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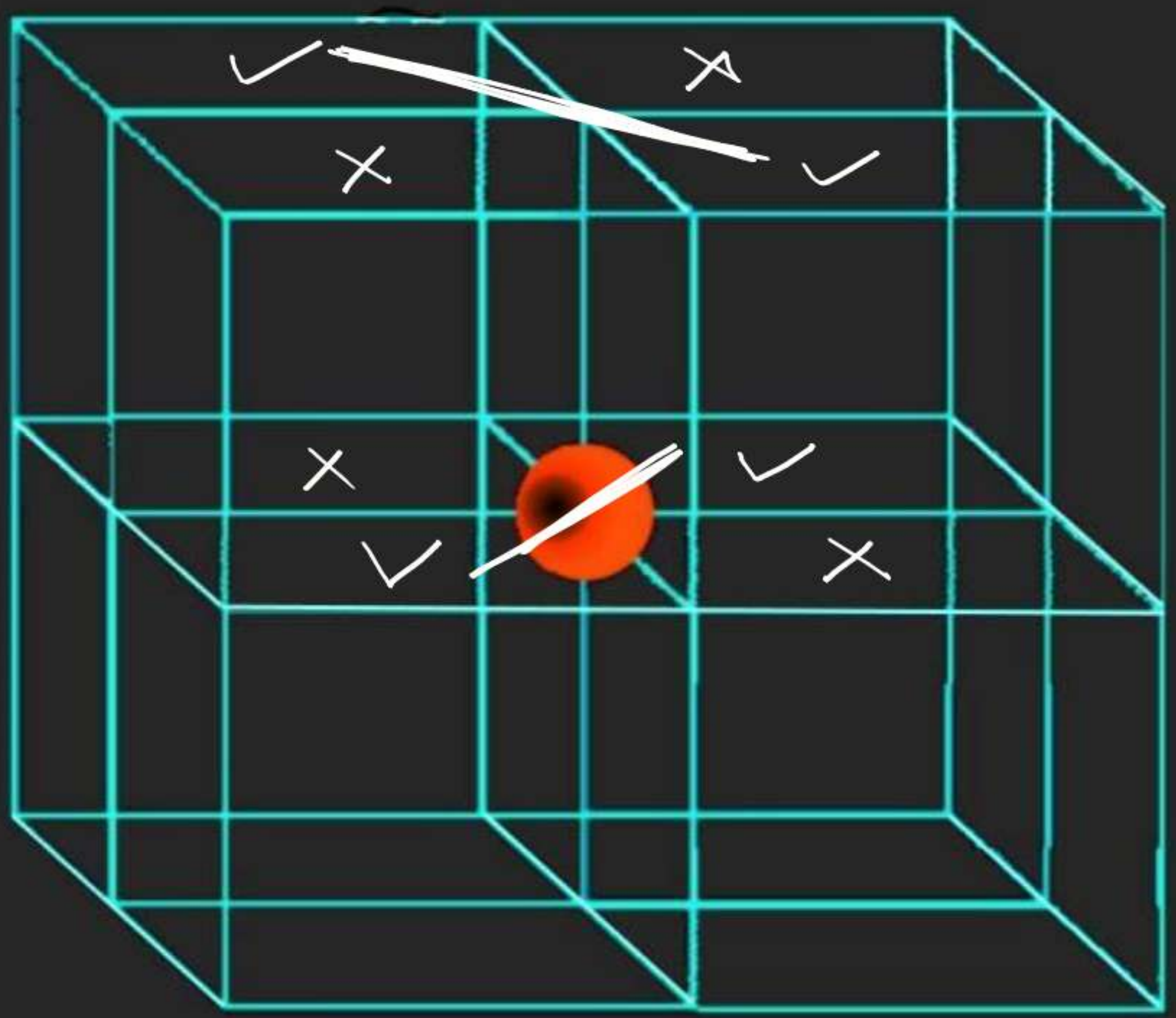
SOLID STATE



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O – I

X	Y
$7 \times \frac{1}{8}$	1
7	8

$X_7 Y_8$

XY

$\boxed{S-I}$ 2^3

$$d = \frac{Z \times M_{KBr}/N_A}{a^3}$$

$$2.75\ gm/cm^3 = \frac{Z \times 119/N_A}{(654 \times 10^{-10})^3}$$

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21

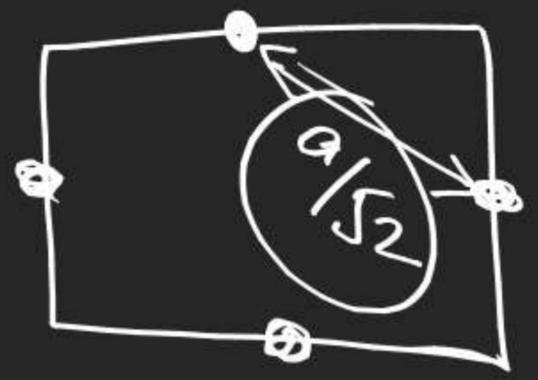
	T V	O.V	
	$1 = 8 \times \frac{1}{8}$	$\frac{1}{2} \times 4 = 2$	
	Al^{3+}	Zn^{2+}	O^{2-}
$\boxed{O.V}$	2	1 $\boxed{T.V}$	4
	+6	+2	−8

