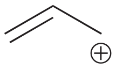
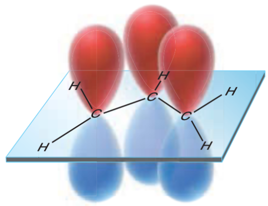
Inter-Lecture A Handout: Introduction to Resonance

1. The Inadequacy of VB Theory

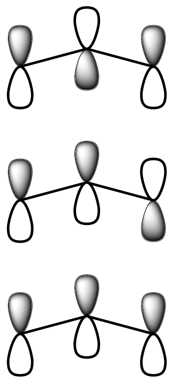
- The Allyl Carbocation

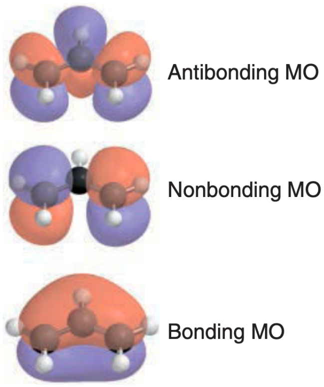




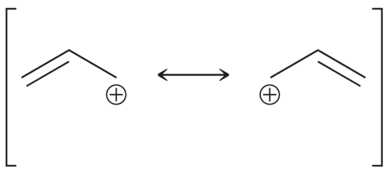
"a conduit of electron flow"

- QMOT





- Resonance

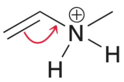


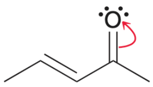
2. Curved Arrows

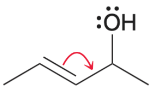
- Rules

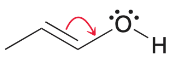
1. *Avoid breaking a single bond.*
2. *Never exceed an octet for second-row elements.*

Practice: in each of the following cases, determine whether the curved arrow violates either of the two rules and describe the violation, if any. (Don't forget to count all hydrogen atoms and all lone pairs.)

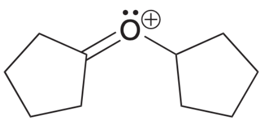
(a) 

(b) 

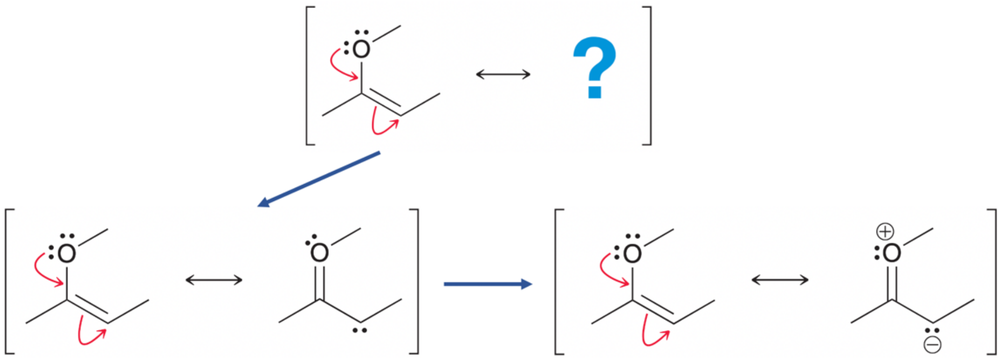
(c) 

(d) 

Practice: drawing the resonance structure of the following compound requires one curved arrow. The head of this curved arrow is placed on the oxygen atom, and the tail of the curved arrow can only be placed in one location without violating the rules for drawing curved arrows. Draw this curved arrow.

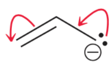


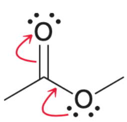
3. Formal Charges in Resonance Structures

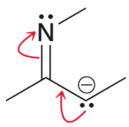


Practice: for each of the structures below, draw the resonance structure that is indicated by the curved arrows. Be sure to include formal charges.

