PAPER-A: CONDENSED MATTER PHYSICS
(B.Sc. Semester-V)

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CONTENTS

- Crystal structure
- Elements of Symmetry

CRYSTAL STRUCTURE

- A **crystalline structure** is any structure of ions, molecules, or atoms that are held together in an ordered, three-dimensional arrangement.
- Crystalline structure is one of two types of structural ordering of atoms, the other being the amorphous structure.
- The key difference in the crystalline and amorphous structure is the ordering of the structure.
- Crystalline structure can be thought of as the highest level of order that can exist in a material, while an **amorphous structure** is irregular and lacks the repeating pattern of a crystal lattice.

CRYSTAL STRUCTURE

- Crystalline substances are made of a three-dimensional repeating design formed by smaller identical units. There are many different types of crystal shapes that substances can take, and their shape is dependent on their chemical makeup.
- The total three-dimensional arrangement of particles of a crystal is called the **crystal structure**. The actual arrangement of particles in the crystal is a **lattice**. The smallest part of a crystal that has the three-dimensional pattern of the whole lattice is called a **unit cell**. This is the smallest repeating unit in the lattice. The edges of each unit cell connect, and the opposite faces are parallel.
- These items make up lattice points in crystalline solids.
- Crystalline solids are made of atoms, ions or molecules. The atoms, ions or molecules are called lattice points.

Basic Of Crystal Structure

- ***Lattice***:-

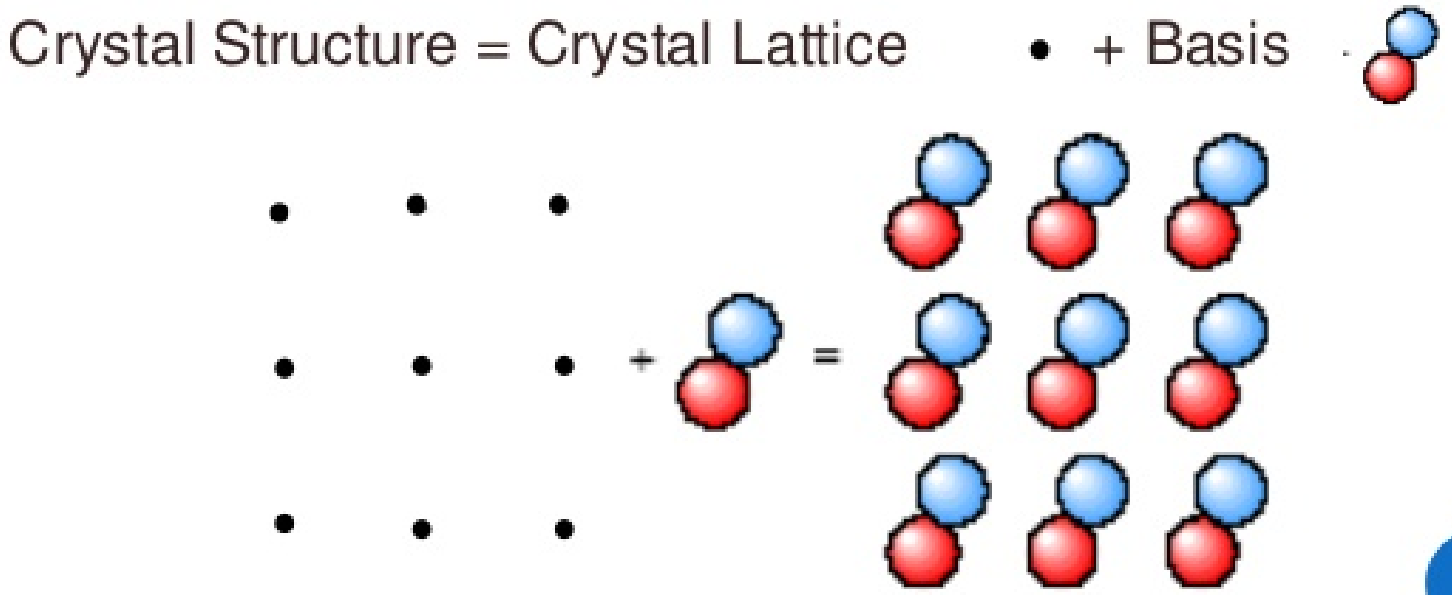
"An infinite periodic array of points in a space "