22

$$\frac{a}{2} = r_+ + r_-$$

$$= 132 + 135$$

$$\frac{a}{2} = 267$$



$$\frac{2 \times 267}{\sqrt{2}}$$

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25

$$PF = \frac{4 \times \frac{4}{3}\pi (r_+^3 + r_-^3)}{a^3} = \frac{4 \times \frac{4}{3}\pi (r_+^3 + 8r_+^3)}{(6r_+)^3}$$

$$\frac{a}{2} = r_+ + r_-$$

$$\frac{a}{2} = r_+ + 2r_+ = 3r_+$$

$$a = 6r_+$$

$$= \frac{4 \times \frac{4}{3}\pi \times 9}{216}$$

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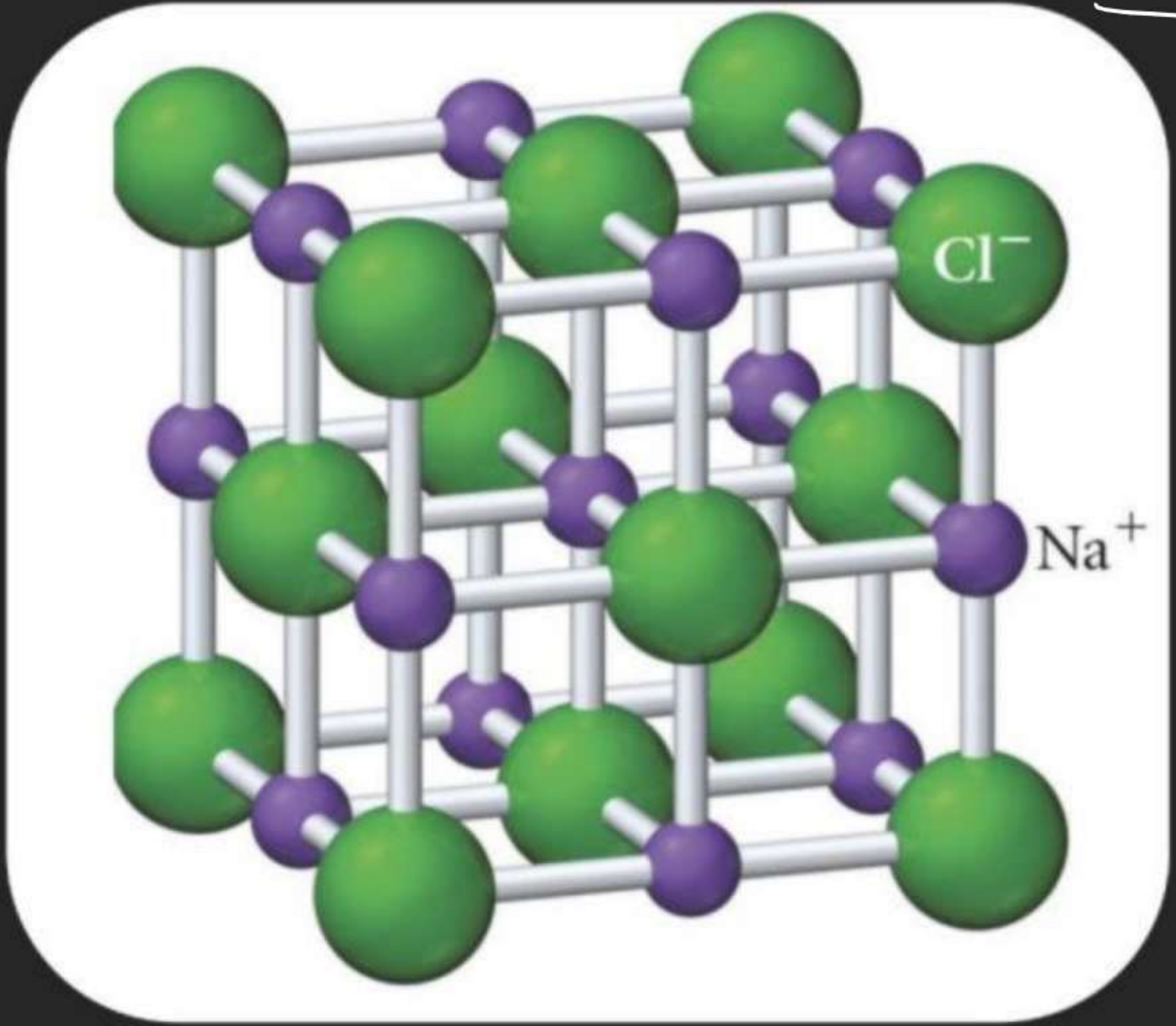
NaCl



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ZnS structure (Zinc blende) [Sphalerite str]

