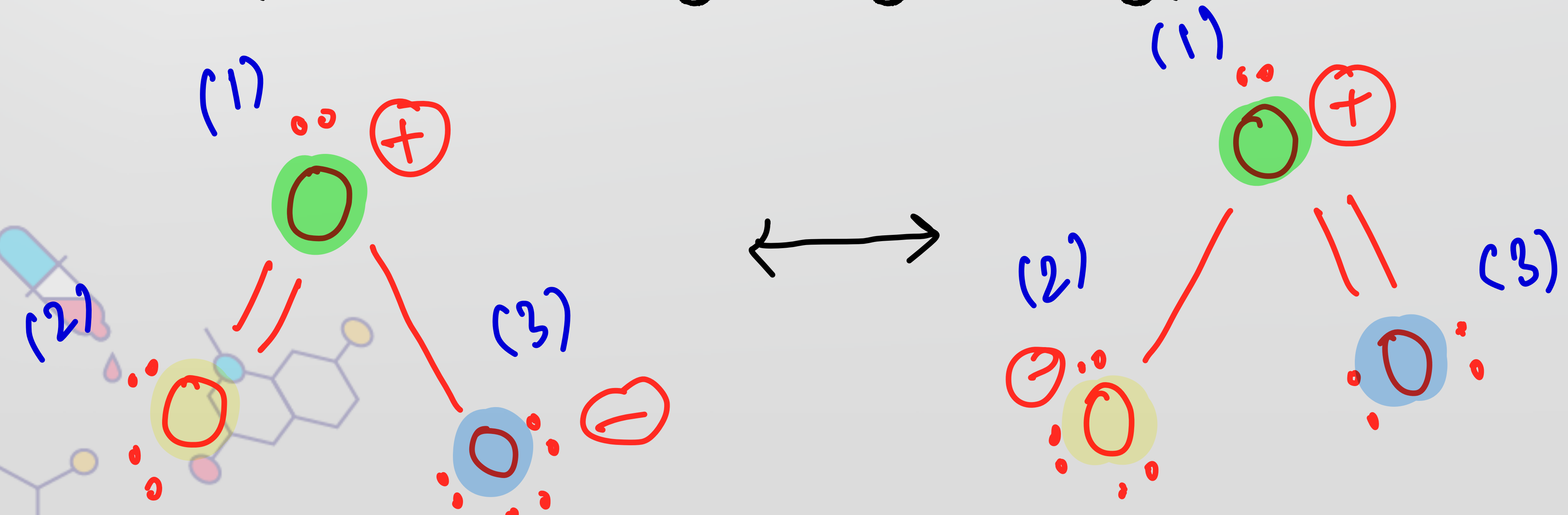
Resonance

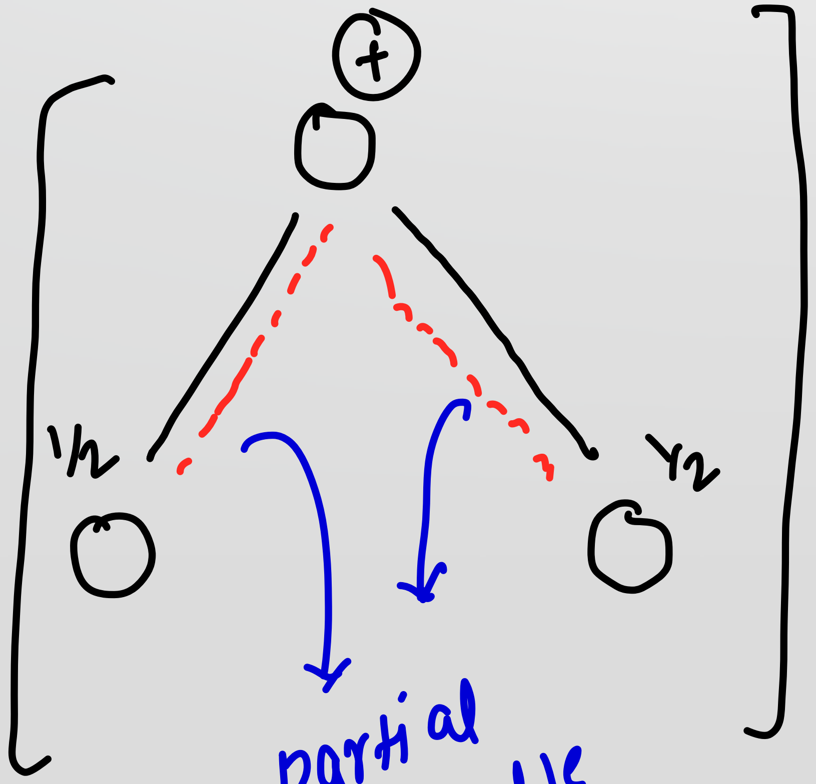
From Lewis structure in O3

1. Two type of bond length
2. Two type of bond strength

*Experimentally only one type of bond length in observed in O3



Lewis Structure (1) $\longleftrightarrow$ Lewis Structure (2)



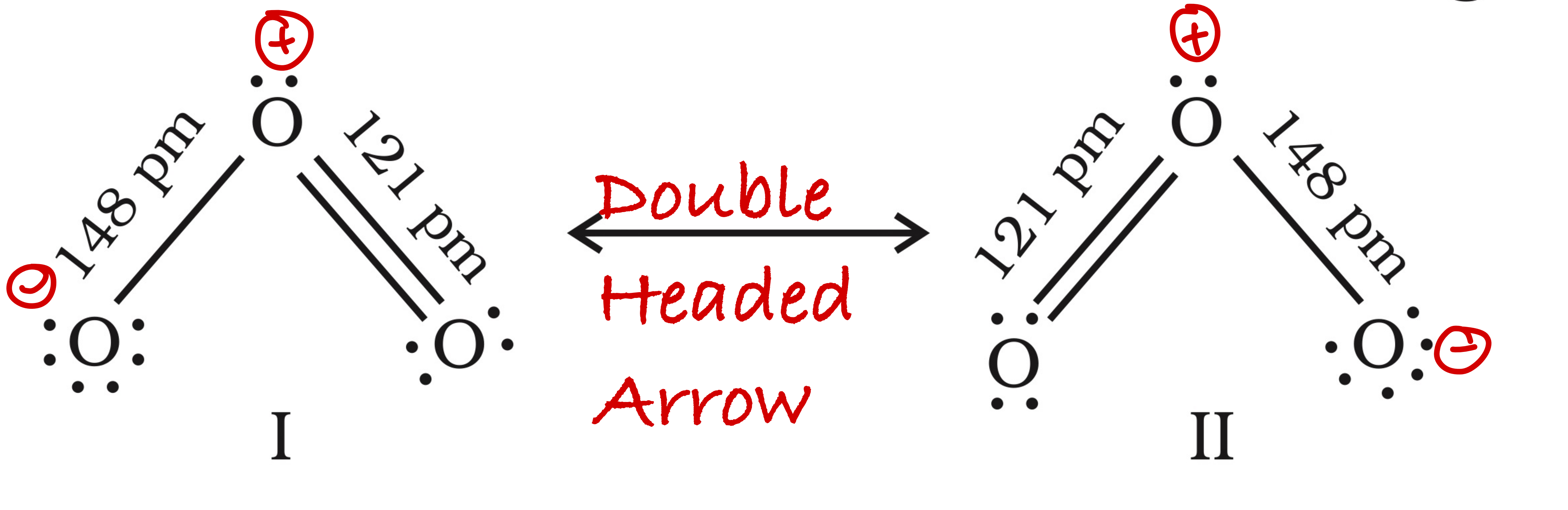
partial double bond

Chemical Bonding

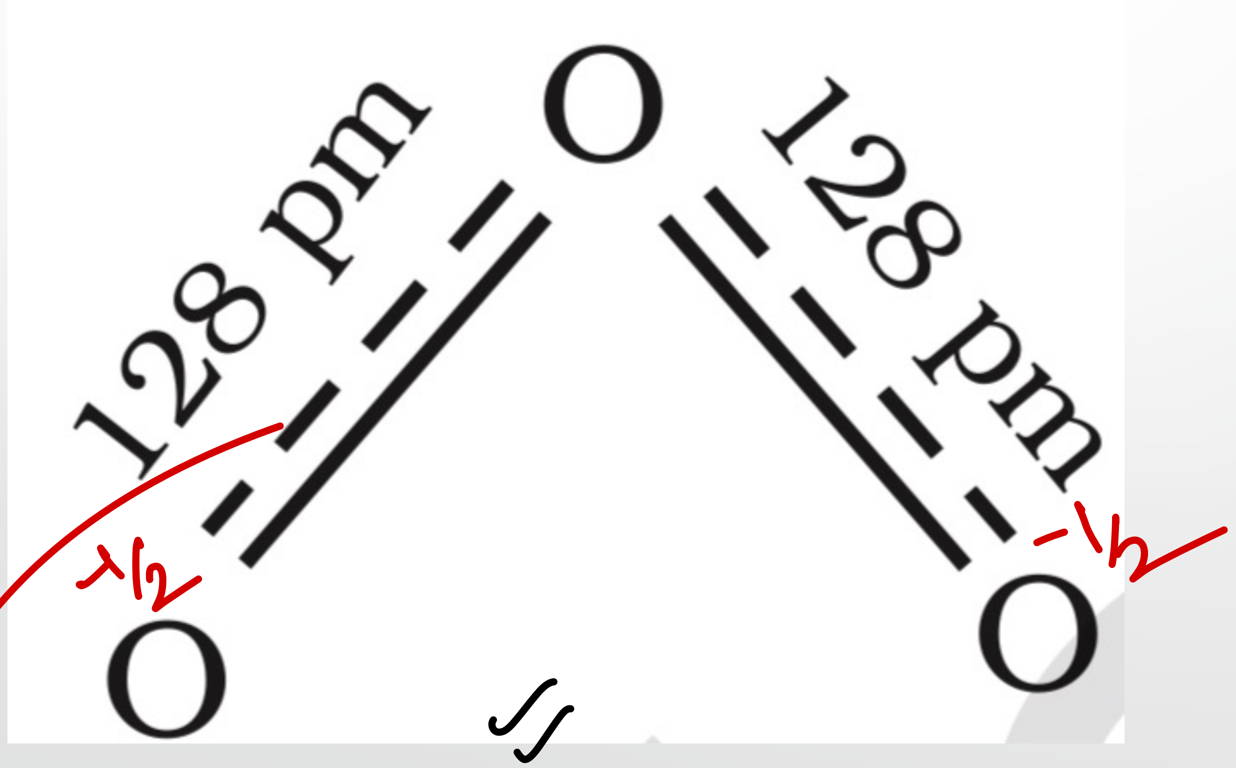
Resonance :

