CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATION

RESIT /SPECIAL EXAMINATION

EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE

CHEM 315: CHEMICAL APPLICATIONS

STREAMS: **TIME: 2 HOURS**

DAY/DATE: FRIDAY 05/11/2021 **11.30 A.M – 1.30 P.M**

INSTRUCTIONS:

Answer question **One** (Compulsory) and any other **Two** questions

QUESTION ONE [30 MARKS]

(a) Determine the point group of each of the following species (**10 marks**)

(i) $CHCl_3$ (ii) CS_2 (iii) NO_2 (iv) NO_3^- (v) NH_4^+

(b) On the basis of symmetry, which of the following molecules cannot have a dipole moment: (**6 marks**)

(i) 1,1-Dichloroethene (ii) Benzene (iii) 1,3,5-Trichlorobenzene (iv) 1,3-Difluorobenzene

(c) Set up the multiplication table for the $\mathbf{C_{3v}}$ point group and confirm that the elements form a mathematical group (**8 Marks**)

(e) Construct a matrix representation for $\mathbf{C_{2v}}$ point group using the s-orbitals of sulphur and the two oxygens of SO_2 (**6 marks**)

QUESTION TWO [20 MARKS]

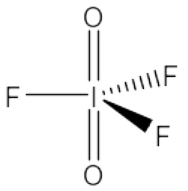
(d) Consider the following multiplication table for the $\mathbf{C_{4v}}$ point group:

$\mathbf{C_{4v}}$	E	C_4	C_2	C_4^3	σ_v	σ_v'	σ_d	σ_d'
E	E	C_4	C_2	C_4^3	σ_v	σ_v'	σ_d	σ_d'
C_4	C_4	C_2	C_4^3	E	σ_d'	σ_d	σ_v	σ_v'
C_2	C_2	C_4^3	E	C_4	σ_v'	σ_v	σ_d'	σ_d
C_4^3	C_4^3	E	C_4	C_2	σ_d	σ_d'	σ_v'	σ_v
σ_v	σ_v	σ_d	σ_v'	σ_d'	E	C_2	C_4	C_4^3
σ_v'	σ_v'	σ_d'	σ_v	σ_d	C_2	E	C_4^3	C_4
σ_d	σ_d	σ_v'	σ_d'	σ_v	C_4^3	C_4	E	C_2
σ_d'	σ_d'	σ_v	σ_d	σ_v'	C_4	C_4^3	C_2	E

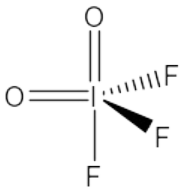
(i) Construct the multiplication table for each of the non-trivial sub-groups of the $\mathbf{C_{4v}}$ point group. (**8 marks**)

(ii) Determine the classes of the $\mathbf{C_{4v}}$ point group (**6 marks**)

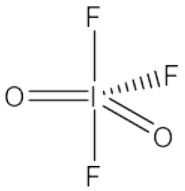
(b) Consider the structures of the three isomers of IF_3O_2. Determine the symmetry elements and the point group of each isomer (**6 marks**)



I



II



III

QUESTION THREE [20 MARKS]

(a) Determine the fundamental vibrational modes of BCl_3 ($\boldsymbol{D_{3h}}$) that are infrared and Raman active (**10 marks**)

(b) Determine the atomic orbitals that Xe can use to form hybrid orbitals in XeF_4 ($\boldsymbol{D_{4h}}$) (**10 marks**)

QUESTION FOUR [20 MARKS]

(a) Define each of the following terms: (**6 marks**)

(i) symmetry operation (ii) symmetry element (iii) rotational axis

(iv) plane of symmetry (v) center of symmetry (vi) improper rotation axis

(b) Discuss the composition of a character table (**8 marks**)

(c) Derive the characters of the irreducible representation of the $\mathbf{C_{3v}}$ point group using the Great Orthogonality Theorem (**6 marks**)