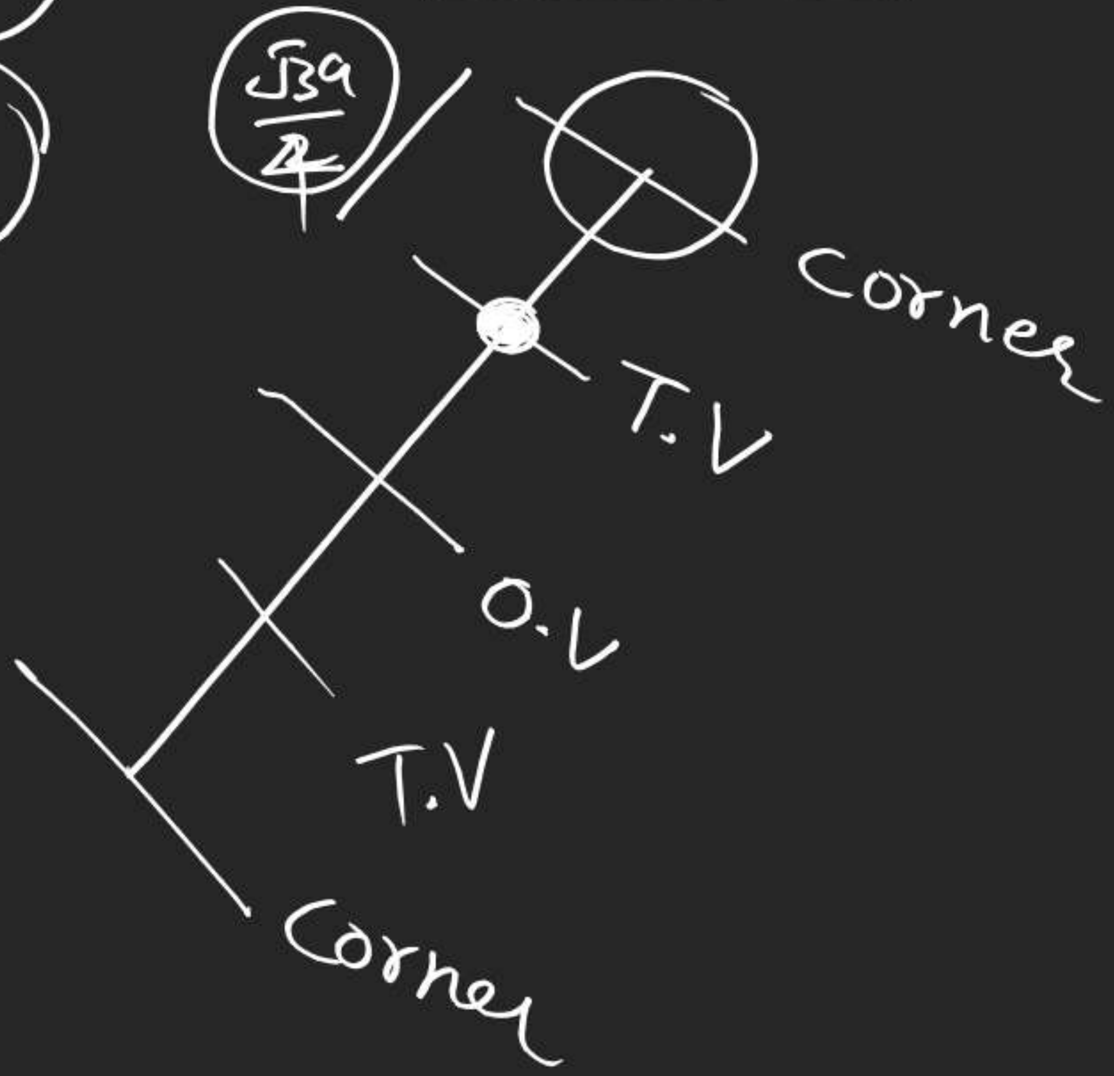
→ S^{2-} form FCC Lattice — 4

→ Zn^{2+} occupy half of T.V — 4

→ $\sqrt{2}a = 4r_-$ (if $\frac{r_+}{r_-} = 0.225$)

→ $\frac{\sqrt{3}a}{4} = r_+ + r_-$ (Always applicable)

ZnS



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$\Rightarrow$ Coordination no $Zn^{2+} = 4$

" " $S^{2-} = 4$

NaCl
ZnS

$\Rightarrow$ S^{2-} are in alternate T.V formed Zn^{2+} ions

Zn^{2+} form fcc lattice

$\Rightarrow$ Packing fraction $= \dfrac{4 \times \frac{4}{3}\pi (r_+^3 + r_-^3)}{a^3}$

