

Química

Propriedades Periódicas

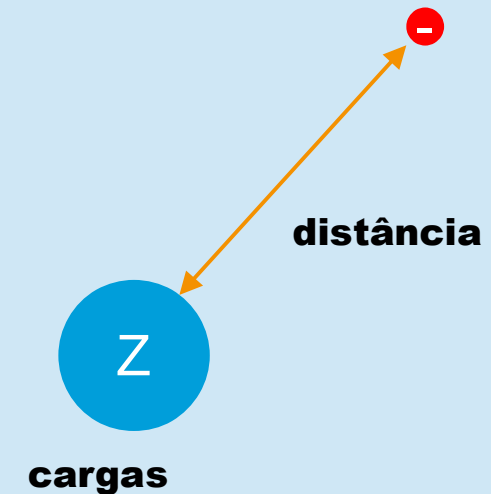
Prof. Diego J. Raposo

UPE – Poli

2025.1

Elétrons de valência

- Como vimos, há dois tipos de elétrons:
 - Elétrons do caroço (configuração de gás nobre);
 - Elétrons de valência (todos os outros).
- A força de atração entre elétrons de valência e o núcleo determina muitas das propriedades dos elementos, inclusive o grau e o tipo de reatividade;
- Sendo uma força eletrostática, ela depende de dois fatores:
 - Da **distância** média dos elétrons de valência ao núcleo;
 - Da **carga** que efetivamente os elétrons de valência sentem ao interagir com o núcleo.
- Através desses dois fatores também podemos entender e fazer previsões com os padrões evidenciados pela tabela periódica: as chamadas propriedades periódicas.



Fe (Z=26)

ENERG. CARGA NUCLEAR EFETIVA

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶
4s²

SUBNÍVEL EXTERNO

Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d⁶

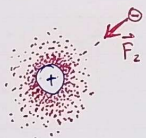
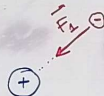
EM ÁTOMOS COM 1 ELÉTRON A ENERGIA SO-
DEPENDE DE n E Z, O NÚMERO DE PRÓTONS
(CARGAS POSITIVAS) NO NÚCLEO:

$$E = -13,6 \text{ eV} \cdot \frac{Z^2}{n^2}$$

EM ÁTOMOS COM MAIS DE UM ELÉTRON A PRESEN-
ÇA DE ELÉTRONS MAIS PRÓXIMOS DO NÚCLEO
BLINDA-O DOS MAIS DISTANTES

ASSIM, ESSES ELÉTRONS "SENTEM" UMA CARGA Z_{ef}
EFETIVA MENOR QUE Z:

$$E = -13,6 \text{ eV} \cdot \frac{Z_{ef}^2}{n^2}$$



GRUPO 15
5-12=3

4p+6=54

+10

+8

70

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

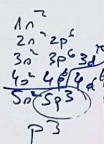
↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

- ESSA BLINDAGEM SE DEVE A PENETRAÇÃO DE SUBNÍVEIS EM UM MESMO NÍVEL, E A ELÉTRONS EM ORBITAIS COM MENOR ENERGIA QUE A DO ELÉTRON NO ORBITAL MAIS DISTANTE
- ELÉTRONS DO CAROÇO BLINDAM FORTEMENTE O NÚCLEO. DOS ELÉTRONS DE VALÊNCIA. EM CERTO NÍVEL DE APROXIMAÇÃO PODEMOS DIZER QUE A CARGA NUCLEAR É SUBTRAÍDA DA CARGA DOS ELÉTRONS DO CAROÇO PARA OS ELÉTRONS DE VALÊNCIA: OU SEJA, EQUIVALE A UM ÁTOMO HIDRÓGENOIDE COM CARGA NUCLEAR Z_{ef} AO INVÉS DE Z:



ELÉTRONS DO CAROÇO

ELÉTRONS DE VALÊNCIA

CHAMADA DE APROXIMAÇÃO ORBITAL

Z_{ef} ≈ Z - C

Sb (Z=51)

