

## Strutture molecolari

Numero di legami  $\sigma$  o  $\sigma$  più  $\pi$  formati per condivisione di elettroni dispari da ciascuno degli elementi non metallici nelle loro combinazioni.

Gruppo	n°	Elemento	C.E.F. o C.E.E.	N° di legami	Esempi
I°	1	H	$(1s)^1$	uno	HF, H <sub>2</sub> O PH <sub>3</sub>
II°	2	Be	$(2s)^1 2(p)^{1,0,0}$	due	BeO, BeF <sub>2</sub> Be <sub>2</sub> C
III°	2	B	$(2s)^1 2(p)^{1,1,0}$	tre	BF <sub>3</sub> , BO <sub>3</sub> <sup>3-</sup>
IV°	2	C	$(2s)^1 2(p)^{1,1,1}$	quattro	CH <sub>4</sub> , CO <sub>2</sub> , C <sub>2</sub> H <sub>6</sub>
	>2	Si, Ge	$(ns)^1 n(p)^{1,1,1} n(d)^{0,0,0,0,0}$	quattro	SiO <sub>2</sub> , GeO <sub>2</sub>

Gruppo	n°	Elemento	C.E.F. o C.E.E.	N° di legami	Esempi
V°	2	N	$(2s)^2 2(p)^{1,1,1}$	tre	NH <sub>3</sub> , N <sub>2</sub> H <sub>4</sub> , NO(OH)
		N <sup>+</sup>	$(2s)^1 2(p)^{1,1,1}$	quattro	NH <sub>4</sub> <sup>+</sup> , NO <sub>3</sub> <sup>-</sup>
		N <sup>-</sup>	$(2s)^2 2(p)^{2,1,1}$	due	NH <sub>2</sub> <sup>-</sup>
	>2	P, As, Sb	$(ns)^2 n(p)^{1,1,1} n(d)^{0,0,0,0,0}$	tre	PH <sub>3</sub> , AsH <sub>3</sub> , SbH <sub>3</sub>
			$(ns)^1 n(p)^{1,1,1} n(d)^{1,0,0,0,0}$	cinque	PCl <sub>5</sub> , PO <sub>4</sub> <sup>3-</sup> , AsO <sub>4</sub> <sup>3-</sup>
VI°	2	O	$(2s)^2 2(p)^{2,1,1}$	due	H <sub>2</sub> O, CO <sub>2</sub> , SiO <sub>2</sub>
		O <sup>+</sup>	$(2s)^2 2(p)^{1,1,1}$	tre	O <sub>3</sub> , H <sub>3</sub> O <sup>+</sup>
		O <sup>-</sup>	$(2s)^2 2(p)^{2,2,1}$	uno	O <sub>3</sub> , NO <sub>3</sub> <sup>-</sup>
	>2	S, Se, Te	$(ns)^2 n(p)^{2,1,1} n(d)^{0,0,0,0,0}$	due	H <sub>2</sub> S, H <sub>2</sub> Se, H <sub>2</sub> Te
			$(ns)^2 n(p)^{1,1,1} n(d)^{1,0,0,0,0}$	quattro	SO <sub>2</sub> , Cl <sub>2</sub> SO, SO <sub>3</sub> <sup>2-</sup>
			$(ns)^1 n(p)^{1,1,1} n(d)^{1,1,0,0,0}$	sei	SO <sub>3</sub> , Cl <sub>2</sub> SO <sub>2</sub> , SO <sub>4</sub> <sup>2-</sup>

Gruppo	n°	Elemento	C.E.F. o C.E.E.	N° di legami	Esempi
VII°	2	F	$(2s)^2 2(p)^{2,2,1}$	uno	HF, BeF <sub>2</sub> , BF <sub>3</sub> , CF <sub>4</sub>
	>2	Cl, Br, I	$(ns)^2 n(p)^{2,2,1} n(d)^{0,0,0,0,0}$	uno	HCl, HBr, Cl <sub>2</sub> O, ClO <sup>-</sup>
			$(ns)^2 n(p)^{2,1,1} n(d)^{1,0,0,0,0}$	tre	Cl <sub>2</sub> O <sub>3</sub> , ClO <sub>2</sub> <sup>-</sup>
			$(ns)^2 n(p)^{1,1,1} n(d)^{1,1,0,0,0}$	cinque	ClO <sub>3</sub> <sup>-</sup> , BrO <sub>3</sub> <sup>-</sup> , BrO <sub>3</sub> <sup>-</sup>
			$(ns)^1 n(p)^{1,1,1} n(d)^{1,1,1,0,0}$	sette	Cl <sub>2</sub> O <sub>7</sub> , ClO <sub>4</sub> <sup>-</sup> , IO <sub>4</sub> <sup>-</sup>



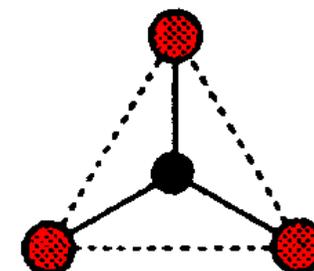
I) *lineare* se  $y = 2$  e  $c = 0$



$\text{XY}_2$   
*lineare*

Esempi:  $\text{BeH}_2$  (iduroruro di berillio) e  $\text{CO}_2$  (diossido di carbonio);

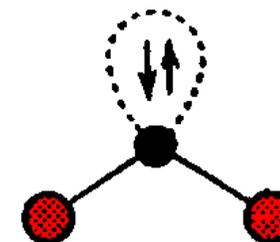
II) a) *trigonale piana* se  $y = 3$  e  $c = 0$



a:  $\text{XY}_3$   
*trigonale piana*

Esempi:  $\text{BF}_3$  (trifluoruro di boro) ed  $\text{SO}_3$  (triossido di zolfo);

b) *angolare* se  $y = 3$  e  $c = 1$



b:  $\text{XY}_2$   
*angolare*

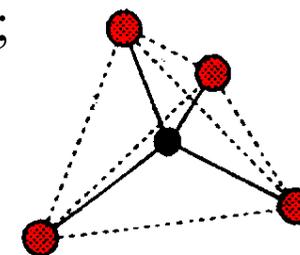
Esempi:  $\text{SO}_2$  (diossido di zolfo) ed  $\text{NO}_2^-$  (ione nitrito);

III)

a) *tetraedrica* se  $y = 4$  e  $c = 0$



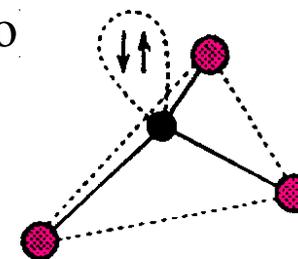
Esempi:  $CH_4$  (metano) ed  $SiF_4$  (tetrafluoruro di silicio);



a:  $XY_4$   
*tetraedrica*

b) *piramidale trigonale* se  $y = 4$  e  $c = 1$   $:XY_3$

Esempi:  $NH_3$  (ammoniaca) e  $PCl_3$  (tricloruro di fosforo);

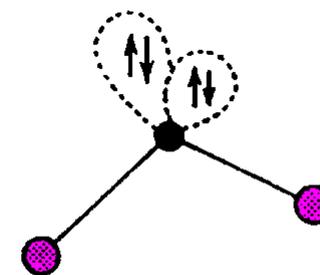


b:  $XY_3$   
*piramidale trigonale*

c) *a forma di V* se  $y = 4$  e  $c = 2$



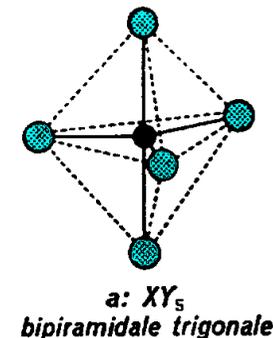
Esempi:  $OH_2$  (acqua) ed  $SH_2$  (acido solfidrico);



c:  $XY_2$   
*angolare*

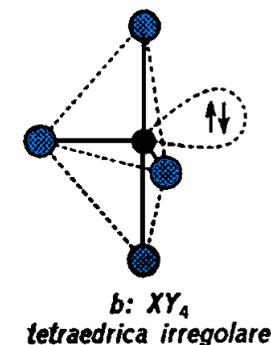
IV) *a) bipiramidale trigonale se  $y = 5$  e  $c = 0$   $XY_5$*

Esempi:  $PCl_5$  (pentacloruro di fosforo)  
ed  $AsF_5$  (pentacloruro di arsenico)



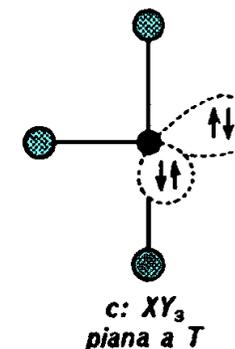
*b) tetraedrica irregolare se  $y = 5$  e  $c = 1$   $:XY_4$*

Esempi:  $SF_4$  (Tetrafloruro di zolfo)  
ed  $SeF_4$  tetrafloruro di selenio



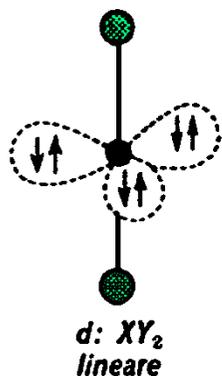
*c) piana a forma di T se  $y = 5$  e  $c = 2$   $(:)_2XY_3$*

Esempi:  $ClF_3$  (trifloruro di cloro)  
e  $BrF_3$  (trifloruro di bromo)



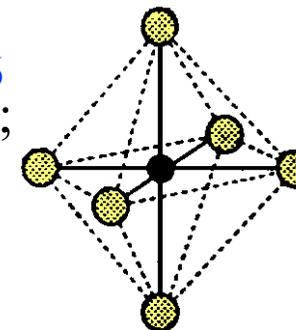
*d) lineare se  $Y = 5$  e  $c = 3$   $(:)_3XY_2$*

Esempi:  $BrCl_2^-$  (ione diclorobromato) ed  $ICl_2^-$  (dicloroiodato)



V) a) *ottaedrica* se  $y = 6$  e  $c = 0$

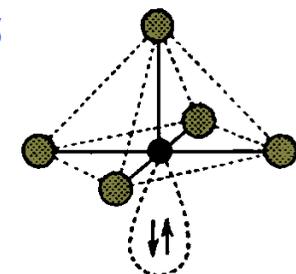
Esempi:  $\text{SF}_6$  (esafloruro di zolfo) e  $\text{PF}_6^-$  (ione esafluorofosfato);



a:  $\text{XY}_6$   
ottaedrica

b) *piramidale tetragonale* se  $Y = 6$  e  $c = 1$

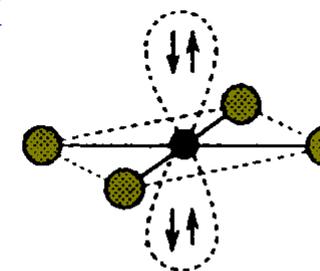
Esempi  $\text{BrF}_5$  (pentafloruro di bromo)  
e  $\text{SbF}_5^-$  (ione pentafluoroantimoniato)



b:  $\text{XY}_5$   
piramidale tetragonale

c) *quadrata piana* se  $Y = 6$  e  $c = 2$

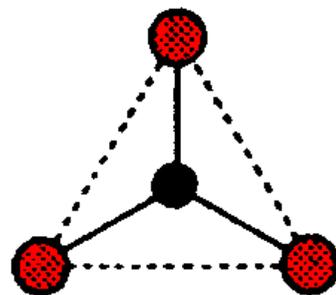
Esempi  $\text{BrF}_4^-$  (ione tetrafluorobromato)  
e  $\text{ICl}_4^-$  (ione tetracloroiodato)



