



Eastern University, Sri Lanka

Third Year Examination in Science 2020/2021 (Oct/Nov 2024)

Honours Degree in Chemistry

CH4012 Advanced Inorganic Chemistry-I

Answer all questions

Time: Two hours

1. a) i) Construct the group multiplication table for the point group S_4 by examining the effects of sequentially applying the various symmetry operations within the group.

S_4	E	C_2	S_4^1	S_4^3
E				
C_2				
S_4^1				
S_4^3				

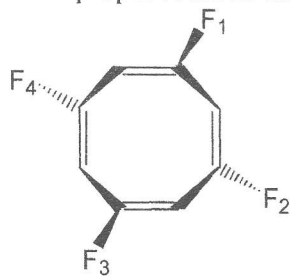
[20 Marks]

- b) Determine all symmetry elements and unique symmetry operations for each of the following molecules, and identify the point group for each molecule.

i) $[\text{NH}_3\text{Cl}]^+$ ii) $[\text{BF}_4]^+$ iii) PF_3 iv) Staggered ferrocene

[40 Marks]

- c) Explain the concept of n-fold improper rotation using the molecule provided below.



[40 Marks]

Contd.

2. a) Diagrammatically show the locations of all possible symmetry elements in each of the following molecules.

- all rotational axis of symmetry and the plane of symmetry for $[\text{Co}(\text{en})_3]^{3+}$
- all rotational axis of symmetry and mirror planes for $[\text{ZrF}_8]^{4-}$
- all rotational axis of symmetry and plane of symmetry for B_2H_6

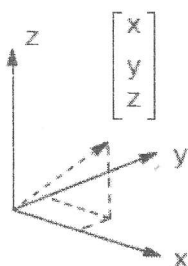
[30 Ma

b) Discuss the following,

- Abelian and non-abelian group
- Metal to Ligand Charge Transfer (MLCT) involving an octahedral metal complex
- Symbiotic theory for linkage isomers

(30 ma

c) i) Deduce the 3 x 3-matrix representation for the following symmetry operation.



- i) Identity ii) $C_2(z)$ c) $\sigma(xy)$ d) inversion

(40 mar

3. a) i) Write down the reduction formulae for reducing the representation spanned by a set of basis functions. Briefly explain each of the terms in the formulae.

ii) Define the term irreducible representations (IRs)

iii) The following is the character table for D_{3h} point group.

D_{3h}	E	$2C_3$	$3C_2$	σ_h	$2S_3$	$3\sigma_v$		
A'_1	1	1	1	1	1	1		$x^2 + y^2, z^2$
A'_2	1	1	-1	1	1	-1	R_z	
E'	2	-1	0	2	-1	0	(x,y)	$(x^2 - y^2, xy)$
A''_1	1	1	1	-1	-1	-1		
A''_2	1	1	-1	-1	-1	1	z	
E''	2	-1	0	-2	1	0	(R_x, R_y)	(xz, yz)

I) Write down the meaning of all the symbols seen in column 1 (under D_{3h})

II) Decompose the given irreducible representation (Γ_{RR}) into irreducible representations by utilizing the appropriate formula

D_{3h}	E	$2C_3$	$3C_2$	σ_h	$2S_3$	$3\sigma_v$
Γ_{RR}	3	0	1	3	0	1

[40 Mar

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b) Provide an explanation of the selection criteria for electronic spectral analysis of transition metal complexes.

(20 marks)

c) i) State Hund's rules to determine the ground state terms of a free metal ion.

ii) Draw Pigeon hole diagram for p^2 configuration and arrange the all state terms by using an energy level diagram.

(40 marks)

4. a) i) Write a short account of Orgel diagrams.

ii) Sketch a single Orgel diagram that clearly shows and classifies the high spin coordination molecules in d^1 , d^4 , d^6 , and d^9 configurations.

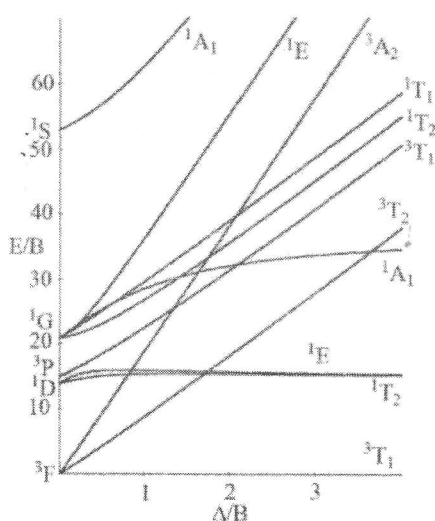
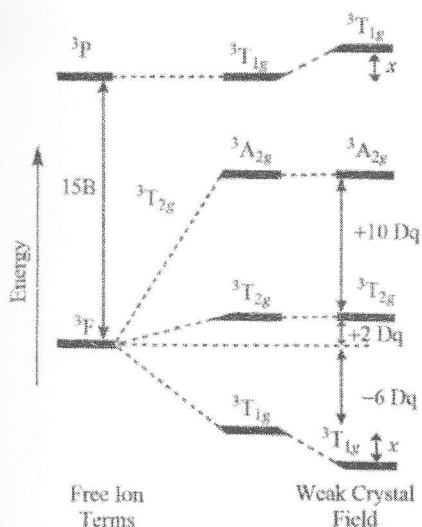
(40 marks)

b) Discuss the expected electronic absorption spectra for the following compounds.

i) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ ii) $[\text{CoCl}_4]^{2-}$

(30 marks)

c) The following Orgel and Tanabe Sugana diagram of $[\text{V}(\text{H}_2\text{O})_6]^{3+}$ is important to consider when answering the question below.



Derive an equation to express the calculation of Racha parameter B using the possible electronic transition for the above complex $[\text{V}(\text{H}_2\text{O})_6]^{3+}$.

(30 marks)

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