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

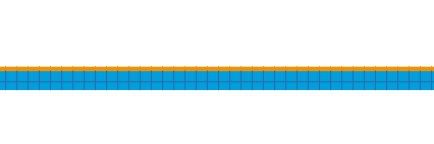
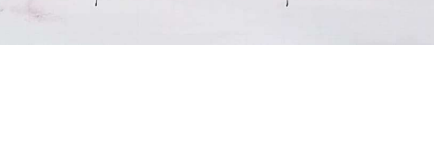
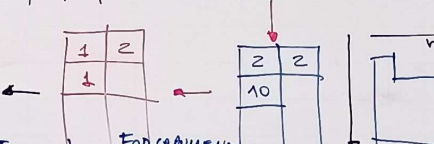
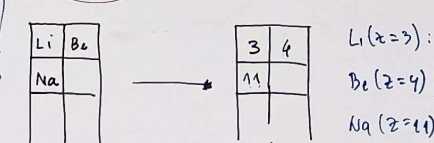
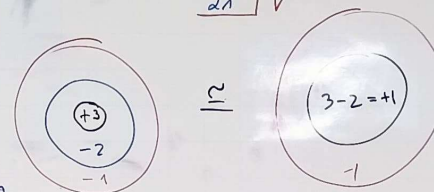
↓ Fe²⁺

1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

↓ Fe²⁺

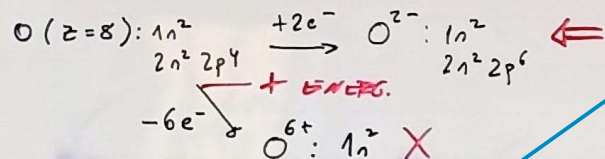
1s²
2s² 2p⁶
3s² 3p⁶ 3d¹⁰
4s² 4p⁶ 4d¹⁰
5s² 5p³

Ex.: Li (Z=3): $\frac{1n^2}{2n^2} V$

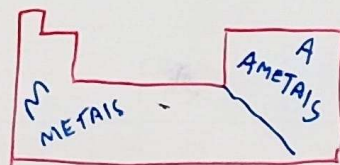
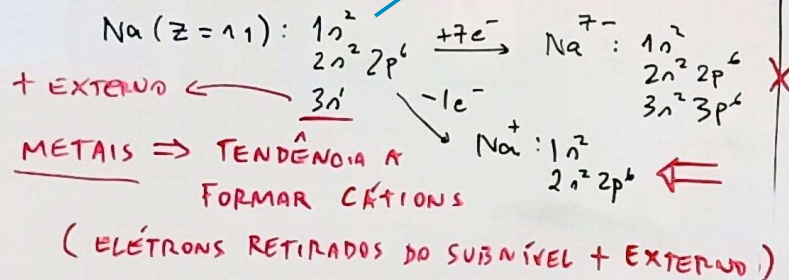


CAP. 7
SEL. 7.2-7.5

→ CONFIGURAÇÕES ELETRÔNICAS DE ÍONS



AMETAIS ⇒ TENDÊNCIA A FORMAR ÂNIONS
 (ELÉTRONS ACRESCENTADOS NO SUBNÍVEL + ENERGÉTICO)

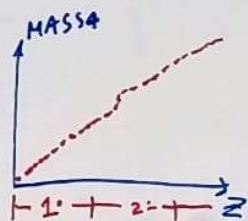


Usar exemplo do Fe

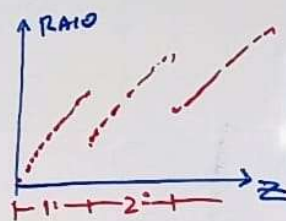
TABLE 1.4 Characteristics of Metals and Nonmetals

Metals	Nonmetals
Physical properties	
good conductors of electricity	poor conductors of electricity
malleable	not malleable
ductile	not ductile
lustrous	not lustrous
typically: solid; high melting point; good conductors of heat	typically: solid, liquid, or gas; low melting point; poor conductors of heat
Chemical properties	
react with acids	do not react with acids
form basic oxides (which react with acids)	form acidic oxides (which react with bases)
form cations	form anions
form ionic halides	form covalent halides

* PROPRIEDADES PERIÓDICAS



NÃO PERIÓDICA
(INDEPENDENTE DO PERÍODO)



