UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2008/2009

April/Mei 2009

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 <u>SEVEN</u> printed pages before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi <u>TUJUH</u> muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

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

Instruction: Answer <u>**FIVE**</u> questions. If candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab <u>**LIMA**</u> soalan. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*
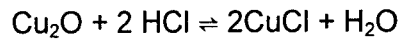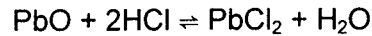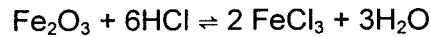
The answers to all questions must start on a new page.
[Mulakan jawapan anda untuk semua soalan pada muka surat yang baru.]

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

1. Fe_2O_3, PbO and Cu_2O present in a dead roasted tin ore react according to the following equations, during leaching with 1.11 M HCl at 298 K:

$$Fe_2O_3 + 6HCl \rightleftharpoons 2 FeCl_3 + 3H_2O$$

$$PbO + 2HCl \rightleftharpoons PbCl_2 + H_2O$$

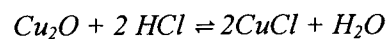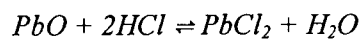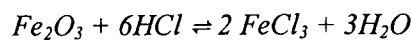$$Cu_2O + 2 HCl \rightleftharpoons 2CuCl + H_2O$$

Calculate the heat of the leaching process at 298 K for 100 kg of ore, assuming that the SiO_2 and SnO_2 present in the ore are unaffected during leaching.

Given: (i) Composition of the dead roasted tin ore is 10% Fe_2O_3, 5% PbO, 5% Cu_2O, 15% SiO_2 and the rest is SnO_2

(ii) Standard heats of formation (kcal/mole)

Fe_2O_3	Cu_2O	PbO	$FeCl_3$	CuCl	$PbCl_2$	H_2O	HCl
-196.3	-40.0	-52.4	-92.0	-30.9	-83.2	-68.32	-17.4

Fe_2O_3, PbO dan Cu_2O yang hadir di dalam bijih timah terpanggang bertindakbalas seperti persamaan berikut semasa tindakbalas pengurasan berlangsung dengan 1.11 M HCl pada 298 K:

$$Fe_2O_3 + 6HCl \rightleftharpoons 2 FeCl_3 + 3H_2O$$

$$PbO + 2HCl \rightleftharpoons PbCl_2 + H_2O$$

$$Cu_2O + 2 HCl \rightleftharpoons 2CuCl + H_2O$$

Kirakan haba pengurasan pada 298 K untuk 100 kg bijih. Anggapkan SiO_2 dan SnO_2 yang hadir di dalam bijih tidak bertindakbalas ketika proses pengurasan berlangsung.

Diberi: (i) Komposisi bijih timah terpanggang ialah 10% Fe_2O_3, 5% PbO, 5% Cu_2O, 15% SiO_2 dan selebihnya SnO_2

(ii) Haba pembentukan piawai (kcal/mole)

Fe_2O_3	Cu_2O	PbO	$FeCl_3$	CuCl	$PbCl_2$	H_2O	HCl
-196.3	-40.0	-52.4	-92.0	-30.9	-83.2	-68.32	-17.4

(20 marks/*markah*)

2. [a]   Consider an isolated system with liquid metal in equilibrium with its vapor at pressure P and temperature T. Derive the Clausius-Clayperon equation using the Van't Hoff equation.

Pertimbangkan suatu sistem terpencil cecair logam yang berada pada keseimbangan dengan wapnya pada tekanan P dan suhu T. Terbitkan persamaan Clausius-Clayperon berdasarkan persamaan Van't Hoff.

(8 marks/*markah*)

[b]   The melting point of gallium is 303 K at 1 atm. The densities of solid and liquid gallium are 5.885 and 6.08 kg/m^3 respectively. The heat of fusion of gallium is 77.40 x 10^3 J/kg. Calculate the change in melting point of gallium for an increase of pressure of 1 atm.

$$1J = 9.87 \times 10^{-3} \text{ m}^3 \text{ atm}$$

Takat lebur gallium ialah 303 K pada 1 atm. Ketumpatan pepejal dan cecair gallium ialah 5.885 dan 6.08 kg/m^3 masing-masing. Haba pelakuran gallium ialah 77.40 x 10^3 J/kg. Kirakan perubahan takat lebur gallium apabila tekanan dinaikkan sebanyak 1 atm.

$$1J = 9.87 \times 10^{-3} \text{ m}^3 \text{ atm}$$

(12 marks/*markah*)

3. In the sublimation process of Au(s) $\rightleftharpoons$ Au(g), ΔH°_{298K} = 380,100 Jmol^{-1} and ΔG°_{298K} = 340,200 Jmol^{-1}. Also given are:

$$Au(g): C_p = 21.0 \text{ Jmol}^{-1}K^{-1}$$
$$Au(s): C_p = 23.56 + 6.04 \times 10^{-3}T \text{ Jmol}^{-1}K^{-1}$$

From the data given obtain an expression for ΔG° as a function of temperature.

