L-1/T-2/MME **Date: 30/01/2025**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-1/T-2 B. Sc. Engineering Examinations 2023-2024

Sub: **CHEM 135** (Inorganic Chemistry)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer to **Q. No. 1** is **compulsory**.

Answer any **TWO** questions from questions 2-4.

1. (a) State the principles of valence bond theory (VBT) for formation of covalent bonding. **(10)**

(CO2)

(b) Draw the molecular orbital diagram with the relative energies of the atoms for the bond formation in HF molecule and discuss the bond order and magnetic properties. **(10)**

(CO4, CO1)

(c) Compare and discuss the polarity of NH_3 and BF_3 by drawing their structures according to VSEPR theory. **(10)**

(CO3)

(d) Draw all possible Lewis structures for N_2O molecule and identify the most preferable one. **(5)**

(CO2)

2. (a) The last electron of potassium atom is placed at *4s* orbital rather than at *3d* – rationalize this based on Aufbau principle and effective nuclear charge. **(15)**

(b) Arrange Mg, Al, Ga according to increasing IE_3 (3^{rd} ionization energy) values and justify your answer. **(10)**

(c) What do you understand by isoelectronic species? Compare and discuss the radii of the ions produced from the atoms with atomic number 9 and 11. **(10)**

3. (a) Draw the energy levels of an atom according to Bohr's atomic model and quantum mechanical model. Justify the differences between them. **(15)**

(b) Draw the radial probability distribution curve for the orbital containing the last electron of Mg atom and discuss its radial and angular nodes. **(10)**

(c) Spectral lines of Paschen and Balmer series do not overlap – prove that by calculating the corresponding wavelengths (R_H = 10973731 m^{-1}). **(10)**

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4. (a) Upon hitting, an object containing metallic bonding suffers denting but an object containing ionic bonding cracks – explain. **(15)**

(b) Both NH_3 and H_2O contain hydrogen bonding, yet NH_3 is gas but H_2O is liquid – justify. **(10)**

(c) The lone pair in the structure of SF_4 molecule stays in the equatorial position rather than in the axial position– discuss this based on the VSEPR theory. **(10)**

SECTION – B

There are **FOUR** questions in this section. Answer to Q. No. 5 is **compulsory.**

Answer any **TWO** questions from Questions 6-8.

5. (a) Write down the formula of the following complexes: **(5)**

(i) Tetraaminebromochloroplatinum(IV) chloride **(CO2)**

(ii) Hexaaminecobalt(III) tetrachloroferrate(III)

Give the systematic names for the following formulas: (iii) $[Cr(NH_3)_6][Cr(CN)_6]$, (iv) $[Co(en)_2Cl_2]NO_3$, (v) $[Ni(C_2O_4)_3]^{2-}$

(b) Use frontier molecular orbital theory to explain the following observations (i) water can act as an oxidizing agent; (ii) water can act as a reducing agent. **(10) (CO2)**

(c) For each of the complex given here, predict its hybridization, structure, the number of unpaired electrons present and whether it is high spin or low spin (i) $[Cr(CN)_6]^{3-}$ and (ii) $[FeF_6]^{3-}$ according to Valence Bond Theory (VBT). **(10) (CO3)**

(d) Analyze and apply your knowledge of Ligand Field Theory (LFT) to construct a molecular orbital diagram for a low spin octahedral complex featuring a d^6 metal ion. **(10) (CO4, CO1)**

6. (a) The magnetic moment of a certain octahedral complex of Co(II) is 4.0 μ_B. Apply your understanding of crystal-field theory and crystal field splitting to determine the d-electron configuration of the central cobalt ion. **(10)**

(b) Construct molecular orbital diagrams for the following octahedral complexes: **(15)**

(i) Low spin Co^{3+}, (ii) High spin Fe^{3+}

(c) Calculate the enthalpy of adduct formation predicted by Drago's E and C equation for the following combination, and explain the trends in terms of the electrostatic and covalent contributions: **(10)**

"BF_3 reacting with ammonia, methylamine, dimethylamine, and trimethylamine."

Acid	E_A	C_A	Base	E_B	C_B
BF_3	9.88	1.63 \ 6.2	NH_3	1.36	3.46
			CH_3NH_2	1.30	5.88
			$(CH_3)_2NH$	1.09	8.73
			$(CH_3)_3N$	0.808	11.54

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7. (a) Analyze the statement using HSAB Concept, "AgI is the most insoluble silver halide, but LiI is the most soluble among the lithium halides." **(10)**

   (b) Determine the crystal field stabilization energy (CFSE) for the following octahedral ions: (i) d^9, (ii) high spin d^6, (iii) low spin d^7. **(15)**

   (c) Employ jahn-Teller effect to explain the following observation: "The Cu^{2+} ion in $[Cu(H_2O)_6]^{2+}$ has a d^9 configuration but instead of one d-d transition, two d-d transitions were observed in the absorption spectra." **(10)**

8. (a) Discuss the role of charge, size, ligand nature, and coordination number in determining the stability of a metal complex. **(10)**

   (b) Calculate the total electron count of the following complexes by both Donor-Pair and Neutral Ligand method and determine if they follow the 18-electron rule. **(15)**

   (i) $(\eta^5\text{–}C_5H_5)_2Fe$

   (ii) $[Ni(CN)_4]^{2-}$

   (iii) $[Re(CO)_5(PF_3)]^+$

   (c) Write a short note on Linkage and Geometrical isomerism of coordination compounds. **(10)**
