

# Crystal structure



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# Outline

- Lattice
- Basis
- Crystal Structure
  - Poly Crystal
  - Single Crystal
- Unit Cell
- Cubic Crystal System
  - Simple Cubic(SC) ,
  - Face Centered Cubic(FCC) ,
  - Body Centered Cubic(BCC)
  - The seven crystal system
  - Hexagonal close pack unit cell(HCP)
  - References

**Crystal structure = Lattice + Basis**

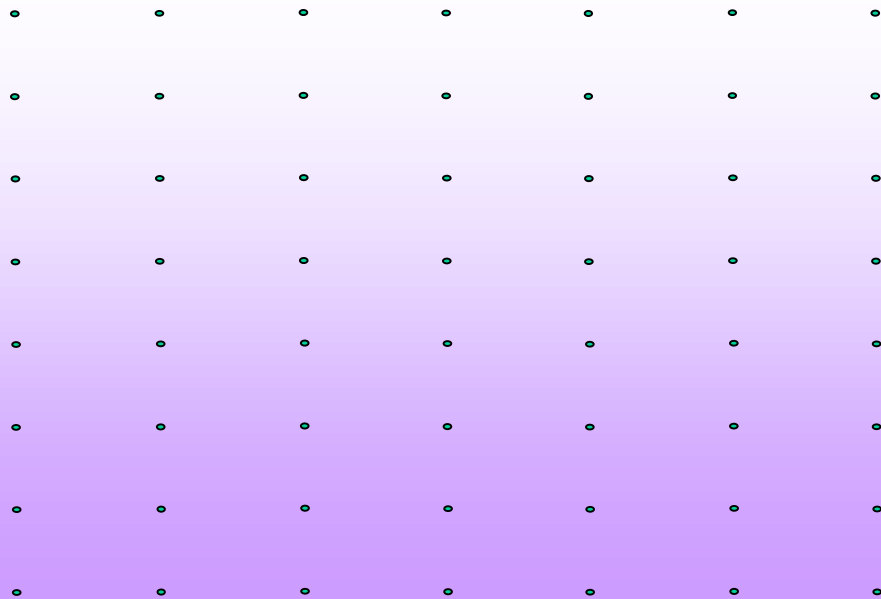
# Basic Of Crystal Structure

## ➤ Lattice:-

"An infinite periodic array of points in a space "

