Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	INORGANIC CHEMISTRY II
COURSE CODE	:	BWK 10503
PROGRAMME CODE	:	BWK
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 (a) Calculate the primary and secondary valency of $[Co(NH_3)_3ClBrI]$ and $[Fe(CN)_6]^{4-}$.

(4 marks)

(b) A researcher reacted iron (II) with Cl^- and CN^- in two separate experiments and found that in each case, the metal center was coordinated with 6 ligands producing complex ions of the general formula $[Fe(X)_6]^{4-}$. He found that one of the complexes has 4 unpaired electrons and the other one has no unpaired electrons. Copy the **Table Q1(b)** in answer script and complete the table below with the right responses.

Table Q1(b)

	Unpaired electron = 4	Unpaired electron = 0
X		
Spin state		
Magnetism		
Orbital Diagram		

(6 marks)

(c) The complex ion $[Co(NH_3)_2(H_2O)_2\ Cl_2]^+$ and $[Pt\ (en)_2Cl_2]$ contains monodentate and bidentate ligands.

(i) Sketch the structure of all possible isomers of the complex ions.

(5 marks)

(ii) Identifies the number of geometrical isomers, plane of symmetry and number of stereoisomers based on structure drawn in **Q1(c)(i)**.

(5 marks)

Q2 (a) Cobalt complex ion of the type $[CoX_6]^{n+}$ if $X = NH_3$. Draw a completely labeled crystal field splitting diagram of the *d* orbitals with the distribution of the *d* electrons.

(6 marks)

(b) The cobalt complex in **Q2(a)** is a low spin complex. Suggest a ligand for X that shall produce a high spin complex in **Q2(b)(i)**. For the proposed complex;

(i) Draw the crystal field splitting diagram of the *d* orbitals.

(6 marks)

(ii) State the number of unpaired electrons.

(1 mark)

(iii) Compare the differences of the magnitudes of the resulting energy difference (Δo) of the *d* orbitals in **Q2(a)** and **Q2(b)(i)**.

(4 marks)

(c) Calculate the crystal field stabilization energy CFSE (Δo) in **Q2(a)** complex ion.

(3 marks)

Q3 (a) Draw the molecular orbitals of the octahedral ion $[TiF_6]^{3-}$ and identify the t_{2g} and eg bonding and antibonding orbitals, and indicate which *d* orbitals of Ti are involved in each.

(10 marks)

(b) Using angular overlap σ interactions method as shown in **Table Q3(b)**, calculate the LFSE of $[Cr(NH_3)_4Cl_2]^+$ complex ion for the net stabilization.

(6 marks)

(c) Predict Jahn-Teller Distortions of $[Co(NH_3)_6]^{3+}$ and $[Co(H_2O)_6]^{3+}$

(4 marks)

Q4 (a) Term symbol is an abbreviated description of the total angular momentum quantum number in a multi-electron atom.

(i) Predicts the possible term symbol of the excited state of Na atom with electronic configuration $[1s^2\ 2s^2\ 2p^6\ 3p^1]$.

(3 marks)

(ii) Identify the possible term symbol for oxygen atom.

(2 marks)

(b) Microstate is the arrangement of the energy of each molecule in the whole system atone instant.

(i) Calculate the number of microstates for np^2.

(3 marks)

(ii) Determine the possible values of $M_L[\Sigma_{ML}]$ and M_S $[\Sigma_{MS}]$.

(1 marks)

(iii) Construct the possible microstates table for np^2 configuration.

(8 marks)

(iv) Calculate the degeneracy and identify the R-S terms.

(3 marks)

- END OF QUESTIONS -

APPENDIX A

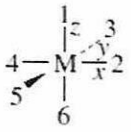
Table: List of elements

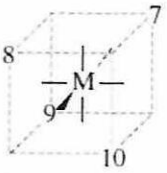
Symbol	Name	Atomic Number	Atomic Mass	Symbol	Name	Atomic Number	Atomic Mass
H	Hydrogen	1	1.008	S	Sulfur	16	32.065
He	Helium	2	4.003	Cl	Chlorine	17	35.453
Li	Lithium	3	6.941	Ar	Argon	18	39.948
Be	Beryllium	4	9.012	K	Potassium	19	39.098
B	Boron	5	10.811	Ca	Calcium	20	40.078
C	Carbon	6	12.011	Sc	Scandium	21	44.960
N	Nitrogen	7	14.007	Ti	Titanium	22	47.880
O	Oxygen	8	15.999	V	Vanadium	23	50.940
F	Fluorine	9	18.998	Cr	Chromium	24	52.000
Ne	Neon	10	20.180	Mn	Maganese	25	54.940
Na	Sodium	11	22.990	Fe	Iron	26	55.850
Mg	Magnesium	12	24.305	Co	Cobalt	27	58.930
Al	Aluminium	13	26.982	Ni	Nickel	28	58.690
Si	Silicon	14	28.086	Cu	Copper	29	63.550
P	Phosphorus	15	30.974	Zn	Zinc	30	65.390

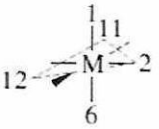
APPENDIX B

Table Q3(b): Angular Overlap σ interactions

Octahedral Positions	Tetrahedral Positions	Trigonal Bipyramidal Positions







Ligand Positions for Coordination Geometries

CN	Shape	Positions
2	Linear	1, 6
3	Trigonal	2, 11, 12
3	T shape	1, 3, 5
4	Tetrahedral	7, 8, 9, 10
4	Square planar	2, 3, 4, 5
5	Trigonal bipyramidal	1, 2, 6, 11, 12
5	Square pyramidal	1, 2, 3, 4, 5
6	Octahedral	1, 2, 3, 4, 5, 6

Sigma Interactions (in units of e_σ) Metal *d* Orbital

Ligand Position	z^2	x^2-y^2	xy	xz	yz
1	1	0	0	0	0
2	$\frac{1}{4}$	$\frac{3}{4}$	0	0	0
3	$\frac{1}{4}$	$\frac{3}{4}$	0	0	0
4	$\frac{1}{4}$	$\frac{3}{4}$	0	0	0
5	$\frac{1}{4}$	$\frac{3}{4}$	0	0	0
6	1	0	0	0	0
7	0	0	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
8	0	0	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
9	0	0	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
10	0	0	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
11	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{9}{16}$	0	0
12	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{9}{16}$	0	0