THE OPEN UNIVERSITY OF SRI LANKA

B.Sc DEGREE PROGRAMME/ STAND ALONE COURSES- LEVEL 4

CHU 2123/CHE 4123- INORGANIC CHEMISTRY

FINAL EXAMINATION- 2006/2007

(2 ½ HOURS)

Wednesday 20th June 2007 *10.00 a.m. – 12.30 p.m.*

Planck constant, h	$= 6.63 \times 10^{-34}$ J s
Avogadro constant, L	$= 6.023 \times 10^{23}$ mol^{-1}
Velocity of light, c	$= 3 \times 10^{8}$ m s^{-1}
Charge on electron	$= 1.602 \times 10^{-19}$ 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.	$= 1.661 \times 10^{-27}$ kg
1 MeV	$= 1.6021 \times 10^{-13}$ J

Answer any **FOUR (04)** questions.

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

1. (a) What is a bidentate ligand ? Give two examples of such ligands. (10 marks)

(b) (i) What are the primary and secondary valencies of Fe in the complex *trans*-$[Fe(SO_4)(gly)(NH_3)_2]$ (**X**)? ($gly^- = H_2NCH_2COO^-$)
(ii) Draw the structure of (**X**). (20 marks)

(c) The substance $CoCl_2.5NH_3$ has a molar conductivity of 100 m^2 ohm^{-1} mol^{-1}.
What is the molecular structure of it? (15 marks)

(d) (i) Give the IUPAC name of $[CrClBr(gly)(H_2O)(NH_3)]$ (**Y**) ($gly^- = H_2NCH_2COO^-$).
(ii) Determine the Effective Atomic Number of Cr in (**Y**).
(Atomic Number of Cr = 24) (15 marks)

(e) State the assumptions of the Crystal Field Theory. (10 marks)

(f) Consider Δ_o values given below.

Complex	Δ_o /kJ mol^{-1}
$[CrCl_6]^{3-}$	163
$[Cr(H_2O)_6]^{3+}$	213
$[Co(H_2O)_6]^{2+}$	111
$[Cr(NH_3)_6]^{3+}$	259
$[Co(NH_3)_6]^{3+}$	296
$[Ir(NH_3)_6]^{3+}$	490
$[Cr(CN)_6]^{3-}$	314

(i) Arrange the ligands, H_2O, Cl^-, CN^- and NH_3, as found in the spectrochemical series.

(ii) Why is there a significant difference in the Δ_o values of $[Co(NH_3)_6]^{3+}$ and $[Ir(NH_3)_6]^{3+}$?

(iii) What is the CFSE of $[CrCl_6]^{3-}$ in kJ mol^{-1}? (Chloride is a weak ligand; Atomic Number of Cr = 24) (30 marks)

2. (a) A **neutral six-coordinate** mononuclear complex (**Z**) of platinum(IV) contains just NH_3 and chloride ligands. The group number of Pt is 10 and its atomic number is 78.

(i) What is the molecular formula of (**Z**)?

(ii) **Draw** and **identify** the two isomers of (**Z**).

(iii) (**Z**) is a diamagnetic compound. According to CFT, what is the d-electron configuration of platinum in (**Z**)? (30 marks)

(b) Give four polymerization isomers with the empirical formula $PtCl_2(NH_3)_2$. (20 marks)

(c) Define the following as applied in studying the symmetry of molecules:

(i) Symmetry operation
(ii) Symmetry element
(iii) Rotational axes of symmetry
(iv) Symmetry plane (20 marks)

(d) Consider the planar molecule AB_3.

(i) Identify all the symmetry planes in it.
(ii) Indicating the order, identify all the rotational symmetry axes in it.
(iii) Giving reasons, identify the dihedral planes in it.
(iv) Giving reasons, identify the vertical planes in it. (30 marks)

3. (a) Indicate the type of attractive forces exist between particles in the following solids:

(i) molecular solids (ii) covalent network crystals

Why do these two types of solids differ so greatly in their hardness and melting points? (15 marks)

(b)(i) Draw a labeled diagram to show the unit cell of CsCl.
(ii) What is the coordination number of Cs^+ ions and that of Cl^- ions?
(iii) Show that the formula of CsCl is consistent with its unit cell picture.
(25 marks)

(c) Crystals of ammonium chloride have a cubic unit cell, which contains one NH_4^+ ion and one Cl^- ion. Using X-ray diffraction, the length of the side of the unit cell was found to be 387 pm. The density of the crystal is 1.53 g cm^{-3}.

