THE OPEN UNIVERSITY OF SRI LANKA
B.Sc/B.Ed DEGREE/STAND ALONE COURSES IN SCIENCE - Level 4
FINAL EXAMINATION – 2015/2016
INORGANIC CHEMISTRY CMU2122/CME4122

10th July 2016 (Sunday) 1.00 p.m. – 3.00 p.m.

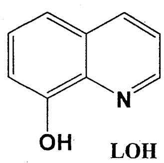
Avogadro constant, L	$= 6.023 \times 10^{23}$ mol^{-1}
Gas constant, R	$= 8.314$ J K^{-1} mol^{-1}
Planck's constant, h	$= 6.63 \times 10^{-34}$ J s
Velocity of light, c	$= 3 \times 10^{8}$ m s^{-1}
Mass of an electron	= 0.0005 a.m.u
Mass of a proton	= 1.0073 a.m.u.
Mass of a neutron	= 1.0089 a.m.u.
1 a.m.u.	$= 1.661 \times 10^{-27}$ kg
1 MeV	$= 1.6021 \times 10^{-13}$ J

$$\ln x = 2.303 \log_{10} x$$

Answer the COMPULSORY Question 1 (200 marks) and THREE other Questions (100 marks each)

1. (a) (i) What is the **molecular formula** of the compound diamminebromocarbonyloxalatocobalt(III) (**A**).
(ii) What is the coordination number of metal centre in (**A**)?
(iii) (**A**) has **four** geometrical isomers.
Draw the **structures** of the **geometrical** isomers of (**A**). (30 marks)

(b) Deprotonation of 8-hydroxyquinoline (LOH) results in the formation of **monoanionic bidentate ligand**, (LO^-). Two equivalents of this anion react with one equivalent of $PtCl_2$ to give a **neutral four-coordinate** Pt(II) complex (**B**).



LOH

(i) Write a **balanced equation** for the above reaction.
(ii) **Draw** and **identify** the **structures** of the two isomers of (**B**). (20 marks)

(c) Write complete nuclear equations for the reactions described below:

(i) Thorium- 231 ($^{231}_{90}Th$) decays to form protactinium- 231 ($^{231}_{91}Pa$).

(ii) 98.2% of potassium- 40 ($^{40}_{19}K$) decays by electron capture. (10 marks)

(d) Write complete nuclear equation for each of the following notations:

(i) $^{16}_{8}O(p,?)^{13}_{7}N$ (ii) $^{27}_{13}Al(n,\alpha)?$ (10 marks)

(e) A nuclear medicine technologist injects a patient with 400 μCi of indium-111–labelled leukocytes (white blood cells). Twenty-four hours later, the patient is imaged. Assuming that none of the activity was excreted, how much activity remains at the time of imaging? Why is indium-111 useful for imaging? ($t_{1/2}$ of ^{111}In is 2.81 days) (20 marks)

(f) What area of the body is investigated using the following as a radio tracer?

(i) *iodine- 131* (ii) *iron- 59* (10 marks)

(g) Identify the unit cell generated by each of the following types of close packing of spheres:

(i) ABABAB.... (ii) ABCABC..... (10 marks)

(h) A compound made up of elements 'X' and 'Y' crystallizes in a cubic close packed structure. 'X' atoms are present at the corners and at the centre of faces whereas 'Y' atoms are present at the centre of edges and at the centre of the cube.
Calculate the number of atoms X and Y in a unit cell. Deduce the formula of the compound. (15 marks)

(i) Draw 2-D diagrams of a sodium chloride lattice with Schottky defect and a silver bromide lattice with Frenkel defect (Use only **three** rows of ions).
Identify these defects as stoichiometric or non- stoichiometric. (25 marks)

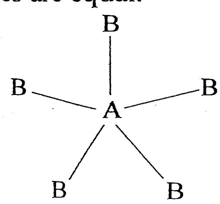
(j) (i) Define the following terms as used in studying symmetry of a molecule.

(α) Symmetry plane

(β) Horizontal plane.

