Answer all questions in the booklets provided. A point-group flow chart, character tables and a periodic table are provided.

Question 1 - (15 marks, 5 marks each)

List <u>all</u> of the symmetry elements and determine the point group for the following:

- a) SF₅Cl
- b) 1,3,5-trichlorobenzene
- c) SiO₂

Question 2 - (10 marks)

- a) Use VSEPR theory to draw and then predict the *actually geometry* of a) SbF_4^- and b) SeF_3^+ (3 marks each)
- b) Explain the trend in the following set of bond angles: NCl_3 (\angle Cl-N-Cl = 107.1°), NF_3 (\angle F-N-F = 102.3°), PCl_3 (\angle Cl-P-Cl = 100.3°), and PF_3 (\angle F-P-F = 97.7°). (4 marks)

Question 3 – (10 marks)

a) Determine the symmetry label of the following three SALC's under $C_{\delta v}$. (6 marks)

- b) Which of the above SALC's will be able to mix with an atomic orbital on the central metal? (1 mark)
- c) Which symmetry types (in general) in $C_{6\nu}$ are IR active and which are Raman active? (3 marks)

Question 4 – (15 marks)

Using the Table below, determine the reducible representation for the planar *trans*- N_2F_2 molecule. Using the appropriate character table, factor the reducible representation into a set of irreducible representations and subsequently into a set of irreducible representations corresponding to the *vibrational modes only*. Give the labels of the IR and Raman active modes.

Symmetry Operation	Character Contribution per Unshifted Atom
Е	3
i	-3
σ	1
C_2	-1
C_3	0
C_4	1
C_6	2
S_3	-2
\mathbf{S}_4	-1
S_6	0

Question 5 – (10 marks)

Consider the *octahedral* complex $[VBr(SCN)(en)_2]Br$ (en = ethylenediamine)

Give one example (draw two structures) of each of the following forms of isomers: a) geometric b) optical c) linkage d) ionization e) name the two structures you drew in part d).