Dr. Babasaheb Ambedkar Marathwada University, Aurangabad

Department of Chemistry

Dr. M. K. Lande
Professor

M.Sc. Chemistry I Semester

Inorganic Chemistry Lect: 1

1. **Symmetry elements and symmetry operations**
2. Classification of symmetry elements

Symmetry

When there is matter, there is symmetry and geometry. Symmetry begins the first property of geometrical entity. If an object is symmetric then one part of it's identical to the other part.

What is meant by symmetry ?

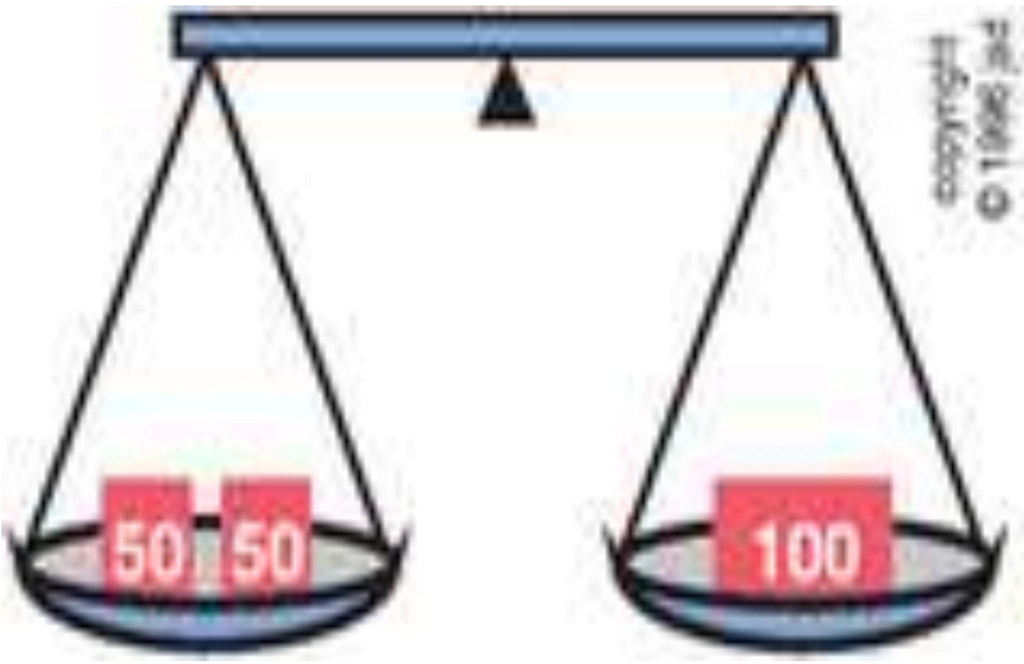
- ❖ Symmetry is a kinds of balancing act
- ❖ Symmetry cannotes harmony of proportion
- ❖ Symmetry is a beautifulness an object
- ❖ Symmetry becomes important when it interpret facts
- ❖ Symmetry possess an order of pattern: Repeating unit

Requirement for defining symmetry

Geometry is a fundamental requirement for defining of symmetry of molecules.

What is meant by symmetry ?

