CHAPTER I
THE CRYSTALLINE STATE

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There are number of ways in which actual crystal structure may be built.

Bravais Lattices: In 1848, Auguste Bravais shown that 14 different lattices can be generated in which lattice points arranged in 3D space such that each point will have identical surroundings. These are known as Bravais lattices.

Three dimensional lattice is represented by lengths $a$, $b$ and $c$ and angles $\alpha$, $\beta$ and $\gamma$.

Based on the relation in between $a$, $b$ and $c$ and value of angles $\alpha$, $\beta$ and $\gamma$, the following crystal systems exists in 3D.
1. Cubic
2. Tetragonal
3. Orthorhombic
4. Monoclinic
5. Rhombohedral
6. Hexagonal
7. Triclinic
1. CUBIC STRUCTURE

- In this crystal structure, all the three lengths of unit cell are equal and are at right angle to each other.
- Hence $a=b=c$ and $\alpha = \beta = \gamma = 90^\circ$,
2. TETRAGONAL STRUCTURE

- In this crystal arrangement, three axes are at right angles. Two sides are equal while third side is different in length.
- Hence $a = b \neq c$ and $\alpha = \beta = \gamma = 90^\circ$
3. Orthorhombic Structure

- In this crystal arrangement, three unequal sides are at right angles.
- Therefore, $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90^\circ$
4. MONOCLINIC STRUCTURE

➢ In this, three sides of unit cells are of different lengths. One of the axes is at are not at right angle to the other, but other two axes are not at right angle to the other.

Therefore:

➢ \( a = b = c \) and \( \alpha \neq \beta = \gamma = 90^\circ \)
5. **Rhombohedral Structure**

- In this, three equal sides are equally inclined but at an angle other than right angle.
- Hence, $a=b=c$ and $\alpha=\beta=\gamma \neq 90^\circ$
6. HEXAGONAL STRUCTURE

➢ In this, three axes of unit cell are equal in one plane at 120° from each other and a fourth axis normal to this plane.

➢ Hence, \( a=b \neq c \) and \( \alpha=\beta=90^\circ \) and \( \gamma=120^\circ \)
In this three unequal sides are unequally inclined and none being at right angles.

Hence, $a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma \neq 90^\circ$
# TABLE: SEVEN CRYSTAL STRUCTURES

<table>
<thead>
<tr>
<th>System</th>
<th>Axial lengths and angles</th>
<th>Bravais lattice</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cubic</td>
<td>Three equal axes at right angles</td>
<td>Simple</td>
<td>Au, Cu, NaCl, CaF₂, NaClO₂</td>
</tr>
<tr>
<td></td>
<td>(a = b = c, \alpha = \beta = \gamma = 90^\circ)</td>
<td>Body-centered</td>
<td></td>
</tr>
<tr>
<td>Tetragonal</td>
<td>Three axes at right angles, two equal</td>
<td>Simple</td>
<td>SnO₂, TiO₂, NiSO₄</td>
</tr>
<tr>
<td></td>
<td>(a = b \neq c, \alpha = \beta = \gamma = 90^\circ)</td>
<td>Body-centered</td>
<td></td>
</tr>
<tr>
<td>Orthorhombic</td>
<td>Three unequal axes at right angles, (a \neq b \neq c, \alpha = \beta = \gamma = 90^\circ)</td>
<td>Simple</td>
<td>KnO₃, BaSO₄, MgSO₄</td>
</tr>
<tr>
<td>Rhombohedral or</td>
<td>Three equal axes, equally inclined</td>
<td>Simple</td>
<td>As, Sb, Bi, Calcite</td>
</tr>
<tr>
<td>Trigonal</td>
<td>(a = b = c, \alpha = \beta = \gamma = 90^\circ)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexagonal</td>
<td>Two equal coplanar axes at 120°, third axis at right angles</td>
<td>Simple</td>
<td>SiO₂, Zn, Mg, Cd, Agl</td>
</tr>
<tr>
<td></td>
<td>(a = b \neq c, \alpha = \beta = 90^\circ, \gamma = 120^\circ)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monoclinic</td>
<td>Three unequal axes, one pair not at right angles</td>
<td>Simple</td>
<td>CaSO₄·2H₂O, FeSO₄, Na₂SO₄</td>
</tr>
<tr>
<td></td>
<td>(a \neq b \neq c, \alpha = \gamma = 90^\circ \neq \beta)</td>
<td>Base-centered</td>
<td></td>
</tr>
<tr>
<td>Triclinic</td>
<td>Three unequal axes, all mutually inclined and none at right angles</td>
<td>Simple</td>
<td>K₂Cr₂O₇, CuSO₄·5H₂O</td>
</tr>
<tr>
<td></td>
<td>(a \neq b \neq c, \alpha \neq \beta \neq \gamma \neq 90^\circ)</td>
<td></td>
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</tbody>
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