

# Supporti visuali per il corso di CHIMICA

## Corso di Laurea in Ingegneria Civile Ambientale

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# Tavola periodica

gruppo 1 IA																	gruppo 13 IIIA	gruppo 14 IVA	gruppo 15 VA	gruppo 16 VIA	gruppo 17 VIIA	gruppo 18 VIIIA												
1 periodo idrogeno H 1,008																	boro B 10,81	carbonio C 12,01	azoto N 14,01	ossigeno O 16	fluoro F 19	elio He 4,003												
2 periodo litio Li 6,941	berillio Be 9,012																	alluminio Al 26,98	silicio Si 28,09	fosforo P 30,97	zolfo S 32,07	cloro Cl 35,45	argon Ar 39,95											
3 periodo sodio Na 22,99	magnesio Mg 24,31	gruppo 3 IIIB	gruppo 4 IVB	gruppo 5 VB	gruppo 6 VIB	gruppo 7 VIIB	gruppo 8 VIII B	gruppo 9 VIII B	gruppo 10 VIII B	gruppo 11 IB	gruppo 12 IIB	gallio Ga 69,72	germanio Ge 72,64	arsenico As 74,92	selenio Se 78,96	bromo Br 79,91	cripton Kr 83,8																	
4 periodo potassio K 39,1	calcio Ca 40,08	scandio Sc 44,96	titanio Ti 47,87	vanadio V 50,94	cromo Cr 52	manganese Mn 54,94	ferro Fe 55,85	cobalto Co 58,93	nicel Ni 58,69	rame Cu 63,55	zinco Zn 65,37	indio In 69,72	stagno Sn 72,64	antimonio Sb 74,92	tellurio Te 78,96	iodio I 126,9	xenon Xe 131,3																	
5 periodo rubidio Rb 85,47	stronzio Sr 87,62	ittrio Y 88,91	zirconio Zr 91,22	niobio Nb 92,91	molibdeno Mo 95,94	tecnecio Tc [98,91]	rutenio Ru 101,1	rodio Rh 102,9	palladio Pd 106,4	argento Ag 107,9	cadmio Cd 112,4	indio In 114,8	stagno Sn 118,7	antimonio Sb 121,8	tellurio Te 127,6	iodio I 126,9	xenon Xe 131,3																	
6 periodo cesio Cs 132,9	bario Ba 137,3	lantano La 138,9	hafnio Hf 178,5	tantalio Ta 180,9	tungsteno W 183,8	renio Re 186,2	osmio Os 190,2	iridio Ir 192,2	platino Pt 195,1	oro Au 197	mercurio Hg 200,6	tallio Tl 204,4	piombo Pb 207,2	bismuto Bi 208,98	polonio Po [209]	astato At [210]	radon Rn [222]																	
7 periodo francio Fr [223]	radio Ra [226]	actinio Ac [227]	rutherfordio Rf [261]	dubnio Db [262]	seaborgio Sg [266]	bohrio Bh [264]	hassio Hs [265]	meitnerio Mt [268]	darwinio Ds [271]	roentgenio Rg [272]	copernicio Cn [285]	ununtrio Uut [284]	flerovio Fl [289]	unpentio Uup [288]	livermorio Lv [292]	unseptio Uus [310]	unocencio Uuo [314]																	
8 periodo ununennio Uue [119]	unbinillio Ubn [120]																	cerio Ce 140,1	praseodimio Pr 140,9	neodimio Nd 144,2	promezio Pm [145]	samario Sm 150,4	europio Eu 152	gadolinio Gd 157,3	terbio Tb 158,9	disprosio Dy 162,5	olmio Ho 164,9	erbio Er 167,3	tullio Tm 168,9	itterbio Yb 173	lutetio Lu 175			
		gruppo 19 Lantanoidi																	torio Th 232	proattinio Pa [231]	uranio U 238	nettonio Np [237]	plutonio Pu [244]	americio Am [243]	curio Cm [247]	berkelio Bk [247]	californio Cf [251]	einsteinio Es [252]	fermio Fm [257]	mendelevio Md [258]	nobelio No [259]	laurenzio Lr [262]		
		gruppo 20 Attinoidi																																

numero di elettroni per livello  
numero atomico Z  
nome elemento; artificiale in rosso  
temperatura di fusione (°C)  
energia di prima ionizzazione (kJ/mol)  
elettronegatività  
proprietà base-acido  
numero di ossidazione  
configurazione elettronica

nero = solido  
blu = liquido  
rosa = gassoso  
rosso = incerto  
in caso di elementi radioattivi, evidenziata

[...] indicano la massa dell'isotopo

Metalli alcalini

Metalli alcalino terrosi

Terre rare

Metalli del blocco d

"Metalli nobili"

Metalli del blocco f

Metalli del blocco p

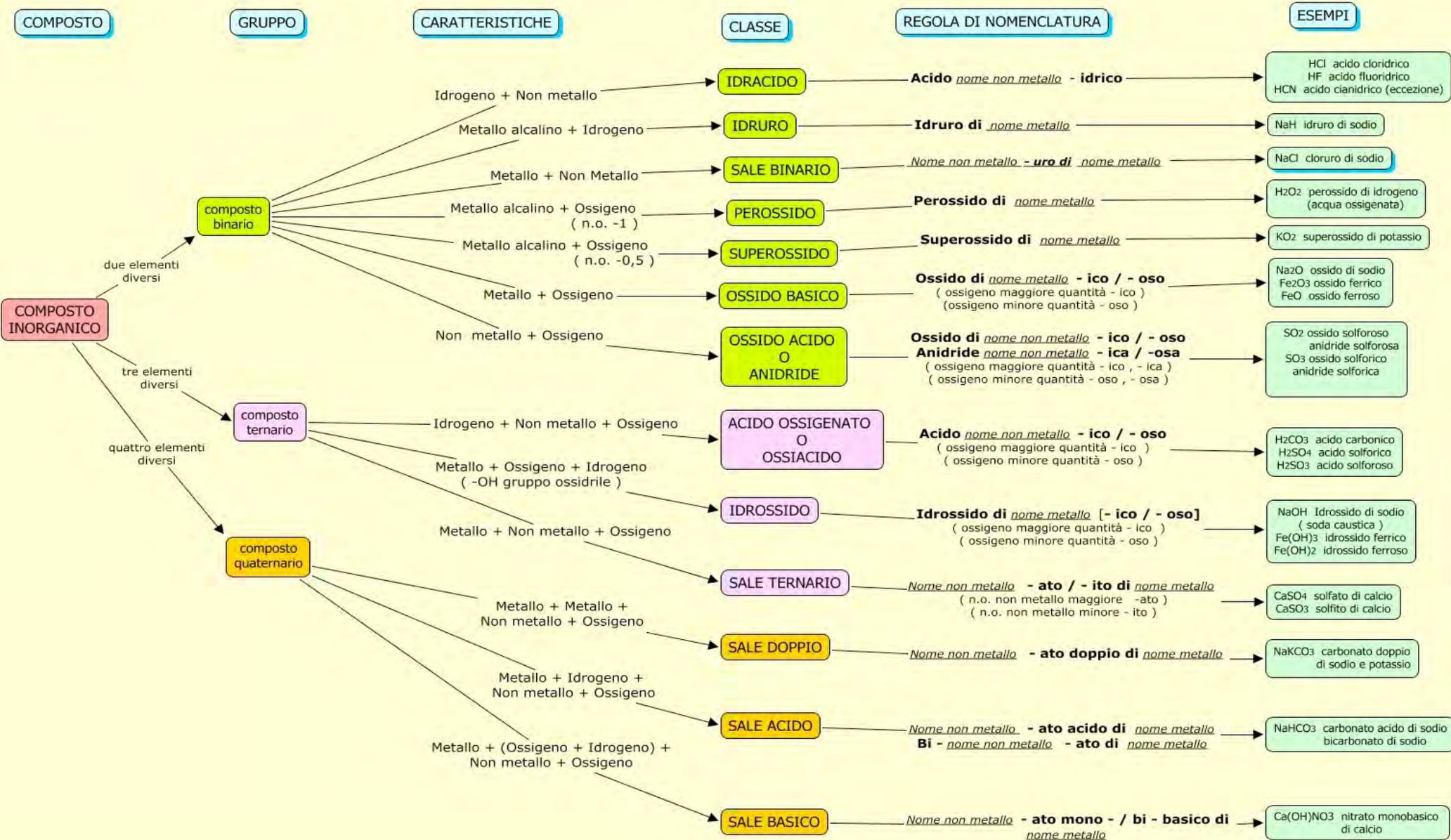
Metalloidi

Nonmetalli

Alogeni

Gas nobili

# Nomenclatura (tratto da prof. R. Giacomino, progetto INNOVARE)



# Anidridi

<i>formula composto</i>	<i>del</i>	<i>nom. tradizionale</i>	<i>nom. di Stock</i>	<i>nom. IUPAC</i>
$B_2O_3$		anidride borica		triossido di diboro
CO		anidride carboniosa	ossido di carbonio (I)	(mon)ossido di carbonio
CO <sub>2</sub>		anidride carbonica	ossido di carbonio (II)	diossido di carbonio
SO <sub>2</sub>		anidride solforosa	ossido di zolfo (II)	diossido di zolfo
SO <sub>3</sub>		anidride solforica	ossido di zolfo (III)	triossido di zolfo
Cl <sub>2</sub> O		anidride ipoclorosa	ossido di cloro (I)	(mon)ossido di dicloro
Cl <sub>2</sub> O <sub>3</sub>		anidride clorosa	ossido di cloro (III)	triossido di dicloro
Cl <sub>2</sub> O <sub>5</sub>		anidride clorica	ossido di cloro (V)	pentossido di dicloro
Cl <sub>2</sub> O <sub>7</sub>		anidride perclorica	ossido di cloro (VII)	eptossido di dicloro
N <sub>2</sub> O		protossido di azoto o ossido nitroso	ossido di azoto (I)	(mon)ossido di diazoto
NO		ossido di azoto o ossido nitrico	ossido di azoto (II)	(mon)ossido di azoto
N <sub>2</sub> O <sub>3</sub>		anidride nitrosa	ossido di azoto (III)	triossido di diazoto
NO <sub>2</sub>		ipoazotide, biossido di azoto	ossido di azoto (IV)	diossido di azoto
N <sub>2</sub> O <sub>5</sub>		anidride nitrica	ossido di azoto (V)	pentossido di diazoto

# Ossiacidi

<i>formula del composto</i>	<i>nom. tradizionale</i>	<i>nom. di Stock</i>	<i>nom. IUPAC</i>
H <sub>3</sub> BO <sub>3</sub>	acido borico		acido triossiborico (III)
H <sub>2</sub> CO <sub>2</sub>	acido carbonioso		acido diossicarbonico (II)
H <sub>2</sub> CO <sub>3</sub>	acido carbonico		acido triossicarbonico (IV)
H <sub>2</sub> SO <sub>3</sub>	acido solforoso		acido triossisolforico (IV)
H <sub>2</sub> SO <sub>4</sub>	acido solforico		acido tetrossisolforico (VI)
HNO <sub>2</sub>	acido nitroso		acido diossinitrico (III)
HNO <sub>3</sub>	acido nitrico		acido triossinitrico (V)
HClO	acido ipocloroso		acido monossiclorico (I)
HClO <sub>2</sub>	acido cloroso		acido diossiclorico (III)
HClO <sub>3</sub>	acido clorico		acido triossiclorico (V)
HClO <sub>4</sub>	acido perclorico		acido tetrossiclorico (VII)

# Idracidi

Elemento	Numero di ossidazione	Formula	Nome tradizionale	Nome IUPAC
F	-1	HF	acido fluoridrico	fluoruro di idrogeno
Cl	-1	HCl	acido cloridrico	cloruro di idrogeno
Br	-1	HBr	acido bromidrico	bromuro di idrogeno
I	-1	HI	acido iodidrico	ioduro di idrogeno
S	-2	H <sub>2</sub> S	acido solfidrico	solfuro di diidrogeno
Se	-2	H <sub>2</sub> Se	acido selenidrico	seleniuro di diidrogeno
Te	-2	H <sub>2</sub> Te	acido telluridrico	tellururo di diidrogeno

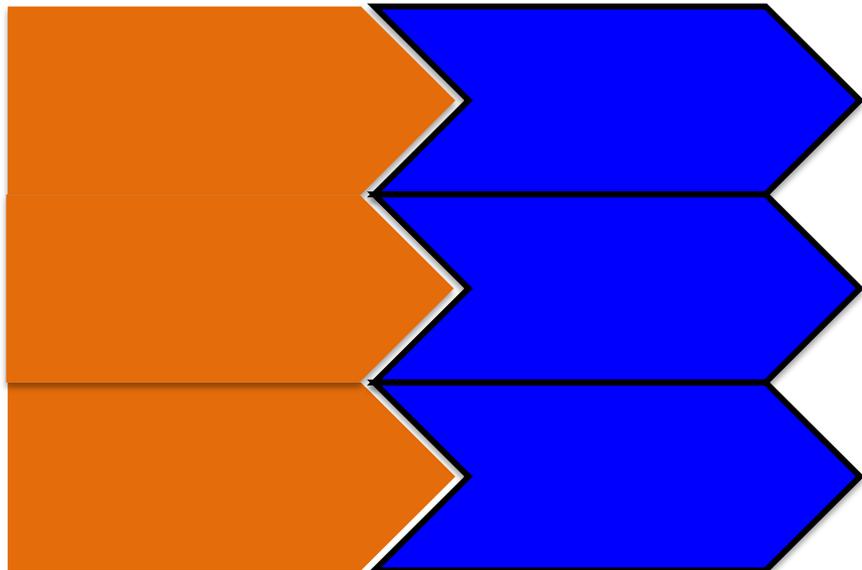
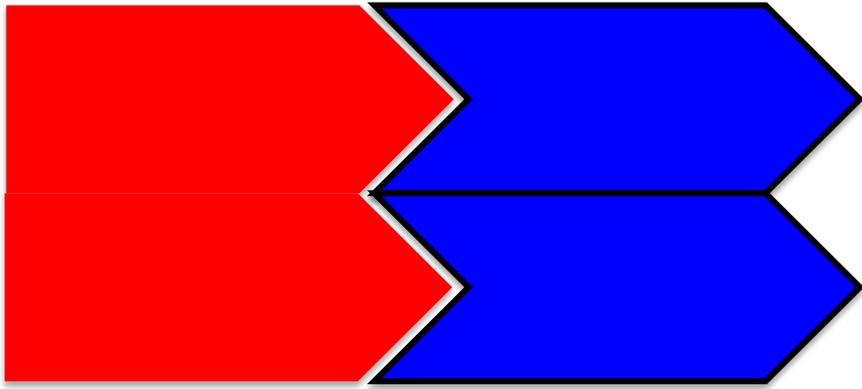
# Anioni da acidi

Anioni acidi	Nome tradizionale	Nome IUPAC
$\text{NO}_3^-$	nitrato	triossonitrato(V)
$\text{NO}_2^-$	nitrito	diossonitrato(III)
$\text{HSO}_4^-$	bisolfato	monoidrogenosolfato(VI)*
$\text{HCO}_3^-$	bicarbonato	monoidrogenocarbonato(IV)*
$\text{CO}_3^{2-}$	carbonato	triossocarbonato(IV)
$\text{H}_2\text{PO}_4^-$	fosfato biacido	diidrogenofosfato(V)*
$\text{HPO}_4^{2-}$	fosfato monoacido	monoidrogenofosfato(V)*
$\text{PO}_4^{3-}$	fosfato	tetraossofosfato(V)
$\text{ClO}^-$	ipoclorito	monoossoclorato(I)
$\text{ClO}_2^-$	clorito	diossoclorato(III)
$\text{ClO}_3^-$	clorato	triossoclorato(V)
$\text{ClO}_4^-$	perclorato	tetraossoclorato(VII)

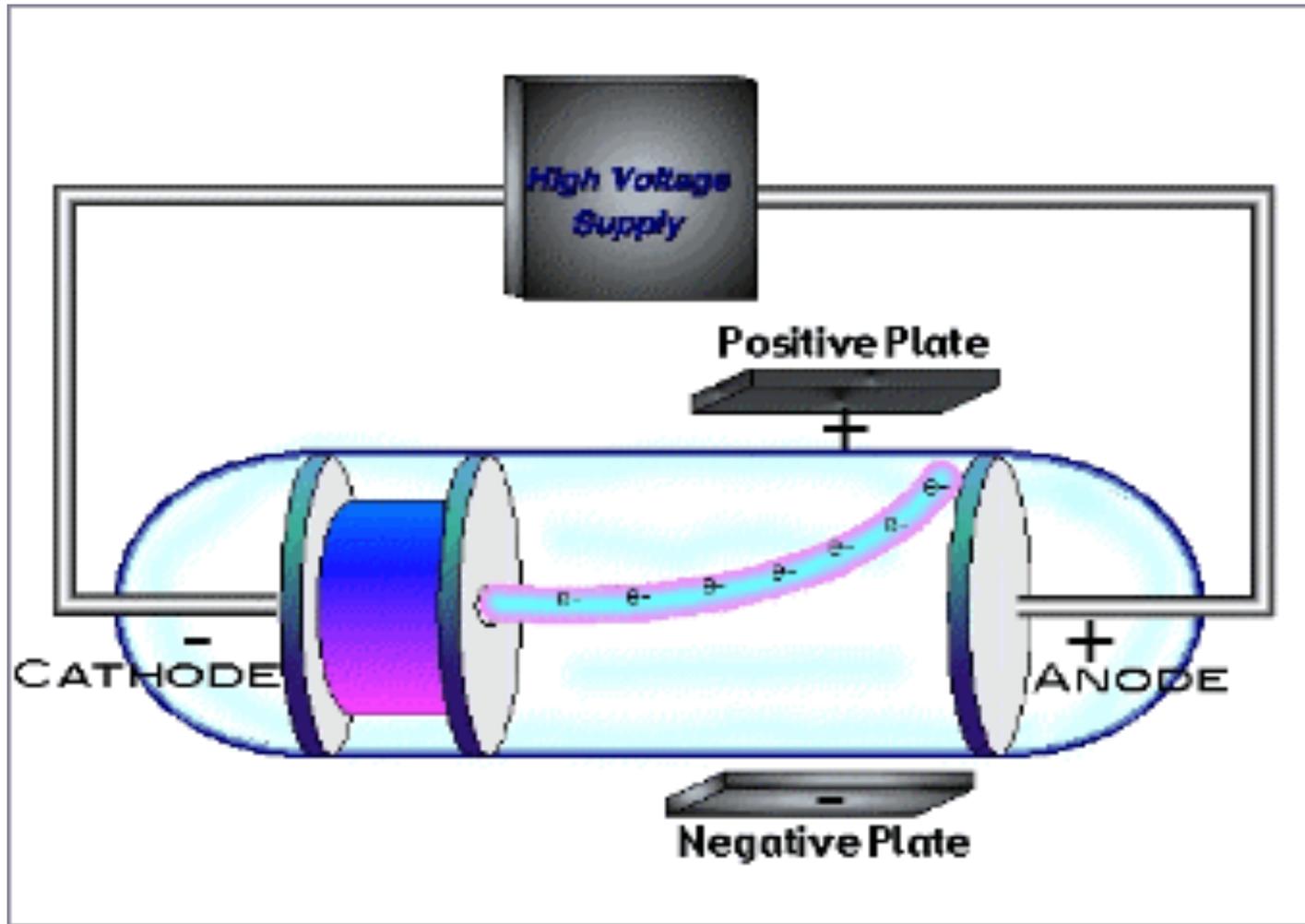
# Sali

<i>formula del composto</i>	<i>nom. tradizionale</i>	<i>nom. di Stock</i>	<i>nom. IUPAC</i>
NaNO <sub>2</sub>	nitrito sodico		diossinitrato (III) di sodio
NaNO <sub>3</sub>	nitrate sodico		triossinitrato (V) di sodio
FeCO <sub>2</sub>	carbonito ferroso		diossicarbonato (II) di ferro (II)
Fe <sub>2</sub> (CO <sub>2</sub> ) <sub>3</sub>	carbonito ferrico		diossicarbonato (II) di ferro (II)
FeCO <sub>3</sub>	carbonato ferroso		triossicarbonato (IV) di ferro (III)
Fe <sub>2</sub> (CO <sub>3</sub> ) <sub>3</sub>	carbonato ferrico		triossicarbonato (IV) di diferro (III)
CaSO <sub>3</sub>	solfito calcico		(III)
CaSO <sub>4</sub>	solfato calcico		triossisolato (IV) di calcio
NaClO	ipoclorito di sodio		tetraossisolato (VI) di calcio
NaClO <sub>2</sub>	clorito di sodio		monossiclorato (I) di sodio
NaClO <sub>3</sub>	clorato di sodio		diossiclorato (III) di sodio
NaClO <sub>4</sub>	perclorato di sodio		triossiclorato (V) di sodio
K <sub>3</sub> PO <sub>4</sub>	fosfato di potassio		tetrossiclorato (VII) di sodio
			tetrossifosfato(V) di tripotassio

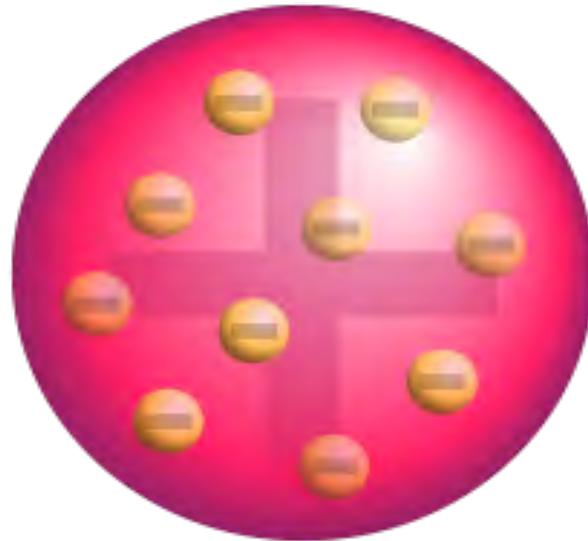
Composti: formati da elementi che hanno una loro caratteristica capacità di formare legami



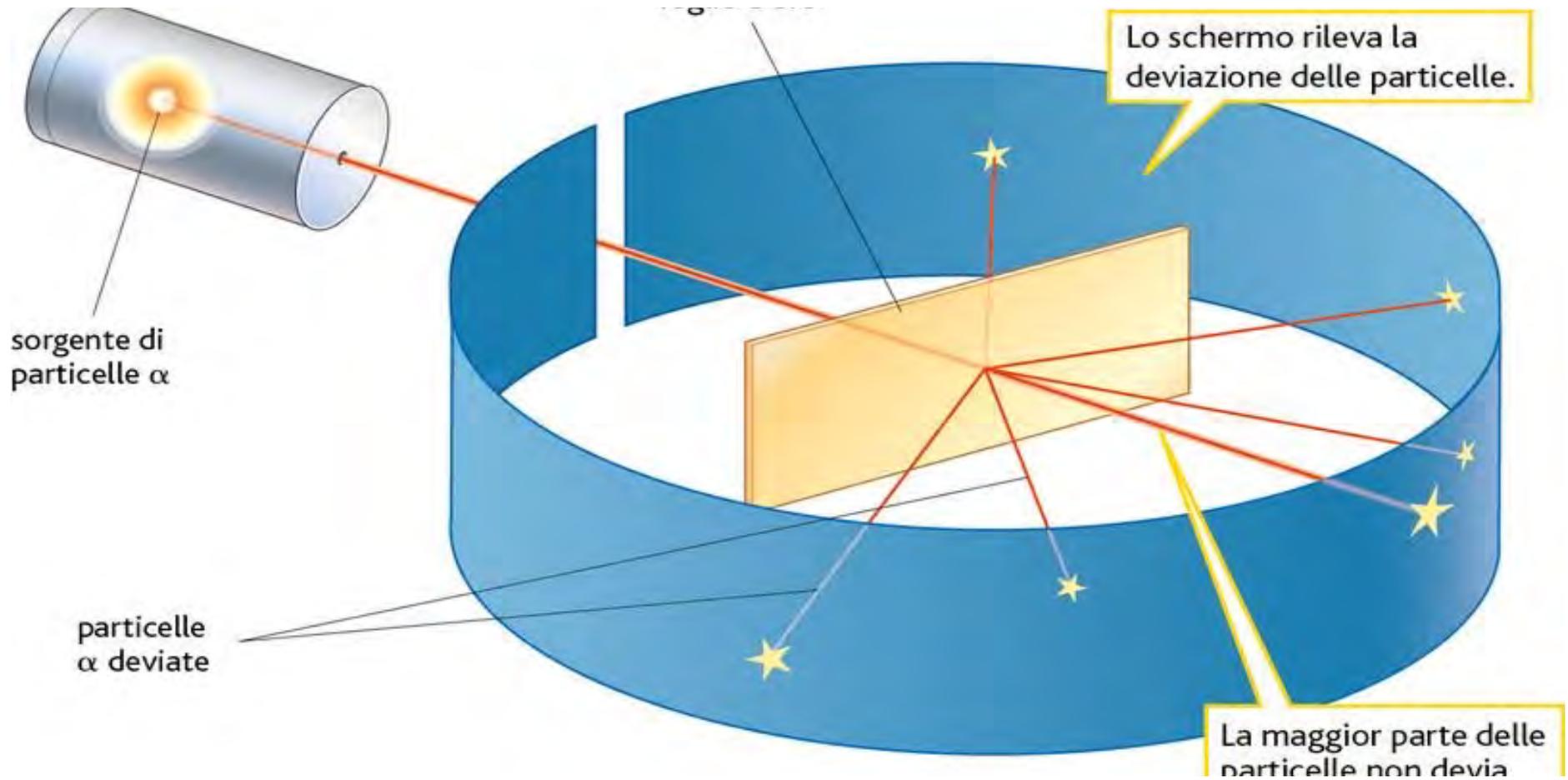
# Esperimento di Thompson



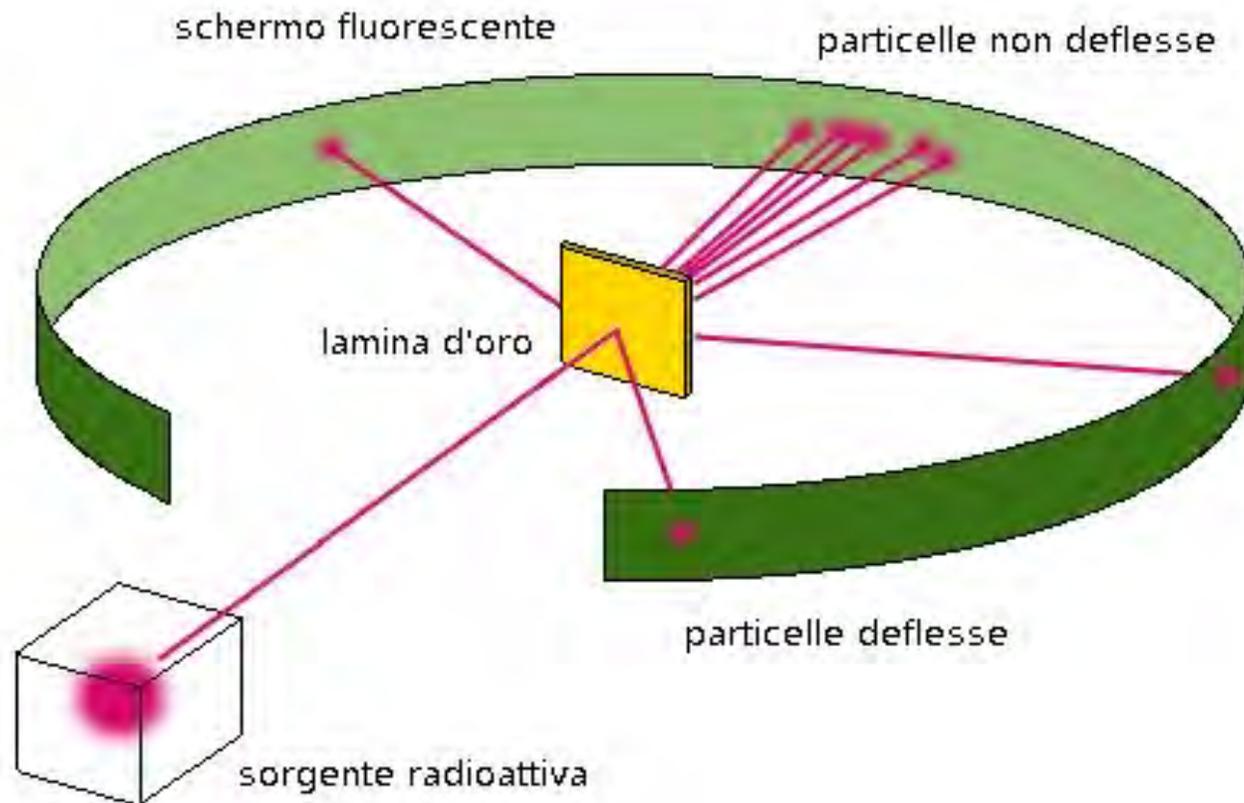
# Atomo di Thompson



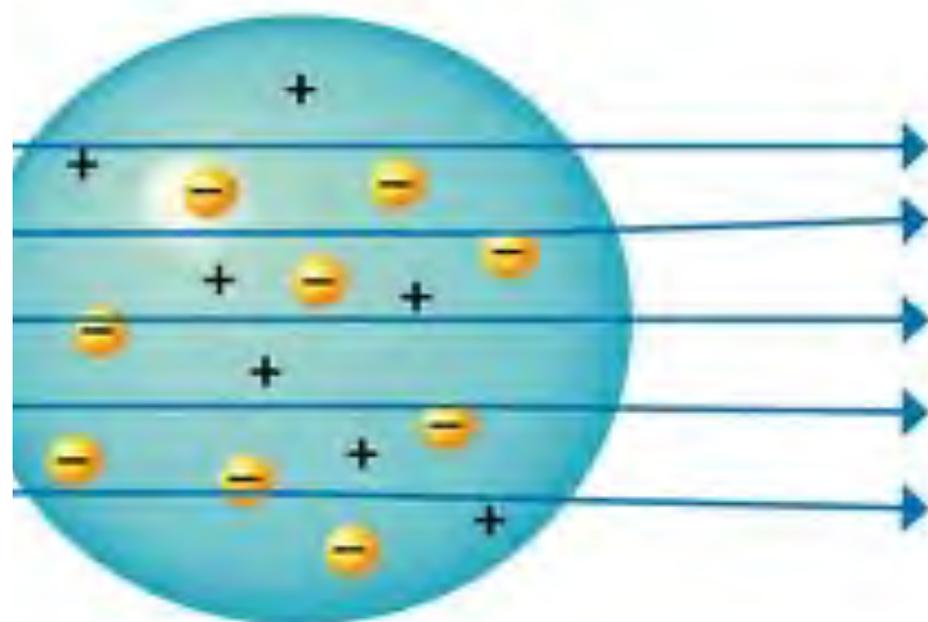
# Esperimento di Rutherford



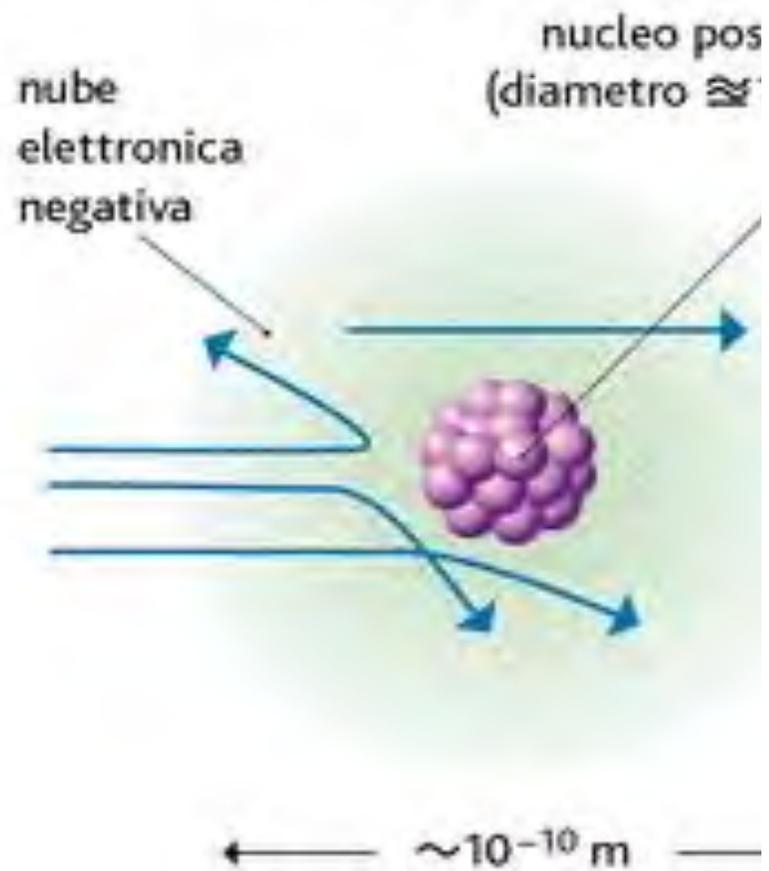
# Esperimento di Rutherford



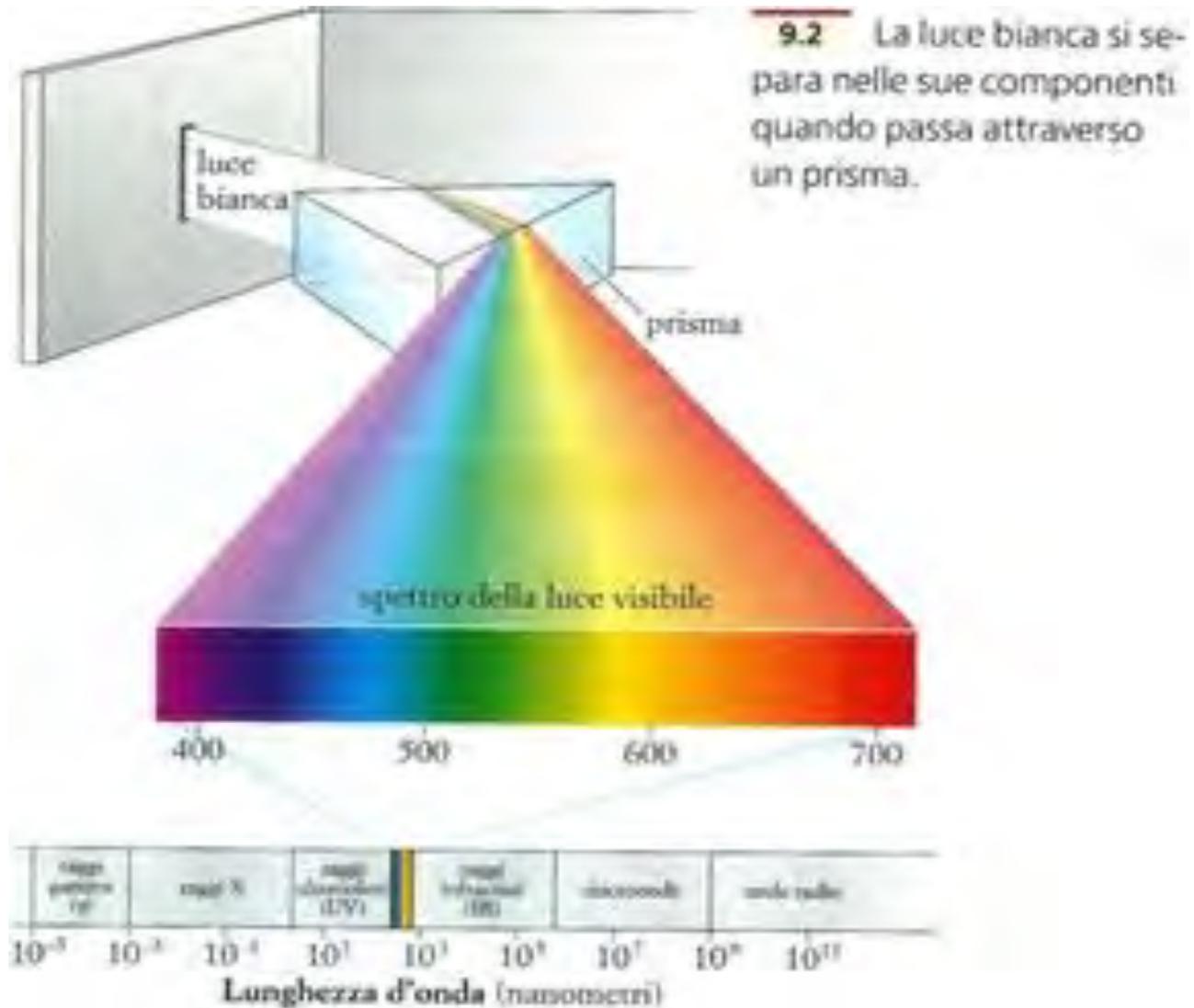
atomo di Thomson



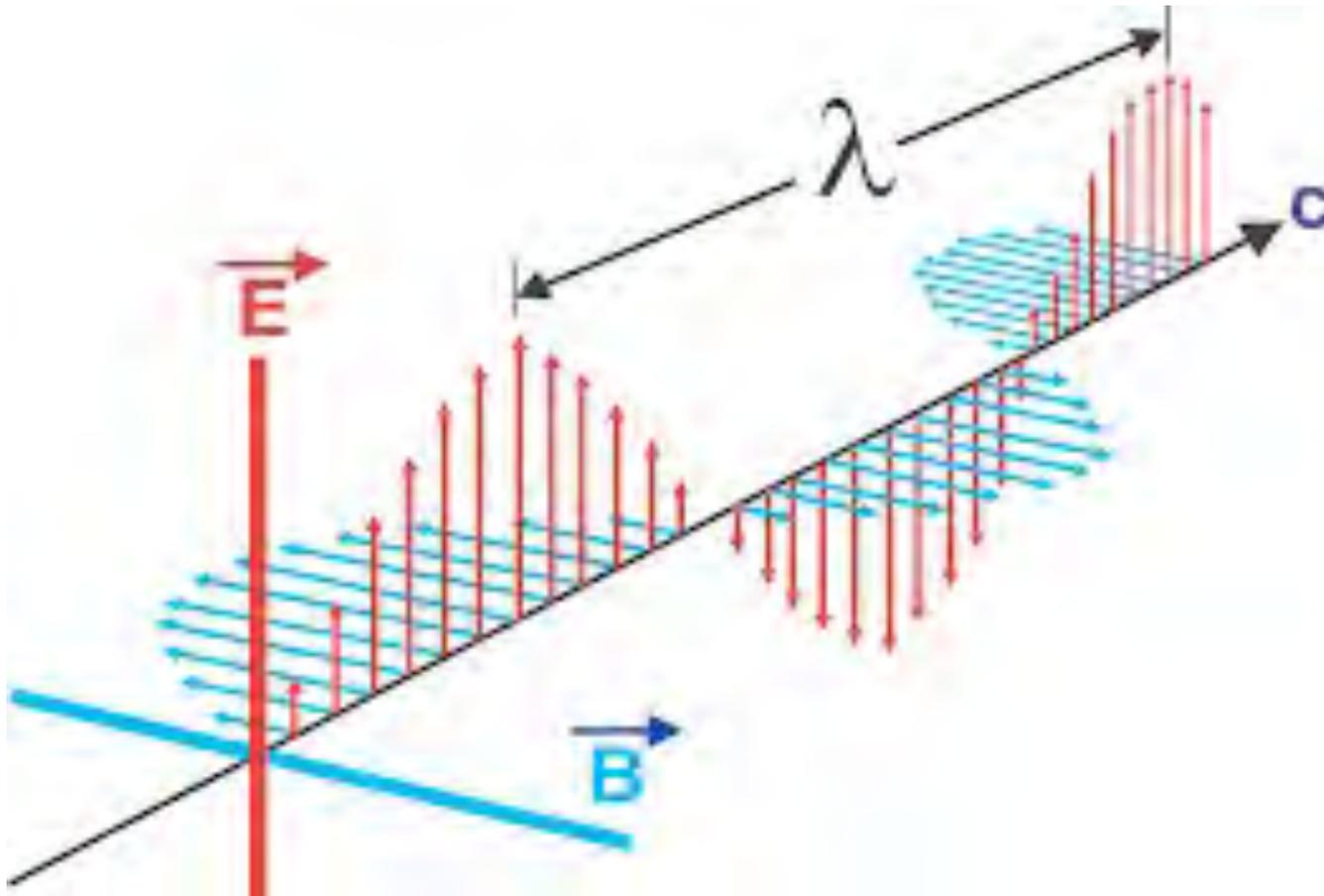
atomo di Rutherford



# Spettro elettromagnetico

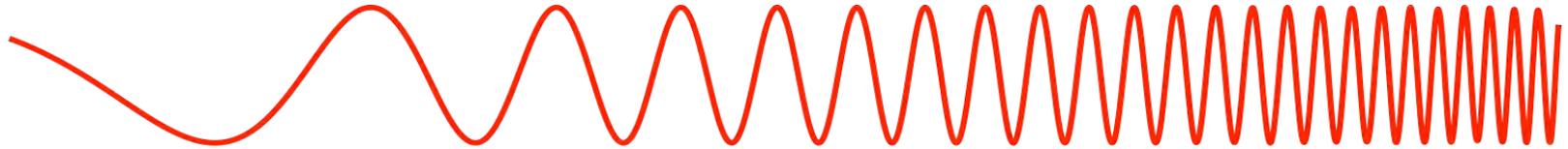


# Radiazione elettromagnetica



# Spettro elettromagnetico

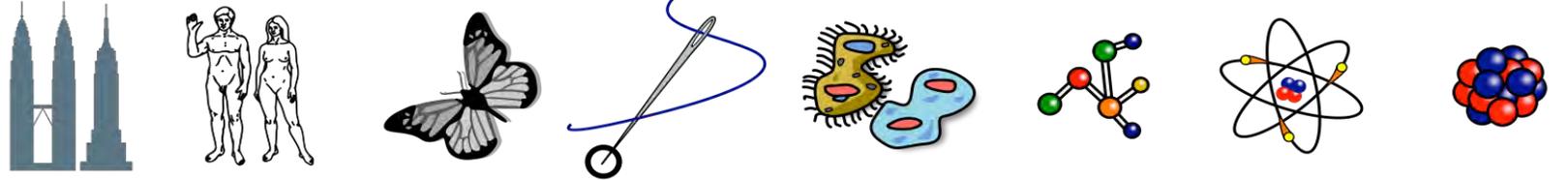
Penetra l'atmosfera terrestre?



Tipo di radiazione  
Lunghezza d'onda (m)

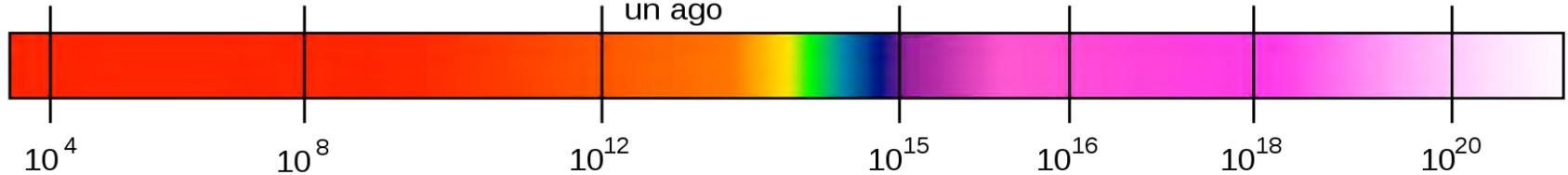


Scala approssimativa della lunghezza d'onda

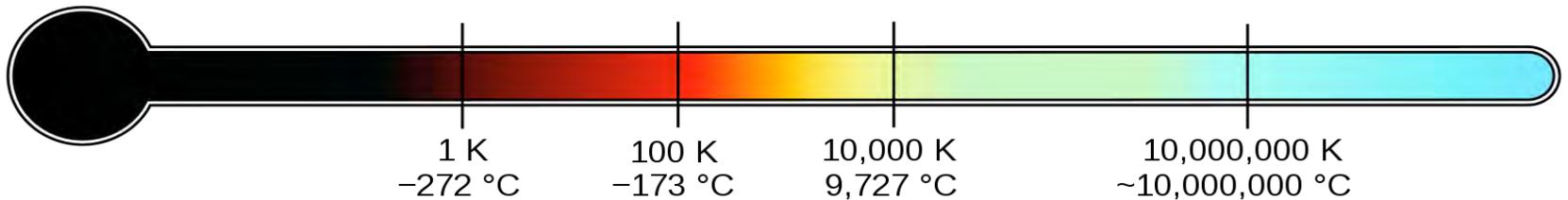


Edifici    Esseri umani    Farfalle    Punta di un ago    Protozoi    Molecole    Atomi    Nuclei atomici

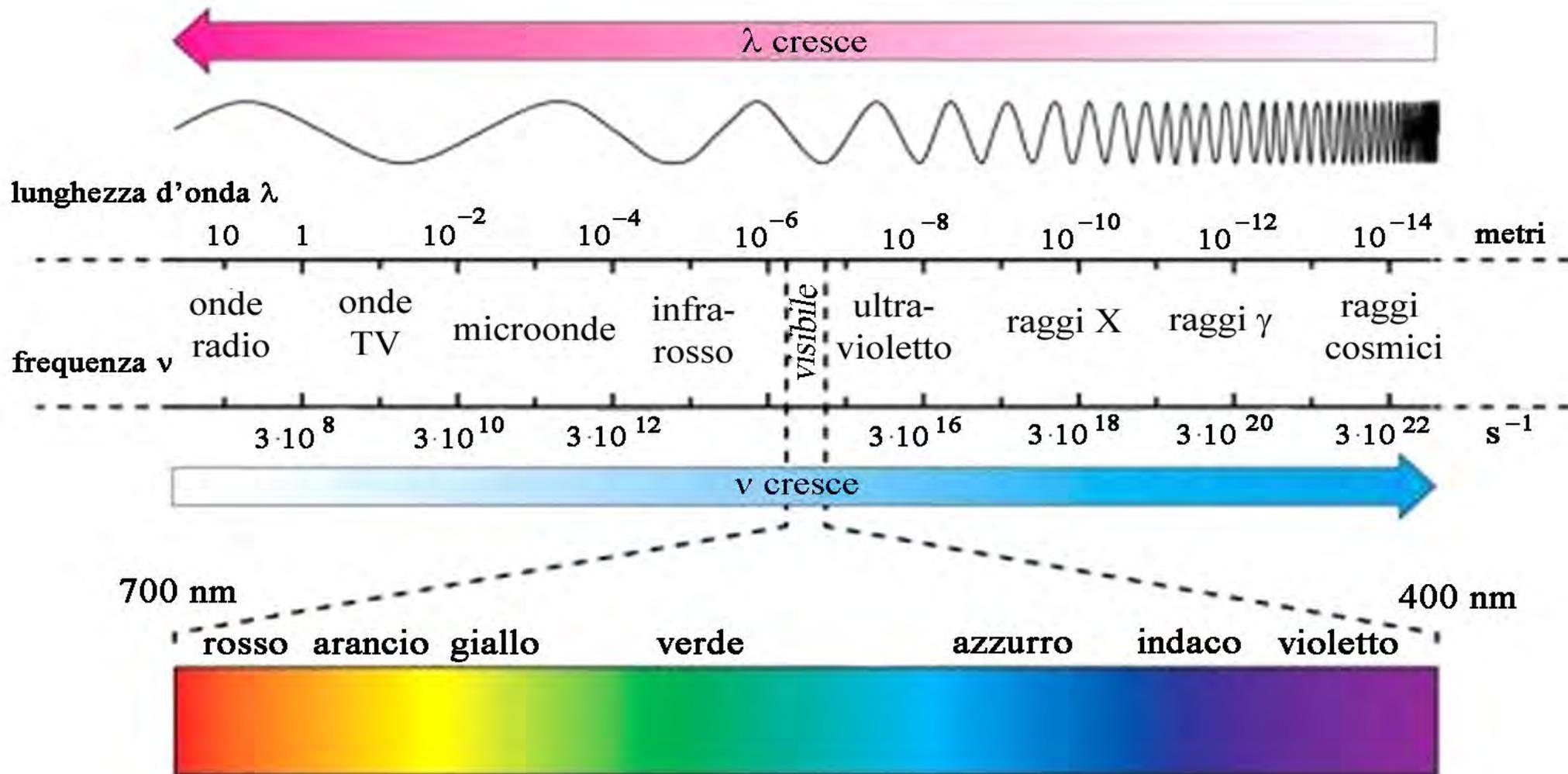
Frequenza (Hz)



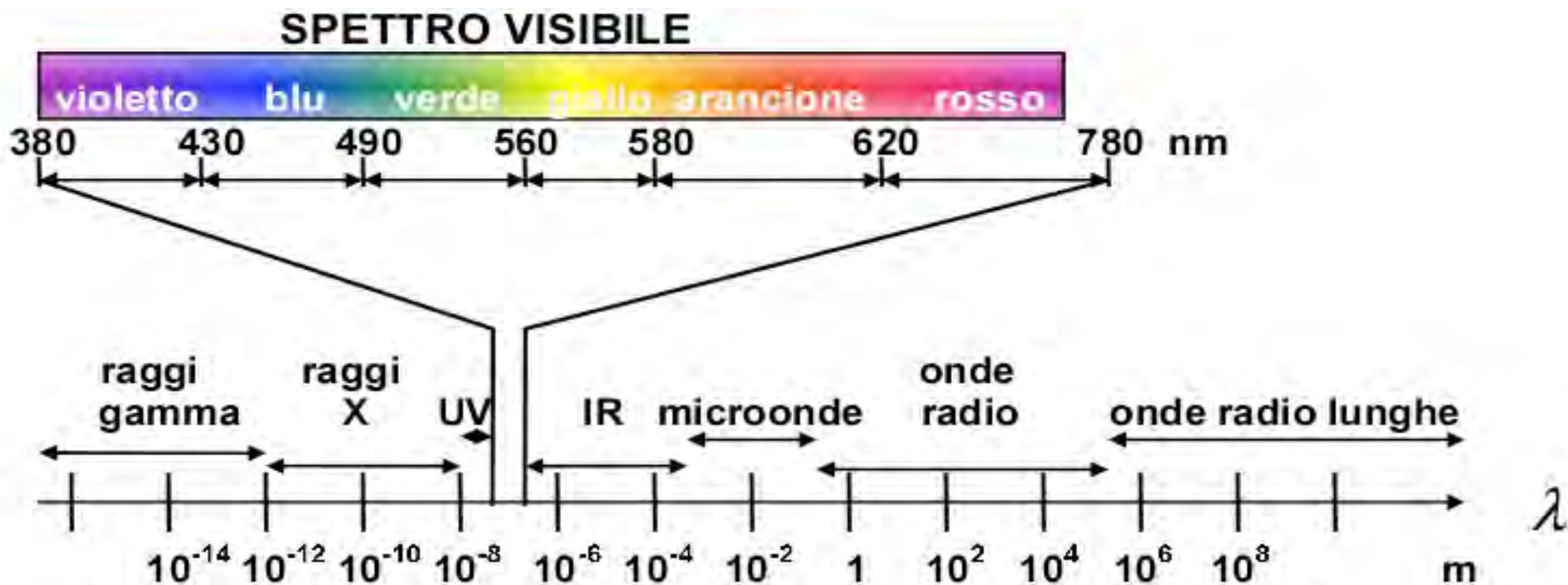
Temperatura degli oggetti alla quale questa radiazione è la più intensa  
lunghezza d'onda emessa



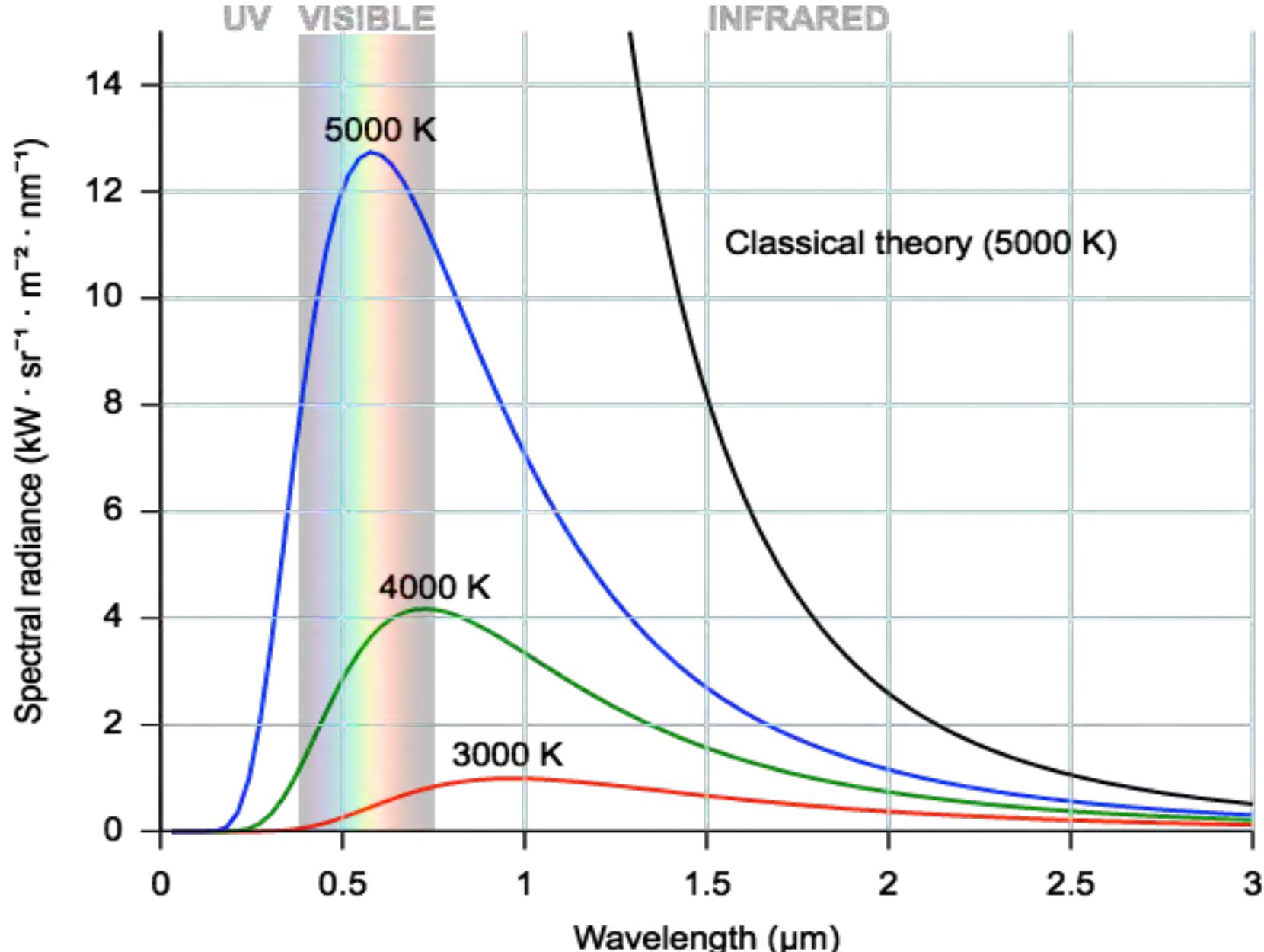
# Spettro elettromagnetico



# Spettro elettromagnetico

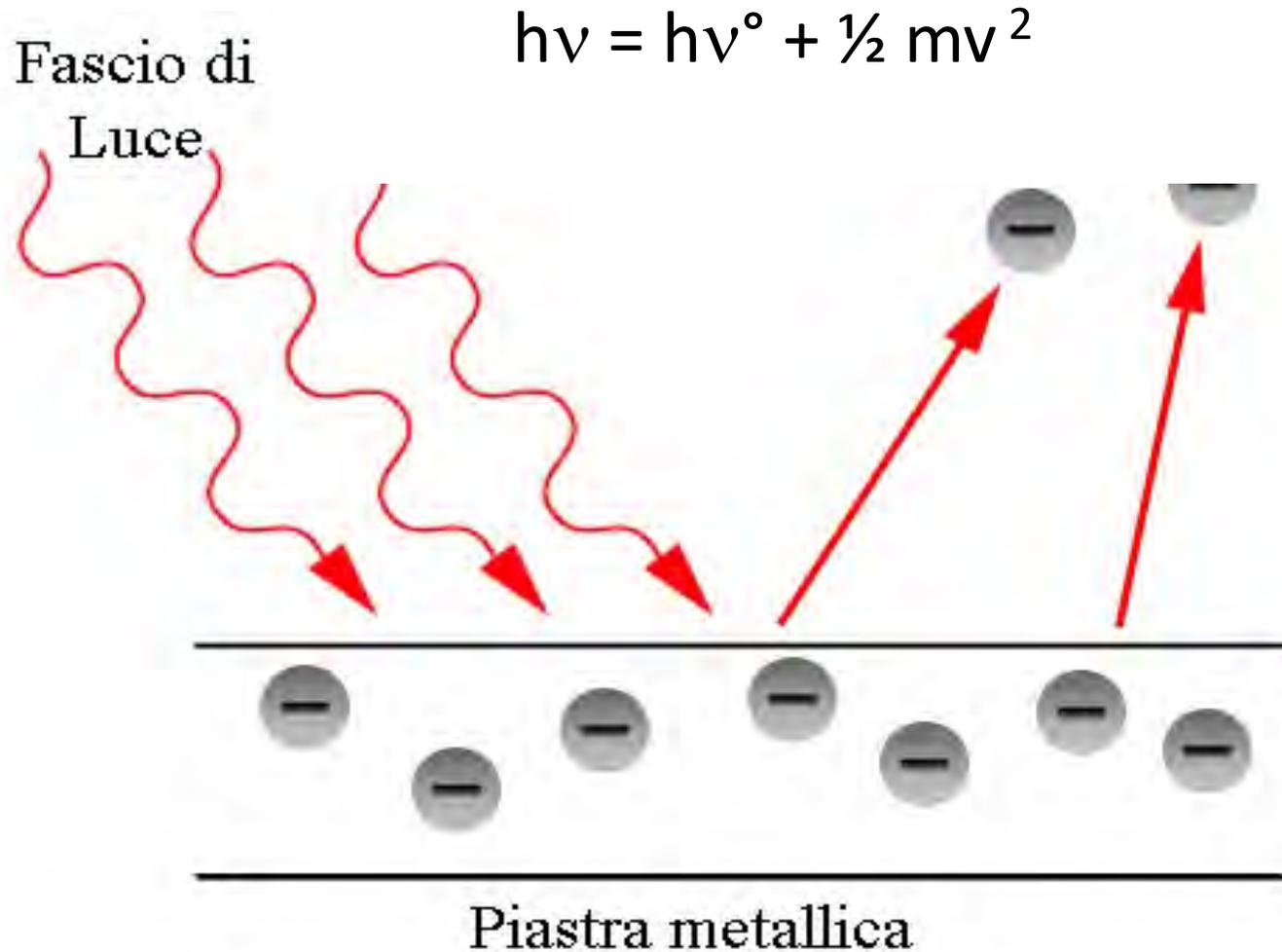


# Planck and the black body radiation



$$E=h\nu$$

# Effetto fotoelettrico



東方夜總會  
3/F



DIAMOND GLORY  
君悅珠寶

中港城 卡拉OK夜總會  
本大廈7字樓

新KDS  
60x 63x  
68x 69x  
五線假日通

King Po Street You Ma Tai 渣甸街新站

全好電  
全好電

會館  
大

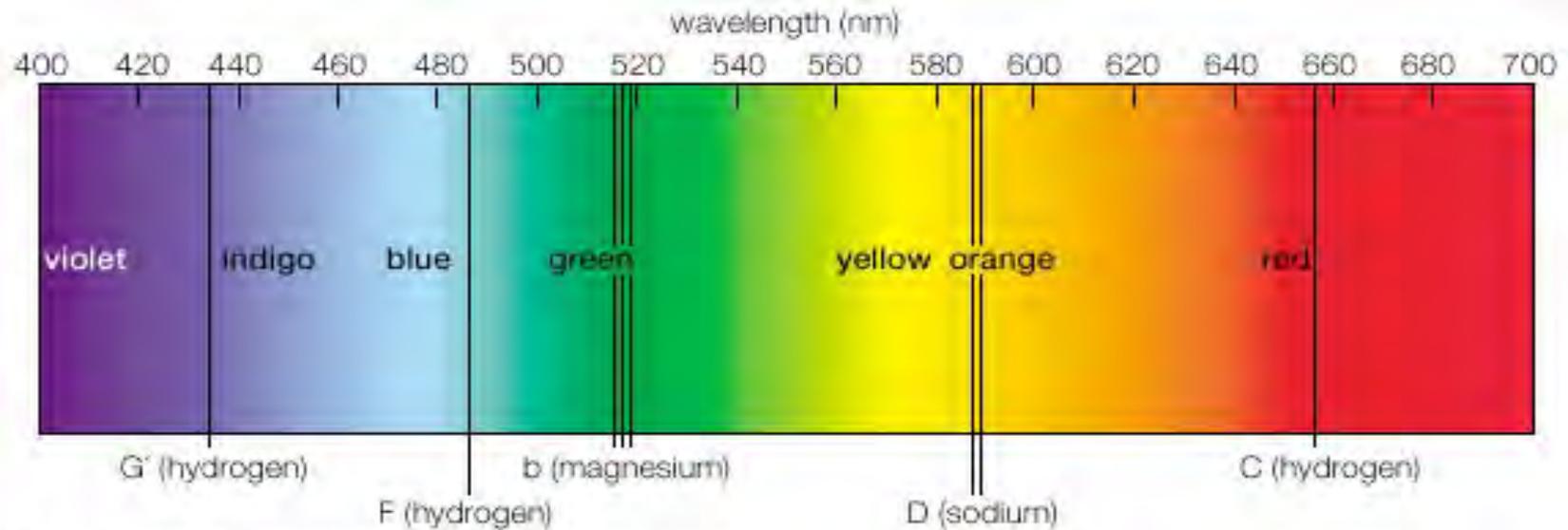
東方夜總會

DSOR PALACE HOTEL





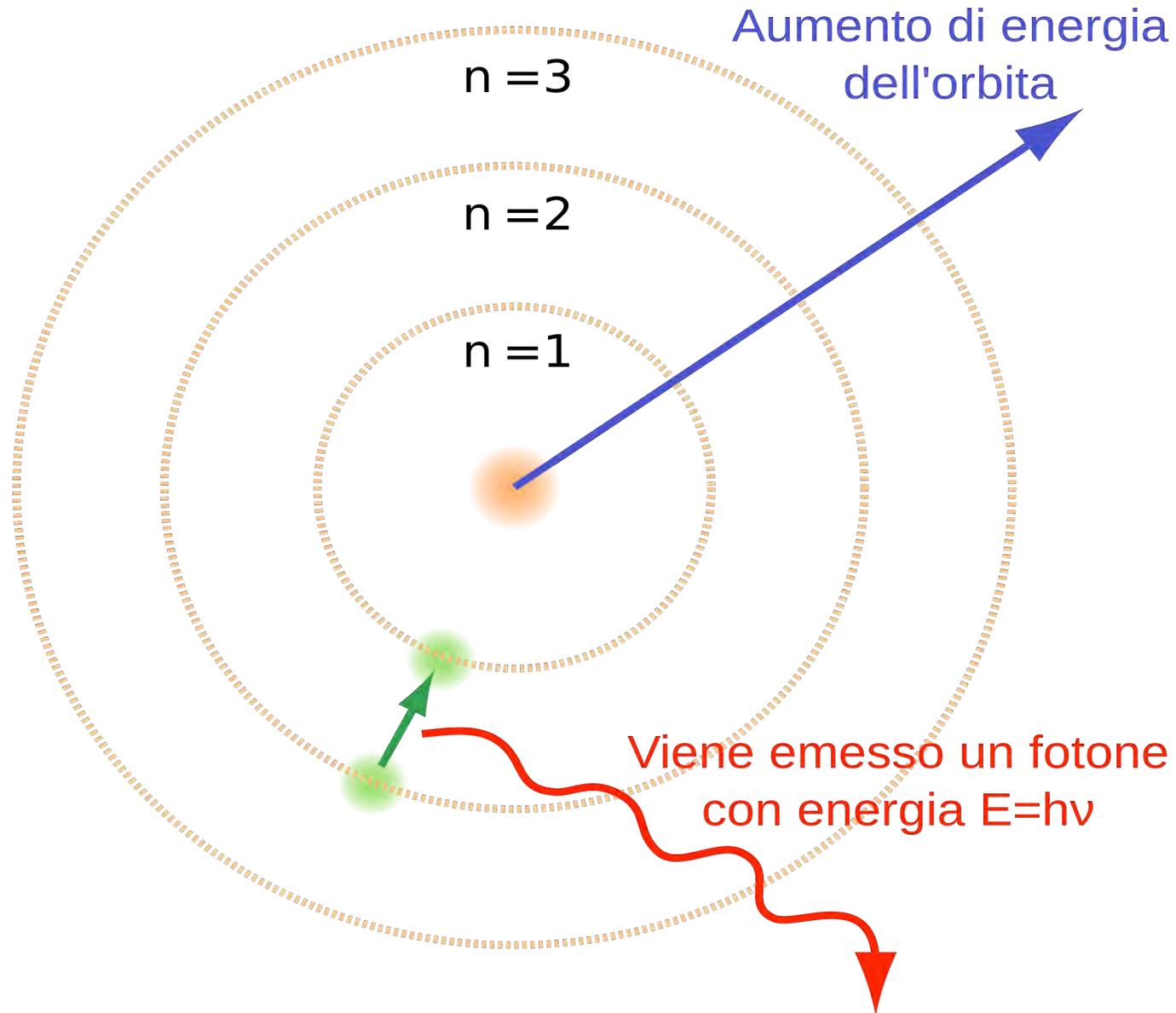
# Spettri di emissione



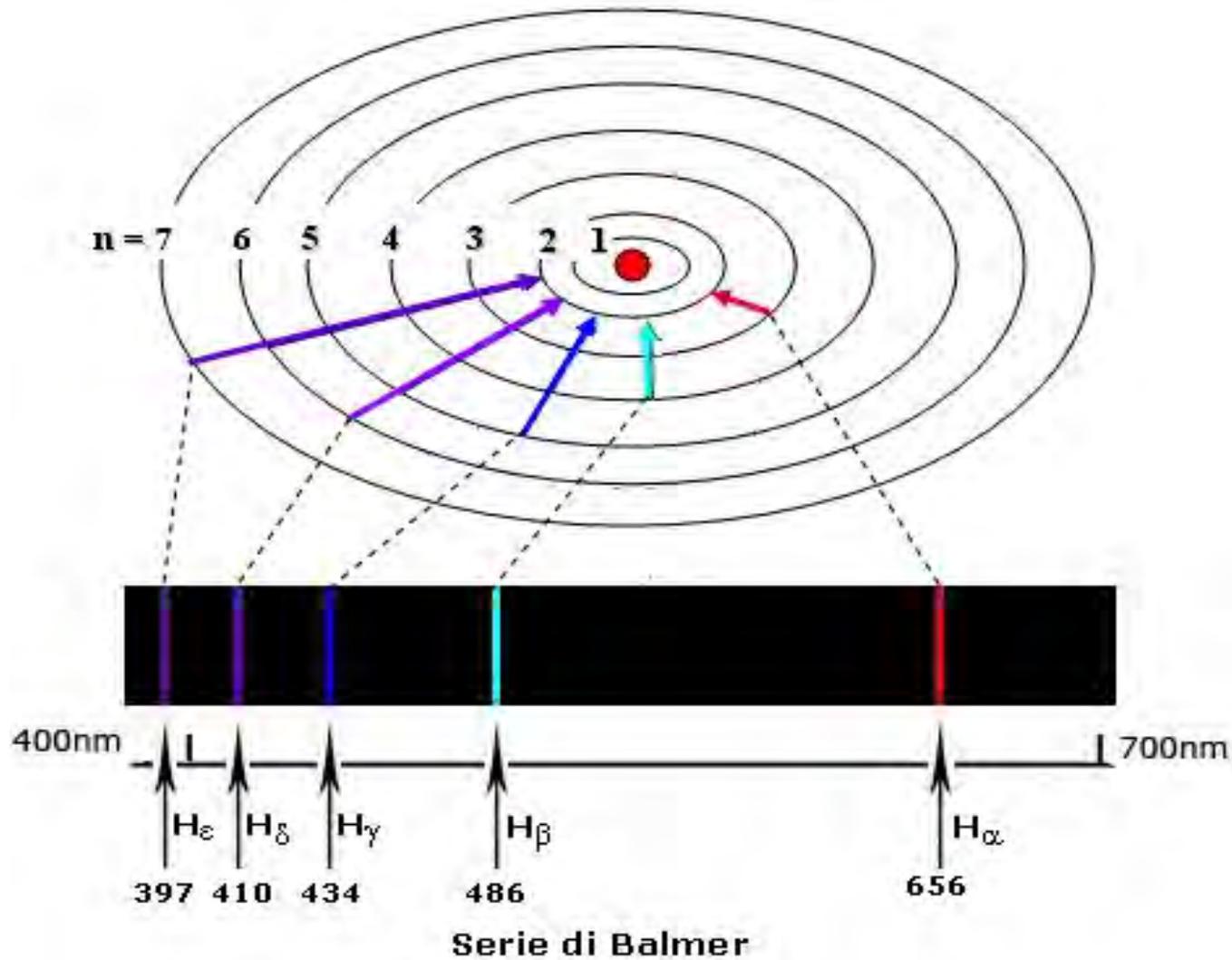
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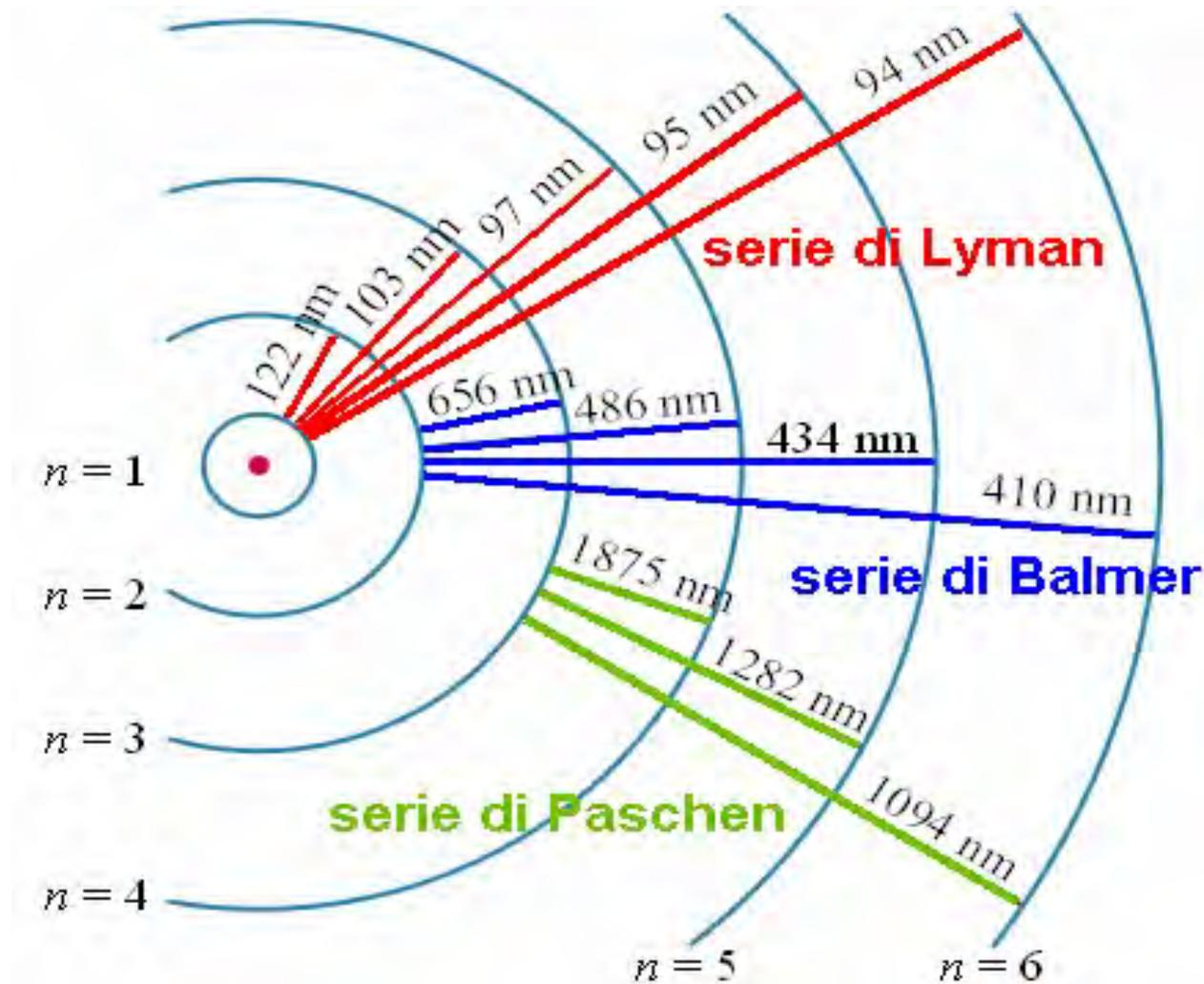
# Atomo di Bohr



