NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF APPLIED CHEMISTRY
SUPPLEMENTARY EXAMINATIONS – AUGUST 2011
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.

$R = 8.314 \text{ JK}^{-1}\text{mol}^{-1} = 0.08205 \text{ dm}^3 \text{ atm}^{-1} \text{ K}^{-1}\text{mol}^{-1}$.
$F = eN_A = 96\ 485 \text{ C mol}^{-1}$
$1 \text{ atm} = 760 \text{ torr} = 760 \text{mmHg} = 101\ 325 \text{ Pa}$
$\ln x = 3.303 \log x$

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

1. (a) The cell constant was given to be 0.367 cm^{-1}. A 0.1M NH$_4$Cl (aq) solution had a resistance of 28.5Ω. Calculate the molar conductivity of NH$_4$Cl (aq) at this concentration.   [4 marks]

   (b) The limiting molar conductivities of KCl, KNO$_3$, and AgNO$_3$ at standard conditions are 149.9 S cm^2 mol^{-1}, 145.0 S cm^2 mol^{-1}, and 133.4 S cm^2 mol^{-1}, respectively. What is the limiting molar conductivity of AgCl at this temperature?   [4 marks]

   (c) State the Kohlrausch's law of independent migration.   [2 marks]

2. (a) Consider an electrode that responds to the equilibrium between manganate(VI) ions and manganese (II) ions according to the following reaction:
   $$MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$$
   Starting from the general expression, derive an expression for the potential difference across the electrode.   [4 marks]

   (b) Consider an electrode that responds to the equilibrium between nitrogen gas, water, hydrogen ions and Nitrate ions, according to the following reaction:
   $$NO_3^-(aq) + 4H^+(aq) + 3e^- \longleftrightarrow NO(g) + 2H_2O(l)$$
   Derive an expression for the potential difference across the electrode interface. How does the potential depend on the concentration of Nitrate

ions? How does the interfacial difference change when the pressure of nitrogen oxide is increased?

Account physically for your answer. [6 marks]

3. (a) Compare and contrast physisorption and chemisorption? [6 marks]

(b) State the three basic assumptions of the Langmuir's adsorption isotherm. [4 marks]

4. (a) Based on the knowledge that the disperse phase and the dispersion medium can be either solid, gas or liquid, complete the following table:

	Class of the disperse system	Disperse phase	Dispersion medium
1	Aerosol		
2	Foam		
3	Emulsion		
4	Sol		

[8 marks]

(b) How can colloidal systems be further classified? [2 marks]

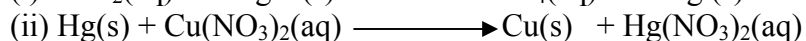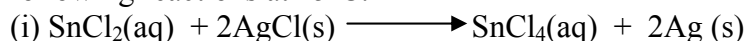## SECTION B
Answer ONLY THREE questions from this section.

5. (a) The cell Zn | Zn SO_4(aq, a =1) || $CuSO_4$(aq, a = 1)| Cu   was set up in a laboratory experiment.

Calculate   (i) the e.m.f of the cell at standard conditions
(ii) the value of $\Delta G_r^{\ominus}$ for the cell reaction
(iii) the equilibrium constant for the cell reaction.

Which electrode is more positive, and which way do electrons flow? [8 marks]

(b) Write the cell reactions and half-reactions for the following cells:
(i) Sn | $SnCl_2$(aq) || $MnCl_2$(aq), HCl(aq) | MnO_2(s) | Pt
(ii) Ag | AgCl(s) | HCl(aq) || HBr(aq) | AgBr(s) | Ag   [6 marks]

(c) Using electrode potentials, calculate the equilibrium constant for the following reactions at 25°C.
(i) $SnCl_2$(aq) + 2AgCl(s) $\longrightarrow$ $SnCl_4$(aq) + 2Ag (s)
(ii) Hg(s) + $Cu(NO_3)_2$(aq) $\longrightarrow$ Cu(s) + $Hg(NO_3)_2$(aq)
[6 marks]

6. The data below relates to the adsorption of carbon monoxide on charcoal at 273K. Confirm that they fit the Langmuir isotherm, and find:
    (a) The constant k
    (b) The volume corresponding to complete coverage

    In each case V has been corrected to 1 atm

P/Torr	100	200	300	400	500	600	700
V/cm^3	10.3	19.3	27.3	34.1	40.0	45.5	48.0

    The Langmuir's isotherm: $\Theta = kP/(1+kP)$ [20 marks]

7. (a) State the size range of colloidal particles. What kind of particles are above and below this range?   [4 marks]

    (b) State the three main sedimentation techniques that are used to evaluate the particle size of colloids in colloidal systems.   [3 marks]

    (c) What is Rayleigh scattering?   [2 marks]

    (d) 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 how this role is performed.   [8 marks]

    (e) What do you understand by the terms (i) aquasol, (ii) alcosol, and (iii) aerosol?   [3 marks]

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

    (b) Draw a rough graph that describes the variation in the conductance of:
    (i) a strong acid titrated with a strong base
    (ii) a weak acid titrated with a strong base
    (iii) a strong acid titrated with a weak base
    State two titrimetric analyses in which conductometric methods may be more preferable.   [8 marks]

    (c) With the aid of a diagram, outline the moving boundary method for determining transport numbers of ions.   [6 marks]

END OF QUESTION PAPER!!!

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