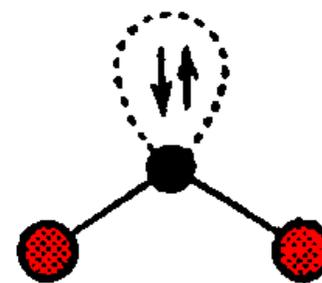
c:  $\text{XY}_4$   
quadrata piana



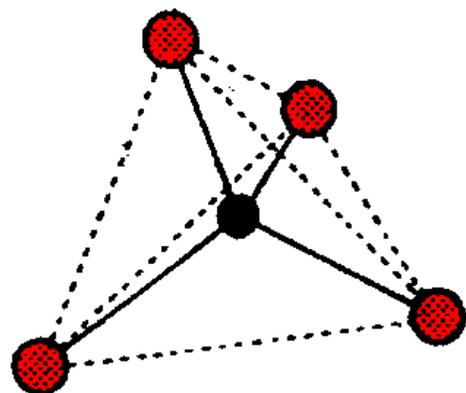
$XY_2$   
*lineare*



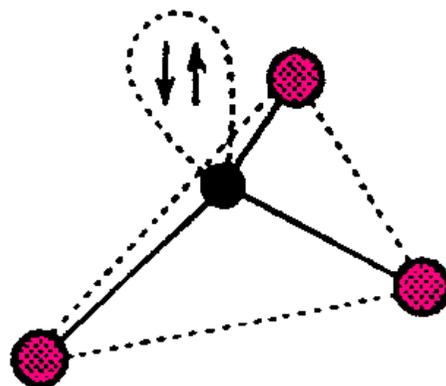
a:  $XY_3$   
*trigonale piana*



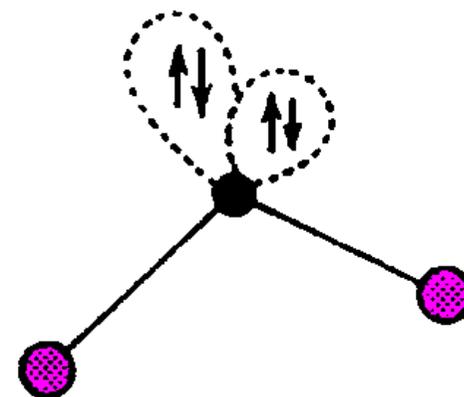
b:  $XY_2$   
*angolare*



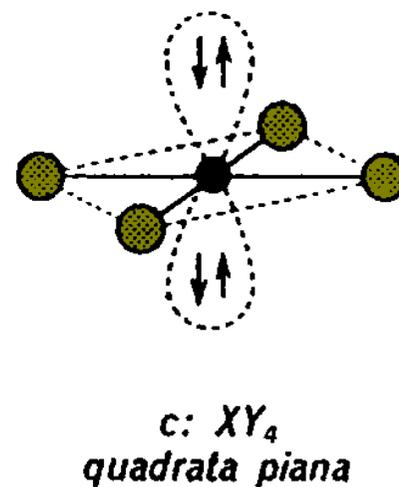
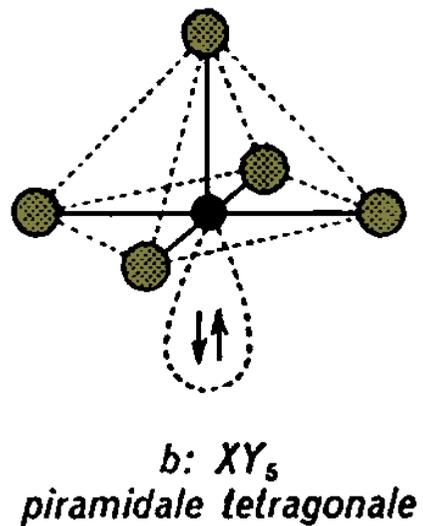
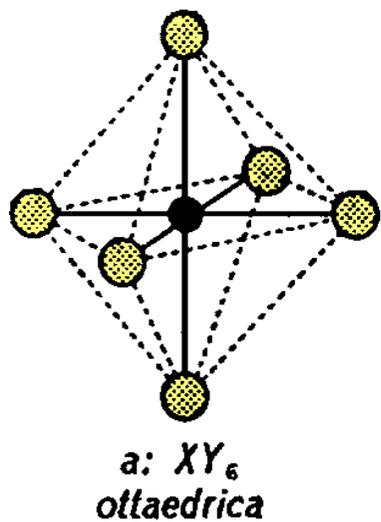
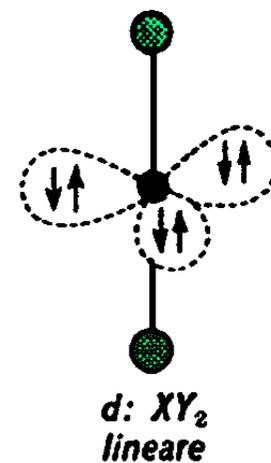
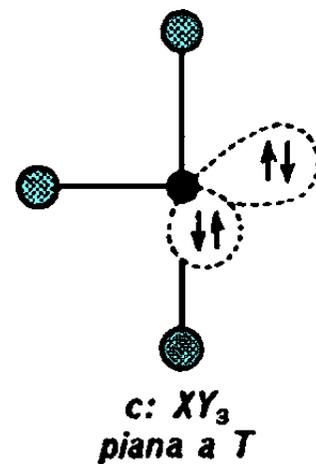
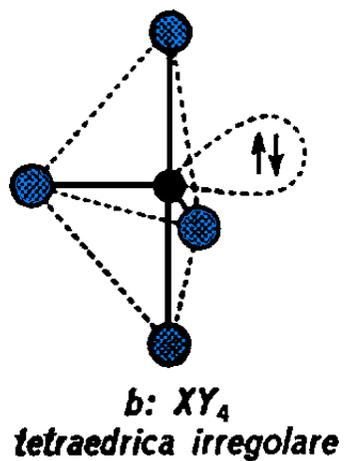
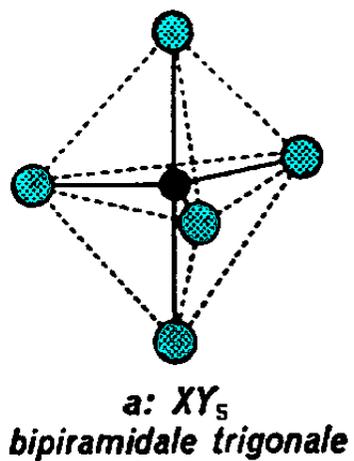
a:  $XY_4$   
*tetraedrica*



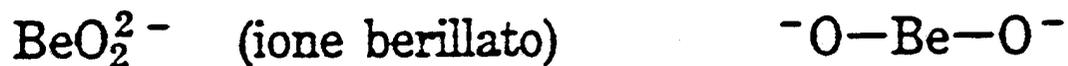
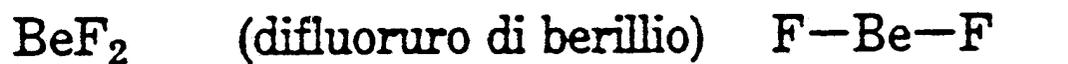
b:  $XY_3$   
*piramidale trigonale*



c:  $XY_2$   
*angolare*

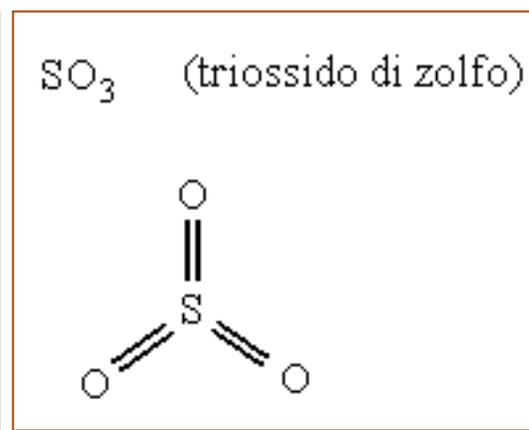
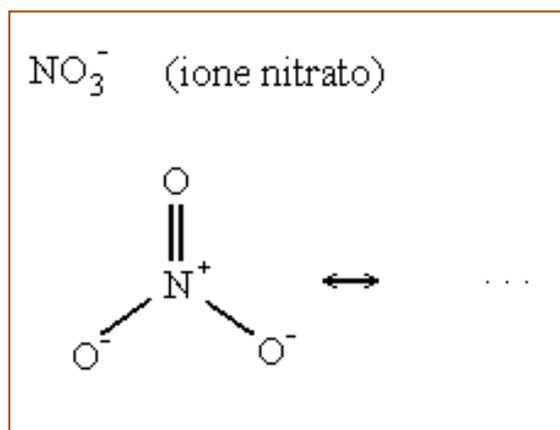
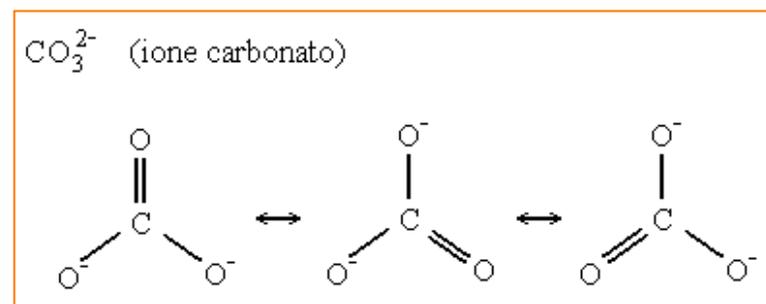
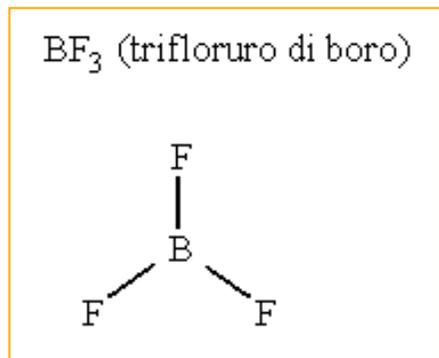
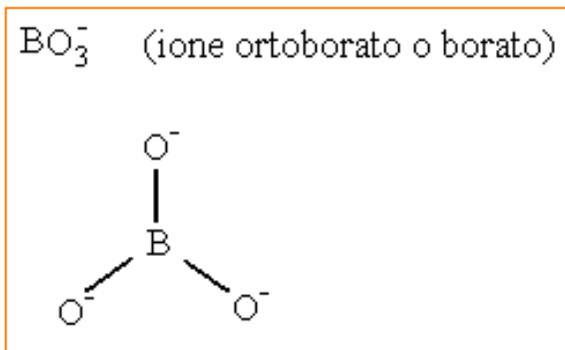
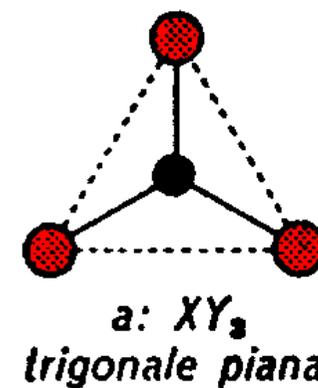
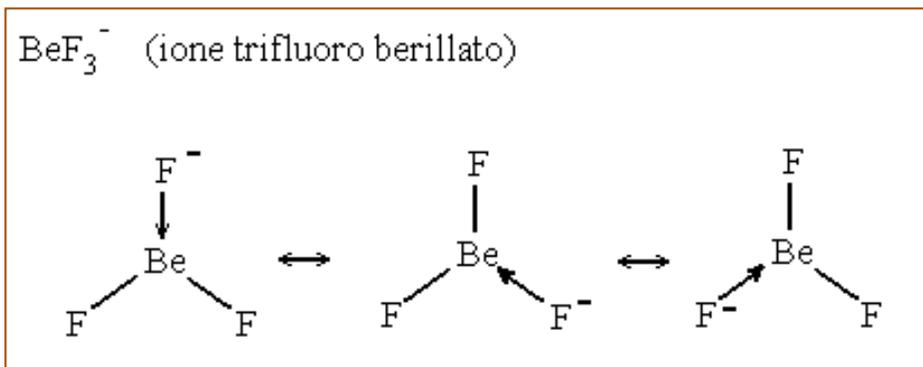


