RAJARATA UNIVERSITY OF SRI LANKA
FACULTY OF APPLIED SCIENCES

B.Sc. (General Degree) in Applied Sciences
Second year Semester I Examination – July / August 2023

CHE 2205 – Inorganic Chemistry

Answer all questions. **Time: Two (02) hours.**

Mass of electron	m_e	$= 9.11 \times 10^{-31}$ kg
Mass of proton	m_p	$= 1.672 \times 10^{-27}$ kg
Mass of neutron	m_n	$= 1.675 \times 10^{-27}$ kg
Avogadro number	N_A	$= 6.022 \times 10^{23}$ mol^{-1}
Universal gas constant	R	$= 8.314$ J mol^{-1} K^{-1}
Planck constant	h	$= 6.63 \times 10^{-34}$ J s
Speed of light	c	$= 3.00 \times 10^{8}$ m s^{-1}
1 atomic mass unit (amu)	1 amu	$= 1.66 \times 10^{-27}$ kg
	1 eV	$= 1.602 \times 10^{-19}$ J

The use of a non-programmable calculator is permitted.

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1. a) Write the IUPAC name for the following compounds

   i. $K_2[Fe(CN)_3(Cl)_2(NH_3)]$

   ii. $[CO(NH_3)_4(H_2O)Cl]Cl_2$

(10 marks)

b) Give the structure for the following compounds.

   i. dichloridobis(ethylenediamine)cobalt (III) sulphate

   ii. chloridobis(ethylenediamine)hydroxido cobalt (III) ion

(10 marks)

c) Write the oxidation state, coordination number, nature of ligand, magnetic property and electronic configuration in octahedral crystal field for the complex $K_4[Mn(CN)_6]$.

(15 marks)

d) Name the type of isomerism when ambidentate ligands are attached to a central metal ion. Give two examples of ambidentate ligands.

(12 marks)

e) A metal complex having composition $[Co(en)_2Cl_2]Br$ has been isolated in two forms A and B. B reacted with silver nitrate to give a white precipitate readily soluble in ammonium hydroxide. Where as A gives a pale yellow precipitate. Write the formula of A and B.

(14 marks)

f) Explain why $[Fe(H_2O)_6]^{3+}$ has a magnetic moment value of 5.92 BM whereas $[Fe(CN)_6]^{3-}$ has a value of only 1.74 BM. Give the hybridization involves in each complex ion.

(15 marks)

g) Draw energy level diagram and indicate the number of electrons in each level for the complex $[Cu(H_2O)_6]^{2+}$. Calculate the value of μ_s and predict the magnetism of the complex.

(18 marks)

h) The theoretical density of nickel (Ni) is 9.036 g/cm^3 and its atomic radius is 1.24 °A. Predict the type of cubic crystal structure of Ni.

(24 marks)

i) Find the angles for the first order diffraction when the spacing between two plane d, are λ and $\lambda/2$ respectively.

(12 marks)

2. a) For the $[CoF_6]^{3-}$ ion the mean pairing energy is found to be 21000 cm^{-1}. The magnitude of Δ_0 is 13000 cm^{-1}. Calculate the crystal field stabilization energy for this complex ion corresponding to low spin and high spin states.

(25 marks)

b) Using crystal field theory, draw an energy level diagram, write electronic configuration of the central metal atom/ion and determine the magnetic moment value and predict the electron pairing in the following complexes:
$[CoF_6]^{3-}$, $[Co(H_2O)_6]^{2+}$, $[Co(CN)_6]^{3-}$

(24 marks)

c) Draw all possible stereo isomers of the complex ion $[CoNH_3Cl(ox)_2]^{2+}$. Show both geometrical and optical isomerism.

(15 marks)

d). i. What are the limitations of valance bond theory (VBT)?

ii. Predict the number of unpaired electrons , coordination number, types of hybridization and the value of the magnetic moment in $[CoCl_4]^{2-}$ ion of basis of VBT. Give the oxidation number of the metal.

(26 marks)

3). a). i. Arrange the following complex ions in increasing order of crystal field splitting energy (Δ_o) : $[Cr(Cl)_6]^{3-}$, $[Cr(CN)_6]^{3-}$, $[Cr(NH_3)_6]^{3+}$.

ii. $[CoF_6]^{3-}$ and $[Co(NH_3)_6]^{3+}$ are paramagnetic and diamagnetic respectively, Explain.

iii. $CuSO_4.5H_2O$ is blue in colour while $CuSO_4$ is colourless. Discuss.

(24 marks)

b). i. Draw the unit cells for the following crystal structures: simple cubic, body-centered cubic and face-centered cubic. Specify the number of atoms and the coordination number of the atoms in each unit cell.

ii. Calculate the atomic packing factor of the body-centered crystal structure. Find the void percentage in the crystal. (Tungsten has a body-centered cubic crystal structure).

iii. Platinum (Pt) has an atomic radius of 1.39 Å and the lattice parameter of its unit cell is 3.93 Å. Show that Pt has a face-centered cubic crystal structure.

(36 marks)

c) (i) Calculate the Miller indices of crystal planes which cut through the crystal axes at (2a, 3b, c), (4a, -3b, 2c) , (6a, 3b, 3c) .

(ii) Draw the plane and determine the axis intersects of a surface with the Miller indices (111), (100) and (111) in a simple cubic lattice.

(30 marks)

4. a) i. Consider the following radioactive decay,

$$^{238}_{92}U \rightarrow ^{206}_{82}Pb$$

Find the total number of α-particles and β-particles.

(12 marks)

b) i. Half-life ($t_{1/2}$)for radioactive ^{14}C is 5760 years. In how many years 200 mg of ^{14}C sample will be reduced to 25 mg. Show that the $t_{1/2}$ is independent of the initial concentration.

ii. A radioactive sample has an initial activity of 23 dis/min. After 30 minutes, the activity is 11.5 dis/min. How many atoms of the radioactive nuclide were present originally? Drive any equations you have used in these calculations.

(40 marks)

c) Calculate the binding energy and binding energy per nucleon in kJ/mol of $_{15}^{30}P$. Mass of $_{15}^{30}P$ = 29.978 amu.

(18 marks)

d) Briefly discuss three uses of radioactive isotopes and state three methods to measure the radioactivity.

(24 marks)

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