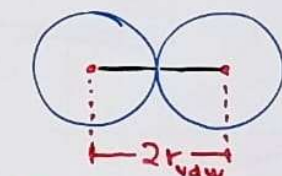
PERIÓDICA
(DEPENDENTE DO PERÍODO)

- RAIO ATÔMICO : OBTIDO A PARTIR DA DISTÂNCIA ENTRE NÚCLEOS, A DEPENDER DO TIPO DE LIGAÇÃO ENTRE OS ÁTOMOS

— ÁTOMOS NEUTROS

~ NÃO LIGADOS

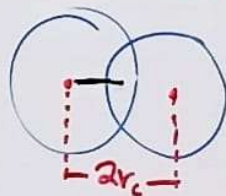
CASES
NOBRES



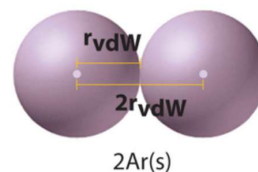
RAIO DE VAN DER WAALS

~ LIGADOS

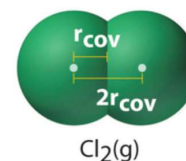
AMETAIS



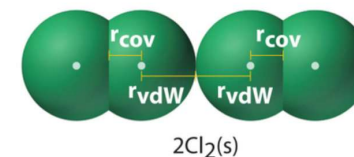
RAIO COVALENTE



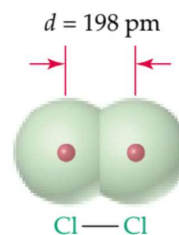
(c) van der Waals radius, r_{vdW}



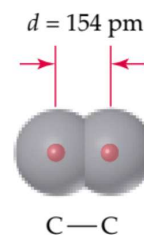
(a) Covalent radius, r_{cov}



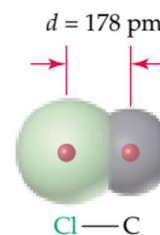
(d) Covalent vs. vdW radii



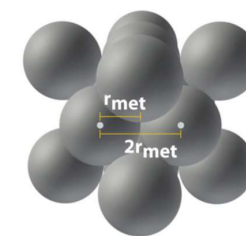
$$\frac{d}{2} = 99 \text{ pm}$$



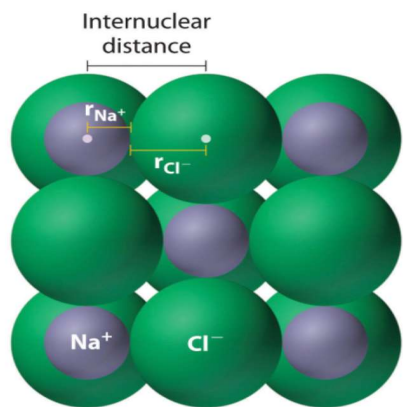
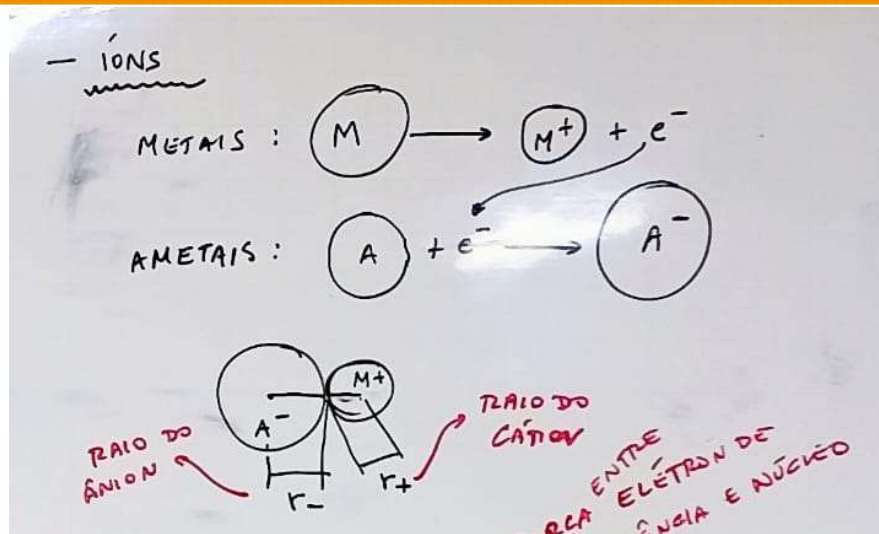
$$\frac{d}{2} = 77 \text{ pm}$$



