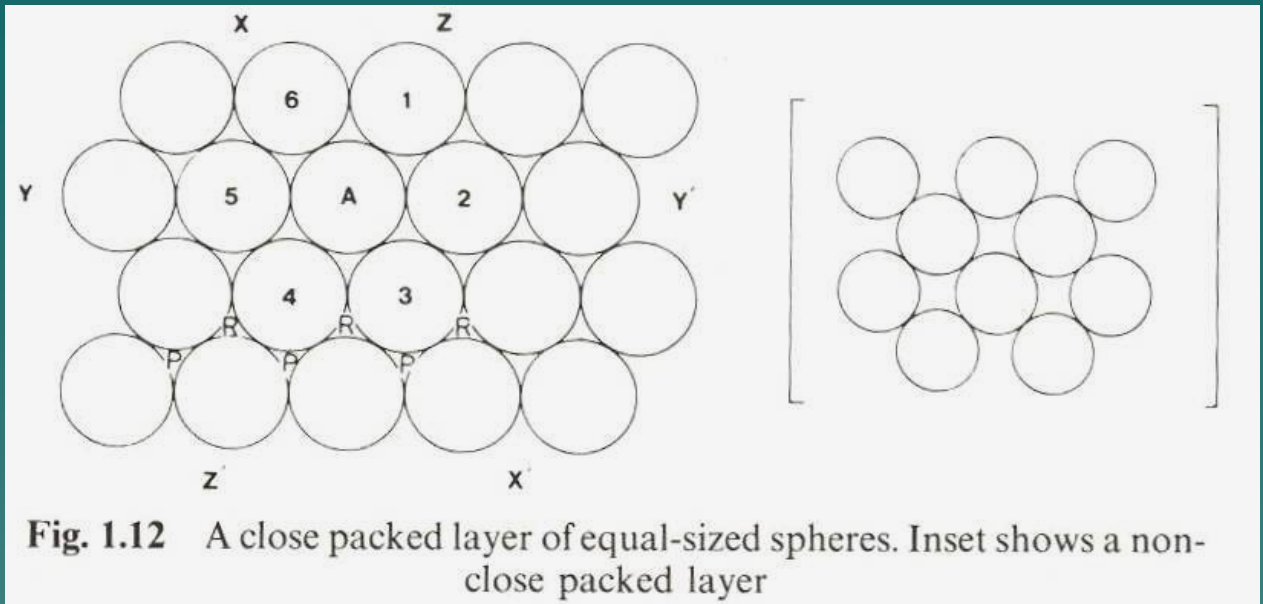
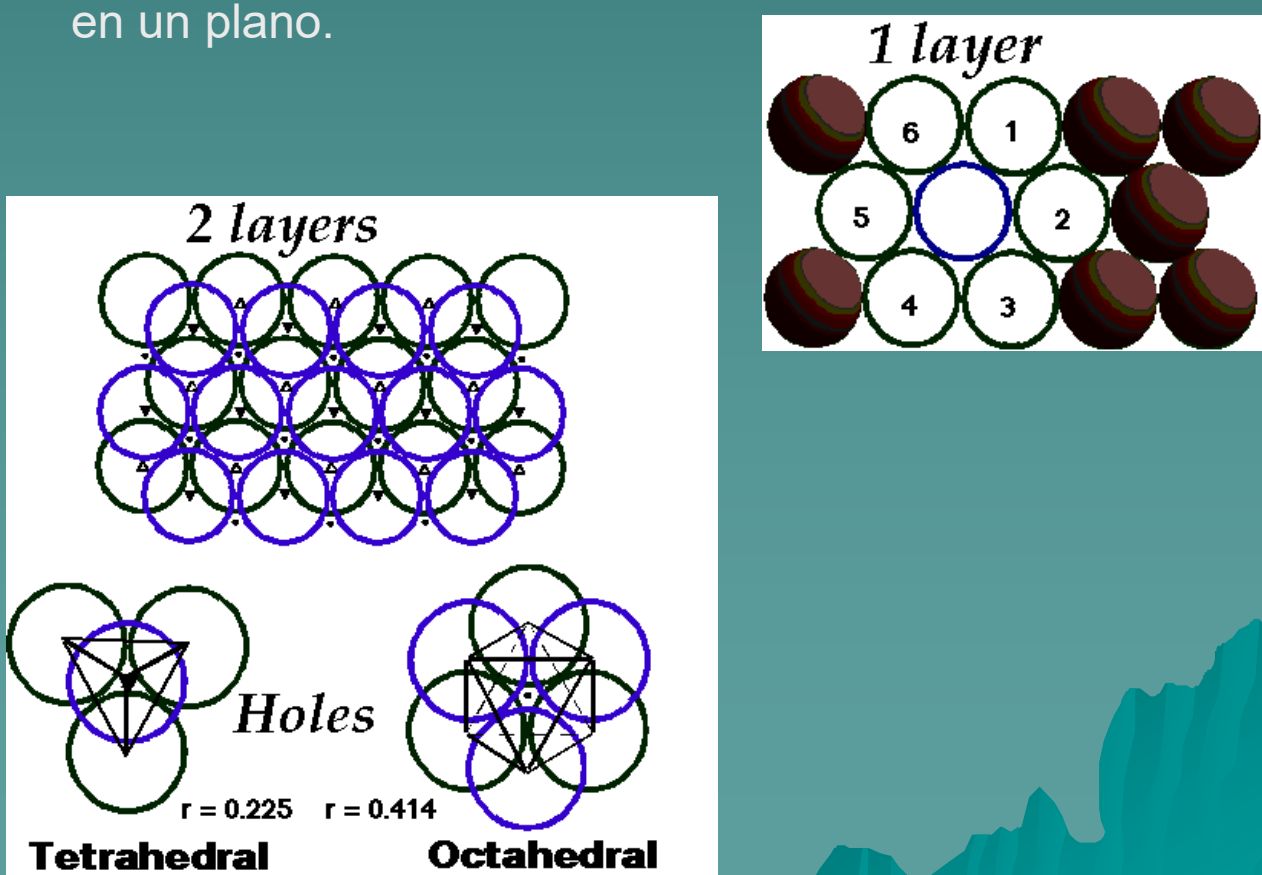
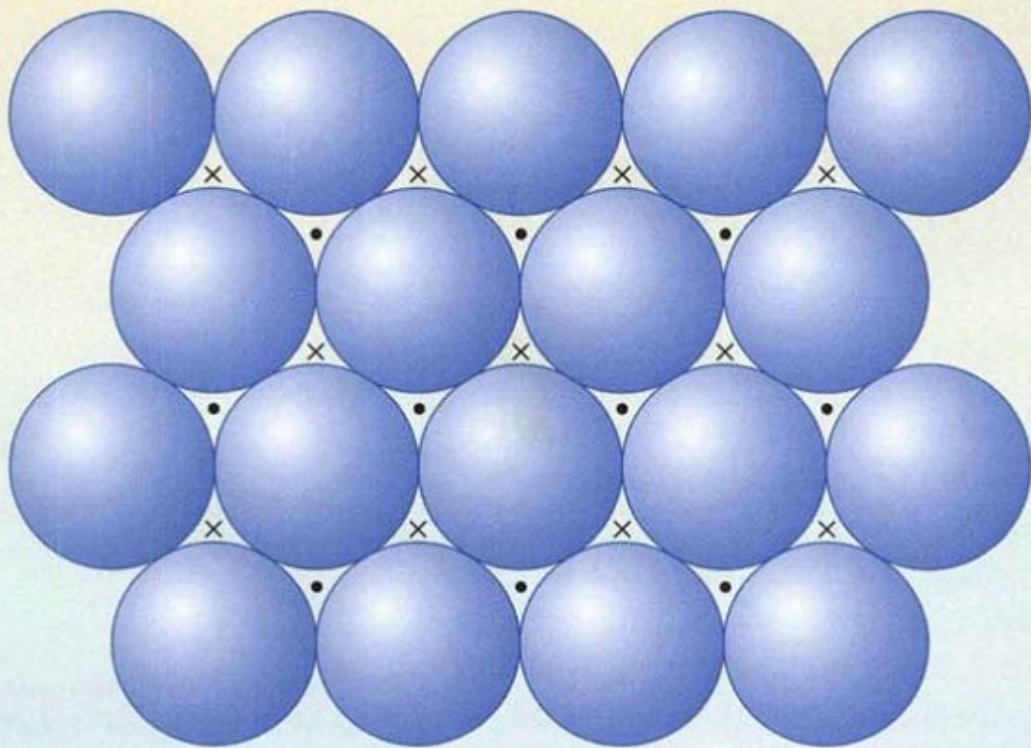


Esferas empacadas vs. no empacadas

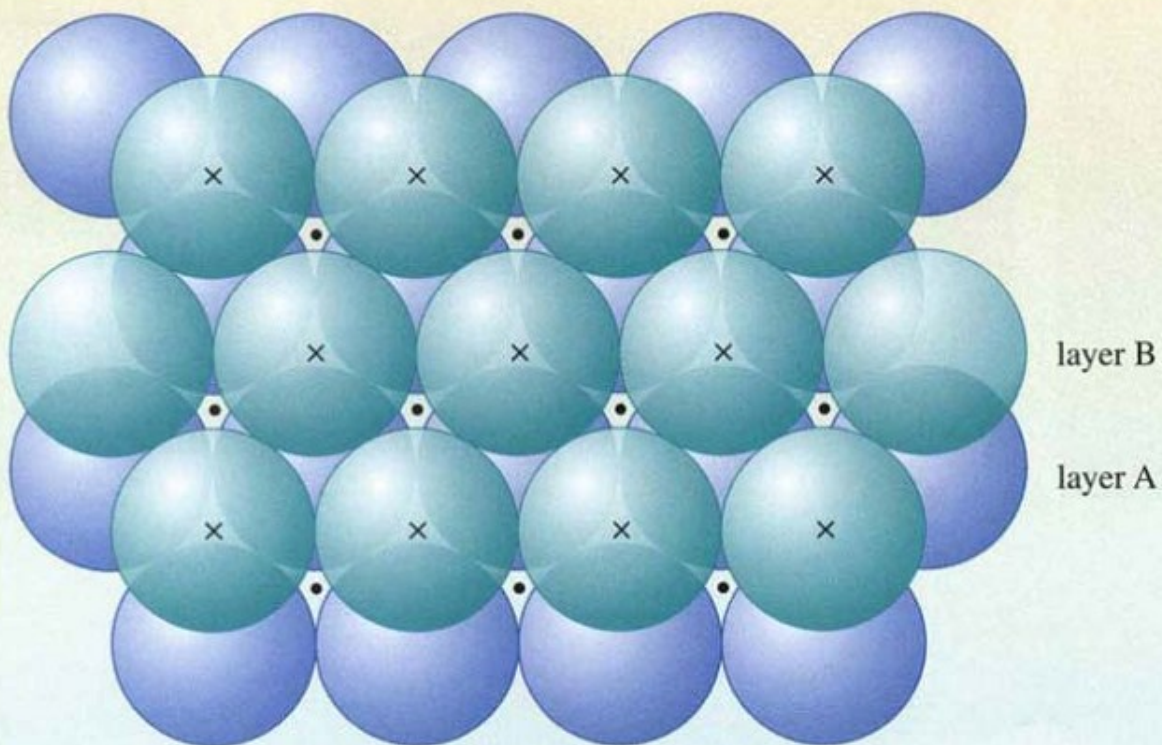


Empacamiento compacto de esferas rígidas en un plano.





(c)



layer B

layer A

Figure 2.5 Two layers of close-packed spheres.

Apilamiento de una camada de esferas empacadas sobre una primera. Observe la presencia de los dos tipos de huecos tetraédricos y octaédricos. Trate de contar cuantos se forman de cada tipo por cada N átomos en cada camada.

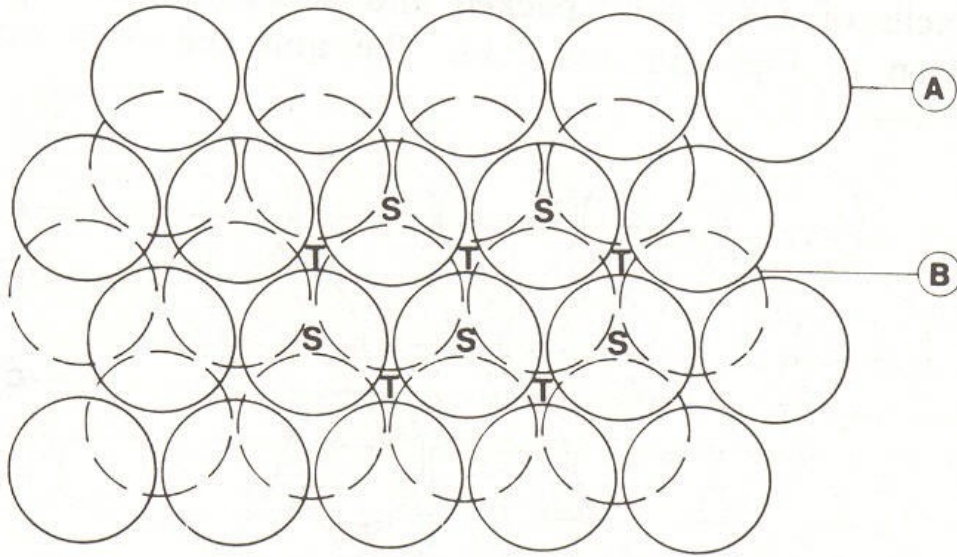
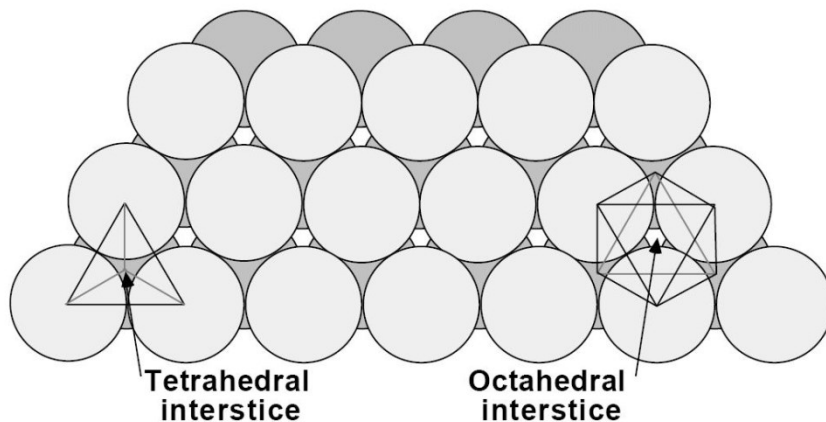
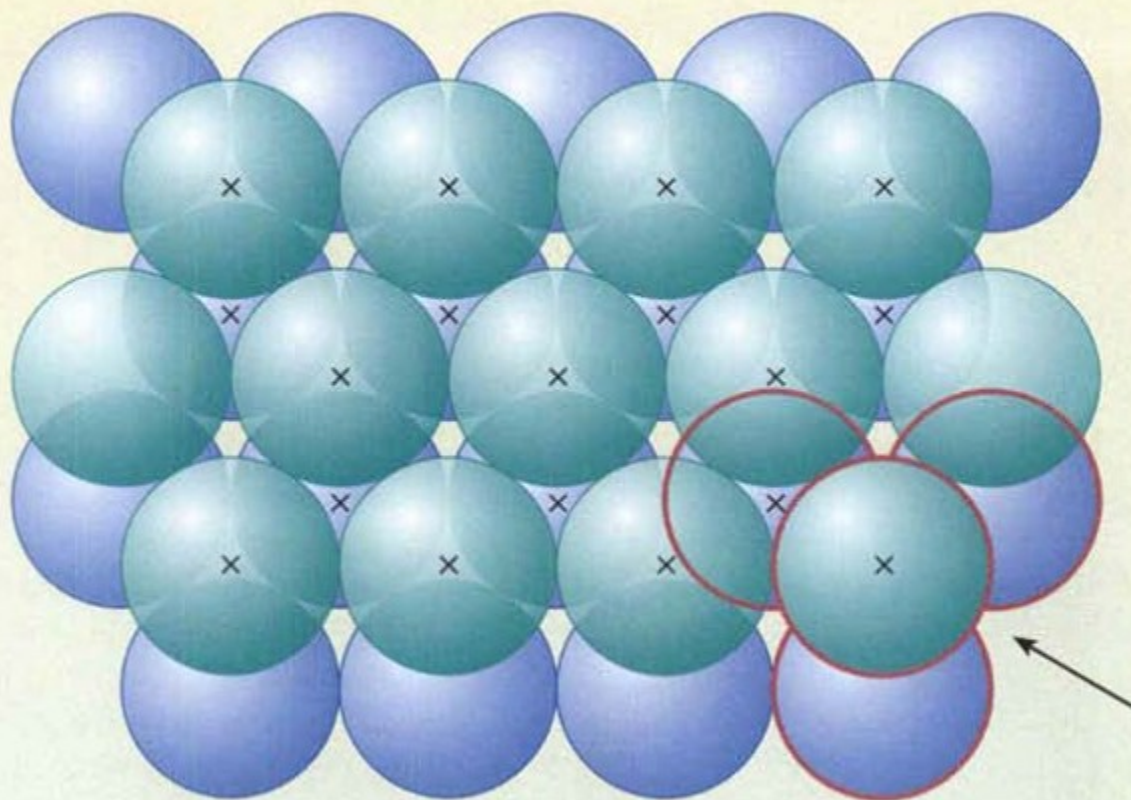


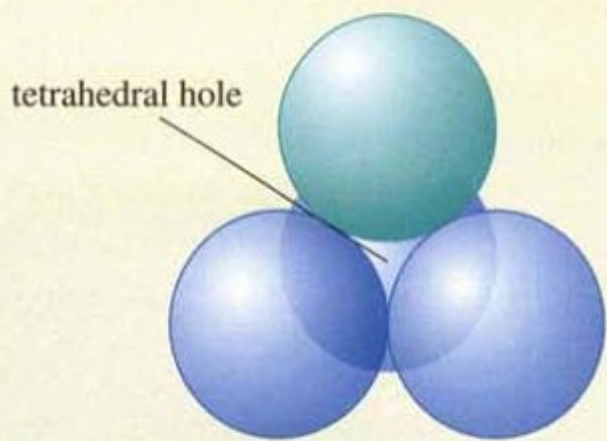
Fig. 1.13 Two close packed layers arranged in A and B positions. The B layer occupies the P positions shown in Fig. 1.12





