Crystallography

Centre of Symmetry:

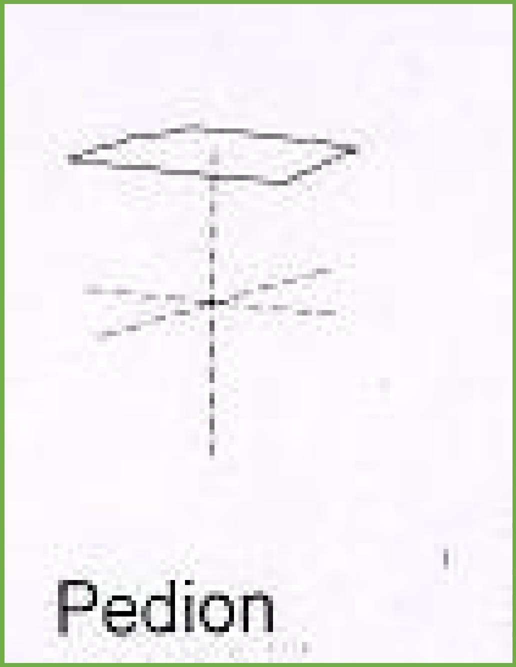
A crystal is said to possess a centre of symmetry if on passing an imaginary line from some definite face, edge or corner on one side of the crystal through its centre, another exactly similar face or edge or corner is found on the other side at an equal distance from the centre. *Many crystals have no planes or axes of symmetry but do possess a centre of symmetry.* The centre of symmetry may not be there whereas the crystal may be symmetrical to a plane of symmetry.

Common Forms in Crystallography:

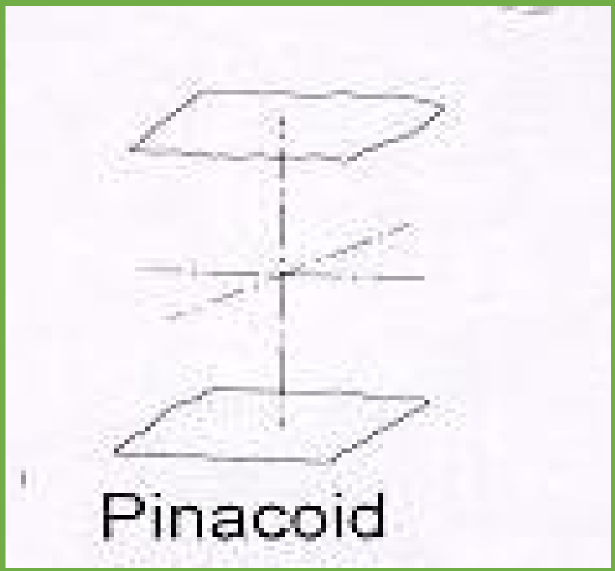
There are 48 possible forms that can be developed as the result of the 32 combinations of symmetry.

Non – Isometric Forms

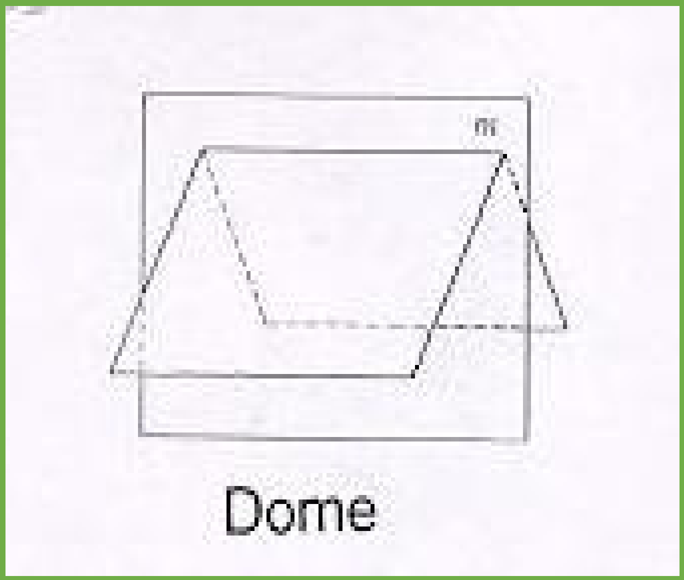
Pedion: A pedion is an open, one face formed.



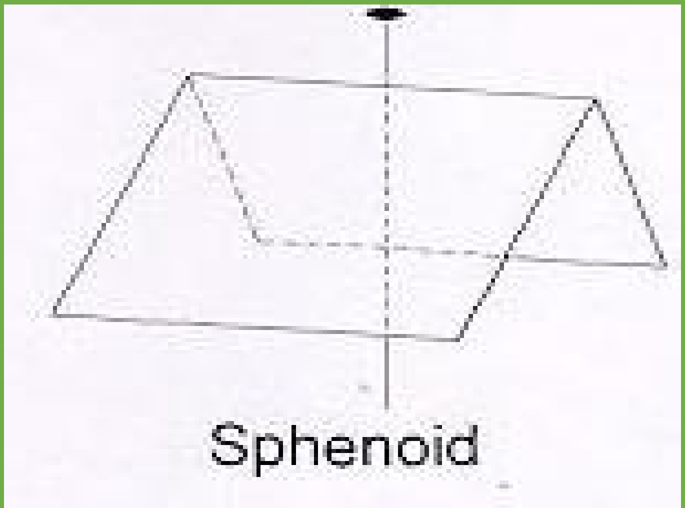
Pinacoid: A Pinacoid is an open 2-faced form made up of two parallel faces.



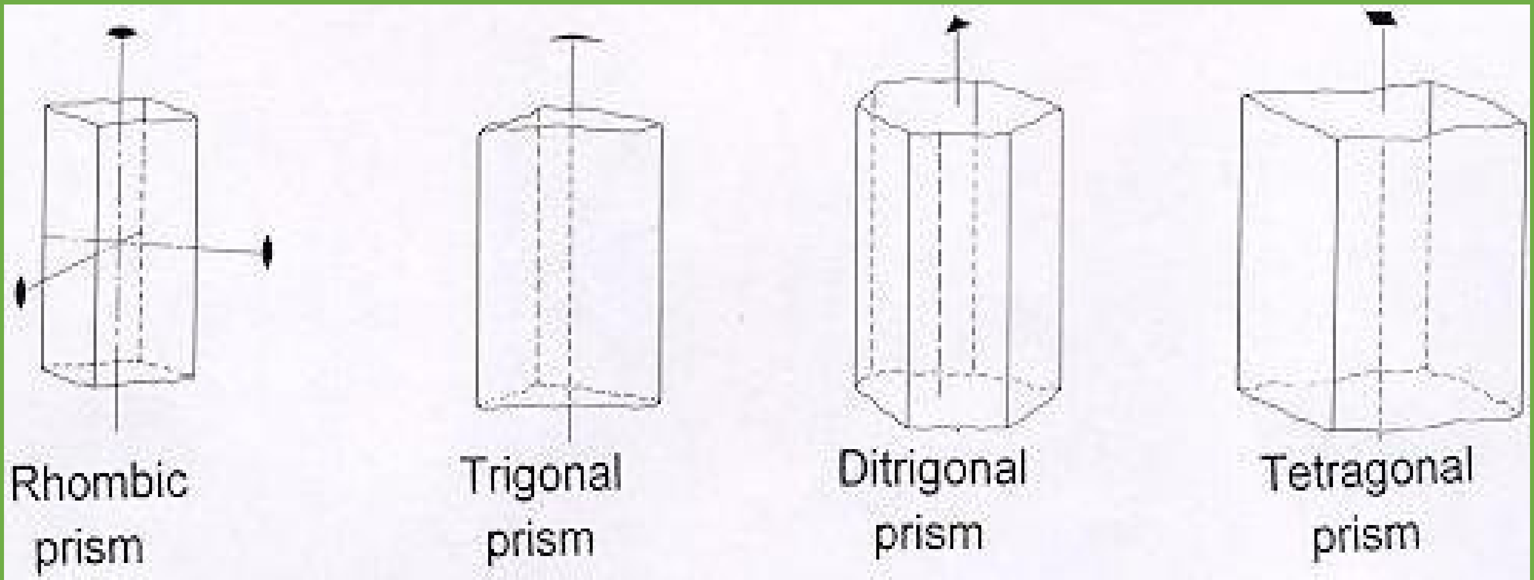
Domes: Domes are 2- faced open forms where the 2 faces are related to one another by a mirror plane.

