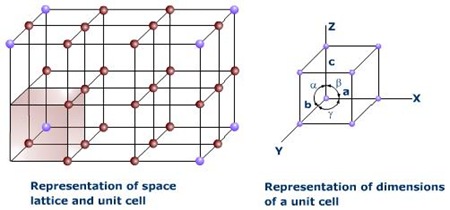
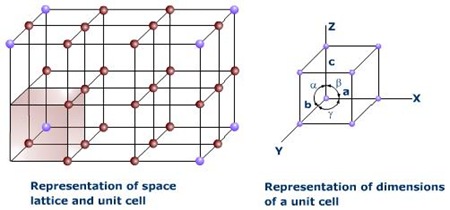
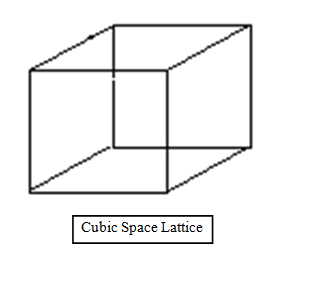
***Lattice parameters:*** Arbitrary arrangements of crystallographic axes, marked *X*, *Y* and *Z*, defining a unit cell shown in the fig. The three sides of a unit cell which are called the *crystallographic axes.* The angles between the three axes are called *interfacial angles*. The intercepts define the dimensions of a unit cell and are known *lattice parameters of the unit cell*. These are also called the *geometrical constants* of a given crystal.

***Unit Cell:*** A crystal lattice is made up of infinite repetitions of a small group of ions in three-dimensional pattern. It is built up by the combination of a regular array of ions in which each ion is surrounded by a definite number of ions of opposite charges.



The small group of ions which is repeated in a crystal lattice in three-dimensional pattern is known as a unit cell. The unit cell is thus the smallest portion of the crystal lattice which has all the various kind of symmetry which characterise the crystal.

*A parallelepiped shaped volume which reproduced by close packing in three dimension gives the whole crystal, is called the unit cell.* There are two types of unit cell:



1. Primitive unit cell
2. Non-primitive unit cell

**Fig. 1.** Unit cell

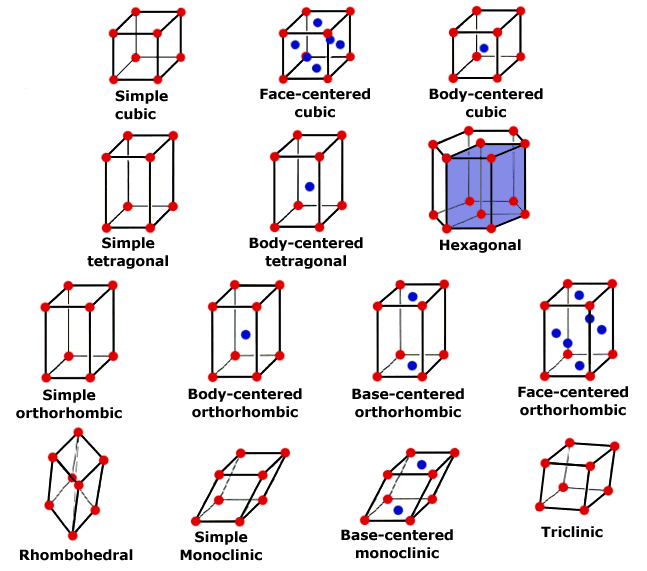
***Primitive unit cell:*** The unit cell occupying the smallest volume in a given lattice is called the primitive unit cell. It contains only one lattice point.

***Non-Primitive unit cell:*** The unit cell which is larger than the minimum volume unit cell is defined as a non-primitive unit cell. A non-primitive unit cell contains more than one lattice point. The volume of a non-primitive unit cell is an integral multiple of a primitive cell.

***Distinguish between primitive unit cell & unit cell:***

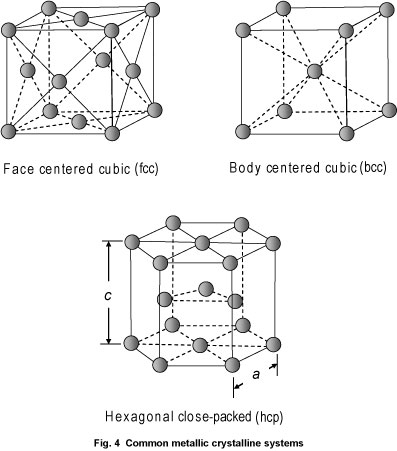
|  |  |
| --- | --- |
| ***Primitive Cell*** | ***Unit Cell*** |
| 1. The unit cell occupying the smallest volume in a given lattice is called the primitive unit cell. | 1. A parallelepiped shaped volume, which reproduced by close packing in three dimensions gives the whole crystal is called the unit cell. |
| 2. It always contains only one lattice point. | 2. It may contain more than one lattice point. |
| 3. A primitive cell is the smallest cell in crystal. A cell smaller than it is never possible. | 3. A unit cell may be smallest or not. |
| 4. It is always a unit cell. | 4. But a unit cell is not always a primitive cell. |

***Lattice symbol ‘P’:*** The lattice symbol ‘P’ means the primitive cell where lattice points are at the corners of the cell. A primitive cell is always a unit cell.

