MATERIALS ENGINEERING

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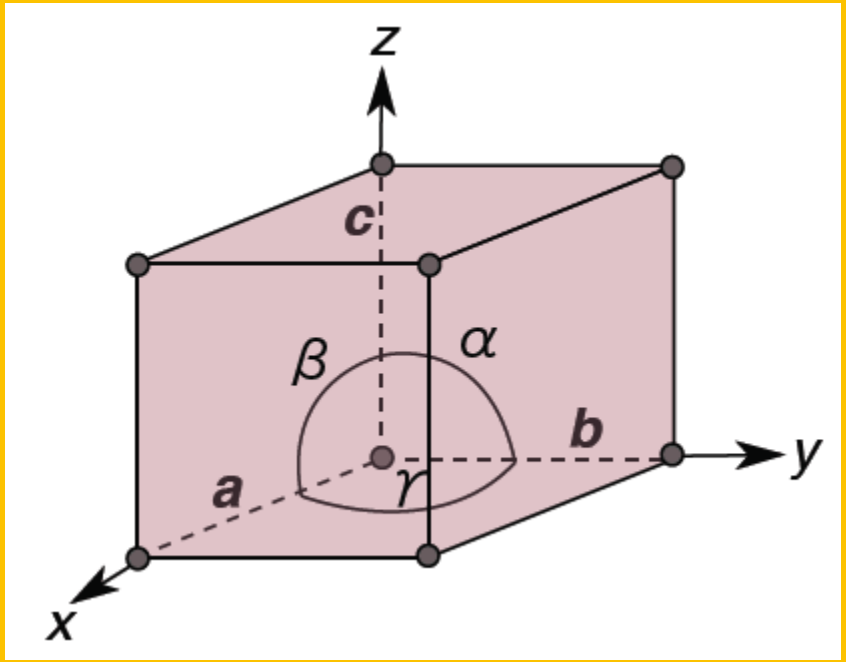
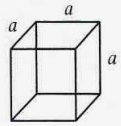
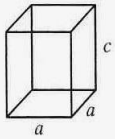
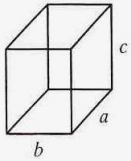
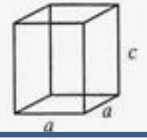
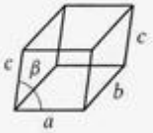
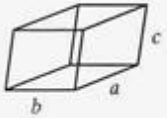
CRYSTAL SYSTEMS
And

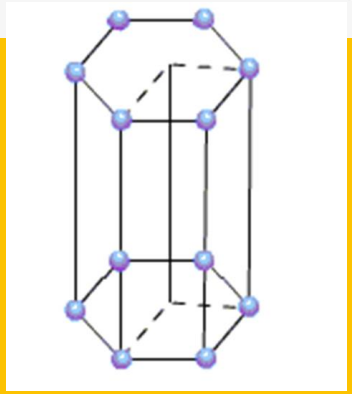
Introduction to Miller Indices

- The unit cell geometry is completely defined in terms of six parameters: the three edge lengths *a*, *b*, and *c*, and the three inter axial angles $\propto, \beta, \gamma$ called lattice parameter



- On this basis there are seven different possible combinations of lattice parame ter each of which represents a distinct **crystal system** .

Cubic	$a = b = c, \alpha = \beta = \gamma = 90°$	
Tetragonal	$a = b \neq c, \alpha = \beta = \gamma = 90°$	
Orthorhombic	$a \neq b \neq c, \alpha = \beta = \gamma = 90°$	
Rhombohedral	$a = b = c, \alpha = \beta = \gamma \neq 90°$	
Hexagonal	$a = b \neq c, \alpha = \beta = 90°, \gamma = 120°$	
Monoclinic	$a \neq b \neq c, \alpha = \gamma = 90° \neq \beta$	
Triclinic	$a \neq b \neq c, \alpha \neq \beta \neq \gamma \neq 90°$	



For a Rhombohedral space lattice, which one of the following is correct?

(a) $\alpha = \beta = \gamma = 90^0$ (b) $\alpha = \beta = \gamma \neq 90^0$ **[IES 2007]**

(c) $\alpha = \gamma = 90^0 \neq \beta$ (d) $\alpha \neq \beta \neq \gamma \neq 90^0$

Ans. (b)

Which one of the following pairs of axis lengths (a, b, c) and inter-axial angles (α, β, γ) represents the tetragonal crystal system? **[IES-2001]**

(a) $a = b = c; \alpha = \beta = \gamma = 90^0$ (b) $a = b \neq c; \alpha = \beta = \gamma = 90^0$

(c) $a \neq b \neq c; \alpha = \beta = \gamma = 90^0$ (d) $a = b = c; \alpha = \beta = \gamma \neq 90^0$