molecole con l'atomo centrale ibridato sp, a geometria lineare:



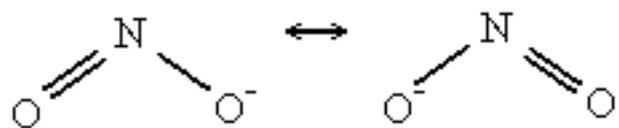
XY<sub>2</sub>  
lineare

II a) molecole con l'atomo centrale ibridizzato  $sp^2$ , a geometria ***trigonale piana***

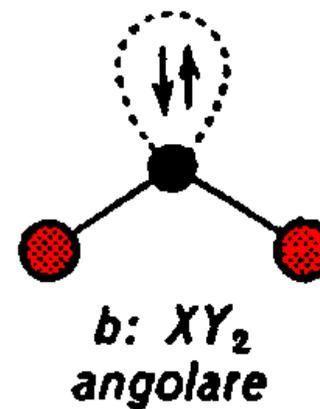
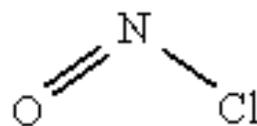


b) molecole con l'atomo centrale ibridizzato  $sp^2$ , a geometria angolare

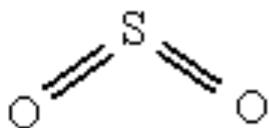
$\text{NO}_2^-$  (ione nitrito)



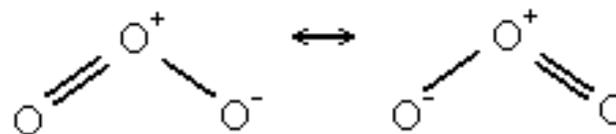
$\text{NOCl}$  (cloruro di nitrosile)



$\text{SO}_2$  (diossido di zolfo)

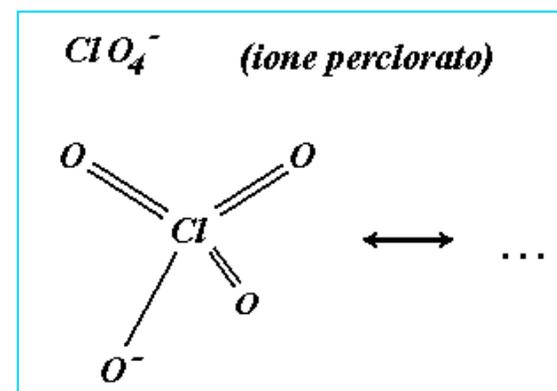
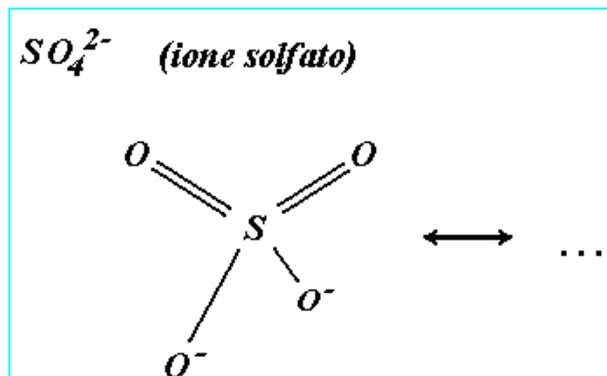
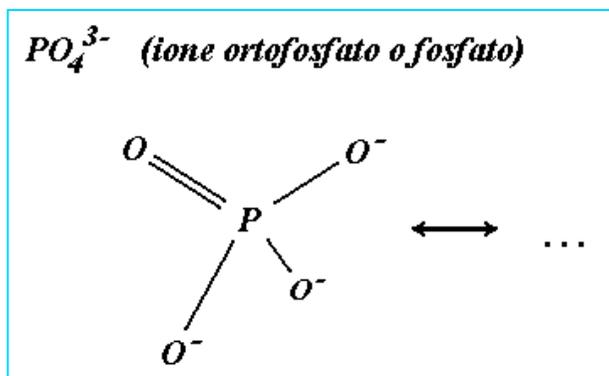
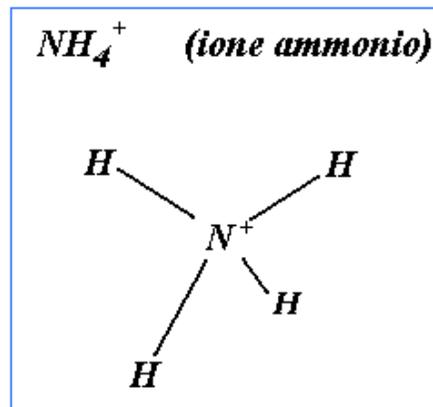
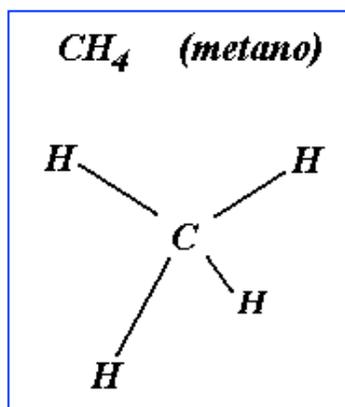
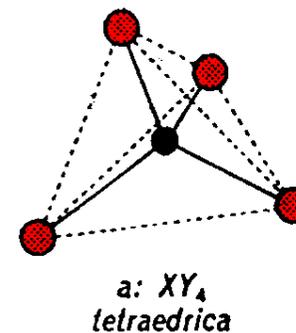
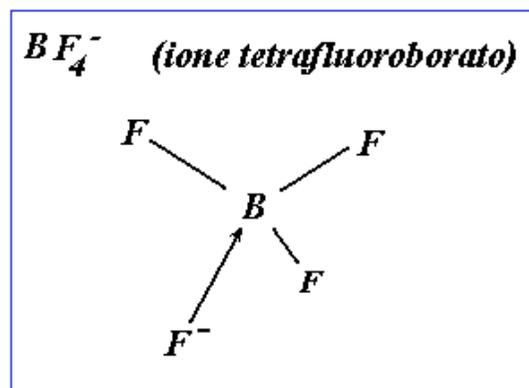
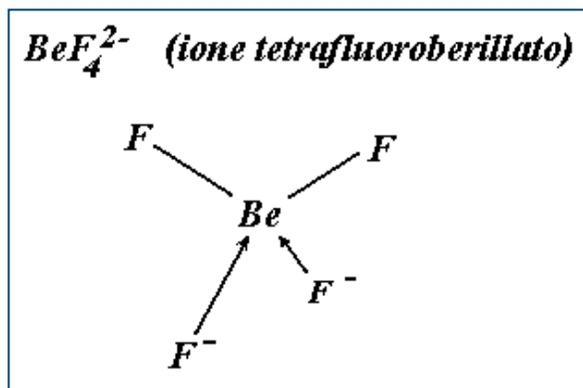


$\text{O}_3$  (ozono)

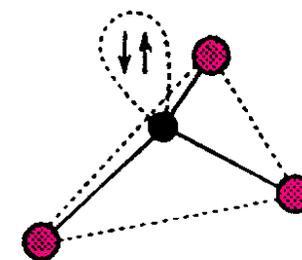
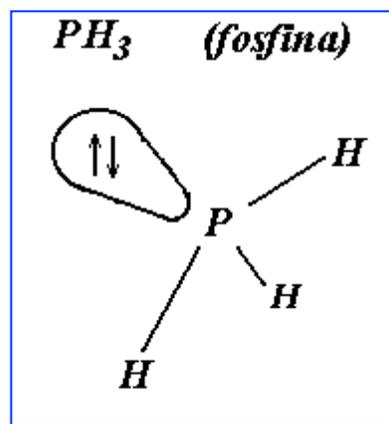
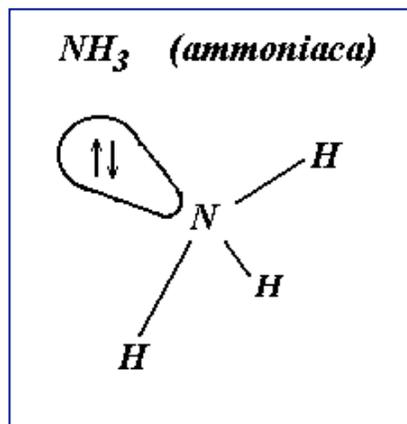


