00422

THE OPEN UNIVERSITY OF SRI LANKA
B.Sc/B.Ed DEGREE/STAND ALONE COURSES IN SCIENCE - Level 4
FINAL EXAMINATION – 2016/2017
INORGANIC CHEMISTRY CMU2122/CME4122

29th July 2017 1.00 p.m. – 3.00 p.m.

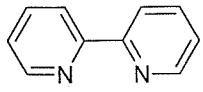
Avogadro constant, L	$= 6.023 \times 10^{23}$ mol^{-1}
Gas constant, R	$= 8.314$ J K^{-1} mol^{-1}
Planck's constant, h	$= 6.63 \times 10^{-34}$ J s
Velocity of light, c	$= 3 \times 10^{8}$ m s^{-1}
Mass of an electron	= 0.0005 a.m.u
Mass of a proton	= 1.0073 a.m.u.
Mass of a neutron	= 1.0089 a.m.u.
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 **oxidation number** of Fe in $[FeBr_2(acac)(NH_3)_2]$ (**A**)?
(acac = acetylacetonate)
(ii) Give the IUPAC name of $[FeBr_2(acac)(NH_3)_2]$ (**A**).
(iii) What is the **coordination number** of Fe in (**A**)?
(iv) Determine the Effective Atomic Number (EAN) of Fe in (**A**).
(Atomic number of Fe is 26)
(v) Does it obey the EAN rule? (30 marks)

(b) (i) One mole of bipyridine (**bipy**) reacts with one mole of $PtCl_2$ to give a neutral **square-planar** complex (**B**). Write the **molecular formula** or draw the structure of (**B**).
(ii) (**B**) reacts with another mole of bipyridine to give (**C**) which is a 2:1 electrolyte in aqueous solutions with a molar conductivity of 250 $m^2ohm^{-1}mol^{-1}$. Write the **molecular formula** or draw the structure of (**C**).
(20 marks)



Bipyridine

(c) Write short hand notation for the nuclear reactions described below:
(i) Bombardment of *nitrogen-14* with α particles produced protons. This was the first artificial transmutation carried out by Rutherford in 1911.

(ii) *Carbon-14* in the atmosphere is produced by neutron irradiation of *nitrogen-14*.

(10 marks)

(d) At a nuclear pharmacy, a pharmacist prepares 60 mCi/cm^3 of *selenium-75* (^{75}Se, $t_{1/2}$= 120 days) at 0800 hours on July 3. He receives an order at 13.00 hrs on the same day for 5 mCi ^{75}Se to be administered to a patient on the same day at 15.00 hrs. What volume of the prepared solution should be dispensed by the pharmacist to provide the requested dose?

(20 marks)

(e) Define the term 'binding energy' of a nuclide. Draw the binding energy curve and comment on its important feature(s).

(20 marks)

(f) Write down the basic difference between an amorphous structure and a crystalline structure.

(10 marks)

(g) Which one of the following radiation is most suitable to be used in an experiment where Bragg equation is used? 5 nm, 300 nm , 450 nm
Give reasons for your choice.