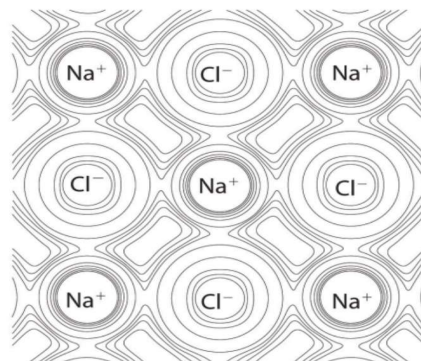
$$(99 \text{ pm} + 77 \text{ pm} = 176 \text{ pm}) \text{ predicted}$$



(b) Metallic radius, r_{met}

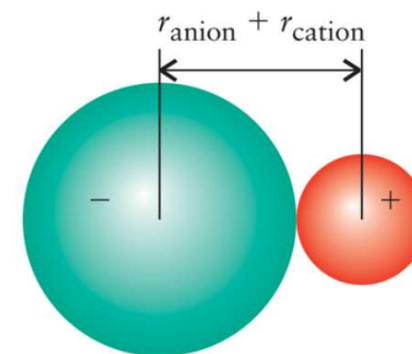
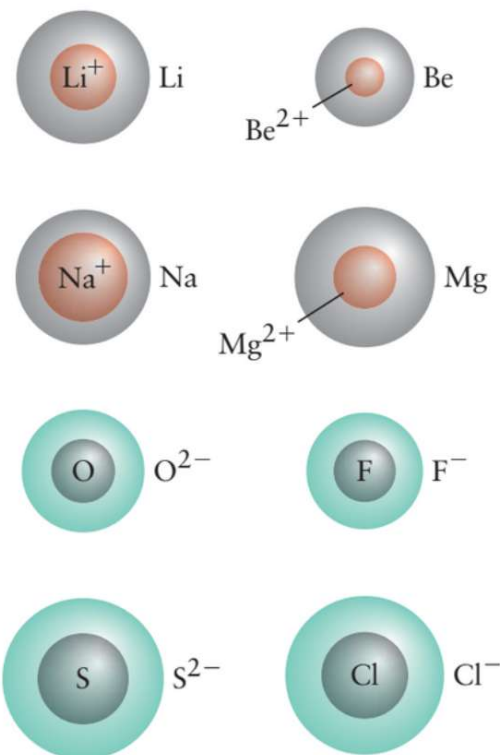


(a)

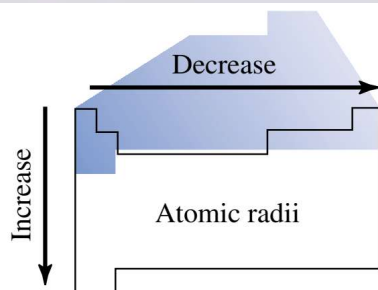
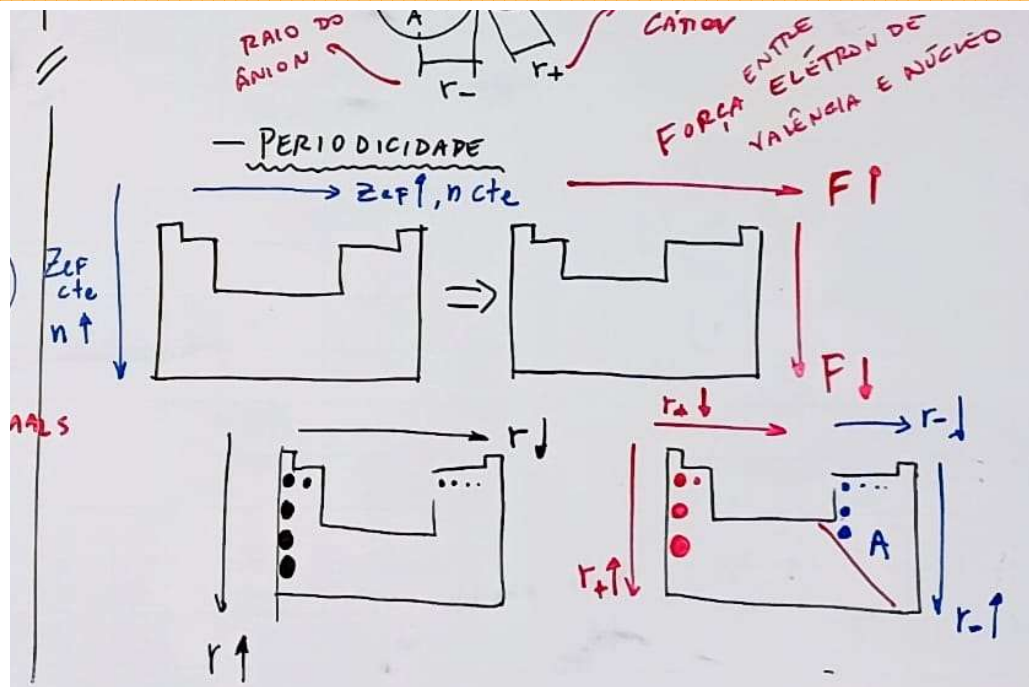


