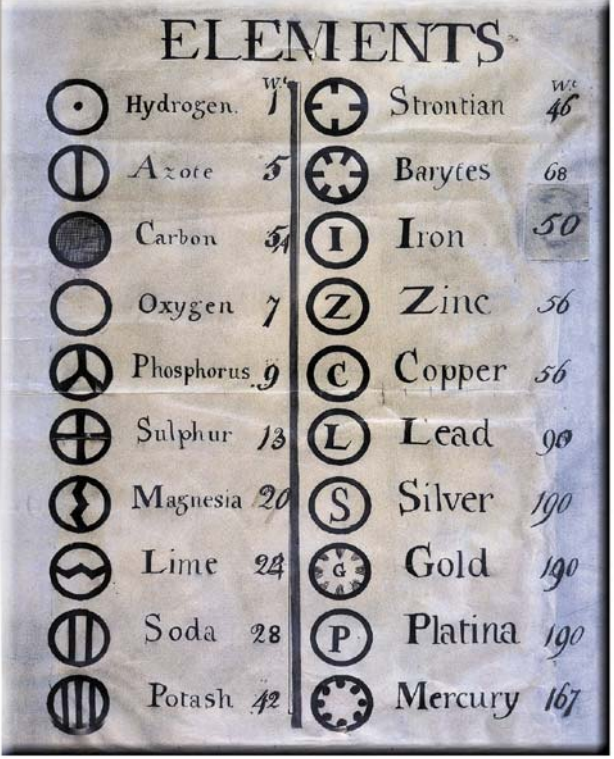
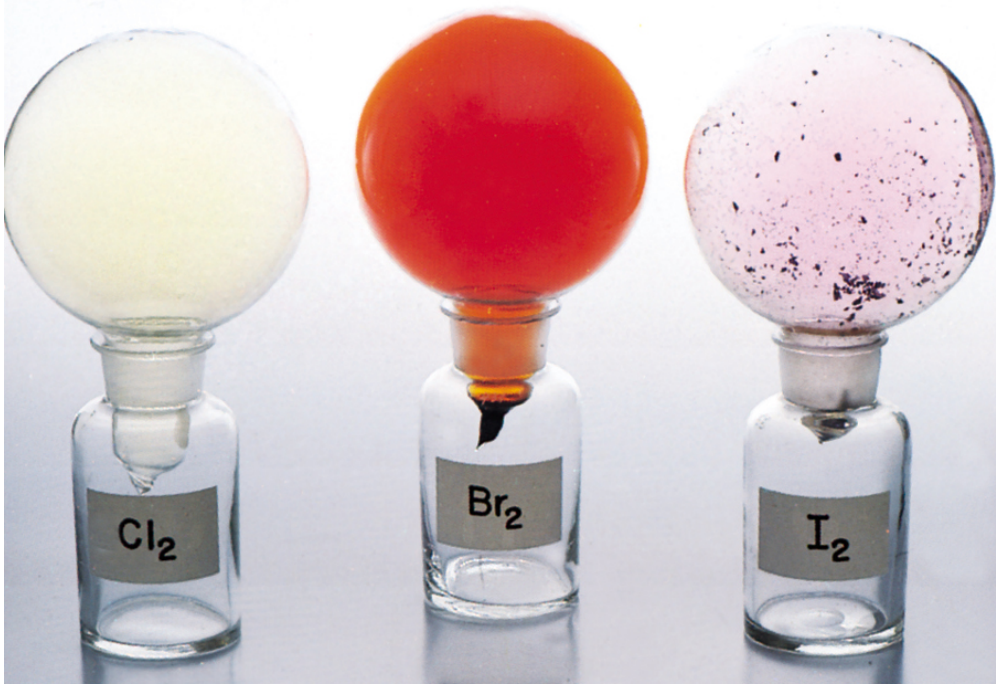
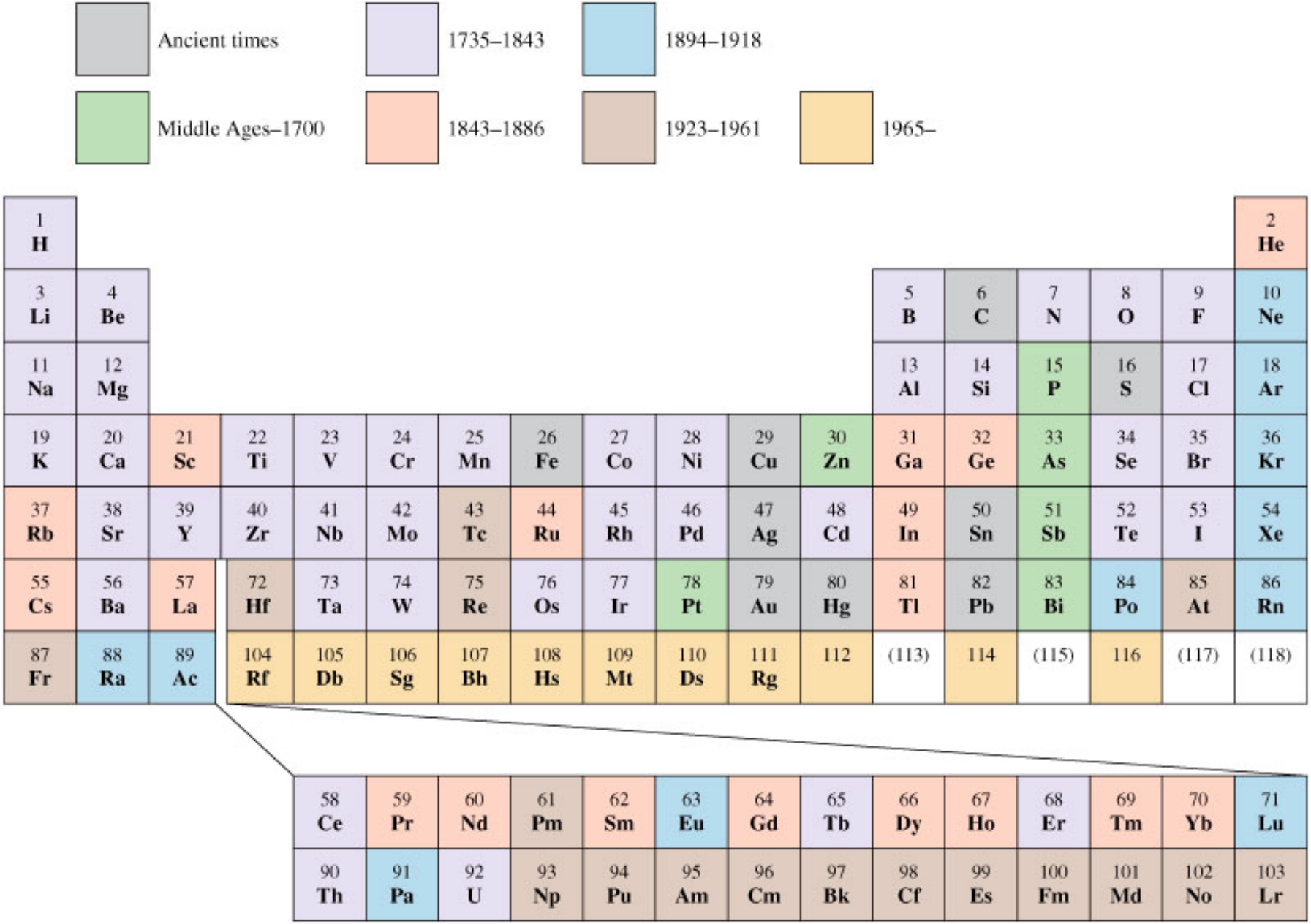