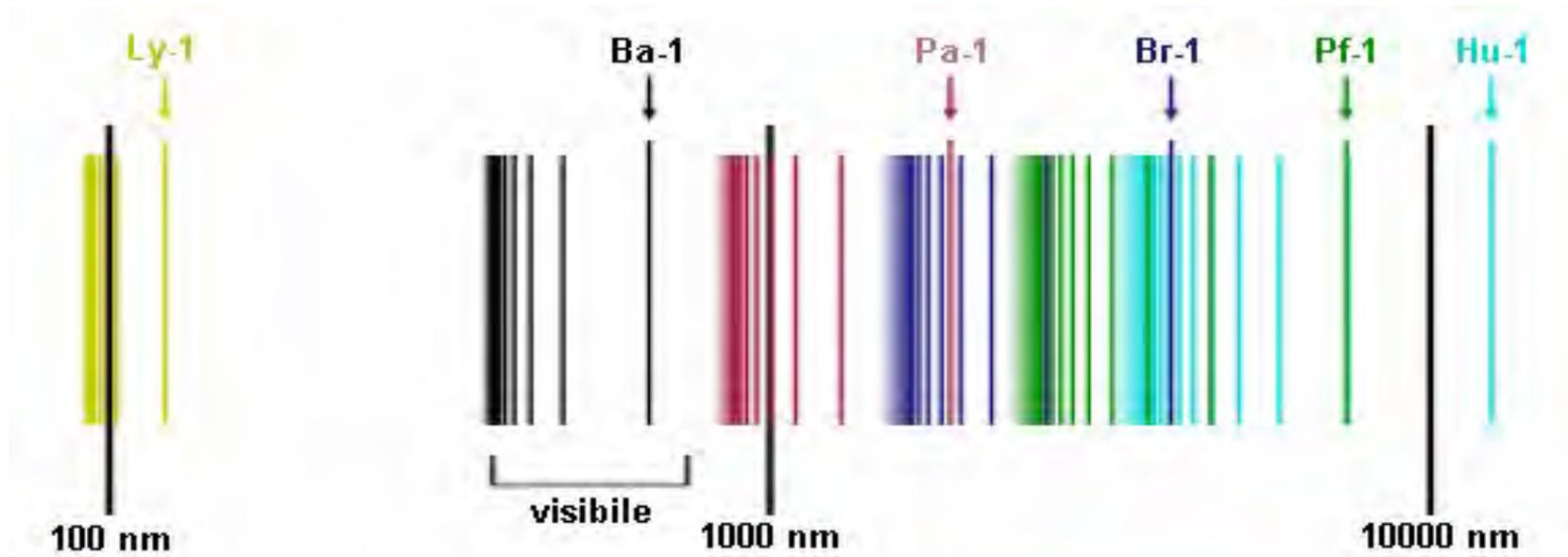
# Spettri di emissione dell'idrogeno



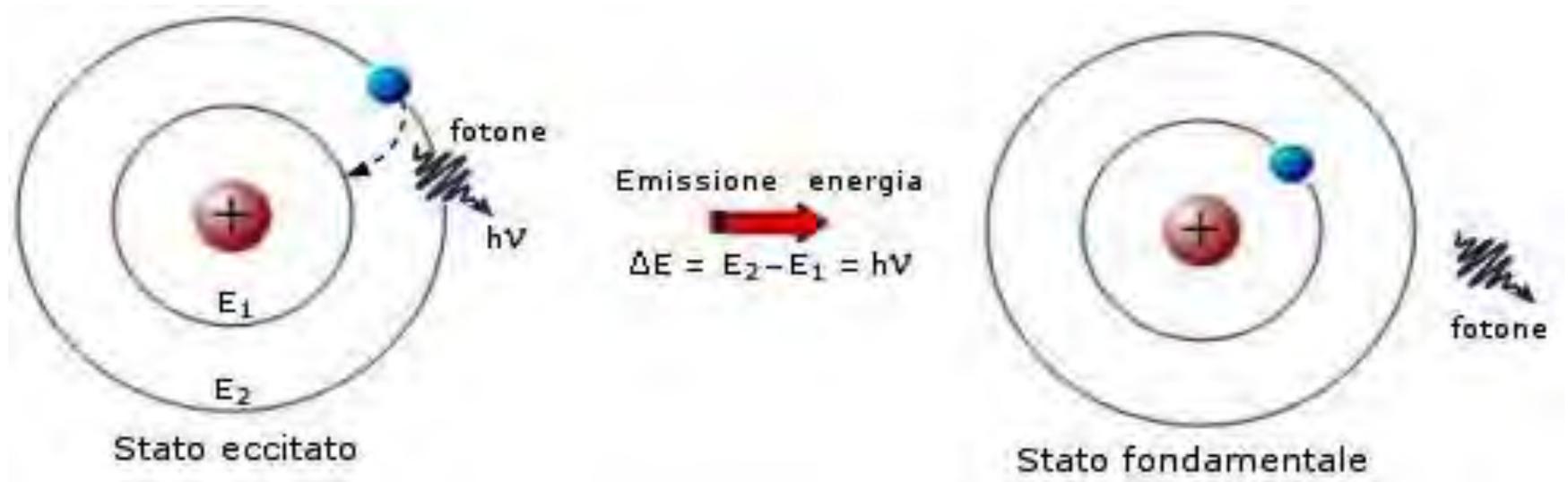
# Altre linee dell'idrogeno



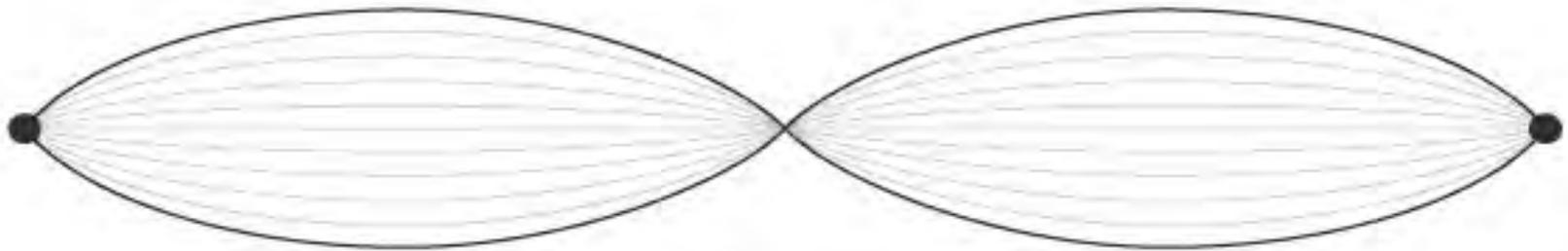
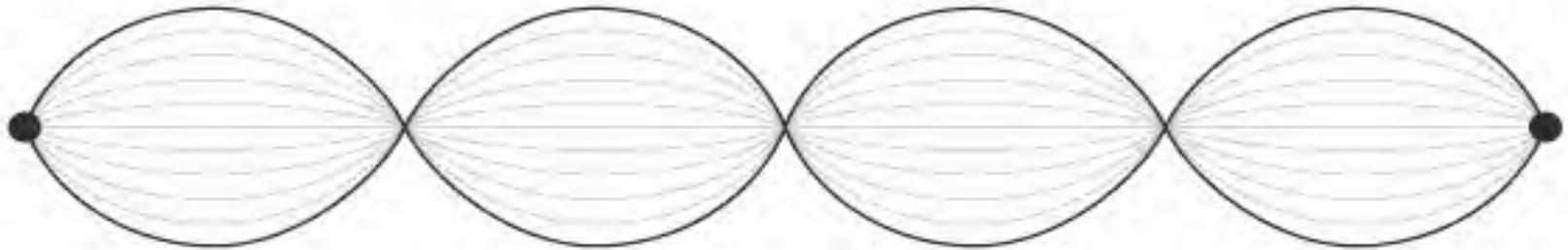
# Altre linee dell'idrogeno



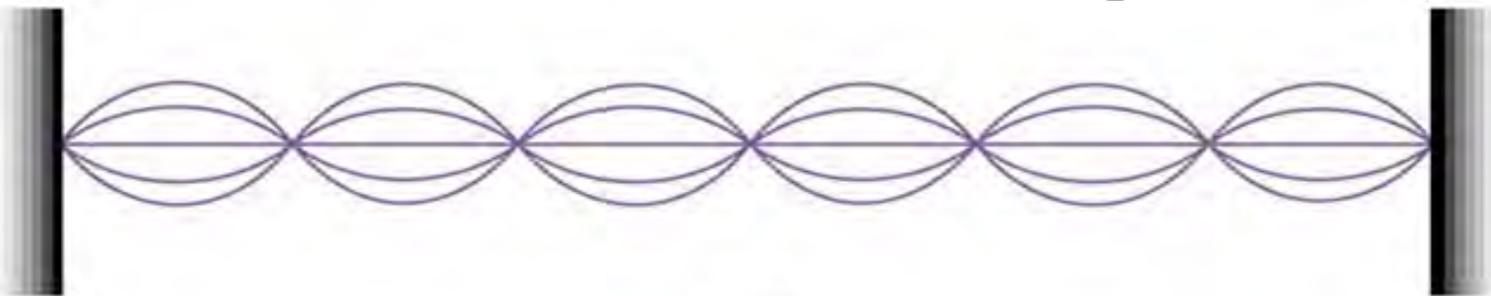
# Transizione elettronica ed emissione di luce



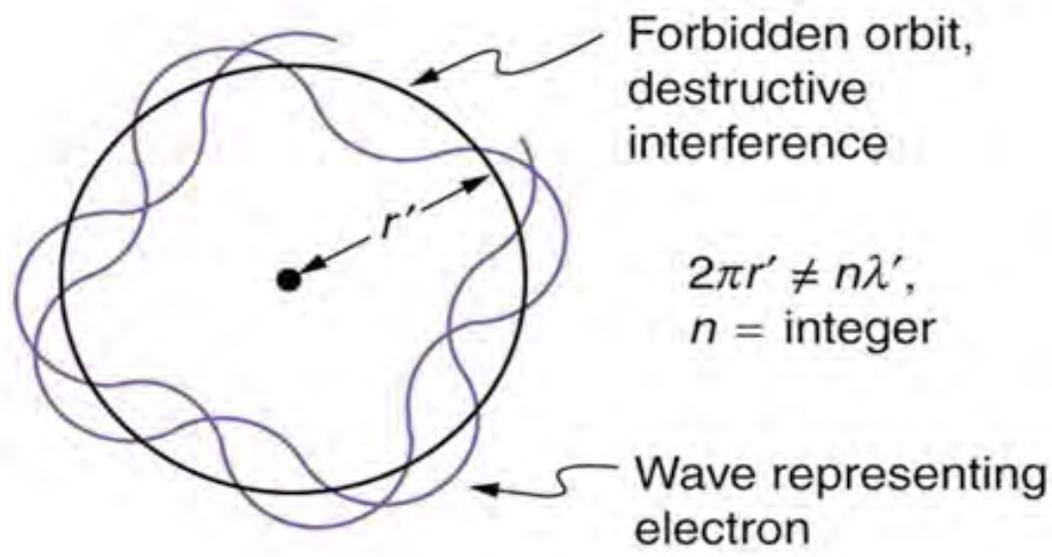
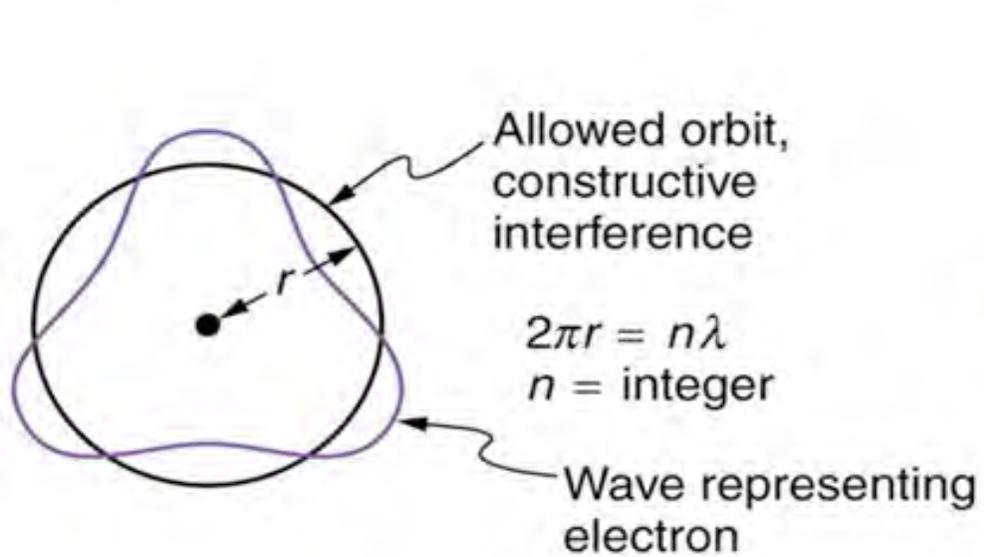
# Waves - vibrations



# De Broglie

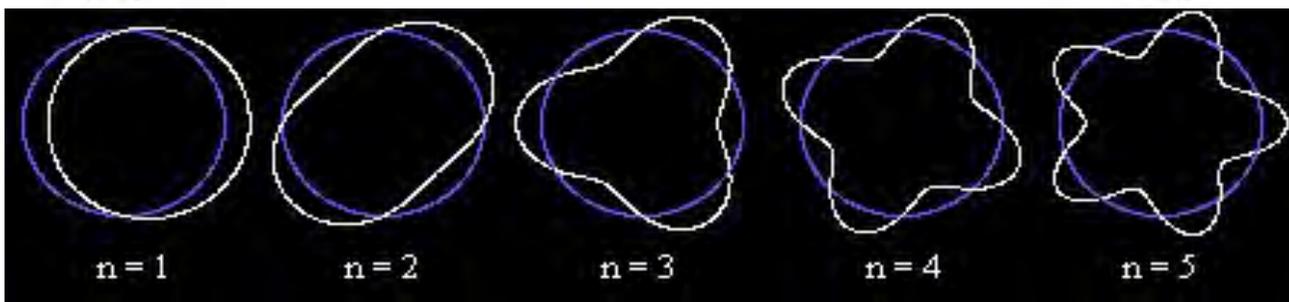


(a)

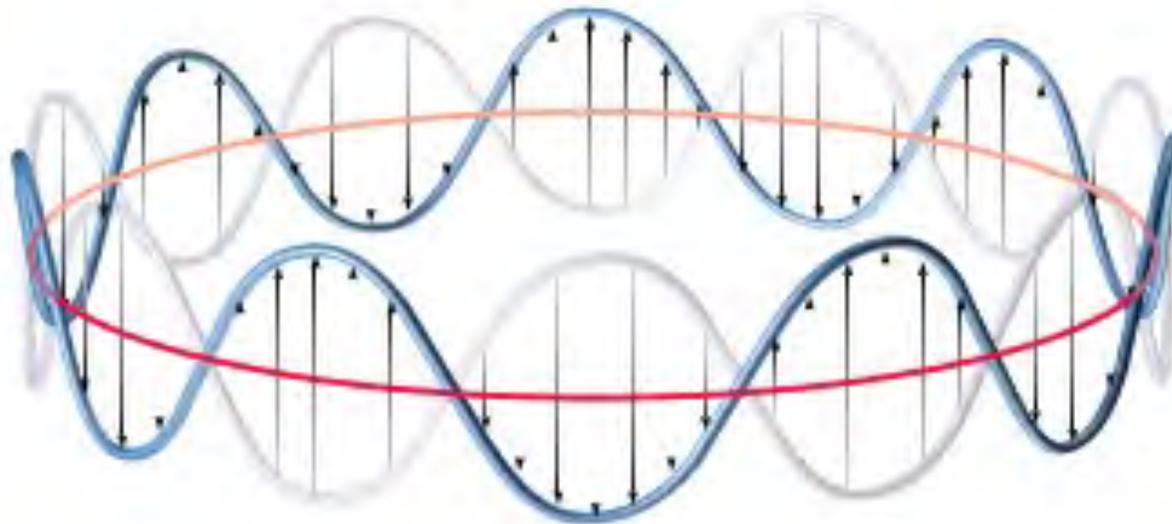


(b)

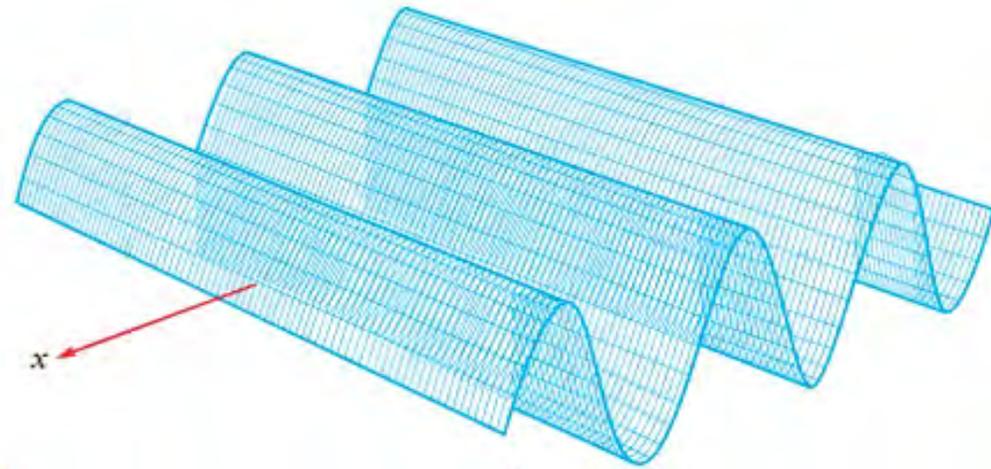
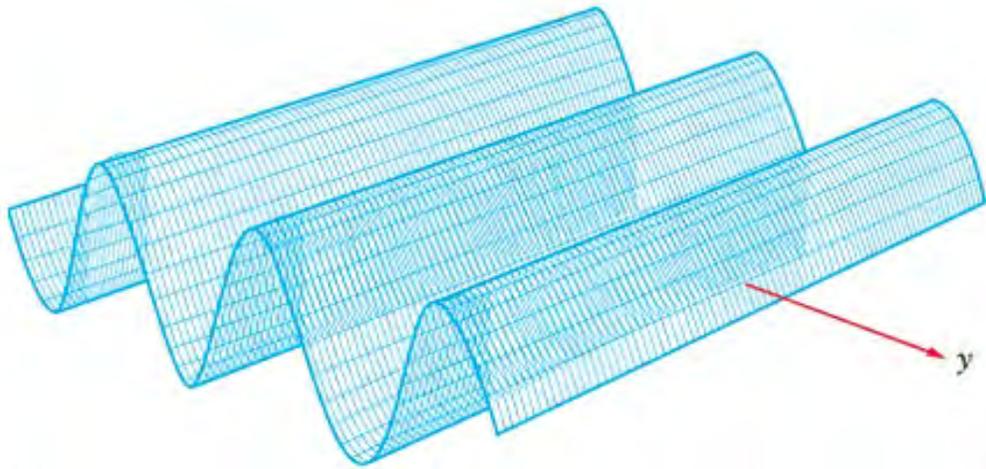
(c)



# Waves of an electron

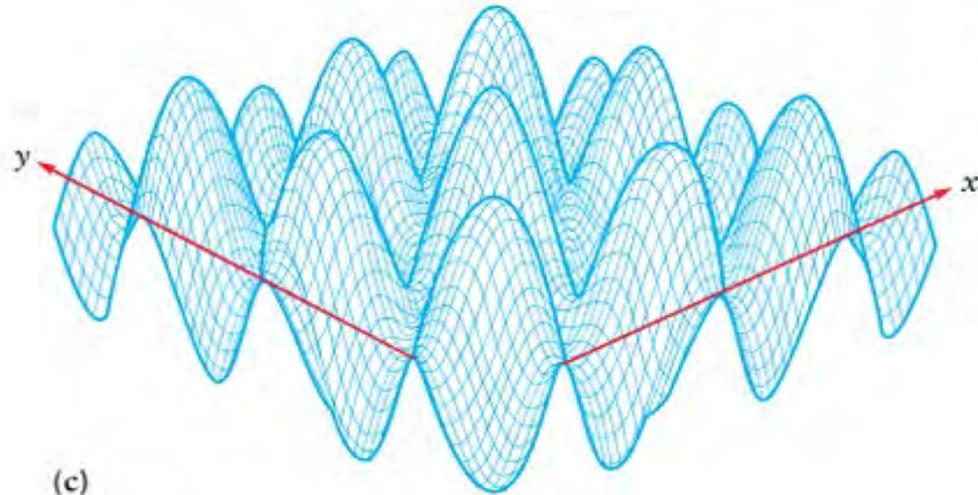


# Wave interference



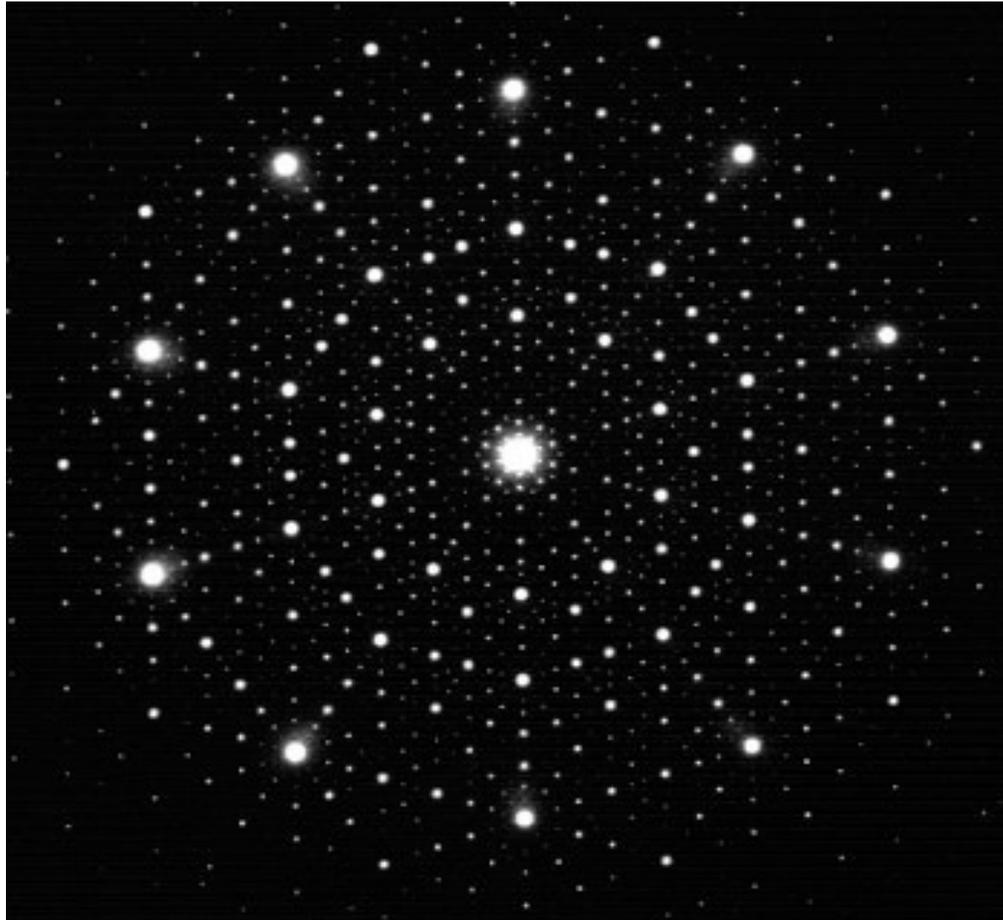
(a)

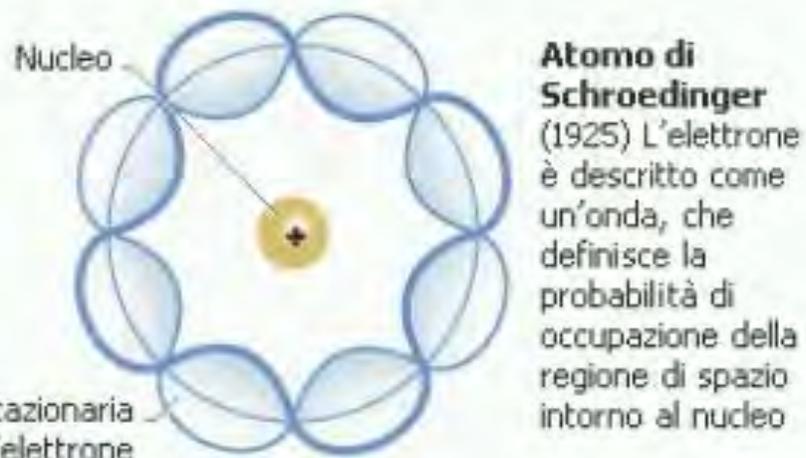
(b)

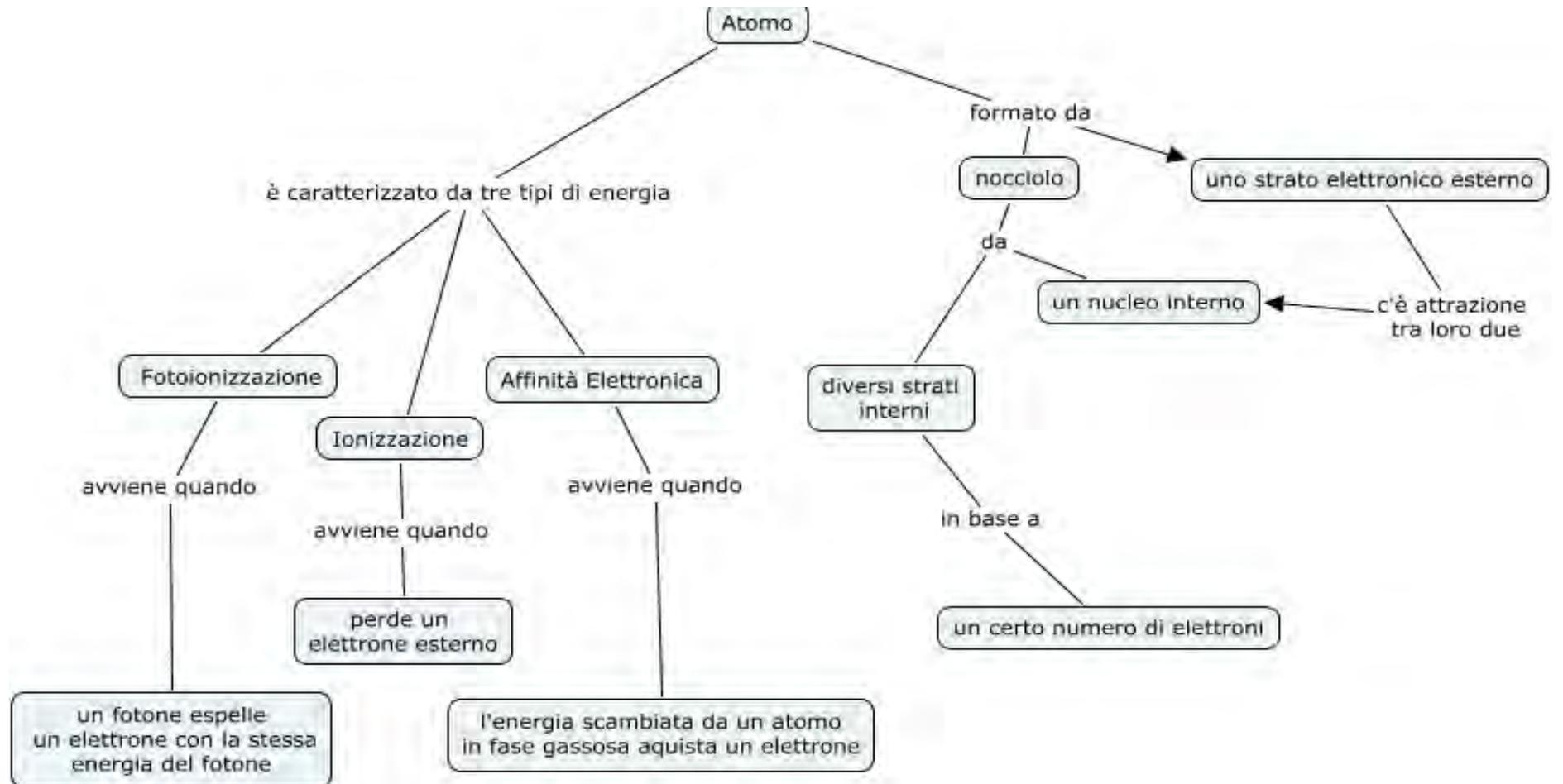


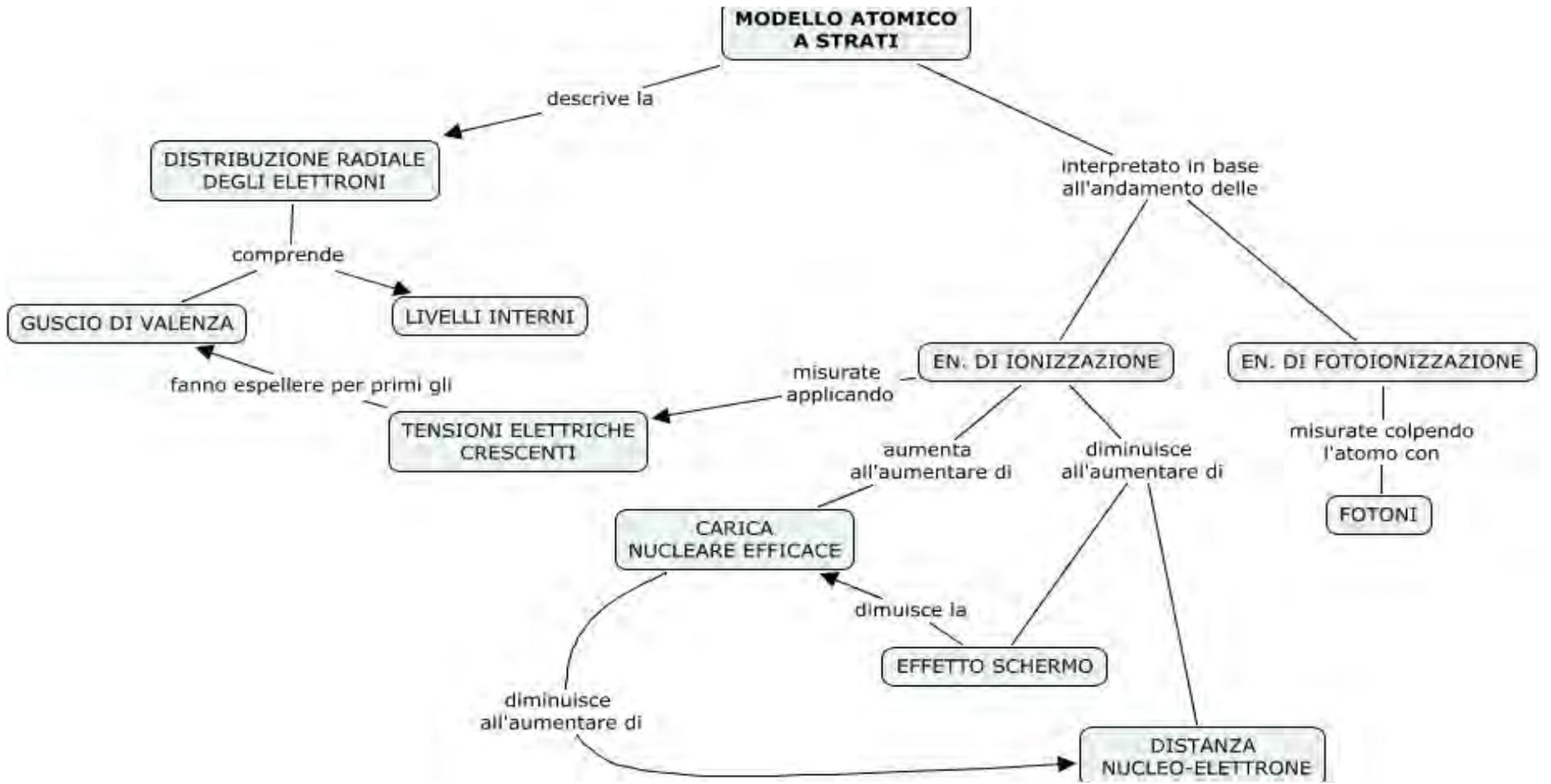
(c)

# Electron diffraction pattern









# Equazione di Schroedinger

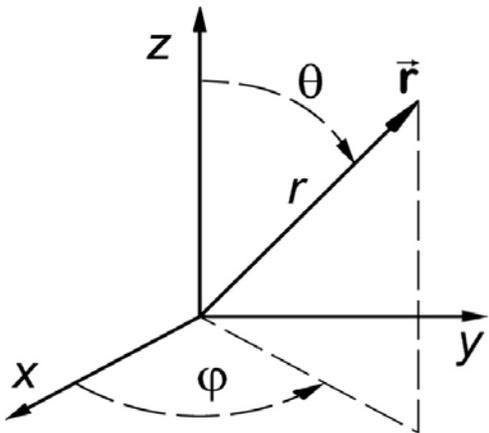
$$\left[ \frac{-\hbar^2}{2m} \frac{\partial^2}{\partial x^2} + V(x) \right] \psi(x) = E \psi(x)$$

Hamiltonian operator      Wave function      Energy

$$\Psi(\rho, \theta, \phi) = R_n(r) P_l(\theta) F_m(\phi)$$

$$\Psi_{n, l, m}$$

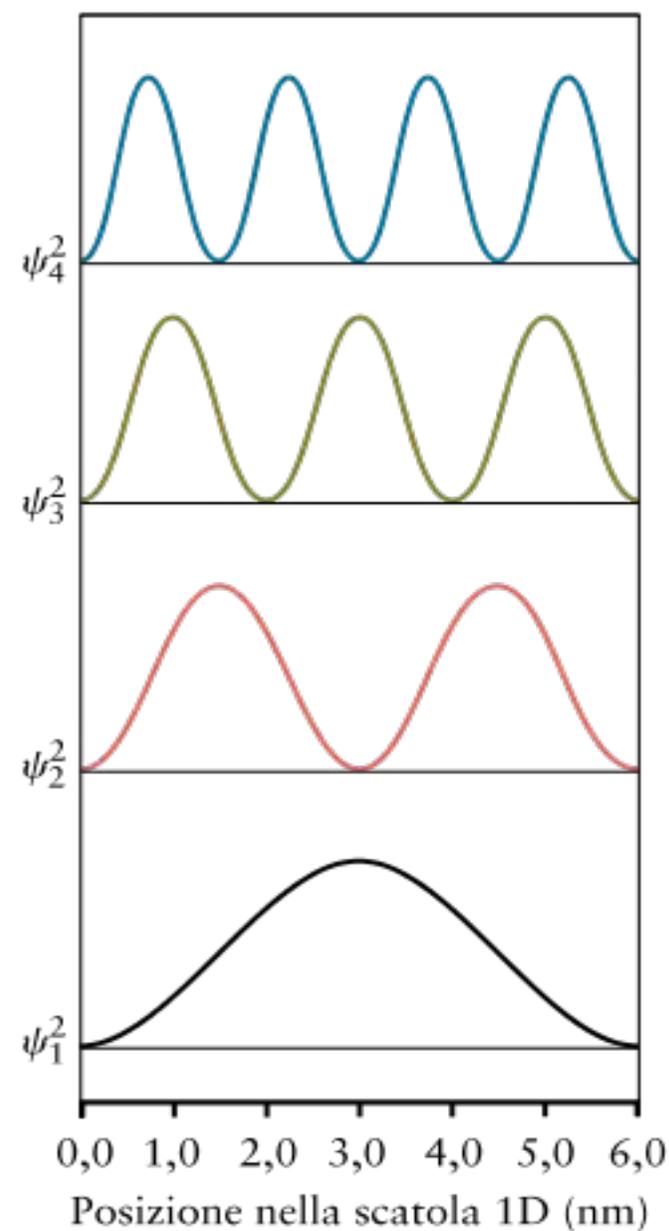
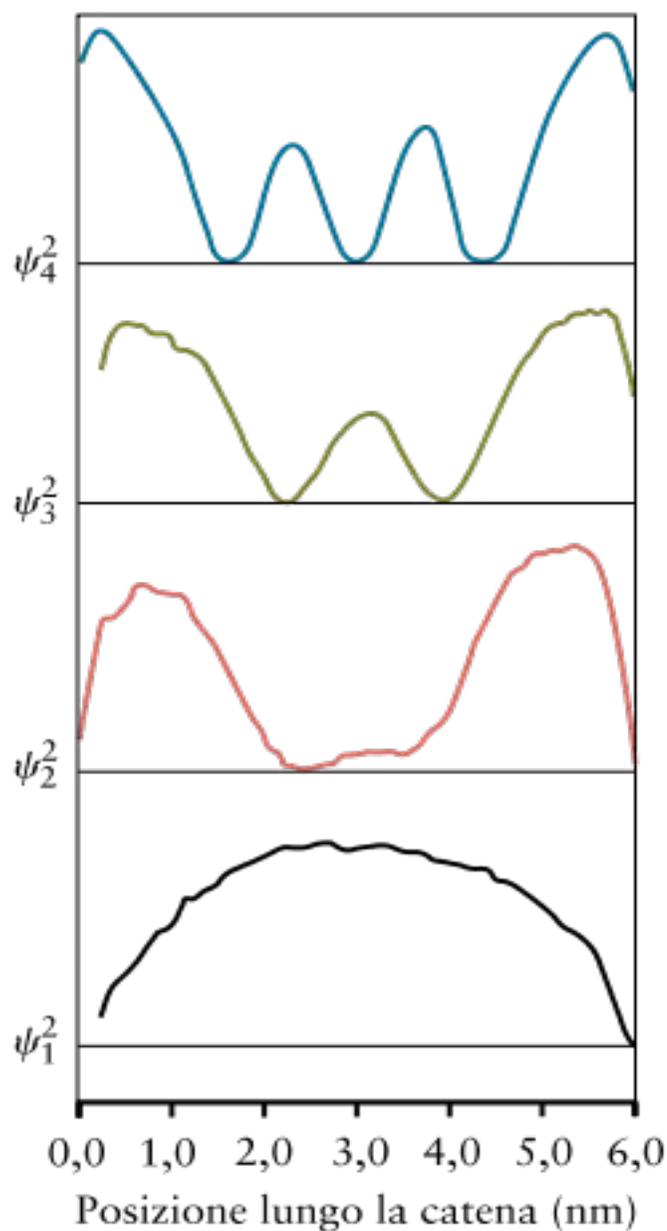
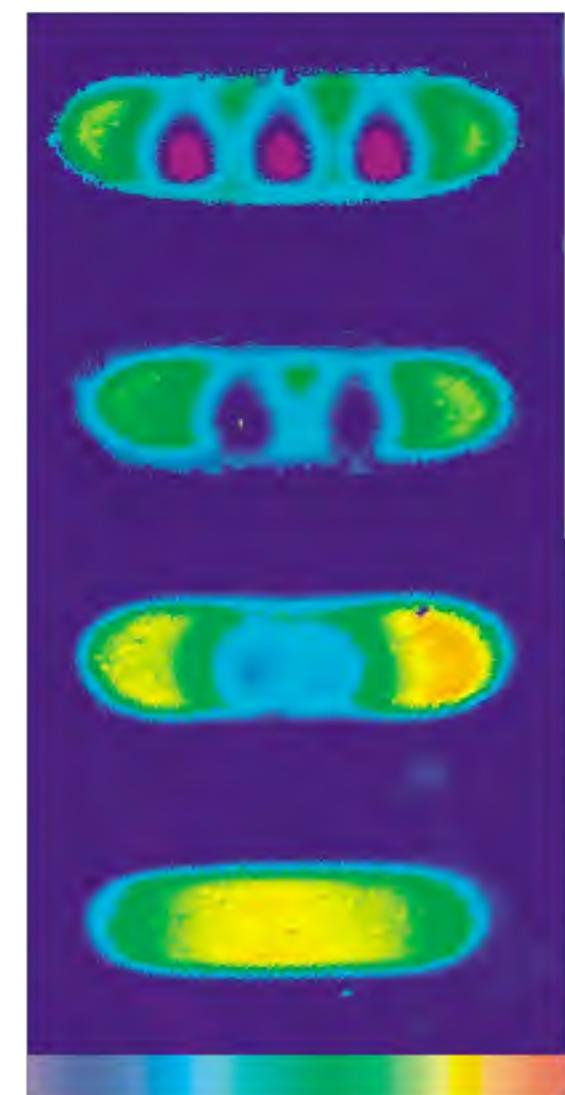
$n, l, m$  numeri quantici



Densità di probabilità 2D  
di una catena lineare Pd<sub>20</sub>

Densità di probabilità di una catena  
lineare Pd<sub>20</sub> per scansione lineare

Modello della particella  
nella scatola

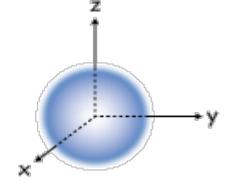
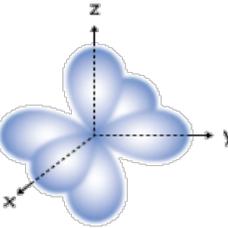
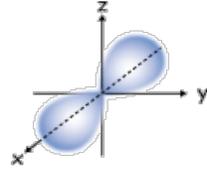
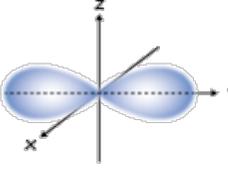
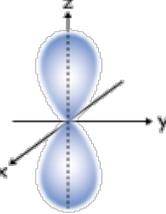
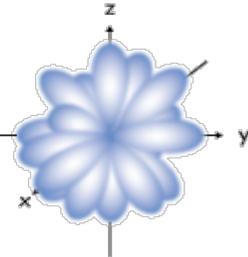
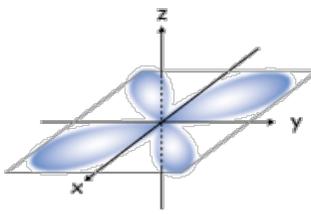
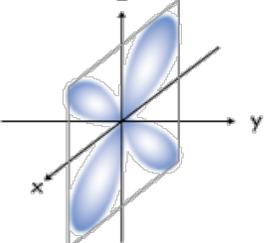
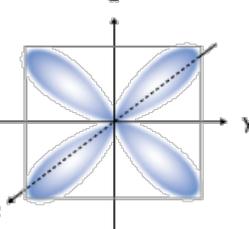
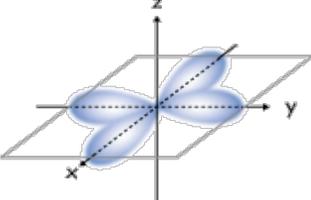
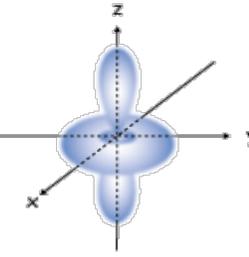


Bassa

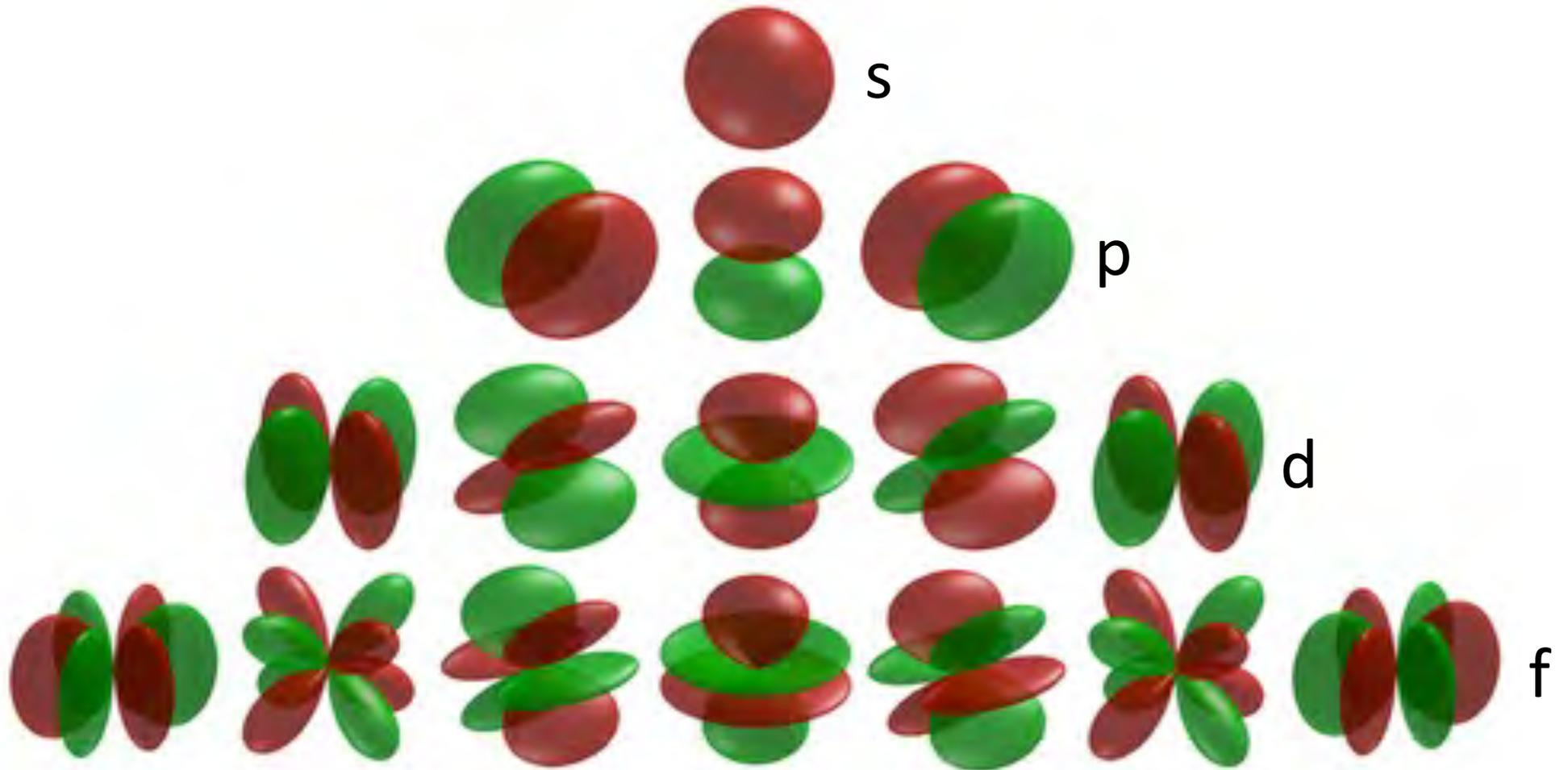
Alta

n	$\ell$	$m_\ell$	$F(\phi)$	$P(\theta)$	$R(r)$	<input checked="" type="checkbox"/> n=1,2 <input type="checkbox"/> n=3 <input checked="" type="checkbox"/> Separated <input type="checkbox"/> Combined
1	0	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{1}{\sqrt{2}}$	$\frac{2}{a_0^{3/2}} e^{-r/a_0}$	
2	0	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2\sqrt{2} a_0^{3/2}} \left[2 - \frac{r}{a_0}\right] e^{-r/2a_0}$	
2	1	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{\sqrt{6}}{2} \cos \theta$	$\frac{1}{2\sqrt{6} a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}$	
2	1	$\pm 1$	$\frac{1}{\sqrt{2\pi}} e^{\pm i\phi}$	$\frac{\sqrt{3}}{2} \sin \theta$	$\frac{1}{2\sqrt{6} a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}$	

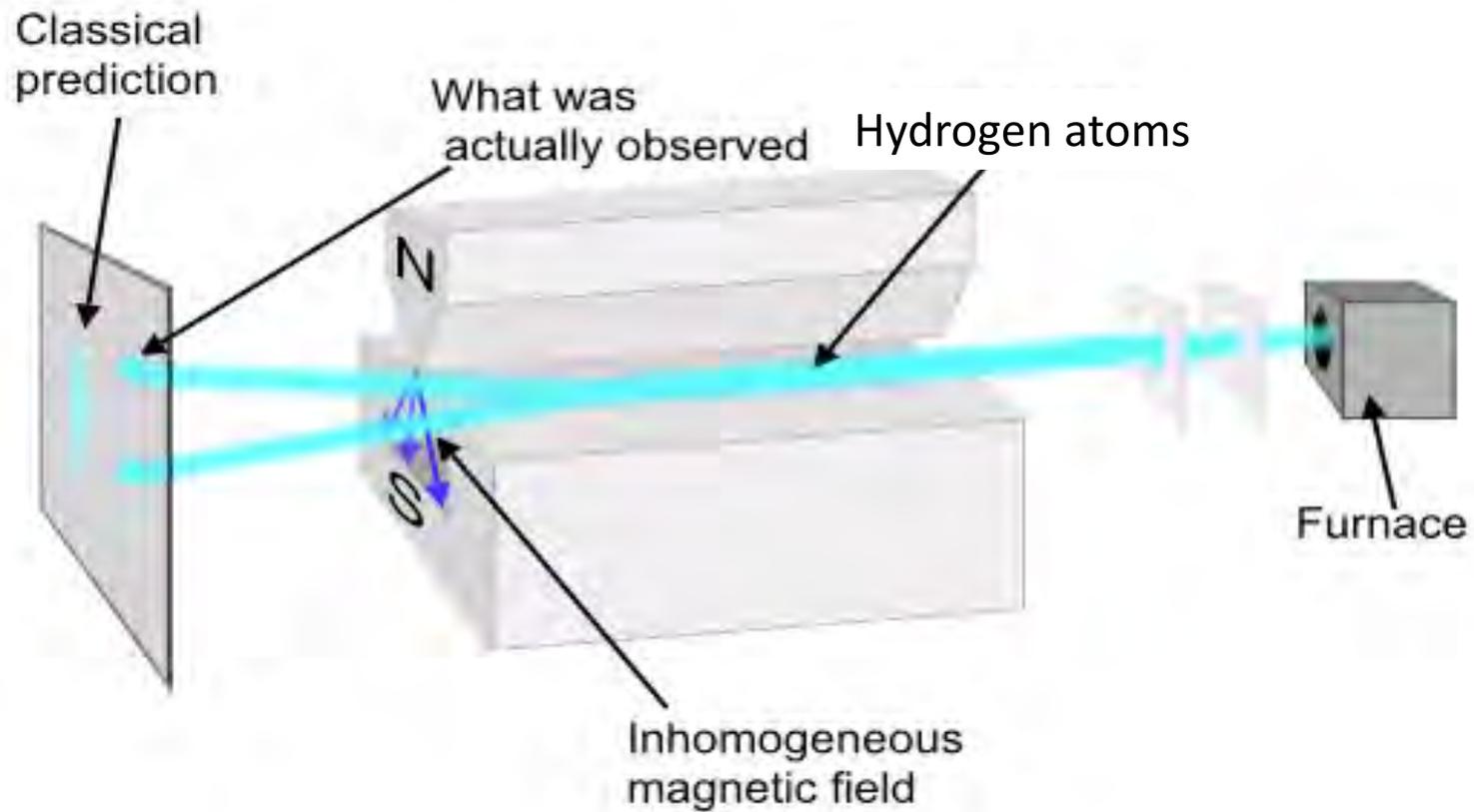
# Orbitali

$\ell = 0$ <b>s</b>						
$\ell = 1$ <b>p</b>		<p><b><math>p_x</math></b></p>  <p><math>m_\ell = -1</math></p>	<p><b><math>p_y</math></b></p>  <p><math>m_\ell = 0</math></p>	<p><b><math>p_z</math></b></p>  <p><math>m_\ell = +1</math></p>		
$\ell = 2$ <b>d</b>		<p><b><math>d_{xy}</math></b></p>  <p><math>m_\ell = -2</math></p>	<p><b><math>d_{xz}</math></b></p>  <p><math>m_\ell = -1</math></p>	<p><b><math>d_{yz}</math></b></p>  <p><math>m_\ell = 0</math></p>	<p><b><math>d_{x^2-y^2}</math></b></p>  <p><math>m_\ell = +1</math></p>	<p><b><math>d_{z^2}</math></b></p>  <p><math>m_\ell = +2</math></p>
$\ell = 3$ <b>f</b>	<p>7 sub-orbitals not pictured</p>					

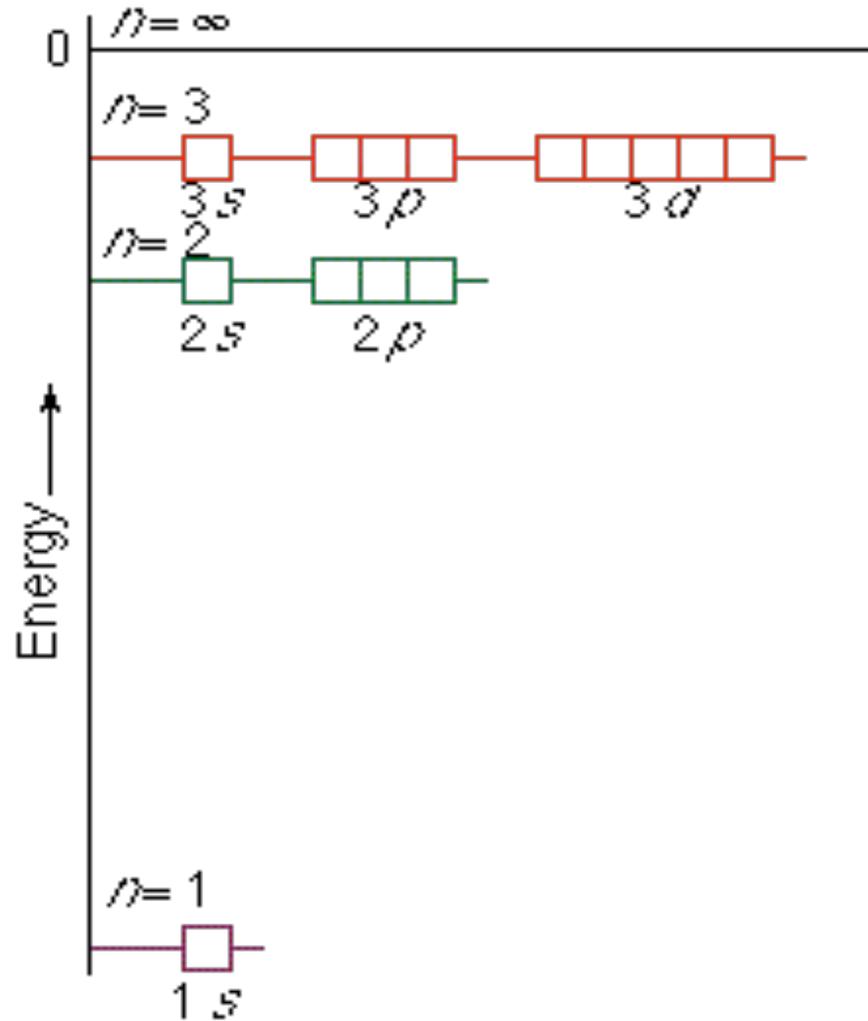
# Atomic orbitals



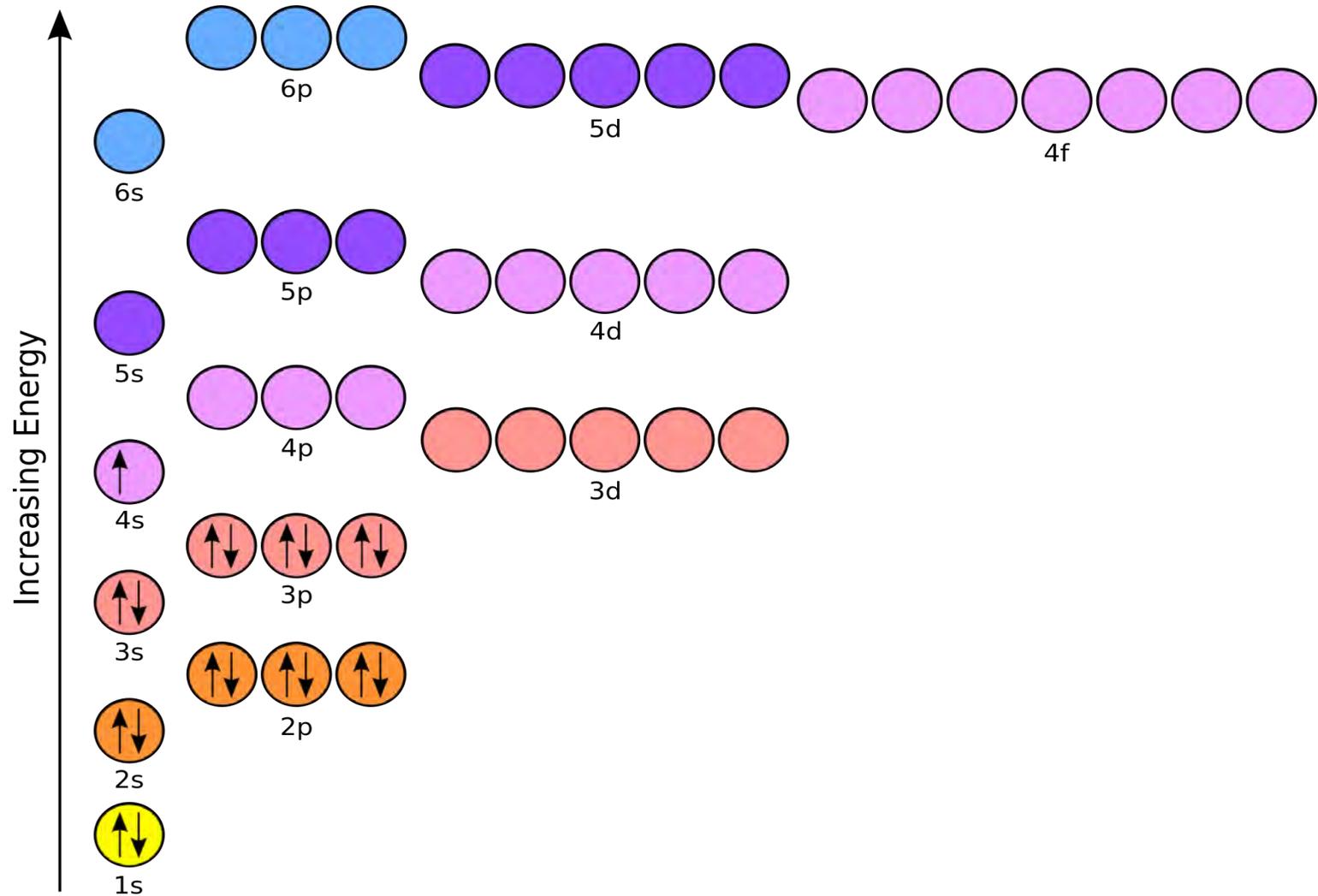
# Stern Gerlach experiment: spin of electrons



