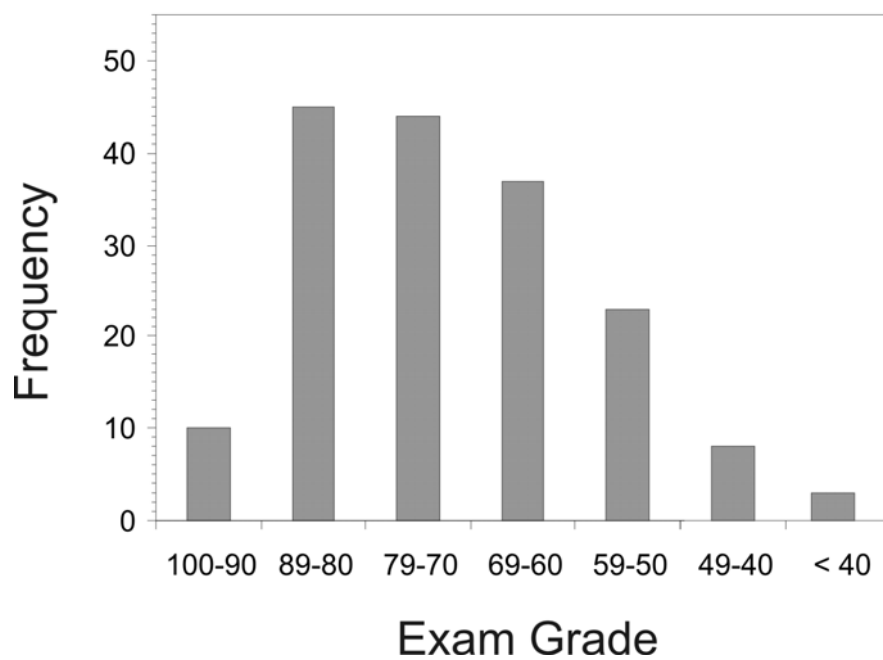


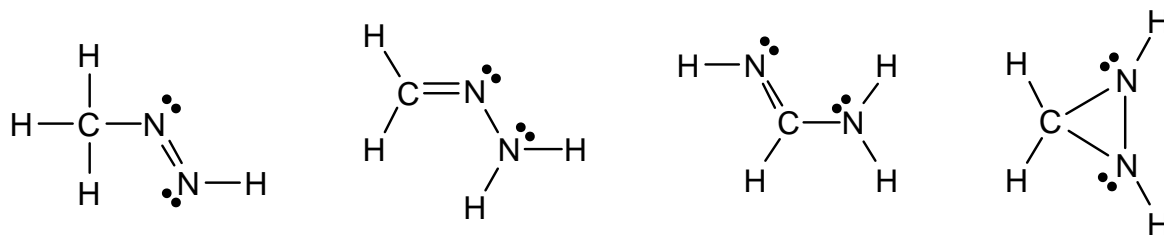
**Exam 1
Answer Key**

Exam 1 Mean: 72
Exam 1 Median: 73
Exam 1 St. Dev.: 14



1. (6 pts) **Draw Lewis dash-bond structures** for two constitutional isomers that have molecular formula CH_4N_2 , and that have **no formal charges** on any atom. Draw all atoms and lone pairs of electrons.

I think there were four possible answers to this question:



Rubric:

3 points each correct structure (x 2, total of 6).