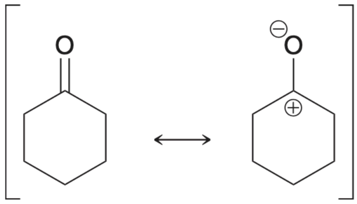
(a) 

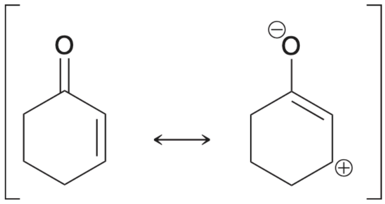
(b) 

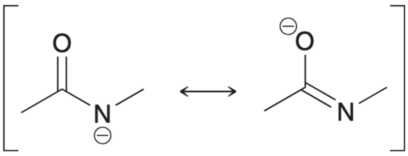
(c) 

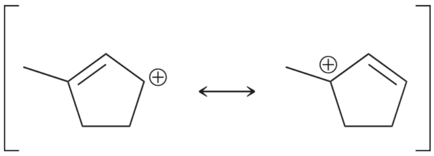
(d) 

Practice: in each case below, draw the curved arrow(s) required in order to convert the first resonance structure into the second resonance structure. In each case, begin by drawing all lone pairs and then use the formal charges to guide you.

(a) 

(b) 

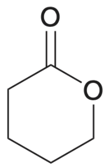
(c) 

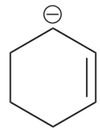
(d) 

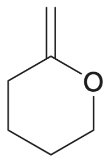
4. Drawing Resonance Structures via Pattern Recognition

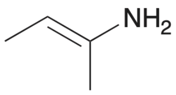
- An Allylic Lone Pair

Practice: for each of the compounds below, locate the pattern we just learned (lone pair next to a π bond) and draw the appropriate resonance structure:

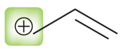
(a) 

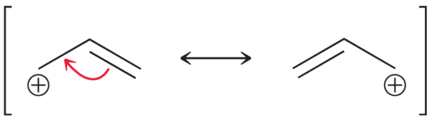
(b) 

(c) 

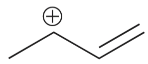
(d) 

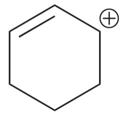
- An Allylic Carbocation

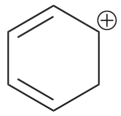


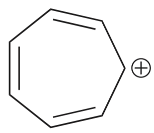


Practice: draw the resonance structure(s) for each of the compounds below:

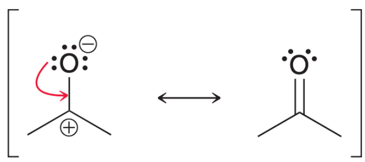
(a) 

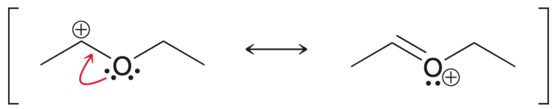
(b) 

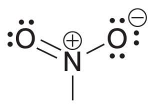
(c) 

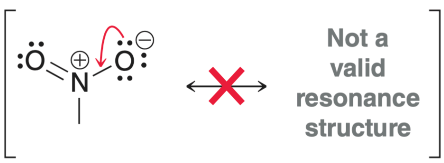
(d) 

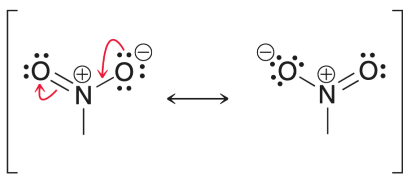
- A Lone Pair Adjacent to C^+



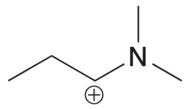


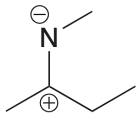
The exception: nitro group 

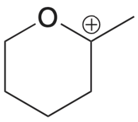




Practice: for each of the compounds below, locate the lone pair adjacent to a positive charge and draw the resonance structure:

(a) 

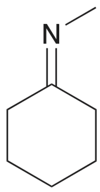
(b) 

(c) 

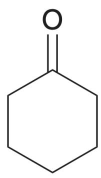
- A π Bond Between Two Atoms of Differing Electronegativity

Practice: draw a resonance structure for each of the compounds below.

(a)



(b)



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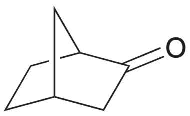
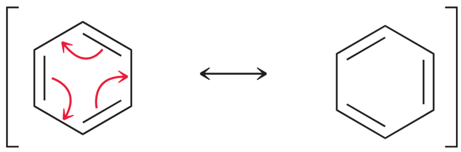
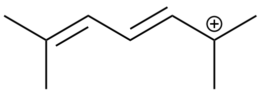
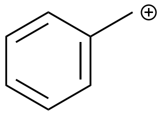


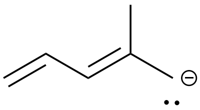
- A Conjugated π Bonds Enclosed in A Ring



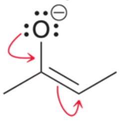
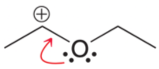
Practice: for each of the following compounds, draw the resonance structures.