- **Symmetry is a kinds of balancing act.**



- **Symmetry cannotes harmony in pr proportion**

Uniform distribution of colour on the flowers

- **It has harmony in the proportions**
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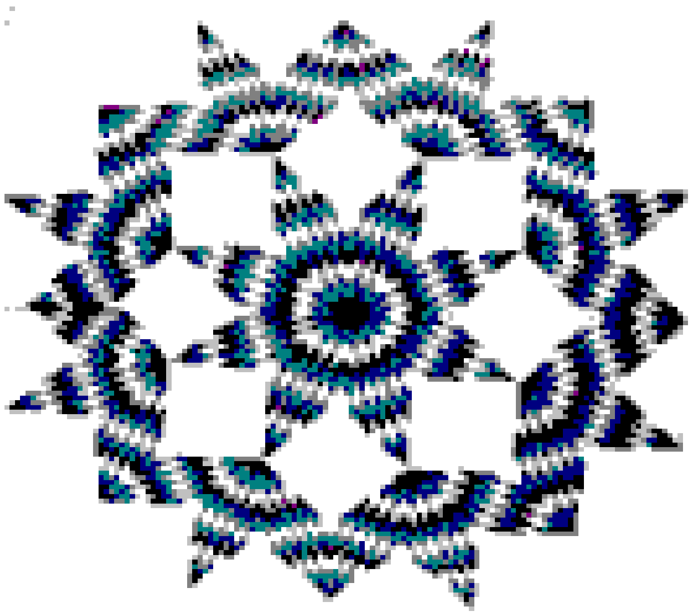
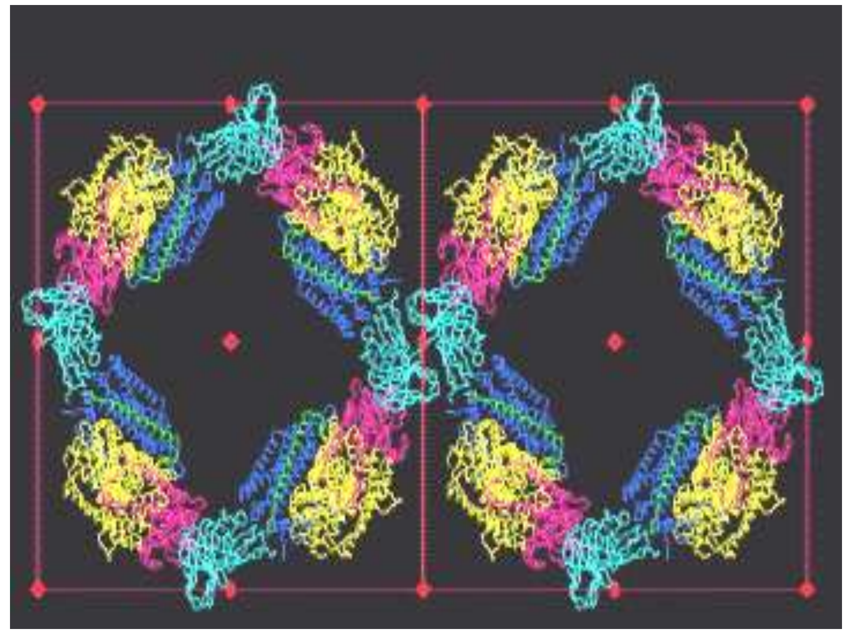




- **Symmetry is a beautifulness an object.**

* Symmetry possess an order of pattern: Repeating unit

Learnt symmetry from nature ?

SYMMETRY IN NATURE:

Nature contains various objects, animals, plants, manmade architectural designs, eating food habits etc.

Symmetry is found in plants: A plants grow vertical direction against gravity; they must adapt some mechanism of balancing act. After they grow into some size. Some part of plants shows radial symmetry. There leaves, flowers and fruits offer the best examples for bilateral, radial and other multidimensional symmetry. colour spreading on the leaves follow certain pattern . so that, it look like very beautiful

Symmetry is found in animal : Few of exception, all the animals possess at least bilateral symmetry in their physical shapes. Each animal can be divided into two equal parts.

Colored markings were observed in some animal. like Zebra & tiger , complement of their colour is a beauty to watch.

