UNIVERSITI SAINS MALAYSIA

Final Examination
Academic Session 2008/2009

April 2009

JIK 216 – SEPARATION CHEMISTRY
[KIMIA PEMISAHAN]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains **NINE** printed pages before you begin the examination.

Answer **FIVE** questions. You may answer **either** in Bahasa Malaysia or in English.

All answers must be written in the answer booklet provided.

Each question is worth 20 marks and the mark for each sub question is given at the end of that question.

Sila pastikan bahawa kertas peperiksaan ini mengandungi ***SEMBILAN*** *muka surat yang bercetak sebelum anda memulakan peperiksaan ini.*

Jawab ***LIMA*** *soalan. Anda dibenarkan menjawab soalan* ***sama ada*** *dalam Bahasa Malaysia atau Bahasa Inggeris.*

Setiap jawapan mesti dijawab di dalam buku jawapan yang disediakan.

Setiap soalan bernilai 20 markah dan markah subsoalan diperlihatkan di penghujung subsoalan itu.

1. One quantitative analytical method for tetraethyltiuranidisulfide, $C_{10}H_{20}N_2S_4$ (Antabuse) oxidize the sulfur to SO_2 and the resulting SO_2 through H_2O_2 to produce H_2SO_4 . The H_2SO_4 is then reacted with NaOH according to the reaction below :

Satu kaedah analisis kuantitatif untuk tetraetiltiuranidisulfida, $C_{10}H_{20}N_2S_4$ (Antabuse) memerlukan pengoksidaan sulfur kepada SO_2.Hasil SO_2 kemudiannya dilalukan terhadap H_2O_2 untuk menghasilkan H_2SO_4. H_2SO_4 kemudiannnya bertindakbalas dengan NaOH seperti tindak balas di bawah :

$$H_2SO_4\,(aq) + 2NaOH\,(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O\,(l)$$

(a) Using appropriate conservation principles, derive an equation relating the moles of $C_{10}H_{20}N_2S_4$ to the moles of NaOH.

Dengan menggunakan prinsip yang sesuai, terbitkan suatu persamaan berkaitan mol $C_{10}H_{20}N_2S_4$ kepada mol NaOH.

[10 marks]

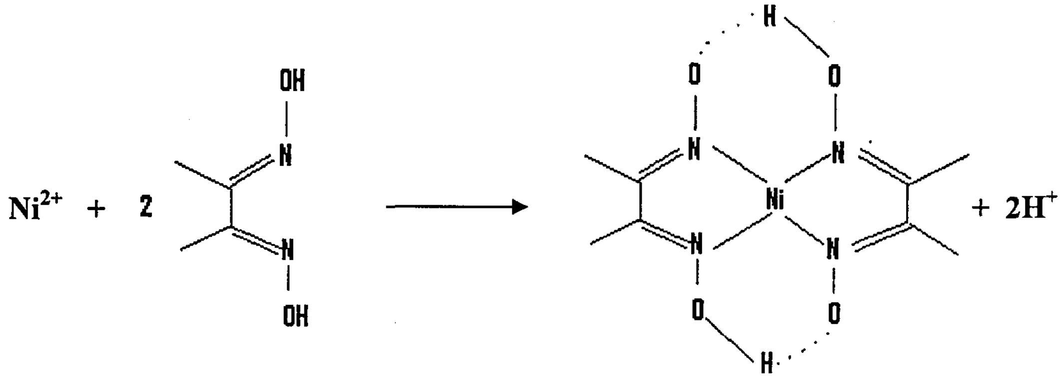
(b) What is the weight percent of $C_{10}H_{20}N_2S_4$ in Antabuse if the H_2SO_4 produced from a 0.4163g portion reacts with 34.85 mL of 0.02500 M NaOH?

Berapakah peratus berat $C_{10}H_{20}N_2S_4$ di dalam sampel Antabuse sekiranya H_2SO_4 yang dihasilkan daripada 0.4163 g sampel bertindakbalas dengan 34.85 mL 0.02500 M NaOH?

[10 marks]

2. To measure the nickel content in steel, the alloy is dissolved in 12 M HCl and neutralized in the presence of citrate ion, which maintains iron in solution. The slightly basic solutions is warmed and dimethylglyoxine (DMG) is added to precipitate the red DMG-nickel complex quantitatively. The product is filtered, washed with cold water and dried at 110 °C.