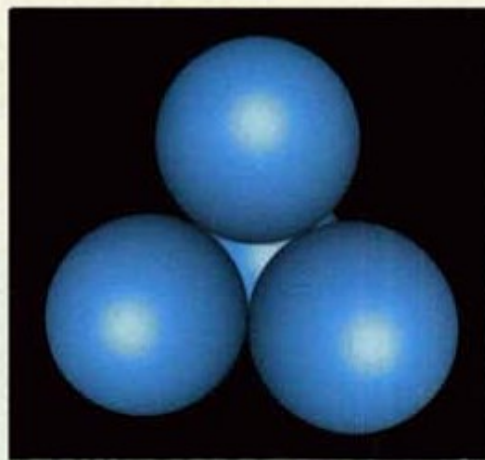
plan view

(a)

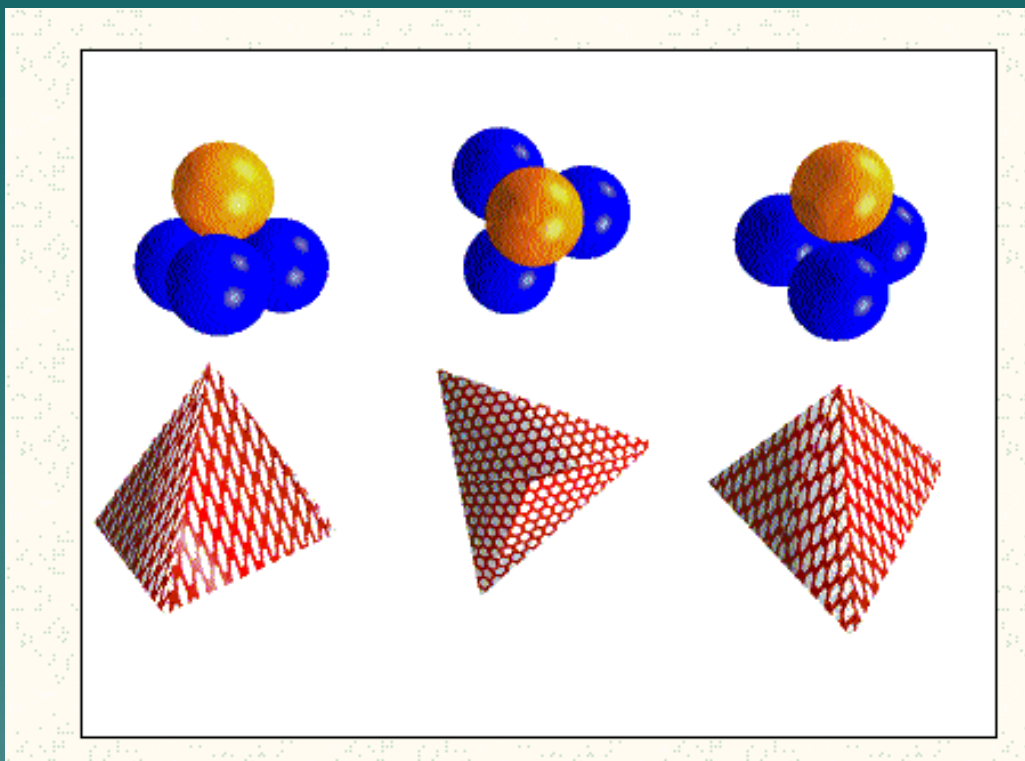


side view

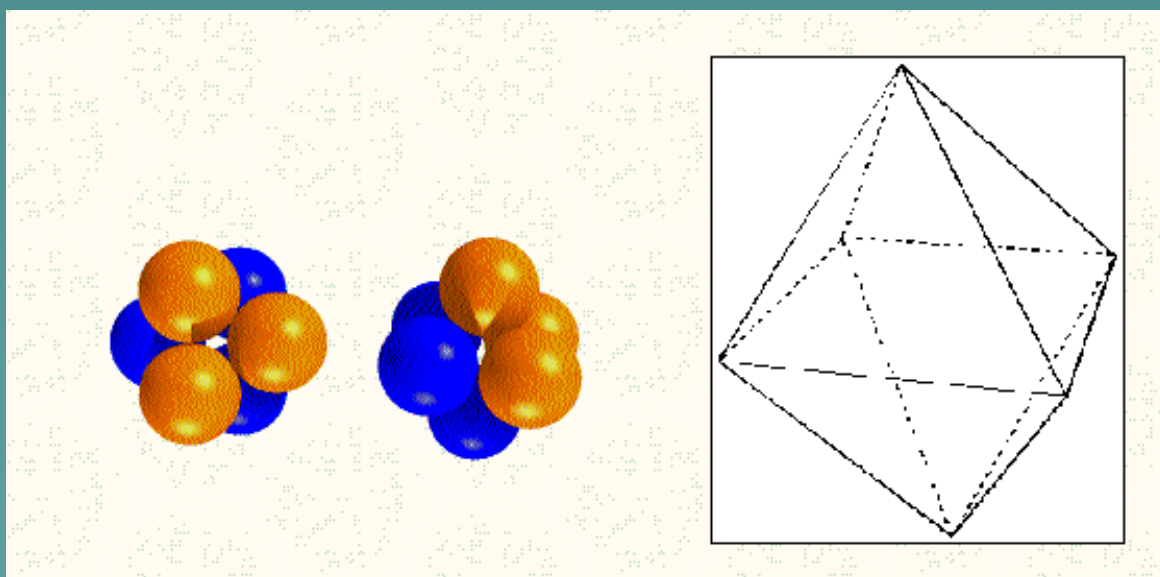
(b)



Huecos tetraédricos generados por el apilamiento de un par de capas de hexágonos de esferas rígidas



Huecos octaédricos generados por el apilamiento de un par de capas de hexágonos de esferas rígidas



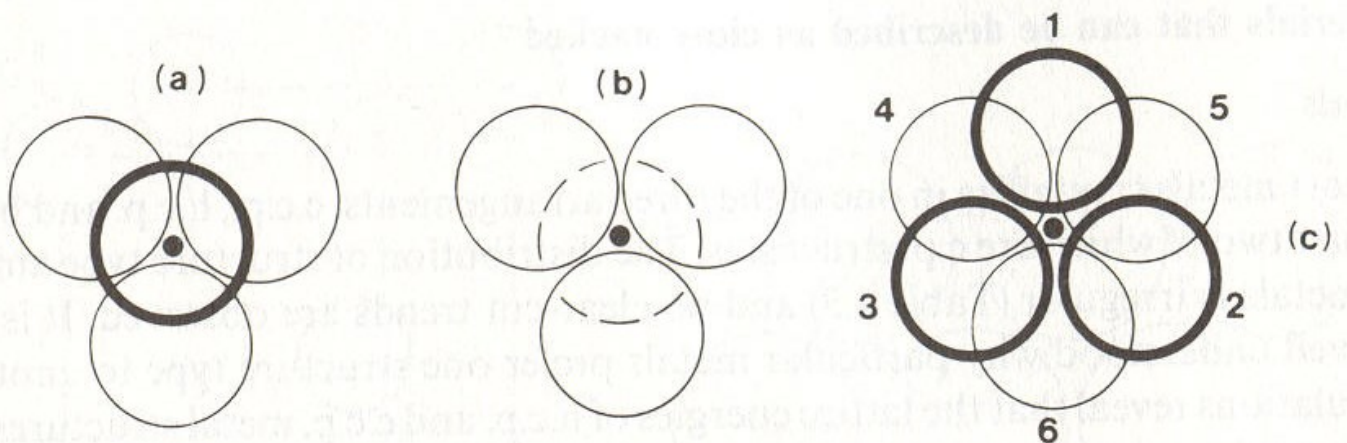
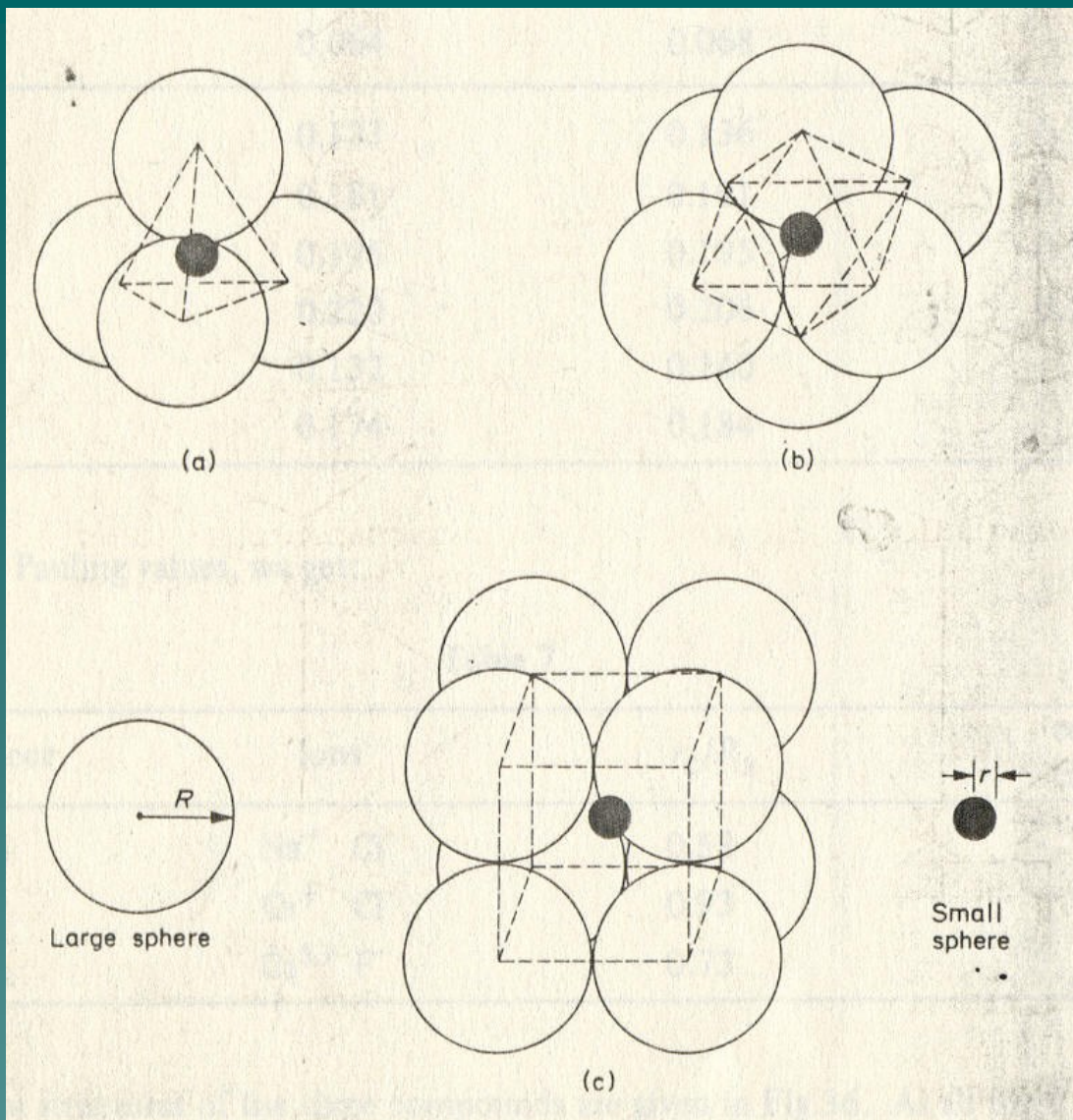
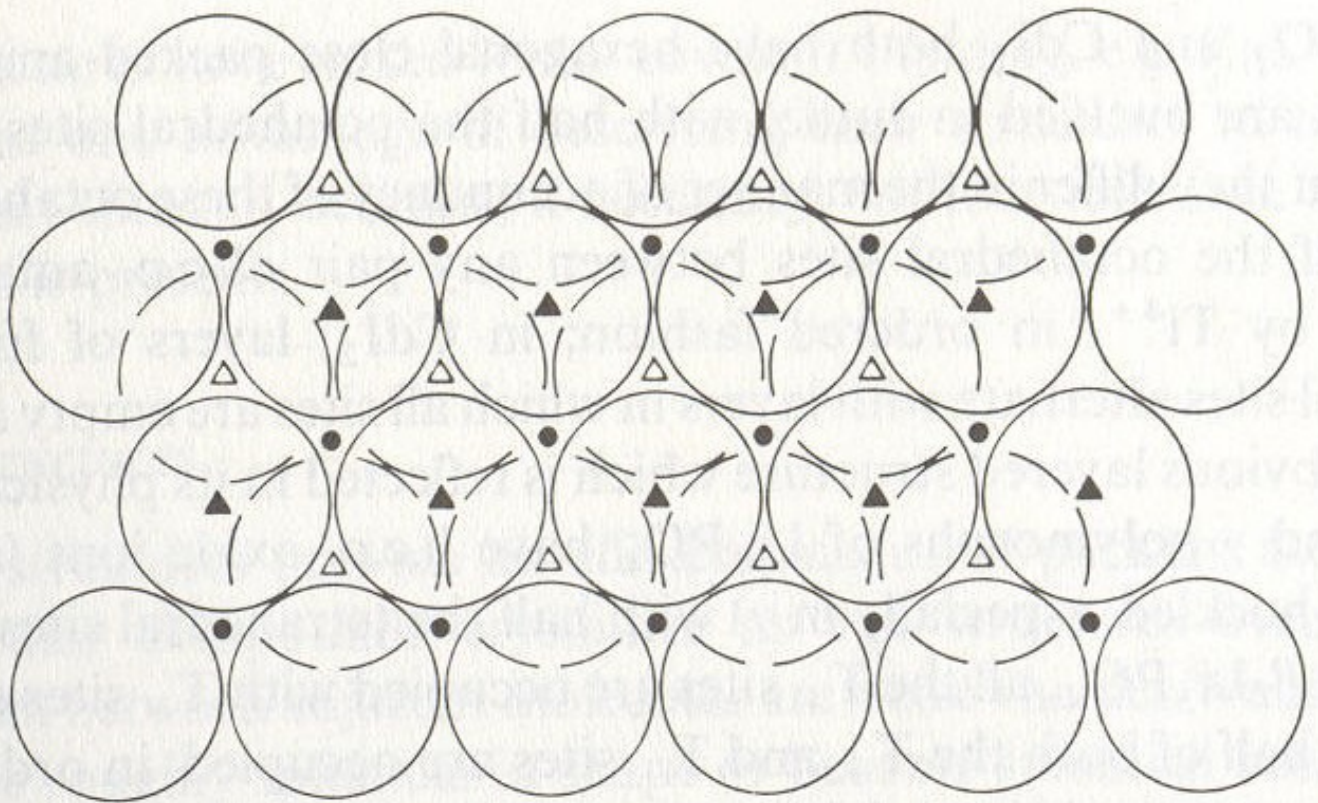
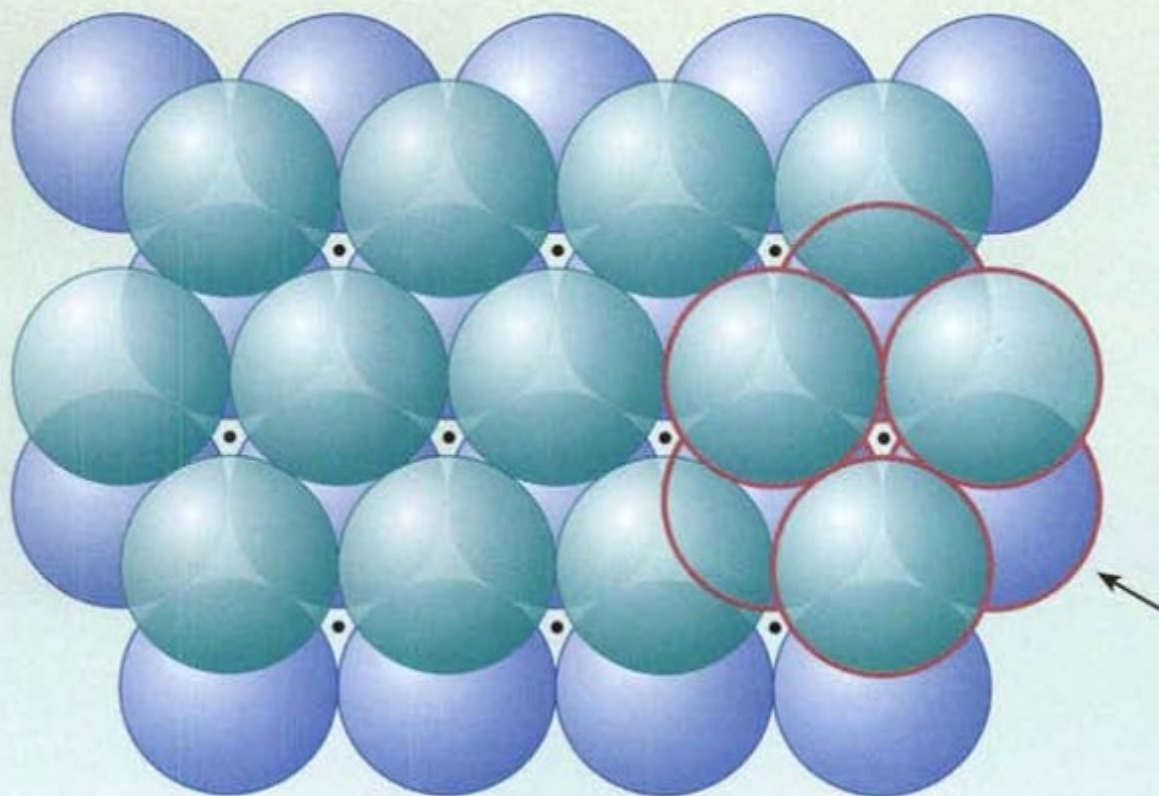


Fig. 1.18 Interstitial sites in a c.p. structure. Heavy circles are above and the dashed circles below the plane of the paper: (a) T_+ site, (b) T_- site (c) O site



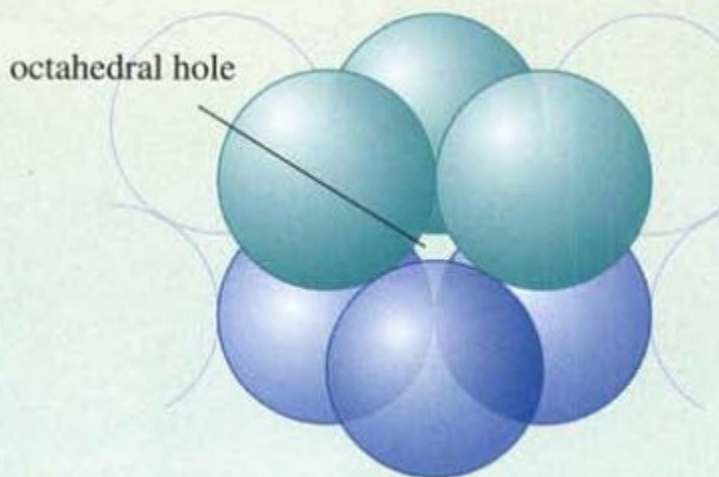
- octahedral sites
- ▲ T+ tetrahedral sites
- △ T- tetrahedral sites

Fig. 1.19 Distribution of interstitial sites between two c.p. layers. Dashed circles are below the plane of the paper



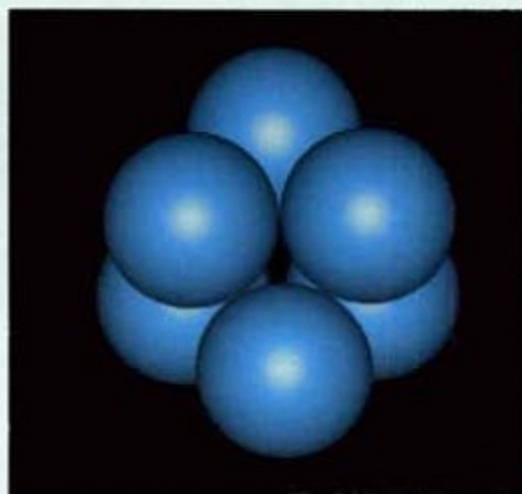
plan view

(c)



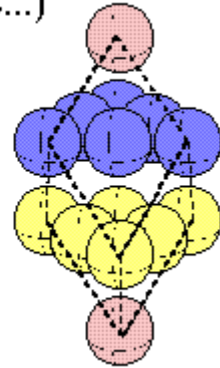
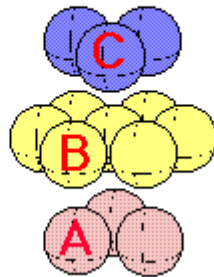
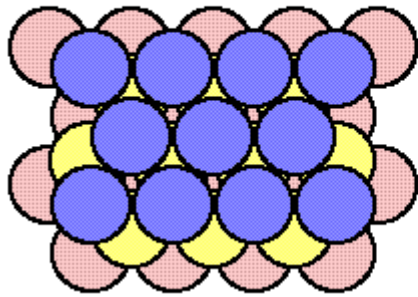
side view

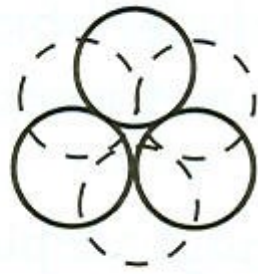
side view



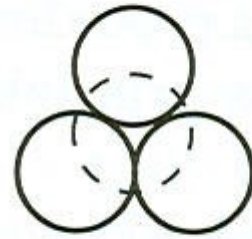
(d)

Cubic close packing (ABCABC...)