(b)

(a) The internuclear distance is apportioned between adjacent cations and anions in the ionic structure, as shown



12 Ionic radius

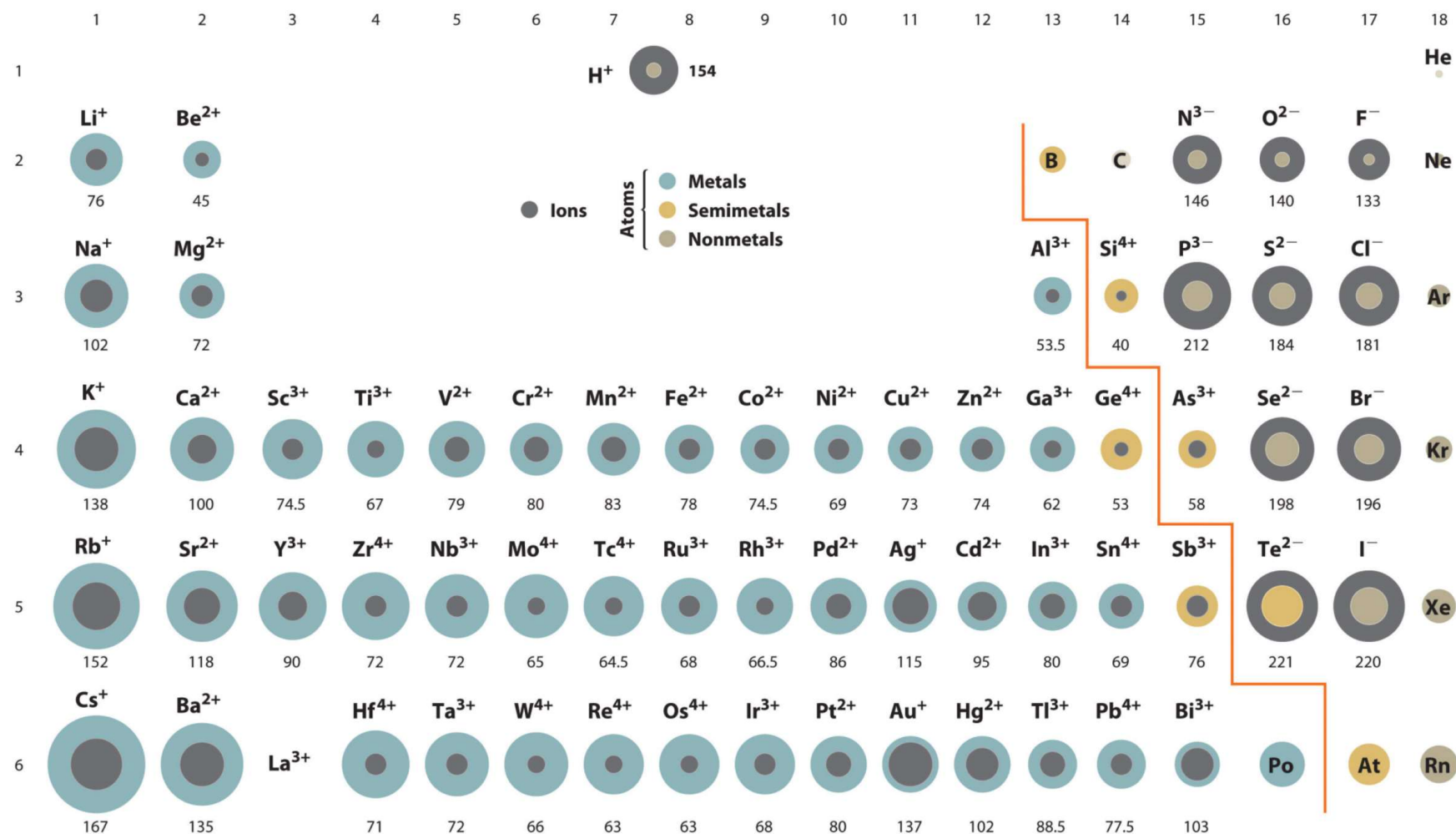


General trends in atomic radii of A group elements with position in the periodic table.

	1	2	13/III	14/IV	15/V	16/VI	17/VII	18/VIII
2	Li 152	Be 113	B 88	C 77	N 75	O 66	F 58	Ne
3	Na 154	Mg 160	Al 143	Si 117	P 110	S 104	Cl 99	Ar
4	K 227	Ca 197	Ga 122	Ge 122	As 121	Se 117	Br 114	Kr
5	Rb 248	Sr 215	In 163	Sn 141	Sb 141	Te 137	I 133	Xe
6	Cs 265	Ba 217	Tl 170	Pb 175	Bi 155	Po 167	At	Rn