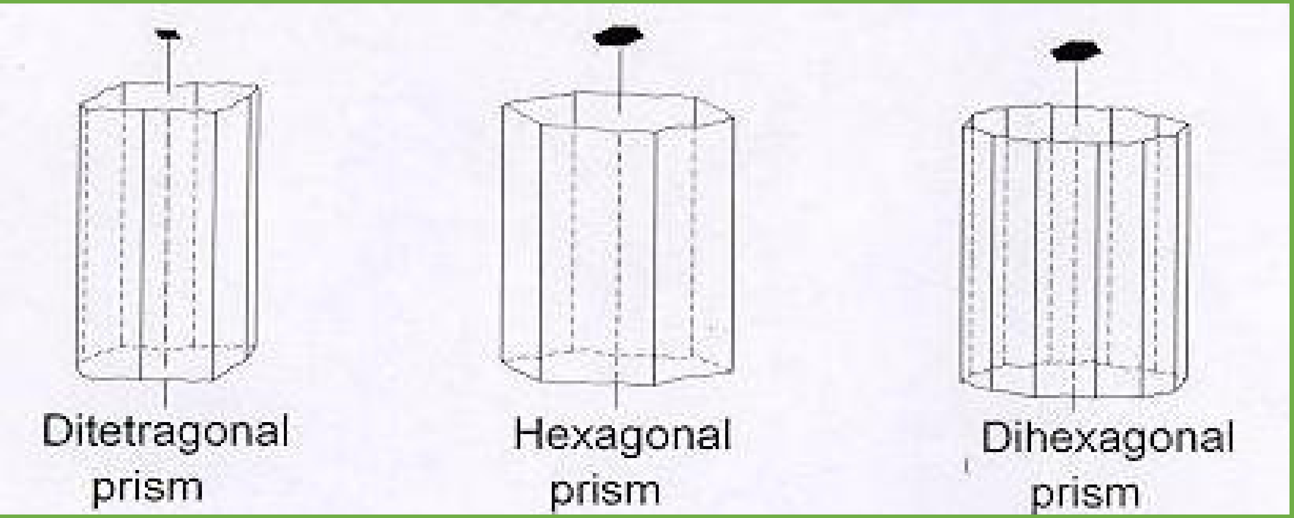


Sphenoids: Sphenoids are2 - faced open forms where the faces are related to each other by a 2-fold rotation axis and are not parallel to each other.

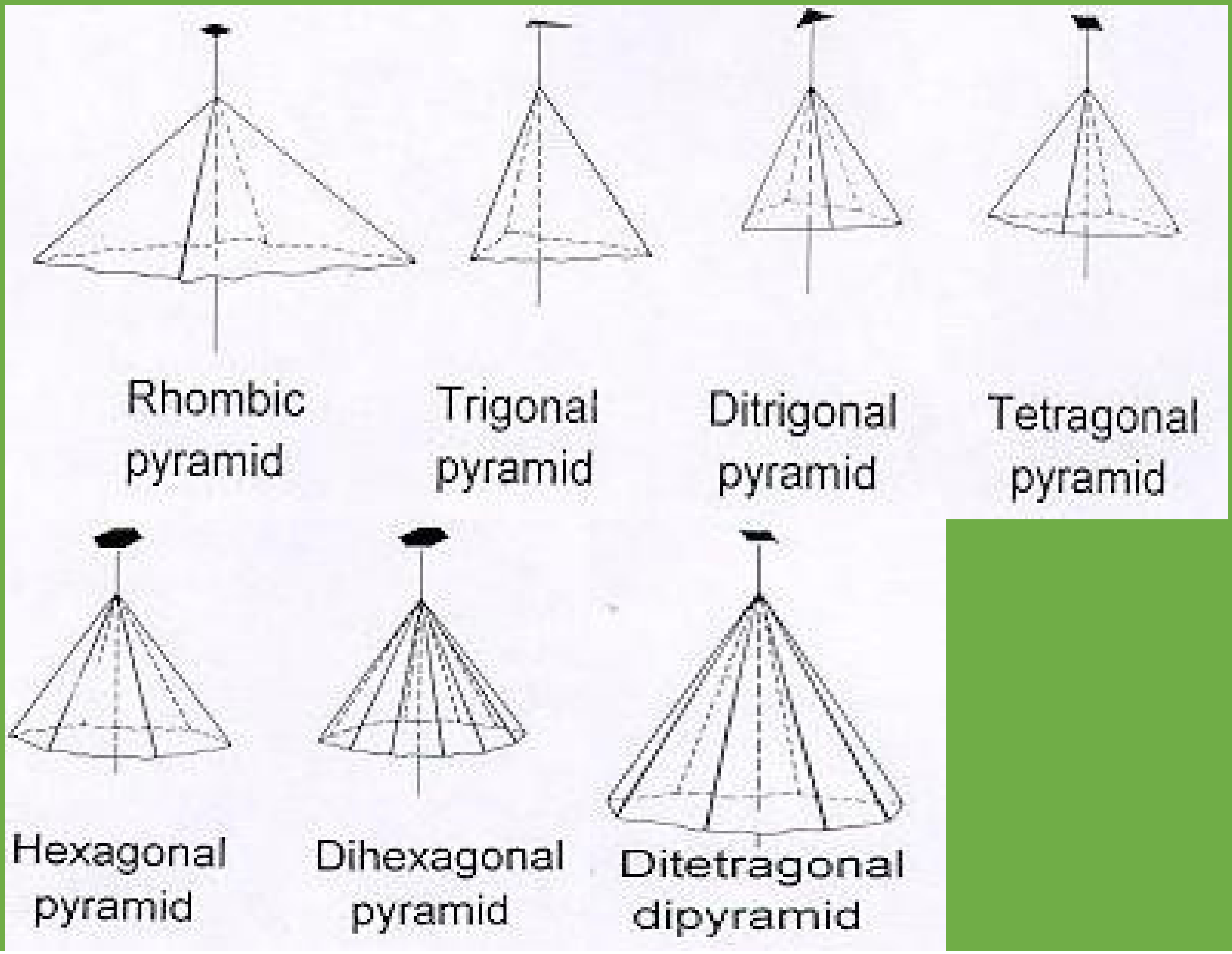


Prism: an open form of 3 (trigonal), 4 (tetragonal or Rhombic prism), 6 (hexagonal or ditrigonal), 8 (ditetragonal), or 12 (dihexagonal) faces all parallel to same axis.



