

Crystallography:

- is the science that deals with the study of crystals and crystalline materials, whether they are prepared in lab or formed by nature.
- study of crystal in terms of their external appearance "geometry" and internal structure.

Crystalline substance

- Has ordered internal structure with or without crystal faces.
- Has sharp, well-defined melting point (regular arrangement).
- Has periods of constant temperature during cooling and crystallization processes.

Amorphous substance

- (lacks) ordered internal structure and crystal face.
- doesn't have a definite melting point.
- Formed by rapid cooling of melt (non-regular arrangement).

Crystal:

- is a homogeneous solid material with a definite chemical composition bounded by naturally formed smooth plane surface which having a symmetry relationships.

Crystal parts:

Face: external smooth plane
 edge: is the line resulting from meeting of 2 neighboring faces.

Solid angle: result from meeting of more than ② faces
 interfacial angle: angle between 2 neighboring faces.

→ are constant regardless to its size

* elements of Symmetry:

* Internal Symmetry is reflected in the external form of perfect crystal.

① plane of Symmetry: [P]

Imaginary line - divide the crystal into 2 equal halves.

② Rotational axes of Symmetry: [L]

imaginary line - pass through the center of crystal.

We have four axes of Symmetry:

- ① Two fold "Diad axis" → crystal face repeats after
- ② triad → " " 120° { a rotation of 180°
- ③ Tetrad → 90°
- ④ Hexad → 60°

③ Center of Symmetry: "C"

Imaginary line starts from any point and passes through its center.

→ All elements of Symmetry can be Combined in

So is called **Complete Symmetry Formula (CSF)**.

* **Note 2** - Minimum Symmetry is Center of Symmetry
Maximum Symmetry is (13 axes, 9 plane, center)

* Element of Crystallization:

① Crystallographic axes:

3 or 4 imaginary lines intersect at the center of crystal.

two or three → horizontal

3rd or 4th $\rightarrow$ vertical called "C"

(b) Crystallographic angles:

$\alpha \rightarrow$ between b, c

$\beta \rightarrow$ between a, c

$\gamma \rightarrow$ between a, b

Crystal form

open

Crystal face can't close

The crystal in all direction alone

Such as / prism - pinacoid

closed

Such as / bipyramid

Simple form of

Cubic system.

Crystal types: number of crystal forms

Simple

Crystal consists only of one closed form

Compound

Crystal have more than one form

Combined together in a regular arrangement.

* crystal systems:

into 7 systems.

crystal systems

System	crystallographic axes	crystallographic angles	elements of symmetry
① Cubic	$a_1 = a_2 = a_3$	$\alpha = \beta = \gamma = 90^\circ$	
② Tetragonal	$a_1 = a_2 \neq c$	$\alpha = \beta = \gamma = 90^\circ$	
③ Orthorhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90^\circ$	
④ Monoclinic	$a \neq b \neq c$	$\alpha = \gamma = 90^\circ, \beta \neq 90^\circ$	
⑤ Triclinic	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90^\circ$	
⑥ Hexagonal	$a_1 = a_2 = a_3 \neq c$	$\alpha = \beta = 90^\circ, \gamma = 120^\circ$	
⑦ Trigonal	$a_1 = a_2 = a_3 \neq c$	$\alpha = \beta = 90^\circ, \gamma = 120^\circ$	No horizontal plane of symmetry.

α
 β
 γ

crystal systems

Seven crystal system $\rightarrow$ 32 crystal classes

acc to their element of symmetry.

* The holosymmetrical class (Normal class) is a class in each crystal system that contains the highest number of elements of symmetry.

* general form

the form which have the largest number of crystal faces.

* A class can be named after its general form.

* Normal class of cubic system

$\rightarrow$ elements of crystallization

crystallographic axes $a_1 = a_2 = a_3$

crystallographic angles $\alpha = \beta = \gamma = 90^\circ$

$\rightarrow$ elements of symmetry

axes 13 ($3 \square, 4 \Delta, 6 \circ$)

plane 9 (4 vertical, 1 horizontal, 4 diagonal)

centre 1 ve

C.S.F $3L_4, 4L_3, 9PC$

* normal class of cubic system :-

→ crystal forms :-

- ① Cube (hexahedron) :- Closed - 6 square faces.
- ② Octahedron :- Closed - 8 triangular faces.
- ③ Rhombic dodecahedron :- Closed - 12 rhombic faces.
- ④ Trapezohedron :- closed form - 24 trapezium faces.
- ⑤ Tetrahexahedron :- closed form - 24 triangle faces.
- ⑥ Trisoctahedron :- closed form - 24 triangular faces.
- ⑦ Hexaoctahedron :- Closed - 48 triangular faces.