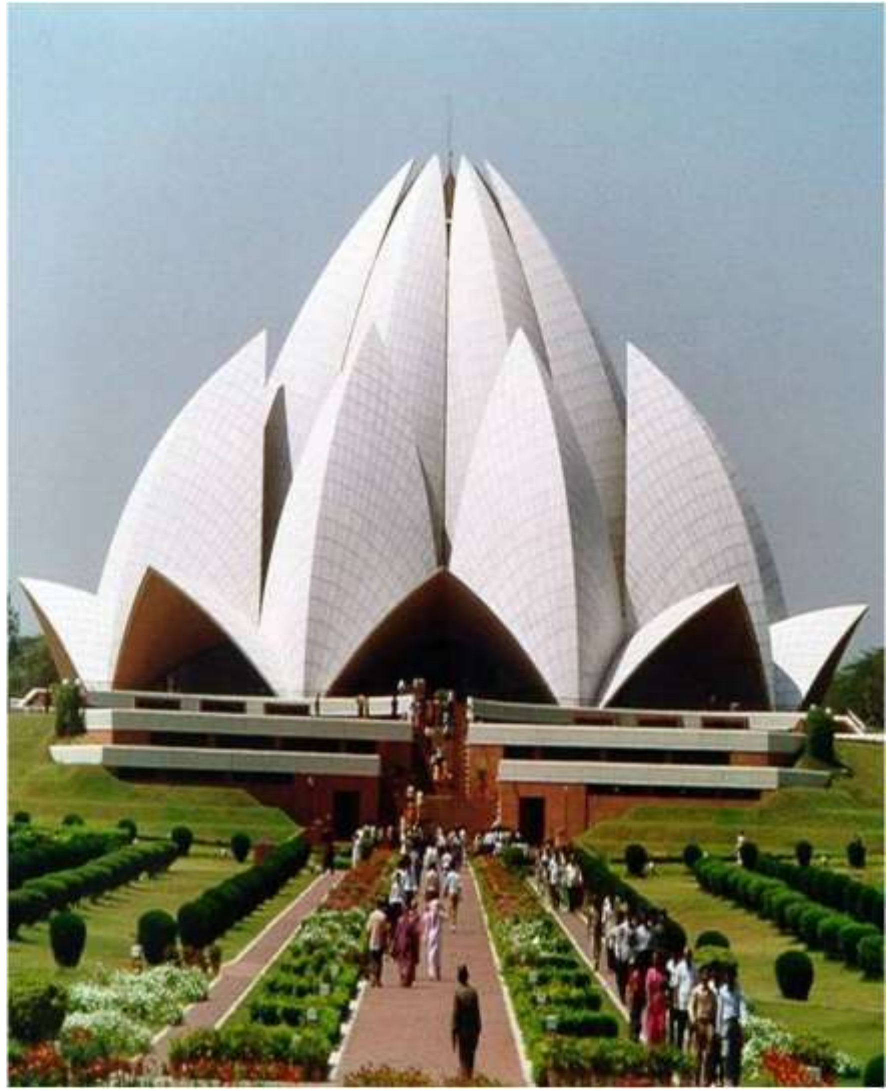
Animal show a sense of order of pattern in their activity., when birds fly in the groups, they follows some rule of symmetry.

Symmetry is found in manmade objects

Architecture :

There are many outstanding examples of symmetry in architecture, available in the form of both modern and historical monuments.

The Lotus temple situated at New Delhi with notable architectural design , Tajmahal , Bibika Makbara, all these structure look like very beautiful due to well designed symmetric manner .



Tajmahal

Symmetry is also found in eating food materials :

Take any item or raw material to be cooked as food . It is mixed with water to form shapeless materials. But we are molding them into different shapes.

- Circular Chapati
- Triangular paratha
- Spherical Gulam Jamun,

Some time shape is attributed to the test and geometrical sense

Symmetry in languages :

Language is a medium of communication , it may be either prose or poetry. each of the poetic line ends with word of repeating phonetic sounds. Which implies a particular pattern of symmetry.

“Engine engine number nine,

when it ready it will shine.

Then we’ll ride on the Mumbai line”

There are some meaningful words or sentences that can be read either backward or forward direction, which has same meaning:

MADAM. REFER, TOOT

MUM LEVEL PUP

Ex. No Melon, No Lemon

Symmetry in music :

Music , whether it is vocal , verbal or instrumental involves some harmony of sound that sensitizes the emotions.

Ex. Sa, Re, Ga ,Ma, Pad, Ni, Sa

Symmetry is also found in dancing habit.