-The arrangement of points defines the lattice symmetry

-A lattice may be one, two or three dimensional

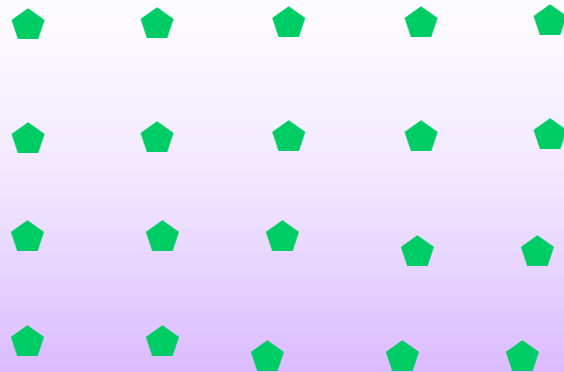


# Cont...

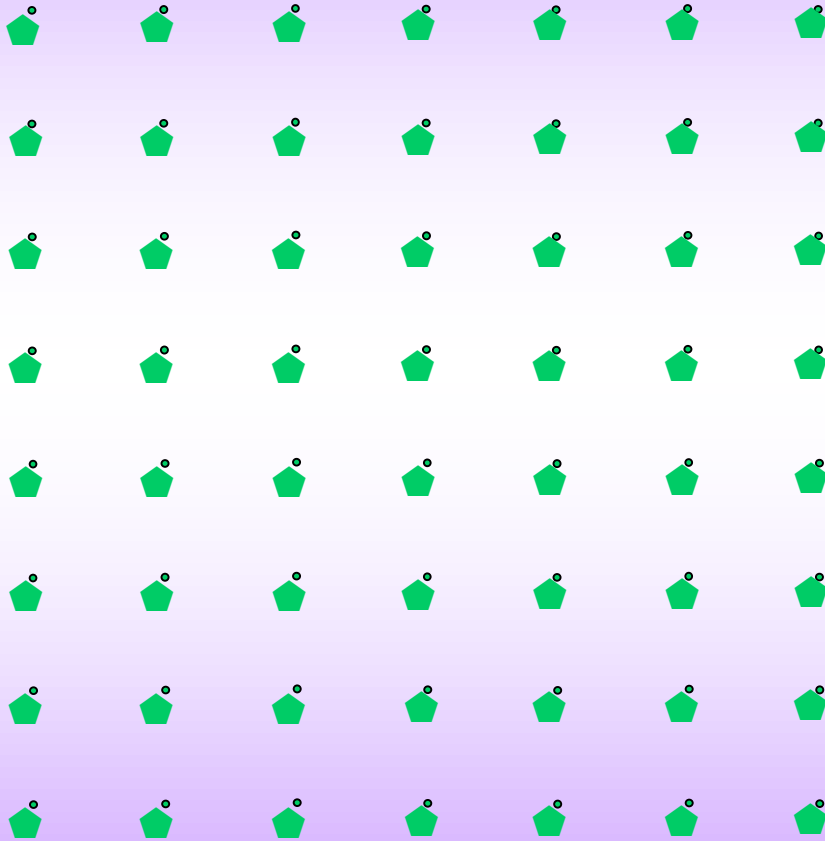
Basis(Motif):-

A group of one or more atoms, located in a particular way with respect to each other and associated with each point, is known as the Motif or Basis.

Motif



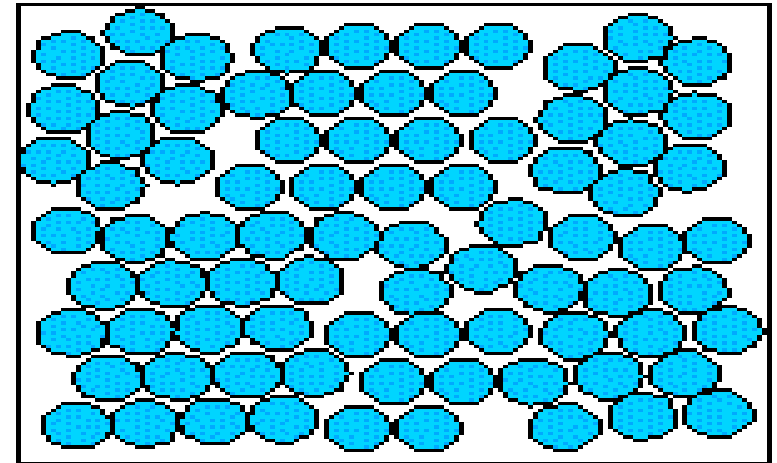
# Crystal structure



-so we obtain a crystal structure by adding the lattice and basis

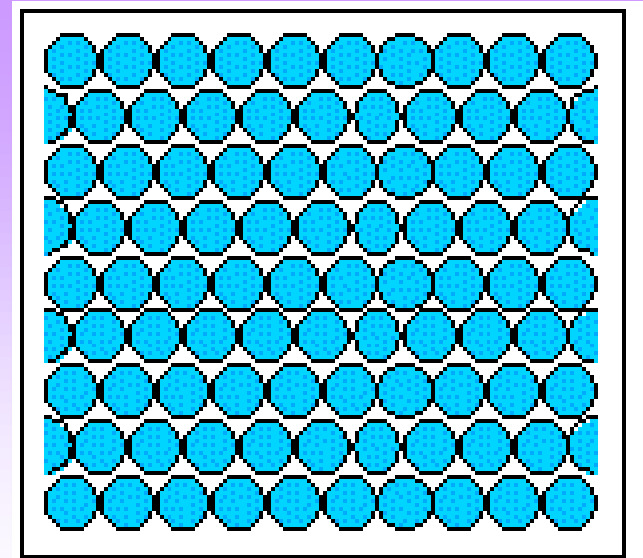
- So we can say that, When an atom or identical group of atoms is attached to every lattice point, we obtain a crystal structure.

- Crystals are classified into two types
  1. Poly crystal
  2. Single crystal
- Poly crystal: In this type of crystal periodicity is not maintained throughout the body.



