Resonance

Video Workbook with Dr. B.

More guides at
www.breslyn.org

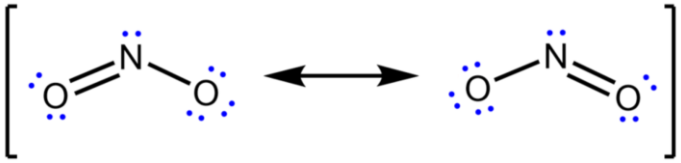
Sometimes there are several valid ways to draw a Lewis Structure. We call these **resonance structures**.

For NO_2^- we can write two Lewis Structures.

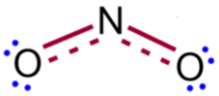
This results in a **resonance hybrid,** which is an average of the two structures. This is a more accurate representation of the structure for the molecule.

We say the electrons are **delocalized** in the hybrid structure. Not all molecules will exhibit resonance.

Resonance Structures for NO_2^-



Hybrid of Two Stuctures



Important Ideas

The symbol ⟷ means there are different possible structures.

They are NOT switching back and forth.

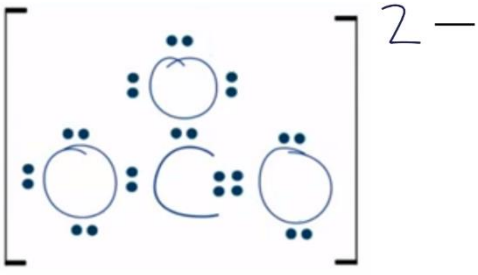
Instead, they should be averaged to better represent how the electrons are **delocalized** around the atoms.

We draw different resonance structures due to the limitations of the Lewis Structure model.

Example

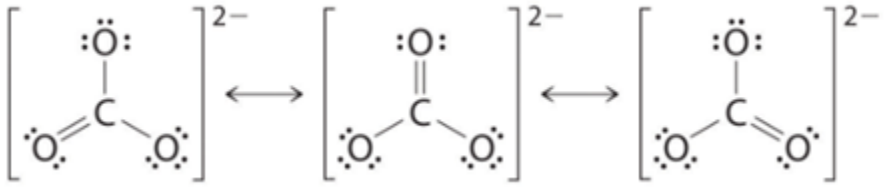
Draw the resonance structures of CO_3^{2-}, the Carbonate ion.

1. Draw the Lewis Structure for CO_3^{2-} (video link).

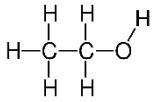
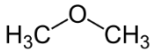


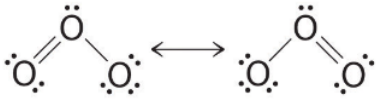
2. Move electrons around to create different, valid, Lewis structures. Here we shift the double bond.

3. Place double sided arrows between structures. Remember, they aren't switching back and forth! The actual structure is an average of these three resonance structures.



Resonance Structures and not Isomers!

An isomer has the same chemical formula but a different arrangement of **atoms**.	
 CH_3CH_2OH Ethanol	 CH_3OCH_3 Dimethyl ether

Resonance is a way of describing the delocalized **electrons** in a molecule.
 Same arrangement of atoms, different arrangment of electrons.

Practice (answers below)

1. What does the ⟷ represent in writing resonance structures for a compound?
   Explanation: see above notes.
2. Which compounds are more likely to exhibit resonance?
3. Write the resonance structures for NO_3^- , the Nitrate ion.
4. How does resonance affect the stability of a molecule?
5. Draw the resonance structures for CH_4.
6. Draw the Lewis structure for Benzene, C_6H_6, and show the major resonance structures.
7. What does the term "delocalized" mean when talking about the electrons in resonance structures?

Answers

1. See notes above for explanation.
2. Compounds with double or triple bonds (these have pi bonds) and compounds with lone pairs.
3. See explanation at https://youtu.be/5m4nvbAcVik .
4. In general, resonance results in a more stable molecule due to the delocalization of electrons.
5. See explanation at: https://youtu.be/DcNukORko1c .
6. Lewis Structure for Benzene: https://youtu.be/2kXe_incMpM
   Explanation of Resonance: https://youtu.be/bmY3YOyHi30
7. When we say the electrons are *delocalized*, we mean that the valence electrons are not limited to one atom but are spread over a larger region of the molecule.

Major and Minor Resonance Structures & Formal Charge

Major resonance structures contribute more significantly to the resonance hybrid. They will have formal charges closest to zero.

Minor resonance structures contribute to the hybrid structure, but to a lesser extent.

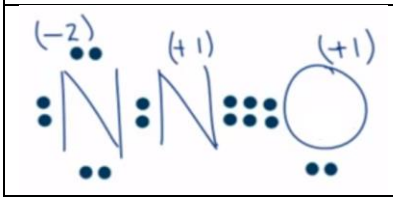
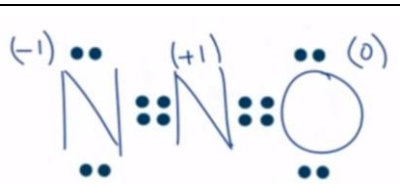
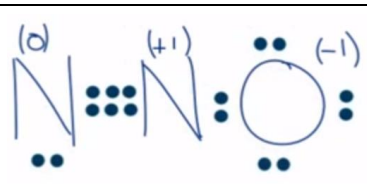
We use formal charge to determine which resonance structures are major and minor.

Example: N_2O

All of the Lewis Structures below are valid (follow the rules for writing Lewis Structures).

Lewis *Structure 1* has formal charges furthest from zero making it a minor contributor to the resonance hybrid.

Structure 2 and *3* are close so they both contribute substantially to the resonance hybrid structure. However, *Structure 3* has the negative formal charge on the most electronegative atom (the O). This means it contributes more and the overall hybrid structure, but *Structure 2* also contributes.

Structure 1 (formal charges not close to zero)	*Structure 2* (formal charges closer to zero)	*Structure 3* (negative formal charge on most electronegative element)
		

How to Find Formal Charge

Practice Finding Formal Charge

Uses and Limitations

Resonance structures provide valuable information to chemists about how electrons are delocalized in a molecule, molecular stability, chemical reactivity, understanding bonding patterns, and in designing organic synthesis.

However, they are simplified representations and do not show the dynamic movement of electrons in a molecule.

Report errors and suggestions to DrB@breslyn.org