B.Sc semester-5 Inorganic chemistry US05CCHE22 Unit-1 Symmetry Lecture-11

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- ***Properties of point-groups*** :

- The point groups are studied with the help of the general mathematical technique called group theory. Let G be some group with g elements. Suppose, some set of elements ,say H_1, H_2 …….. H_h which are present in G are found to be obey four rules of the point group. then this sets of elements H_1, H_2 …….. H_h form a subgroup H. The number of elements in a group or subgroup is called order of the group. now take an element F, of the group G, which is absent in the subgroup H and form the products FH_1, FH_2 ……..FH_h.They must all be in the group G but not in the subgroup H. If $FH_i = FH_j$ were one of the members of H then F= H_j H_i^{-1}should also be in the subgroup H. This is contrary to our assumption concerning the selection of F. We have thus found 2h members of the group G. If 2h<g, it will be possible to find another element D not present among H_1, H_2 …….. H_h nor among FH_1, FH_2 ……..FH_h.Repeating the same arguments we obtain h new elements DH_1, DH_2 ……..DH_h.

- Since the group G is of finite order, i.e, g, this procedure will end until
- kh = g
- where k is an integer. Thus, a group of six elements, for example, can only have subgroups of order either one or two or three.
- Que : A group of six elements can have subgroups of order either one(1) or two(2) or three(3) only.Explain.
- Ans : We know that *k x h = g, k* is an integer, g is the total numer of member in the group and *h is* number of members in the subgroup (order),
- *This* value of six can be obtained in three ways 6x1=6,3x2=6,and 2x3 =6 i.e by putting h = 1,2 or 3.
- *Hence,* A group of six elements can have subgroups of order either one(1) or two(2) or three(3) only.

- ***Conjugate Elements :***
- Two elements says,A and B, of a group are said to be conjugate if A = X^{-1}B X ……………………………………….*(i)*
- where X is a another element of the same group. such transformation is known as similarity transformation.
- If we multiply A on its left side by X and on its right by X^{-1} and do the same on the right hand side of eq.(i), we have
- X A X^{-1} = X X^{-1}B X X^{-1} …………………(ii)
- Since X X^{-1} = *E, one may write eq.(ii) as* X A X^{-1} = *B.*
- *I*n other words, the conjugate properties of A and E is mutual.
- ***Class :*** A complete set of elements, such has A,B,C,………..etc. of a group, which are mutually conjugate with each other, is called a class. each class is completely determined by any one element of it.

- For,example,if an element A of a group is known we obtain the whole class by forming the product X A X^{-1} where X is successively every element of the group.the unit element E of any group is a class by itself, Since for every other element of the group X E X^{-1} = E.it is impotent to note that a class of a group is not a subgroup because a class does not have to contain a unit element.
- We can now show that the C_{3v} group which has six elements E, C_3^1 C_3^2,σva,σvb, σvc has three classes of operations. The identity operation E is a class by itself. The C_3^1 and C_3^2 form a class can be shown by examining their similarity transformation eq.(i) with every other element of the group
- $E^{-1}\ C_3^1\ E = E\ C_3^1\ E = C_3^1$
- $C_3^{-1}\ C_3^1\ C_3^1 = C_3^2\ C_3^1\ C_3^1 = C_3^2\ C_3^2 = C_3^1$
- $C_3^1\ C_3^1\ C_3^2 = C_3^1\ C_3^3 = C_3^1\ E = C_3^1$

- $\sigma va\ C_3^1\ \sigma va = \sigma va\ \sigma vc = C_3^2$
- $\sigma vb\ C_3^1\ \sigma vb = \sigma vb\ \sigma va = C_3^2$
- $\sigma vc\ C_3^1\ \sigma vc = \sigma vc\ \sigma vb = C_3^2$
- similarity, the similarity transformation of C_3^2 by E, C_3^1 and C_3^2 gives C_3^2 and by σva, σvb and σvc gives C_3^1.Therefore, C_3^2 and C_3^1 are conjugate and the members of the same class.In an exactly same manner, the three σv-planes can be shown to belong to a class.The three classes of the C_{3v} group are as follows,
- E, (C_3^1 and C_3^2), (σva, σvb,σvc)
- They can be written as E, $2C_3$, $3\sigma v$.

Reference Books :

1.Introductary Quantum Chemistry-4th edition By A.K.Chandra.

2.Group Theory and its chemical applications. By P.K. Bhattacharya.

3. internet and Wikipedia source.

THANK YOU