* tetragonal system :-

Elements of crystallization :-

Crystallographic axes :- $a_1 = a_2 \neq c$

Crystallographic angles :- $\alpha = \beta = \gamma = 90^\circ$

elements of symmetry :-

Axes :- 3 (C_4, C_2)

plane :- 5 (4 vertical, 1 horizontal)

Centre :- 1

CSF :- C_4, C_2, C, σ, i

Normal class of tetragonal systems

- ① Basal (c) pinacoid - open form - Made up of two parallel faces that intercept c and parallel to a, b axes.
- ② Tetragonal prism first order - open - Consists of 4 faces parallel to c, intercept a, b axes.
(4 موجهات متوازية مع c، تقاطع a, b المحاور)
- ③ Tetragonal prism second order - open - Consists of 4 faces parallel to c axis.
- ④ Ditetragonal prism - open form - Consists of 8 faces parallel to c axis.
- ⑤ Tetragonal bipyramid first order - closed - Consists of 8 isosceles triangular faces intersect all crystallographic axes - all faces intersect c-axis and a, b
- ⑥ Tetragonal bipyramid second order - closed - consists of 8 isosceles triangular faces - all intersect the c axis and either a or b axis.
- ⑦ Ditetragonal bipyramid "general form" - closed - consists of 16 isosceles triangular faces. All faces intersect c axis and both a, b axis

* orthorhombic system:

* elements of crystallization:

crystallographic axes: $a \neq b \neq c, (c > b > a)$

crystallographic angles: $\alpha = \beta = \gamma = 90^\circ$

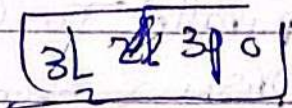
* elements of symmetry:

planes: 3 ((2) vertical, (1) horizontal)

axes: 3

Centre: 1

CSF: $3L_2, 3PC$



* normal class of orthorhombic systems:

→ Crystal form

(1) Basal (C) pinacoid: open form - made up of (2) parallel faces, intercept C axis and parallel to a & b axes.

(2) Front (a) pinacoid: open form - made up of two parallel faces that intercept a axis and parallel to c and b axes.

(3) Side (b) pinacoid: open form - made up of 2 parallel faces that intercept b axis, parallel to a and c axes.

(4) Brachy dome or (a) open form - consists of 2 faces parallel to (a) axis and intersect c, b axes.

⑤ (b) or macro dome 2 - open form - Consists of 2 ⁴ faces parallel to b axis and intersect c, a axes.

⑥ orthorhombic bipyramid (general form) 2 - Closed - Consists of ⑧ triangular faces, each of them intersects all 3 crystallographic axes.

⑦ orthorhombic prism 2 -

Consists of ④ faces, parallel to c (axis) and intercept the other 2 axis

→ hexagonal system

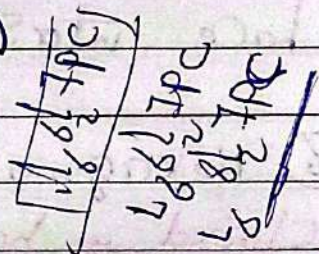
element of symmetry 2 -

plane 2 ⑦ ⑥ (vertical, 1 horizontal)

axes 2 ① ②, 6 ③

Centre +ve

C.S.F. 2 $L_6 6L_2 7PC$



Normal class of hexagonal system 2 -

① Basal (c) pinacoid 2 - open - Consist of two parallel faces that intercept c axis, parallel to other 3 horizontal axes.

② Hexagonal prism 2nd order 2 - open form - having 6 faces parallel to c axis and each face intersect two horizontal axes parallel to other horizontal axis.

- ③ Hexagonal prisme 1st order 2 - open form - having 6 faces parallel to C-axis - each faces intersects two horizontal axes ~~at the same~~ intersect the other horizontal face axis
- ④ Dihexagonal prisme 2 open - consist of 12 faces parallel to C axis and intersect horizontal axes but at different distances
- ⑤ hexagonal bipyramid 1st order 2 - closed - have 12 isosceles triangular faces, each face intersect two horizontal axes at the same distance but intersect the other horizontal face axis at longer distance - All face intersect C axis
- ⑥ Hexagonal bipyramid 2nd order 2 - closed - have 12 isosceles triangular faces, each face intersects 2 horizontal axes at the same distance - parallel to other horizontal axes - All face intersect C axis
- ⑦ Dihexagonal bipyramid (general form) 2 - closed - have 24 faces, intersect horizontal axes but at different distance - All faces intersect C axis