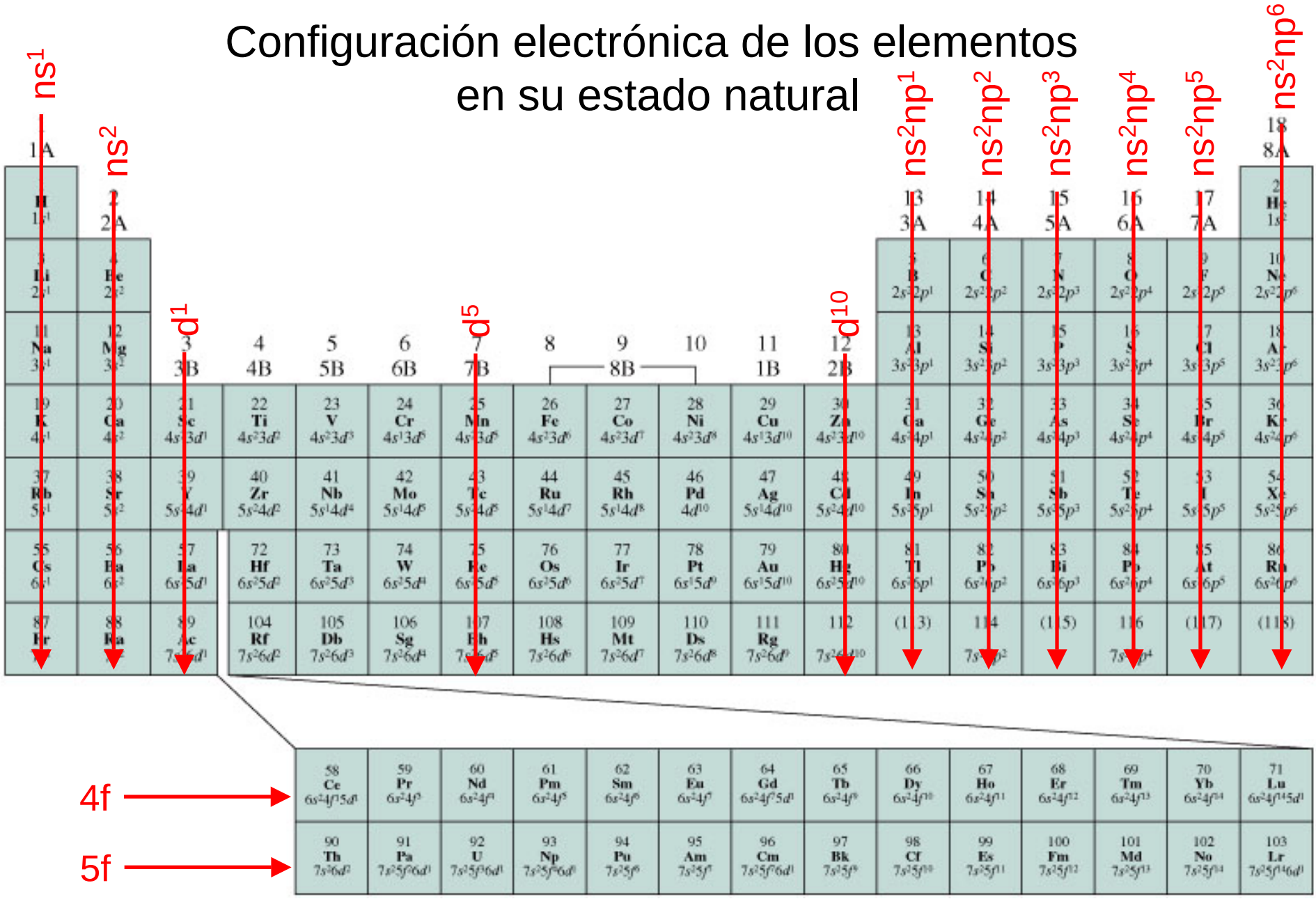

# Relaciones periódicas entre los elementos

*Capítulo 8*

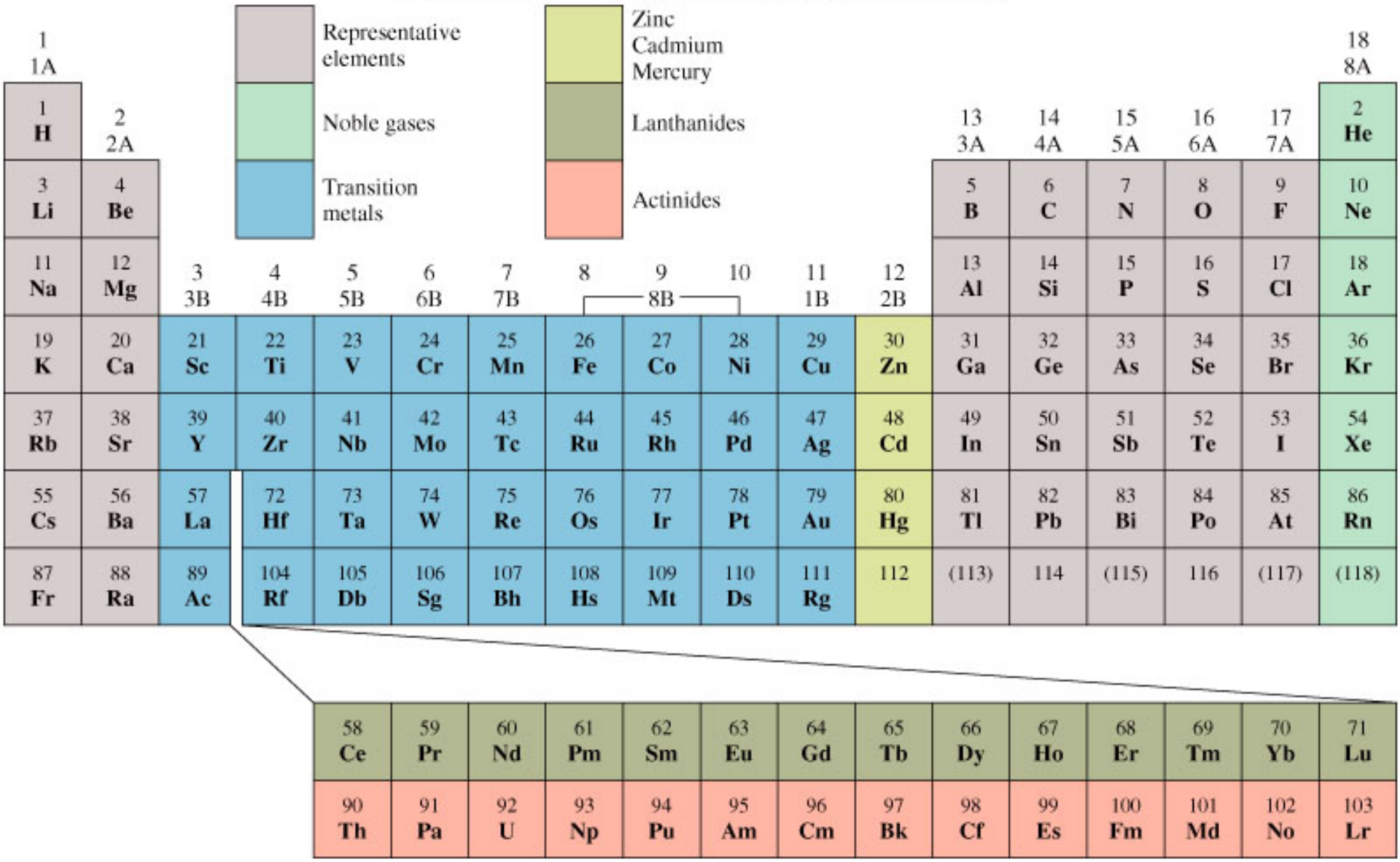
# Cuándo se descubrieron los elementos



# Configuración electrónica de los elementos en su estado natural



# Clasificación de los elementos



# Configuraciones electrónicas de cationes y aniones de elementos representativos

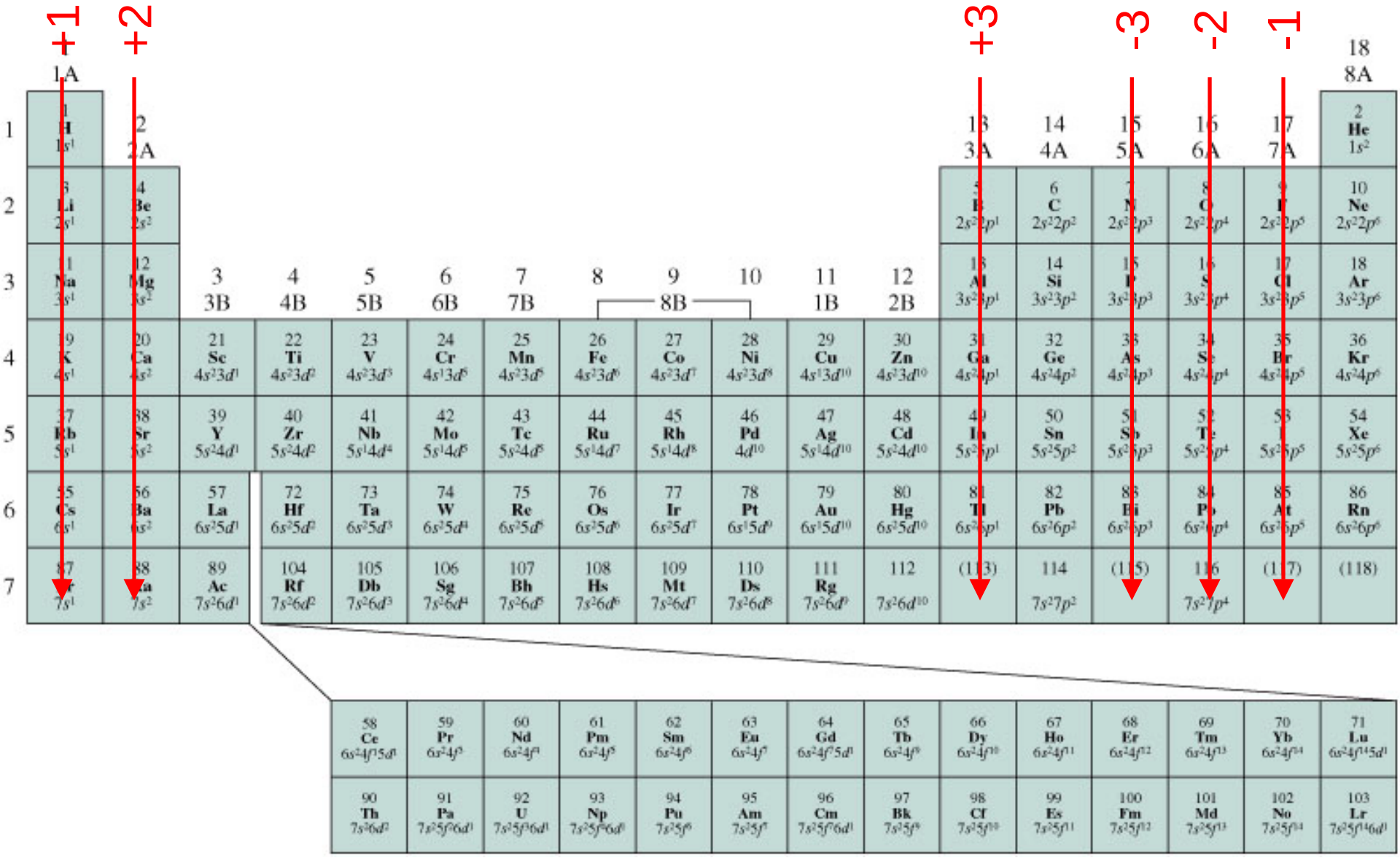
| | | | |
|---|---|---|---|
| Na | $[Ne]3s^1$ | $Na^+$ | [Ne] |
| Ca | $[Ar]4s^2$ | $Ca^{2+}$ | [Ar] |
| Al | $[Ne]3s^23p^1$ | $Al^{3+}$ | [Ne] |

Los átomos ceden electrones de modo que los cationes adquieren la configuración electrónica de un gas noble.

Los átomos aceptan electrones de modo que los aniones adquieren la configuración electrónica de un gas noble.

| | | | |
|---|---|---|---|
| H | $1s^1$ | $H^-$ | $1s^2$ or [He] |
| F | $1s^22s^22p^5$ | $F^-$ | $1s^22s^22p^6$ or [Ne] |
| O | $1s^22s^22p^4$ | $O^{2-}$ | $1s^22s^22p^6$ or [Ne] |
| N | $1s^22s^22p^3$ | $N^{3-}$ | $1s^22s^22p^6$ or [Ne] |

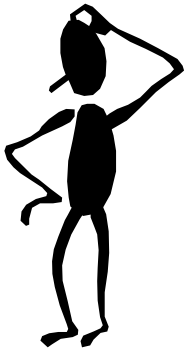
# Aniones y cationes de los elementos representativos



$Na^+$: [Ne]  $Al^{3+}$: [Ne]  $F^-$: $1s^2 2s^2 2p^6$ or [Ne]

$O^{2-}$: $1s^2 2s^2 2p^6$ or [Ne]  $N^{3-}$: $1s^2 2s^2 2p^6$ or [Ne]

$Na^+$, $Al^{3+}$, $F^-$, $O^{2-}$, y $N^{3-}$ son todos ***isoelectrónicos*** con Ne



¿Qué átomo neutro es isoelectrónico con $H^-$ ?

$H^-$: $1s^2$  La misma configuración electrónica que el He.

# Configuración electrónica de cationes de metales de transición

Cuando un átomo metálico se transforma en un catión los electrones primeramente son retirados del orbital *ns* y después de los orbitales (*n* – 1)*d*.

Fe: $[Ar]4s^2 3d^6$

$Fe^{2+}$: $[Ar]4s^0 3d^6$ or $[Ar]3d^6$

$Fe^{3+}$: $[Ar]4s^0 3d^5$ or $[Ar]3d^5$

Mn: $[Ar]4s^2 3d^5$

$Mn^{2+}$: $[Ar]4s^0 3d^5$ or $[Ar]3d^5$

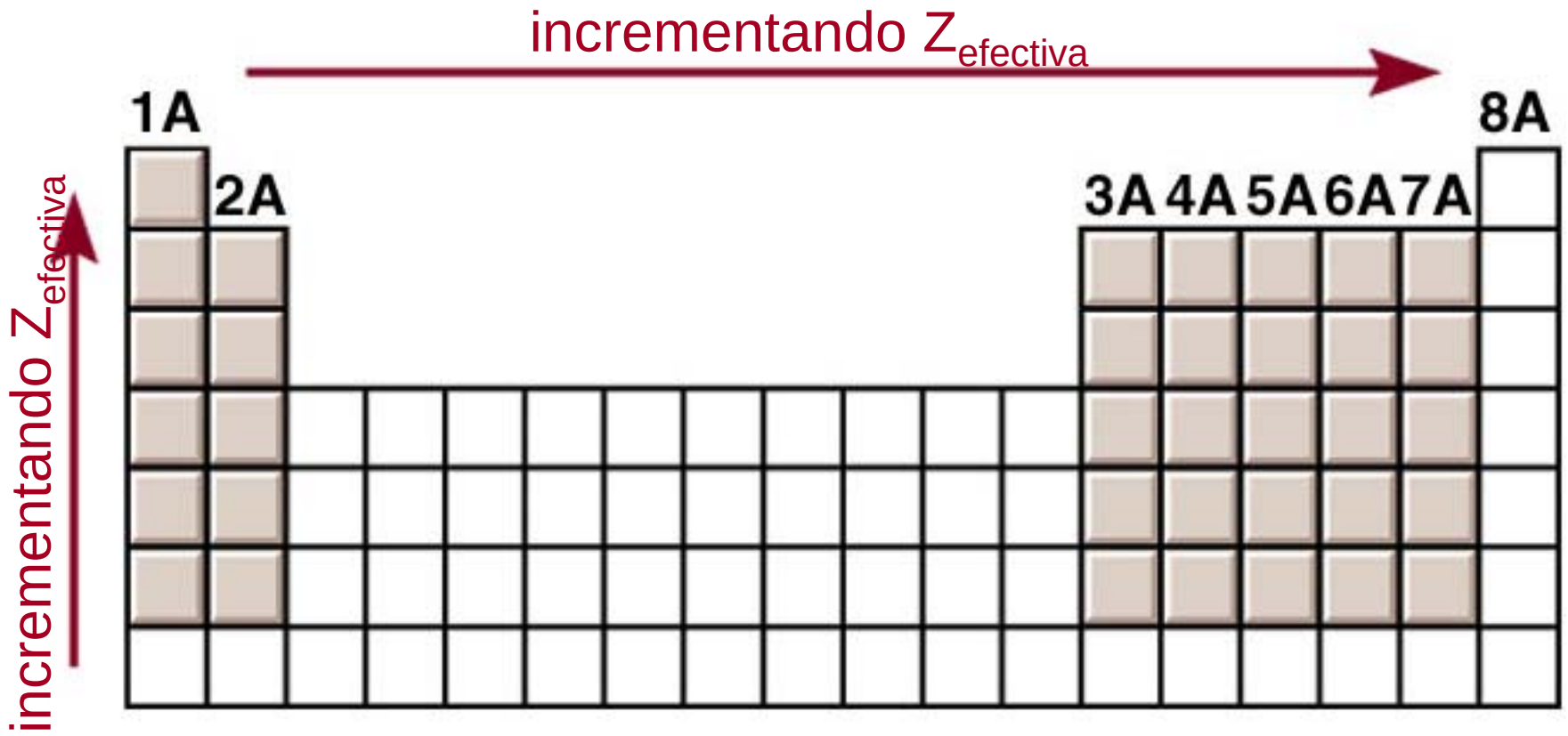
***Carga nuclear efectiva*** ($Z_{efectiva}$) es la "carga positiva" que siente un electrón.

$Z_{efectiva} = Z - \sigma$ $0 < \sigma < Z$ ($\sigma$ = constante de shielding)

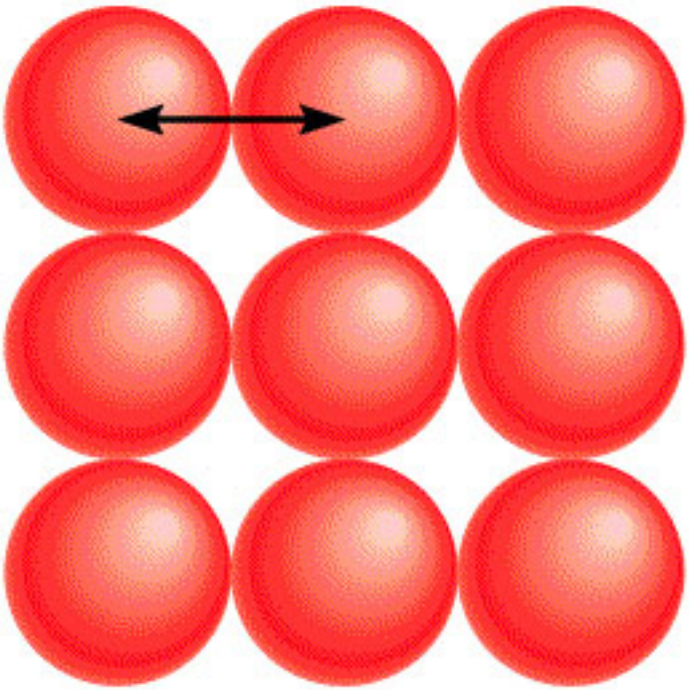
$Z_{efectiva} \approx Z$ – número de electrones internos o de base

| | Z | Base | $Z_{efectiva}$ | Radio (pm) |
|---|---|---|---|---|
| Na | 11 | 10 | 1 | 186 |
| Mg | 12 | 10 | 2 | 160 |
| Al | 13 | 10 | 3 | 143 |
| Si | 14 | 10 | 4 | 132 |

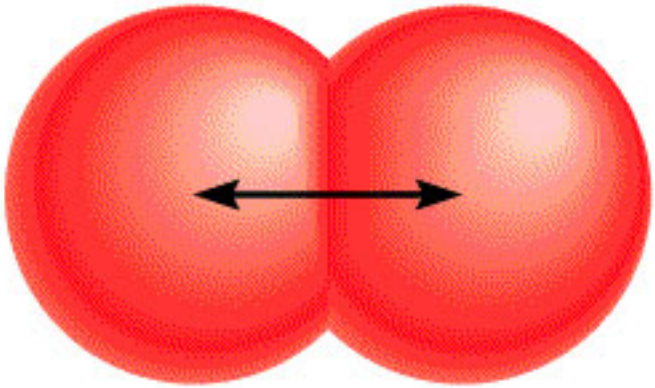
# Carga nuclear efectiva ($Z_{efectiva}$)