Ans. (b)

System	Bravais Lattice
Cubic	Simple Body-Centered Face Centered
Tetragonal	Simple Body-Centered
Orthorhombic	Simple Base Centered Body-Centered Face Centered
Monoclinic	Simple Base Centered
Triclinic	Simple
Trigonal (Rhombohedral)	Simple
Hexagonal	Simple

Relation between Atomic radius and Lattice constant

- Simple cubic:

  $a = 2R$

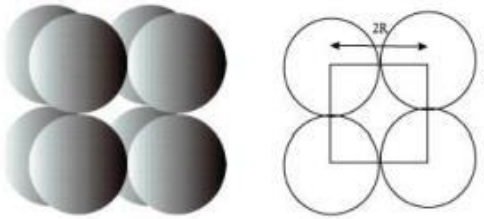


Figure 7.15 *Simple cubic packing*

- Body centered cubic

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

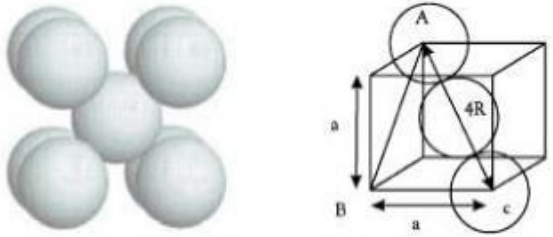
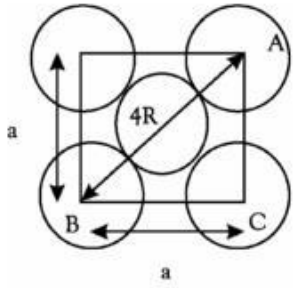


Figure 7.16 *Body centered cubic structure*

- Face centered cubic

$$a = 2\sqrt{2}R$$



Which one of the following pairs is not correctly matched? **[IES-2006]**

Space Lattice — Relation between Atomic radius **r** and Edge element **a**

(a) Simple cubic structure : $\mathbf{a^2 = 4\ r^2}$

(b) Body-centred cubic structure : $\mathbf{3a^2 = 16r^2}$

(c) Triclinic : $\mathbf{2a^2 = 3r^2}$

(d) Face-centred cubic structure : $\mathbf{a^2 = 8r^2}$

Ans. (c)

Match List-I (Name of the Element) with List-II (Crystal Structure) and select the correct answer using the codes given below the lists: **[IES-2001]**

List I	**List II**
A. Fluorspar	1. Body-centered cubic
B. Alpha-Iron	2. Hexagonal closed packed
C. Silver	3. Simple cubic
D. Zinc	4. Face-centered cubic

Codes:	**A**	**B**	**C**	**D**		**A**	**B**	**C**	**D**
(a)	3	2	4	1	(b)	4	1	3	2
(c)	4	2	3	1	(d)	3	1	4	2

Ans. (d)

Match List-I (Element) with List-II (Crystal Structure) and select the correct answer using the code given below the Lists: **[IES-2006]**

List - I	List - II
A. Alpha Iron	1. Hexagonal closed packed
B. Copper	2. Body-centred cubic
C. Zinc	3. Amorphous
D. Glass	4. Face-centred cubic

Codes:	A	B	C	D		A	B	C	D
(a)	2	3	1	4	(b)	1	4	2	3
(c)	2	4	1	3	(d)	1	3	2	4

CRYSTALLOGRAPHIC DIRECTIONS AND PLANES

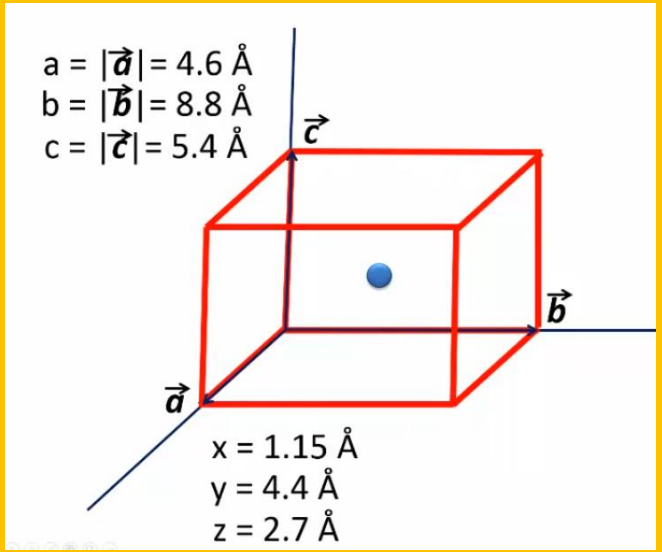
- Miller indices are used to specify directions and planes.