Example :

In both structures we have a O–O single



$\equiv$



Canonical form / Resonating structure (R.S)

Lewis structure (Hypothetical)

Resonance hybrid

actual molecule

Equivalent R.S

Partial double bond character

(Bond length b/w single and double bond)

* Resonance : delocalisation of π electron

Resonance analogy:

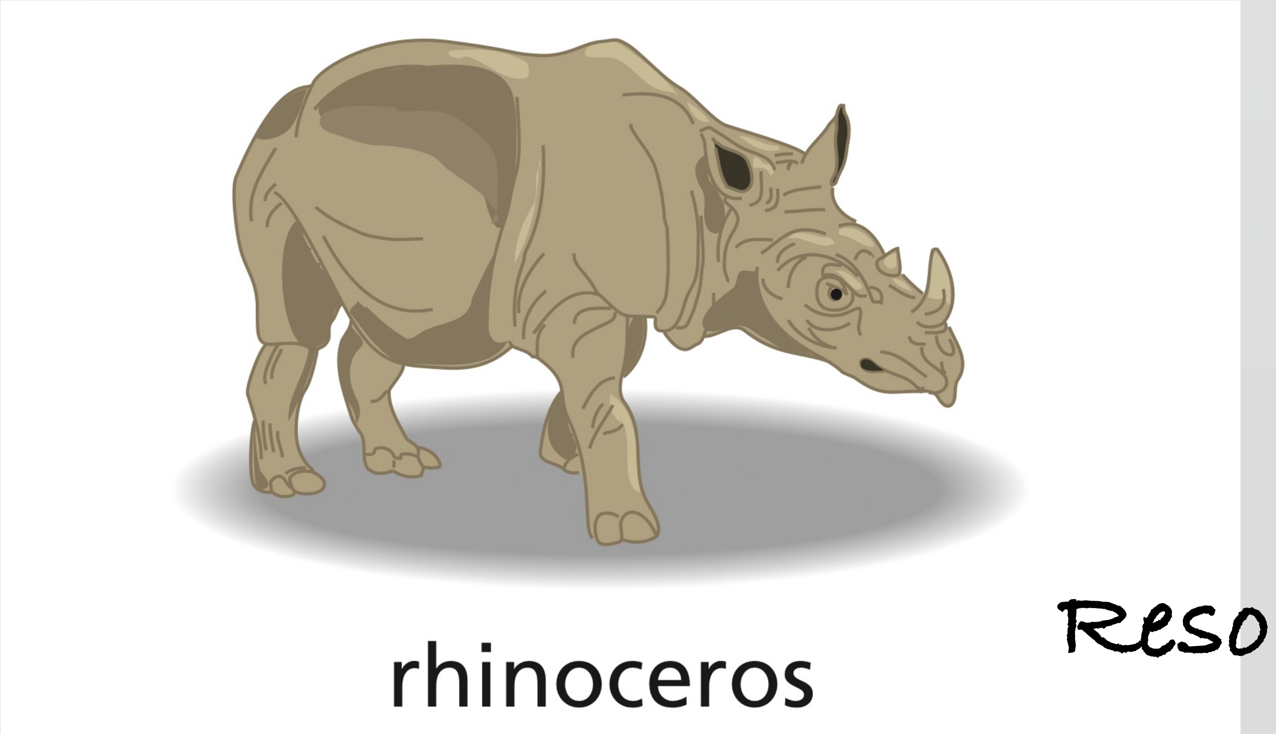
Hypothetical

Resonance contributor

Hypothetical

Resonance contributor

Real



Resonance hybrid

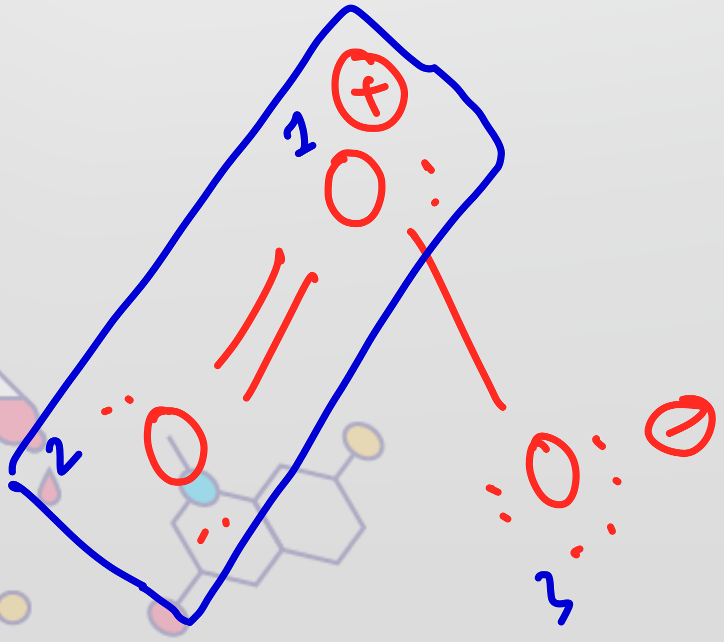
Chemical Bonding

Bond order

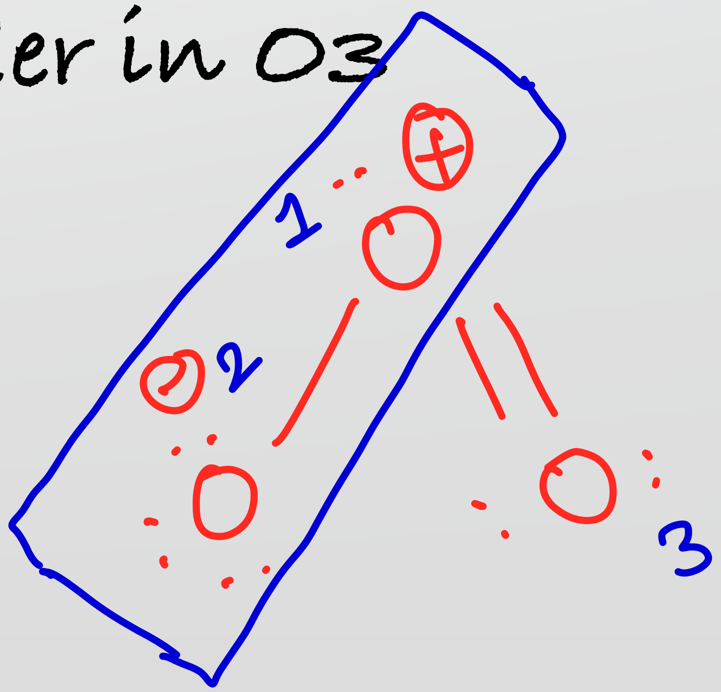
$$B.O = \frac{\text{number of covalent bond b/w two atom in R.S}}{\text{Total R.S}}$$

