THE OPEN UNIVERSITY OF SRI LANKA

B.Sc/B.Ed DEGREE/STAND ALONE COURSES IN SCIENCE – LEVEL 4

FINAL EXAMINATION – 2008/2009

CHU2123/CHE4123 – INORGANIC CHEMISTRY

10^{th} July 2009 (Friday) 10.00 a.m.- 12.30 p.m.

Gas constant, R	= 8.314 J K^{-1} mol^{-1}
Plank's constant, h	= 6.63 x 10^{-34} J s
Avogadro constant, L	= 6.023 x 10^{23} mol^{-1}
Velocity of light, c	= 3 x 10^{8} m s^{-1}
Charge on electron	= 1.602 x 10^{-19} C
Mass of an electron	= 0.0005 a.m.u.
Mass of a proton	= 1.0073 a.m.u.
Mass of a neutron	= 1.0089 a.m.u.
1 a.m.u.	= 1.661 x 10^{-27} kg
1 Mev	= 1.6021 x 10^{-13} J

Answer any FOUR (04) questions.

If more than four questions are answered, **only the first four answers will be marked.**

1. (a) (i) Give the IUPAC name of $[Fe(C_2O_4)(en)(NH_3)_2]$ (**A**).
($en = H_2NCH_2CH_2NH_2$)

(ii) What is the coordination number of Fe in (**A**)?

(iii) Determine the Effective Atomic Number (EAN) of Fe in (**A**).
(Atomic number of Fe is 26)

(iv) Draw and identify the structures of the two **geometrical** isomers of (**A**).

(v) One of the above isomers shows optical isomerism. Draw the structure of the **other optical** isomer.

(vi) Draw the structure of μ-amidooctaaqua-μ-hidroxydicobalt(II) dichloride.

(vii) Arrange the following ligands in order of increasing Crystal Field Strength.
Br^-, CN^-, H_2O and NH_3 (50 marks)

(b) Using Valence Bond Theory predict the hybridization of cobalt in $[CoF_6]^{3-}$ if the magnetic moment of the complex is 4.9 B.M. (15 marks)

(c) An octahedral complex (**B**) with the empirical formula $CoCl_3 \cdot 4NH_3$ shows a molar conductivity typical for a 1:1 electrolyte (100 $m^2\Omega^{-1}mol^{-1}$). What is the molecular formula of (**B**)? Draw the structures of the two isomers of (**B**) and identify the type of isomerism involved. (15 marks)

(d) (i) What is the relationship between the overall stability constant β_N and the stepwise formation constants K_1, K_2, K_3, ... K_N.

(ii) $\log\beta_3$ and $\log\beta_4$ values for the formation of $[Ni(NH_3)_3]^{2+}$ and $[Ni(NH_3)_4]^{2+}$ are 6.7 and 7.9, respectively. Calculate the K_4 value for the following reaction.

$$[Ni(NH_3)_3]^{2+} + NH_3 \rightleftharpoons [Ni(NH_3)_4]^{2+}$$

The $\log\beta_4$ value for the formation of $[Cu(NH_3)_4]^{2+}$ is 12.7, comment on the stability of $[Cu(NH_3)_4]^{2+}$ and $[Ni(NH_3)_4]^{2+}$. (20 marks)

2. (a) (i) Write the molecular formulae of the **three** hydrate isomers with the empirical formula $CrCl_3(H_2O)_6$. (**Hint**: They are salts with the octahedral geometry)

(ii) Give two experimental methods that can be used to distinguish these isomers. (20 marks)

(b) (i) Calculate the **Crystal Field Stabilization Energy** (CFSE) for the aqua-cations $[Cr(H_2O)_6]^{2+}$ (**P**) and $[Cr(H_2O)_4]^{2+}$ (**Q**). On the basis of CFSE, which of the above two species is expected to be more stable in aqueous solutions?

(ii) Calculate the 'spin only' magnetic moment (μ_s) of (**Q**).
(Atomic number of Cr = 24) (20 marks)

(c) The tetradentate ligand $H_2NCH_2CH_2NHCH_2CH_2NHCH_2CH_2NH_2$ (**trien**) reacts $CrCl_3$ to give a **symmetrical, octahedral Co(III)** complex (**R**). With an excess of $AgNO_3$ a mole of (**R**) gives a mole of AgCl. Draw the structure of (**R**). (10 marks)

(d) Define the following as applied in studying symmetry of molecules.
(i) Equivalent configuration.
(ii) Symmetry axis
(iii) Symmetry plane (21 marks)

(e) Indicate the symmetry elements and their locations in the following molecules.
(i) NH_3 (ii)C_6H_6 (29 marks)

3). (a) Write complete nuclear equations for the nuclear reactions represented as follows:
(i) ....(p , γ) ${}^{8}_{4}Be$ (ii) ${}^{240}_{95}Am$(...., n) ${}^{243}_{97}Bk$ (iii) ${}^{9}_{4}Be$(α , n) .....
(12 marks)

(b) Below is a part of the (4n+2) decay series

$$^{238}_{92}\mathrm{U} \xrightarrow{-\alpha} \mathrm{X} \xrightarrow{?} {}^{234}_{91}\mathrm{Pa} \xrightarrow{-\beta} \mathrm{Y} \xrightarrow{?} {}^{230}_{90}\mathrm{Th} \xrightarrow{-\alpha} \mathrm{Z}$$

Complete the portion of the series by adding missing particles, and mass numbers and atomic numbers of X, Y and Z. (18 marks)

(c) The radioactive ^{40}K undergoes electron capture to give ^{40}Ar. The half-life for this decay process is $1x10^{10}$ years.