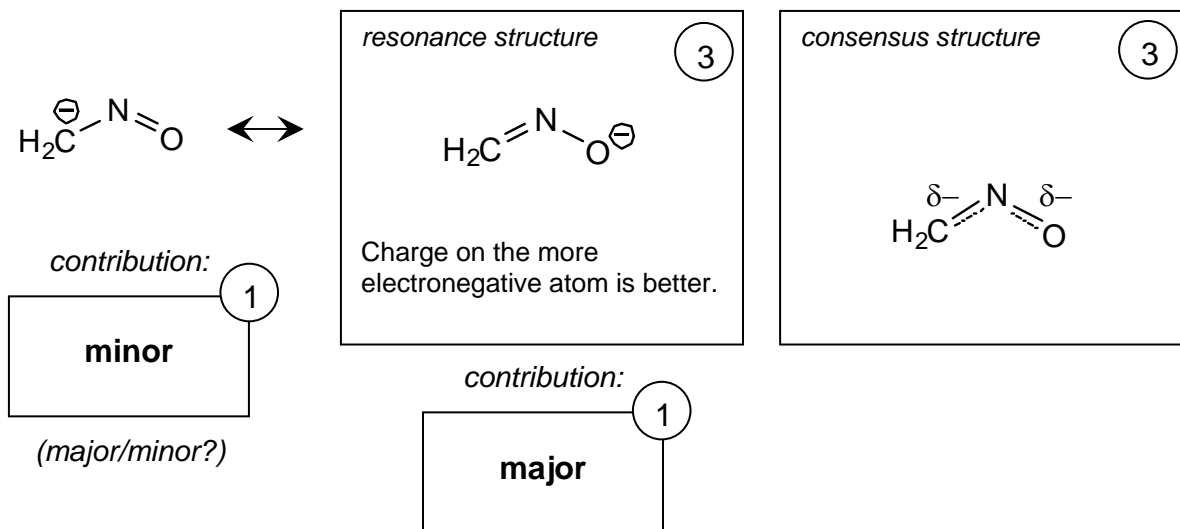
-1 point for each missing electron pair, dot, bond, or atom.

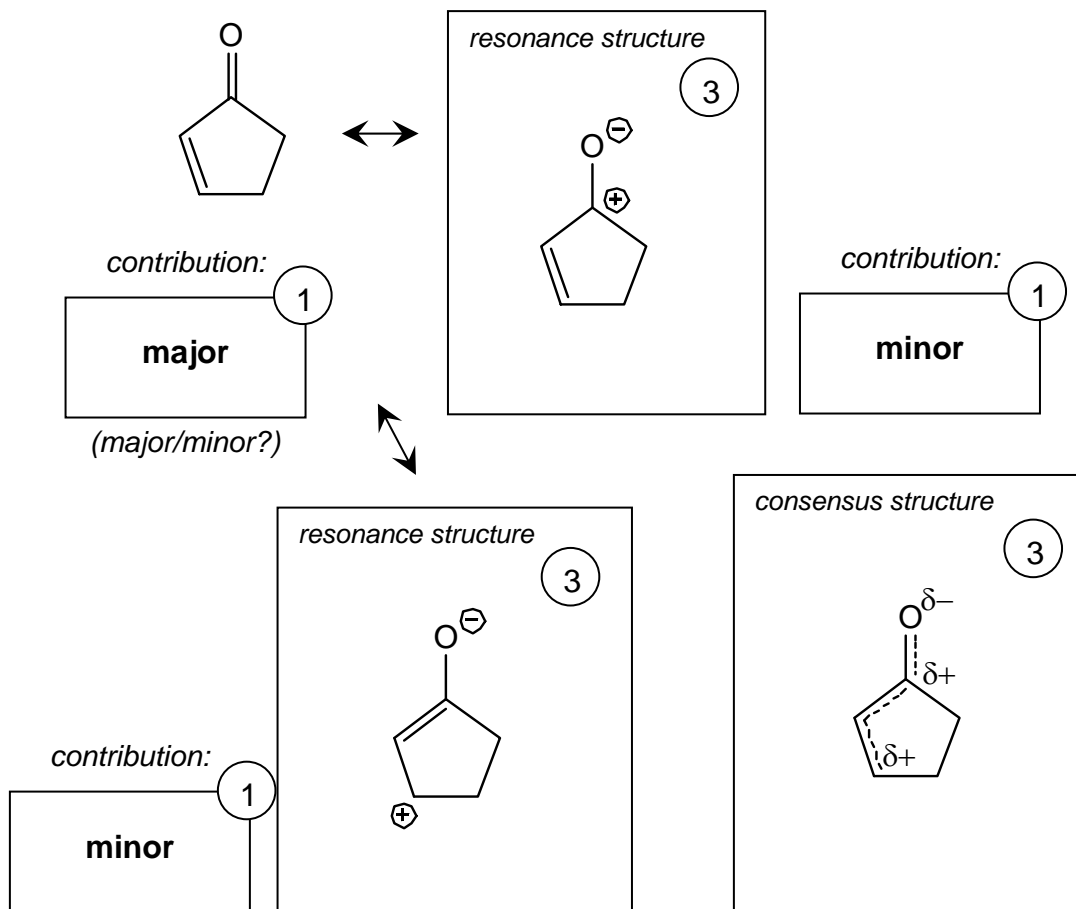
Structures that have formal charges, or that should have formal charges, receive no credit.

