[Time: 2.5 Hours]  [Marks: 60]

Please check whether you have got the right question paper.

N.B. 1. All questions are compulsory.
2. Figures to the right indicate full marks.

Q.1. a) Attempt ANY TWO of the following:
   i) Derive the wave functions for sp² hybrid orbitals considering sigma bonding only.  
   ii) Explain the concept of resonance. Draw the resonating structures for sulphate ion.  
   iii) On the basis of molecular orbital theory explain the structure and bonding in diborane molecule.  
   iv) What are Van der Waals forces? Explain any two types with suitable examples.

Q.1. b) Attempt ANY ONE of the following:
   i) On the basis of Valence Bond Theory, explain the structure and bonding of ClF₃ and PF₅.  
   ii) Draw a molecular orbital diagram for triiodide ion and explain its structure and bonding.

Q.2. a) Attempt ANY TWO of the following:
   i) On the basis of group theory, explain optical activity in a molecule.  
   ii) Discuss the criteria for a set of elements to form a group by giving suitable example.  
   iii) With the help of suitable example explain Abelian and non-Abelian point groups.  
   iv) On the basis of Symmetry Adapted Linear Combination (SALC), draw the molecular orbital diagram for methane molecule.

Q.2. b) Attempt ANY ONE of the following:
   i) Give and explain the character table for Cᵥ point group.  
   ii) Derive the matrix representation for rotation operation.

Q.3. a) Attempt ANY TWO of the following:
   i) Explain the electrical property of alkali metal on the basis of band theory.  
   ii) Draw the structure of TiO₂ and discuss its salient features.  
   iii) Describe the precursor method for the preparation of inorganic solids. Mention its merits and demerits.  
   iv) Explain the Co-precipitation method for the preparation of nanomaterials.
Q.3. b) Attempt ANY ONE of the following:
i) Discuss the structure for an inorganic solid of type AB. 4
ii) Describe the microwave method for the preparation of nanomaterials. 4

Q.4. a) Attempt ANY TWO of the following.
i) With respect to complex formation, explain the following evidences:
   1) dissolution of insoluble precipitate  2) pH metric study.
ii) Draw the Orgel diagram for [Ni(H₂O)₆]²⁺. Assign the electronic transitions. 4
iii) Rationalize the IR data for the following:
<table>
<thead>
<tr>
<th>Species</th>
<th>v CO in cm⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>[V(CO)₆]⁻</td>
<td>1860</td>
</tr>
<tr>
<td>[Cr(CO)₆]</td>
<td>2000</td>
</tr>
<tr>
<td>[Mn(CO)₆]⁻</td>
<td>2090</td>
</tr>
</tbody>
</table>
iv) Explain the potentiometric method for the determination of formation constant in complexes. 4

Q.4. b) Attempt ANY ONE of the following:
i) Discuss the Faraday’s method for the determination of magnetic moment. 4
Calculate μₑffect for the complex [Cr(H₂O)₆]Cl₂.
ii) Explain the slope-ratio method for the determination of formation constant. 4

Q.5. Attempt ANY FOUR of the following. 12
a) Explain in brief any two methods for the detection of hydrogen bonding.
b) What are limitations of valence bond theory?
c) Write a note on Mulliken’s notations for irreducible representations.
d) Give the characteristics of a subgroup. Write the subgroups for C₂ᵥ point group.
e) Mention the merits and demerits of ceramic method.
f) Discuss the applications of nanomaterials in the field of solar cells.
g) The ¹H NMR for the complex [Fe (η¹-C₅H₅)(η⁵-C₅H₅) (CO)₂] shows two peaks. Explain.
h) Write a note on continuous variation method for the determination of formation constant.

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