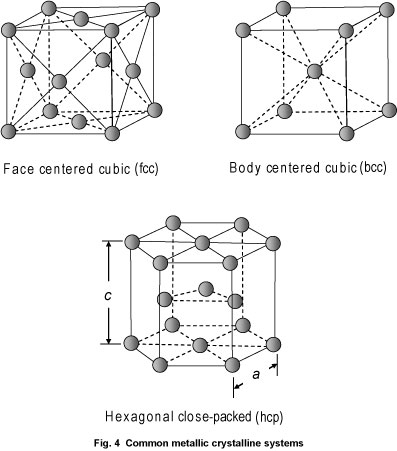


Simple cubic (sc)

***Lattice symbol ‘I’:*** The lattice symbol ‘I’ means the body centered lattice. In the body centered lattice, the lattice points are at the corners and inside the cell.



***Lattice symbol ‘F’:*** The lattice symbol ‘F’ means the face-centered lattice. In the face centered lattice, the lattice points are at the corners and all the faces centered.



***Lattice symbol ‘C’:*** The lattice symbol ‘C’ means the lattice is base centered or the side centered or C-face centered. In the base centered lattice, the lattice points are at the corners and at the face centered of opposite sides.

***Total Number of atoms in different unit cells***

The formula for the total number of atoms in a unit cell is

Where,

***Primitive cell:*** For a primitive cell, the lattice points are at the eight corners of the cell. So for primitive cell

Thus the total number of atoms in a primitive cell is

So, the primitive cell has only one lattice point.

***Body centered cubic:*** For a body centered cubic lattice, the lattice points are at the eight corners and inside the cell. So, for body centered cubic lattice

Thus the total number of atoms in body centered cubic lattice is

So, the body centered cubic lattice has only two lattice points.

***Face-centered cubic:*** For a face centered cubic lattice, the lattice points are at the eight corners and all (six) the faces centered. So, for face centered cubic lattice

Thus the total number of atoms in a face centered cubic lattice is

So, the face centered cubic lattice has only four lattice points.

***Base centered cubic:*** For a base centered cubic lattice, the lattice points are at the eight corners and two opposite faces centered. So for base centered cubic lattice

Thus the total number of atoms in a base centered cubic lattice is

So, the base centered cubic lattice has only two lattice points.

**[Include figure in each cases]**

***Seven crystal system***

The names of seven crystal system are: Triclinic, Monoclinic, Orthorhombic, Tetragonal, Cubic, Trigonal and Hexagonal.

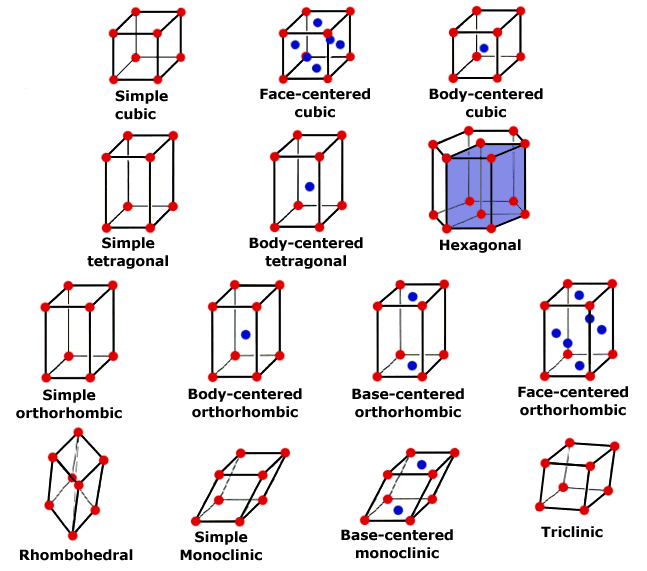
***Restrictions on conventional cell axex and angles:***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **System** | **No. of lattice in the system** | **Lattice Symbol** | **Restrictions on** | |
| **Conventional cell axes** | **Conventional axial angles** |
| Triclinic | 1 | *P* |  |  |
| Monoclinic | 2 | *P, C* |  |  |
| Orthorhombic | 4 | *P, C, I, F* |  |  |
| Tetragonal | 2 | *P, I* |  |  |
| Cubic | 3 | *P, I, F* |  |  |
| Trigonal | 1 | *R* |  |  |
| Hexagonal | 1 | *P* |  |  |