# Orbitals energy, hydrogen case



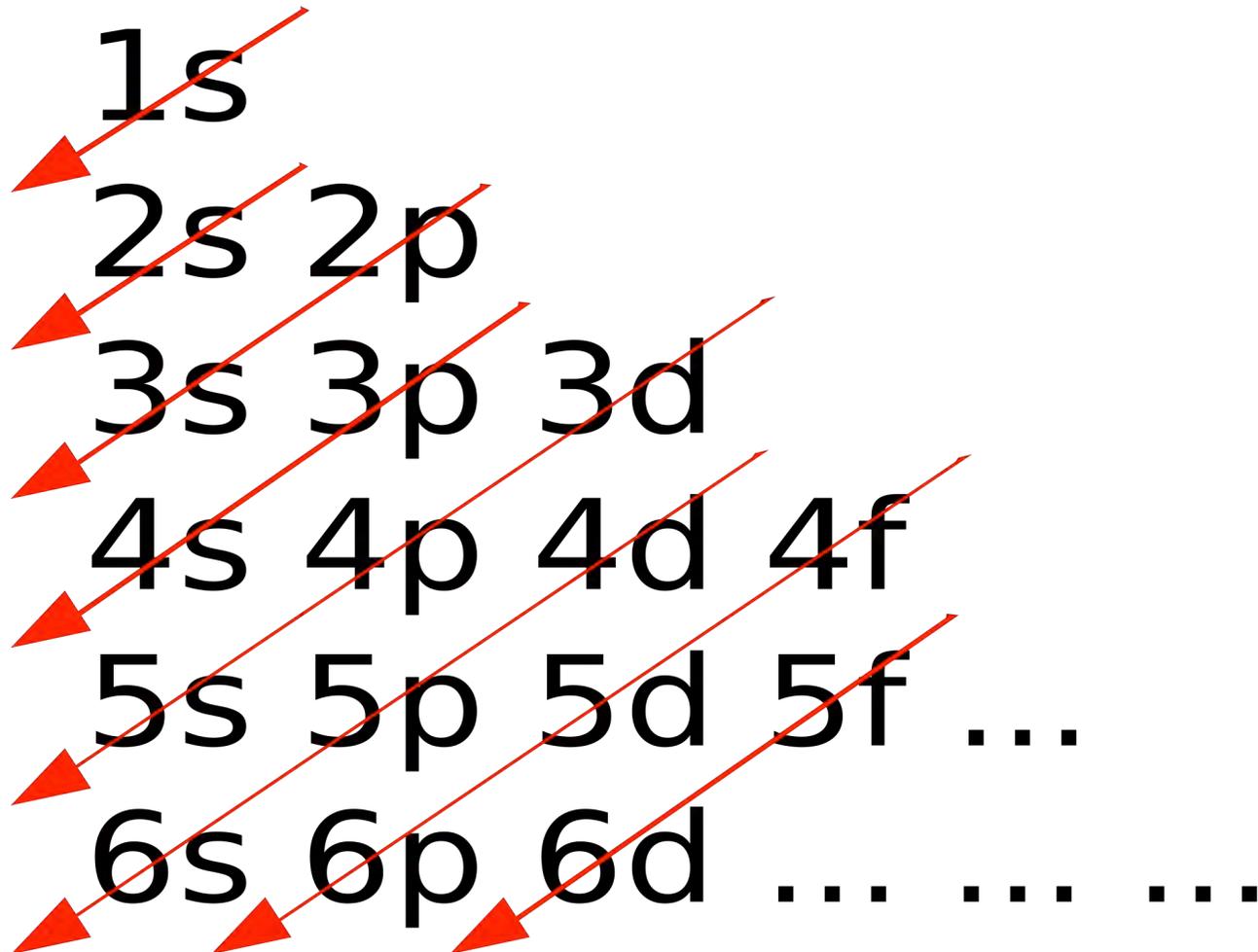
# Orbitals energy, polyelectronic case

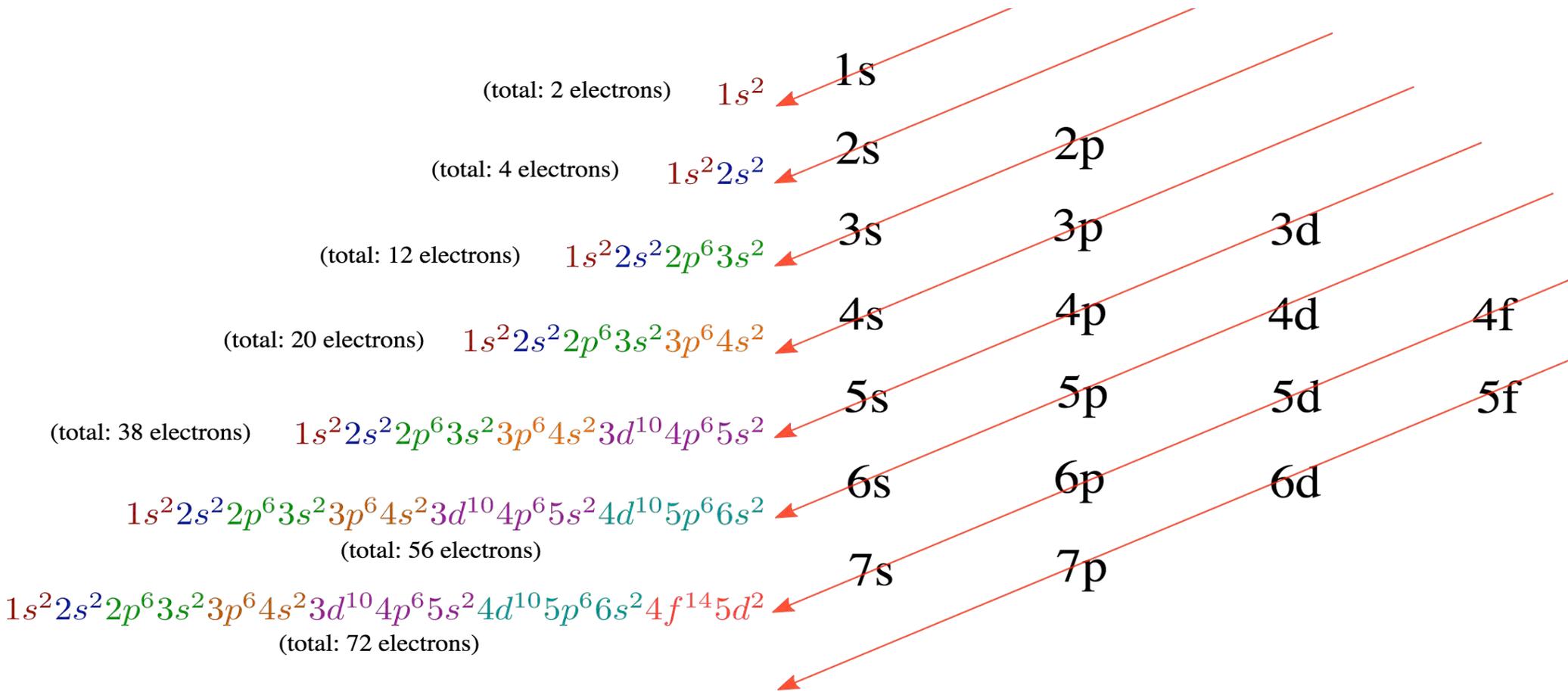


# Aufbau rule, 1920 (Bohr and Pauli)

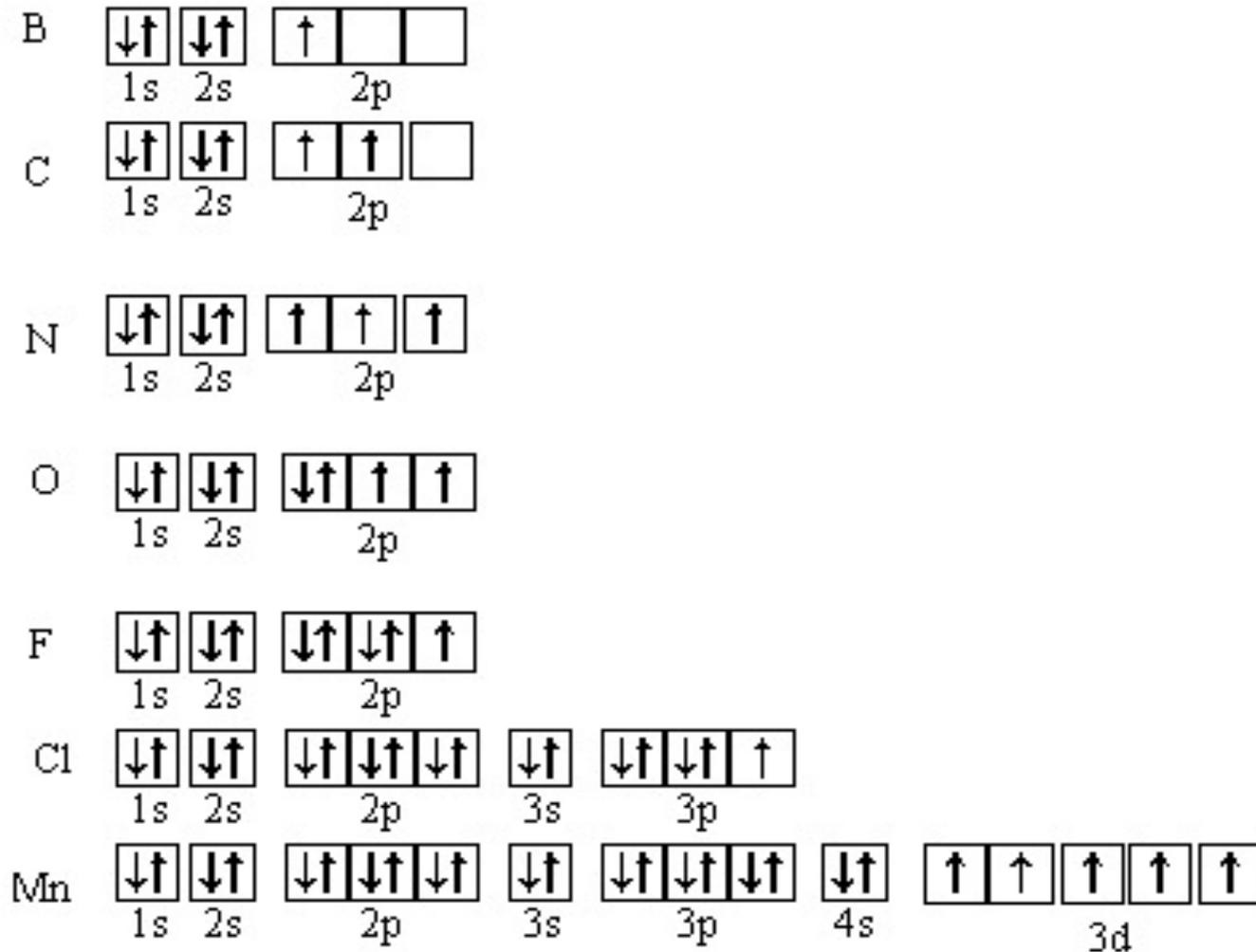
“ The orbitals of lower energy are filled in first with the electrons and only then the orbitals of high energy are filled.

”





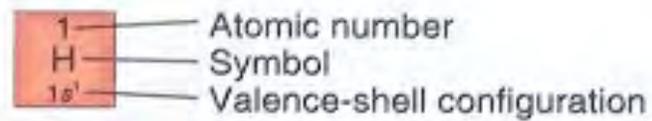
# Electronic configurations of some atoms (with Hund's rule)



Main-Group Elements  
s Subshell fills

Main-Group Elements  
p Subshell fills

	Transition Metals d Subshell fills																					
1	1 IA H 1s <sup>1</sup>															18 VIIIA He 1s <sup>2</sup>						
2	3 Li 2s <sup>1</sup>	4 Be 2s <sup>2</sup>											5 B 2s <sup>2</sup> 2p <sup>1</sup>	6 C 2s <sup>2</sup> 2p <sup>2</sup>	7 N 2s <sup>2</sup> 2p <sup>3</sup>	8 O 2s <sup>2</sup> 2p <sup>4</sup>	9 F 2s <sup>2</sup> 2p <sup>5</sup>	10 Ne 2s <sup>2</sup> 2p <sup>6</sup>				
3	11 Na 3s <sup>1</sup>	12 Mg 3s <sup>2</sup>	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII B			9 IB	10 IIB	13 Al 3s <sup>2</sup> 3p <sup>1</sup>	14 Si 3s <sup>2</sup> 3p <sup>2</sup>	15 P 3s <sup>2</sup> 3p <sup>3</sup>	16 S 3s <sup>2</sup> 3p <sup>4</sup>	17 Cl 3s <sup>2</sup> 3p <sup>5</sup>	18 Ar 3s <sup>2</sup> 3p <sup>6</sup>				
4	19 K 4s <sup>1</sup>	20 Ca 4s <sup>2</sup>	21 Sc 3d <sup>1</sup> 4s <sup>2</sup>	22 Ti 3d <sup>2</sup> 4s <sup>2</sup>	23 V 3d <sup>3</sup> 4s <sup>2</sup>	24 Cr 3d <sup>5</sup> 4s <sup>1</sup>	25 Mn 3d <sup>5</sup> 4s <sup>2</sup>	26 Fe 3d <sup>6</sup> 4s <sup>2</sup>	27 Co 3d <sup>7</sup> 4s <sup>2</sup>	28 Ni 3d <sup>8</sup> 4s <sup>2</sup>	29 Cu 3d <sup>10</sup> 4s <sup>1</sup>	30 Zn 3d <sup>10</sup> 4s <sup>2</sup>	31 Ga 4s <sup>2</sup> 4p <sup>1</sup>	32 Ge 4s <sup>2</sup> 4p <sup>2</sup>	33 As 4s <sup>2</sup> 4p <sup>3</sup>	34 Se 4s <sup>2</sup> 4p <sup>4</sup>	35 Br 4s <sup>2</sup> 4p <sup>5</sup>	36 Kr 4s <sup>2</sup> 4p <sup>6</sup>				
5	37 Rb 5s <sup>1</sup>	38 Sr 5s <sup>2</sup>	39 Y 4d <sup>1</sup> 5s <sup>2</sup>	40 Zr 4d <sup>2</sup> 5s <sup>2</sup>	41 Nb 4d <sup>4</sup> 5s <sup>1</sup>	42 Mo 4d <sup>5</sup> 5s <sup>1</sup>	43 Tc 4d <sup>5</sup> 5s <sup>2</sup>	44 Ru 4d <sup>7</sup> 5s <sup>1</sup>	45 Rh 4d <sup>8</sup> 5s <sup>1</sup>	46 Pd 4d <sup>10</sup>	47 Ag 4d <sup>10</sup> 5s <sup>1</sup>	48 Cd 4d <sup>10</sup> 5s <sup>2</sup>	49 In 5s <sup>2</sup> 5p <sup>1</sup>	50 Sn 5s <sup>2</sup> 5p <sup>2</sup>	51 Sb 5s <sup>2</sup> 5p <sup>3</sup>	52 Te 5s <sup>2</sup> 5p <sup>4</sup>	53 I 5s <sup>2</sup> 5p <sup>5</sup>	54 Xe 5s <sup>2</sup> 5p <sup>6</sup>				
6	55 Cs 6s <sup>1</sup>	56 Ba 6s <sup>2</sup>	57 La* 5d <sup>1</sup> 6s <sup>2</sup>	72 Hf 5d <sup>2</sup> 6s <sup>2</sup>	73 Ta 5d <sup>3</sup> 6s <sup>2</sup>	74 W 5d <sup>4</sup> 6s <sup>2</sup>	75 Re 5d <sup>5</sup> 6s <sup>2</sup>	76 Os 5d <sup>6</sup> 6s <sup>2</sup>	77 Ir 5d <sup>7</sup> 6s <sup>2</sup>	78 Pt 5d <sup>9</sup> 6s <sup>1</sup>	79 Au 5d <sup>10</sup> 6s <sup>1</sup>	80 Hg 5d <sup>10</sup> 6s <sup>2</sup>	81 Tl 6s <sup>2</sup> 6p <sup>1</sup>	82 Pb 6s <sup>2</sup> 6p <sup>2</sup>	83 Bi 6s <sup>2</sup> 6p <sup>3</sup>	84 Po 6s <sup>2</sup> 6p <sup>4</sup>	85 At 6s <sup>2</sup> 6p <sup>5</sup>	86 Rn 6s <sup>2</sup> 6p <sup>6</sup>				
7	87 Fr 7s <sup>1</sup>	88 Ra 7s <sup>2</sup>	89 Ac**	104 Db 6d <sup>1</sup> 7s <sup>2</sup>	105 Jl 6d <sup>2</sup> 7s <sup>2</sup>	106 Rf 6d <sup>4</sup> 7s <sup>2</sup>	107 Bh 6d <sup>6</sup> 7s <sup>2</sup>	108 Hn 6d <sup>8</sup> 7s <sup>2</sup>	109 Mt 6d <sup>9</sup> 7s <sup>2</sup>	Inner-Transition Metals f Subshell fills												



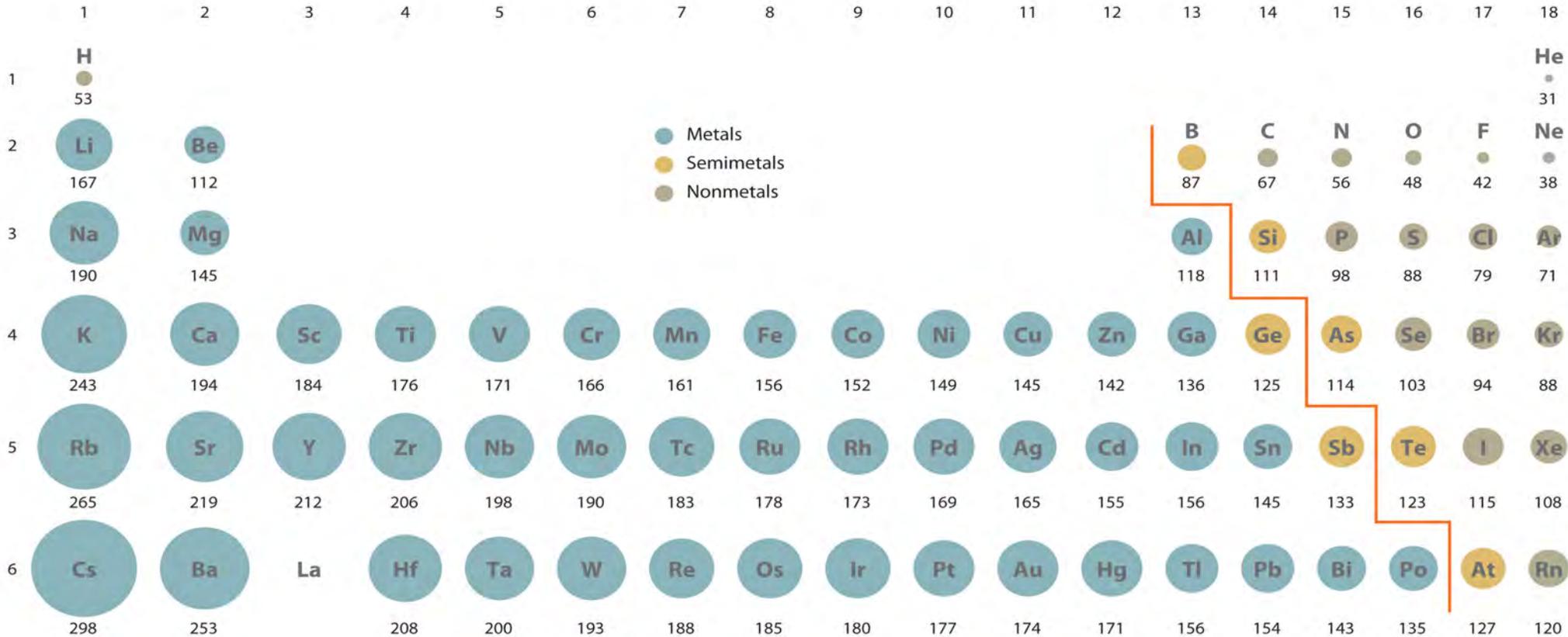
\*Lanthanides

\*\*Actinides

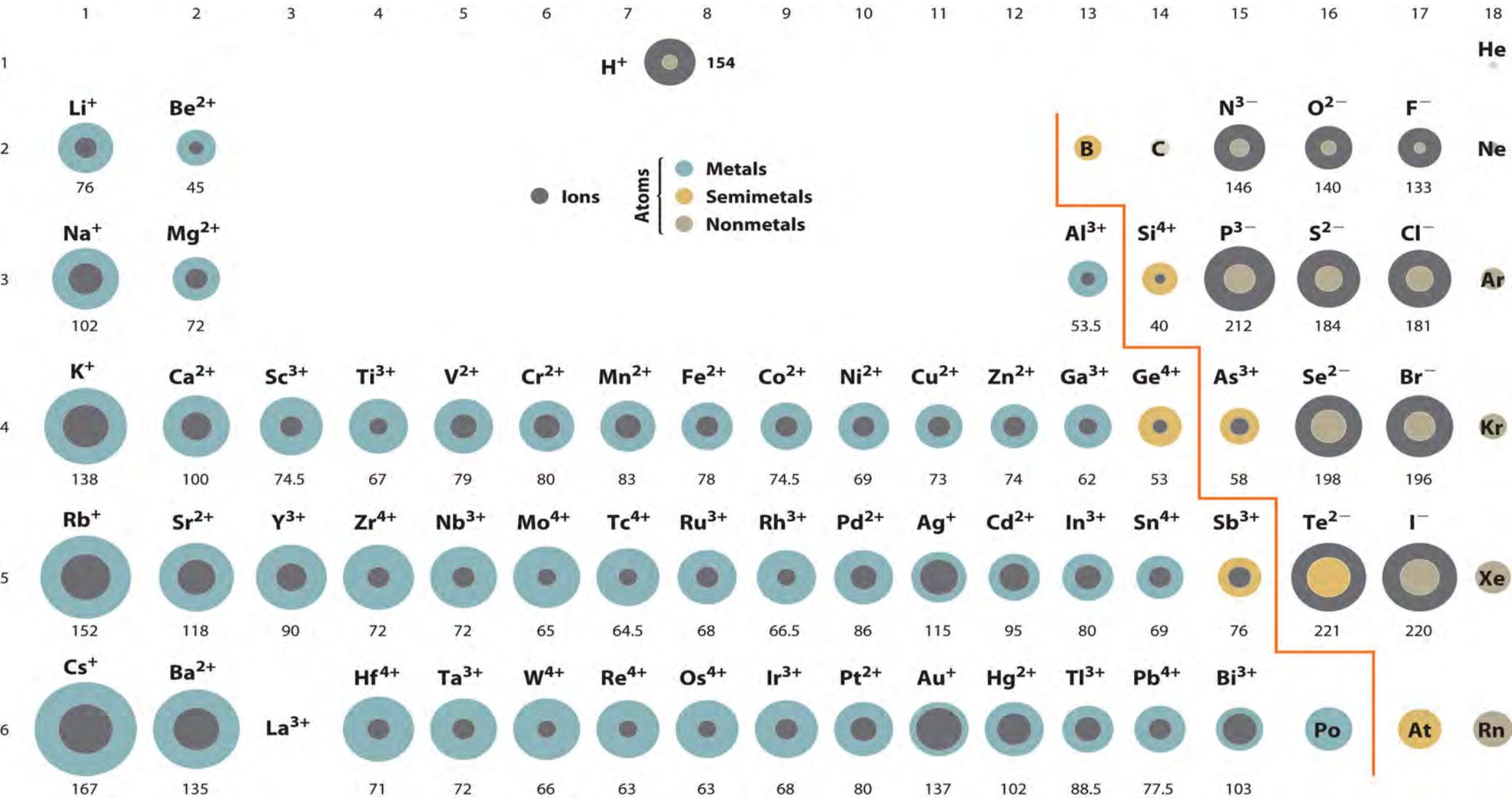
- Metal
- Metalloid
- Nonmetal

58 Ce 4f <sup>1</sup> 5d <sup>1</sup> 6s <sup>2</sup>	59 Pr 4f <sup>3</sup> 6s <sup>2</sup>	60 Nd 4f <sup>4</sup> 6s <sup>2</sup>	61 Pm 4f <sup>5</sup> 6s <sup>2</sup>	62 Sm 4f <sup>6</sup> 6s <sup>2</sup>	63 Eu 4f <sup>7</sup> 6s <sup>2</sup>	64 Gd 4f <sup>7</sup> 5d <sup>1</sup> 6s <sup>2</sup>	65 Tb 4f <sup>9</sup> 6s <sup>2</sup>	66 Dy 4f <sup>10</sup> 6s <sup>2</sup>	67 Ho 4f <sup>11</sup> 6s <sup>2</sup>	68 Er 4f <sup>12</sup> 6s <sup>2</sup>	69 Tm 4f <sup>13</sup> 6s <sup>2</sup>	70 Yb 4f <sup>14</sup> 6s <sup>2</sup>	71 Lu 4f <sup>14</sup> 5d <sup>1</sup> 6s <sup>2</sup>
90 Th 6d <sup>2</sup> 7s <sup>2</sup>	91 Pa 5f <sup>2</sup> 6d <sup>1</sup> 7s <sup>2</sup>	92 U 5f <sup>3</sup> 6d <sup>1</sup> 7s <sup>2</sup>	93 Np 5f <sup>4</sup> 6d <sup>1</sup> 7s <sup>2</sup>	94 Pu 5f <sup>6</sup> 7s <sup>2</sup>	95 Am 5f <sup>7</sup> 7s <sup>2</sup>	96 Cm 5f <sup>7</sup> 6d <sup>1</sup> 7s <sup>2</sup>	97 Bk 5f <sup>9</sup> 7s <sup>2</sup>	98 Cf 5f <sup>10</sup> 7s <sup>2</sup>	99 Es 5f <sup>11</sup> 7s <sup>2</sup>	100 Fm 5f <sup>12</sup> 7s <sup>2</sup>	101 Md 5f <sup>13</sup> 7s <sup>2</sup>	102 No 5f <sup>14</sup> 7s <sup>2</sup>	103 Lr 5f <sup>14</sup> 6d <sup>1</sup> 7s <sup>2</sup>

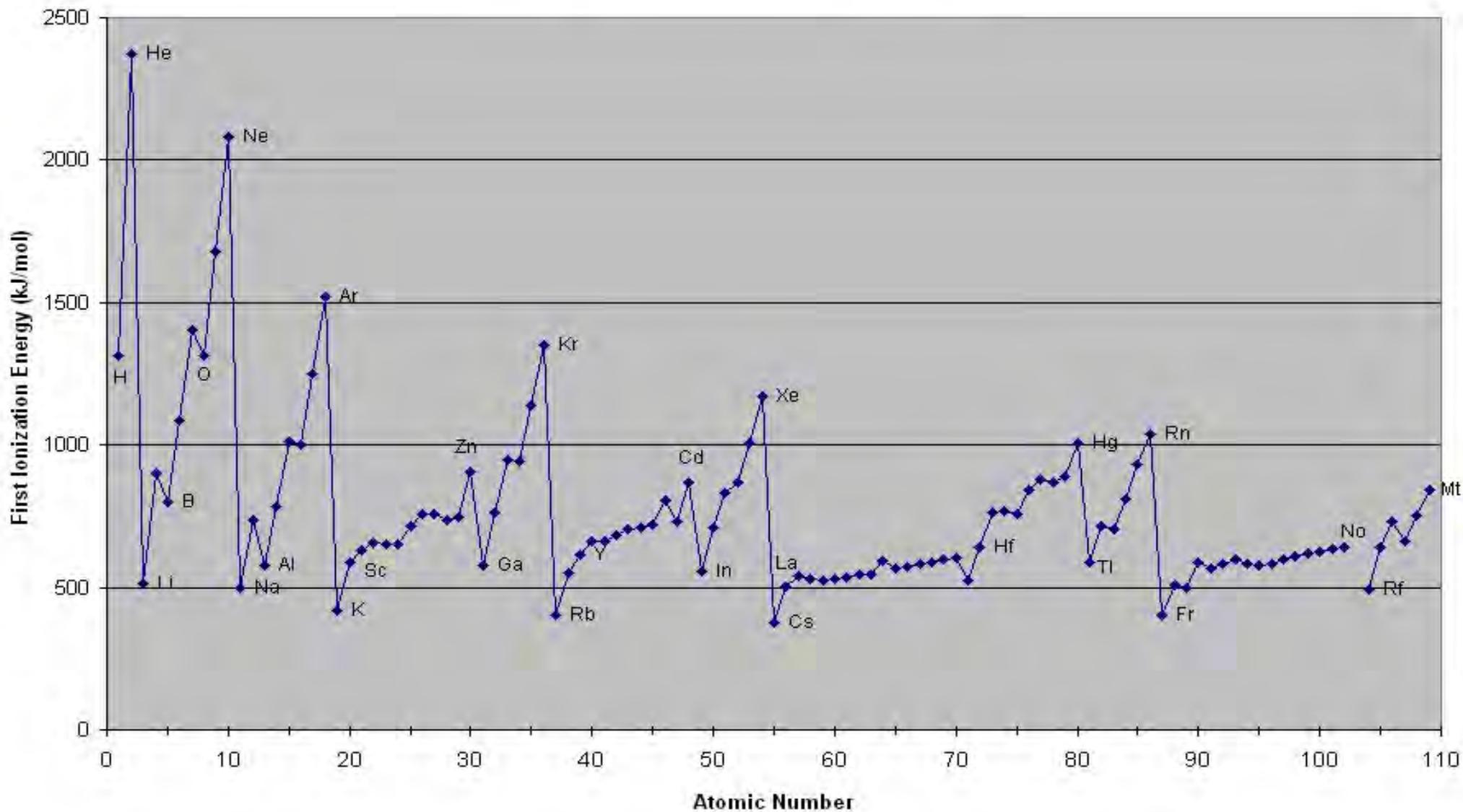
# RAGGI ATOMICI pm



# RAGGI IONICI pm



## Periodic Trends in First Ionization Energy



# Energia di ionizzazione

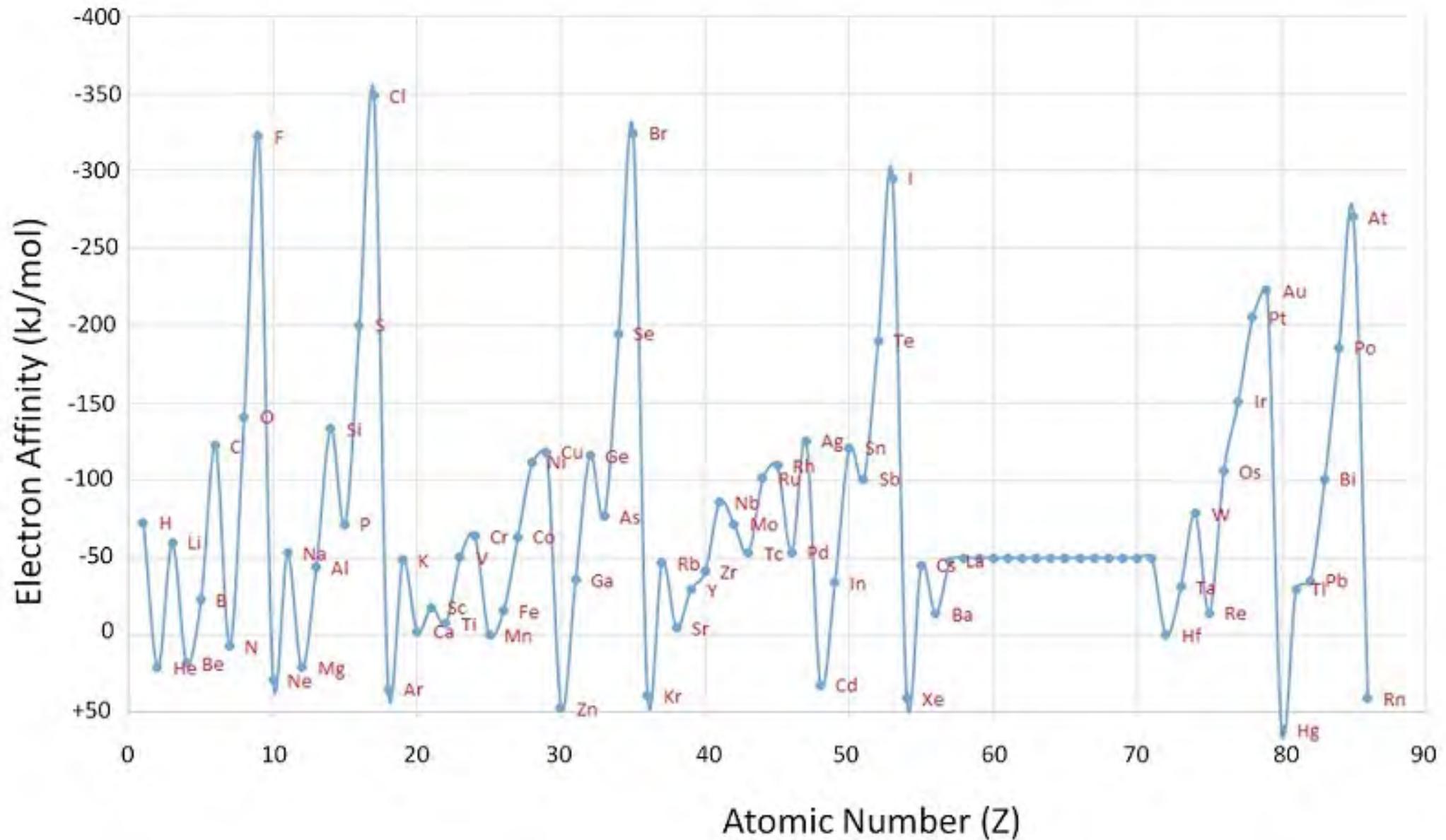


## Electron Affinity Values for Selected Elements (kJ/mol)

Period	Group 1												Group 13	Group 14	Group 15	Group 16	Group 17	Group 18	
1	H -72																		He +20*
2	Li -60	Be +240*											B -23	C -123	N 0	O -141	F -322	Ne -30	
3	Na -53	Mg +230*											Al -44	Si -120	P -74	S -20	Cl -348	Ar +35*	
4	K -48	Ca +150*	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga -40*	Ge -115	As -7	Se -195	Br -324	Kr +40*	
5	Rb -46	Sr +160*	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In -40*	Sn -121	Sb -101	Te -190	I -295	Xe +40*	
6	Cs -45	Ba +50*	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl -50	Pb -101	Bi -101	Po -170	At -270*	Rn +40*	
7	Fr	Ra																	

\* Calculated value

# Electron affinity

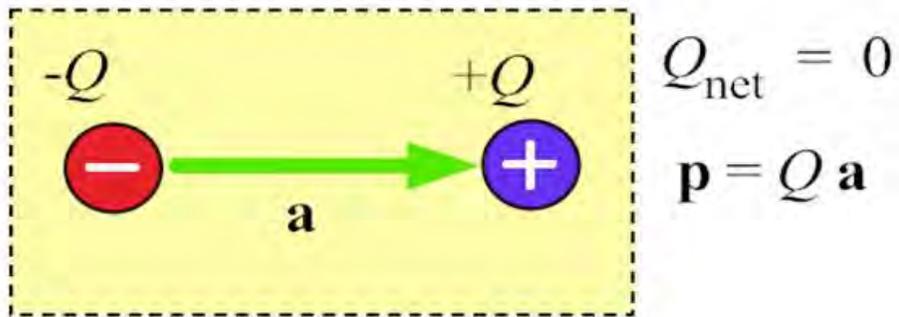


## Periodic table of electronegativity using the Pauling scale

→ Atomic radius decreases → Ionization energy increases → Electronegativity increases →

Group →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
↓ Period																			
1	H 2.20																		He
2	Li 0.98	Be 1.57											B 2.04	C 2.55	N 3.04	O 3.44	F 3.98		Ne
3	Na 0.93	Mg 1.31											Al 1.61	Si 1.90	P 2.19	S 2.58	Cl 3.16		Ar
4	K 0.82	Ca 1.00	Sc 1.36	Ti 1.54	V 1.63	Cr 1.66	Mn 1.55	Fe 1.83	Co 1.88	Ni 1.91	Cu 1.90	Zn 1.65	Ga 1.81	Ge 2.01	As 2.18	Se 2.55	Br 2.96		Kr 3.00
5	Rb 0.82	Sr 0.95	Y 1.22	Zr 1.33	Nb 1.6	Mo 2.16	Tc 1.9	Ru 2.2	Rh 2.28	Pd 2.20	Ag 1.93	Cd 1.69	In 1.78	Sn 1.96	Sb 2.05	Te 2.1	I 2.66		Xe 2.60
6	Cs 0.79	Ba 0.89	*	Hf 1.3	Ta 1.5	W 2.36	Re 1.9	Os 2.2	Ir 2.20	Pt 2.28	Au 2.54	Hg 2.00	Tl 1.62	Pb 1.87	Bi 2.02	Po 2.0	At 2.2		Rn 2.2
7	Fr 0.7	Ra 0.9	**	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus		Uuo
* Lanthanoids	La 1.1	Ce 1.12	Pr 1.13	Nd 1.14	Pm 1.13	Sm 1.17	Eu 1.2	Gd 1.2	Tb 1.1	Dy 1.22	Ho 1.23	Er 1.24	Tm 1.25	Yb 1.1	Lu 1.27				
** Actinoids	Ac 1.1	Th 1.3	Pa 1.5	U 1.38	Np 1.36	Pu 1.28	Am 1.13	Cm 1.28	Bk 1.3	Cf 1.3	Es 1.3	Fm 1.3	Md 1.3	No 1.3	Lr 1.3				

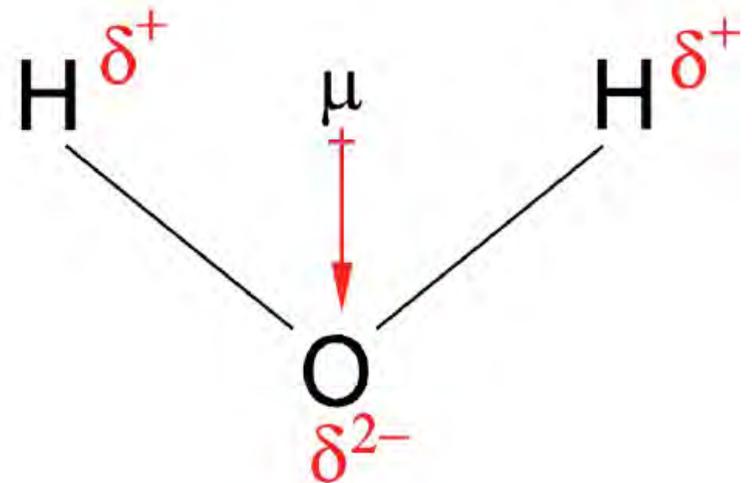
## Definition of Dipole Moment



The definition of electric dipole moment.

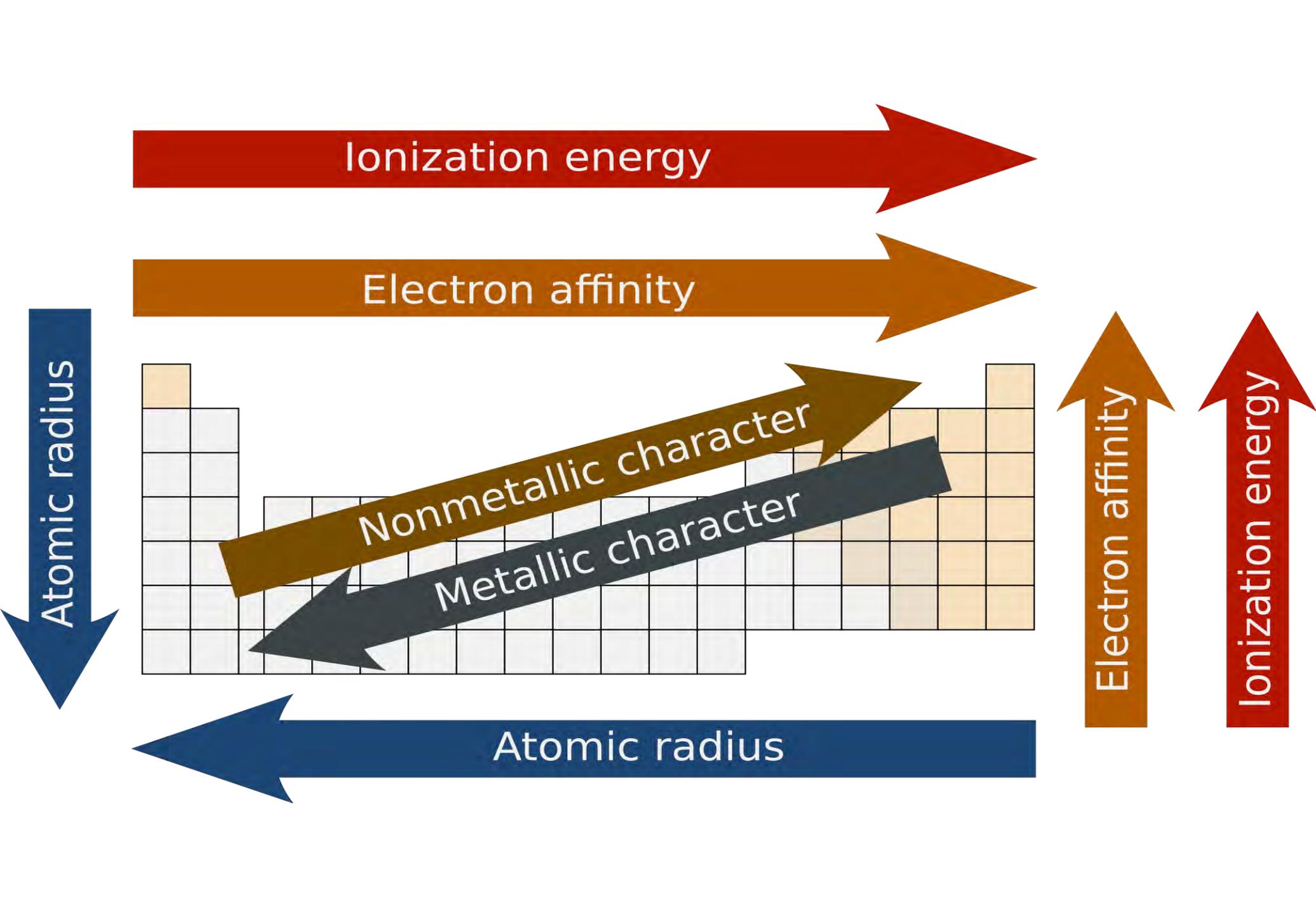
$$\mathbf{p} = Q\mathbf{a}$$

$\mathbf{p}$  = electric dipole moment,  $Q$  = charge,  $\mathbf{a}$  = vector from the negative to the positive charge



**TABELLA 3.7****Momenti di dipolo di molecole biatomiche**

<b>Molecola</b>	<b>Lunghezza di legame (Å)</b>	<b>Momento di dipolo (D)</b>	<b>% di carattere ionico (100 <math>\delta</math>)</b>
H <sub>2</sub>	0,751	0	0
CO	1,131	0,112	2
NO	1,154	0,159	3
HI	1,620	0,448	6
ClF	1,632	0,888	11
HBr	1,424	0,828	12
HCl	1,284	1,109	18
HF	0,926	1,827	41
CsF	2,347	7,884	70
LiCl	2,027	7,129	73
LiH	1,604	5,882	76
KBr	2,824	10,628	78
NaCl	2,365	9,001	79
KCl	2,671	10,269	82
KF	2,176	8,593	82
LiF	1,570	6,327	84
NaF	1,931	8,156	88



Atomic radius

Ionization energy

Electron affinity

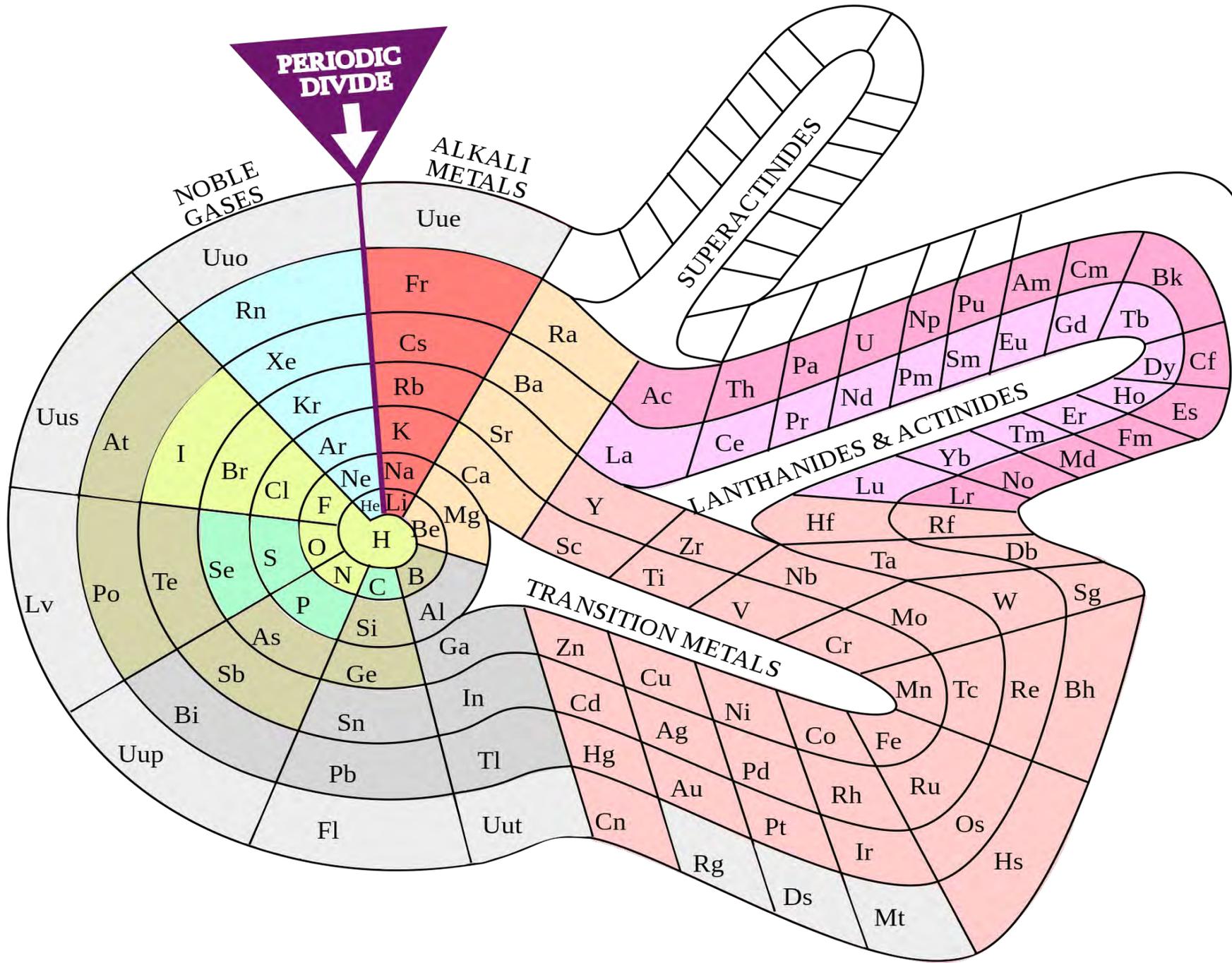
Nonmetallic character

Metallic character

Atomic radius

Electron affinity

Ionization energy



**PERIODIC DIVIDE**

**NOBLE GASES**

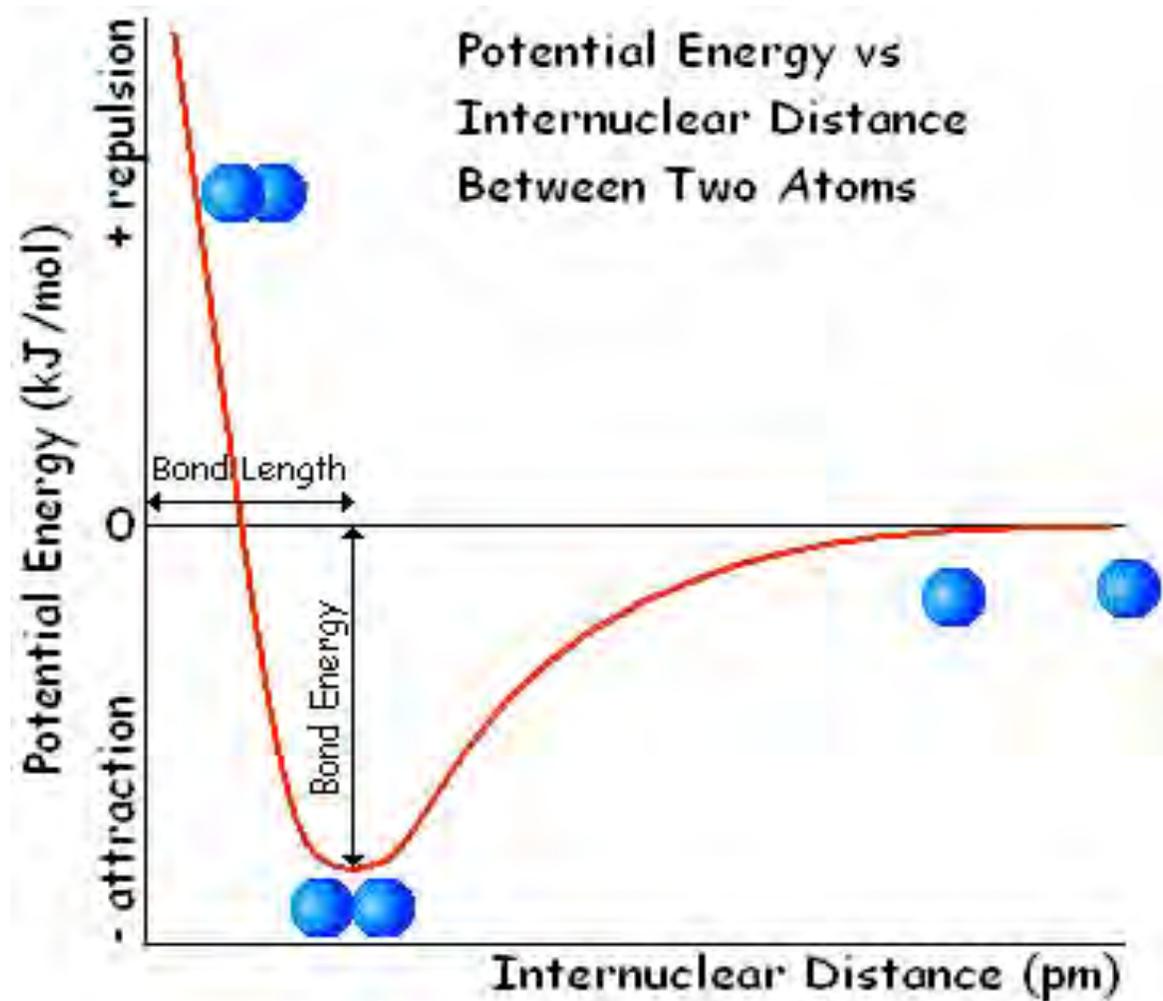
**ALKALI METALS**

**SUPERACTINIDES**

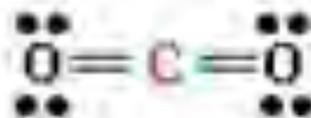
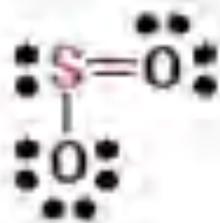
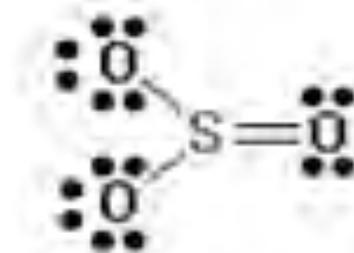
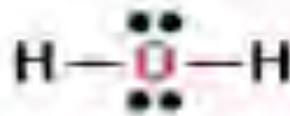
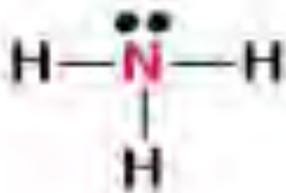
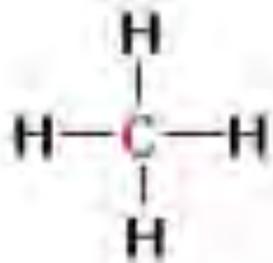
**LANTHANIDES & ACTINIDES**

**TRANSITION METALS**

# Energia potenziale vs distanza internucleare



# Lewis approach



**TABELLA 3.5****Tre tipi di legame carbonio-carbonio**

<b>Legame</b>	<b>Molecola</b>	<b>Lunghezza di legame (Å)</b>	<b>Energia di legame (kJ mol<sup>-1</sup>)</b>
C—C	C <sub>2</sub> H <sub>6</sub> (o H <sub>3</sub> CCH <sub>3</sub> )	1,536	345
C=C	C <sub>2</sub> H <sub>4</sub> (o H <sub>2</sub> CCH <sub>2</sub> )	1,337	612
C≡C	C <sub>2</sub> H <sub>2</sub> (o HCCH)	1,204	809

TABELLA 3.7

## Momenti di dipolo di molecole biatomiche

Molecola	Lunghezza di legame (Å)	Momento di dipolo (D)	% di carattere ionico (100 $\delta$ )
H <sub>2</sub>	0,751	0	0
CO	1,131	0,112	2
NO	1,154	0,159	3
HI	1,620	0,448	6
ClF	1,632	0,888	11
HBr	1,424	0,828	12
HCl	1,284	1,109	18
HF	0,926	1,827	41
CsF	2,347	7,884	70
LiCl	2,027	7,129	73
LiH	1,604	5,882	76
KBr	2,824	10,628	78
NaCl	2,365	9,001	79
KCl	2,671	10,269	82
KF	2,176	8,593	82
LiF	1,570	6,327	84
NaF	1,931	8,156	88

1) Contare il numero totale di elettroni di valenza disponibili, sommando gli elettroni di valenza di tutti gli atomi presenti, che per ciascun atomo è pari al numero del gruppo di appartenenza. Se la specie è uno ione negativo, aggiungere il numero sufficiente di elettroni per ottenere la carica totale. Se è uno ione positivo, sottrarre il numero di elettroni sufficiente per ottenere la carica totale.

2) Calcolare il numero totale di elettroni necessario per far sì che ciascun atomo abbia attorno a sé un numero di elettroni pari a quello del gas nobile successivo (due per l'idrogeno, otto per il carbonio e gli elementi più pesanti).

3) Sottrarre a questo numero quello calcolato nel punto 1. Questo è il numero di elettroni condivisi (o di legame) presenti.

4) Assegnare due elettroni di legame (una coppia) ad ogni legame della molecola o dello ione. Se rimangono elettroni di legame, assegnarli a coppie, rendendo alcuni dei legami doppi o tripli. In alcuni casi ci può essere più di un modo per fare questo. Di solito, legami doppi si formano solo tra gli atomi degli elementi C, N, O e S. Legami tripli in genere sono formati solo da C, N ed O.

5) Sistemare i restanti elettroni come coppie solitarie intorno agli atomi, facendo in modo che tutti gli atomi, tranne l'idrogeno, ne abbiano otto (configurazione a ottetto).

6) Calcolare la carica formale di ciascun atomo e scriverla vicino ad esso. Controllare che la somma delle cariche formali sia pari alla carica totale vera della molecola o dello ione poliatomico, (questo stadio non solo guida alla formula migliore, ma fornisce anche una verifica per errori involontari quale un numero errato di punti).

7) Nel caso siano possibili più formule di Lewis, scegliere quella che prevede il minor numero di cariche formali (0, +1, -1) e con le cariche formali negative collocate sugli atomi più elettronegativi.

# DRAW A LEWIS DOT STRUCTURE

## STEP 1



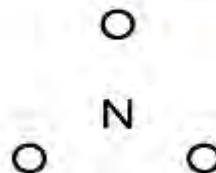
Nitrogen:	5e-
Oxygen:	6x3=18e-
Ion's charge:	1e-

24 electrons

COUNT ALL VALENCE ELECTRONS

## STEP 2

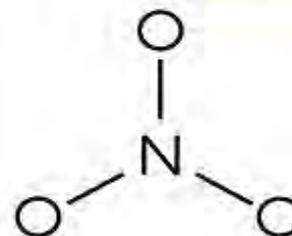
0 electrons



DRAW THE LEAST ELECTRONEGATIVE ATOM IN THE CENTER WITH THE OTHER ATOMS SPACED EVENLY AROUND IT

## STEP 3

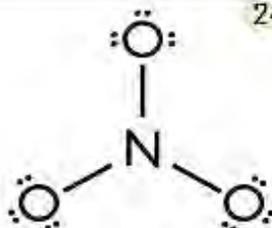
6 electrons



DRAW SINGLE BONDS TO THE CENTRAL ATOM

## STEP 4

24 electrons

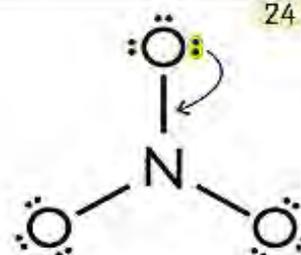


COMPLETE OCTETS WITH REMAINING ELECTRONS FOR THE OUTER ATOMS FIRST AND ADD REMAINING ELECTRONS (IF ANY) TO THE CENTRAL ATOM

NOTE 1: FOR HYDROGEN USE THE DUET RULE

## STEP 5

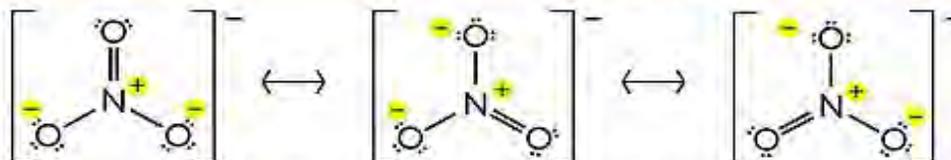
24 electrons



COMPLETE THE CENTER ATOM'S OCTET BY MAKING COVALENT BOND(S) USING LONE PAIR ELECTRONS FROM AN OUTER ATOM OF YOUR CHOICE

## STEP 6 - DRAWING RESONANCE STRUCTURES & DETERMINING FORMAL CHARGE

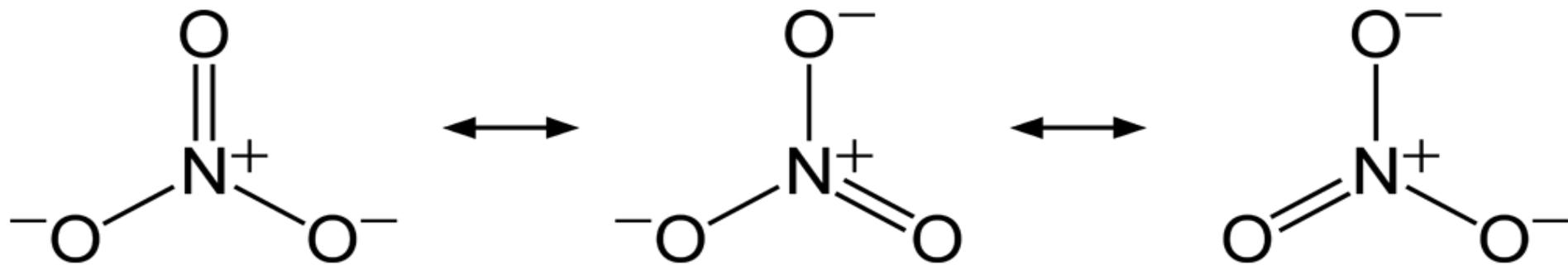
formal charge of an atom = [#valence electrons] - [#dots] - [#lines]



DEPENDING ON WHICH ELECTRONS YOU MOVE IN STEP 5  
A VARIETY OF RESONANCE STRUCTURES CAN BE DETERMINED

NOTE 2: THE "CORRECT" STRUCTURE CONSIDERS ALL RESONANCES AND CAN ONLY BE DETERMINED EXPERIMENTALLY

PERIOD 4 ELEMENTS FOLLOW THE DUET RULE - PERIOD 2 ELEMENTS FOLLOW THE OCTET RULE - PERIOD 3 ELEMENTS CAN HAVE EXPANDED OCTETS

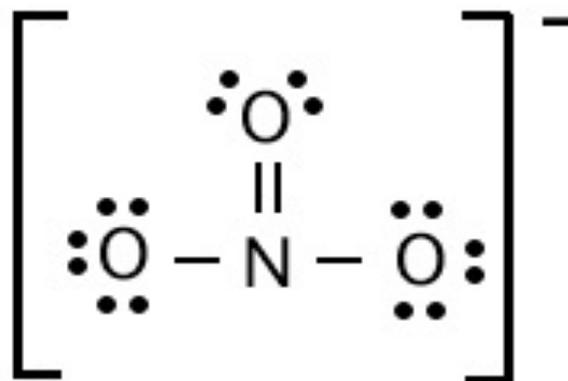


# Lewis approach: resonance

nitrate -  $\text{NO}_3^-$

#valence of  $e^-$

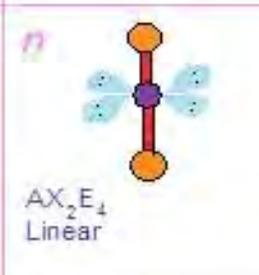
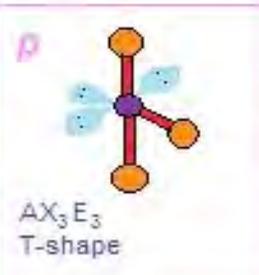
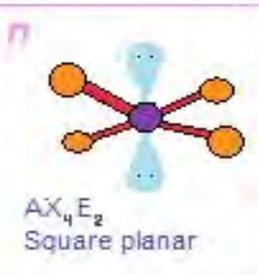
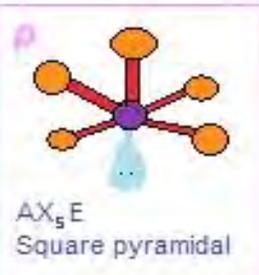
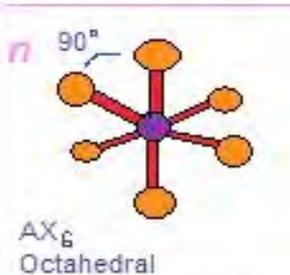
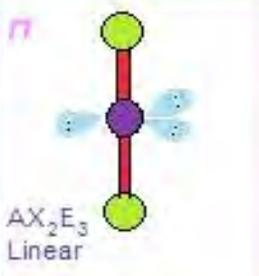
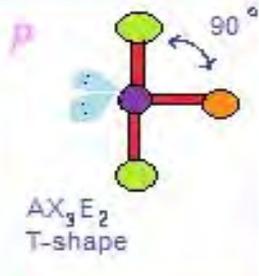
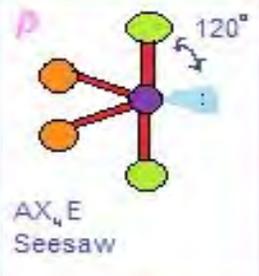
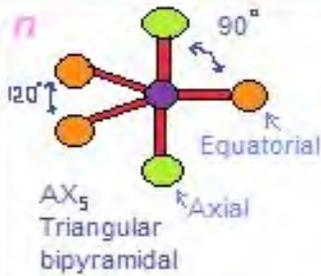
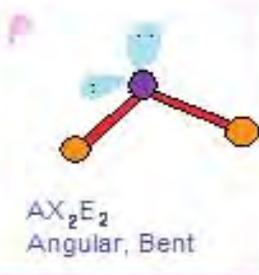
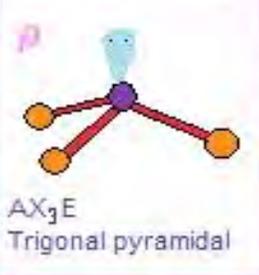
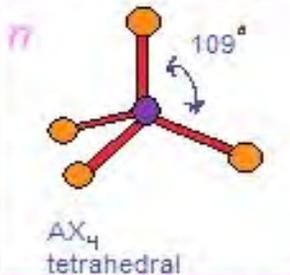
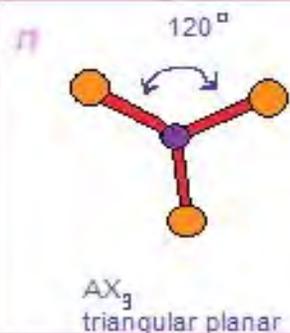
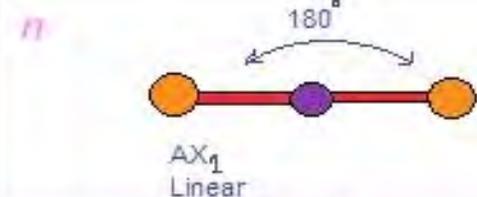
$$\begin{array}{r} \text{N} - 5 \\ \text{O} - 18 \\ \hline 23 \\ + 1 \\ \hline 24 \end{array}$$



There are *Resonance Structures* for this ion because the double bond can be on ANY of the oxygen atoms.