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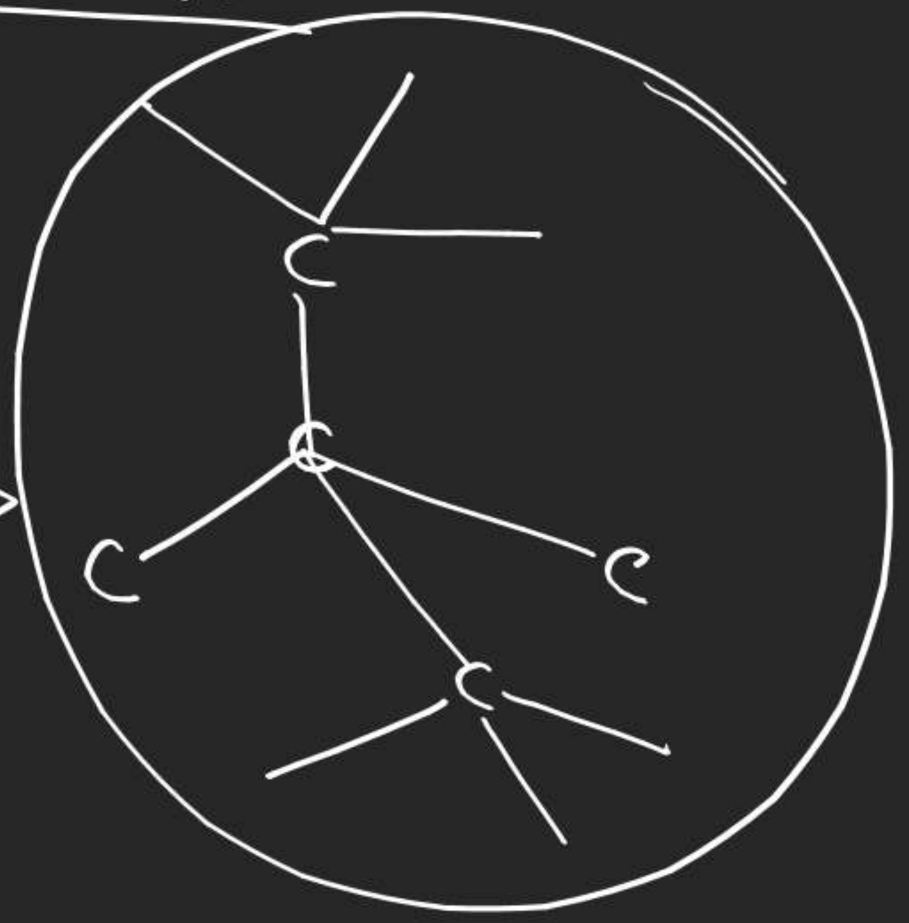
$$\text{Density} = \frac{4 \times M_{ZnS}/N_A}{a^3}$$

e.g

BeO

Diamond →



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In Diamond

(I) half of the 'C' atoms form FCC lattice

(II) remaining half of the " " occupy half of the T.V.

$$\Rightarrow \frac{\sqrt{3}a}{4} = r_+ + r_-$$

$$= r_c + r_c$$

radius of carbon

(III) $\boxed{\frac{\sqrt{3}a}{4} = 2r_c}$

(IV) no. of carbon atom per unit cell $= 8$

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Packing fraction of diamond $= \dfrac{8 \times \frac{4}{3}\pi r_c^3}{a^3}$

$$\frac{\sqrt{3}a}{4} = 2r_c$$

$$a = \frac{8r_c}{\sqrt{3}}$$

$$= \frac{\cancel{8} \times \frac{4}{\cancel{3}} \times \pi \cancel{r_c^3}}{\cancel{8} \times 64 \cancel{r_c^3}} \times \cancel{3}\sqrt{3}$$