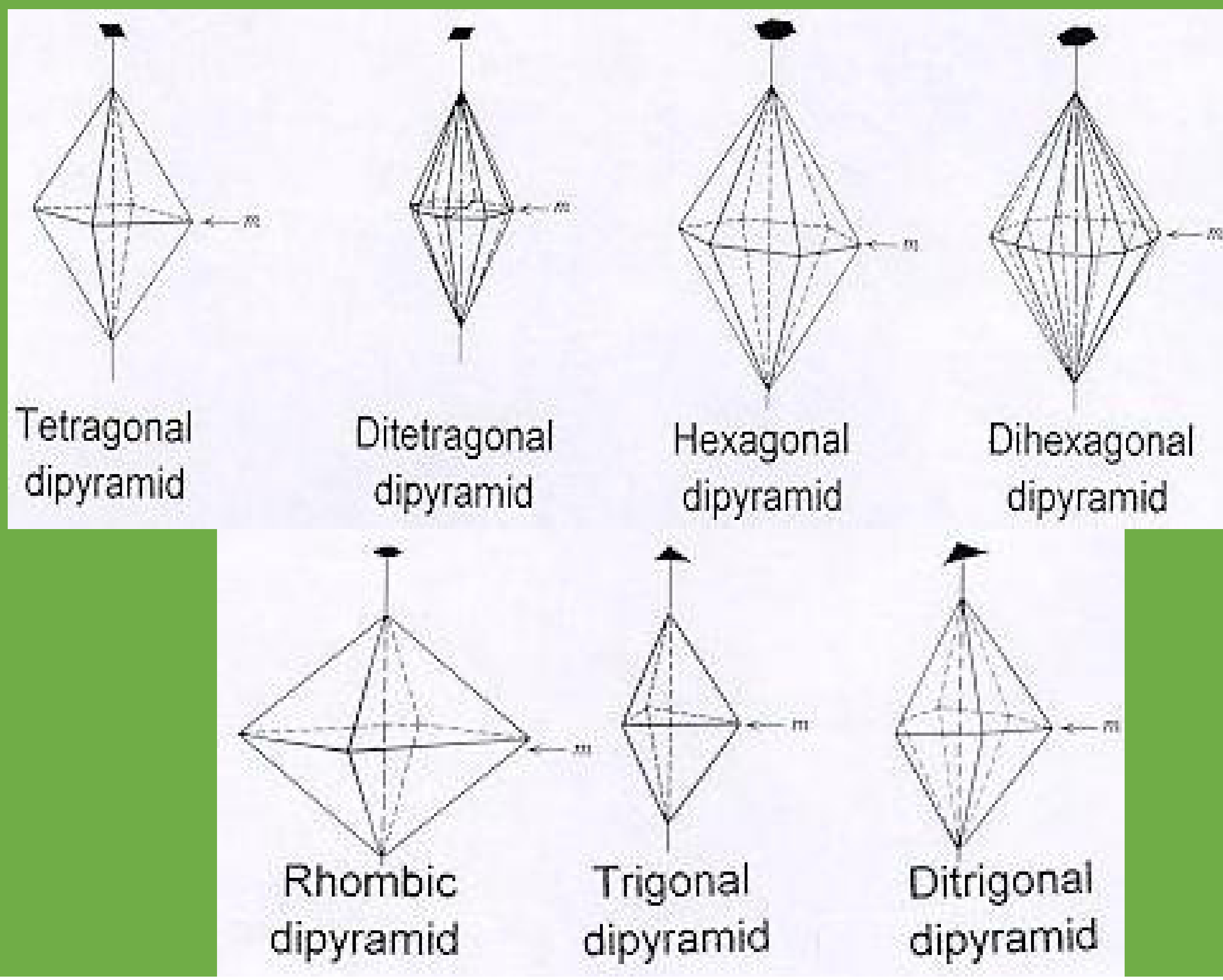

Ditetragonal
prism
Hexagonal
prism
Dihexagonal
prism

Pyramids: A pyramid is a 3(trigonal), 4(tetragonal or rhombic), 6(hexagonal or ditrigonal), 8(ditetragonal) or 12(dihexagonal) faced open form where all faces in the form meet, or could meet if extended, at a point.



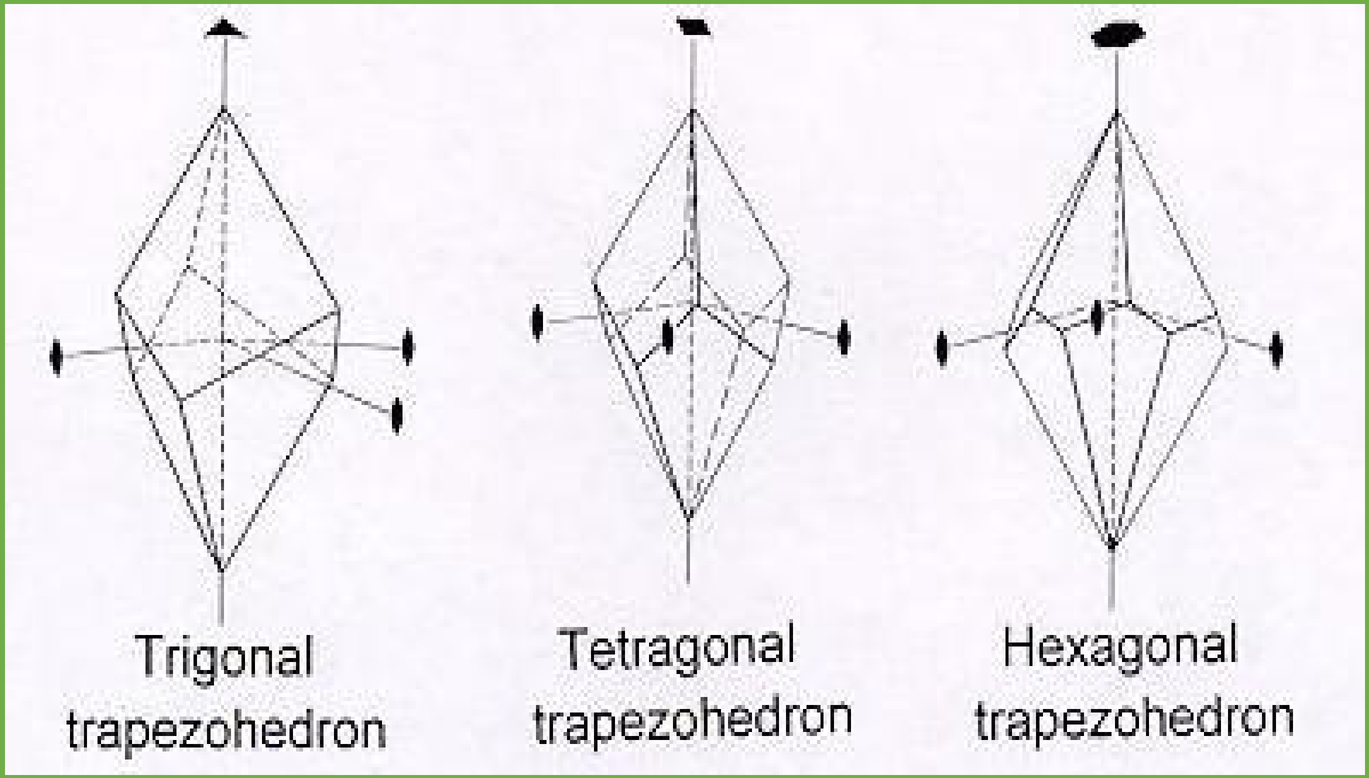
Dipyramids:

Dipyramids are closed forms consisting of 6, 8, 12, 16, or 24 faces. Dipyramids are pyramids that are reflected across a mirror plane. Thus, they occur in crystal classes that have a mirror plane perpendicular to a rotation or rotoinversion axis.



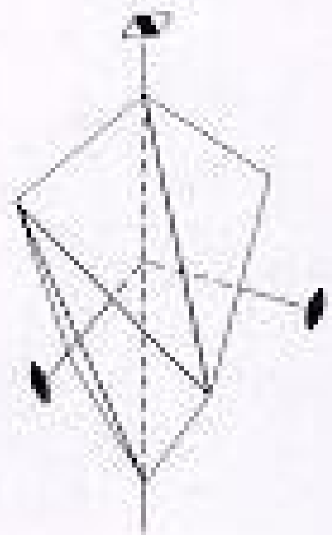
Trapezohedrons:

Trapezohedrons are closed 6, 8, or 12 faced forms, with 3 (trigonal), 4(tetragonal), or 6(hexagonal) upper faces offset from 3, 4, or 6 lower faces.