Bagi proses pemejalwapan Au(s) $\rightleftharpoons$ Au(g), di mana ΔH°_{298K} = 380,100 Jmol^{-1} dan ΔG°_{298K} = 340,200 Jmol^{-1}.

$$Au(g): C_p = 21.0 \text{ Jmol}^{-1}K^{-1}$$
$$Au(s): C_p = 23.56 + 6.04 \times 10^{-3}T \text{ Jmol}^{-1}K^{-1}$$

Daripada data diberi dapatkan hubungan ΔG° sebagai fungsi kepada suhu.

(20 marks/*markah*)

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

Takat lebur biasa bagi aluminium ialah 931.7 K dengan haba pelakuran ΔH_f = 10.76 kJmol^{-1}. Kirakan perubahan entropi untuk proses pemejalan aluminium pada 931.7 K.

(5 marks/*markah*)

[b] If super-cooled aluminium solidifies at 903K, find the entropy change in aluminium, given

Aluminium (solid): $C_p = 20.7 + 12.4 \times 10^{-3}T$ Jmol^{-1}K^{-1}
Aluminium (liquid): $C_p = 29.3$ Jmol^{-1}K^{-1}

Jika aluminium sejuk lampau memejal pada 903 K, kirakan perubahan entropi aluminium, diberi

Aluminium (pepejal): $C_p = 20.7 + 12.4 \times 10^{-3}T$ Jmol^{-1}K^{-1}
Aluminium (cecair): $C_p = 29.3$ Jmol^{-1}K^{-1}

(9 marks/*markah*)

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

Jika persekitaran aluminium di dalam (b) pada suhu sedikit rendah daripada 903 K, kirakan perubahan entropi persekitaran dan bagi sistem terpencil tersebut.

(6 marks/*markah*)

5.   For the reaction:

$$CO_2 (g) + C = 2CO \qquad \Delta G^o = 170.8 - 0.175T \text{ kJ}$$

The reaction is well known as the Boudourd reaction.

Find the temperature at which graphite would be in equilibrium with a mixture of CO and CO_2 (total pressure 1 atm) containing 30% CO. Hence find the composition of the mixture CO-CO_2 in equilibrium with graphite at 1100 K and total pressure 0.1 atm.

Bagi tindakbalas:

$$CO_2 (g) + C = 2CO \qquad \Delta G^o = 170.8 - 0.175T \text{ kJ}$$
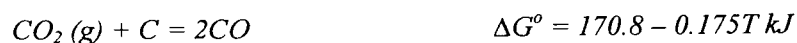
Tindakbalas ini dikenali sebagai tindakbalas Boudourd

Dapatkan suhu apabila grafit akan berada di dalam keseimbangan dengan campuran CO dan CO_2 (jumlah tekanan 1 atm) mengandungi 30% CO. Dapatkan komposisi campuran CO-CO_2 pada keseimbangan dengan grafit pada 1100 K dan jumlah tekanan 0.1 atm.
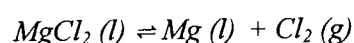
(20 marks/*markah*)

6. [a] The electrolytic dissociation of fused $MgCl_2$ is given by:

$$MgCl_2 (l) \rightleftharpoons Mg (l) + Cl_2 (g)$$

$$\Delta G° = 618.9 + 0.057T\log T - 0.30T \text{ kJ}$$

Calculate the decomposition voltage of $MgCl_2$ at 700°C. Assume that the fused salt solution used as electrolyte is saturated with $MgCl_2$.

Ciri-ciri elektrolit $MgCl_2$ terlakur diberi seperti berikut:

$$MgCl_2 (l) \rightleftharpoons Mg (l) + Cl_2 (g)$$

$$\Delta G° = 618.9 + 0.057T\log T - 0.30T \text{ kJ}$$

Kirakan voltan penguraian $MgCl_2$ pada 700°C. Anggapkan larutan garam terlakur tepu dengan $MgCl_2$.

(8 marks/*markah*)

[b] A teapot is to be coated with silver in the inside as well as the outer part over a surface area of 0.5 m^2. It is dipped in a 0.1M silver nitrate solution in an electrochemical cell with 1.00A current passing through for 8 hours. Calculate the weight of silver coated on the teapot in grams. Given the density of Ag as 10.50 g/cm^3, determine the average thickness of the silver coating on the teapot in mm.

Sebuah teko hendak disalut dengan perak pada bahagian luar dan dalam dengan luas permukaan 0.5 m^2. Teko dicelup ke dalam larutan nitrat perak menggunakan sel elektrokimia dengan 1.00 A arus elektrik dialirkan selama 8 jam. Kirakan jisim salutan perak yang terbentuk pada teko di dalam gram. Diberi ketumpatan Ag ialah 10.50 g/cm^3. Kirakan juga purata ketebalan salutan terbentuk di dalam mm.

(12 marks/*markah*)

7.   The denitriding of iron is a second order reaction.   If the initial concentration of nitrogen in iron is 0.4 mol/litre and the reaction is 30% completed in 80 minutes, calculate the:

(a)   reaction rate constant

(b)   time required for 80% completion

Proses penyahnitridaan bagi besi merupakan tindakbalas tertib kedua.   Jika kepekatan mula nitrogen di dalam besi ialah 0.4 mol/liter dan 30% tindakbalas lengkap berlaku di dalam 80 minit, kirakan:

(a)   pemalar kadar tindakbalas

(b)   masa supaya 80% tindakbalas lengkap berlaku

(20 marks/*markah*)

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