$$= \frac{\sqrt{3}\pi}{16}$$

$$= 0.34 \equiv 34\%$$

74%

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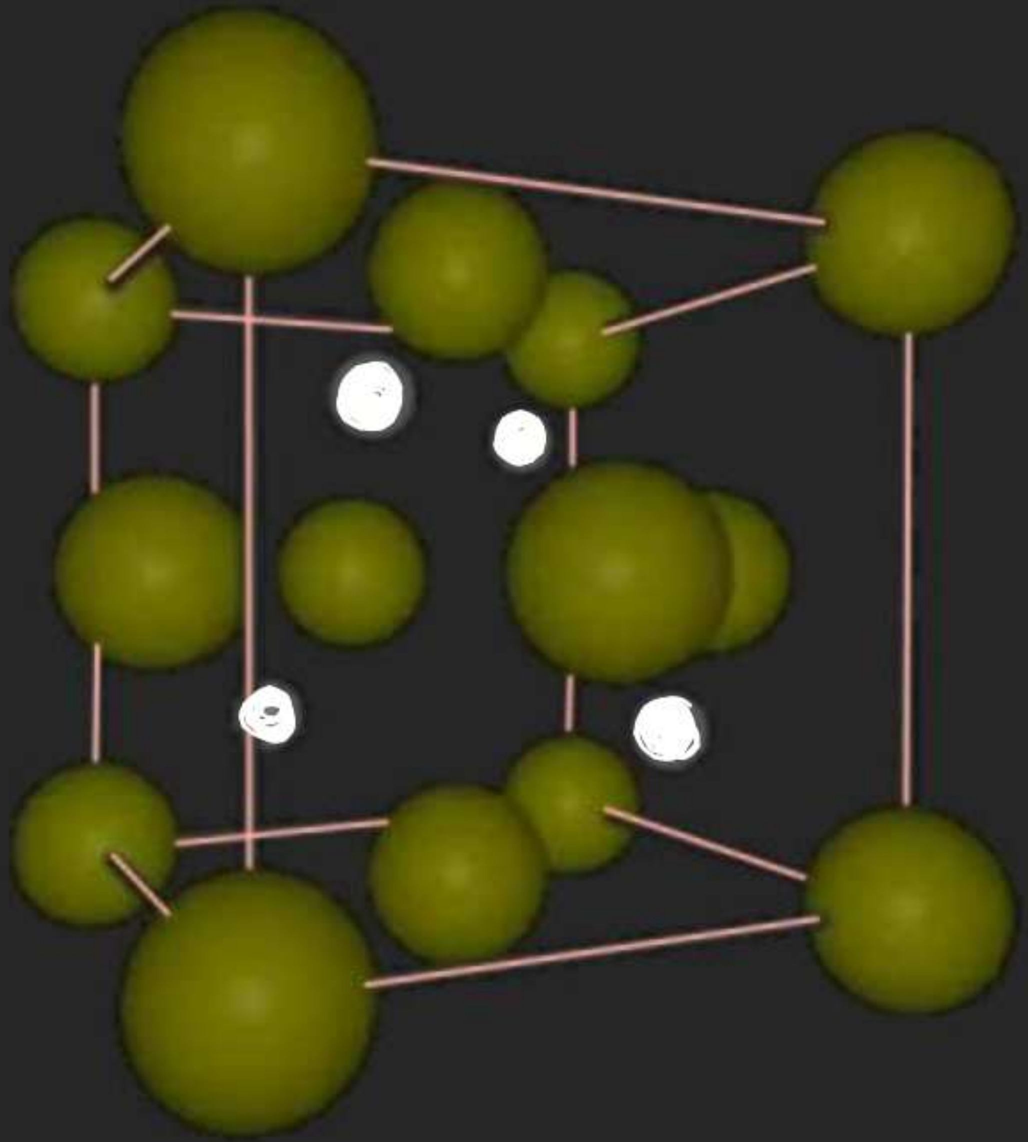
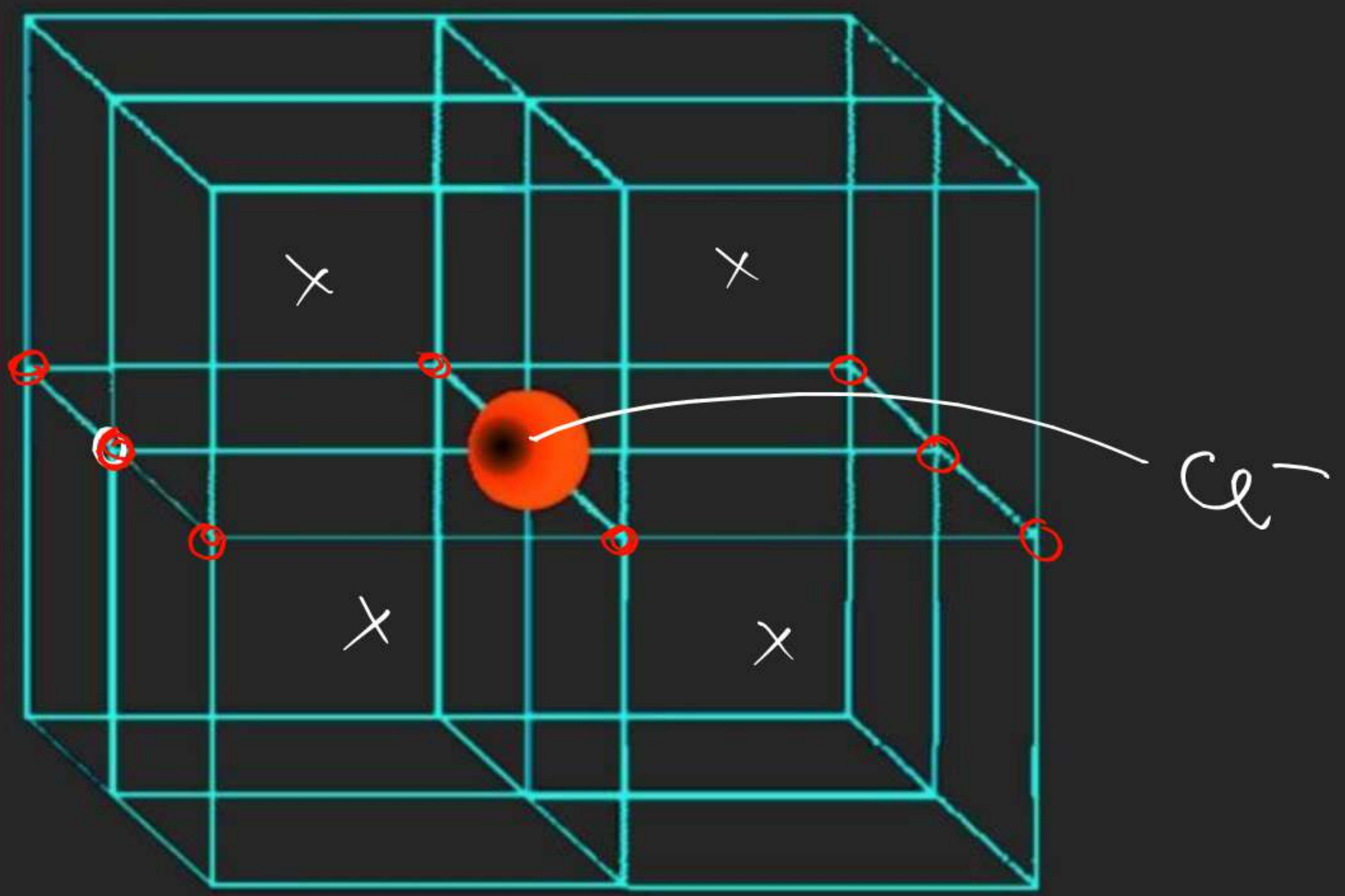


SOLID STATE



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$CsCl$

\# Cl^- forms SC unit cell — 1

\# Cs^+ occupy cubic void — 1

\# $a = 2r_-$ $\left(\text{if } \frac{r_+}{r_-} = 0.732\right)$

\# $\frac{\sqrt{3}a}{2} = r_+ + r_-$ (Always applicable)