# Valence Shell Electron Pair Repulsion (VSEPR) Model Electron Geometry



$n$  : non-polar (symmetrical)  
 $p$  : polar (non symmetrical)

Bonded Pair, atom X  
 Central atom A  
 Lone pair

# Paramagnetismo di $O_2$

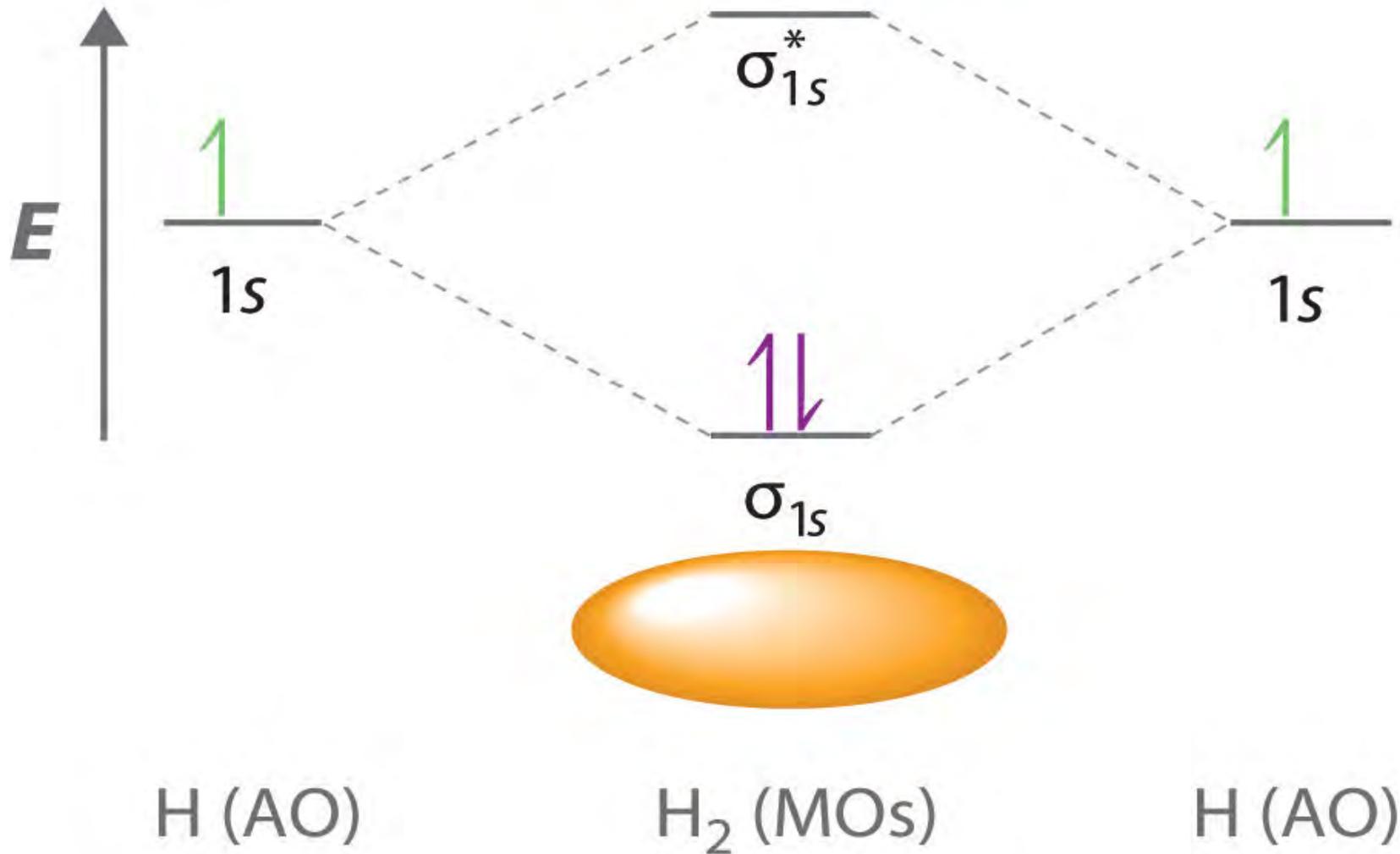
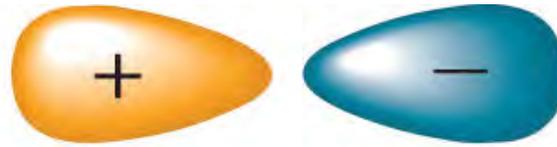


Magnete acceso



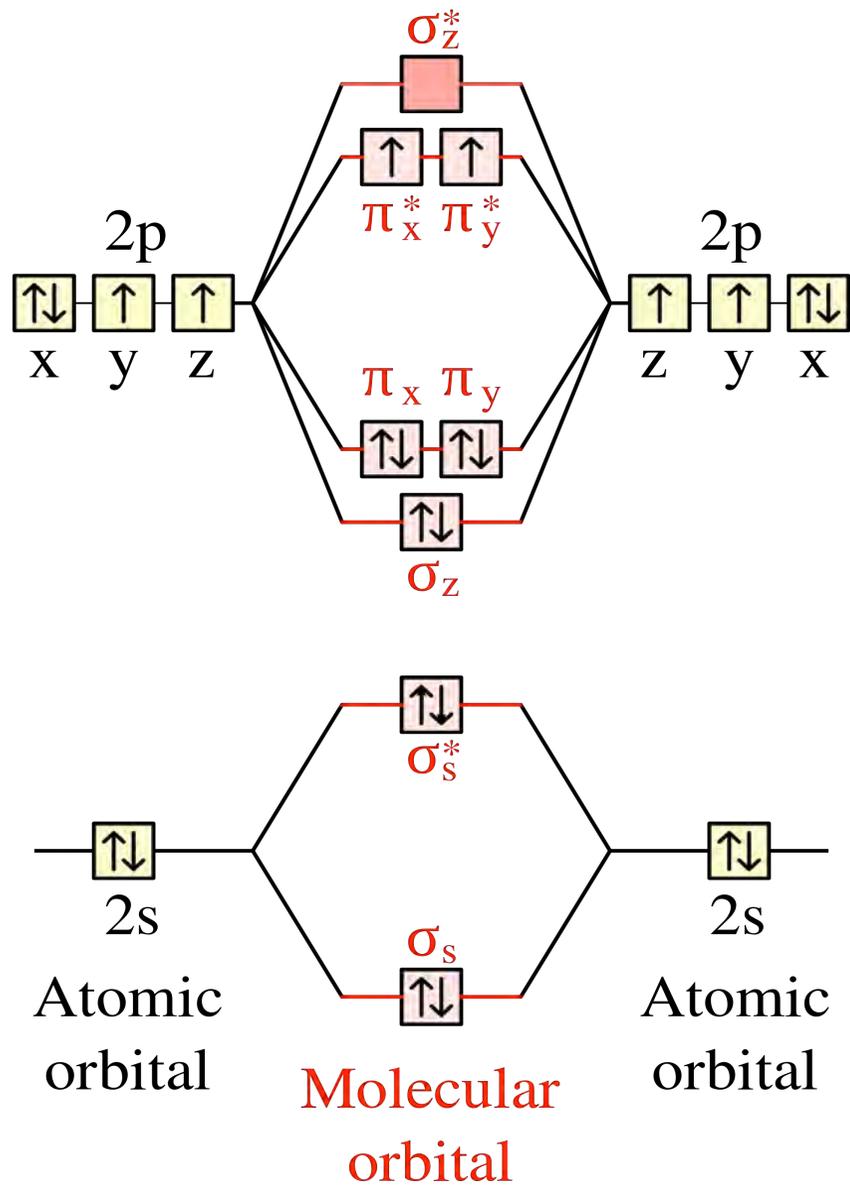
Magnete spento

# MO-LCAO: basic idea

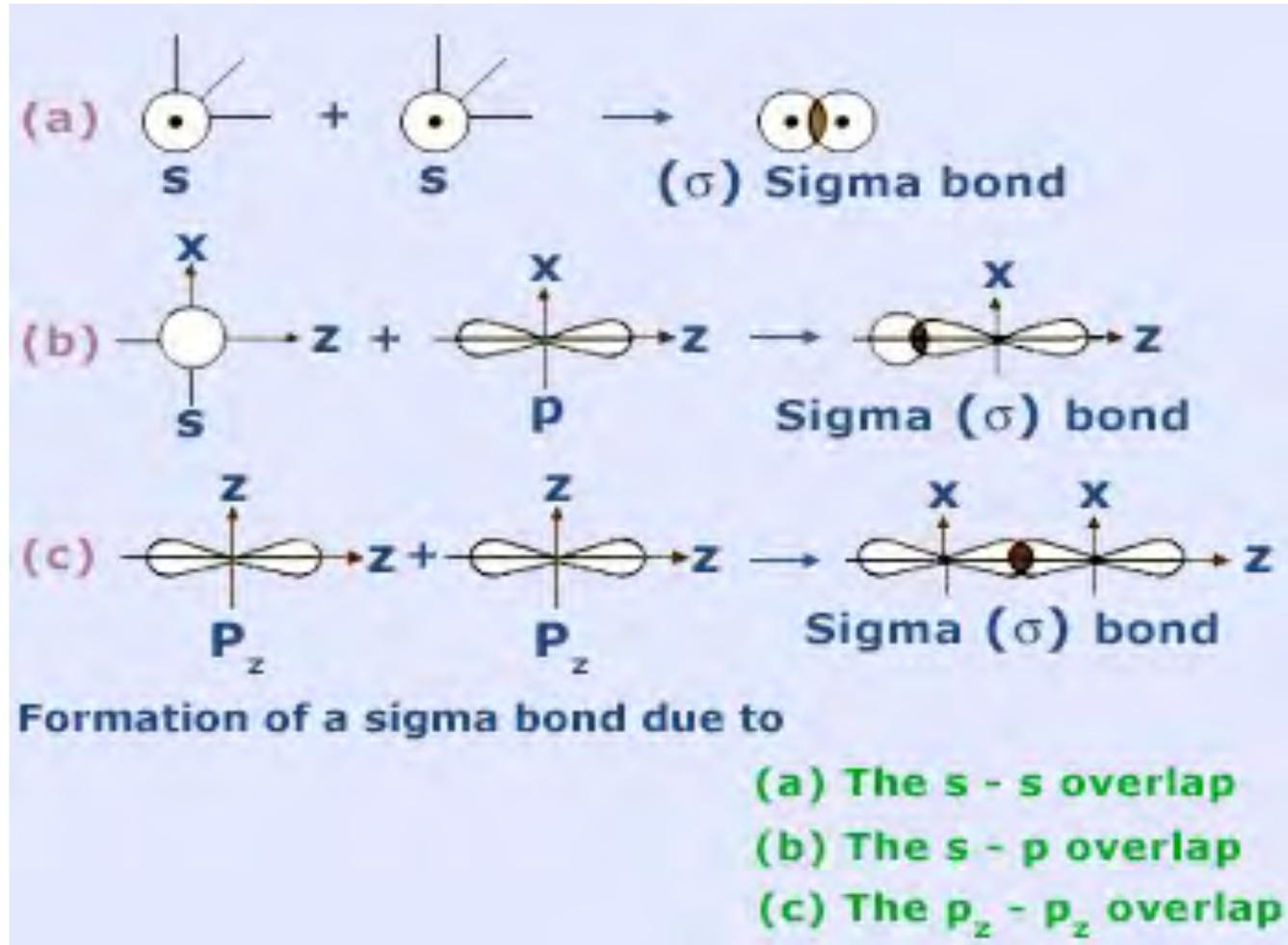




# MO – LCAO

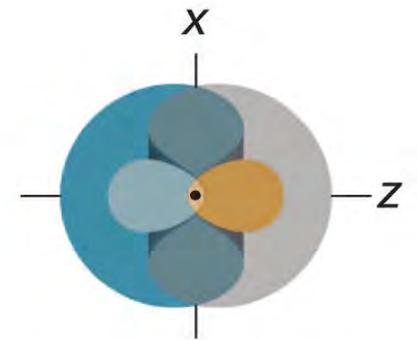
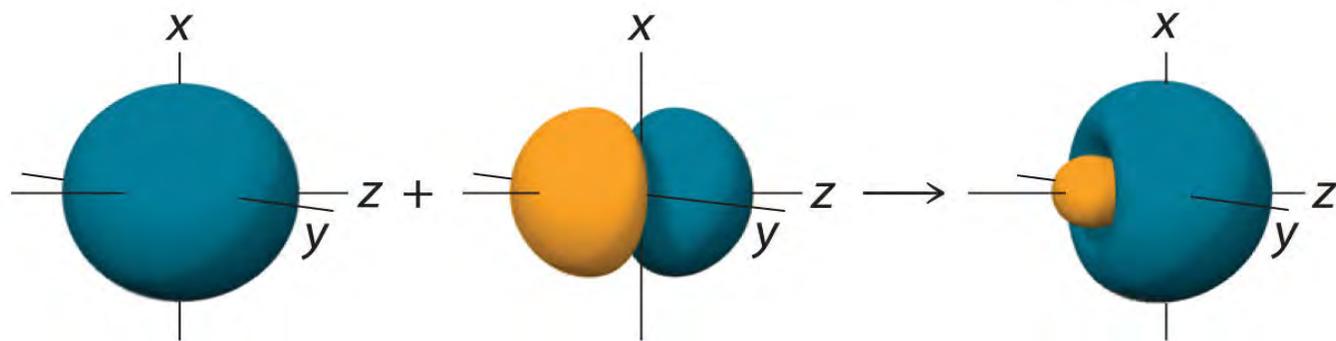
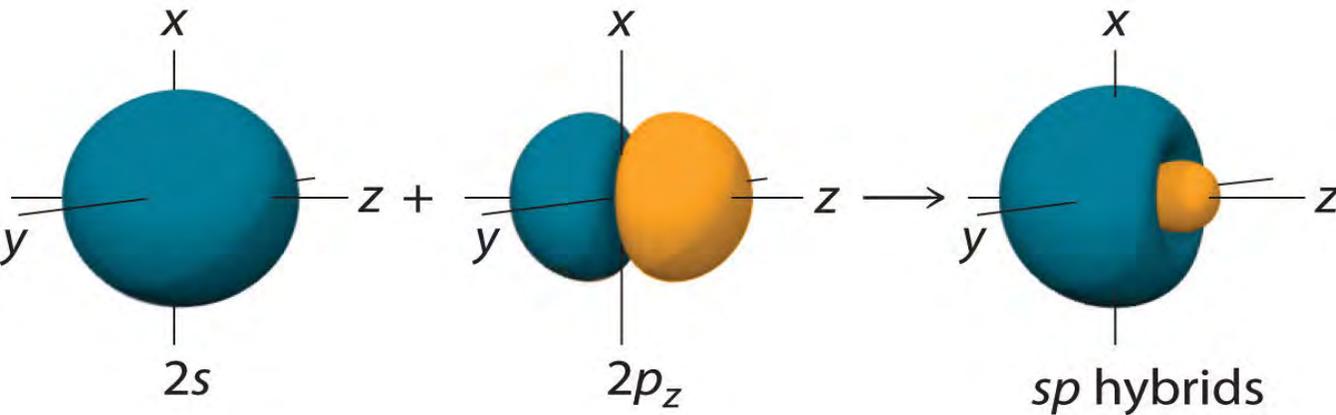


# Legame di Valenza

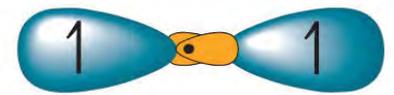


Anidride carbonica, carbon dioxide

# Valency Bond Theory: hybridization

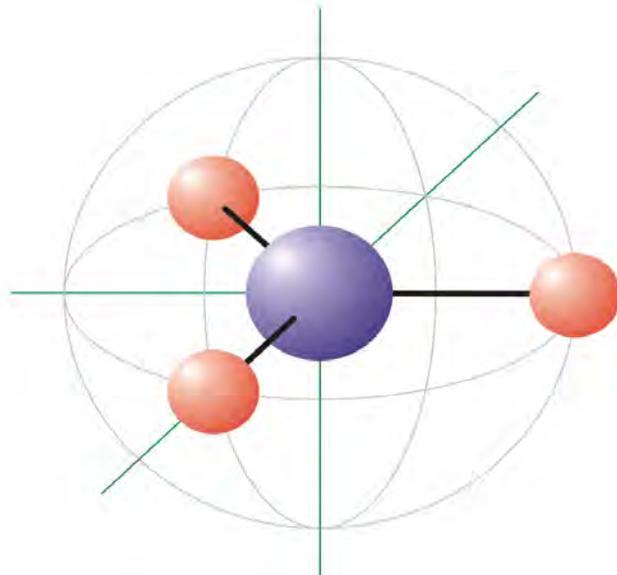
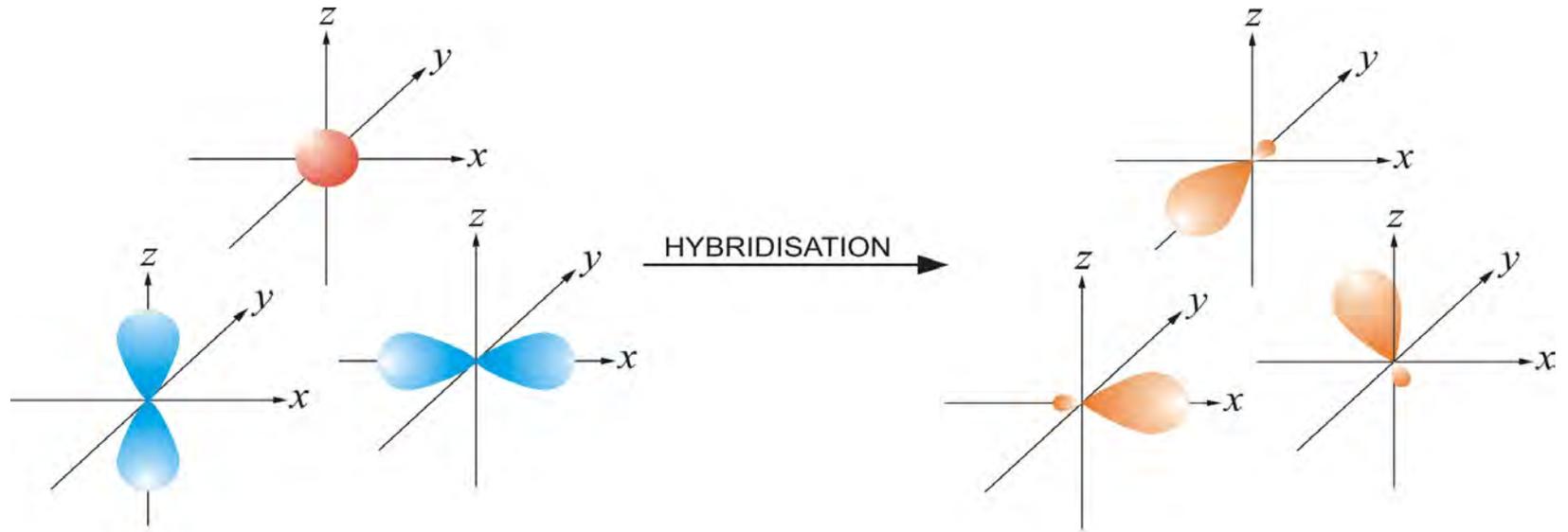


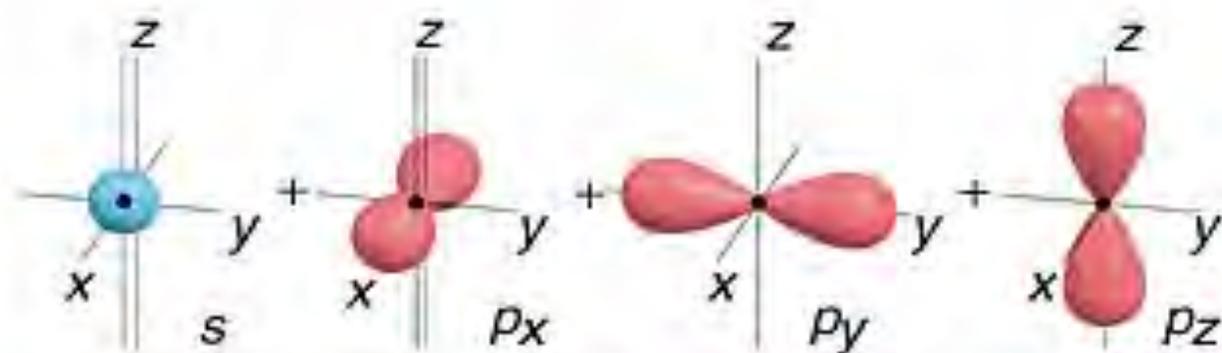
Hybrids shown together in cross-section



Schematic representation of hybrids shown together

# Sp<sup>2</sup>

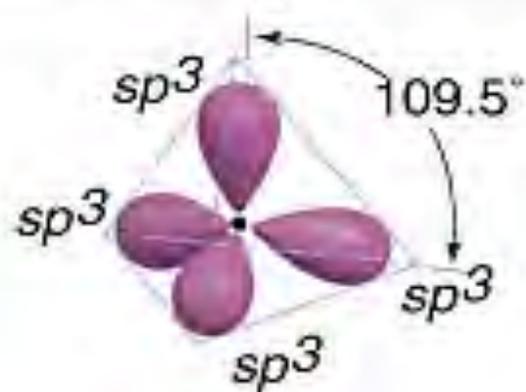




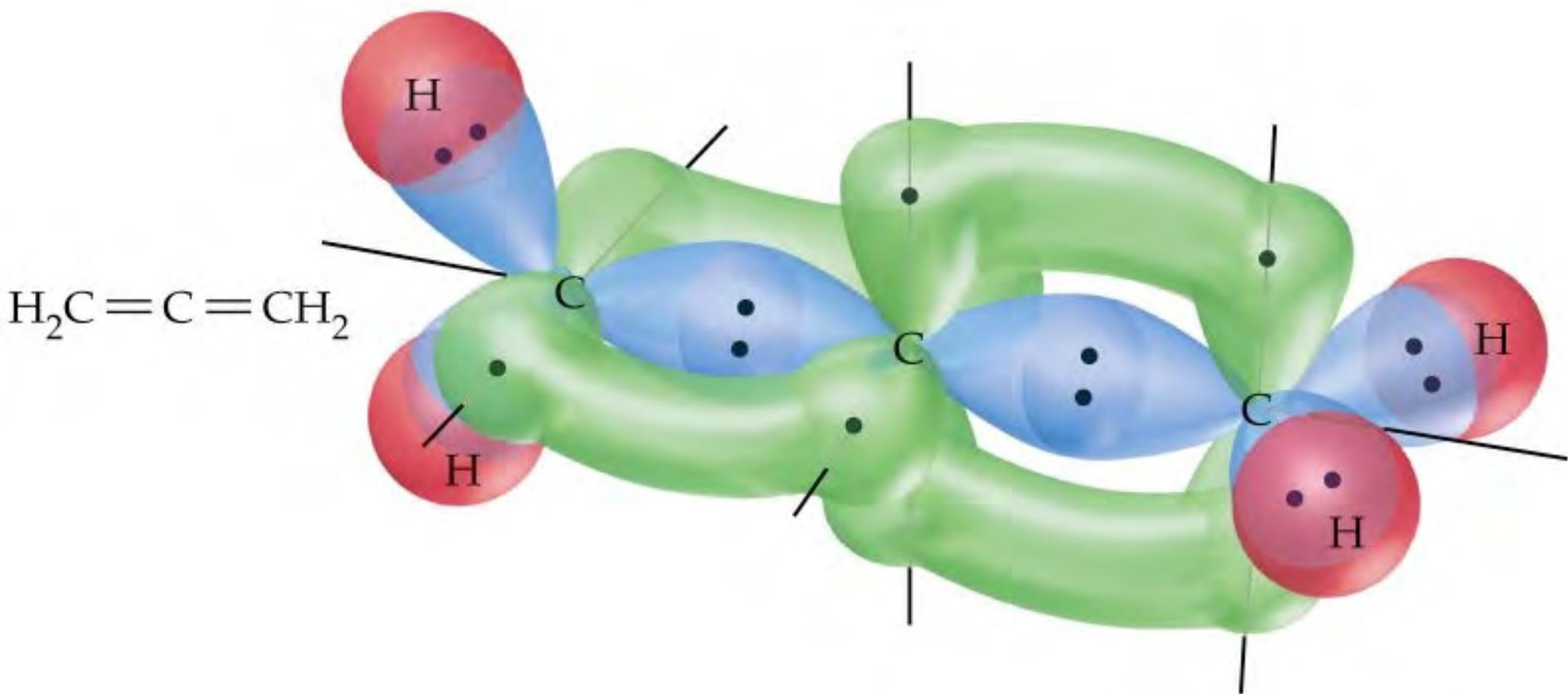
Hybridize to form four  $sp^3$  hybrid orbitals

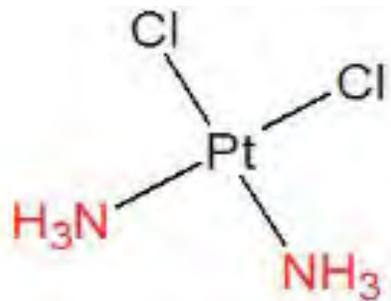


Shown together (large lobes only)



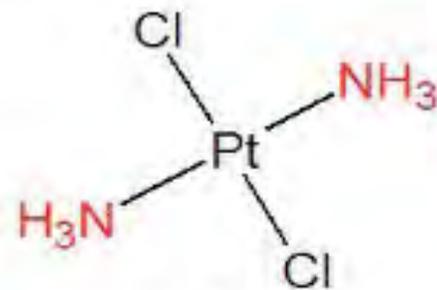
Allene: central C  $sp$ , lateral C's  $sp^2$





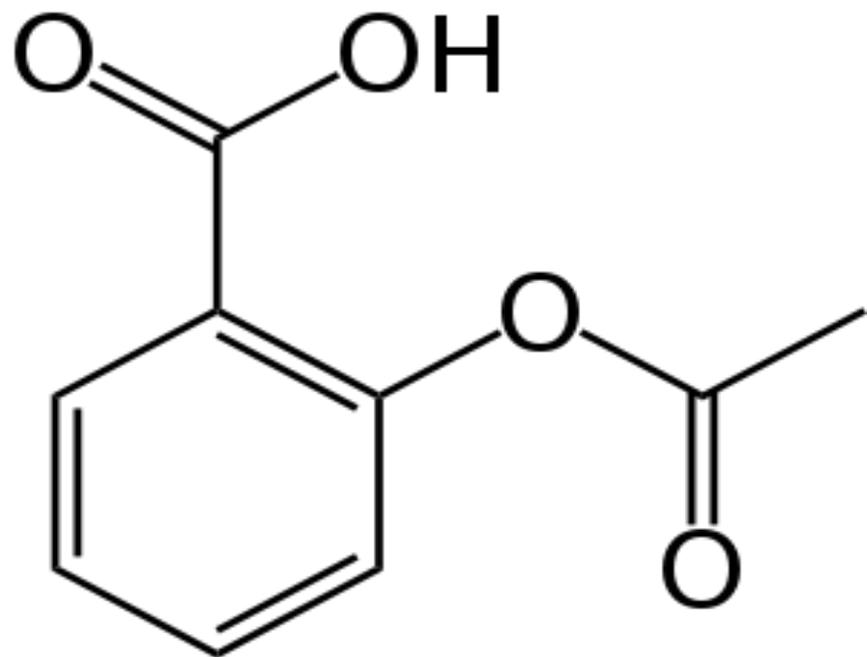
(a)

**cis**-diamminodichloroplatino (II)  
(cisplatino)

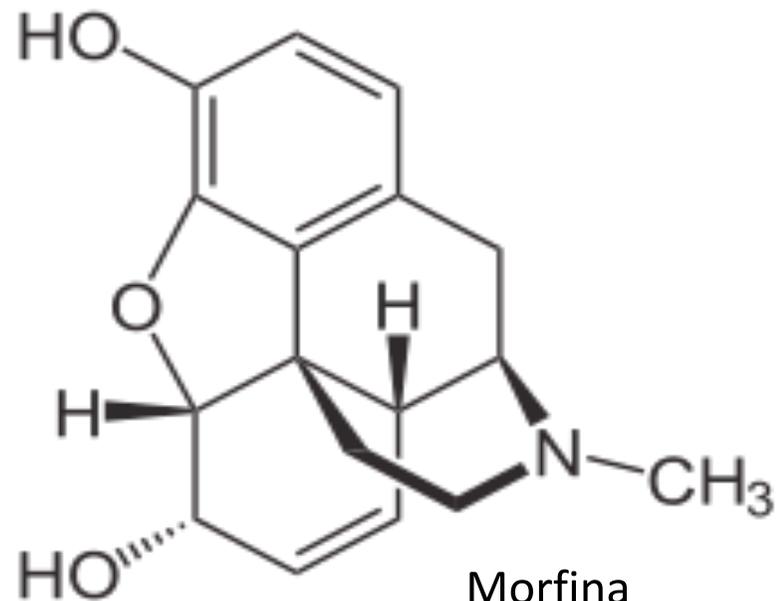


(b)

**trans**-diamminodichloroplatino (II)

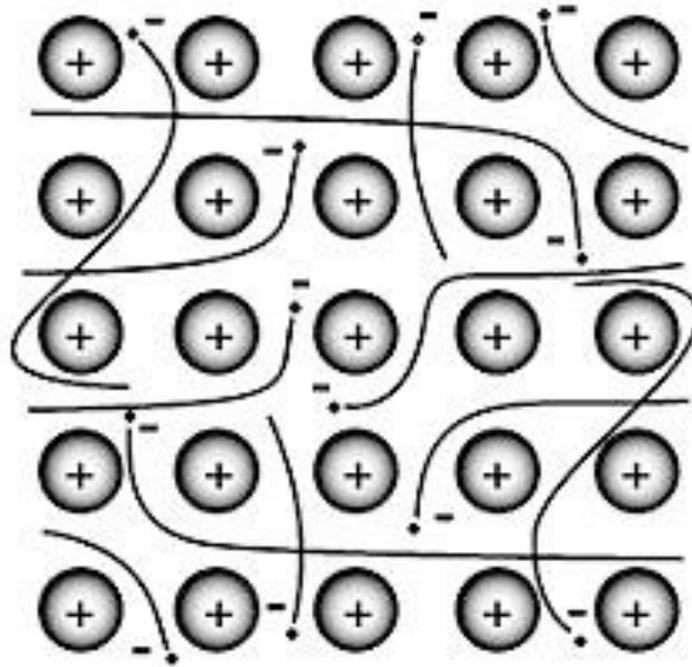


Aspirina



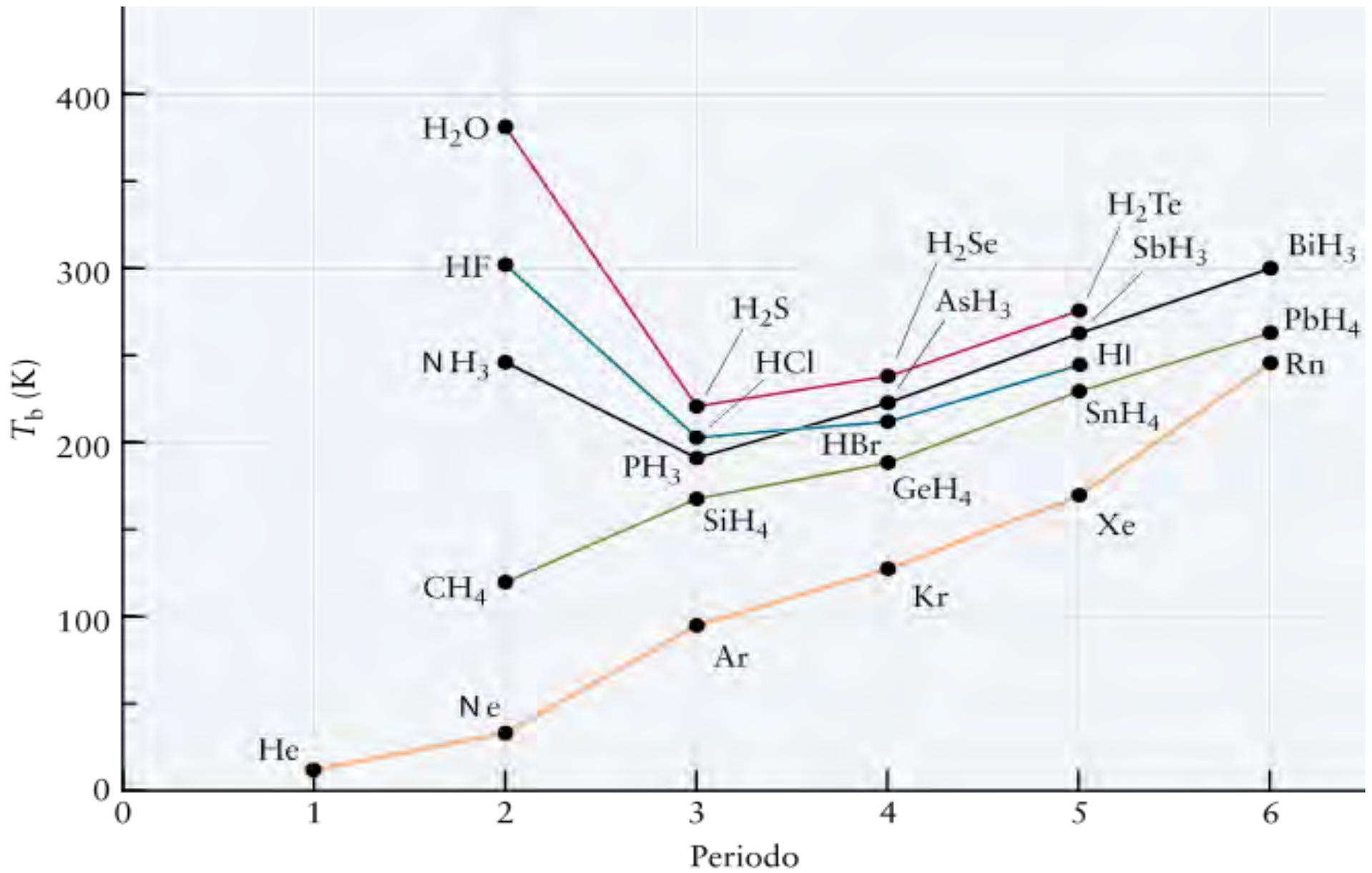
Morfina

# Metallic bond

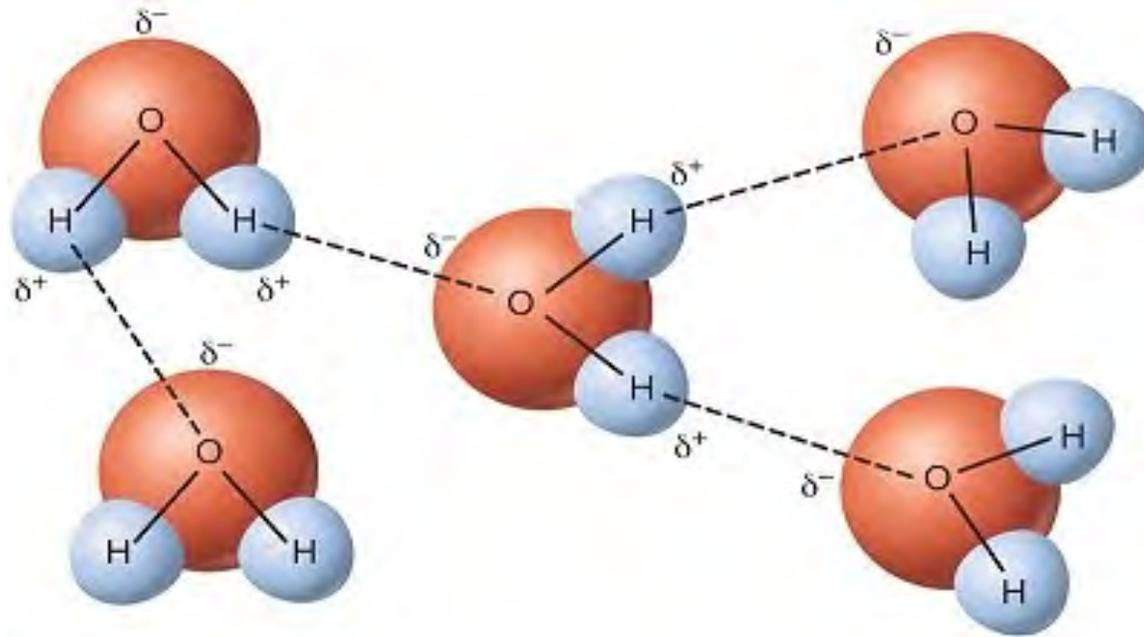


- Good electrical conductor
- Ductile

# Boiling points of some liquids

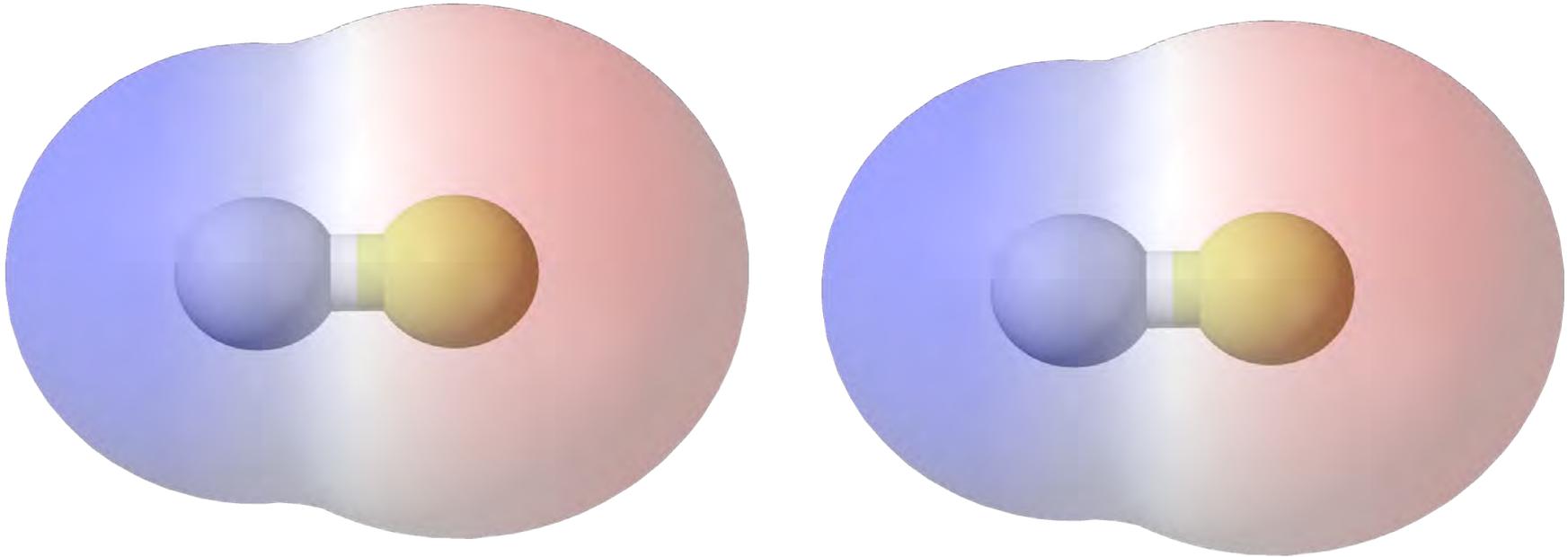


# Hydrogen bonding and Van der Waals interactions

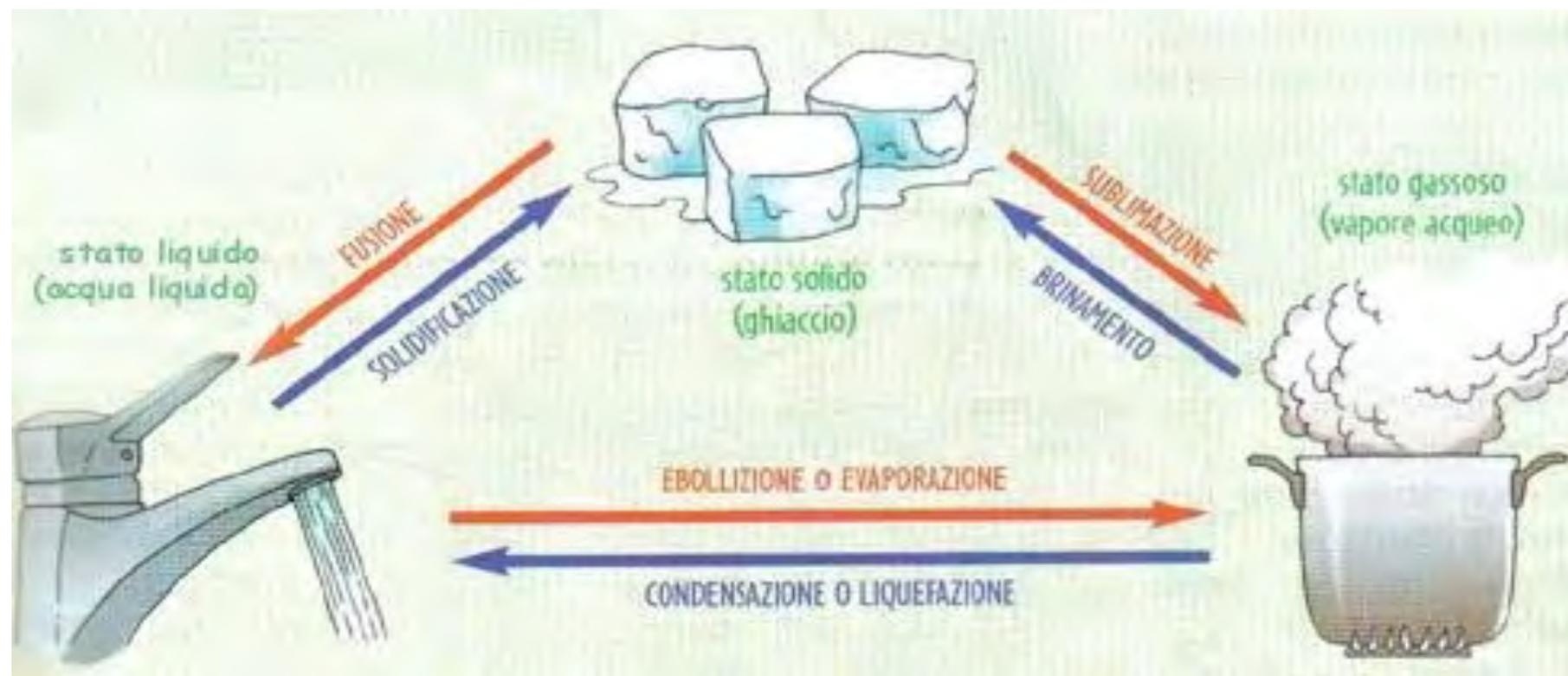


# Dipole-dipole interactions

Weakly attractive, and can be present even in neutral atoms/molecules

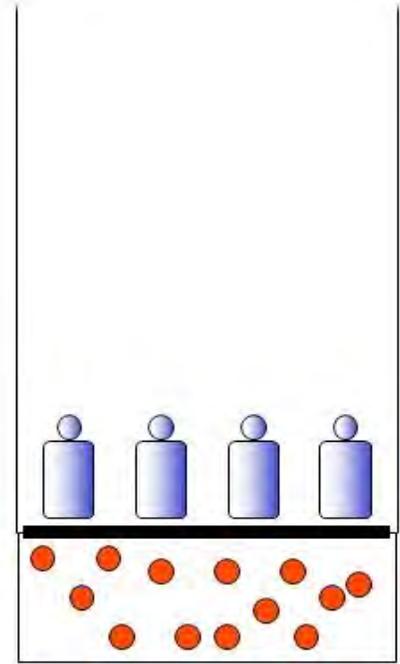
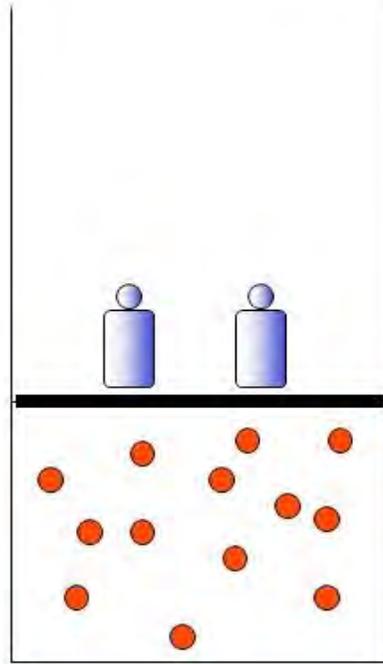
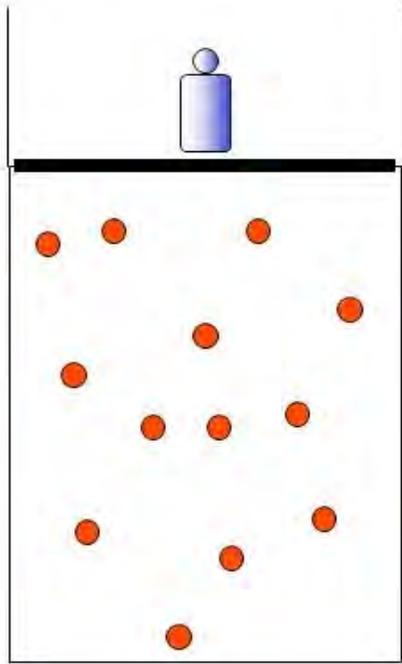


- ) Dipole-dipole interaction (Keesom Energy)
- ) Dipole – induced dipole interaction (Debye energy)
- ) Induced dipole – induced dipole (London dispersion energy)



# Legge di Boyle

a **temperatura costante** il prodotto  $P \times V$  è costante

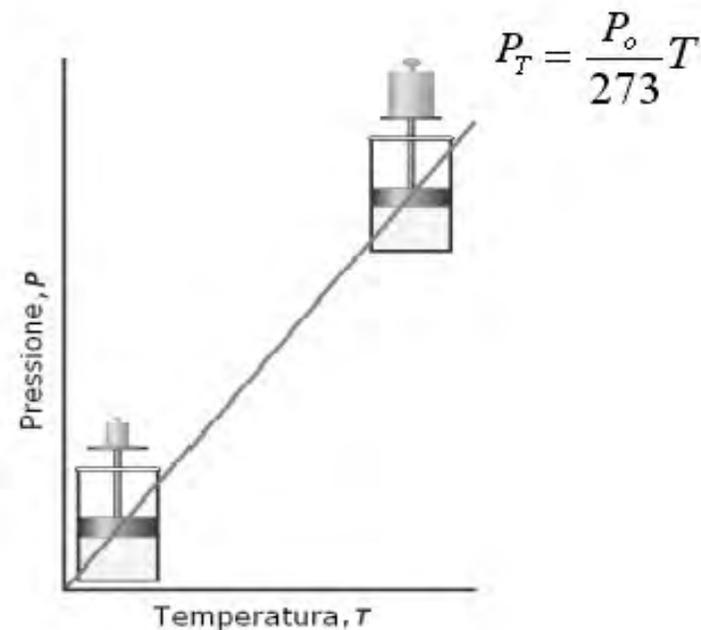
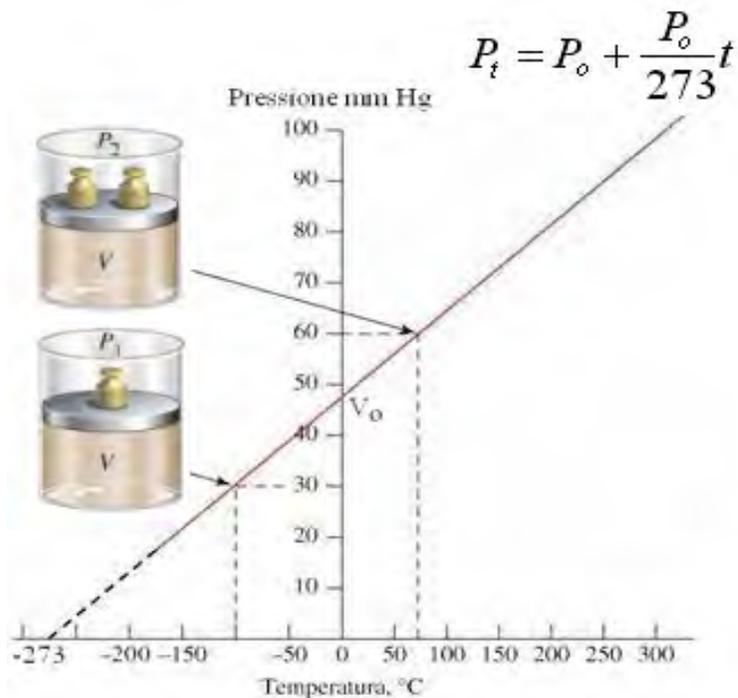
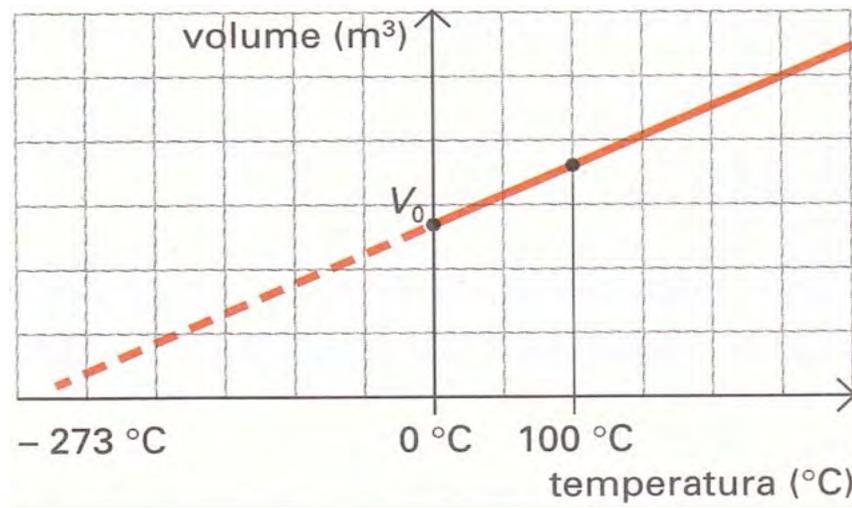


**pressione:**  $P$   
**volume:**  $V$

**$2P$**   
 **$V/2$**

**$4P$**   
 **$V/4$**

# Leggi di Charles / Gay-Lussac



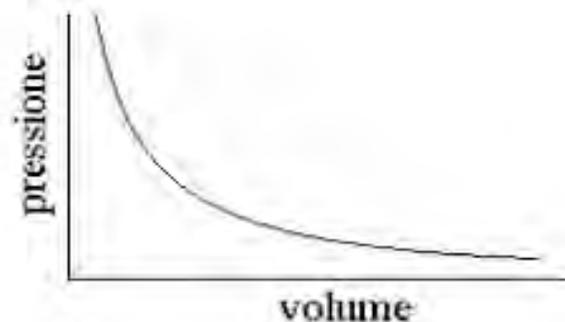
# Legge di Avogadro



# Le leggi dei gas => legge di stato dei gas perfetti

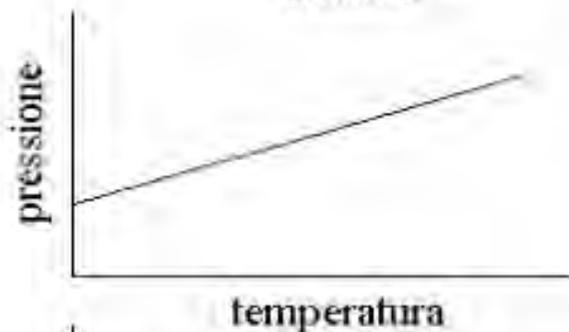
l'isoterma di Boyle

$$P V = \text{cost.}$$



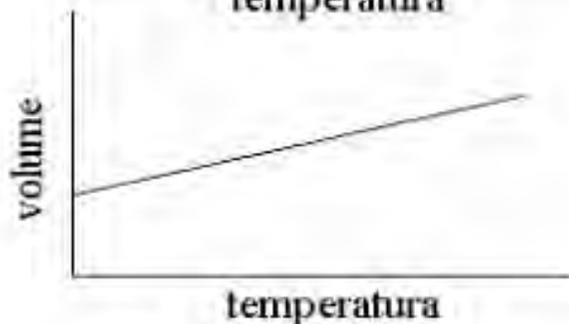
l'isocora  
(= a volume costante)  
di Charles

$$P_t = P_0 \left( 1 + \frac{1}{273} \Delta t \right)$$



e l'isobara di  
Gay Lussac

$$V_t = V_0 \left( 1 + \frac{1}{273} \Delta t \right)$$

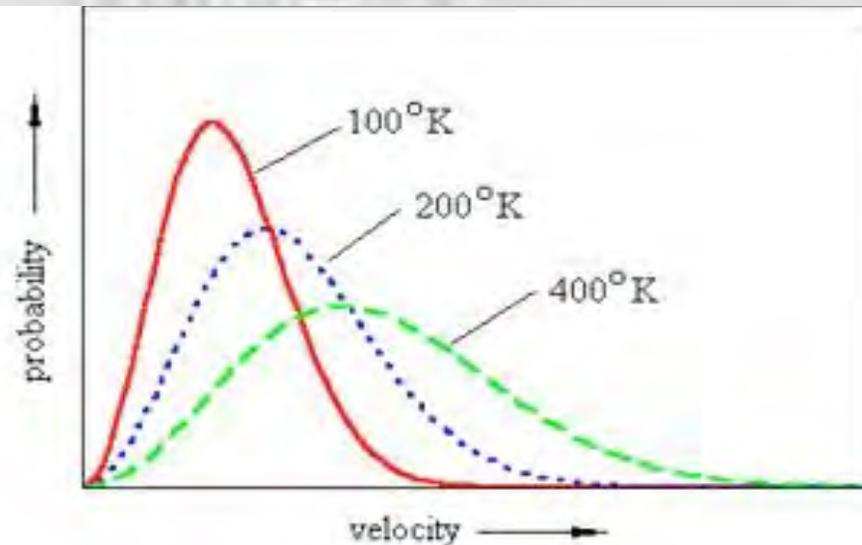


$$PV = nRT$$

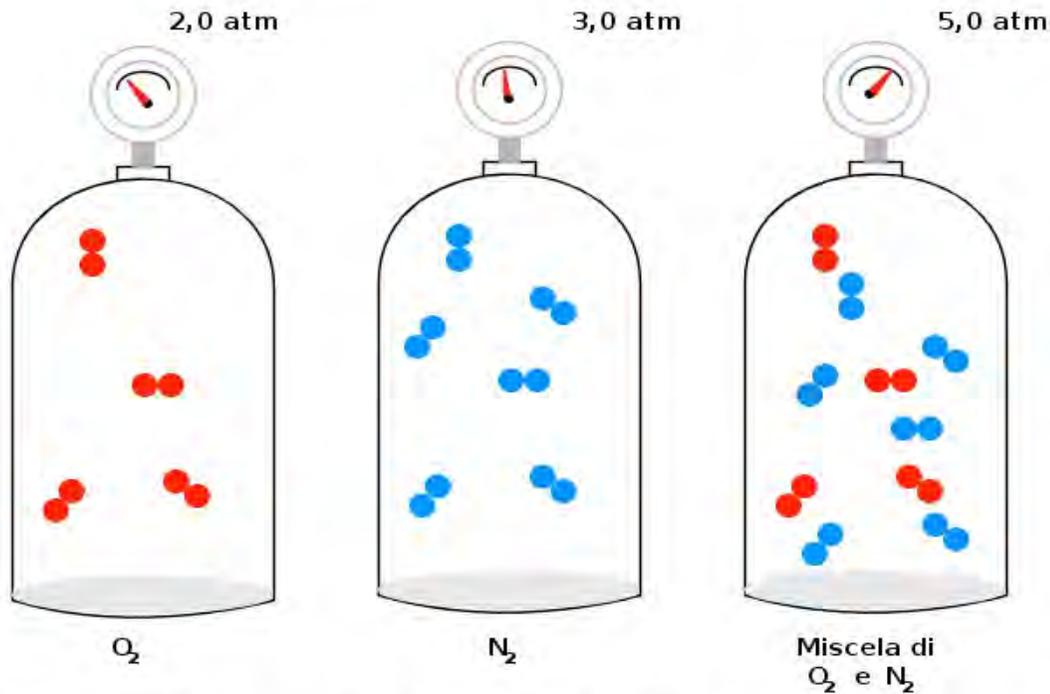
# Teoria cinetica dei gas ed Equazione di Maxwell - Boltzmann



$$f(\mathbf{v}) = 4\pi \left( \frac{m}{2\pi k_B T} \right)^{\frac{3}{2}} \cdot v^2 \cdot e^{-\frac{mv^2}{2k_B T}}$$



# Legge di Dalton (o delle pressioni parziali)



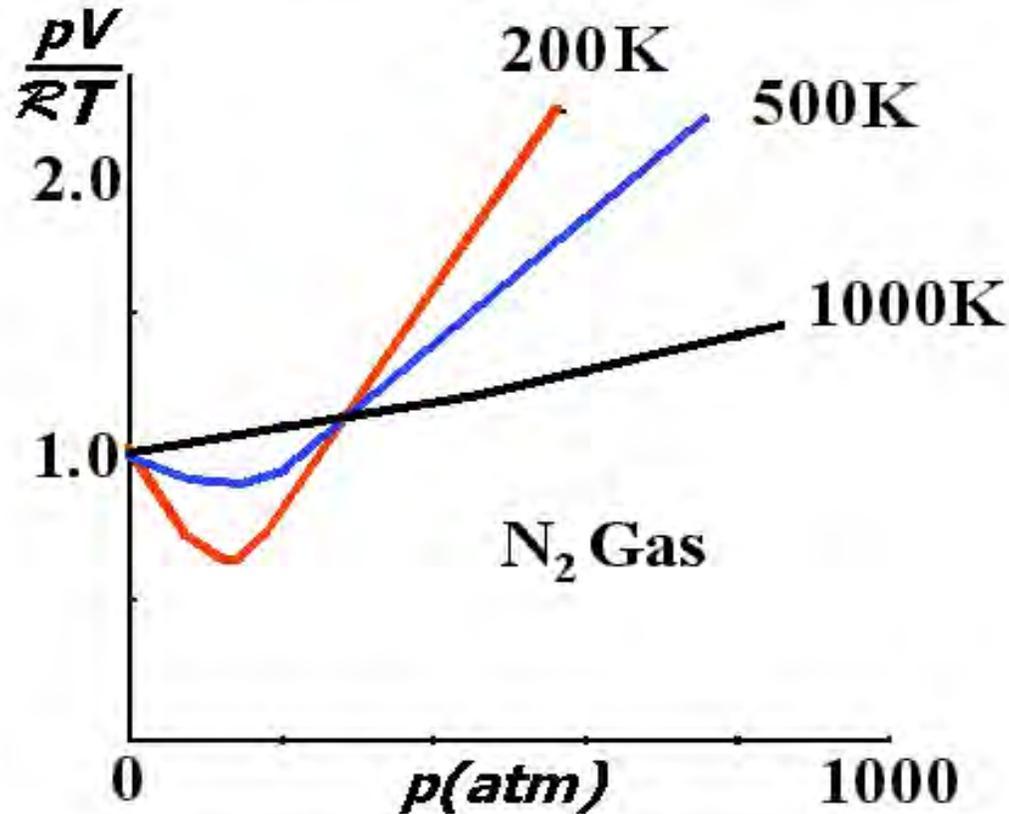
La legge di Dalton afferma che la pressione totale di una miscela di gas è pari alla somma delle pressioni esercitate dai singoli gas.  
(Il volume totale dei recipienti è lo stesso)

$$P_{tot} = P_A + P_B + \dots + P_n$$

$$P_A = n_A \left( \frac{RT}{V_{tot}} \right)$$

$$P_{tot} = n_{tot} \left( \frac{RT}{V_{tot}} \right)$$

# Van der Waals equation



actual pressure

$$P + a \left( \frac{n}{V} \right)^2$$

ideal gas pressure

actual volume

$$\times (V - nb) = nRT$$

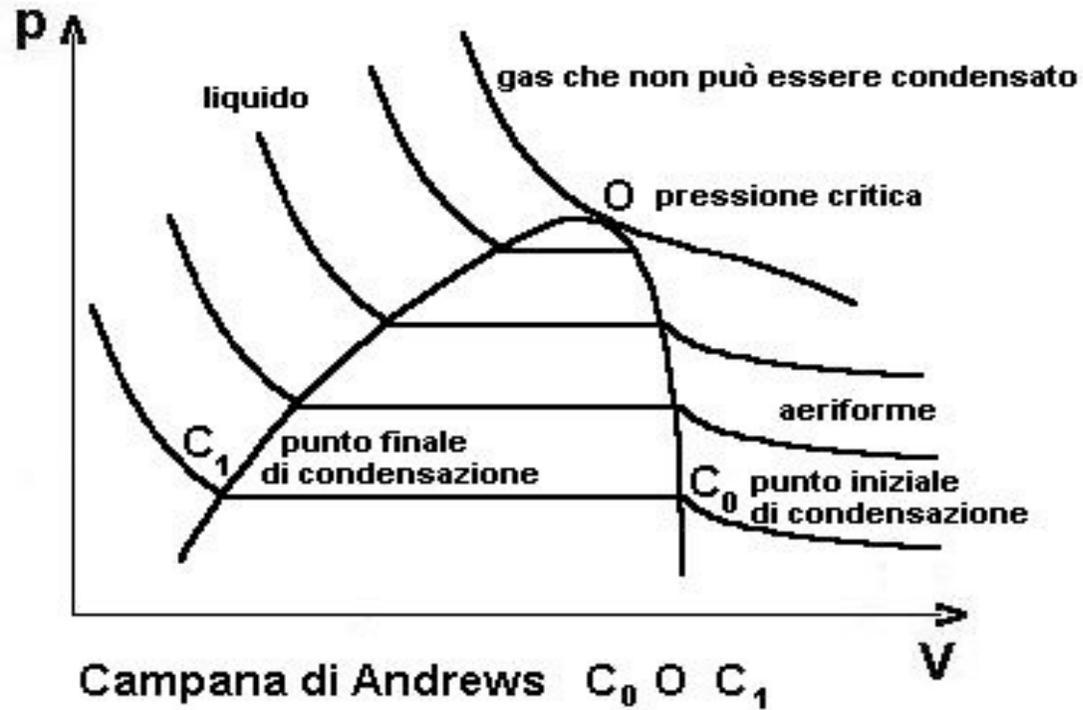
ideal gas volume

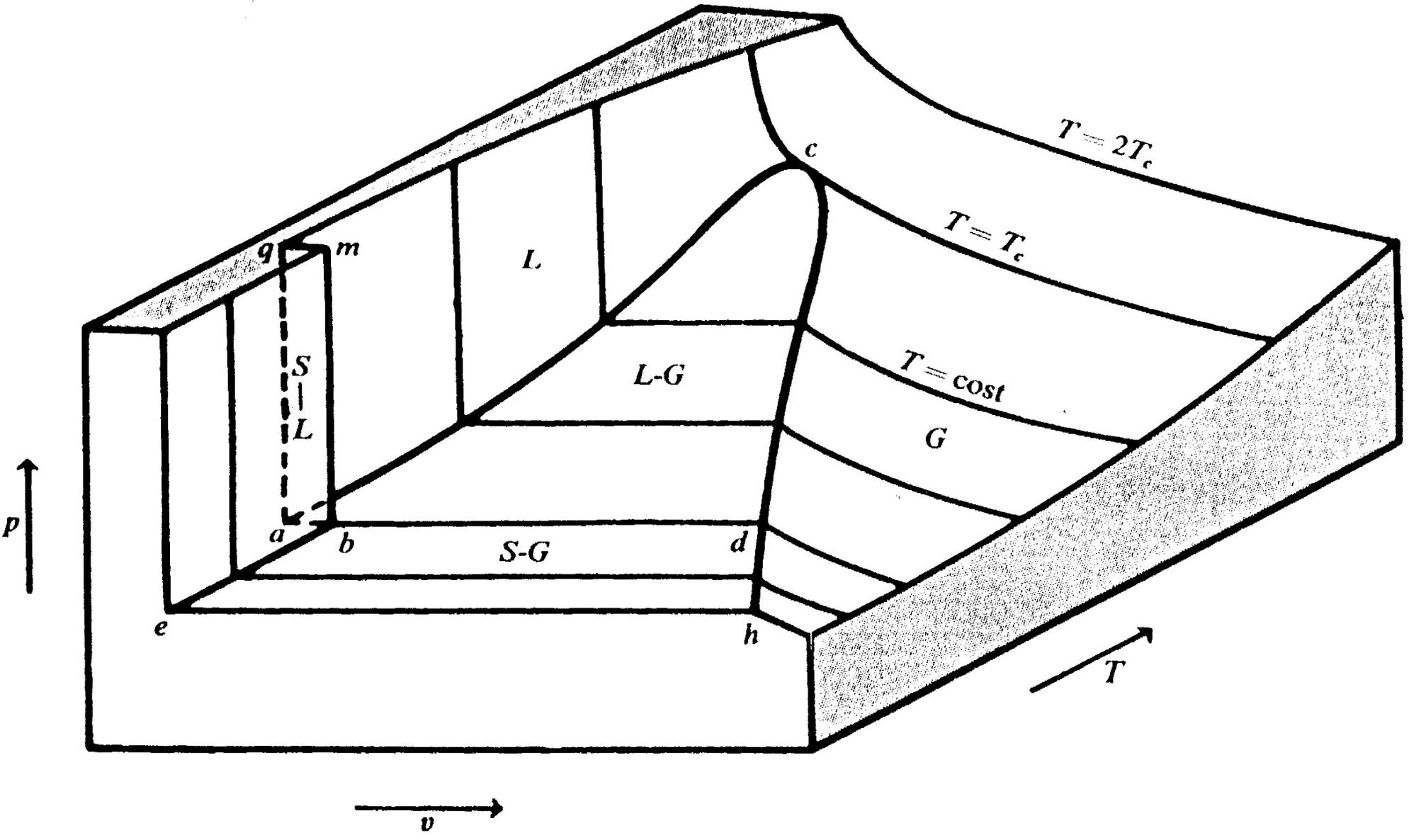
# Van der Waals

Van der Waals equation of state for real gas was derived by Johannes Diderik van der Waals in the year 1873 and got noble prize for the same in year 1910