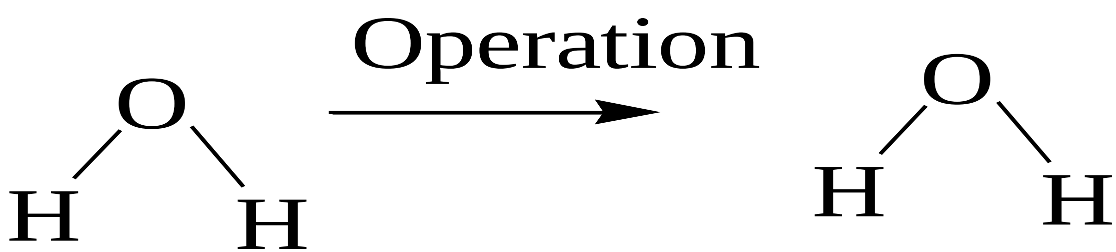
Why symmetry is important in Chemistry ?

Symmetry predict the properties of molecules without performing any experimental work .

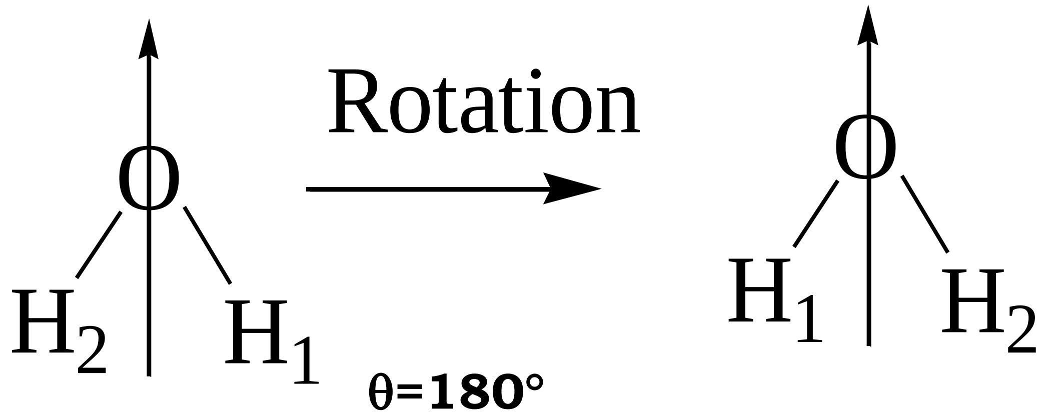
i.e. Dipole moment, polarity of molecules, orbital symmetry, Electronic transitions, Optical activity, Modes of vibration , bonding in molecules and their behavior

Symmetry elements & Symmetry operations :

Symmetry operation : It is process carried out on the molecule, to obtain an equivalent orientation, this equivalent orientation must be indistinguishable .



Can, we predict the type operation is performed on above molecule !


Rotation
θ=180°
O
H2
H1
O
H1
H2

Various types of operation we are performing

1. Rotation

2 Reflection

3. Inversion

4. Walking

5. Eating

6. Dancing

7. Reading

Any operations will be performed with help of an element

Symmetry elements : Symmetry elements are axis , plane or points through which a symmetry operation can be performed . Symmetry elements are geometric entities such as axes , planes or point with respect to which operation can be carried out. Symmetry operations are actions with respect to the symmetry element that leave the molecule in indistinguishable orientation

Symmetry element	Symmetry operation
Axis	Rotation operation
Plane	Reflection operation
Point	Inversion operation

Classification of symmetry elements

1. Center of Symmetry (i)
2. Axis of Symmetry (C_n)
3. Plane symmetry(σ)
4. Rotation reflection axis of symmetry: (S_n)
5. Identity (E)

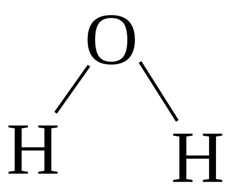
1. Center of Symmetry : “ It is an imaginary point in the center of molecule through which the inversion /reflection of each atom can be carried out to get coincidence of an equivalent atom”

