

Inorganic chemistry

- ① VSEPR النظرية الإلكترونية للتكافؤ
 ② V.B.T نظرية رابطة التكافؤ
 ③ MOT النظرية الأوربيتالية للجزيئات

hybridization التهجين

① Molecular orbital theory (M.O.T) النظرية الأوربيتالية للجزيئات

* Linear combination between two atomic orbitals to form two molecular orbitals.
 (تداخل خطي)

- Atomic orbital $\rightarrow$ A.O

- Molecular orbital $\rightarrow$ M.O

$s + s \rightarrow \sigma$, $p_x + p_x \rightarrow \sigma$

$p_y + p_y \rightarrow \pi$, $p_z + p_z \rightarrow \pi$

M.O.T

① Homonuclear diatomic molecule

بين ذرتين متشابهتين

Ex: $[H_2, He_2, Li_2, Be_2], [B_2, C_2]$

$[N_2, O_2, F_2, Ne_2]$

② Heteronuclear diatomic molecule

بين ذرتين مختلفتين

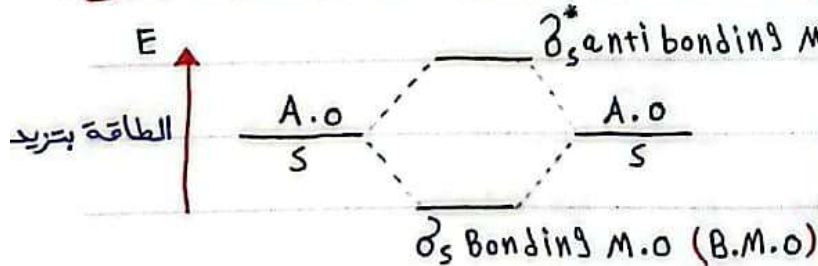
Ex: HF, HCl, HBr, HI

$NO, NO^+, NO^-, CO, CO^+, CO^-$

CN, CN^+, CN^-

- يوجد فرق في الطاقة بين الذرتين

① Homonuclear diatomic molecule :-

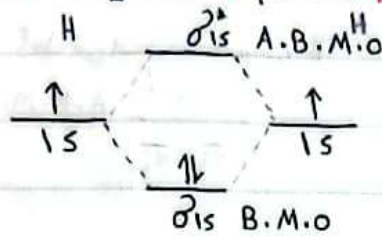


① Bond order = $\frac{\text{no. of Bonding } e^- - \text{no. of A.B. } e^-}{2}$

② magnetic properties : Para , dia

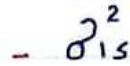
③ electronic configuration
 التوزيع الإلكتروني

الأقصى

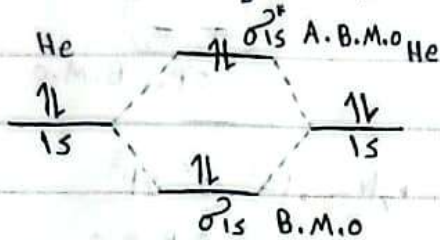


$$B.O = \frac{2-0}{2} = 1$$

- Diamagnetic

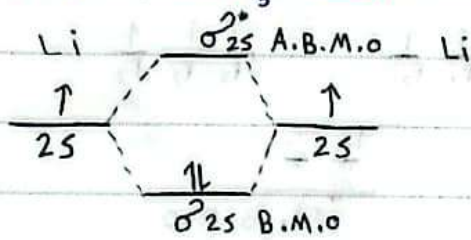
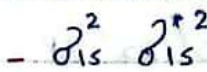


not exist.



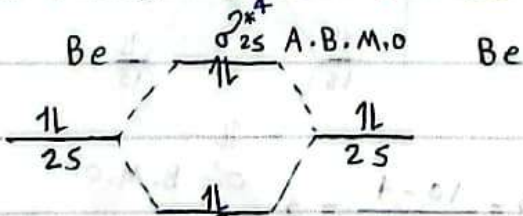
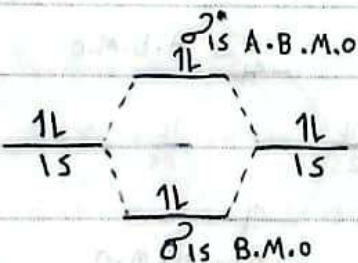
$$B.O = \frac{2-2}{2} = 0$$

- Diamagnetic



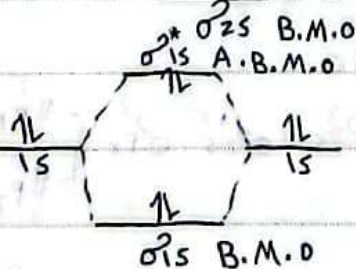
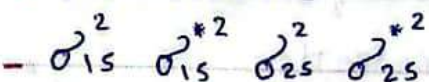
$$B.O = \frac{4-2}{2} = 1$$