Octahedral



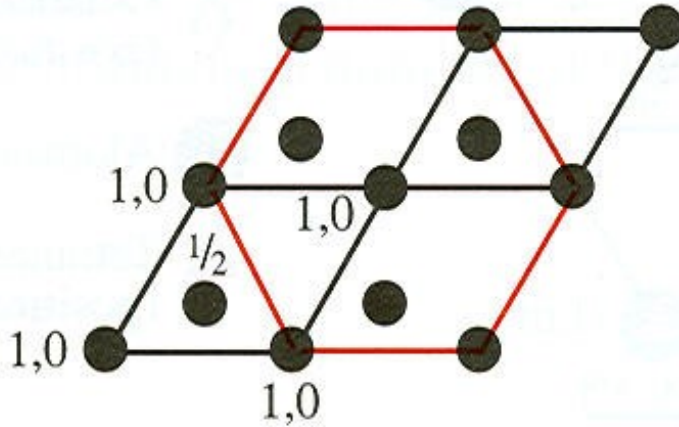
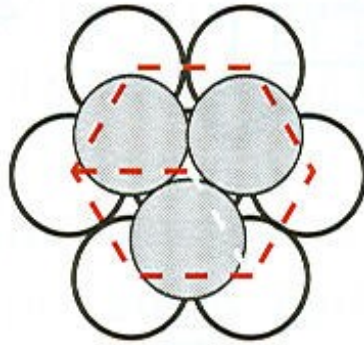
Tetrahedral



ABABABAB
Two-layer repeat
Hexagonal close-packed

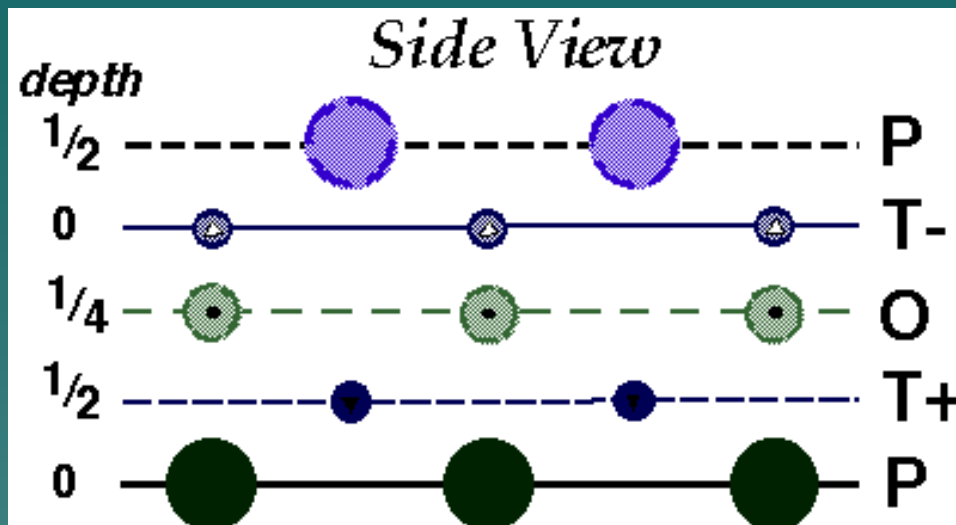


ABCABCABC
Three-layer repeat
Cubic close-packed

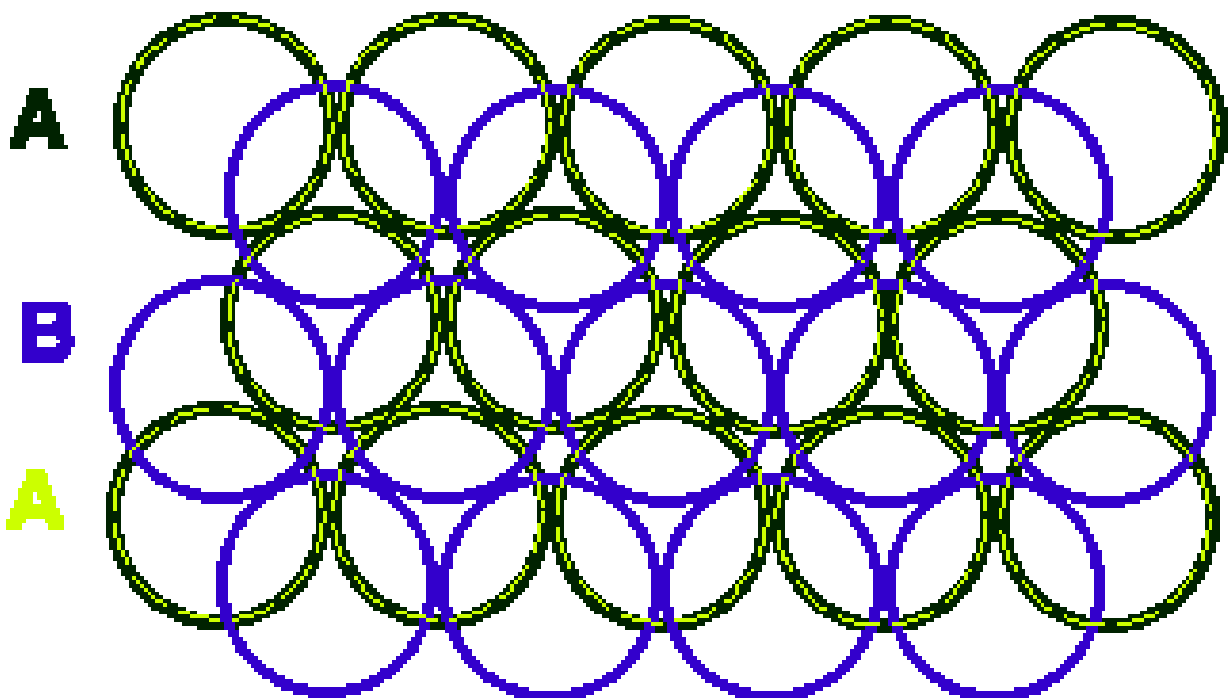


Arreglo del tipo ABABAB de una estructura Hexagonal Compacta

Vista lateral de un apilamiento de 2 capas de esferas rígidas compactas en arreglo hexagonal en un plano.

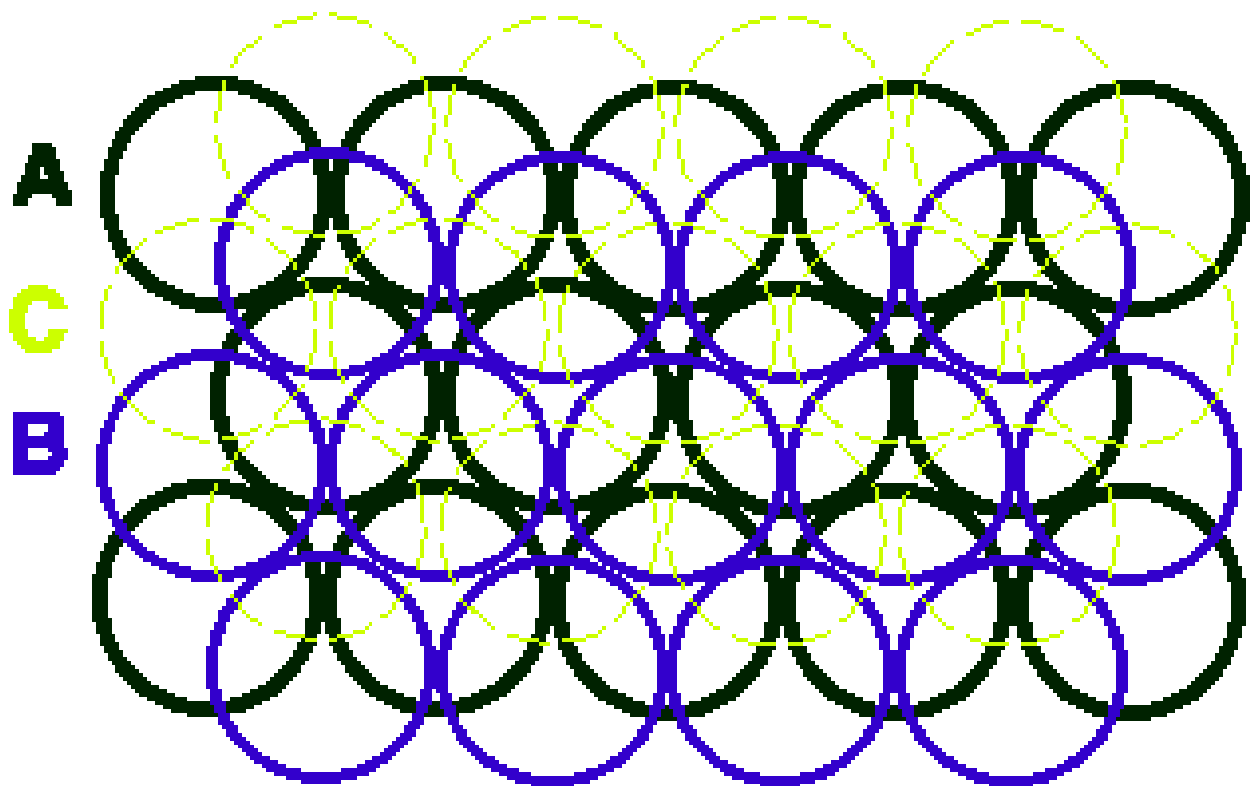


3 Layers



ABA Hexagonal Close-Packing (HCP)

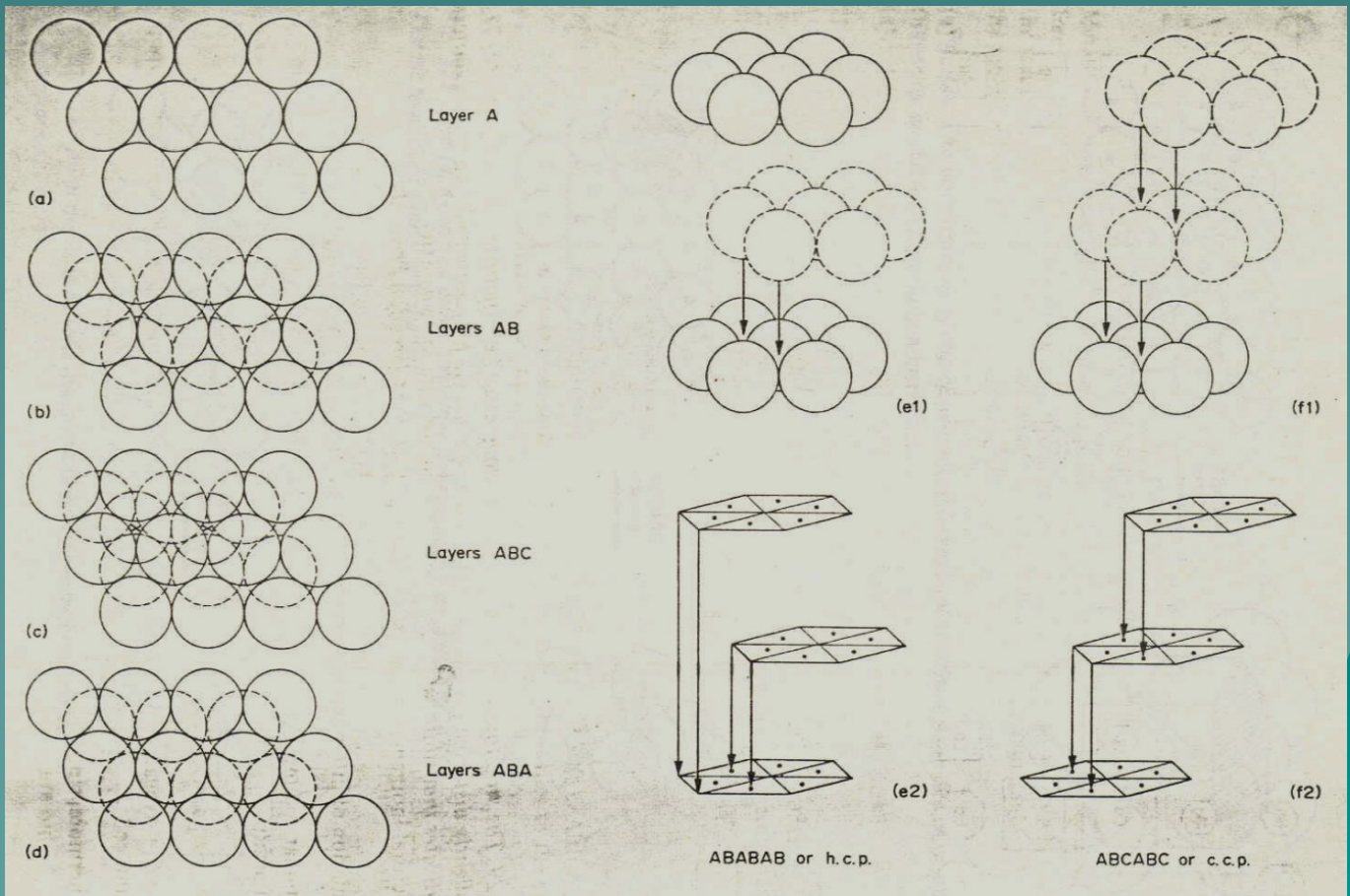
ABC Cubic Close-Packing (CCP)

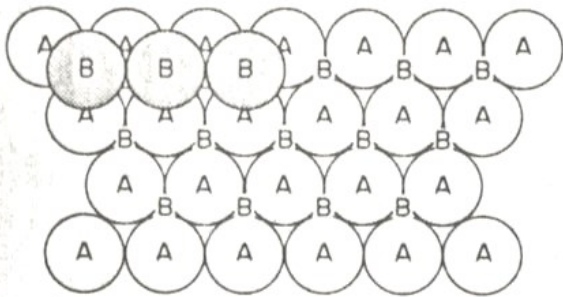


Cuando una tercera capa de hexágonos se añade a las dos anteriores existen dos posibilidades de arreglo:

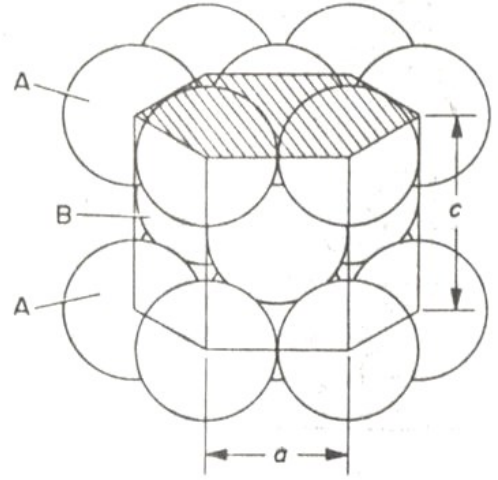
Si la primera capa es totalmente eclipsada por la tercera que se añade se dice que es un arreglo del tipo ABA y es diferente en varios aspectos que aquel que resulta cuando...