-The arrangement of points defines the lattice symmetry

-A lattice may be one, two or three dimensonal

Crystal Structure

- Crystal structure can be obtained by attaching atoms, groups of atoms or molecules which are called basis (motif) to the lattice sides of the lattice point.



Crystal Systems – Some Definitional information

Unit cell: smallest repetitive volume which contains the complete *lattice pattern* of a crystal.

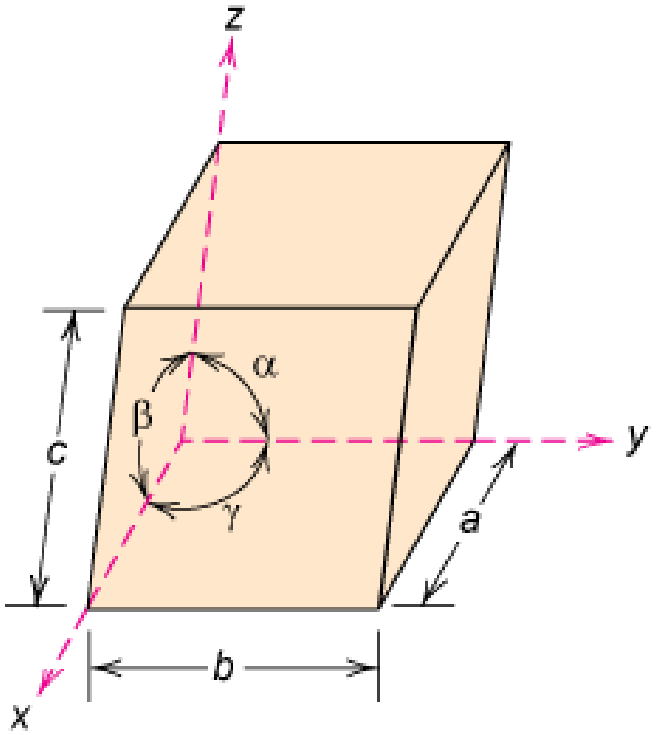


Fig. 3.4, *Callister 7e.*

7 crystal **systems of varying symmetry are known**

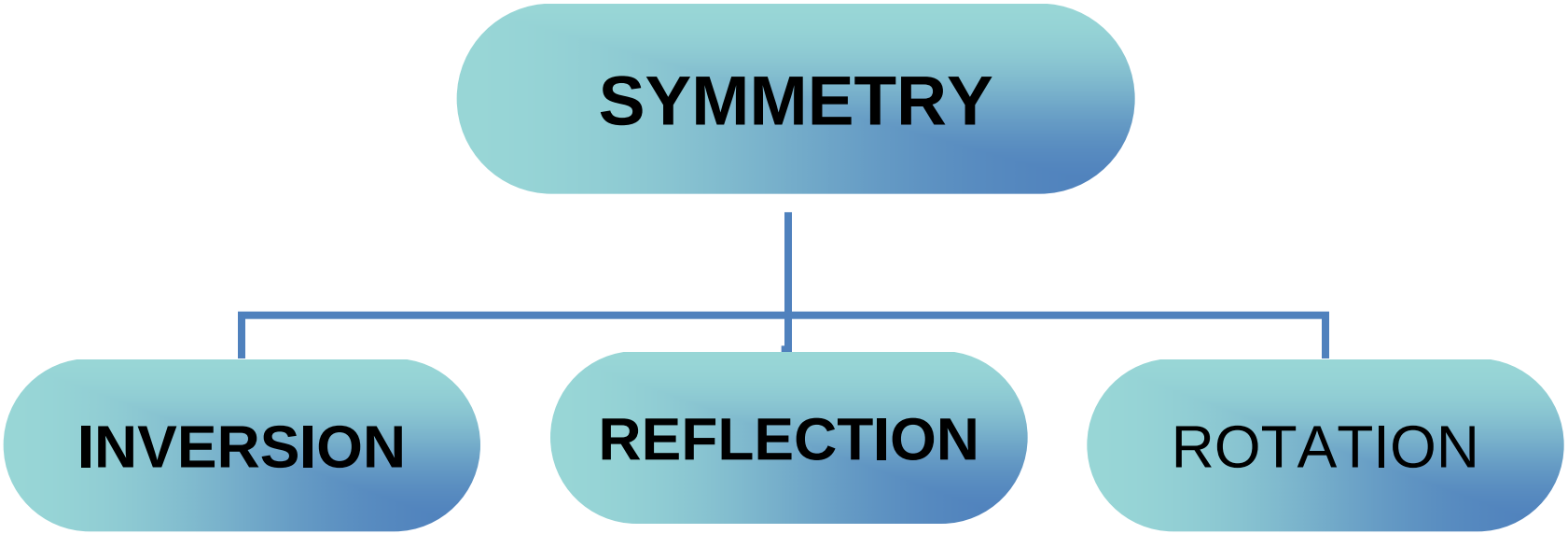
These systems are built by changing the lattice parameters:

a, b, and *c* are the edge lengths

α, β, and γ are interaxial angles

ELEMENTS OF SYMMETRY

- Each of the unit cells of the 14 Bravais lattices has one or more types of symmetry properties, such as inversion, reflection or rotation,etc.

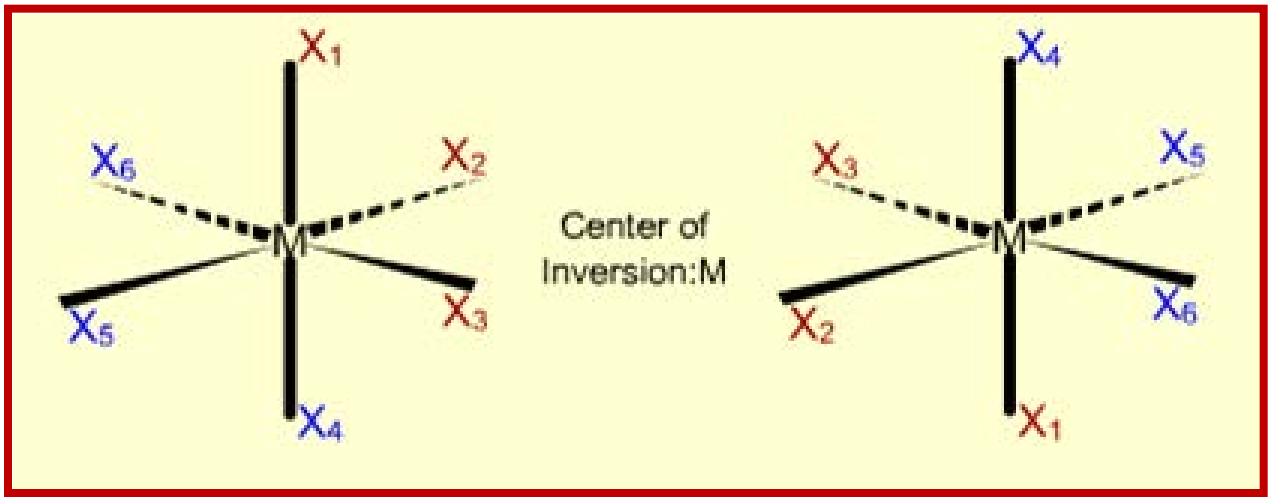


Inversion

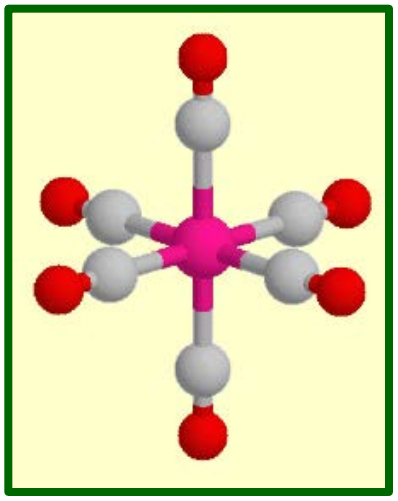
- A center of inversion: A point at the center of the molecule.