Ex: CO_2, H_2O, NH_3, H_2, $[PtCl_4]^{-2}$, $[FeF_6]^{3-}$

Cl—Cl It has a Center of symmetry

H—Cl Does not have Center of symmetry

O=C=O It has a Center of symmetry



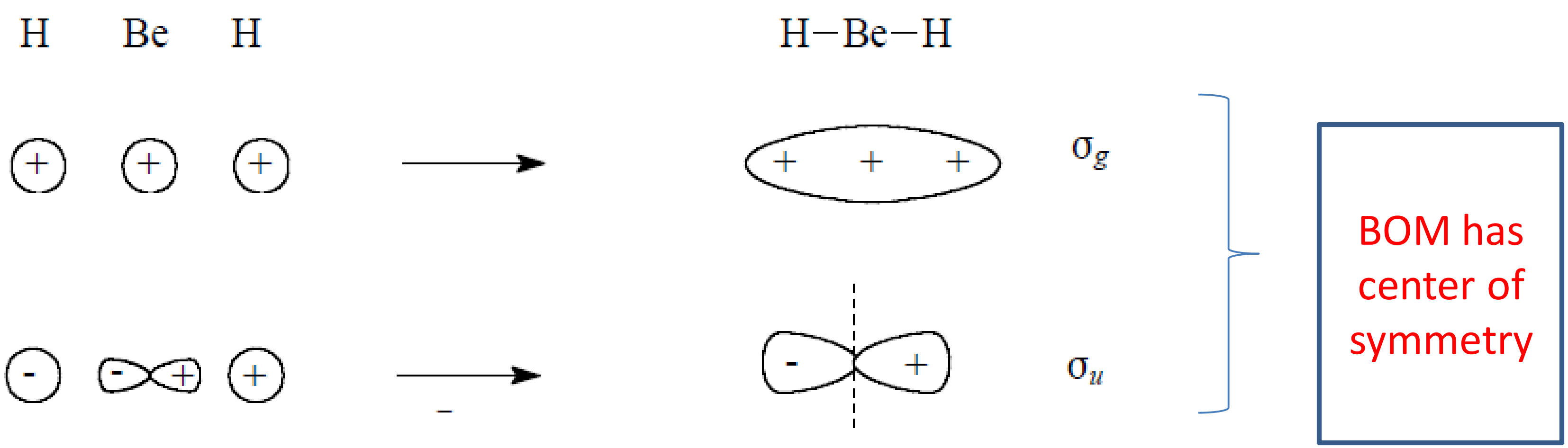
Does not have Center of symmetry

Application of center of symmetry :

- To predict dipole moment of molecule
- To predict polarity of molecules
- To label ‘g’ & ‘u’ symmetry to orbital's, bonding and anti-bonding orbital’s

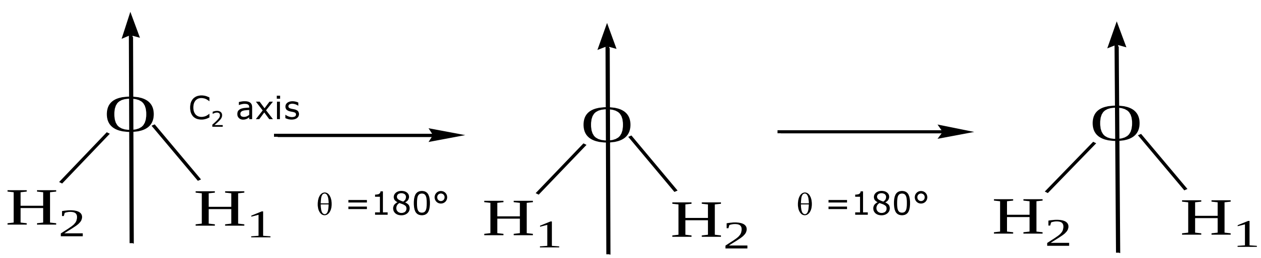
  i.e

A_{1g} for s orbital , T_{2g} and E_g for d orbital‘s T_{1u} for p orbitals



2. Axis of Symmetry (C_n) : Imaginary axis passing through the center of molecule, through which molecule can be rotated clockwise direction till to get identical orientation. The orientation must be indistinguishable

Angle of rotation (θ) = 360°/ n



Draw the structure and predict the order of axis of symmetry.