La tercera capa cae en espacios en los que no se eclipsa a los de la primera, sino que están desplazados con respecto a ésta se dice que es un arreglo ABC ABC



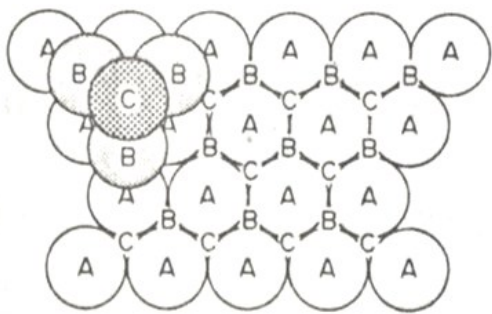


ABAB
packing
→

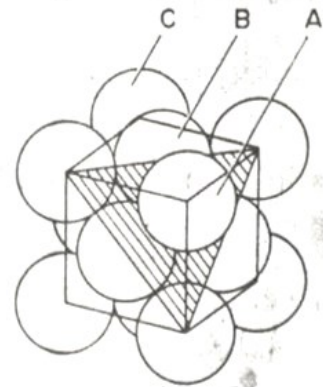


(a)

Fig. 32a The development of the close-packed hexagonal structure from the close-packed layer by an ABABAB packing sequence

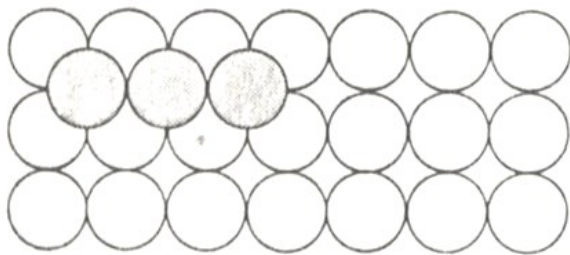


ABCABC
packing



(b)

Fig. 32b The face-centred cubic structure developed by an ABCABCABC packing sequence. The close-packed planes are shaded



Open
packing

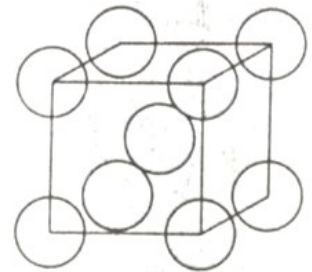
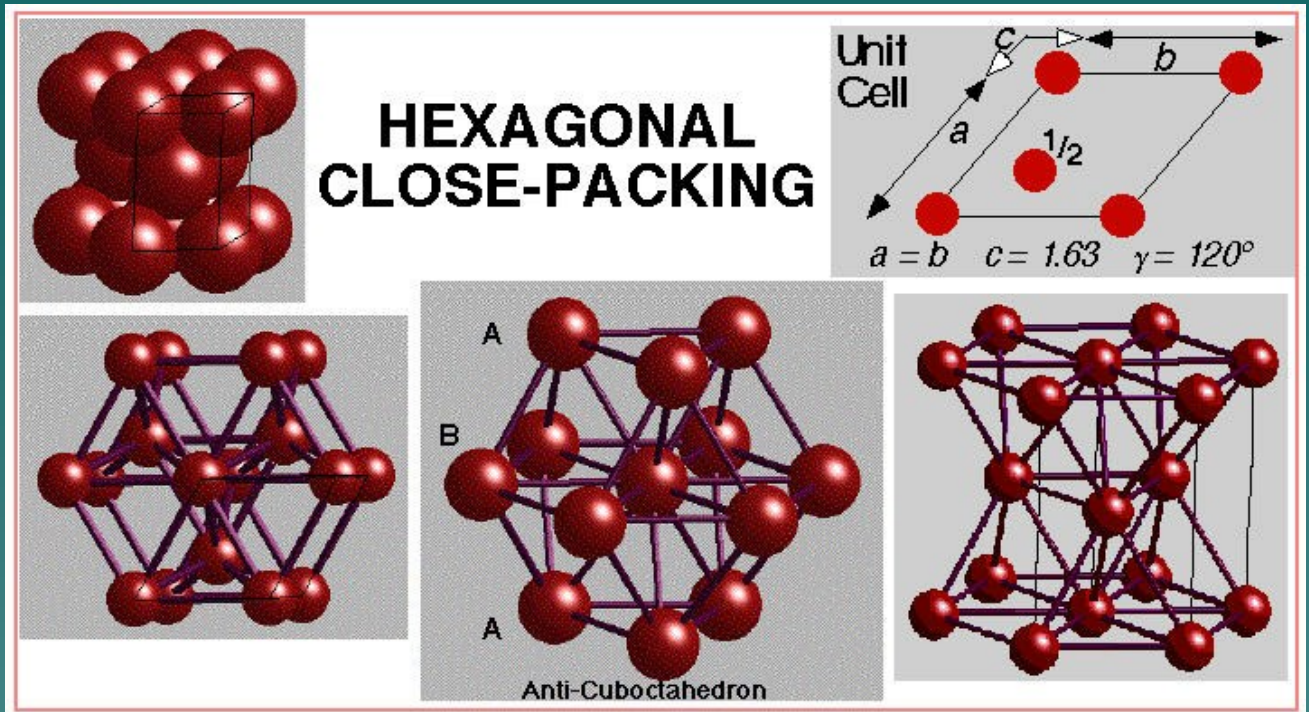


Fig. 32c The open packing of ions leads to the body-centred cubic structure which possesses no close-packed layers

EL EMPACAMIENTO HCP



- Se representa por ABAB
- La simetría completa del arreglo es hexagonal con $a=b$ y $c = 1.63a$ $\alpha=\beta=90^\circ$ $\gamma=120^\circ$
- Hay 2 átomos por unidad de celda, colocados en $(0,0,0)$ y $(2/3, 1/3, 1/2)$

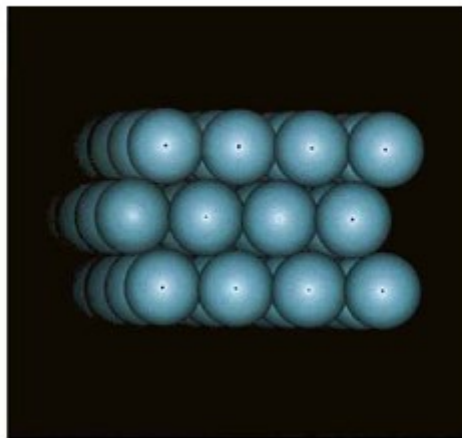
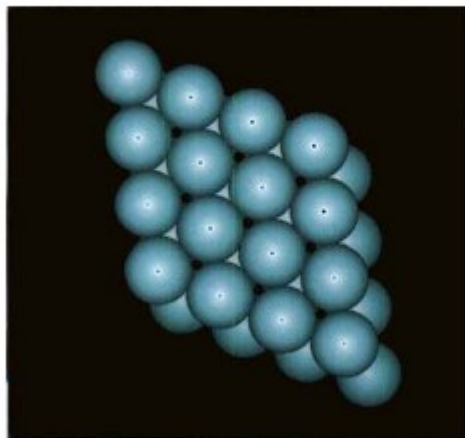
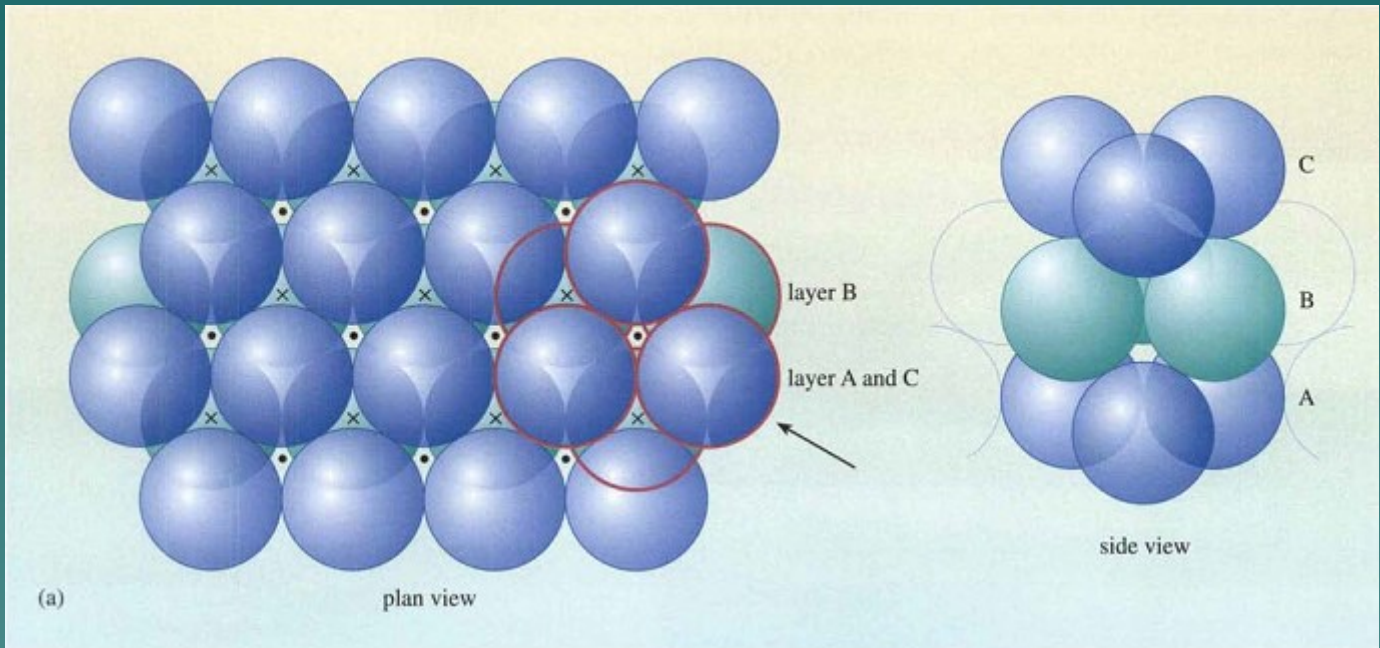
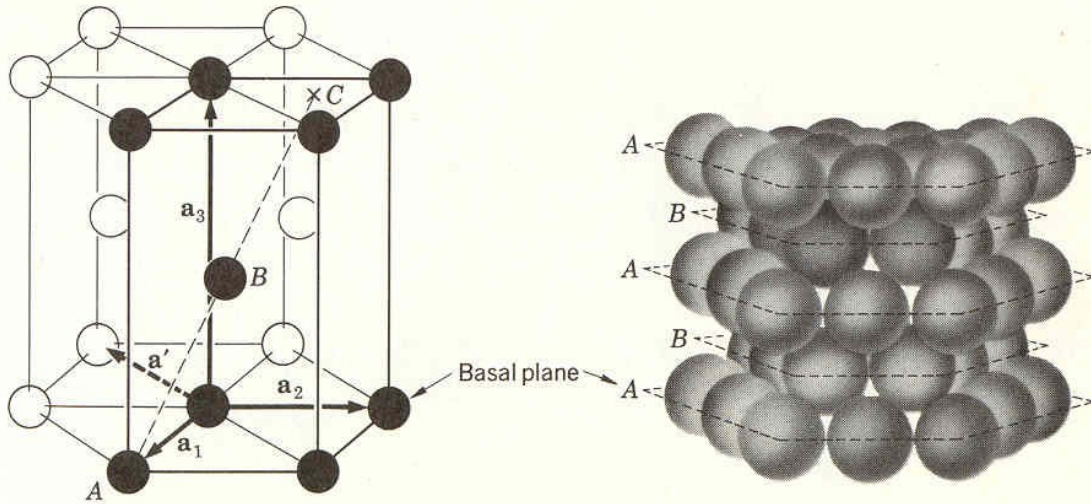


Figure 2.8

(a) Plan view and side view (of spheres outlined in red from arrowed direction) of three layers of close-packed spheres in a hexagonal close-packed, *hcp*, arrangement; (b) computer representation of three *hcp* layers, showing the narrow channels; (c) three *hcp* layers showing the ABAB... stacking sequence. □

Empacamiento HCP



(a) The crystal structure consists of *AB* atom pairs on the points of the hexagonal space lattice.

(b) Successive basal planes are stacked in *ABABAB* arrangement.

Figure 1.20 Important features of the hexagonal close-packed crystal structure.

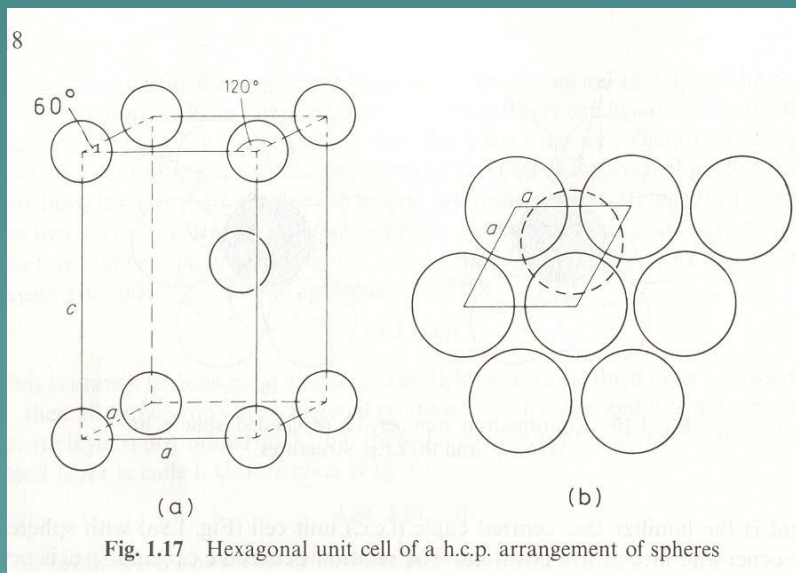
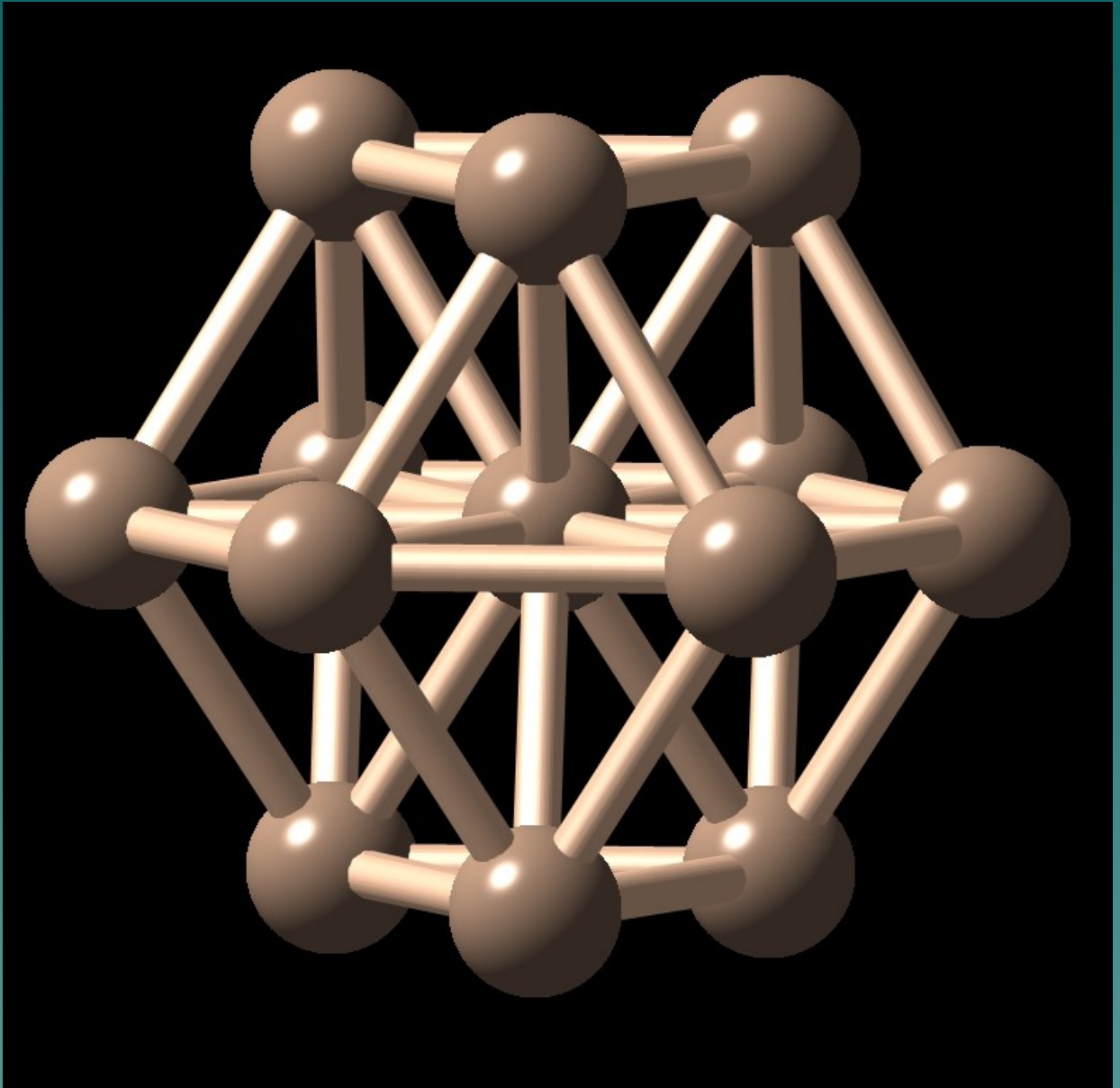
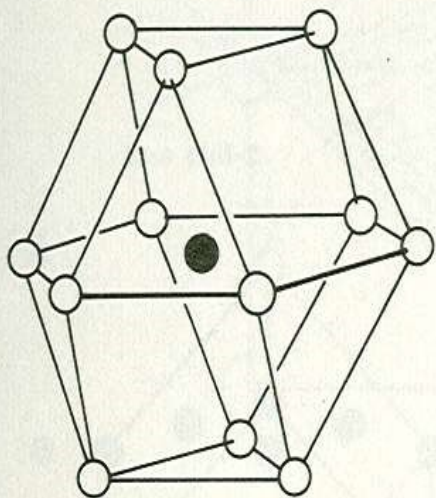


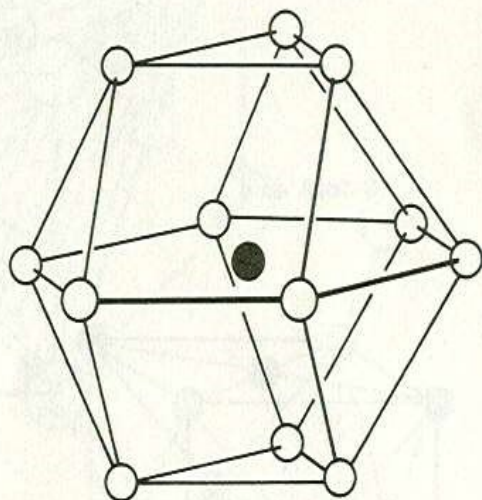
Fig. 1.17 Hexagonal unit cell of a h.c.p. arrangement of spheres



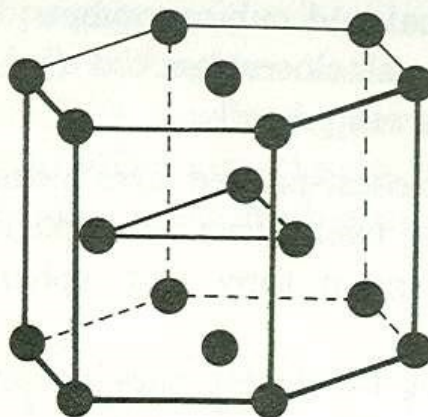
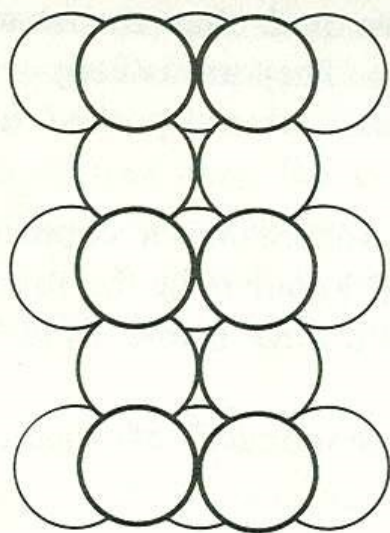
Se ven aquí los huecos tetraédricos y octaédricos?
Cuéntelos