1 point partial for drawing a structure with incorrect molecular formula—any molecular formula—but otherwise completely correct (and with no formal charges).

If you drew same structure twice (e.g., as resonance structures), or you drew stereoisomers instead of constitutional isomers, we gave you credit for one but not the other.

2. (20 pts) For each of the molecules on the left, draw as many of the best Lewis dash-bond resonance structures as there are boxes to put them in. (Feel free to omit lone pairs and C-H's, or draw them—your choice.) Then, below each resonance structure, describe whether each would be a major or minor contributor. Finally, draw a resonance hybrid that illustrates partial charges and multiple bonds.





Rubric:

3 points for each structure.

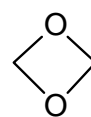
2 points for all charges correct and internally consistent.

1 point for all correct bond orders.

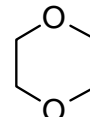
1 point for each contribution.

Just "major" and "minor" are enough. (No partial credit. Must have correct structure for point.)

3. (12 pts) This problem compares 1,3-dioxetane and 1,4-dioxane (shown at right).



1,3-dioxetane



1,4-dioxane

- a. *Angle strain* and *torsional strain* are both repulsive forces between pairs of electrons that make some cyclic molecules less stable than others. **Does 1,3-dioxetane show angle strain and/or torsional strain?** Circle your answers in the boxes below. Then, if you circled “YES” in either box, **illustrate the electron-pair repulsion** (the strain) on my skeleton structure **with a double-headed arrow**. You may have to add to my drawing in order to show the repelling electrons. (If you circled “NO”, leave the rest of that box blank.)

Angle strain: YES ¹ or NO ?

2

2 points for double-headed arrow connecting any adjacent pair of C-O bonds.
No partial credit.

Torsional strain: YES ¹ or NO ?

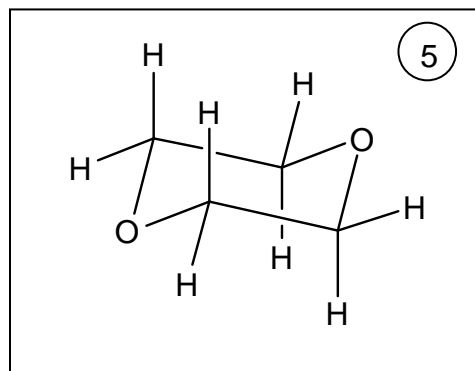
3

3 points for double-headed arrow connecting any C-H bond with an adjacent lone pair. Must draw the lone pair and C-H bond in to get these points.
No partial credit.

Angle strain is repulsion of two bonding pairs of electrons attached to the same ring atom, made worse by the fact that the bond angle is less than the optimal 109.5° .

Torsional strain is due to eclipsed interactions between electron pairs on adjacent carbons. Those interactions are often between two C-H bonds, but they can also be between bonding or non-bonding pairs of electrons on adjacent atoms.

- b. 1,4-Dioxane puckers from planarity in order to avoid angle and torsional strain. In the box on the right, draw the most stable conformation of 1,4-dioxane. In your drawing, **include all H atoms**, but feel free to omit lone pairs.



Rubric for part (b):

5 points total.

2 points partial for drawing a chair. Any chair. Must have three pairs of parallel lines.

