



Estruturas Cerâmicas

- Cristais
- Defeitos
- Vidros



Caráter da ligação química

Table 12.1 For Several Ceramic Materials, Percent Ionic Character of the Interatomic Bonds

<i>Material</i>	<i>Percent Ionic Character</i>
CaF ₂	89
MgO	73
NaCl	67
Al ₂ O ₃	63
SiO ₂	51
Si ₃ N ₄	30
ZnS	18
SiC	12

Cerâmicas iônicas - Nc

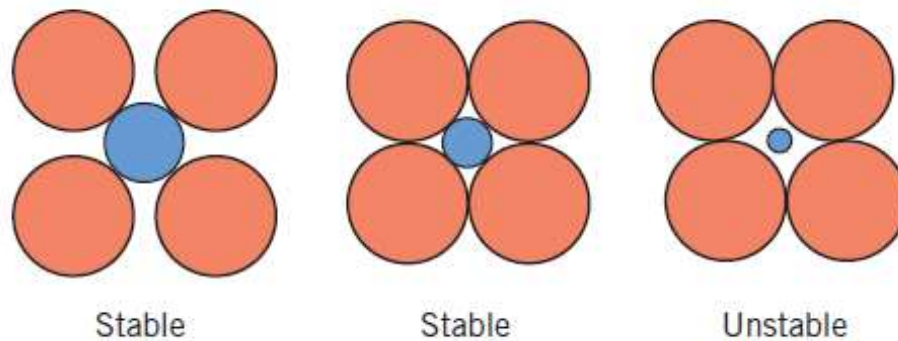

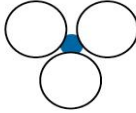
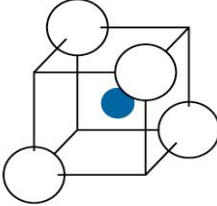

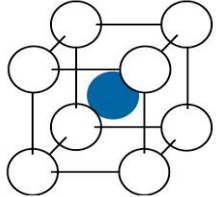


Figure 12.1 Stable and unstable anion–cation coordination configurations. Red circles represent anions; blue circles denote cations.

Estabilidade do arranjo iônico

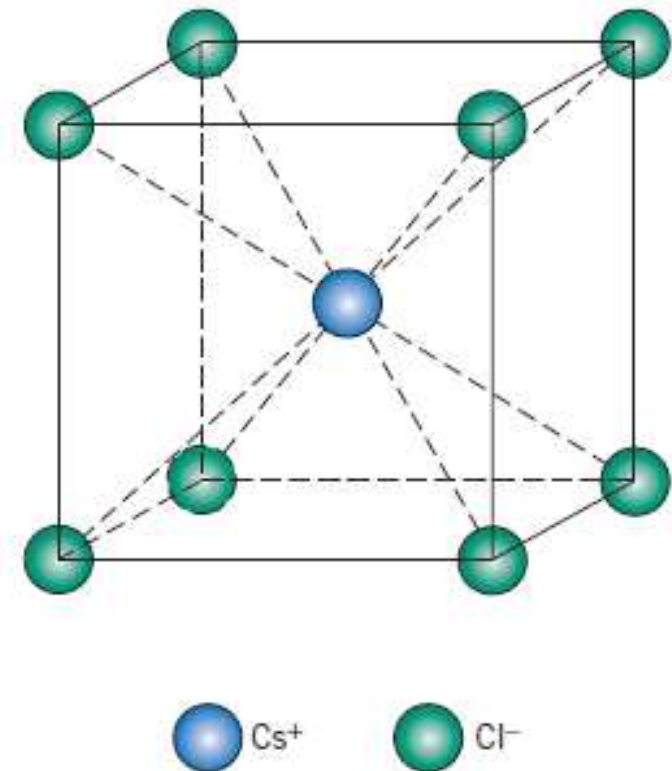
Cerâmicas iônicas - Nc

TABLE 3-6 ■ *The coordination number and the radius ratio*

Coordination Number	Interstitial Location of Number	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	

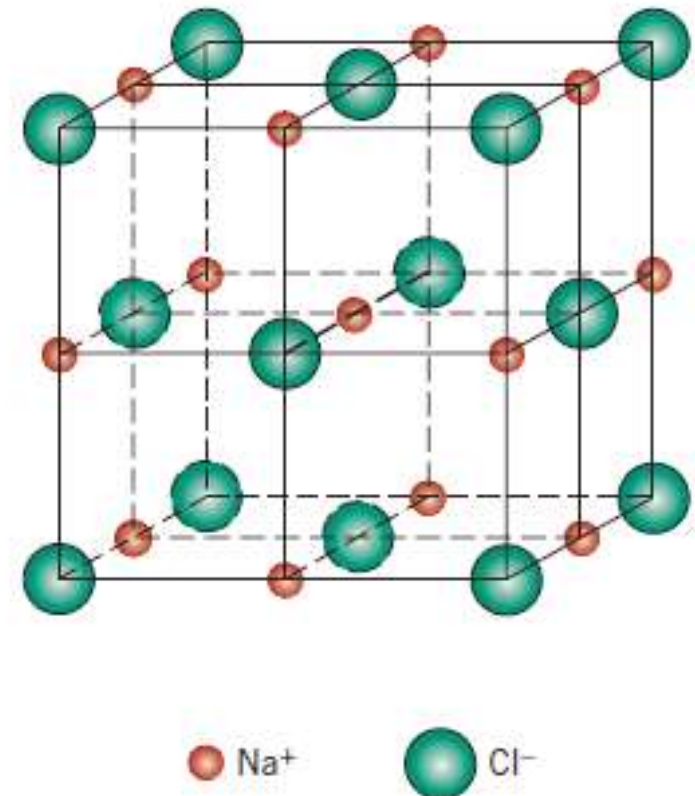
Cloreto de Césio

- CsCl
 - NC = 8
 - Estrutura CS
 - Ânions nos pontos da rede
 - Cátions no interstício cúbico da rede



Sal de cozinha

- NaCl
 - NC = 6
 - Estrutura CFC ([clique aqui](#))
 - Ânions nos pontos da rede
 - Cátions nos interstícios octaédricos da rede





NaCl

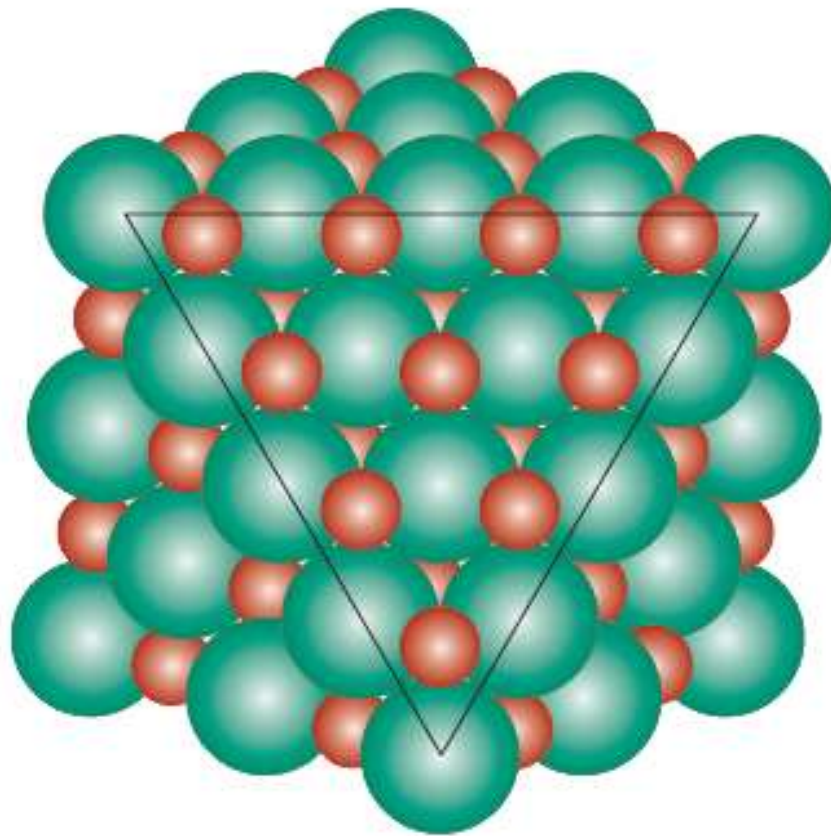
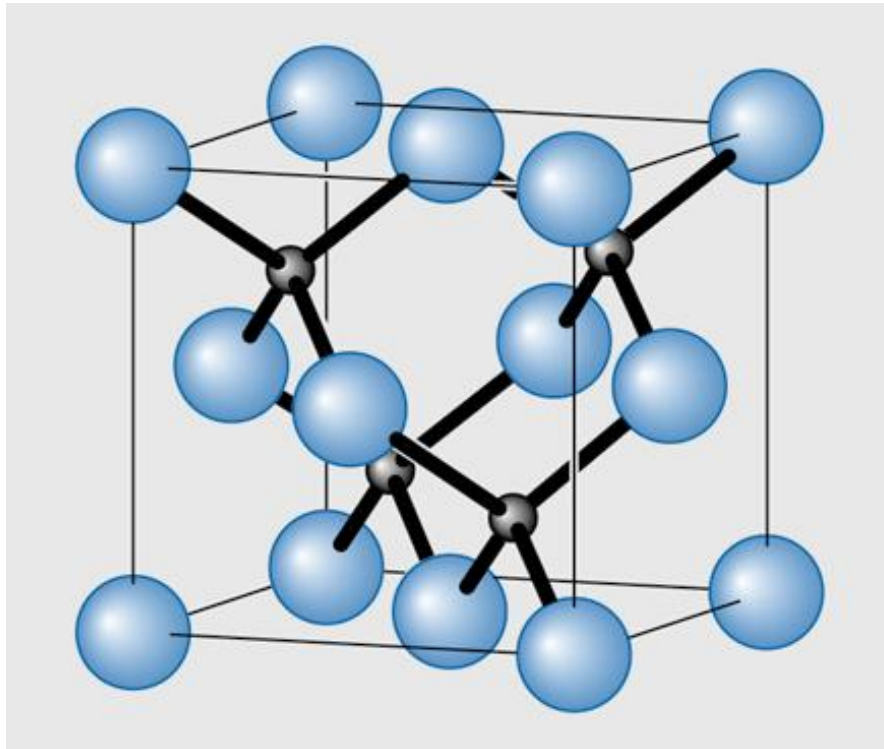
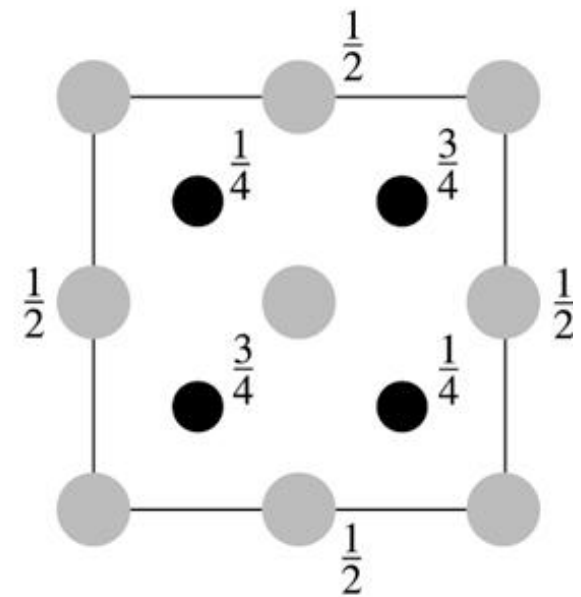