$B.O$ = effective number of bonds b/w two atoms

Calculate O-O bond order in O_3



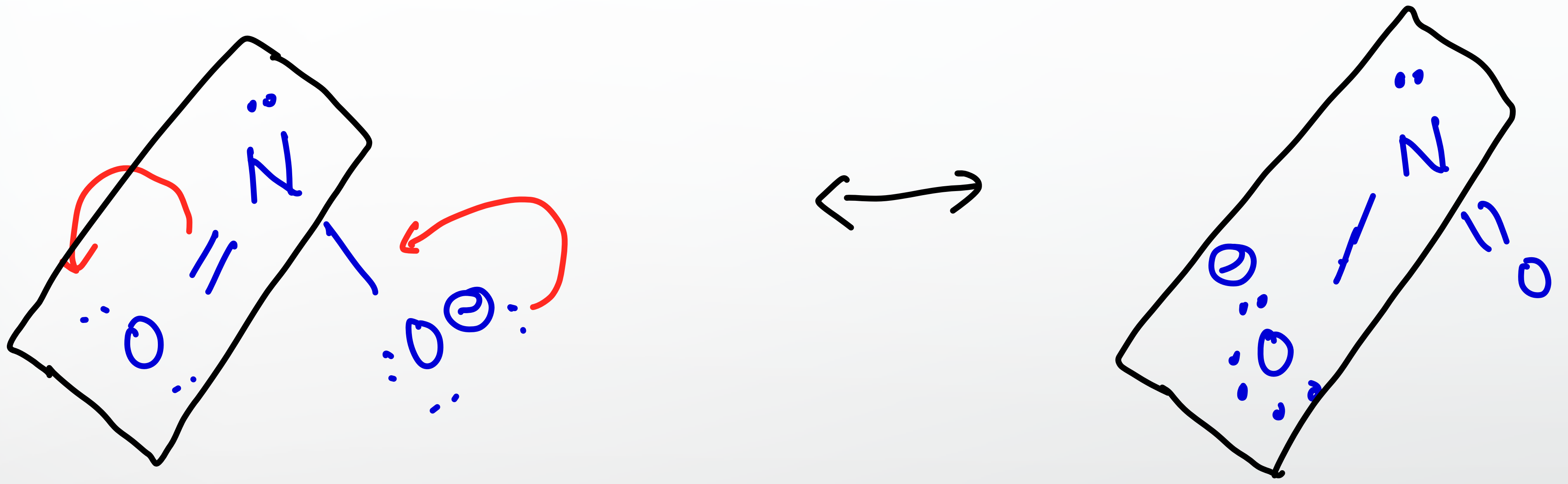
Resonating 1 Structure



Resonating 2 Structure

$$\underset{(O_1 - O_2)}{B.O} = \frac{(2+1)}{2} = \frac{3}{2} = 1.5$$

Draw resonating structure of NO_2^- and also calculate Bond order



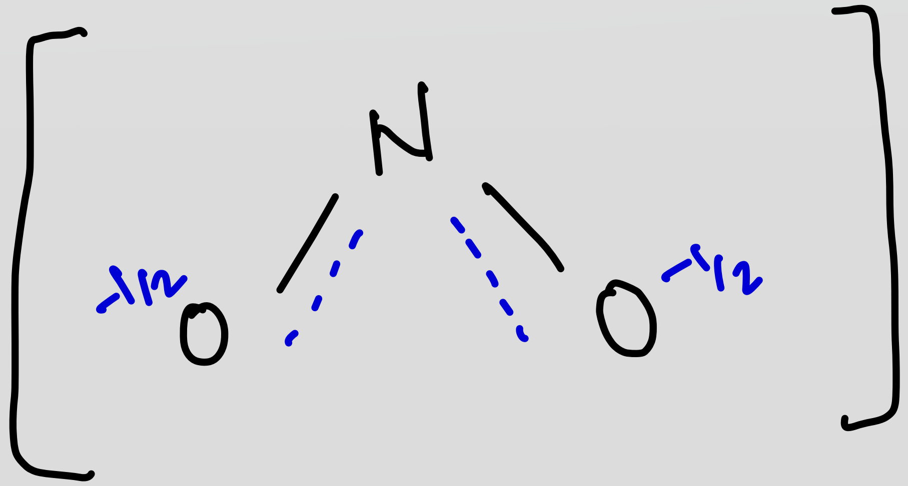
Resonating Structure 1

Resonating Structure 2.

Bond order : $\frac{2+1}{2}$

$= 3/2 = 1.5$

Equivalent R.S



Resonance Hybrid.

Rules for drawing resonating structure:

1. Only move electron. Never move atom
2. Only π electron (electron in π bonds) and lone pair can move. If conjugation possible
3. Hybridisation of any atom does not change

How to identify conjugation ?

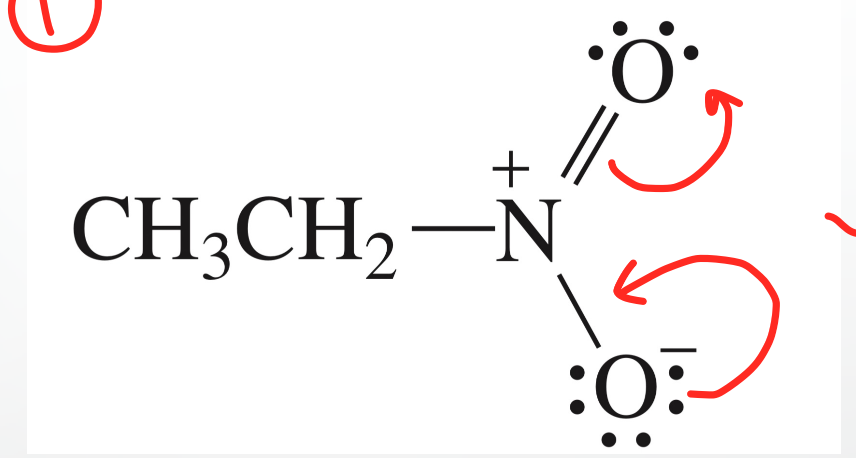
1. (Negative-charge) — (σ bond) — (π bond)

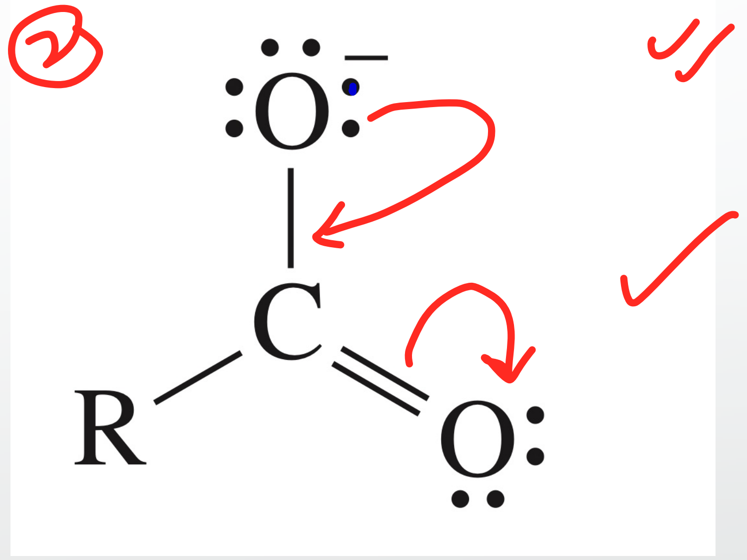
2. (π bond) — (σ bond.) — (π bond)

3. (lone pair) — (σ bond) — (πbond)

4. (positive charge) — (σ bond) — (π bond)

Identify in which molecule resonance possible ?

1

✓

2

✓✓

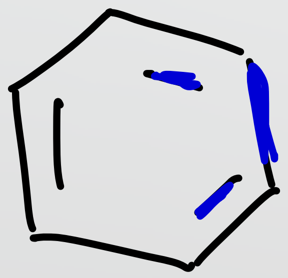
3
$CH_2=CH-CH=CH_2$

$(\pi \; \sigma \; \pi)$ Resonance ✓

4
$CH_2=CH-CH_2-CH=CH_2$ ✗

$\pi - \sigma - \pi$ ✓

$\pi - \sigma - \sigma - \pi$ ✗

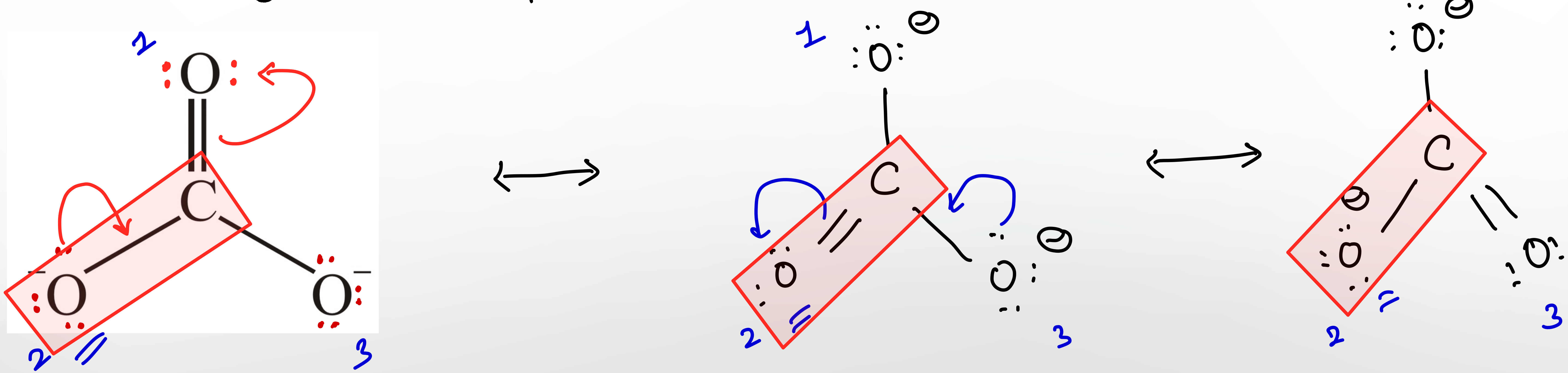
5

$(\pi \; \sigma \; \pi)$ ✓

Benzene

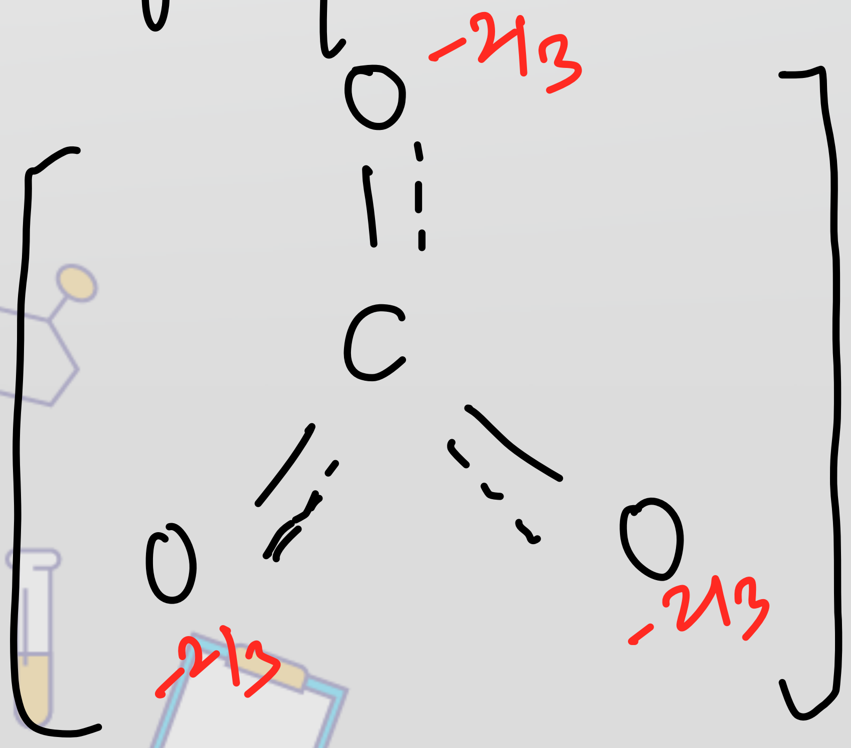
6
$CH_2 = CH - \overset{+}{CH_2}$ ✓

$(\pi - \sigma - \oplus)$ } organic compounds

Resonating structure of CO_3^{2-}



Number of Equivalent R.S = 3.