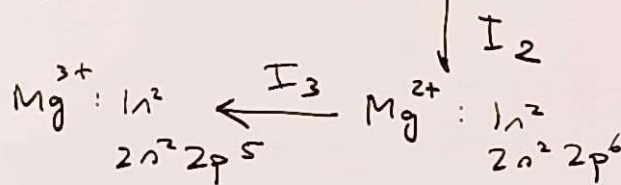
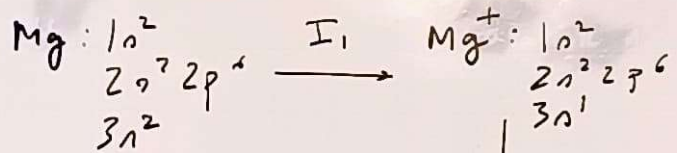
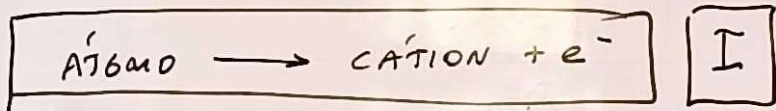
	1	2	13/III	14/IV	15/V	16/VI	17/VII	18/VIII
2	Li ⁺ 76	Be ²⁺ 45	B ³⁺ 23	C	N ³⁻ 171	O ²⁻ 140	F ⁻ 133	Ne
3	Na ⁺ 102	Mg ²⁺ 72	Al ³⁺ 54	Si	P ³⁻ 212	S ²⁻ 184	Cl ⁻ 181	Ar
4	K ⁺ 138	Ca ²⁺ 100	Ga ³⁺ 62	Ge	As ³⁻ 222	Se ²⁻ 198	Br ⁻ 196	Kr
5	Rb ⁺ 152	Sr ²⁺ 118	In ³⁺ 80	Sn	Sb	Te ²⁻ 221	I ⁻ 220	Xe
6	Cs ⁺ 167	Ba ²⁺ 135	Tl ³⁺ 89	Pb	Bi	Po	At	Rn

Figure 7.9 *Ionic Radii (in Picometers) of the Most Common Oxidation States of the s-, p-, and d-Block Elements*

