Tricks to find out Bond Order

(O_2 bond order)

1.

No. of e^- in molecule	Bond Order
10	1.0
11	1.5
12	2.0
13	2.5
14	3
15	2.5
16	2
17	1.5
18	1.0

2. no. of e^- in p subshell is 6 or less than 6 and divide by 2
if no. of e^- in p (after adding) more than 6
than $\frac{12 - \text{no. of } e^- \text{ in p-shell}}{2}$ (Applicable till 20 e^-)

Example →

NO	NO^-	NO^+
$e^- = 7$	$e^- = 8$	$e = 6$
$\frac{12-7}{2} = \frac{5}{2}$	$= \frac{4}{2}$	✓ B.O $= \frac{6}{2} = 3$
$= 2.5$	$= 2$	

B.O ↑ stability ↑ B.L ↓

B.O — $NO^+ > NO = NO^-$

Stability — $NO^+ > NO > NO^-$

B.L — $NO^- > NO > NO^+$

Bond energy = $NO^+ > NO > NO^-$

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Que Write down the ↑ing order of Bond order, Bond length, Stability, Bond energy in following -

a) CO, CO^+, CO^-

CO	CO^+	CO^-
e = 6	$= \frac{5}{2} = 2.5$	$e^- = 7$
$B.O = \frac{6}{2} = 3$		$B.O = \frac{12-7}{2} = 2.5$

B.O = $CO > CO^+ = CO^-$
Stability = $CO > CO^+ > CO^-$
Bond length = $CO^- > CO^+ > CO$
Bond Energy = $CO > CO^+ > CO^-$

b)

N_2	N_2^+	N_2^-
B.O - 3	2.5	2.5

Bond order = $N_2 > N_2^+ = N_2^-$
Stability = $N_2 > N_2^+ > N_2^-$
Bond length = $N_2^- > N_2^+ > N_2$
Bond Energy = $N_2 > N_2^+ > N_2^-$

Bond order is inversely proportional to bond length

Stability ↑ Bond energy ↑ Bond order ↑

Trick for magnetic Properties -
no. of e^- is even - Diamagnetic (except 10 an 16)
no. of e^- is odd - Paramagnetic

examples - O_2^+ → Paramagnetic
B_2 → Paramagnetic
C_2 → Diamagnetic
NO^+ → Diamagnetic

O_2 → Paramagnetic
O_2^- → Paramagnetic
O_2^{-2} → Diamagnetic

Note – Acc. to V.B.T Oxygen gas (O_2) is diamagnetic but acc. to M.O.T oxygen gas (O_2) is Paramagnetic.

Que Write down the electronic configuration (M.O) for F_2 and Be^{-1} CO^-

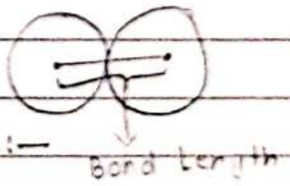
F_2 – $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \pi 2p_x^2 = \pi 2p_y^2, \pi^* 2p_x$
$= \pi^* 2p_y^2$

CO^- – $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2, \pi 2p_x^2 = \pi 2p_y^2, \pi^* 2p_x$

BOND PARAMETERS :→

i) Bond length
ii) Bond angle
iii) Bond energy

1) Bond length:-
The average distance between the centre of nuclei of the 2 bonded atoms



Factors affecting Bond length:–

(a) Bond order (Multiplicity of Molecule):–
Bond order ↑ Bond length ↓
C–C ⇒ 1.54 Å / 154 pm
C=C ⇒ 1.36 Å
$C \equiv C$ ⇒ 1.20 Å

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Two highly electronegative elements attract or repel each other..

(b) Hybridisation –

% s character ↑ Bond length ↓

Hb	SP	SP²	SP³
% S	50%	33%	25%

b. length = $SP < SP^2 < SP^3$, $C_2H_2 < C_2H_4 < C_2H_6$

(c) Electronegativity –

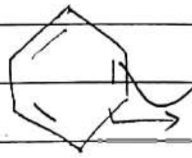
Electronegativity difference ↑ Bond length ↓

Bond length – HI > HBr > HCl > HF

(d) Resonance –

Resonance is a process in which delocalization of πe^- should be carried out.

