



Universidade Federal do ABC

UNIVERSIDADE FEDERAL DO ABC

CENTRO DE ENGENHARIA, MODELAGEM E CIÊNCIAS SOCIAIS APLICADAS

MATERIAIS E SUAS PROPRIEDADES

- ✓ **Classificação dos materiais em função das ligações químicas**
-

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TIPOS DE MATERIAIS



Polímeros



Metais



Cerâmicas

MATERIAIS E SUAS PROPRIEDADES

ELEMENTOS QUÍMICOS - TABELA PERIÓDICA

Os elementos químicos são classificados de acordo com a sua configuração eletrônica

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IA
1A

2
IIA
2A

13
IIIA
3A

14
IVA
4A

15
VA
5A

16
VIA
6A

17
VIIA
7A

18
VIIIA
8A

1
H
Hydrogen
1.008

3
Li
Lithium
6.941

11
Na
Sodium
22.990

19
K
Potassium
39.098

37
Rb
Rubidium
84.468

55
Cs
Cesium
132.905

87
Fr
Francium
223.020

4
Be
Beryllium
9.012

12
Mg
Magnesium
24.305

20
Ca
Calcium
40.078

38
Sr
Strontium
87.62

56
Ba
Barium
137.328

88
Ra
Radium
226.025

5
B
Boron
10.811

13
Al
Aluminum
26.982

21
Sc
Scandium
44.956

29
Cu
Copper
63.546

31
Ga
Gallium
69.723

49
In
Indium
114.818

67
Tl
Thallium
204.383

81
Tl
Thallium
204.383

101
Md
Mendelevium
258.1

6
C
Carbon
12.011

14
Si
Silicon
28.086

22
Ti
Titanium
47.867

30
Zn
Zinc
65.38

32
Ge
Germanium
72.631

50
Sn
Tin
118.711

68
Er
Erbium
167.259

100
Fm
Fermium
257.095

7
N
Nitrogen
14.007

15
P
Phosphorus
30.974

23
V
Vanadium
50.942

31
As
Arsenic
74.922

33
As
Arsenic
74.922

51
Sb
Antimony
121.760

69
Tm
Thulium
168.934

103
Lr
Lawrencium
[262]

8
O
Oxygen
15.999

16
S
Sulfur
32.066

24
Cr
Chromium
51.996

32
Se
Selenium
78.971

34
Se
Selenium
78.971

52
Te
Tellurium
127.6

84
Po
Polonium
[208.982]

9
F
Fluorine
18.998

17
Cl
Chlorine
35.453

25
Mn
Manganese
54.938

33
Br
Bromine
79.904

35
Br
Bromine
79.904

53
I
Iodine
126.904

85
At
Astatine
209.987

10
Ne
Neon
20.180

18
Ar
Argon
39.948

26
Fe
Iron
55.845

34
Kr
Krypton
84.798

36
Kr
Krypton
84.798

54
Xe
Xenon
131.294

86
Rn
Radon
222.018

118
Uuo
Ununoctium
unknown

11
Ni
Nickel
58.693

19
Co
Cobalt
58.933

27
Ni
Nickel
58.693

35
Rh
Rhodium
102.906

43
Pd
Palladium
106.42

51
Ag
Silver
107.868

79
Au
Gold
196.967

107
Ds
Darmstadtium
[269]

12
Zn
Zinc
65.38

20
Ga
Gallium
69.723

28
Ge
Germanium
72.631

36
As
Arsenic
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Radon
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Fe
Iron
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Co
Cobalt
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Ni
Nickel
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32
Cu
Copper
63.546

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Zn
Zinc
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48
Ga
Gallium
69.723

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Ge
Germanium
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As
Arsenic
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Selenium
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NÚMEROS QUÂNTICOS E CONFIGURAÇÃO ELETRÔNICA

- ✓ Cada elétron em um átomo é caracterizado por quatro parâmetros → os números quânticos.
- ✓ **Não existem dois elétrons com os mesmos números quânticos**

<i>Principal Quantum Number n</i>	<i>Shell Designation</i>	<i>Subshells</i>	<i>Number of States</i>	<i>Number of Electrons</i>	
				<i>Per Subshell</i>	<i>Per Shell</i>
1	<i>K</i>	<i>s</i>	1	2	2
2	<i>L</i>	<i>s</i>	1	2	8
		<i>p</i>	3	6	
3	<i>M</i>	<i>s</i>	1	2	18
		<i>p</i>	3	6	
		<i>d</i>	5	10	
		<i>f</i>	7	14	
4	<i>N</i>	<i>s</i>	1	2	32
		<i>p</i>	3	6	
		<i>d</i>	5	10	
		<i>f</i>	7	14	



NÚMEROS QUÂNTICOS E CONFIGURAÇÃO ELETRÔNICA

Número Quântico Principal (n)

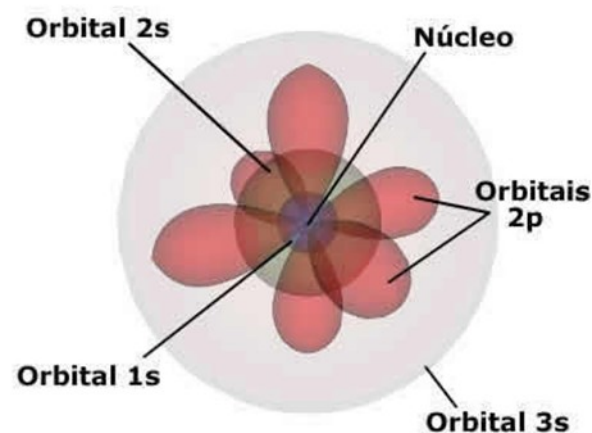
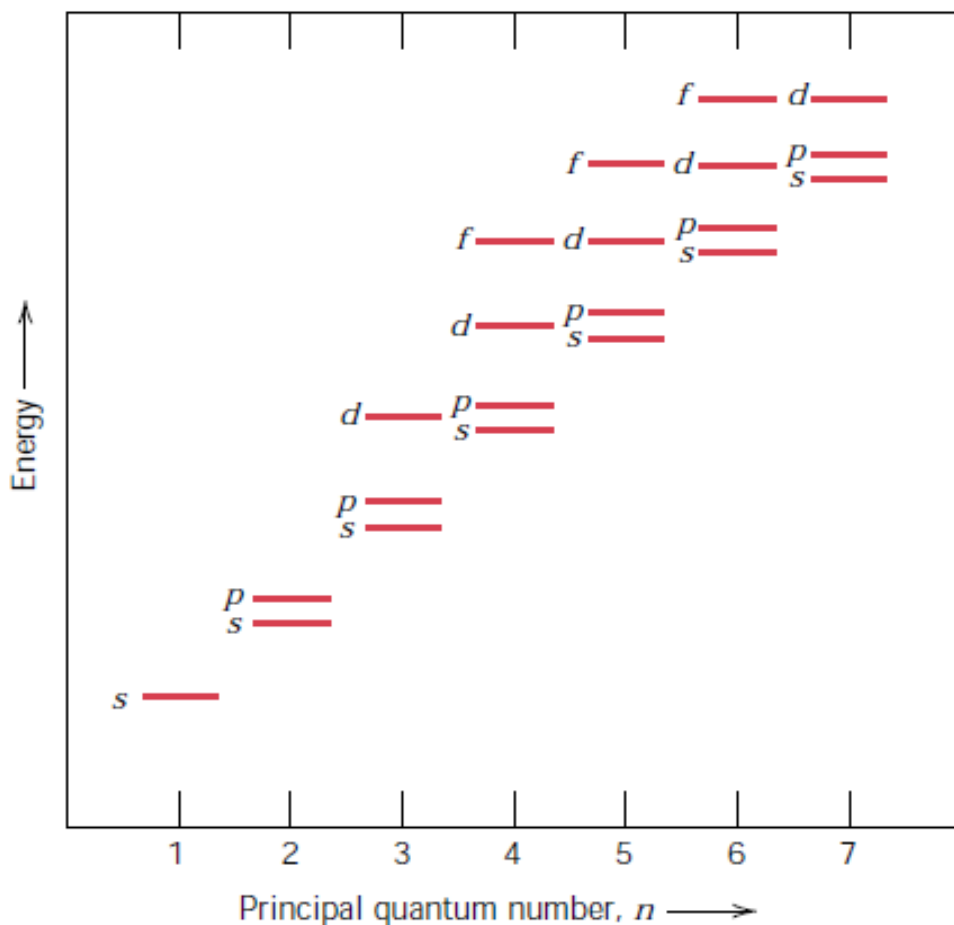
K (n=1)	$1s^2$			
L (n=2)	$2s^2$	$2p^6$		
M (n=3)	$3s^2$	$3p^6$	$3d^{10}$	
N (n=4)	$4s^2$	$4p^6$	$4d^{10}$	$4f^{14}$
O (n=5)	$5s^2$	$5p^6$	$5d^{10}$	$5f^{14}$
P (n=6)	$6s^2$	$6p^6$	$6d^{10}$	
Q (n=7)	$7s^2$			

Subníveis em cada camada
(número quântico secundário)

Ocupação dos elétrons



NÚMEROS QUÂNTICOS E CONFIGURAÇÃO ELETRÔNICA

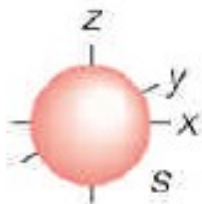


**Representação
esquemática das energias
relativas para várias
camadas e subcamadas**

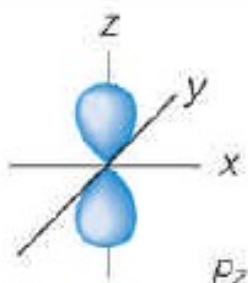
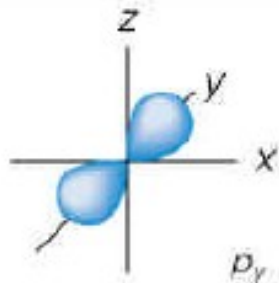
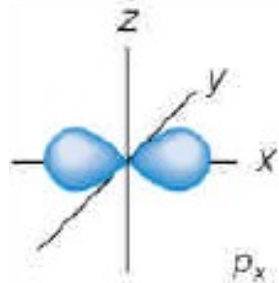