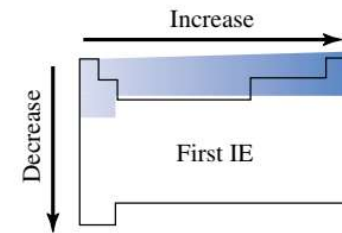
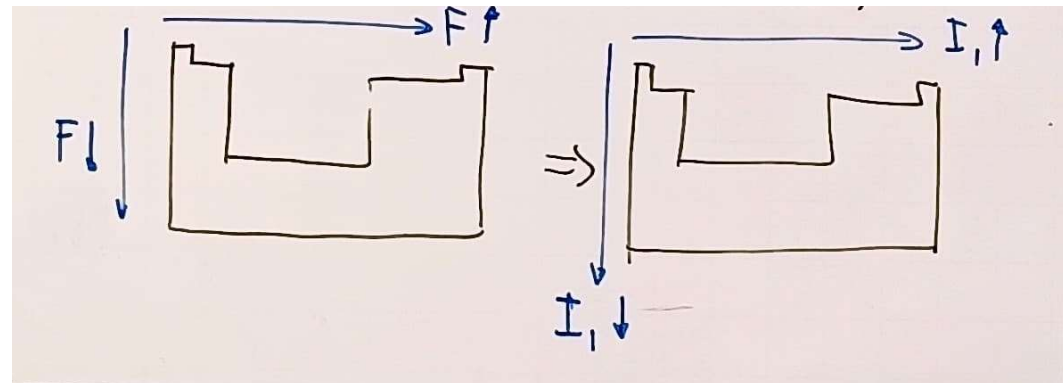


5

- ENERGIA DE IONIZAÇÃO { POSITIVA
FORMAÇÃO DE CÂTIONS
- ENERGIA P/ RETIRAR e^- DO ÁTOMO NA FASE GASOSA



$I_3 > I_2 > I_1$
↓
ELÉTRONS DO CAROÇO



General trends in first ionization energies of A group elements with position in the periodic table. Exceptions occur at Groups IIIA and VIA.

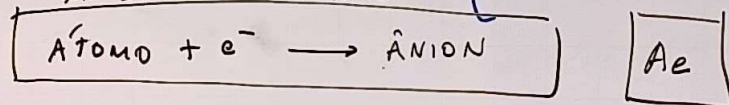
É PRECISO MAIS ENERGIA P/ RETIRAR e^-
DE AMETAIS QUE DE METAIS: METAIS = I_1 BAIXO
AMETAIS = I_1 ALTO

TABLE 6-1 *First Ionization Energies (kJ/mol of atoms) of Some Elements*

H 1312																	He 2372
Li 520	Be 899											B 801	C 1086	N 1402	O 1314	F 1681	Ne 2081
Na 496	Mg 738											Al 578	Si 786	P 1012	S 1000	Cl 1251	Ar 1521
K 419	Ca 599	Sc 631	Ti 658	V 650	Cr 652	Mn 717	Fe 759	Co 758	Ni 757	Cu 745	Zn 906	Ga 579	Ge 762	As 947	Se 941	Br 1140	Kr 1351
Rb 403	Sr 550	Y 617	Zr 661	Nb 664	Mo 685	Tc 702	Ru 711	Rh 720	Pd 804	Ag 731	Cd 868	In 558	Sn 709	Sb 834	Te 869	I 1008	Xe 1170
Cs 377	Ba 503	La 538	Hf 681	Ta 761	W 770	Re 760	Os 840	Ir 880	Pt 870	Au 890	Hg 1007	Tl 589	Pb 715	Bi 703	Po 812	At 890	Rn 1037

