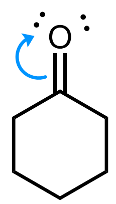
Resonance

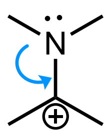
1A. **Draw the resonance contributor** indicated by the curved-arrows shown.

B. Based on your understanding of how to assess the stability of Lewis structures, determine which resonance structure is more stable or if they are equal in stability.



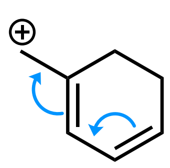
resonance contributor 1
more stable
all atoms have 8 electrons
(full octet, closed-shell)

resonance contributor 2
less stable
carbocation has only 6 electrons
(open-shell)



resonance contributor 1
less stable
carbocation has only 6 electrons
(open-shell)

resonance contributor 2
more stable
all atoms have 8 electrons (full octet, closed-shell)

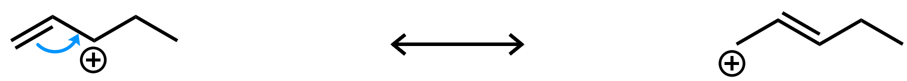


resonance contributor 1
less stable
1° carbocation (open-shell)
very unstable

resonance contributor 2
more stable
2° carbocation (open-shell)
more stable than a 1° carbocation

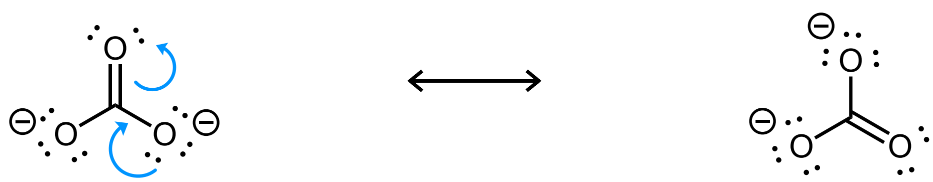
2A. **Draw the missing curved arrow(s)** on resonance contributor 1 that are required to convert it to resonance contributor 2.

B. Based on your understanding of how to assess the stability of Lewis structures, determine which resonance structure is more stable or if they are equal in stability.



resonance contributor 1
more stable
2° carbocation (open-shell)
more stable than a 1° carbocation

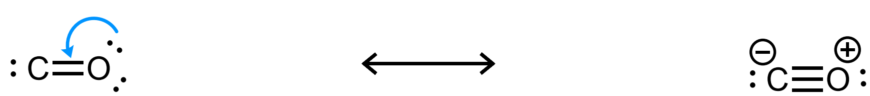
resonance contributor 2
less stable
1° carbocation (open-shell)
very unstable



resonance contributor 1

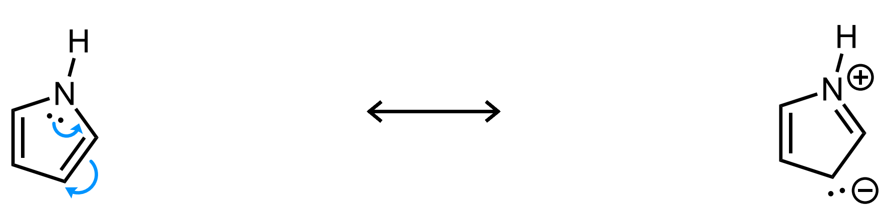
resonance contributor 2

equal in stability
all atoms have full octet (closed-shell)
2 negatively charged oxygen atoms



resonance contributor 1
less stable
carbon has 6 electrons
(open-shell)

resonance contributor 2
more stable
all atoms have full octet
(closed-shell)



resonance contributor 1
more stable
all atoms have full octet
and neutral atoms

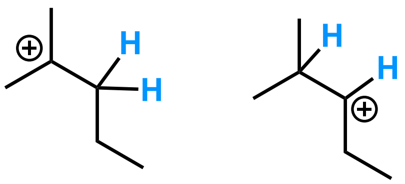
resonance contributor 2
less stable
all atoms have full octet,
but two charged atoms

3. Determine if each pair of molecules below are **resonance contributors of the same species *or* different molecules**. Briefly justify your explanation.

Recall the rules for drawing resonance contributors:
do not break single bonds
only move electrons

Explanation:

A.



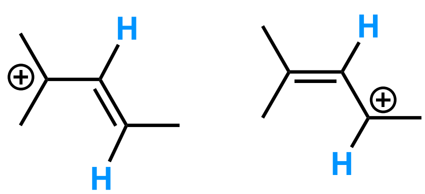
☐ resonance contributors

or

■ different molecules

Explanation: different number of H's on C atoms in the two structures

B.



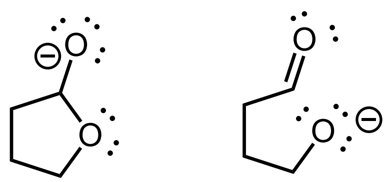
■ resonance contributors

or

☐ different molecules

Explanation: only the electrons in the π-bond have moved

C.



