## Study of crystals

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Crystal: A crystal is a homogenous portion of a solid substance made by regular pattern of structural units bonded by plane surface making definite angles with each other.

Space lattice: The arrangement of constituents like atom, ions and molecules in different sites in three-dimensional space is called space lattice.

Unit cell: The smallest repeating unit in space lattice which when repeats over and over again, results in a crystal of the given substance called unit cell.

Face: the plane surface of the Crystal is called faces.
Edge: An edge is formed by the intersection of two adjacent faces.
Corner: A corner is formed by intersection of two or more edges.
Interfacial angles: the angle between the perpendiculars two intersecting faces called interfacial angles


## Type of symmetry

A crystal possesses following three types of symmetry.

1. Plane Symmetry: It is an imaginary line which passes through the center of a crustal, that divides it into two equal portions which are exactly mirror image of each other.

(a)

Plane of symmetry


Rectangular plane of symmetry

(c)

Diagonal plane
of symmetry

## 2. Axis Symmetry:

(a) It is an imaginary line about which the crystal may be rotated so that it presents the same appearance more than once in a complete rotation through 360 degrees.
(b) The axis of symmetry is called diad, triad, tetrad and hexad respectively. It is the original appearance and is repeated twice $\left(180^{\circ}\right)$, thrice $\left(120^{\circ}\right)$, four times $\left(90^{\circ}\right)$ and six times $\left(60^{\circ}\right)$ in one rotation.
(c) These axes of symmetry are also called as two-fold, three-fold, fourfold and six-fold respectively.

$60^{\circ}$ rotation
$\frac{360}{60}=6$ fold axis

$90^{\circ}$ rotation
$\frac{360}{90}=4$ fold axis

$120^{\circ}$ rotation

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\frac{360}{120}=3 \text { fold axis }
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$180^{\circ}$ rotation
$\frac{360}{180}=2$ fold axis
(d) Fivefold symmetry is not found in crystals.
3. Centre of symmetry: It is a point in the crystal that any line drawn through it intersects the surface of the Crystal at equal distance on either side.


Note: Only simple cubic system has one centre of symmetry. Other systems do not have centre of symmetry.
(1) mid-points of two opposite edges. (As a cube has 12 edges, there are $12 \div 2=6$ axes of this type.)
(2) two opposite vertices. (As a cube has 8 vertices, there are $8 \div 2=4$ axes of this type.)
(3) the centres of two opposite faces. (As a cube has 6 faces, there are $6 \div 2=3$ axes of this type.)

So it has 13 axes of symmetry.
There is something interesting. A cube has 12 edges and $13(=12+1)$ axes of symmetry. 6 of them are of order $2($ and $6 \times 2=12), 4$ of them are of order $3(4 \times 3=12)$ and 3 of them are of order $4($ and $3 \times 4=12)$.

Elements of symmetry: Total number of planes, axis and centre of symmetries possessed by a crystal is termed as elements of symmetry. A cubic crystal possesses total 23 elements of symmetry.
$\begin{array}{ll}\text { (i) plane of symmetry: } & 3+6=9 \\ \text { (ii) axis of symmetry: } & 3+4+6=13 \\ \text { (iii) centre of symmetry: } & 1=1\end{array}$

## Total 23



Crystal lattice or space lattice: "A crystal lattice is a regular arrangement of the constituent particles (atoms, ions or molecules) of a crystalline solid is three-dimensional space." The position which are occupied by the atoms and molecules in the crystal lattice are called lattice points are lattice sites.

## Lattice points





Unit cell: If we carefully look a crystal lattice, it is observed that we can select a group of lattice point (a smallest three dimensional portion) which is repeated over and over again in the whole crystal lattice. This smallest repeating pattern (motif) is called a unit cell.
"Unit cell is the smallest repeating unit in space lattice which when repeated over and over again produces the
complete crystal lattice". This smallest repeating pattern (unit cell) represents the shape of the entire crystal. we can generate the complete lattice by moving the unit cell in the direction of its edges by a distance equal to the cell edge. In fact, crystal

Parameters of a unit cell: A unit cell is characterized by:
(i) Its dimension (lengths) along the three edges as a, b and c. These edges may or may not be mutually perpendicular.
(ii) Angles $\alpha, \beta$ and $\Upsilon$ between the pair of edges. The angle $\alpha$ is between the edges $b$ and c , angle $\beta$ is between the angle c and a and angle $\Upsilon$ is between the edges of a and b . Thus, a unit cell is characterized by 6 parameters, $a, b, c, \alpha, \beta$, and $\Upsilon$. The complete crystal lattice can be obtained by extending the unit cell in all three directions


## Assignment

1.The pink shaded plane in the figure is referred to as $\qquad$
(A) rectangular plane of symmetry
(B) diagonal plane of symmetry
(C) unit plane
(D) none of these

2. The elements of symmetry in a crystal are--------
(A) Plane of symmetry
(B) axis of symmetry
(C) centre of symmetry
(D) all
3. A crystal may have one or more planes and one or more axes of symmetry but it possesses only ------
(A) two centres of symmetry
(B) one centre of symmetry
(C) no centre of symmetry
(D) none of these
4. How many faces are there in a cube?
(A) 4
(B) 6
(C) 12
(D) 8
5. How many parameters of a unit cell is characterized by?
(A) 3
(B) 2
(C) 6
(D) 8
(D) ${ }^{\circ}$
(g) $\cdot \downarrow$
$(g) \cdot \mathcal{E}$
(C) ${ }^{\circ}$
(d) $\cdot \mathrm{I}$