NÚMEROS QUÂNTICOS E CONFIGURAÇÃO ELETRÔNICA

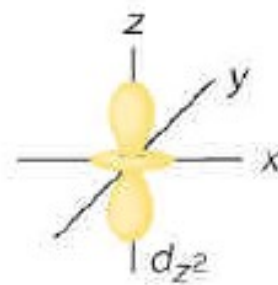
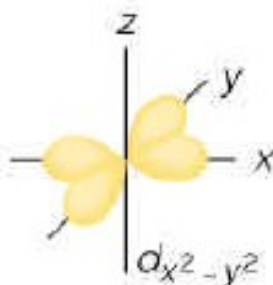
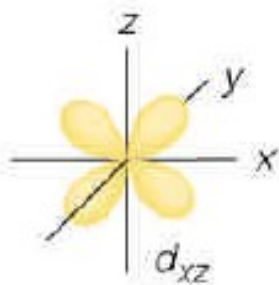
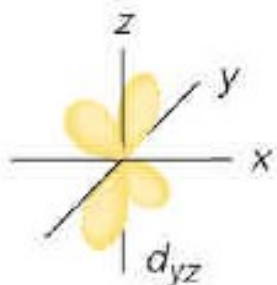
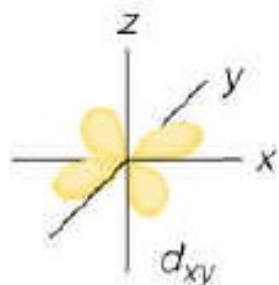
Número Quântico Orbital ou Secundário (l)



Orbital s (número quântico secundário = 0)








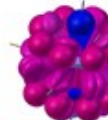







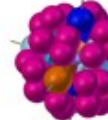

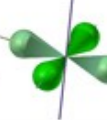

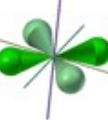
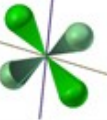


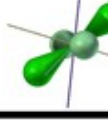






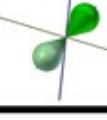
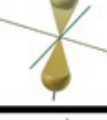
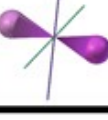


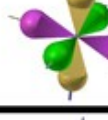

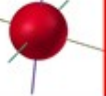







Orbital p (número quântico secundário = 1)



Orbital d (número quântico secundário = 2)

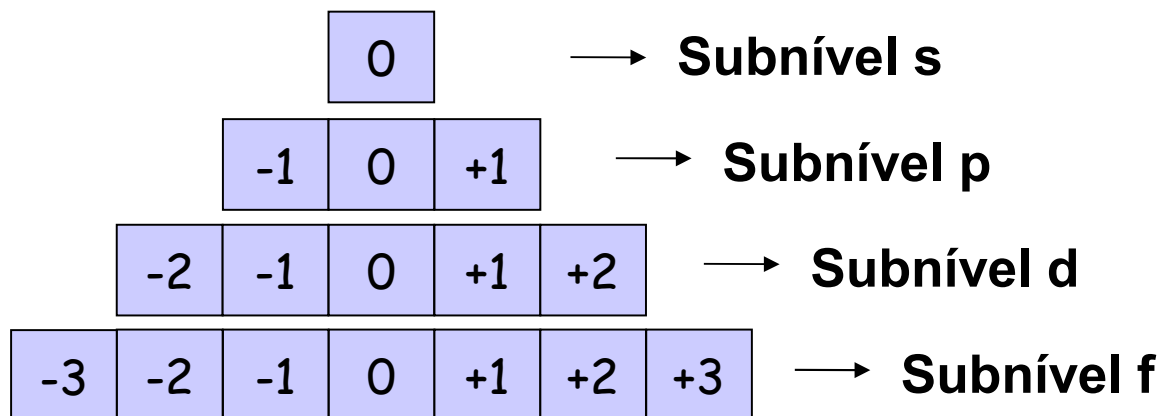
NÚMEROS QUÂNTICOS E CONFIGURAÇÃO ELETRÔNICA

THE spdf ORBITALS									
(An artistic rendition)									
TYPE	SET	INDIVIDUAL ORBITALS						COLLECTIVE	
f	Cubic								
	General								
d	Common								
	"Tri-torus"								
p									
s									



NÚMEROS QUÂNTICOS E CONFIGURAÇÃO ELETRÔNICA

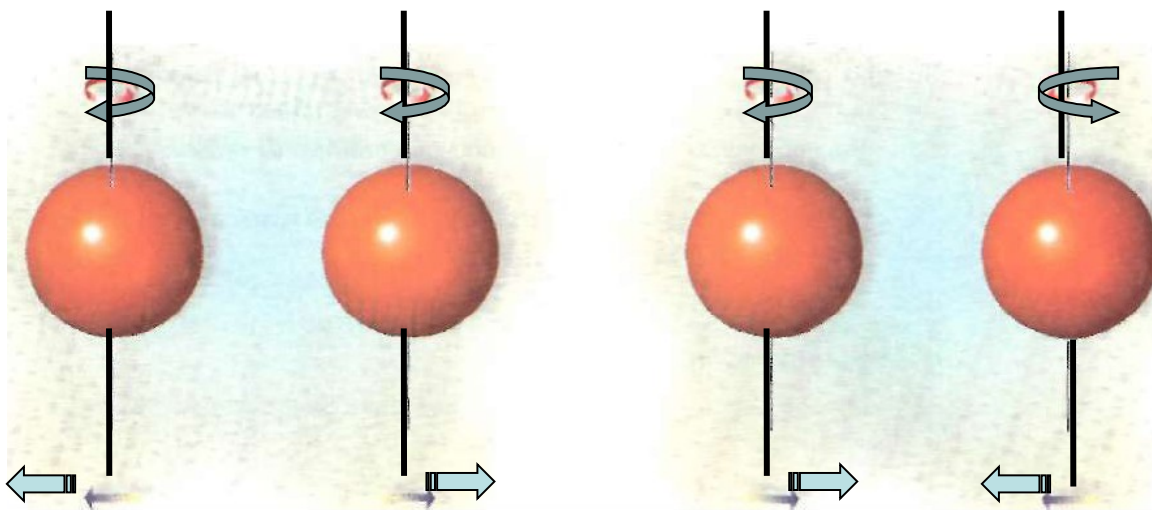
Número Quântico Orbital magnético (m_l)





NÚMEROS QUÂNTICOS E CONFIGURAÇÃO ELETRÔNICA

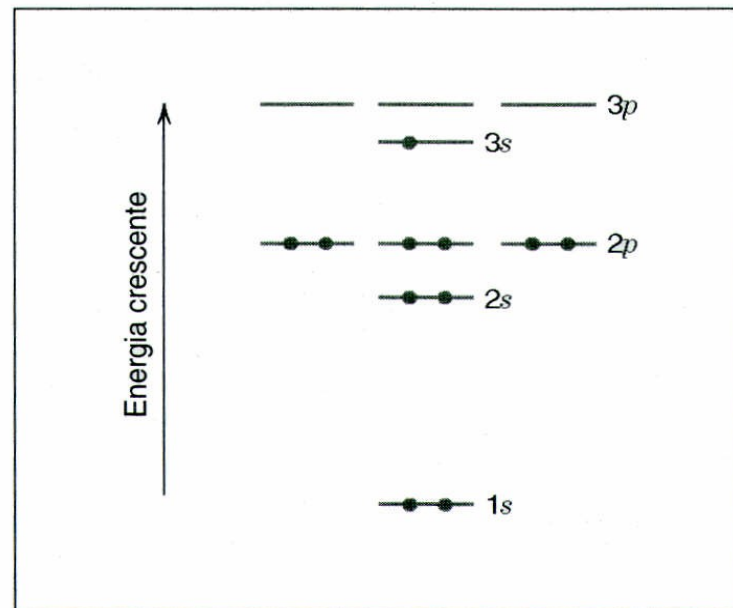
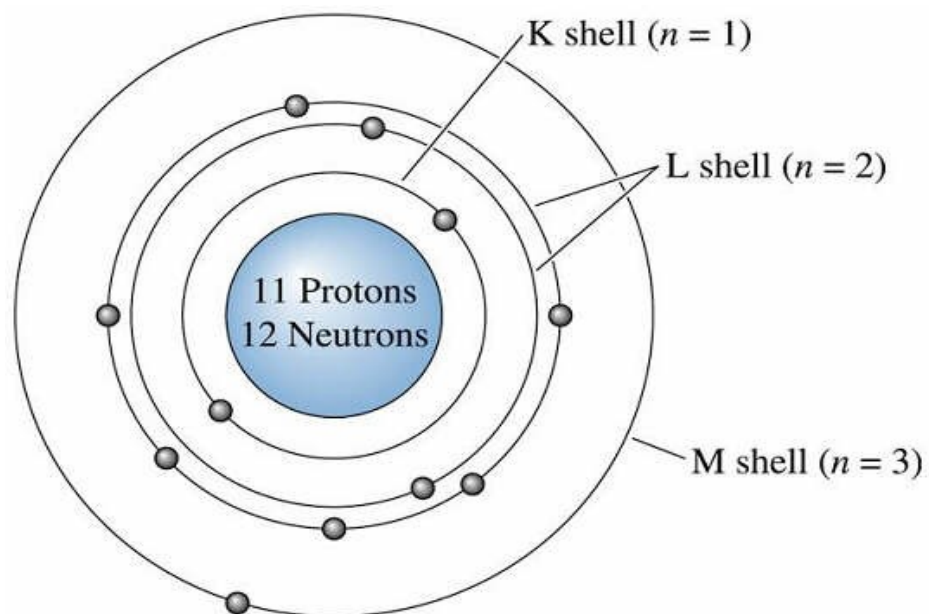
Número Quântico de Spin (m_s)



+1/2 ou -1/2



NÚMEROS QUÂNTICOS E CONFIGURAÇÃO ELETRÔNICA





NÚMEROS QUÂNTICOS E CONFIGURAÇÃO ELETRÔNICA

Configuração Eletrônica do Átomo de Sódio

3s ¹	electron 11	$n = 3, l = 0, m_l = 0, m_s = +\frac{1}{2} \text{ or } -\frac{1}{2}$
2p ⁶	electron 10	$n = 2, l = 1, m_l = +1, m_s = -\frac{1}{2}$
	electron 9	$n = 2, l = 1, m_l = +1, m_s = +\frac{1}{2}$
	electron 8	$n = 2, l = 1, m_l = 0, m_s = -\frac{1}{2}$
	electron 7	$n = 2, l = 1, m_l = 0, m_s = +\frac{1}{2}$
	electron 6	$n = 2, l = 1, m_l = -1, m_s = -\frac{1}{2}$
	electron 5	$n = 2, l = 1, m_l = -1, m_s = +\frac{1}{2}$
2s ²	electron 4	$n = 2, l = 0, m_l = 0, m_s = -\frac{1}{2}$
	electron 3	$n = 2, l = 0, m_l = 0, m_s = +\frac{1}{2}$
1s ²	electron 2	$n = 1, l = 0, m_l = 0, m_s = -\frac{1}{2}$
	electron 1	$n = 1, l = 0, m_l = 0, m_s = +\frac{1}{2}$