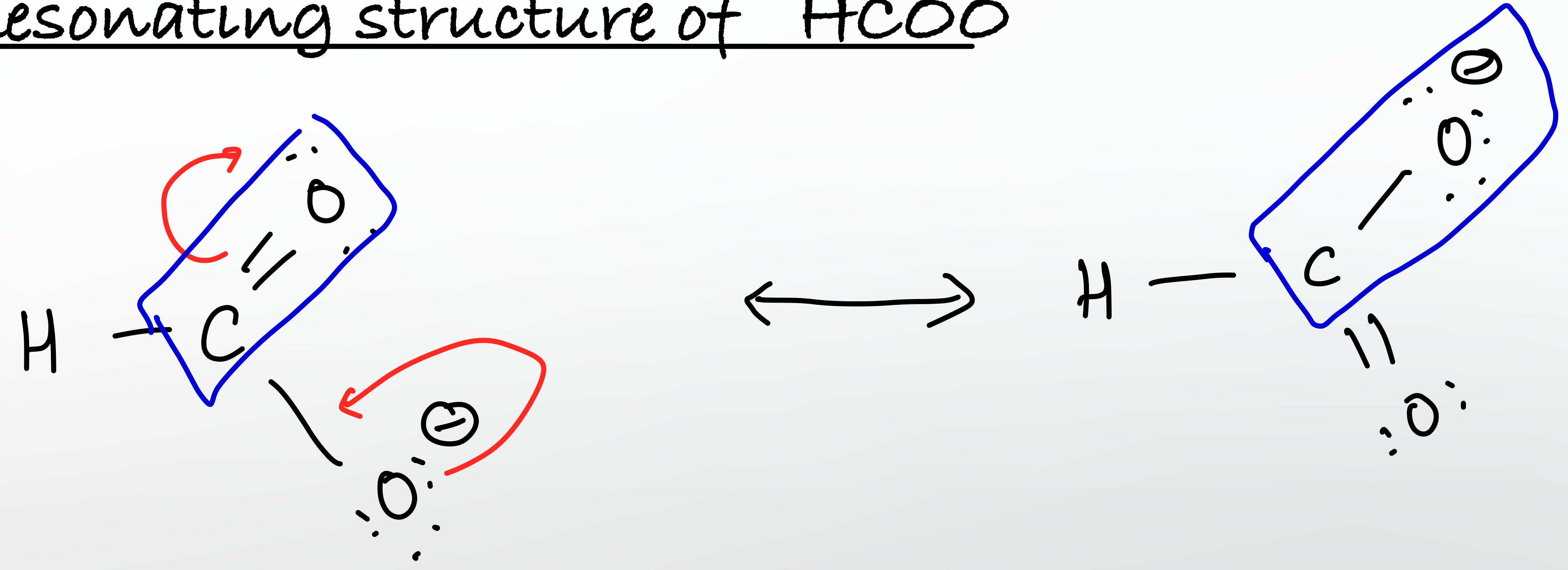
$$B.O = \frac{\text{total Bonds b/w two atom in R.S}}{R.S} = 1 + \frac{1}{3}$$

$\therefore \; 4/3 = 1.33$

σ Bond, π

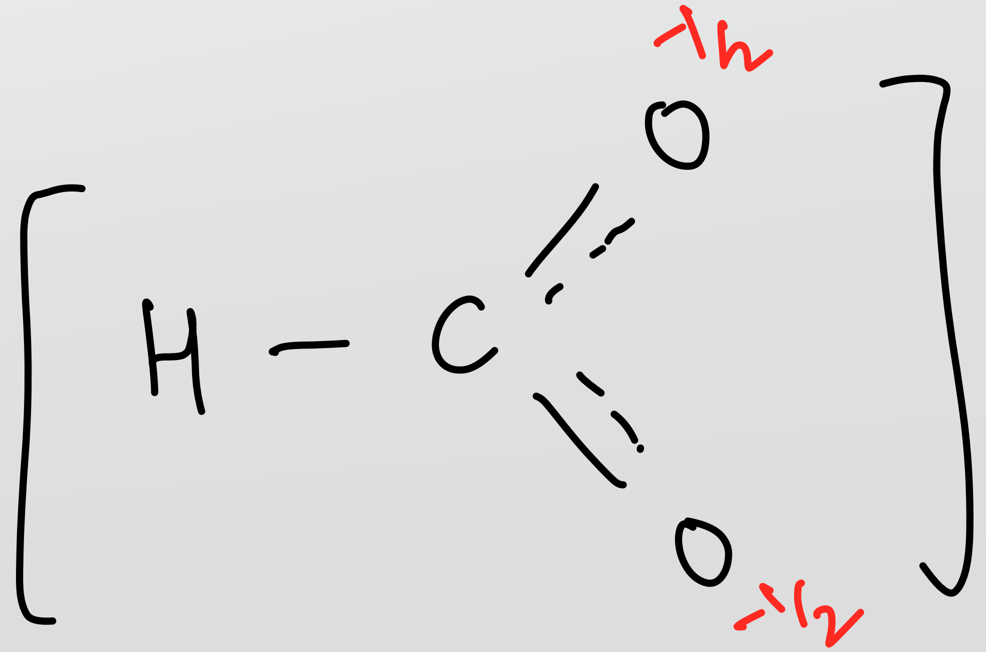
$= 1.33$

Resonating structure of $HCOO^{\ominus}$



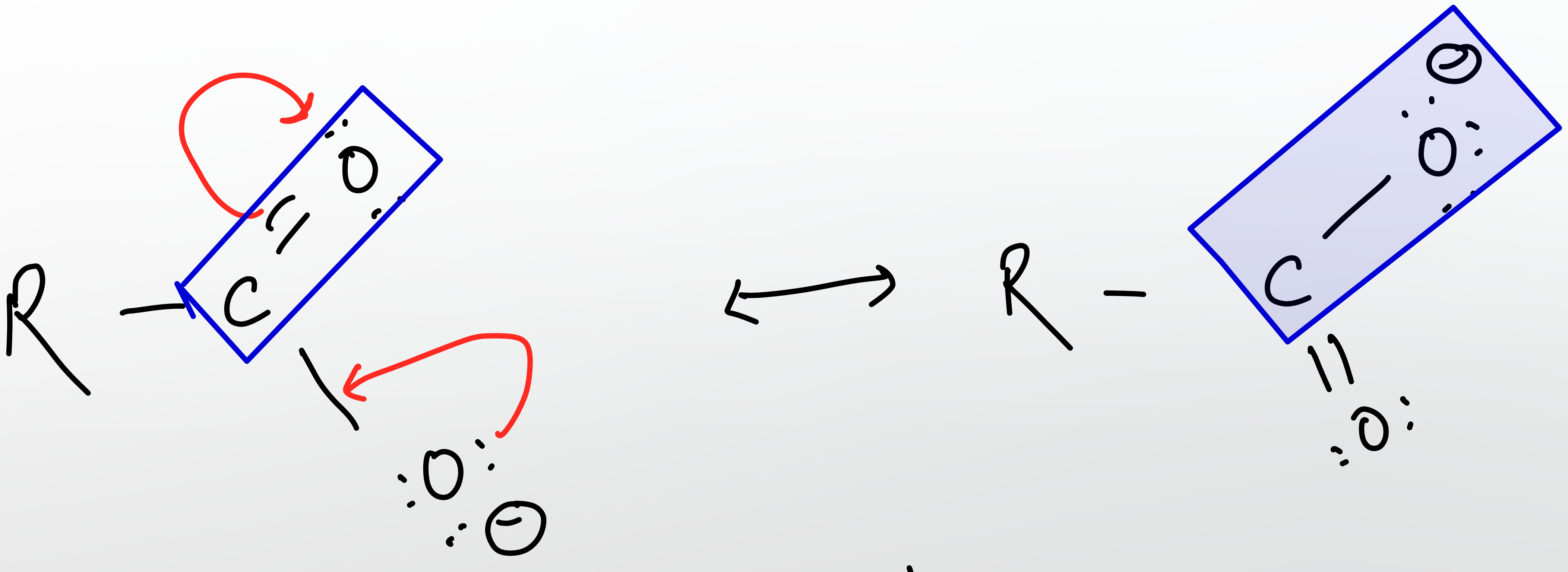
B.O = $3/2$

= 1.5



Resonance hybrid

Resonating structure of $RCOO^{\ominus}$

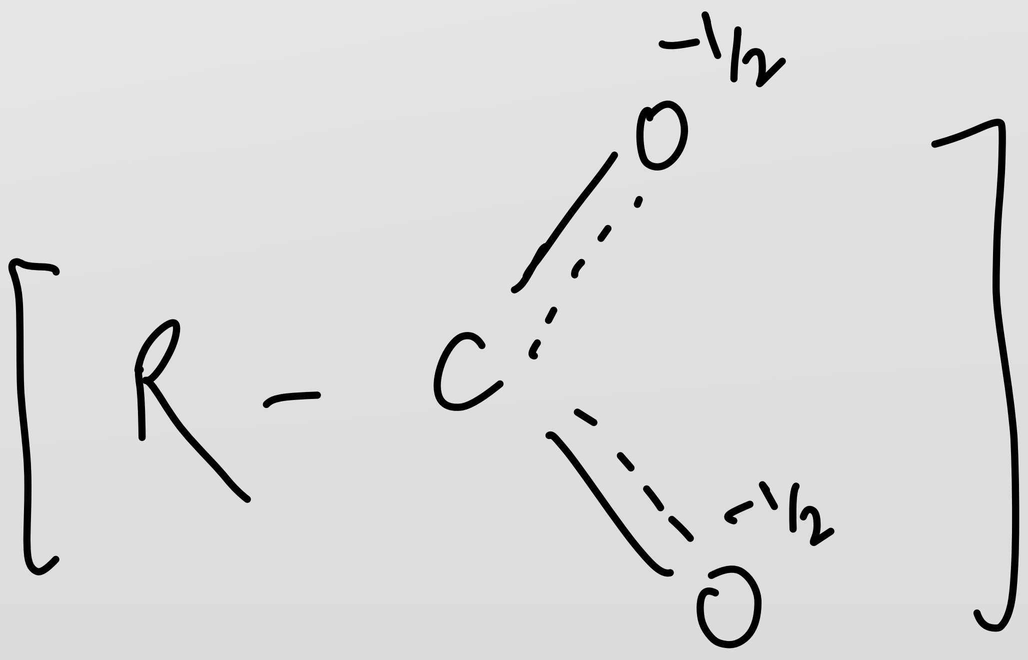


$B.O = 3/2 = 1.5$

R = Alkyl group.