(i) Explain the reasons for using X- rays in the experiment.
(ii) Calculate the value for the Avogadro constant.
(Relative atomic masses of N = 14.00; H = 1.00; Cl = 35.5) (40 marks)

(d) Sodium chloride and barium oxide have the same crystal structure and the inter ionic distances in the two lattices are almost equal. Explain why the melting point of barium oxide is much higher than that of sodium chloride. (20 marks)

4. (a) Use compounds of boron to describe the following:
(i) Electron deficient compound (ii) dimer (iii) Lewis acid
(30 marks)

(b)(i)What is the most notable change in the chemical character of elements down the group headed by carbon in the periodic table? Explain your answer by comparing the types of compounds which the first and the last member of this group form.
(ii) By referring to the structure of diamond, explain why it is often used as a cutting medium in glass cutters. Could graphite perform the same function? Give reasons for your answer. (30 marks)

(c) Account for the following observations:
(i) Phosphate rock is not effective as a phosphate fertilizer.
(ii) Phosphorus forms a pentachloride whereas nitrogen does not.
(10 marks)

(c) Quantitative **estimation** of NO_3^- is possible by reacting it with an active metal to reduce NO_3^- to $NH_3(g)$ in basic solution according to the equation below.

$$NO_3^- + Zn\,(s) + OH^- + H_2O \longrightarrow Zn(OH)_4^{2-} + NH_3(g)$$

The $NH_3(g)$ released can be neutralized by passing the gas into an excess of HCl(aq). The unreacted HCl can then be titrated against standard NaOH solution. In such an analysis, a 25.0 cm^3 sample of a solution containing nitrate ion was treated according to the above procedure. The liberated NH_3 was passed into 50.00 cm^3 of 0.15 mol dm^{-3} HCl. The excess HCl required 32.10 cm^3 of 0.100 mol dm^{-3} NaOH for its titration.
Calculate the concentration of NO_3^- in the original sample.
(Relative atomic masses: N= 14, O = 16, H = 1, Na = 23) (30 marks)

5. (a) Distinguish between
(i) A stoichiometric defect and a non stoichiometric defect
(ii) A line defect and a plane defect
(iii) An interstitial atom and a hole (30 marks)

(b)(i) Use a clearly labeled diagram to explain the Frenkel defect. Will this defect Affect the density of a solid? Explain.
(ii) How does this defect differ from the defect present in a crystal of ruby? (30 marks)

(c)(i) Which of the following reactions will take place as written below?

$$Cl_2 + 2I^-(aq) \rightarrow 2Cl^-(aq) + I_2$$
$$I_2 + 2Br^-(aq) \rightarrow 2I^-(aq) + Br_2$$
$$Br_2 + 2Cl^-(aq) \rightarrow 2Br^-(aq) + Cl_2$$

Explain your answer and give a general statement as to which halogen elements will displace others from the aqueous solutions of the halide ions.

(ii) Write the oxidation number of chlorine in each of the species given in the reaction:

$$3\,ClO^-(aq) \longrightarrow 2Cl^-(aq) + ClO_3^-(aq)$$

Why is this reaction described as disproportionation?

(iii) Explain why the boiling point of hydrogen fluoride is much higher than the that of other hydrogen halides. (30 marks)

(d) Use an appropriate example to explain what is meant by "inert pair effect". (10 marks)

6. (a) Write complete nuclear equations for the nuclear reactions represented as follows:

(i) ${}^{9}_{4}Be(\alpha,)^{12}_{6}C$ (ii) ${}^{14}_{7}N(, p)\ {}^{17}_{8}O$ (iii) ${}^{14}_{7}N$ (n , p)

(15 marks)

(b) One Curie is equal to the disintegration rate of 1 g of ${}^{226}_{88}Ra$, which decays by α emission. The half- life for the decay is 1622 years.

(i) Write nuclear equation for the decay of ${}^{226}_{88}Ra$.

(ii) Calculate the decay constant λ for the process.

(iii) Show that 1 Curie = 3.7×10^{10} Bq.

(iv) How long will it take for 93.75% of ${}^{226}_{88}Ra$ to decay? (36 marks)

(c) A part of the (4n+1) decay series is given below:

${}^{233}_{92}U \xrightarrow{-\alpha} X \xrightarrow{?} {}^{225}_{88}Ra \xrightarrow{-\beta} Y \xrightarrow{?} {}^{221}_{87}Fr$

Identify the missing particles and the mass numbers and atomic numbers of X and Y. (10 marks)

(d) Identify the type of nuclear reaction:

(i) ${}^{2}_{1}H + {}^{3}_{2}He \rightarrow {}^{4}_{2}He + {}^{1}_{1}H$

(ii) ${}^{235}_{92}U \rightarrow {}^{231}_{90}Th + {}^{4}_{2}He$

(iii) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{139}_{54}Xe + {}^{95}_{38}Sr + 2({}^{1}_{0}n)$ (09 marks)

(e)(i) What is meant by an 'aprotic solvent'? Give **two** examples of it.

(ii) Define an acid and a base in a non- aqueous solvent.
Explain why urea acts as an acid in liquid ammonia and a base in water.

(30 marks)

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