Quantum physics 1900311187
Home Assignment - 1 Radhakrishna

1.

Basic definitions

(i) Space lattice

(ii) Basis

(iii) Lattice parameter

Ans:- (1) A space lattice is an array of points showing how particles are arranged at different states in three dimensional spaces

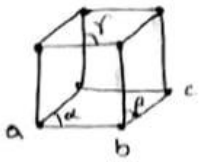
(2) Basis: An atom or a group of atoms associated with each lattice point in crystal. It is also known as motif.

(3) Lattice parameter: Lattice parameters are the unit lengths along each crystallographic axis and their internal angles.

2. Explain seven crystal Diagrams
Systems with

Ans The seven crystal structures are:

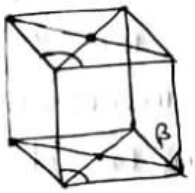
(1) Triclinic System: All the three axes are inclined towards each other and they are of same length. Based on the three inclined angles, the various forms of crystals are in the paired forces some standard triclinic systems include kyanite, Amazonite, Aventurine feld spar, turquoise, Rhalonite



$a \neq b \neq c$

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

(2) Monoclinic system : It comprises three axes where two are at right angles to each other and the third axis is inclined. All three axes are of different length. Based on the inner structure the monoclinic system includes pinacoi -ds and prisms with inclined and faces. Some examples include diopside, petalite, Gypsum, Howlite and more

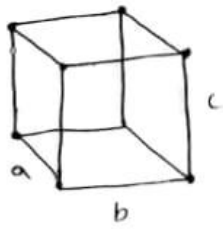


$\beta \neq 90^\circ$

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

(3) ortho Rhombic system :-

It comprises three axes and is at right angles to each other. There are 3 different lengths. Based on their Rhombic structure and orthorhombicsystem includes various crystal shapes namely, pyramids, double pyramids. Some common orthorhombic crystal include tolite and more



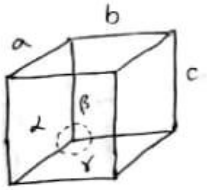
$a \neq b \neq c$

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

(4) Trigonal system:-

Angle and Axis in a trigonal system are similar to the hexagonal system, there will be 6 sides. In trigonal system, there will be three sides crystal shapes in a trigonal system include three-sides pyramids, scalenohedr-al and 'Rhombohedral.

Some typical examples includes Ruby, Quartz, calcite, Jasper and more.



$a = b = c$

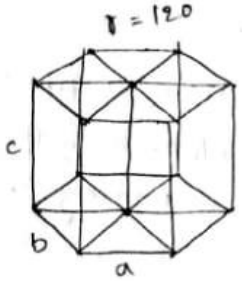
$\alpha = \beta = \gamma \neq 90^\circ$

Rhombohedral (Trigonal)

(5) Hexagonal system:-

It comprises four axes. Among these, three axes are of the same length and are of one plane. They intersect each other at an angle of 60°. Crystal shapes of hexagonal system include Double pyramid Double sided pyramid and four sided pyramid

Ex:- Beryl, Apatite etc.



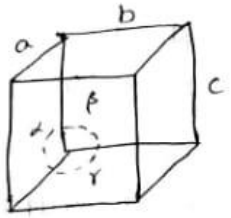
$a = b \neq c$

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

$\gamma = 120^\circ$

6) Tetragonal Systems :-

It consists of three axes. The main axis varies in length. It can either be short or long. The two axes lie in the same plane and are of the same length. The shape of crystal in tetragonal include double and eight-sided pyramid, four sided prism etc.



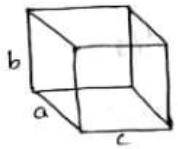
$a \neq b \neq c$

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

7) Simple Cubic :-

All three angles intersect at right angles and are of equal length crystal shapes of a cubic system based on inner structure include octahedron, cube etc.

Ex :- silver, granite, gold and diamond



$a = b = c$

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

8. primitive unit cells :-

contains only one lattice point in the unit cell.

Ex :- simple cubic.

Non-primitive unit cells :-

contains more than one lattice point in the unit cell

Ex :- Body centered cubic (BCC)

Face centered cubic (FCC)

4. Simple Cubic Structure

In a simple cubic crystal structure, the atoms or molecules located at each corner of the cube or the unit cell. As it is the cubic crystal structure, the lattice constants along the crystallographic axes are equal.

Thus, we have $a = b = c$

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

(i) No. of atoms:

Total share of the entire corner atoms $= 8 \times \frac{1}{8} = 1$

No. of atoms = 1

Thus, simple cube is a primitive cell

(ii) Coordination number:

coordination no. of an atom is 6.

(iii) Relation b/w a and r

The nearest distance is $2r = a$

$\therefore r = a/2$.

Body centered Cubic (BCC)

In BCC, there are 8 atoms at each corner of the unit cell plus one atom at the geometric centre of the unit cell.

(i) No. of atoms

No. of unshared atoms / unit cell = 1

Total share of all the corner atoms per unit cell $= 8 \times \frac{1}{8} = 1$

$\therefore$ The total no. of atoms is $1 + 1 = 2$

(ii) Coordination number of an atom is 8

(iii) Relation b/w 'a' and 'r':

diagonal of the cube is 4r.

$(AD)^2 = AD^2 + CD^2 = AB^2 + BC^2$

$AD^2 = a^2 + a^2 + a^2 = 3a^2$

$AD = a\sqrt{3}$

But $AD = 4r$

$r = \frac{a\sqrt{3}}{4}$

c) Face centered cubic (FCC)

In FCC, there are 8 atoms at each corner of unit cell.

(i) No. of atoms:

The total share of all the corner atoms per unit cell is $8 \times \frac{1}{8} = 1$

The total share of all the face-centred atoms per unit cell is $6 \times \frac{1}{2} = 3$

Total no. of atoms per unit cell = $1 + 3 = 4$

(ii) Co-ordination Number:

The total no. of nearest atoms to any corner atoms is $4 + 4 + 4 = 12$

Hence co-ordination number = 12

(iii) Relation b/w a and r:

The diagonal of cube AC is 4r

$(AC)^2 = (AB)^2 + (BC)^2$

$= a^2 + a^2$

$AC = a\sqrt{2}$

$4r = a\sqrt{2}$ $\quad r = \frac{a\sqrt{2}}{4}$