UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2009/2010

April/May 2010

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 EIGHT printed pages before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi LAPAN muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

This paper consists of ONE question from PART A and SIX questions from PART B.
[Kertas soalan ini mengandungi SATU soalan dari BAHAGIAN A dan ENAM soalan dari BAHAGIAN B.]

Instruction: Answer **ONE** question from PART A and **FOUR** questions from PART B. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab **SATU** soalan dari BAHAGIAN A dan **EMPAT** soalan dari BAHAGIAN B. 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, the English version must be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

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PART A / *BAHAGIAN A*

1. [a] Sketch a galvanic cell and explain in brief the working principle of the galvanic cell.

Lakarkan sel galvanik dan terangkan dengan ringkas prinsip kerjanya.

(50 marks/*markah*)

[b] One mole of ammonia (considered to be a perfect gas) initially at 25°C and 1 bar pressure is heated at constant pressure until volume has trebled. Calculate:

(i) Heat change, q

(ii) Work done, w

(iii) Enthalpy change, ΔH

(iv) Internal energy change, ΔU

given: $C_p = 25.895 + 32.998 \times 10^{-3}T - 30.461 \times 10^{-7}T^2$ JK^{-1} mol^{-1}

Satu mol gas ammonia (pertimbangan gas ini sebagai gas sempurna) bermula pada suhu 25°C dan tekanan 1 bar telah dipanaskan ke tekanan tetap sehingga isipadu menjadi tiga kali ganda. Hitung:

(i) Haba, q

(ii) Kerja yang berlaku, w

(iii) Perubah entalpi, ΔH

(iv) Perubah tenaga dalaman, ΔU

diberi: $C_p = 25.895 + 32.998 \times 10^{-3}T - 30.461 \times 10^{-7}T^2$ JK^{-1} mol^{-1}

(50 marks/*markah*)

PART B / *BAHAGIAN B*

2. [a] List down the formula and the unit (in SI) for the following reactions:

(i) A zero-order reaction.

(ii) A first-order reaction.

(iii) A second-order reaction.

Senaraikan formula dan unit (dalam unit SI) bagi tindakbalas berikut:

(i) Tindak balas tertib sifar.

(ii) Tindak balas tertib pertama.

(iii) Tindak balas tertib kedua.

(15 marks/*markah*)

[b] Name 5 factors that have an effect on reaction rates.

Nyatakan 5 faktor yang memberi kesan ke atas kadar tindak balas.

(25 marks/*markah*)

[c] From the equation $-\frac{d[A]}{dt} = \kappa[A]$ prove that ln [A] vs t is a linear graph of a first-order reaction; and the half-life period of a first order reaction, $t_{0.5}$ = 0.6932/k, where k = rate constant.

Daripada persamaan $-\frac{d[A]}{dt} = \kappa[A]$ *buktikan ln [A] melawan t merupakan suatu graf linear bagi tindak balas tertib pertama; dan tempoh separuh hayatnya* $t_{0.5} = 0.6932/k$, *disini k = nilai pemalar.*

(60 marks/*markah*)

3. [a] If reaction A → products is zero-order, sketch [A] vs t with help of relevant equations.

Jika tindak balas A → produk adalah tertib sifar, lakarkan [A] vs t dengan bantuan persamaan berkenaan.

(40 marks/*markah*)

[b] The activation energy for the reaction:
$2N_2O_5$ (aq) → $2N_2O_4$ (aq) + O_2 (g) is 100 kJ mol^{-2}. The rate constant of the reaction is 2.35 x 10^{-4} s^{-1} at 293 K. What is the rate constant of the reaction at 303 K?
Gas constant is given as 8.314J K^{-1} mol^{-1}.

Tenaga pengaktifan bagi tindak balas:
$2N_2O_5$ (aq) → $2N_2O_4$ (aq) + O_2 (g) adalah 100 kJmol^{-2}. Pemalar kadar bagi tindakbalas adalah 2.35 x 10^{-4} s^{-1} pada 293 K. Apakah pemalar kadar tindak balas ini pada 303 K?
Pemalar gas diberi sebagai 8.314J K^{-1} mol^{-1}.

(60 marks/*markah*)

4. [a] (i) Define what is meant by electrolysis.

Takrifkan apa yang dimaksudkan dengan elektrolisis.

(30 marks/*markah*)

(ii) Name 2 factors that affect the hydration degree.

Namakan 2 faktor yang mempengaruhi darjah penghidratan.

(10 marks/*markah*)

[b] Calculate the ionic strength I_m of a solution that contains 0.0100 mol KCl, 0.0050 mol $MgCl_2$, 0.0020 mol $MgSO_4$, and 100 g H_2O.

Hitungkan kekuatan ionik I_m dalam larutan yang mengandungi 0.0100 mol KCl, 0.0050 mol $MgCl_2$, 0.0020 mol $MgSO_4$, dan 100 g H_2O.