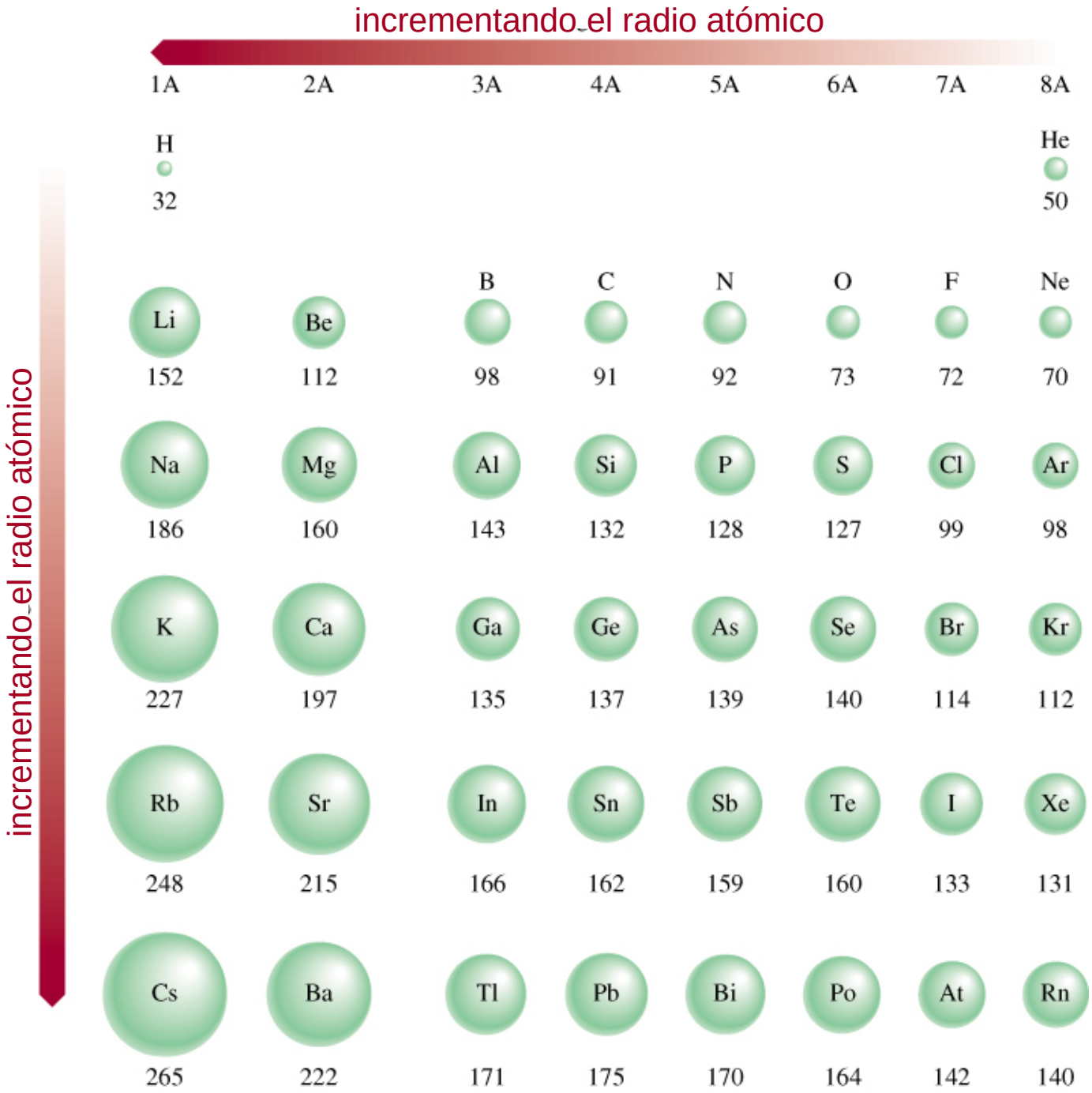
# Radio atómico



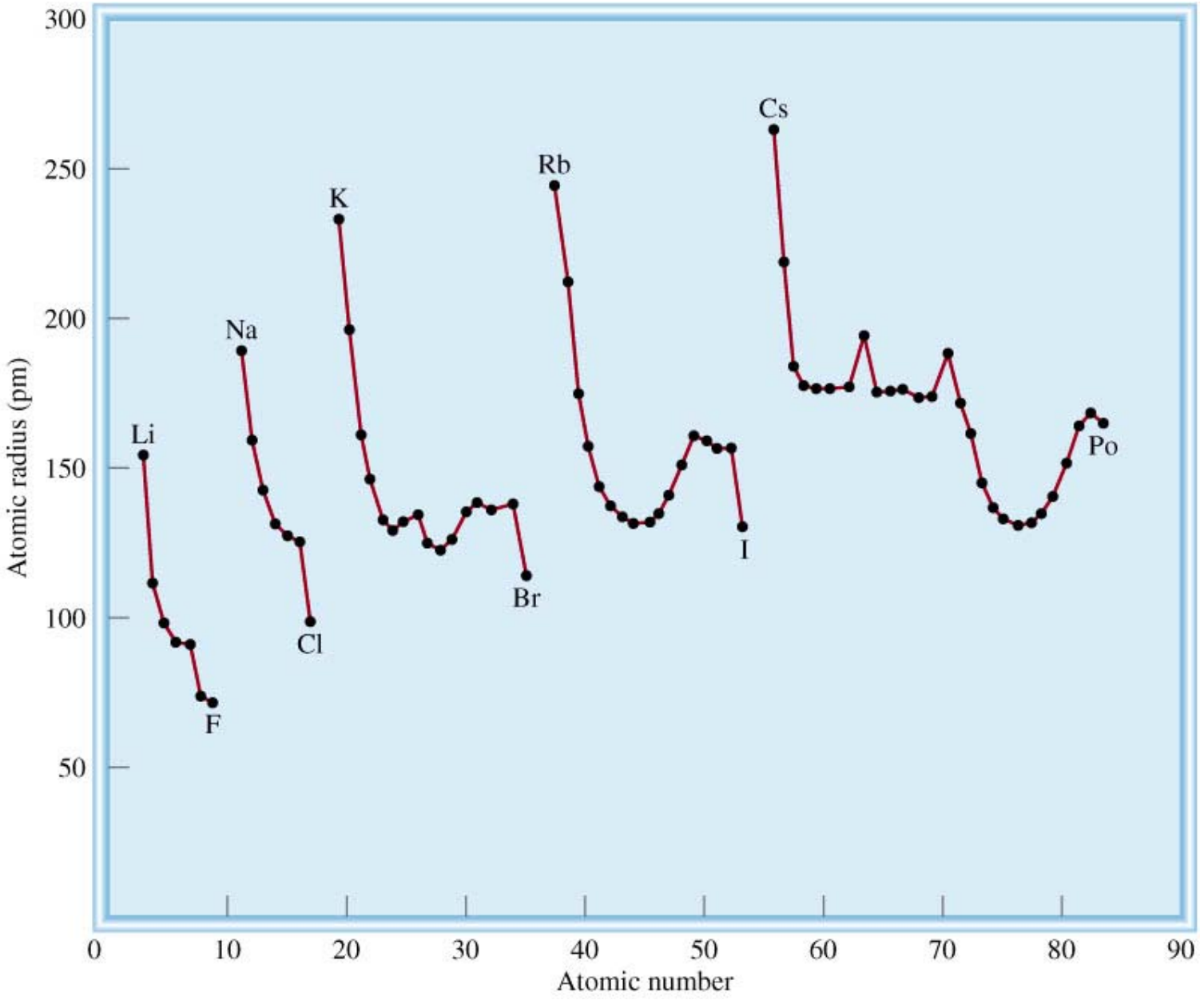
(a)



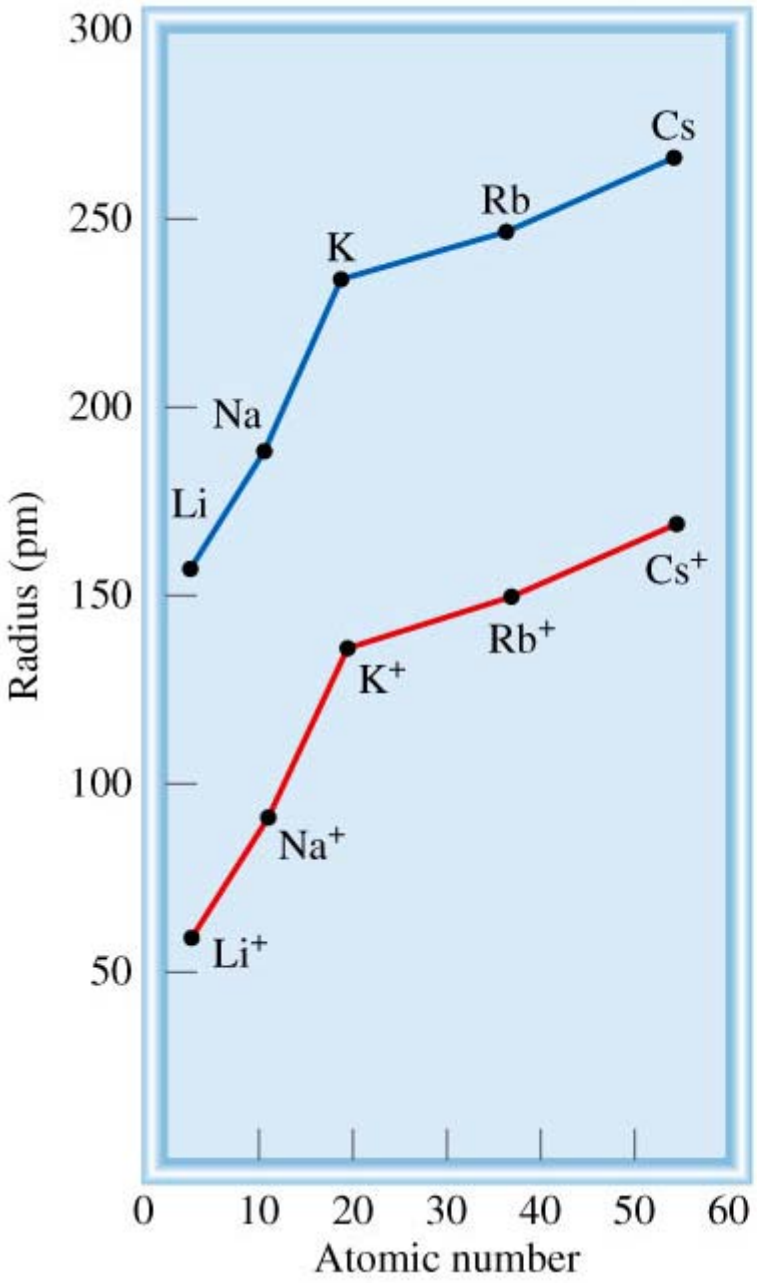
(b)

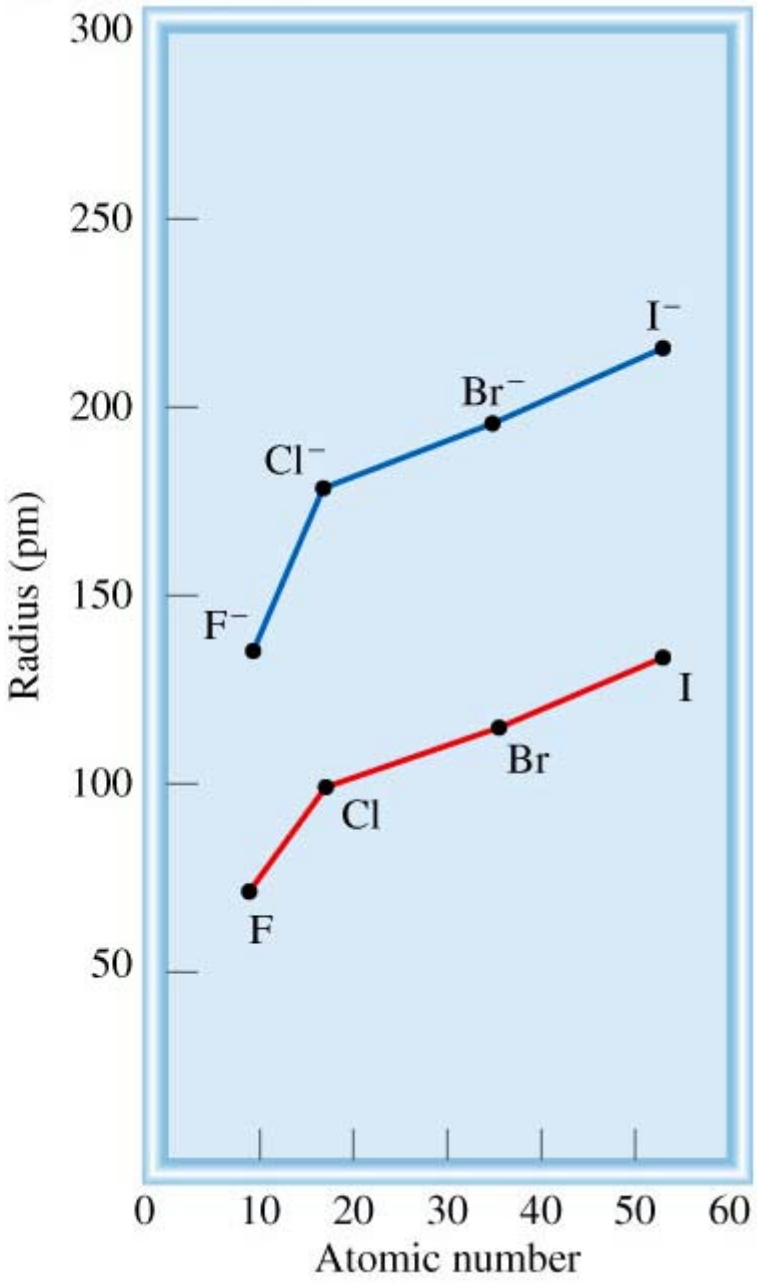

incrementando el radio atómico
incrementando el radio atómico
1A
2A
3A
4A
5A
6A
7A
8A
H
32
He
50
B
C
N
O
F
Ne
Li
Be
152
112
98
91
92
73
72
70
Na
Mg
Al
Si
P
S
Cl
Ar
186
160
143
132
128
127
99
98
K
Ca
Ga
Ge
As
Se
Br
Kr
227
197
135
137
139
140
114
112
Rb
Sr
In
Sn
Sb
Te
I
Xe
248
215
166
162
159
160
133
131
Cs
Ba
Tl
Pb
Bi
Po
At
Rn
265
222
171
175
170
164
142
140