\# Co-ordination no $Cs^+ = 8$

$Cl^- = 8$

Cs^+ ions form Simple (primitive) unit cell & Cl^- occupy cubic

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CsCl str

NaCl

for ionic compound BCC structure mean CsCl str

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Na_2O str (Anti-flourite)

\# O^{2-} form FCC lattice — 4

\# Na^+ occupy all T.V — 8

\# $\sqrt{2}a = 4r_-$ (if $\frac{r_+}{r_-} = 0.225$)

\# $\frac{\sqrt{3}a}{4} = r_+ + r_-$ (Always applicable)

Co-ordination no of $Na^+ = 4$

$O^{2-} = 8$

O^{2-} are in Cubic void of Na^+

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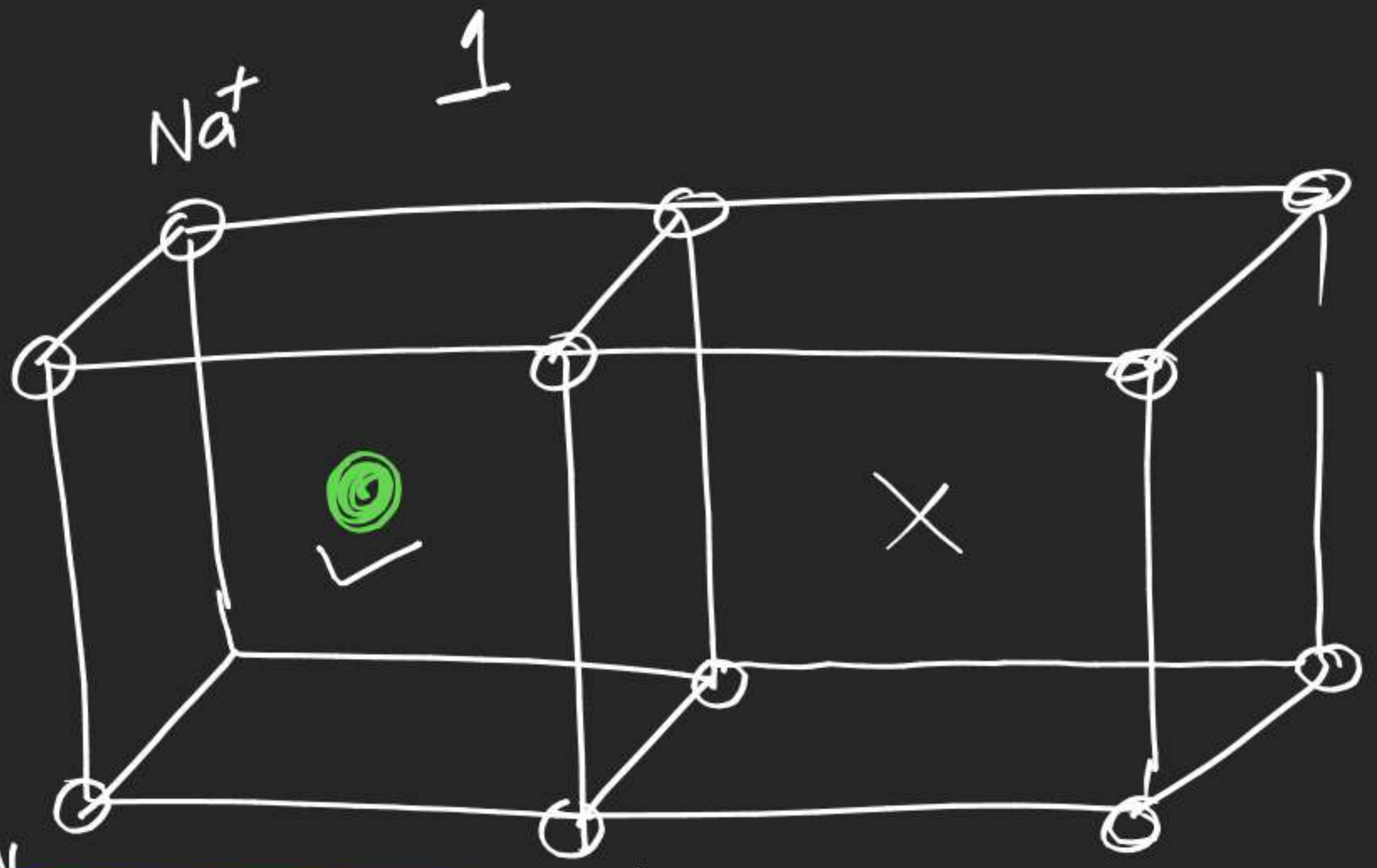