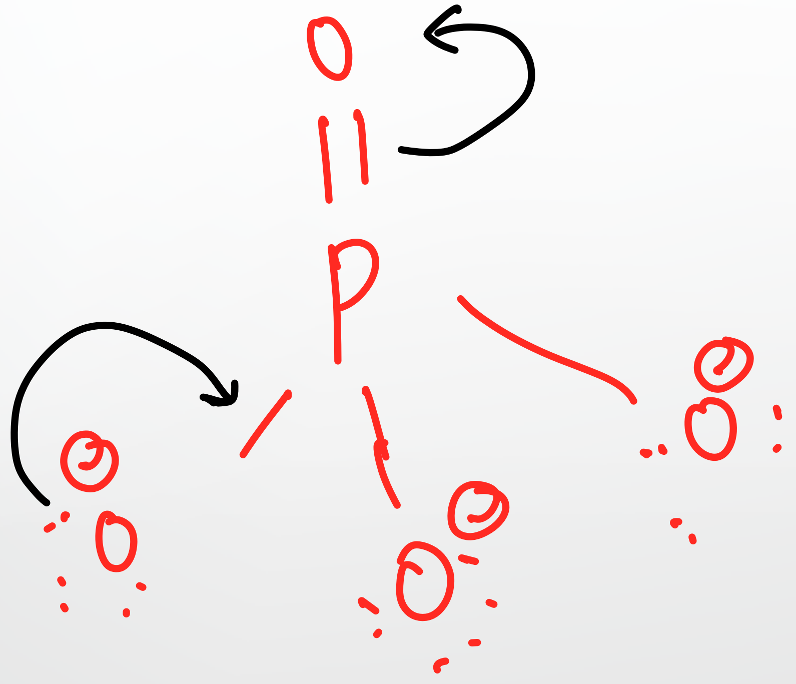
CH_3-

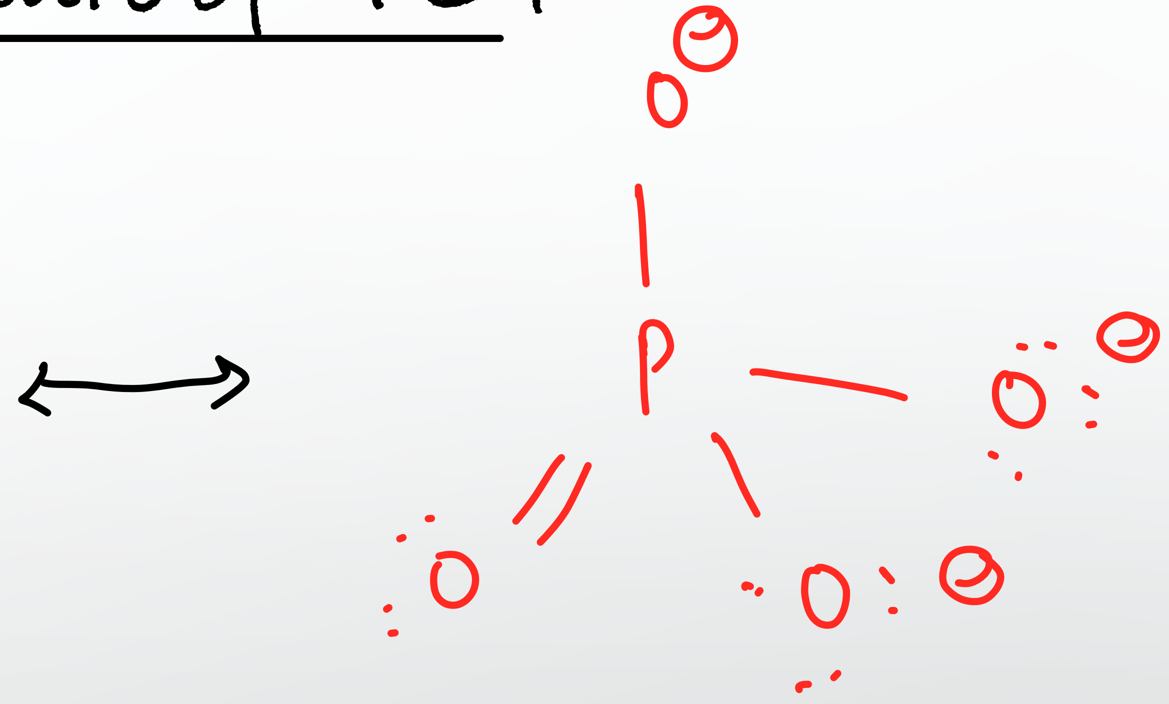
CH_3-CH_2-

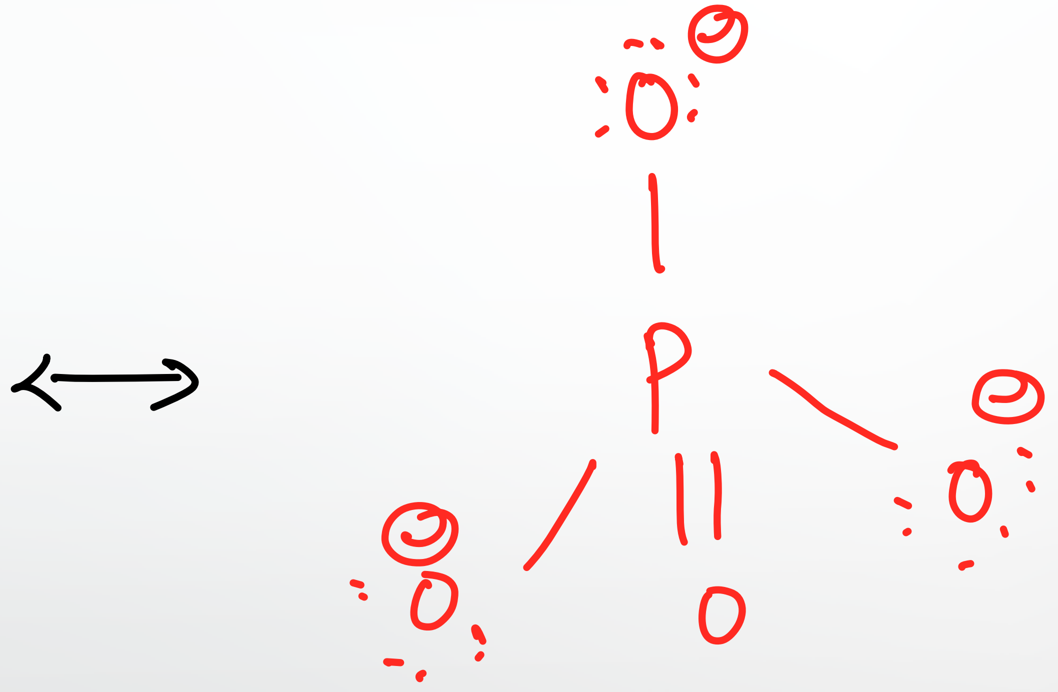


Resonance Hybrid.