III

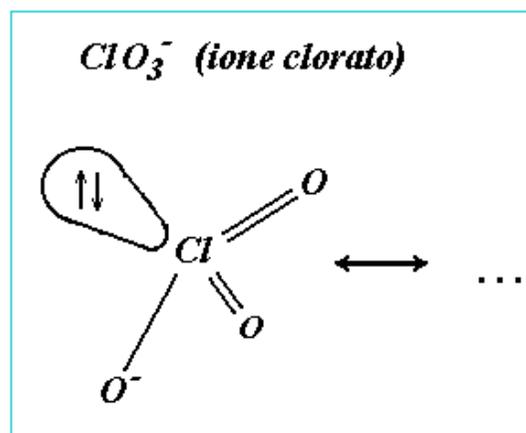
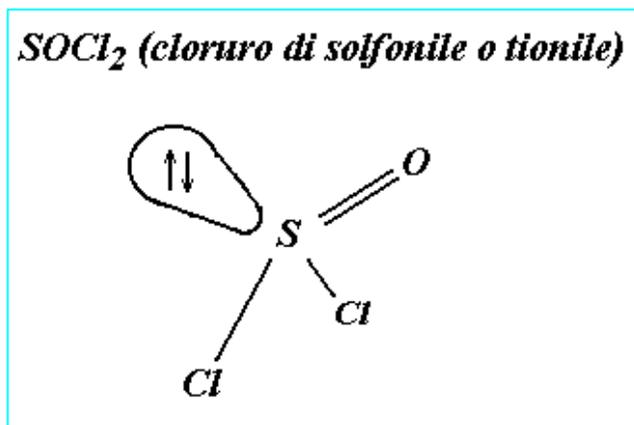
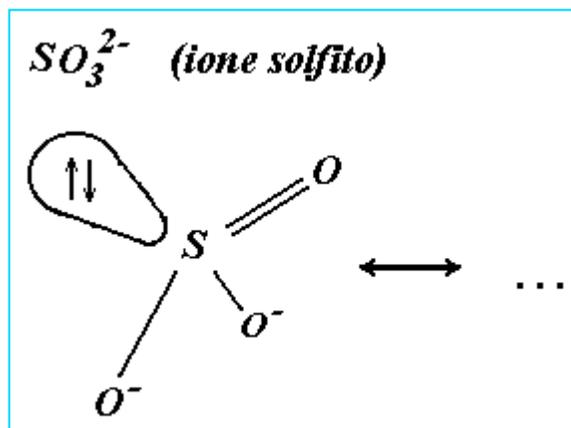
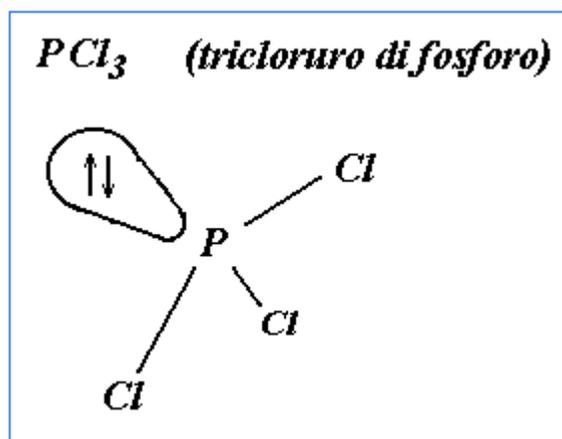
a) molecole con l'atomo centrale ibridizzato  $sp^3$ , a geometria ***tetraedrica***



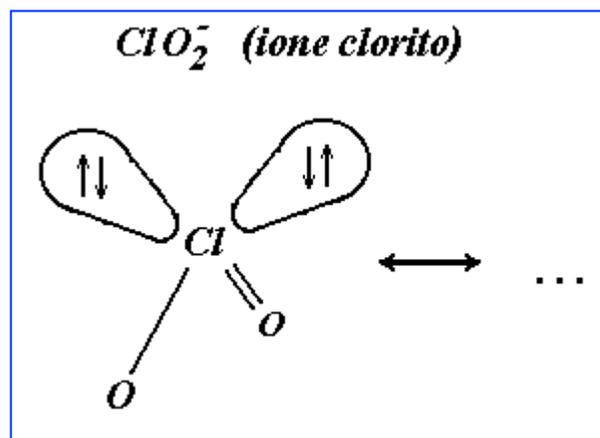
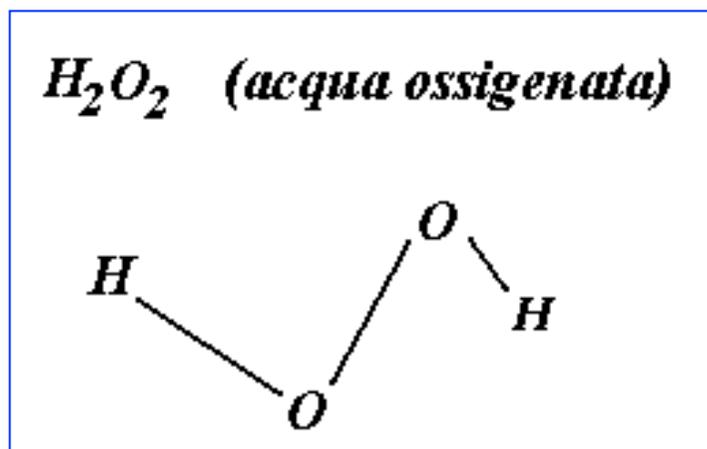
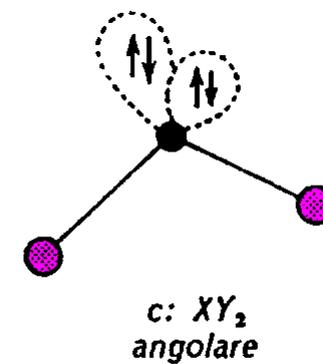
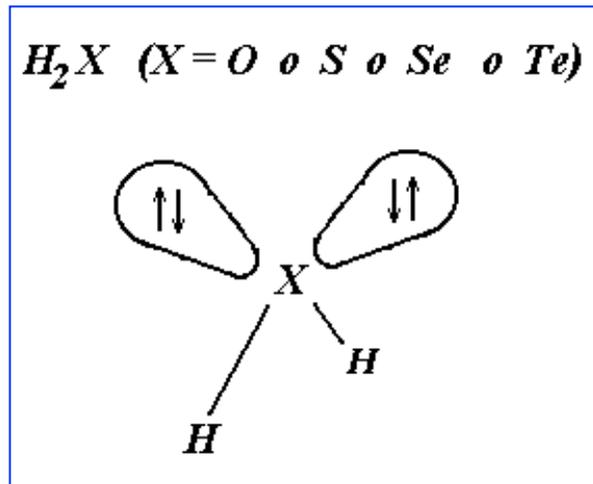
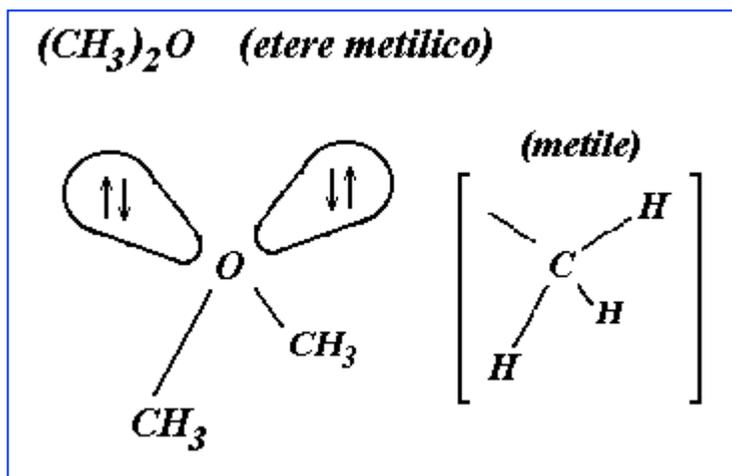
b) molecole con l'atomo centrale ibridizzato  $sp^3$ , a geometria ***piramidale trigonale***



b:  $XY_3$   
piramidale trigonale

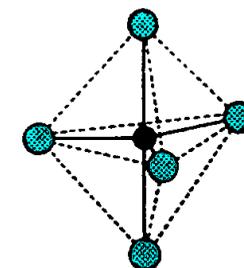


c) molecole con l'atomo centrale ibridizzato  $sp^3$ , a geometria a  $V$



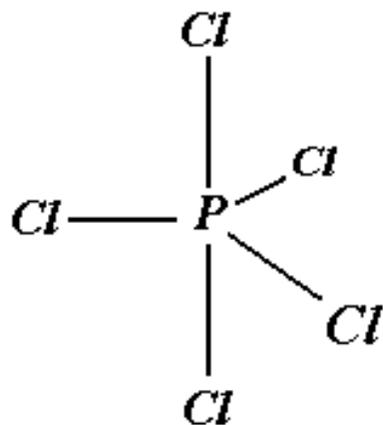
IV

a) molecole con l'atomo centrale ibridizzato  $sp^3d$ , a geometria a ***bipiramidale trigonale***

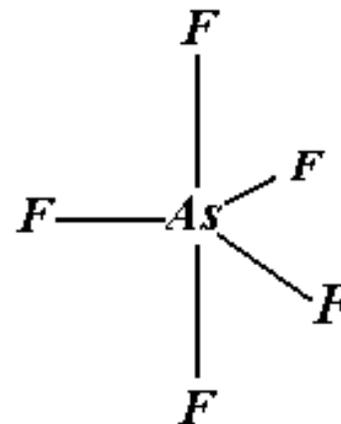


a:  $XY_5$   
*bipiramidale trigonale*

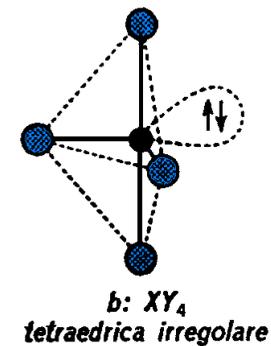
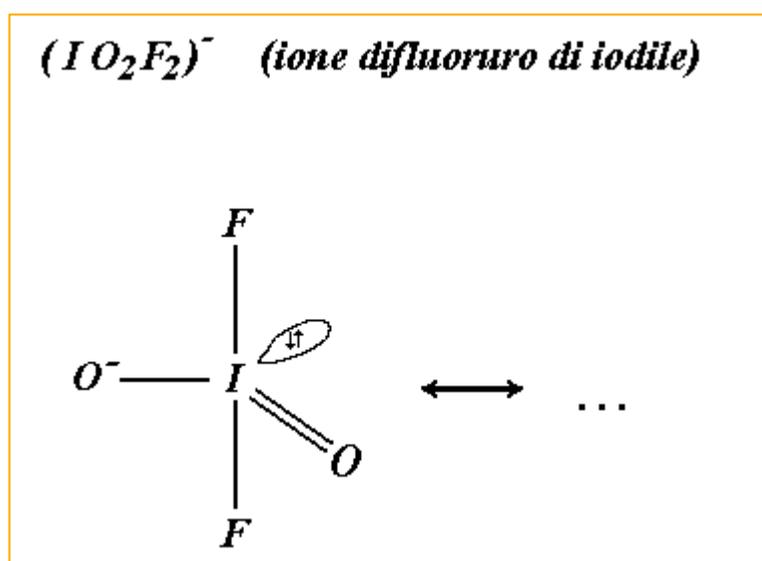
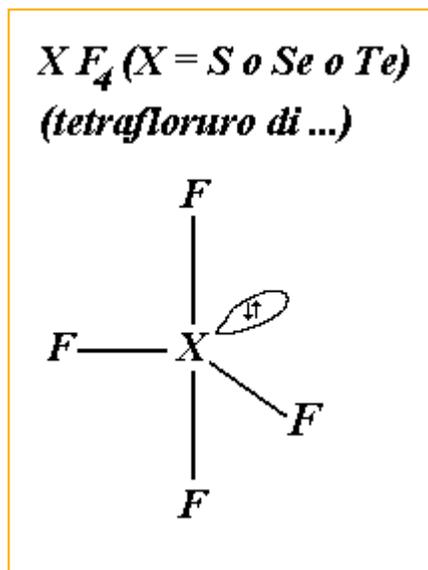
*$PCl_5$  (pentacloruro di fosforo)*



