

M.Sc. CHEMISTRY
SECOND SEMESTER
INORGANIC CHEMISTRY-II
MSC – 202
[USE OMR FOR OBJECTIVE PART]

**SET
A**

Duration: 3 hrs.

Full Marks: 70

Time: 30 min.

Marks: 20

(Objective)

Choose the correct answer from the following:

1×20=20

- Spin crossover is most commonly observed in complexes of which metal ion?
 - Cu^{2+}
 - Zn^{2+}
 - Fe^{2+}
 - Ni^{2+}
- Diamagnetic correction is applied during magnetic susceptibility measurements to account for:
 - The presence of unpaired electrons
 - The crystal structure of the compound
 - The effect of external pressure
 - The contribution of paired electrons
- Which of the following is a key reason for the occurrence of temperature independent paramagnetism (TIP)?
 - Thermal excitation of electrons
 - Mixing of ground and excited states due to magnetic field
 - Crystal field splitting
 - Formation of metal-ligand bonds
- In the complex $\text{K}_4[\text{Cr}(\text{CN})_6] \cdot 3\text{H}_2\text{O}$, the chromium ion is in the (+3) oxidation state. Considering the nature of the cyanide ligand and its ligand field strength, what would be the magnetic moment of this complex in terms of Bohr magnetons (BM)?
 - 0 BM, as all the electrons are paired in a low-spin octahedral configuration
 - 4.90 BM, as Cr^{3+} undergoes a high-spin octahedral configuration with 5 unpaired electrons
 - 2.83 BM, corresponding to a low-spin octahedral configuration with 2 unpaired electrons
 - 1.73 BM, corresponding to a weakly paramagnetic low-spin octahedral configuration
- Which of the following statements best explains the effect of spin-orbit coupling on the electronic properties of a transition metal complex?
 - Spin-orbit coupling strengthens the crystal field splitting and increases the splitting energy in weak-field complexes.
 - Spin-orbit coupling is significant only in first-row transition metal complexes and has no noticeable effect on second and third-row metals.
 - Strong spin-orbit coupling causes the mixing of electronic states, leading to the lifting of degeneracy and the potential for low-spin states in high-field complexes.
 - Spin-orbit coupling generally reduces the number of unpaired electrons in a complex by promoting electron pairing in weak-field ligands.

6. The spectroscopic ground state symbol and the total number of electronic transition of $[\text{Ti}(\text{H}_2\text{O})_6]^{2+}$ are
 - a. ${}^3\text{T}_{1g}$ and 1
 - b. ${}^3\text{A}_{2g}$ and 3
 - c. ${}^3\text{T}_{1g}$ and 3
 - d. ${}^3\text{A}_{2g}$ and 2
7. Which of the following octahedral complex shows ${}^3\text{A}_{2g} \rightarrow {}^3\text{T}_{2g}$ transition as the lowest energy visible band in its electronic spectrum?
 - a. $[\text{Cr}(\text{NH}_3)_6]^{3+}$
 - b. $[\text{Co}(\text{NH}_3)_6]^{3+}$
 - c. $[\text{FeF}_6]^{3-}$
 - d. $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$
8. Which of the following complexes is expected to exhibit the highest energy d-d transition?
 - a. $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
 - b. $[\text{Fe}(\text{CN})_6]^{4-}$
 - c. $[\text{Fe}(\text{en})_3]^{2+}$
 - d. $[\text{Fe}(\text{SCN})_6]^{3-}$
9. The ground state term symbol of Ni^{2+} ions is
 - a. ${}^3\text{F}$
 - b. ${}^3\text{A}$
 - c. ${}^3\text{P}$
 - d. ${}^3\text{E}$
10. The ground state term for $t_{2g}^4 e_g^2$ in octahedral field is
 - a. ${}^3\text{E}_g$
 - b. ${}^2\text{T}_{1g}$
 - c. ${}^4\text{T}_{1g}$
 - d. ${}^3\text{A}_{2g}$
11. The composition of calomel is
 - a. AgCl
 - b. Hg_2Cl_2
 - c. HgCl
 - d. KCl
12. The reaction $2\text{H}_2\text{O}_2(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$ is ----- reaction
 - a. Disproportionation
 - b. Comproportionation
 - c. Split
 - d. Free radical
13. Dimals are salicylates of
 - a. As and Pr
 - b. Nd and Gd
 - c. Am and U
 - d. Pr and Nd
14. Based on standard electrode possible, which pair will *not* undergo redox reaction (Given: $\text{Fe}^{3+}/\text{Fe}^{2+}=+0.77$, $\text{Ag}^+/\text{Ag}=+0.84$, $\text{Cu}^{2+}/\text{Cu}=+0.34$, $\text{I}_2/\text{I}^- = +0.54$)
 - a. Ag^+ and Cu
 - b. Fe^{3+} and Ag
 - c. Fe^{3+} and Cu
 - d. Fe^{3+} and I^-
15. The orange red colour of Ce^{+4} is due to
 - a. f-f transition
 - b. d-d transition
 - c. f-d transition
 - d. Charge transfer transition
16. Identify the *incorrect* statement about actinides
 - a. All are non-radioactive
 - b. Uranium is an actinide
 - c. Actinide contraction is present
 - d. The last electron enters 5f shell
17. The ligands that support quadruple bonds are
 - a. pi-donor but not pi-acceptor
 - b. sigma-donor but not sigma- acceptor
 - c. sigma-acceptor but not pi- donor
 - d. sigma donor only