(x,y,z) --> (-x,-y,-z)

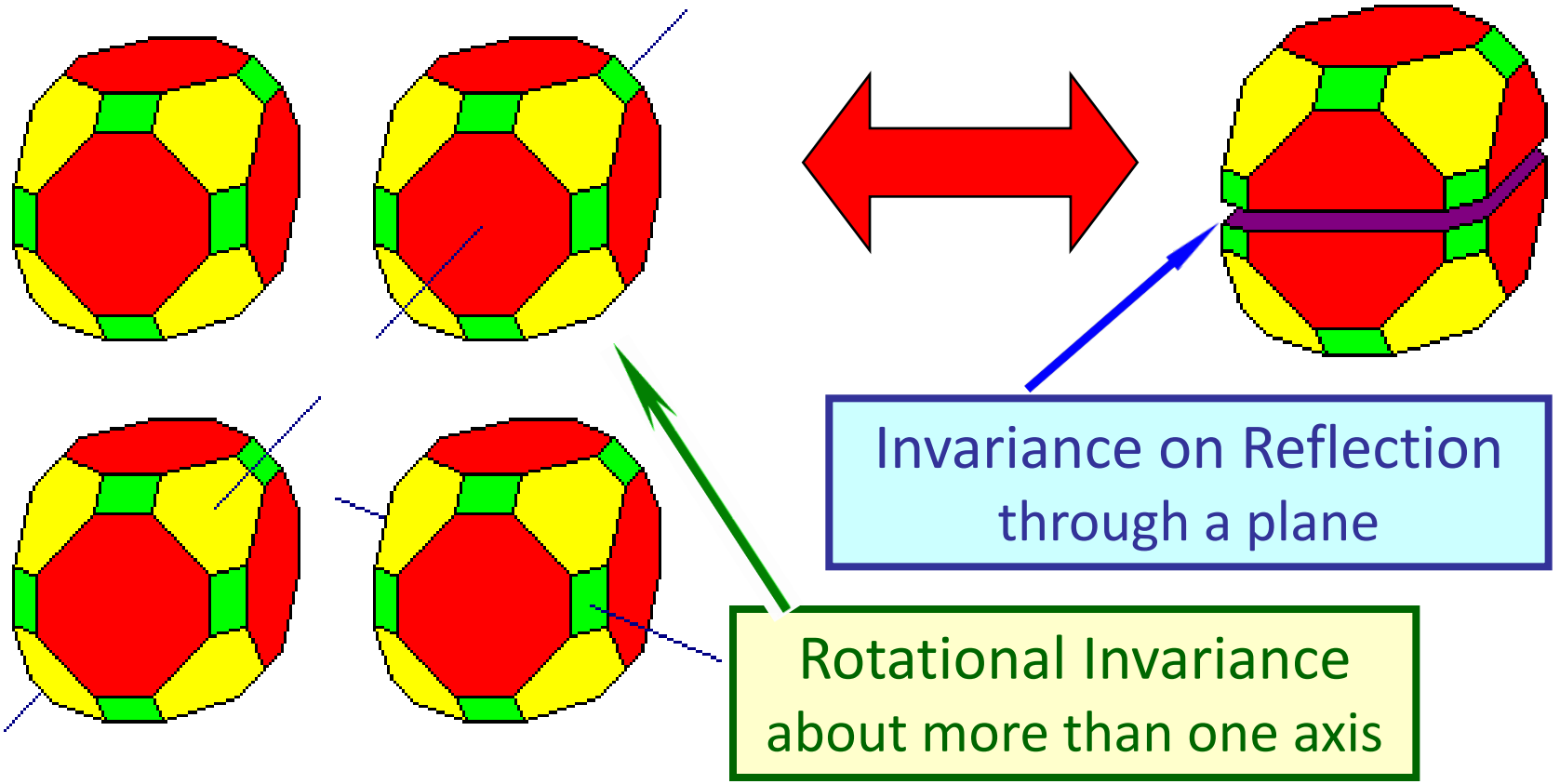
- A center of inversion can only occur in a molecule. It is not necessary to have an atom in the center (benzene, ethane). Tetrahedral, triangles, pentagons don't have centers of inversion symmetry. All Bravais lattices are inversion symmetric.