- Diamagnetic



$$B.O = \frac{4-4}{2} = 0$$

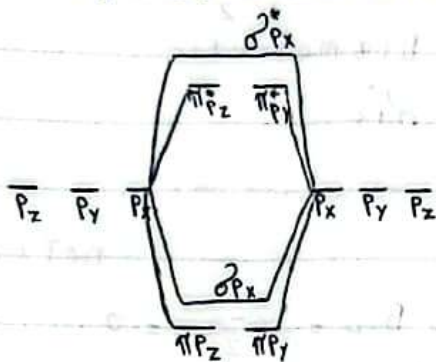
- Diamagnetic



الأسفل

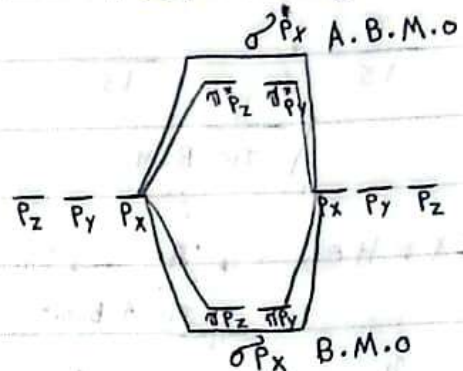
(B₂, C₂)

π أقل في الطاقة من σ

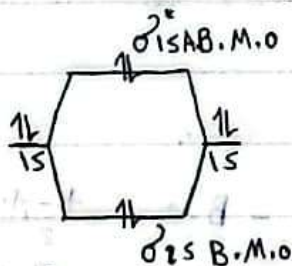
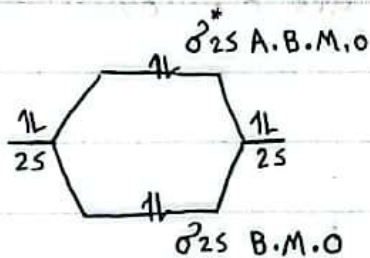
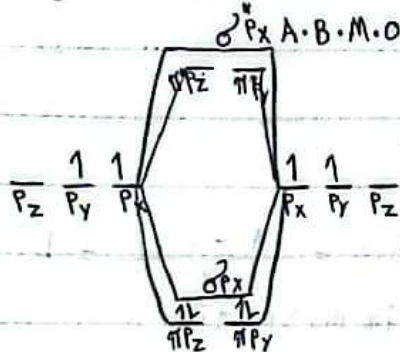


(N₂, O₂, F₂, Ne₂)

σ أقل في الطاقة من π

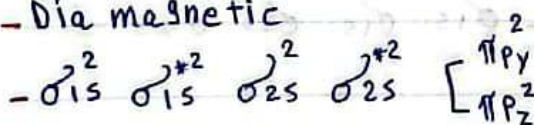


EX: C₂ → ₆C → 1s² 2s² 2p²

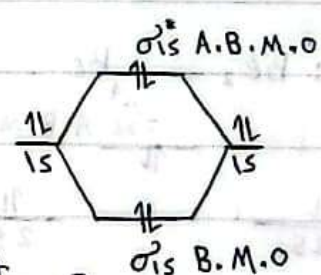
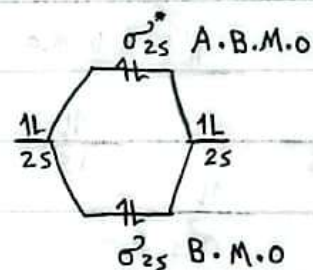
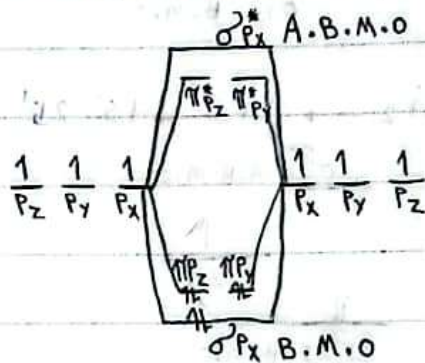


$$-B.O = \frac{8-4}{2} = 2$$

- Dia magnetic

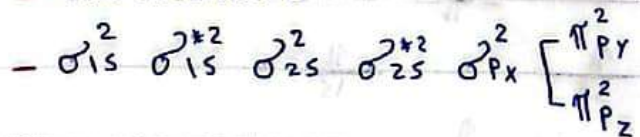


EX: N₂ → ₇N → 1s² 2s² 2p³

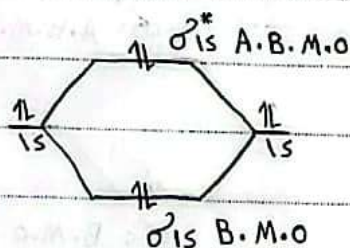
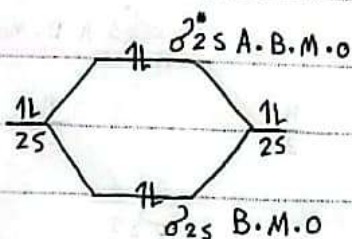
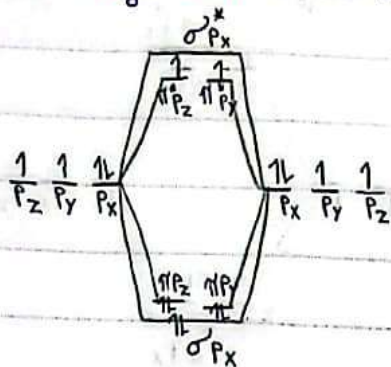


$$-B.O = \frac{10-4}{2} = 3$$

- Dia magnetic

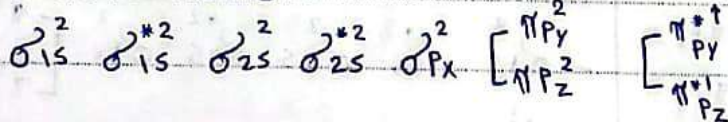


الأقوى



$$B.O = \frac{10 - 6}{2} = 2$$

Paramagnetic



$O_2 \rightarrow$ OXYGEN molecule

$O_2^+ \rightarrow$ OXYGENYL cation

$O_2^- \rightarrow$ superoxide

$O_2^{2-} \rightarrow$ peroxide

* The greater bond order,
The shorter bond length,
The greater bond strength.