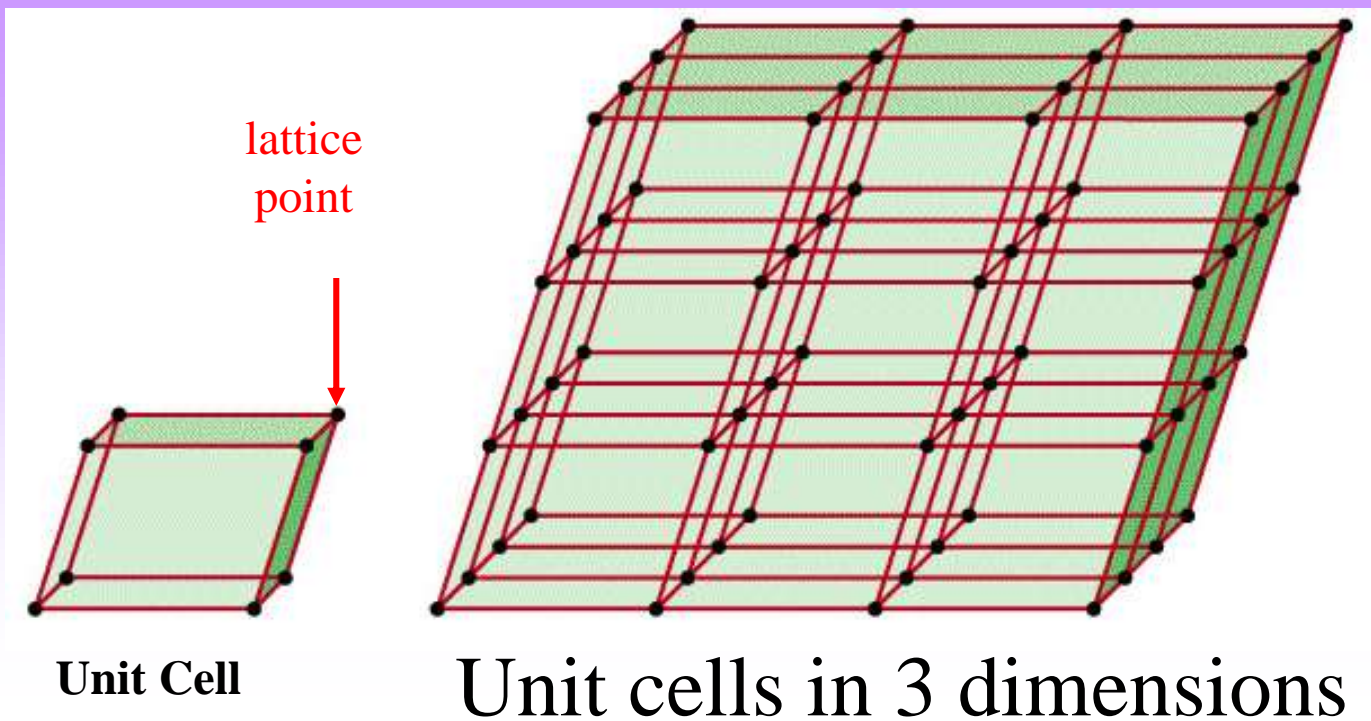
Polycrystal

- Single crystal: In this type of crystal periodicity is maintained throughout the body.



Single crystal

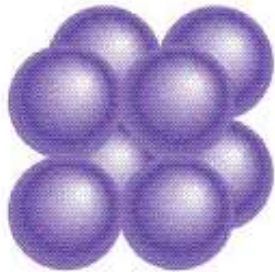
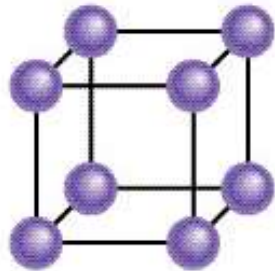
Unit cell:- " Atoms or group of atoms forming a building block of the smallest acceptable size of the whole volume of a crystal is defined as a unit cell ".



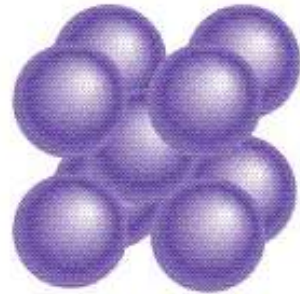
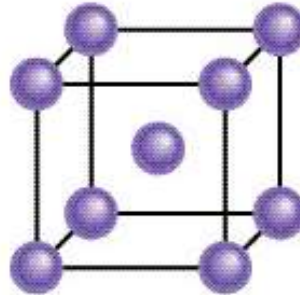
- By stacking identical unit cells, the entire lattice can be constructed.
- Lattice points are located at the corner of the unit cell and in some cases, at either faces or the centre of the unit cell.