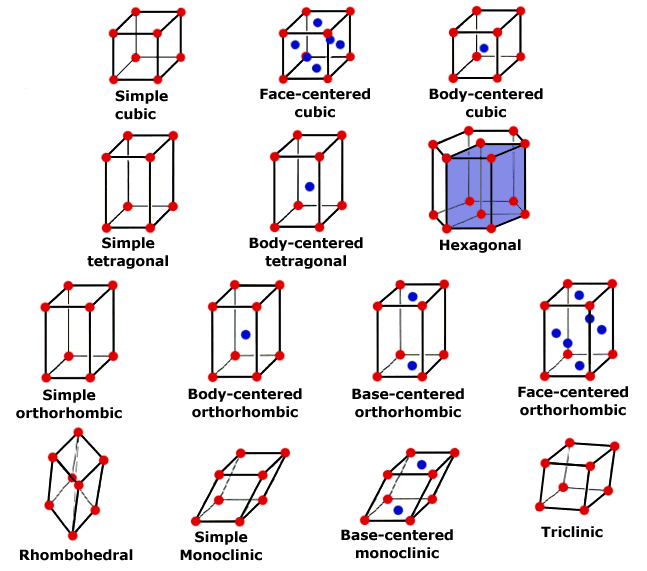
In practice seven crystal systems are possible. In real, lattices are grouped into seven crystal system according to certain specifications about the length of edges and angles between them of a conventional unit cell.

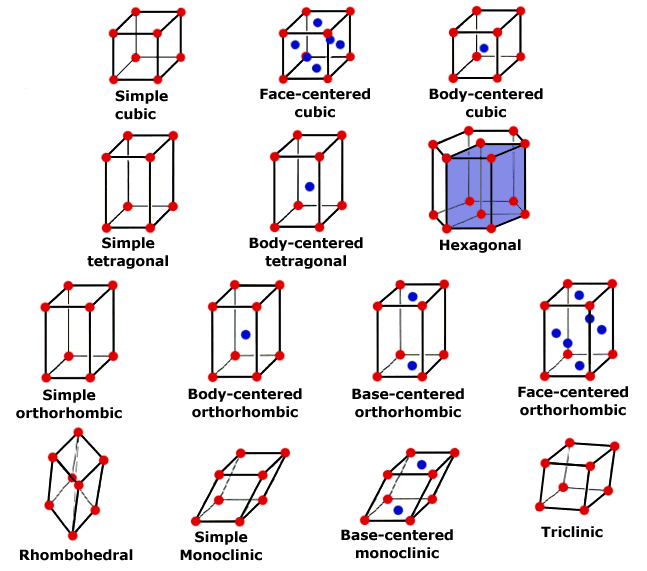
The seven crystal systems are: Triclinic, Monoclinic, Orthorhombic, Tetragonal, Cubic, Trigonal and Hexagonal.

***Triclinic:*** In the triclinic system, the single lattice type has a primitive unit cell (P) with three crystallographic axes of unequal lengths and unequal angles between them. *i.e.*

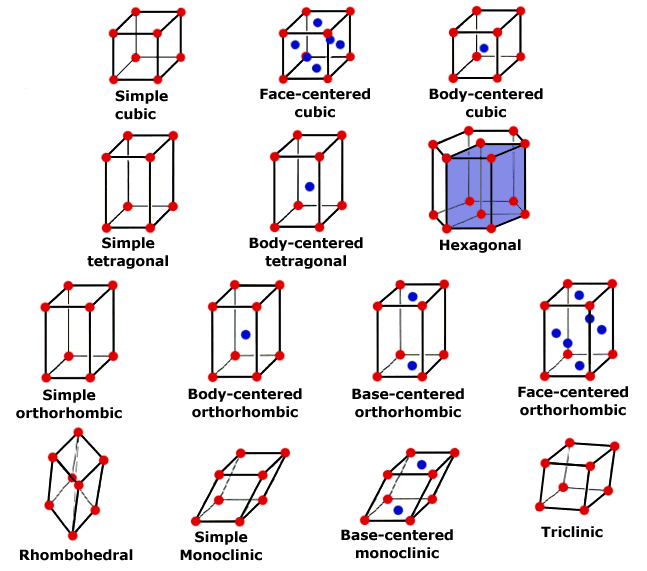
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***Monoclinic:*** In the monoclinic system, there are two lattice types: one with a primitive unit cell (P) and other with a non-primitive conventional cell which may be base centred with the lattice point at the centre of the rectangular cell faces. Where

