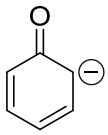
Organic Chemistry Workshop **Spring 2021**

Day 1 (1pm – 5pm on January 12th): Resonance, acidity, nucleophilic substitution, elimination

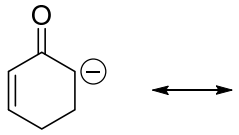
1) Draw all relevant resonance structures for the molecule shown. In addition, circle the resonance structure that is lowest in energy.

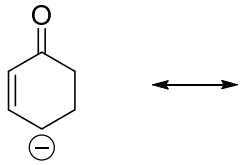


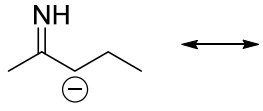
2) Rank the following compounds by acidity. The most acidic compound is 1, while the least acidic compound is 5.

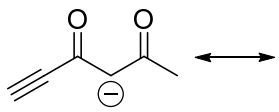
CH_3OH	CH_3CO_2H	HCl	CH_3NH_2	CH_3SH
___	___	___	___	___

3) a. Draw all relevant resonance structures for compounds **A-D** shown below.

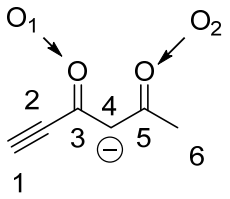
A 

B 

C 

D 

b. Indicate the hybridization of all nonhydrogen atoms in structure **D**.



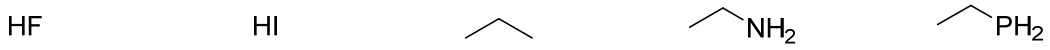
C_1 ___ C_2 ___ C_3 ___ O_1 ___ C_4 ___ C_5 ___ O_2 ___ C_6 ___

c. For structure **D**, indicate how many sigma and pi bonds are present.

sigma _____ pi _____

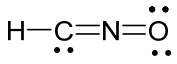
d. Rank the acidity of the conjugate of the indicated anions for compounds **A**-**D**. The conjugate that is the most acidic is 1, while the conjugate that is the least acidic is 4.

4) Rank by acidity. The most acidic compound is 1, while the least acidic compound is 5.

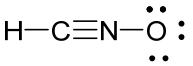


___ ___ ___ ___ ___

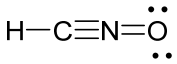
5) Consider the following Lewis dot structures (1-4) for a compound CHNO. Indicate the answer to the following questions on the line following the question. Answers could be one, two or none.



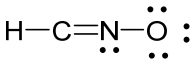
1



2



3



4

Which structures have a formal negative charge on carbon? ___

Which structures have a formal negative charge on nitrogen? ___

Which structures have a formal negative charge on oxygen? ___

Which structures have a formal positive charge on carbon? ___

Which structures have a formal positive charge on nitrogen? ___

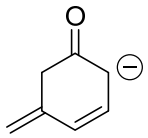
Which structures have a formal positive charge on oxygen? ___

Which structure is the most stable? ___

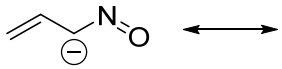
Which structure is the least likely? ___

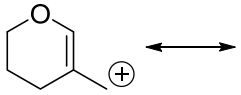
6) Draw all major resonance structures for the following anion. In addition, circle the resonance structure that is lowest in energy.

a.



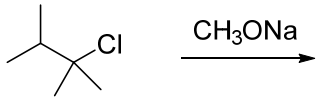
b. Draw the lowest energy resonance structure for the following compounds.



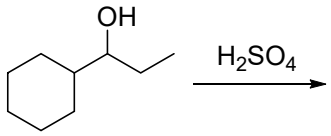


7) Draw the preferred product for the following reactions.

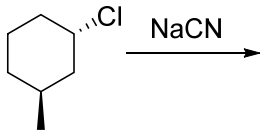
a.



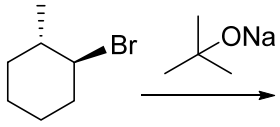
b.



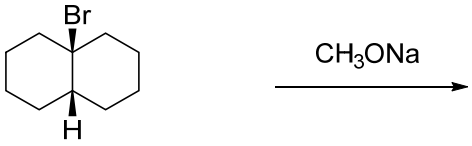
c.



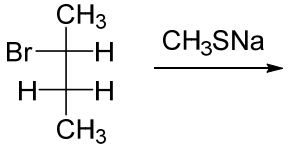
d.



