MACHAKOS UNIVERSITY

University Examination for 2019/2020 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCE

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE AND BACHELOR OF EDUCATION (SPECIAL NEEDS)

SCH 301: COORDINATION AND ORGANOMETALLIC CHEMISTRY

DATE: **TIME: 2 HOURS**

***INSTRUCTIONS*:**

1. Question **ONE** is **COMPULSORY (Section A) (30mks)**
2. Answer **ANY** other **TWO** questions from **Section B (each 20marks)**

SECTION A

QUESTION ONE (30 MARKS)

a. Define the following terms (4mks)

   i. Ligand

   ii. Coordination sphere

   iii. Organometallic compound

   iv. Chelate

b. Write the formulas of the following coordination compounds (3mks)

   i) Potassium hexacyanoferrate (III)

   ii) Pentaaquathiocyanatoiron (III)sulfate

   iii) Tetraamineaquachlorocobalt (III)chloride

c. Draw three geometrical isomers of diaminetetracyanoiron (III) (3mks)

d. Calculate the oxidation number of the metal in the following co-ordination compounds

   i) $[PtCl_4]^{2-}$ (1mks)

   ii) $[Cr(NH_3)_3Cl_3]$ (2mks)

e. Give two differences between organometallic and coordination compounds (2mks)

f. Explain why Scandium and Zinc are not considered as transition elements

   (Zn=30, Sc=21 (2mks)

g. Explain why Fe^{3+} is stable ($Fe=3d^6\ 4s^2$) (2mks)

h. State three limitations of valence bond theory (3mks)

i. Distinguish between bidentate and polydentate ligands and give an example in each case

   (4mks)

j. Identify two coordination compounds that are biologically important and explain their functions (4mks)

SECTION B

QUESTION TWO (20 MARKS)

a) Explain the meaning of lanthanoid contraction and its net effect on physical and chemical properties of transition metals (5mks)

b) Write the systematic name of following:

i) $\left[Pt(NH_{3)4}Cl(NO_2)\right]SO_2$ (2mks)

ii) $[(H_2O)_4Fe(\mu_2 - OH)_2Fe(H_2O)_4](SO4)_2$ (2mks)

iii) $Na_3[FeCl(CN)_5]$ (2mks)

c) i) Explain the term crystal field splitting energy (2mks)

ii) Explain how the magnitude of Δ_O affect the actual configuration of d-orbitals in coordination identity. (4mks)

d) Explain why Cu ($3d^{10}$ $4s^1$), Ag ($4d^{10}$ $5s^1$) and Au ($5d^{10}$ $6s^1$) are considered transition elements yet they have fully filled d-orbitals. (3mks)

QUESTION THREE (20 MARKS)

a) Given the coordination compound $\left[\boldsymbol{Cr}(\boldsymbol{NH_3})_6\right]^{3+}$ (Cr=24) use the valence bond theory to;

i) Determine the oxidation state of the central metal atom (2mks)

i) Identify the magnetic nature of the complex (3mks)

ii) State the hybridized state of the central atom (2mks)

iii) State the geometry of the complex (1mk)

iv) Describe the stability of the complex (2mks)

Hint: Ammonia is a strong field ligand. Use of diagrams is highly encouraged where possible.

b) Draw three solvate isomers of chromium (III) chloride hexahydrate and give their systematic names. (6mks)

c) Explain bonding in coordination compounds in terms of Werner's postulates (4mks)

QUESTION FOUR (20 MARKS)

a) Contrast the magnetic nature of $[NiCl_4]^{2-}$ and $[Ni(CO)_4]$ in their tetrahedral structure (Ni=28) (5mks)

b) Using a suitable example, show how isomerism can affect the usefulness of a coordination compound.

(5mks)

c) Using crystal field theory explain why $[Ti(H_2O)_6]^3$ is violet octahedral complex (Ti= 22) (5mks)

d) Using a suitable diagram show splitting of d-orbitals in the tetrahedral crystal field (5mks)

QUESTION FIVE (20 MARKS)

a) A metal complex having composition $Cr(NH_3)_4Cl_2Br$ has been isolated in two forms A and B. A reacts with silver nitrate producing a white precipitate which is soluble in dilute ammonia solution. B reacts with silver nitrate producing a pale yellow precipitate soluble in concentrated ammonia solution. Identify A and B using relevant equations (6mks)

Hint: maintain $Cr(NH_3)_4$ *backbone.*

d) Briefly describe two methods of synthesizing organometallic compounds (4mks)

e) Analyse the complex below and identify whether they are coloured or not (Ti=22, Cu=29, Fe=26, V=23) (8mks)

i) $\mathbf{[Ti(NO_3)_4]}$

ii) $\mathbf{[Cu(NCCH_3)]^+BF_4}$

iii) $\mathbf{[Fe(CN)_6]^{4-}}$

iv) $\mathbf{K_3[VF_6]}$

f) Show whether $HMn(CO)_5$ obeys 18 electron rule given that the neutral atom electron count for constituent atoms are, Mn=7, CO=2 and H=1 (2mks)

END