Figure 12.8 A section of the rock salt crystal structure from which a corner has been removed. The exposed plane of anions (green spheres inside the triangle) is a {111}-type plane; the cations (red spheres) occupy the interstitial octahedral positions.

GaAs, ZnS, SiC

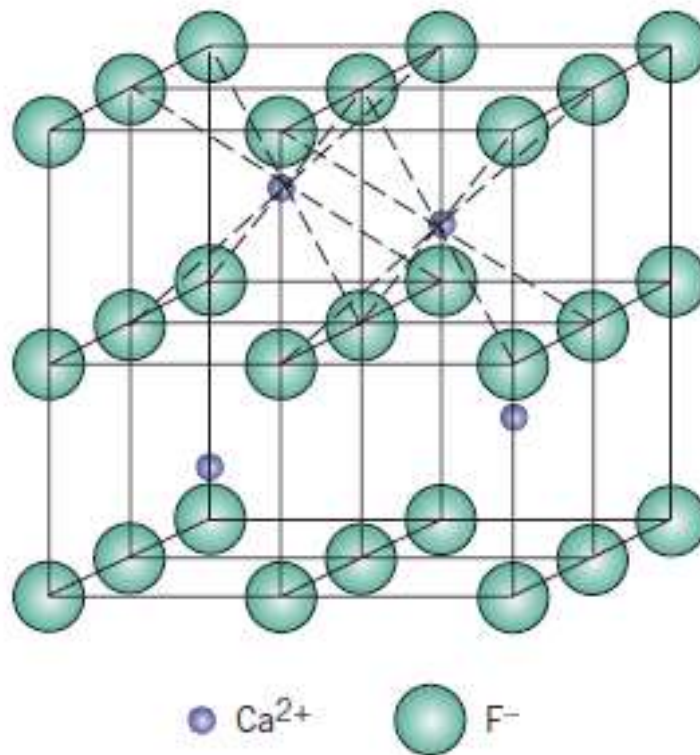


(a)



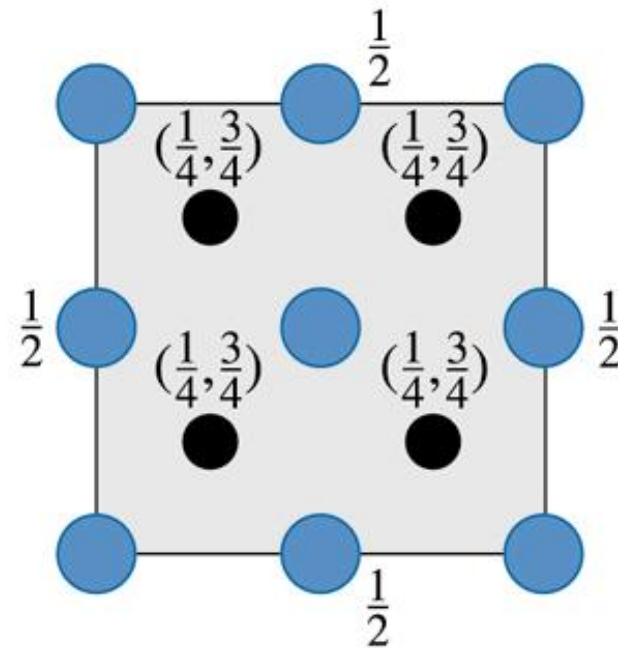
(b)

Fluorita (CaF_2)



Fluorite cell

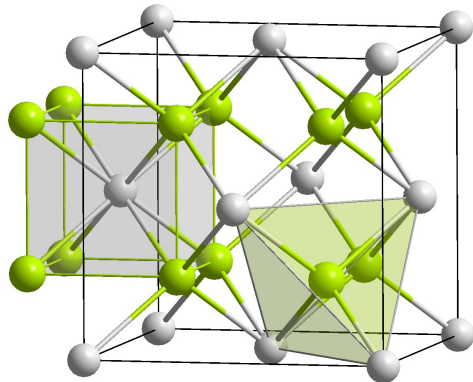
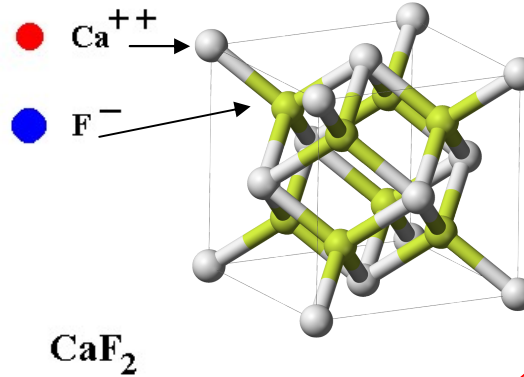
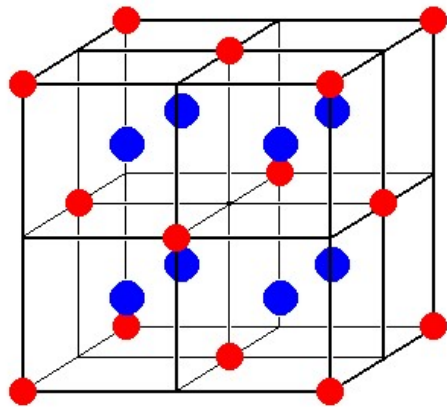
(a)



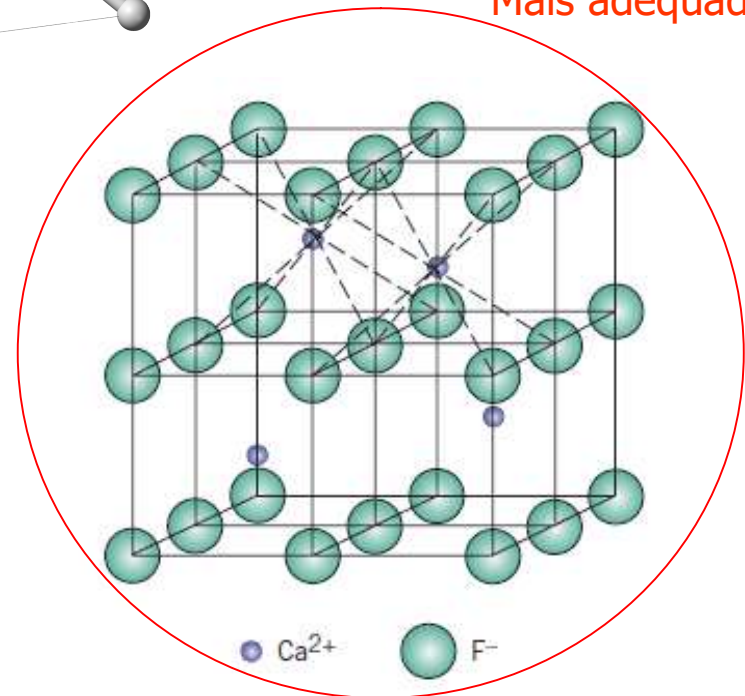
Plan view

(b)

Fluorita (CaF₂)

