



MACHAKOS UNIVERSITY

University Examinations 2022/2023 Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCE

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ANALYTICAL CHEMISTRY)

BACHELOR OF EDUCATION (SPECIAL NEEEDS)

BACHELOR OF EDUCATION (SCIENCE)

SCH 301: COORDINATION AND ORGANOMETALLIC CHEMISTRY

DATE: 12/4/2022

TIME: 2:00 – 4:00 PM

INSTRUCTIONS

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks)
- Answer any **two** questions from section **B** (each 20 marks)
- Check for useful periodic Tables behind the Question paper (page 5)

SECTION A

QUESTION ONE (30 MARKS)

- (a)
- (i) State and explain which of the two complexes is more stable; $K_4[Fe(CN)_6]$ and $K_3[Fe(CN)_6]$ (2 marks)
 - (ii) Name an ionization isomer of $[Cr(H_2O)_5Br]SO_4$ (2 marks)
 - (iii) Discuss the nature of bonding in metal carbonyls (2 marks)
 - (iv) Under Fischer Tropsch synthesis state the water gas shift equation (2 marks)
- (b) Provide the IUPAC names of the following
- (i) $[Co(C_2O_4)_3]^{3-}$. (2 marks)
 - (ii) $K_2[CrCO(CN)_5]$ (2 marks)
 - (iii) $K_3[Fe(CN)_5NO]$ (2 marks)

- (c) Determine the oxidation states of the metals in the following complexes
- (i) $[Ni_4(CO)_9]^{2-}$ (ii) $[HRhCl(CO)(PPh_3)_2]^+$ (iii) $[Mn(NO)_3CO]$ (3 marks)
- (d) Using a reaction mechanism show how you will differentiate the two geometric isomers *cisplatin* and *trans-platin* (4 marks)
- (e) Arrange the following complexes in descending order of ligand exchange briefly stating the reason
- (i) $[Na(H_2O)_6]^+$, $[Mg(H_2O)_6]^{2+}$, $[Al(H_2O)_6]^{3+}$ (2 marks)
- (ii) $[Mg(H_2O)_6]^{2+}$, $[Ca(H_2O)_6]^{2+}$, $[Sr(H_2O)_6]^{2+}$ (2 marks)
- (f) A chelate effect is an entropy factor. Discuss (5 marks)

SECTION B

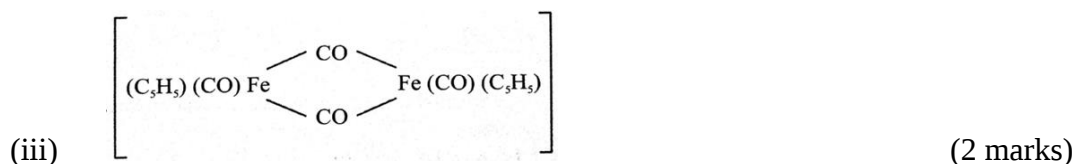
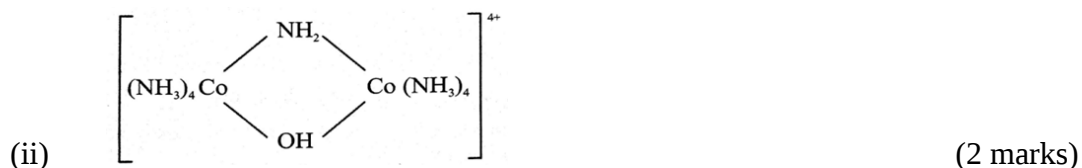
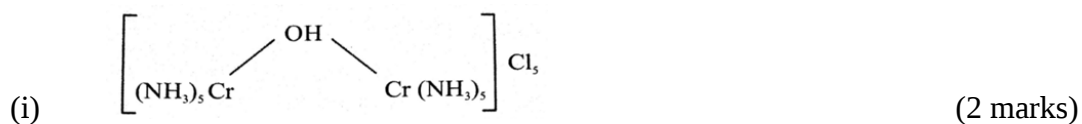
QUESTION TWO (20 MARKS)

- (a) State four applications of organometallic compounds (4 marks)
- (b) Using Ziegler Natta catalysts show the catalytic cycle in the synthesis of $C_8H_{16}R$ (5 marks)
- (c) Determine the number of unpaired electrons and the magnetic moments at 25 °C for:
- (i) $[Fe(CN)_6]^{4-}$ (3 marks)
- (ii) $[Cr(NH_3)_6]^{2+}$ (2 marks)
- (iii) $[Co(NH_3)_6]^{3+}$ (2 marks)
- (d) Write an equation for an associative reaction mechanism and give its rate law (4 marks)

QUESTION THREE (20 MARKS)

- (a) Using relevant reaction equations, differentiate between acid hydrolysis and base hydrolysis (4 marks)
- (b) State any four factors that will affect acid hydrolysis (4 marks)
- (c) Explain why anhydrous diethyl ether and tetrahydrofuran (THF) are common solvents for the generation of Grignard reagents (2 marks)

(d) Provide the IUPAC names of the following compounds



(e) Draw all the geometrical isomers of $[\text{Pt}(\text{NH}_3)(\text{Br})(\text{Cl})(\text{Py})]$ and state how many will exhibit optical isomerism. (Py = Pyridine) (4 marks)

QUESTION FOUR (20 MARKS)

(a) A metal ion Mn^{n+} having d^4 valence electronic configuration combines with three bidentate ligands to form a complex compound. (Assuming $\Delta_o > p$).