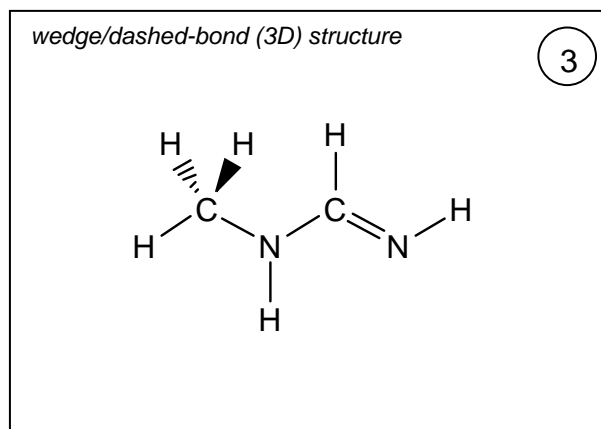
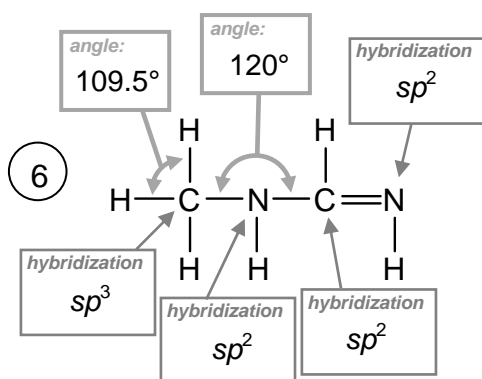
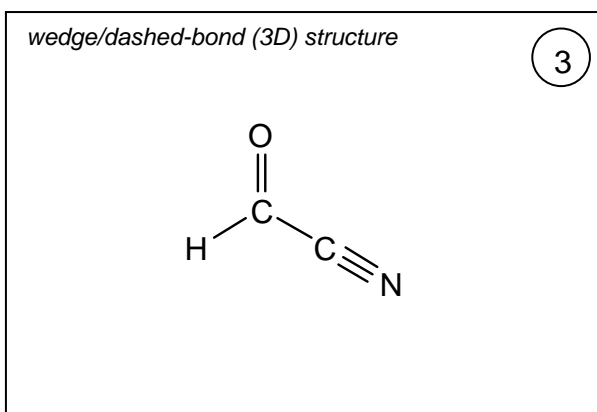
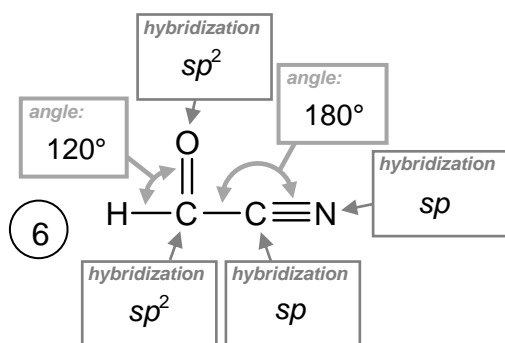
1 point for placing oxygen atoms at opposite positions on chair. I've drawn them on the "flap" positions (1,4), but they can be (2,5) or (3,6) as well.

1 point partial for drawing every axial hydrogen correctly.

1 point partial for drawing every equatorial hydrogen correctly. Each C-H bond must be parallel to a ring C-C bond.

4. (18 pts) For each of the Lewis structures drawn below, in the boxes provided:

- Draw Lewis wedge/dashed-bond structures that illustrate the most stable three-dimensional structure of the molecule. Draw all atoms, but feel free to omit lone pairs.
- In the boxes provided, write the hybridization state for any atom heavier than hydrogen.
- In the boxes provided, give any bond angle indicated by curved arrows in the original Lewis structure.



Rubric:

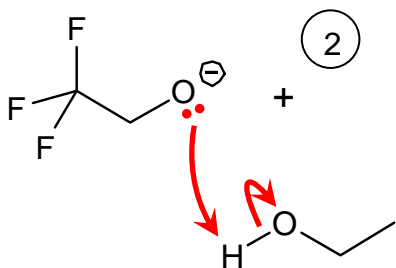
1 point for each bond angle and hybridization (12 total).

3 points for each 3-D structure (6 total).