Miller indices for direction is denoted as [u v w] or family of directions as <u v w>

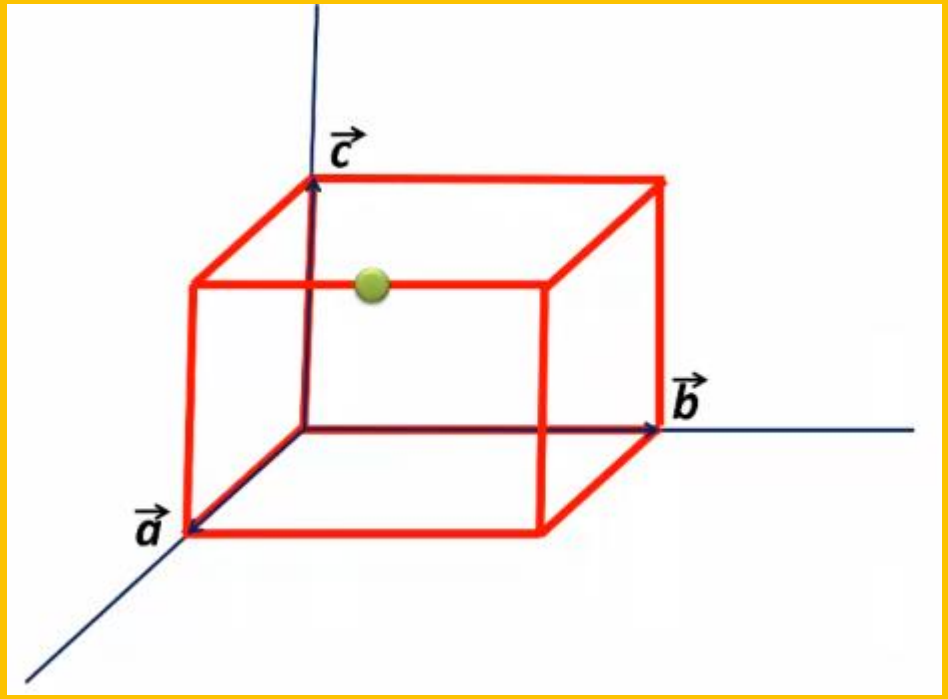
Miller indices for crystal plane is denoted as (h k l) or family of planes as {h k l}

POINT COORDINATES

The position of point located within a unit cell CAN BE specified in terms of its coor dinates as fractional multiples of the unit cell edge lengths (i.e., in terms of *a*, *b*, an d *c*).

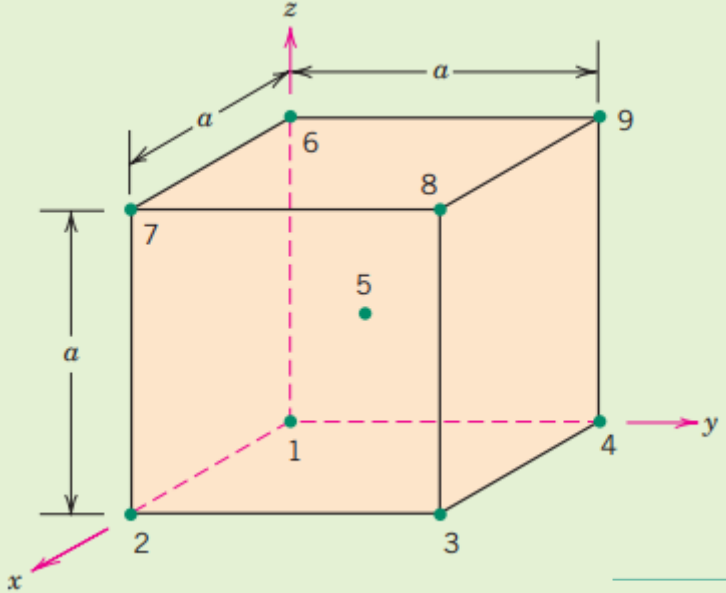


$$\frac{1}{4}\frac{1}{2}\frac{1}{2}$$



$1\ \frac{1}{2}\ 1$

Point coordinates for all atom positions for a BCC unit cell



Point Number	Fractional Lengths			Point Coordinates
	x axis	*y axis*	*z axis*	
1	0	0	0	0 0 0
2	1	0	0	1 0 0
3	1	1	0	1 1 0
4	0	1	0	0 1 0
5	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}\frac{1}{2}\frac{1}{2}$
6	0	0	1	0 0 1
7	1	0	1	1 0 1
8	1	1	1	1 1 1
9	0	1	1	0 1 1

References

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- https://www.slideserve.com/mildred/unit-vii-crystal-structure

Thank You