(a)



(b)

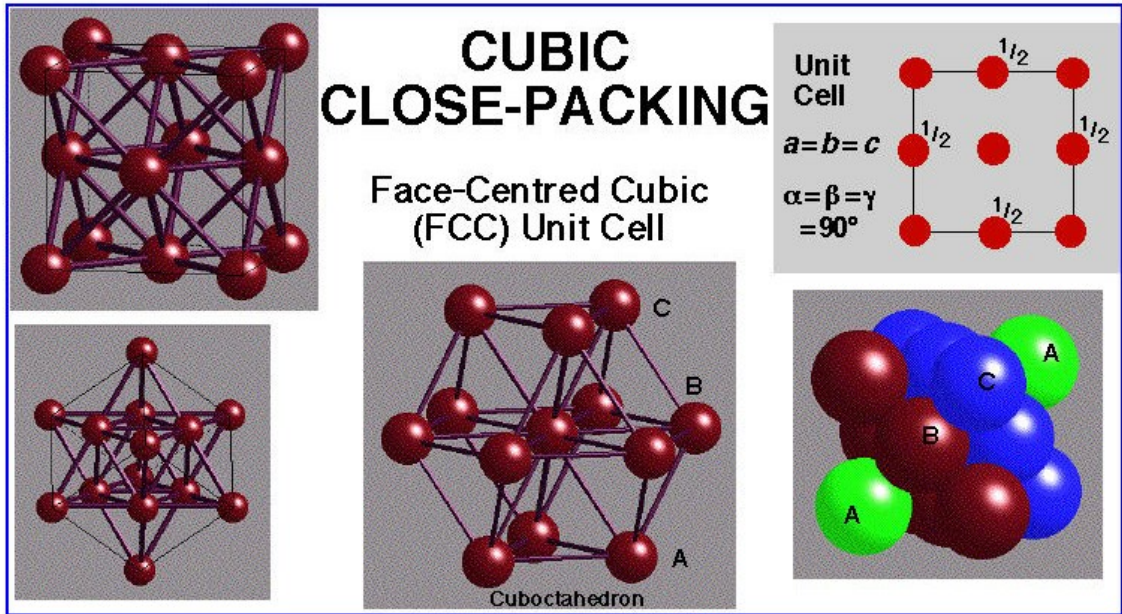


A

B

A

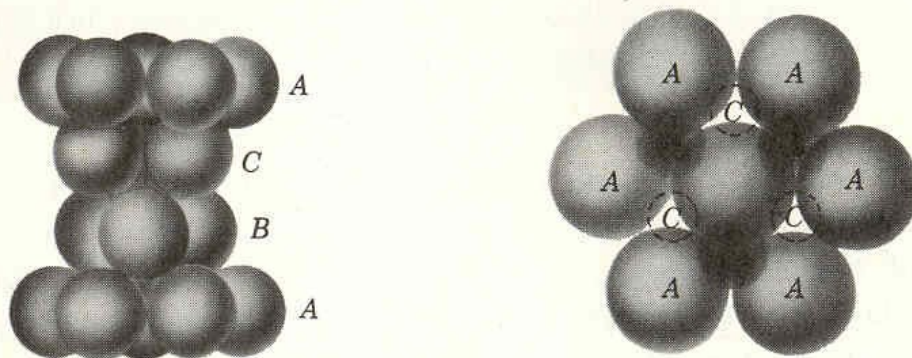
(a)



4 atoms in the unit cell $(0, 0, 0)$ $(0, 1/2, 1/2)$ $(1/2, 0, 1/2)$ $(1/2, 1/2, 0)$

El arreglo ABCABC da lugar a un empacamiento cúbico. La celda unitaria es cúbica de caras centradas con $a=b=c$ y con ángulos $\alpha=\beta=\gamma=90^\circ$. Los cuatro átomos de la celda unitaria están en $(0, 0, 0)$ $(0, 1/2, 1/2)$ $(1/2, 0, 1/2)$ $(1/2, 1/2, 0)$

Empacamiento cúbico compacto



(c) Two views of the $ABCABC\dots$ stacking of octahedral planes.

Figure 1.18 Several aspects of the hard-sphere model of a face-centered cubic metal such as copper. (After *W. D. Kingery and L. V. Azároff.*)

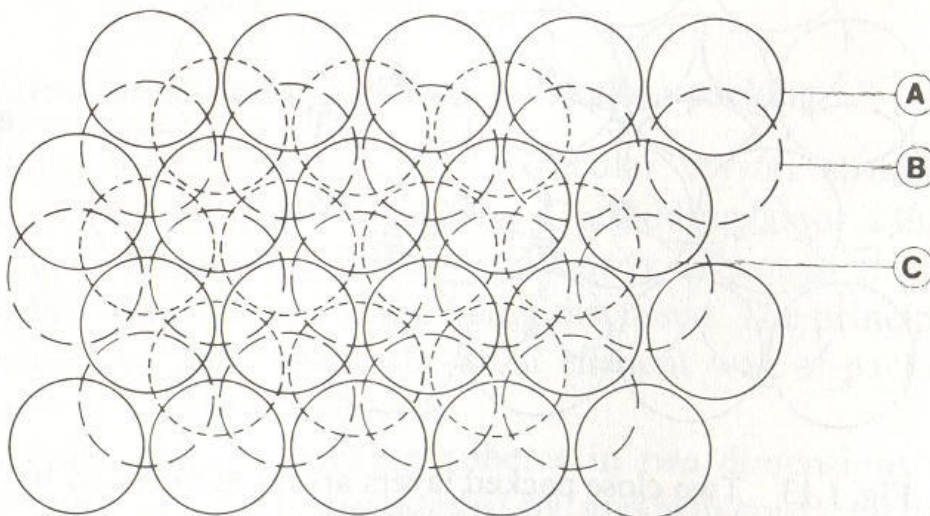
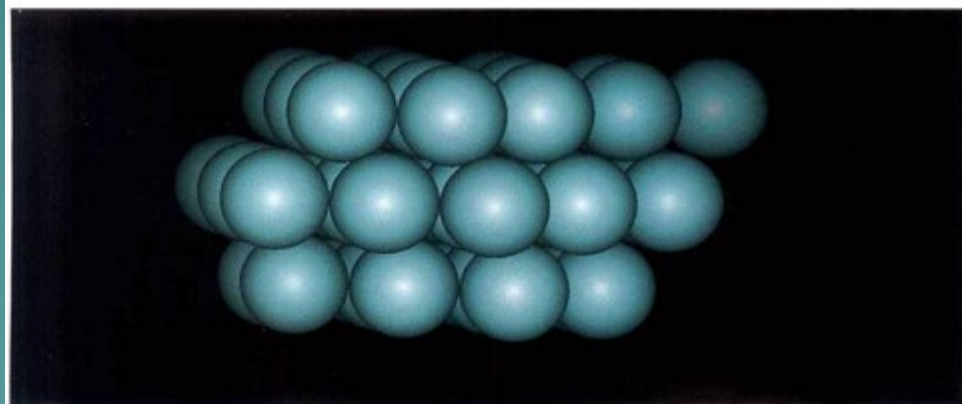
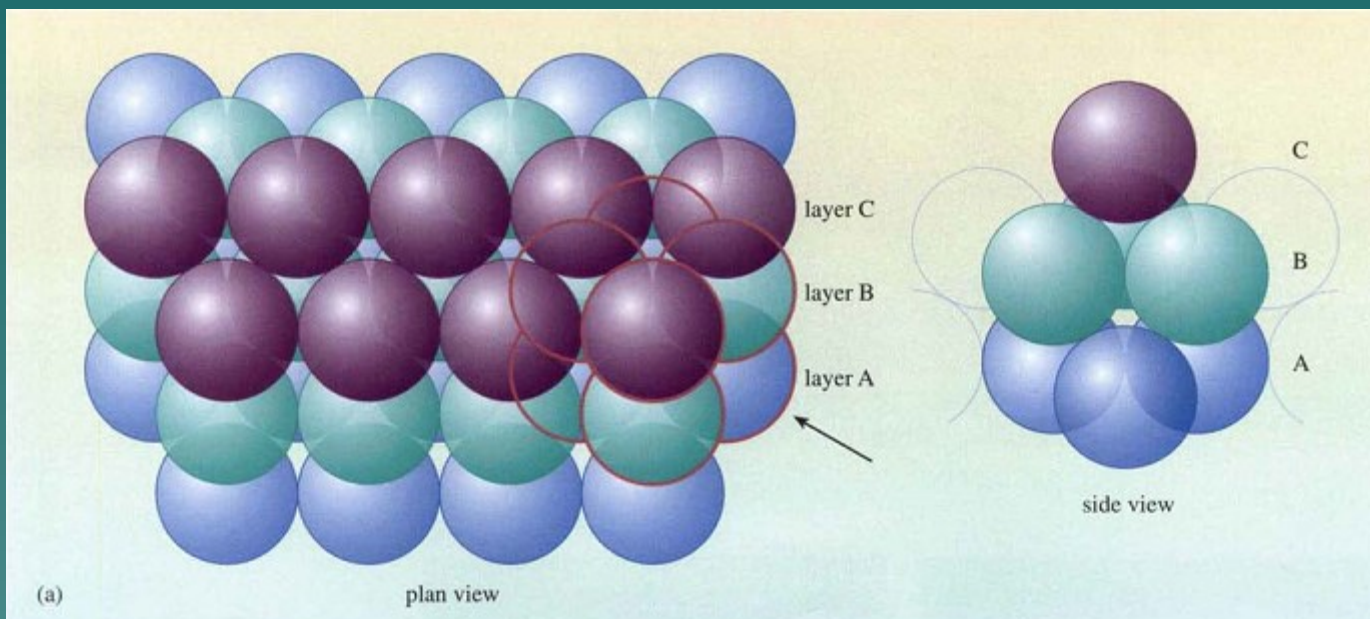

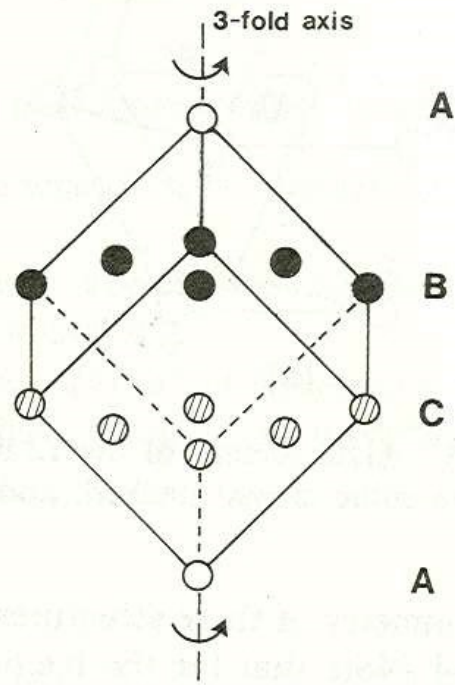
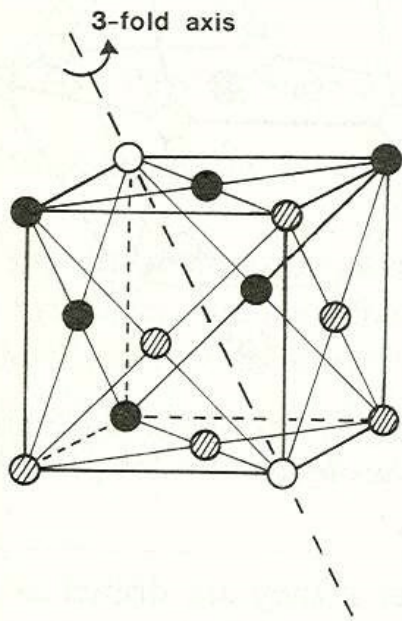


Fig. 1.14 Three close packed layer in c.c.p. sequence

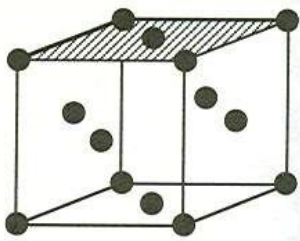


(b)

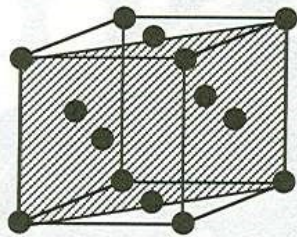
Figure 2.10
 (a) Three layers of close-packed spheres in a cubic close-packed, *ccp*, arrangement, shown in plan view and side view (of spheres outlined in red from arrowed direction);
 (b) computer representation of three *ccp* layers. 



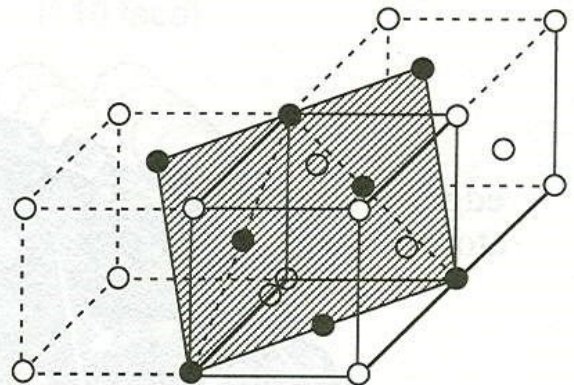
(b)



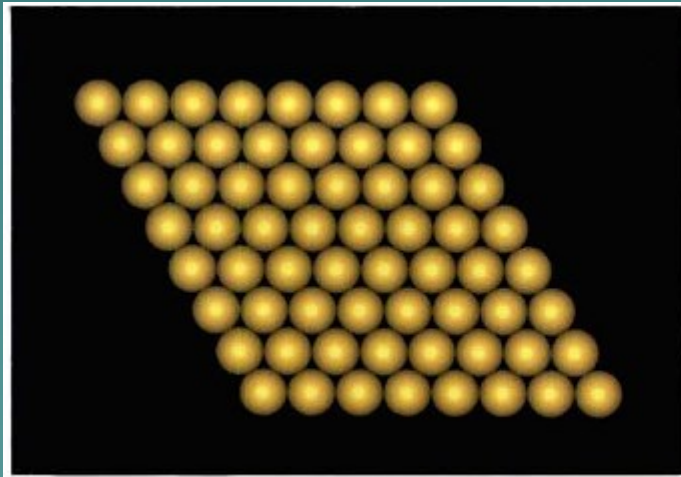
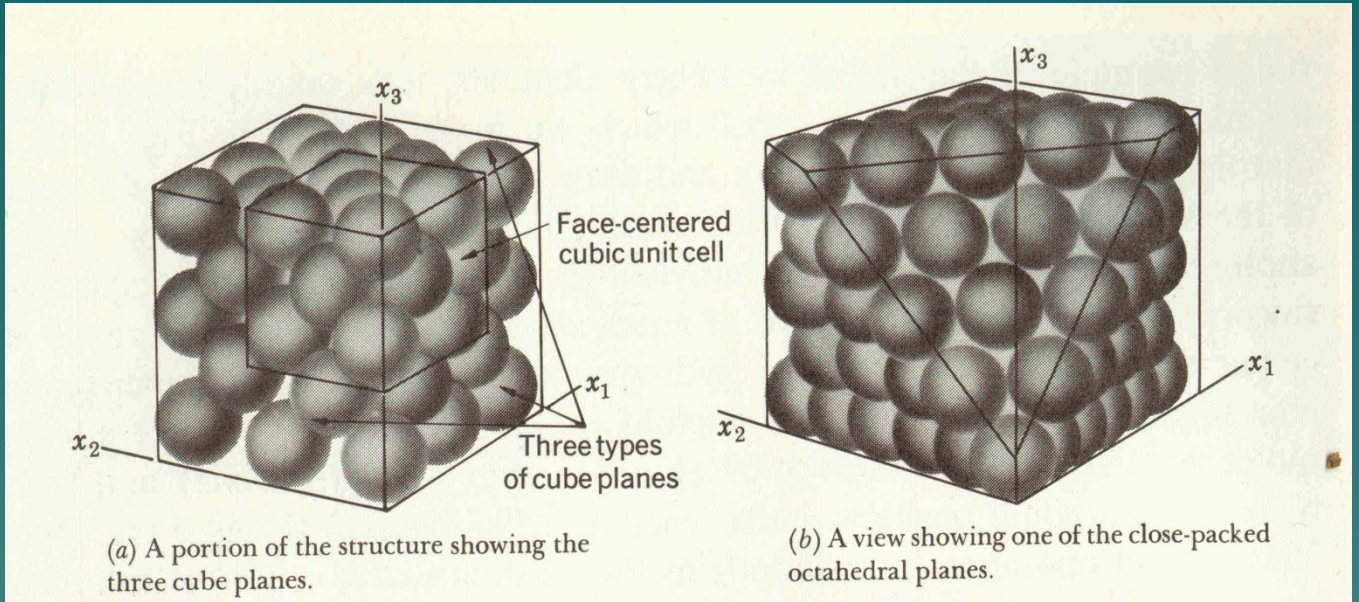
(001)



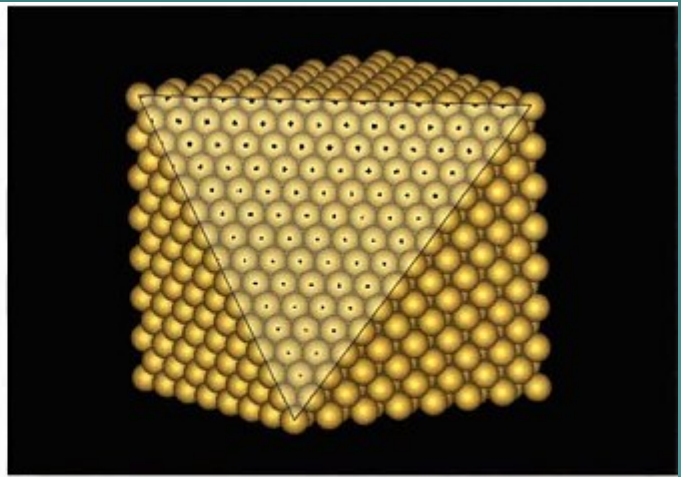
(110)