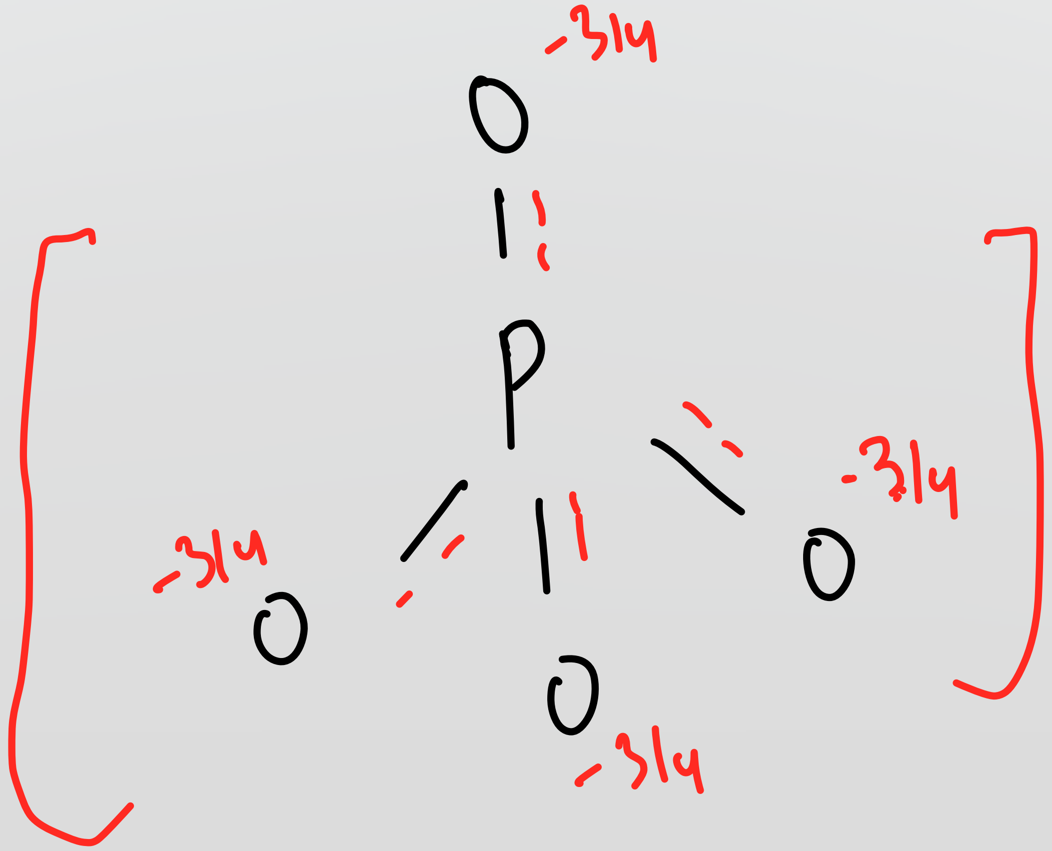
Draw resonating structure of PO_4^{3-}





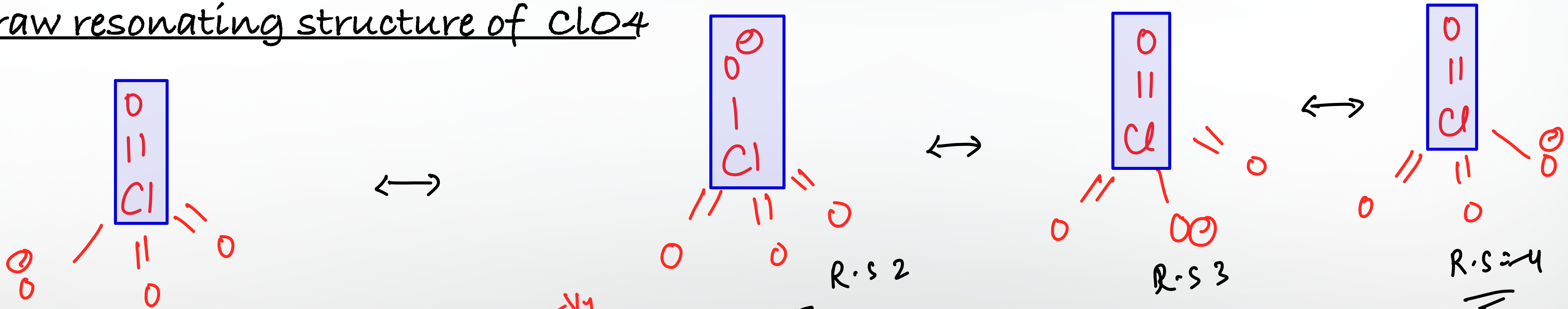


B.O : 5/4.



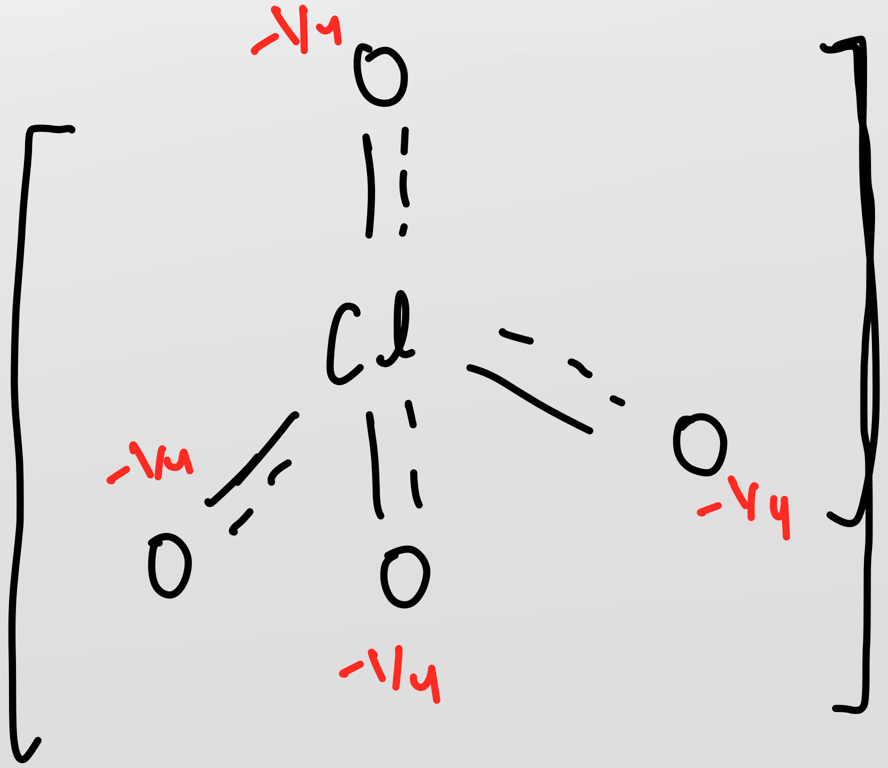
regular tetrahedral

Draw resonating structure of ClO_4^-



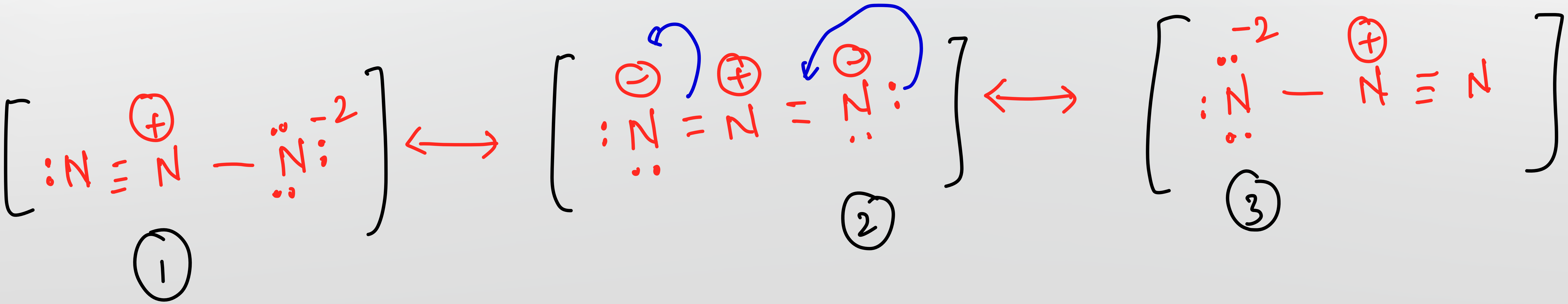
R·S 1 $\longleftrightarrow$ R·S 2 $\longleftrightarrow$ R·S 3 $\longleftrightarrow$ R·S = 4

R·H :



Bond order : $7/4$: $1 + 3/4$

(Q) Draw resonating structure of azide ion (N_3^-)