كلما زاد رتبة الرابطة، قل طول الرابطة
وزاد قوة الاستقرار

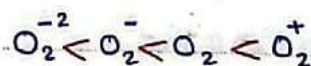
EX: Which is more stable:-

$O_2 \rightarrow 2$

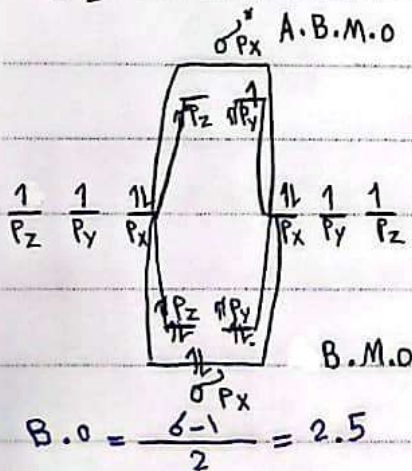
$O_2^+ \rightarrow 2.5$

$O_2^- \rightarrow 1.5$

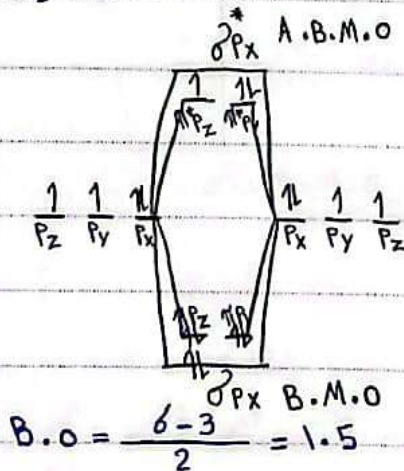
$O_2^{2-} \rightarrow 1$



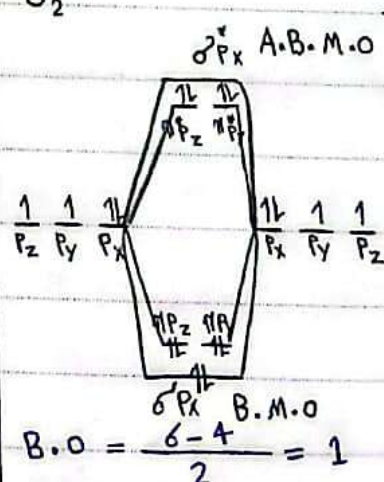
O_2^+



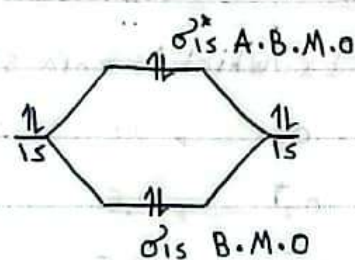
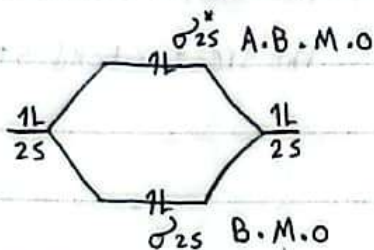
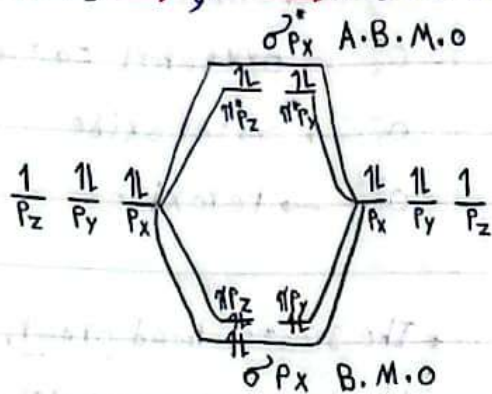
O_2^-



O_2^{2-}

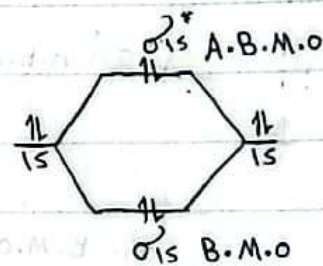
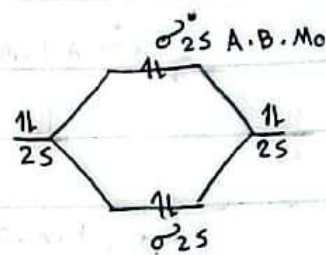
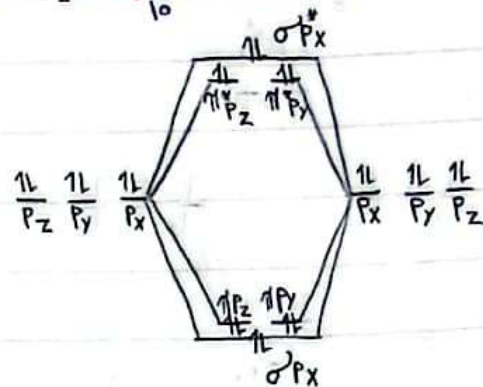
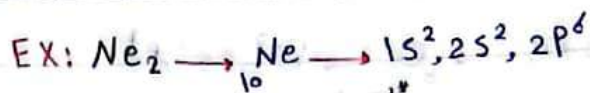
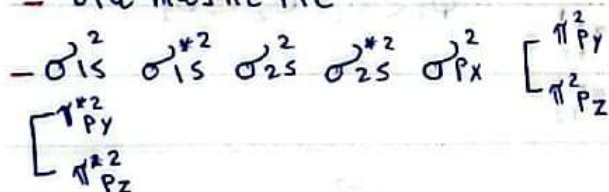