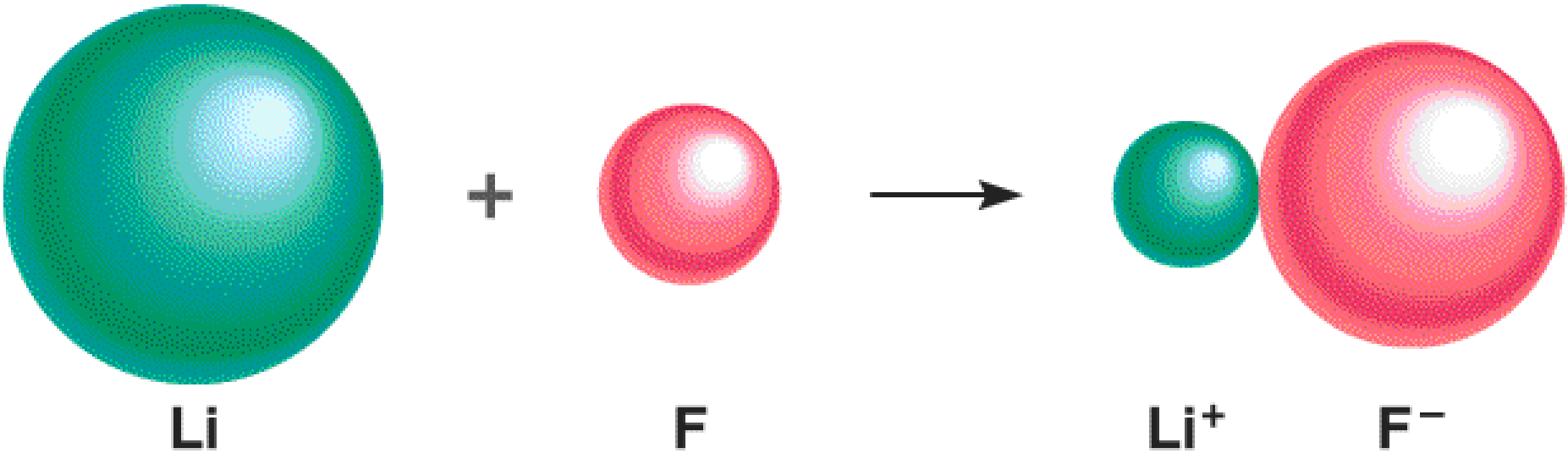
# Radios atómicos



# Comparación de radios atómicos con radios iónicos

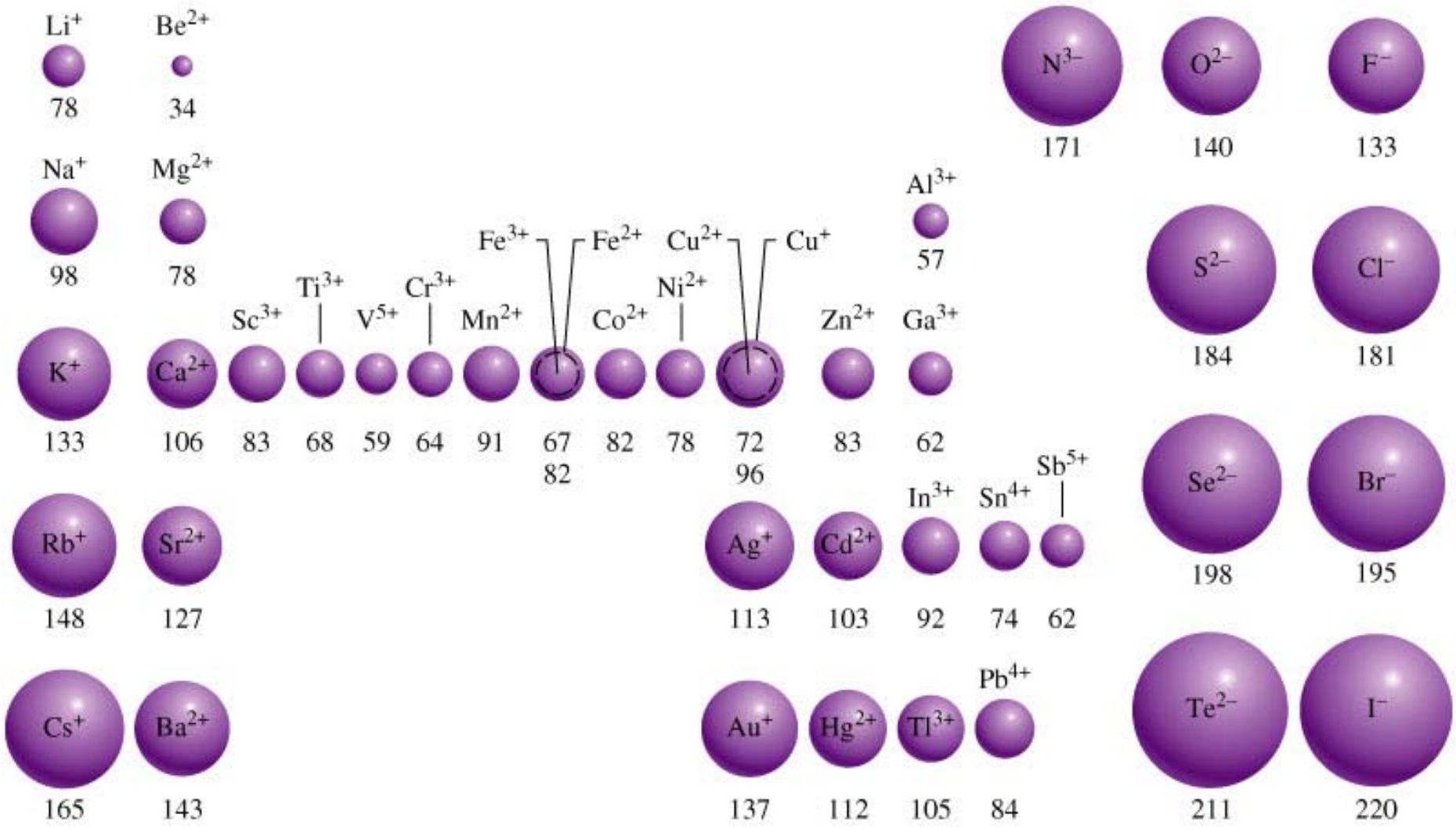





El **catión** siempre es **más pequeño** que el átomo a partir del cual se formó.
El **anión** siempre es **más grande** que el átomo a partir del cual se formó.

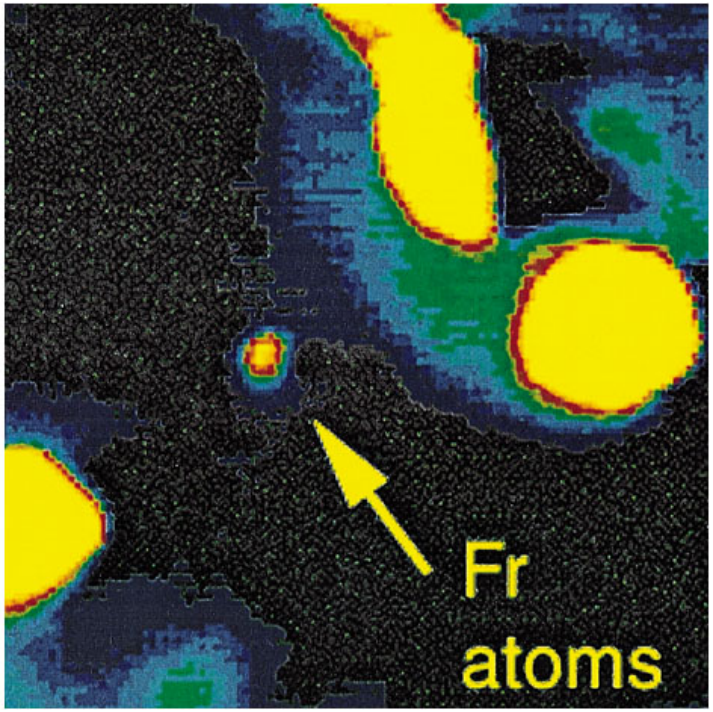
# Radios de iones (en pm) de elementos familiares

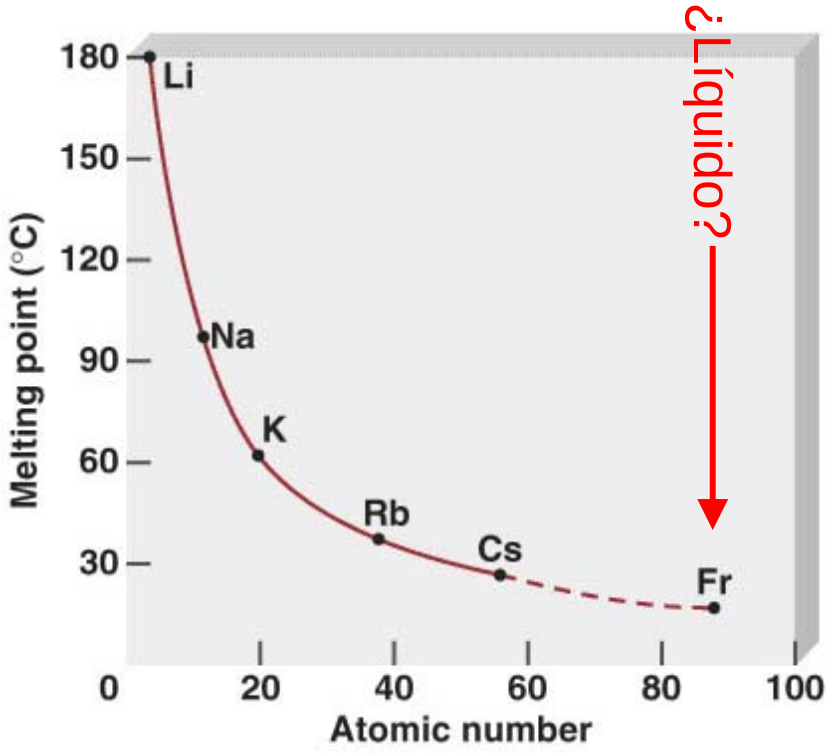


# La química en acción:
# ¿El 3er elemento líquido?

113 elementos, 2 son líquidos a 25˚C – $Br_2$ y Hg

$^{223}Fr$, $t_{1/2}$ = 21 minutos



La ***energía de ionización*** es la energía mínima (kJ/mol) requerida para remover un electrón de un átomo gaseoso en su estado natural.

$I_1 + X_{(g)} \longrightarrow X^+_{(g)} + e^-$ $I_1$ primera energía de ionización

$I_2 + X^+_{(g)} \longrightarrow X^{2+}_{(g)} + e^-$ $I_2$ segunda energía de ionización

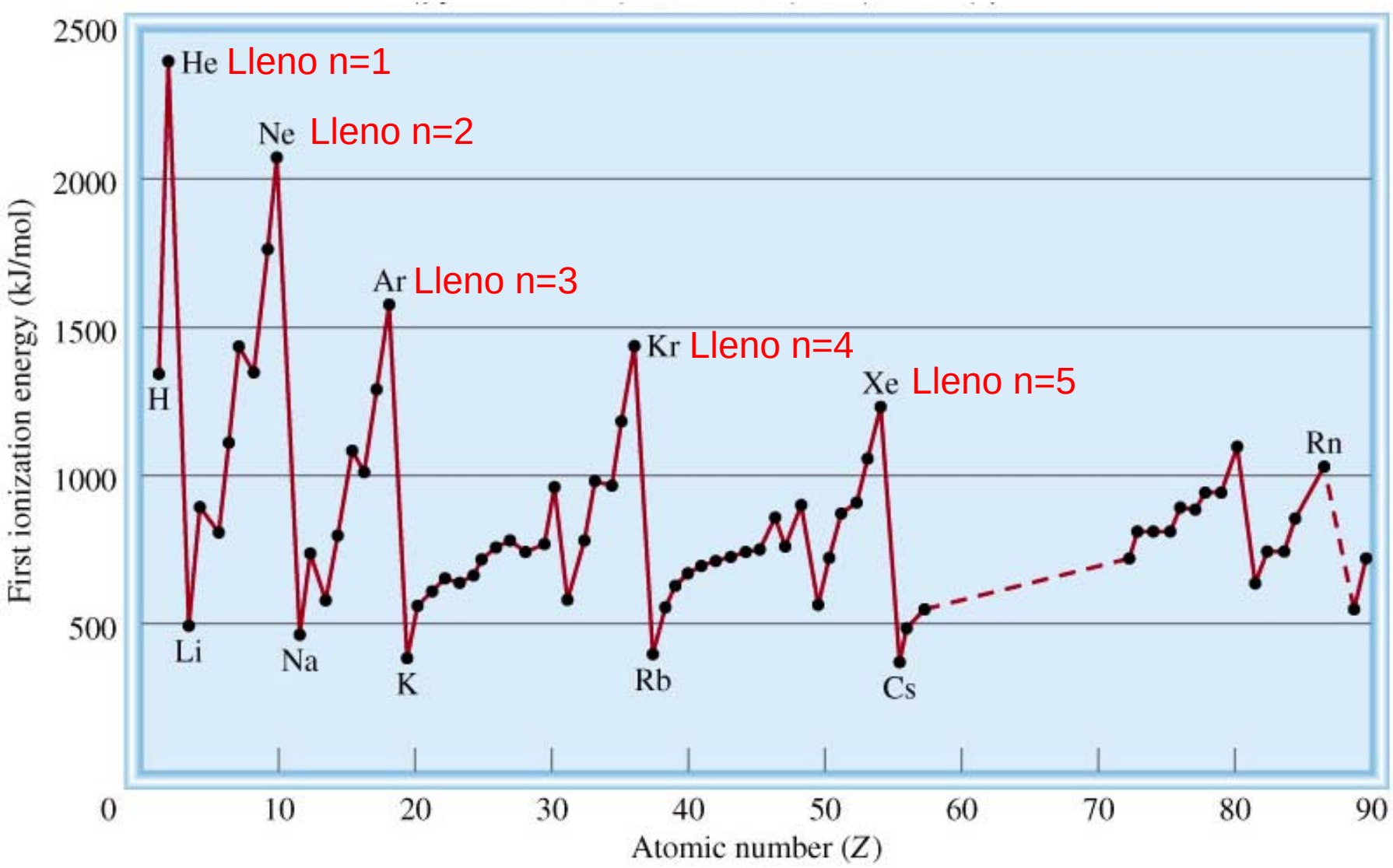
$I_3 + X^{2+}_{(g)} \longrightarrow X^{3+}_{(g)} + e^-$ $I_3$ tercera energía de ionización