Untuk menentukan kandungan nikel dalam keluli, suatu loyang telah dilarutkan dalam 12 M HCl dan dineutralkan dengan kehadiran ion sitrat yang mana ia akan mengekalkan besi di dalam larutannya. Larutan yang agak beralkali itu dipanaskan dan ditambah dengan dimetilglioksina (DMG) untuk memendakkan kompleks DMG-nikel merah secara kuantitatif. Hasilnya ditapis, dibasuh dengan air sejuk dan dikeringkan pada suhu 110°C.



MW = 58.69 | DMG MW = 116.12 | Ni(DMG) II MW = 288.91

(a) If the nickel content is known to be near 3% (wt) and you wish to analyze 1.0 g of the steel, what volume of 1.0% (wt) alcoholic DMG solution should be used to give 50% excess of DMG for the analysis? Assume that the density of the alcohol solution is 0.79 g/mL.

Jika kandungan nikel diketahui lebih kurang 3% (berat) dan anda diminta untuk menganalisis 1.0 g keluli, berapakah isipadu 1.0% (berat) larutan DMG beralkohol yang diperlukan untuk mendapatkan 50% DMG berlebihan untuk dianalisis? Anggapkan ketumpatan larutan alkohol ialah 0.79 g/mL.

[15 marks]

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(b) If 1.1634 g of steel gave 0.1795 g of precipitate, what is the percentage of Ni in the steel?

Jika 1.1634 g keluli menghasilkan 0.1795 g mendakan, berapa peratuskah Ni yang terdapat dalam keluli?

[5 marks]

3. (a) The amount of oxalic acid in a sample of rhubarb was determined by reacting with Fe^{3+}. In a typical analysis, the oxalic acid in 10.62 g of rhubarb was extracted with a suitable solvent. The complete oxidation of the oxalic acid to CO_2 required 36.44 mL of 0.0130 M Fe^{3+}. What is the weight percent of oxalic acid in the sample of rhubarb?

Kandungan asik oksalik dalam sampel rhubarb boleh ditentukan dengan menindakbalaskan dengan ion Fe^{3+}. Dalam analisis tipikal, asid oksalik di dalam 10.62 g rhubarb telah diekstrak dengan menggunakan pelarut yang sesuai. Pengoksidaan lengkap asik oksalik kepada CO_2 memerlukan 36.44 mL 0.0130 M Fe^{3+}. Berapakah peratus berat asid oksalik di dalam sampel rhubarb?

Reactions :

Tindakbalas :

$$2Fe^{3+}(aq) + H_2C_2O_4(aq) + 2H_2O(l) \longrightarrow 2Fe^{2+}(aq) + 2CO_2(g) + 2H_3O^+(aq)$$

[10 marks]

(b) A stock solution of KI contains 107.6 g of KI per liter of solution. The solution's density at 20 °C is 1.0781 g/mL. What is the concentration of the solution in % (w/v) and in % (w/w).

Larutan stok KI mengandungi 107.6 g KI per liter larutan. Ketumpatan larutan ialah 1.0781 g/mL pada suhu 20°C. Berapakah kepekatan larutan itu dalam % (w/v) dan dalam % (w/w)?

Catatan: w = weight = berat ; v = volume = isipadu

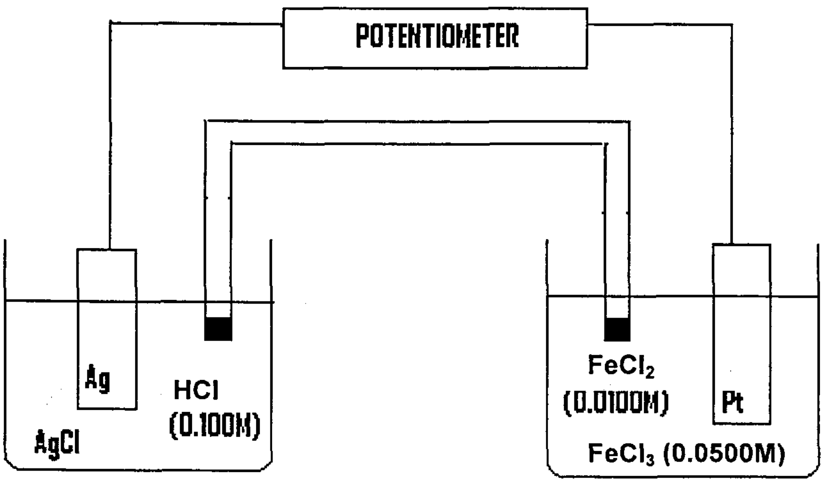
[5 marks]