الأيون



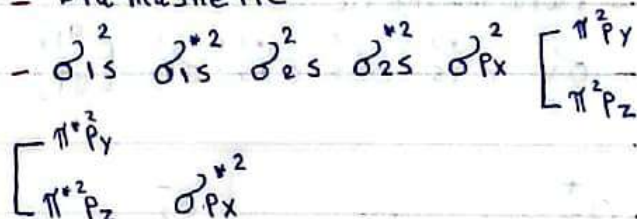
- $B.O = \frac{10-8}{2} = 1$

- Diamagnetic



- $B.O = \frac{10-10}{2} = 0$

- Diamagnetic



Hetero nuclear diatomic molecule

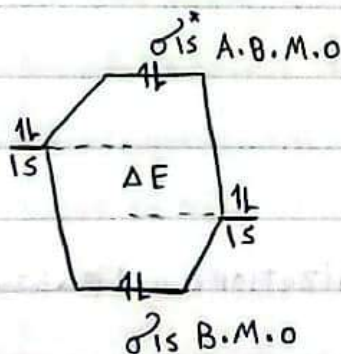
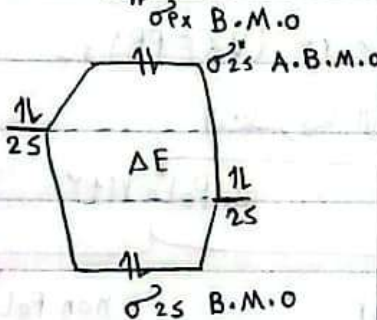
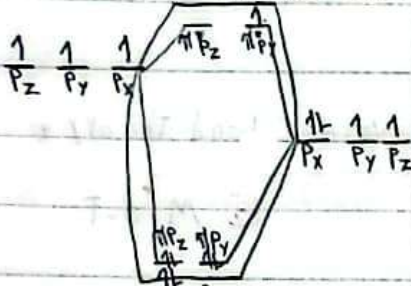
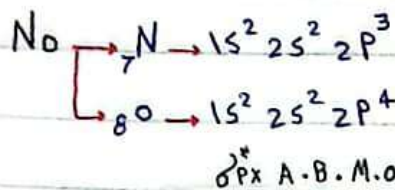
* Which is more stable? No , No^+ , No^-

- B.O of $\text{No} = 2.5$

- B.O of $\text{No}^+ = 3$

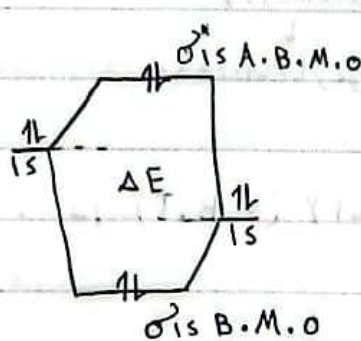
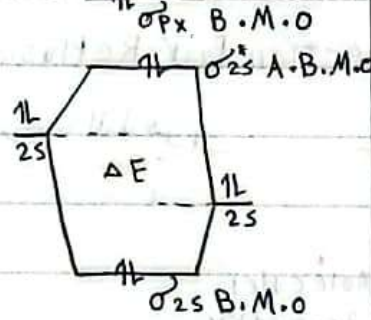
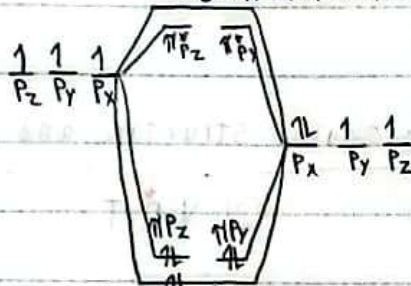
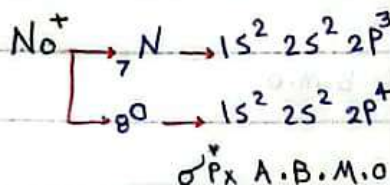
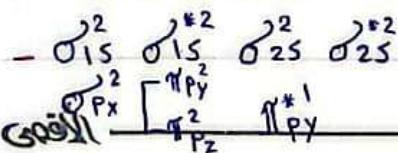
$\text{No}^- < \text{No} < \text{No}^+$