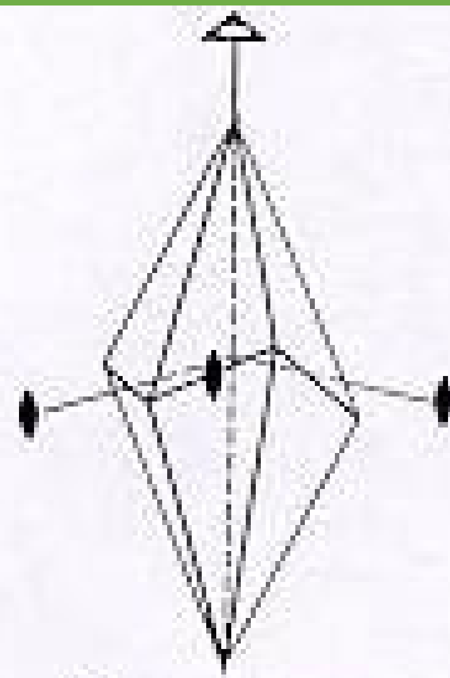


Scalenohedrons:

A scalenohedron is a closed form with 8 (tetragonal) or 12 (hexagonal) faces. In ideally developed faces each of the faces is a scalene triangle.



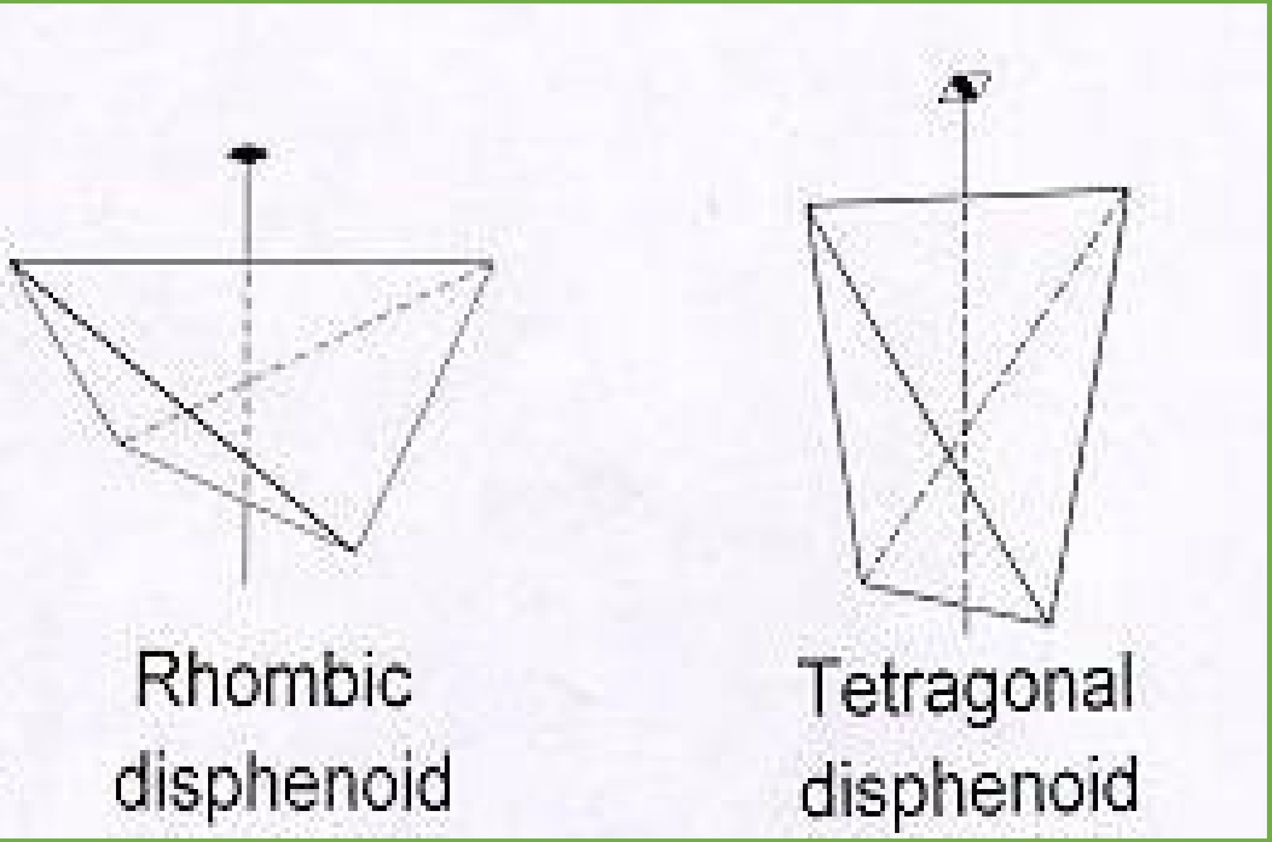
Tetragonal scalenohedron



Hexagonal scalenohedron

Disphenoids

A disphenoid is a closed form consisting of 4 faces. With 2 upper faces alternating with 2 lower faces offset by 90 degrees.

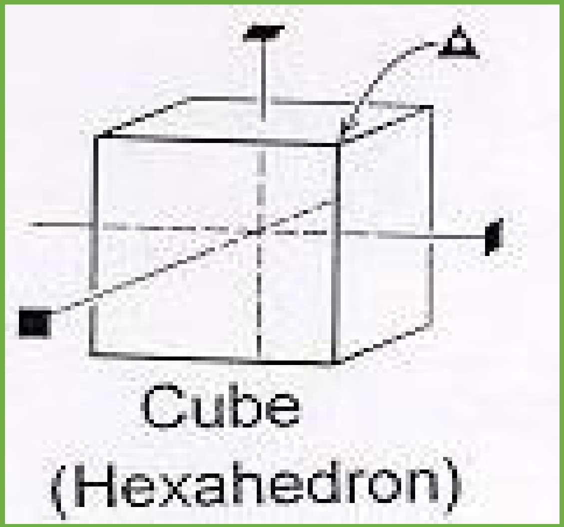


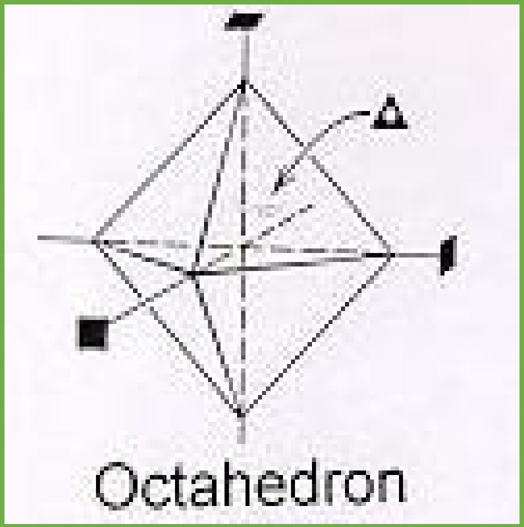
Isometric Forms

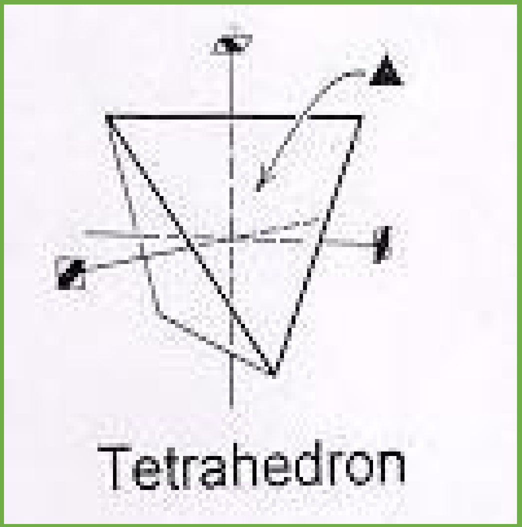
Cube (hexahedron)--6 equal faces intersecting at 90 degrees.

Octahedron--8 equilateral triangular faces.

Tetrahedron--4 equilateral triangular faces.