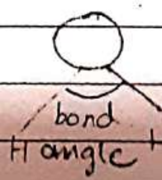
Due to Resonance c–c having S double bond character. So, we can say that due to Resonance Bond length should be decreases.



Partially double bond character.

2) Bond angle :–

The angle b/w two bond is known as bond angle.



Factors affecting Bond angle –

(a) Hybridisation –

% S ~~angle~~ character ↑ bond angle ↑

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Hb	SP	SP²	SP³
%	50%	33%	25%
B.A	180°	120°	109.28'

$CO_2 > BCl_3 > CH_4$

(b) Presence of Lone pair. –

Lone pair ↑ B.A ↓

If hybridisation of diff. molecule is same but no. of lone pair should be different then lone pair reduce bond angle.

Molecule	CH_4	NH_3	H_2O
Hb	sp^3	sp^3	sp^3
N.o of lone pair	0	1	2
B. angle	109.28	≃ 108	≃ 105

(c) Electronegativity –

If no. of lone pair same and hybridisation is also same then higher electronegative central atom molecule have higher bond angle.

Molecule	H_2O	H_2S
L.P	2	2
Hb	sp^3	sp^3
EN	O >	S
B.A	H_2O >	H_2S

B.A $NH_3 > PH_3$

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(d) Size of terminal atoms -

If central atom same, lone pair same, hb also same then bond angle decide by size of ~~cen~~ terminal atom

$OF_2 < OCl_2 < OBr_2$

and Exception -

$OH_2 < OF_2 < OCl_2 < OBr_2$ ✗

$OF_2 < OH_2 < OCl_2 < OBr_2$ ✓

Magnetic moment of O_2 molecule

$m.m = \sqrt{2(2+2)}$

$= \sqrt{8}$ BM

$= 2.8$ 'μ'

★ If 2 unpaired $e^- \simeq 2.75$

3 unpaired $e^- \simeq 3.75$

1 $\simeq 1.75$

4 $\simeq 4.75$ (in coordination Chemistry)

3) Bond Energy -

~~Energy sequire~~ The amount of energy release when 1 mole of bonds are formed OR amount of energy absorbed to break 1 mole of bond.

unit - kcal/mole OR kJ/mole.

Factors affecting bond energy -

a) Bond order -

Bond order ↑ Bond Energy ↑

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b) Bond length -

Bond length ↑ Bond energy ↓

$HF > HCl > HBr > HI$

c) Electronegativity -

E.N diff ↑ B.E ↑

$HF > HCl > HBr > HI$

d) Hybridisation :-

% s character ↑ Bond energy ↑

e) Atomic size -

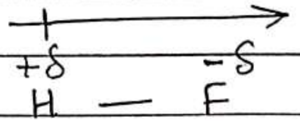
Atomic size ↑ B.E ↓

$F_2 > Cl_2 > Br_2 > I_2$

⊙ Dipole Moment (μ):-

It tell us ionic character in covalent compounds
covalent compound may be polar and non-polar

It is denoted by $+\!\!\!\longrightarrow$ towards lower electronegative element to higher electronegative element.



It is calculated as $\boxed{\mu = q \times d}$

Here, q = charge on any atom in esu
d = diff. b/w dipole in cm

$q = -1.6 \times 10^{-19}$ C.
$= 4.8 \times 10^{-10}$ esu (electrostatic unit)

Unit = Debye (D)

$$\boxed{\text{\% Ionic character in covalent compound} = \frac{\text{Observed dipole}}{\text{Theoritical dipole}} \times 100}$$

Que) Observe dipole moment of HCl is 1.03 D and HCl bond length is 1.275 Å. find out the % ionic character in HCl

$$\mu = q \times d = \frac{4.8 \times \cancel{10^{-10}} \times 1.275 \times \cancel{10^{-8}}}{\cancel{10^{-18}}} \text{ Debye}$$

$$\text{\% ionic character} = \frac{1.03}{4.8 \times 1.275} \times 100$$

Significance of dipole moment -

- If $\mu = 0$ (Non-polar)
- If $\mu \neq 0$ (Polar)

example -

★ Homoatomic molecules - H_2, Cl_2, Br_2, F_2 etc.
(Non- Polar)

★ Heteroatomic molecules-

$$+\!\!\!\longrightarrow$$

$$\overset{+\delta}{H} — \overset{-\delta}{F}$$

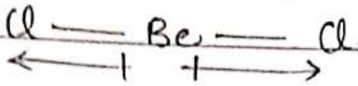
HF > HCl > HBr > HI $\mu \neq 0$ (Polar)