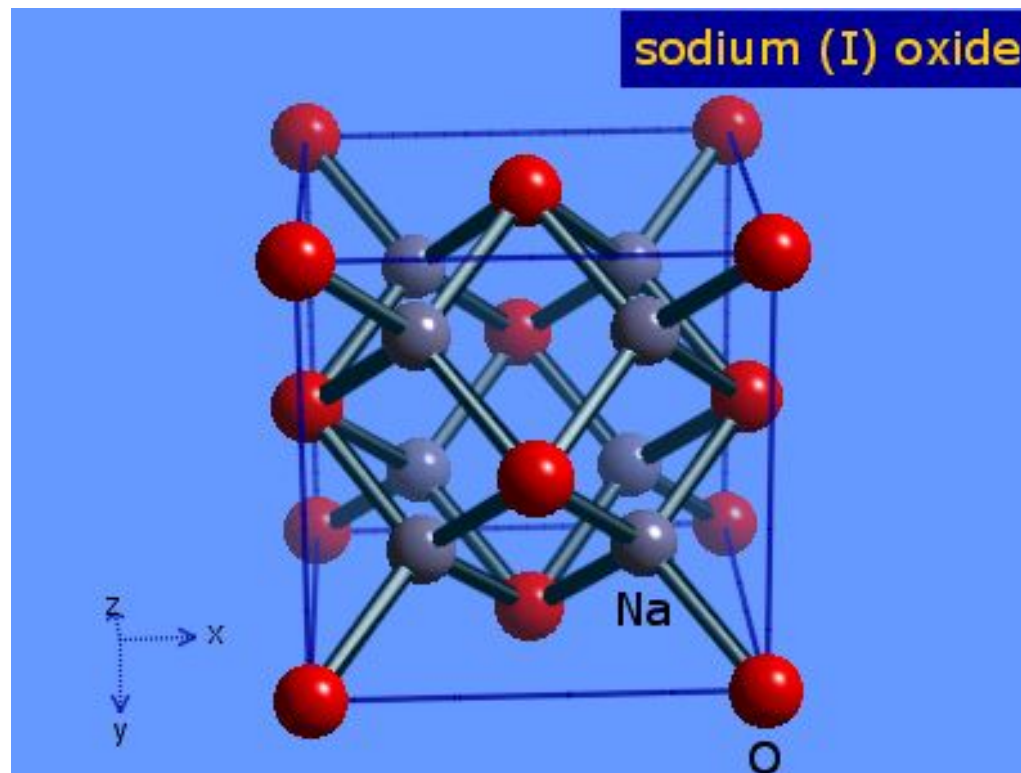


equivalentes

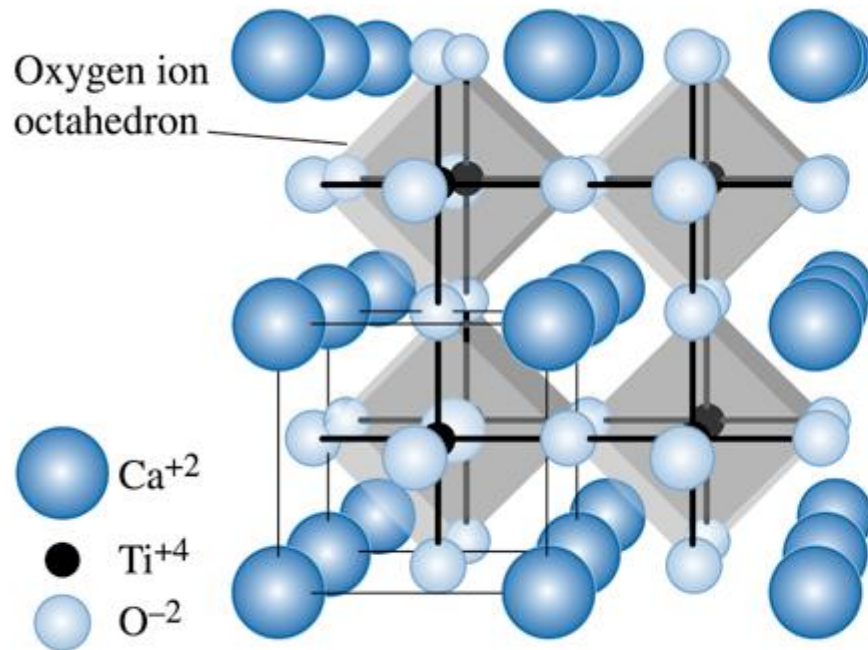


Antifluorita

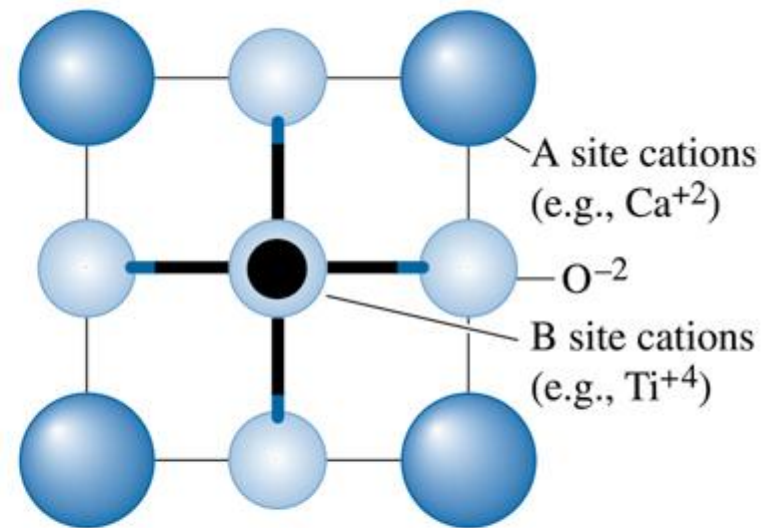
- Ex.: Na_2O



Perovskita, BaTiO₃



Perovskite



Perovskite, plan view

Arranjos compactos de ânions (CFC e HCP)

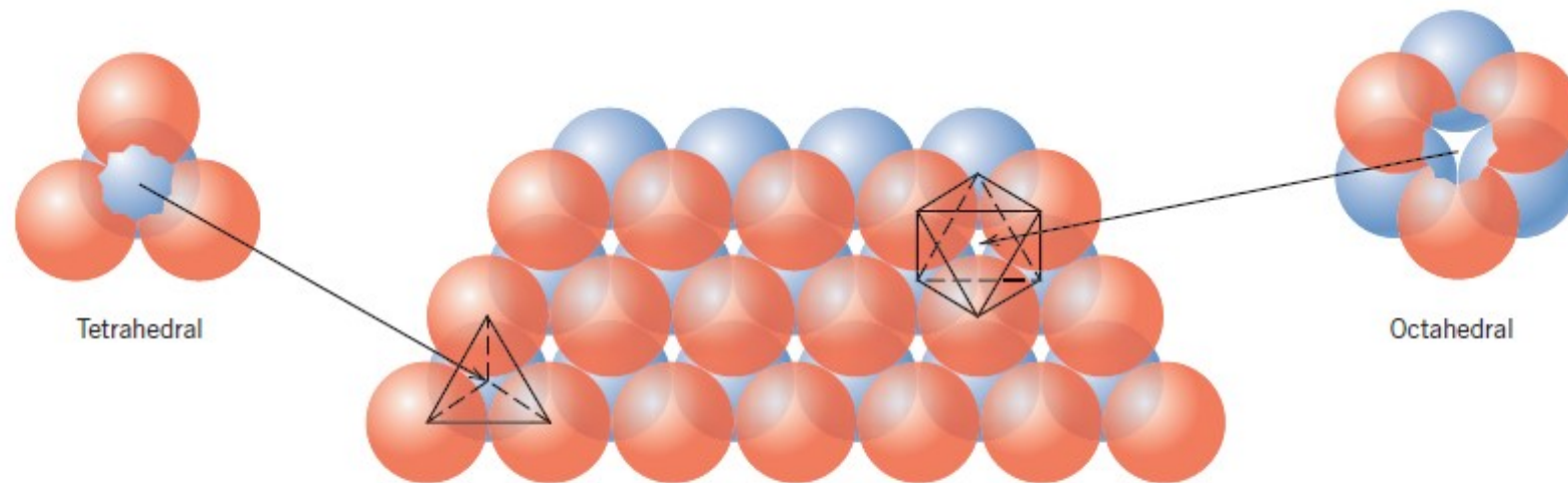
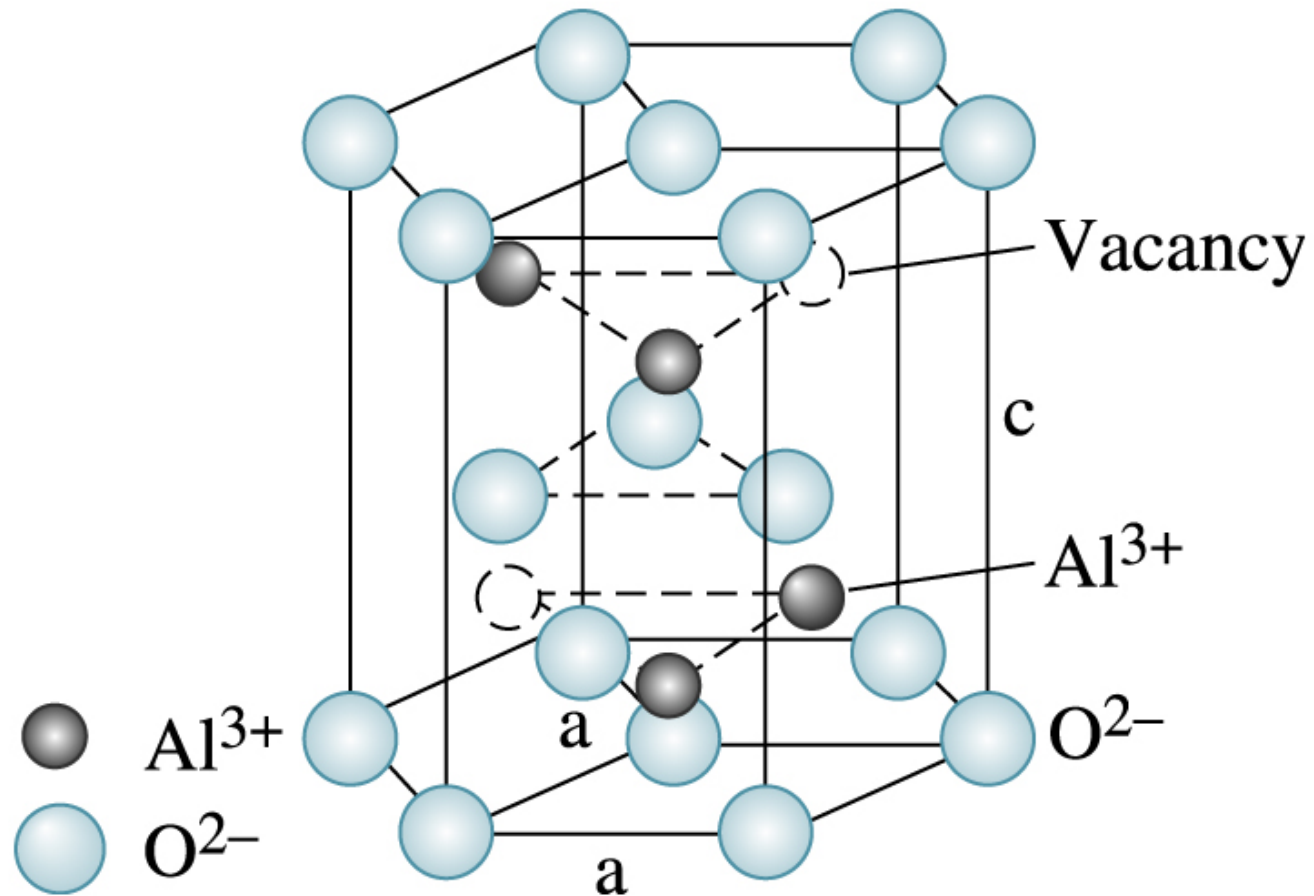