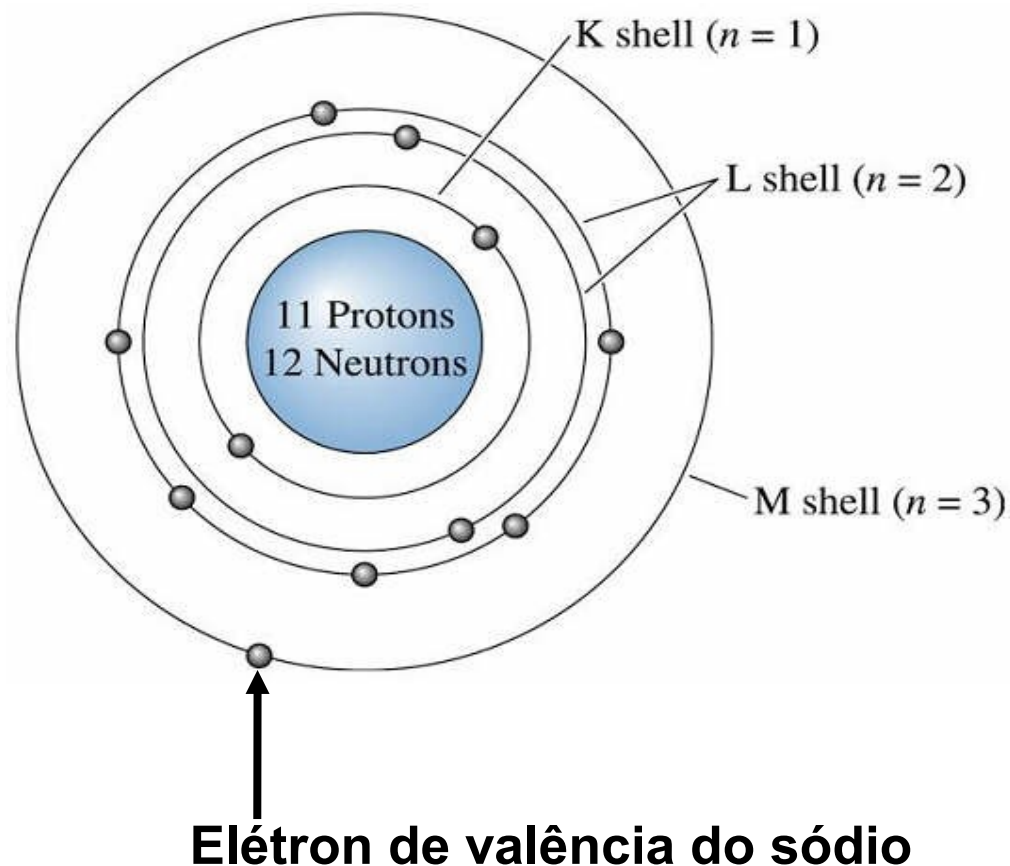
NÚMEROS QUÂNTICOS E CONFIGURAÇÃO ELETRÔNICA

✓ **Elétrons de Valência**

- ✓ São aqueles que ocupam a camada eletrônica mais externa.

✓ **Configurações Eletrônicas Estáveis**

- ✓ As camadas eletrônicas mais externas estão completamente preenchidas.





Universidade Federal do ABC

CENTRO DE ENGENHARIA, MODELAGEM E CIÊNCIAS SOCIAIS APLICADAS

MATERIAIS E SUAS PROPRIEDADES

LIGAÇÕES QUÍMICAS EM MATERIAIS SÓLIDOS

Os elementos se ligam para formar os sólidos para atingir uma configuração mais estável: oito elétrons na camada mais externa.

A ligação química é formada pela interação dos elétrons de valência através de um dos seguintes mecanismos:

- Ganho de elétrons**
- Perda de elétrons**
- Compartilhamento de elétrons**



LIGAÇÕES QUÍMICAS EM MATERIAIS SÓLIDOS

Quais as ligações químicas primárias (entre os átomos) ?

- **Iônica**: forte e não direcional (grande diferença de eletronegatividade). Os íons se comportam como esferas.
- **Metálica**: forte e não direcional (nenhuma diferença de eletronegatividade e elétrons não localizados). Os átomos se comportam como esferas.
- **Covalente**: muito forte e direcional (pequena ou nenhuma diferença de eletronegatividade e elétrons localizados). A direção de ligação é dada pela direção dos orbitais.



LIGAÇÕES QUÍMICAS EM MATERIAIS SÓLIDOS

Table 2.3 Bonding Energies and Melting Temperatures for Various Substances

<i>Bonding Type</i>	<i>Substance</i>	<i>Bonding Energy</i>		<i>Melting Temperature (°C)</i>
		<i>kJ/mol (kcal/mol)</i>	<i>eV/Atom, Ion, Molecule</i>	
Ionic	NaCl	640 (153)	3.3	801
	MgO	1000 (239)	5.2	2800
Covalent	Si	450 (108)	4.7	1410
	C (diamond)	713 (170)	7.4	>3550
Metallic	Hg	68 (16)	0.7	−39
	Al	324 (77)	3.4	660
	Fe	406 (97)	4.2	1538
	W	849 (203)	8.8	3410
van der Waals	Ar	7.7 (1.8)	0.08	−189
	Cl ₂	31 (7.4)	0.32	−101
Hydrogen	NH ₃	35 (8.4)	0.36	−78
	H ₂ O	51 (12.2)	0.52	0



METAIS – LIGAÇÕES METÁLICAS

Metais na tabela periódica

1
1A
1A

2
IIA
2A

13
IIIA
3A

14
IVA
4A

15
VA
5A

16
VIA
6A

17
VIIA
7A

18
VIIIA
8A

1
H
Hydrogen
1.008

3
Li
Lithium
6.941

11
Na
Sodium
22.990

19
K
Potassium
39.098

37
Rb
Rubidium
84.468

55
Cs
Cesium
132.905

87
Fr
Francium
223.020

4
Be
Beryllium
9.012

12
Mg
Magnesium
24.305

20
Ca
Calcium
40.078

38
Sr
Strontium
87.62

56
Ba
Barium
137.328

88
Ra
Radium
226.025

5
B
Boron
10.811

13
Al
Aluminum
26.982

31
Ga
Gallium
69.723

49
In
Indium
114.818

67
Tl
Thallium
204.383

6
C
Carbon
12.011

14
Si
Silicon
28.086

32
Ge
Germanium
72.631

50
Sn
Tin
118.711

68
Pb
Lead
207.2

7
N
Nitrogen
14.007

15
P
Phosphorus
30.974

33
As
Arsenic
74.922

51
Sb
Antimony
121.760

69
Bi
Bismuth
208.980

8
O
Oxygen
15.999

16
S
Sulfur
32.066

34
Se
Selenium
78.971

52
Te
Tellurium
127.6

70
Po
Polonium
[208.982]

9
F
Fluorine
18.998

17
Cl
Chlorine
35.453

35
Br
Bromine
79.904

53
I
Iodine
126.904

85
At
Astatine
209.987

10
Ne
Neon
20.180

18
Ar
Argon
39.948

36
Kr
Krypton
84.798

54
Xe
Xenon
131.294

86
Rn
Radon
222.018

118
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Ununoctium
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119
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Universidade Federal do ABC

METAIS – LIGAÇÕES METÁLICAS

- ✓ Átomos dos metais possuem de um a três elétrons de valência.
- ✓ A ligação resultante é *não-direcional*.
- ✓ Os elétrons de valência passam a se comportar como *elétrons “livres”* :
 - ✓ Apresentam a mesma probabilidade de se associar a um grande número de átomos vizinhos.
 - ✓ Formam uma “nuvem eletrônica”.



METAIS – LIGAÇÕES METÁLICAS

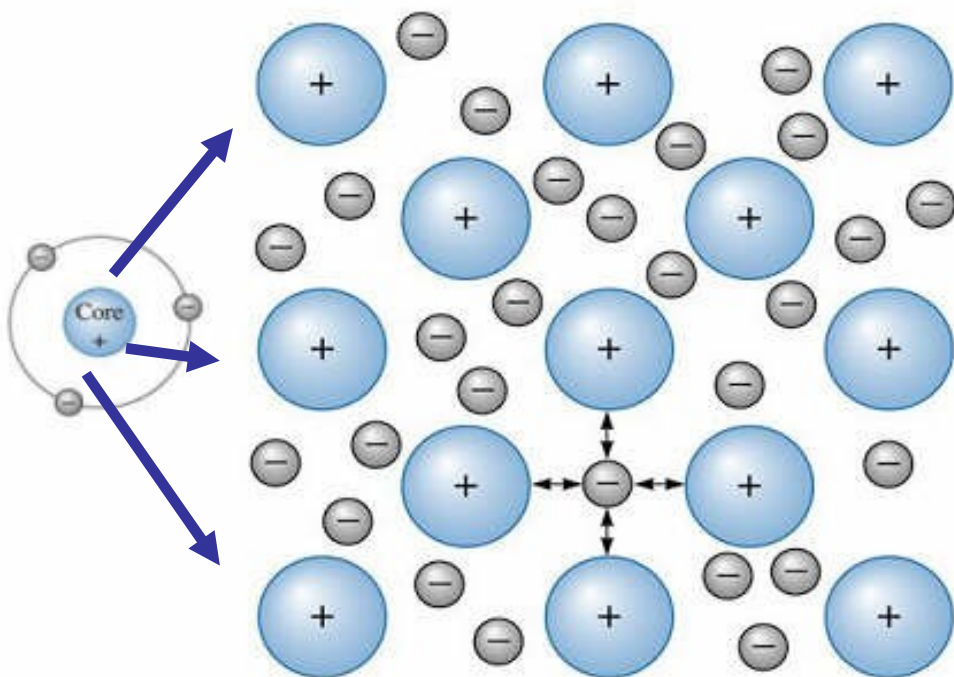
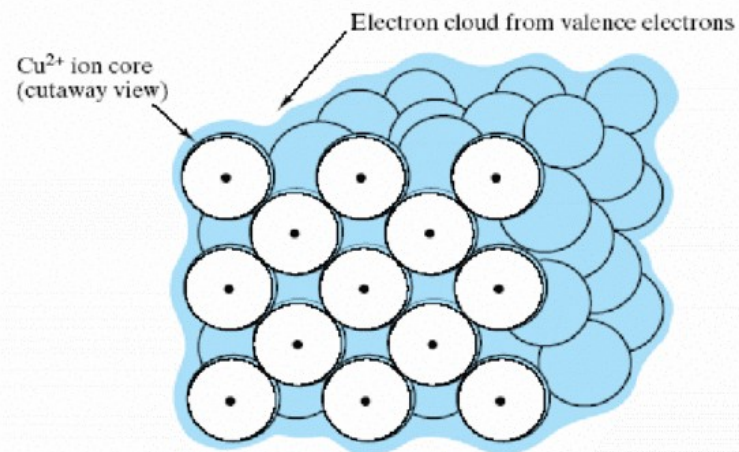


Ilustração esquemática da ligação metálica

Ligações metálicas envolvem a deslocalização de eletrons de valência





TIPOS DE MATERIAIS

Materiais metálicos

- **Dúctil**
- **Alta densidade**
- **Condutividade térmica e elétrica**
- **Temperatura de fusão relativamente elevada**