(111)

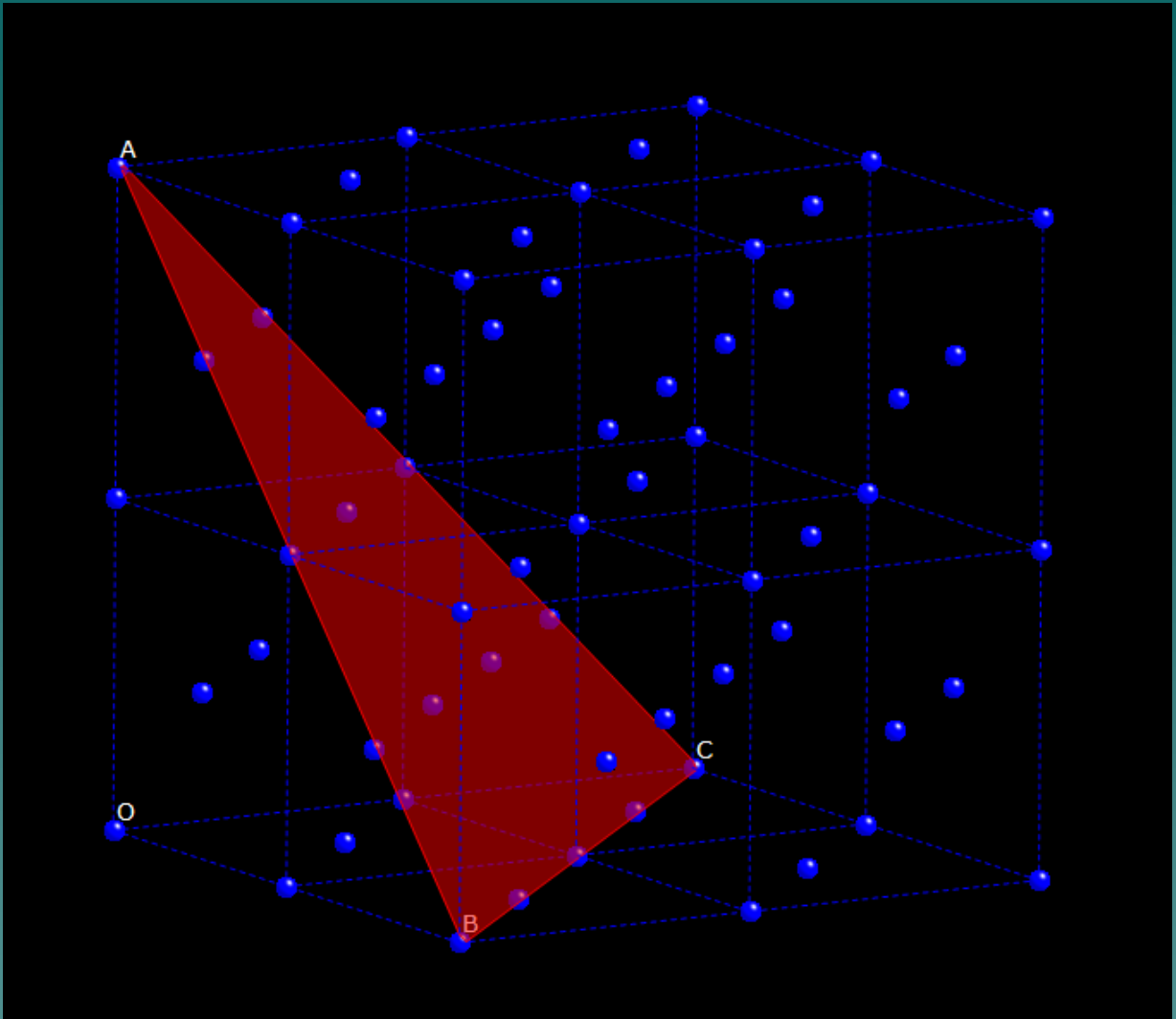


(a)

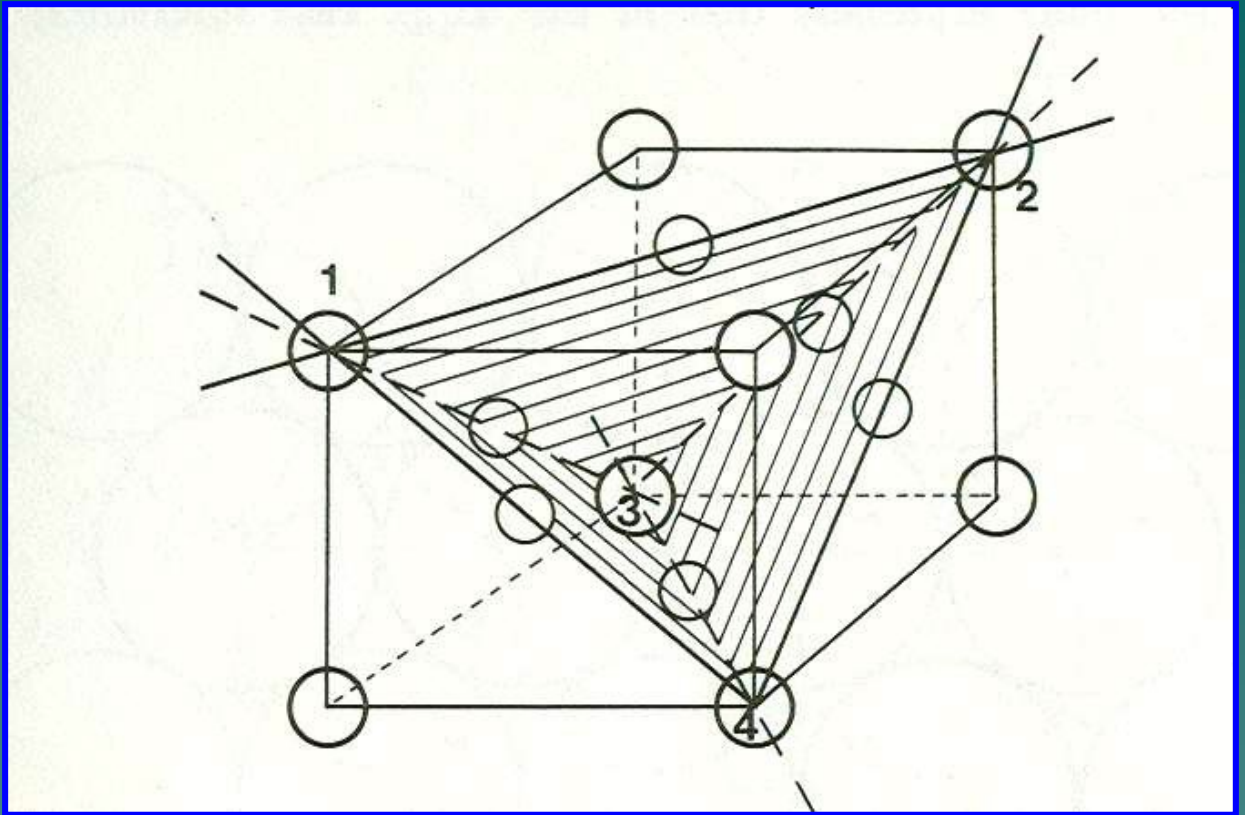


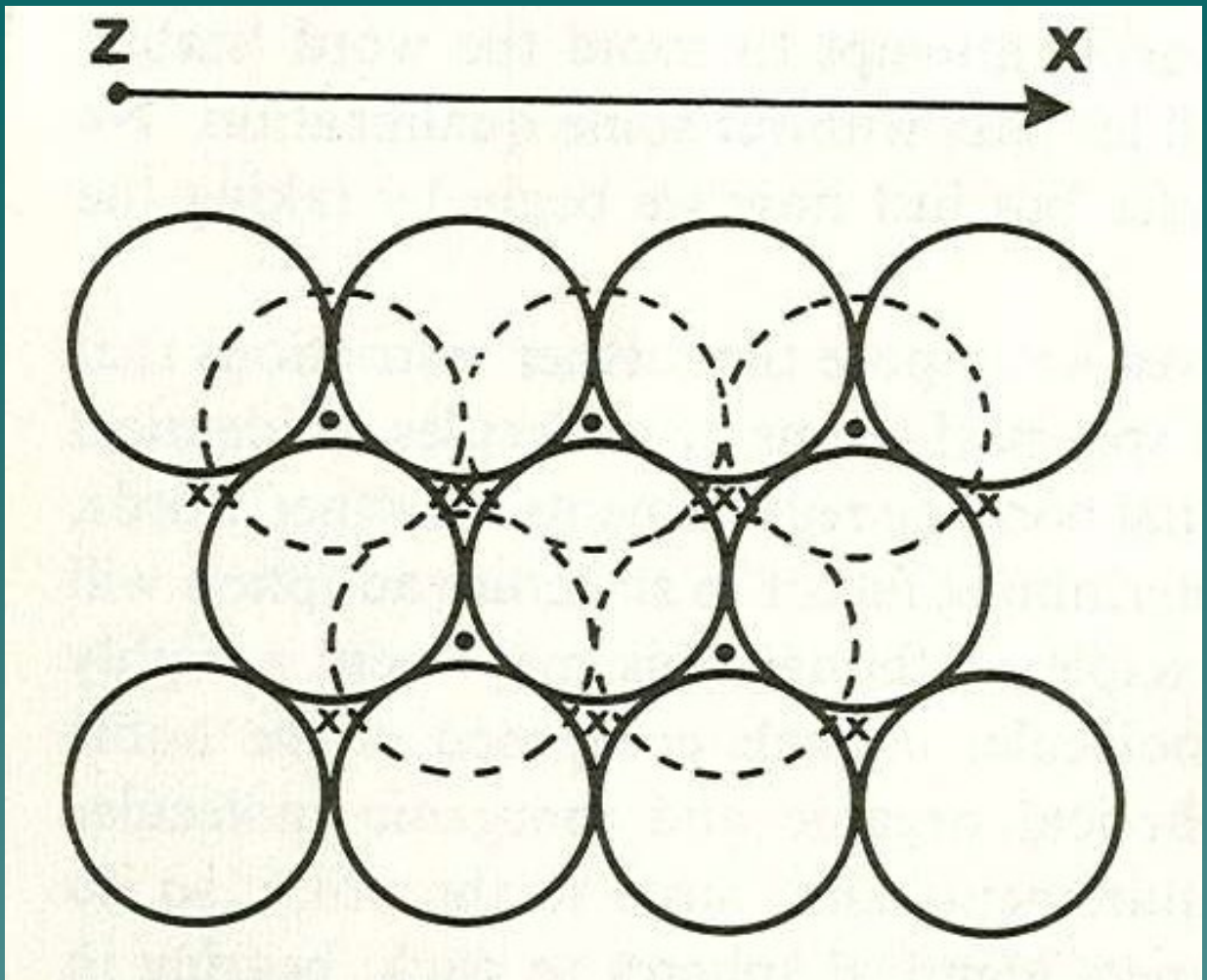
(b)

Figure 2.11 The structure of gold: (a) close-packed layer; (b) position of close-packed layer (toned triangle) in a cubic crystal. 



Celda FCC donde se puede ver el empacamiento hexagonal

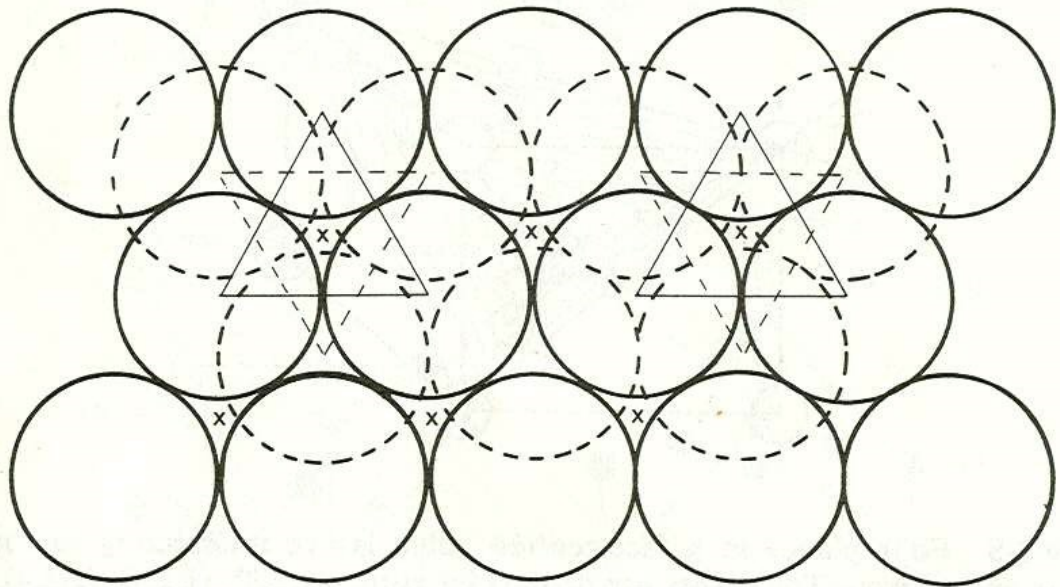




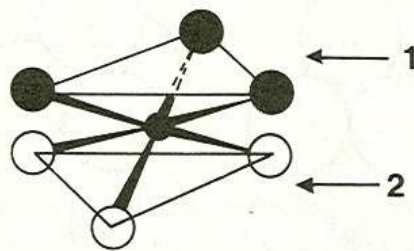
En esta estructura, puede usted estimar el número de huecos tetraédricos que se forman por cada una de las esferas de la primera camada (las oscuras) ?, N

Y cuántos huecos octaédricos por cada esfera de la misma camada??

Ya notó que alrededor de cada una de las esfera de las empacadas existen 8 huecos tetraédricos y 6 octaédricos ?

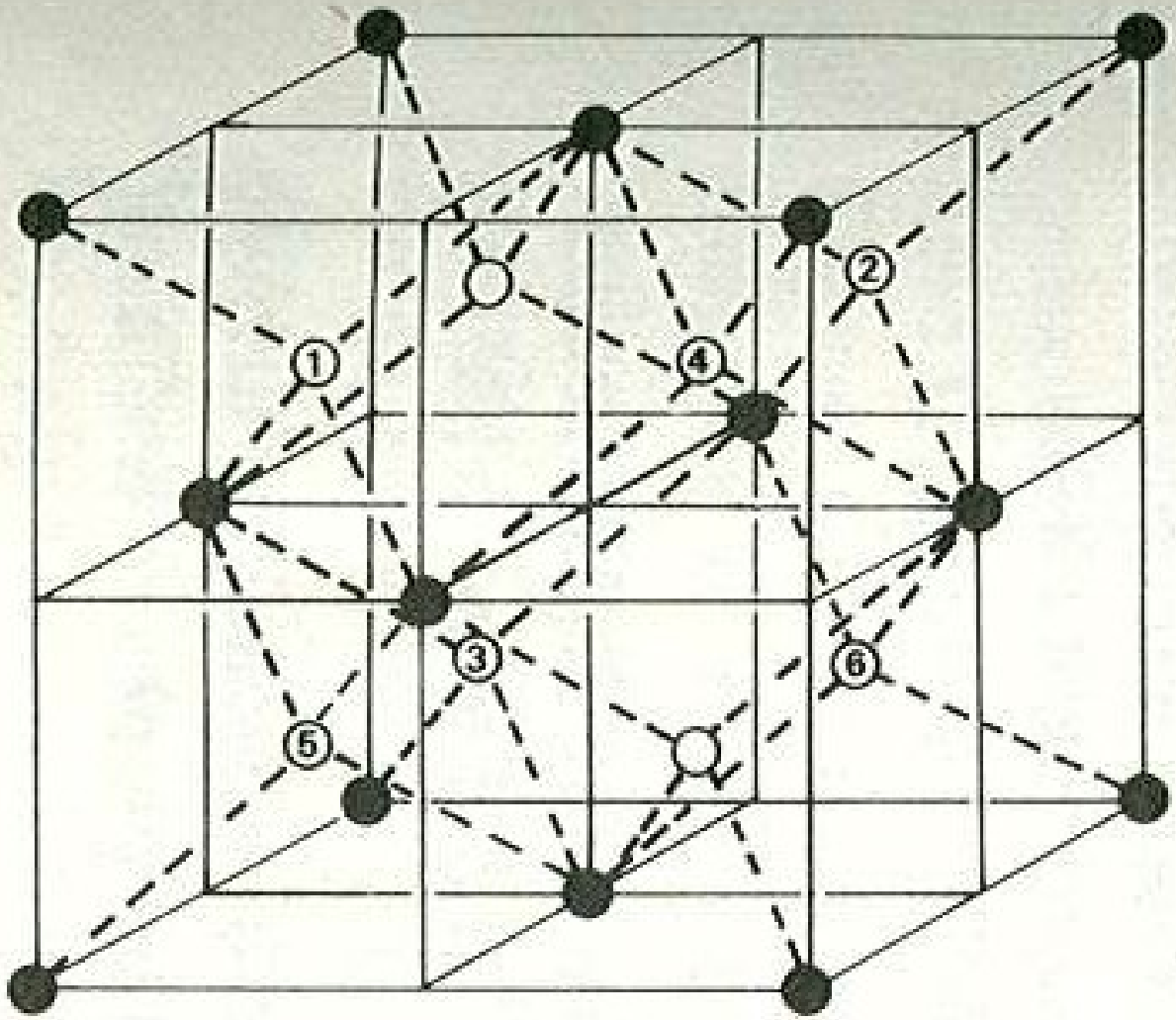


(a)