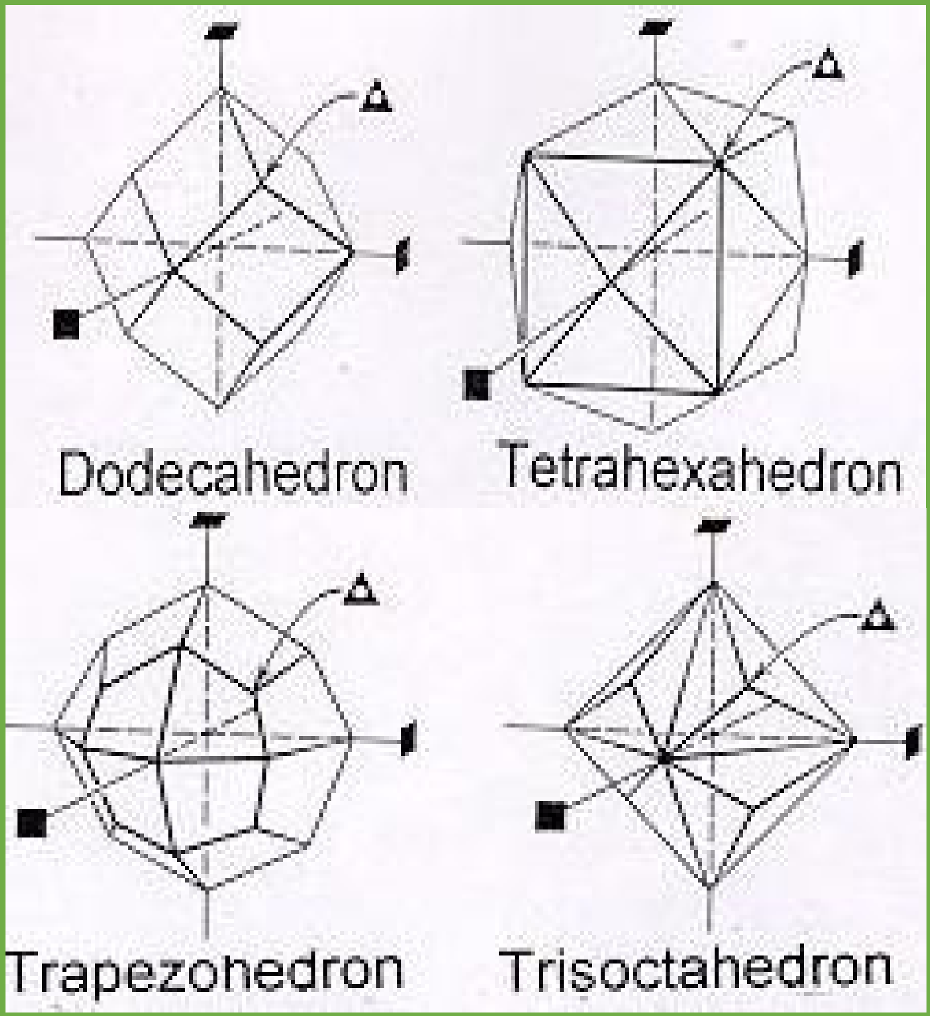


Dodecahedron--12 rhombed faces.

Tetrahexahedron--24 isosceles triangular faces--4 faces on each basic hexahedron face.

Trapezohedrons--24 trapezium shaped faces.

Trisoctahedron--24 isosceles triangular faces--3 faces on each octahedron face.

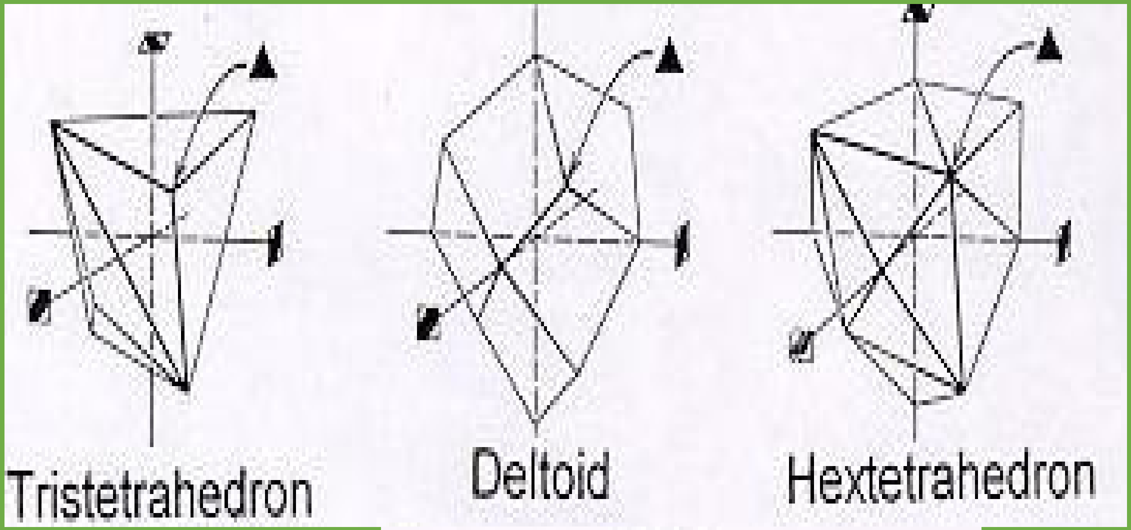


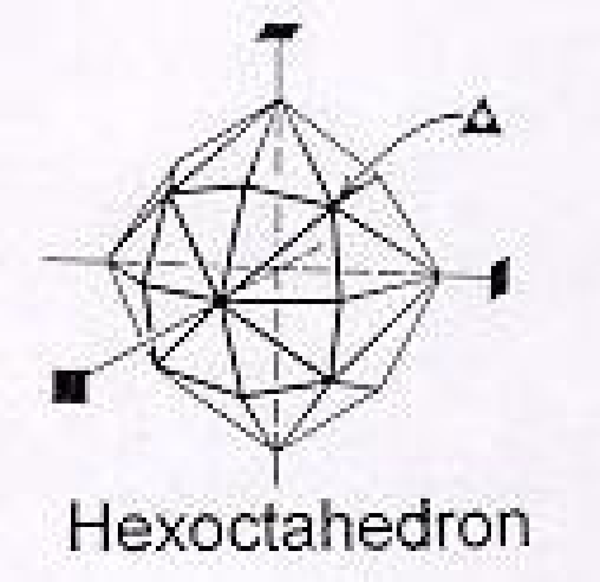
Hexoctahedron--48 triangular faces--6 faces on each basic octahedron face.

Tristetrahedron--12 triangular faces--3 faces on each basic tetrahedron face.

Deltoid dodecahedron--12 faces corresponding to 1/2 of trisoctahedron faces.

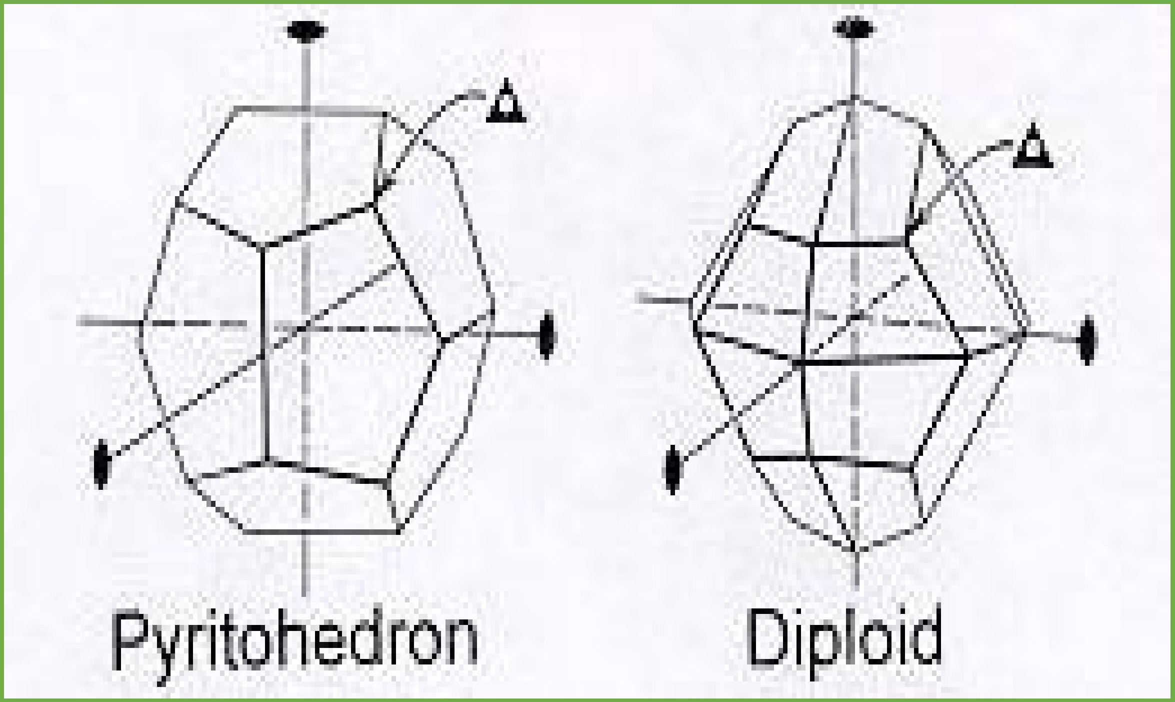
Hextetrahedron--24 faces--6 faces on each basic tetrahedron faces.





