubahan entropi persekitaran.
(3 marks / *markah*)

(iii) Calculate the total entropy change of the universe (system + surroundings).

Kiraka nperubahan entropi keseluruhan semesta (sistem + persekitaran)
(4 marks / *markah*)

(b) Calculate the enthalpy for this reaction:
Kirakan entalpi untuk tindakbalas berikut:

$$2C(s) + H_2(g) \rightarrow C_2H_2(g)$$

Given the following thermochemical equations:
Diberikan persamaan termokimia seperti berikut:

$C_2H_2(g) + (5/2)O_2(g) \rightarrow 2CO_2(g) + H_2O(\ell)$ $\Delta H° = -1299.5$ kJ

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H° = -393.5$ kJ

$H_2(g) + (1/2)O_2(g) \rightarrow H_2O(\ell)$ $\Delta H° = -285.8$ kJ

(6 marks / *markah*)

(5). (a) Briefly explain the types of thermodynamic systems. Give ONE example for each type of the system.

Terangkan secara ringkas jenis-jenis sistem termodinamik. Berikan SATU contoh bagi setiap jenis sistem.

(6 marks / *markah*)

(b) Chromium and carbon in stainless steel form chromium carbide at 600^oC. Show by thermodynamic calculation which of the metals among Si, Ti, and V should be alloyed to stainless steel so as to prevent the formation of chromium carbide.

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

Given / *Diberi:*

$3Cr+2C= Cr_3C_2$

ΔG^o= -87,027 -16.74T J

Si +C=SiC

ΔG^o = -53,430 -6.95 T J

V + C = VC

ΔG^o = -83,680 -6.69 T J

Ti +C =TiC

ΔG^o = -188,280 +11 .71 T J

(4 marks / *markah*)

(c) One mole of supercooled liquid copper crystallizes to solid copper spontaneously at a constant temperature of 1000 K. Calculate the heat released during this process. The following thermodynamics informations are given about copper:

Satu mol cecair super-dingin kuprum menghablur kepada pepejal kuprum secara spontan pada suhu tetap 1000 K. Kirakan haba yang dibebaskan semasa proses tersebut. Maklumat termodinamik mengenai kuprum adalah seperti berikut:

The melting point of copper (at 1 atm) / *Takat lebur kuprum (pada 1 atm)* = 1356 K

The latent heat of fusion at 1356 K / *Haba pendam pelakuran pada 1356 K* = 13 kJ/mol

The heat capacity of solid copper at 1 atm / *Kapasiti haba kuprum pepejal pada 1 atm* = 22.6 - 6.3 x 10^{-3} T J mol^{-1} K^{-1}

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The heat capacity of the super-cooled copper melt / *Kapasiti haba cecair super-dingin kuprum* = 31.4 J mol^{-1} K^{-1}

(10 marks / *markah*)

(6). (a). Derive an equation that explains the relationship between the electromotive force (emf) of an electrochemical cell and the spontaneity of the chemical reaction. Explain when the reaction will be spontaneous, in equilibrium and nonspontaneous.

Terbitkan persamaan yang menerangkan hubungan antara daya elektromotif (emf) sel elektrokimia dan tindak balas spontan kimia. Jelaskan bila reaksi akan menjadi spontan, dalam keseimbangan dan tidak spontan.

(6 marks/*markah*)

(b). Electrolytic decomposition of fused $MgCl_2$ is as follows:

Penguraian elektrolit $MgCl_2$ lakur adalah seperti berikut:

$MgCl2 \rightarrow Mg\ (s) + Cl_2\ (g)$

$\Delta G^o = 618.9 + 0.057\ T \log T - 0.30\ T$ kJ

Calculate the decomposition voltage $MgCl_2$ at 700°C. Although the melting point is 712°C for $MgCl_2$, it is assumed it is in the liquid state as it is in the liquid solution. Also assume that the fused salt solution used as the electrolyte is saturated with $MgCl_2$

Kira voltan penguraian $MgCl_2$ pada 700°C. Walaupun takat lebur adalah 712°C, Ia di andaikan dalam keadaan cecair seperti dalam larutan cecair. Juga andaikan bahawa larutan garam terlakur yang digunakan sebagai elektrolit adalah tepu dengan $MgCl_2$.

(7 markah)

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(b). For a cell, with the following reaction Ag + HgCl = AgCl + Hg, at 25 ° C, have d.g.e 0.0455 V and the temperature coefficient of 3:38 x10^{-4} V/K. Determine ΔG_o, ΔS_o, ΔH_o for the above reaction

Bagi satu sel, dengan tindak balas berikut Ag + HgCl = AgCl + Hg, pada 25 ° C, mempunyai d.g.e 0.0455 V dan pekali suhu 3:38 x10^{-4} V/K. Angarkan ΔG_o, ΔS_o, ΔH_o untuk tindakbalas di atas

(7 marks/*markah)*

(7). (a) . Name 4 factors that have an effect on reaction rates.
Namakan 4 faktor yang mempengaruhi kadar tindakbalas.

(4 marks/*markah*)

(b). In a second-order reaction, where the initial concentration of the reactants is the same, half of the reactants are consumed in 60 minutes.
If the rate constant is 5.2 x 10^{-3} $mol^{-1}Lmin^{-1}$, what is the initial concentration of the reactants?

Dalam sesuatu tindakbalas tertib kedua, di mana kepekatan awal bahan tindakbalas adalah sama, separuh bahan tindakbalas digunakan dalam 60 minit.
Jika pemalar kadar adalah 5.2 x 10^{-3} $mol^{-1}Lmin^{-1}$, apakah kepekatan awalnya.

(6 marks/markah)

(c). 75% of the first-order reaction was completed in 32 minutes. Estimate the time taken for 50% of the reaction to be completed ?

75% sesuatu tindakbalas tertib pertama lengkap dalam masa 32 minit. Anggarkan masa untuk lengkapkan 50% tindakbalas.

(10 marks/*markah*)

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