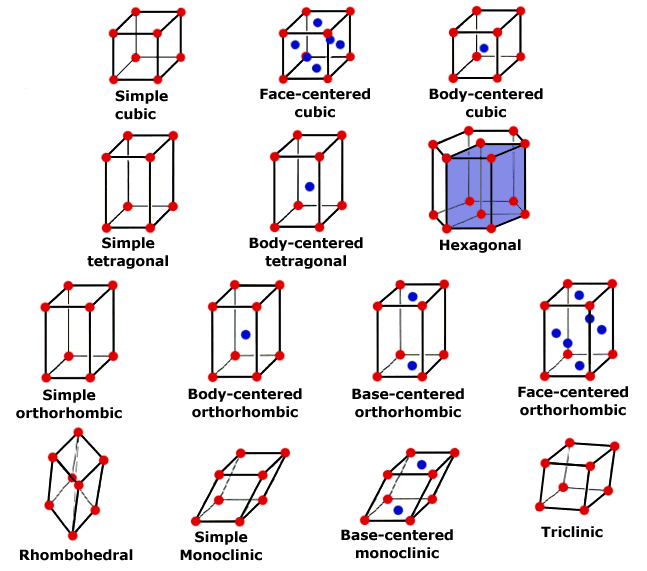




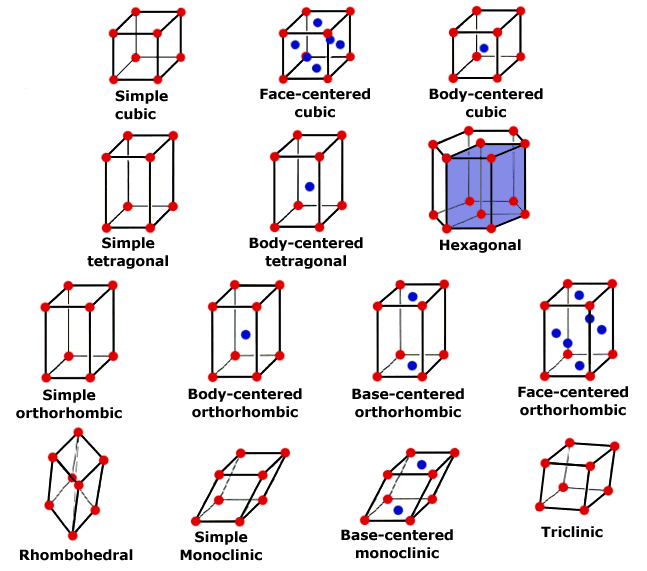
***Orthorhombic:*** In the orthorhombic system, there are four lattice types: one lattice has a primitive unit cell (P), one lattice is base centered (C), one lattice is body centered (I), and one lattice is face centered (F). In this case



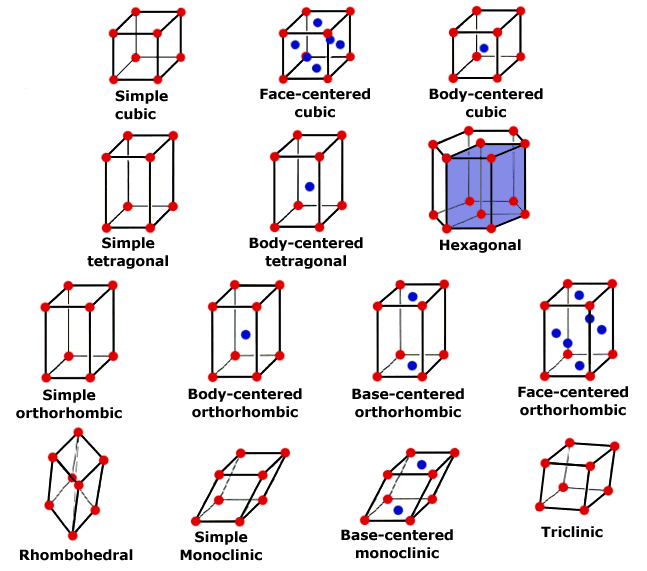
***Tetragonal:*** In the tetragonal system, there are two lattice types: one is primitive unit cell (*P*) and another is body centered (*I*). In this case



***Cubic:*** In the cubic system, there are three lattice types: the simple-cubic lattice (sc), the body centered cubic (bcc), and the face centered cubic (bcc). In this case

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***Trigonal:*** In the Trigonal system, a rhombohedron is usually chosen as the primitive cell. In this case

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***Hexagonal:*** In the Hexagonal system, the lattice is primitive and for this