$Na^+ \rightarrow 2$

$O^{2-} \rightarrow 1$

Defect X

J-Main

1, 3, 4, 7, 9, 10

11–16, 18

20–22, 24–30

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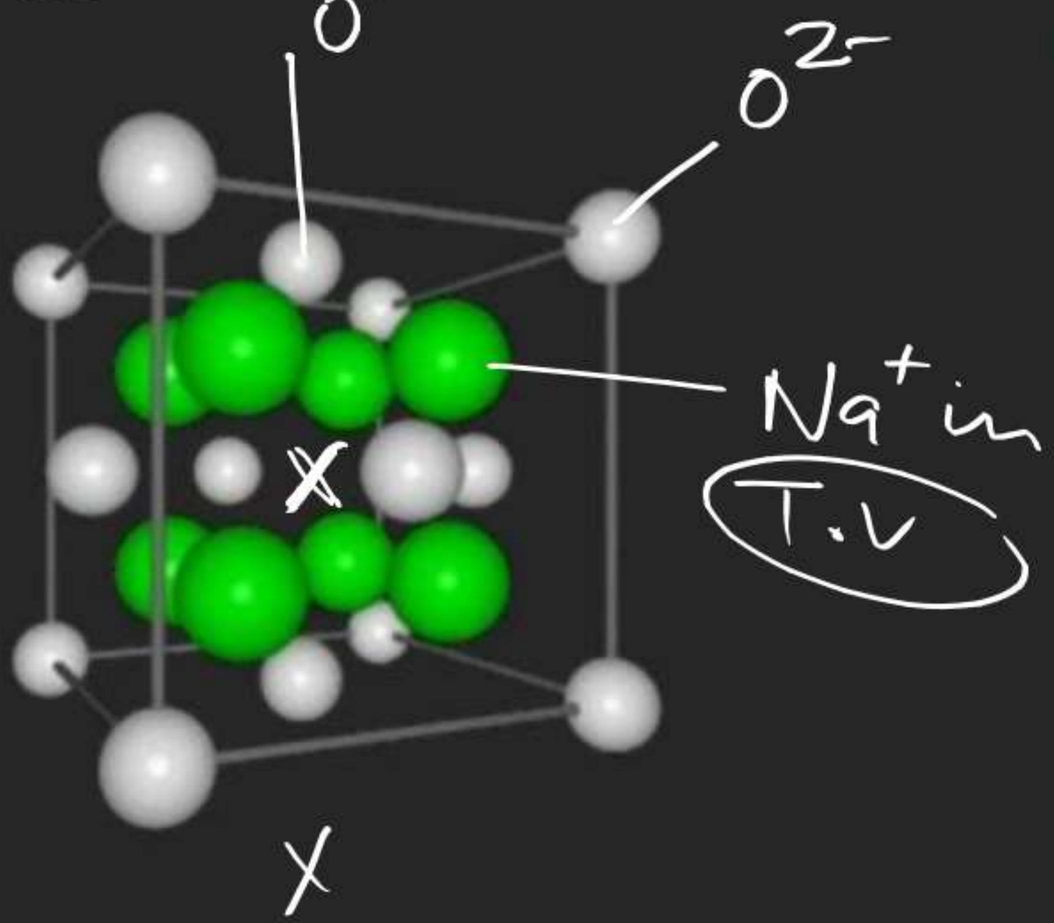
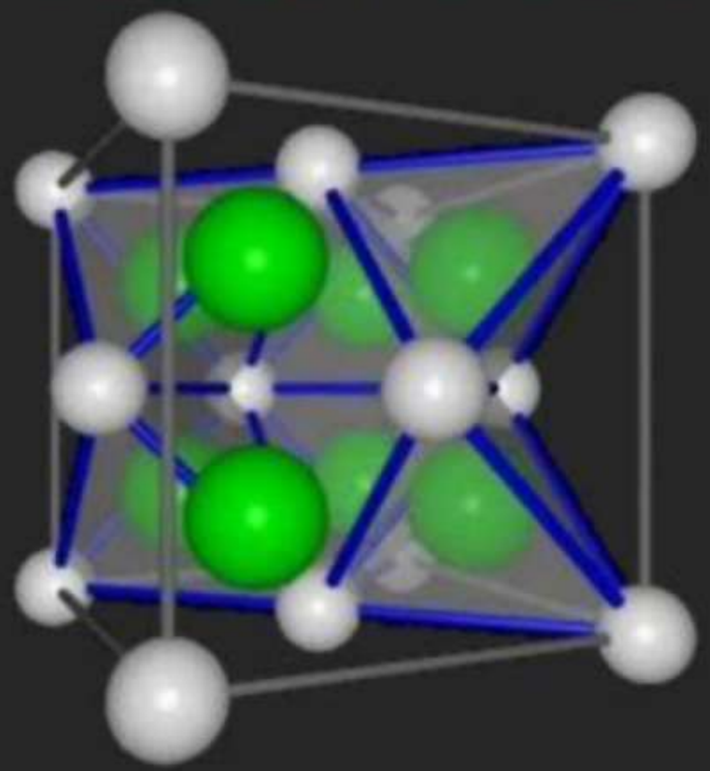
Cubic void