Figure 12.7 The stacking of one plane of close-packed (orange) spheres (anions) on top of another (blue spheres); the geometries of tetrahedral and octahedral positions between the planes are noted. (From W. G. Moffatt, G. W. Pearsall, and J. Wulff, *The Structure and Properties of Materials*, Vol. I, *Structure*. Copyright © 1964 by John Wiley & Sons, New York. Reprinted by permission of John Wiley & Sons, Inc.)

Alumina





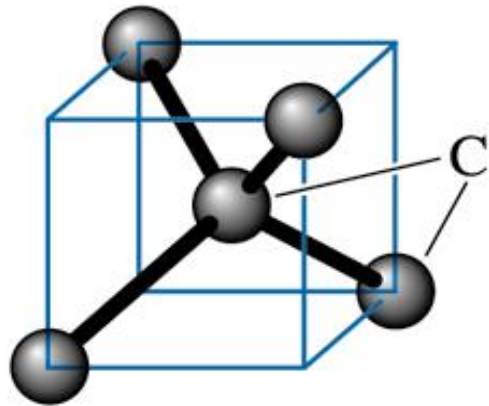
Resumo das estruturas mais simples

Table 12.4 Summary of Some Common Ceramic Crystal Structures

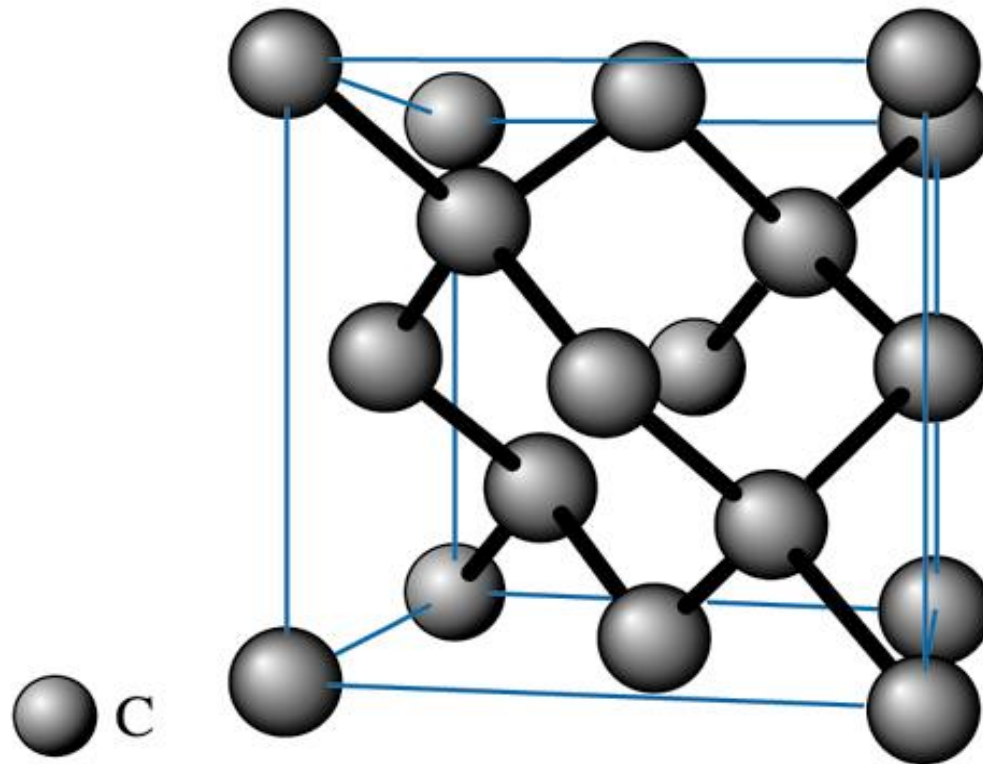
<i>Structure Name</i>	<i>Structure Type</i>	<i>Anion Packing</i>	<i>Coordination Numbers</i>		<i>Examples</i>
			<i>Cation</i>	<i>Anion</i>	
Rock salt (sodium chloride)	AX	FCC	6	6	NaCl, MgO, FeO
Cesium chloride	AX	Simple cubic	8	8	CsCl
Zinc blende (sphalerite)	AX	FCC	4	4	ZnS, SiC
Fluorite	AX ₂	Simple cubic	8	4	CaF ₂ , UO ₂ , ThO ₂
Perovskite	ABX ₃	FCC	12(A) 6(B)	6	BaTiO ₃ , SrZrO ₃ , SrSnO ₃
Spinel	AB ₂ X ₄	FCC	4(A) 6(B)	4	MgAl ₂ O ₄ , FeAl ₂ O ₄

Source: W. D. Kingery, H. K. Bowen, and D. R. Uhlmann, *Introduction to Ceramics*, 2nd edition. Copyright © 1976 by John Wiley & Sons, New York. Reprinted by permission of John Wiley & Sons, Inc.

Diamante (covalente)