- B.O of $\text{No}^- = 2$



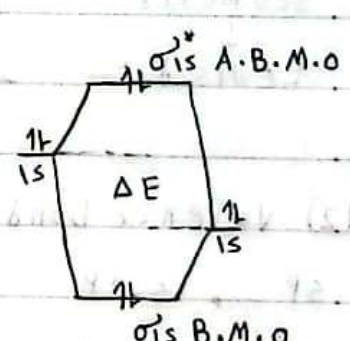
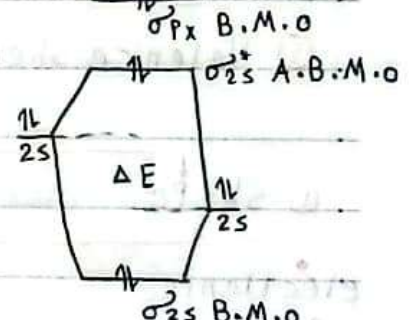
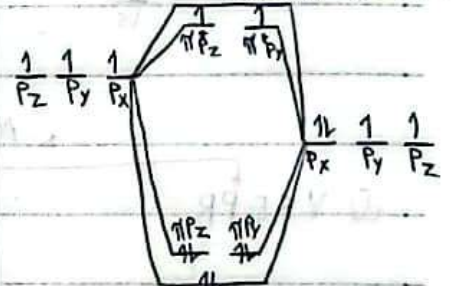
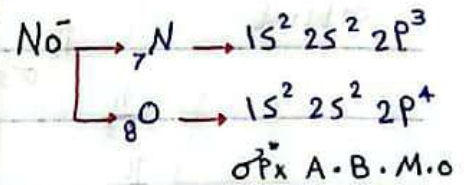
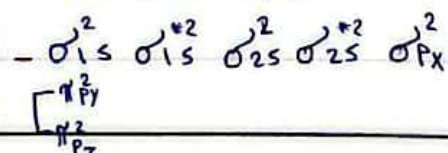
- $B.O = \frac{10 - 5}{2} = 2.5$

- Paramagnetic



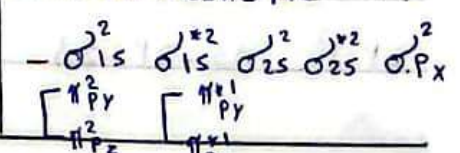
- $B.O = \frac{10 - 4}{2} = 3$

- Diamagnetic



- $B.O = \frac{10 - 6}{2} = 2$

- Paramagnetic



no. of Region of high electron	shape	bond angle	type of hybridization
2	Linear	180°	sp
3	Trigonal Planar	120°	sp^2
4	Tetra hedral	109.5°	sp^3
5	Trigonal bi Pyramidal	$180^\circ/120^\circ/190^\circ$	sp^3d
6	octa hedral	$90^\circ/180^\circ$	sp^3d^2

* أي مركب يكون موجود على الصيغة -

AB_n

AB_nU_n

A → central atom

A → central atom

B → Bonding atom / Trimenal atom

B → Bonding atom

n → عدد الذرات الطرفية

n → عدد الذرات الطرفية

U → Lone Pair الذوايح الحرة

n → عدد الذوايح الحرة

EX: $BeCl_2$

Be → $1s^2 2s^2$

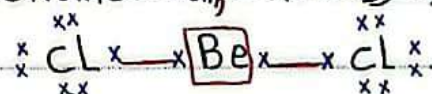
① central atom → Be

Cl → $1s^2 2s^2 2p^6 3s^2 3p^5$

② bonded atom → Cl

1 (electronic geometry) بطريقة Lewis

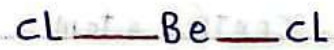
③ no. of unshared (no. of Lone Pair) → zero



④ no. of bonded atom → 2

1 (molecular geometry) بطريقة تمريض بالروابط

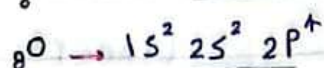
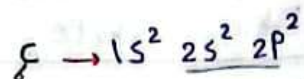
⑤ no. of region of high electron → $0 + 2 = 2$



⑥ shape → Linear

⑦ Bond angle → 180°

EX: CO_2



1- Central atom $\rightarrow \text{C}$

2- bonded atom $\rightarrow \text{O}$

3- no. of unshared (no. of Lone Pair) $\rightarrow$ zero

4- no. of bonded atom $\rightarrow 2$

5- no. of region of high electron $\rightarrow 2$

6- shape $\rightarrow$ Linear

7- Bond angle $\rightarrow 180^\circ$

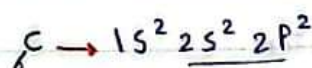
بطريقة Lewis (electronic geometry)



بطريقة تعريف بالروابط (molecular geometry)



EX: CH_4



1- Central atom $\rightarrow \text{C}$

2- bonded atom $\rightarrow \text{H}$

3- no. of unshared (no. of Lone Pair) $\rightarrow$ zero

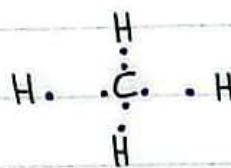
4- no. of bonded atom $\rightarrow 4$

5- no. of region of high electron $\rightarrow 4$

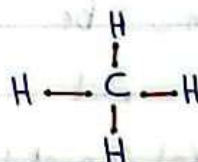
6- shape $\rightarrow$ Tetrahedral

7- Bond angle $\rightarrow 109.5^\circ$

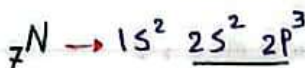
بطريقة Lewis (electronic geometry)



بطريقة تعريف بالروابط (molecular geometry)



EX: NH_3



1- Central atom $\rightarrow \text{N}$

2- bonded atom $\rightarrow \text{H}$

3- no. of unshared (no. of Lone Pair) $\rightarrow 1$

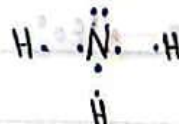
4- no. of bonded atom $\rightarrow 3$

5- no. of region of high electron $\rightarrow 4$

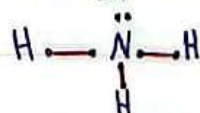
6- shape $\rightarrow$ Tetrahedral

7- Bond angle $\rightarrow 107^\circ$

بطريقة Lewis (electronic geometry)