$$I_1 < I_2 < I_3$$

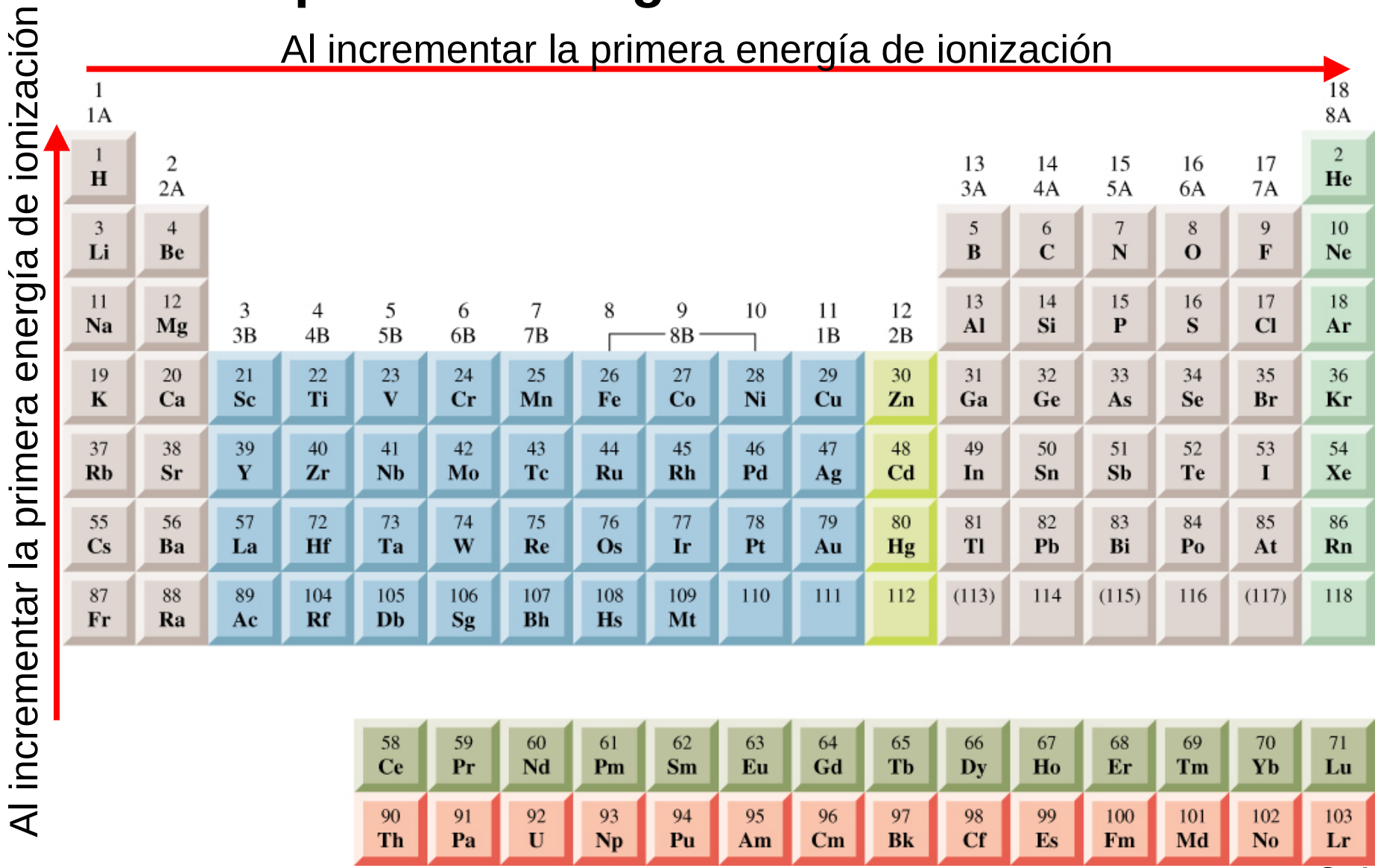
# Energías de ionización de los primeros 20 elementos

| Z | Element | First | Second | Third | Fourth | Fifth | Sixth |
|---|---|---|---|---|---|---|---|
| 1 | H | 1,312 | | | | | |
| 2 | He | 2,373 | 5,251 | | | | |
| 3 | Li | 520 | 7,300 | 11,815 | | | |
| 4 | Be | 899 | 1,757 | 14,850 | 21,005 | | |
| 5 | B | 801 | 2,430 | 3,660 | 25,000 | 32,820 | |
| 6 | C | 1,086 | 2,350 | 4,620 | 6,220 | 38,000 | 47,261 |
| 7 | N | 1,400 | 2,860 | 4,580 | 7,500 | 9,400 | 53,000 |
| 8 | O | 1,314 | 3,390 | 5,300 | 7,470 | 11,000 | 13,000 |
| 9 | F | 1,680 | 3,370 | 6,050 | 8,400 | 11,000 | 15,200 |
| 10 | Ne | 2,080 | 3,950 | 6,120 | 9,370 | 12,200 | 15,000 |
| 11 | Na | 495.9 | 4,560 | 6,900 | 9,540 | 13,400 | 16,600 |
| 12 | Mg | 738.1 | 1,450 | 7,730 | 10,500 | 13,600 | 18,000 |
| 13 | Al | 577.9 | 1,820 | 2,750 | 11,600 | 14,800 | 18,400 |
| 14 | Si | 786.3 | 1,580 | 3,230 | 4,360 | 16,000 | 20,000 |
| 15 | P | 1,012 | 1,904 | 2,910 | 4,960 | 6,240 | 21,000 |
| 16 | S | 999.5 | 2,250 | 3,360 | 4,660 | 6,990 | 8,500 |
| 17 | Cl | 1,251 | 2,297 | 3,820 | 5,160 | 6,540 | 9,300 |
| 18 | Ar | 1,521 | 2,666 | 3,900 | 5,770 | 7,240 | 8,800 |
| 19 | K | 418.7 | 3,052 | 4,410 | 5,900 | 8,000 | 9,600 |
| 20 | Ca | 589.5 | 1,145 | 4,900 | 6,500 | 8,100 | 11,000 |

# Variación de la primera energía de ionización con número atómico



# Tendencia general en la primera energía de ionización



***Afinidad electrónica*** es el cambio de energía que ocurre cuando un electrón es aceptado por un átomo en estado gaseoso para formar un anión.

$$X_{(g)} + e^- \longrightarrow X^-_{(g)}$$

$$F_{(g)} + e^- \longrightarrow X^-_{(g)} \qquad \Delta H = -328 \text{ kJ/mol} \qquad EA = +328 \text{ kJ/mol}$$

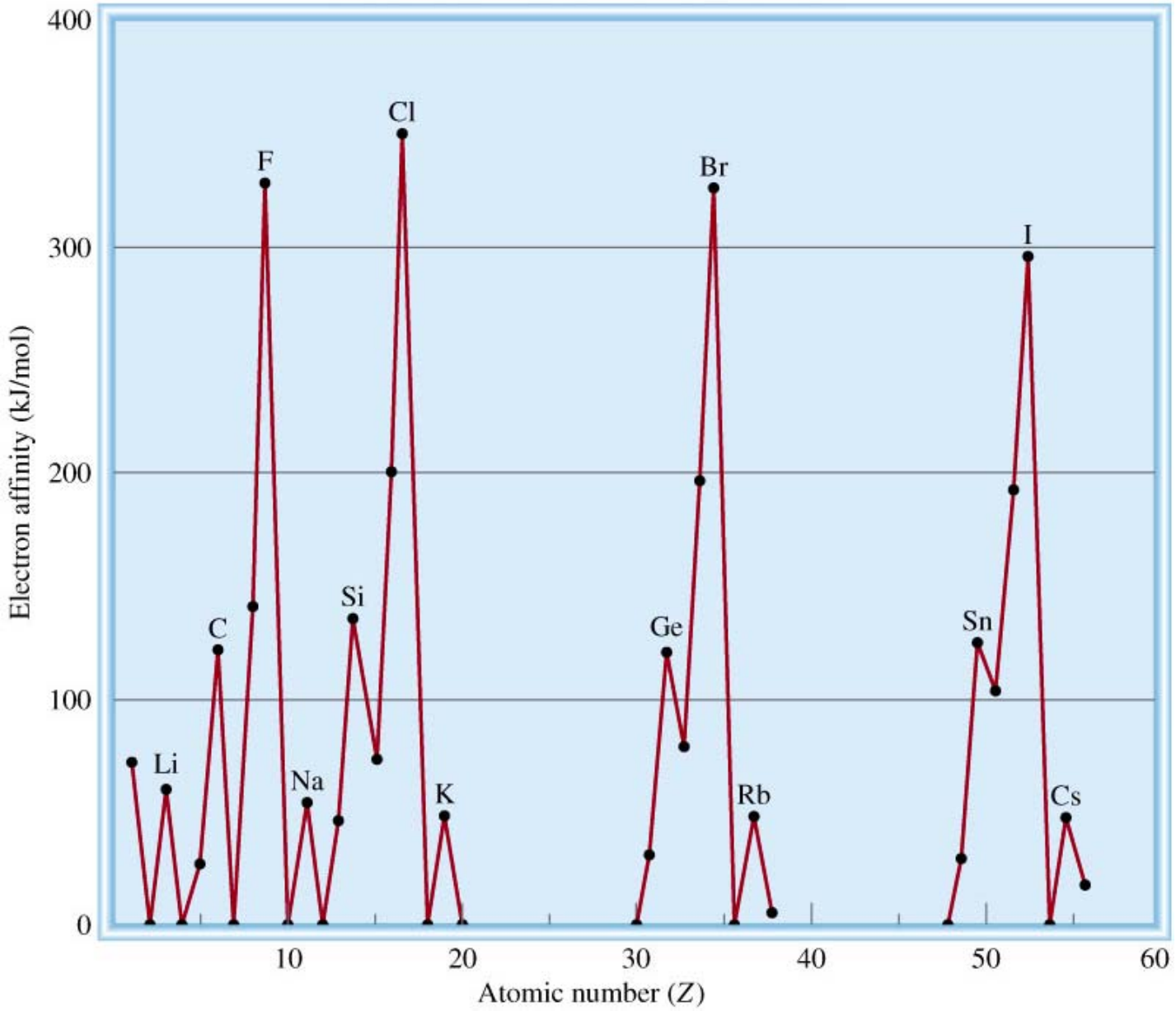
$$O_{(g)} + e^- \longrightarrow O^-_{(g)} \qquad \Delta H = -141 \text{ kJ/mol} \qquad EA = +141 \text{ kJ/mol}$$

# Afinidades electrónicas (kJ/mol) de algunos elementos representativos y de los gases nobles

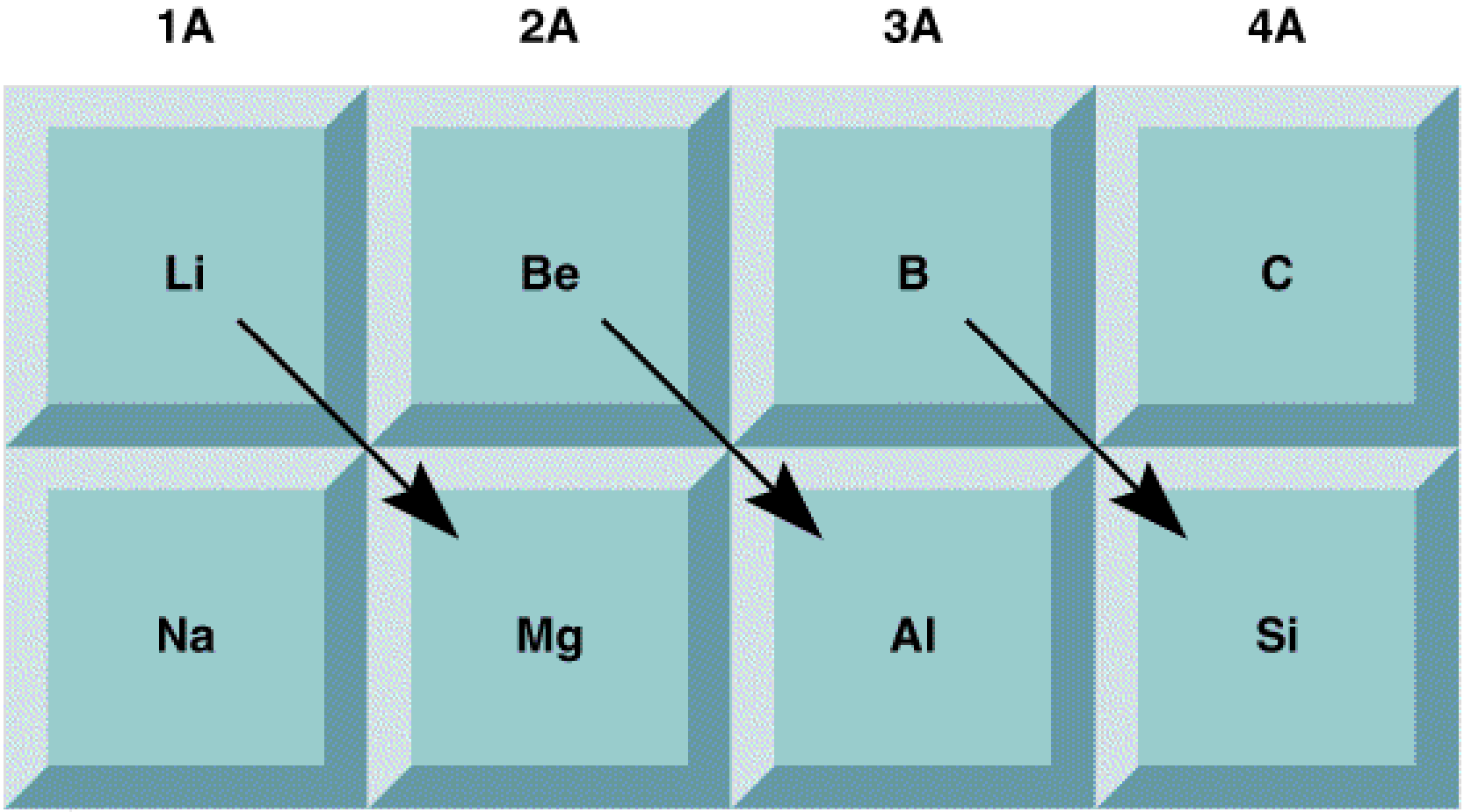
| 1A | 2A | 3A | 4A | 5A | 6A | 7A | 8A |
|---|---|---|---|---|---|---|---|
| H | | | | | | | He |
| 73 | | | | | | | $<0$ |
| Li | Be | B | C | N | O | F | Ne |
| 60 | $\leq 0$ | 27 | 122 | 0 | 141 | 328 | $<0$ |
| Na | Mg | Al | Si | P | S | Cl | Ar |
| 53 | $\leq 0$ | 44 | 134 | 72 | 200 | 349 | $<0$ |
| K | Ca | Ga | Ge | As | Se | Br | Kr |
| 48 | 2.4 | 29 | 118 | 77 | 195 | 325 | $<0$ |
| Rb | Sr | In | Sn | Sb | Te | I | Xe |
| 47 | 4.7 | 29 | 121 | 101 | 190 | 295 | $<0$ |
| Cs | Ba | Tl | Pb | Bi | Po | At | Rn |
| 45 | 14 | 30 | 110 | 110 | ? | ? | $<0$ |

*The electron affinities of the noble gases, Be, and Mg have not been determined experimentally, but are believed to be close to zero or negative.