- Here for the cubic crystal system we have Simple cubic (SC), Face-centred cubic (FCC), and Body-centred cubic (BCC).

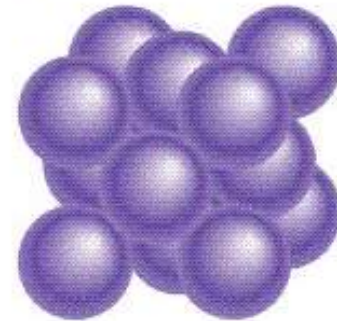
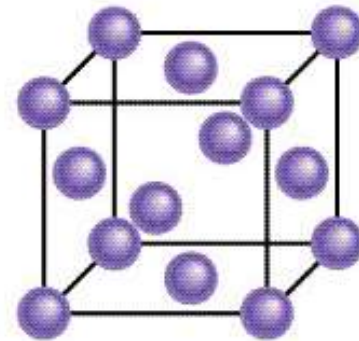
## Three Types of Cubic Cells



Simple cubic

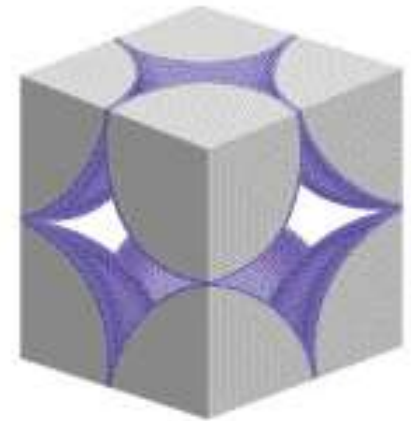
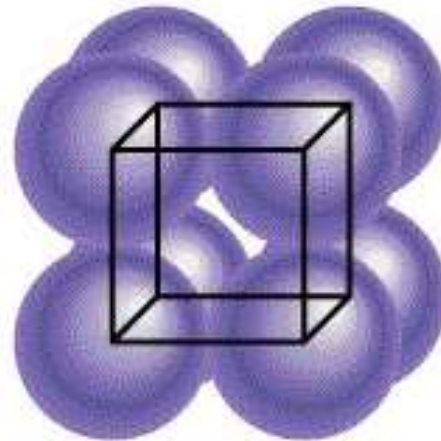
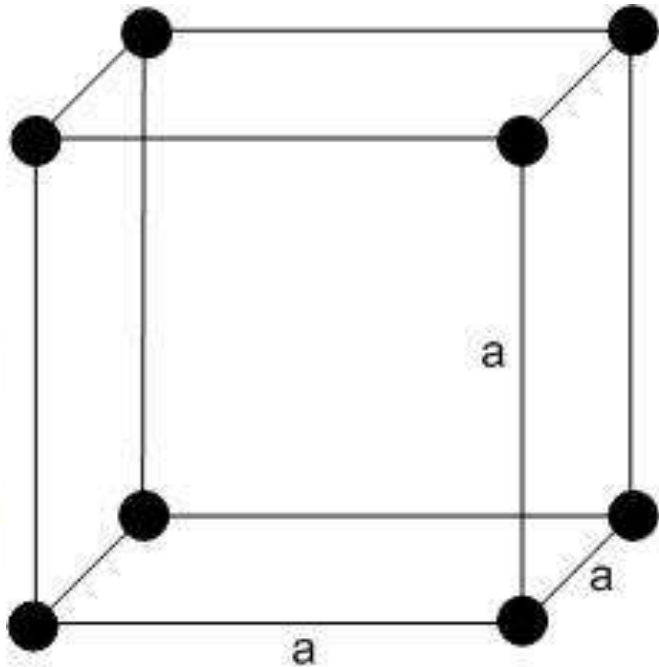