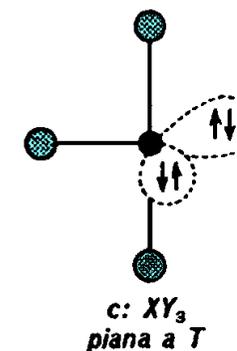
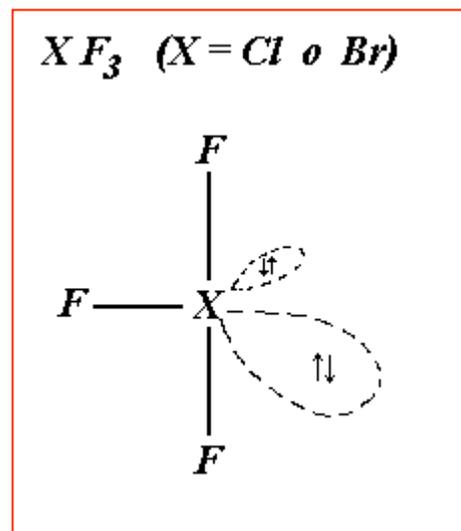
*$AsF_5$  (pentafluoruro di arsenico)*



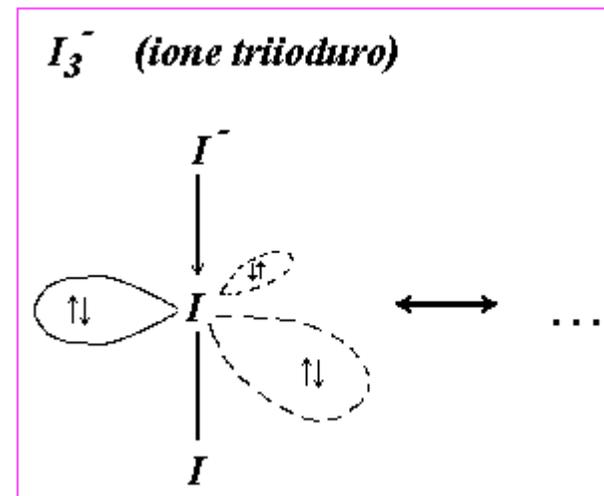
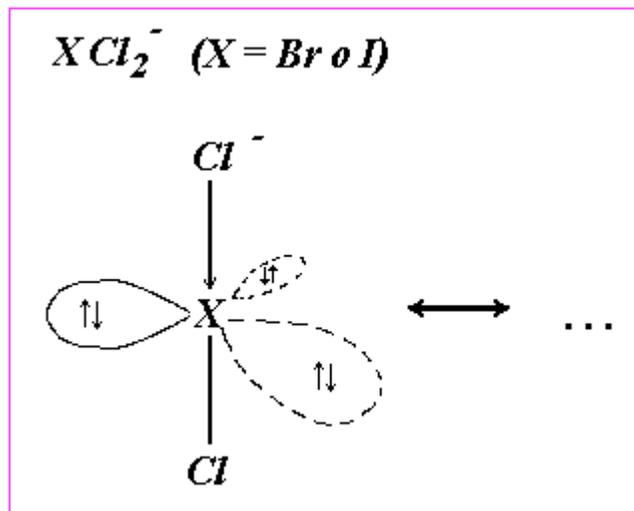
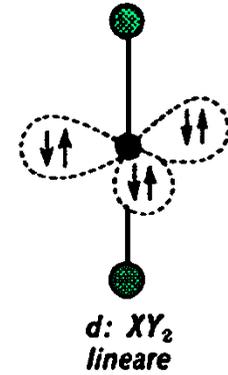
b) molecole con l'atomo centrale ibridizzato  $sp^3d$ , a geometria **tetraedrica irregolare**



c) molecole con l'atomo centrale ibridizzato  $sp^3d$ , con geometria a **T**

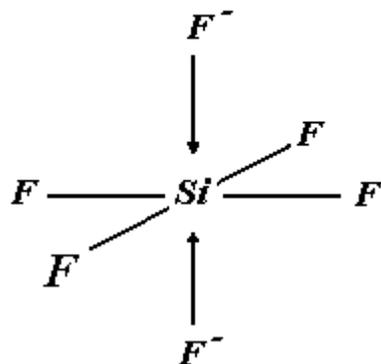


d) molecole con l'atomo centrale ibridizzato  $sp^3d$ , con geometria a **lineare**

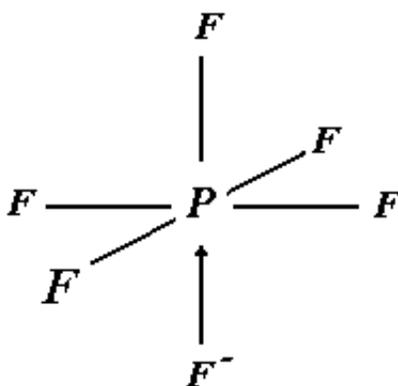


V a) molecole con l'atomo centrale ibridizzato  $sp^3d^2$ , a geometria a **ottaedrica**

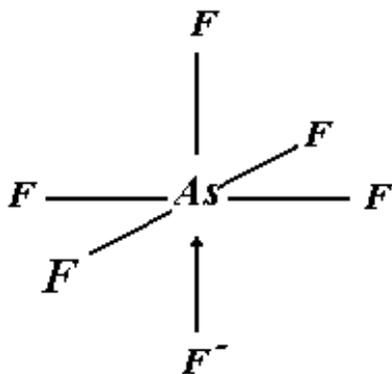
$SiF_6^{2-}$  (ione esafluoro silicato)



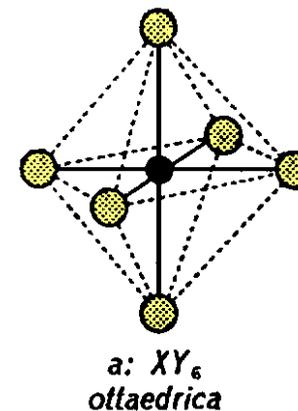
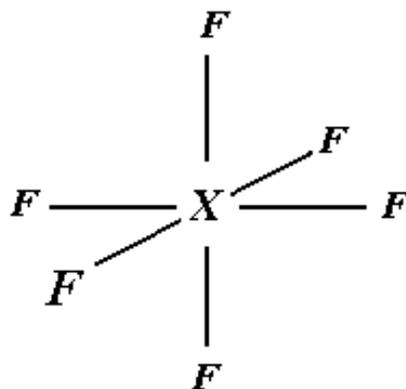
$PF_6^-$  (ione esafluorofosfato)



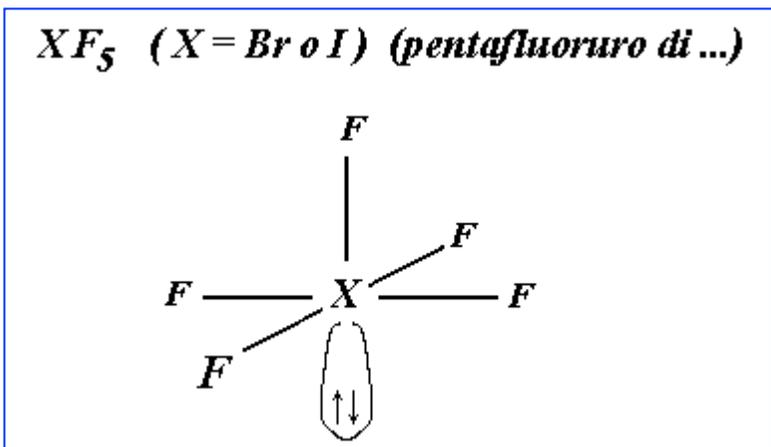
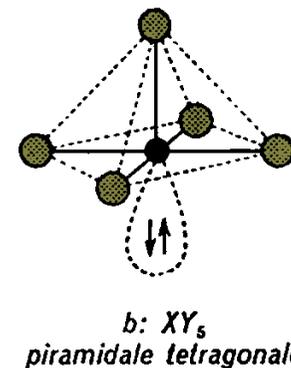
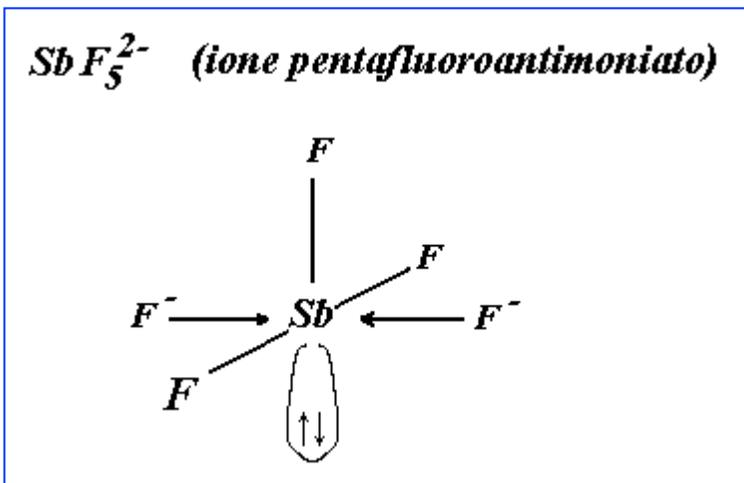
$AsF_6^-$  (ione esafluoroarseniato)



$XF_6$  ( $X = S$  o  $Se$ ) (esafluoruro di ...)

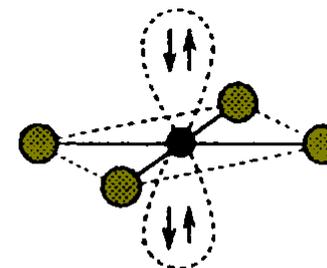
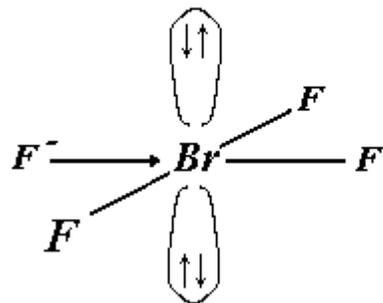


b) molecole con l'atomo centrale ibridizzato  $sp^3d^2$ , a geometria a **piramidale tetragonale**



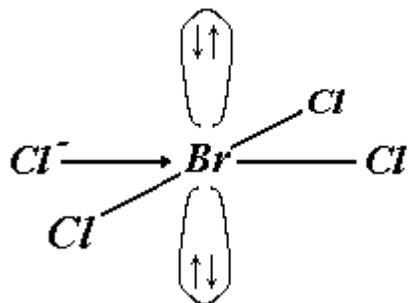
c) molecole con l'atomo centrale ibridizzato  $sp^3d^2$ , a geometria a **quadrata**

$BrF_4^-$  (ione tetrafluorobromato)