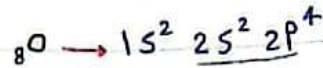


بطريقة تعريف بالروابط (molecular geometry)



قلت الزاوية بسبب وجود زوج حر

EX: H_2O



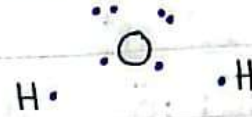
1- central atom $\rightarrow O$



2- bonded atom $\rightarrow H$

بطريقة Lewis (electronic geometry)

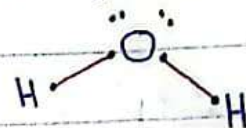
3- no. of Lone pair $\rightarrow 2$



4- no. of bonded atom $\rightarrow 2$

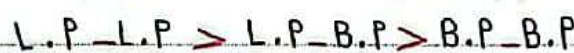
5- no. of region of high electron $\rightarrow 4$ (molecular geometry) بالروابط

6- shape $\rightarrow$ Tetrahedral



7- bond angle $\rightarrow 105^\circ$

* تنريد قوة التنافر Repulsion Force بزيادة الزوج المرة

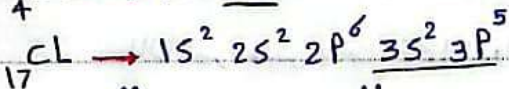


L.P $\rightarrow$ Lone Pair

B.P $\rightarrow$ Bond Pair

* VSEPR :-

EX: $BeCl_2$



1- Linear e.g

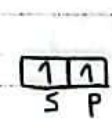
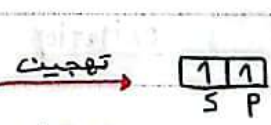
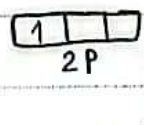
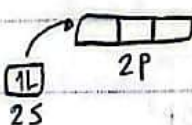
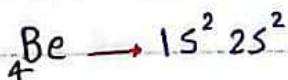
2- Linear m.g

3- Angle 180°

4- non Polar

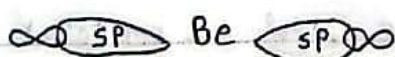
5- Zero $\rightarrow$ عدم الزوج

* V.B.T :-



1- Linear E.g

2- Linear m.g



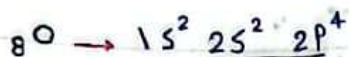
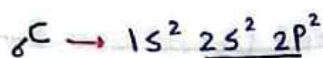
3- Bond angle $\rightarrow 180^\circ$

4- Type of hybridization $\rightarrow sp$

الأقوى

* VSEPR :-

Ex: CO_2



1- Linear E.G

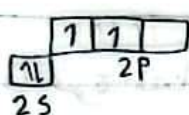
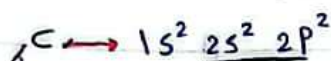
2- Linear m.g

3- Angle 180°

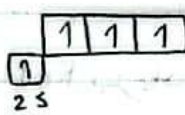
4- non Polar

5- hybridization $\rightarrow \text{sp}$

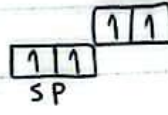
* V.B.T :-



excitation

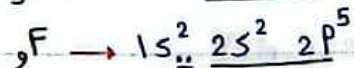


تهجين



Ex: BF_3

* VSEPR :-



1- Trigonal Planer E.G

2- Trigonal Planer m.g

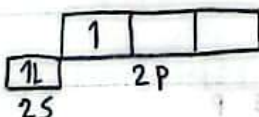
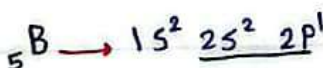
3- bond angle $\rightarrow 120^\circ$

4- non Polar

5- طالما غير قطبي يبقى عزم الازدواج بمفر

6- hybridization $\rightarrow \text{sp}^2$

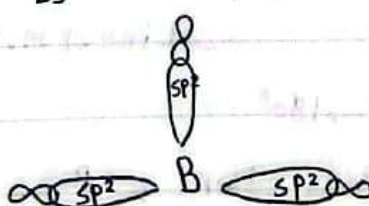
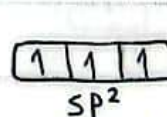
* V.B.T :-



excitation



تهجين



1- Trigonal Planer E.G 2- Trigonal Planer m.g

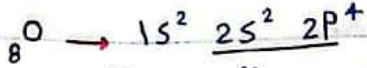
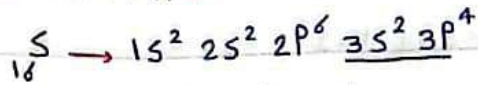
3- bond angle $\rightarrow 120^\circ$ 4- non Polar

5- sp²

الأقوى

Ex: SO_2 حالة شاذة

* VSEPR :-



1- Trigonal Planer E.G

2- Angular (bent) m.g

3- Polar , net dipole > zero

4- bond angle < 120° أقل من 120°

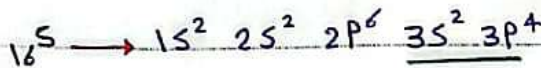
5- sp^2

* وجود زوج حر خلى في فرق بين E.G و M.G

* لها M.G تكون Angular يبقى لازم يكون في ذرة مركزية حولها اثنين طرفيه وواحد أو اثنين زوج حر -

