NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
BACHELOR OF SCIENCE HONOURS DEGREE
END OF FIRST SEMESTER EXAMINATIONS – FEBRUARY 2010
PHYSICAL CHEMISTRY FOR ENGINEERS – SCH 1120
TIME: (3) THREE HOURS

INSTRUCTIONS TO CANDIDATES

MATERIAL
Reduction potential tables, graph papers

INSTRUCTIONS TO STUDENTS
Answer All questions in section A and Any Three questions in Section B.
Answer each question on a FRESH page.

$R = 8.314\ JK^{-1}mol^{-1} = 0.08205\ dm^3atmK^{-1}mol^{-1}$.
$F = eN_A = 96500\ C\ mol^{-1}$
1 atm = 760 torr = 760mmHg = 101 325 Pa
lnx = 3.303logx

SECTION A *Answer ALL questions. Each question carries 10 marks*

1. (a) The conductivity at 25^0C of a saturated aqueous solution of strontium sulphate is $1.48 \times 10^{-2}\ Sm^{-1}$ while that of the water from which the solution was made is $1.5 \times 10^{-4}\ Sm^{-1}$. The limiting molar conductivities of $\frac{1}{2}\ Sr^{2+}$ and $\frac{1}{2}\ SO_4^{2-}$ are $5.95 \times 10^{-3}\ Sm^2mol$ and $8.00 \times 10^{-3}\ Sm^2mol^{-1}$, respectively. What is the solubility of strontium sulphate in water at 25^0C. [3 marks]

(b) In a tube of 8mm diameter, the boundary between aqueous solution of hydrochloric acid and sodium chloride moves with a velocity of 0.085 mms^{-1} when the current is 5mA. The concentration of the hydrochloric acid solution is $0.01moldm^{-3}$. Calculate the transport number of the hydrogen ions [3 marks]

[$t = \frac{FcAh}{Q}$]

(c) To show the difference between weak and strong electrolytes, sketch the graphical representation of the variation of:
(i) Molar conductivity with concentration
(ii) Molar conductivity with dilution [3 marks]

2. (a) What is the difference between a primary reference electrode and a secondary reference electrode. Give at least one example for each kind of electrode

[2 marks]

(b) Name the two special kinds of electrodes mentioned under the study of the common types of electrodes. [4 marks]

(c) Calculate the equilibrium constant for the disproportionation reaction,

$2Cu^{+}(aq) \rightarrow Cu(s) + Cu^{2+}(aq)$ at 298K. [3 marks]

(d) At 298K the standard redox potentials of the electrodes, Pt| Ce^{4+}, Ce^{3+} and Pt| Fe^{3+}, Fe^{2+}, are 1.61V and 0.77V, respectively. When these two electrodes are brought together the reaction comes to equilibrium. Write the spontaneous reaction and calculate the equilibrium constant [3 marks]

3. (a) From the principle of light scattering, explain why the sky is blue during the day [2 marks]

(b) Copy and complete the following table:

Disperse system	Disperse phase	Dispersion medium	Examples
(a)……..	(b)……	(c)…….	toothpaste
	(d)……	Solid	
(e)……...	(f)……	(g)…….	
	(h)……	(i)…….	Fog
(j)……	Gas	Solid	
	(k)……..	(l)…….	
(m)……..	liquid	Solid	
(n)……	(o)……..		milk

[8 marks]

4. (a) A solution of 5 x 10^{-3}kg acetone, $(CH_3)_2CO$, in 1.000kg of glacial acetic acid, CH_3CO_2H, froze at a temperature 0.32K below the freezing point of the pure solvent. Calculate the freezing-point constant K_{fus} for glacial acetic acid [3 marks]

[$K_{fus} = \dfrac{RT_{fus}^2 M_1}{\Delta H_{fus}^0 1000} kgmol^{-1}K$; $\Delta T = K_{fus} m$]

(b) A solution of 1.8 x 10^{-3} kg of a substance of high molecular weight in 1.00kg of toluene, $C_6H_5CH_3$, has an asmotic pressure of 4.0 mm of toluene (density 860 kgm^{-3} at 298K). Estimate the molecular weight of the substance [4 marks]

(c) What do the following terms refer to:
(i) Cryoscopy
(ii) Ebullioscopy
(iii)Osmometry

[3 marks]

SECTION B

Answer ONLY THREE questions from this section.

5. (a) The molar conductivity of 0.1M KCl (aq) at 298K is 129 $Scm^{-1}mol^{-1}$. The measured resistance in a conductivity cell was 28.44Ω. The resistance was 31.60Ω when the same cell contained 0.05M NaOH(aq). Calculate the molar conductivity of NaOH(aq) at the concentration. [4 marks]

(b) With the aid of a diagram outline the moving boundary method for determining transport numbers of ions in solution [6 marks]

(c) State the four common electrodes, and for each write the reaction of the equilibrium and the equation for the interfacial potential difference [10 marks]

6. (a) At 298K the vapour pressures of two liquids A and B which are completely miscible and form an ideal solution are 0.20 atm and 0.35 atm, respectively. For an equimolar mixture [x_A= 0.4] calculate the total vapour pressure and the mole fraction of A in the vapour phases. [4 marks]

(b) Calculate the estimate mole fractions (x_A, x_B, y_A, y_B) in the respective phases at equilibrium when the total pressure of the solution is 0.35atm [8 marks]

(c) Calculate the estimate mole fractions (x_A, x_B,, y_B) in the respective phases, and also the total vapour pressure when y_A (the mole fraction of A in the vapour phase at equilibrium with the liquid mixture) is fixed at 0.85. [8 marks]

7. (a) Derive the Langmuir's isotherm. Include the steps for its conversion to the linear form. [6 marks]

(b) The Langmuir isotherm reduces to three distinct equations with the change of pressure. Write these equations, showing the derivation wherever possible. [10 marks]

(c) State the three assumptions that the Langmuir isotherm is based on. [4 marks]

8. (a) What is a colloid and what is its major physical property? [2 marks]

(b) Outline the formation of an electric double layer on the surface of a colloidal particle. State the prime role of the electric double layer and

explain how this role is performed

[6 marks]

(c) With the means of a diagram, show the effect of added solute on the chemical potential of a liquid solvent as a function of temperature. Clearly show the changes that are responsible for the two named colligative properties [6 marks]

(d) Calculate the ionic strength and the mean activity coefficient of $0.001 molkg^{-1}$ $CaCl_2(aq)$ at 25^0C.

$\log \gamma_{\pm} = -|z_- z_+| AI^{1/2}$, $I = \frac{1}{2} \sum z_i^2 m_i$, $A = 0.509 /(molkg^{-1})^{1/2}$

[6 marks]

END OF QUESTION PAPER!!