(γ) Vertical plane (12 marks)

(ii) A student prepared an unstable planar molecule, AB_5, with the structure shown the diagram (where A and B represent atoms). All five $A-B$ bonds are of equal length and all the $B-A-B$ bond angles are equal.



(α) Locate all the symmetry planes in AB_5.

(β) Locate the principal axis of the molecule and calculate its order.
Briefly explain your answer.

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(γ) Giving reasons classify the symmetry planes you have identified above as horizontal or vertical planes.

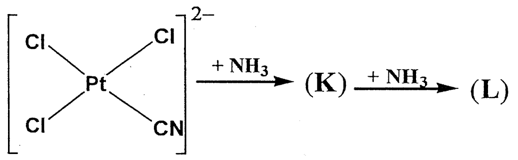
(δ) Giving reasons identify the plane which satisfies the relationship $\sigma = E$ where σ and E is a reflection and the identity operation, respectively, about that plane.

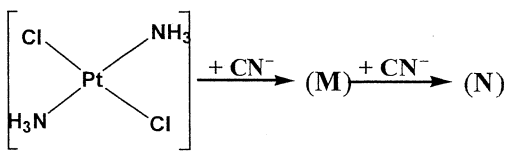
(38 marks)

2. (a) (i) Give the IUPAC name of $[CrF(H_2O)_3(NH_3)_2]Br_2$ (**C**).
(Atomic number of Cr is 24)
(ii) What is the oxidation number of Cr in (**C**)?
(iii) Determine the Effective Atomic Number (EAN) of Cr in (**C**).
(iv) Does it obey the EAN rule?
(v) Comment on the molar conductivity of (**C**) suggesting a value. (25 marks)

(b) Write the **molecular formulae** of the following complexes.
(i) Ionization isomer of $[Cr(CNS)(NH_3)_4(H_2O)]Cl$.
(ii) Hydrate isomer of $[MnCl(NH_3)_4(H_2O)]\cdot 2H_2O$
(iii) Three polymerization isomers of $[PtCl_2(NH_3)_2]$. (25 marks)

(c) (i) What is meant by "*trans* effect"?
(ii) Identify (**K**), (**L**), (**M**) and (**N**) if the *trans*-effect order is $CN^- > Cl^- > NH_3$.





Note: Indicate *cis-trans* isomerism and the **charge** of (**K**), (**L**), (**M**) and (N), if any.

(25 marks)

(d) A **neutral mononuclear** complex (**X**), contains a cobalt(I) centre which is coordinated **only** to chloride and ammine (NH_3) ligands. Its Effective Atomic Number is 36 and the Atomic number of cobalt is 27.
(i) What is the **molecular formula** of (**X**)?
(ii) Name the possible **geometries** of (**X**).
(iii) If (**X**) has an apical (or axial) chloride ligand.
Draw the **structures** of the two isomers of (**X**).
(iv) Comment on **optical** isomerism of the compounds given in (iii). (25 marks)

3. (a) (i) State **three** assumptions of the Crystal Field Theory (CFT).
(ii) The **neutral** ligand (L) forms complex ions $[CrL_4]^{2+}$ and $[CrL_6]^{2+}$.
Using CFT predicts which ion is more stable.
Assume that L is a **weak field ligand** and $\Delta_t = 0.5\ \Delta_o$.
(Group number of Cr is 6).

(iii) Calculate the **spin only magnetic moment** (μ_s) of $[CrL_6]^{2+}$.
(iv) If L is a **strong field Ligand** and the **Pairing Energy**, P = 100 kJ mol^{-1} = 0.5 Δ_t.
Calculate the Crystal Field Stabilization Energy (**CFSE**) and the Total Stabilization Energy (**TSE**) of $[CrL_4]^{2+}$ in kJ mol^{-1}. (45 marks)

(b) The **octahedral** complex (**Y**) has the empirical formula $CoCl_3 \cdot 3CO \cdot 2H_2O$.
With an excess of $AgNO_3$ a mole of (**Y**) gives two moles of AgCl.
(i) What is the molecular formula of (**Y**)?
(ii) Write the IUPAC name of (**Y**).
(iii) If (**Y**) is a **diamagnetic** complex, predict the hybridization of the metal centre.
(iv) **How many** geometrical isomers does (**Y**) have? (30 marks)

