UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2010/2011

April/May 2011

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 NINE printed pages before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEMBILAN 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 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 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.]

…2/-

PART A / *BAHAGIAN A*

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

Kadar pemalar bagi tindakbalas tertib pertama adalah 3.5 x 10^{-2} minit^{-1}. Hitungkan masa yang diambil untuk tindakbalas kepekatan separuh daripada kepekatan awal.

(25 marks/*markah*)

[b] Calculate the standard emf of the cell below:

$$Cd \mid Cd^{2+}_{(a=1)} \parallel Cu \mid Cu^{2+}_{(a=1)}$$

Kirakan emf sel piawai bagi sel di bawah:

$$Cd \mid Cd^{2+}_{(a=1)} \parallel Cu \mid Cu^{2+}_{(a=1)}$$

Electrode	Oxidation reaction	Standard potential (volts)	Nature
$Li \mid Li^+$	$Li \longrightarrow Li^+ + e^-$	+3.040	reducing agents
$K \mid K^+$	$K \longrightarrow K^+ + e^-$	+2.924	
$Ca \mid Ca^{2+}$	$Ca \longrightarrow Ca^{2+} + 2e^-$	+2.870	
$Na \mid Na^+$	$Na \longrightarrow Na^+ + e^-$	+2.710	
$Al \mid Al^{3+}$	$Al \longrightarrow Al^{3+} + 3e^-$	+1.660	
$Zn \mid Zn^{2+}$	$Zn \longrightarrow Zn^{2+} + 2e^-$	+0.762	
$Fe \mid Fe^{2+}$	$Fe \longrightarrow Fe^{2+} + 2e^-$	+0.441	
$Cd \mid Cd^{2+}$	$Cd \longrightarrow Cd^{2+} + 2e^-$	+0.403	
$Ni \mid Ni^{2+}$	$Ni \longrightarrow Ni^{2+} + 2e^-$	+0.236	
$Sn \mid Sn^{2+}$	$Sn \longrightarrow Sn^{2+} + 2e^-$	+0.140	
$Pb \mid Pb^{2+}$	$Pb \longrightarrow Pb^{2+} + 2e$	+0.126	
$Pt \mid H_2 \mid H^+$	$H_2 \longrightarrow 2H^+ + 2e^-$	0.000	
$Cu \mid Cu^{2+}$	$Cu \longrightarrow Cu^{2+} + 2e^-$	-0.337	oxidising agents
$Ag \mid Ag^+$	$Ag(s) \longrightarrow Ag + e^-$	-0.799	
$Hg \mid Hg^+$	$Hg(l) \longrightarrow Hg^{2+} + 2e^-$	-0.920	
$Cl_2 \mid Cl^-$	$2Cl^- \longrightarrow Cl_2(g) + e^-$	-1.359	

(25 marks/*markah*)

…3/-

[c] One mole of a perfect gas at 27^{o}C expands isothermally and reversibly from 10 to 1 bar against a pressure that is gradually reduced. Calculate q and w and each of the thermodynamic quantities changes of internal energy (ΔU), changes of enthalpy (ΔH), free energy (ΔG), Helmholtz energy (ΔA), and entropy (ΔS). Since the process is carried out isothermally and reversibly.

Pada suhu 27^{o}C, satu mol gas unggul berkembang secara isoterma dan berbalik dari 10 ke 1 bar menentang tekanan yang dikurangkan secara perlahan. Hitungkan perubahan haba, q dan kerja, w serta setiap kuantiti termodinamik seperti perubahan tenaga dalam (ΔU), perubahan entalpi (ΔH), tenaga beban (ΔG), tenaga Helmholtz (ΔA), dan entropi (ΔS). Anggap prosesnya berlaku secara isoterma dan berbalik.

