THE OPEN UNIVERSITY OF SRI LANKA

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

FINAL EXAMINATION – 2009/2010

CHU2123/CHE4123 – INORGANIC CHEMISTRY

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09th July 2010 (Friday) 9.30 a.m. – 12.00 noon

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| Gas constant, R | $= 8.314\ J\ K^{-1}\ mol^{-1}$ |
| Planck's 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) (i) Give the IUPAC name of $[CoCl(CO)(NH_3)_2]$ (**A**).

(ii) This **diamagnetic** complex (**A**) shows two **geometrical** isomers. **Draw** and **identify** each isomer.

(iii) Determine the effective atomic number (EAN) of Co in (**A**). (Atomic number of Co is 27).

(iv) According to valence bond theory (VBT), what is the hybridisation of Co in (**A**) (40 marks)

(b) (i) According to the **Crystal Field Theory** what is the *d*-electron configuration of cobalt in $[CoBr_4]^-$? (Atomic number of Co is 27).

(ii) Calculate the Crystal Field Stabilisation Energy (**CFSE**) in kJ $mol^{-1}$ if $\Delta_t = 90$ kJ $mol^{-1}$.

(iii) Calculate the Total Stabilisation Energy (**TSE**) in kJ $mol^{-1}$ if the pairing energy is 120 kJ $mol^{-1}$.

(iv) Calculate the spin only magnetic moment ($\mu_s$) of $[CoBr_4]^-$. (40 marks)

(c) (i) What is the relationship between the overall stability constant $\beta_N$ of a metal complex $[ML_N]^{m+}$ and the stepwise formation constants $K_1, K_2, K_3, \ldots K_N$ for each step in the formation of the complex.

(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.

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

(iii) 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) A **neutral six-coordinate** mononuclear complex (**B**) of iron(II) contains only ethylenediamine (en) and chloride ligands. The Group number of Fe is 8 and its atomic number is 26.

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

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

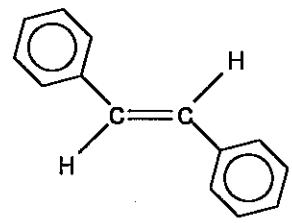
(iii) (**B**) is a **diamagnetic** compound. According to crystal field theory (CFT), what is the *d*-electron configuration of iron in (**B**)? (30 marks)

(b) How would you prepare *cis*-$[NiCl_2(CO)(NH_3)]$ from $[NiCl_4]^{2-}$ if the *trans*-effect order is $CO > Cl > NH_3$. (20 marks)

(c) Define the following as applied in the study of molecular symmetry.
(i) Vertical plane
(ii) Dihedral plane

(10 marks)

(d) Consider the planar molecule with two benzene rings as shown below.




(i) Copy the above structural formula on to your answer sheet and indicate all the improper axes of rotation of the molecule in standard notation (clearly indicating the order of each axis) on it.

(ii) What is the symmetry point group of this molecule?
Briefly explain your answer.

(24 marks)

(e) Briefly explain the following statements.

(i) The dipole moment of a molecule must be aligned with an axis of rotation (of order greater than 1) of the molecule.

(ii) A molecule with more than one axis of rotation (of order greater than 1) cannot have a dipole moment.

(16 marks)

3. (a). (i) What is meant by the term 'binding energy' of a nucleus?
(ii) Calculate the mass defect (in kg) equivalent to the binding energy of $9 \times 10^{-11}$ Joule.

(b) A part of the (4n+2) decay series is given below.

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

Complete the portion of the series by **adding missing particles** and, **mass** numbers and **atomic** numbers of X, Y, Z.

(c) Strontium-90 undergoes β-decay with a half life of 28 years.
(Atomic number of Sr = 38)
(i) What is meant by the term 'Half life'?
(ii) Calculate the decay constant
(iii) Write down the nuclear equation for the above decay process.
(iv) If strontium-90 is accidentally released into the environment. what fraction will remain after 7 year?
(v) What fraction of the strontium-90 released in the atomic bomb explosions of 1945 would still be remaining in the year 2029? (40 marks)

(d) Write a short account on "Applications of Radioactive Nuclides". (20 marks)

4. (a) What kind of attractive forces exist in
(i) solid carbon dioxide (ii) graphite (iii) diamond (15 marks)

(b) Relate the type of attractive forces described in (a) to explain the difference in hardness between graphite and diamond. (20 marks)

(c) (i) Comment on the statement "The unit cell of CsCl cannot be strictly described as body centred cubic".
(ii) Show that the formula of CsCl is consistent with its unit cell picture.
(iii) Give the coordination number of $Cs^+$ ion and $Cl^-$ ion. (30 marks)

(d) Chromium form cubic unit cell with a cell edge of 2.885 Å. The density of metal is 7.2 g $cm^{-3}$.
(i) Calculate the number of atoms in the unit cell.
(ii) Identify the type of cubic unit cell in chromium.
(Atomic mass of chromium is 51.9 g $mol^{-1}$) (35 marks)

5. (a) (i) Why is diborane called an electron deficient compound?
(ii) Describe the formation of a three centre bond in diborane. (35 marks)

(b) Use $E^\circ$ values given below for Thallium to explain "inert pair effect".
$E^\circ(Tl^{3+}/Tl) = +2.18$ V ; $E^\circ(Tl^+/Tl) = -0.34$ V (15 marks)

(c) Considering three suitable examples illustrate how lithium behaves differently from the rest of Group 1 elements. (20 marks)

(d) Give reasons for the following
(i) "Pyrex glass can withstand high temperature".
(ii) Nitrogen gas is substituted by Helium to dilute oxygen in gas cylinders used by divers.
(iii) Chlorofluorocarbons are not used as refrigerants any more. (30 marks)

6. (a) Distinguish between
(i) A stoichometric defect and a non stoichiometric defect
(ii) A line defect and a plane defect (30 marks)

(b) (i) Use a clearly labelled diagram to explain the Frenkel defect in crystals. Does the Frenkel defect have any effect on the density of a solid? Explain.
(ii) How does this defect differ from the defect present in a crystal of Ruby? (30 marks)

(c) A sample of sodium chloride is contaminated with sodium carbonate. The carbonate ion can be removed from a solution in water as insoluble barium carbonate and the remaining chloride ions can be analysed by titration with silver nitrate solution using the reaction,

$$Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$$

In such an analysis 5.65 g of the contaminated sodium chloride was dissolved In water and made up to 250.0 $cm^3$. A 25.00 $cm^3$ of this solution was taken and mixed with excess barium nitrate solution. After filtering and washing the residue the filtrate was titrated with silver nitrate solution of concentration 0.430 mol $dm^{-3}$. The volume of silver nitrate required for a complete reaction was 19.7 $cm^3$. (Mass numbers of Na = 23 and Cl = 35.5).

(i) Determine the mass of sodium chloride in the solution.

(ii) Calculate the purity (by mass) of the sodium chloride (40 marks)

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