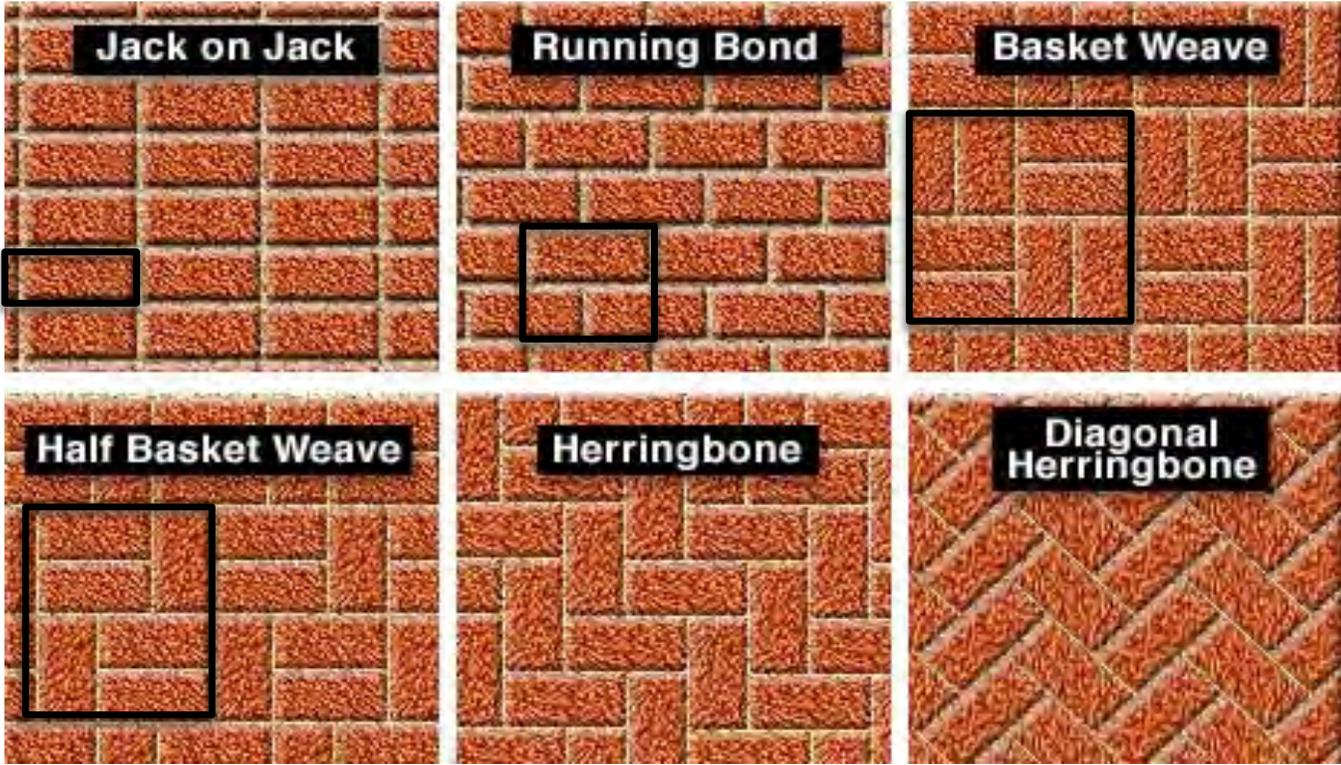


# Liquefazione di un gas e campana di Andrews



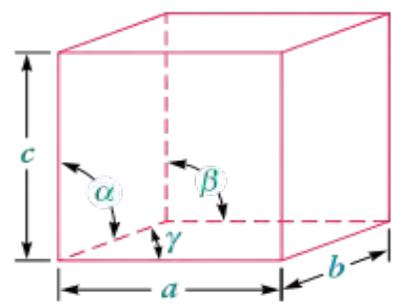


# Solid state

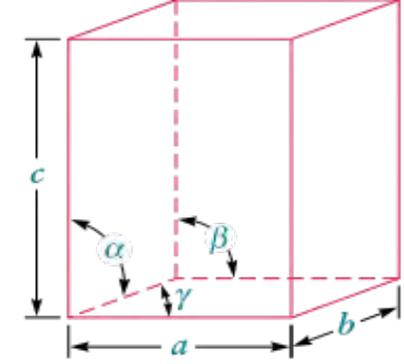


$$a = b = c$$

$$\alpha = \beta = \gamma = 90^\circ$$



Cubico



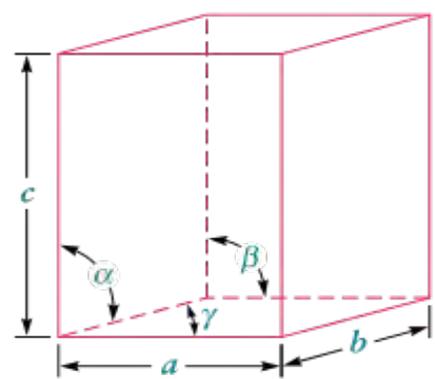
Tetragonale

$$a = b \neq c$$

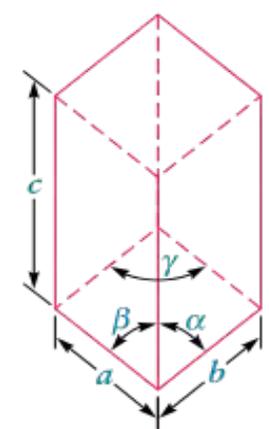
$$\alpha = \beta = \gamma = 90^\circ$$

$$a \neq b \neq c$$

$$\alpha = \beta = \gamma = 90^\circ$$



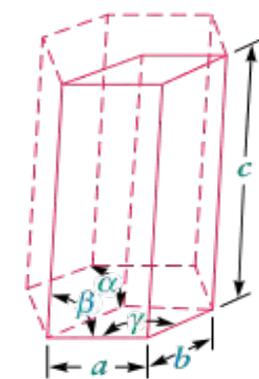
Ortorombico



Trigonale

$$a = b = c$$

$$\alpha = \beta = \gamma \neq 90^\circ$$



Esagonale

$$a = b \neq c$$

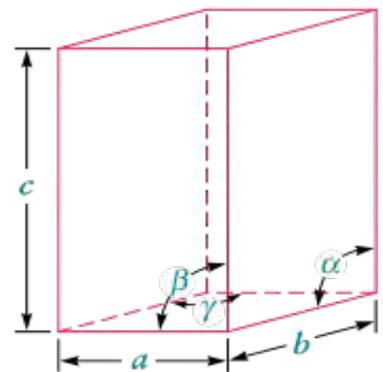
$$\alpha = \beta = 90^\circ$$

$$\gamma = 120^\circ$$

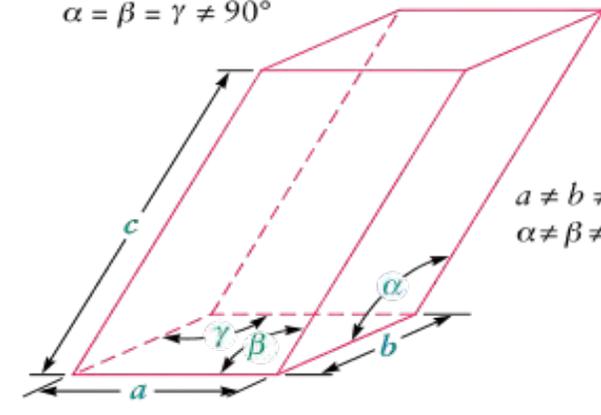
$$a \neq b \neq c$$

$$\alpha = \gamma = 90^\circ$$

$$\beta \neq 90^\circ$$



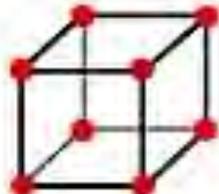
Monoclinico



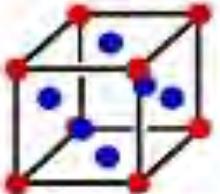
Triclinico

$$a \neq b \neq c$$

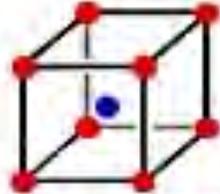
$$\alpha \neq \beta \neq \gamma \neq 90^\circ$$



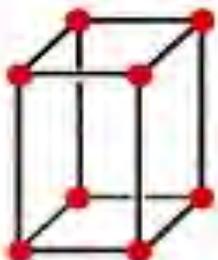
**Simple cubic**



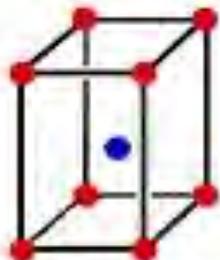
**Face-centered cubic**



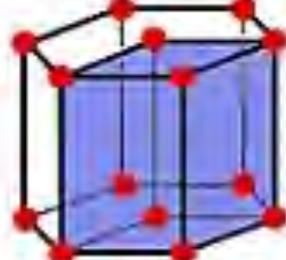
**Body-centered cubic**



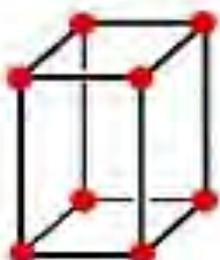
**Simple tetragonal**



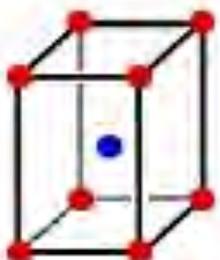
**Body-centered tetragonal**



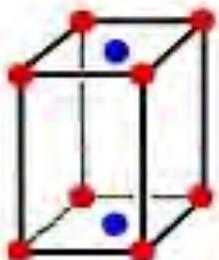
**Hexagonal**



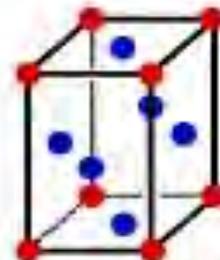
**Simple orthorhombic**



**Body-centered orthorhombic**



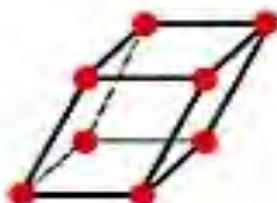
**Base-centered orthorhombic**



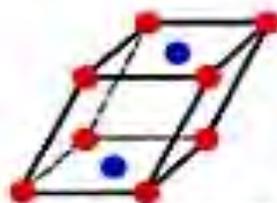
**Face-centered orthorhombic**



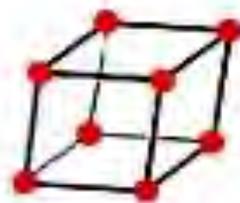
**Rhombohedral**



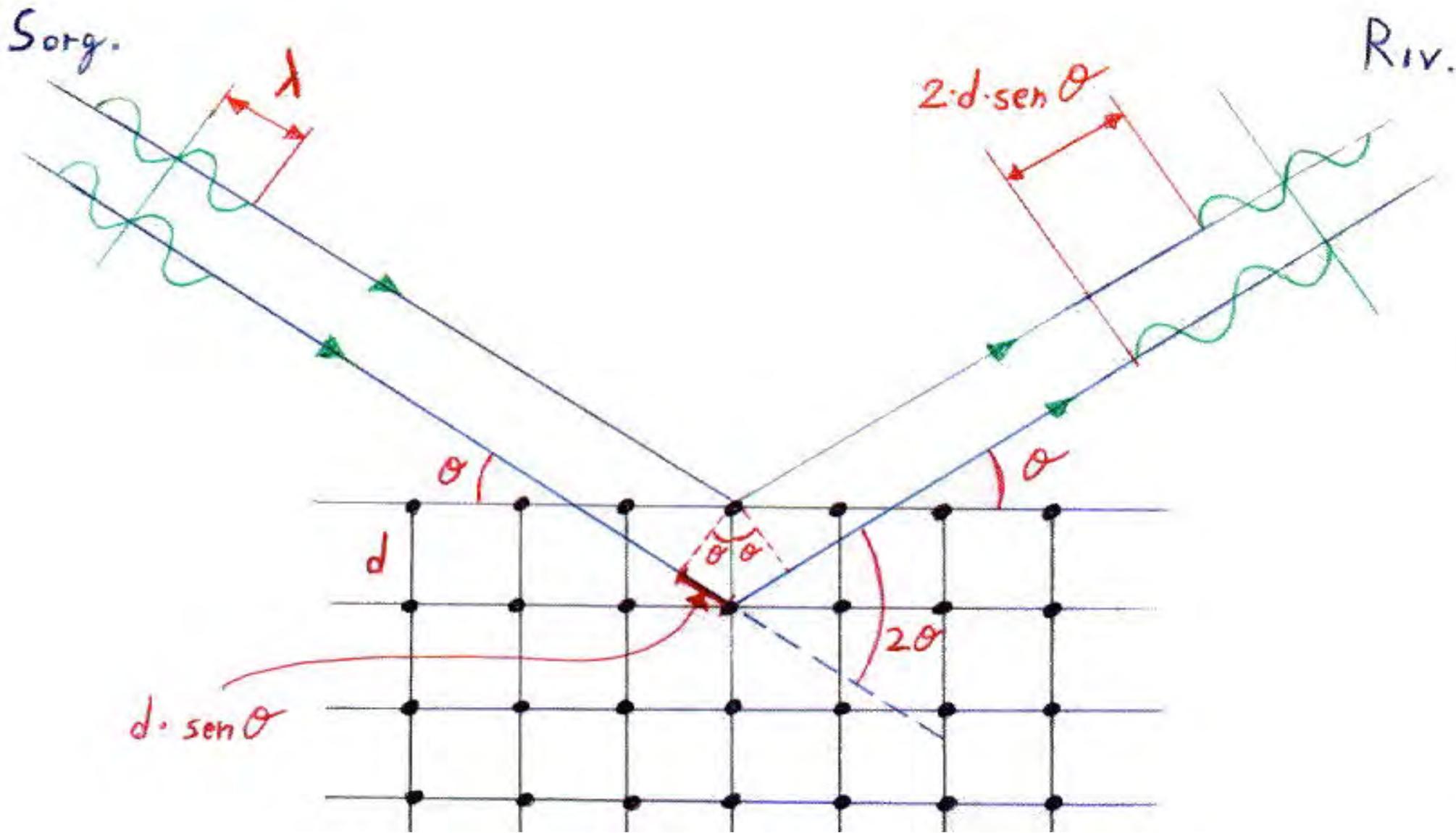
**Simple Monoclinic**



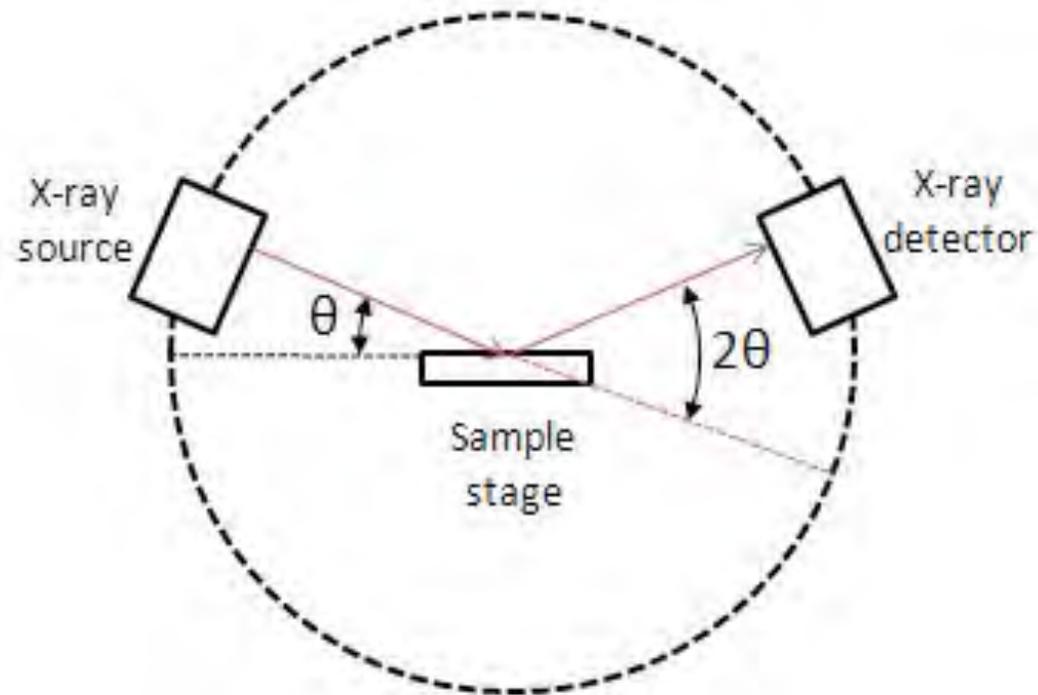
**Base-centered monoclinic**



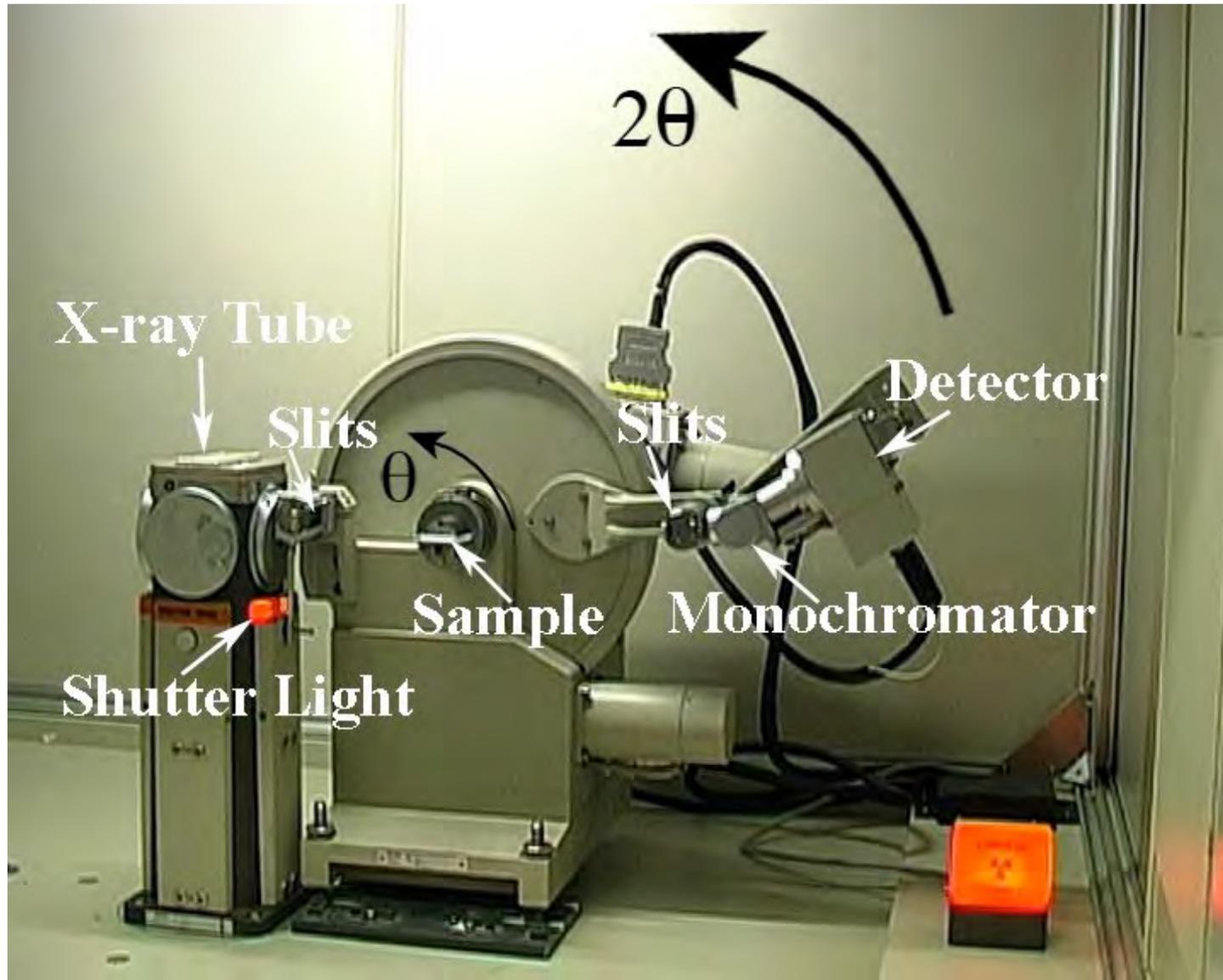
**Triclinic**



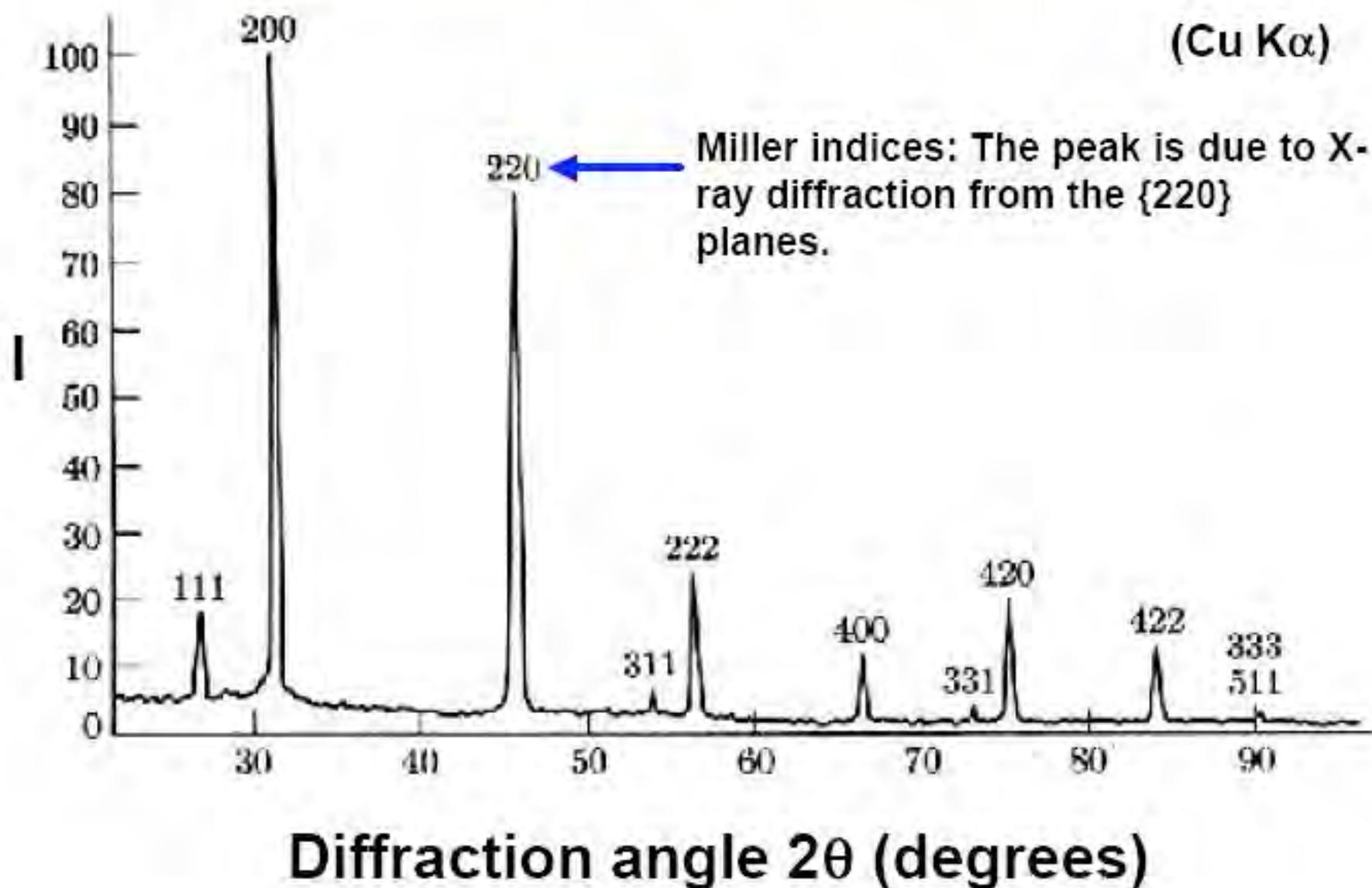
# Schematic of a XRD diffractometer



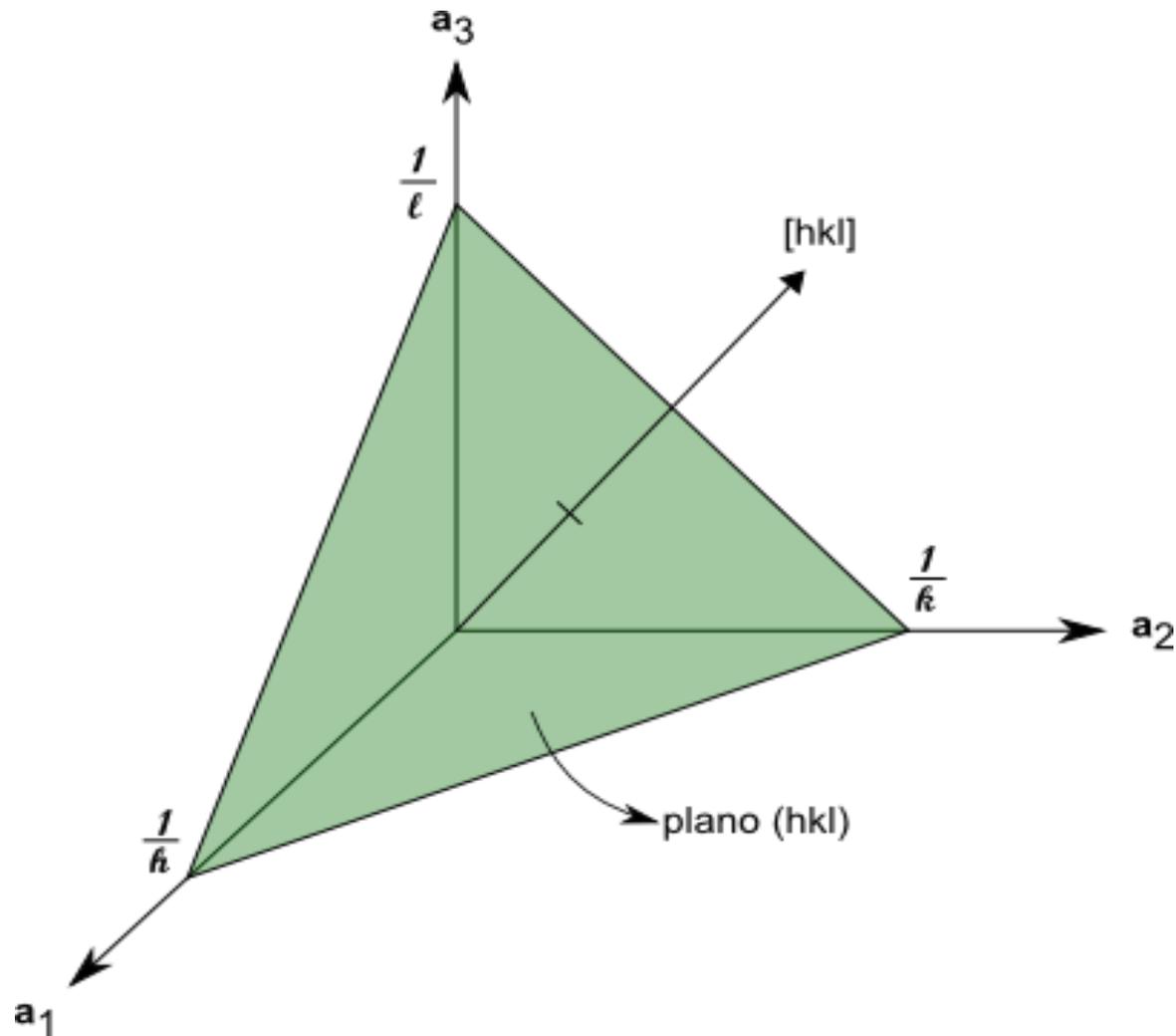
# X-ray Diffractometer



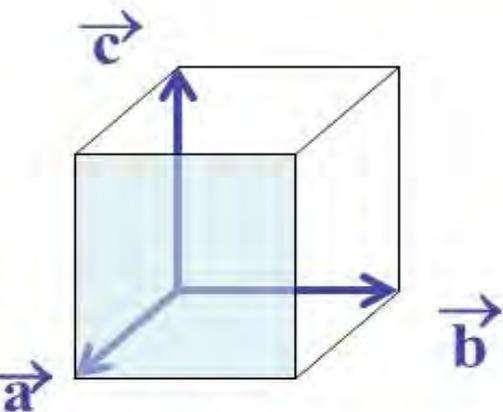
# XRD Pattern of NaCl Powder



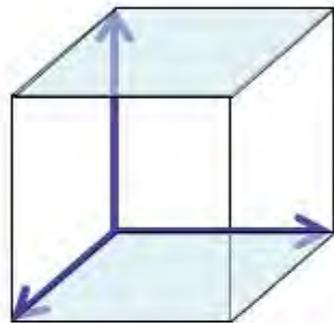
Miller indices (h, k, l):  
reciprocal of intercepts with cell axis



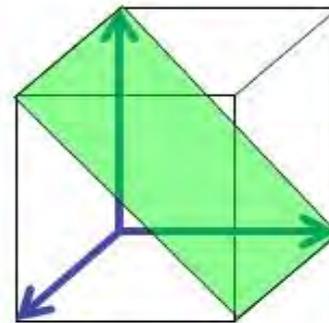
# Miller indices



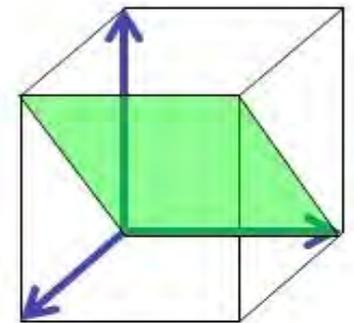
(1 0 0)



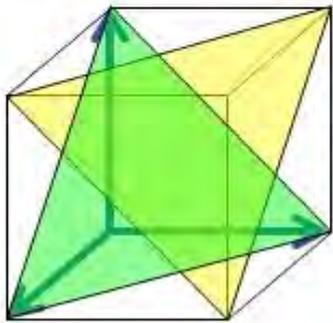
(0 0 1)



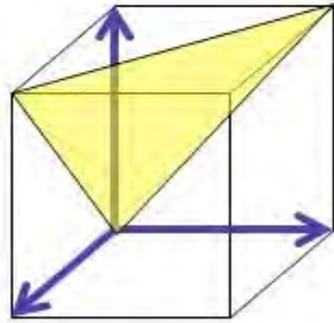
(0 1 1)



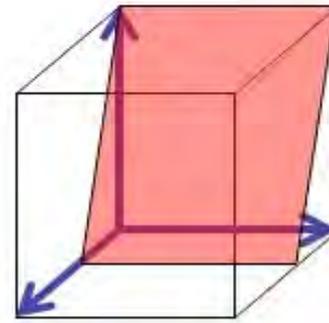
(-1 0 1)



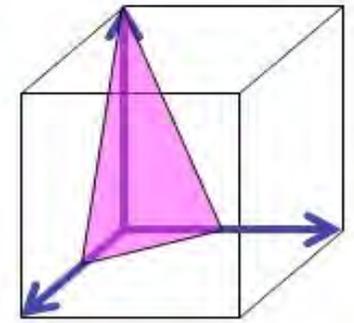
(1 1 1)



(1 1 -1)



(2 0 1)



(2 2 1)

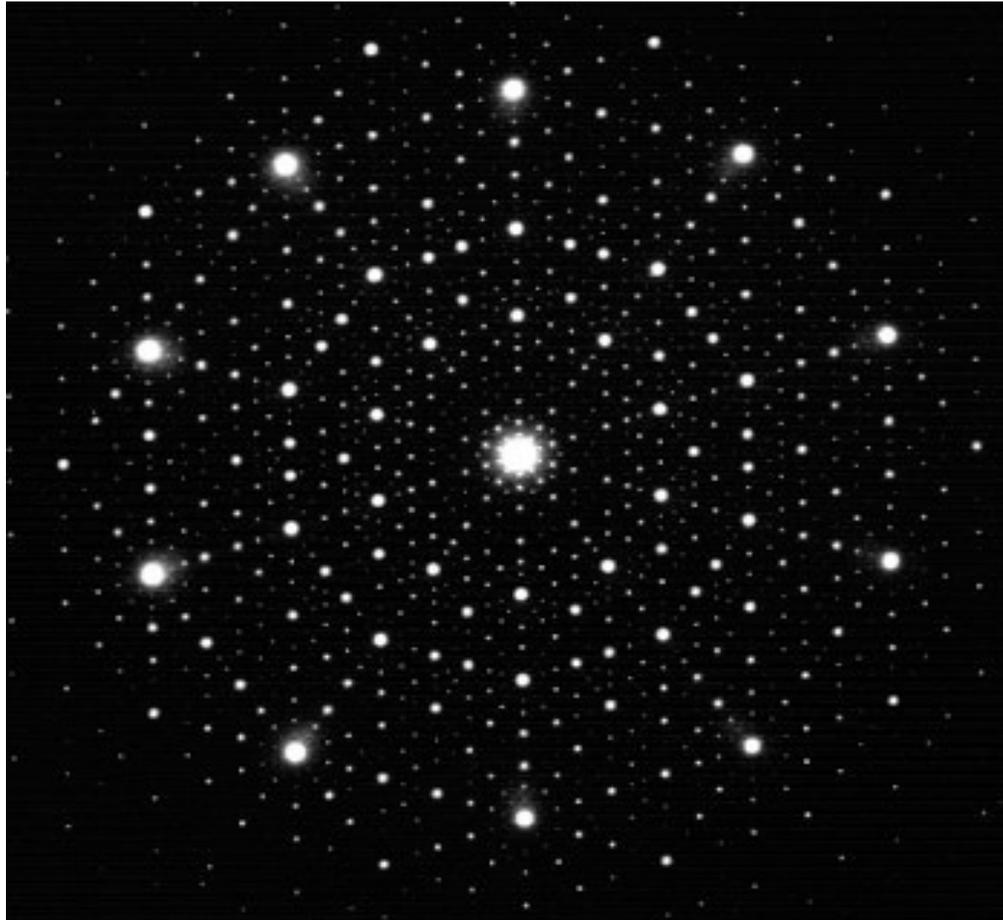
# JCPDS Card

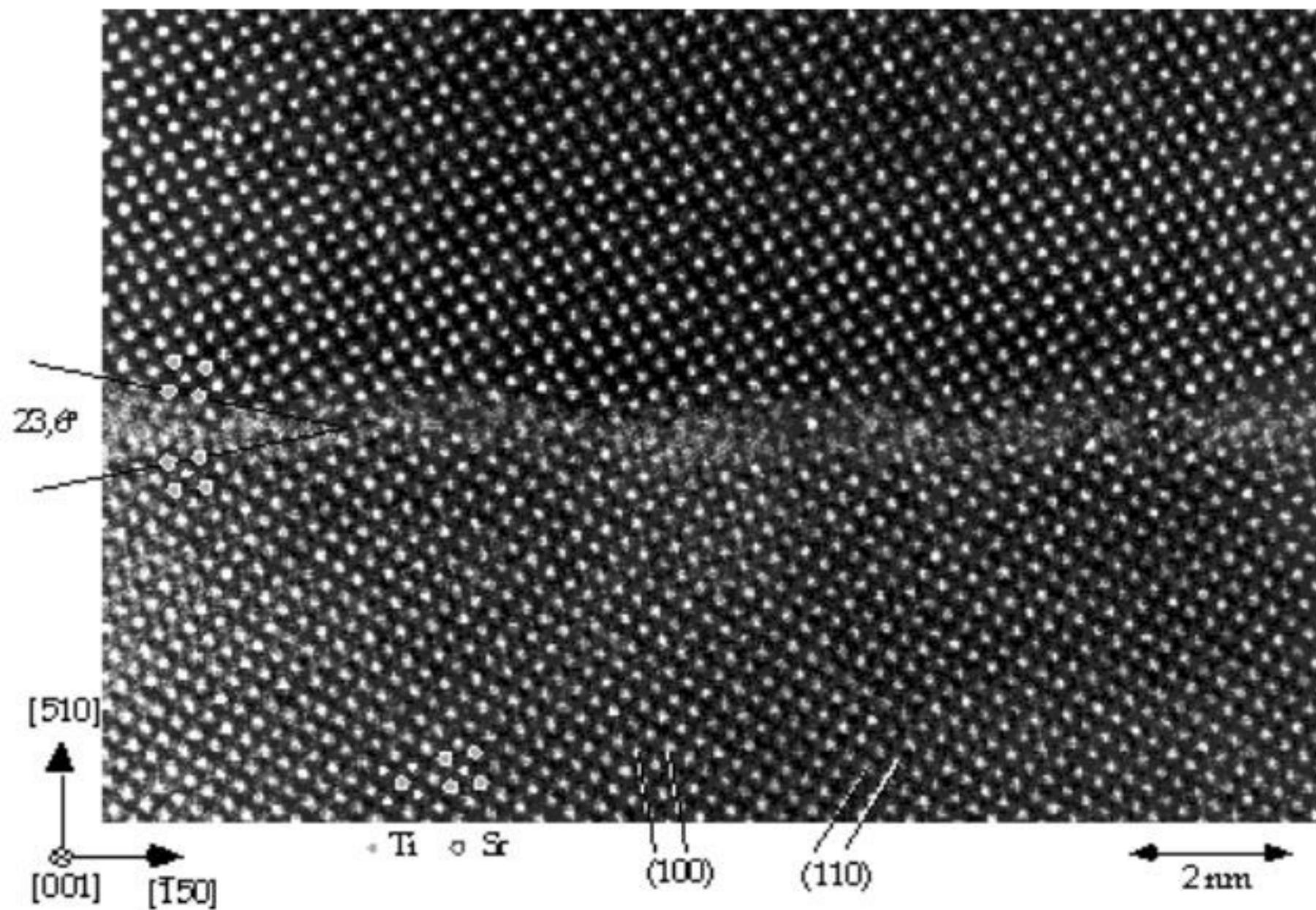
27-204

i

DyScO <sub>3</sub>	d Å	Int	hkl	d Å	Int	hkl
Dysprosium Scandium Oxide	3.94	20	110			
	3.52	6	111			
	2.859	25	020			
	2.790	100	112			
	2.720	25	200			
	2.686	8	021			
	2.344	6	211			
	2.314	10	022			
	2.241	12	202			
	2.188	8	113			
	1.971	35	004			
	1.934	8	023			
	1.911	16	221			
	1.764	12	114			
	1.752	25	131			
	1.636	10	132			
	1.623	10	024			
	1.596	16	204			
	1.583	30	312			
	1.484	10	133			
	1.405	4	041			
	1.394	6	224			
	1.247	16	116			
<b>Rad.</b> CuKα <sub>1</sub> <b>λ</b> 1.54056 <b>Filter</b> Monò. <b>d-sp</b> <b>Cut off</b> <b>Int.</b> Diffractometer <b>V<sub>cor.</sub></b> 2.60 <b>Ref.</b> Price, McCarthy, Penn State University, University Park, Penn- sylvania, USA., <i>JCPDS Grant-in-Aid Report</i> , (1974)						
<b>Sys.</b> Orthorhombic <b>S.G.</b> Pbnm (62) <b>a</b> 5.440 <b>b</b> 5.713 <b>c</b> 7.887 <b>A</b> <b>C</b> <b>α</b> <b>β</b> <b>γ</b> <b>Z</b> 4						
<b>Ref.</b> Ibid.						
<b>D<sub>s</sub></b> 6.922 <b>D<sub>m</sub></b> <b>mp</b>						
<b>Color</b> White Prepared by heating (Dy <sub>2</sub> O <sub>3</sub> + Sc <sub>2</sub> O <sub>3</sub> ) in air at 1400 C for 96 hours with three intermediate regrindings. GdFeO <sub>3</sub> structure type. C.D. Cell: a = 5.713, b = 7.887, c = 5.440, a/b = 0.7244, c/b = 0.6897. S.G. = Pnma (62), F <sub>23</sub> = 19.2(0158,76), PSC: oP20.						

# Electron diffraction pattern





Ni

$(111)$

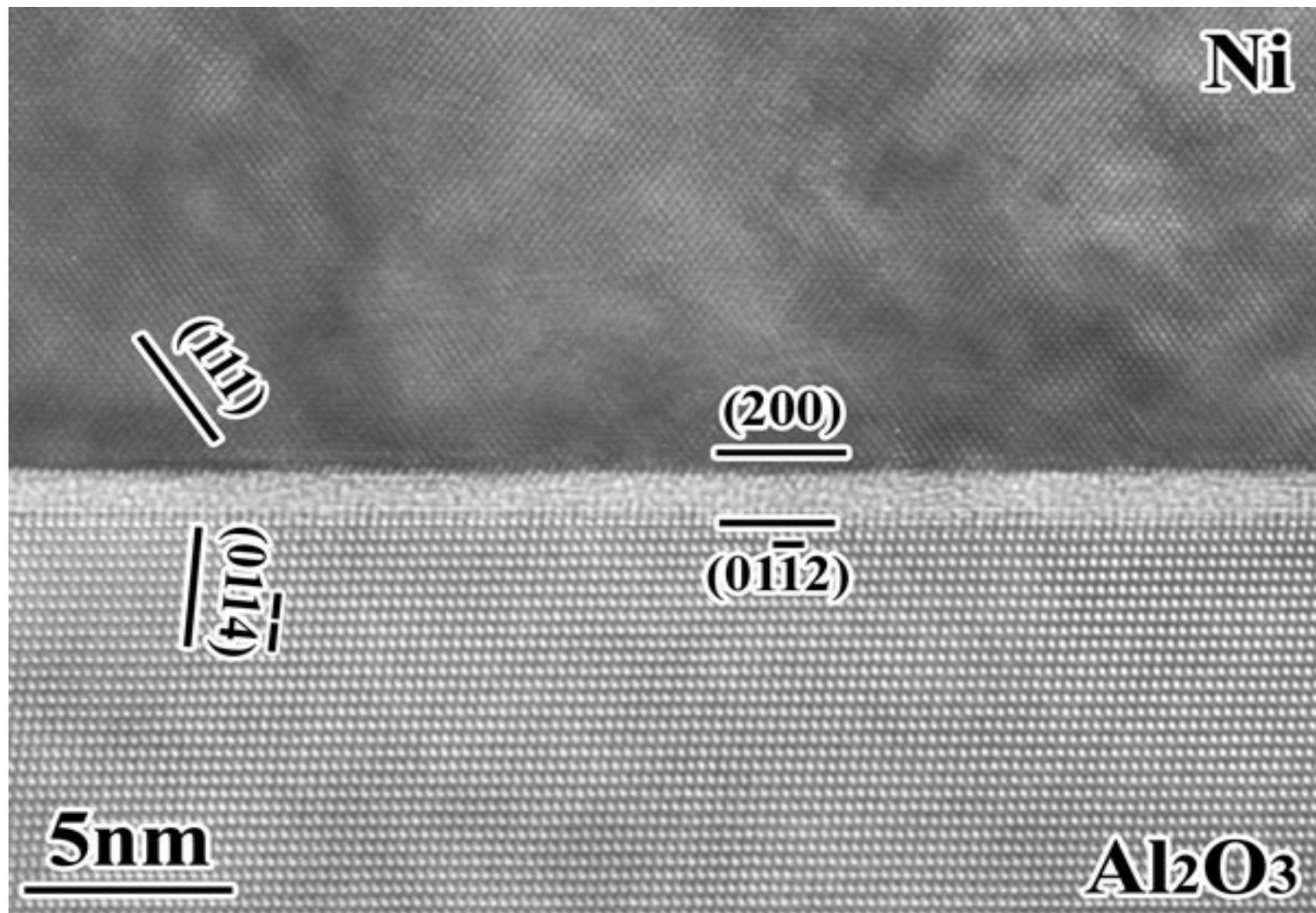
$(200)$

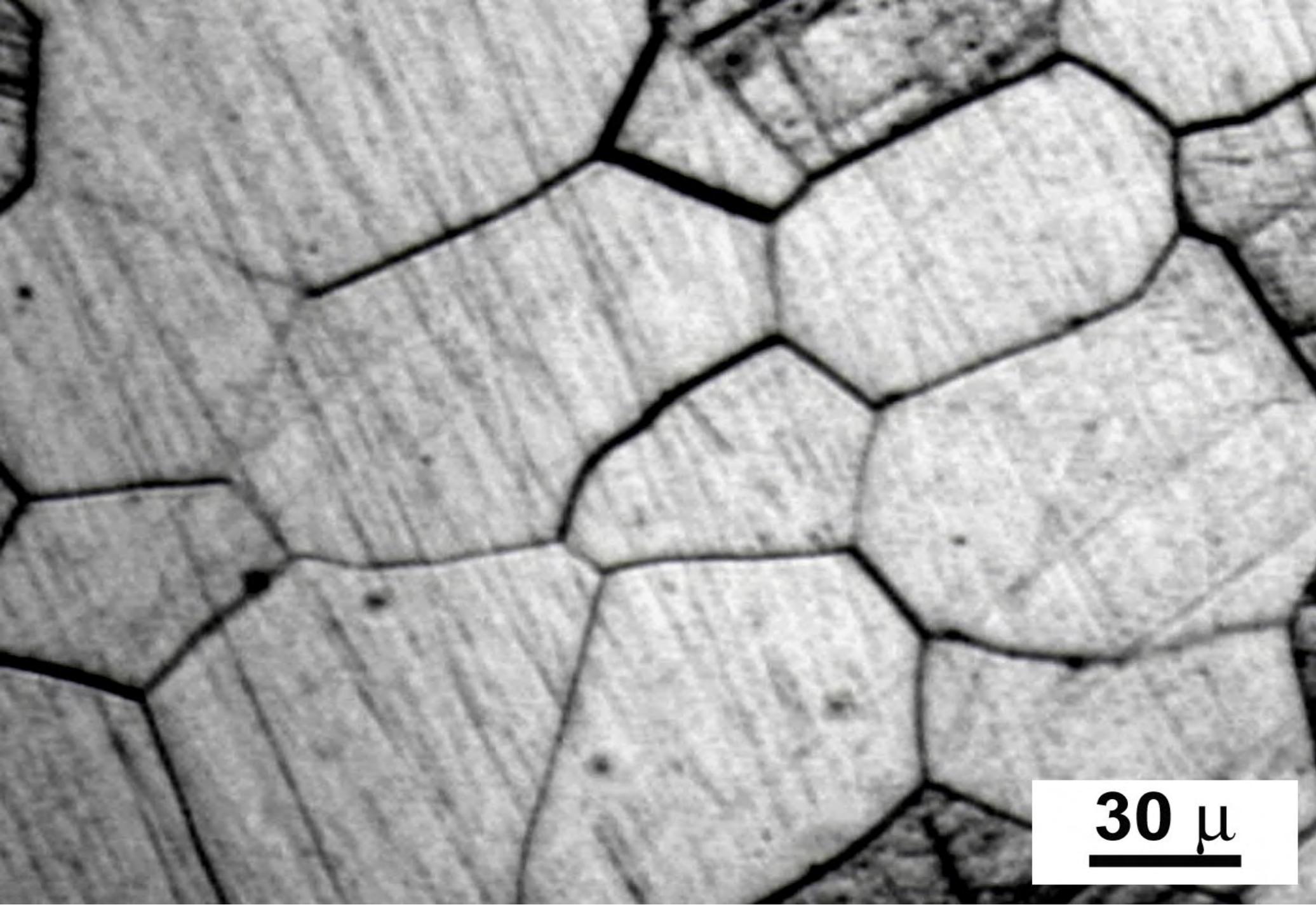
$(01\bar{1}4)$

$(01\bar{1}2)$

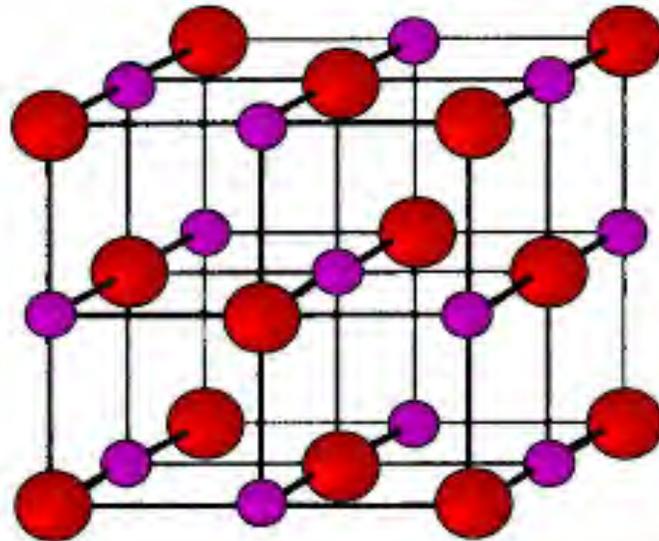
5nm

$\text{Al}_2\text{O}_3$

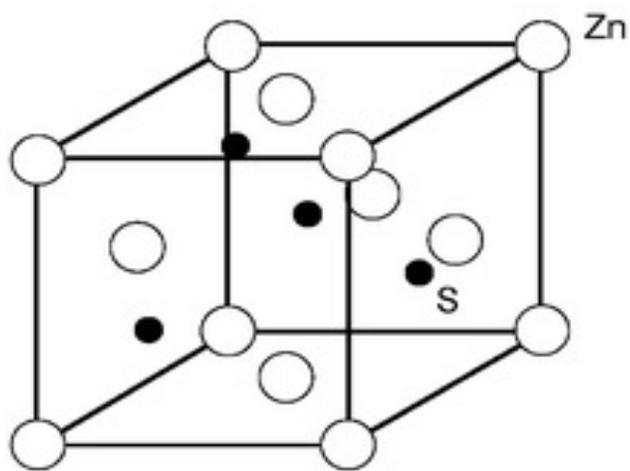




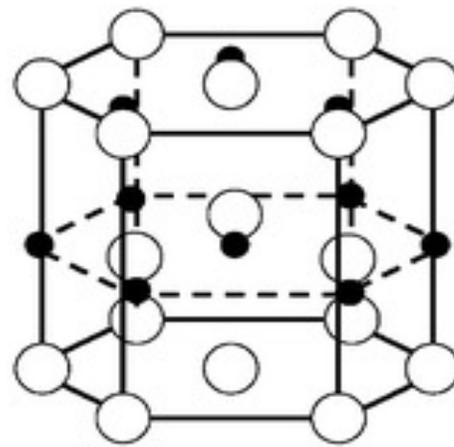
**30  $\mu$**



Rock Salt: MgO, CaO, NiO

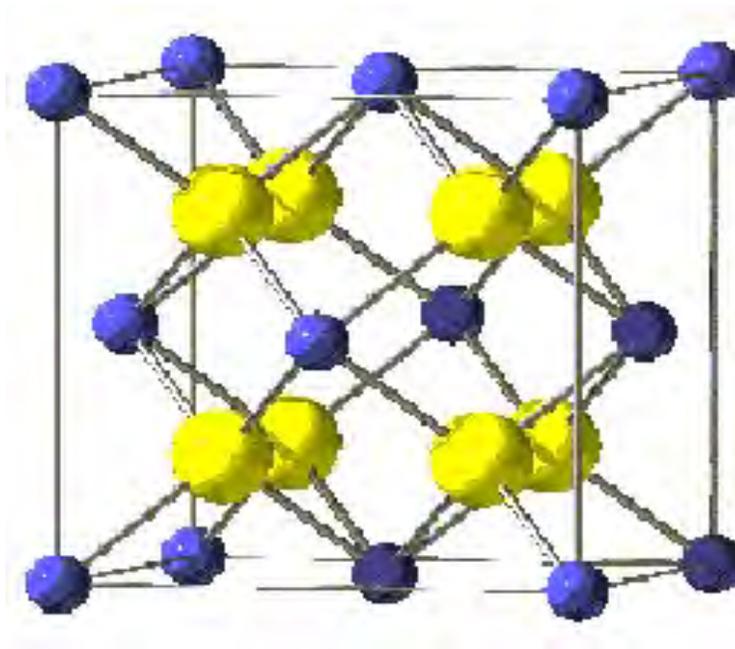


Zinc Blend



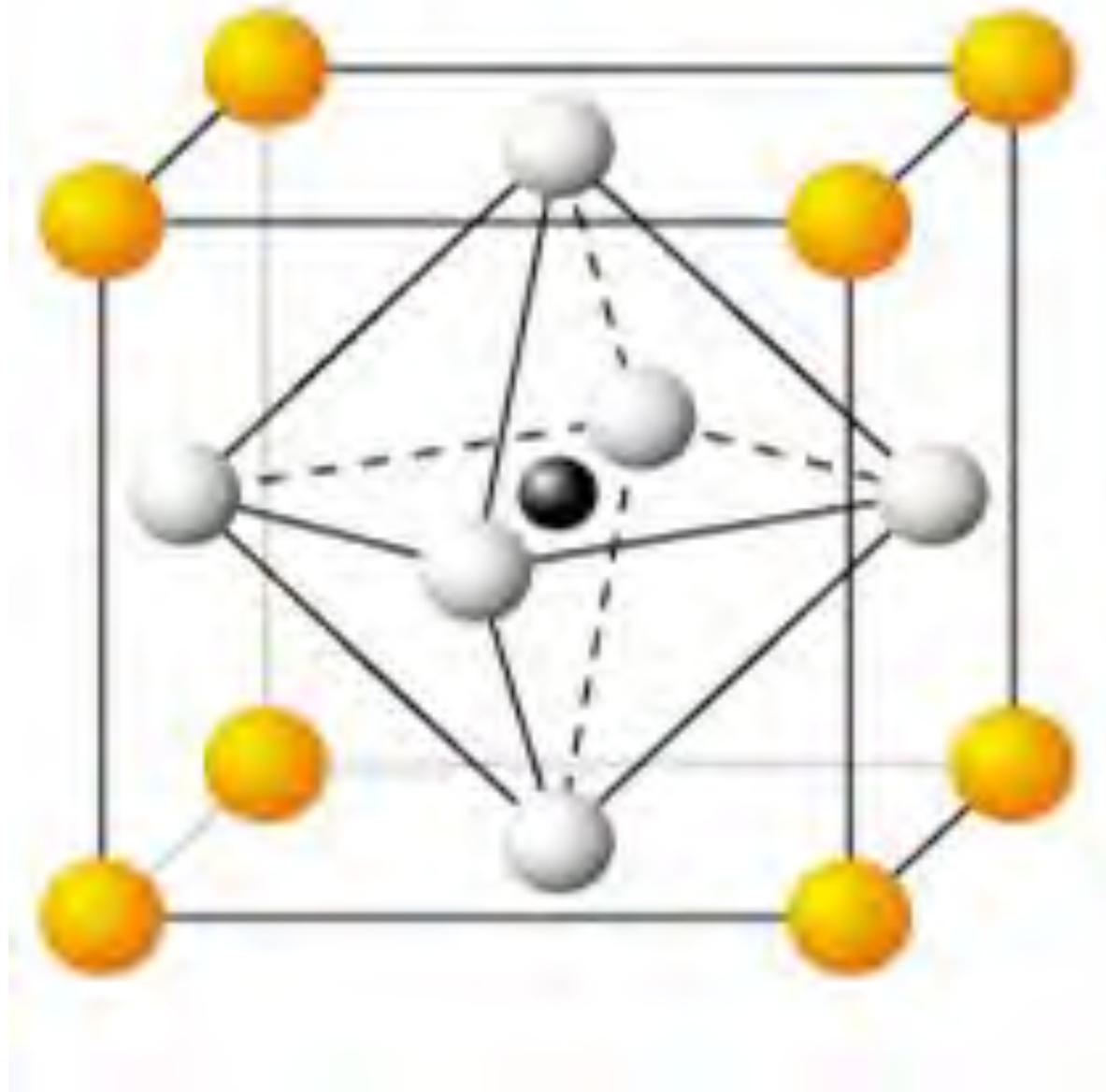
Wurtzite

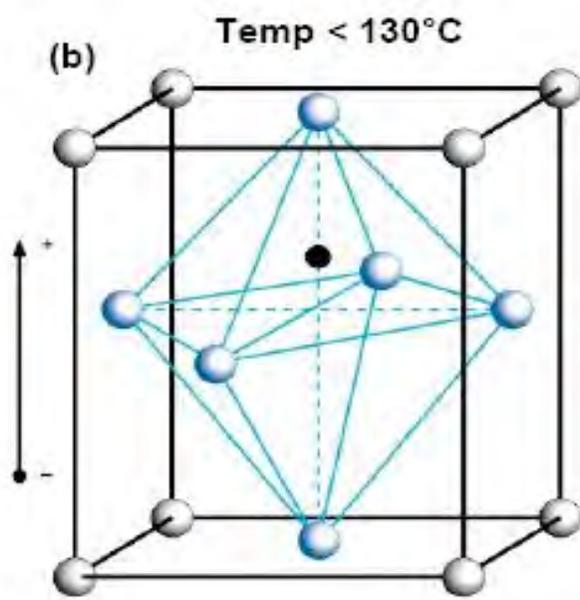
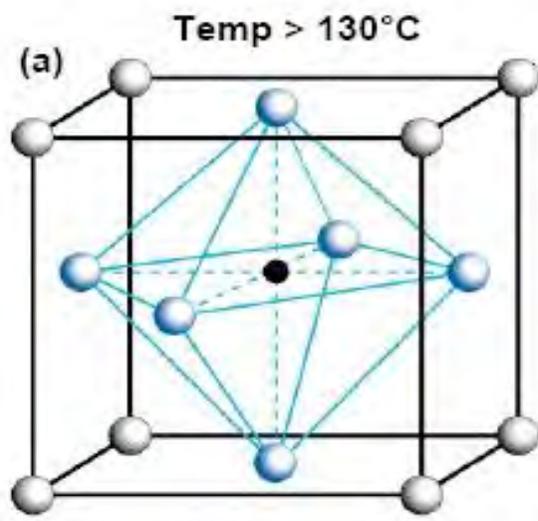
Zinc Blend and wurtzite: ZnO, SiC, BeO



Fluorite structure:  $\text{ZrO}_2$ ,  $\text{CeO}_2$ ,  $\text{UO}_2$

Perovskite

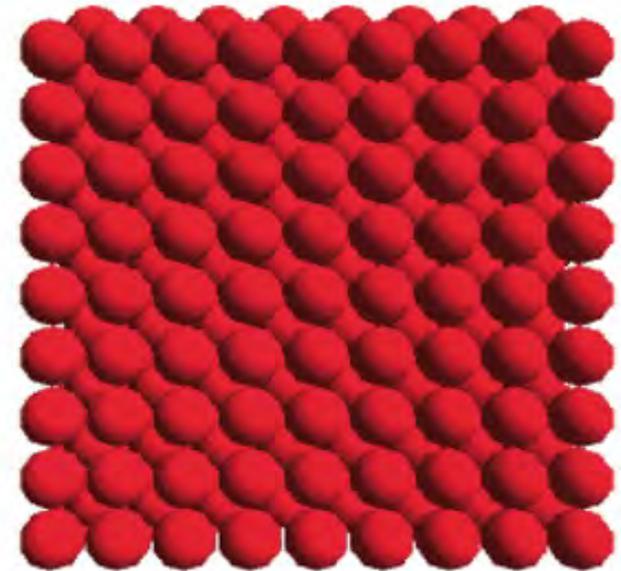
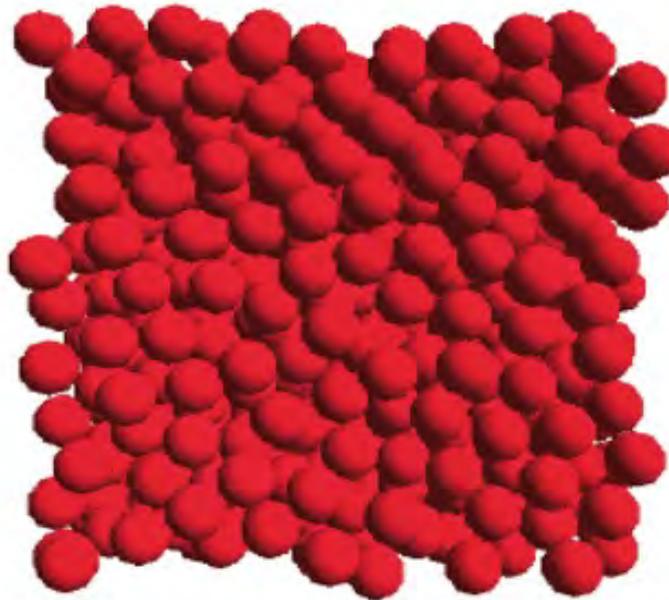
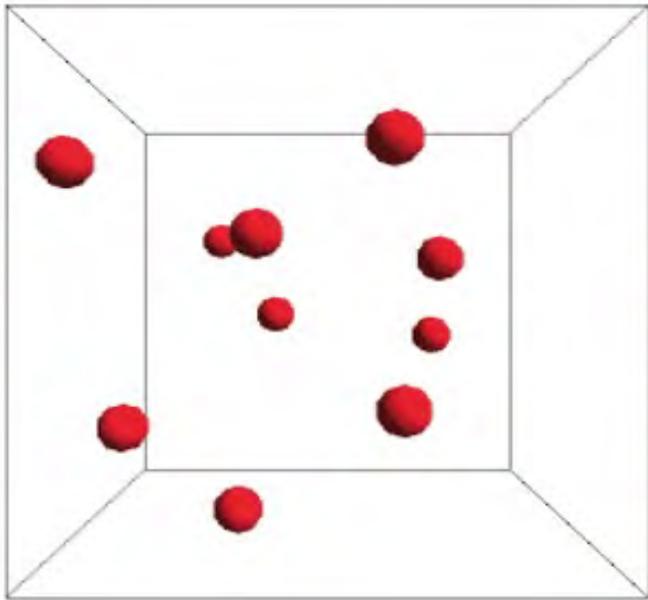




-  Ba<sup>2+</sup>
-  O<sup>2-</sup>
-  Ti<sup>4+</sup>



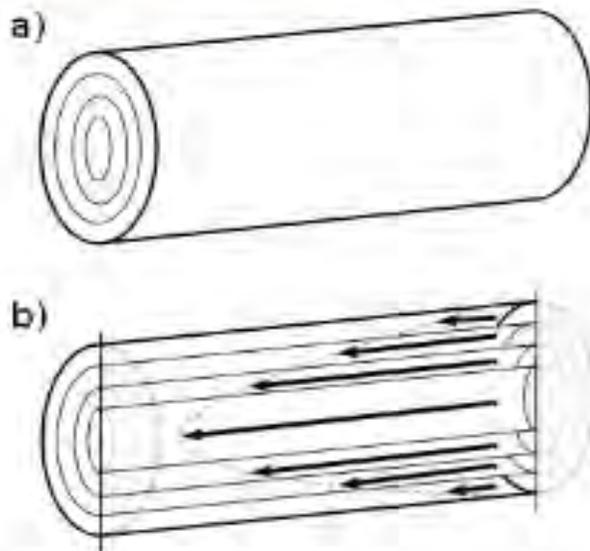
# Stato liquido: intermedio tra gas e solidi



# Legge di Poiseuille

- L'equazione di Poiseuille mette in relazione la differenza di pressione, condizione essenziale per il moto di un fluido, con le caratteristiche geometriche del condotto, la viscosità del liquido e la portata che risulta direttamente proporzionale alla differenza di pressione:

$$Q = \frac{\pi R^4}{8\eta L} (P_1 - P_2)$$



- La velocità è maggiore al centro del condotto e decresce a mano a mano che ci si avvicina alle pareti secondo un profilo parabolico.
- Il moto avviene in regime laminare.

# Tensione superficiale

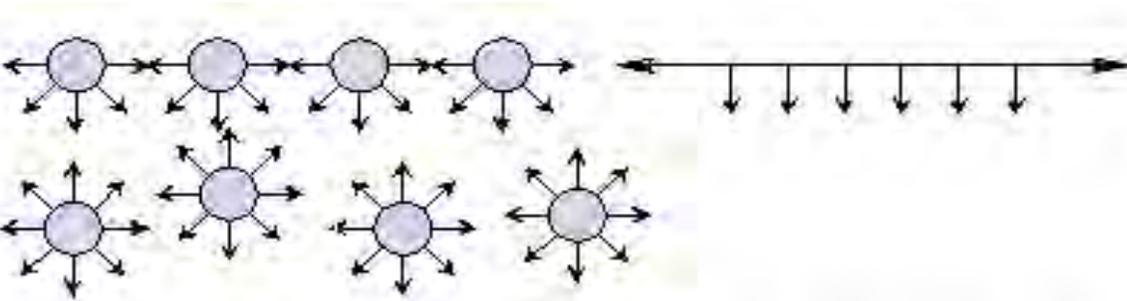


Figura 2 - Schema delle forze di attrazione fra le molecole di un liquido. Le molecole interne sono in equilibrio fra loro. Le forze che agiscono sulle molecole di superficie non sono invece equilibrate verso l'alto e da ciò risulta una compressione verso l'interno. Inoltre, la coesione fra le molecole determina una tensione tangenziale alla superficie. La superficie di un liquido si comporta quindi come una membrana elastica.