# Variación de la afinidad electrónica con el número atómico (H – Ba)



# Relaciones diagonales en la Tabla Periódica

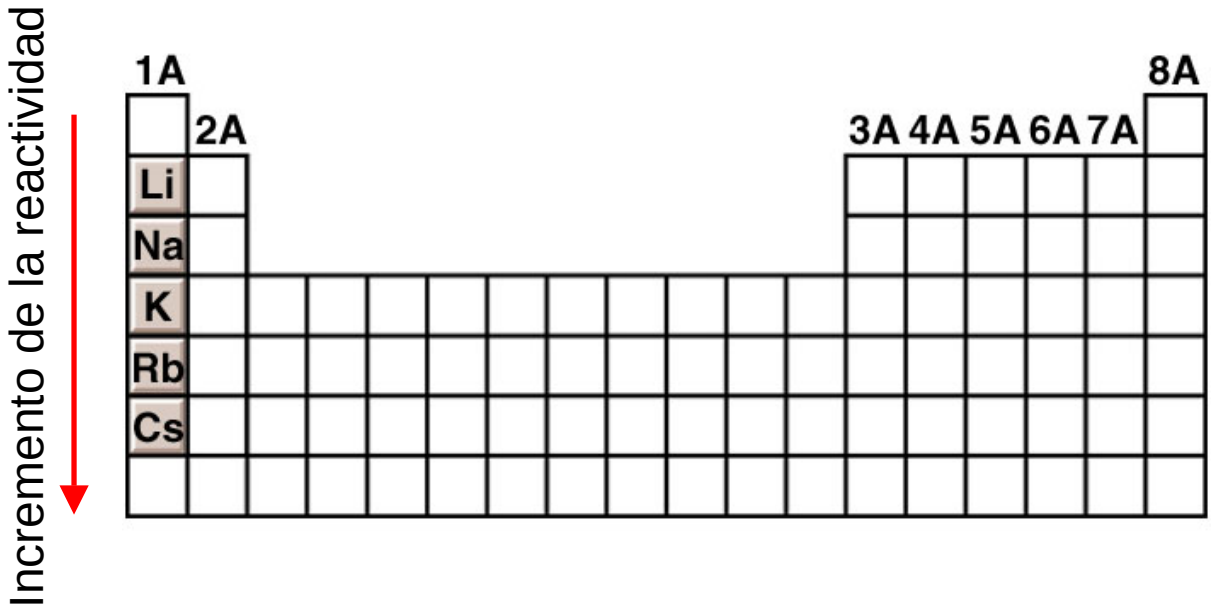


# Elementos del Grupo 1A ($ns^1$, $n \geq 2$)

$$M \longrightarrow M^{+1} + 1e^-$$

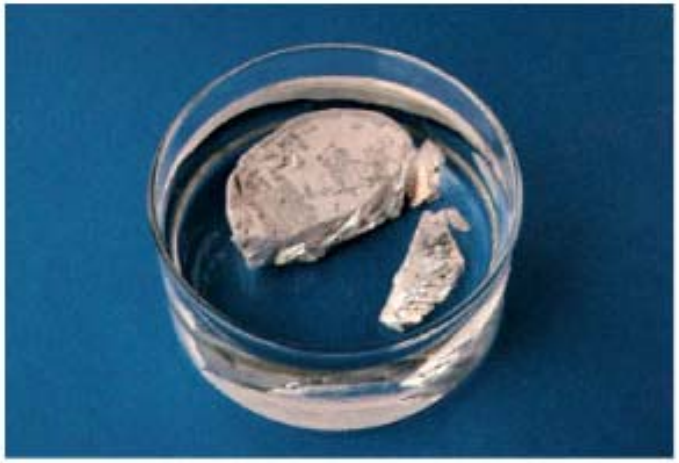
$$2M_{(s)} + 2H_2O_{(l)} \longrightarrow 2MOH_{(aq)} + H_{2(g)}$$

$$4M_{(s)} + O_{2(g)} \longrightarrow 2M_2O_{(s)}$$



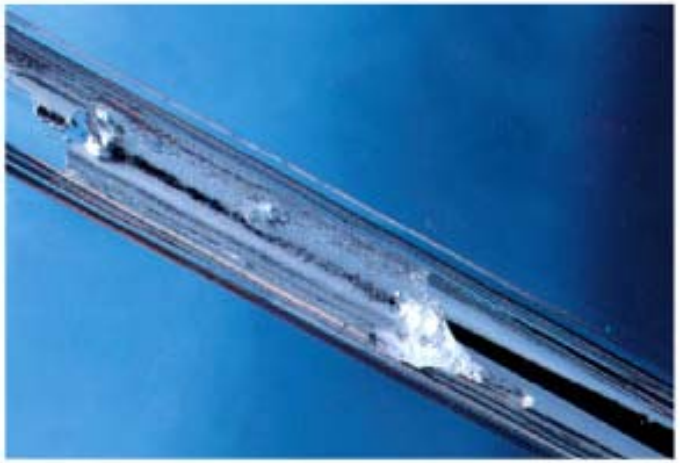
# Elementos del Grupo 1A ($ns^1$, $n \geq 2$)

Lithium (Li)

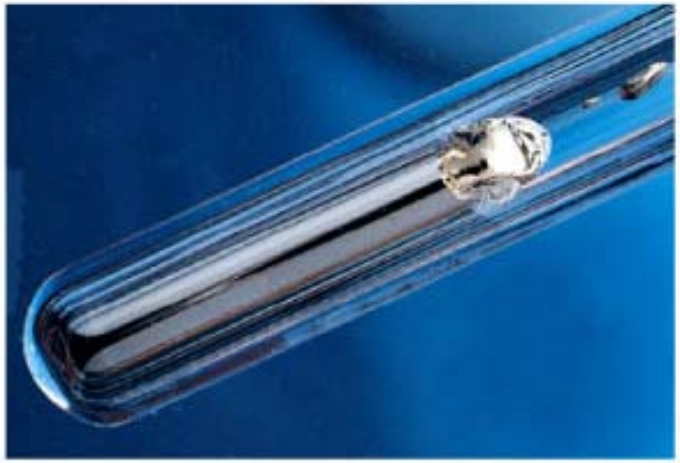


Sodium (Na)

Potassium (K)



Rubidium (Rb)



Cesium (Cs)

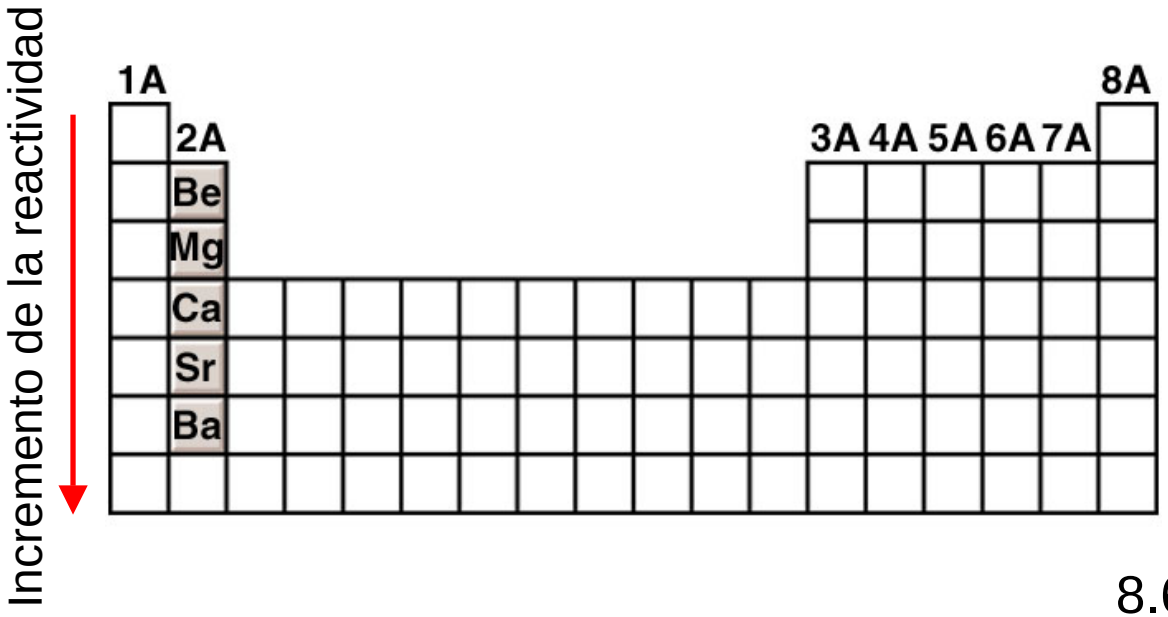
# Elementos del Grupo 2A ($ns^2$, $n \geq 2$)

$M \longrightarrow M^{+2} + 2e^-$

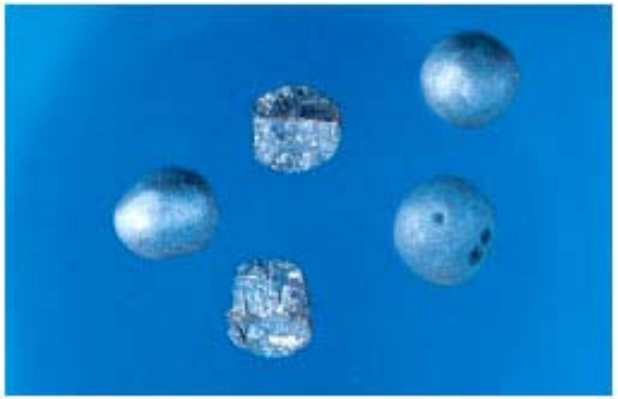
$Be_{(s)} + 2H_2O_{(l)} \longrightarrow$ No hay reacción

$Mg_{(s)} + 2H_2O_{(g)} \longrightarrow Mg(OH)_{2(ac)} + H_{2(g)}$

$M_{(s)} + 2H_2O_{(l)} \longrightarrow M(OH)_{2(ac)} + H_{2(g)}$ M = Ca, Sr, or Ba



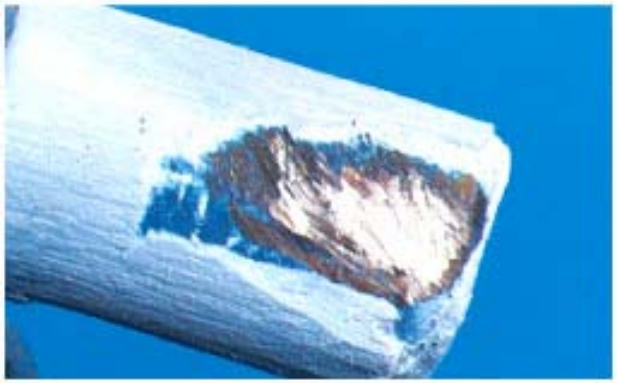
# Elementos del Grupo 2A ($ns^2$, $n \geq 2$)



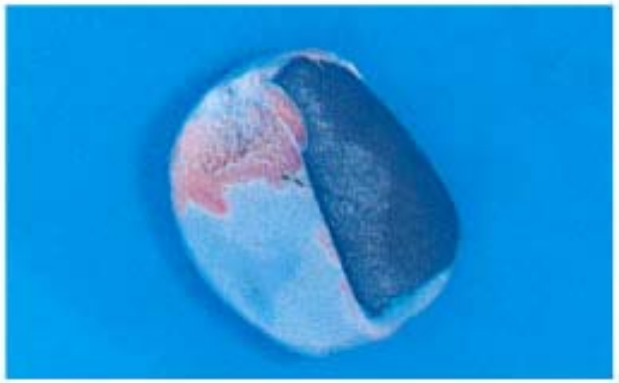
Beryllium (Be)

Magnesium (Mg)

Calcium (Ca)



Strontium (Sr)



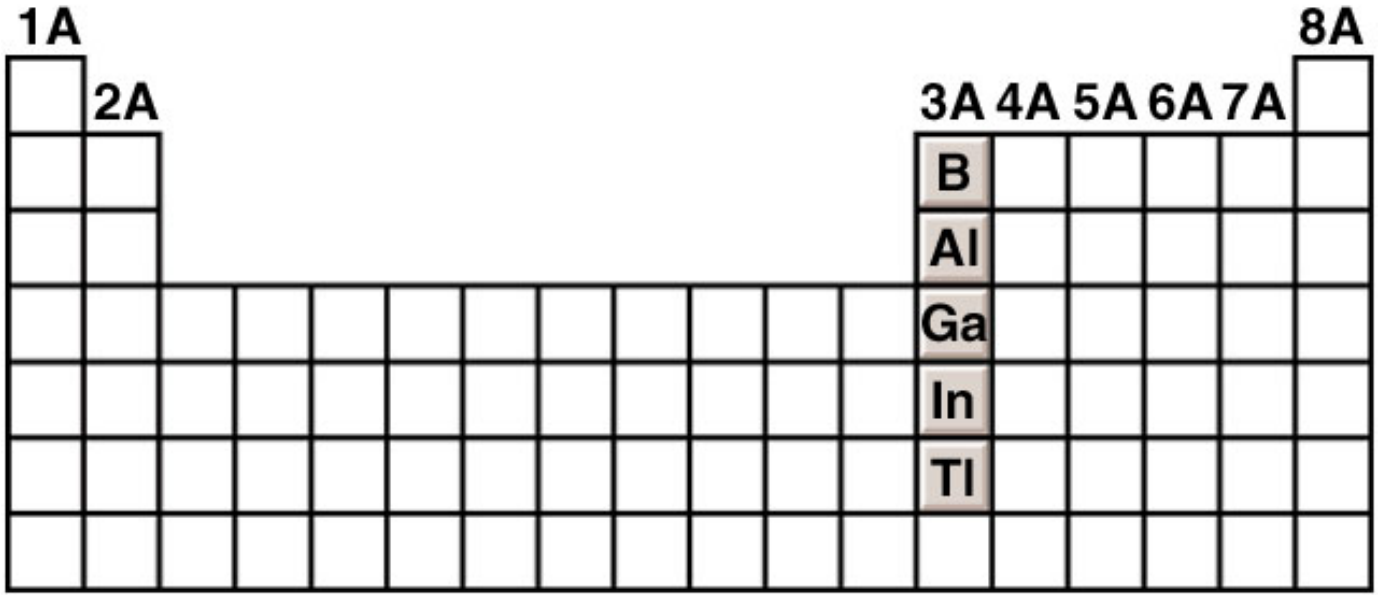
Barium (Ba)

Radium (Ra)