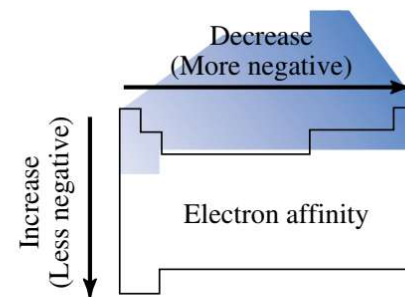
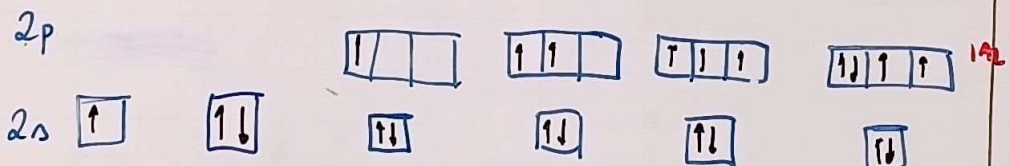
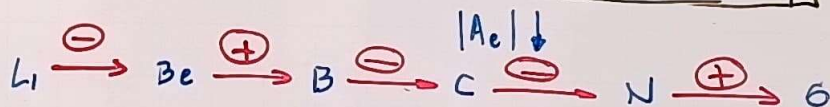
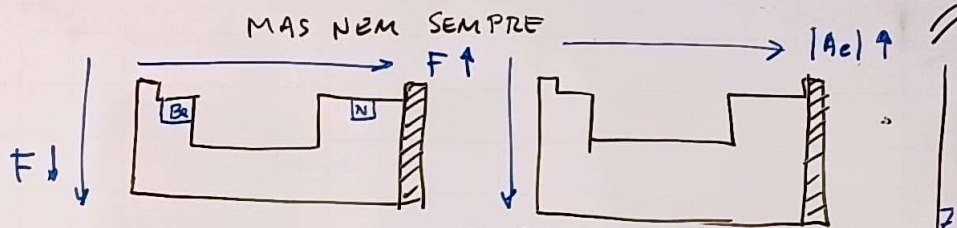
É PRECISO MAIS ENERGIA ?/ RETIRAR e^-
DE AMETAIS QUE DE METAIS: METAIS = I, BAIXO
AMETAIS = I, ALTO

- AFINIDADE ELETRÔNICA { NEGATIVA (GERALMENTE)
- ENERGIA ASSOCIADA À ADIÇÃO DE $1e^-$ A UM ÁTOMO FORMAS DE ÂNIONS



- NORMALMENTE $Ae < 0$ (PROCESSO ESPONTÂNEO)

MAS NEM SEMPRE



General trends in electron affinities of A group elements with position in the periodic table. There are many exceptions.

1	H -73									He 0
2	Li -60	Be (-0)		B -29	C -122	N 0	O -141	F -328	Ne 0	
3	Na -53	Mg (-0)		Cu -118	Al -43	Si -134	P -72	S -200	Cl -349	Ar 0
4	K -48	Ca (-0)		Ag -125	Ga -29	Ge -119	As -78	Se -195	Br -324	Kr 0
5	Rb -47	Sr (-0)		Au -282	In -29	Sn -107	Sb -101	Te -190	I -295	Xe 0
6	Cs -45	Ba (-0)			Tl -19	Pb -35	Bi -91			

Figure 7.13 Electron Affinities (in kJ/mol) of the s-, p-, and d-Block Elements

1																	18	
1	H -72.8																He ≥0	
2	Li -59.6	Be ≥0																Ne ≥0
3	Na -52.9	Mg ≥0																Ar ≥0
4	K -48.4	Ca -2.4	Sc -18	Ti -8	V -51	Cr -65.2	Mn ≥0	Fe -15	Co -64.0	Ni -111.7	Cu -119.2	Zn ≥0	Ga -40	Ge -118.9	As -78	Se -195.0	Br -324.5	Kr ≥0
5	Rb -46.9	Sr -5.0	Y -30	Zr -41	Nb -86	Mo -72.1	Tc -60	Ru -101.0	Rh -110.3	Pd -54.2	Ag -125.9	Cd ≥0	In -39	Sn -107.3	Sb -101.1	Te -190.2	I -295.2	Xe ≥0
6	Cs -45.5	Ba -14.0	La -45	Hf ≥0	Ta -31	W -79	Re -20	Os -104.0	Ir -150.9	Pt -205.0	Au -222.7	Hg ≥0	Tl -37	Pb -35	Bi -90.9	Po -180	At -270	Rn ≥0
7	Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub	Uut	Uuq	Uup			
Lanthanides				Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
Actinides				Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

≥0 kJ/mol  -348.6 kJ/mol

Bons estudos!