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(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY MAIN EXAMINATIONS

2021/2022 ACADEMIC YEAR

FOURTH YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE
OF
BACHELOR OF SCIENCE (CHEMISTRY) AND BACHELOR OF EDUCATION (SCIENCE)

COURSE CODE: SCH 410

COURSE TITLE: COORDINATION AND ORGANOMETALLIC CHEMISTRY

DATE: MONDAY 25TH JULY 2022 **TIME:** 8.00-10.00 AM

INSTRUCTIONS TO CANDIDATES

Total Marks: 70

Answer all the Questions

TIME: 2 Hours

Question One **(19 marks)**

a. Explain the following terms as used in coordination and organometallic Chemistry. Use of relevant examples is encouraged (6 Marks)

i. Effective atomic number
ii. A polynucleating ligand
iii. Hard acids

b. Give the systematic names of the complexes below (4 Marks)

i. $[Fe(C_5H_5)_2]\ Cl$;
ii. $K[Co(CN)(CO)_2NO]$;
iii. $[(NH_3)_5Cr\text{-}OH\text{-}Cr(NH_3)_5]Cl_5$;
iv. $[CrCl(H_2O)(en)_2]^{2+}$;

c. Determine whether the compound below obeys the 18 electron rule. If it does not, explain why (5 marks)

d. Show that $K_n = [ML_n]/[ML_{(n-1)}][L]$ and $\beta_n = [ML_n]/[L]^n$ where M is the central metal ion, L is ligand, K_n stepwise stability constant and β_n is overall stability constant (4 Marks)

Question Two **(17 Marks)**

a. Outline any FOUR uses of chelating agents in industrial processes (4 Marks)

b. Calculate the spin only magnetic moment (μ_S) for both high and low spin Cr^{2+} (6 marks)

c. Define the term isomerism as it applies to coordination compounds (2 Marks).

d. Consider a pair of isomeric cationic complexes having the molecular formula $[Co(en)_2Br_2]ClO_4$.

i. What is coordination number of the central metal ion (1 Mark)

ii. What is the role of ClO_4^- in the complex (1Mark)

iii. What is the systematic name of this complex (1 mark)

iv. Draw the molecular structures of the possible geometric isomers of the complex above (2 Marks)

Question Three **(19 Marks)**

a. Calculate the crystal Field stabilization Energy in $kJmol^{-1}$ for $[CoF_6]^{3-}$, given that 10 Dq = 13,000 cm^{-1} and pairing energy is 16,800 cm^{-1} and 1 $kJmol^{-1}$ = 83 cm^{-1} (4 Marks)

b. Explain the following observations

i. Intra-ligand charge transfers are of less interest to transition metal chemists than the other types of absorption (3 Marks)

ii. Ligand-to-metal Charge Transfer is the basis for photography (2 Marks)

iv. Transition metal form coloured ions (2 marks)

c. State and explain the two selection rules governing which electronic transitions of a metal complexes (6 marks)

d. Removing all the water from hydrates of transition metal complexes is notoriously difficult. Typically, simply heating the complex is ineffective and reaction with something like thionyl chloride is required. For example, cobalt(II) chloride hexahydrate only loses four water molecules to become cobalt(II) chloride dihydrate when heated in an oven at 150 °C. Suggest an explanation for this observation (2 marks).

e. What determines the magnetic behaviour of metal complex when placed in magnetic field (2 Marks)

Question Four **(15 marks)**

Using examples, briefly describe the following types of organometallic compounds (6 marks)

i. Sigma bonded organometallic compounds
ii. Pi-bonded organometallic compounds
iii. Sigma and Pi bonded organometallic compounds

b. Potassium trichloro(ethene)platinate(II), also known as Zeise's salt, has the formula $K_2[PtCl_3(C_2H_4)]$ and contains η^2-ethylene ligand. What are the products, when Zeise's salt is reacted with the following (3 Marks)

i. $K_2[PtCl_3(C_2H_4)] + H_2O$

ii. $K_2[PtCl_3(C_2H_4)] + CO$

iii. $K_2[PtCl_3(C_2H_4)] + RNH_2$

c. Explain how organometallic compounds can be produced using the following methods. Illustrations using chemical equations is encouraged (6 marks)

i. Methylenation

ii. Insertion

Periodic Table of the Elements

MAIN-GROUP ELEMENTS | TRANSITION ELEMENTS | MAIN-GROUP ELEMENTS

- Metals (main-group)
- Metals (transition)
- Metals (inner transition)
- Metalloids
- Nonmetals

Period	1A (1)	2A (2)	3B (3)	4B (4)	5B (5)	6B (6)	7B (7)	8B (8)	8B (9)	8B (10)	1B (11)	2B (12)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
1	1 **H** 1.008																	2 **He** 4.003
2	3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
3	11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
4	19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
5	37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
6	55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.9	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
7	87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (266)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 (269)	111 (272)	112 (277)						

As of mid-1999, elements 110 through 112 have not yet been named.

INNER TRANSITION ELEMENTS

Period															
6	Lanthanides	58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
7	Actinides	90 **Th** 232.0	91 **Pa** (231)	92 **U** 238.0	93 **Np** (237)	94 **Pu** (242)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)