Ligações metálicas



POLÍMEROS – LIGAÇÕES QUÍMICAS

Polímeros na tabela periódica

1
1A
H
Hydrogen
1.008

2
2A
He
Helium
4.003

3
1A
Li
Lithium
6.941

4
2A
Be
Beryllium
9.012

5
3A
B
Boron
10.811

6
4A
C
Carbon
12.011

7
5A
N
Nitrogen
14.007

8
6A
O
Oxygen
15.999

9
7A
F
Fluorine
18.998

10
8A
Ne
Neon
20.180

11
1A
Na
Sodium
22.990

12
2A
Mg
Magnesium
24.305

13
3A
Al
Aluminum
26.982

14
4A
Si
Silicon
28.086

15
5A
P
Phosphorus
30.974

16
6A
S
Sulfur
32.066

17
7A
Cl
Chlorine
35.453

18
8A
Ar
Argon
39.948

19
1A
K
Potassium
39.098

20
2A
Ca
Calcium
40.078

21
3B
Sc
Scandium
44.956

22
4B
Ti
Titanium
47.867

23
5B
V
Vanadium
50.942

24
6B
Cr
Chromium
51.996

25
7B
Mn
Manganese
54.938

26
8
Fe
Iron
55.845

27
9
Co
Cobalt
58.933

28
10
Ni
Nickel
58.693

29
11
Cu
Copper
63.546

30
12
Zn
Zinc
65.38

31
13
Ga
Gallium
69.723

32
14
Ge
Germanium
72.631

33
15
As
Arsenic
74.922

34
16
Se
Selenium
78.971

35
17
Br
Bromine
79.904

36
18
Kr
Krypton
83.798

37
1A
Rb
Rubidium
84.468

38
2A
Sr
Strontium
87.62

39
3B
Y
Yttrium
88.906

40
4B
Zr
Zirconium
91.224

41
5B
Nb
Niobium
92.906

42
6B
Mo
Molybdenum
95.95

43
7B
Tc
Technetium
98.907

44
8
Ru
Ruthenium
101.07

45
9
Rh
Rhodium
102.906

46
10
Pd
Palladium
106.42

47
11
Ag
Silver
107.868

48
12
Cd
Cadmium
112.411

49
13
In
Indium
114.818

50
14
Sn
Tin
118.711

51
15
Sb
Antimony
121.760

52
16
Te
Tellurium
127.6

53
17
I
Iodine
126.904

54
18
Xe
Xenon
131.294

55
1A
Cs
Cesium
132.905

56
2A
Ba
Barium
137.328

57-71
Lanthanide Series

72
4B
Hf
Hafnium
178.49

73
5B
Ta
Tantalum
180.948

74
6B
W
Tungsten
183.84

75
7B
Re
Rhenium
186.207

76
8
Os
Osmium
190.23

77
9
Ir
Iridium
192.217

78
10
Pt
Platinum
195.085

79
11
Au
Gold
196.967

80
12
Hg
Mercury
200.592

81
13
Tl
Thallium
204.383

82
14
Pb
Lead
207.2

83
15
Bi
Bismuth
208.980

84
16
Po
Polonium
[208.982]

85
17
At
Astatine
209.987

86
18
Rn
Radon
222.018

87
1A
Fr
Francium
223.020

88
2A
Ra
Radium
226.025

89-103
Actinide Series

104
4B
Rf
Rutherfordium
[261]

105
5B
Db
Dubnium
[262]

106
6B
Sg
Seaborgium
[266]

107
7B
Bh
Bohrium
[264]

108
8
Hs
Hassium
[269]

109
9
Mt
Meitnerium
[268]

110
10
Ds
Darmstadtium
[269]

111
11
Rg
Roentgenium
[272]

112
12
Cn
Copernicium
[277]

113
13
Uut
Ununtrium
unknown

114
14
Fl
Flerovium
[289]

115
15
Uup
Ununpentium
unknown

116
16
Lv
Livermorium
[298]

117
17
Uus
Ununseptium
unknown

118
18
Uuo
Ununoctium
unknown

57
Lanthanide Series
La
Lanthanum
138.905

58
Ce
Cerium
140.116

59
Pr
Praseodymium
140.908

60
Nd
Neodymium
144.243

61
Pm
Promethium
144.913

62
Sm
Samarium
150.36

63
Eu
Europium
151.964

64
Gd
Gadolinium
157.25

65
Tb
Terbium
158.925

66
Dy
Dysprosium
162.500

67
Ho
Holmium
164.930

68
Er
Erbium
167.259

69
Tm
Thulium
168.934

70
Yb
Ytterbium
173.055

71
Lu
Lutetium
174.967

89
Actinide Series
Ac
Actinium
227.028

90
Th
Thorium
232.038

91
Pa
Protactinium
231.036

92
U
Uranium
238.029

93
Np
Neptunium
237.048

94
Pu
Plutonium
244.064

95
Am
Americium
243.061

96
Cm
Curium
247.070

97
Bk
Berkelium
247.070

98
Cf
Californium
251.080

99
Es
Einsteinium
[254]

100
Fm
Fermium
257.095

101
Md
Mendelevium
258.1

102
No
Nobelium
259.101

103
Lr
Lawrencium
[262]

Alkali Metal

Alkaline Earth

Transition Metal

Basic Metal

Semimetal

Nonmetal

Halogen

Noble Gas

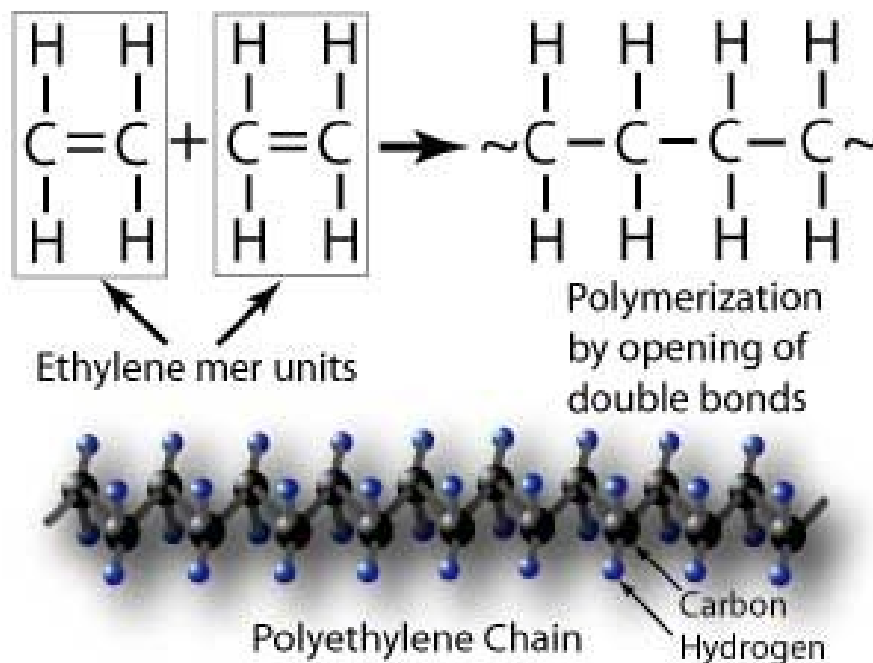
Lanthanide

Actinide



POLÍMEROS – LIGAÇÕES QUÍMICAS

Ligações Primárias - Ligação Covalente



<https://www.nde-ed.org/EducationResources/CommunityCollege/Materials/Graphics/PolyethyleneChain.jpg>

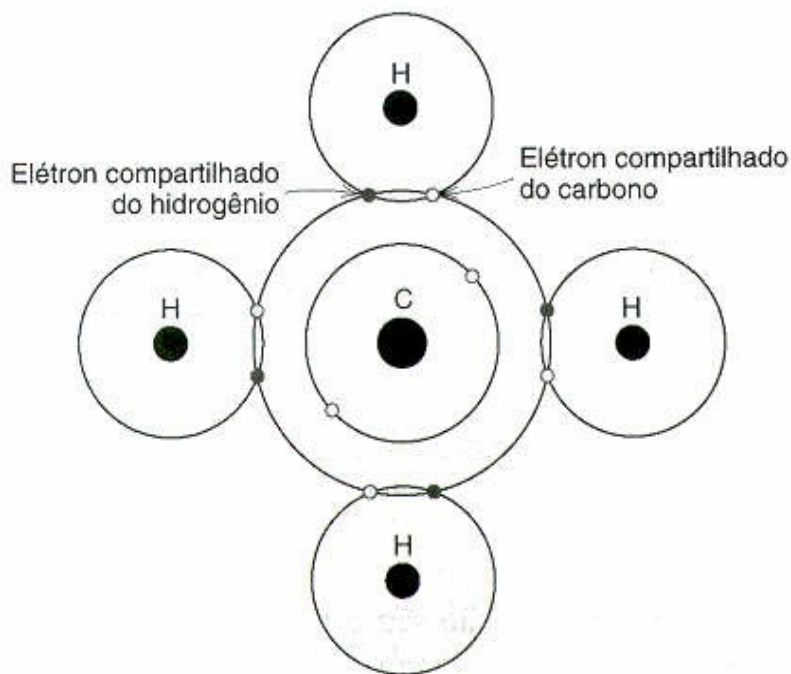
- ▶ Envolve o **compartilhamento** dos elétrons de valência de átomos adjacentes.
- ▶ A ligação resultante é **altamente direcional**.
- ▶ Menor diferença de eletronegatividade entre os elementos do que o observado em ligações iônicas.



POLÍMEROS – LIGAÇÕES QUÍMICAS

Ligações Primárias - Ligação Covalente

*Representação esquemática da
ligação covalente na molécula
de metano (CH_4)*



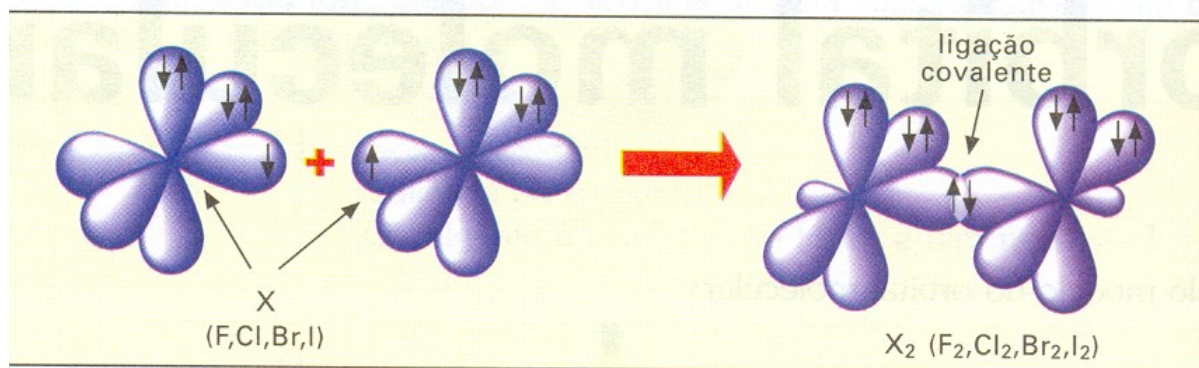
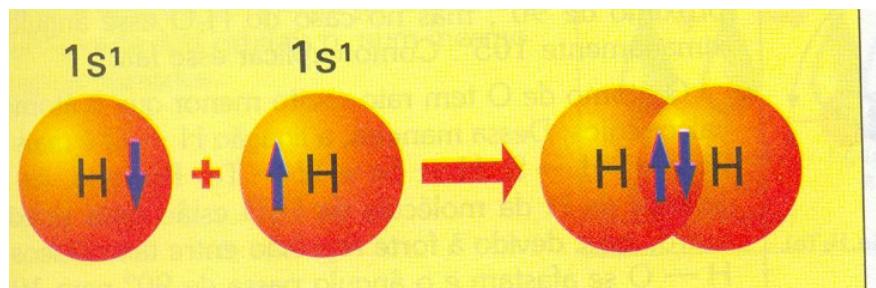
**C = 2,5
H = 2,1
 $D_E = 0,4$
Forte caráter
covalente**



POLÍMEROS – LIGAÇÕES QUÍMICAS

Ligações Primárias - Ligação Covalente

Modelo do Orbital Molecular → uma ligação é formada pela interpenetração de um orbital semi-cheio do átomo A com um orbital semi-cheio do átomo B.