(i) Calculate the decay constant.
(ii) Write down the nuclear equation for the decay process.
(iii) How long will it take for 80% of ^{40}K to decay? (20 marks)

(d) The mass defect for the formation of an alpha particle from protons and neutrons is 0.0311 a.m.u.. Calculate the binding energy produced per nucleon in Joules for this process? (20 marks)

(e) (i) What is meant by an 'amphoteric solvent'? Give two examples.
(ii) Give a balanced equation, indicating any preciptate/s formed, for the reaction taking place when AgCl and $Ba(NO_3)_2$ are mixed in liquid ammonia?
(iii) What products are formed when $SOCl_2$ is dissolved in liquid ammonia?
(iv) Acetic acid is not an acid in H_2SO_4. Explain. (30 marks)

4. (a) Use your knowledge in chemical bonding to explain the following:.
(i) The density of ice is lower compared to water.
(ii) The boiling point of *trans*-1,2-dichloroethene is lower than that of *cis*-1,2-dichloroethene.
(iii) Glass is an amorphous substance.
(iv) Graphite is used as a lubricant. (32 marks)

(b) (i) What is the essential feature of a crystalline solid?

(ii) Helium–Neon laser produce light of wavelength 632 nm. When this light was passed through a crystal of sodium chloride no diffraction pattern was seen. However, the same crystal diffracts X-rays of wavelength 1.395 Å. Give reasons for this observation. (20 marks)

(c) X-rays of wavelength 70 pm was allowed to fall upon a platinum crystal. The first order diffraction was observed at an angle of 5.564°. Calculate the spacing between parallel planes of platinum atoms. (20 marks)

(d) Use examples from group III to explain the following terms.

(i) dimer (ii) electron deficient compounds (iii) Lewis acid (iv) adduct (28 marks)

5. (a) What is the difference between a point defect and a plane defect? (10 marks)

(b) Use clear sketches of NaCl crystal to explain

(A) Schottky defect (B) Frenkel defect

(i) In each case, state whether the defect will lead to a stoichiometric compound or a non-stoichiometric compound.

(ii) What will be the mode of conduction of electricity in compounds with defects mentioned in (i) and (ii)?

(iii) Comment on the density of crystalline NaCl with a Schokkty defect as compared to a perfect crystal. (40 marks)

(c) Work out the chemical formula of an oxide of rhenium using the following information.

The oxide has a cubic unit cell.

Each rhenium atom occupies a corner of the cube.

Each oxygen atom is at the centre of each edge of the unit cell. (20 marks)

(d) Potassium chloride has a structure similar to sodium chloride. Density of potassium chloride is 1.98×10^{3} kg m^{-3}. If the molecular mass is given as 74.6×10^{-3} kg mol^{-1}, calculate the length of the unit cell of potassium chloride. Express your answer in pm. (30 marks)

6. (a) Briefly discuss the properties and characteristics of transition elements using chromium to illustrate your answer. (20 marks)

(b) An acidic solution of potassium manganate will liberate chlorine from a dilute solution of chloride solution whereas an acidic solution of potassium dichromate will not.

Explain this observation with reference using the data given below.

$MnO_4^-(aq) + 8H^+(aq) + 5e \rightarrow Mn^{2+}(aq) + 4H_2O \quad E^o/V = +1.52$

$Cl_2(g) + 2e \rightarrow 2Cl^-(aq) \quad E^o/V = +1.36$

$Cr_2O_7^{2-}(aq) + 14H^+ + 6e \rightarrow 2Cr^{3+}(aq) + 7H_2O \quad E^o/V = +1.33$

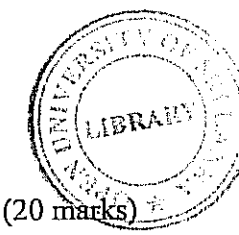
(30 marks)

(c) What is meant by the term "disproportionation"?
Use standard electrode potentials for the reactions,

$Cu^{2+}(aq) + e \rightarrow Cu^+(aq) \; ; \quad E^0 = +0.15\,V$

$Cu^+(aq) + e \rightarrow Cu(s) \; ; \quad E^0 = +0.52\,V$

to show that $Cu^+(aq)$ disproportionate in aqueous medium. (20 marks)



(d) A sample of brass containing only copper and zinc was dissolved and a solution was prepared with only Cu^{2+} and Zn^{2+} as the only cations present. The solution was used in the following titrations.

(i) A measured portion of the solution was treated with an excess of potassium iodide. The iodine liberated required 15.0 cm^3 of 0.100 m $Na_2S_2O_3$ solution for the titration.
(ii) Another sample of the same volume as used in experiment (i) was passed through anion exchange resin in the H^+ form. After complete exchange the resulting solution required 40.0 cm^3 of 0.100 M NaOH solution for titration.

Calculate the molar ratio of Cu^{2+} and Zn^{2+} in the brass sample. (30 marks)