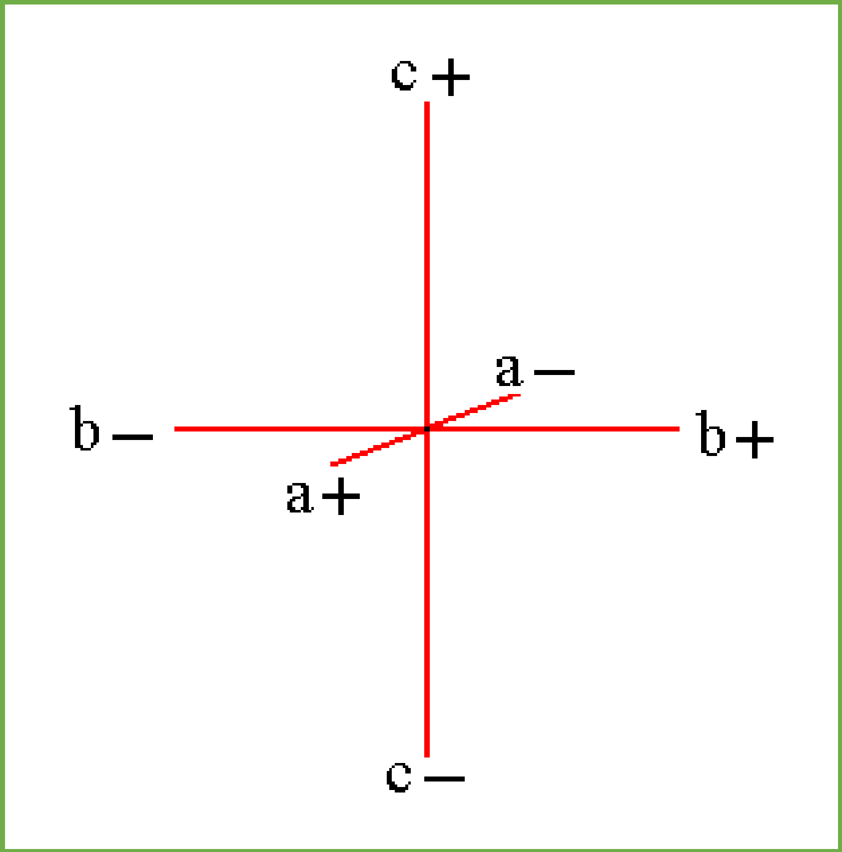
Diploid--24 faces

Pyritohedron--12 pentagonal faces



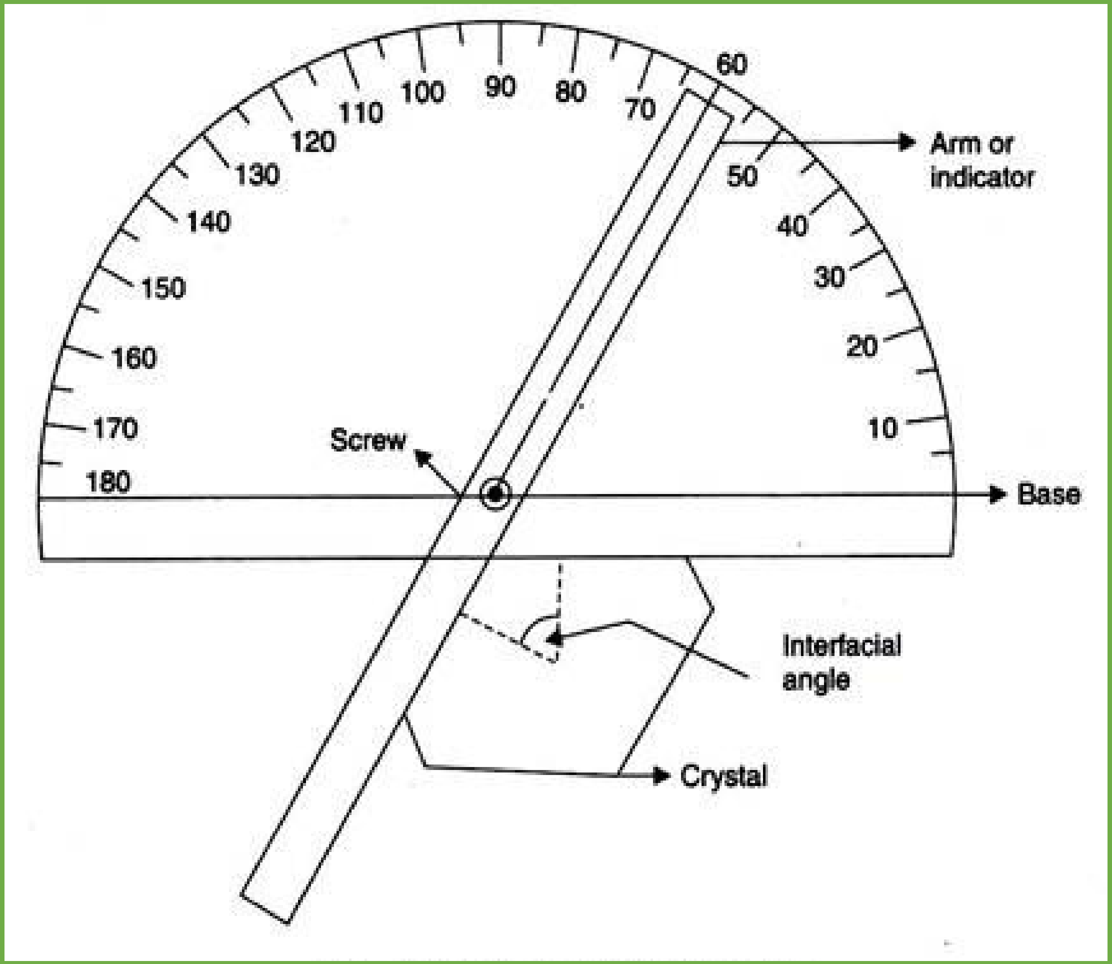
Crystallographic Axes:

Crystallographic Axes are the imaginary lines passing through the centre of the crystal, but not lying in the same plane, and used as axes of reference for denoting the position of faces.



Interfacial Angle (IFA):

Interfacial angle is angle between any two adjacent faces of a crystal. The instrument used to measure interfacial angle is called Contact Goniometer.



Law of constancy of interfacial angle:

Law of constancy of interfacial angle states that measured at the same temperature, similar angle on crystal of the same substances remain constant, regardless the size and shape of the crystal.