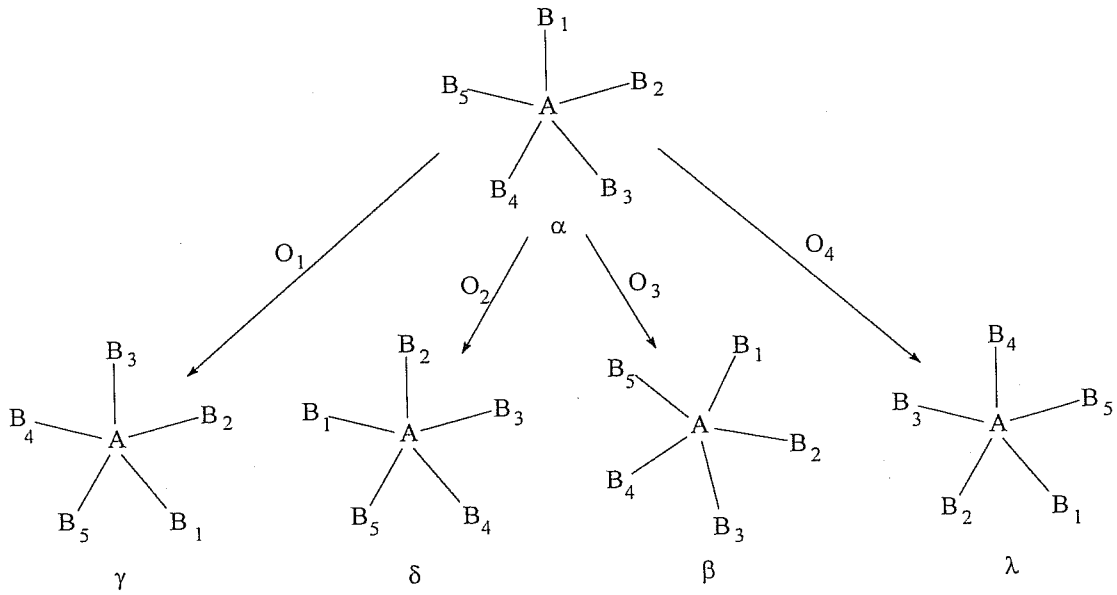
(20 marks)

(h) Using Bragg equation determine the distance in Å between crystal planes in an atomic solid if electromagnetic radiation of frequency 3.32 $\times 10^{17} s^{-1}$ incident at a 40° angle creates constructive interference (assume n=1).

(20 marks)

(I) A student prepared an unstable planar molecule, AB_5, with the structure shown in 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. Also, Atom A is much more electronegative than atom B.

Following diagram shows the resultant configurations, β, γ, δ and λ, of four operations, O_1, O_2, O_3 and O_4, performed on the configuration α.



(i) Giving reasons, identify the symmetry operations out of O_1, O_2, O_3 and O_4.

(ii) Classify each symmetry operation you have identified in part (i) above as rotation, reflection, inversion or improper rotation and locate the associated symmetry element.

(iii) Giving reasons state whether a AB_5 molecule has a dipole moment.

(50 marks)

2. (a) (i) Draw the structures of the **four** geometrical isomers with the **trigonal bipyramidal** geometry for $[FeBr(Cl)(NH_3)_3]$ (**D**).

(ii) Comment on optical isomerism of (**D**). (25 marks)

(b) (i) State **three** assumptions made in the Crystal Field Theory.

(ii) According to the Crystal Field Theory what is the *d*-electron configuration (as number of electrons in $\mathbf{e_g}$ and $\mathbf{t_{2g}}$ levels) of cobalt in $[CoCl_4]^{2-}$? (Z of Co is 27).

(iii) Calculate the Crystal Field Stabilization Energy in kJ mol^{-1} if $\Delta_t = 200$ kJ mol^{-1}.

(iv) Calculate the Total Stabilisation Energy in kJ mol^{-1} if the pairing energy is 100 kJ mol^{-1}.

(v) Calculate the spin only magnetic moment (μ_s) of $[CoCl_4]^{2-}$. (35 marks)

(c) (i) State **three** assumptions made in the Valence Bond Theory.

(ii) Using Valence Bond Theory predict the hybridization of cobalt in $[CoCl_6]^{3-}$. if the magnetic moment of the complex is 4.9 B.M.

(25 marks)

(d) The tetradentate ligand $H_2NCH_2CH_2NHCH_2CH_2NHCH_2CH_2NH_2$ (trien) reacts $CrCl_3$ to give a **symmetrical, octahedral** complex (**E**). With an excess of $AgNO_3$ a mole of (**E**) gives a mole of AgCl. Draw the **structure** of (**E**).

(15 marks)

3. (a) (i) $CrCl_3(H_2O)_6$ shows hydrate isomerism, Write the **molecular formulae** of **three salts** obtained with this empirical formula.

(ii) Give **two** methods to distinguish these isomers. (25 marks)

(b) (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 $[Pd(NH_3)_3]^{2+}$ and $[Pd(NH_3)_4]^{2+}$ are 7.0 and 8.0, respectively. Calculate the K_4 value for the following reaction.