Body-centered cubic



Face-centered cubic

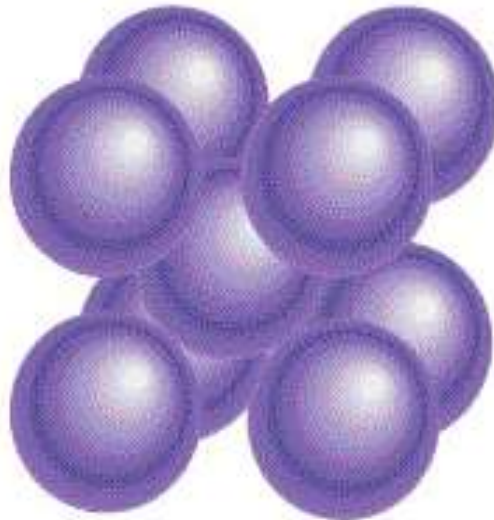
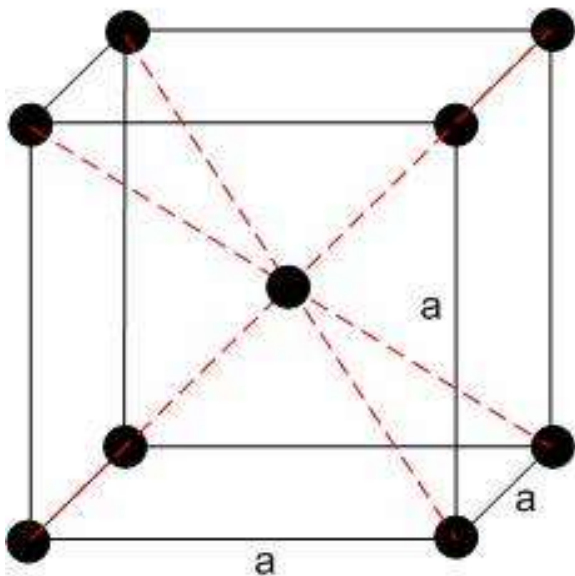
# Arrangement of Identical Spheres in a simple Cubic Cell



Total no. of atom per simple cubic cell is  
 $8(1/8) = 1$  atom

# Arrangement of Identical Spheres in a Body-Centered Cube

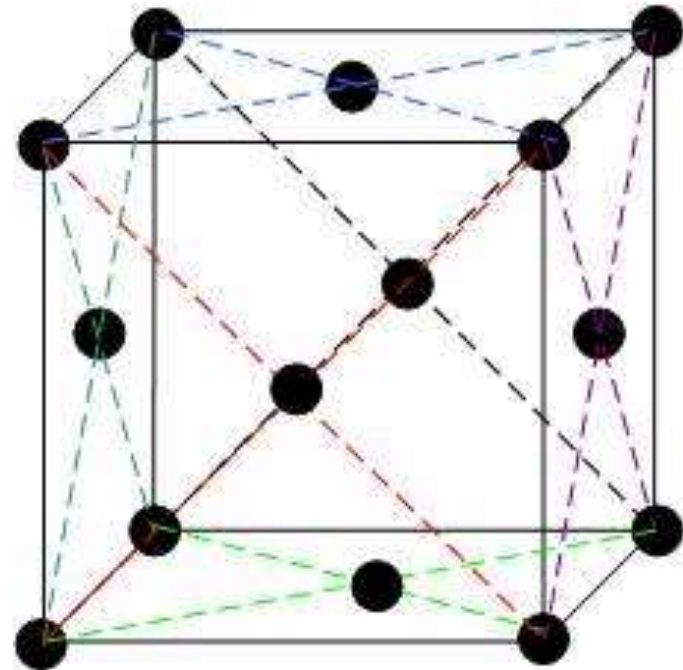
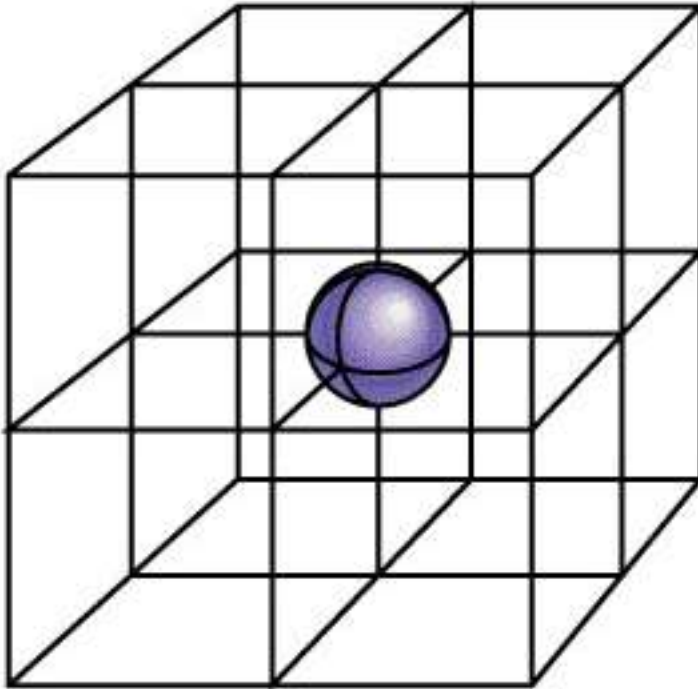
Body Centered  
Cubic



