Unit: Solid State

B.Sc-I

Paper-1

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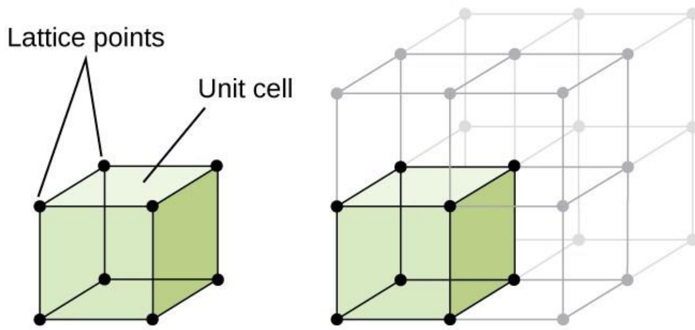
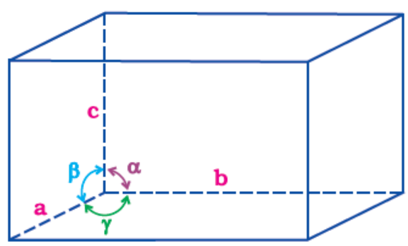
Unit Cell

The smallest possible portion or part of the crystal lattice which repeats itself in different directions of the lattice is called the unit cell. Many unit cells combine to geometrically form the crystal lattice.



A unit cell is the shortest portion of a lattice

Characteristics of Unit Cell



The following characteristics define a unit cell:

- A unit cell has three edges a, b and c and three angles α, β and γ between the respective edges
- The a, b and c may or may not be mutually perpendicular
- The angle between edge b and c is α, a and c is β and that of between a and b is γ

Unit cells are of two types namely:

- Primitive Unit Cells
- Centred Unit Cells

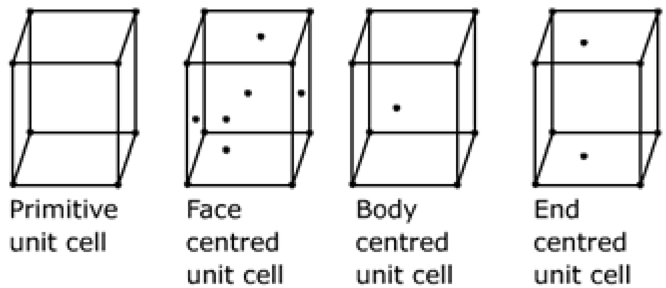
Primitive Unit Cells

The unit cell in which the constituent particles (atoms, ions or molecules) are located only on the corners of the lattice is called a primitive unit cell**.**

Centred Unit Cells

The unit cell in which the constituent particles (atoms, ions or molecules) are located on the corners, as well as other positions of the lattice, is known as centred unit cells. A centred unit cell is further divided into three types:

- Body Centred Unit Cells
- Face Centred Unit Cells
- End Centred Unit Cells



Body Centred Unit Cells

The unit cell which contains one constituent particle (atom, molecule or ion) at its body centre and other constituent particles are located on the corners is called body centred unit cells**.**

Face Centred Unit Cells

The unit cell which contains constituent particles (atoms, molecules or ions) on each face of the unit cell and other constituent particles on the corners is called the face centred unit cell**.**

End Centred Unit Cells

In an end centred unit cell, one constituent particle (atom, molecule or ion) is present at the centre of opposite faces besides the ones located on the corners.

Formation of Lattice

Formation of unit cells takes place in seven forms, namely:

- Cubic Lattice

- Tetragonal Lattice
- Orthorhombic Lattice
- Monoclinic Lattice
- Hexagonal Lattice
- Rhombohedral Lattice
- Triclinic Lattice

Cubic Lattice: Cubic lattice is formed into three possible geometries of unit cells: primitive, body-centred and face centred unit cells. In a cubic lattice, all the edges are equal and the angle between their faces is 90° that is, mutually perpendicular.

Tetragonal Lattice: The formation of tetragonal lattice takes place in two geometries of unit cells: primitive and body centred unit cells. In a tetragonal lattice, only one edge has different length and angle between respective edges is 90° that is, mutually perpendicular

Orthorhombic Lattice: There are four types of orthorhombic lattice mainly: primitive, end-centred, body-centred and face centred. In orthorhombic lattice, the edge lengths are unequal in nature and the angle between respective edges is 90° that is, mutually perpendicular

Monoclinic Lattice: Monoclinic lattice is formed from two types of unit cells namely: primitive and end centred. Monoclinic lattice has unequal sides and two angles between the faces of the lattice are 90°.

Hexagonal Lattice: Hexagonal lattice is formed from only one type of unit cell that is, primitive. In hexagonal lattice, only one side and two angles are 90° and one angle is 120°.

Rhombohedral Lattice: Rhombohedral Lattice is also formed from one type of unit cell that is, primitive. In Rhombohedral Lattice all the sides are equal and two angles between the faces of the rhombohedral lattice are less than 90°.

Triclinic Lattice: The formation of triclinic lattice also takes place from one type of unit cell that is, primitive. In triclinic lattice all the sides are unequal and none of the angles between the faces of the triclinic lattice are 90°.

The table given below can be used to summarize types of lattice formation.

Crystal System	**Possible Variation**	**Axial distances or edge lengths**	**Axial angles**	**Examples**
Cubic Primitive	Primitive, Body-centred, Face-centred	$a = b = c$	$\alpha = \beta = \gamma = 90°$	Cu, NaCl, Zinc blende
Tetragonal	Primitive, Body-centred	$a = b \neq c$	$\alpha = \beta = \gamma = 90°$	White tin, SnO_2, TiO_2, $CaSO_4$
Orthorhombic	Primitive, , Body-centred, Face-centred, End-centred	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90°$	Rhombic sulphur KNO_3, $BaSO_4$
Hexagonal	Primitive	$a = b \neq c$	$\alpha = \beta = 90°$, $\gamma = 120°$	Graphite, ZnO, CdS,
Rhombohedral or Trigonal	Primitive	$a = b = c$	$\alpha = \beta = \gamma \neq 90°$	Calcite ($CaCO_3$), HgS (cinnabar)
Monoclinic	Primitive, , End-centred	$a \neq b \neq c$	$\alpha = \gamma = 90°$, $\beta \neq 90°$	Monoclinic sulphur $Na_2SO_4.10H_2O$
Triclinic	Primitive	$a \neq b \neq c$	$\alpha \neq \beta \neq \gamma \neq 90°$	$K_2Cr_2O_7$, $CuSO_4.5H_2O$, H_3BO_3