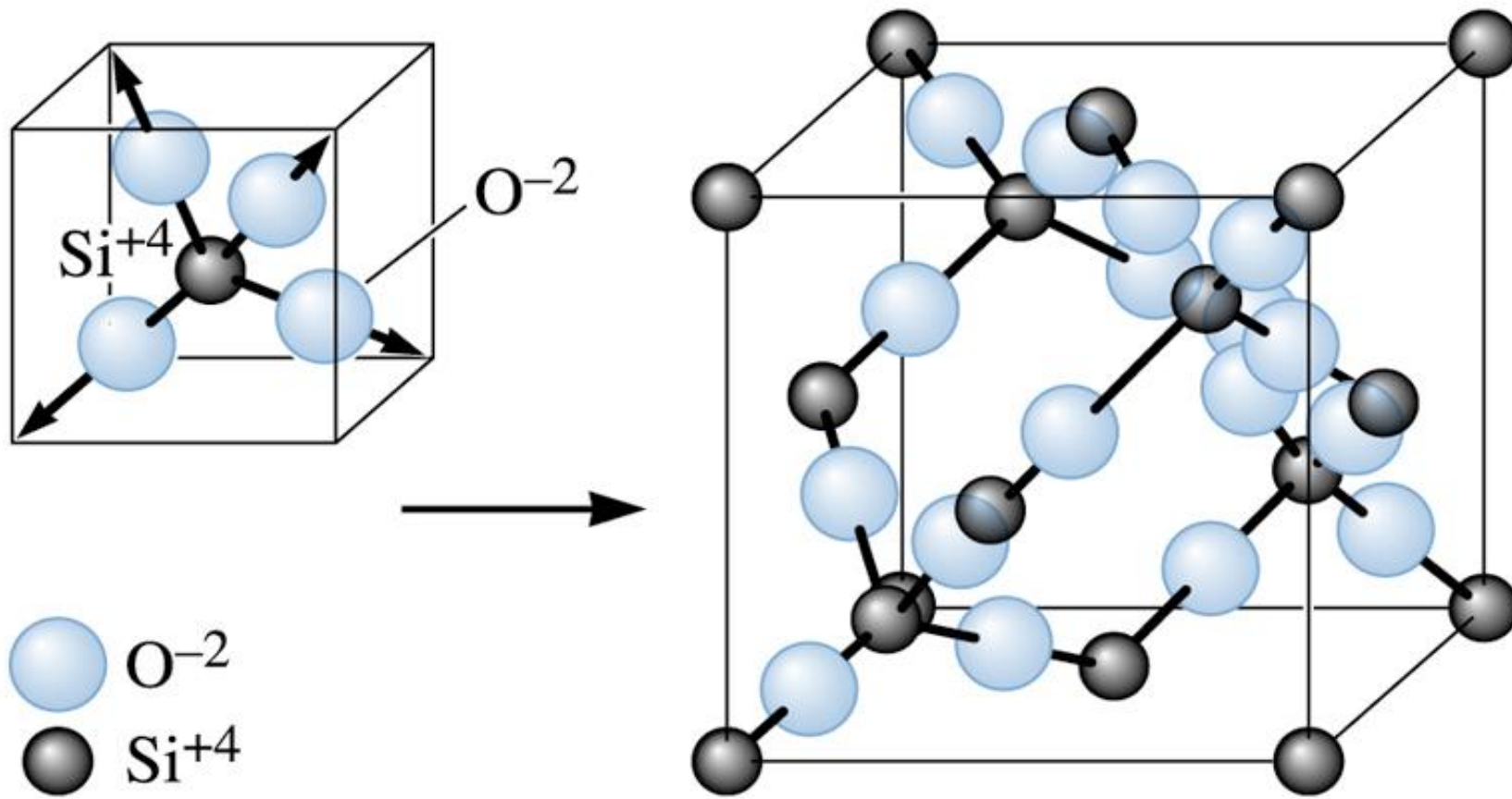


(a)



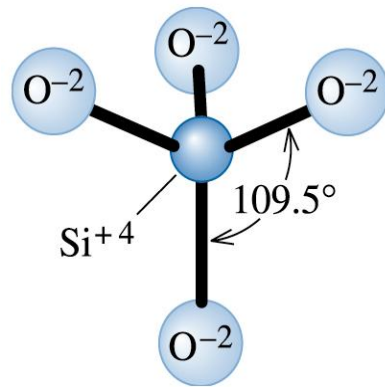
(b)

Cristobalita (coval. + iônica)

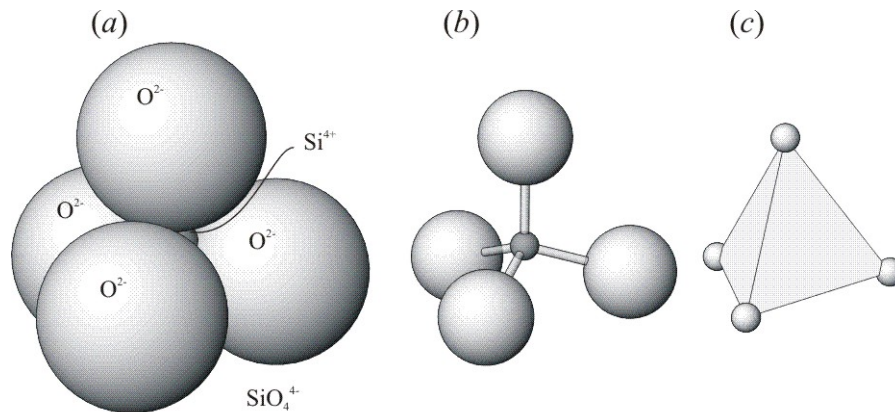


Tecto-silicato

Silicatos



Unidade básica



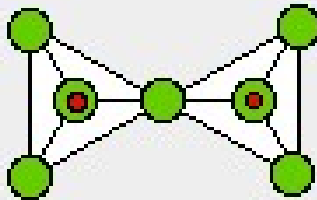
Ortossilicatos (1 tet.)
Ex.: Ca_2SiO_4

Figure 11.1



Dissilicatos $(\text{Si}_2\text{O}_7)^{6-}$

Arrangement of
silica tetrahedra



Formula of
complex ion

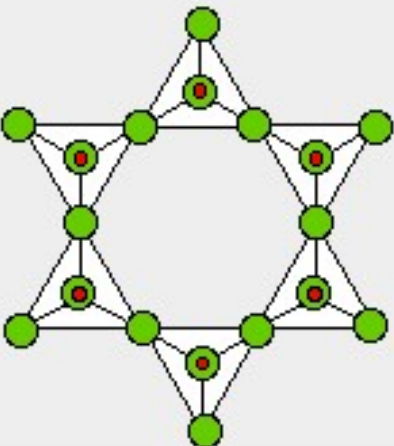


Common minerals

Epidote

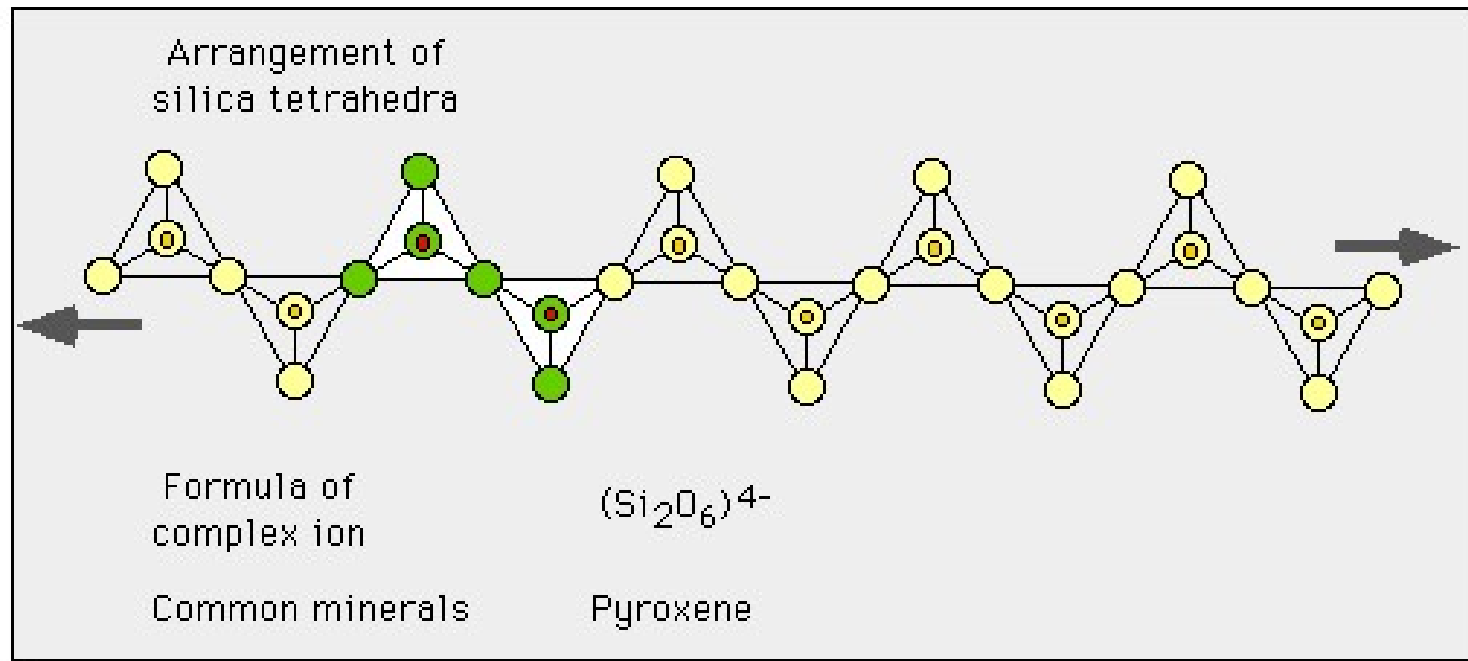
Ciclo-silicatos

- Ex.: $(\text{Si}_6\text{O}_{18})^{12-}$
- Berilo: $\text{Be}_3\text{Al}_2(\text{Si}_6\text{O}_{18})$

