

Resonance Structures

The resonance means shifting multiple bond or bonds between equivalent positions in a given molecule. That means a single Lewis structure cannot adequately describe the single molecule. In that case more than one Lewis structure are used describe the molecule. These structures are known as resonance structures. There are, however, two requirements; (a) must have at least one multiple bond, and (b) must have same two atoms in different location with the same environments. Let us illustrate this with following example.

Example

Write the possible resonance structures for nitrate ion (NO_3^-).

Answer

Lewis dot symbols: $\cdot \ddot{\text{N}} \cdot$, $\cdot \ddot{\text{O}} \cdot$

Step 1. From the above dot notations, count the total number of valence electrons. There is one N atom and three O atoms in nitrate ion.

$$\begin{aligned} \text{Total number of valence electrons} &= 5 \text{ (for N)} + 6 \text{ (for O)} + 6 \text{ (for O)} + 6 \text{ (for O)} \\ &\quad + 1 \text{ (for 1 negative charges)} \\ &= 24 \text{ electrons} \end{aligned}$$

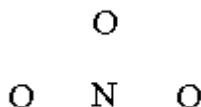
Step 2: All atoms obey octet rule.

$$\begin{aligned} \text{Number of electrons needed to obey the rules} &= 8 \text{ (for N)} + 8 \text{ (for O)} + 8 \text{ (for O)} + 8 \text{ (for O)} \\ &= 32 \text{ electrons.} \end{aligned}$$

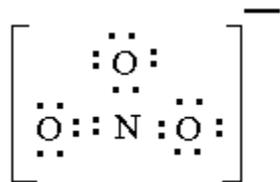
Step 3. Number of electrons engaged in bonding = 32 electrons - 24 electrons = 8 electrons.

Step 4. Number of single bonds = 8 electrons / 2 electrons = 4 single bonds.

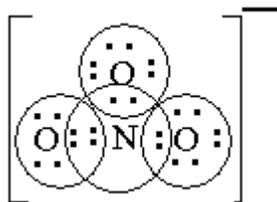
Step 5. Now place the C atom in the center and O atoms on any 3 sides.



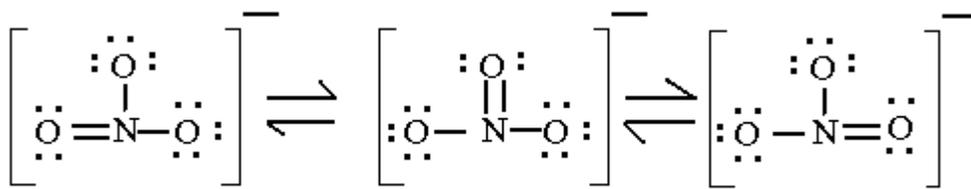
You have 8 electrons (or 4 bonds) to be distributed. First place the single bond (2 dots) between each O and N. You have placed 6 electrons so far. You have 2 more left; place them between any one of the O and N. Now you have distributed all bonding electrons. Total you have 24 valence electrons and still you have 16 valence electrons to be distributed. Place required number of electrons around each O atom to complete the octet.



Now you can see that all the atoms obey the octet rule.

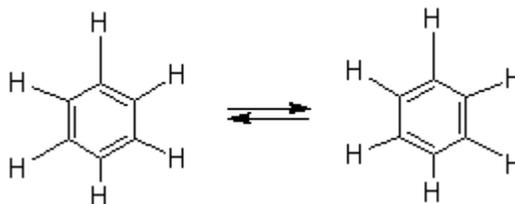


Now replace bonding electrons with double bond and single bond, and resonate the double between N and O to come with 3 resonance structures. And write equilibrium sign between all resonance structures.



Thus NO_3^- has 3 three resonance structures. Similarly, the CO_3^{2-} (discussed above) also has 3 resonance structures. **In resonance, the positions of atoms are fixed, but only the double or triple bond changes the position.**

The concept of resonance is also applicable to organic molecules. The benzene (C_6H_6) molecule is the best example of that.



Exercise

Draw the Lewis structures for the followings. All obey the octet rule except H, which obeys the duet rule.