Fluoride Ions Occuy Tetrahedral Holes



NaCl
ZnS
CsCl

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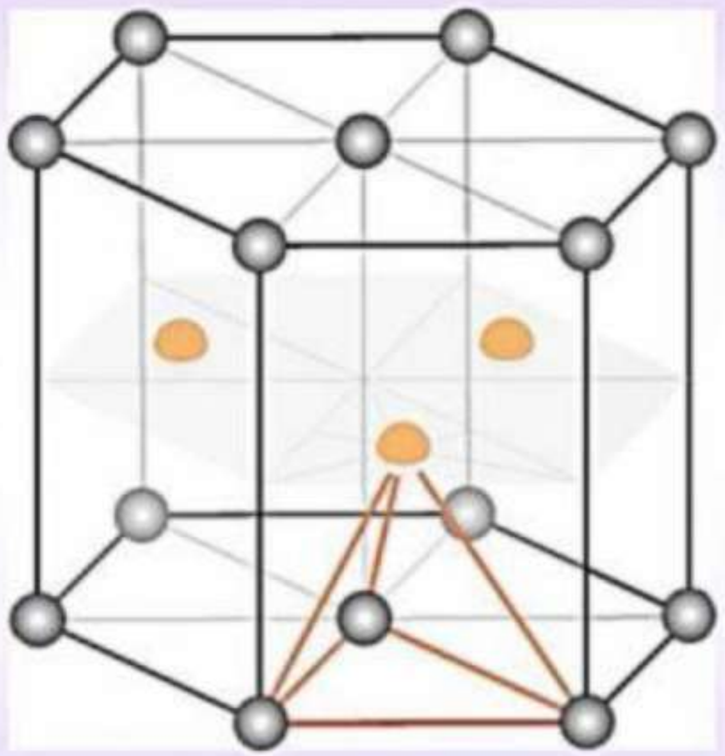
HCP

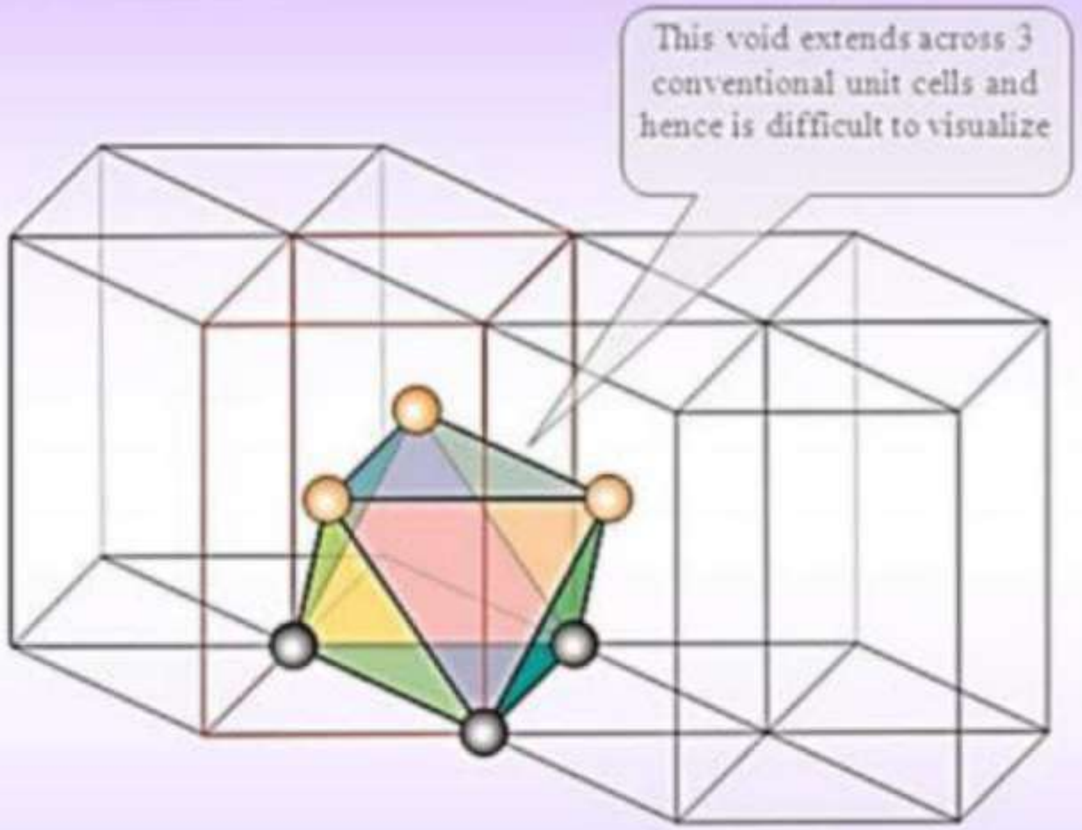
VOIDS

TETRAHEDRAL



Coordinates: $(0,0,\frac{3}{8}),(0,0,\frac{5}{8}),(\frac{2}{3},\frac{1}{3},\frac{1}{8}),(\frac{2}{3},\frac{1}{3},\frac{7}{8})$

OCTAHEDRAL



Coordinates: $(\frac{1}{3}\ \frac{2}{3},\frac{1}{4}),(\frac{1}{3},\frac{2}{3},\frac{3}{4})$

- ➢ These voids are identical to the ones found in FCC *(for ideal c/a ratio)*.
- ➢ When the c/a ratio is non-ideal then the octahedra and tetrahedra are distorted *(non-regular)*.

Important Note: often in these discussions an ideal c/a ratio will be assumed (without stating the same explicitly).

If c/a ratio is not the ideal one – then the voids will not be 'regular' (i.e. regular octahedron and regular tetrahedron).

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Q. Atom X occupies the fcc lattice sites as well as alternate tetrahedral voids of the same lattice. The packing efficiency (in %) of the resultant solid is closest to [JEE Adv. 2022]

(A) 25 (B) 35 (C) 55 (D) 75