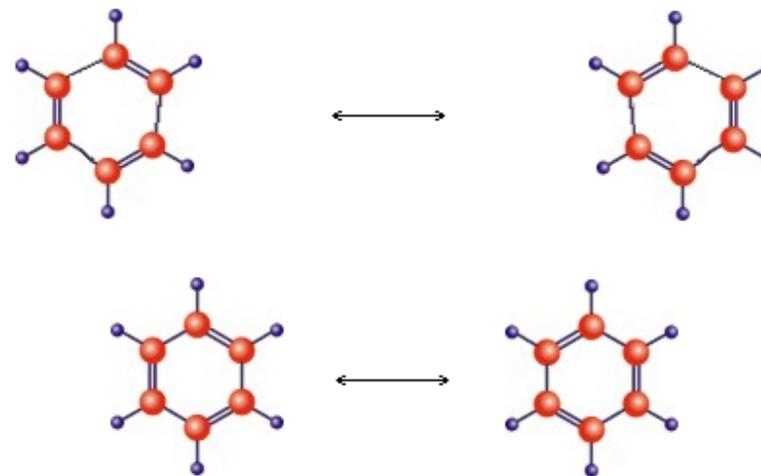
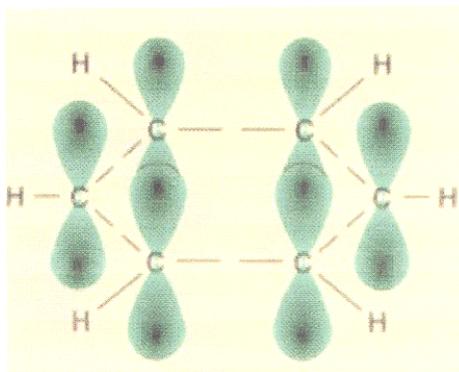


c:  $XY_4$   
quadrata piana

$ICl_4^-$  (ione tetracloroiodato)

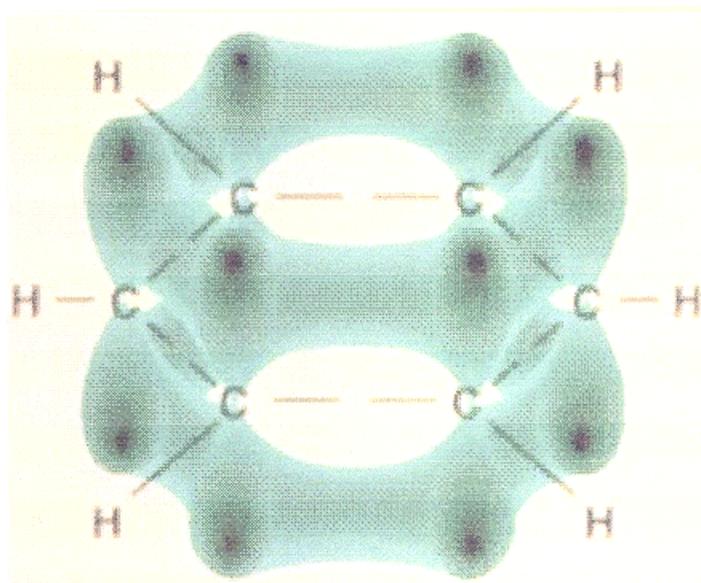


# Il benzene $C_6H_6$

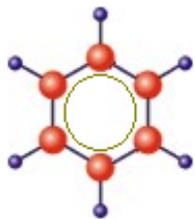


Formule limite di kekulé

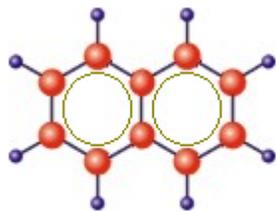
Composti aromatici: il numero di elettroni  $p$  di atomi di C adiacenti deve soddisfare la formula  $4n+2$



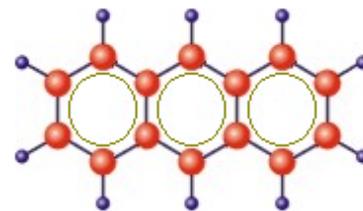
Composti aromatici: il numero di elettroni p di atomi di C adiacenti deve soddisfare la formula  $4n+2$



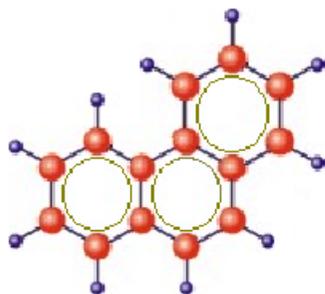
Benzene



Naftalina

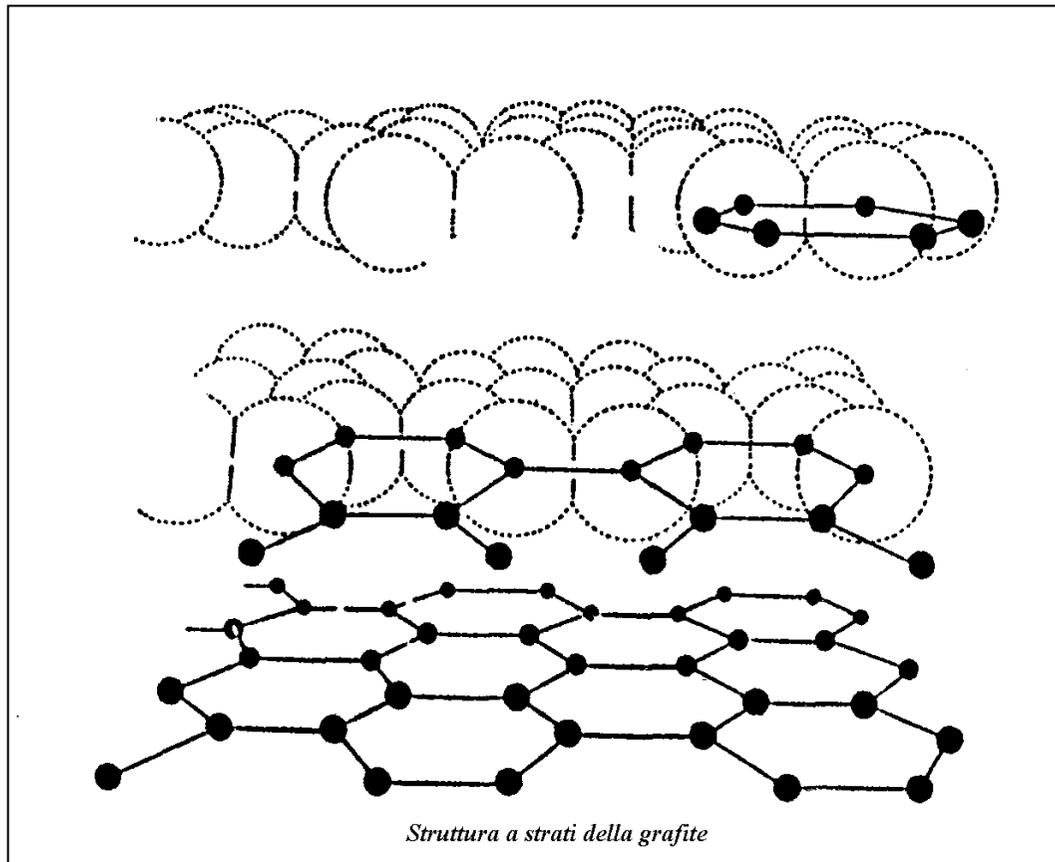
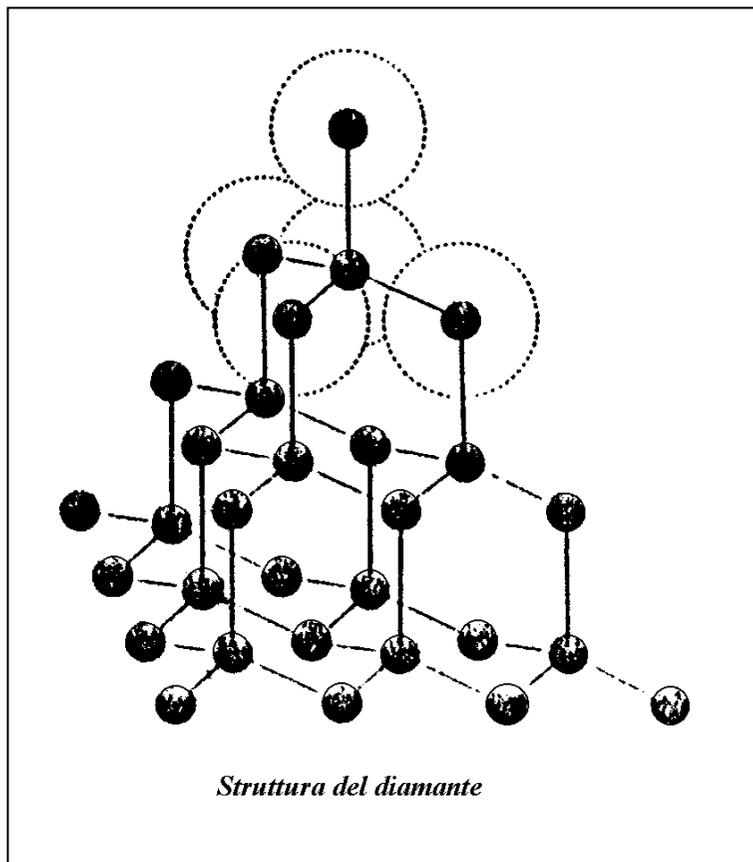


Antracene



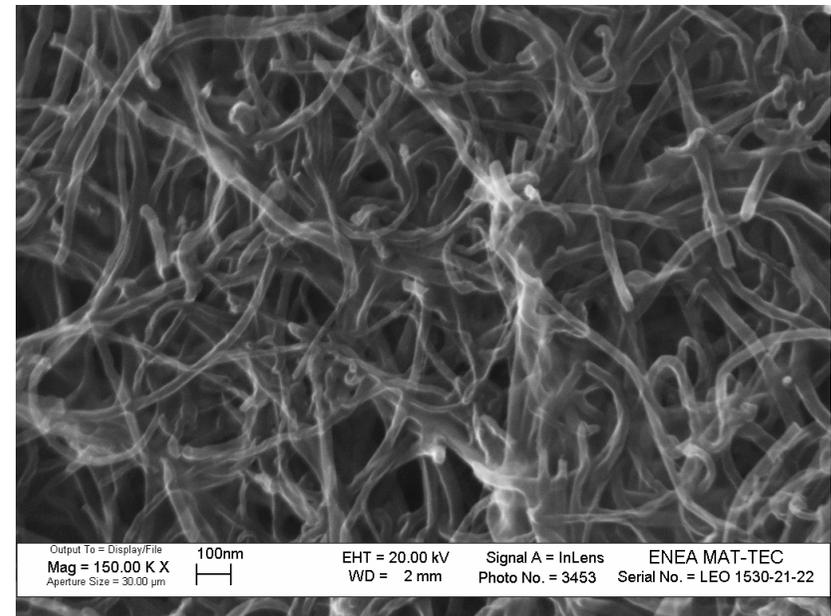
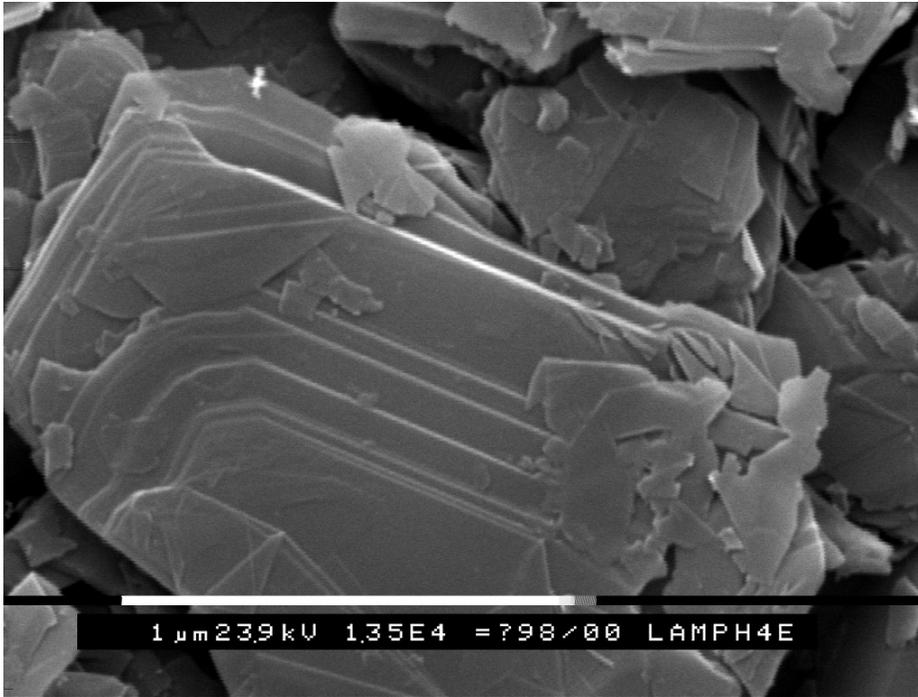
Fenantrane