(c) An analysis for cadmium in water gave a value of 1.20 ppb (w/v). What mass of cadmium is contained in 1.00 L of water?

Satu analisis bagi kadmium dalam air memberikan nilai sebanyak 1.20 ppb (w/v). Berapakah jisim kadmium di dalam 1.00 L air?

[5 marks]

4.



(a) What are the anodic, cathodic and overall reaction responsible for the potential in the electrochemical cell shown here? Write the shorthand notation for the electrochemical cell.

Apakah tindakbalas di anod, katod dan tindakbalas keseluruhan yang terlibat untuk keupayaan dalam sel elektrokimia yang ditunjukkan? Tuliskan persamaan bagi sel elektrokimia tersebut.

[5 marks]

(b) Calculate the potential of the electrochemical cell.

Kirakan keupayaan sel elektrokimia.

[7 marks]

(c) Calculate the concentration of Fe^{3+} if the concentration of HCl in the left hand cell is 1.0 M, the concentration of $FeCl_2$ in the right hand cell is 0.0151 M and the measured potential is + 0.546 V?

Kirakan kepekatan Fe^{3+} jika kepekatan HCl pada sel kiri ialah 1.0 M, kepekatan $FeCl_2$ pada sel kanan ialah 0.0151 M dan keupayaan yang diukur ialah +0.546 V.

[8 marks]

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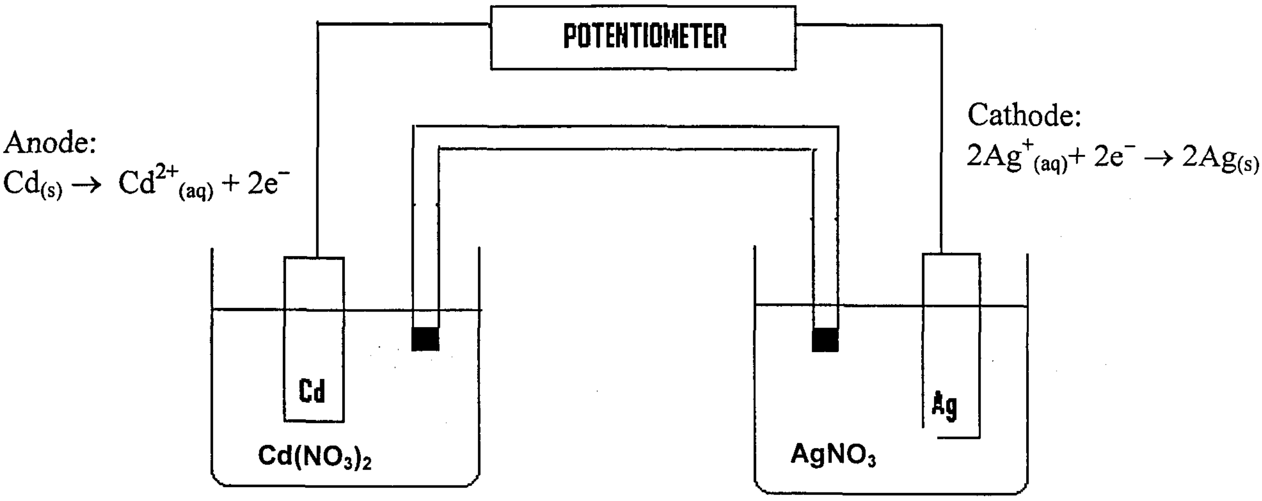
5. (a) Find the voltage of the cell in the figure :-

Hitung voltan sel dalam gambarajah di bawah :-



The right half cell contains 0.50 M $AgNO_{3(aq)}$ and the left half cell contains 0.010 M $Cd(NO_3)_{2(aq)}$.