Total no. of atom per BCC unit cell is  
 $8(1/8)+1 = 2$  atom

# A Corner Atom and a Face-Centered Atom

Face Centered Cubic

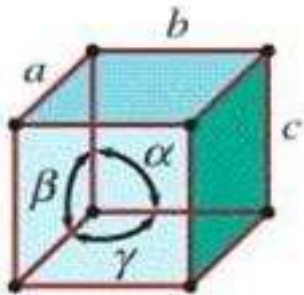


Shared by **8**  
unit cells

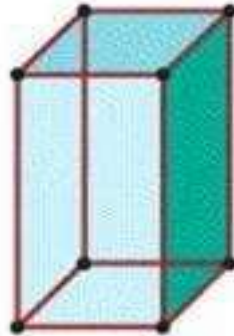
Total no. of atom per FCC unit  
cell is

$$8(1/8) + 6(1/2) = 4 \text{ atom}$$

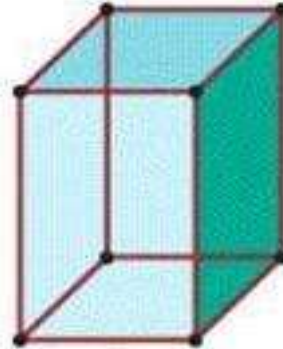
- There are seven unique arrangements, known as crystal systems, which fill in a three dimensional space.



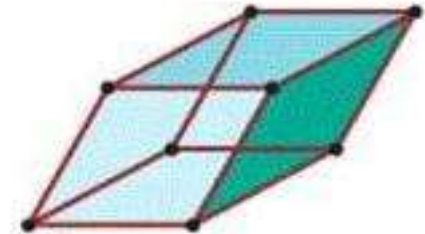
**Simple cubic**  
 $a = b = c$   
 $\alpha = \beta = \gamma = 90^\circ$



**Tetragonal**  
 $a = b \neq c$   
 $\alpha = \beta = \gamma = 90^\circ$



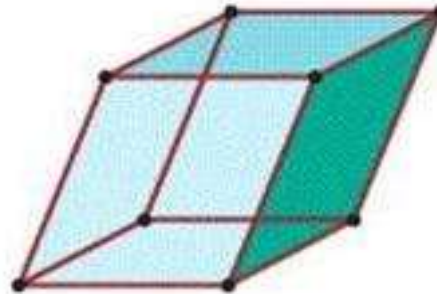
**Orthorhombic**  
 $a \neq b \neq c$   
 $\alpha = \beta = \gamma = 90^\circ$



**Rhombohedral**  
 $a = b = c$   
 $\alpha = \beta = \gamma \neq 90^\circ$



**Monoclinic**  
 $a \neq b \neq c$   
 $\alpha = \gamma = 90^\circ, \beta \neq 90^\circ$



**Triclinic**  
 $a \neq b \neq c$   
 $\alpha \neq \beta \neq \gamma \neq 90^\circ$



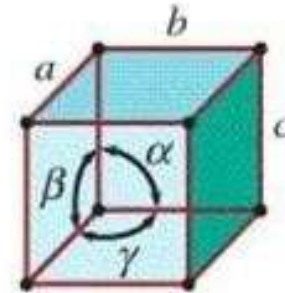
**Hexagonal**  
 $a = b \neq c$   
 $\alpha = \beta = 90^\circ, \gamma = 120^\circ$