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

(iii) The $\log\beta_4$ value for the formation of $[Cu(NH_3)_4]^{2+}$ is 13.0. Comment on the stability of $[Cu(NH_3)_4]^{2+}$ and $[Pd(NH_3)_4]^{2+}$. (20 marks)

(c) Complex cation $[PtCl_3(NH_3)_2]^+$ (**P**) undergoes an association reaction with HCl to give a **neutral octahedral** complex (**Q**).

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

(ii) Write a balanced equation for this process. (15 marks)

(d) How would you prepare *trans*-$[PtF_2(py)(CO)]$ from $[PtF_4]^{2-}$ if the *trans* effect order is CO > F^- > py = pyridine? (20 marks)

(e) (i) Write the **molecular formula** of acetylacetonatoamminebromodicarbonyl chromium(II) (**R**).
(ii) If (**R**) is optically **inactive** draw the **two structures** of (**R**). (20 marks)

4. (a) Predict, giving reasons, the mode/s of decay that each of the following radionuclides may undergo. Write nuclear equation(s) for such decay process(es).
(i) $^{22}_{9}F$ (ii) $^{8}_{5}B$ (30 marks)

(b) (i) Define the term 'half- life' of a radionuclide.
(ii) Calculate the activity of 1 μg of pure *indium- 111* ($t_{1/2}$= 67 hours) in Becquerel (Bq).

(25 marks)

(c) Two deuterium nuclei (mass of deuterium nucleus = 2.013553 a.m.u) combine through fusion to form a tritium nucleus (mass 3.015501 a.m.u) and a proton. Calculate the energy released (in MeV) in one fusion reaction.

(20 marks)

(d) Write the principles behind Isotope dilution analysis. Briefly describe the method of analysis of an amino acid from a mixture.

(25 marks)

5 (a) According to X-ray Crystallographic Data of Minerals, the following data is provided for the mineral, bunsenite (NiO).
Crystal system: cubic, structure type: rock salt, edge length of the unit cell $a = 4.177 \times 10^{-8}$ cm.
In the table of Physical Constants of Inorganic Compounds, the density of bunsenite (NiO) is reported as 6.67g / cm^3.
From the given values, evaluate
(i) the cell volume (volume of the unit cell),
(ii) sum of Ni^{2+} and O^{2-} radii ($r_{Ni^{2+}} + r_{O^{2-}}$),
(iii) (X-ray) density, and
(iv) vacancy percentage.
(relative atomic mass: Ni = 58.69; O = 16.00)

(40 marks)

(b) (i) Differentiate between an interstitial impurity and a substitutional impurity.
(ii) Can any one of the impurity mentioned above cause any change in density of a crystal? Give reasons for your answer.

(iii) Brass is a metal alloy made of copper and zinc whereas 'mild steel' or 'plain carbon steel' is carbon in iron. By studying the Atomic radius of Zn, Cu, C and Fe given below, predict the type of impurity in the formation of Brass and steel.

Element	Atomic radius/nm
Zinc(Zn)	0.133
Copper(Cu)	0.128
Carbon(C)	0.071
Iron(Fe)	0.124

(40 marks)

(c) Using your knowledge on transition metal Chemistry, explain how the same metal ion Fe^{3+} ions are responsible for the yellow colour of Topaz and violet colour of Amathyst.

(20 marks)

6. (a) Explain why a molecule with the formula AB_5, where A and B represent atoms, **cannot** have a centre of inversion.

(20 marks)

(b) Consider the square planar ion $[XA_4]^{q-}$ where X and A represent atoms. It has a negative charge of q.

(i) Locate all the rotational symmetry axes of $[XA_4]^{q-}$.

Indicate the order of each of them.
Identify the principal axis.

(ii) Locate all the symmetry planes of $[XA_4]^{q-}$.

Classify each of them as vertical, dihedral or horizontal plane.

(iii) Explain why $C_n^{n+2} = C_n^2$ where C_n is the principal axis of $[XA_4]^{q-}$.

(50 marks)

(c) (i) Define a symmetry operation of a molecule.

(ii) Using an example, explain why the compound operation of a *rotational* symmetry operation and a *reflection* symmetry operation of a molecule is also a symmetry operation of the same molecule.

(30 marks)