

# CHEMISTRY STUDY MATERIALS FOR CLASS 12 (NCERT BASED NOTES OF CHAPTER- 01)

**GANESH KUMAR**

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## The Solid State

### Unit cell

A unit cell is the smallest repeating unit of a crystal lattice which, when repeated in three dimension we get a whole crystal. Or, it is the building block of a crystal. A unit cell is characterized by its edge lengths (a, b and c) and angle between the edges –  $\alpha$  (between b and c),  $\beta$  (between a and c) and  $\gamma$  (between a and b). Thus a unit cell is characterized by 6 parameters – a, b, c,  $\alpha$ ,  $\beta$  and  $\gamma$ .

Unit cells can be broadly divided into two - primitive and centred unit cells.

#### 1. Primitive Unit Cells:

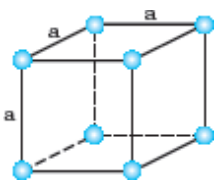

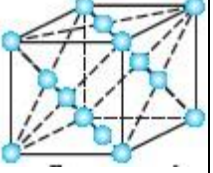
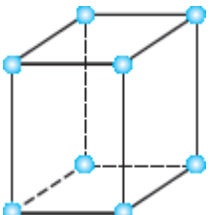
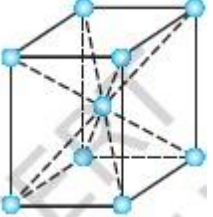
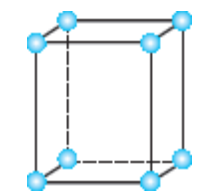
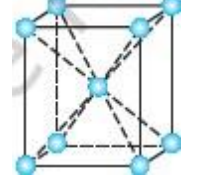
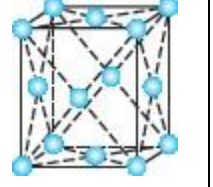
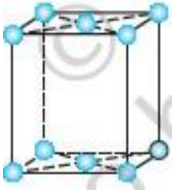
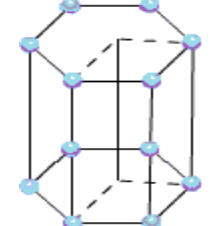
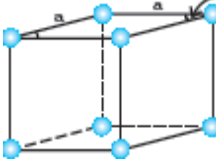
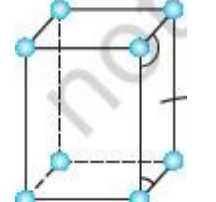
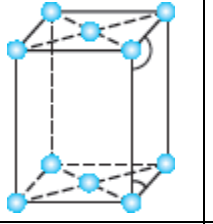
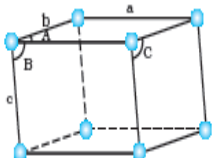
Here the constituent particles are present only at the corners of the unit cell.

#### 2. Centred Unit Cells:

Here the constituent particles are present at the corners and other positions of the unit cell. These are of three types:

- i. *Body-centred unit cells*: Here the constituent particles are present at the body centre and at the corners of the unit cell.
- ii. *Face-centred unit cells*: Here the constituent particles are present at the centre of each faces and at the corners of the unit cell.
- iii. *End-centred unit cells*: Here the constituent particles are present at the centre of any two opposite faces and at the corners of the unit cell

## Seven types of crystal systems and their possible variations

Crystal	Possible variations				Examples
<b>1. Cubic</b> $a = b = c$ $\alpha = \beta = \gamma = 90^\circ$	Primitive 	Body-centered 	Face-centered 		NaCl, Zinc Blende, Cu
<b>2. Tetragonal</b> $a = b \neq c$ $\alpha = \beta = \gamma = 90^\circ$	Primitive 	Body-centered 			White tin, $\text{SnO}_2$ , $\text{TiO}_2$ , $\text{CaSO}_4$
<b>3. Orthorhombic (Rhombic)</b> $a \neq b \neq c$ $\alpha = \beta = \gamma = 90^\circ$	Primitive 	Body-centered 	Face-centered 	End-centered 	Rhombic sulphur, $\text{KNO}_3$ , $\text{BaSO}_4$
<b>4. Hexagonal</b> $a = b \neq c$ $\alpha = \beta = 90^\circ$ , $\gamma = 120^\circ$	Primitive 				Graphite, ZnO, CdS
<b>5. Rhombohedral / Trigonal</b> $a = b = c$ $\alpha = \beta = \gamma \neq 90^\circ$	Primitive 				Calcite ( $\text{CaCO}_3$ ), HgS (Cinnabar)
<b>6. Monoclinic</b> $a \neq b \neq c$ $\alpha = \gamma = 90^\circ$ , $\beta \neq 90^\circ$	Primitive 			End-centered 	Monoclinic sulphur, $\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}$
<b>7. Triclinic</b> $a \neq b \neq c$ $\alpha \neq \beta \neq \gamma \neq 90^\circ$	Primitive 				$\text{K}_2\text{Cr}_2\text{O}_7$ , $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ , $\text{H}_3\text{BO}_3$

## Calculation of Number of atoms in a unit cell (z)

### 1. Primitive cubic (Simple Cubic) unit cell:

Here atoms are present only at the corners of the cube. Each corner atom is shared by 8 unit cells. Therefore, contribution to one unit cell =  $1/8$

Since each unit cell has 8 atoms at the corners, the total number of atoms in one unit cell =  $8 \times 1/8 = 1$  So for a primitive (simple cubic) unit cell,  $z = 1$

### 2. Body-centred cubic (bcc) unit cell:

Here the particles are present at the corners of the cube and also one atom at the body centre. The number of atoms at the corner =  $8 \times 1/8 = 1$

The atom present at the centre of the body is not shared by other atoms. So the number of atoms at the body-centre = 1

Therefore, total number of atoms in the unit cell =  $1+1=2$ , so for a bcc,  $z = 2$

### 3. Face-centred cubic (fcc) unit cell:

Here the atoms are present at the corners and also at the centre of each faces. Each corner atom is shared by 8 unit cells and each face centre atom is shared by 2 unit cells.

Number of corner atoms =  $8 \times 1/8 = 1$

Number of face-centre atoms =  $6 \times 1/2 = 3$

Therefore, total number of atoms =  $1+3=4$  so, for an fcc,  $z = 4$

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