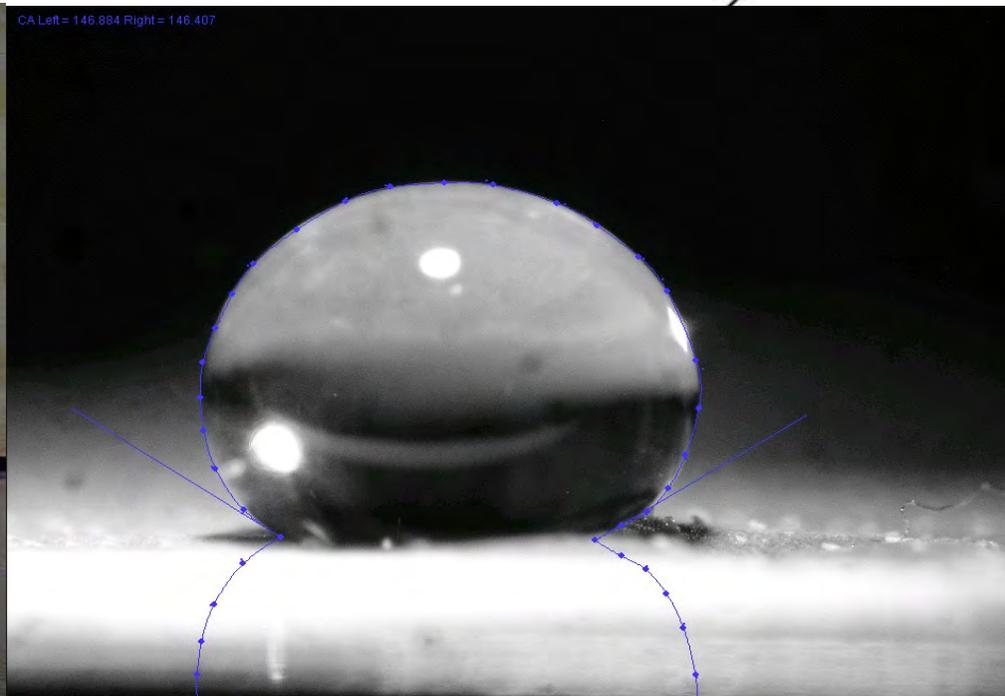
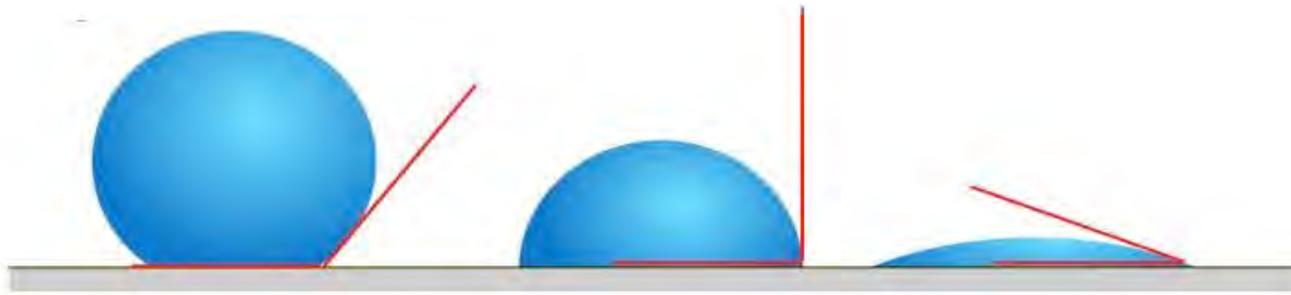
$$\theta > 90$$

*Negligible wetting*  
(water  $\rightarrow$  hydrophobic)

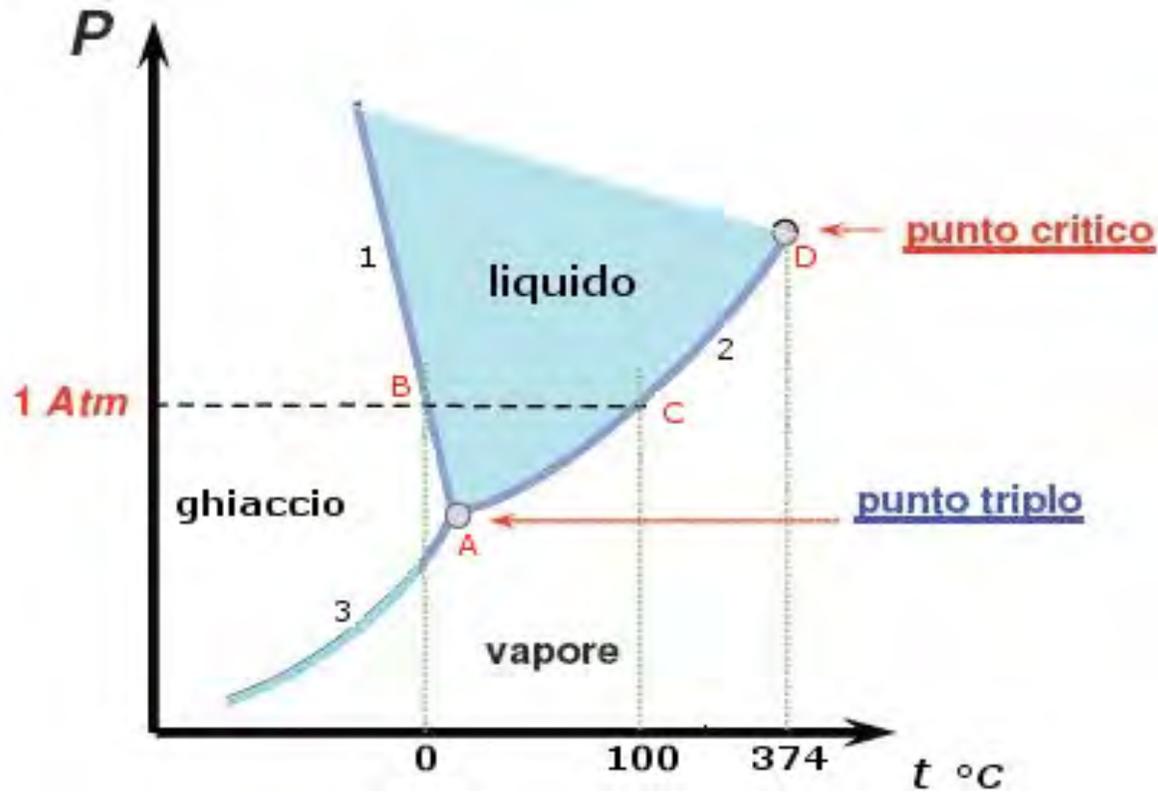
$$\theta = 90$$

$$\theta < 90$$

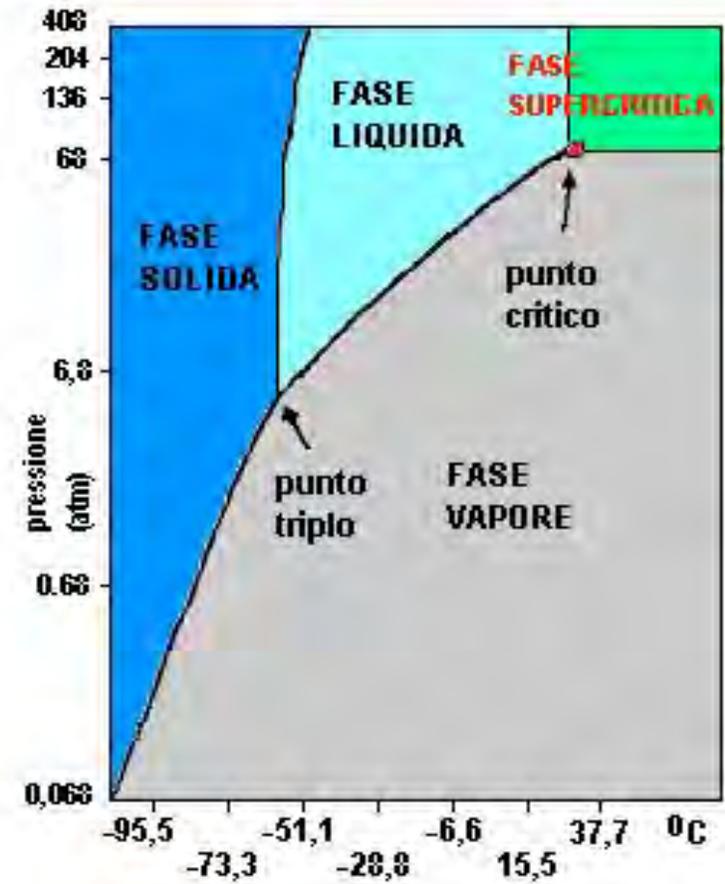
*Good wetting*  
(water  $\rightarrow$  hydrophilic)



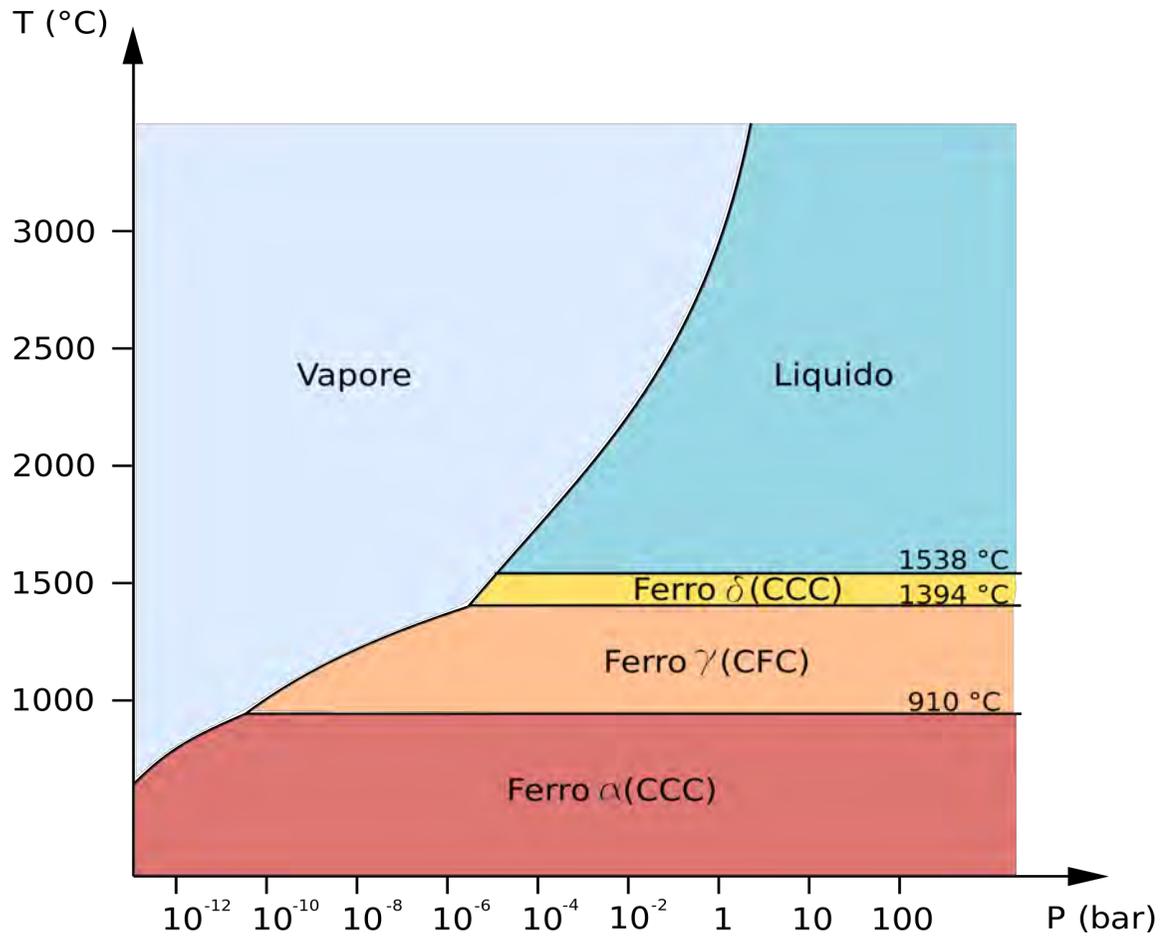
# H<sub>2</sub>O



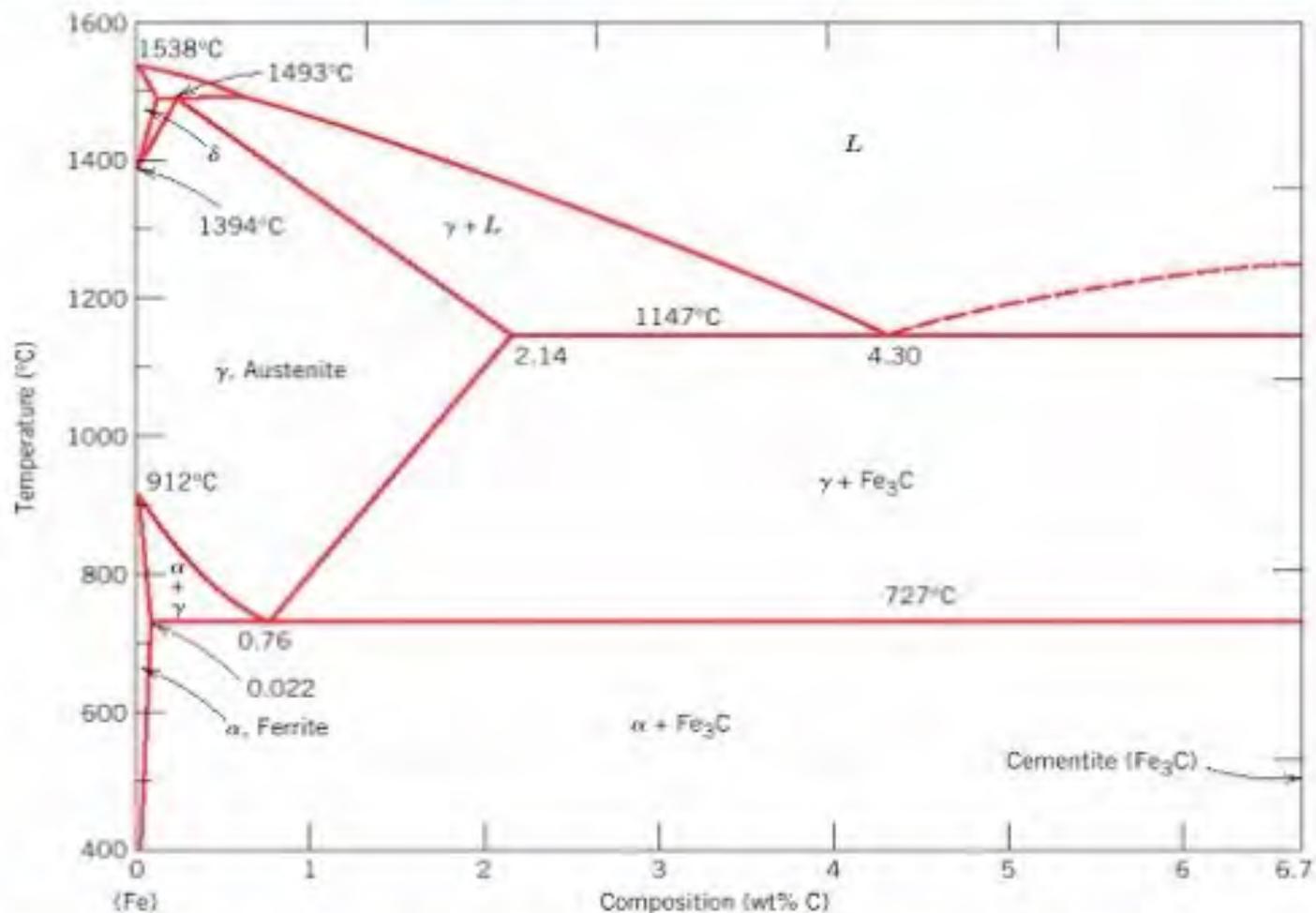
# CO<sub>2</sub>



# Fe

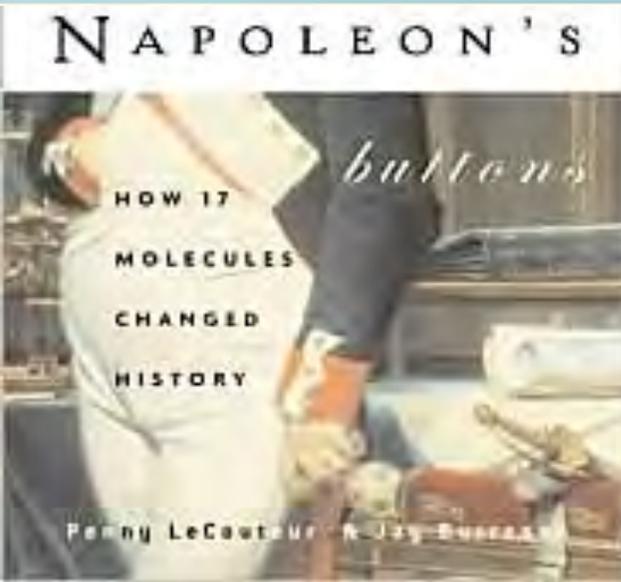
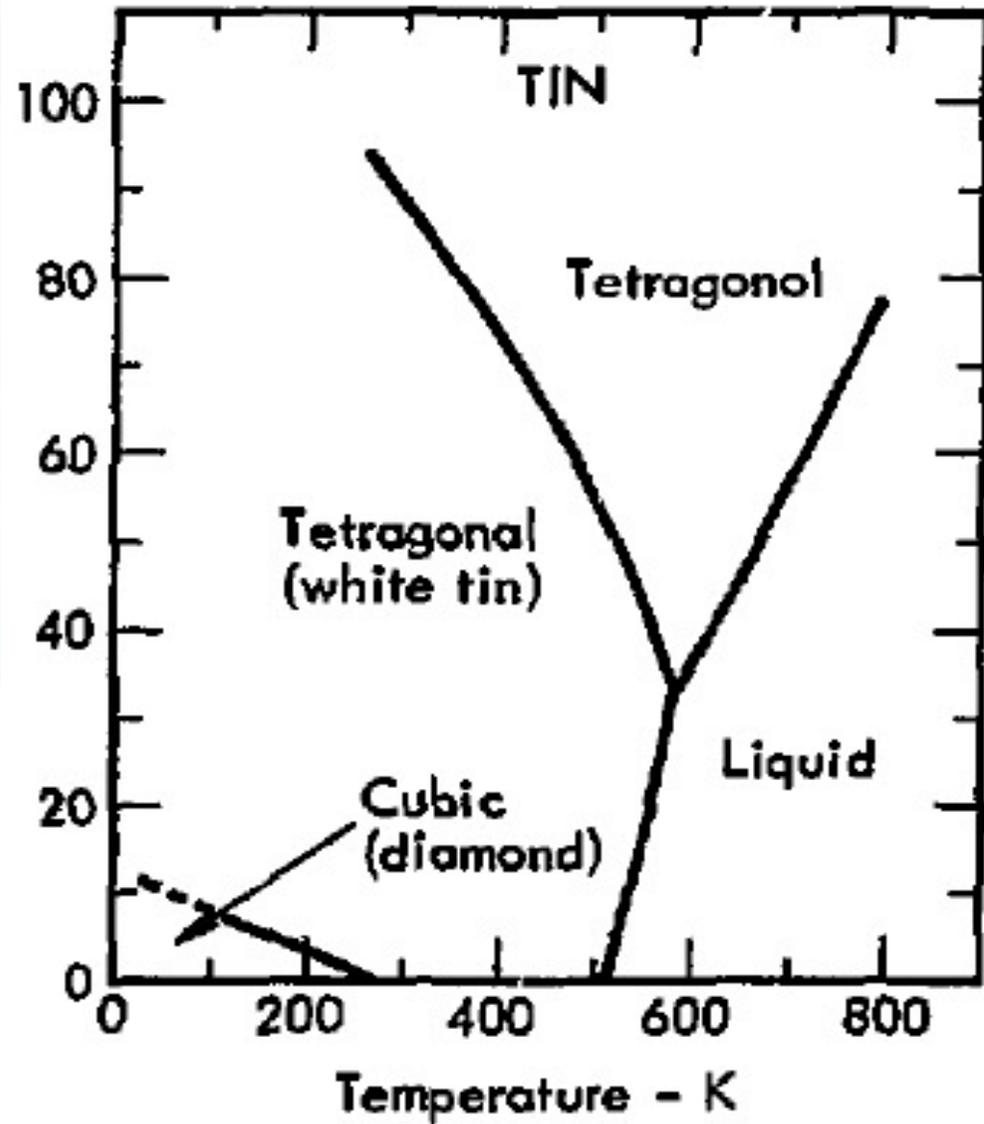


# The Iron–Iron Carbide (Fe–Fe<sub>3</sub>C) Phase Diagram

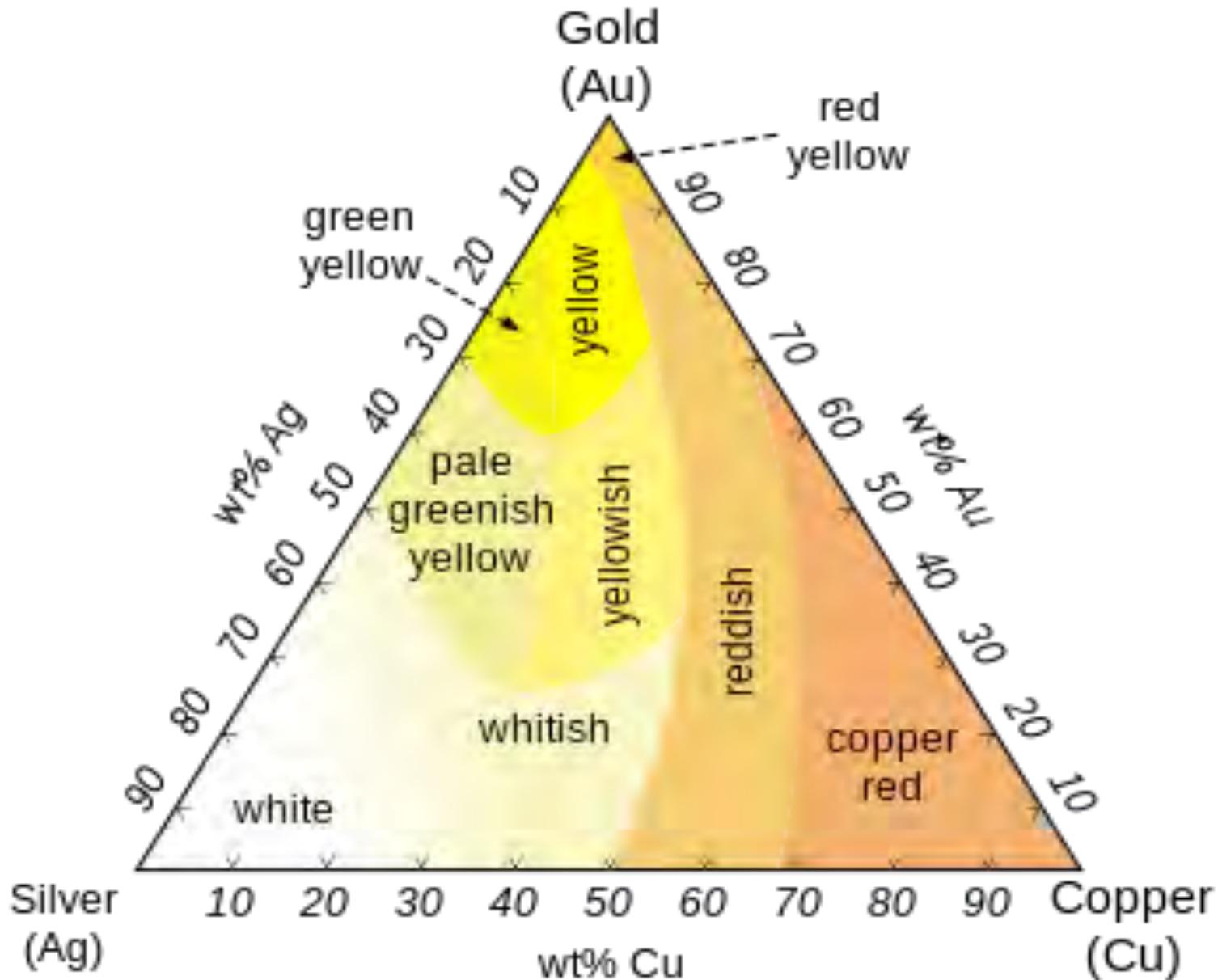


In their simplest form, steels are alloys of Iron (Fe) and Carbon (C).

# Tin pest



# Gold-copper-silver alloys



# Mechanical properties of Gold alloys

Carat	Composition %, wt.		Condition	Hardness HV	Tensile Strength N/mm <sup>2</sup>
	Silver	Copper			
24	-	-	Annealed	20	45
			Worked	55	200
22	5.5	2.8	Annealed	52	220
			Worked	138	390
	3.2	5.1	Annealed	70	275
			Worked	142	463
21	4.5	8.0	Annealed	100	363
			Worked	190	650
	1.75	10.75	Annealed	123	396
			Worked	197	728
18	12.50	12.5	Annealed	150	520
			Worked	212	810
	4.5	20.5	Annealed	165	550
			Worked	227	880

**24 carat = 100% gold**

**22 carat = 91,67 %**

**18 carat = 75% gold**

# Espressioni per la composizione di soluzioni

Frazione molare

$$X_1 = \frac{n_1}{n_1 + n_2}$$

$$X_2 = \frac{n_2}{n_1 + n_2} = 1 - X_1$$

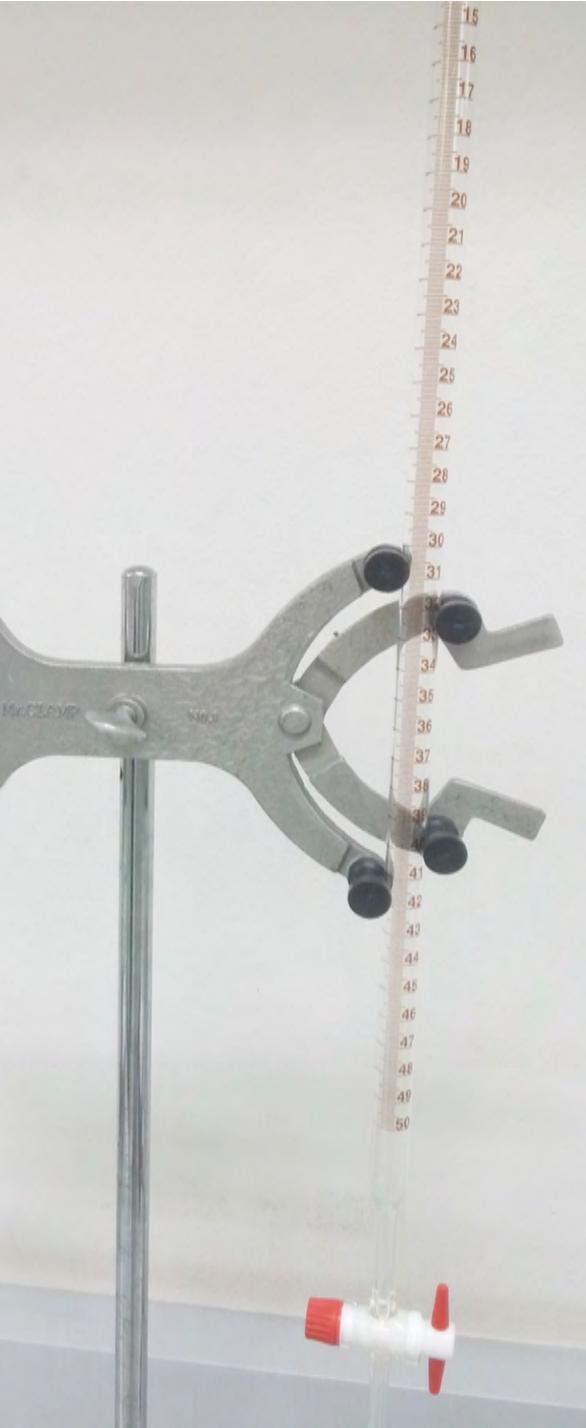
$$\text{molarità} = \frac{\text{moli di soluto}}{\text{litri di soluzione}} = \text{mol L}^{-1}$$

$$\text{molalità} = \frac{\text{moli di soluto}}{\text{chilogrammi di solvente}} = \text{mol kg}^{-1}$$

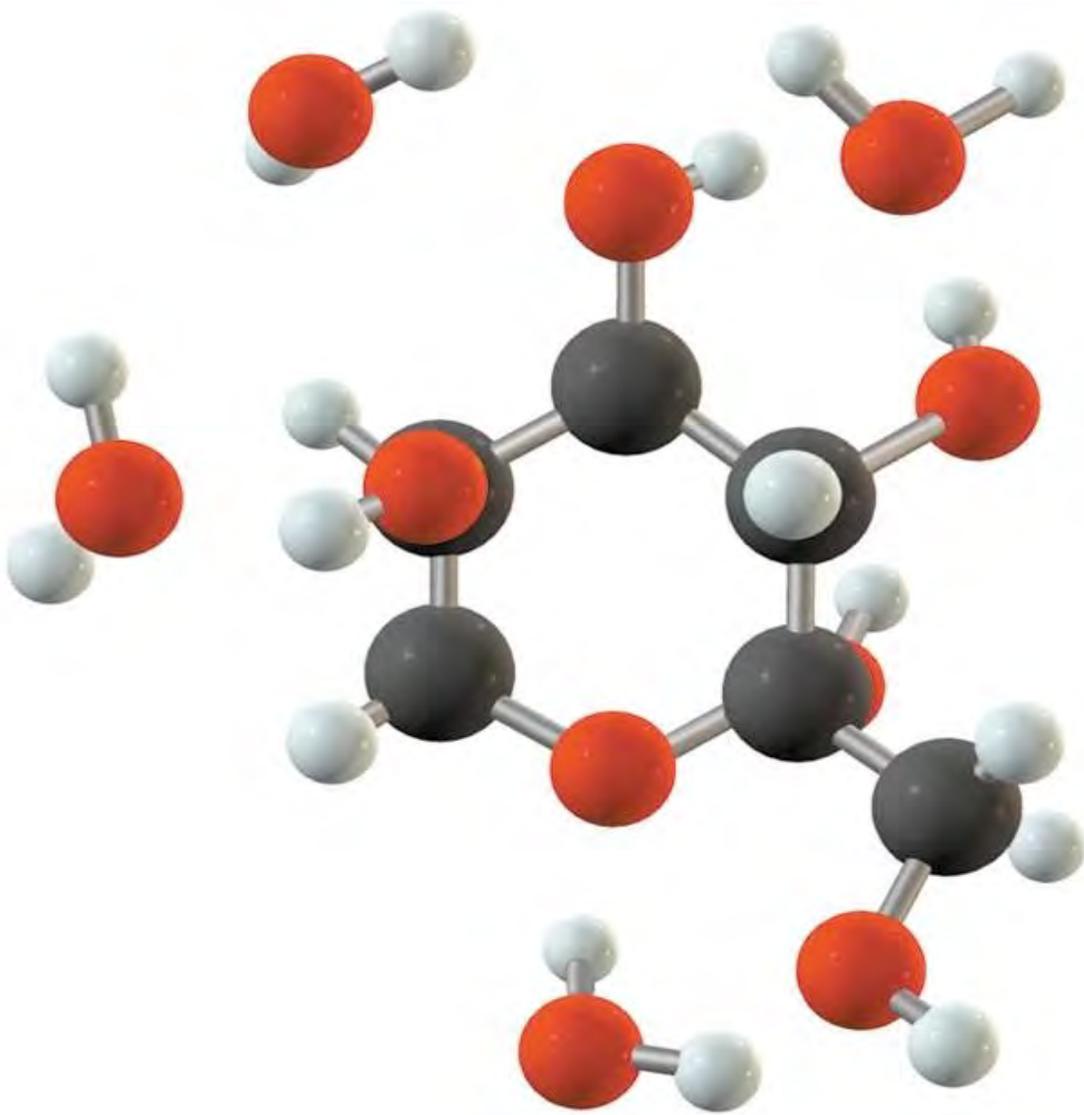
# Flasks



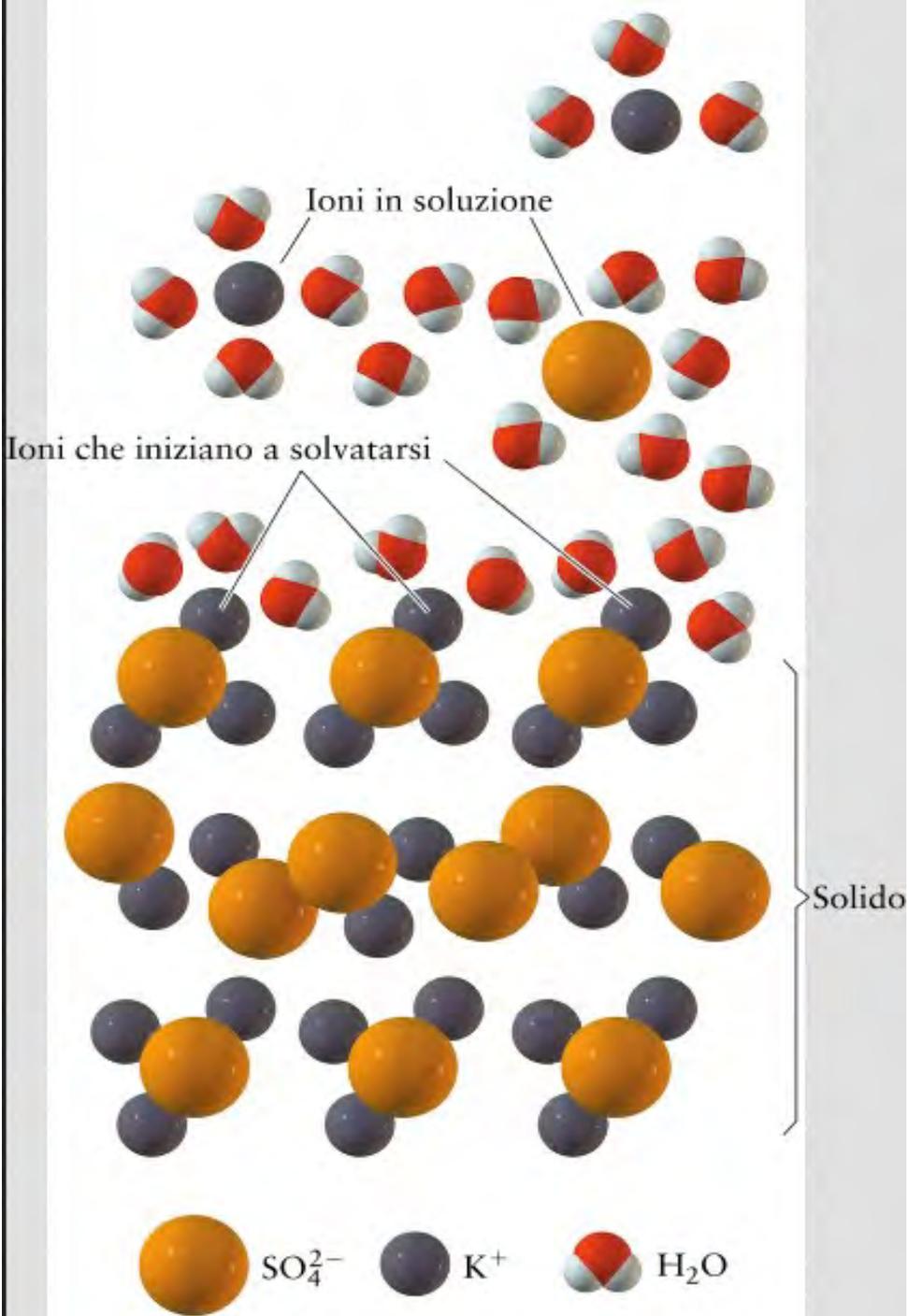
# Burette



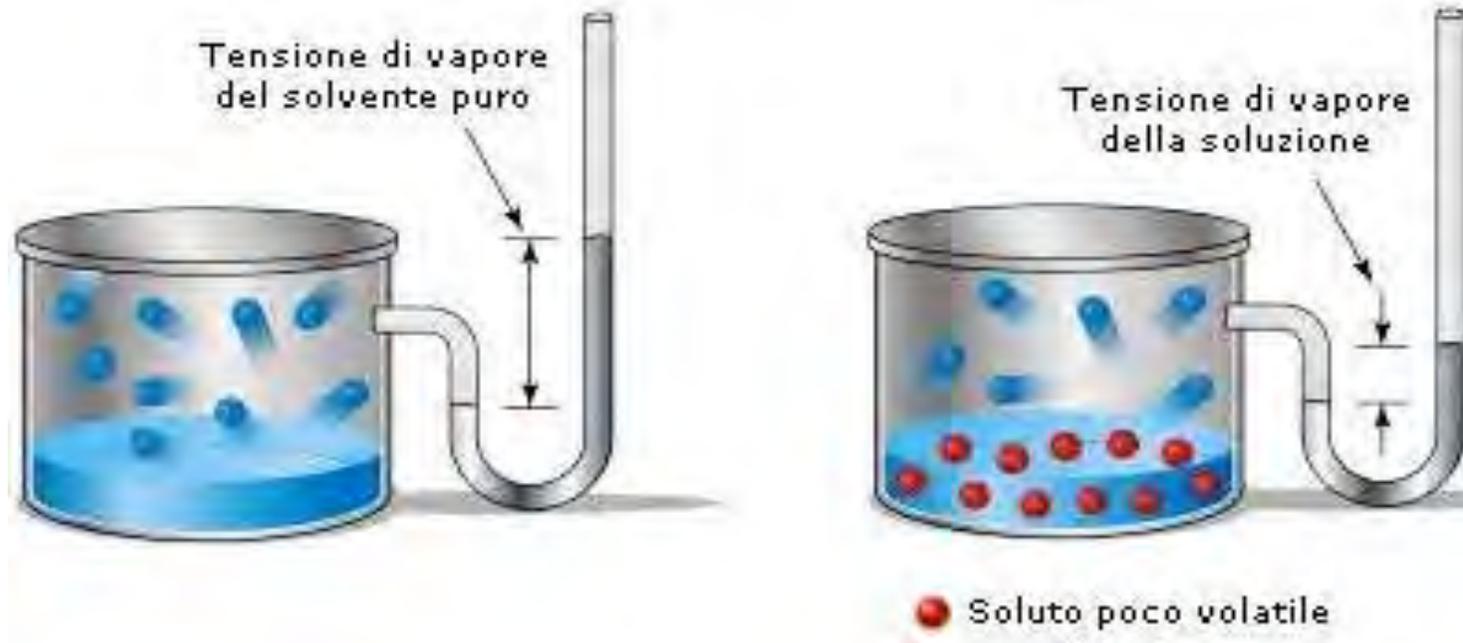
# Soluti molecolari



# Soluzioni ioniche



# Legge di Raoult

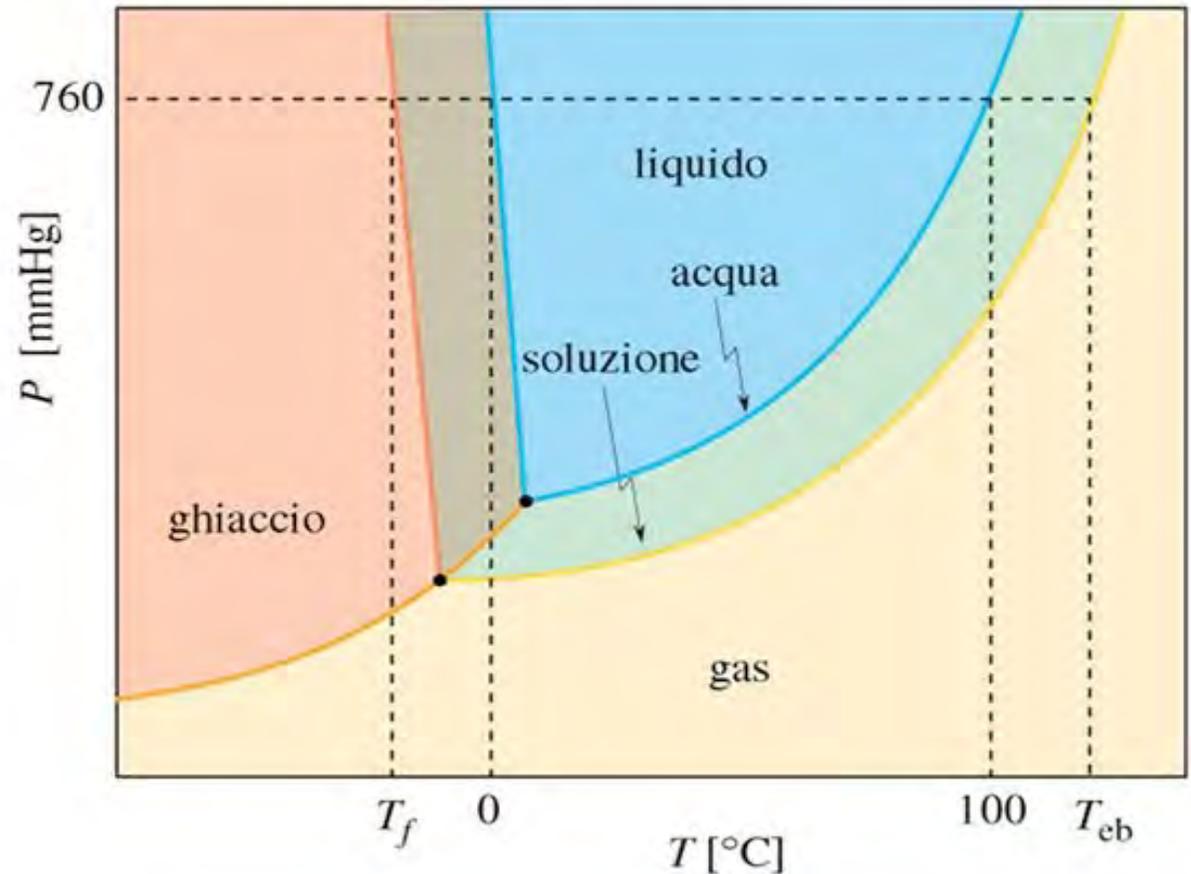


$$P_i = x_i P_i^*$$

# Innalzamento ebullioscopico

## Abbassamento crioscopico

L'aggiunta di un soluto ad un solvente fa aumentare la  $T_{eb}$  della soluzione e fa diminuire la  $T_f$  rispetto ai valori del solvente puro



# Innalzamento ebullioscopico e Abbassamento crioscopico

Dalla legge di Raoult si puo' ricavare:

$$\Delta T_{\text{eb}} = K_{\text{eb}} C_m$$

Le costanti  $K_{\text{eb}}$  e  $K_{\text{cr}}$  sono caratteristiche di ogni dato solvente e non variano al variare del soluto fino a che la soluzione si comporta come una soluzione ideale

$$\Delta T_{\text{cr}} = K_{\text{cr}} C_m$$

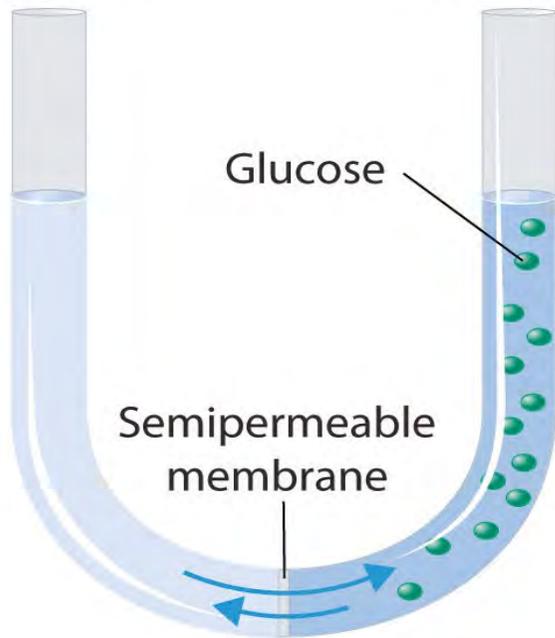
Tabella 12.4 Costanti erioscopiche ed ebullioscopiche molali

solvente	$T_{\text{eb}}$ (°C)	$K_{\text{eb}}$ (K kg mol <sup>-1</sup> )	$T_f$ (°C) (K kg mol <sup>-1</sup> )	$K_{\text{cr}}$
H <sub>2</sub> O	100,0	0,52	0,0	1,86
CHCl <sub>3</sub>	61,7	3,63	-63,5	4,70
C <sub>6</sub> H <sub>6</sub>	80,1	2,53	5,5	5,12
(C <sub>2</sub> H <sub>5</sub> ) <sub>2</sub> O	34,5	2,02	-116,2	1,79
CH <sub>3</sub> COOH	117,9	2,93	16,6	3,90

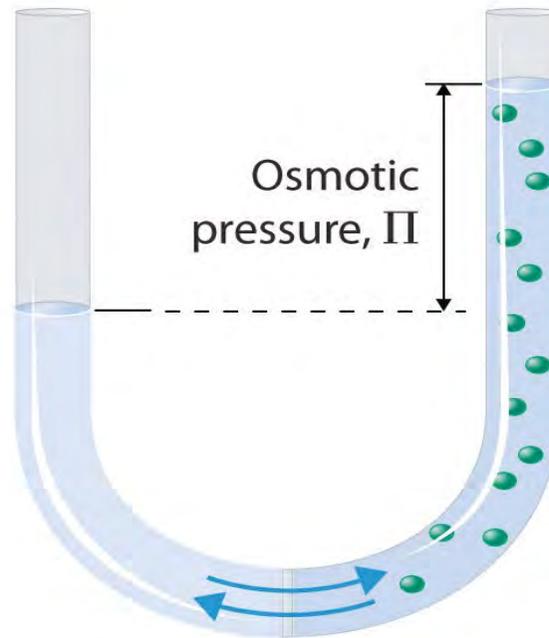
# Pressione osmotica

Pure water

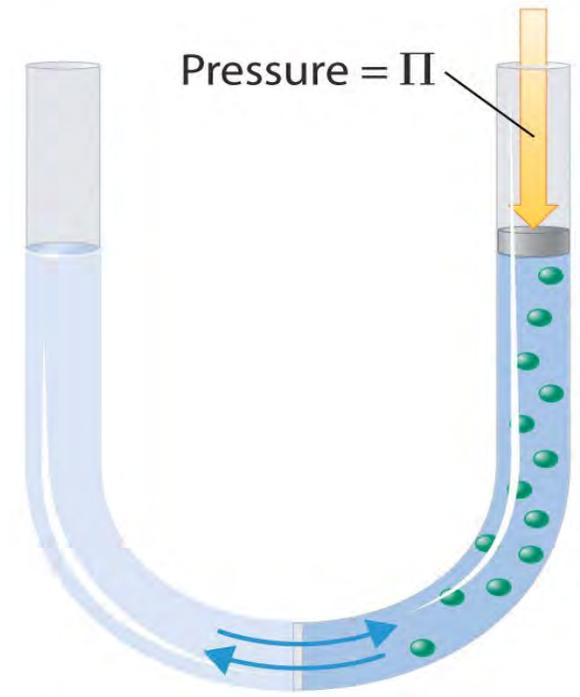
Solution



(a) Initial state



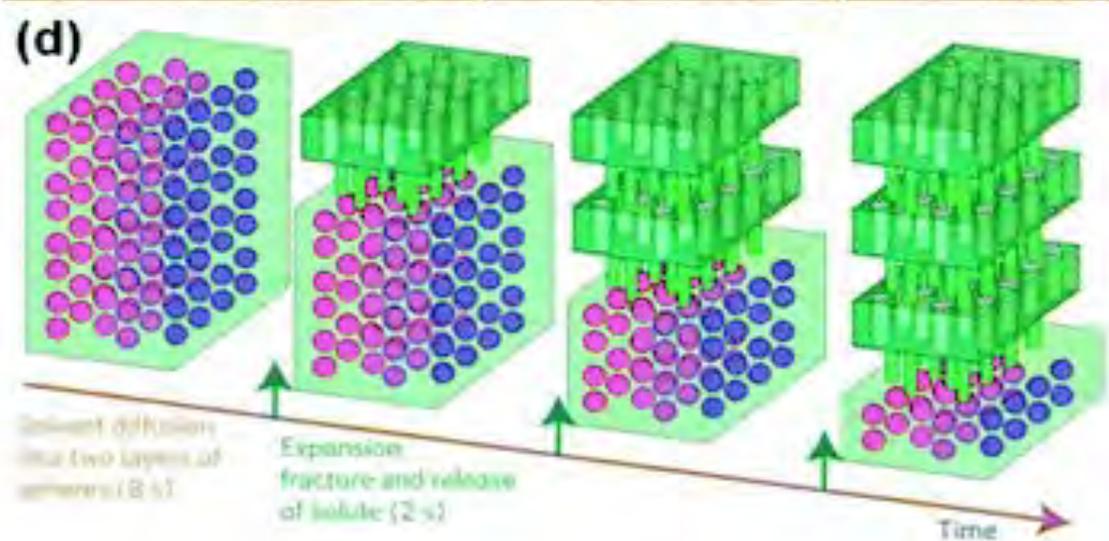
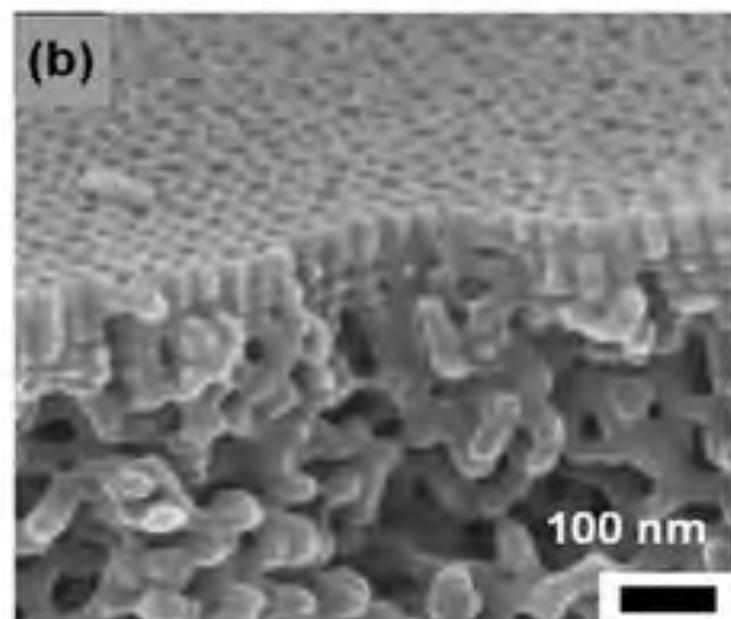
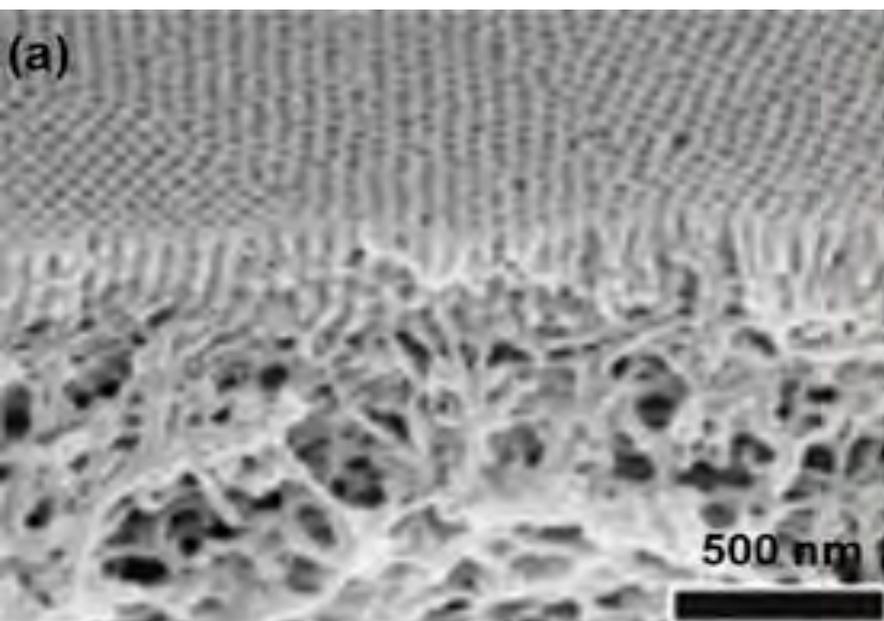
(b) Equilibrium



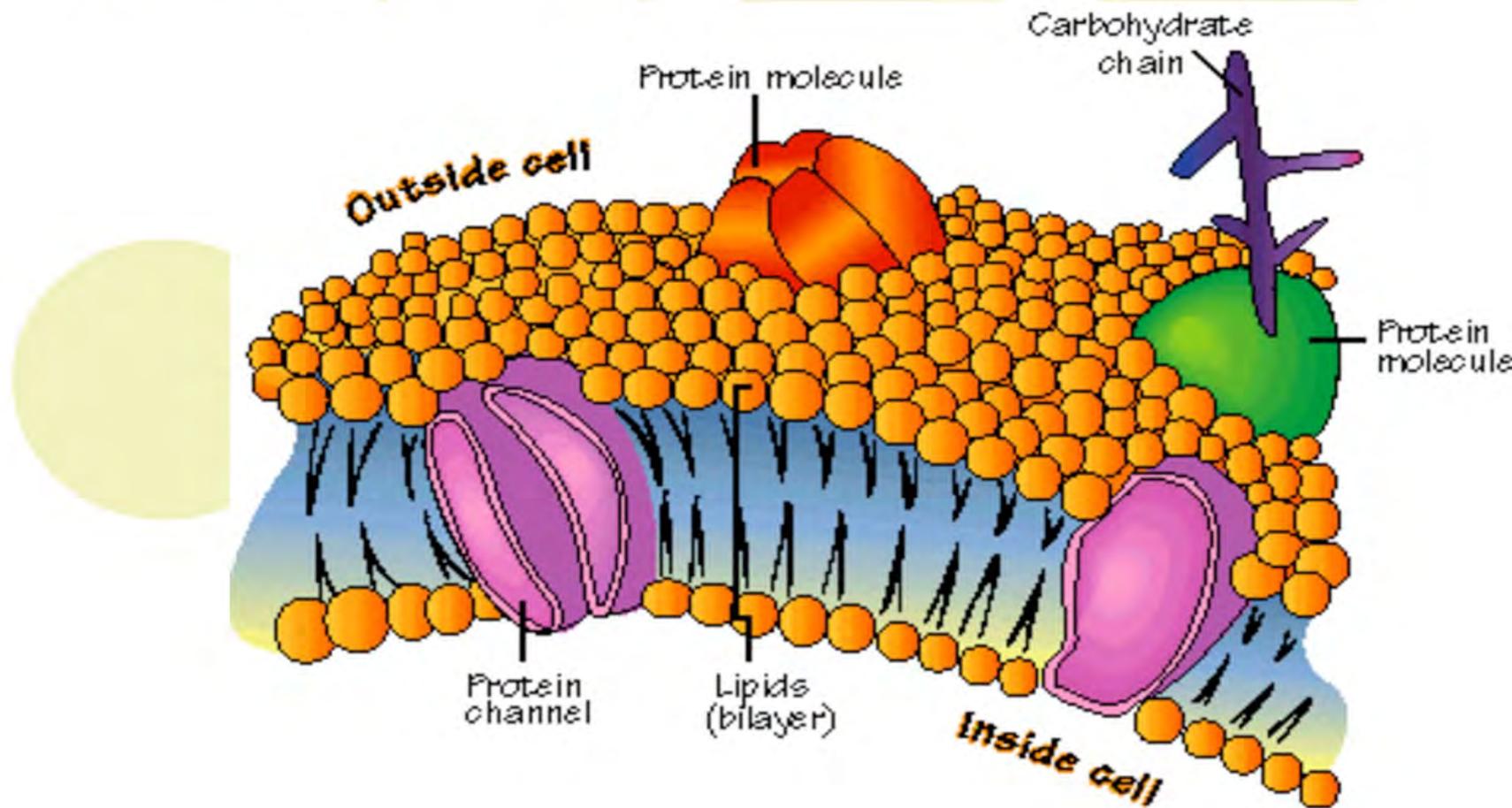
(c) External pressure applied

# Membrana semipermeabile

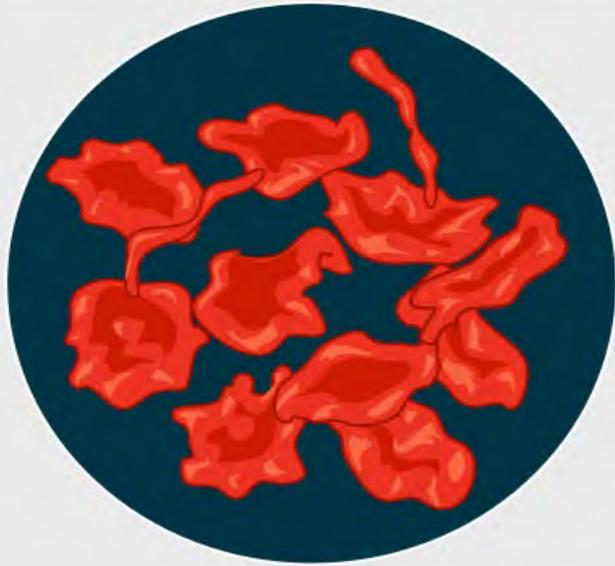




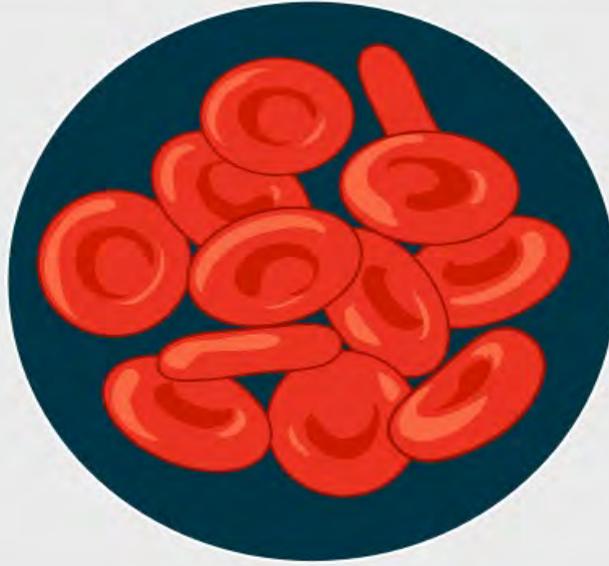
# CELL MEMBRANE AND CELL TRANSPORT NOTES



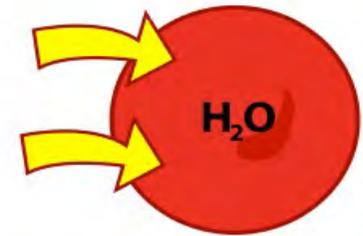
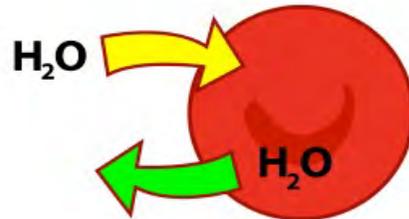
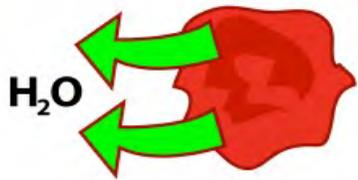
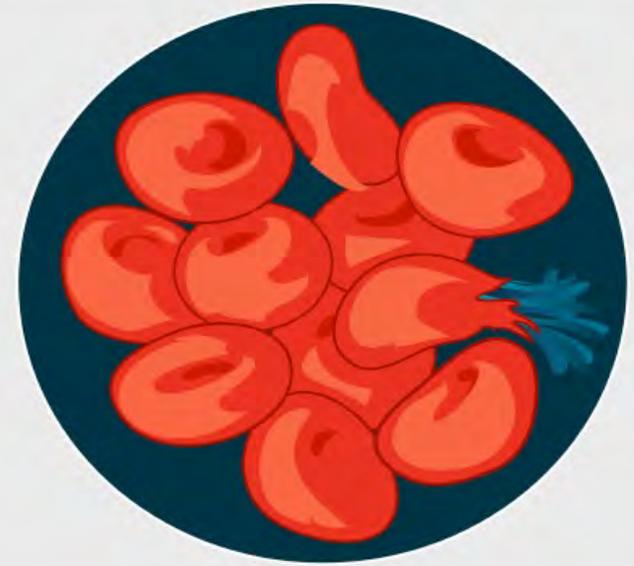
Hypertonic



Isotonic



Hypotonic



## Coefficiente di Van't Hoff:

tiene conto del numero di particelle effettivamente in soluzione

$$i = 1 - \alpha(1 - n)$$

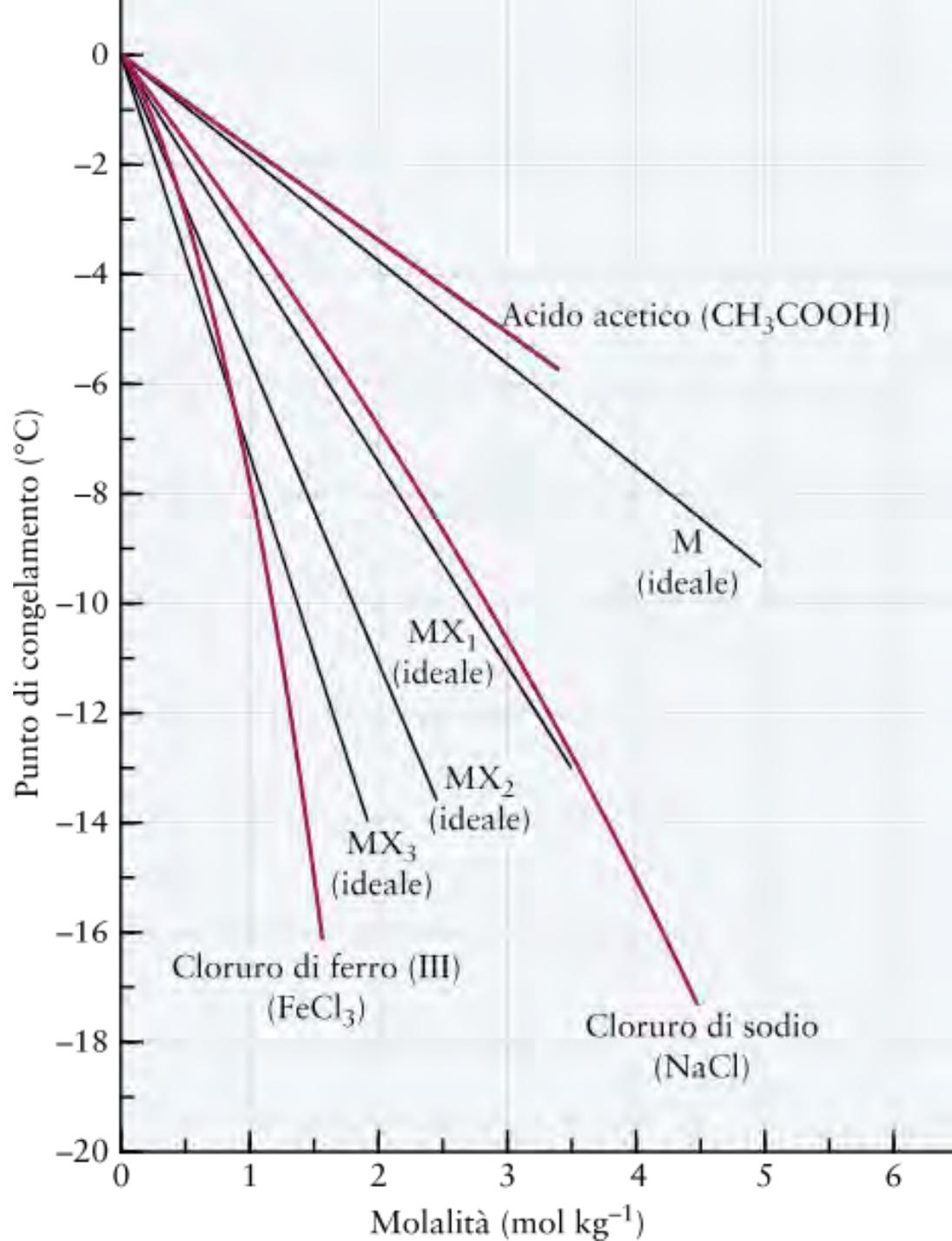
$\alpha$  = grado di dissociazione

$n$  = numero di parti in cui la molecola si dissocia

Compound	Concentration			Limiting Value
	0.100 <i>m</i>	0.0100 <i>m</i>	0.00100 <i>m</i>	
Sucrose	1.00	1.00	1.00	1.00
NaCl	1.87	1.94	1.97	2.00
K <sub>2</sub> SO <sub>4</sub>	2.32	2.70	2.84	3.00
MgSO <sub>4</sub>	1.21	1.53	1.82	2.00

$$\Delta T_f = K_f \cdot m \cdot i$$

# Abbassamento crioscopico ideale e reale



# Preparazione di una soluzione di $\text{NiCl}_2$



(a)