# THE 7 CRYSTAL SYSTEMS

## 1. Cubic Crystals

$$a = b = c$$

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



**Simple cubic**  
 $a = b = c$   
 $\alpha = \beta = \gamma = 90^\circ$



**Fluorite**  
*Octahedron*

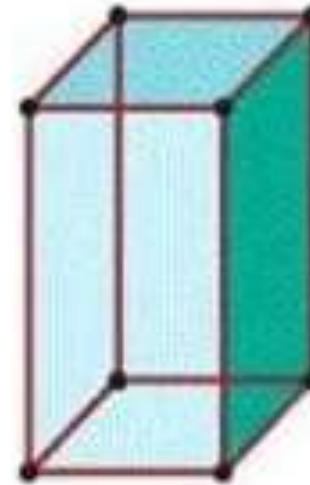


**Pyrite**  
*Cube*

## 2. Tetragonal Crystals

$$a = b \neq c$$

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



**Tetragonal**

$$a = b \neq c$$

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

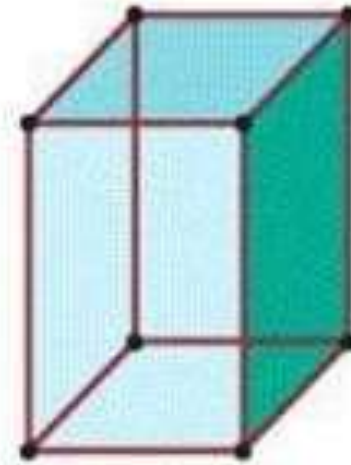
### Zircon



### 3. Orthorhombic Crystals

$$a \neq b \neq c$$

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



**Orthorhombic**

$$a \neq b \neq c$$

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

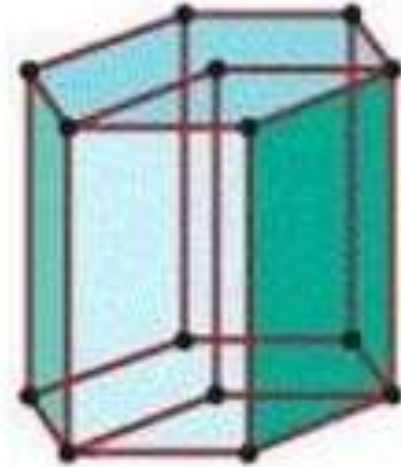
### Topaz



## 4. Hexagonal Crystals

$$a = b \neq c$$

$$\alpha = \beta = 90^\circ \quad \gamma = 120^\circ$$



**Hexagonal**

$$a = b \neq c$$

$$\alpha = \beta = 90^\circ, \gamma = 120^\circ$$

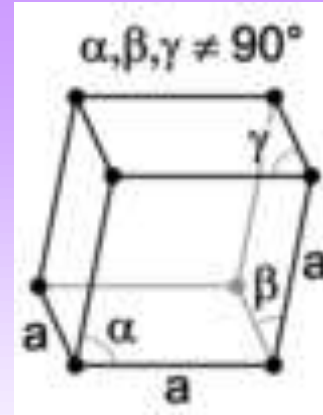


**Corundum**

## 5. Rhombohedral Crystals

$$a = b = c$$

$$\alpha, \beta, \gamma \neq 90^\circ$$