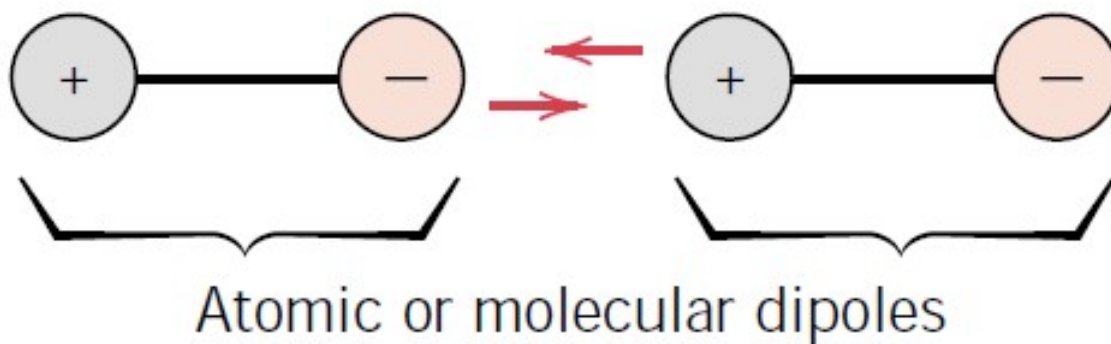




POLÍMEROS – LIGAÇÕES QUÍMICAS

Ligações Secundárias ou de Van der Waals

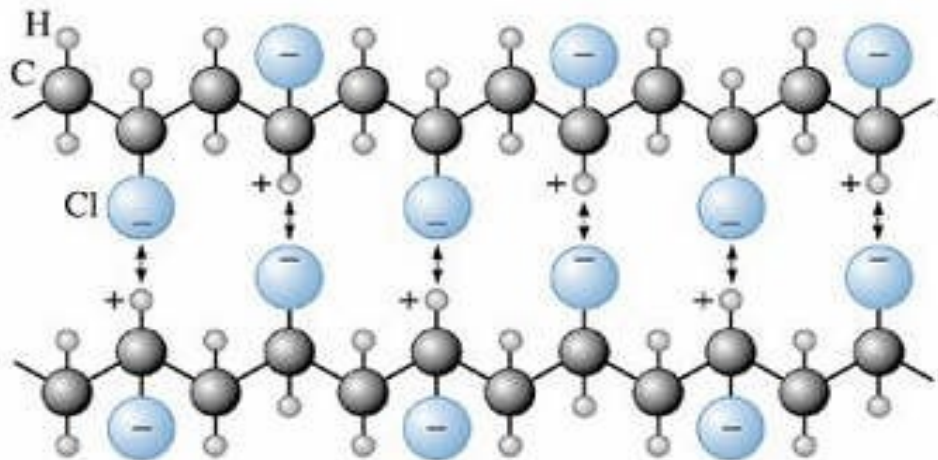
- ✓ Ocorrem atrações entre dipolos gerados pela assimetria de cargas.
- ✓ O mecanismo dessas ligações é similar ao das ligações iônicas, porém não existem elétrons transferidos.





POLÍMEROS – LIGAÇÕES QUÍMICAS

Ligações Secundárias ou de Van der Waals



**Ligações de Van der Waals no PVC
(entre duas moléculas distintas)**

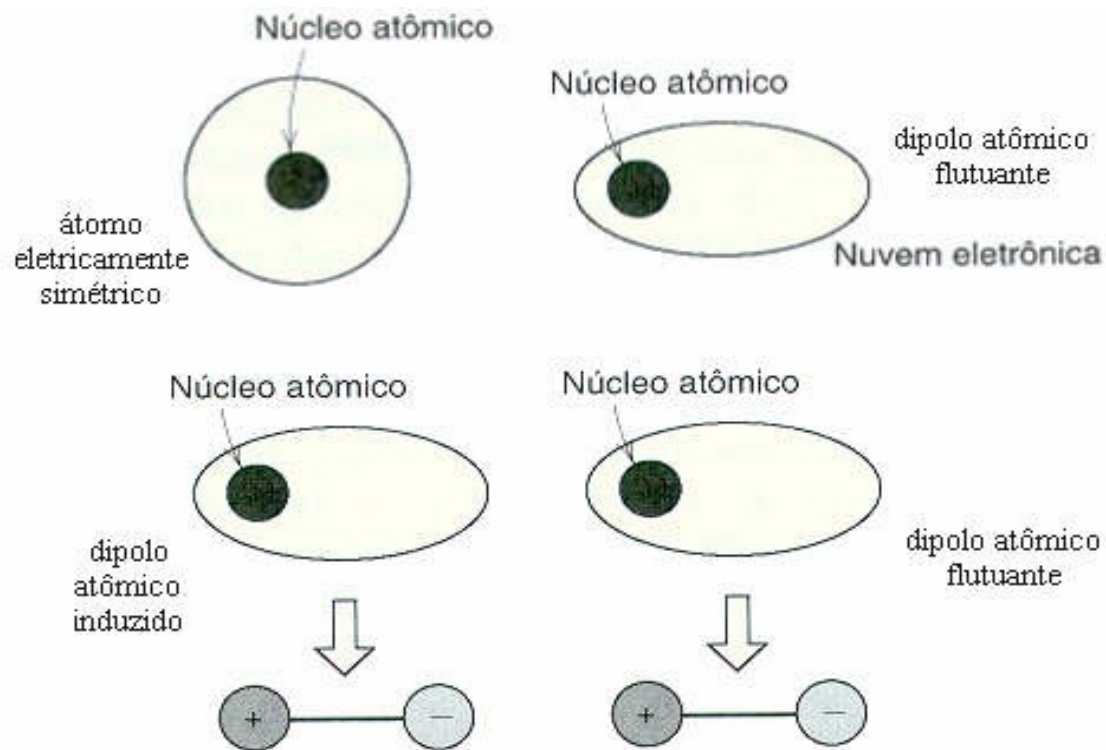
As ligações dipolares podem ser entre:

- dipolos permanentes.**
- dipolos permanentes e induzidos.**
- dipolos induzidos flutuantes.**

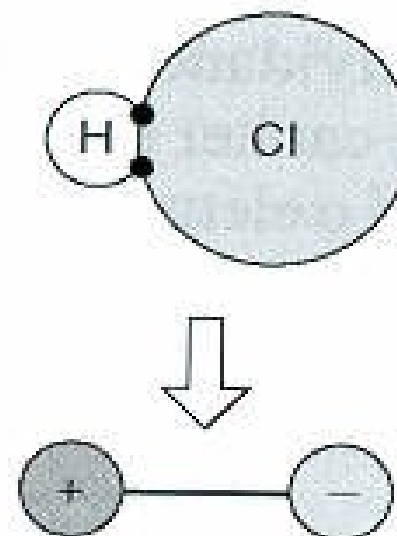


POLÍMEROS – LIGAÇÕES QUÍMICAS

Ligações Secundárias ou de Van der Waals



Dipolos Induzidos Flutuantes



Dipolo Molecular Permanente



POLÍMEROS – LIGAÇÕES QUÍMICAS

Ligações Secundárias ou de Van der Waals

Ligações do hidrogênio

- ▶ É um caso especial de ligação entre moléculas polares.
- ▶ É o tipo de ligação secundária mais forte.
- ▶ Ocorre entre moléculas em que o H está ligado covalentemente ao flúor (como no HF), ao oxigênio (como na água) ou ao nitrogênio (por exemplo, NH_3).