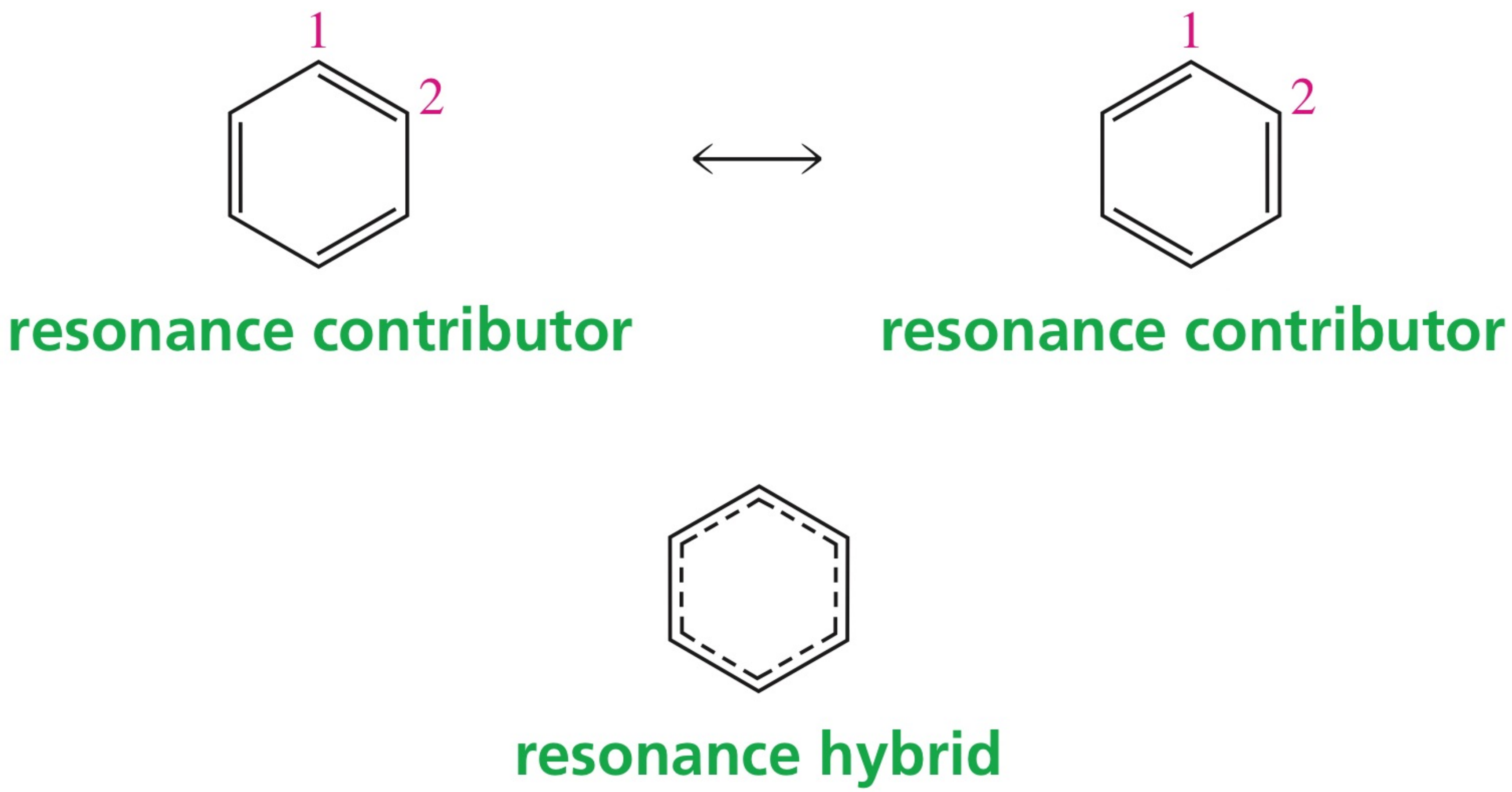


(1) & (3) are equivalent R.S

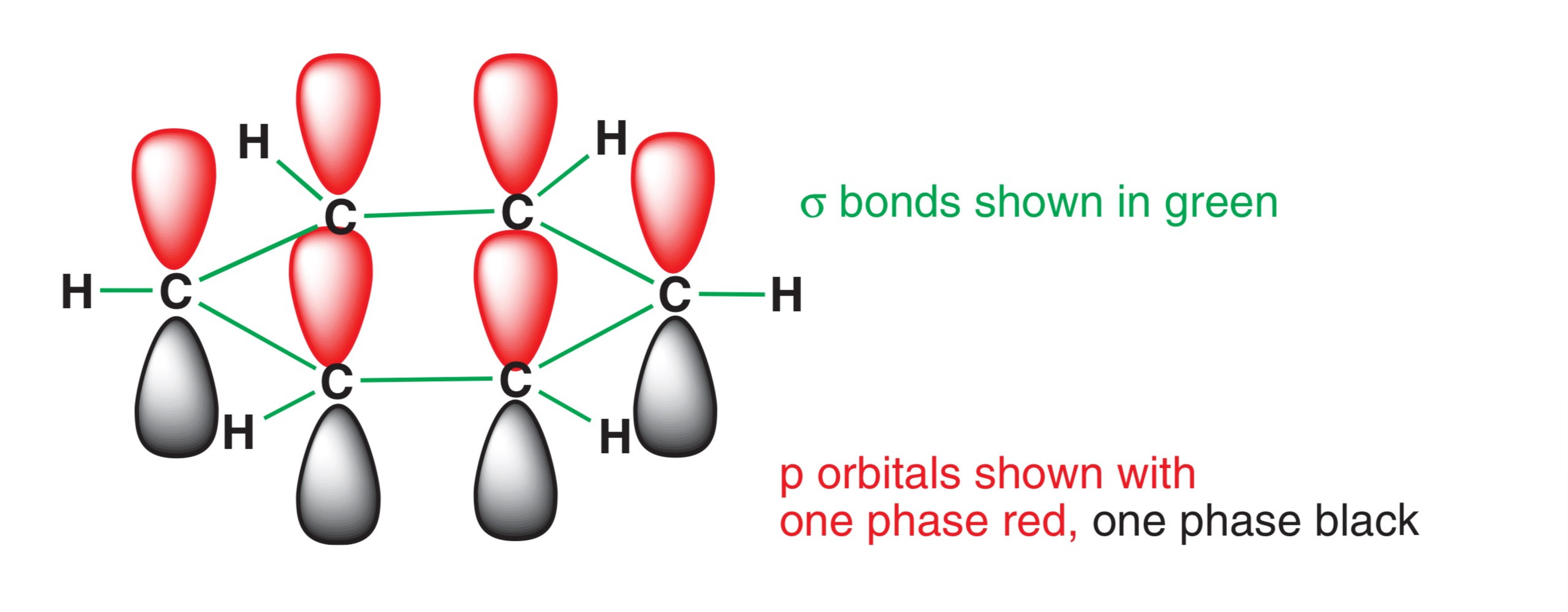
(Q) draw resonating structure of N_2O

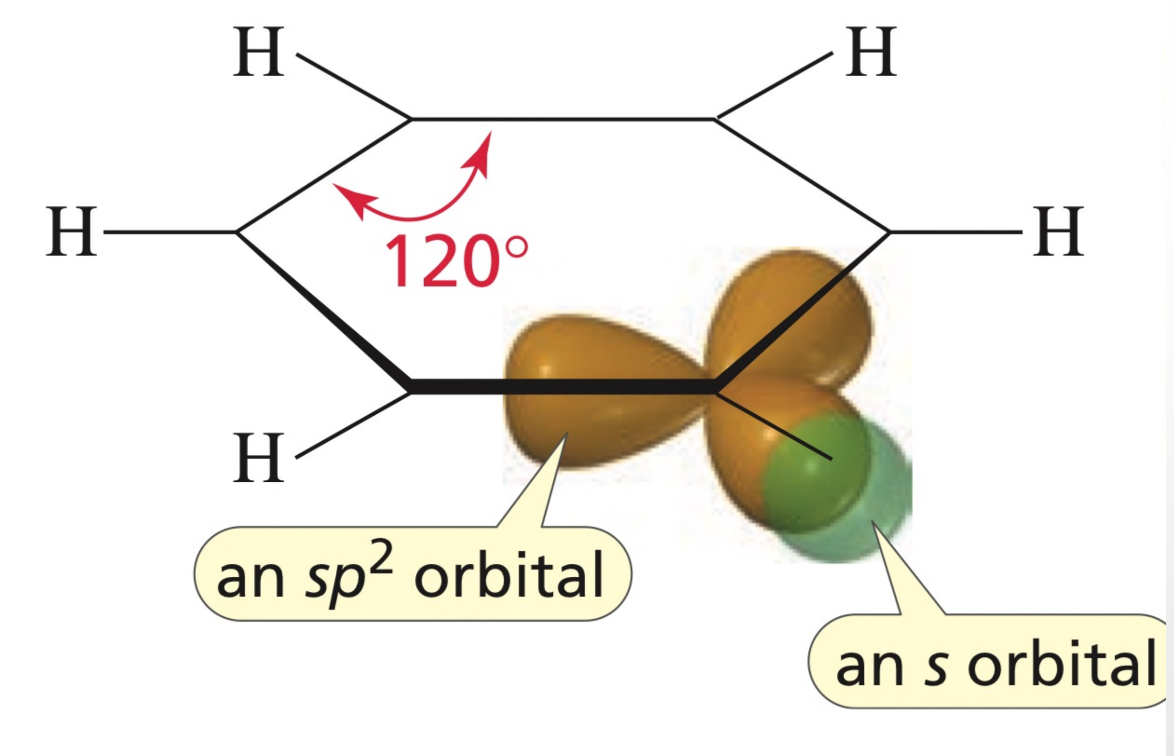
HW

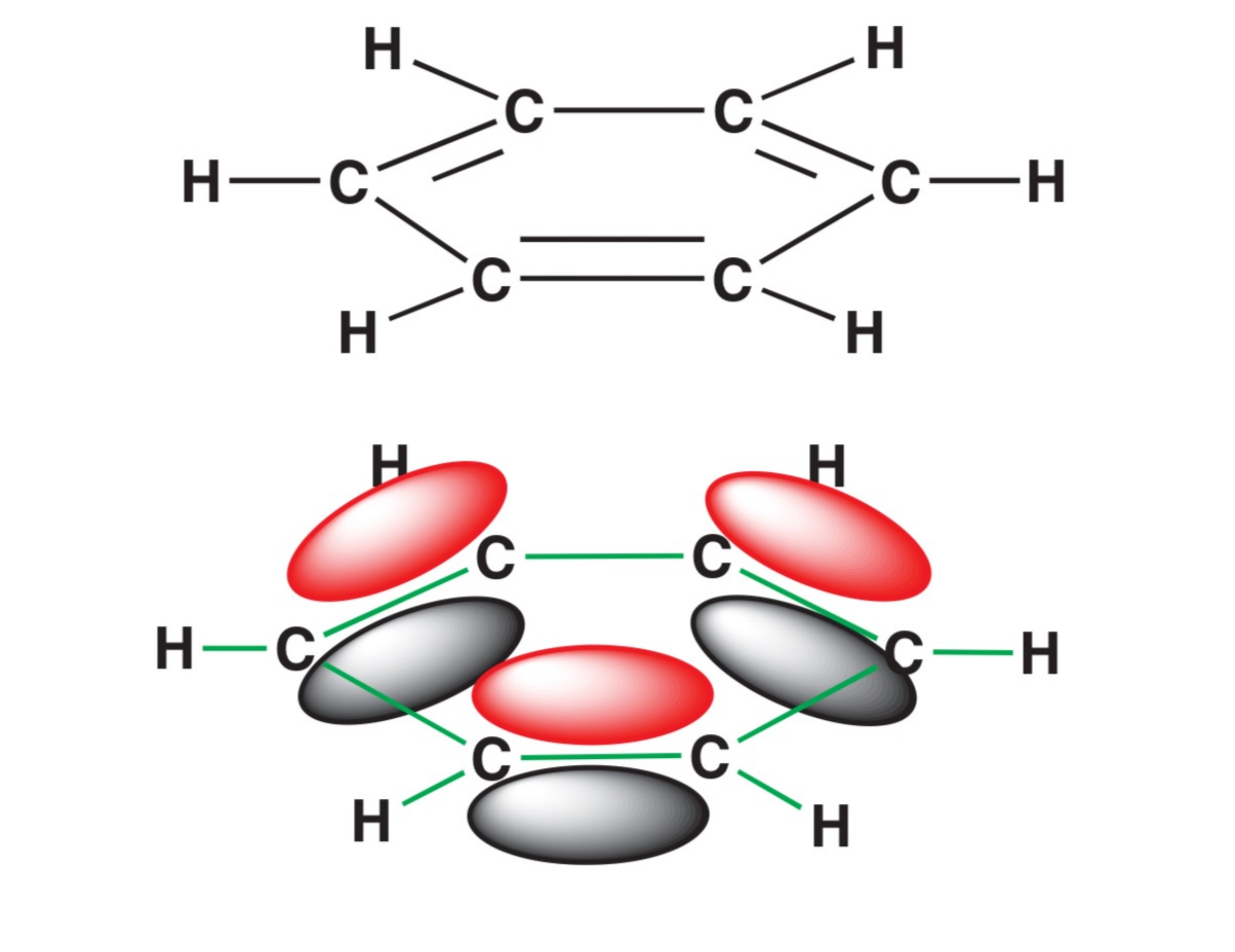
(Q) draw resonating structure of Benzene .