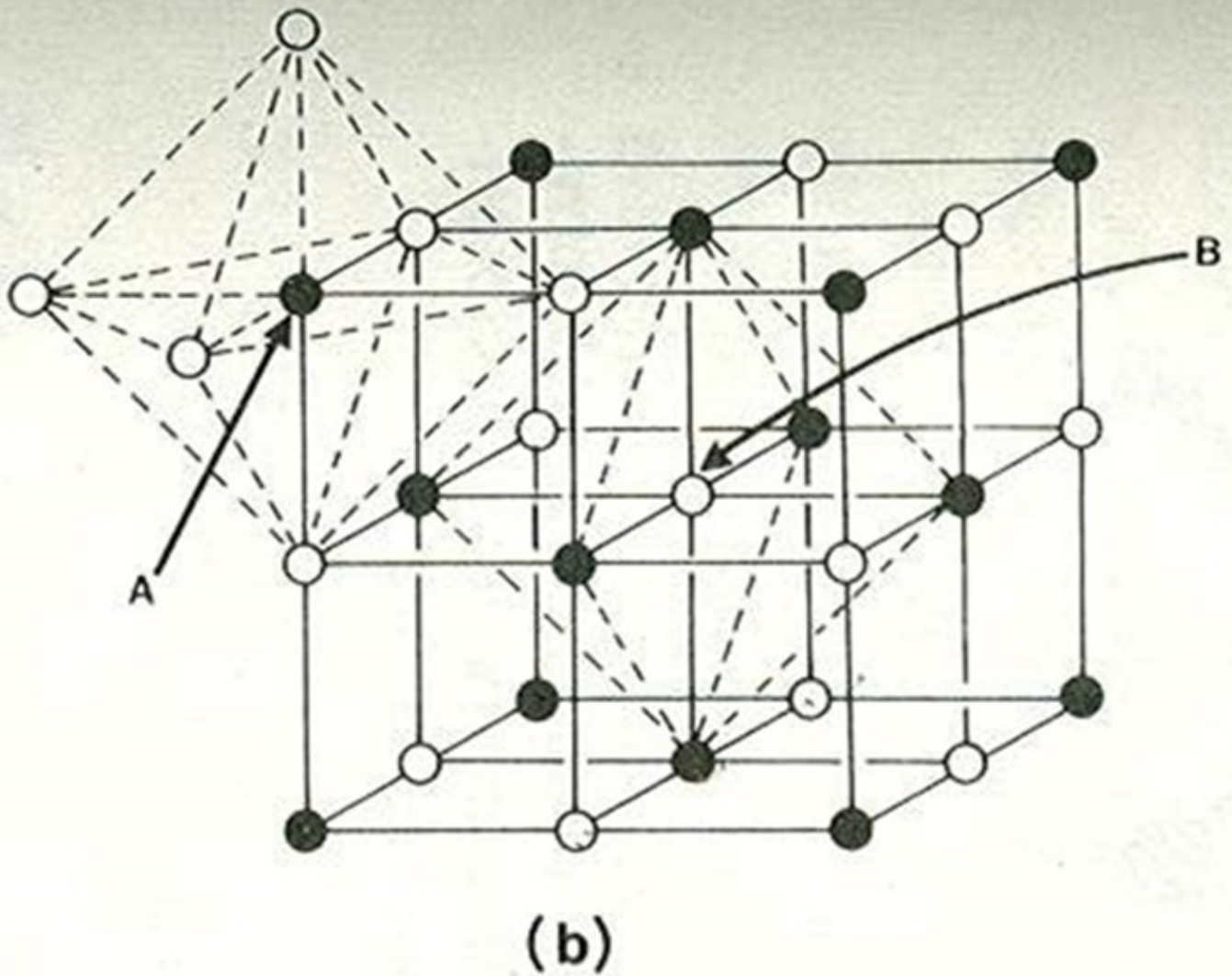
(b)

Figure 3-7 (a) Occurrence of octahedral sites (X) between a pair of closest-packed layers. (b) Detail of one such site. Note that three of the six atoms defining each site come from each layer



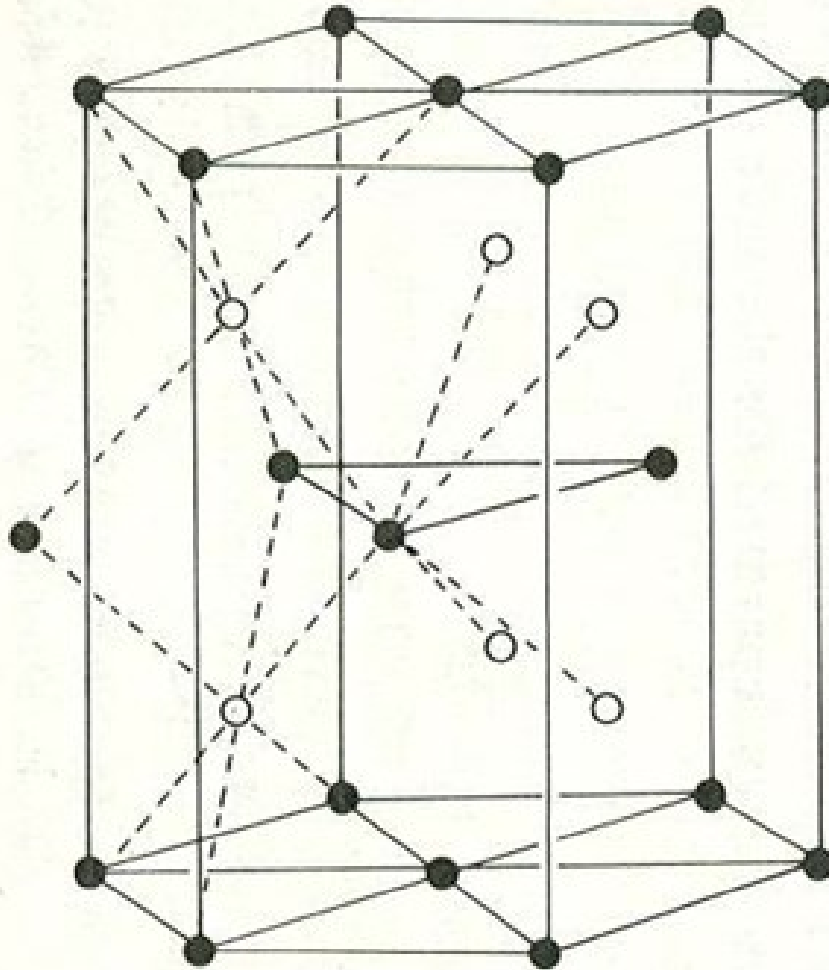
(a)

a) Huecos tetraédricos en cúbica F (CCP)



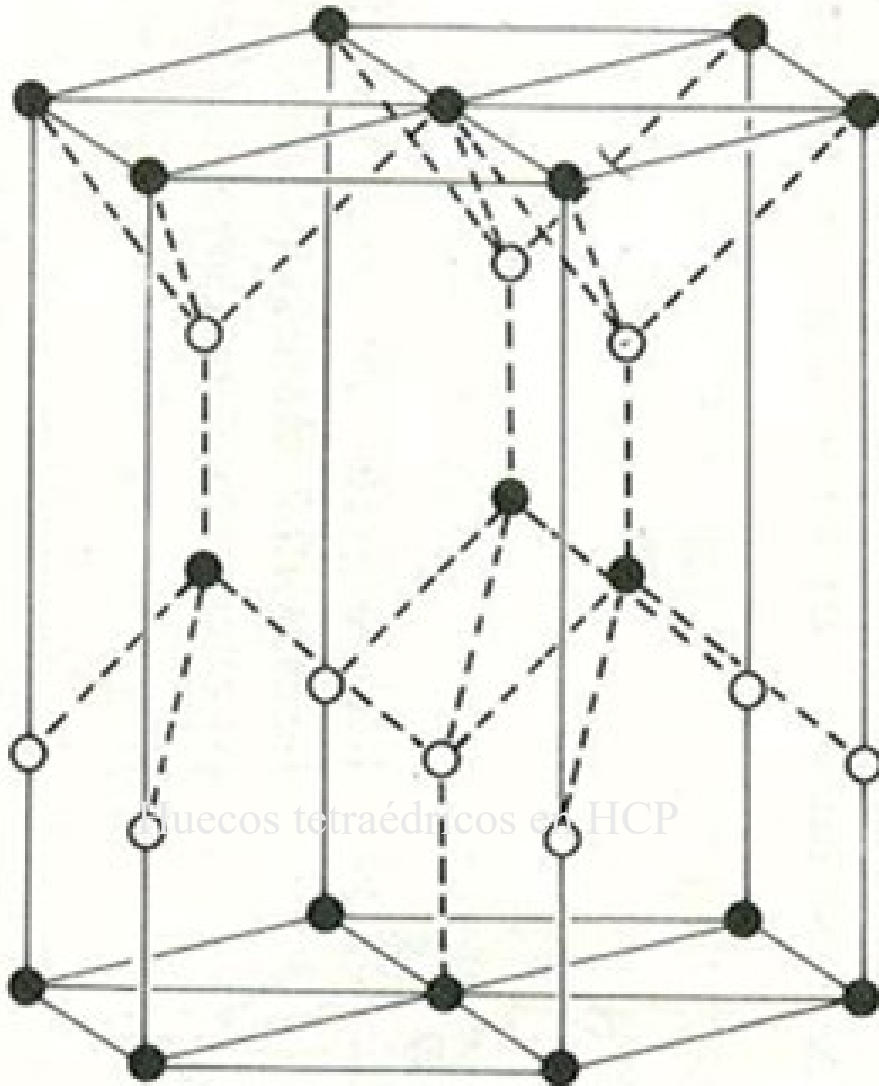
a) Huecos octaédricos en cúbica F (CCP)

Huecos octaédricos en cúbica F
(CCP)



(c)

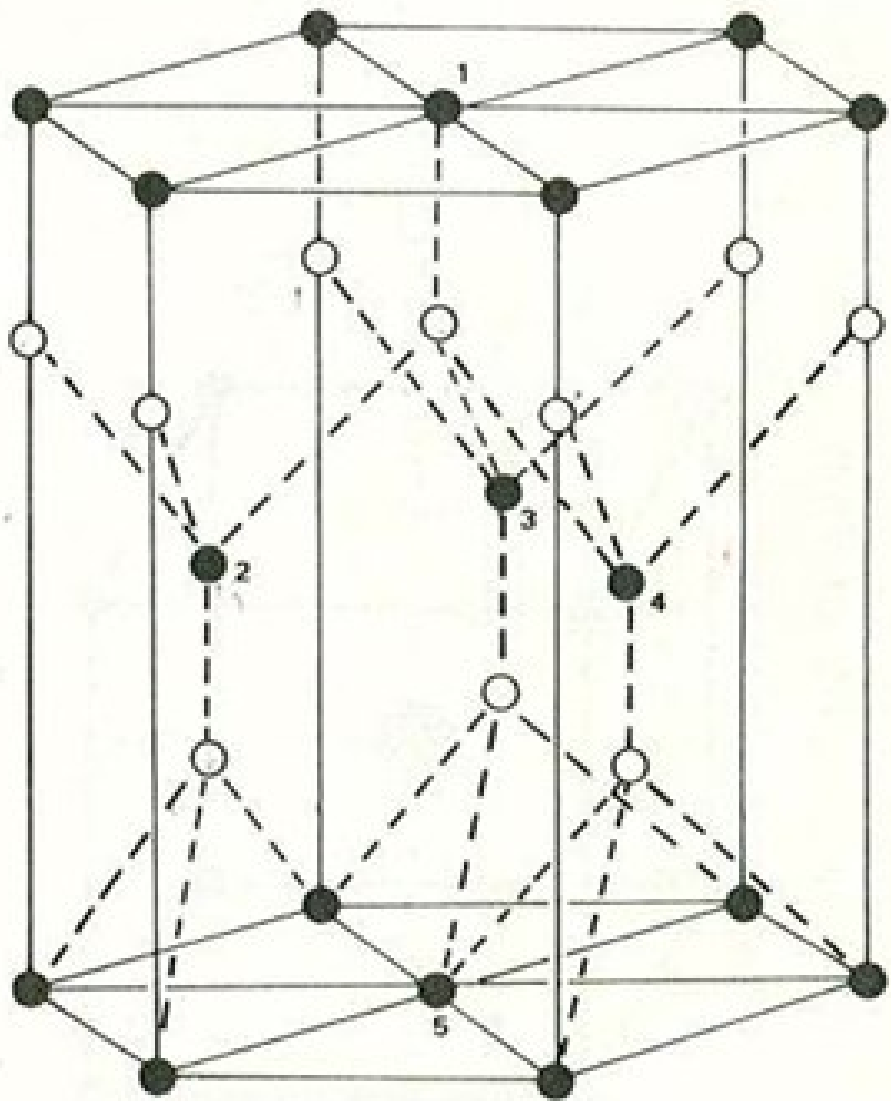
Huecos octaédricos en HCP



Huecos tetraédricos en HCP

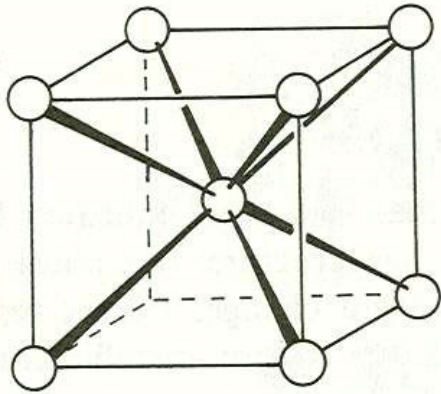
(d)

Huecos tetraédricos en HCP

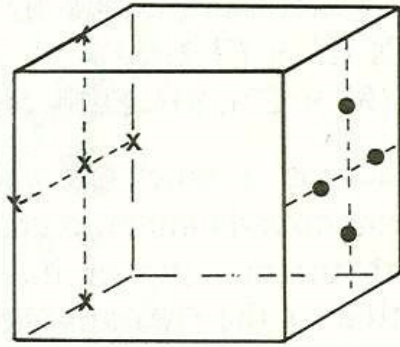


(e)

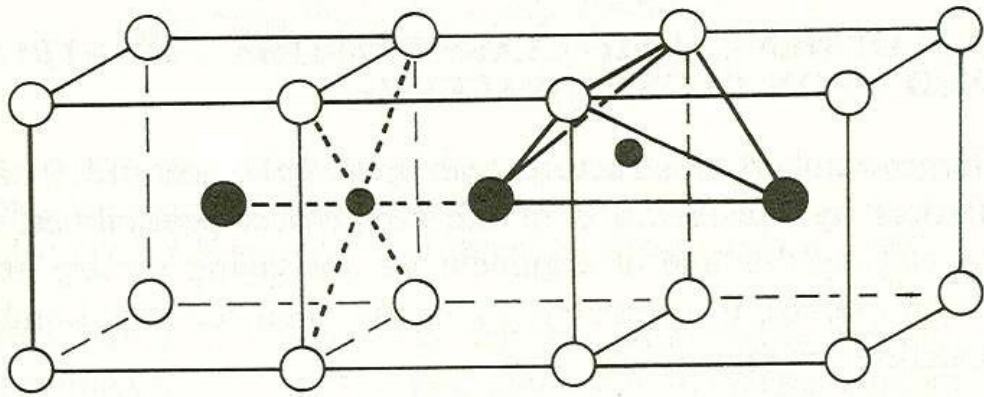
Huecos tetraédricos en HCP



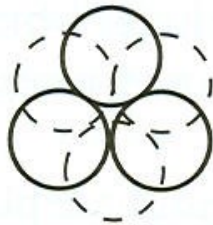
(a)



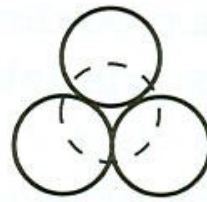
(b)



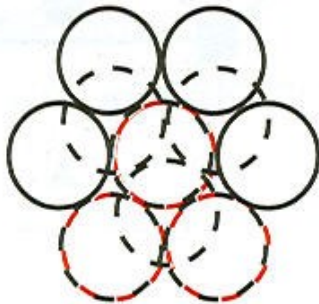
(c)



Octahedral



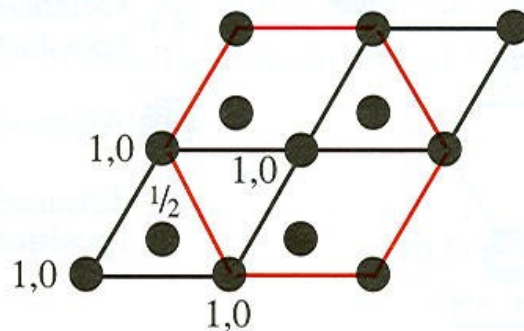
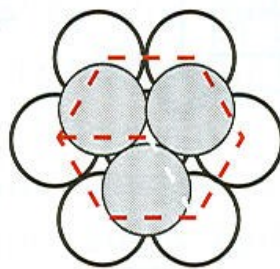
Tetrahedral

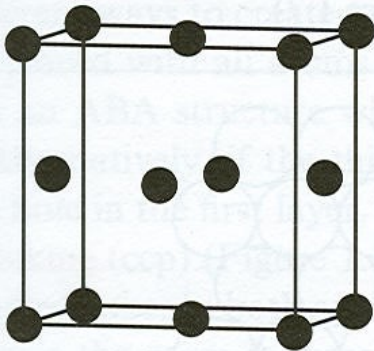
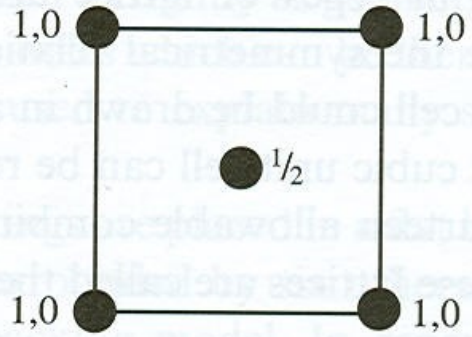
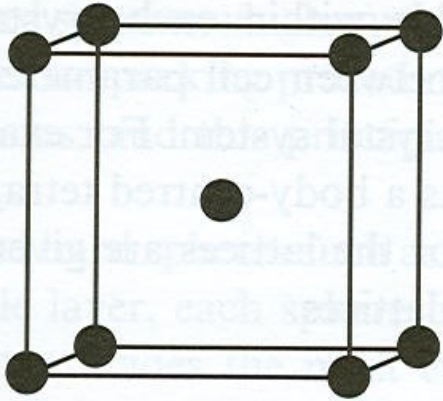