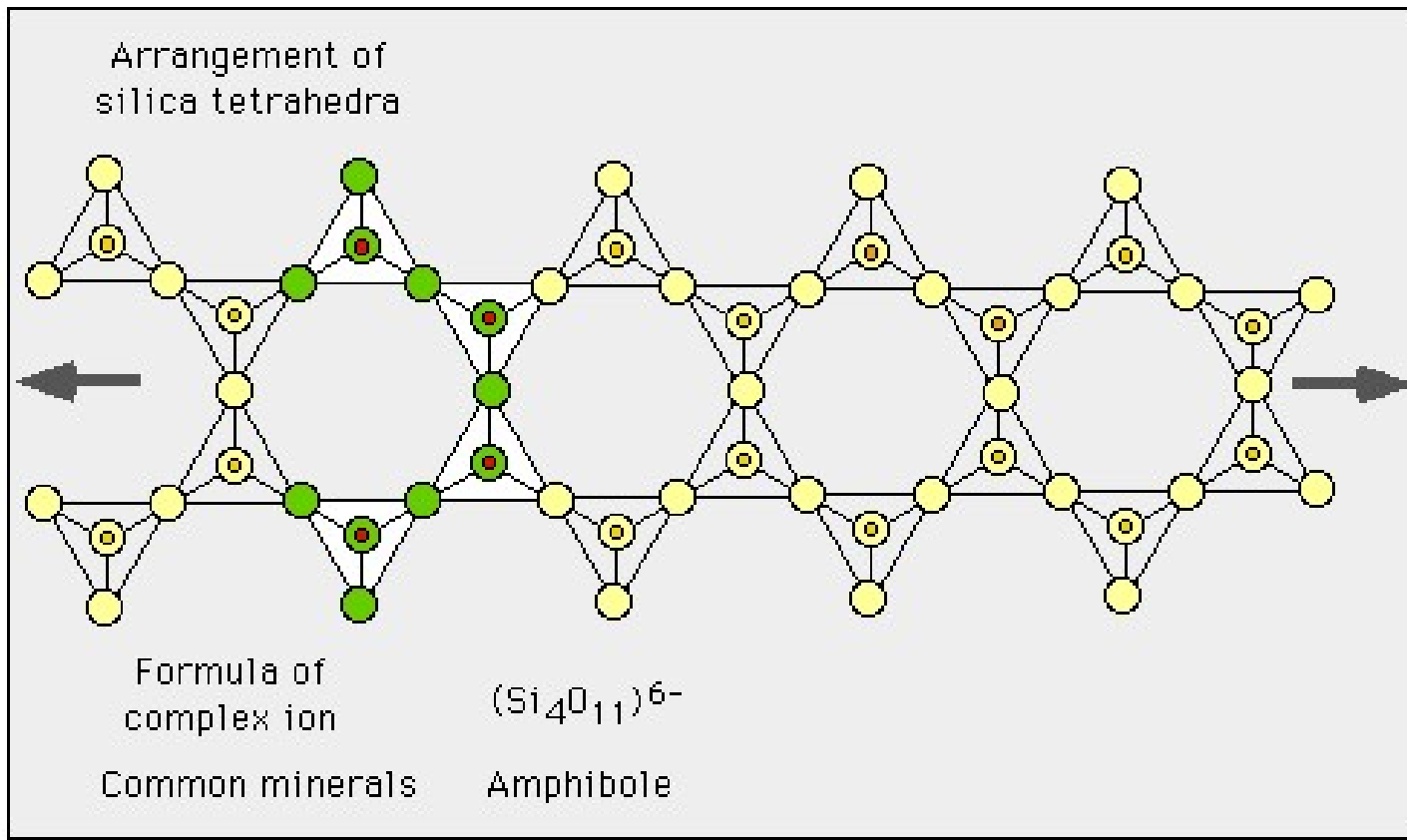
Arrangement of silica tetrahedra	Formula of complex ion	Common minerals
	$(\text{Si}_6\text{O}_{18})^{12-}$	Tourmaline Beryl