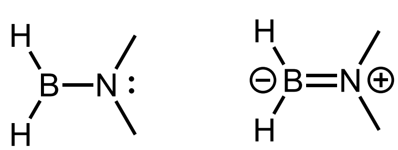
☐ resonance contributors

or

■ different molecules

Explanation: C—O bond has broken

D.



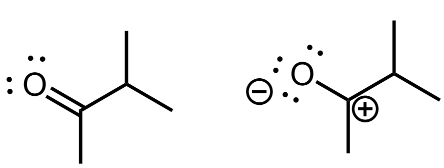
■ resonance contributors

or

☐ different molecules

Explanation: Only the nitrogen lone pair has moved into the open-shell B atom

E.



■ resonance contributors

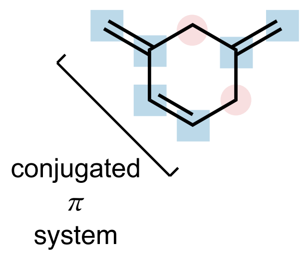
or

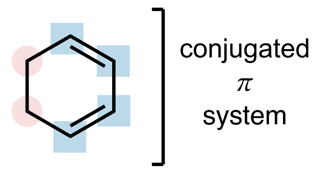
☐ different molecules

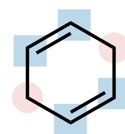
Explanation: only the electrons in the π-bond have moved

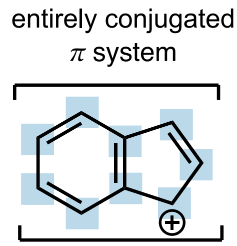
4. A. **Circle** any sp^3-hybridized carbon atoms in molecule X and **square** any sp^2-hybridized carbon atoms in each of the molecules below

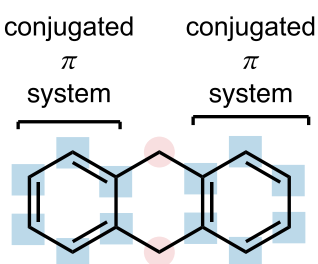
B. Then, **identify where 3 or more sp^2-hybridized atoms are uninterrupted** by any **sp^3-atoms**. These are referred to as conjugated π systems.

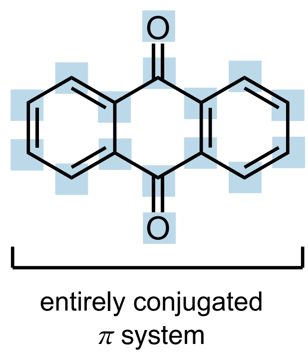


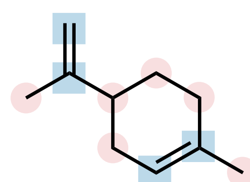




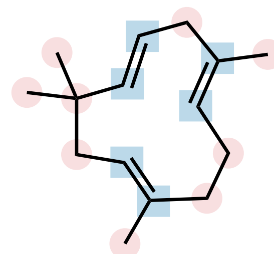








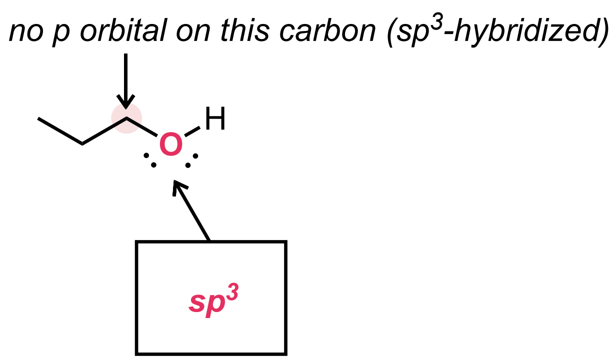
Limonene
(citrus fruits)



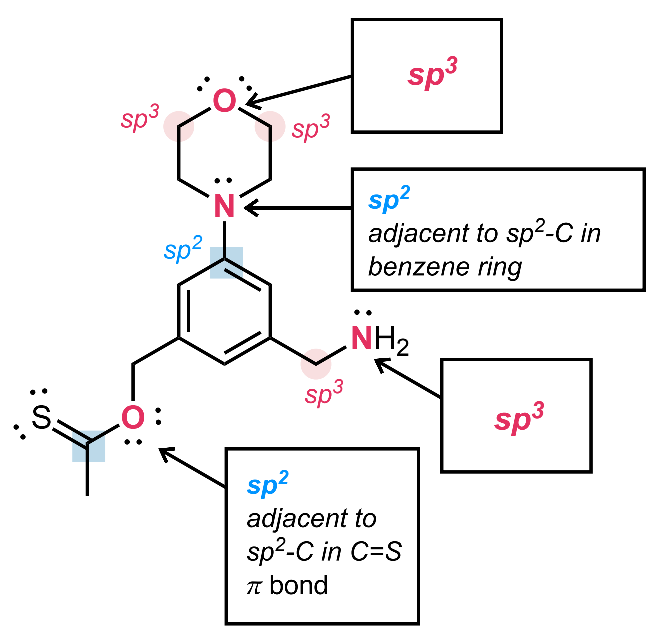
Humulene
(hops)

5. Based on the information provided in the “Resonance in Delocalized Lone Pairs” section of the Core Concept sheet, **assign the hybridization** of the indicated atoms below.

e.g.