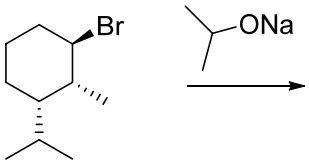
e.


Br
H
CH3ONa

f.


CH3
Br
H
H
H
CH3
CH3SNa

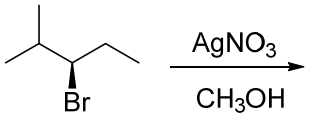
g.


Br
ONa

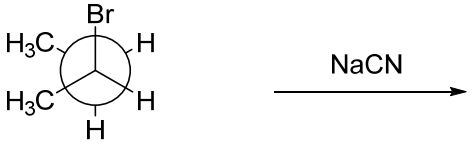
h.


Br
CH3SNa

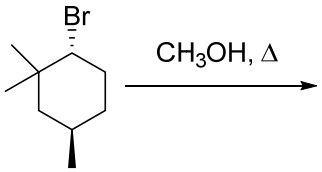
i.


Br
AgNO3
CH3OH

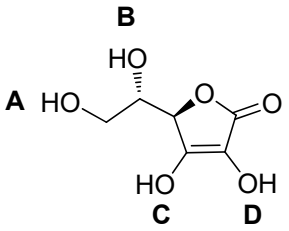
j.


Br
H3C
H
H3C
H
H
NaCN

k.



8) Ascorbic acid (shown below) has a pKa of 4.1 which is in the range of a carboxylic acid. Draw the structures of the conjugate bases obtained from the deprotonation of each hydroxyl group (A-D). Show the resonance structures for the conjugate bases for which electron delocalization can occur.



a. Conjugate base for deprotonation of A:

b. Conjugate base for deprotonation of B:

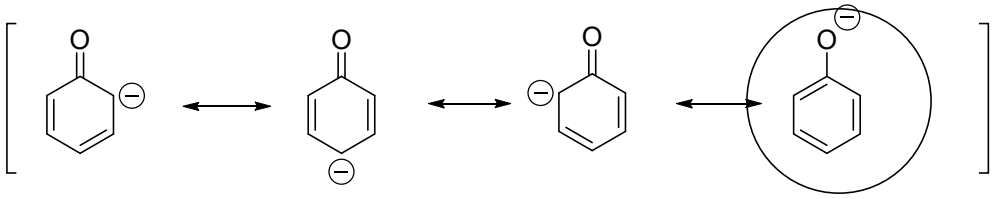
c. Conjugated base for deprotonation of C

d. Conjugated base for deprotonation of D:

e. Which of the four OH groups is the most acidic? Why is it similar in acidity to a carboxylic acid?

Keys

1) Draw all relevant resonance structures for the molecule shown. In addition, circle the resonance structure that is lowest in energy.

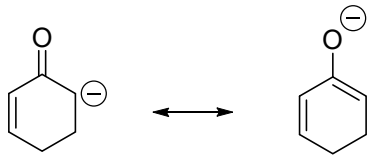


2) Rank the following compounds by acidity. The most acidic compound is 1, while the least acidic compound is 5.

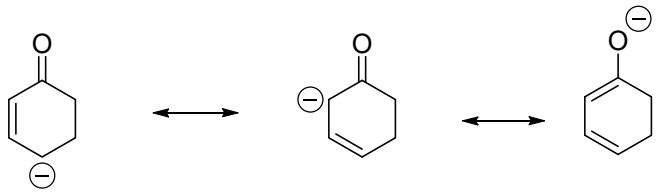
CH_3OH	CH_3CO_2H	HCl	CH_3NH_2	CH_3SH
4	2	1	5	3

3) a. Draw all relevant resonance structures for compounds **A**-**D** shown below.

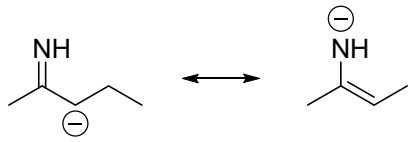
A



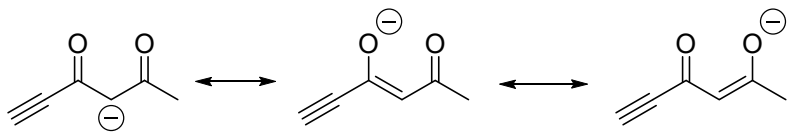
B



C



D



b. Indicate the hybridization of all nonhydrogen atoms in structure **D**.