(c) (i) Write two characteristics of an **oxidative addition** reaction? Give an example.
(ii) $[PtCl_4]^{2-}$ undergoes **mono substitution** reaction with CO. Write the balanced equation for this reaction.
(iii) If it proceeds *via* an **associative mechanism** write the molecular formula of the intermediate formed. (25 marks)

4. (a) Indicate, giving reasons, whether each of the following nuclides will be expected to be stable or not.
(i) ${}^{18}_{9}F$ (ii) ${}^{4}_{2}He$
If the nuclide is not stable, predict its mode of decay. Write nuclear equation(s) for such decay process(es). (25 marks)
(b) (i) Define the term 'activity' of a radionuclide.
(ii) Calculate the activity of 1 μg of pure *americium- 241* ($t_{1/2}$= 432.2 y) in Becquerel (Bq). (25 marks)
(c) (i) Write the principle behind radio carbon dating of artifacts. Briefly describe the method of carrying out radio carbon dating. Give one limitation of this method.
(ii) A scrap of paper taken from the Dead Sea Scrolls was found to have a ^{14}C content 0.795 times that found in plants living today. Estimate the age of the scroll. (half-life of ^{14}C is 5720 years) (30 marks)
(d) Draw a labelled diagram of Geiger- Muller counter and briefly describe the method of detection of radiation. Give one limitation of this counter (20 marks)

5. (a) Compare the following properties of diamond and graphite in terms of their structure:
(i) hardness
(ii) electrical conductivity (20 marks)
(b) Draw 2-D diagrams to show the lattice defects of crystals produced by the following treatments (Use only **three** rows of ions):
(i) Cooling molten NaCl containing a small amount of $SrCl_2$ as impurity
(ii) Heating KCl in a potassium vapour. Identify the defects introduced.
Comment on the properties of the crystal(s) formed. (40 marks)

(c) KCl crystallizes out in *fcc* structure. The length of the unit cell of KCl is found to be 6.31×10^{-8} cm. Molar mass of KCl is 74.551 g mol^{-1}.
(i) Draw the unit cell of KCl crystal.
(ii) Calculate the number of K^+ and Cl^- in a unit cell and the number of formula units of KCl per unit cell.

(iii) Calculate the volume of the unit cell and the density of the KCl in g cm^{-3}.

(40 marks)

6. (a) Locate all the symmetry elements in an ethylene molecule and identify them with standard symbols. (20 marks)

(b) Consider the molecule *tarns*- XA_3B_2 which has a trigonal bipyramidal geometry (X, A and B represent atoms).

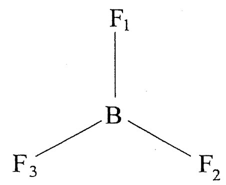
(i) Locate the improper axis of rotation of the molecule.

(ii) Calculate the order, n, of the improper axis of rotation. Briefly explain your answer.

(iii) Explain why $S_n^n \neq E$ for the above mentioned improper axis of rotation.

(iv) Drawing the initial configuration and configurations after each improper rotation deduce the maximum number of distinct improper rotations that can be performed about the above mentioned axis. (40 marks)

(c) Consider the configuration α of a BF_3 molecule which is shown in the figure.



(i) Copy configuration α on your answer script and then draw configuration β that is obtained by rotating BF_3 in α clockwise by 60° about the principal axis.
Giving reasons state whether the above mentioned rotation is a symmetry operation of BF_3.

(ii) Draw configuration γ that is obtained by performing an inversion operation, through the boron nucleus, on BF_3 in configuration β.
Giving reasons state whether the above mentioned inversion operation is a symmetry operation of BF_3.

(iii) Show that the compound operation of the above mentioned rotation and inversion is a symmetry operation (rotoinvertion) of BF_3.

(iv) By continuing to draw the configurations resulting from rotation (clockwise) of BF_3 in γ by 60° followed by inversion through boron, deduce the number of distinct rotoinversion symmetry operations, that can be performed on BF_3, about the principal axis.

(40 marks)

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