# Solidi covalenti

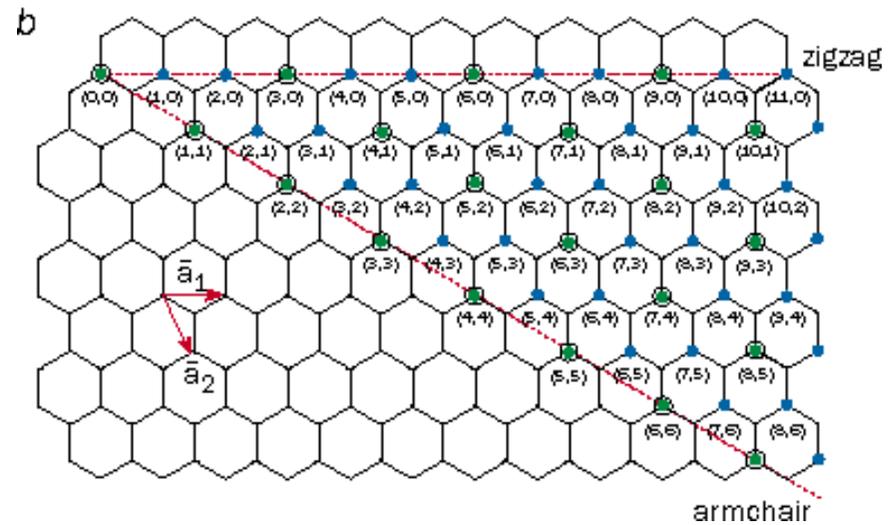
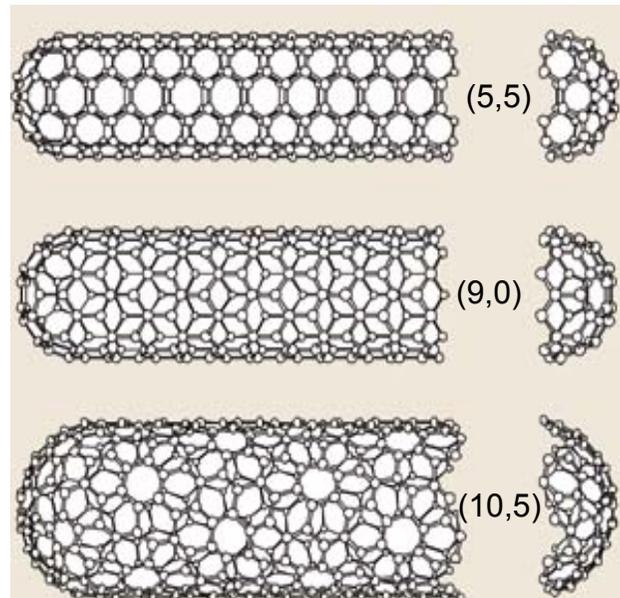
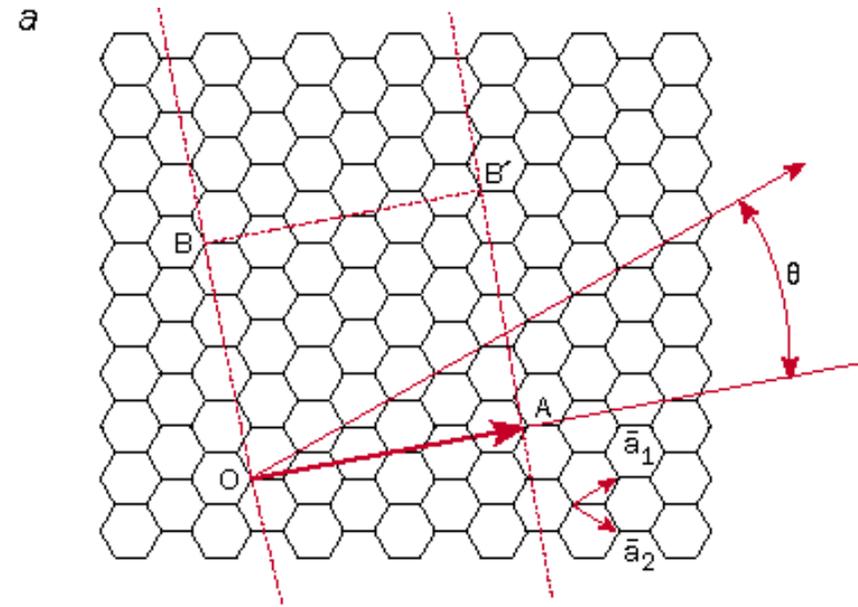
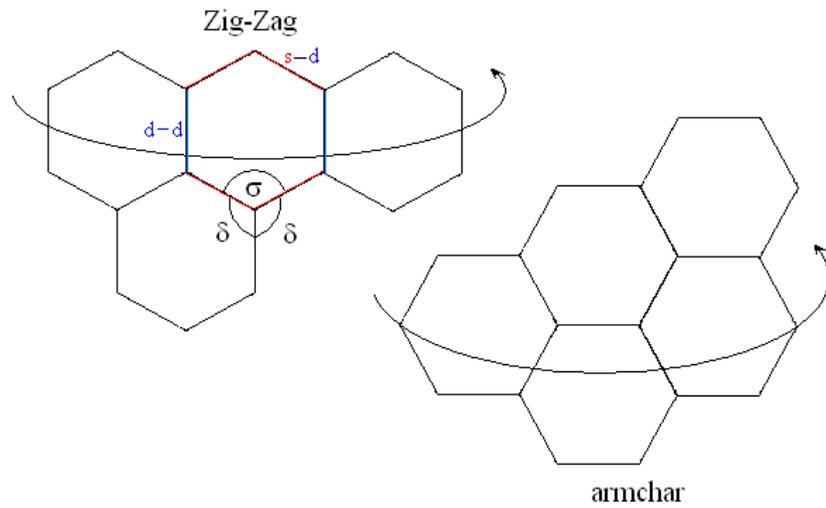


$$T_{\text{fusione}} = 3500 \text{ }^{\circ}\text{C}$$

$$T_{\text{ebollizione}} = 4200 \text{ }^{\circ}\text{C}$$

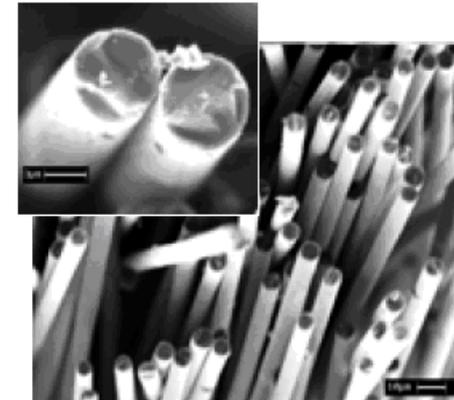
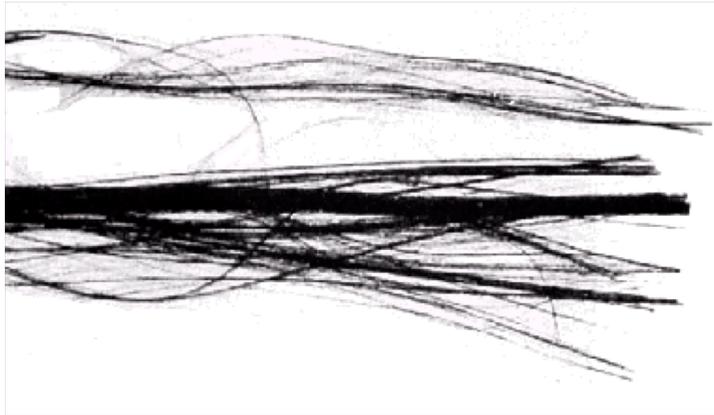


# Nanotubi di carbone



# FIBRE DI CARBONIO

Le fibre di carbonio sono un polimero di atomi di carbonio strutturato in forma grafitea ovvero da esagoni legati tra loro in modo da formare dei piani di carbonio grafiteo.