Summary

Allylic lone pair	Allylic carbocation	Lone pair adjacent to C+	π bond between two atoms of differing electronegativity	Conjugated π bonds enclosed in a ring
				
Two curved arrows	One curved arrow	One curved arrow	One curved arrow	Three curved arrows

5. Assessing Relative Stabilities

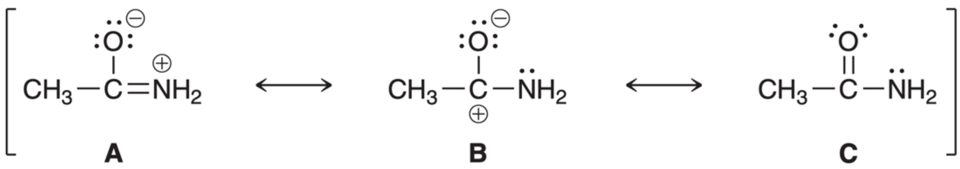
(1) The most significant resonance forms have the greatest number of filled octets

(2) The structure with fewer formal charges is more significant

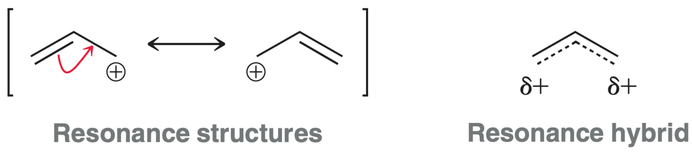
(3) A structure with a negative charge on the more electronegative element will be more significant

(4) Resonance forms that have equally good Lewis structures are described as equivalent and contribute equally to the resonance hybrid

Practice: rank the following resonance forms, from most significant to least significant, and briefly explain the rankings.



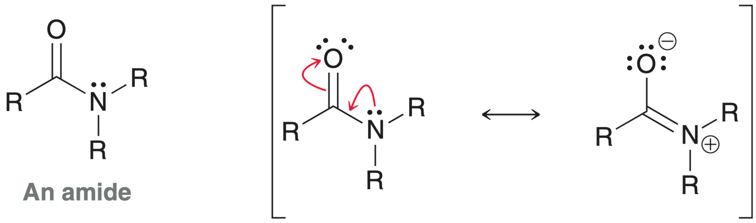
6. The Resonance Hybrid

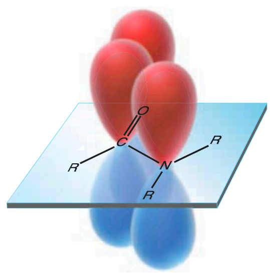


Practice: draw a resonance hybrid for each of the following.

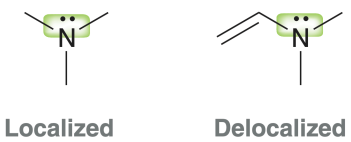
7. Delocalized and Localized Lone Pairs

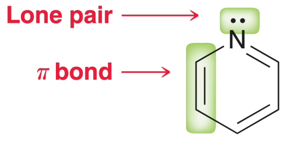
- Delocalized Lone Pairs

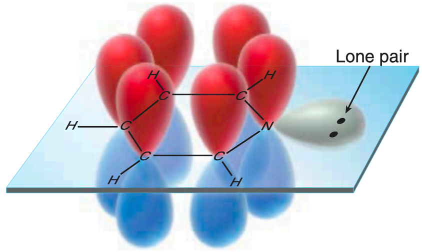


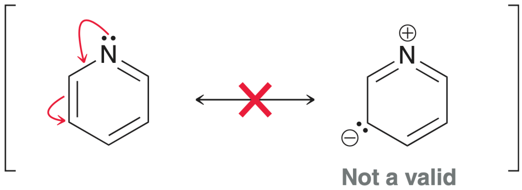


- Localized Lone Pairs

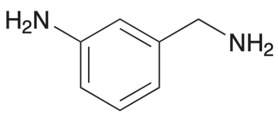


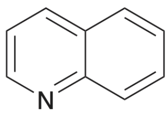






Practice: for each compound below, identify all lone pairs and indicate whether each lone pair is localized or delocalized. Then, use that information to predict the geometry for each atom that exhibits a lone pair.

(a) 

(b) 

(c)