(60 marks/*markah*)

5. For the equilibrium ZnO(s) + C (s) ⇌ Zn(s) +CO (g).

Bagi keseimbangan persamaan ZnO(s) + C (s) ⇌ Zn(s) +CO (g).

[a] Deduce the direction in which the reaction would be feasible at 300 K and 1500 K, when all reactants and products are in their standard states (i.e. unit activities).

Simpulkan arah mana tindakbalas pada suhu 300 dan 1500K boleh berlaku apabila semua reaktan dan produk berada pada keadaan piawai (dalam unit aktiviti).

(30 marks/*markah*)

[b] Calculate equilibrium constant K_p, for the reaction using the relationship $\Delta G^o = \Delta H^o - T\Delta S^o$ for the reaction.
Given enthalpies and entropies of reaction:

Hitung pemalar keseimbangan K_p bagi tindakbalas yang menggunakan kaitan persamaan $\Delta G^o = \Delta H^o - T\Delta S^o$.

ΔH_{400} = + 70 kJ mol^{-1} ΔH_{1500} = + 200 $kJ.mol^{-1}$

ΔS_{400} = + 18.5 $JK^{-1}mol^{-1}$ ΔS_{1500} = + 288.6$JK^{-1}mol^{-1}$

(30 marks/*markah*)

[c] Derive the Gibb – Helmholtz equation:

Terbitkan persamaan Gibbs – Helmholtz:

$$\left[\partial \frac{\left[(\Delta G / T)\right]}{\partial T}\right]_p = -\frac{\Delta H}{T^2}$$

(40 marks/*markah*)

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6. [a] Calculate enthalpy for one mole of platinum initially at 300K and one atmosphere pressure is taken through an isobaric process in temperature to 1000K.

Given volume of platinum V (300K, 1 atm) = 9.10 (cc/mol). Coefficient of thermal expansion α = 27X 10^{-6} (1/T):

$$C_p = 24.69 + 5.02x10^{-3}T\frac{-0.50x10^5}{T^2} \text{ (J mol}^{-1}\text{ K}^{-1}\text{)}$$

Hitung entalpi bagi satu mol platinum yang dipanaskan secara proses isobarik dari suhu 300K pada tekanan 1 atm ke suhu 1000K.

Diberi isipadu platinum V (300K, 1atm) = 9.10 (cc/mol). Pekali pengembangan terma α = 27 X 10^{-6}(1/T):

$$C_p = 24.69 + 5.02x10^{-3}T\frac{-0.50x10^5}{T^2} \text{ (J mol}^{-1}\text{ K}^{-1}\text{)}$$

(60 marks/*markah*)

[b] Derive the expression to show how the heat capacity varies with pressure is related to the coefficient of thermal expansion for a system is given by Maxwell relation:

$$\left[\frac{\partial\left(C_p/T\right)}{\partial P}\right]_T = \left[\frac{\partial\left(-V\alpha\right)}{\partial T}\right]_P$$

Terbitkan sebutan yang dapat menunjukkan hubungan muatan haba dengan tekanan itu berkait dengan pekali perkembangan terma bagi suatu sistem dapat diberikan oleh persamaan Maxwell:

$$\left[\frac{\partial\left(C_p/T\right)}{\partial P}\right]_T = \left[\frac{\partial\left(-V\alpha\right)}{\partial T}\right]_P$$

(40 marks/*markah)*

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7. [a] What is a colloidal system?
Describe briefly 3 of the colloidal systems and give two examples for each system.

Apakah itu sistem koloid?
Perihalkan secara ringkas 3 daripada sistem utamanya dan berikan dua contoh untuk setiap sistem tersebut.

(20 marks/*markah*)

[b] The following data refer to the adsorption at 77K of nitrogen on 0.92g of a clay sample, p/p_o being relative pressure and V the volume adsorbed.

p/p_o	0.037	0.084	0.150	0.233	0.311	0.377	0.453	0.541
V/cm^3 (s.t.p)	82	106	124	142	157	173	196	227

Data berikut merujuk kepada jerapan gas nitrogen 0.92g ke atas sampel tanah liat pada suhu 77K, p/p_o ialah tekanan relatif dan V ialah isipadu jerapan.

p/p_o	*0.037*	*0.084*	*0.150*	*0.233*	*0.311*	*0.377*	*0.453*	*0.541*
V/cm^3 (s.t.p)	*82*	*106*	*124*	*142*	*157*	*173*	*196*	*227*

Calculate the monolayer capacity (V_m) by 'point B' and B.E.T methods. Use, (V_m) value from BET, to calculate the specific surface area for the clay sample, taking the cross section molecular area of nitrogen as 16.2 $x10^{-20}$ m^2.

Hitung kapasiti jerapan monolapisan (V_m) secara kaedah titik B dan kaedah B.E.T. Dengan menggunakan V_m nilai BET, hitung luas pemukaan spesifik bagi tanah liat tersebut, dengan mengambil kira luas keratan rentas molekul nitrogen adalah 16.2 $X10^{-20}$ m^2.

(80 marks/*markah*)

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