(50 marks/*markah*)

PART B / *BAHAGIAN B*

2. [a] Calculate the standard heat formation of PbO from Pb and O_2 at 227°C from the following data:

Hitungkan haba pembentukan piawai bagi PbO daripada Pb dan O_2 pada suhu 227°C dengan menggunakan data berikut:

$$Pb_{(s)} + ½\ O_{2\ (g)} = PbO_{(s)}$$

$\Delta H^{o}_{298} = -219.24k\ J\ mol^{-1}$

$C_{p\ PbO(s)} = 44.35 + 16.74X\ 10^{-3}\ T\ JK^{-1}\ mol^{-1}$

$C_{p\ Pb\ (s)} = 23.56 + 9.75X\ 10^{-3}\ T\ J\ K^{-1}mol^{-1}$

$C_{p\ O2(g)} = 22.96 + 4.184\ X\ 10^{-3}T - 1.67\ X10^{5}\ T^{-2}\ J\ K^{-1}mol^{-1}$

(50 marks/*markah*)

[b] The heat of combustion (ΔH) of tungsten carbide at 300°K is - 1195.13 kJ/mole WC, and the reaction is:

$$WC_{(s)} + 5/2\ O_2(g) = WO_3(s) + CO_2(g)$$

Calculate the heat for the same reaction if it takes place in a constant-volume bomb calorimeter at 300°K. Assume that the gases behave ideally and that corrections to standard states are neglible for solid species.

Haba pembakaran (ΔH) tungsten karbida pada 300°K ialah - 1195.13 kcal/mol WC, dan tindakbalasnya adalah seperti:

$$WC_{(p)} + 5/2\ O_2(g) = WO_3(p) + CO_2(g)$$

Hitungkan haba bagi tindakabalas yang serupa jika dilakukan dalam kalorimeter bom dengan isipadu tetap pada suhu 300 K. Anggaplah gas bersifat unggul dengan pembetulan isipadu dianggap tersangat kecil bagi pepejal.

(50 marks/*markah*)

3. [a] Calculate the energy required and the cost of heating a copper slab of mass one metric ton (1000 kg) from 300 K to 1000 K, the copper will be heated by passing it through a furnace that uses electricity as its source of energy. The cost of electrical energy is assumed to be 20 cents per kilowatt-hour. Assume that there are no extraneous heat losses from the furnace; that is, all the electrical energy entering the furnace is used to heat the copper. Given C_p for copper is $22.64 + 6.28 \times 10^{-3}$ T J K^{-1} $mole^{-1}$. Atomic weight of copper is 63.54 g/mole. Given 1 KWh = 3.600×10^6 J.

Hitungkan tenaga yang diperlukan dan kos pembakaran dari suhu 300 K sehingga 1000 K bagi plat logam kuprum seberat satu ton matrik (1000kg). Kuprum dibakar dengan menggunakan relau yang menggunakan kuasa elektrik. Kos tenaga elektrik bagi per unit kilowat-jam sebanyak 20sen. Anggapkan tidak ada kehilangan tenaga haba, bermaksud semua tenaga elektrik yang memasuki relau dianggap memanaskan kuprum sepenuhnya. Diberi C_p kuprum = $22.64 + 6.28 \times 10^{-3}$ T J K^{-1} mol^{-1}. Berat atom kuprum 63.54 g/mol. Diberi 1 KWh = 3.600×10^6 J.

(50 marks/*markah*)

[b] Zinc melts at 420°C and its standard entropy at 25°C is 41.63 J $K^{-1}$$mole^{-1}$. Calculate the standard entropy of zinc at 800°C.

Given:

Heat of fusion of Zn at the melting point,

ΔH_f = 7.28 k J/mole

$C_{p\ zn(s)}$ = 22.38 + 10.04 X 10^{-3} T J K^{-1} $mole^{-1}$

$C_{p\ Zn(l)}$ = 31.38 J K^{-1} $mole^{-1}$

Logam Zink melebur pada suhu 420°C dan entropi piawainya pada 25°C ialah 41.63 J $K^{-1}$$mol^{-1}$. Hitungkan entropi piawai bagi Zink pada 800°C.