$Mo(CO)_6$



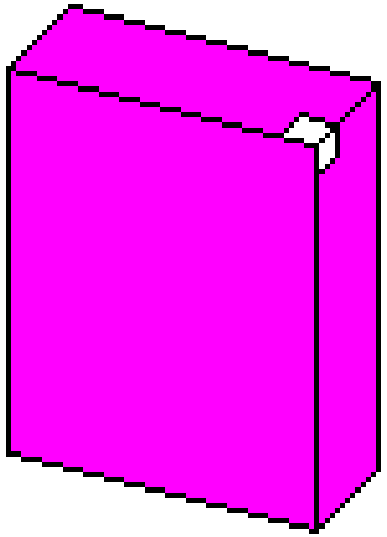
Rotational Invariance &
Invariance on Reflection Through a Plane



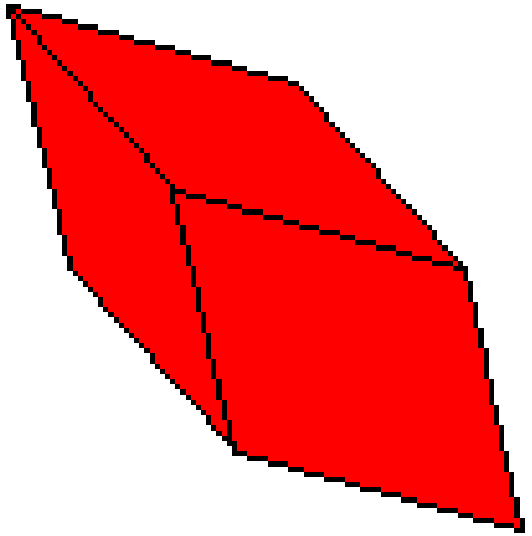
- A plane in a cell such that, when a mirror reflection in this plane is performed, the cell remains invariant.

Examples

Monoclinic



Triclinic



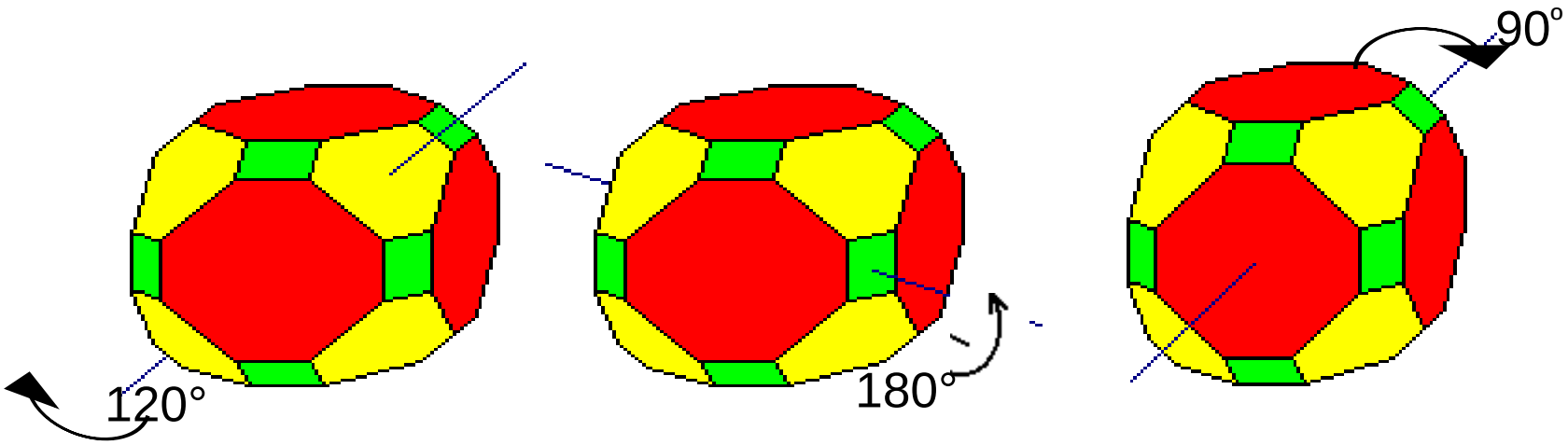
- A triclinic lattice has no reflection plane.
- A monoclinic lattice has one plane midway between and parallel to the bases, and so forth.