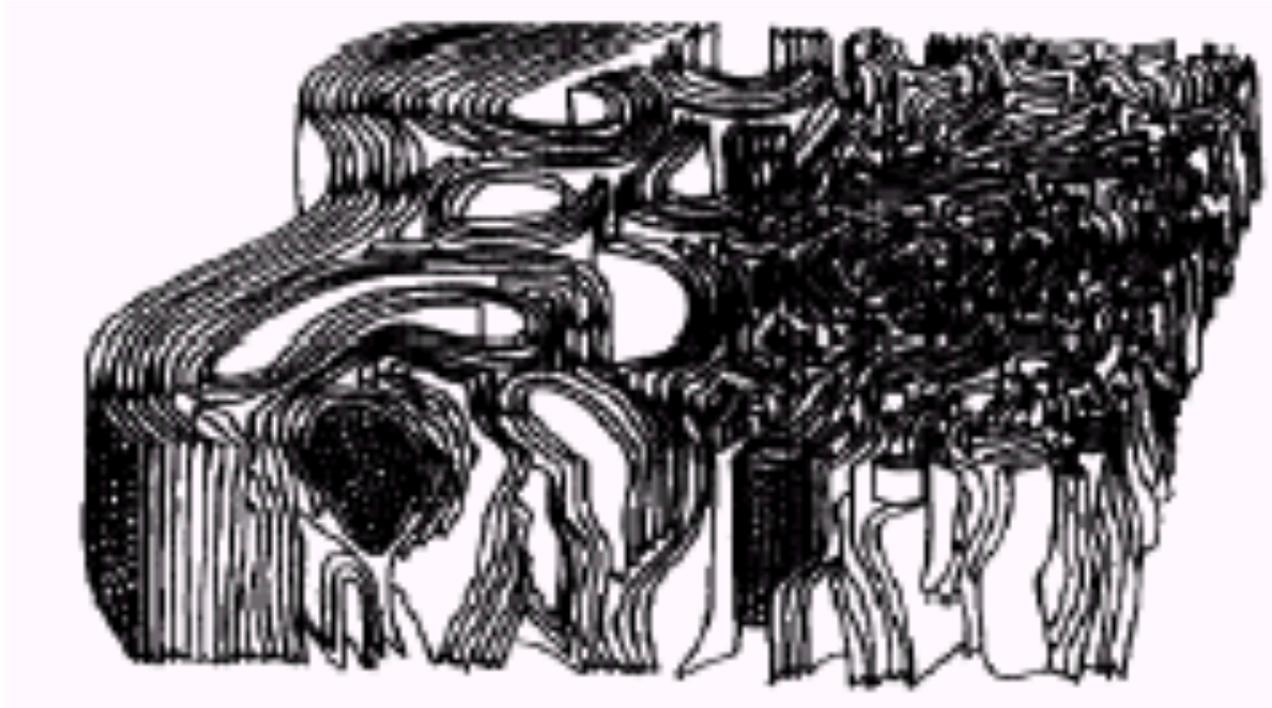


Ogni piano ha un'elevata resistenza meccanica e la differenza dalla grafite è che in quest'ultima i piani sono di piccole dimensioni (come lamelle) e c'è un facile scorrimento tra questi. Nelle fibre di carbonio questi piani sono di grandi dimensioni e lo scorrimento relativo è maggiormente impedito a favore di una maggiore resistenza meccanica.

Sono prodotte per modificazione di fibre organiche (rayon, acriliche, ecc.) o da residui della distillazione del petrolio o del catrame. Le prime sono chiamate **Carbonio-PAN**, le altre **Carbonio da pece (Pitch)**.

## Analisi della struttura delle fibre di PAN

Anche se l'orientamento degli strati tende ad essere parallelo all'asse della fibra, gli strati non risultano allineati ma, talvolta, presentano una grossa disorientazione intercristallina



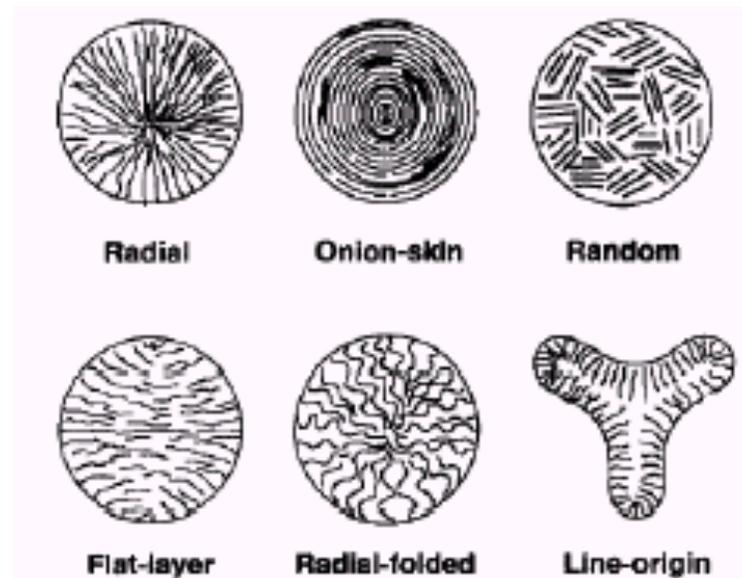
# FIBRE DI CARBONIO

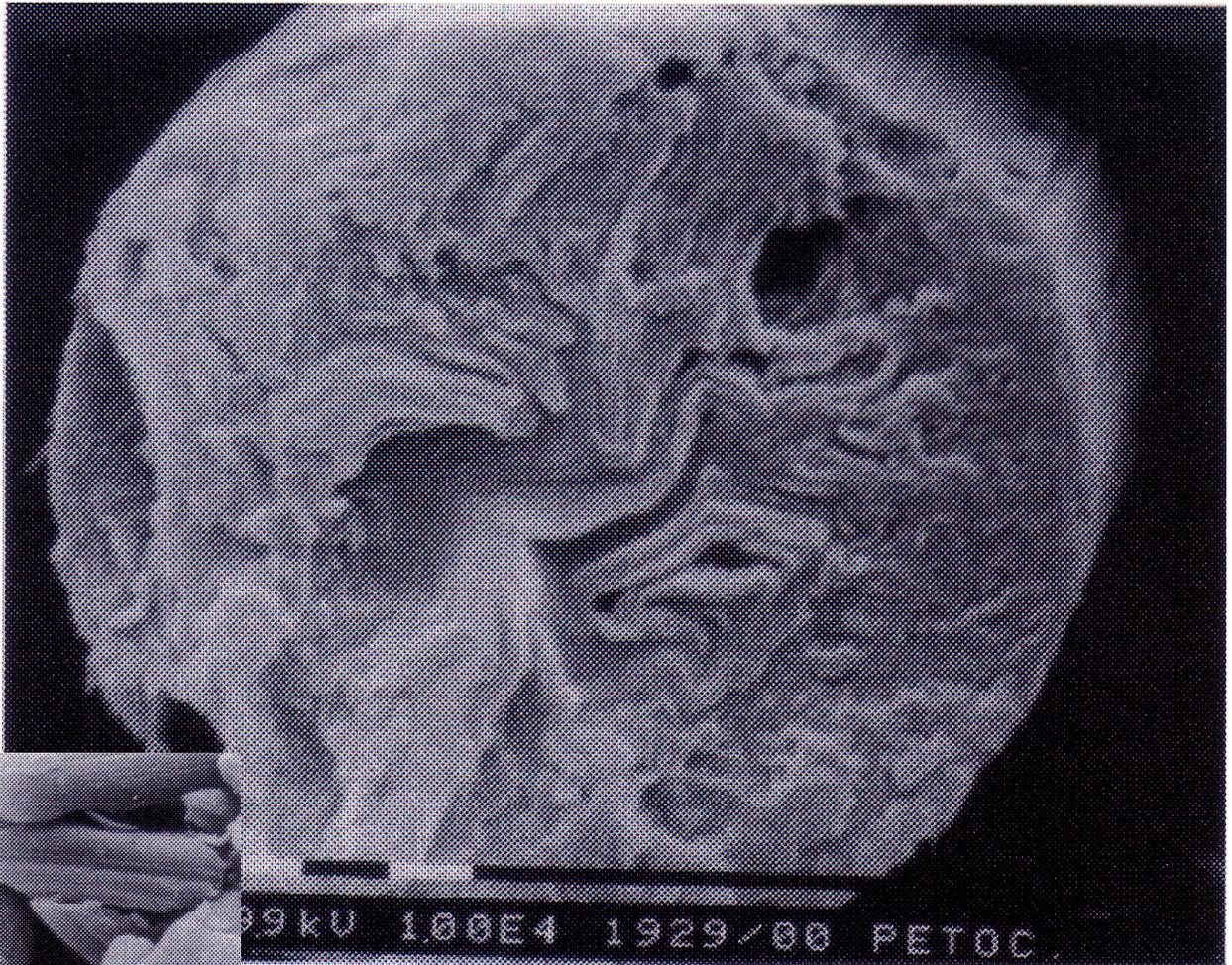
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## STRUTTURA DELL FIBRE PITCH-BASED

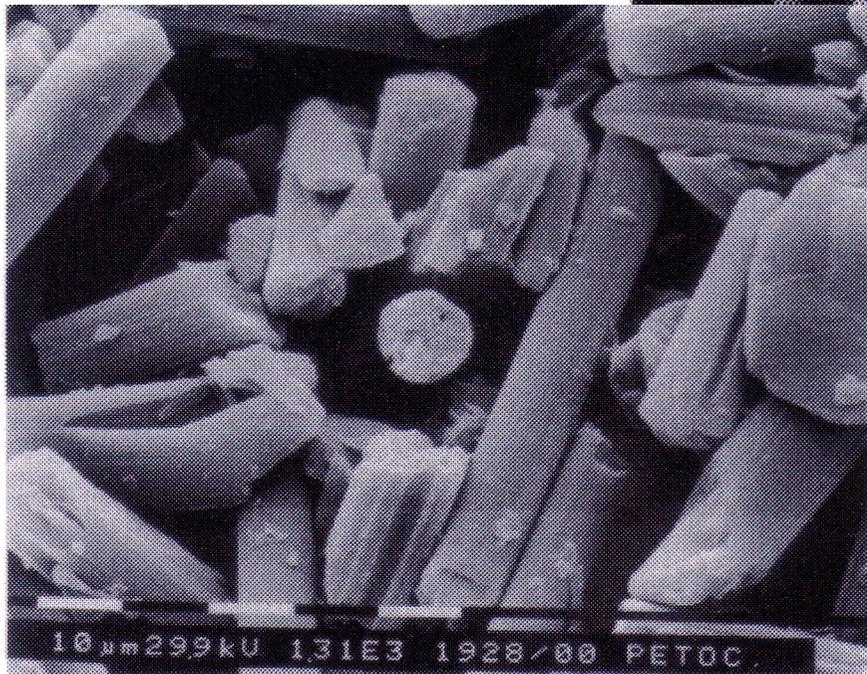
Il melt spinning per le fibre mesofasiche riesce a sviluppare moduli significativamente alti. Ciò costituisce una conseguenza della microstruttura della sezione trasversale e della orientazione molecolare lungo l'asse del precursore liquido-cristallino. Tipicamente, la microstruttura trasversale è radiale o stratificata e i piani degli strati tendono ad allinearsi parallelamente all'asse della fibra.

Fibre con tessitura trasversale random possono essere ottenute attraverso la dispersione del flusso durante l'estrusione.

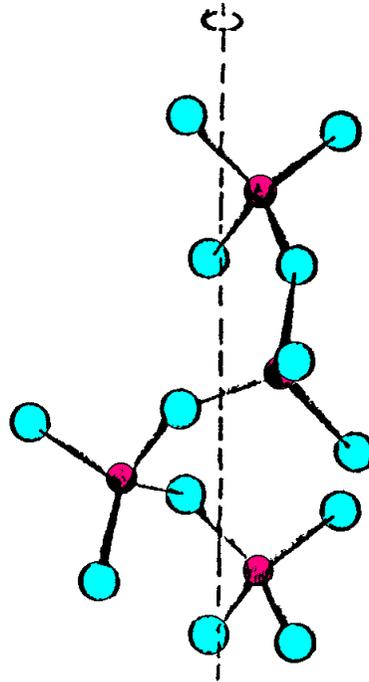




9kU 180E4 1929/88 PETOC



10 μm 299kU 131E3 1928/88 PETOC



*Concatenazione elicoidale di tetraedri di  $\text{SiO}_4$  nel reticolo cristallino del quarzo.*

$$\underline{T_{\text{fusione}} = 1710 \text{ }^\circ\text{C}}$$