Sel setengah kanan mengandungi 0.50 M $AgNO_{3(aq)}$ dan sel setengah kiri mengandungi 0.010 M $Cd(NO_3)_{2(aq)}$.

[8 marks]

(b) Calculate the voltage of each of these cell.

Kirakan voltan bagi setiap sel berikut.

(i) $Fe_{(s)}$| $FeBr_2$ (0.010 M)|| NaBr (0.050 M)| $Br_{2(\ell)}$ (l)| $Pt_{(s)}$

[4 marks]

(ii) $Cu_{(s)}$| $Cu(NO_3)_2$ (0.020 M)|| $Fe(NO_3)_2$ (0.050 M)| $Fe_{(s)}$

[4 marks]

(iii) $Hg_{(\ell)}$| $Hg_2Cl_{2(s)}$| KCl (0.060 M)|| KCl (0.040 M)| $Cl_{2(g)}$ (0.50 atm)| $Pt_{(s)}$

[4 marks]

...7/-

6. Calculate the standard potential (E°) and equilibrium constant (K) for each of these reactions.

Kirakan keupayaan piawai (E°) dan pemalar keseimbangan (K) bagi setiap tindakbalas berikut.

(a) $Cr^{2+} + Fe_{(s)} \rightleftharpoons Fe^{2+} + Cr_{(s)}$

[4 marks]

(b) $Mg_{(s)} + Cl_{2(g)} \rightleftharpoons Mg^{2+} + 2Cl^{-}$

[4 marks]

(c) $5MnO_{2(s)} + 4H^{+} \rightleftharpoons 3Mn^{2+} + 2MnO^{4-} + 2H_2O$

[4 marks]

(d) $Ag^{+} + 2S_2O_3^{2-} \rightleftharpoons Ag(S_2O_3)_2^{3-}$

[4 marks]

(e) $CuI_{(s)} \rightleftharpoons Cu^{+} + I^{-}$

[4 marks]

Standard and Formal Electrode Potentials

Silver

Half-Reaction	E°, V*	Formal Potential, V†
$Ag^+ + e^- \leftrightarrows Ag(s)$	+0.799	0.228 in 1 M KCI; 0.792 in 1 M $HClO_4$; 0.77 in 1 M H_2SO_4
$AgBr(s) + e^- \leftrightarrows Ag(s) + Br^-$	+0.073	
$AgCl(s) + e^- \leftrightarrows Ag(s) + Cl^-$	+0.222	0.228 in 1 M KCI
$Ag(CN)_2^- + e^- \leftrightarrows Ag(s) + 2CN^-$	-0.31	
$Ag_2CrO(s) + e^- \leftrightarrows 2Ag(s) + CrO_4^{2-}$	+0.446	
$AgI(s) + e^- \leftrightarrows Ag(s) + I^-$	-0.151	
$Ag(S_2O_3)_2^3- + e^- \leftrightarrows Ag(s) + 2S_2O_3^{2-}$	+0.017	

Iodine

Half-Reaction	E°, V*	Formal Potential, V†
$I_2(s) + 2e^- \leftrightarrows 2I^-$	+0.5355	
$I_2(aq) + 2e^- \leftrightarrows 2I^-$	+0.615‡	
$I_3^- + 2e^- \leftrightarrows 3I^-$	+0.536	
$ICl_2^- + e^- \leftrightarrows \frac{1}{2} I_2(s) + 3H_2O$	+1.056	
$IO_3^- + 6H^+ + 5e^- \leftrightarrows \frac{1}{2} I_2(aq) + 3H_2O$	+1.196	
$IO_3^- + 6H^+ + 5e^- \leftrightarrows \frac{1}{2} I_2(aq) + 3H_2O$	+1.178‡	
$IO_3^- + 2Cl^- + 6H^+ + 4e^- \leftrightarrows ICl_2^- + 3H_2O$	+1.24	
$H_5IO_6 + H^+ + 2e^- \leftrightarrows IO_3^- + 3H_2O$	+1.601	