* طالما في زوج حري يبقى Polar وطالما Polar يبقى عزم الازدواج net dipole < zero

* V.B.T :-



* مش عملنا excitation عشان الـ p اصلاً عامله ازدواج فمش محتاج نصل لإثارة ثاني نصل تهجين على طول و مش شرط عشان في ازدواج في الـ p يبقى مش عمل لإثارة مش عمل لإثارة نهوضه لواله الـ p مكنتين



كل اوريبتال فيه 2 الكترون

1- Trigonal Planer E.G

2- Angular m.g

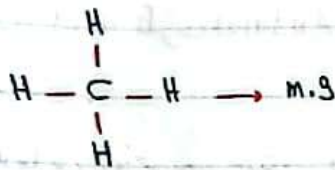
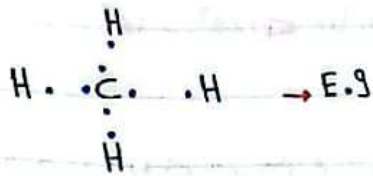
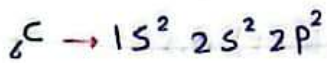
3- bond angle < 120

4- Polar , net dipole > zero

5- sp^2

EX: CH_4

* VSEPR:-



1- Tetrahedral E.g

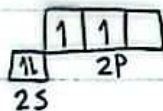
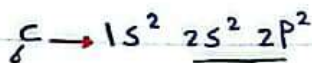
2- Tetrahedral m.g

3- bond angle 109.5°

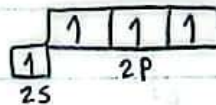
4- non Polar, net dipole $\rightarrow$ zero

5- sp^3

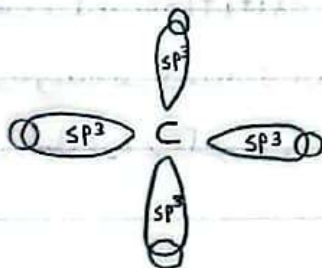
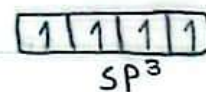
* V.B.T:-



excitation



تهجين



1- Tetrahedral E.g

2- Tetrahedral m.g

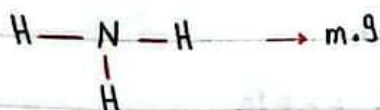
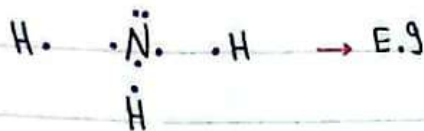
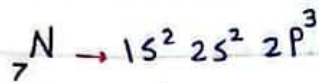
3- non Polar

4- net dipole $\rightarrow$ zero

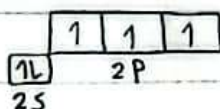
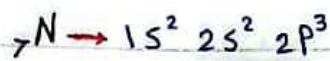
5- sp^3

EX: NH_3

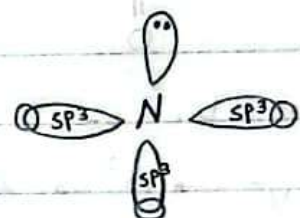
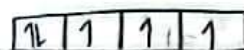
* VSEPR :-



* V.B.T :-



تهجين $\rightarrow$



1- Tetrahedral E.g

2- Pyramidal m.g

3- Polar

4- net dipole > zero

5- sp^3

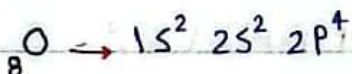
6- Bond angle < 109.5° (107)

* طالفاي ذرة مركزية حولها 3 ذرات طرفية وزوج حر

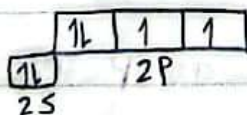
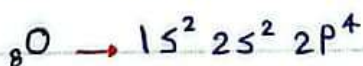
تبقى m.g تسمى Pyramidal

EX: H_2O

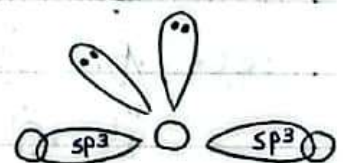
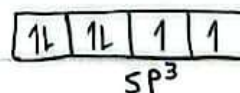
* VSEPR :-



* V.B.T :-



تهجين $\rightarrow$



1- Tetrahedral E.g

2- Angular m.g

3- sp^3

4- Polar

5- Angle < 109.5°

6- net dipole > zero

* هناك بعض المركبات مثل H_2Fe , H_2Se , H_2S , H_2O ليس لهم تهجين لأن الزوايا

اقتربت من 90°

89.5

91

92

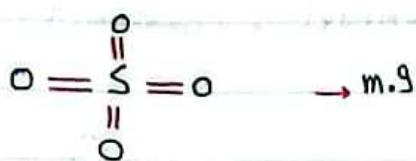
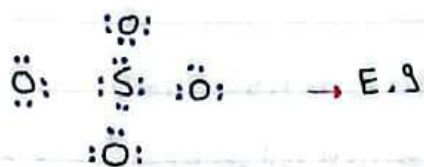
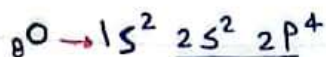
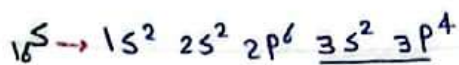
105