(b)



(c)



(d)

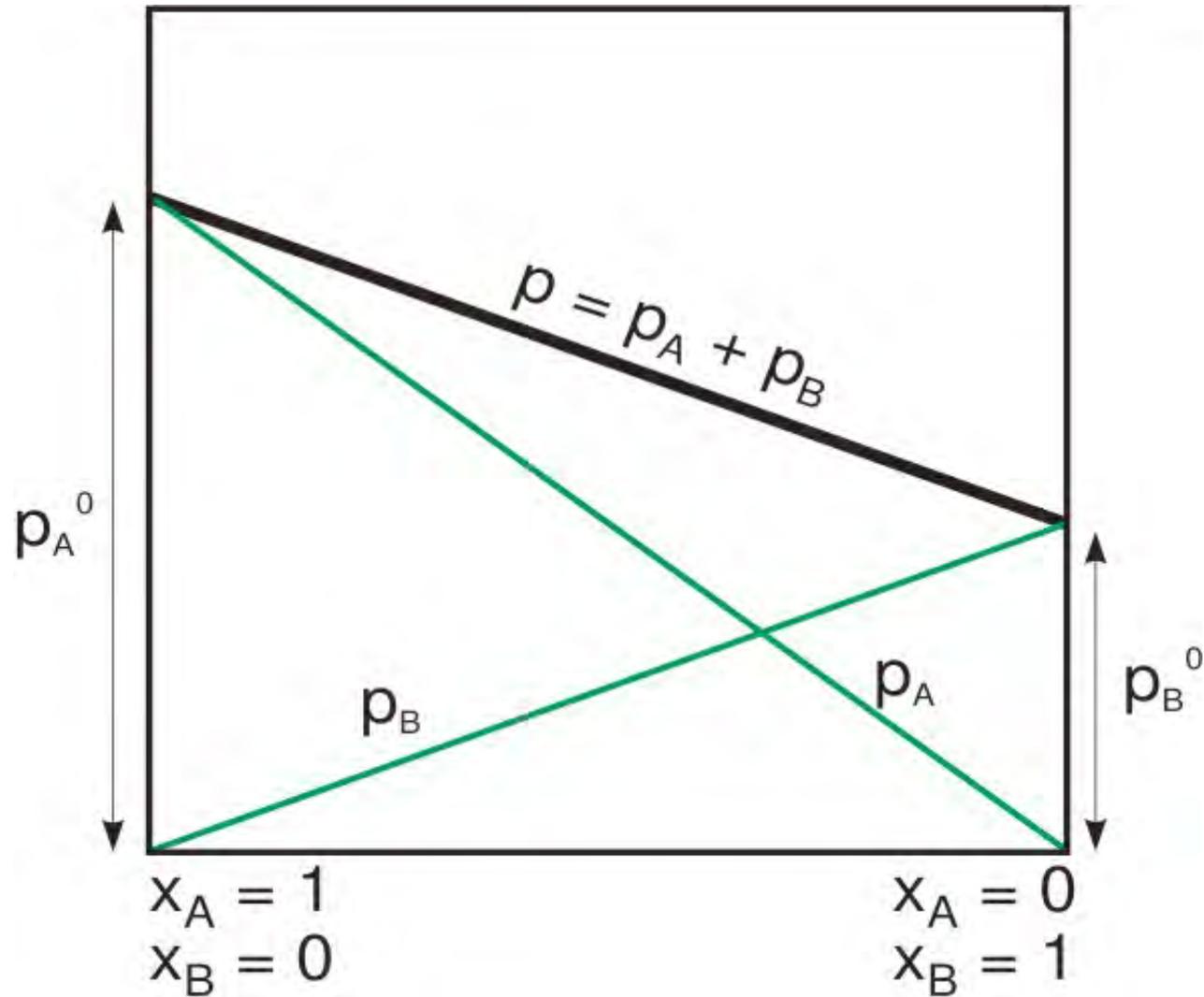


(e)

# Salt precipitation

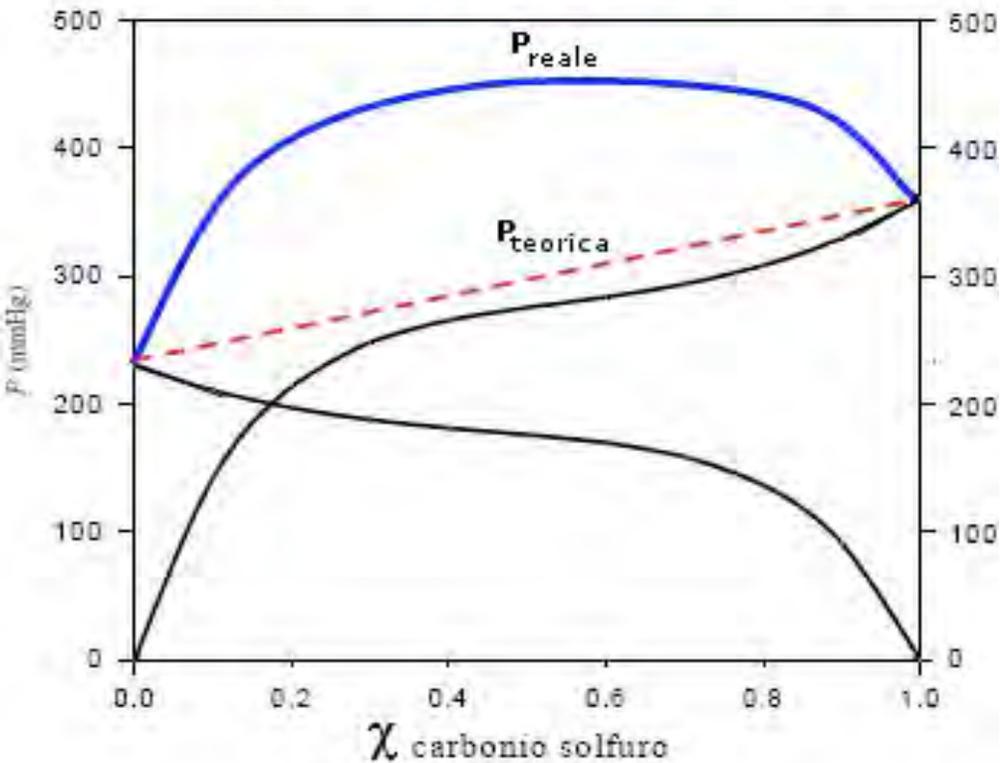


# Tensione di vapore di una soluzione ideale di due componenti volatili

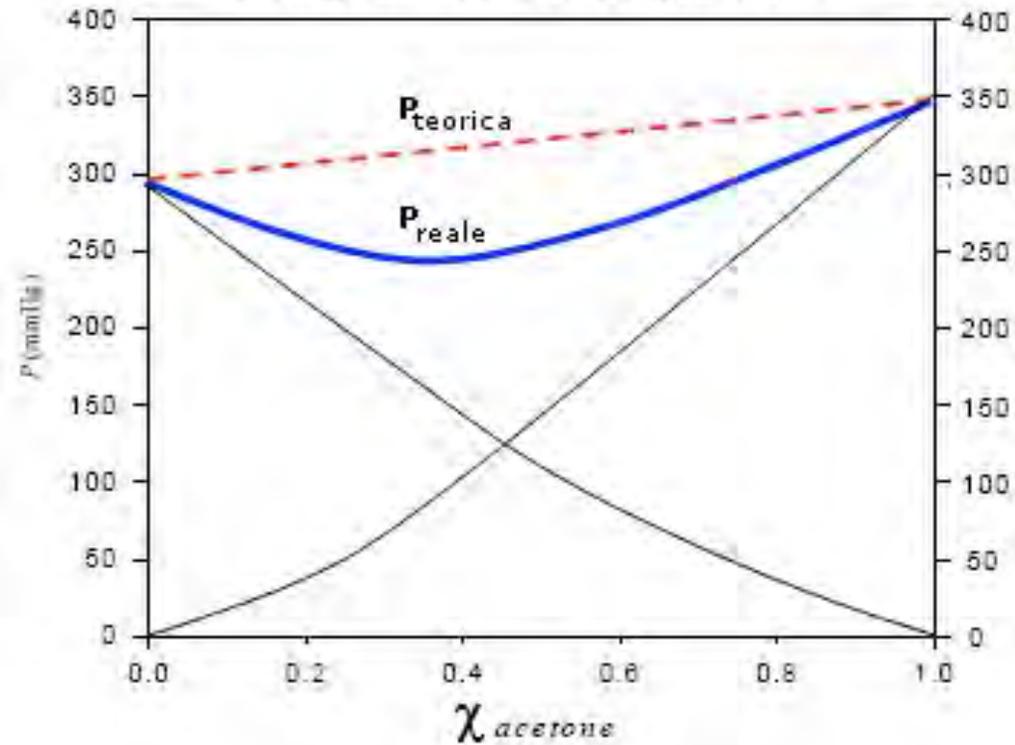


# Deviazioni dalla idealità

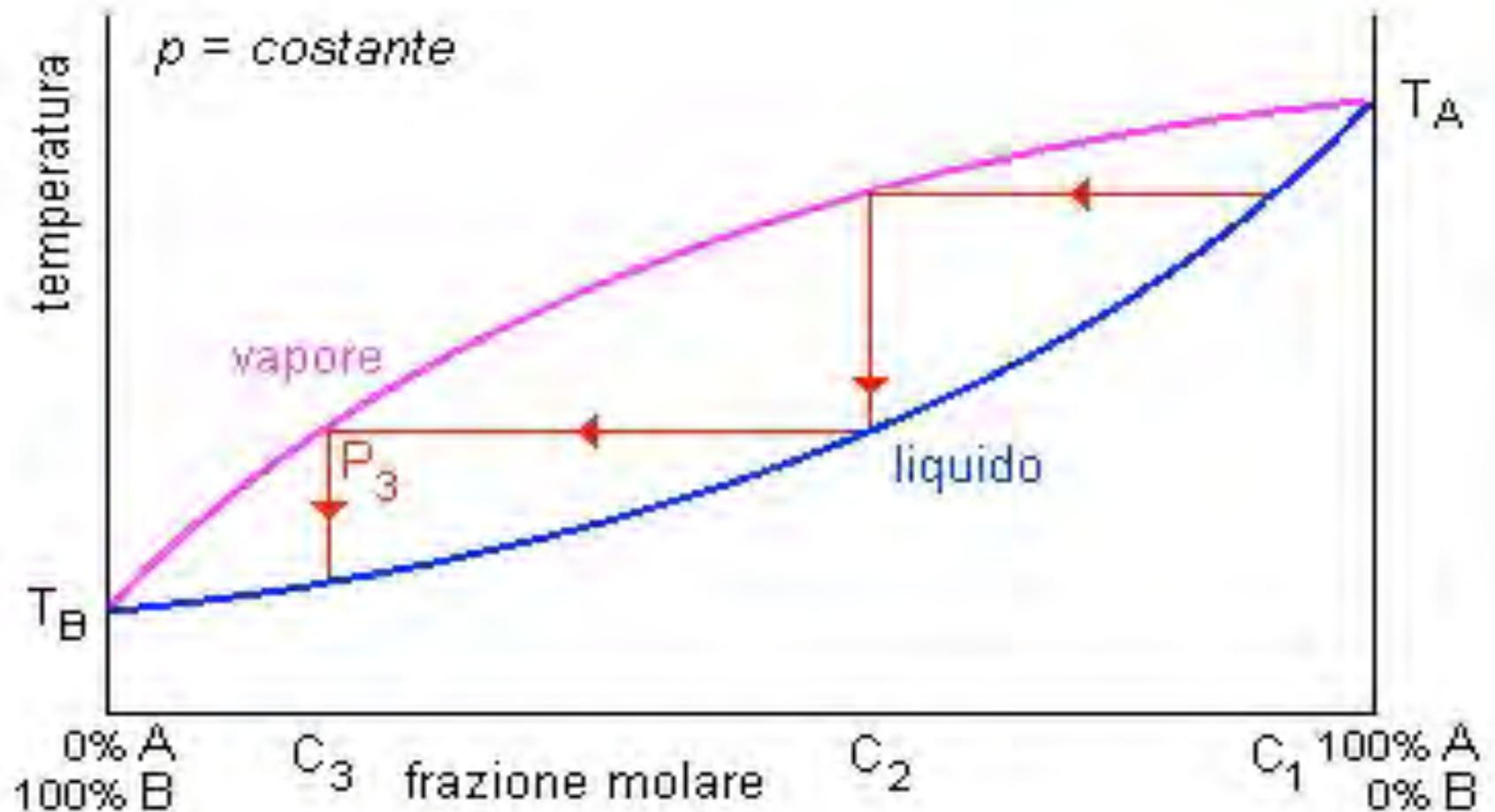
Pressioni di vapore della miscela acetone - carbonio solfuro misurate a 25°C



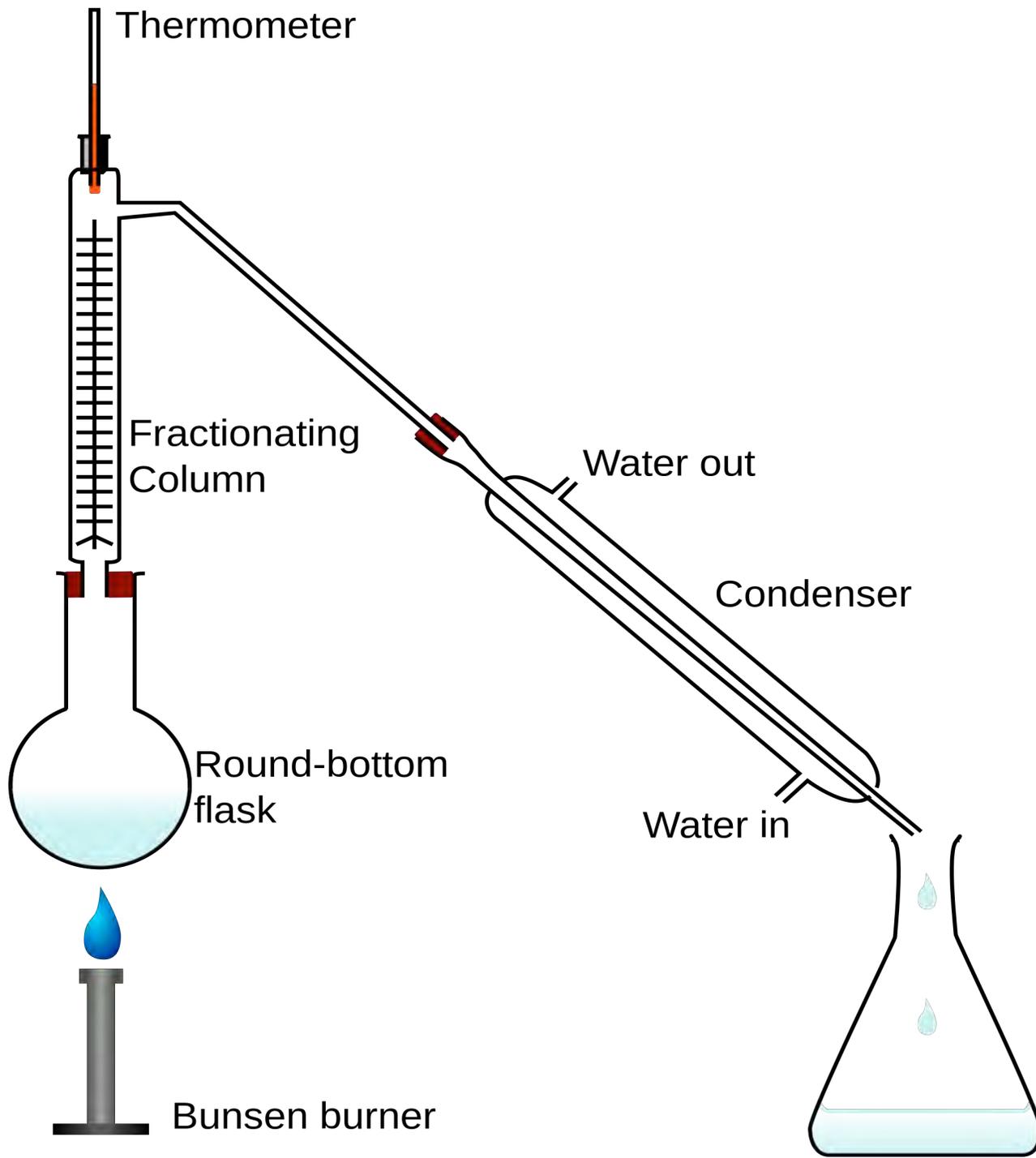
Pressioni di vapore della miscela acetone - cloroformio misurate a 35°C



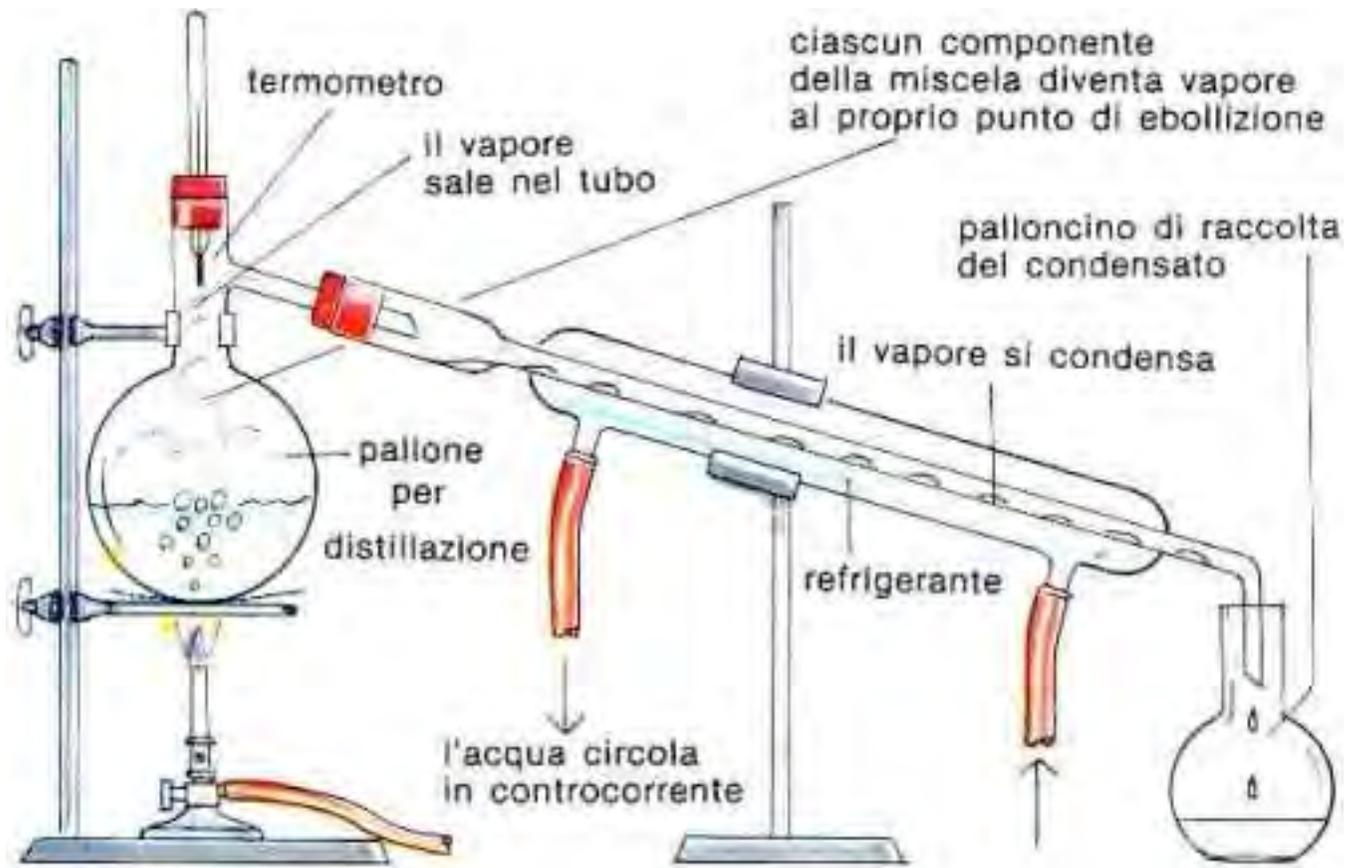
# Diagramma di distillazione



# Distillation



# Distillazione



# Distillatore per grappa

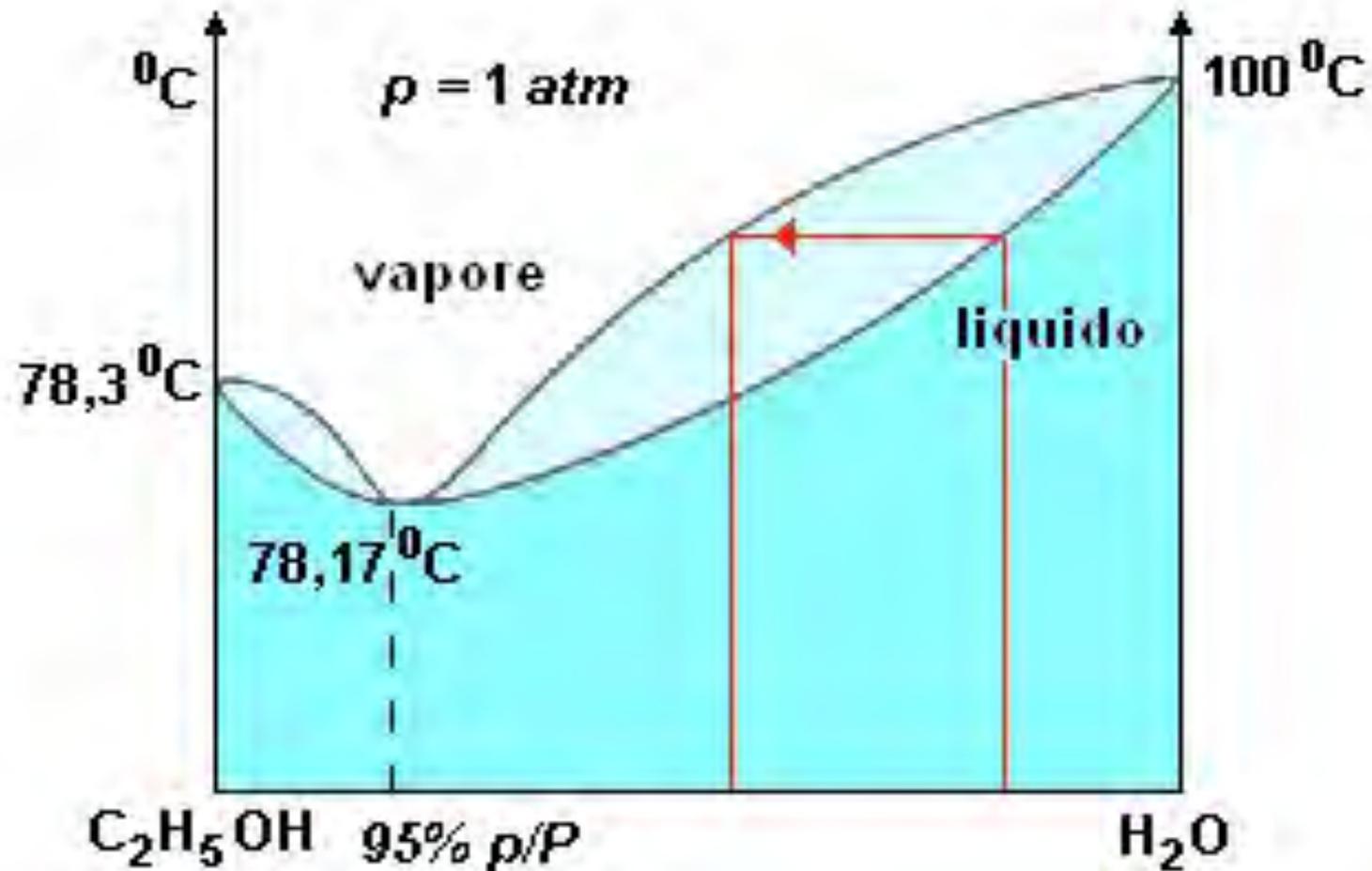


# Distillazione in corrente di vapore



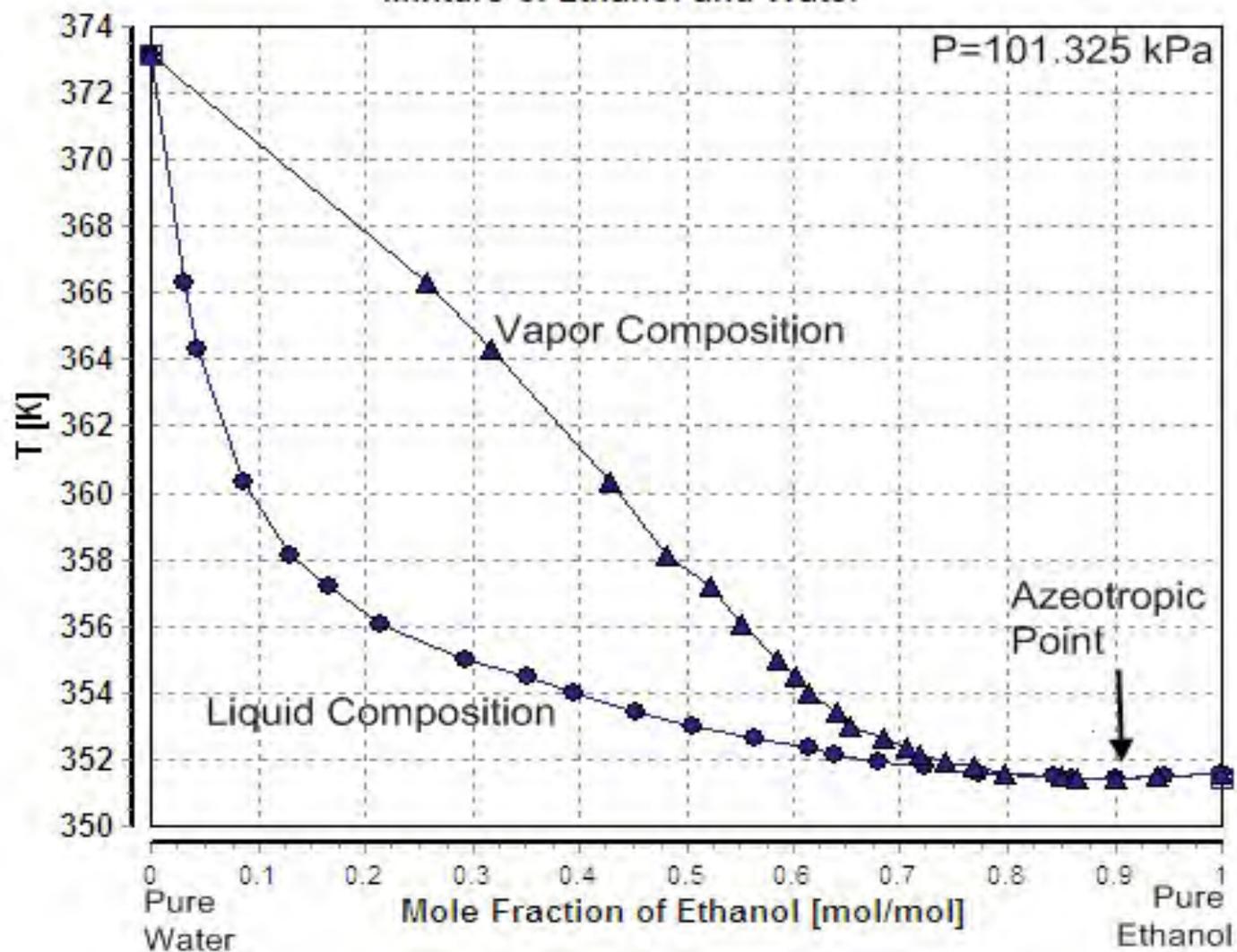


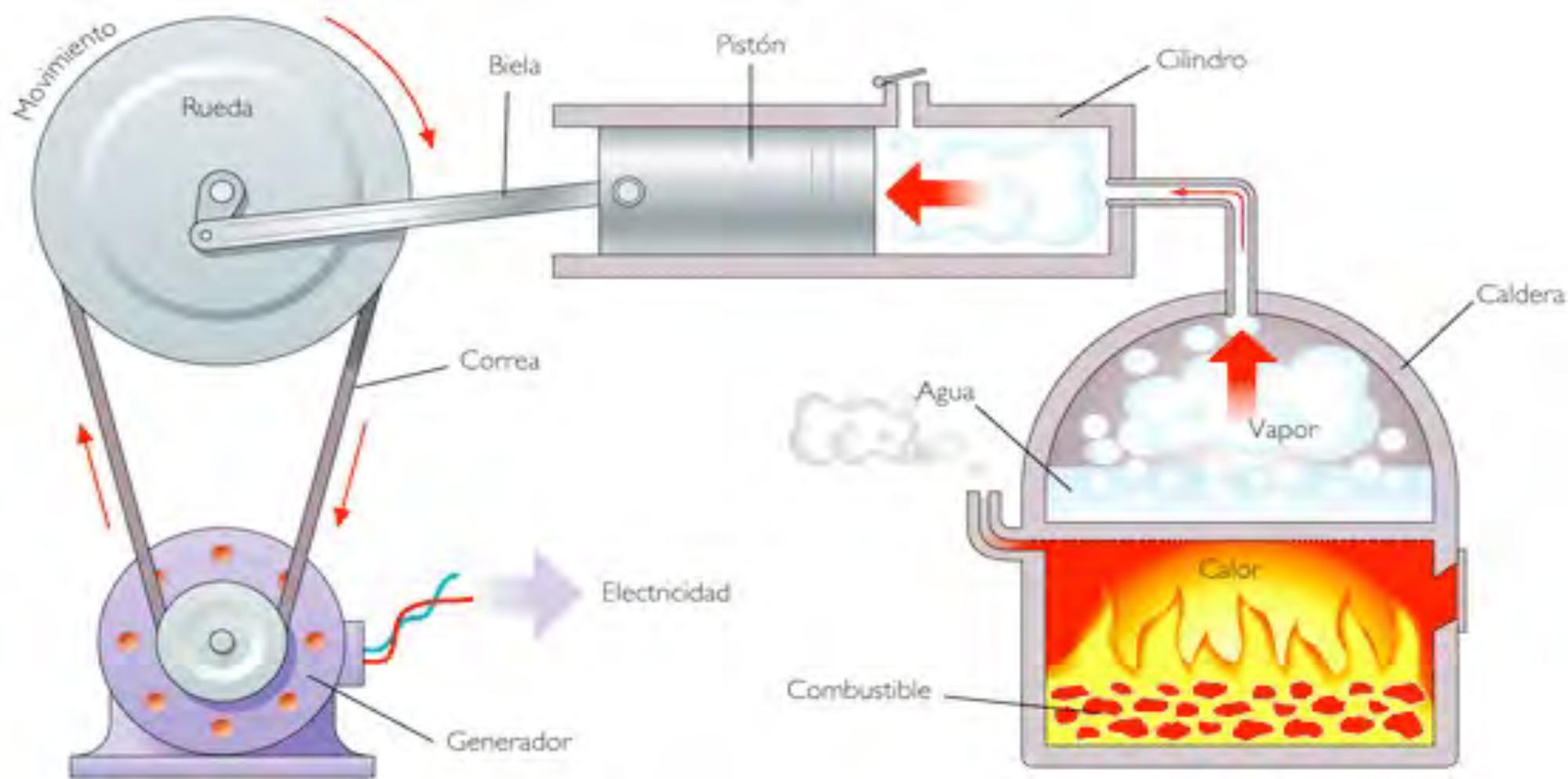
# Azeotropo



Data taken from Dortmund Data Bank

### Vapor-Liquid Equilibrium Mixture of Ethanol and Water







aperto



chiuso



isolato

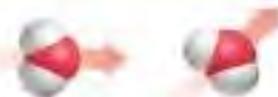
# Energia interna

*Energia:* capacità di compiere lavoro.

*E' la somma dell'energia cinetica e dell'energia potenziale delle particelle che formano il sistema.*

Energia cinetica: moto delle particelle

Energia potenziale: legami chimici, interazione elettroni-nucleo etc...



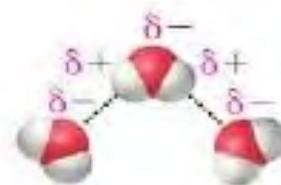
Traslazionale



Rotazionale

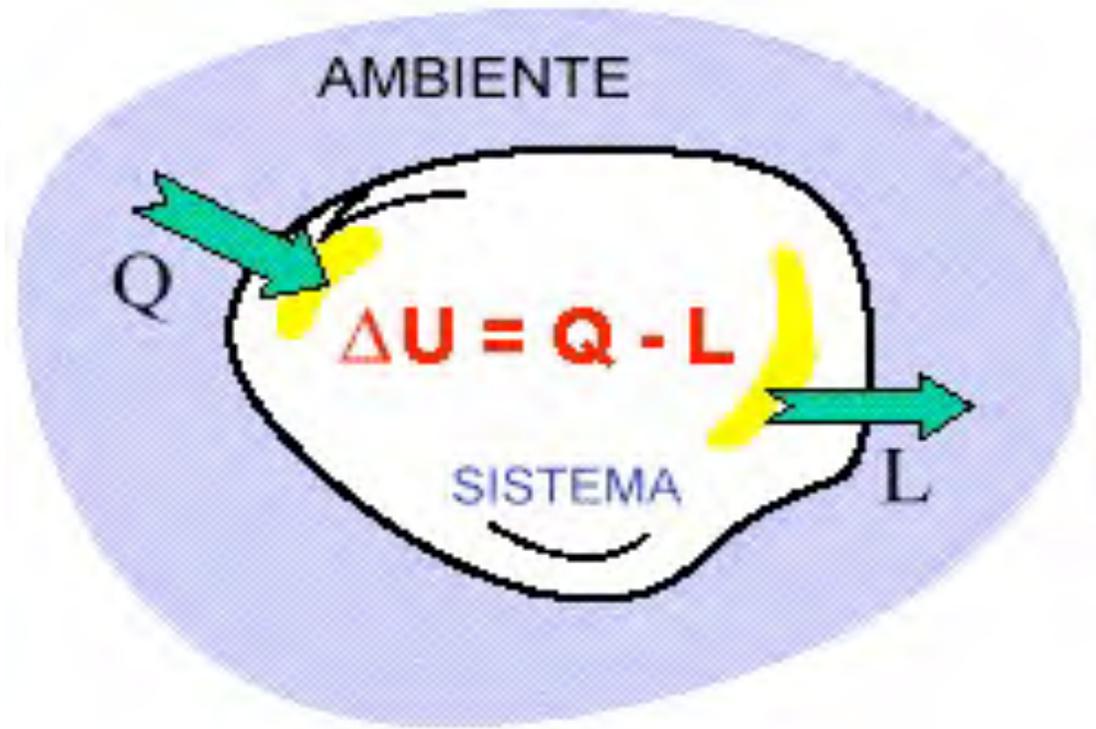
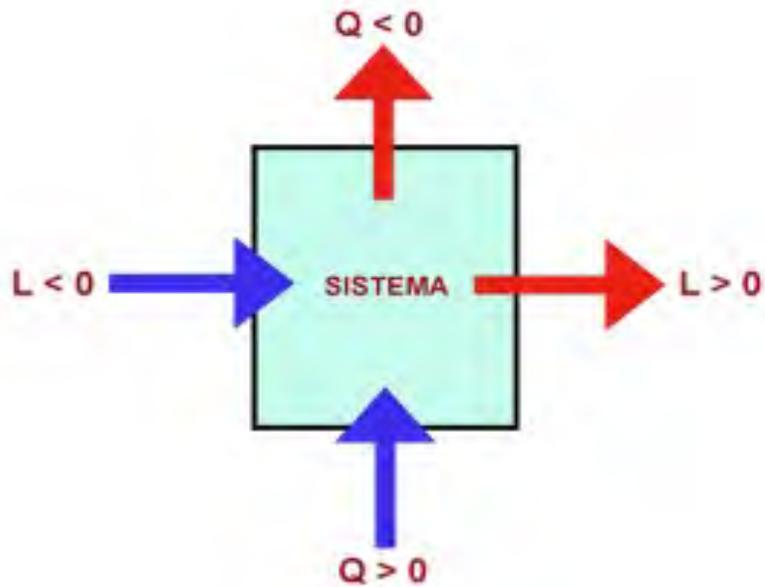


Vibrazionale



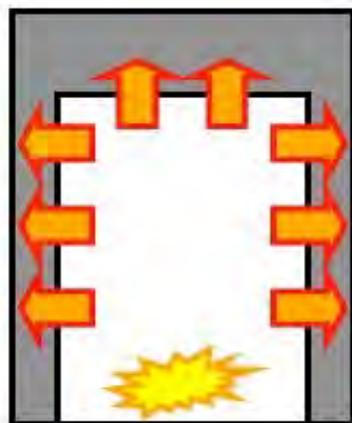
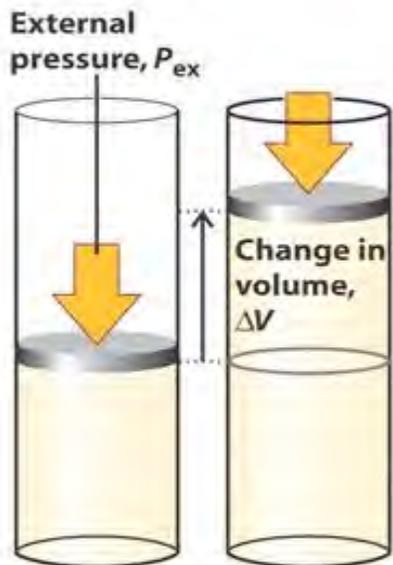
Elettrostatica  
(Attrazioni intermolecolari)

# I principio della termodinamica



# Il Trasferimento del Calore

1. A VOLUME COSTANTE,  $\Delta V = 0$

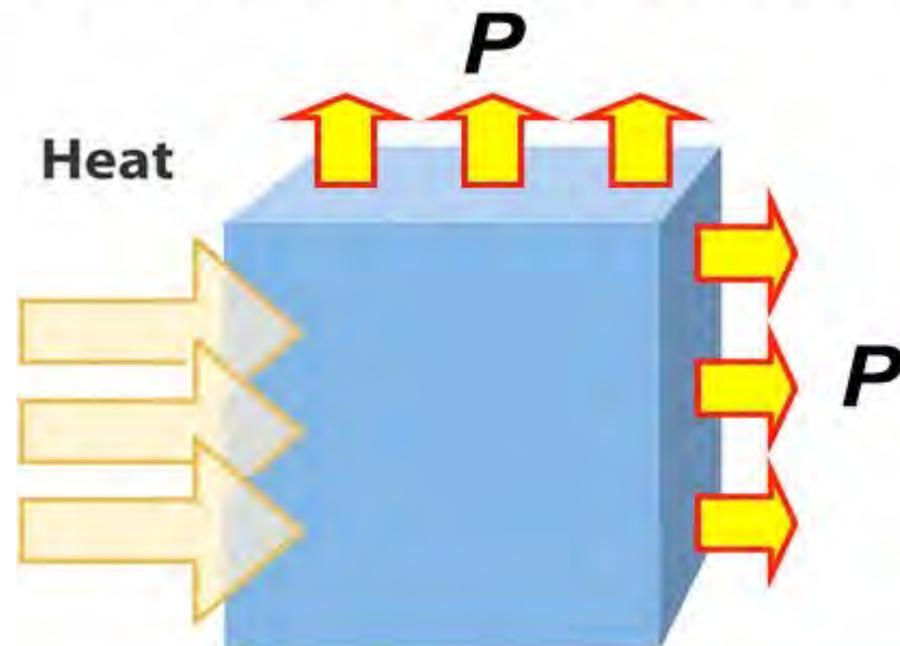


$$w = 0$$
$$\Delta U = q$$

**A VOLUME COSTANTE**

$$\Delta U = q$$

2. A PRESSIONE COSTANTE,  $\Delta H = q$



$$\Delta U = \Delta H - P\Delta V$$

$\Delta H$  – energia lavoro espansione

$\Delta V > 0$  LAVORO DI ESPANSIONE

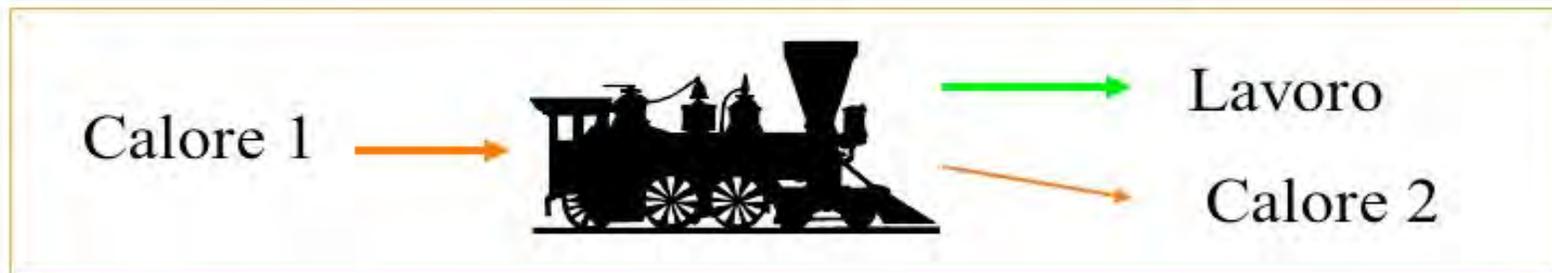
$\Delta V < 0$  LAVORO SUL SISTEMA

**A PRESSIONE COSTANTE**

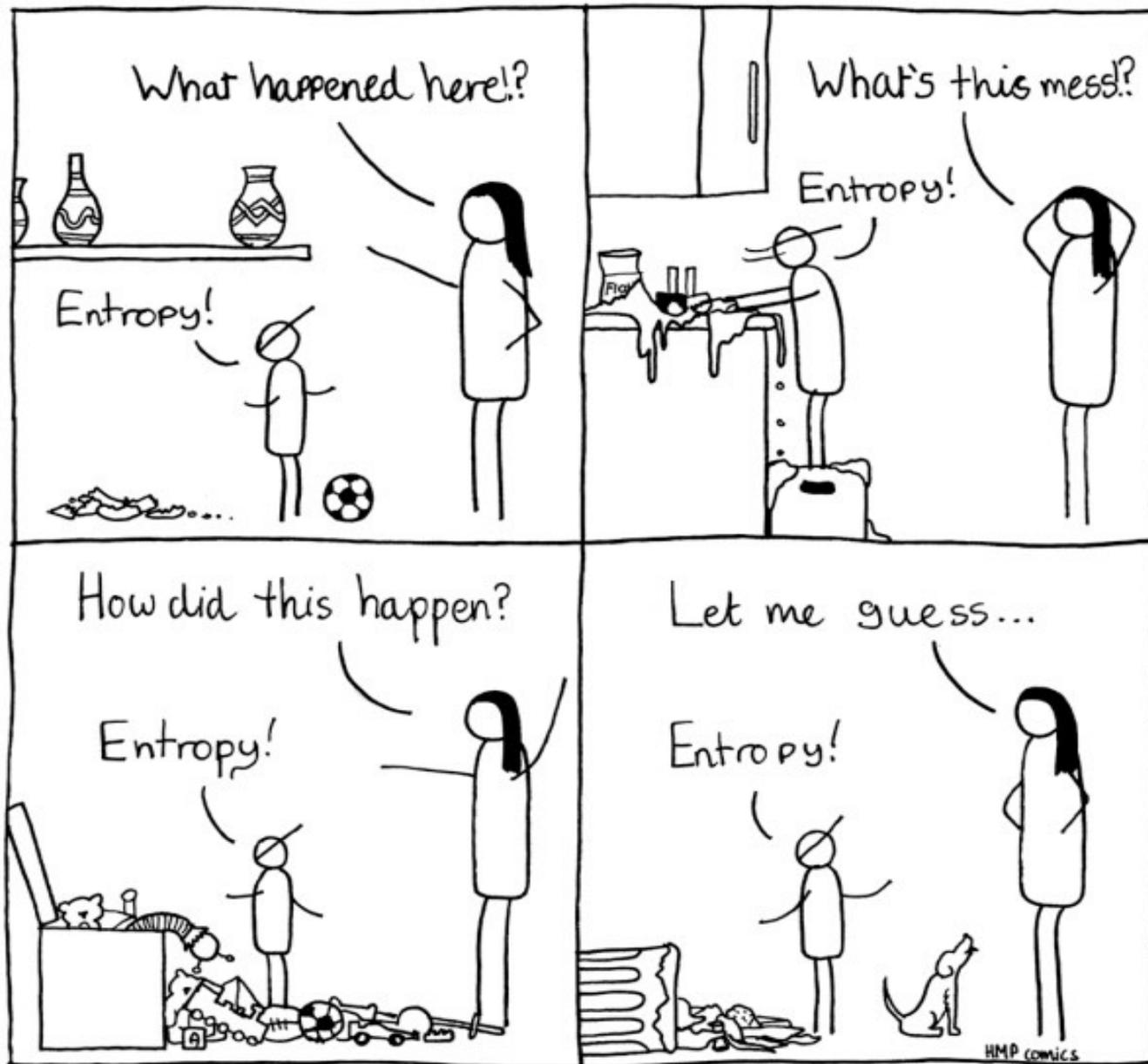
$$\Delta U = \Delta H - P\Delta V$$

# Il principio della Termodinamica

- L'energia meccanica e il lavoro si possono trasformare completamente in energia termica;
- la trasformazione inversa di energia termica in lavoro può essere ottenuta soltanto mediante una macchina

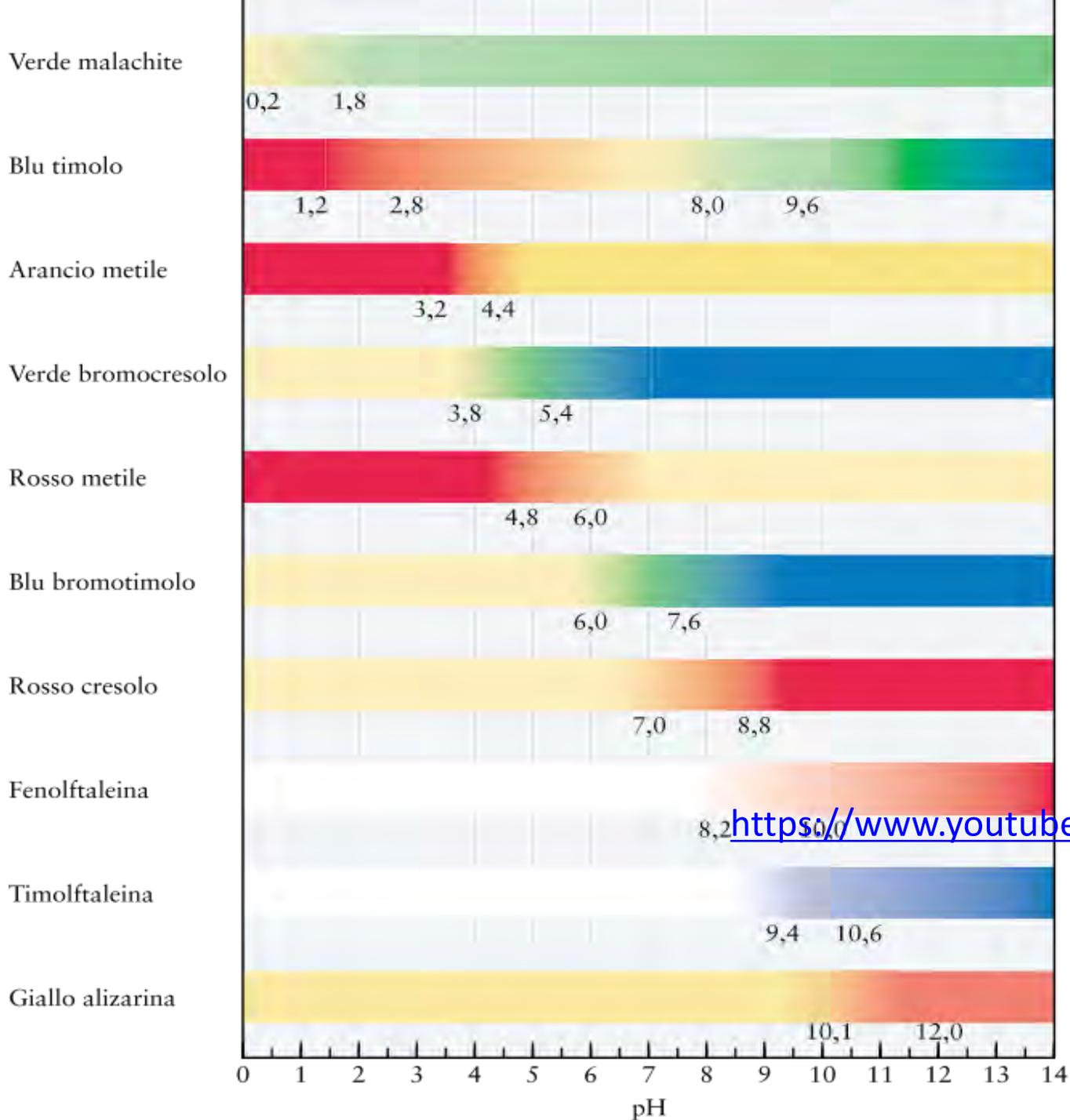


Questa limitazione sembra essere una legge della natura ed è espressa in diversi modi dal secondo principio della



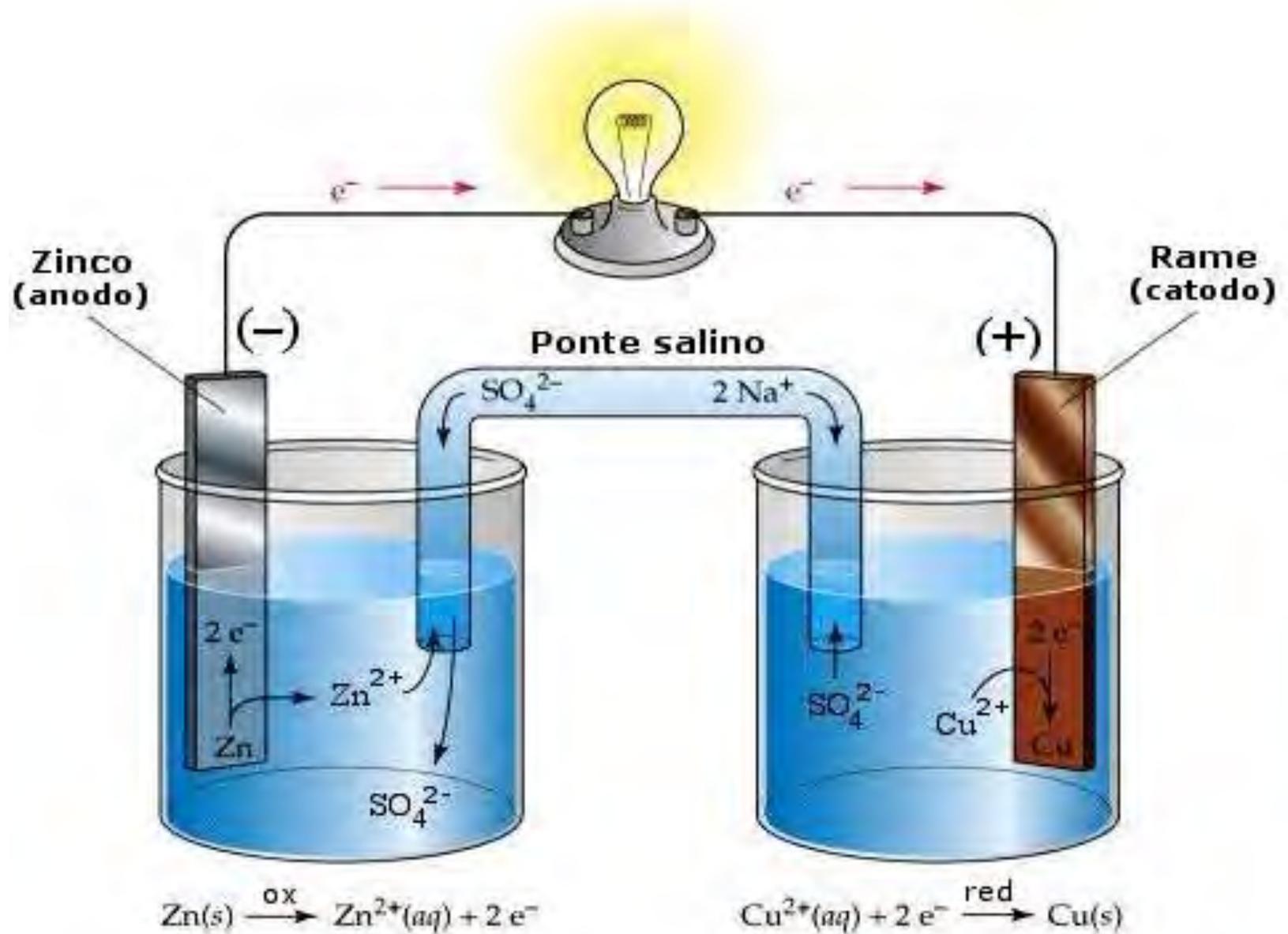
This is why we don't teach our children about entropy until much later...

# Equilibrio Acido-base



<https://www.youtube.com/watch?v=g8jdCWC10vQ>

# Pila Daniell



# Pila Daniell

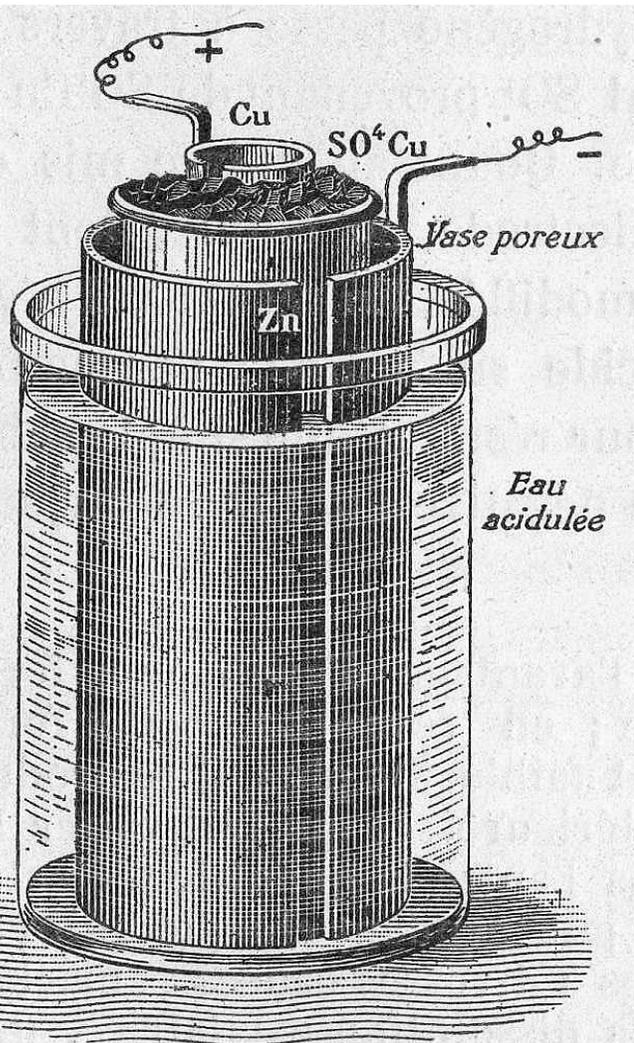
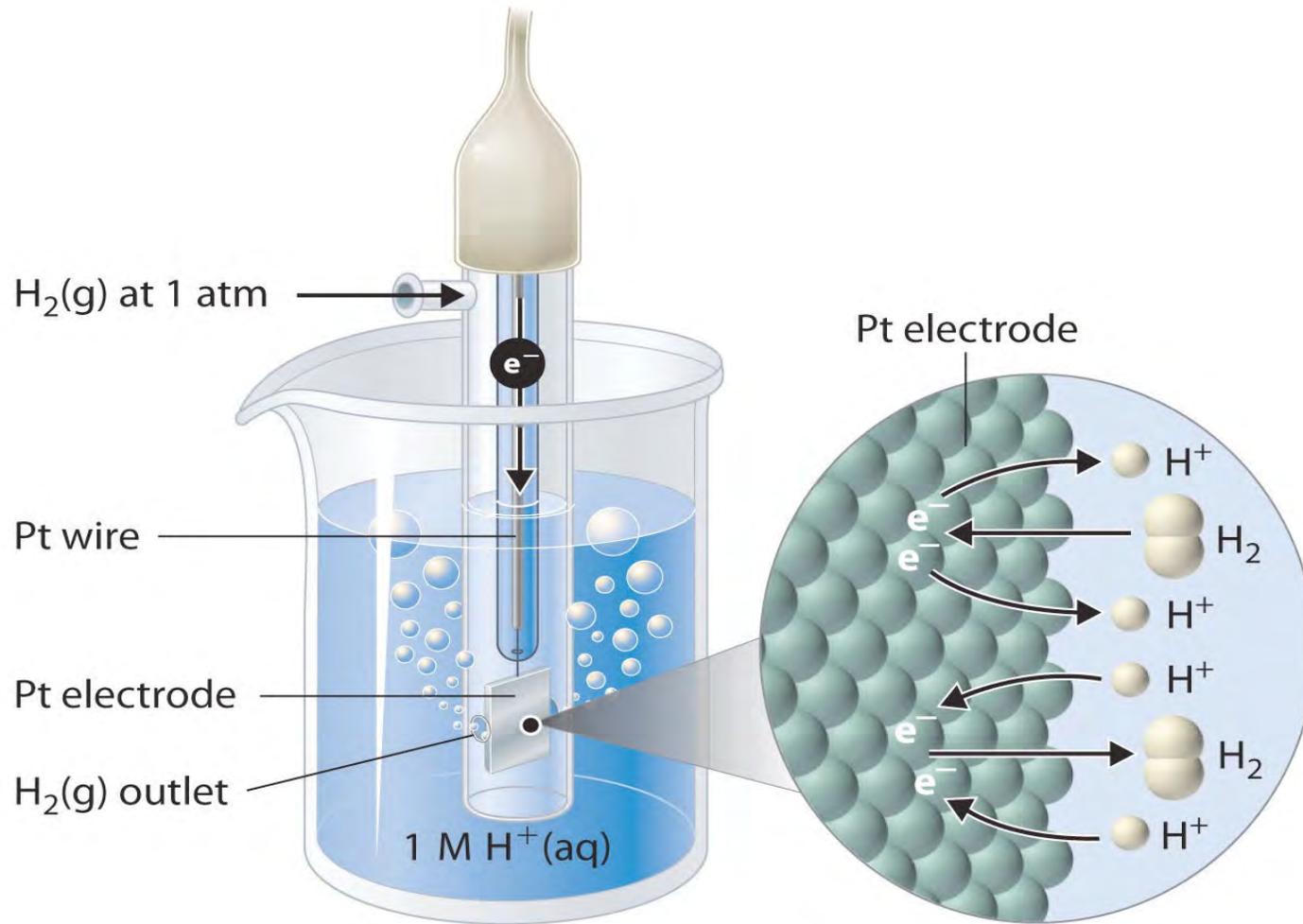


Fig. 284. — Élément Daniell.

