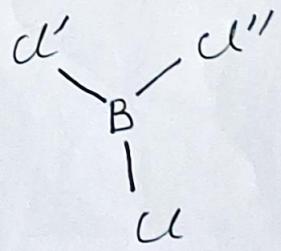
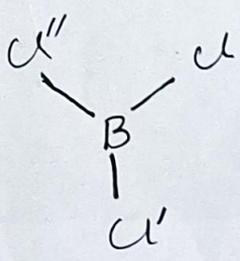
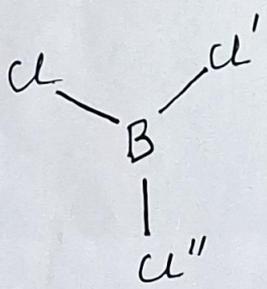


SYMMETRY IN CHEMISTRY (contd.)

2. The Rotation axis (C_n) or Proper rotation:

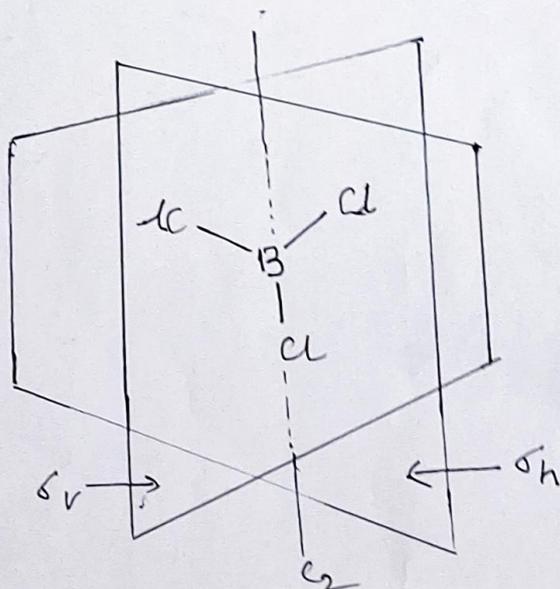
If a rotation of a molecule by $360^\circ/n$ results in to produce an equivalent orientation, then the molecule have n fold rotation axis. The axis about which the rotation takes place is the symmetry element. It may be possible to carry out several symmetry operation around a single rotation axis. If the molecule can occupy n-different equivalent position about this axis, the order of the axis is order n. For example, in case of BCl_3 , let the axis through the centre of the Boron atom perpendicular to the plane of the molecule rotation about this axis three times through an angle of 120° each time produces two equivalent orientations. The order n of this axis is three. Three rotations are needed to return to the original position. The molecule possess a three fold rotation axis, indicated by the symbol C_3 . Rotation of the molecule through $2\pi/n$ produces equivalent orientation and n operations produces the starting configuration. The BCl_3 molecule indicate the lack of centre of and the presence of the three additional two fold two fold rotation axes C_2 (Fig. 4). The highest fold rotation axis is referred to as the principal axis and is labeled as C_n . The symbol C_3^2 is employed to indicate a rotation of 240° around a C_3 axis. The C_3^2 operation is identical to counter clockwise rotation of 120° which is indicated as C_3^- . A rotation axis of order n generates operations i.e. $C_n, C_n^2, C_n^3, \dots, C_n^{n-1}, C_n^n$. The operation C_4^2 is equivalent to C_2 , C_6^2 is equivalent to C_3 and C_n^n is the identity. If the molecule contains several C_n rotation axes, the principal one is usually selected as the one collinear with a unique molecular axis. If all the C_n axis are equivalent then any one may be chosen as the Principal axis.



Three fold rotation axis
of BCl_3 .

3) The mirror plane (σ): -

If a molecule there exist a plane which separates the molecule into two halves that are mirror image of each other, the molecule possesses the symmetry element of a mirror plane. This plane can not lie outside but must pass through it. This process involves selecting a plane dropping a perpendicular from every atom in the molecule to the plane, and placing the atom at the end of the line formed by extending this line an equal distance to the opposite side of the plane. If an equivalent configuration is obtained after this is done to all the atom, the plane selected is a mirror plane in those molecule that contain more than one mirror plane the horizontal plane σ_h is taken as the one perpendicular to the principal axis. For example: in BCl_3 the plane of the paper is and there are three vertical plane perpendicular to σ_h .



A mirror plane in BCl_3 .