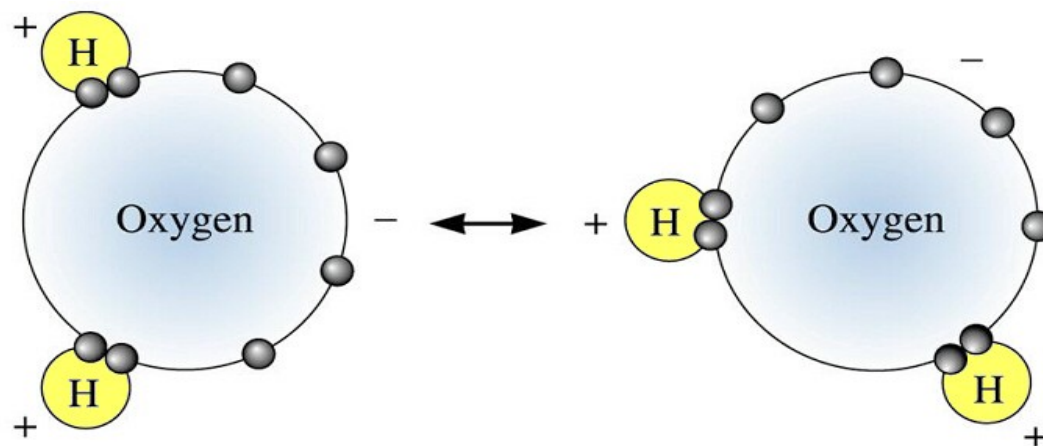
POLÍMEROS – LIGAÇÕES QUÍMICAS

Ligações Secundárias ou de Van der Waals

Ligações do hidrogênio



Ligação de hidrogênio no HF



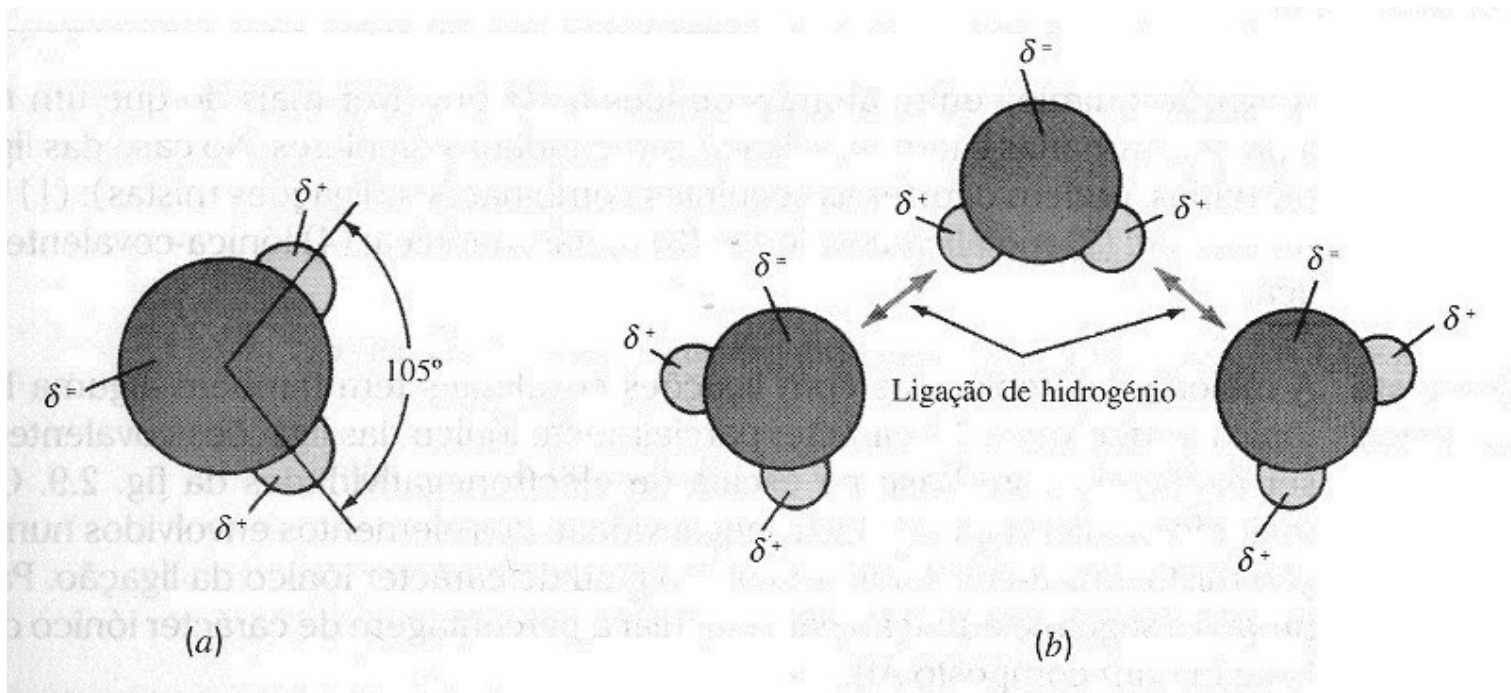
Ligação de hidrogênio na molécula da água



POLÍMEROS – LIGAÇÕES QUÍMICAS

Ligações Secundárias ou de Van der Waals

Ligações do hidrogênio



(a) Dipolo permanente da molécula de água;

(b) Ligação de hidrogênio entre moléculas de água (atração entre dipolos permanentes).



Universidade Federal do ABC

CENTRO DE ENGENHARIA, MODELAGEM E CIÊNCIAS SOCIAIS APLICADAS

MATERIAIS E SUAS PROPRIEDADES

TIPOS DE MATERIAIS

Materiais poliméricos

- Baixa densidade
- Isolantes térmicos e elétricos
- Temperatura de fusão relativamente baixa
- Resistência mecânica relativamente baixa



**Ligações covalentes
(primárias e secundárias)**



CERÂMICAS – LIGAÇÕES COVALENTES E LIGAÇÕES IÔNICAS

Cerâmicas na tabela periódica

1
IA
1A

2
IIA
2A

13
IIIA
3A

14
IVA
4A

15
VA
5A

16
VIA
6A

17
VIIA
7A

18
VIIIA
8A

1
H
Hydrogen
1.008

3
Li
Lithium
6.941

11
Na
Sodium
22.990

19
K
Potassium
39.098

37
Rb
Rubidium
84.468

55
Cs
Cesium
132.905

87
Fr
Francium
223.020

4
Be
Beryllium
9.012

12
Mg
Magnesium
24.305

20
Ca
Calcium
40.078

38
Sr
Strontium
87.62

56
Ba
Barium
137.328

88
Ra
Radium
226.025

5
B
Boron
10.811

13
Al
Aluminum
26.982

31
Ga
Gallium
69.723

49
In
Indium
114.818

67
Tl
Thallium
204.383

6
C
Carbon
12.011

14
Si
Silicon
28.086

32
Ge
Germanium
72.631

50
Sn
Tin
118.711

68
Pb
Lead
207.2

7
N
Nitrogen
14.007

15
P
Phosphorus
30.974

33
As
Arsenic
74.922

51
Sb
Antimony
121.760

69
Bi
Bismuth
208.980

8
O
Oxygen
15.999

16
S
Sulfur
32.066

34
Se
Selenium
78.971

52
Te
Tellurium
127.6

84
Po
Polonium
[208.982]

9
F
Fluorine
18.998

17
Cl
Chlorine
35.453

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Br
Bromine
79.904

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I
Iodine
126.904

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At
Astatine
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Neon
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Ar
Argon
39.948

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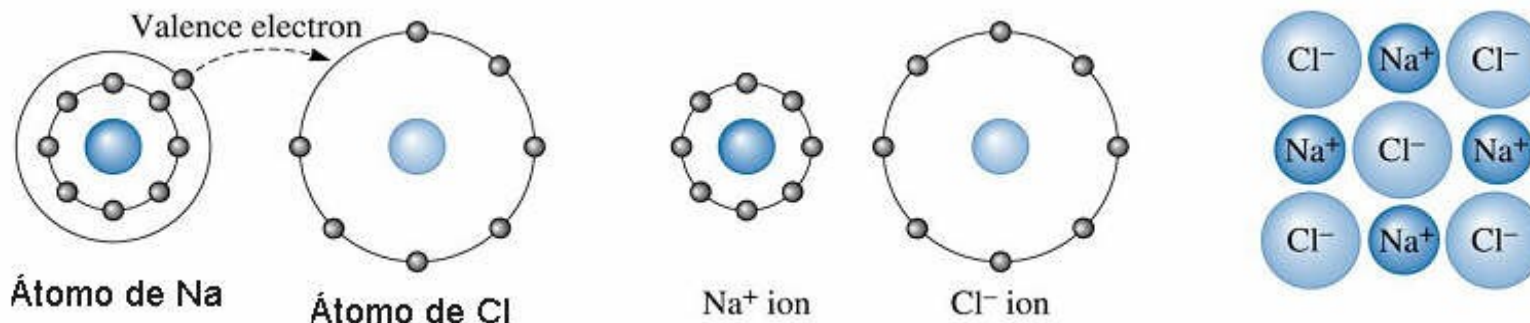
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CERÂMICAS – LIGAÇÕES IÔNICAS

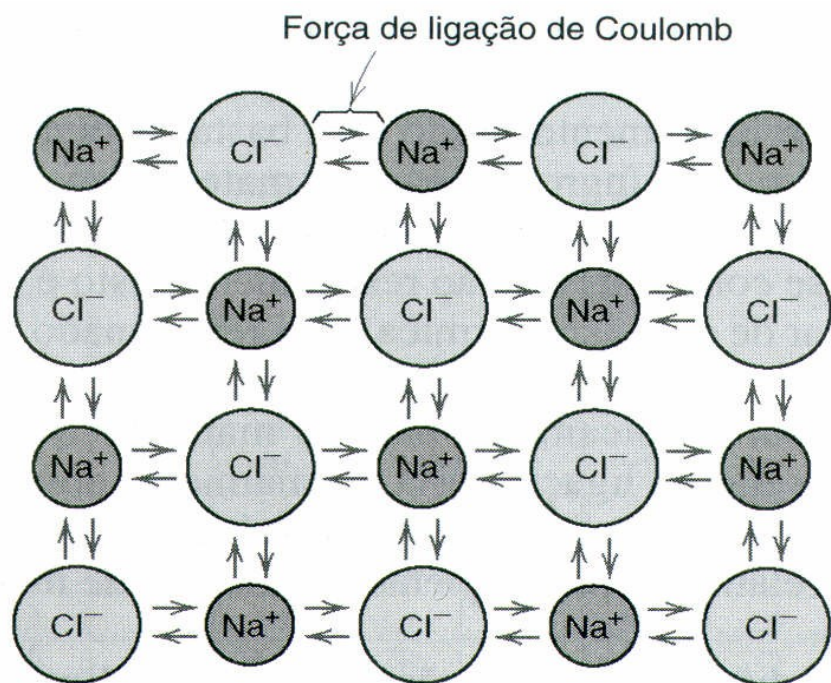


- ✓ Envolve a **transferência de elétrons** de um átomo para outro.
- ✓ A ligação é **não-direcional**.
- ✓ Grande diferença de eletronegatividade entre os elementos:
 $\text{Na} = 0,9$; $\text{Cl} = 3,0$
- ✓ A ligação iônica resulta da atração eletrostática entre dois íons de cargas opostas.