C_1 _sp_ C_2 _sp_ C_3 _sp^2_ O_1 _sp^2_ C_4 _sp^2_ C_5 _sp^2_ O_2 _sp^2_ C_6 _sp^3_

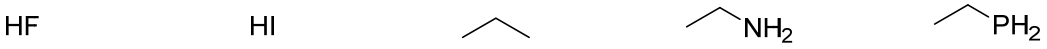
c. For structure **D**, indicate how many sigma and pi bonds are present.

σ __12___ π __4___

d. Rank the acidity of the conjugate of the indicated anions for compounds **A**-**D**. The conjugate that is the most acidic is 1, while the conjugate that is the least acidic is 4.

A	**B**	**C**	**D**
3	2	4	1

4) Rank by acidity. The most acidic compound is 1, while the least acidic compound is 5. (3 points each)



2	1	5	4	3

5) Consider the following Lewis dot structures (1-4) for a compound CHNO. Indicate the answer to the following questions on the line following the question. Answers could be one, two or none.

1 2 3 4

Which structures have a formal negative charge on carbon? __1_

Which structures have a formal negative charge on nitrogen? —none–

Which structures have a formal negative charge on oxygen? —2,4–

Which structures have a formal positive charge on carbon? —4–

Which structures have a formal positive charge on nitrogen? —1,2–

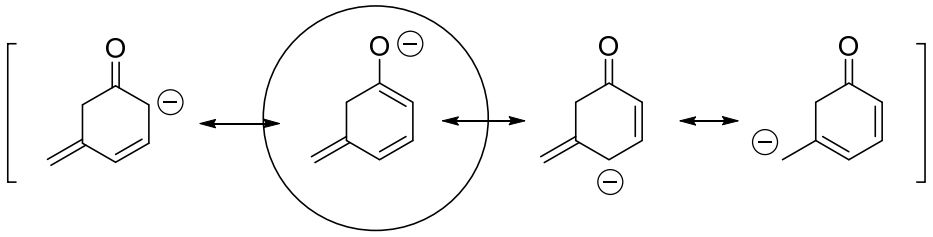
Which structures have a formal positive charge on oxygen? —none–

Which structure is the most stable? —2–

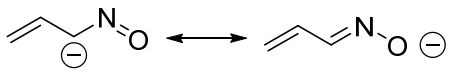
Which structure is the least likely? —3–

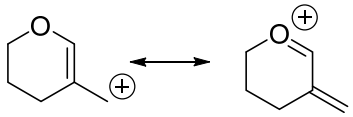
6) Draw all major resonance structures for the following anion. In addition, circle the resonance structure that is lowest in energy.

a.



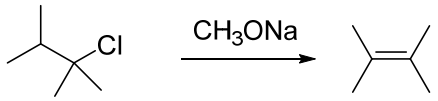
b. Draw the lowest energy resonance structure for the following compounds.



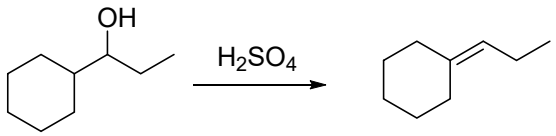


7) Draw the preferred product for the following reactions.

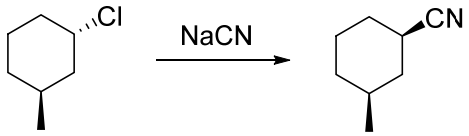
a.



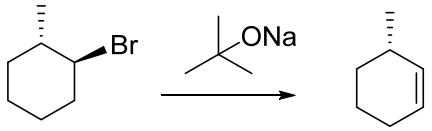
b.



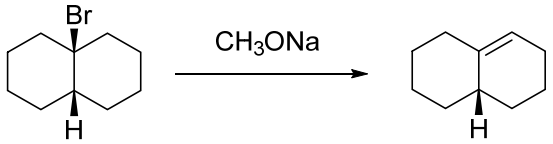
c.



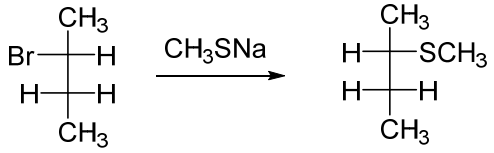
d.