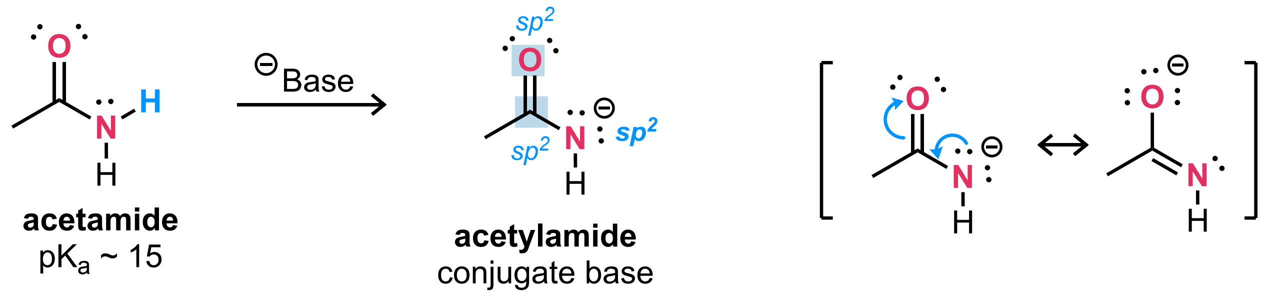


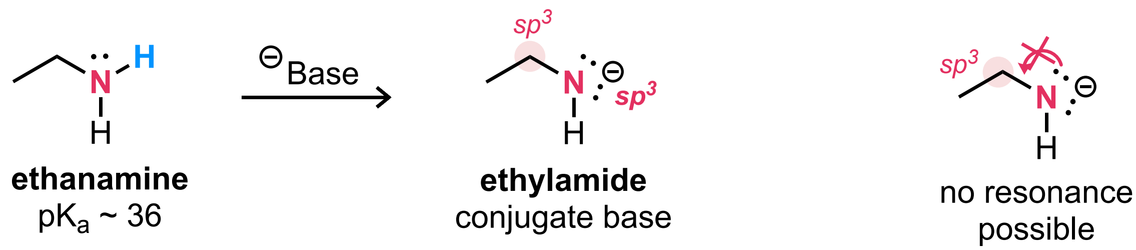
This oxygen is sp^3
since it has 4 electron regions
(2 single bonds and 2 lone pairs)
and the lone pairs on the O are localized
(there is no adjacent p orbital on the
neighboring carbon atom)



Impact of Resonance on Reactivity

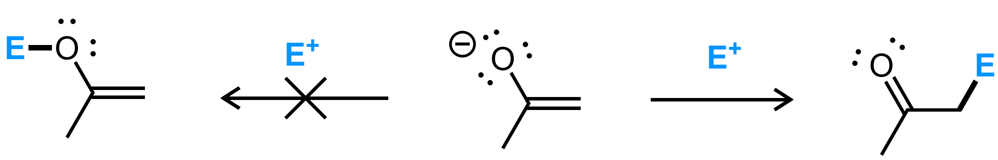
6. Acetamide, below, has a pK_a value of approximately 15 whereas ethanol has a pK_a of approximately 36. Using your knowledge of acid-base chemistry and resonance, describe why acetamide is approximately 10^{21} times more acidic than ethanamine.





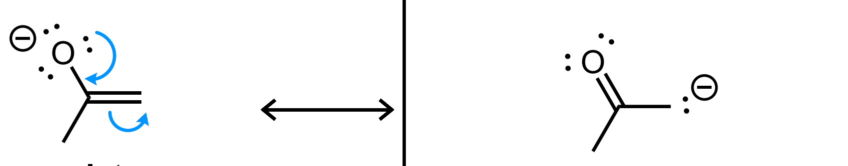
Explanation:
More stable conjugate bases are associated with stronger parent acids. Since the negative charge in acetylamide can delocalize through resonance, acetylamide is a more stable conjugate base than ethylamide. Due to this, acetamide is significantly more acidic.

7. Below is a species you likely have not encountered yet: an **enolate.** The more stable resonance contributor is shown. Despite that the more stable resonance contributor has a negatively charged O atom, enolates react with electrophiles (**E^+**) as shown below, wherein the carbon atom bonds to **E** rather than the O atom.



enolate
resonance contributor 1
more stable

A. **Draw curved-arrows** on resonance contributor 1 and the related resonance contributor that explains the observation above.



enolate
resonance contributor 1
more stable

resonance contributor 2
less stable