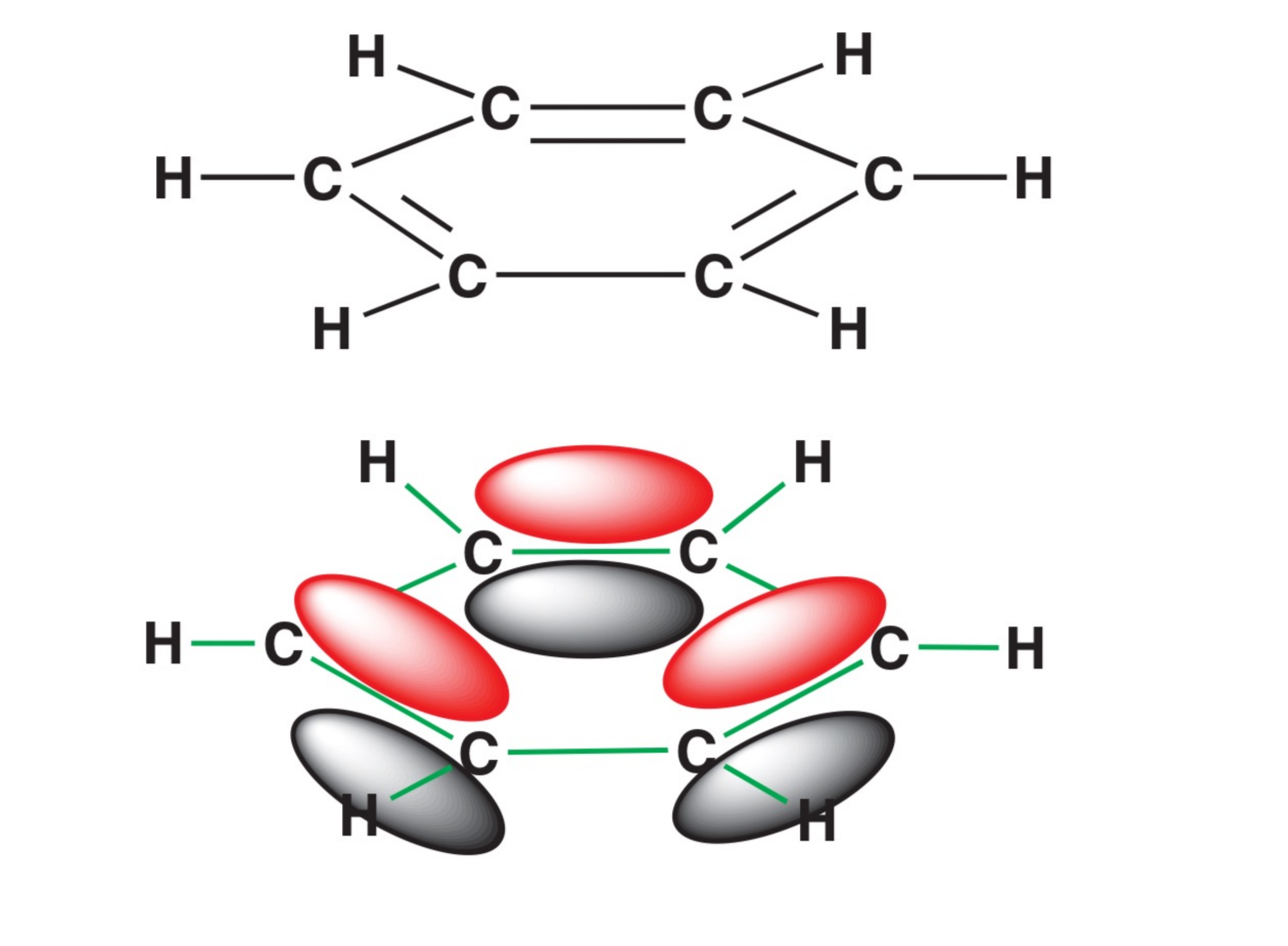


Understanding resonance in terms of orbital diagram.









Resonance

** When a molecule cannot be completely represented by a single Lewis structure but it's characteristic properties can be described by two or more different structures, with similar energy position of nuclei, bonding and non-bonding pairs of electrons, then the true structure is said to be resonance hybrid of these structures. The phenomenon is called resonance and different contributing structures are called resonating structures or canonical structures.

Important point of resonance:

- Resonance stabilizes the molecule as the energy of the resonance hybrid is less than the energy of any single canonical structure.
- Resonance averages the bond characteristics as a whole.
- The canonical forms have no real existence.

Most stable Resonating structure:

1.structure with maximum no of covalent bonds or pi bonds.

2. If number of covalent bonds are same structure with negative charge on more electronegative atom is more stable.

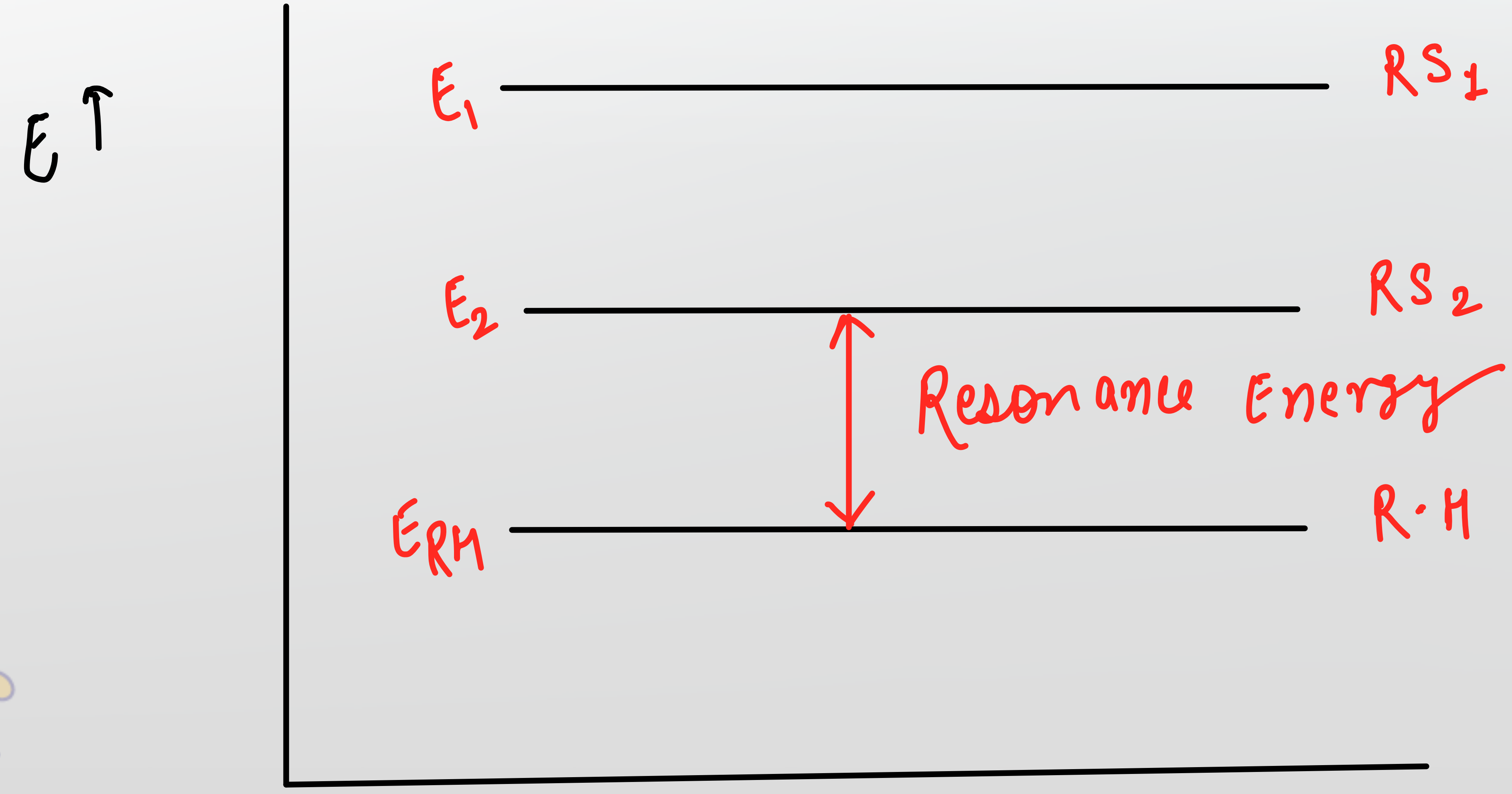
3. Like (same charges far away)

4.oppsite charges close

(Q) compare the stability of R.S in N_2O

Resonance Energy

* The resonance energy of the species is the extra stability of the resonance hybrid compared with the most stable resonating structure.



$R.E = |E_2 - E_{RH}|$