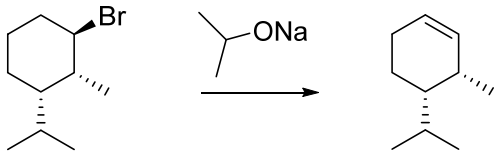
e.


Br
H
CH3ONa
H

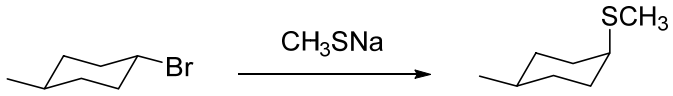
f.


CH3
Br
H
H
H
CH3
CH3SNa
CH3
H
SCH3
H
H
CH3

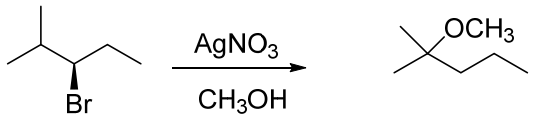
g.


Br
ONa

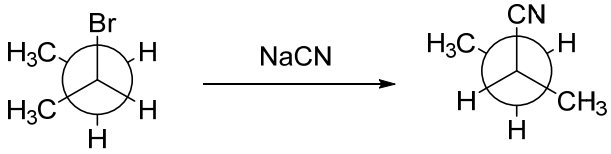
h.


Br
CH3SNa
SCH3

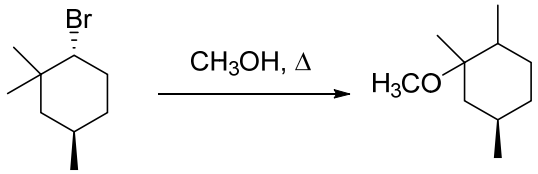
i.


Br
AgNO3
CH3OH
OCH3

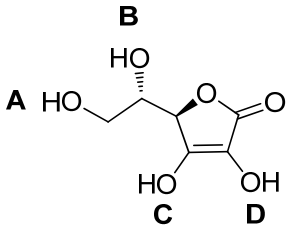
j.


Br
H3C
H
H3C
H
H
NaCN
CN
H3C
H
H
CH3
H

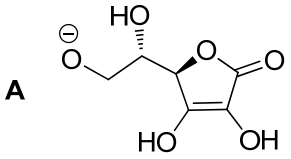
k.


Br
CH3OH, Δ
H3CO

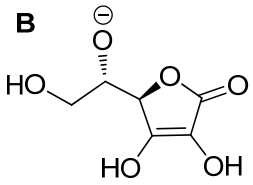
8) Ascorbic acid (shown below) has a pKa of 4.1 which is in the range of a carboxylic acid. Draw the structures of the conjugate bases obtained from the deprotonation of each hydroxyl group (A-D). Show the resonance structures for the conjugate bases for which electron delocalization can occur.



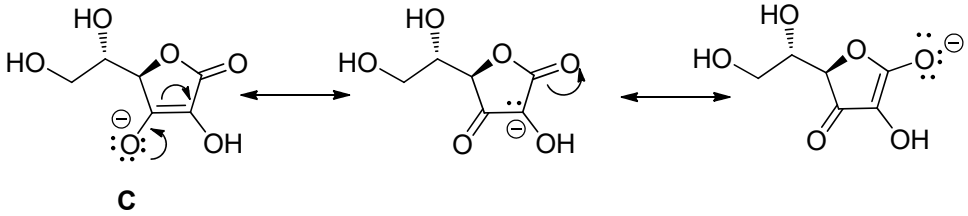
a. Conjugate base for deprotonation of A:



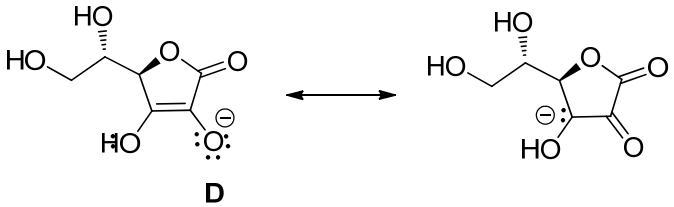
b. Conjugate base for deprotonation of B:



c. Conjugated base for deprotonation of C



d. Conjugated base for deprotonation of D:



e. Which of the four OH groups is the most acidic? Why is it similar in acidity to a carboxylic acid?

C is the most acidic. It is similar in acidity with carboxylic acids because the negative charge of the conjugated base is delocalized over two oxygen atoms.