NH_3, BF_3 SO_2, H_2S, $POCl_3$, PCl_5 Square planer –AB_4, Cis & Trans isomer of AB_2C_2

Classification of axis of Symmetry:

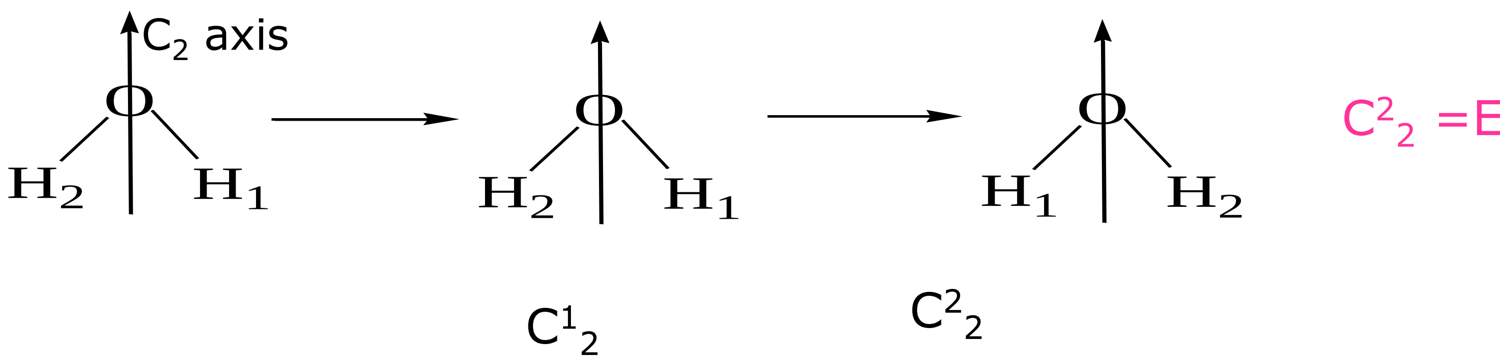
* **Principal Axis (C_n)** : highest fold of axis of symmetry

***Subsidiary axis** : Perpendicular to principal axis

$C_n = C^1{}_n, C^2{}_n, \ldots\ldots C_n{}^{n-1}, C^n{}_n$

$C^n{}_n = E$,

$C^1{}_n, C^2{}_n, \ldots\ldots C_{n-1}$ equivalent orientation , Indistinguishable



Ex: BF_3 SO_2, H_2S, $POCl_3$, PCl_5 Square planer $-AB_4$, Cis & Trans isomer of AB_2C_2

3. Plane symmetry (σ) :

Plane which divide the object/ molecule into equal two part , these two parts must be mirror image of each other .