Rotational Symmetry

- There are always a finite number of rotational symmetries for a lattice.

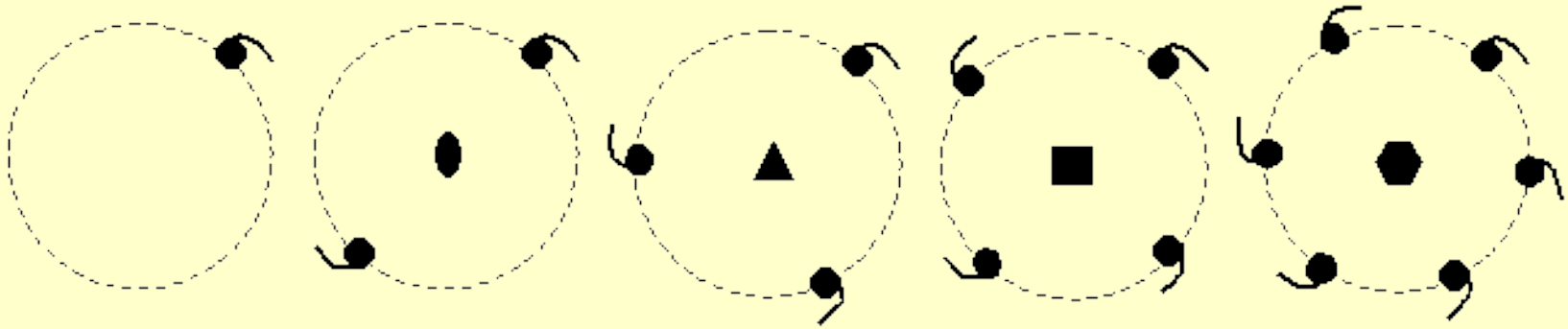
- A single molecule can have any degree of rotational symmetry, but an infinite periodic lattice – can not.

Rotational Symmetries



- This is an axis such that, if the cell is rotated around it through some angles, the cell remains invariant.
- The axis is called n-fold if the angle of rotation is $2\pi/n$.

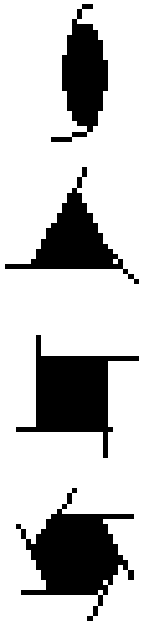
Axes of Rotation



Fold (n)	1	2	3	4	6
Angles	360	180	120	90	60

Axes of Rotation

1-fold	2-fold	3-fold	4-fold	6-fold
Objects with symmetry:				
a identity	**Z**	▼	✚	❄



REFERENCES

- Introduction To Solid State Physics- Kittle
- Elementary Solid state Physics- Omar
- Solid state Physics- S. O. Pillai

THANK YOU !