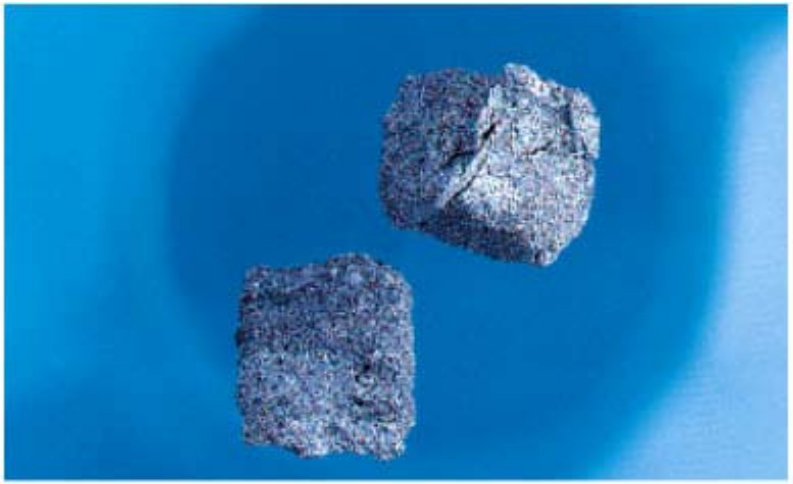
# Elementos del Grupo 3A ($ns^2np^1$, $n \geq 2$)

$$4Al_{(s)} + 3O_{2(g)} \longrightarrow 2Al_2O_{3(s)}$$

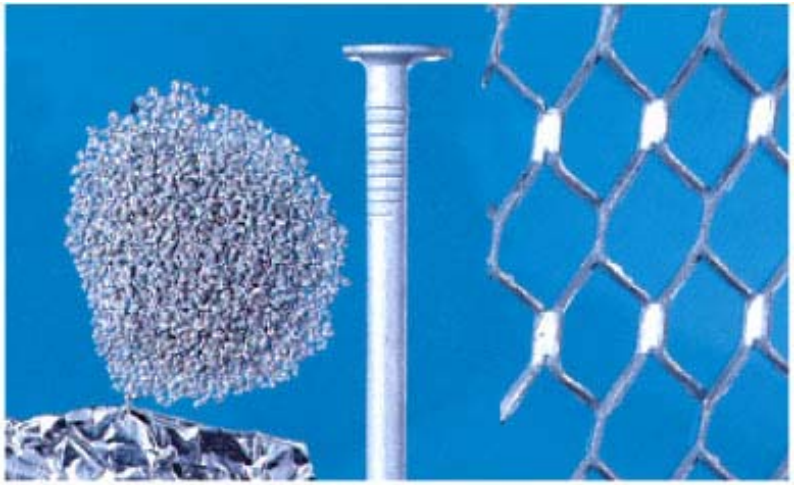
$$2Al_{(s)} + 6H^+_{(ac)} \longrightarrow 2Al^{3+}_{(ac)} + 3H_{2(g)}$$



# Elementos del Grupo 3A ($ns^2np^1$, $n \geq 2$)



Boron (B)



Aluminum (Al)

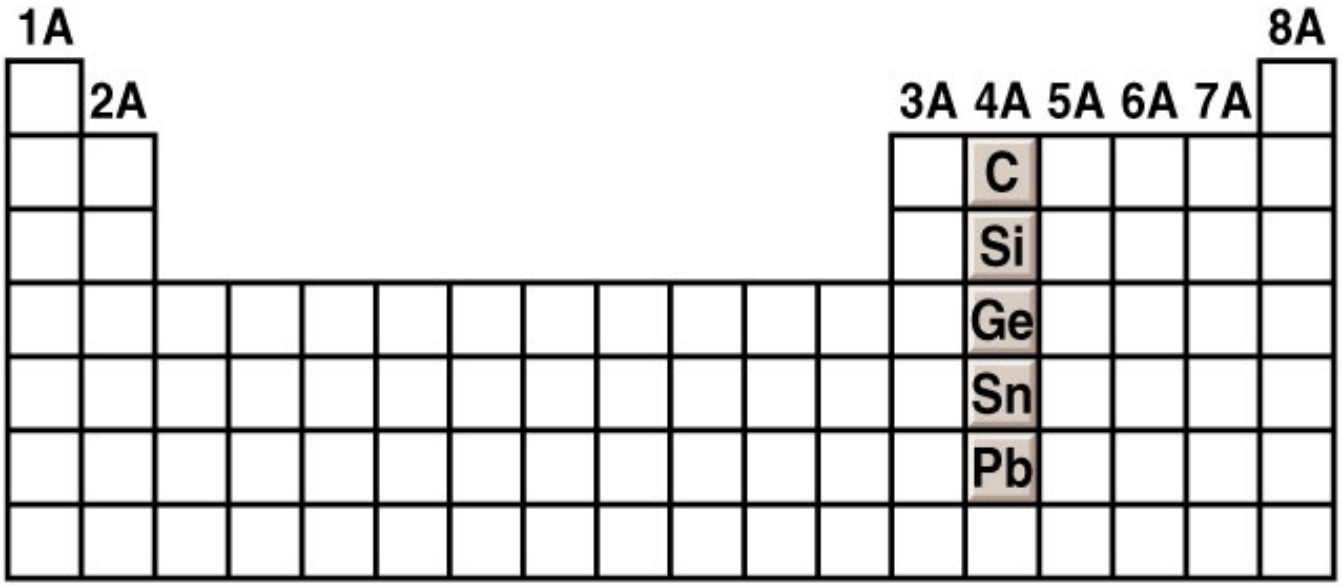
Gallium (Ga)

Indium (In)

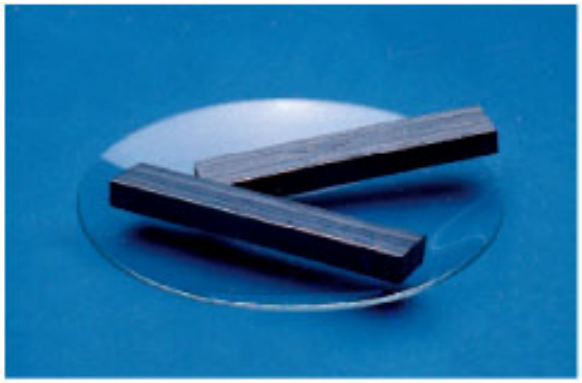
# Elementos del Grupo 4A ($ns^2np^2$, $n \geq 2$)

$$Sn_{(s)} + 2H^+_{(ac)} \longrightarrow Sn^{2+}_{(ac)} + H_{2\,(g)}$$

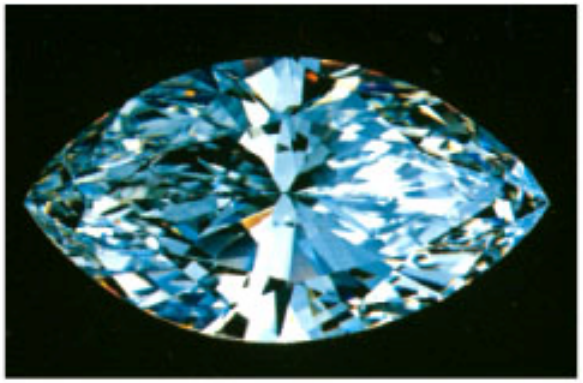
$$Pb_{(s)} + 2H^+_{(ac)} \longrightarrow Pb^{2+}_{(ac)} + H_{2\,(g)}$$



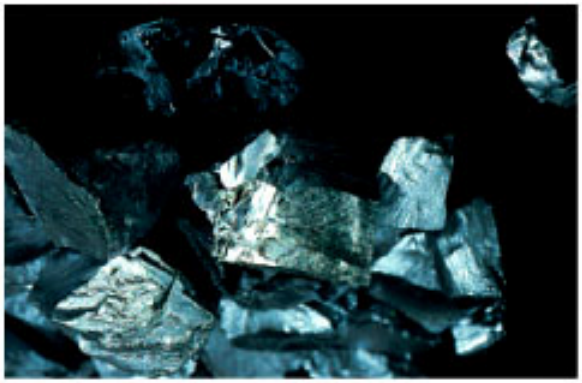
# Elementos del Grupo 4A ($ns^2np^2$, $n \geq 2$)



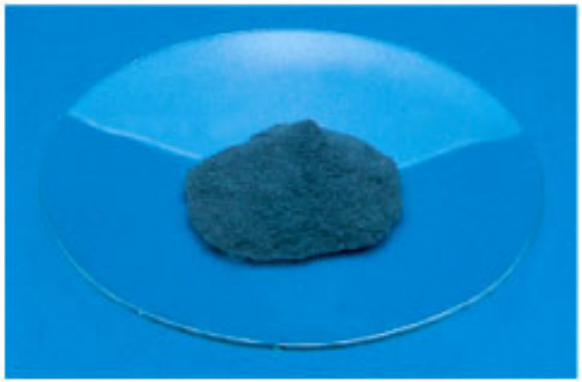
Carbon (graphite)



Carbon (diamond)

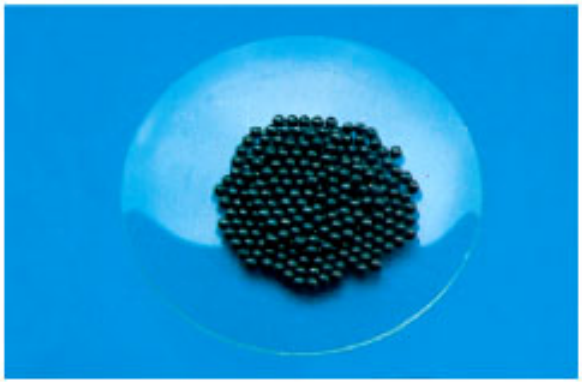


Silicon (Si)



Germanium (Ge)

Tin (Sn)

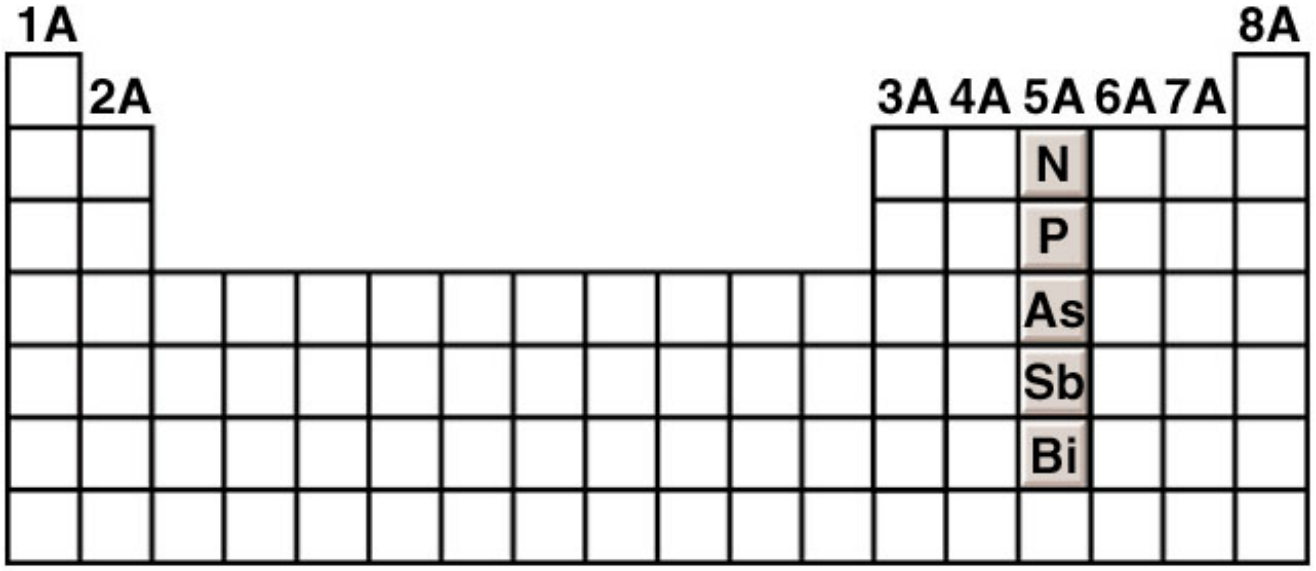


Lead (Pb)

# Elementos del Grupo 5A ($ns^2np^3$, $n \geq 2$)

$$N_2O_{5(s)} + H_2O_{(l)} \longrightarrow 2HNO_{3(ac)}$$

$$P_4O_{10(s)} + 6H_2O_{(l)} \longrightarrow 4H_3PO_{4(ac)}$$

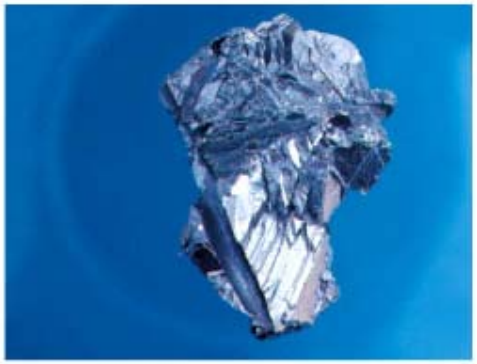


# Elementos del Grupo 5A ($ns^2np^3$, $n \geq 2$)


Nitrogen ($N_2$)

White and red phosphorus (P)

Arsenic (As)

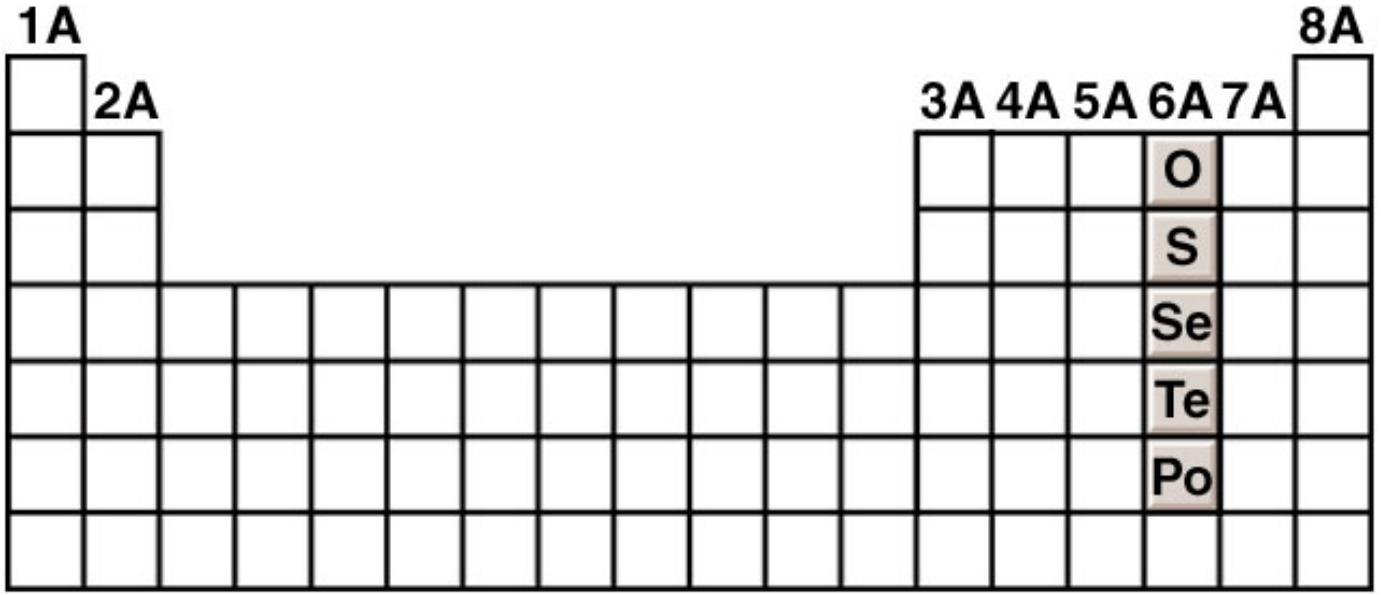


Antimony (Sb)