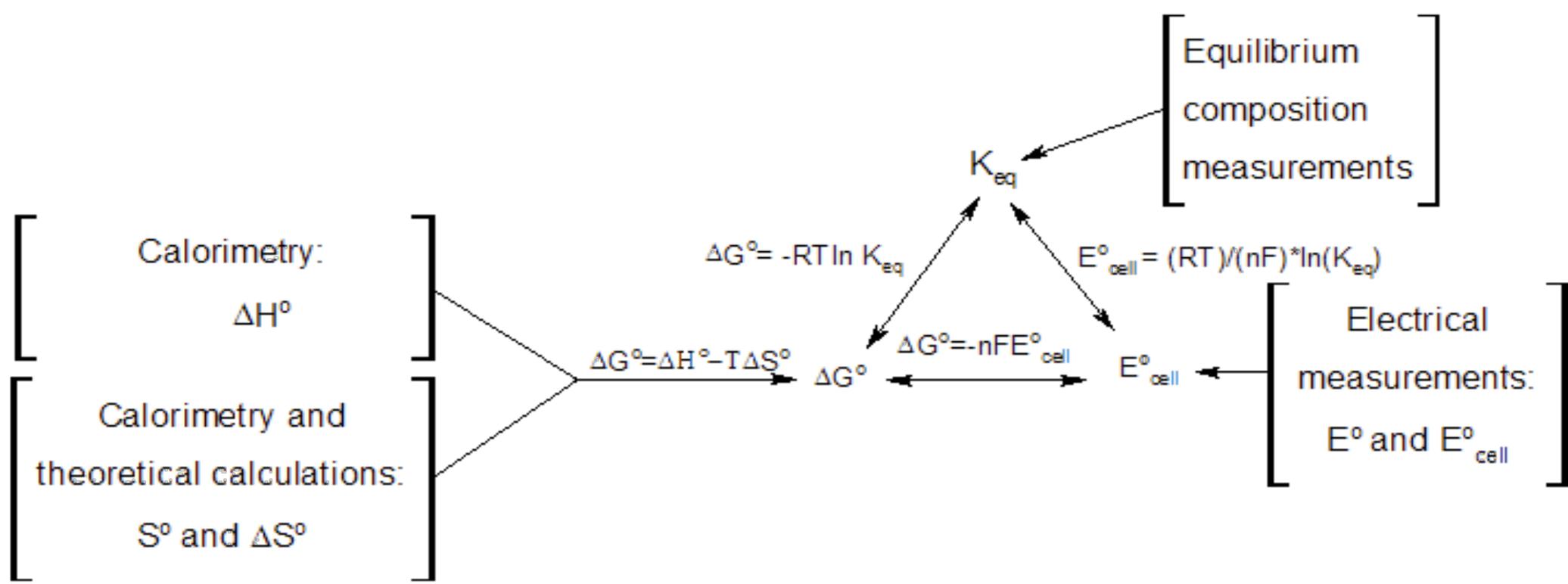


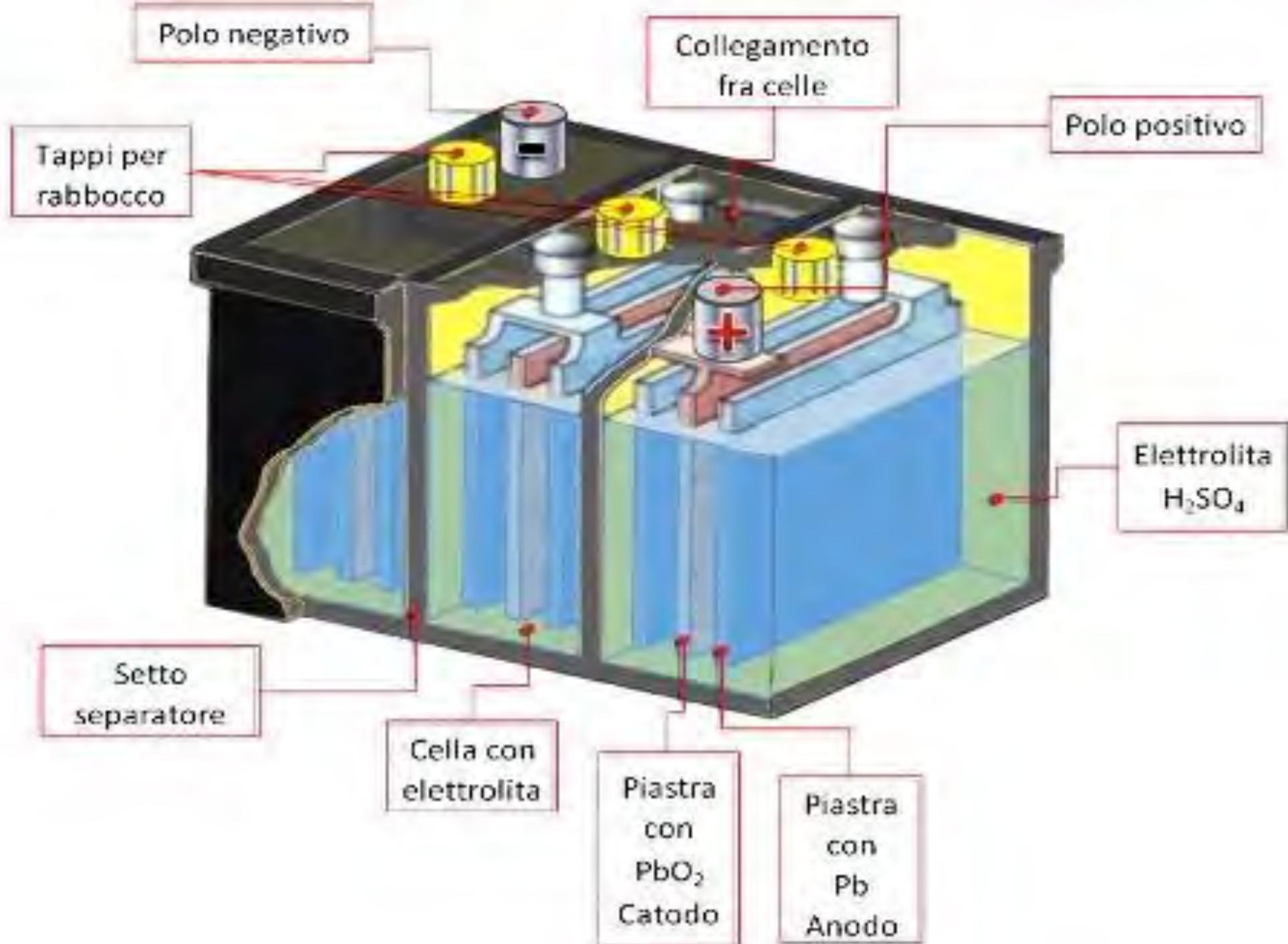
Figura 7 - Cella di Daniell,  
versione con ponte salino

# Elettrodo ad idrogeno

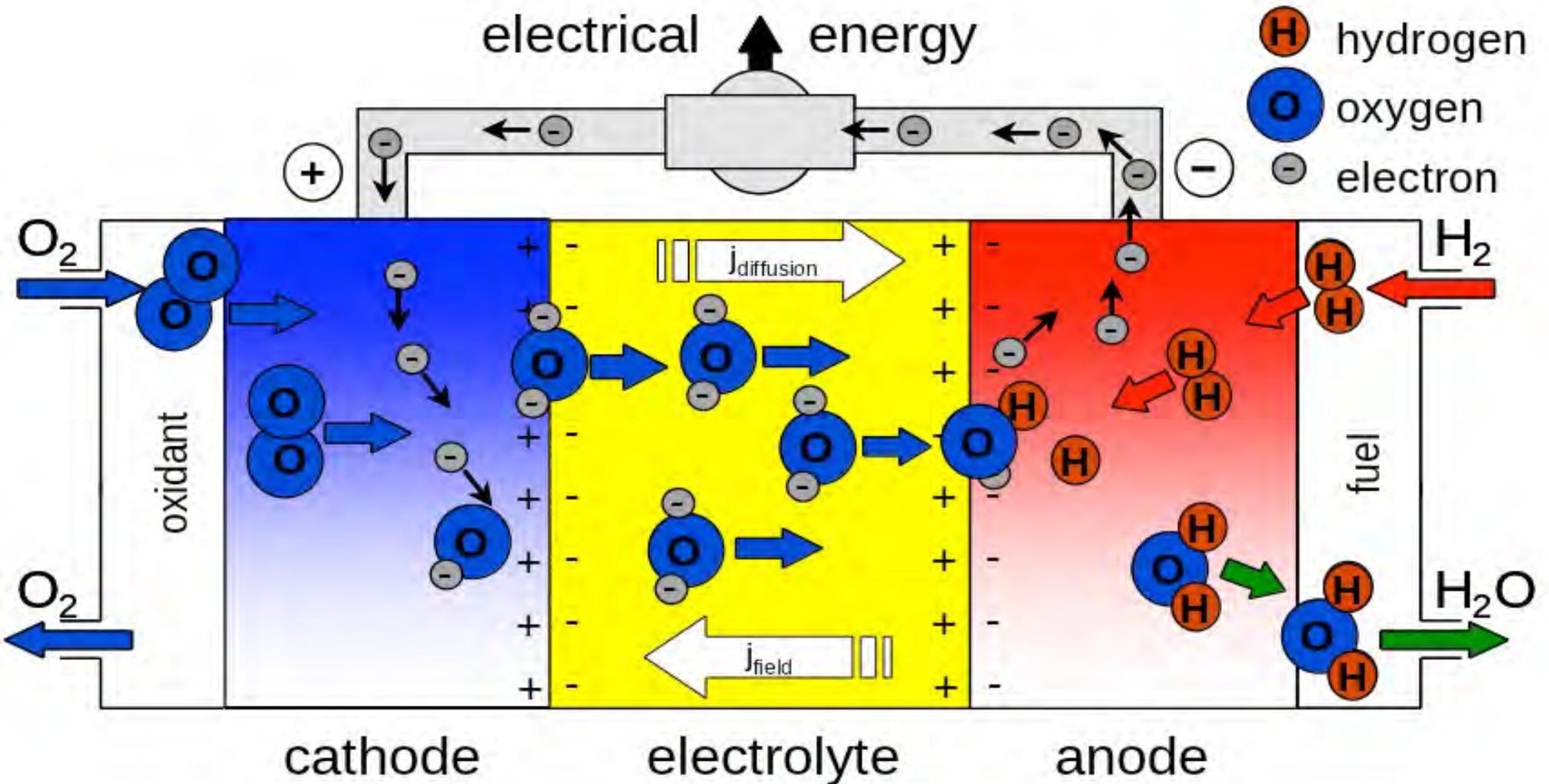


*half-reaction at Pt surface:*  
 $2\text{H}^+(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{H}_2(\text{g})$



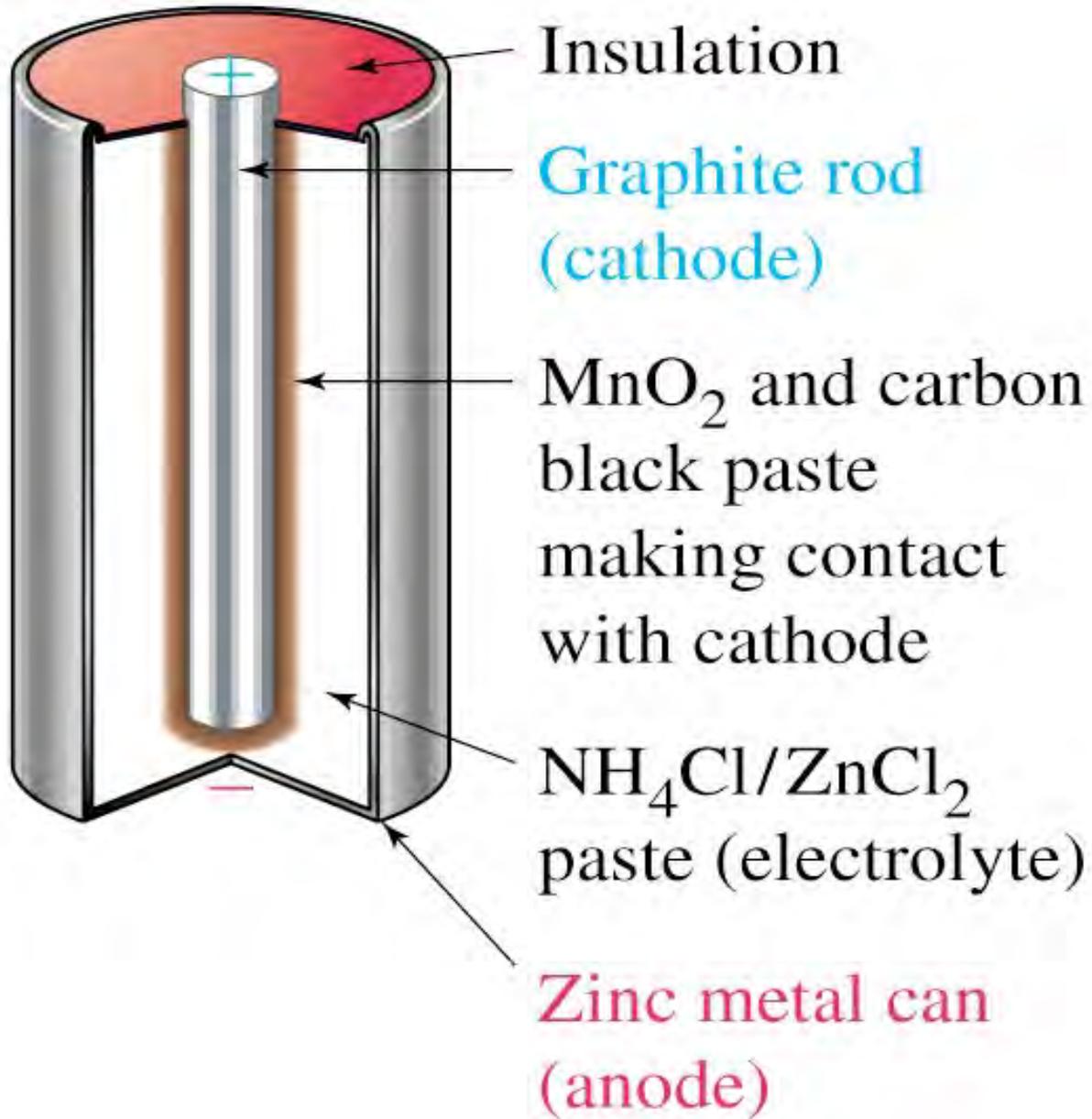


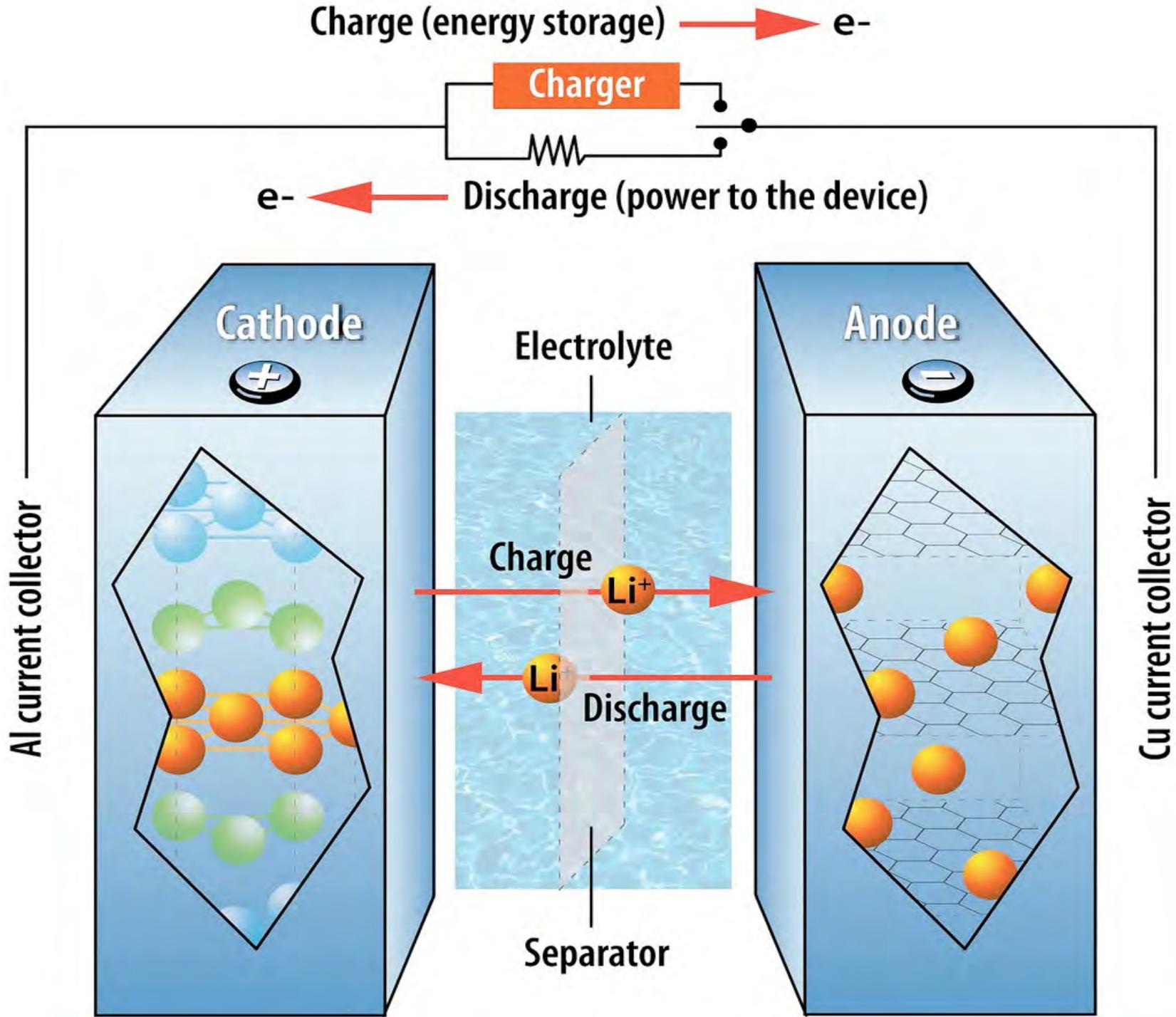
# Solid Oxide Fuel Cell



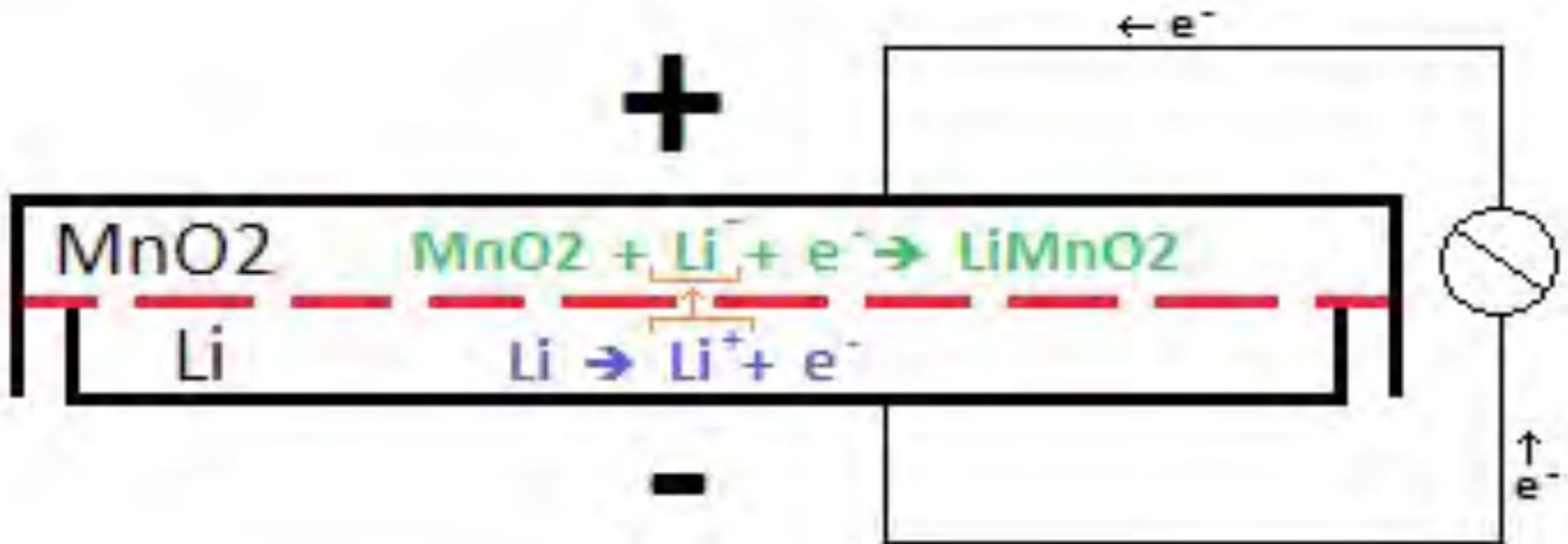


# Pila Leclanchè





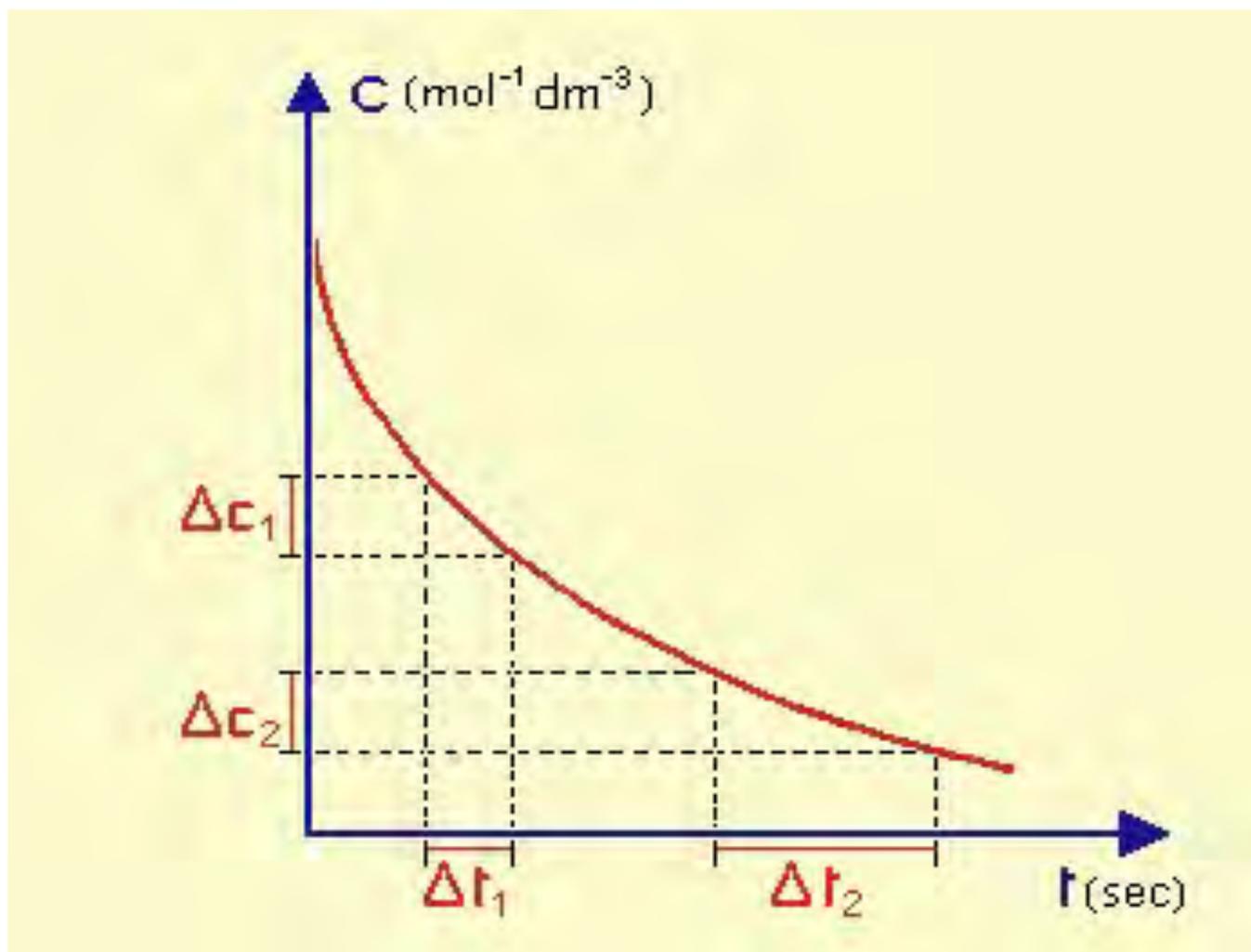
# Lithium battery

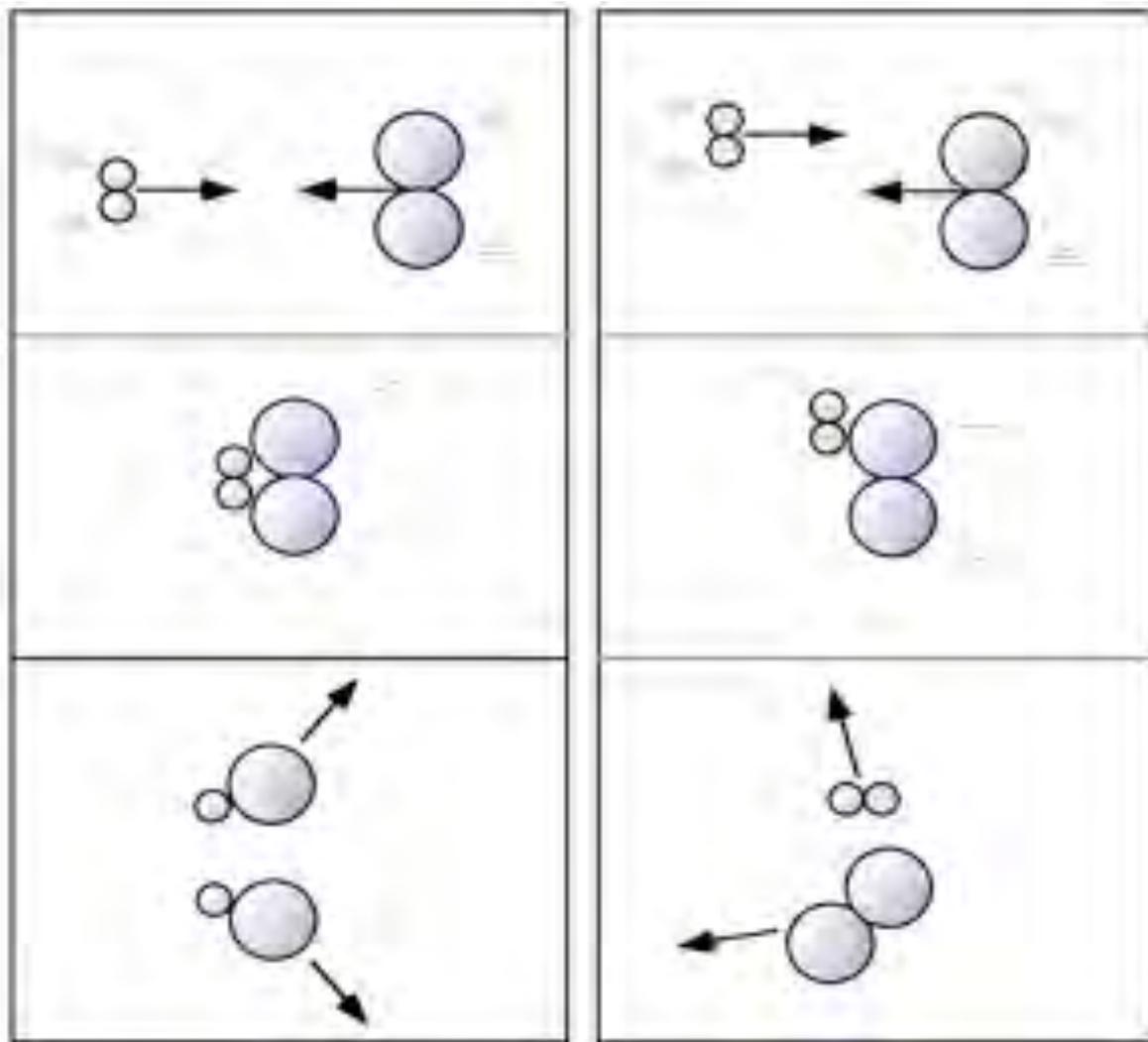
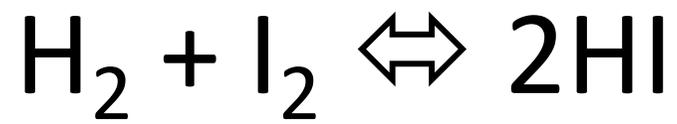




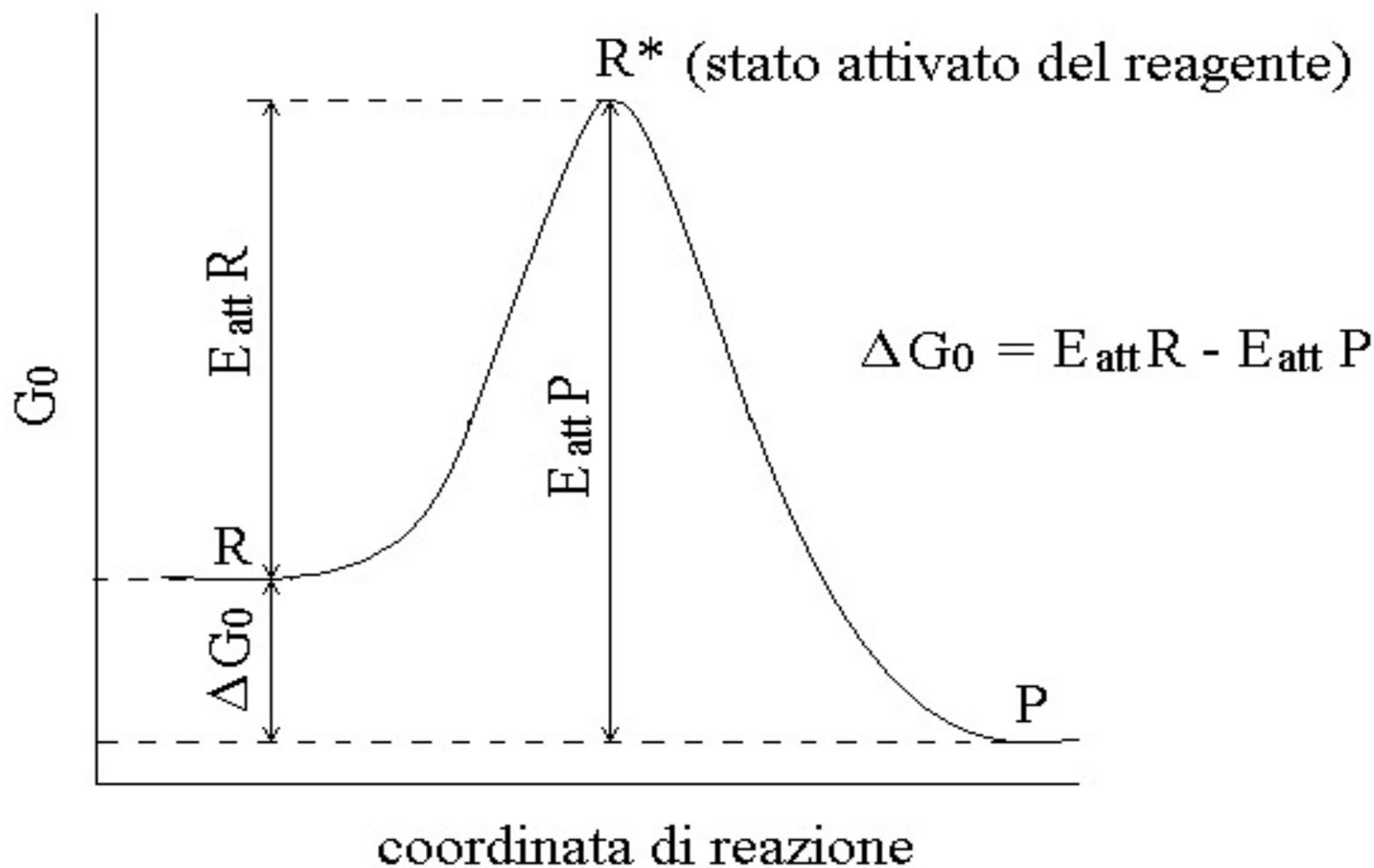
Disassembled Lithium battery From left — negative cup from inner side with layer of lithium (oxidized in air), separator (porous material), cathode (manganese dioxide), metal grid — current collector, metal casing (+)

# Cinetica Chimica

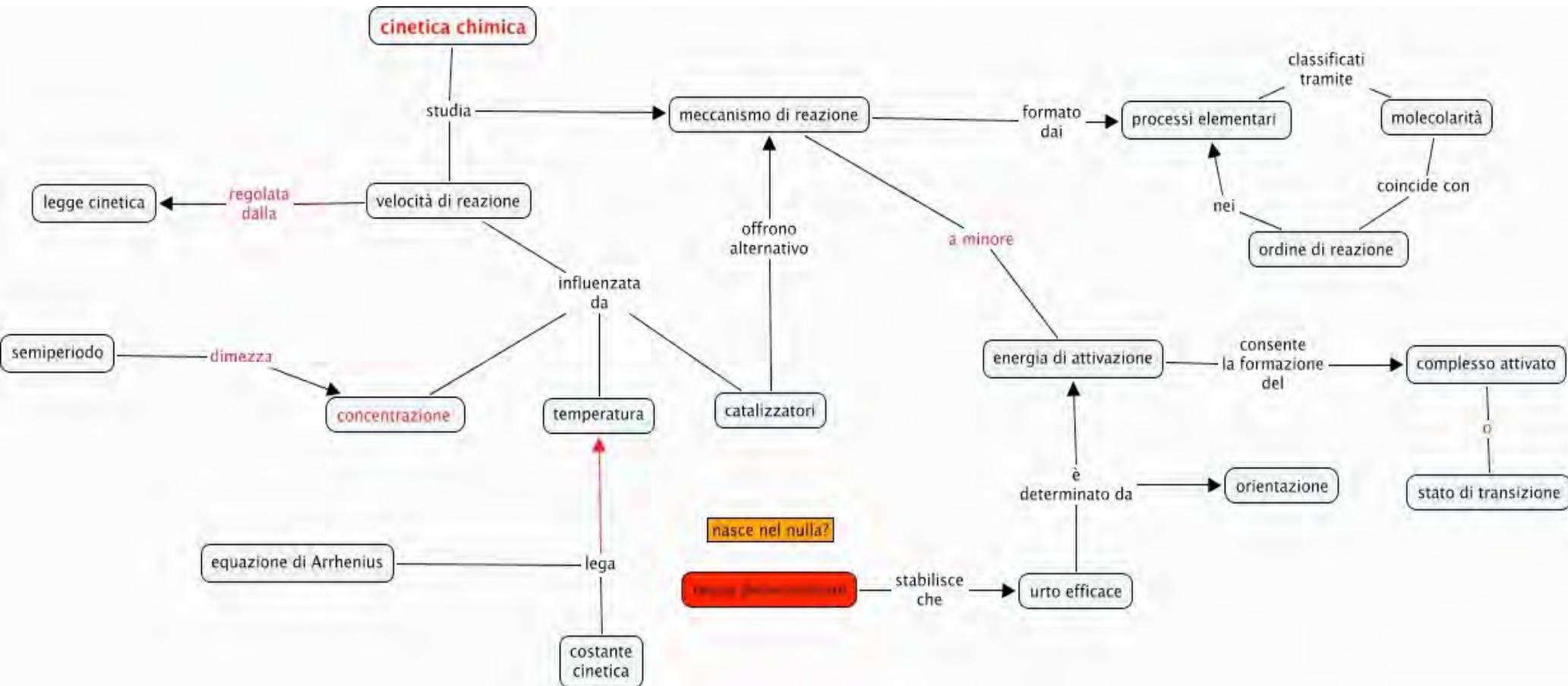




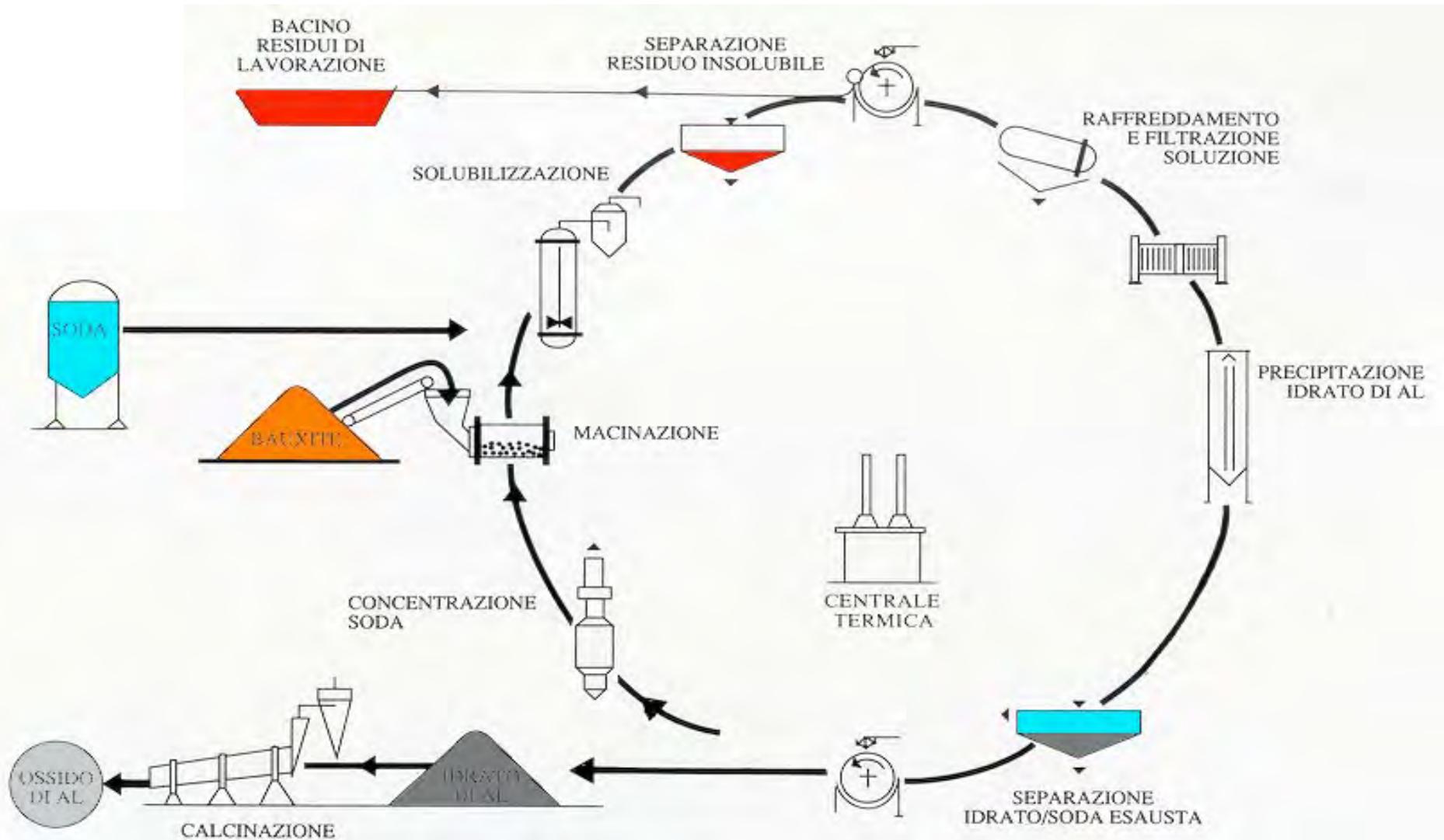
# ENERGIA DI ATTIVAZIONE



# MAPPA CONCETTUALE: CINETICA CHIMICA



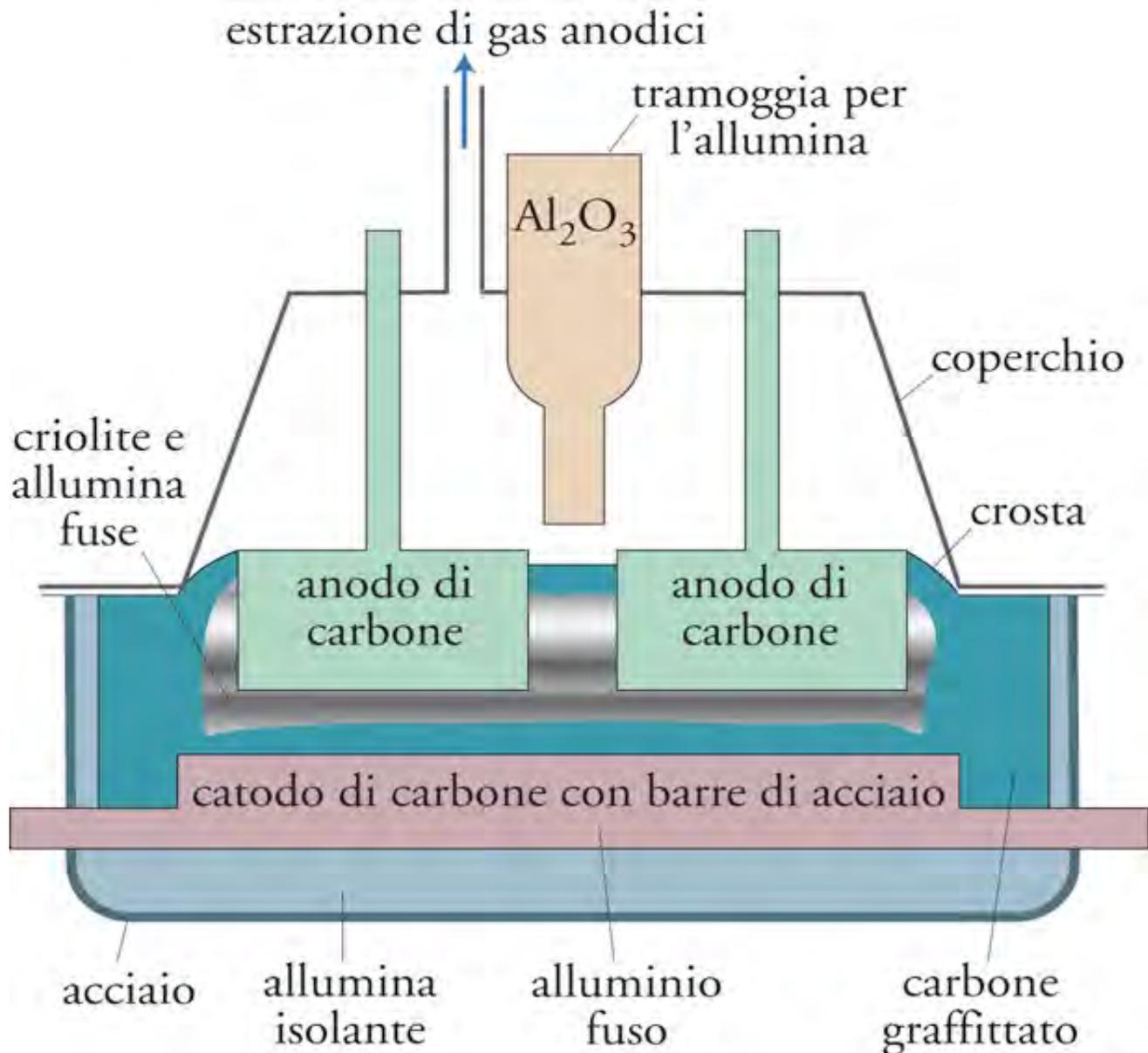
# Processo Bayer



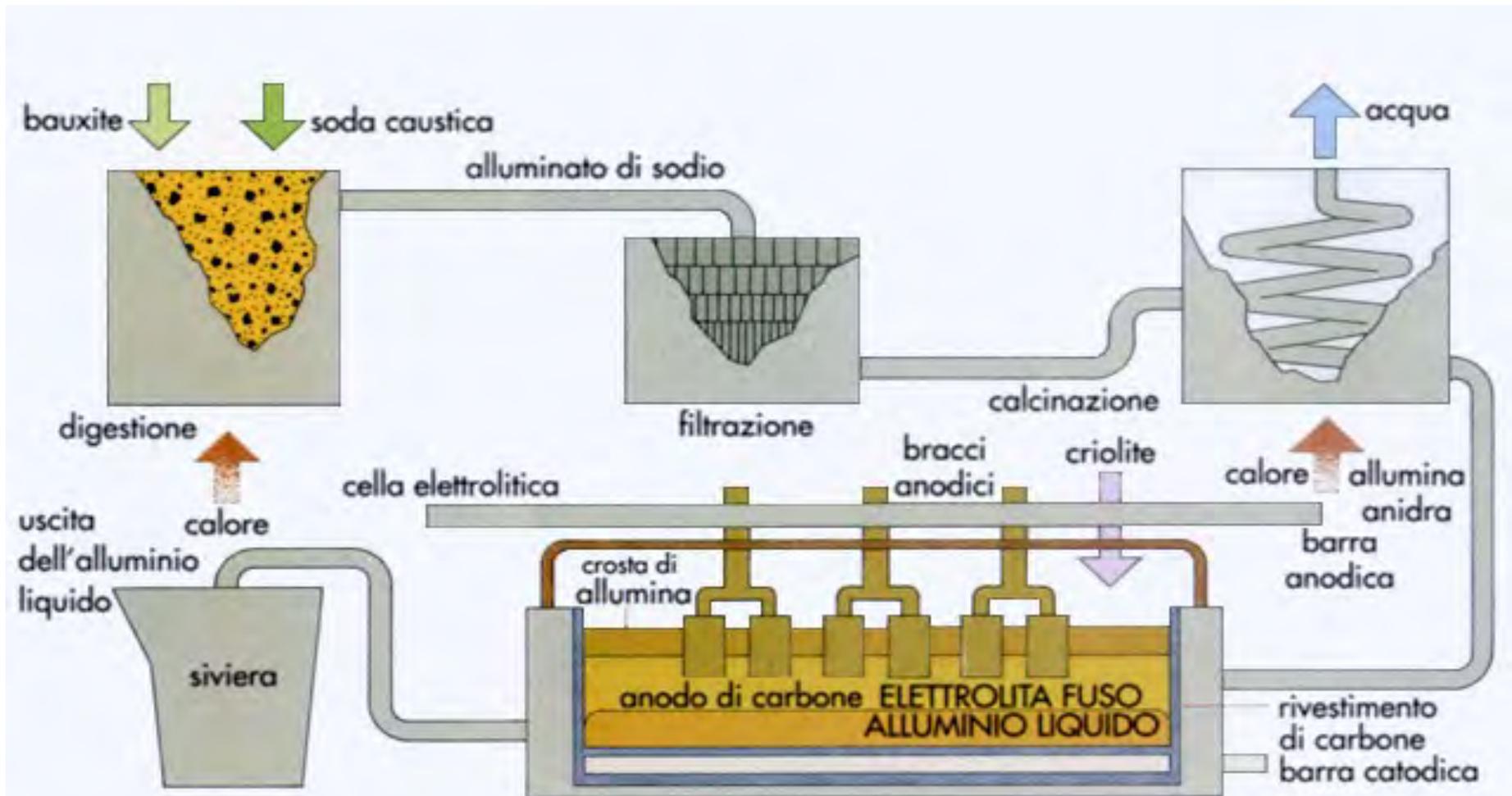
# Fanghi rossi: disastro in Ungheria (Ajka), ottobre 2010



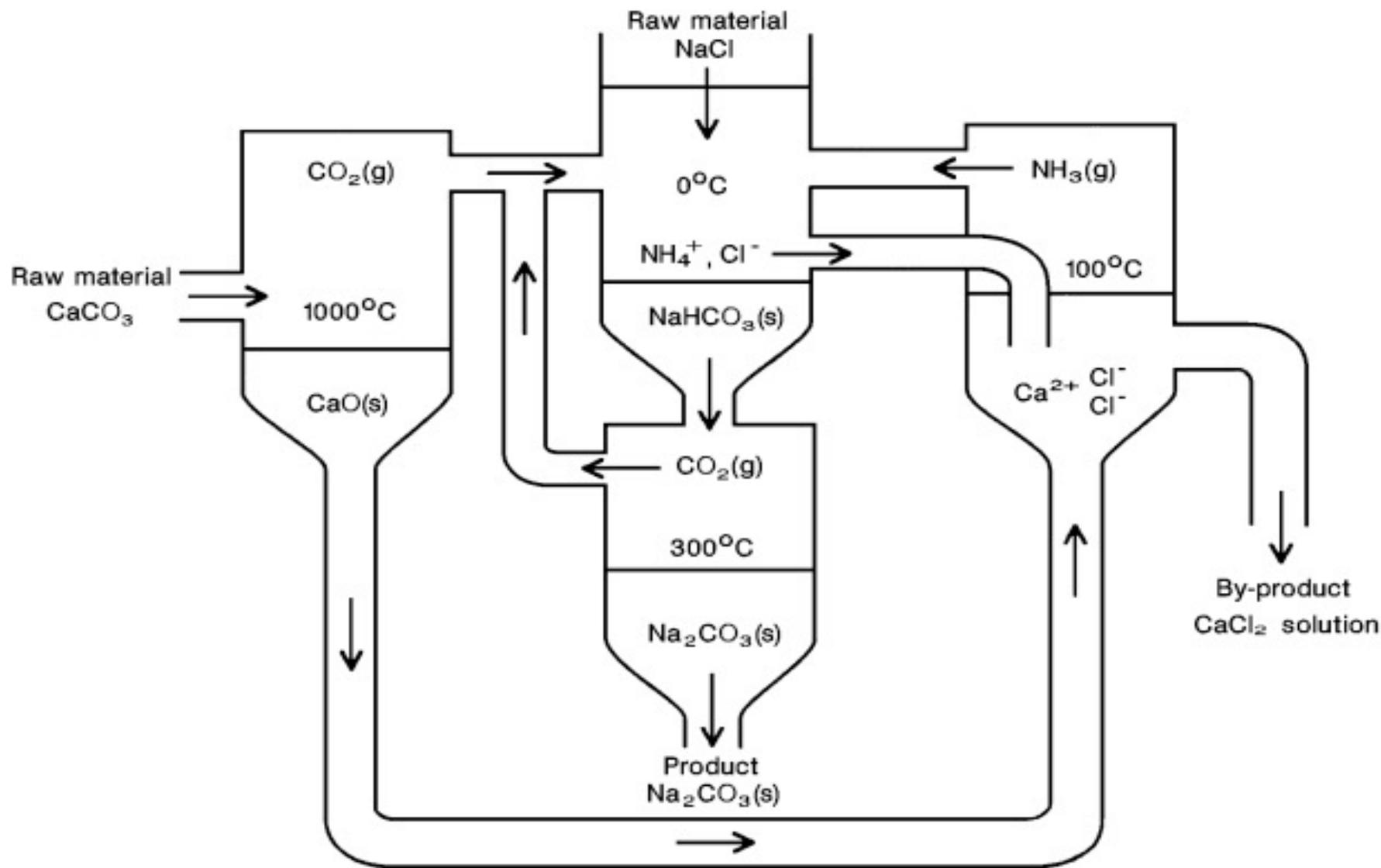
# Processo Hall



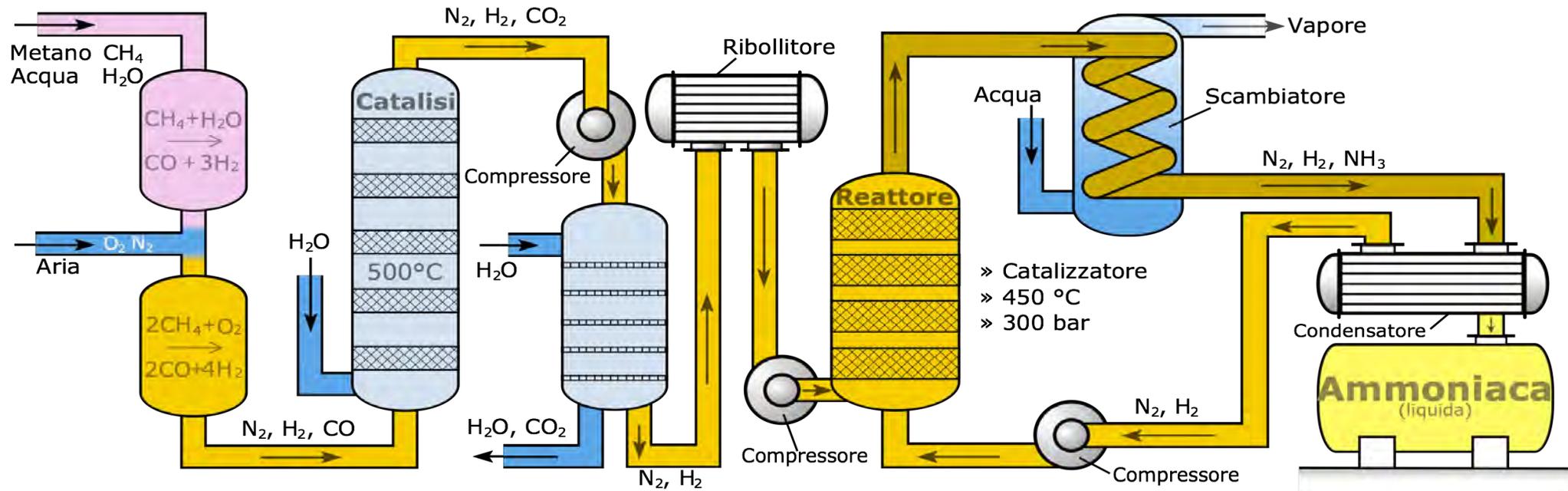
# Bayer + Hall



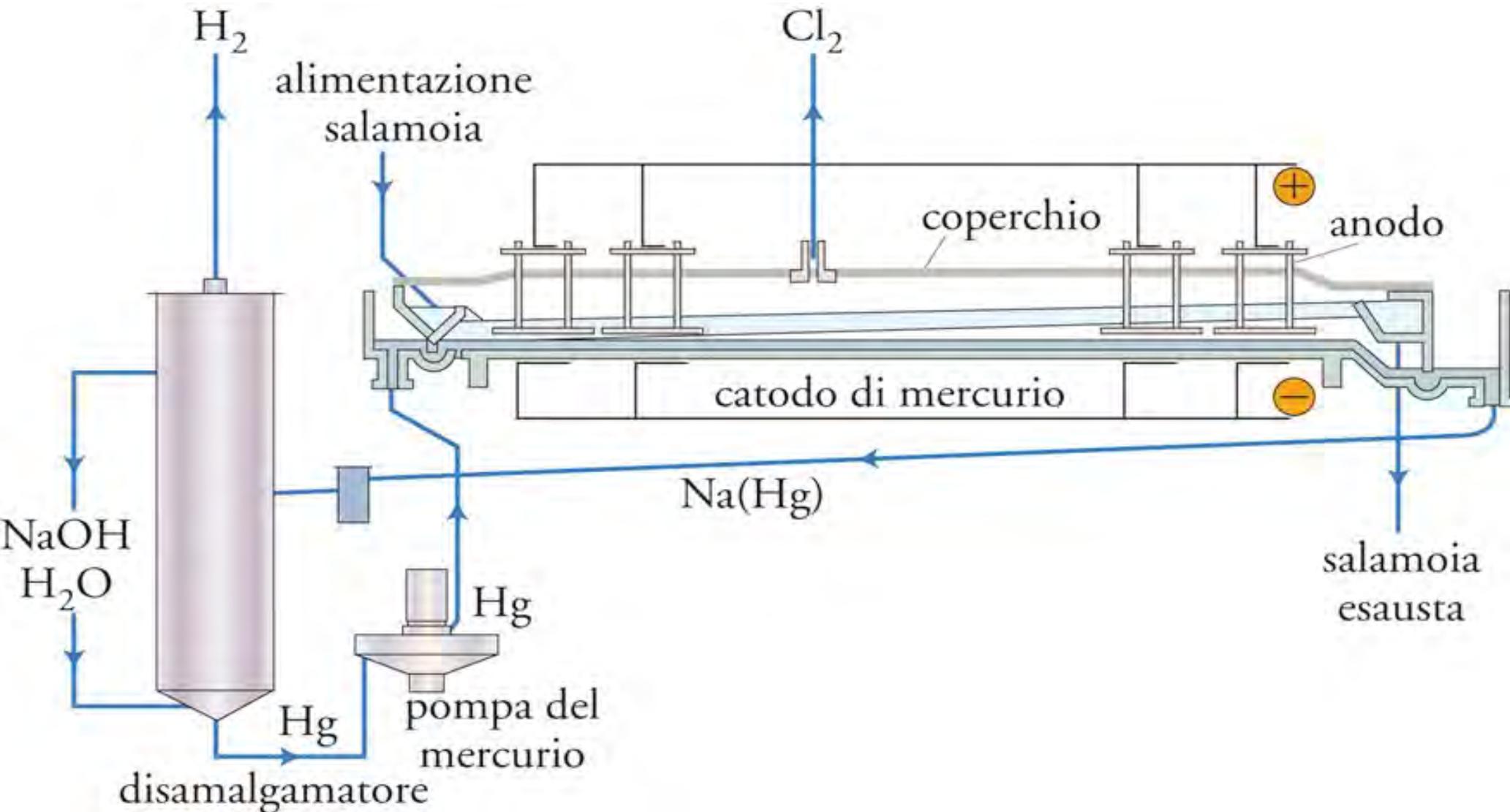
# Processo Solvay



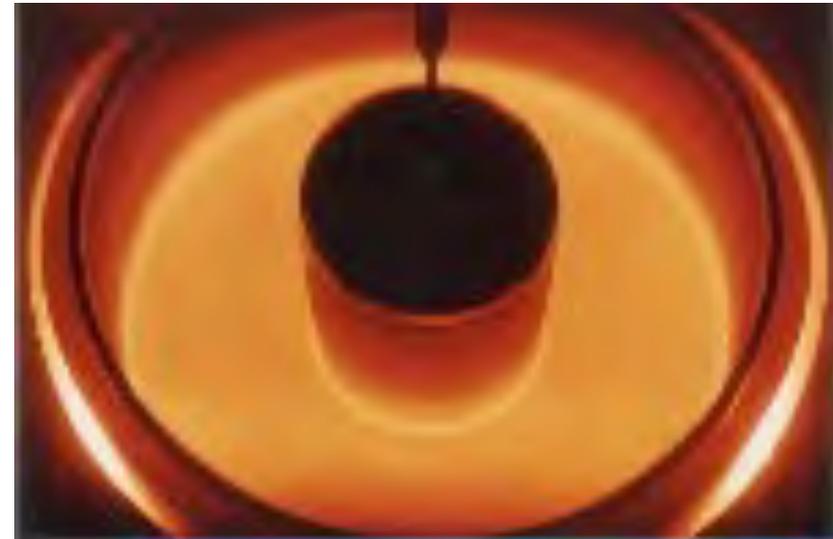
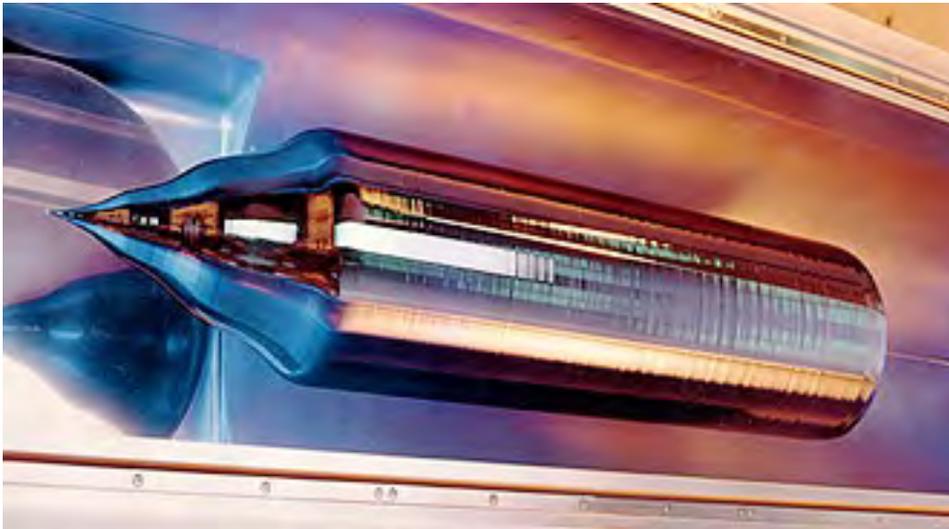
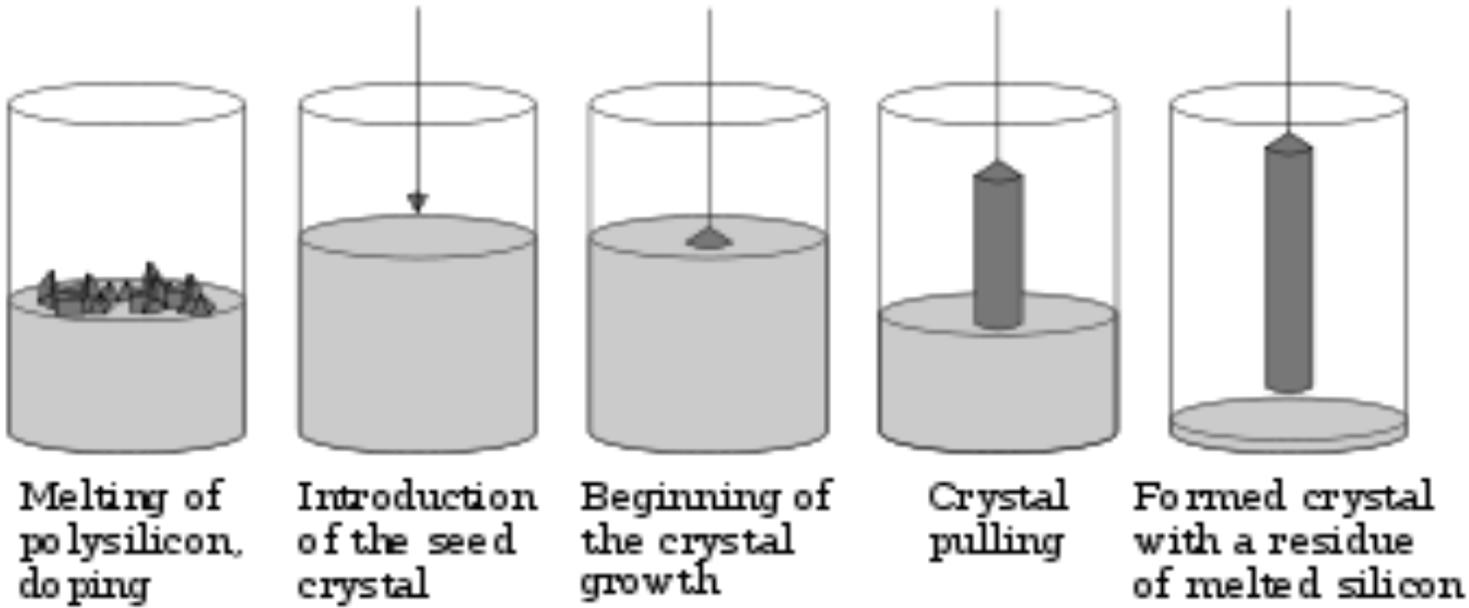
# Processo Haber Bosch



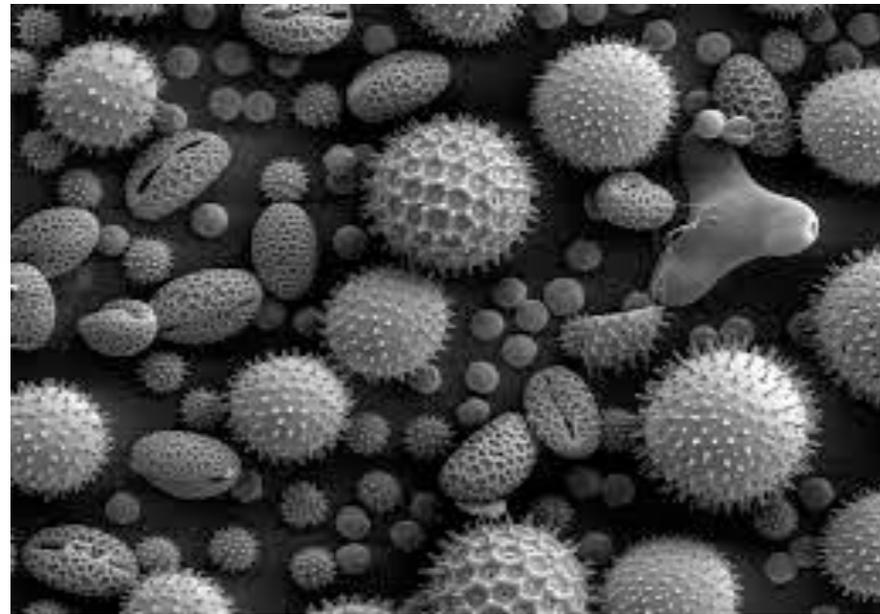
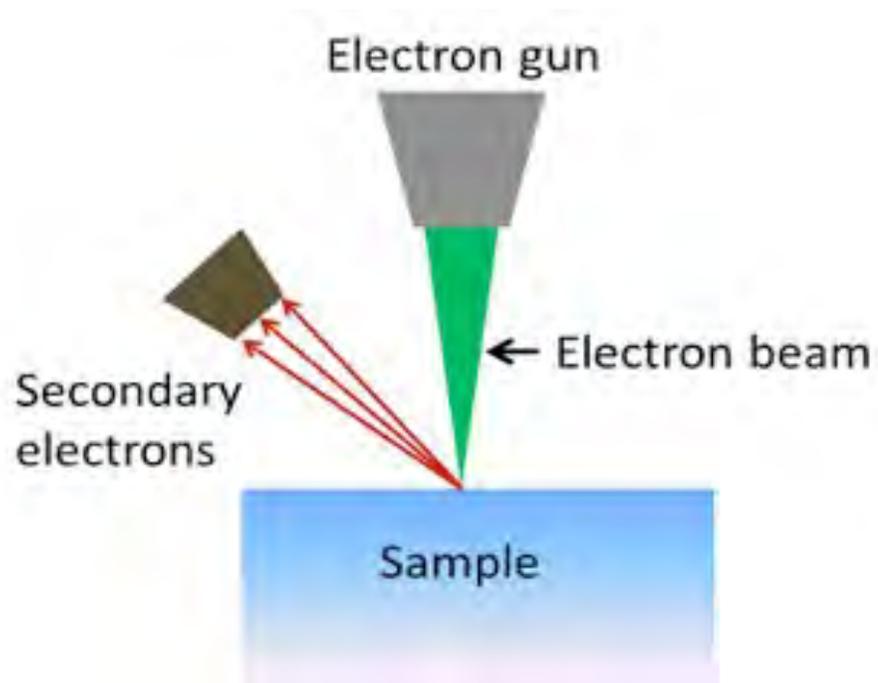
# Prep NaOH su catodo di mercurio



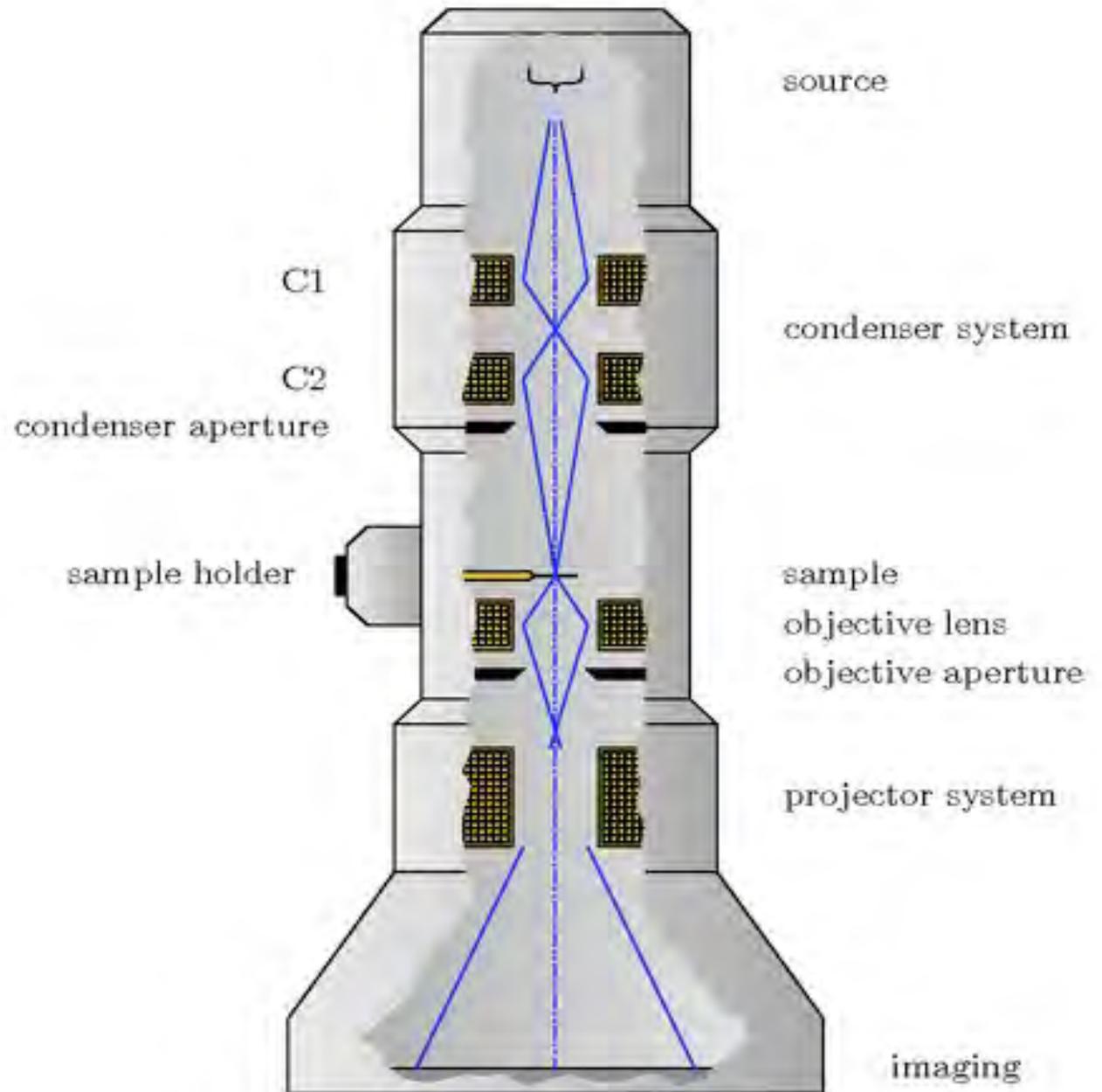
# Processo Czochralski



# SEM



# TEM



# Scheda di sicurezza prodotti chimici (Materials Safety Data Sheet)

## Regolamento del Parlamento europeo 1907/2016 del 18/12/2006

1. identificazione della sostanze / miscela e della società / impresa produttrice;
2. identificazione dei pericoli
3. composizione / informazione sugli ingredienti;
4. misure di primo soccorso;
5. misure antincendio;
6. misure in caso di rilascio accidentale;
7. manipolazione e immagazzinamento;
8. controllo dell'esposizione / protezione individuale;
9. proprietà fisiche e chimiche;
10. stabilità e reattività;
11. informazioni tossicologiche;
12. informazioni ecologiche;
13. considerazioni sullo smaltimento;
14. informazioni sul trasporto;
15. informazioni sulla regolamentazione;
16. altre informazioni.