Bromine

Half-Reaction	E°, V*	Formal Potential, V†
$Br_2(l) + 2e^- \leftrightarrows 2Br^-$	+1.065	1.05 in 4 M HCl
$Br_2(aq) + 2e^- \leftrightarrows 2Br^-$	+1.087‡	
$BrO_3^- + 6H^+ + 5e^- \leftrightarrows \frac{1}{2} Br_2(l) + 3H_2O$	+1.52	
$BrO_3^- + 6H^+ + 6e^- \leftrightarrows Br^- + 3H_2O$	+1.44	

Chlorine

Half-Reaction	E°, V*	Formal Potential, V†
$Cl_2(g) + 2e^- \leftrightarrows 2Cl^-$	+1.359	
$HClO + H^+ + e^- \leftrightarrows \frac{1}{2} Cl_2(g) + H_2O$	+1.63	
$ClO_3^- + 6H^+ + 5e^- \leftrightarrows \frac{1}{2} Cl_2(g) + 3H_2O$	+1.47	

Chromium

Half-Reaction	E°, V*	Formal Potential, V†
$Cr^{3+} + e^- \leftrightarrows Cr^{2+}$	-0.408	
$Cr^{3+} + 3e^- \leftrightarrows Cr(s)$	-0.744	
$Cr_2O_7^{2-} + 14H^+ + 6e^- \leftrightarrows 2 Cr^{3+} + 7H_2O$	+1.33	

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Copper

Half-Reaction	E°, V*	Formal Potential, V†
$Cu^{2+} + 2e^- \leftrightarrows Cu(s)$	+0.337	
$Cu^{2+} + 2e^- \leftrightarrows Cu^+$	+0.153	
$Cu^+ + e^- \leftrightarrows Cu(s)$	+0.521	
$Cu^{2+} + I^- + e^- \leftrightarrows CuI(s)$	+0.86	
$CuI(s) + e^- \leftrightarrows Cu(s) + I^-$	-0.185	

Iron

Half-Reaction	E°, V*	Formal Potential, V†
$Fe^{2+} + 2e^- \leftrightarrows Fe(s)$	+0.440	
$Fe^{3+} + e^- \leftrightarrows Fe^{2+}$	+0.771	0.700 in 1 M HCl; 0.732 in 1 M $HClO_4$; 0.68 in 1 M H_2SO_4
$Fe(CN)_6{}^{3-} + e^- \leftrightarrows Fe(CN)_6{}^{4-}$	+0.36	0.71 in 1 M HCl; 0.72 in 1 M $HClO_4$, H_2SO_4

Magnesium

Half-Reaction	E°, V*	Formal Potential, V†
$Mg^{2+} + 2e^- \leftrightarrows Mg(s)$	-2.363	

Manganese

Half-Reaction	E°, V*	Formal Potential, V†
$Mn^{2+} + 2e^- \leftrightarrows Mn(s)$	-1.180	
$Mn^{3+} + e^- \leftrightarrows Mn^{2+}$		1.51 in 7.5 M H_2SO_4
$MnO_2(s) + 4H^+ + 2e^- \leftrightarrows Mn^{2+} + 2H_2O$	+1.23	
$MnO_4^- + 8H^+ + 5e^- \leftrightarrows Mn^{2+} + 4H_2O$	+1.51	
$MnO_4^- + 4H^+ + 3e^- \leftrightarrows MnO_2(s) + 2H_2O$	+1.695	
$MnO_4 + e^- \leftrightarrows MnO_4{}^{2-}$	+0.564	

Mercury

Half-Reaction	E°, V*	Formal Potential, V†
$Hg_2{}^{2+} + 2e^- \leftrightarrows 2Hg(l)$	+0.788	0.274 in 1 M HCl; 0.776 in 1 M $HClO_4$; 0.674 in 1 M H_2SO_4
$2Hg^{2+} + 2e^- \leftrightarrows Hg_2{}^{2+}$	+0.920	0.907 in 1 M $HClO_4$
$Hg^{2+} + 2e^- \leftrightarrows Hg(l)$	+0.854	
$Hg_2Cl_2(s) + 2e^- \leftrightarrows 2Hg(l) + 2Cl^-$	+0.268	0.244 in sat'd KCl; 0.282 in 1 M KCl; 0.334 in 0.1 M KCl
$Hg_2SO_4(s) + 2e^- \leftrightarrows 2Hg(l) + SO_4{}^{2-}$	+0.615	

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