ABABABAB
Two-layer repeat
Hexagonal close-packed

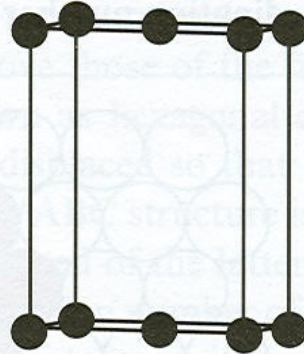


ABCABCABC
Three-layer repeat
Cubic close-packed





i

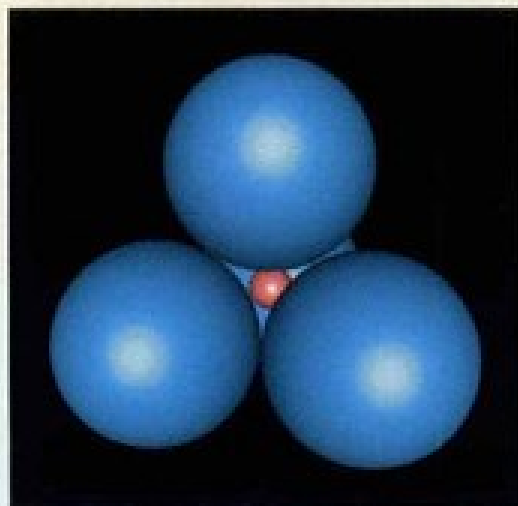
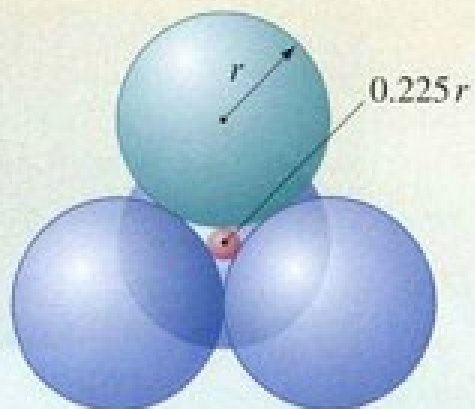


ii

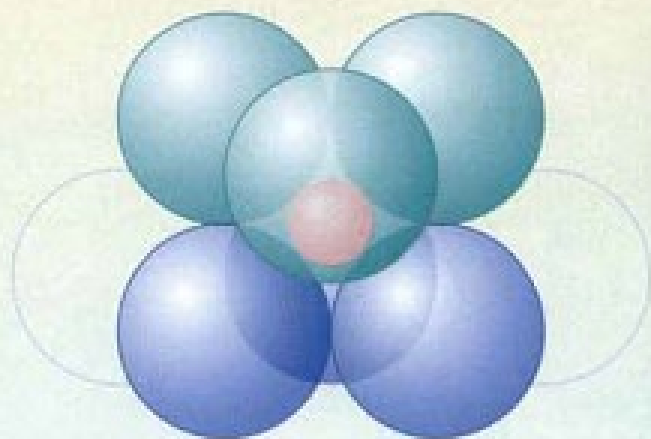
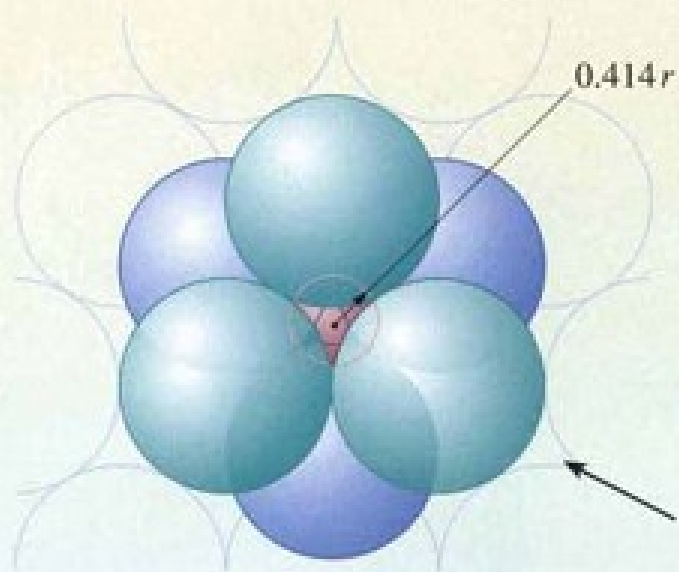
Table 1.4 Bravais lattices

<i>Crystal system</i>	<i>Lattice types</i>
Cubic	P, I, F
Tetragonal	P, I
Orthorhombic	P, C, I, F
Monoclinic	P, C
Triclinic	P
Hexagonal	P
Trigonal (rhombohedral)	P*

* Often the primitive rhombohedral lattice is referred to as R.



(a)



(b)

plan view

side view

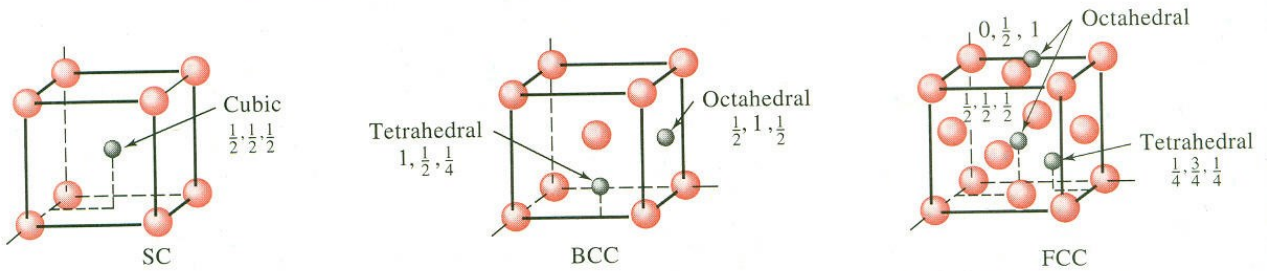
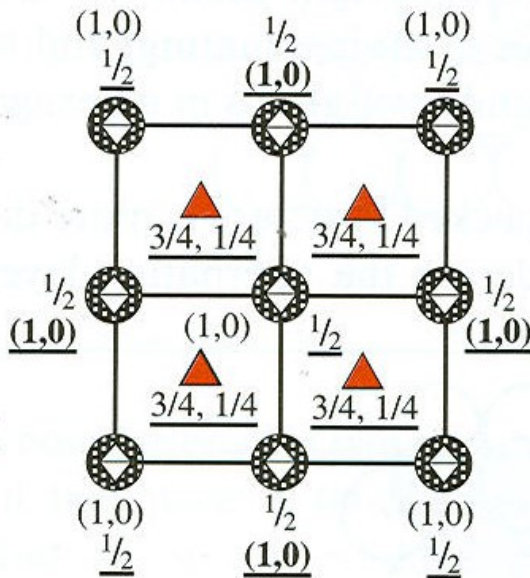
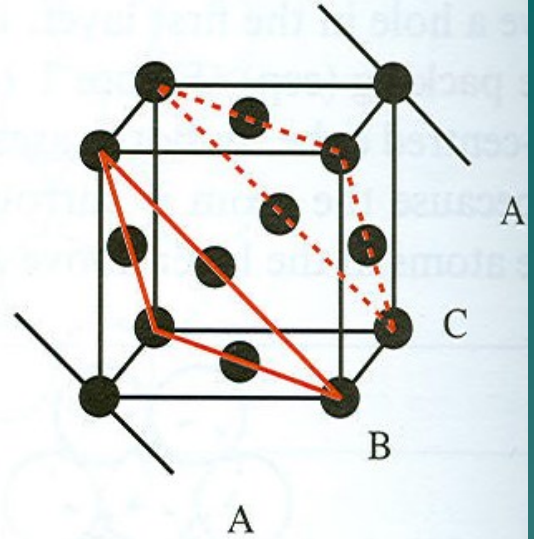
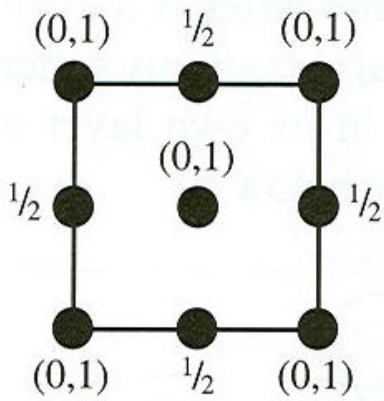





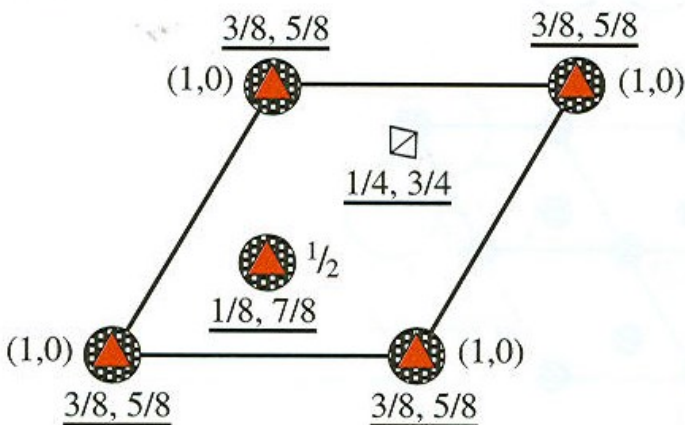
FIGURE 3-21 The location of the interstitial sites in cubic unit cells. Only representative sites are shown.




TABLE 3-6 The coordination number and the radius ratio

Coordination Number	Location of Interstitial	Radius Ratio	Representation
2	Linear	0–0.155	
3	Center of triangle	0.155–0.225	
4	Center of tetrahedron	0.225–0.414	
6	Center of octahedron	0.414–0.732	
8	Center of cube	0.732–1.000	

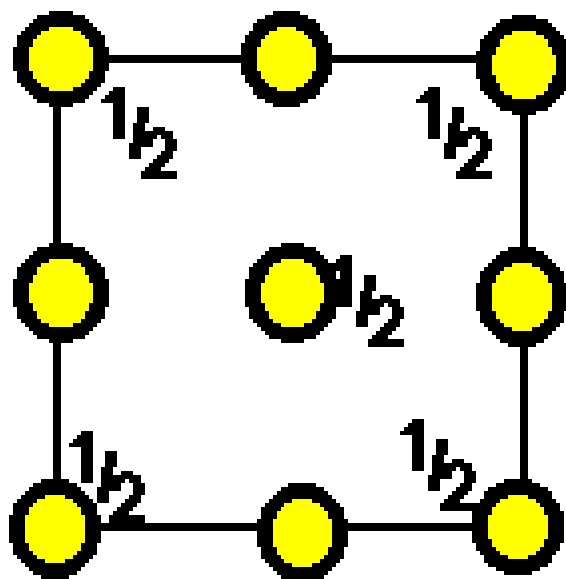
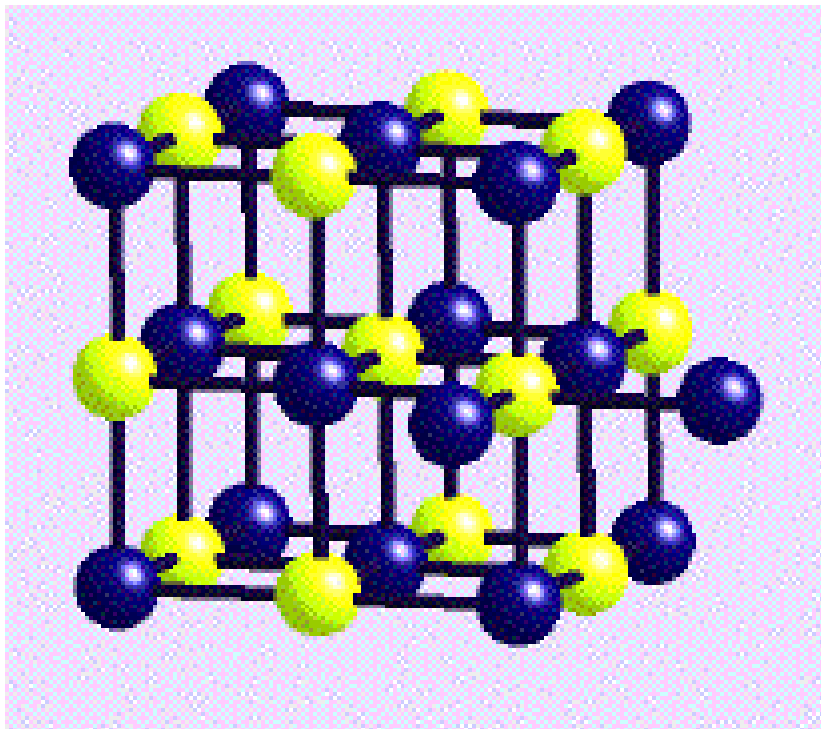


-  Octahedral hole (positions – underlined numbers)
-  Atoms or ions
-  Tetrahedral hole (positions – underlined)



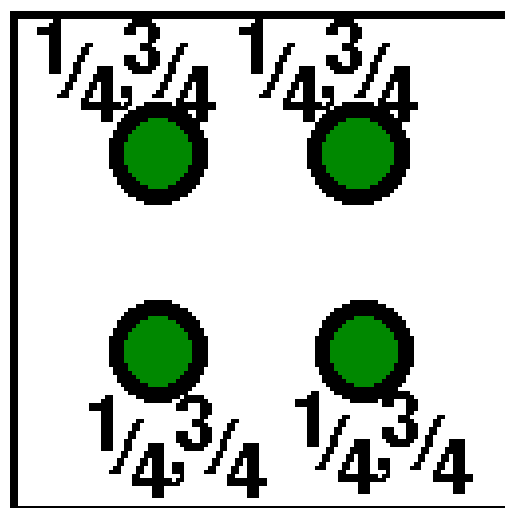
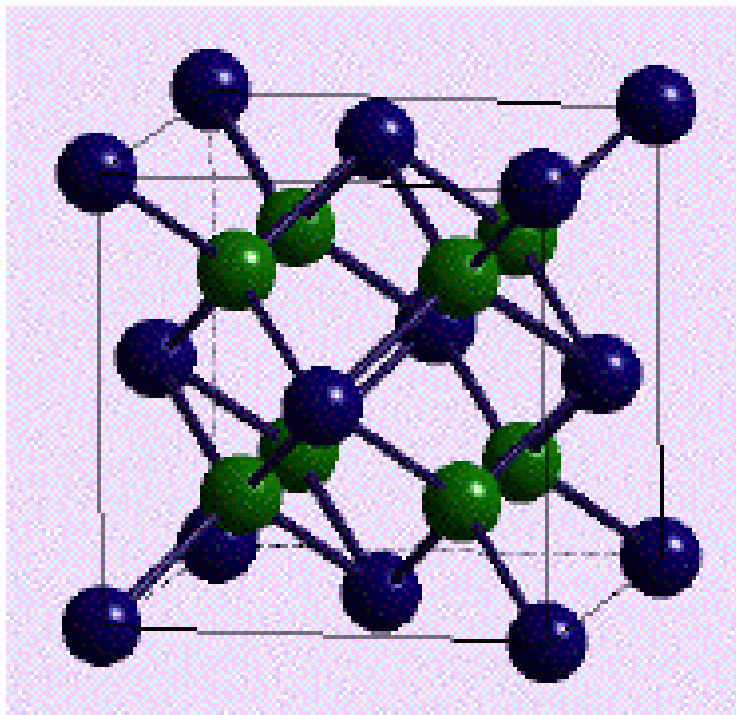
-  Octahedral hole (positions – underlined numbers)
-  Atoms or ions
-  Tetrahedral hole (positions – underlined)

CCP



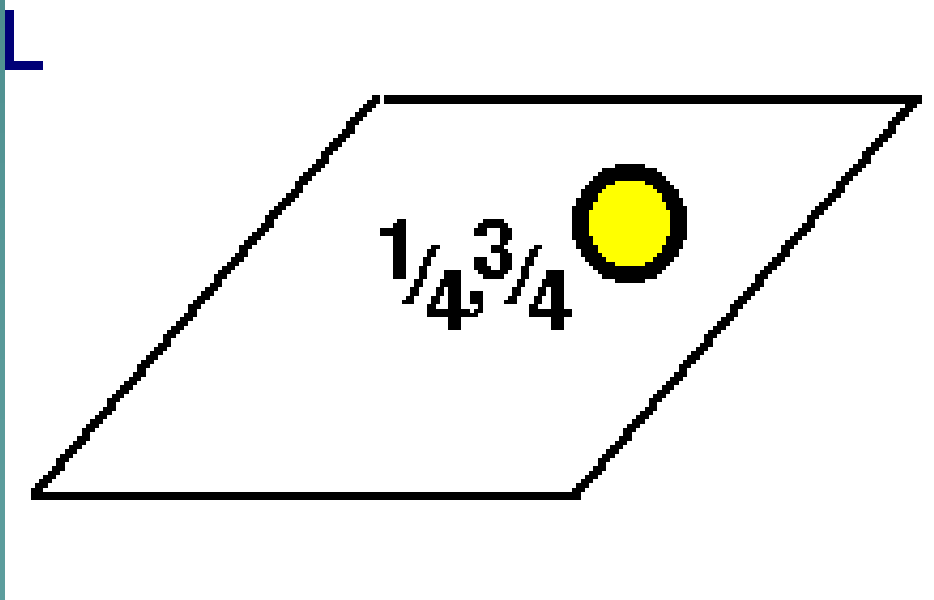
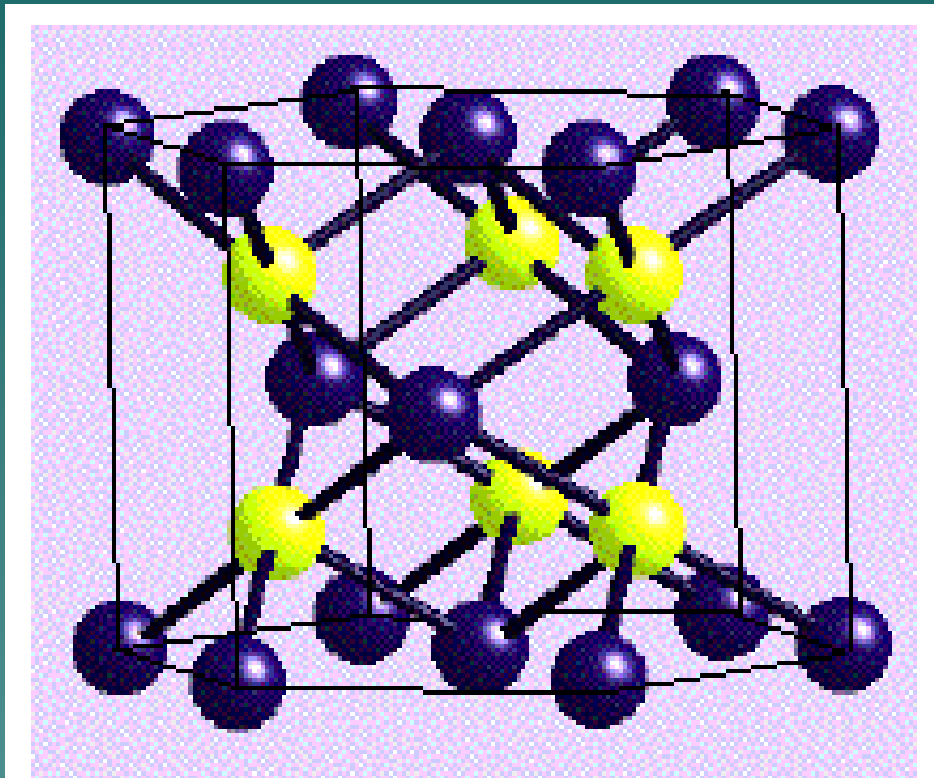
0

Localización de huecos tetraédricos en CCP



TET
2

Huecos octaédricos en HCP



Localización de huecos tetraédricos en HCP