CERÂMICAS – LIGAÇÕES IÔNICAS

Ligações Primárias - Ligação Iônica



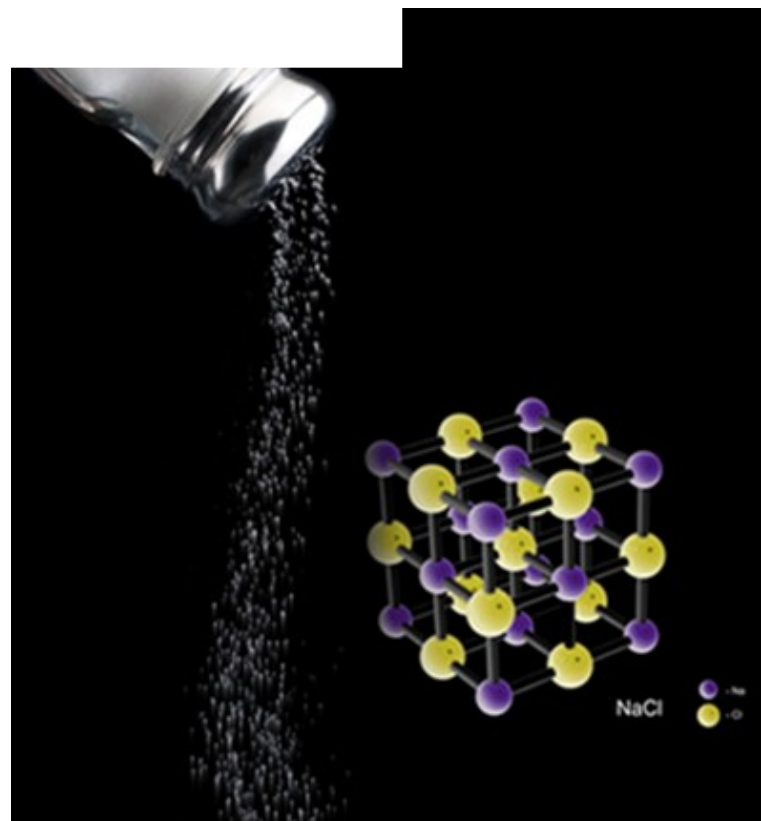
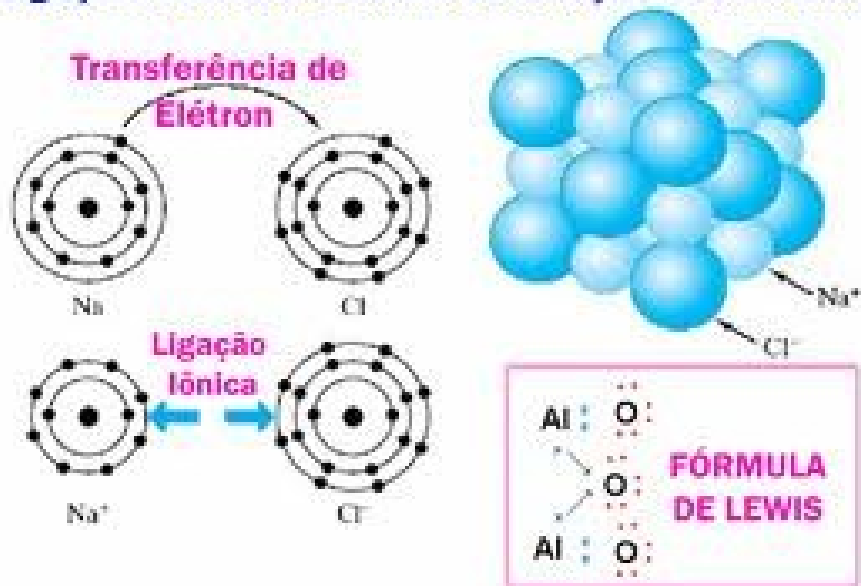
Exemplo: Cloreto de sódio → tanto o cátion Na^+ quanto o ânion Cl^- ficam com seus orbitais externos completos.



CERÂMICAS – LIGAÇÕES IÔNICAS

Ligações Primárias - Ligação Iônica

Ligações iônicas resultam da atração coulombiana

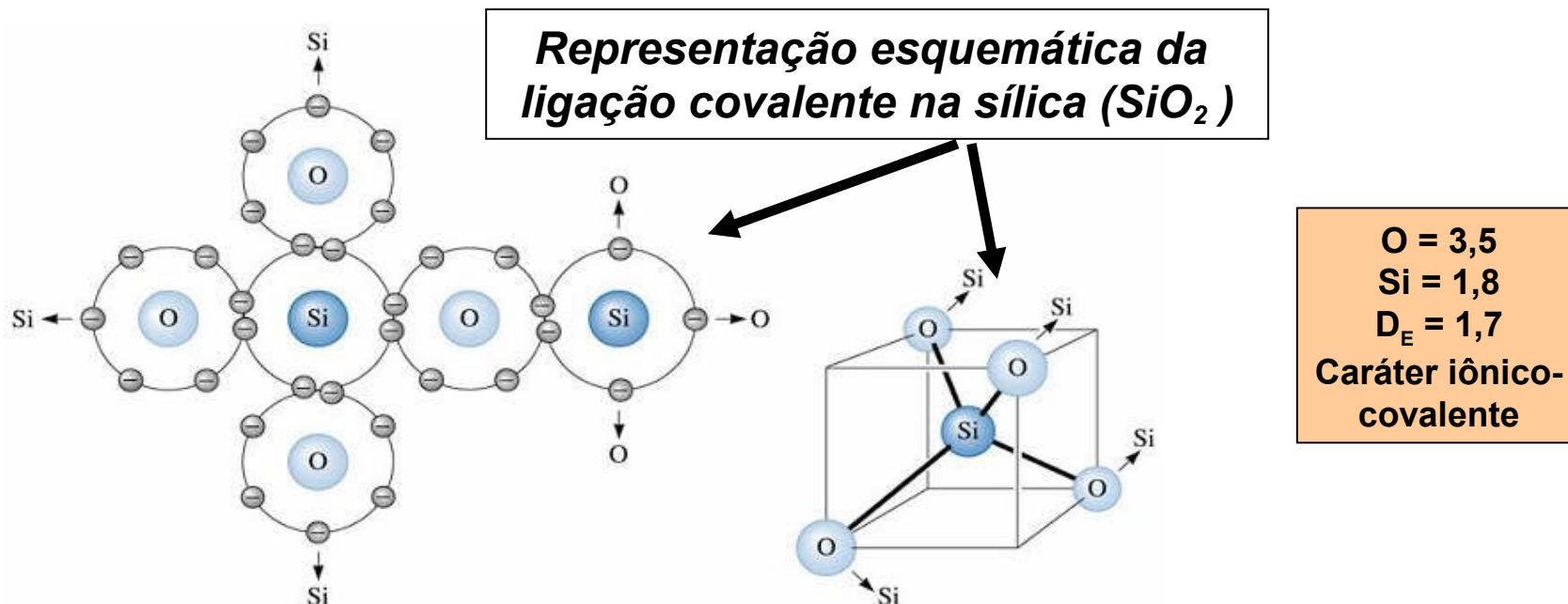


- Forças de atração Coulombianas (variam com o quadrado do inverso da distância interatômica).



CERÂMICAS – LIGAÇÕES COVALENTES

Ligações Primárias - Ligação Covalente



- ▶ Envolve o **compartilhamento** dos elétrons de valência de átomos adjacentes.
- ▶ A ligação resultante é **altamente direcional**.
- ▶ Menor diferença de eletronegatividade entre os elementos do que o observado em ligações iônicas.



TIPOS DE MATERIAIS

Materiais cerâmicos

- Frágil
- Elevada dureza
- Boa refratariedade
- Isolantes térmicos e elétricos



**Ligações iônicas e/ou
covalentes**



ELETRONEGATIVIDADE

- Eletronegatividade → “poder que um átomo tem de atrair elétrons para si”

IA																		0
1																		2
H																		He
2,1																		-
	IIA											IIIA	IVA	VA	VIA	VIIA		
3	4											5	6	7	8	9	10	
Li	Be											B	C	N	O	F	Ne	
1,0	1,5											2,0	2,5	3,0	3,5	4,0	-	
11	12											13	14	15	16	17	18	
Na	Mg											Al	Si	P	S	Cl	Ar	
0,9	1,2											1,5	1,8	2,1	2,5	3,0	-	
		IIIB	IVB	VB	VIB	VIIB	VIII				IB	IIB						
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
0,8	1,0	1,3	1,5	1,6	1,6	1,5	1,8	1,8	1,8	1,9	1,6	1,6	1,8	2,0	2,4	2,8	-	
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
0,8	1,0	1,2	1,4	1,6	1,8	1,9	2,2	2,2	2,2	1,9	1,7	1,7	1,8	1,9	2,1	2,5	-	
55	56	57-71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
0,7	0,9	1,1-1,2	1,3	1,5	1,7	1,9	2,2	2,2	2,2	2,4	1,9	1,8	1,8	1,9	2,0	2,2	-	
87	88	89-102																
Fr	Ra	Ac-No																
0,7	0,9	1,1-1,7																

Maior “facilidade” em
ceder elétrons
= CÁTIONS

Maior facilidade em
ganhar elétrons
= ÂNIONS

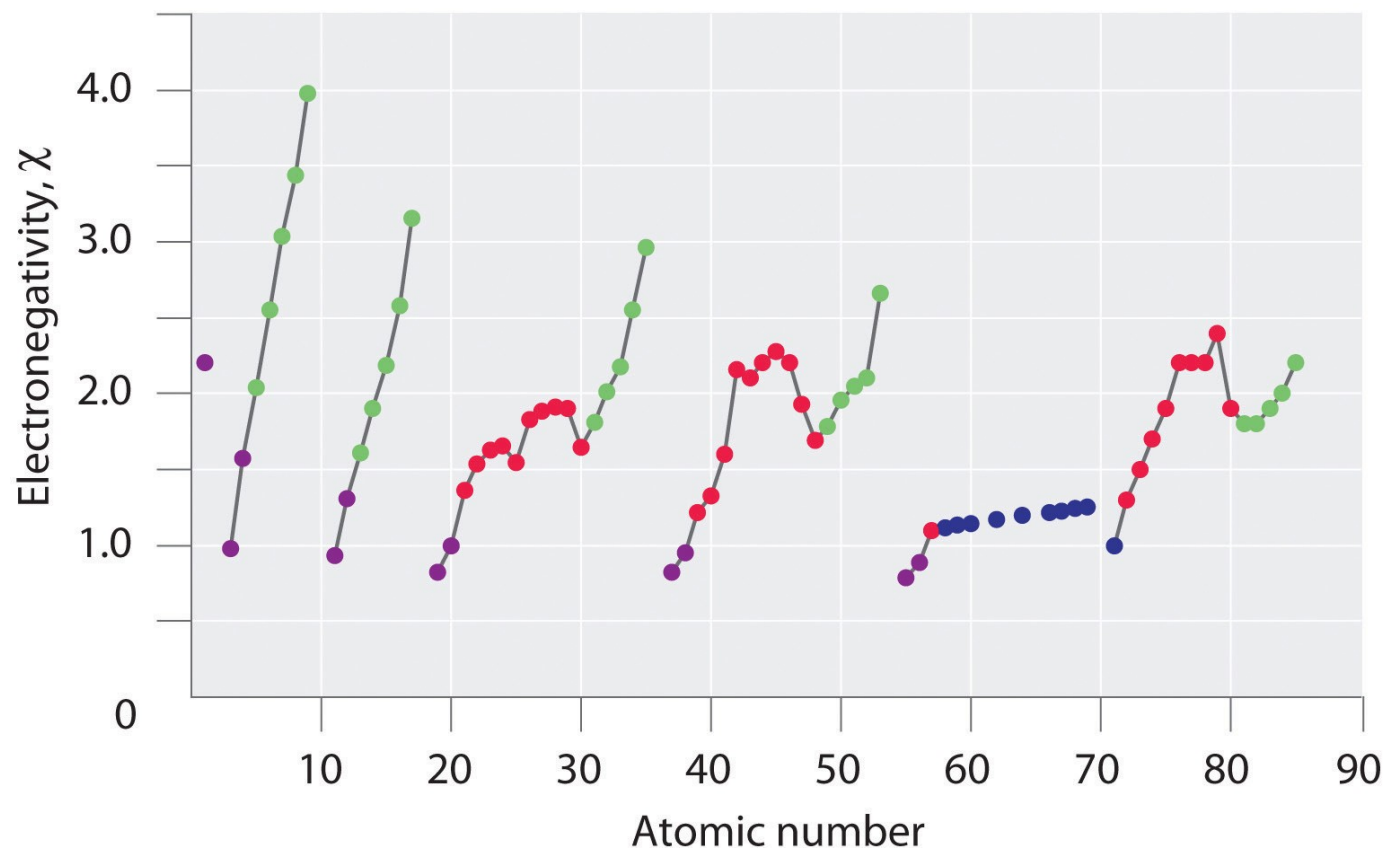
Inertes –
Gases Nobres



ELETRONEGATIVIDADE

Escala de Eletonegatividade de Pauling

- Main groups 1-2
(*s* block)
- Main groups 13-18
(*p* block)
- Transition metals
(*d* block)
- Lanthanides
(*f* block)