★ Triatomic molecules -

$BeCl_2$, CO_2

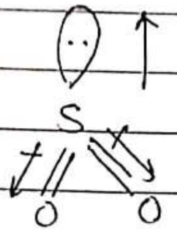
$$O = C = O$$
$$\longleftarrow\!\!\!+ \;\; +\!\!\!\longrightarrow$$

$\mu = 0$ (Non-Polar)



* AB_3 —

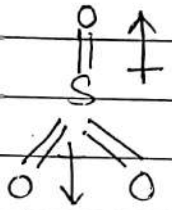
eg— SO_2, BBr_3, BI_3



$\mu \neq 0$ Polar

NOTE — Generally lone pair containing molecule should be polar.

SO_3



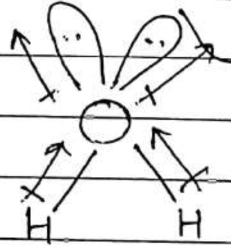
$\mu = 0$ (Non-polar)

* AB_4 —

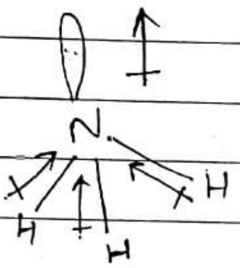
CCl_4, CH_4 ($\mu = 0$ Non-Polar)

$CHCl_3$, CH_2Cl_2, H_2O, NH_3 → $\mu \neq 0$ (Polar)

H_2O

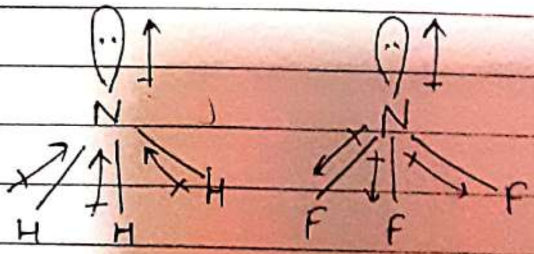


NH_3



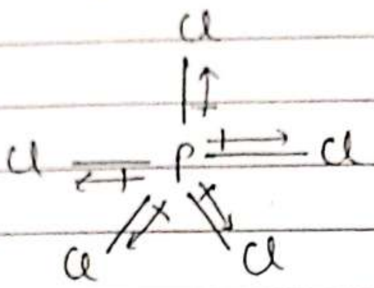
Que NH$_3$ molecule have higher dipole movement than NF_3? Why

— Resultant of NF_3 is zero.

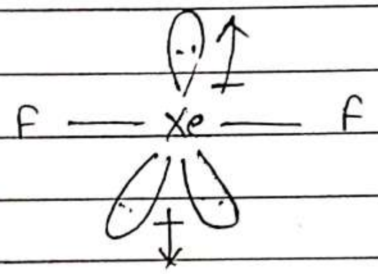


★ AB_5 —

eg – PCl_5 $\mu = 0$ (non-polar)



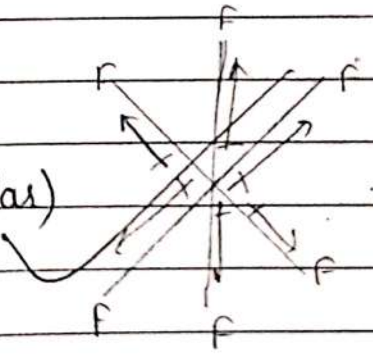
XeF_2 , $8-2=6$ → 3 lone pair



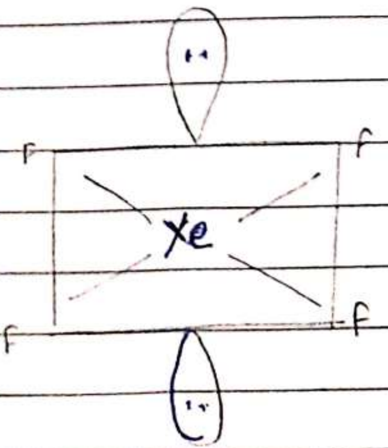
★ AB_6 —

eg – SF_6

$\mu = 0$ (Non-polar)



XeF_4



$\mu = 0$ (Non-polar)