2 SEM PG CHM (CBCS) IC–II 201

2026

(June)

CHEMISTRY

Paper : Core–201

(Inorganic Chemistry–II)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **Unit (I** and **II)** and **Unit III** in separate book.*

UNIT–I

(Marks : 20)

1. Answer ***any four*** of the following : 5×4=20

   (i) What is thermodynamic stability of metal complex? In what way thermodynamic stability is different than kinetic stability of coordination compounds? Predict following complexes will be labile or inert. Give reason for your answer. 1+1+3=5

   $[Co(CN)_6]^{3-}$; $[Cr(H_2O)_6]^{2+}$, $[Ni(CN)_4]^{2-}$

(ii) Define stepwise and overall formation constants. Derive a relation between the two formation constants. Explain why the complex, $[Ag(NH_2CH_2CH_2NH_2]^+$.is less stable than $[Ag(NH_3)_2]^+$. 2+2+1=5

(iii) Taking a suitable example, discuss the mechanism of base hydrolysis reaction. Mention *two* major factors that influence the rate of base hydrolysis in an octahedral complex. 3+2=5

(iv) Write electrostatic polarisation and π-bonding theory of trans effect. Give synthesis of *cis*– and *trans*– $[Pt(NH_3)Cl_2(NO_2)]^-$ from $[PtCl_4]^{2-}$. 3+2=5

(v) Discuss inner sphere electron transfer reaction with a suitable example.

UNIT–II

(Marks : 20)

2. Outline the steps involved in constructing a character table for a point group. Using these steps, construct the character table for the C_{3v} point group. State the significance of the Great Orthogonality Theorem (GOT) in chemistry. 4+1=5

3. What is the character of a representation? Assign the point groups of d_{z^2} and P_x orbitals. 1+2=3

Or

For *any two* of the following molecules, list all their symmetry elements and identify the point group to which each belongs. 1.5×2=3

(i) IF_3

(ii) Staggered ferrocene

(iii) Allene

(iv) *cis*– H_2O_2

4. Answer ***any four*** questions from the following : 3×4=12

(a) What is group generating elements? Determine the group generating elements for D_{3h} point group. 1+2=3

(b) Using NH_3 as an example, demonstrate that conjugate elements form a class within a group.

(c) Write down the transformation matrices for the C_2 operation and the σ_{xz} mirror plane. Show that the inversion and rotation (C_2) commute.

(d) Using projection operators, construct SALCs for the σ-bonding orbitals of any AB_3 system.

(e) What is a subgroup? With suitable example state the necessary conditions for a subset to be a subgroup. 1+2=3

(f) Using bond vectors as the basis find the reducible and irreducible representation for H_2O molecule.

(g) What is a direct product representation and how is it useful in predicting IR and Raman activity?

UNIT–III

(Marks : 20)

5. Answer ***any two*** of the following questions : 2×2=4

(i) What is meant by the mutual exclusion rule?

(ii) What is defined by the term E_{2g}?

(iii) Why is CO_2 Raman active but its symmetric stretch IR inactive?

(iv) What is the significance of character tables in spectroscopy? Define the term 'basis set' in group theory. 1+1=2

6. Answer ***any four*** of the following questions : 4×4=16

(i) What are the requirements for obtaining hybrid orbitals for sigma bonding? Using bond vectors as a basis for $[PtCl_4]^{2-}$ we get the *IR*s as $\Gamma_{bond(R)} = A_{1g} + B_{1g} + E_u$ Now, find the sigma (σ) hybrid orbitals for $[PtCl_4]^{2-}$ (Use the D_{4h} character table).

(ii) Show that the S_2 symmetry element is equivalent to the inversion center *(i)* with the help of *two* suitable examples.

(iii) Which normal modes of H_2O molecule are IR active? Explain the selection rule for vibrational Raman spectra of a molecule with an example. 1+3=4

(iv) Find out the IR active vibrational modes of $POCl_3$ molecule using the character table.

Or

Find out the IR active vibrational modes of NH_3 molecule using the character table.

(v) Using the character table of tetrahedron (T_d), answer the following questions :

(a) Find out the value of the direct product $A_1 \times E$ and $E \times E$.

(b) Considering an AB_4 molecule with T_d point group with s, p and d orbitals on the central atom, find out the combination of orbitals for σ bonding. 1+3=4

(vi) What are Wood-Hoffman symmetry-based selection rules for cycloaddition reaction? Briefly explain the dimerization of ethylene to obtain cyclobutane.

Character tables

C_{2v}	E	C_2	$\sigma(xz)$	$\sigma(yz)$		
A_1	1	1	1	1	z	x^2, y^2, z^2
A_2	1	1	−1	−1	R_z	xy
B_1	1	−1	1	−1	x, R_y	xz
B_2	1	−1	−1	1	y, R_x	yz

C_{3v}	E	$2C_3$	$3\sigma_v$		
A_1	1	1	1	z	x^2+y^2, z^2
A_2	1	1	−1	R_z	−
E	2	−1	0	$(x,y),(R_x,R_y)$	$(x^2-y^2, xy)(xz, yz)$

T_d	E	$8C_3$	$3C_2$	$6S_4$	$6\sigma_d$		
A_1	1	1	1	1	1	−	$x^2+y^2+z^2$
A_2	1	1	1	−1	−1	−	−
E	2	−1	2	0	0	−	$(2z^2-x^2-y^2, x^2-y^2)$
T_1	3	0	−1	1	−1	(R_x, R_y, R_z)	−
T_2	3	0	−1	−1	1	(x, y, z)	(xy, xz, yz)

D_{4h} :

	E	$2C_4$	$C2$	$2C_2'$	$2C_2''$	i	$2S_4$	σ_h	$2\sigma_v$	$2\sigma_d$	Linears Rotation	Quadratic
A_{1g}	1	1	1	1	1	1	1	1	1	1		x^2+y^2, z^2
A_{2g}	1	1	1	−1	−1	1	1	1	−1	−1	R_z	
B_{1g}	1	−1	1	1	−1	1	−1	1	1	−1		x^2-y^2
B_{2g}	1	−1	1	−1	1	1	−1	1	−1	1		xy
E_g	2	0	−2	0	0	2	0	−2	0	0	(R_x, R_y)	(xz, yz)
A_{1u}	1	1	1	1	1	−1	−1	−1	−1	−1		
A_{2u}	1	1	1	−1	−1	−1	−1	−1	1	1	z	
B_{1u}	1	−1	1	1	−1	−1	1	−1	−1	1		
B_{2u}	1	−1	1	−1	1	−1	1	−1	1	−1		
E_u	2	0	−2	0	0	−2	0	2	0	0	(x,y)	