Based on the crystallographic axis all the crystals are classified into six different crystal systems such as:

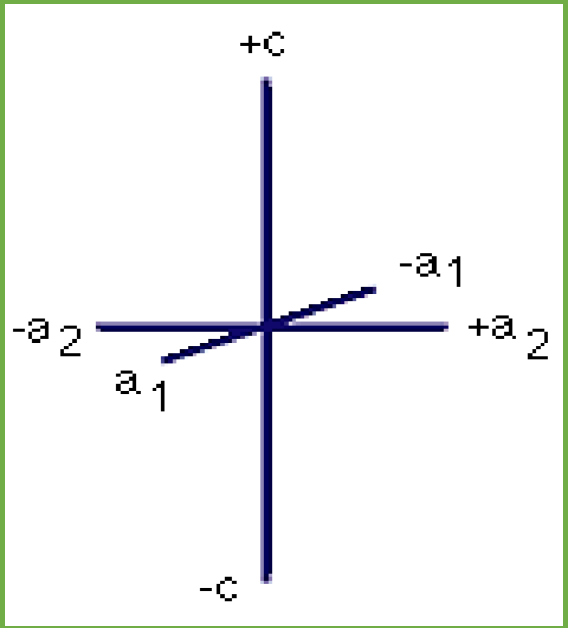
1. Isometric System.
2. Tetragonal System.
3. Hexagonal System.
4. Orthorhombic System.
5. Monoclinic System.
6. Triclinic System.

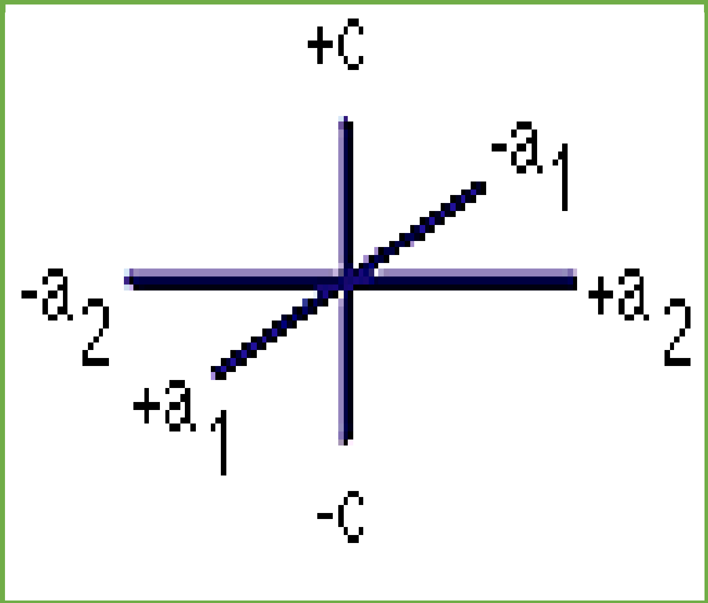
Isometric System:

In this system there are three crystallographic axes. All the three crystallographic axes which are equal and interchangeable cut at 90°, therefore, the symbol is $\boldsymbol{a} = \boldsymbol{b} = \boldsymbol{c}$ and the axial angle is $\alpha = \beta = \gamma = 90°$.

Tetragonal System:

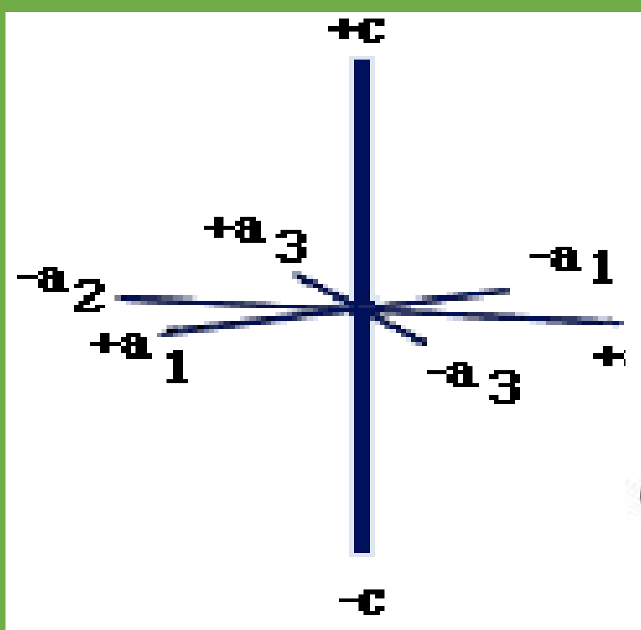
In this system there are three crystallographic axes, among these two crystallographic axes (Front to Back and Side to Side) which are equal and interchangeable. The third crystallographic axes (vertical crystallographic axis) which is unequal (it may be bigger or smaller) therefore the symbol is $\boldsymbol{a} = \boldsymbol{b} \neq \boldsymbol{c}$ and the axial angle is $\alpha = \beta = \gamma = 90°$. *Zircon*.

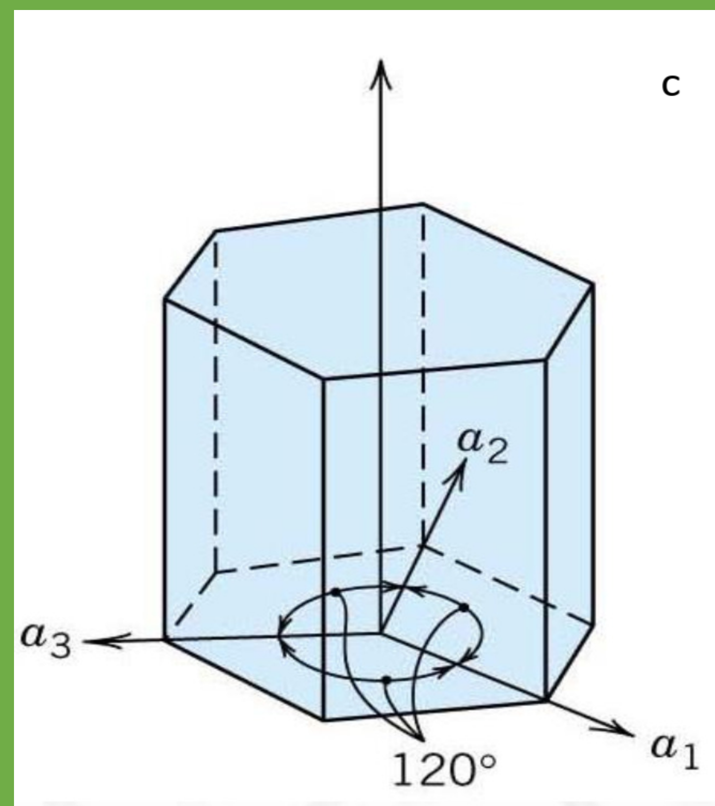




Hexagonal System:

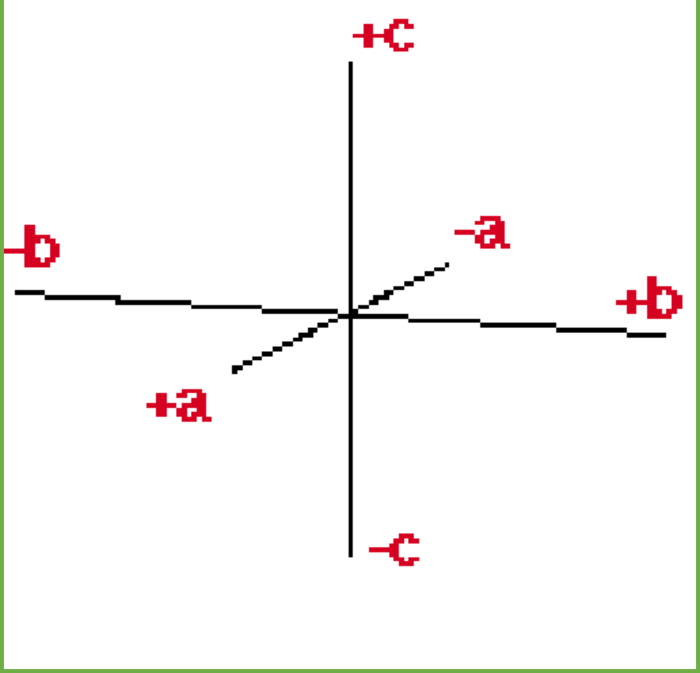
In this system there are four crystallographic axes. Three crystallographic axes which are equal and interchangeable cut at 60° or 120°. The fourth one that is vertical crystallographic axis which is unequal (it may be bigger or smaller), therefore, the symbol is $a_1=a_2$, a_3 and the axial angle is ∠a ∠a = 60° or 120°, ∠a ∠c = 90°.Quartz.