Diberi:

Haba lakuran zink pada takat leburnya

ΔH_f = 7.28 k J/mol

$C_{p\ zn(p)}$ = 22.38 + 10.04 X 10^{-3} T J K^{-1} mol^{-1}

$C_{p\ Zn(c)}$ = 31.38 J K^{-1} mol^{-1}

(50 marks/*markah*)

4. [a] What is the Gibbs–Helmholtz Equation? Using Gibbs-Helmholtz equation, calculate the standard enthalpy and entropy changes at 25°C for the reaction:

Apakah persamaan Gibbs–Helmholtz? Dengan menggunakan persamaan tersebut, hitungkan perubahan entalpi dan entropi piawai pada 25°C bagi tindakbalas:

$$2\ Cu_{(s)} + \tfrac{1}{2}\ O_{2(g)} = Cu_2O_{(s)}$$

Given / *Diberi*:

$\Delta G^o = -169{,}452 - 16.40T \log T + 123.43T$ J

(60 marks/*markah*)

[b] Using the above equation, calculate the equlibrium pressure of oxygen which allows cuprous oxide,(Cu_2O) and metallic copper to exist at temperature above 1000°C. Calculate the oxygen pressure when only metallic copper exist?

Dengan menggunakan persamaan dan data di atas, hitungkan tekanan keseimbangan bagi gas oksigen bagi membolehkan logam kuprum dan kuprum oksida (Cu_2O) wujud bersama pada suhu 1000°C. Hitungkan tekanan oksigen yang hanya membenarkan logam kuprum sahaja wujud?

(40 marks/*markah*)

5. [a] 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 specific reaction rate is 5.2 x 10^{-3} $mol^{-1}Lminutes^{-1}$, what is the initial concentration of the reactants?

Dalam sesuatu tindakbalas tertib kedua, di mana kepekatan bahan tindakbalas adalah sama, separuh daripada bahan tindakbalas telah bertindakbalas dalam 60 minit. Jika kadar tindakbalas spesifik adalah 5.2 x 10^{-3} $mol^{-1}Lminit^{-1}$, apakah kepekatan awal bahan tindakbalas?

(50 marks/*markah*)

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

Kadar tindakbalas spesifik bagi sesuatu tindakbalas kimia pada suhu 273 K dan 303 K di dapati masing-masing adalah 2.45 x 10^{-5} dan 162 x 10^{-5}. Kirakan tenaga pengaktifan bagi tindakbalas ini.

(50 marks/*markah)*

6. [a] Calculate the emf of a Daniell cell at 25°C, when the concentration of $ZnSO_4$ and $CuSO_4$ are 0.001 M and 0.1 M respectively. The standard potential of the cell is 1.1 V.

Kirakan emf sel Daniell pada 25°C, apabila kepekatan of $ZnSO_4$ dan $CuSO_4$ masing-masing adalah 0.001 M dan 0.1 M. Keupayaan piawai sel ini didapati 1.1 V.

(50 marks/*markah*)

[b] Reproduce a sketch of galvanic cell and explain the function of the galvanic cell in brief.

Lakarkan sel galvanik dan terangkan fungsinya secara ringkas.

(50 marks/*markah*)

7. [a] Name four factors that affect reaction rate.

Namakan empat faktor yang mempengaruhi kadar tindakbalas.

(20 marks/*markah*)

[b] Name four examples of commercial cells (batteries) and justify the metals used in each of them.

Berikan empat contoh sel komersial (bateri) dan tunjukkan logam-logam yang digunakan dalam setiap satu.

(40 marks/*markah*)

[c] Write down Nernst's equation and calculate the reduction potential for the reduction of O_2 at pH = 7 given a partial pressure of O_2. $[pO_2]$ = 0.20 bar and E^o = 1.229 V at pH = 7.

Tuliskan persamaan Nernst dan hitungkan keupayaan bagi penurunan O_2 pada pH = 7. Diberikan tekanan separa O_2 $[pO_2]$ = 0.20 bar dan E^o = 1.229 V pada pH = 7.

(40 marks/*markah*)

- oooOooo -