(i) Draw the diagram showing d -orbital splitting during this complex formation (2 marks)

(ii) Identify the type of hybridization exhibited by M^{n+} (1 mark)

(iii) Name the type of isomerism exhibited by this complex (1 mark)

(iv) Write the electronic configuration of metal M^{n+} (2 marks)

(b) Calculate the magnetic moments of the following complexes

(i) $[\text{FeCl}_4]^-$ (2 marks)

(ii) $[\text{Cr}(\text{CN})_6]^{4-}$ (2 marks)

(c) Calculate the effective atomic number (EAN) of the following and determine whether they obey the 18-electron rule

(i) $[\text{Re}(\text{CO})_2(\text{PR}_3)_2(\text{CH}_3)(\text{C}_2\text{H}_4)]$ (2 marks)

(ii) $[\text{Ni}(\text{NH}_3)_6]^{2+}$ (2 marks)

(iii) Determine the overall charge of $[\text{Co}(\text{CO})_5]^z$ if it obeys 18 electron rule (2 marks)

(d) State four applications of chelate complexes (4 marks)

QUESTION FIVE (20 MARKS)

- (a) (i) Define a transition element (2 marks)
- (ii) Explain why transition metals generally form coloured compounds (3 marks)
- (iii) The hexaquomanganese(II) ion contains five unpaired electrons, while the hexacyanomanganese(II) ion contains only one unpaired electron. Explain these observations using Crystal Field Theory (5 marks)
- (b) Explain why $[\text{Co}(\text{NH}_3)_6]^{3+}$ is an inner orbital complex whereas $[\text{Ni}(\text{NH}_3)_6]^{2+}$ is an outer orbital complex (5 marks)
- (c) Explain why $[\text{Cr}(\text{CO})_6]$ is known while $[\text{Cr}(\text{CO})_6]^{3+}$ is unknown (2 marks)
- (d) Predict the number of unpaired electrons in the square planar $[\text{Pt}(\text{CN})_4]^{2-}$ ion (Pt $5d^9 6s^1$). (3 marks)

Periodic Table of the Elements 2006																		He 4.00																			
H 1.01		2														13		14		15		16		17		18											
3		4														5		6		7		8		9		10											
Li 6.94		Be 9.01														B 10.81		C 12.01		N 14.01		O 15.99		F 19.00		Ne 20.18											
11		12														13		14		15		16		17		18											
Na 22.99		Mg 24.31														Al 26.98		Si 28.09		P 30.97		S 32.07		Cl 35.45		Ar 39.95											
19		20		3		4		5		6		7		8		9		10		11		12		30		31		32		33		34		35		36	
K 39.10		Ca 40.08		Sc 44.96		Ti 47.87		V 50.94		Cr 52.00		Mn 54.94		Fe 55.85		Co 58.93		Ni 58.69		Cu 63.55		Zn 65.41				Ga 69.72		Ge 72.64		As 74.92		Se 78.96		Br 79.90		Kr 83.80	
37		38		39		40		41		42		43		44		45		46		47		48		49		50		51		52		53		54			
Rb 85.47		Sr 87.62		Y 88.91		Zr 91.22		Nb 92.91		Mo 95.94		Tc (98)		Ru 101.07		Rh 102.91		Pd 106.42		Ag 107.87		Cd 112.41		In 114.82		Sn 118.71		Sb 121.76		Te 127.60		I 126.90		Xe 131.29			
55		56		57		72		73		74		75		76		77		78		79		80		81		82		83		84		85		86			
Cs 132.91		Ba 137.33		La 138.91		Hf 178.49		Ta 180.95		W 183.84		Re 186.21		Os 190.23		Ir 192.22		Pt 195.08		Au 196.97		Hg 200.59		Tl 204.38		Pb 207.2		Bi 208.98		(209)		(210)		(222)			
87		88		89		104		105		106		107		108		109		110		111																	
Fr (223)		Ra (226)		Ac (227)		Rf (261)		Db (262)		Sg (266)		Bh (264)		Hs (270)		Mt (268)		Ds (281)		Rg (272)																	

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
140.12	140.91	144.24	(145)	150.36	151.97	157.25	158.93	162.50	164.93	167.26	168.93	173.04	174.97
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
232.04	231.04	238.03	(237)	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(262)