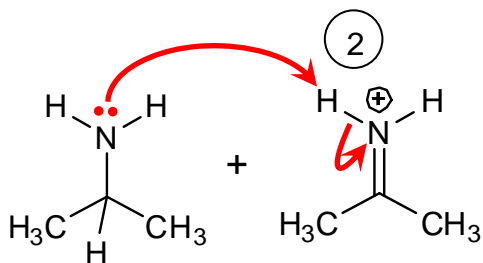
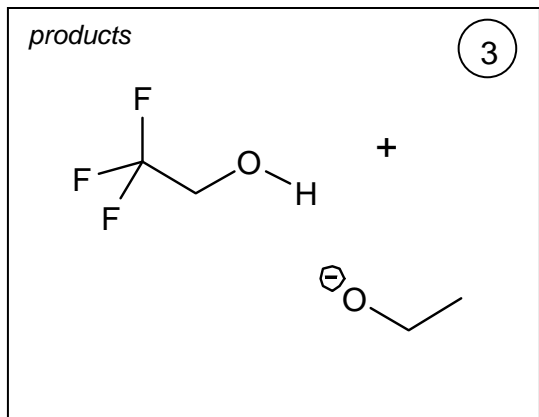
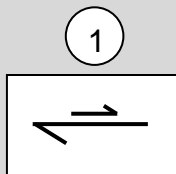
-1 for each incorrect center or bond rotation (up to 3).

5. (18 pts) For each of the sets of molecules below:

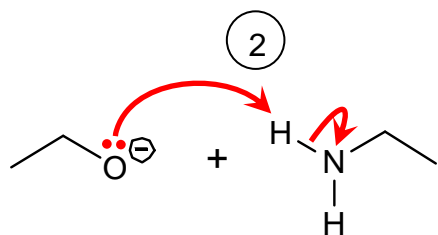
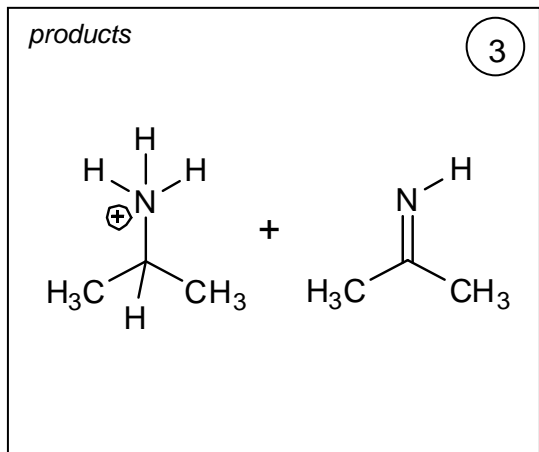
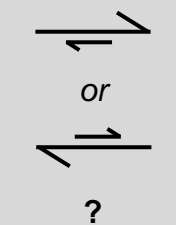
- Using “electron pushing” (with double-barbed arrows), show how the molecules on the left would react in an acid-base reaction to transfer a proton from one to the other.
- In the box on the right, draw the conjugate acid and base products of each reaction.
- In the middle, draw an equilibrium arrow that shows whether you feel the acid-base equilibrium would lie on the left or the right.



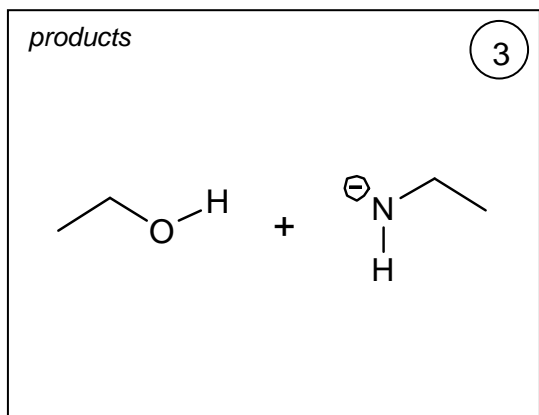
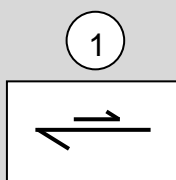
Starting anion is stabilized by inductive effect of electron-withdrawing fluorine groups, but product anion is not. Equilibrium favors starting anion.