18. Polyoxometallate anion can be prepared by carefully adjusting
- a. pressure
 - b. pH and concentration
 - c. temperature
 - d. the volume
19. Charge-transfer originates from a redistribution of
- a. Electric Charge density within the molecule
 - b. Electronic charge density within and outside the molecule
 - c. only in the exterior
 - d. Not in the interior
20. The characteristics of a mixed valence complex is that the ion strongly absorbs light in the
- a. mid infrared region
 - b. near infrared region
 - c. far infrared region
 - d. UV region
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(Descriptive)

Time : 2 hrs. 30 mins.

Marks : 50

[Answer question no.1 & any four (4) from the rest]

1.
 - a. Compare the "Gouy and Faraday" methods for determining magnetic susceptibility by listing two advantages and two disadvantages of each. 2+2+2+2
+2=10
 - b. Write the selection rules for electronic transition in metal complexes.
 - c. Define standard electrode potential and write its relation with free energy (ΔG).
 - d. Why species of Ln^{+3} ions are considered to be more stable than Ln^{+2} and Ln^{+4} species in solids and solution?
 - e. What is ruthenium red? What are its applications?

2.
 - a. What is the Curie-Weiss law, and how does it describe the relationship between temperature and the magnetic susceptibility of materials? 3+2+3+2
=10
 - b. Explain the principle behind "Gouy method" for measuring the magnetic susceptibility of a substance.
 - c. How do spin motion and orbital motion contribute to the magnetic properties of transition metal complexes?
 - d. Define the following terms: Magnetic permeability, magnetic susceptibility, ferromagnetism and antiferromagnetism

3.
 - a. Explain the concept of orbital contribution to the magnetic properties of transition metal complexes, and illustrate it with a detailed example. 3+2+2+3
=10
 - b. Describe the antiferromagnetic behavior observed in copper-acetate complexes and explain the possible pathways for this interaction.
 - c. What do you mean by "Racah parameter"?
 - d. Write down the differences between "Orgel and Tanabe Sugano" diagram.

4. a. Draw "Orgel Diagram" for "F" ground term. State limitations of it. 5+5=10
 b. Discuss how relaxation of Laporte and spin selection rules can occur. Write the number of possible d-d transition of $[\text{Cu}(\text{NH}_3)_6]^{2+}$ and assign those.
5. a. Explain the difference between comproportionation and disproportionation reactions using suitable example. 3+3+4=10
 b. Explain briefly the working of silver-silver chloride electrode.
 c. Consider the following two reactions
 (i) $\text{CuO} + \text{H}_2 \rightarrow \text{Cu} + \text{H}_2\text{O}$
 (ii) $\text{BaCl}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + 2\text{HCl}$
 Identify which of the above reaction is not a redox reaction and explain why?
6. a. What are the types of coupling present in lanthanides? Determine the magnetic moment (μ) of Gd^{3+} . 3+3+1+3=10
 b. What is the most common type of transition exhibited by Ln^{+3} ions? Write its characteristics.
 c. Write the structural details of UO_2F_2 .
 d. Write briefly the steps involved in actinide separation.
7. a. Show the Latimer diagram for chlorine in acidic solution and explain briefly the steps. 2+2+2+4=10
 b. Calculate the emf of the cell. $\text{Zn} | \text{Zn}^{2+} (0.001\text{M}) || \text{Ag}^+ (0.1\text{M}) | \text{Ag}$. The standard potential of Ag/Ag^+ half-cell is +0.80 V and Zn/Zn^{2+} is -0.76 V.
 c. What are the consequences of decrease in basicity of lanthanides?
 d. What are dinitrogen complexes? How pentammine(dinitrogen) ruthenium(II) could be synthesised?
8. a. What is Creutz-Taube ion metal complex? How was the compound isolated? 3+4+3=10
 b. What is Tungsten Bronze? Outline the properties of Sodium Tungsten Bronze.
 c. What is quadruple bond? Name the first compound to be synthesised containing quadruple bond.

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