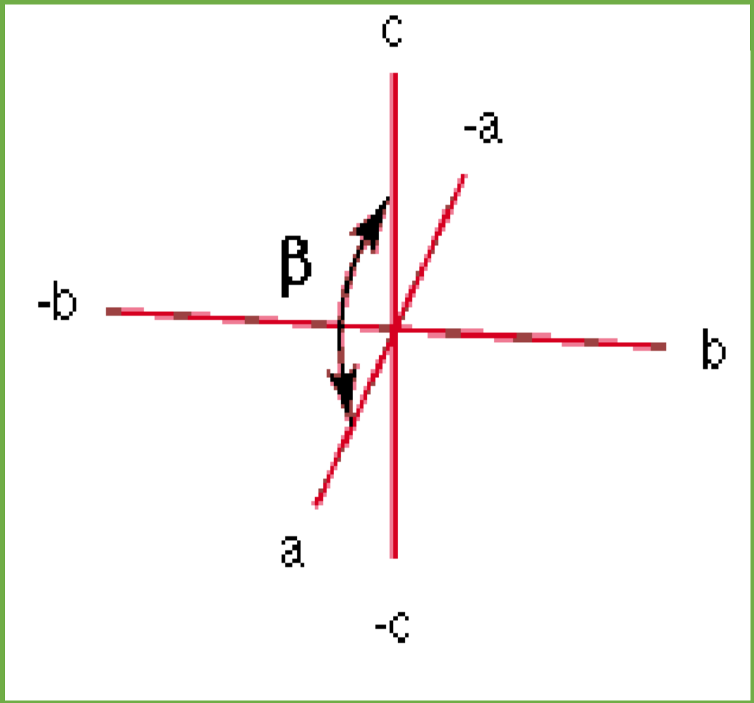
Orthorhombic System:

In this system there are three crystallographic axes. All the three crystallographic axes, which are unequal in length and cut at 90°, therefore, the symbol is a : b : c and the axial angle is ∠a ∠b ∠c = 90°. Staurolite.



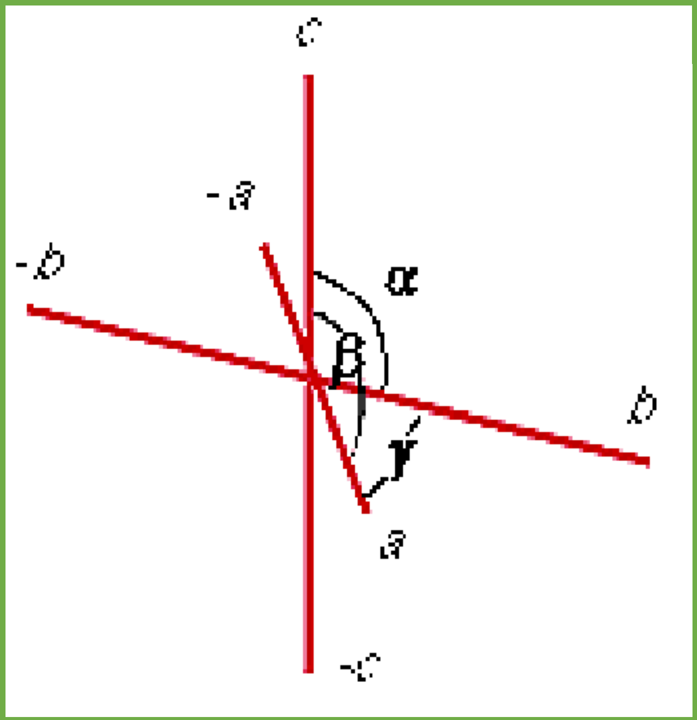
Monoclinic System:

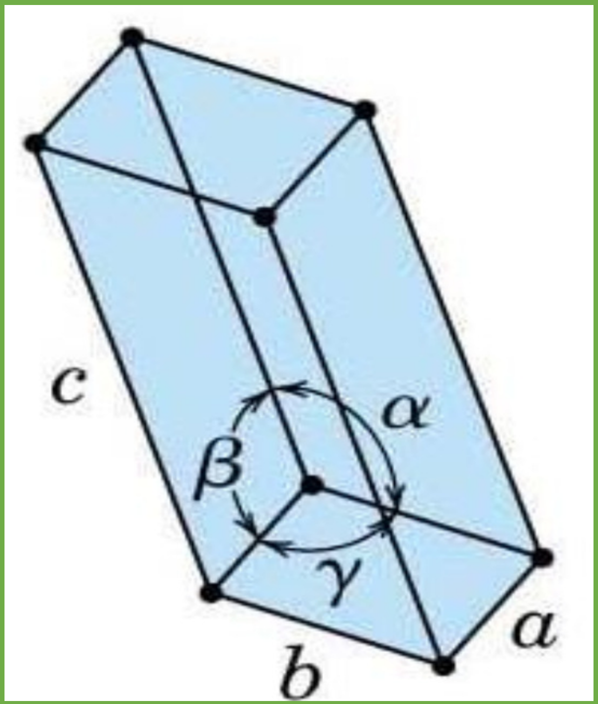
In this system there are three crystallographic axes. All the three crystallographic axes, which are unequal in length. Therefore, the symbol is a: b: c and the axial angle is ∠a ∠c = 90°, ∠b ∠c = 90°, ∠a ∠c not equal to 90°. Orthoclase.



Triclinic System:

In this system there are three crystallographic axes. All the three crystallographic axes, which are unequal in length and not cut at 90°, therefore, the symbol is a :b : c and the axial angle is ∠a ∠a ∠c not equal to 90°. example Albite.





***Note:** The lengths of the crystallographic axes are controlled by the dimensions of the unit cell upon which the crystal is based. The angles between the crystallographic axes are controlled by the shape of the unit cell.*

Axial Ratios

Axial ratios are defined as the relative lengths of the crystallographic axes. They are normally taken as relative to the length of the b crystallographic axis. Thus, an axial ratio is defined as follows:

$$\text{Axial Ratio} = a/b : b/b : c/b$$

Where a is the actual length of the crystallographic axis, b, is the actual length of the b crystallographic axis, and c is the actual length of the c crystallographic axis.

- For Triclinic, Monoclinic, and Orthorhombic crystals, where the lengths of the three axes are different, this reduces to

  a/b : 1 : c/b (this is usually shortened to a : 1 : c)

- For Tetragonal crystals where the length of the a and b axes are equal, this reduces to

  1 : 1 : c/b (this is usually shorted to 1 : c)

- For Isometric crystals where the length of the a, b, and c axes are equal this becomes

  1 : 1 : 1 (this is usually shorted to 1)

- For Hexagonal crystals where there are three equal length axes (a_1, a_2, and a_3) perpendicular to the c axis this becomes:

  1 : 1 : 1: c/a (usually shortened to 1 : c)

Intercepts of Crystal Faces (Weiss Parameters):

Crystal faces can be defined by their intercepts on the crystallographic axes.

Miller Indices:

The Miller Index for a crystal face is found by

- First determining the parameters.
- second inverting the parameters, and
- Third clearing the fractions.

For example, if the face has the parameters 1 a, 1 b, ∞ c

Inverting the parameters would be 1/1, 1/1, 1/ ∞

This would become 1, 1, 0

The Miller Index is written inside parentheses with no commas - thus (110)

Examples: