B.Sc. Examination, 2025
Semester-IV (CBCS)
Chemistry
Generic Elective Course: GEC-4
(Inorganic and Physical Chemistry)

Time: Three Hours **Full Marks: 60**

Questions are of value as indicated in the margin.

[Use a separate answer script for different groups]

Group-A (Marks: 30)
(Inorganic Chemistry)

*Answer **any three** questions*

1. (a) Draw the shape of different d orbitals and then show the crystal field splitting of the *d*-orbitals in the octahedral and tetrahedral fields.

   (b) What do you mean by CFSE? Calculate CFSE value for high-spin and low-spin d^7 configuration in octahedral geometry (Note: you should answer with the help of crystal field theory). (5 + 5)

2. (a) Comment on the coordination number and describe the geometry of the following compounds

   (i) $[Co(en)_3]Cl_3$

   (ii) $Na_2[Co(NCS)_4]$

   Note: [en = ethylenediamine].

   (b) Comment on the magnetic properties and geometry for $[Fe(H_2O)_6]^{2+}$ and $[Fe(CN)_6]^{4-}$, considering valence bond theory.

   (c) Explain why VBT fails to explain the colour of coordination complexes. (4+4+2)

3. (a) Give IUPAC Nomenclature (any three):

   (i) $[Cu(NH_3)_4]Cl_2$

   (ii) $[Co(en)_2(NH_3)_2]Cl_2$

   (iii) $[Fe(H_2O)_5NO]SO_4$

   (iv) $[Ni(CO)_4]$

   (Note: IUPAC = International Union of Pure and Applied Chemistry)

   (b) State the Jahn-Teller Theorem. Draw the splitting of *d* orbitals for *z*-out distortion and explain the reason.

   (c) Calculate the extra stabilization energy of d^9 system for z-out distortion. (3 + 4 + 3)

4. (a) Explain the general trends in properties of 1st row transition elements.

(b) ‘Aqueous solutions of most of the transition metal complexes are coloured.’ Explain with examples.

(c) At room temperature, the observed value of μ_{eff} for $[VCl_4(CH_3CN)_2]$ is 1.77 μ_B. Calculate the number of unpaired electrons. (4 + 3 + 3)

5. (a) What is the most common oxidation state of lanthanoid ions?

(b) Write the electronic configuration of chromium and copper atom.

(d) Which of the following will show Jahn-Teller distortion: (a) high spin d^4 (b) d^3 (c) Low spin d^6. (1 + 3 + 6)

Undergraduate Programme 2025
Major Course in Chemistry: MJCH 07
[*Inorganic Chemistry Theory*]

Time: Three Hours **Full Marks: 80**

Questions are of value as indicated in the margin.

Group A

(Answer Any Four Questions)

1. (a) Define coordination complex with at least two examples. Give stereochemistry with coordination numbers 3, 5, and 6 with justification. (2 + 3)

(b) Magnetic moment of $K_4[Fe(CN)_6]$ and $K_4[FeF_6]$ is 0.10 and 4.89 BM. respectively-explain. (3)

(c) The tetrahedral complexes are always high-spin, while the octahedral complexes depend on both splitting magnitude and pairing energy. (2)

2. (a) What are lanthanide and actinide elements? (3)

(b) The spectra in transition metals due to *d-d* transition are broad, while the spectra due to *f-f* transition in lanthanides are sharp. The spectra for *f-f* transition in actinides are broad for the early members upto Am-Cm region but are sharp for the later members upto Lr (At. No. 103). Explain. (7)

3. (a) Mn is most versatile in oxidation states ranging from -3 to +7. Explain. (3)

(b) What is the specialty of Tc in the series Mn, Tc, and Re? (3)

(c) $[VO(acac)_2]$ shows the magnetic moment of 1.79 BM while $[VO(SB)_2]$ shows magnetic moment of 1.05 BM at 298 K, where SB is the condensation product of salicylaldehyde and 2-aminophenol. (4)

4. (a) Illustrate how the d-orbital energy levels split when an octahedral complex $[M(NH_3)_4(OH_2)_2]$ slowly transforms into a square planar $[M(NH_3)_4]$ complex via a tetragonally elongated octahedral intermediate. (1.5)

(b) 'F^- is a weaker field ligand than H_2O, while CO is a stronger field ligand than H_2O in the spectrochemical series.' Explain the statement with the help of MO diagrams. (2.5)

(c) Write down the relationship of $\Delta_{tetrahedral}$ and Δ_{cubic} with $\Delta_{octahedral}$. (1)

(d) (i) State the Jahn-Teller theorem. (ii) Which among the following complexes exhibits Jahn-Teller distortion: $[Co(CN)_5(H_2O)]^{3-}$, $[NiF_6]^{4-}$ and $[Co(en)_2F_2]^+$? Explain. (iii) $K_4[Cu(NO_2)_6]$ shows two types Cu-N bond lengths and two types N-O stretching frequencies. Justify. (1+ 2 + 2)

5. (a) What do you mean by OSSE? Among Co(II), Ni(II) and Cu(II), Co(II) can readily form the tetrahedral complexes. Explain. (1 + 1.5)

(b) What do you mean by nephelauxetic effect? Arrange the nephelauxetic effect in increasing order for F^-, NH_3, and I^-. Justify. (1 + 2)

(c) Arrange in the increasing order of molar absorptivity for $[Ti(H_2O)_6]^{3+}$, $[CoCl_4]^{2-}$, $[MnO_4]^-$, and $[Mn(H_2O)_6]^{2+}$ complexes and justify the reason. (2)

(d) $[Ni(en)_3]Cl_2$ exhibits ligand field band at 11200, 18350 and 29000 cm^{-1}. Explain these electronic transitions with the help of the Orgel diagram and calculate the 10Dq value. (2.5)

6. (a) How many microstates are in a d^3 configuration and a ^4P term? Rank the energy level order when the ^4P state undergoes spin-orbit coupling and specify the energy gaps in terms of the spin-orbit coupling constant. (2 + 2)

(b) Write down the relationship between magnetic permeability and magnetic susceptibility, and then define paramagnetic and diamagnetic compounds. (1 + 1)

(c) Why is orbital angular momentum quenched in 3*d* metal complexes, while it contributes significantly to the magnetic moment in 4*d* and 5*d* metal complexes? (2)

(d) Calculate the spin-only magnetic moment of Cs_2CoCl_4 (μ_{obs} = 4.6 BM). Explain the reason behind the differences between the spin-only and observed magnetic moment for this complex (Given: Δ = 3100 cm^{-1}, λ = -172 cm^{-1}). (2)

Group B

(Answer Any Four Questions)

1. (a) What is the difference between the Weiss model and Pauling model of the structure of oxy-Hb/oxy-Mb? (2.5)

(b) What is the origin of deadly toxicity of cyanide? How can it be detoxified? (2.5)

(c) Draw the structures of active site of oxy- and deoxy-forms of hemocyanin (Hc). Explain the origin of colour of oxy-Hc. (2.5)

(d) Why do you mean by blue protein? Give its biological function. (2.5)

2. (a) What is glucose tolerance factor (GTF)? (2)

(b) What are peroxidase and catalase? Give their biological functions. (2)

(c) Give the functions of xanthine oxidase and aldehyde oxidase. (2)

(d) What is the function of carbonic anhydrase? Draw its active site structure. (2)

(e) What is the role of distal histidine in reducing CO toxicity? (2)

3. (a) Define oligomer and polymer with suitable examples. Elucidate the uniqueness of polymer molecule compared to small molecule. (2+2)

(b) What is chain growth polymerization? Mention its salient features. Discuss briefly the mechanistic path involved. (1+2+3)

4. (a) What are the repeating units of starch? What is the origin of the violet color of iodine vapor? Why does the starch-iodine adduct become blue? (1+2+2)

(b) What is Ziegler-Natta catalyst? Mention its novelties. (1+1)

(c) Define glass transition temperature. How does it control the quality of a polymer? (1+2)

5. (a) Briefly describe the theory underlying the qualitative examination of Cu^{2+} and Cd^{2+} in a binary combination. (2.5)

(b) Discuss the chemistry behind the oxidative fusion test for the detection of chromium and manganese. Write down the reactions of every step. (2.5)

(c) Attempt any two: (2.5 × 2)

(i) What is the structure of bone as a nanocomposite?

(ii) What are the biological functions of hemoglobin (Hb) and myoglobin (Mb)?

(iii) What do you mean by porphyrin doming in hemoglobin (Hb) and myoglobin (Mb)? How is it removed?

6. (a) What do you mean by the common ion effect? Discuss the salting-in phenomenon of a sparingly soluble salt. (2.5)

(b) Why do you consider phosphate as an interfering anion? Write a chemical test to identify phosphate anions. (2.5)

(c) A titration was repeated four times, and the volumes of titrant used were: 24.9, 25.1, 25.0, and 24.8 mL. Find the standard deviation. (2.5)

(d) What is the group reagent for group IIIB basic radicals? How can you separate group IIIB cations? (2.5)

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