Starting cation is stabilized by resonance; product cation is not. Equilibrium favors starting material.



O is more electronegative than N, so it's happier with the negative charge. Equilibrium pushed to the left.



Rubric: For each acid-base reaction,

2 points for electron pushing (one point each curved arrow).

1 point total for the set of 2 arrows if you drew the lines in the correct place, but arrow heads were incorrect.

You can start arrow from a lone pair or from a negative charge sign (if available).

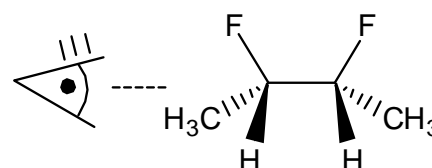
1 point for equilibrium arrow direction.

3 points for each set of products. Structures must be correct.

2 points partial for one of two products correct.

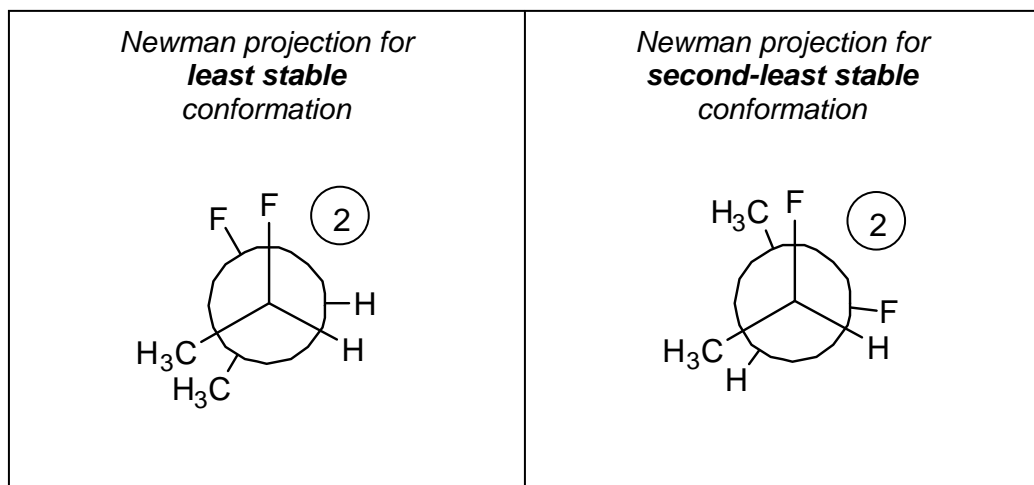
6. (20 pts)

- a. For the difluorobutane shown at right, in the boxes below, draw Newman projections that show the most stable, second-most stable, least stable, and second-least stable conformations of the molecule. Draw your projections looking down the central C-C bond, using the perspective I've shown in the drawing.



- b. Different conformations can contribute different polarities to the overall, average polarity of a molecule. For each of the two most stable conformations of the molecule above, circle whether the molecule is polar or non-polar when it is in that conformation. If you circle "POLAR", also draw one dipole arrow (\rightarrow) that shows the total dipole moment for that conformer.

| | |
|---|--|
| <p>Newman projection for most stable conformation</p> <p>(2)</p> | <p>Newman projection for second-most stable conformation</p> <p>(2)</p> |
| <p>POLAR or NON-POLAR ? (circle one) (2)</p> | <p>POLAR or NON-POLAR ? (circle one) (2)</p> |



Rubric:

2 points for each Newman projection.

-2 points, applied only once, if your Newman projections are mirror images of correct answers.

1 point partial for drawing any staggered projection for more stable, any eclipsed projection for less stable.

1 point partial for substituents in correct position.

2 points for each correct assignment of non-polar or polar.

You can still get these points if Newman projections are incorrect, as long as your answer matches the projection.