الأقوى

EX: SO_4^{2-}

ال central atom هي الى بتفقد او تكتسب

* VSEPR :-



1- Tetrahedral E.g

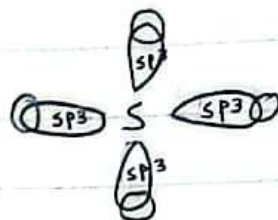
2- Tetrahedral m.g

3- 109.5

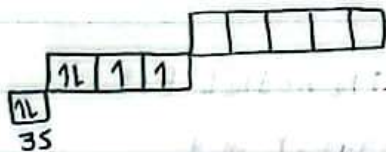
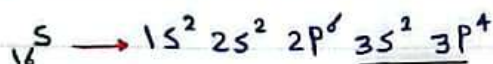
4- sp^3

5- non Polar

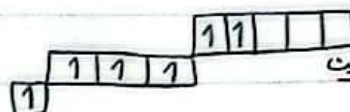
6- net dipole = zero



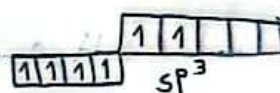
* V.B.T :-



اثر

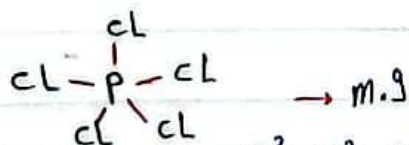
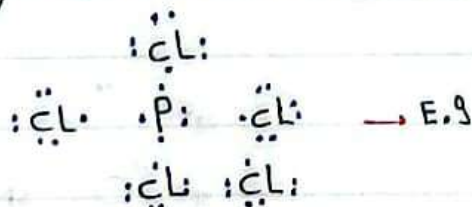
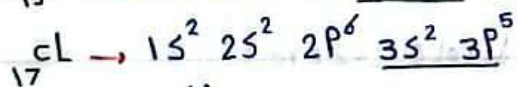
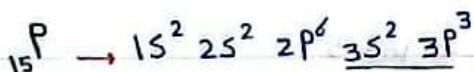


تجيب



EX: PCl_5 , PF_5

* VSEPR :-



* V.B.T :- $15P \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^3$

1- Trigonal bi Pyramidal E.g

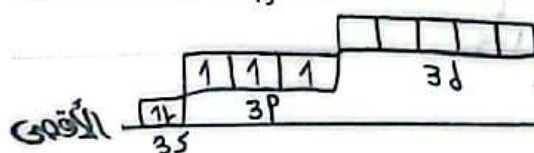
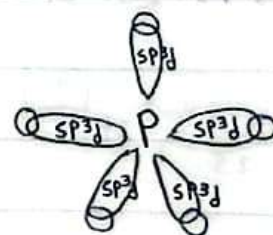
2- Trigonal bi Pyramidal m.g

3- bond angle $\rightarrow 180/120/90$

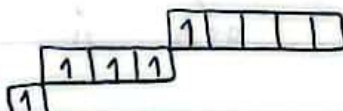
4- non Polar

5- net dipole = zero

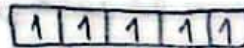
6- sp^3d



اثر

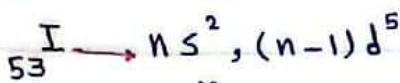


تجيب

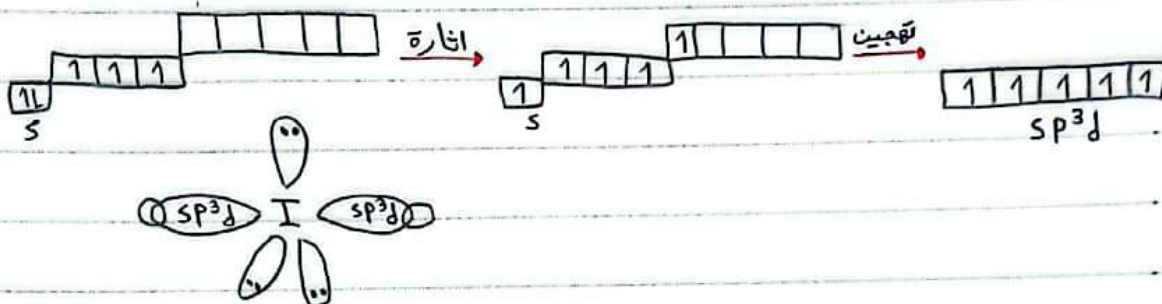
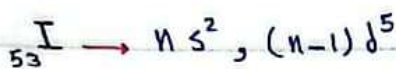


EX: I_3^-

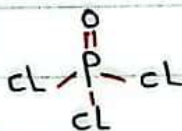
* VSEPR :-



* V.B.T :-



مثال $POCl_3$



* E.g. $\neq$ m.g.

* Two bond angle

SF_6 → Octahedral E.G.
Octahedral M.G.
bond angle = $180, 90$
non-Polar
 sp^3d^2

BrF_5 → Octahedral E.G.
square pyramidal M.G.
(regular)
bond angle decrease
Polar
 sp^3d^2

مثال

V.B.T

M.O.T

criticism V.B.T

O_2 is diamagnetic

O_2 Paramagnetic

* المركب لو عليه 1 زوج حر مع 3 ذرات طرفية فان M.G. يسمى Pyramidal

* المركب لو عليه 1 زوج حر أو 2 زوج حر مع 2 ذرة طرفية فان M.G. يسمى Angular

الأقوى