Bismuth (Bi)

# Elementos del Grupo 6A ($ns^2np^4$, $n \geq 2$)

$$SO_{3(g)} + H_2O_{(l)} \longrightarrow H_2SO_{4(ac)}$$



# Elementos del Grupo 6A ($ns^2np^4$, $n \geq 2$)

Sulfur ($S_8$)

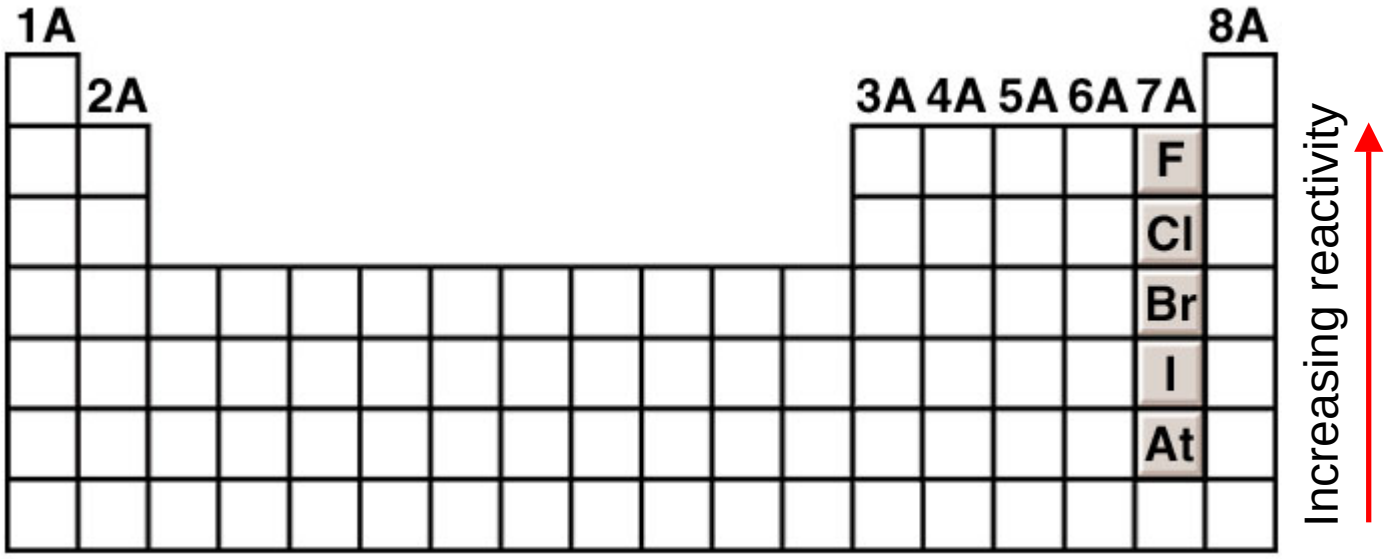
Selenium ($Se_8$)

Tellurium (Te)

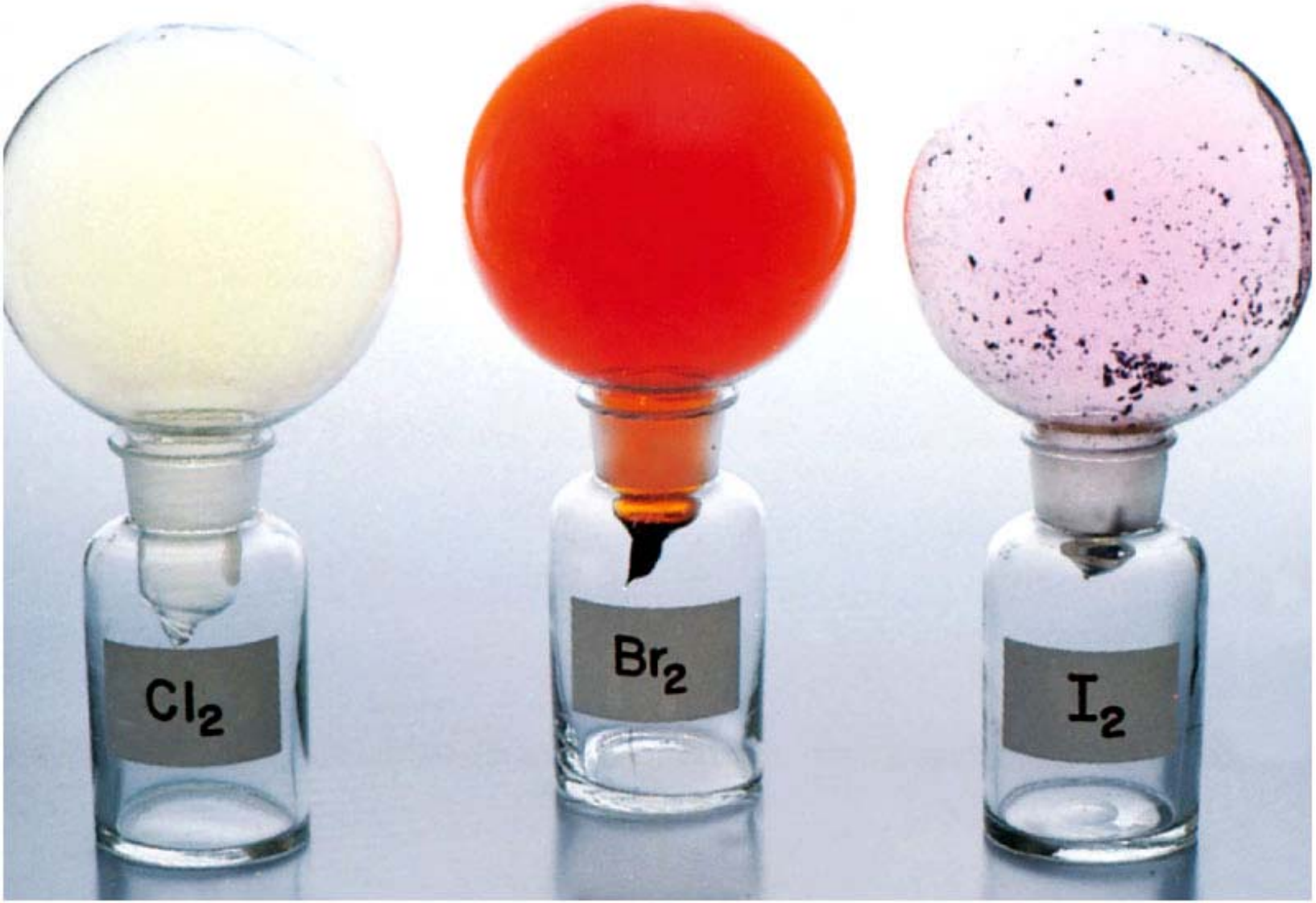
# Elementos del Grupo 7A ($ns^2np^5$, $n \geq 2$)

$X + 1e^- \longrightarrow X^{-1}$

$X_{2(g)} + H_{2(g)} \longrightarrow 2HX_{(g)}$

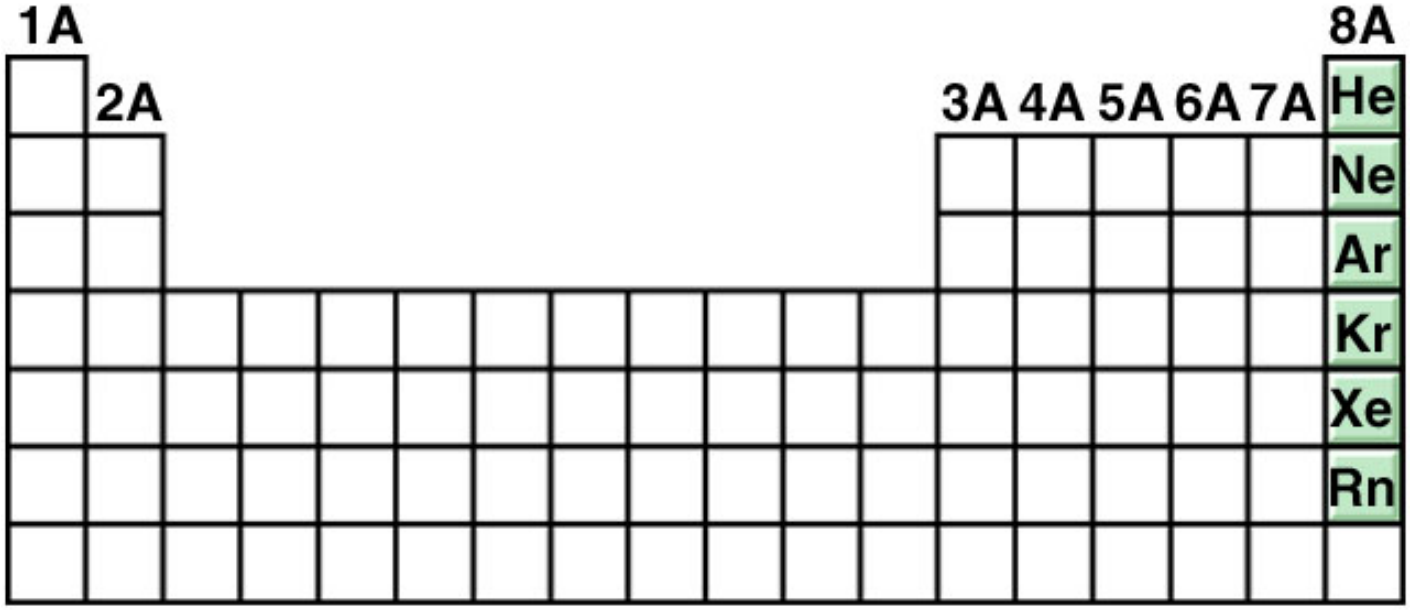


# Elementos del Grupo 7A ($ns^2np^5$, $n \geq 2$)

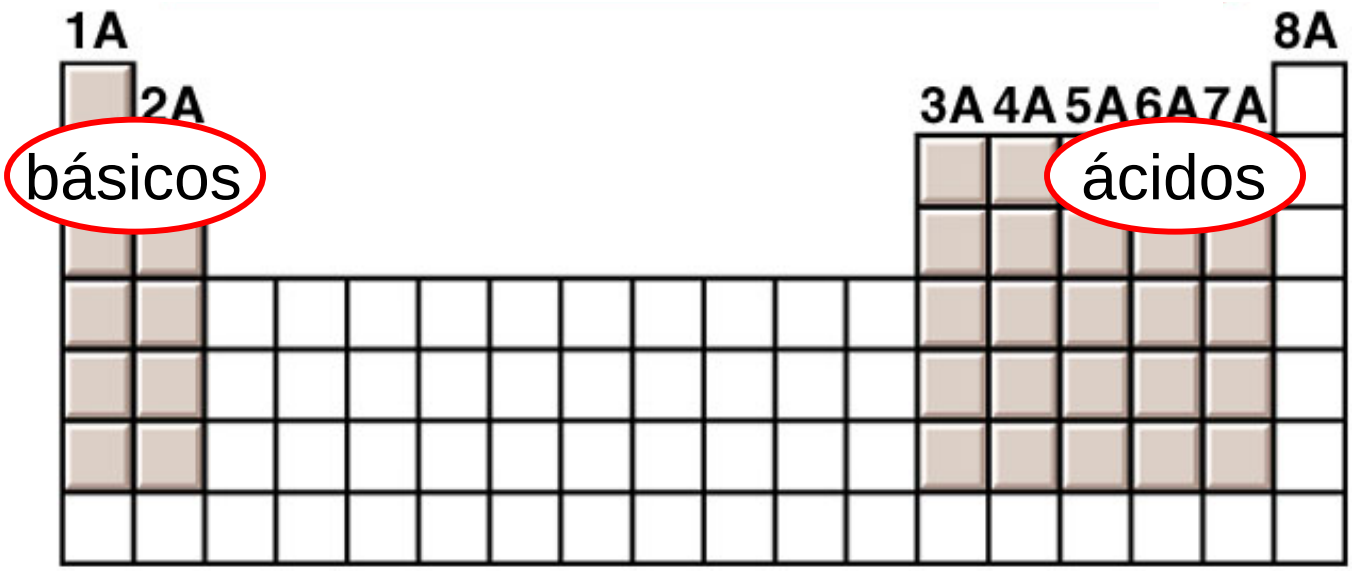


# Elementos del Grupo 8A ($ns^2np^6$, $n \geq 2$)

Niveles *ns* y subniveles *np* completamente llenos. Energías de ionización más altas que todos los elementos.
No tienden a aceptar electrones extras.



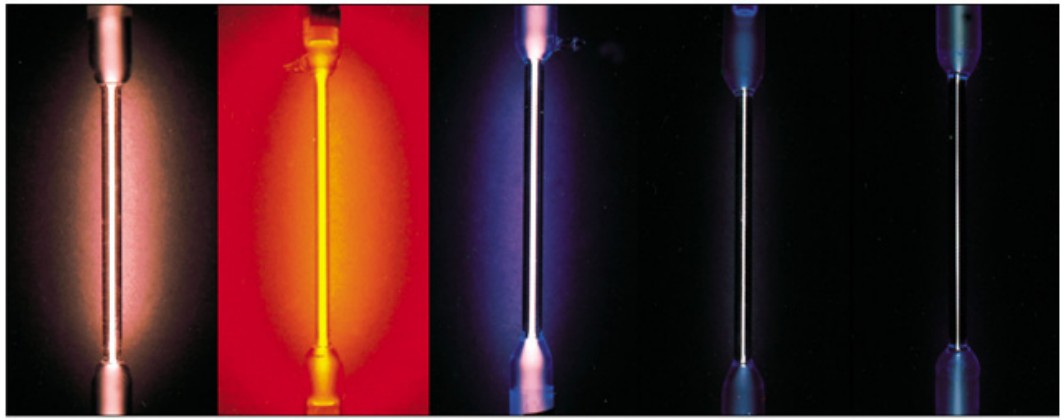
# Propiedades de los óxidos a través de un período




# Algunas propiedades de los óxidos del tercer período

| | $Na_2O$ | MgO | $Al_2O_3$ | $SiO_2$ | $P_4O_{10}$ | $SO_3$ | $Cl_2O_7$ |
|---|---|---|---|---|---|---|---|
| Type of compound | ← Ionic → | | | ← Molecular → | | | |
| Structure | ← Extensive three-dimensional → | | | ← Discrete molecular units → | | | |
| Melting point (°C) | 1275 | 2800 | 2045 | 1610 | 580 | 16.8 | −91.5 |
| Boiling point (°C) | ? | 3600 | 2980 | 2230 | ? | 44.8 | 82 |
| Acid-base nature | Basic | Basic | Amphoteric | ← Acidic → | | | |

# La química en acción:
# El descubrimiento de los gases nobles




Sir William Ramsay