2 points for one dipole arrow on one polar stable conformation. (Maximum 2 points for this.)

c. Would you call the 2,3-difluorobutene shown at right a

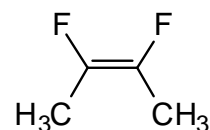
CONFIGURATIONAL ISOMER,

STEREOISOMER,

or

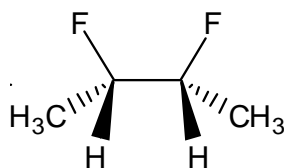
NEITHER

3

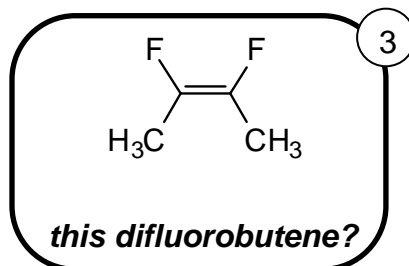


compared to the 2,3-difluorobutane on the previous page? (Circle one answer.)

d. Which is more polar:



this difluorobutane?



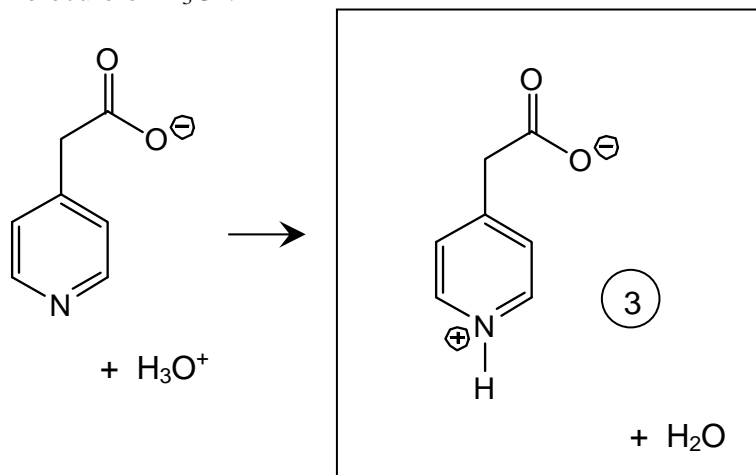
this difluorobutene?

**or are they
equally polar?**

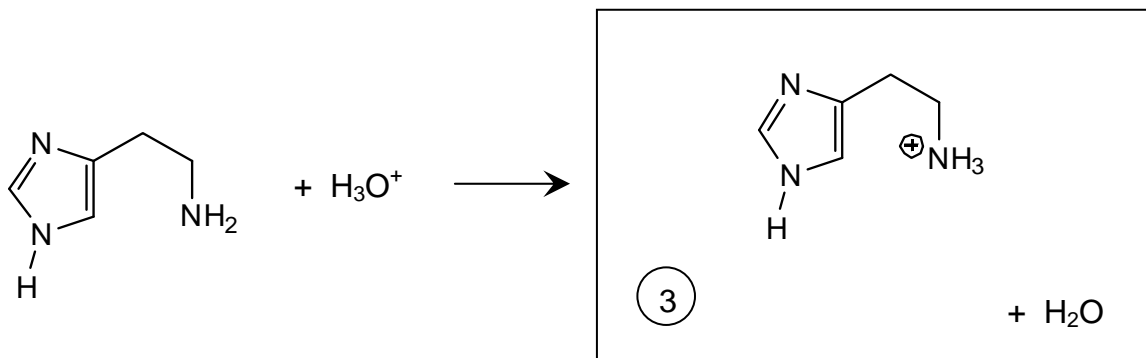
(Circle one answer.)

The C-F bond dipoles of difluorobutane are only sometimes in a polar conformation, whereas the bond dipoles of difluorobutene are always in a polar conformation. Difluorobutene is more polar.

7. (6 pts) Each of the basic molecules below has multiple potential protonation sites. Given the pKa values in the chart on the right, draw the organic product you would expect if each molecule was combined with just one molecule of H₃O⁺.



| | pK _a |
|--|-----------------|
| | 10.6 |
| | 7.0 |
| | 5.3 |
| | 4.7 |



Rubric:

3 points for each answer.

-1 point for attaching proton to correct site, but omitting charge.