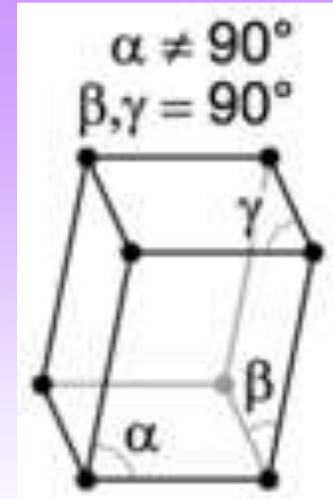


**Tourmaline**

## 6. Monoclinic Crystals

$$a \neq b \neq c$$

$$\alpha \neq 90^\circ, \beta, \gamma = 90^\circ$$

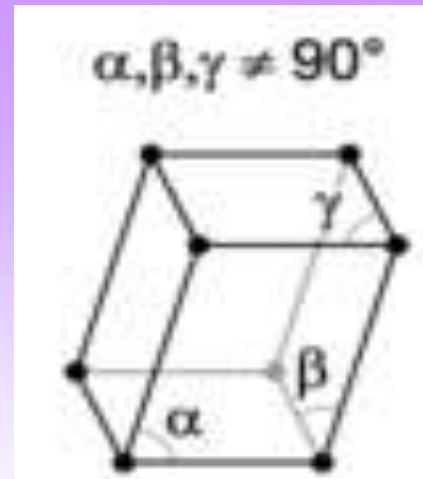


**Kunzite**

## 7. Triclinic Crystals

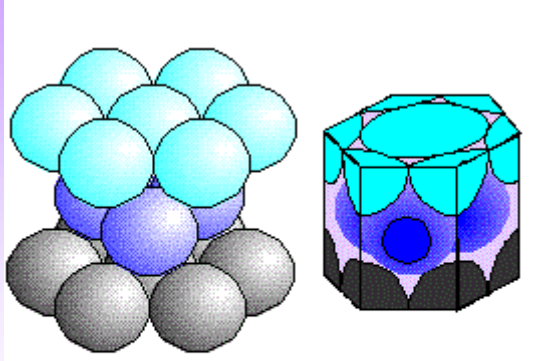
$$a \neq b \neq c$$

$$\alpha \neq \gamma \neq \beta$$



**Amazonite**

# Hexagonal structure

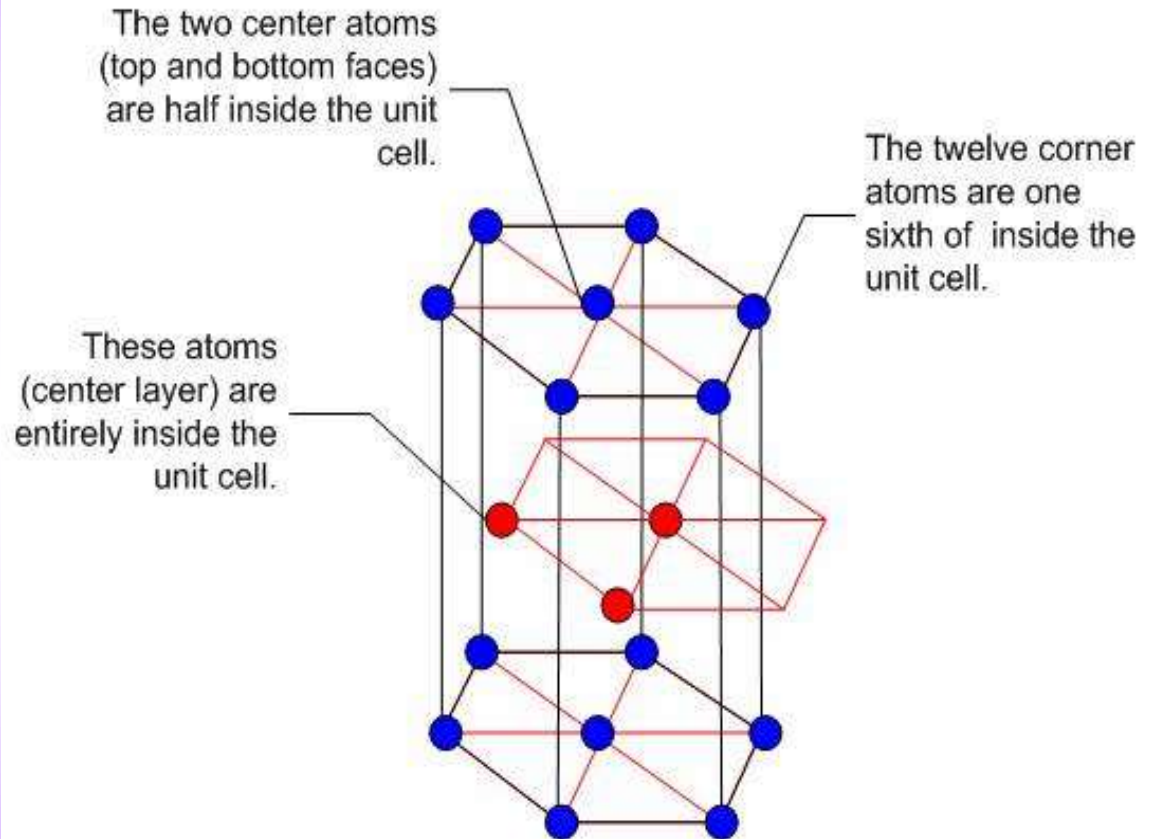


Hexagonal Structure



Quartz is the example of hexagonal close pack solid

## Hexagonal Close Pack Unit Cell



This means that a total of  $12(1/6) + 2(1/2) + 3 = 6$  atoms are inside the unit cell

- *References*

- The science and engineering of Materials

By Donald R. Askeland

Pradeep P.Phule

Forth Edition

Publisher : Bill stenquist

Page no. 76 to 84

- Google images (Crystal structure)

A dense collection of autumn leaves in various colors including red, orange, yellow, and green. The leaves are scattered across the frame, with some showing signs of aging and discoloration. A prominent green leaf is visible in the center-right area.

**Thank You**