Universidade Federal do ABC

ELETRONEGATIVIDADE

Polaridade das ligações químicas

Relacionada com a diferença de eletronegatividade:

$\Delta E > 1,7$ – ligação iônica

$\Delta E < 1,7$ – ligação covalente polar

$\Delta E = 0$ – ligação covalente apolar

Fração de caráter iônico

$$\% \text{ caráter iônico} = (1 - e^{-0,25(X_A - X_B)^2}) \times 100\%$$

X_A e X_B correspondem aos valores de eletronegatividade dos elementos envolvidos nas ligações



CLASSIFICAÇÃO DOS MATERIAIS

Metais

- Ligação metálica

• Au, Ag, Pb, Fe, aço (Fe + C), duralumínio (Al + Cu), Na, Hg

Cerâmicas

- Ligação iônica ou covalente
- Cristalinos ou amorfos (vidros)
- Óxidos e não-óxidos

• SiO₂, Al₂O₃, MgO, NaCl, vidro de janela, diamante, tijolo, cascalho

Polímeros

- Ligação covalente e secundária
- Orgânicos ou inorgânicos
- Alto peso molecular

• Polietileno, polipropileno, borracha, fibras naturais, silicone, teflon

Semi-condutores

- Ligação covalente
- Comportamento intermediário de condução eletrônica

• Si e Ge (naturais), polianilina (sintéticos)

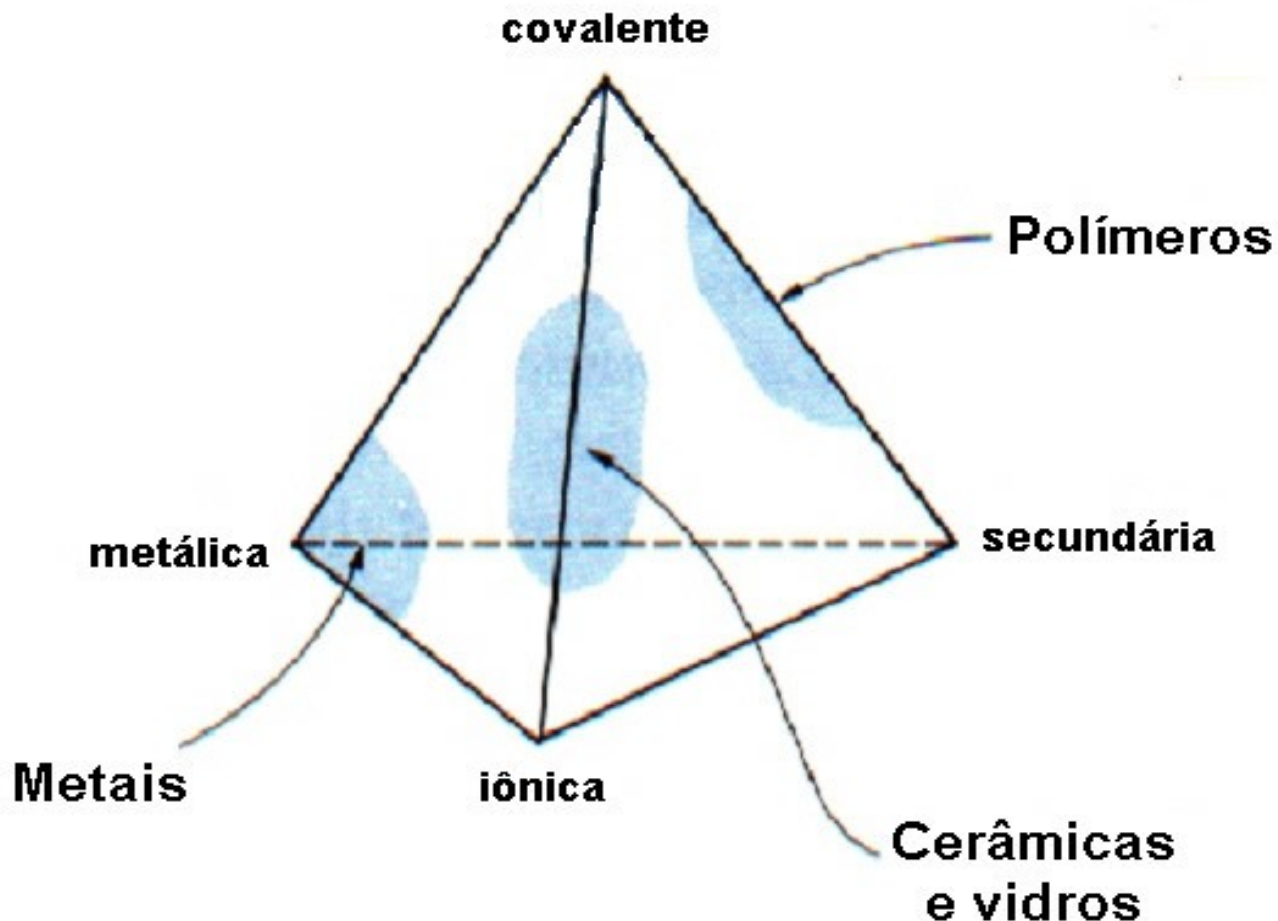
Compósitos ou conjugados

- União de mais de um material

• Concreto, poliéster + fibra de vidro, lapis, casca de ovo, MDF, circuito impresso



CLASSIFICAÇÃO DOS MATERIAIS: SEGUNDO O TIPO DE LIGAÇÃO QUÍMICA



Tetraedro que representa a contribuição relativa dos diferentes tipos de ligação para categorias de Materiais de Engenharia (metais, cerâmicas e polímeros)



ESTRUTURA DOS SÓLIDOS

SÓLIDOS CRISTALINOS E AMORFOS

Estrutura: organização das partes ou dos elementos que formam um todo.

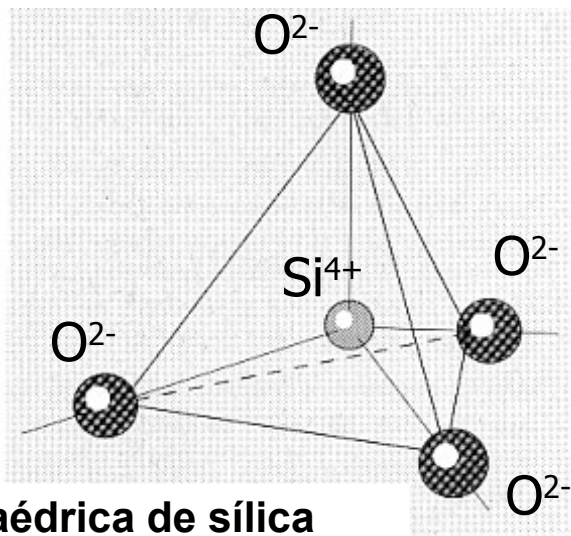
As duas principais classificações de materiais sólidos de acordo com a distribuição espacial dos átomos, moléculas ou íons, são:

- ✓ **Sólidos Cristalinos:** compostos por átomos, moléculas ou íons arranjados de uma forma periódica em três dimensões. A ordem se repete para grandes distâncias atômicas (de longo alcance).
- ✓ **Sólidos Amorfos:** compostos por átomos, moléculas ou íons que não apresentam uma ordenação de longo alcance. Podem apresentar ordenação de curto alcance.

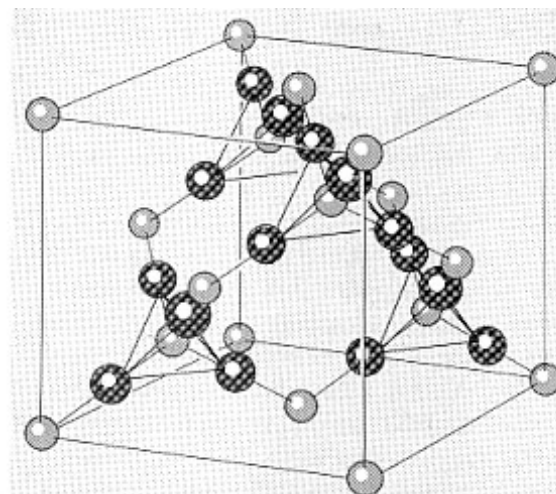


ESTRUTURA DOS SÓLIDOS

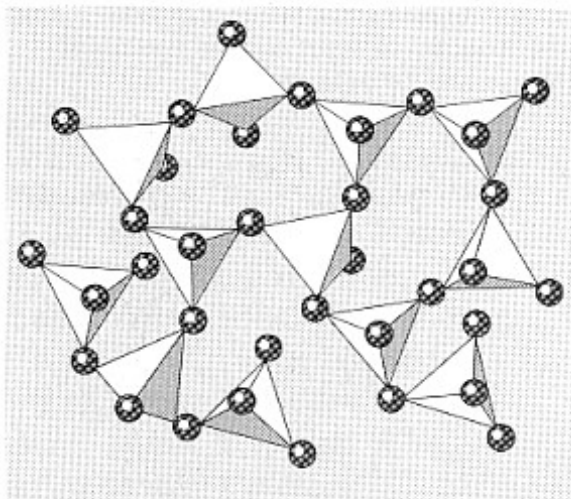
SÓLIDOS CRISTALINOS E AMORFOS



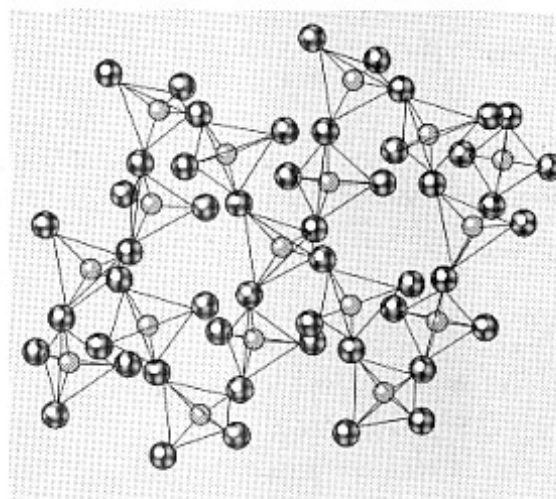
unidade tetraédrica de sílica



cristobalita - cristalina



vidro de sílica - amorfo



quartzo - cristalino