Ino-silicatos $(\text{SiO}_3)^{2-}_n$

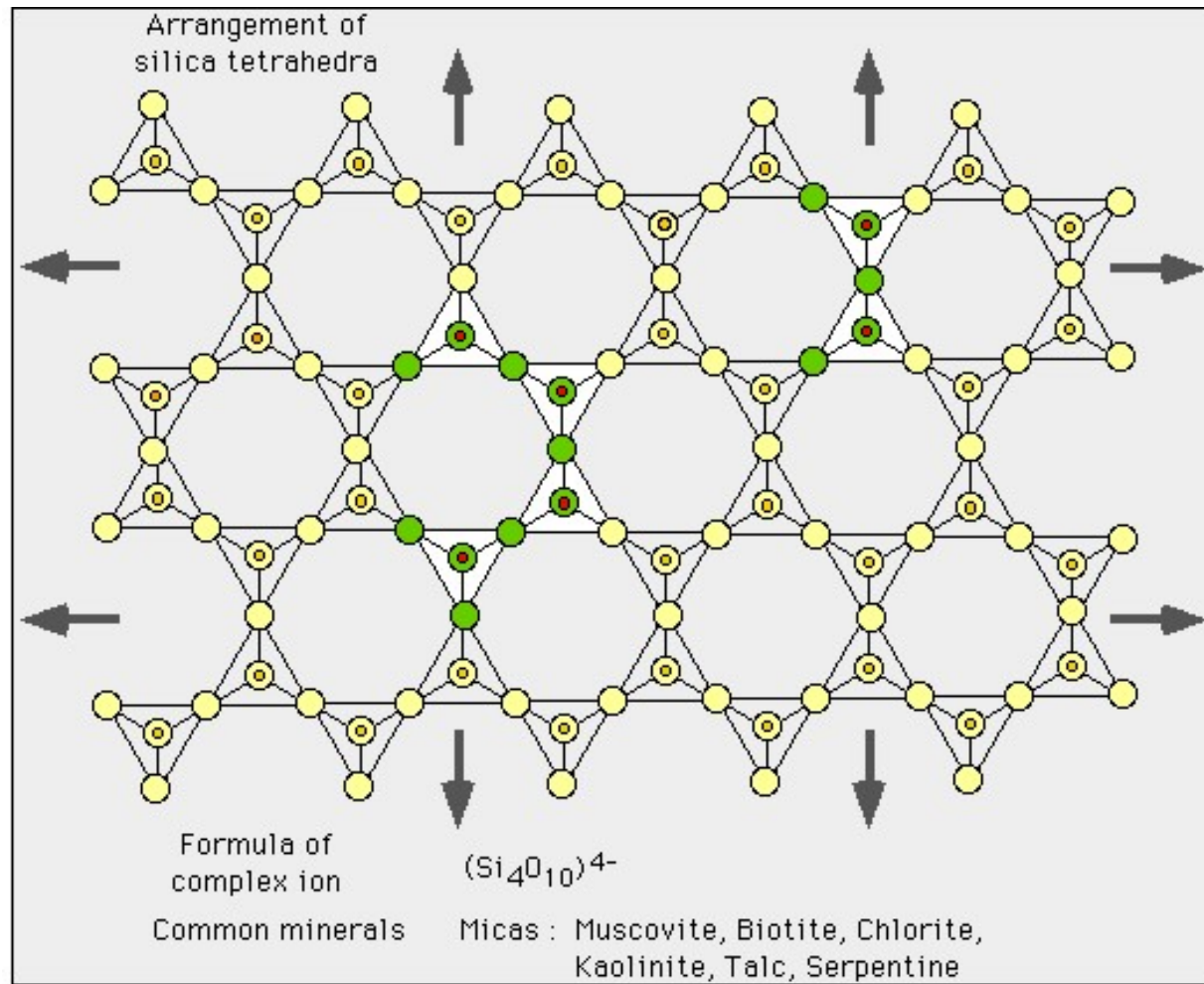
Cadeias Simples



Cadeias duplas $(\text{Si}_4\text{O}_{11})^{6-}_n$



Filossilicatos $(\text{Si}_2\text{O}_5)^{2-}_n$



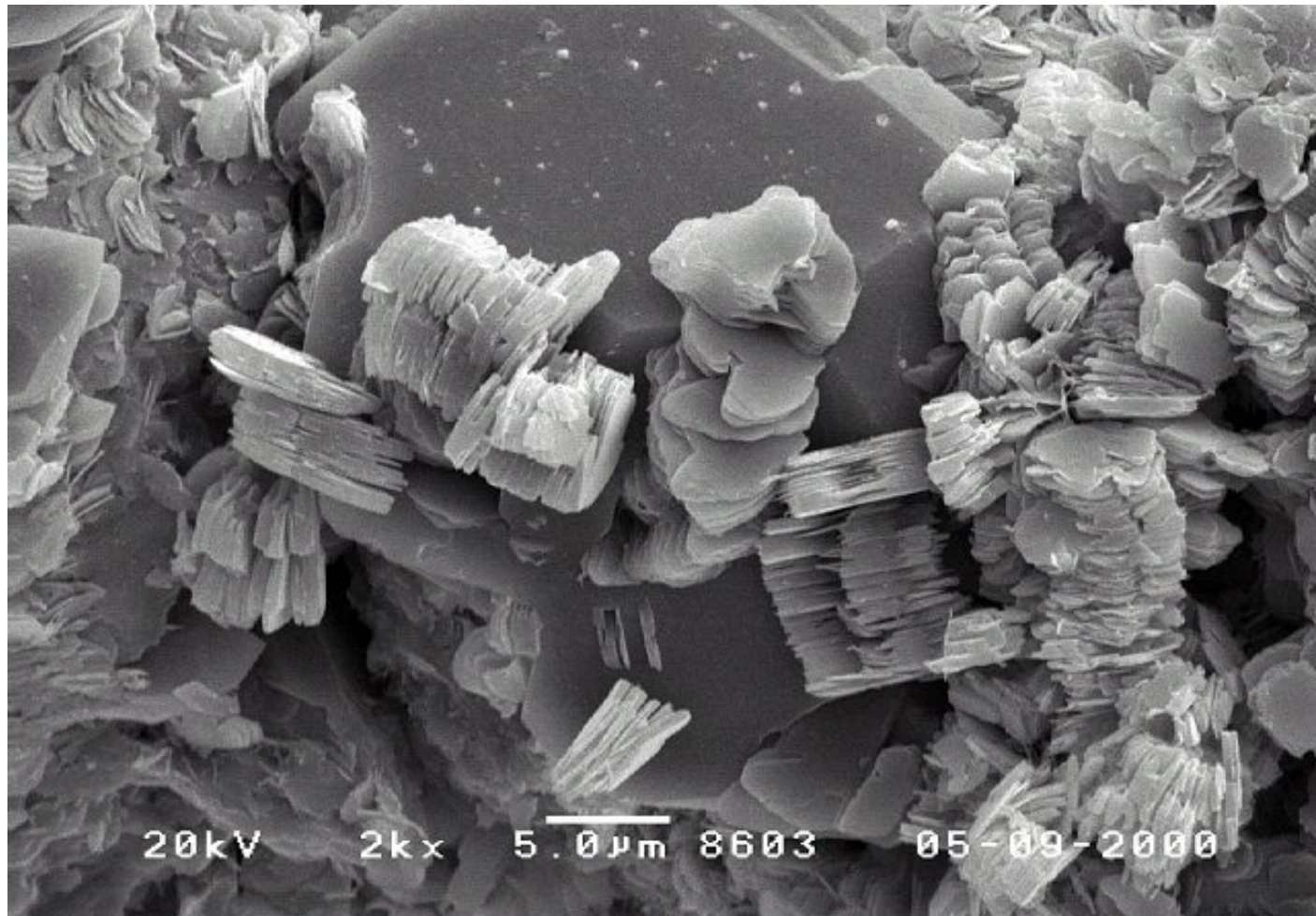


Cristais em camadas

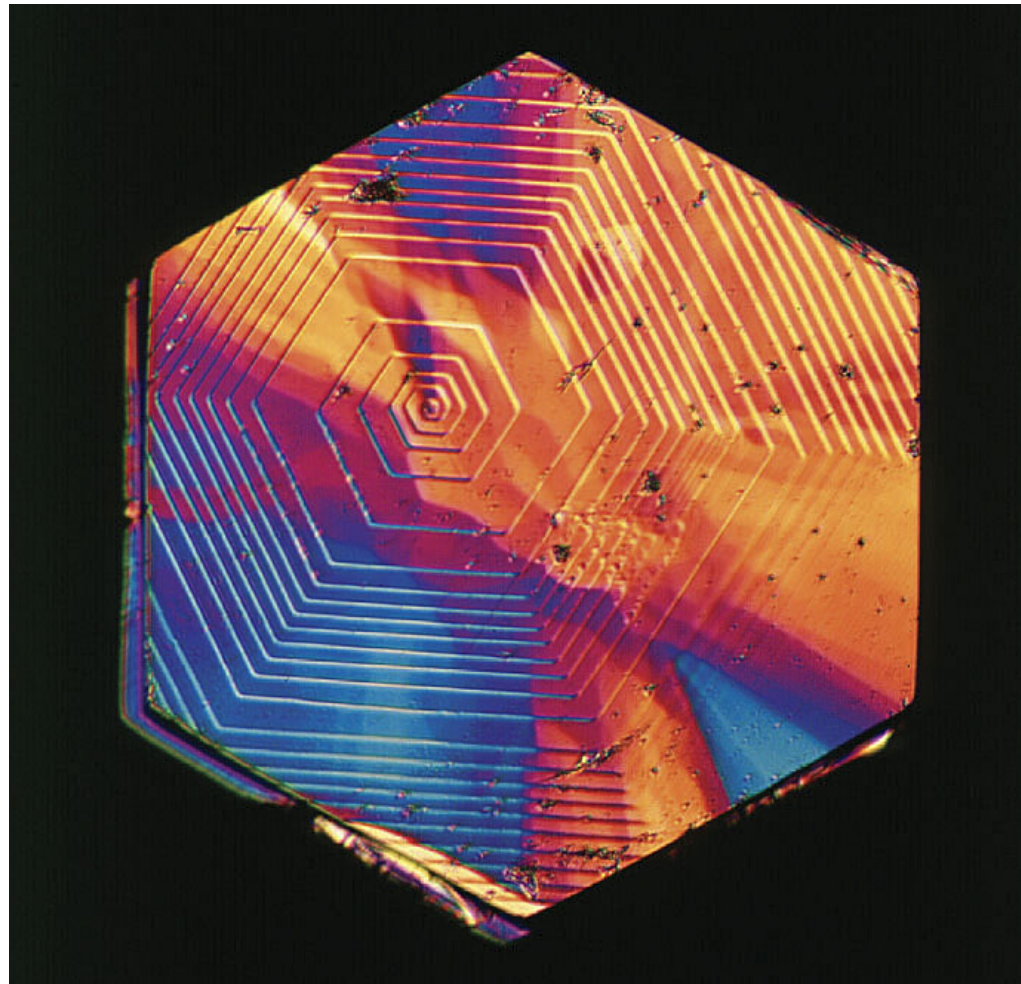
- [Caulinita](#) (filossilicato) $\text{Al}_2(\text{OH})_4\text{Si}_2\text{O}_5$
- [Montmorilonita](#) (filossilicato)
- [Talco](#) (filossilicato) $\text{Mg}_3(\text{OH})_2\text{Si}_4\text{O}_{10}$
- [Grafita](#)
- [MoS₂](#)

■ obs.: os nomes são links p/ as estruturas

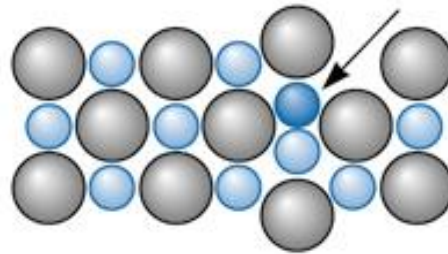
Cristais de Caulinita



Monocristal de Grafita



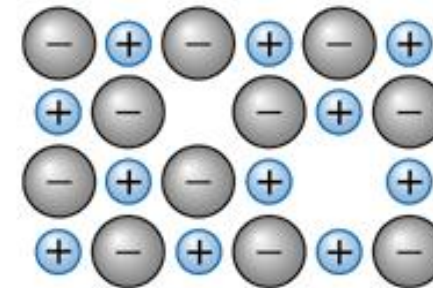
Defeitos em cristais cerâmicos



(e)

Figure 4.1 Point defects: (e) Frenkel defect.
All of these defects disrupt the perfect arrangement of the surrounding atoms.

Defeitos em cristais cerâmicos



(f)

Figure 4.1 Point defects: (a) vacancy, (b) interstitial atom, (c) small substitutional atom, (d) large substitutional atom, (e) Frenkel defect, (f) Schottky defect. All of these defects disrupt the perfect arrangement of the surrounding atoms.

Cristais não estequiométricos

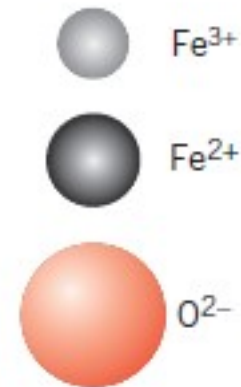
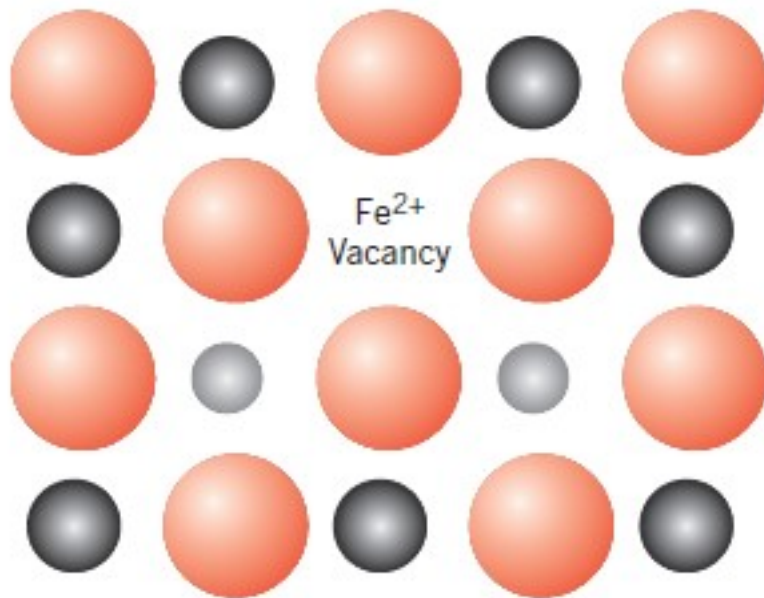


Figure 12.22 Schematic representation of an Fe²⁺ vacancy in FeO that results from the formation of two Fe³⁺ ions.