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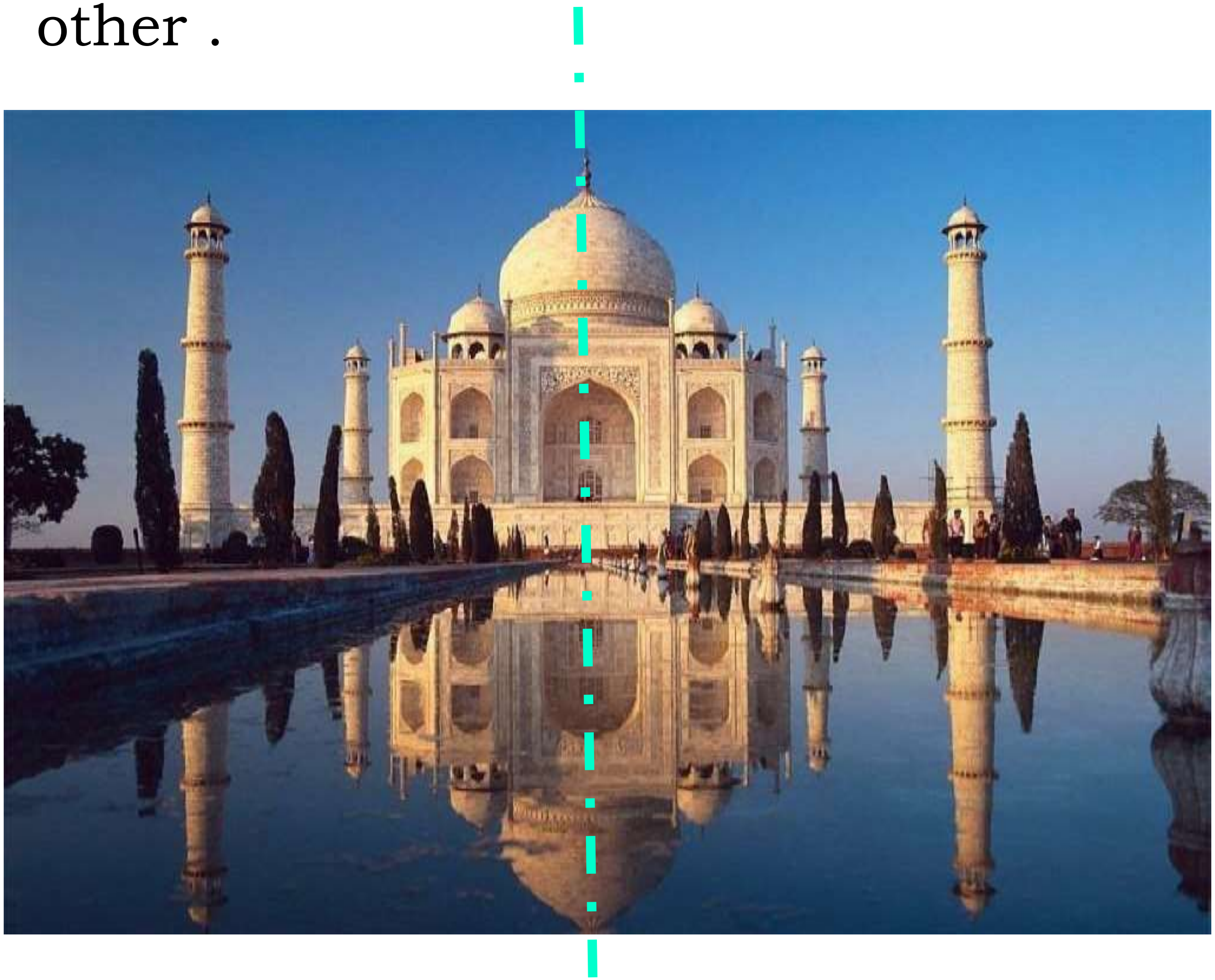

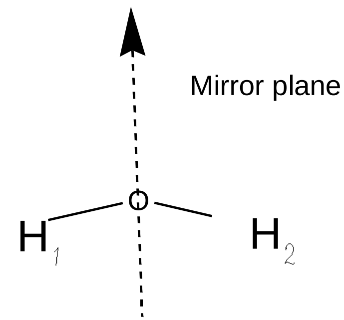

Mirror plane = H_2O Molecule

Classification of Plane symmetry

Vertical plane (σ_v)

Passes through the principal axis an one of the subsidary axis if present

Horizontal plane (σ_h)

perpendicular to principal axis.

Dihedral plane (σ_d)

It is present in between two similar C_2 axis.

Draw the structure and identify types of planes.

NH_3, BF_3 SO_2, H_2S, $POCl_3$, PCl_5 Square planer –AB_4,

4. Rotation reflection axis of symmetry: (S_n) : It is product of two operation and it is generated by rotating the molecule by angle 360°/n and reflected in plane perpendicular to principal axis.

$$S_n = C_{n\,(z)} \cdot \sigma_h$$

$S_n = C_{n\,(z)} \cdot \sigma_h$

Generation of S_n has two conditions :

1. **When "n" is odd** : $S_n \Rightarrow S^1_n, S^2_n, S^3_n --- S^{2n}_n$

$$S^{2n}_n = E$$

2. **When "n" is even ;** $S_n \Rightarrow S^1_n, S^2_n, S^3_n --- S^n_n$

$$S_n = S^n_n = E$$

Q. Prove that PCl_5 & BF_3 has S_3 axis of symmetry.

Q. Prove that $PtCl_4$ has S_4 axis of symmetry.

THE END