Sol. Sol. Em Cerâmicas e a formação de vacâncias

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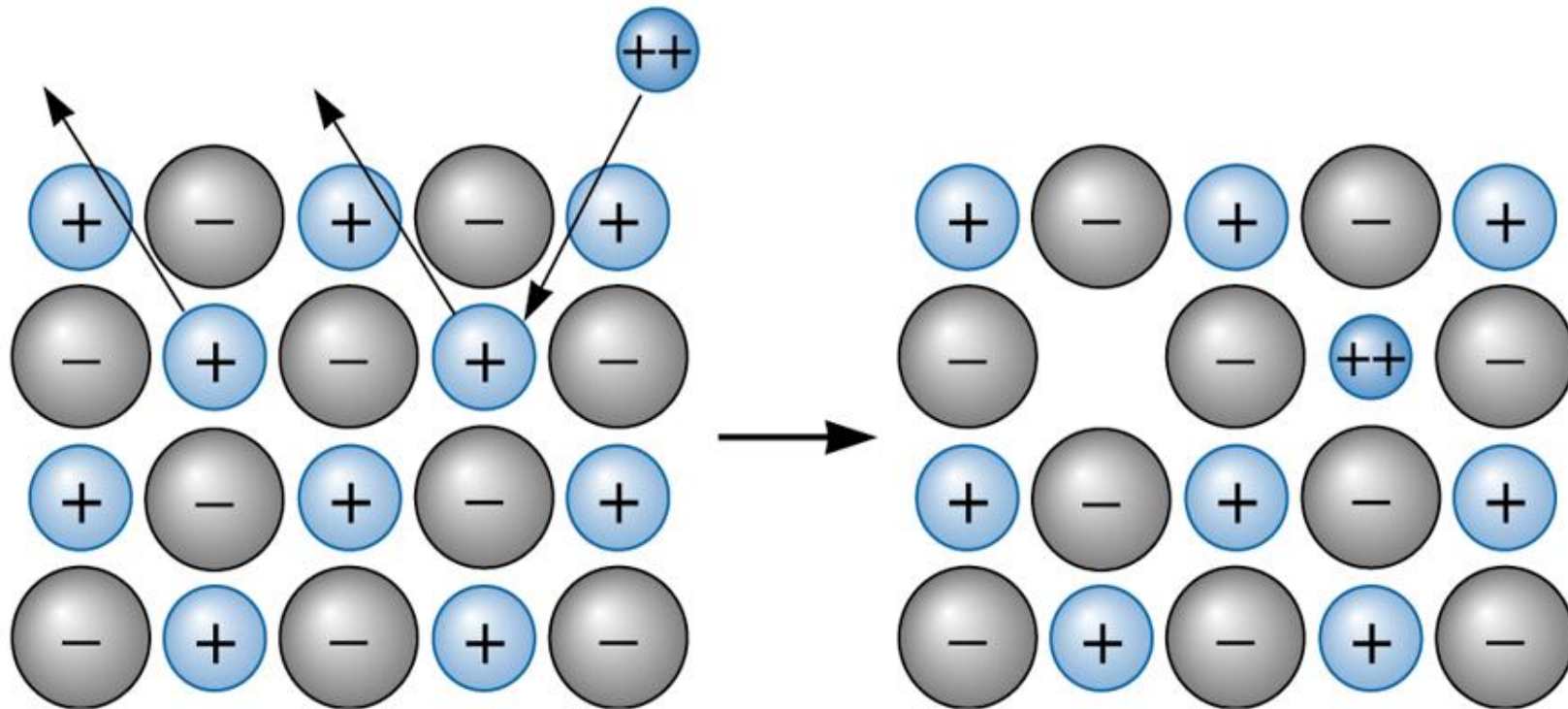
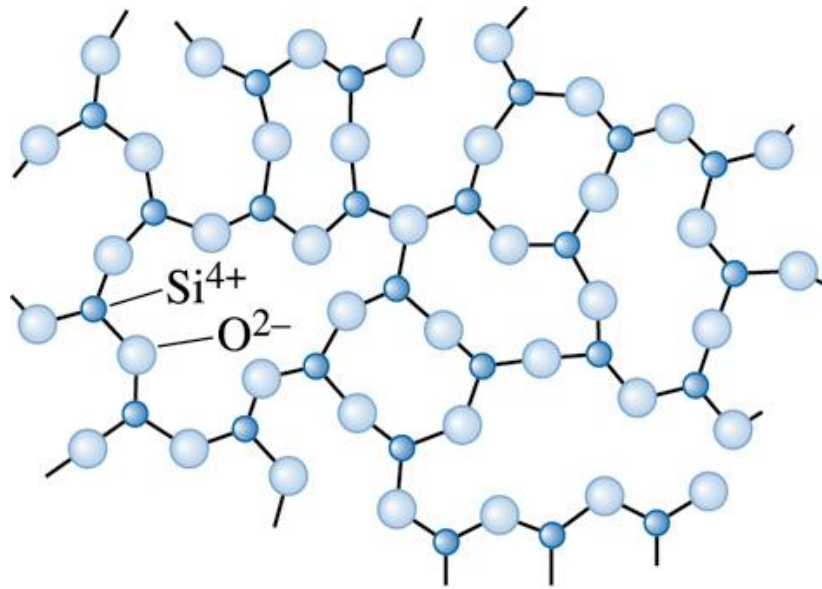


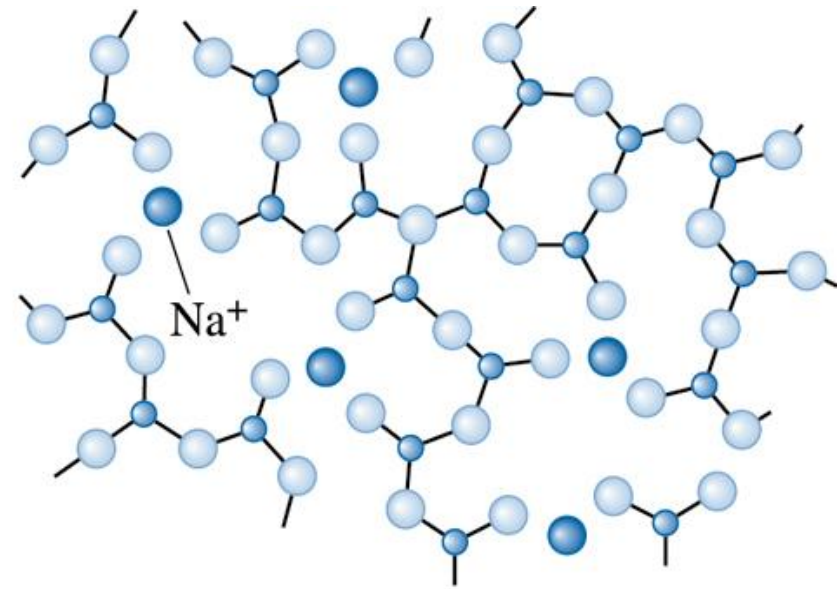
Figure 4.3 When a divalent cation replaces a monovalent cation, a second monovalent cation must also be removed, creating a vacancy.

Estruturas amofas

Vidros de Silicatos



SiO₂ glass



Na₂O modified glass



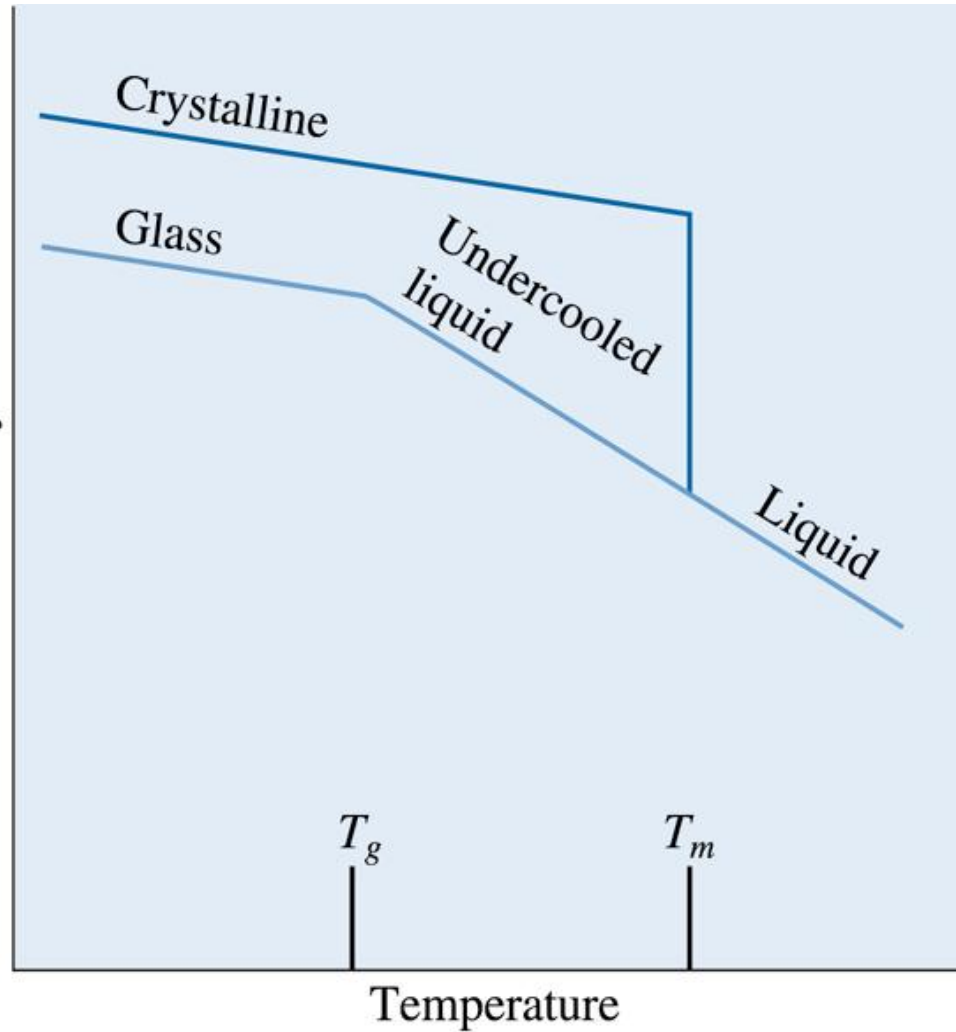
Formadores e Modificadores

TABLE 14-5 ■ *Division of the oxides into glass formers, intermediates, and modifiers*

Glass Formers	Intermediates	Modifiers
B ₂ O ₃	TiO ₂	Y ₂ O ₃
SiO ₂	ZnO	MgO
GeO ₂	PbO ₂	CaO
P ₂ O ₅	Al ₂ O ₃	PbO
V ₂ O ₃	BeO	Na ₂ O

Transição Vítre

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Expansão térmica

