

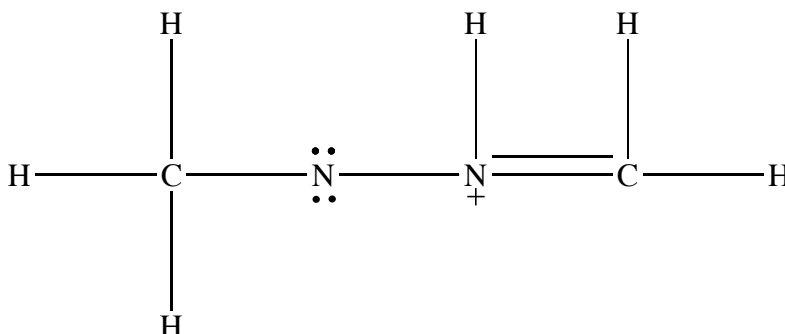
KEY

(1) (28 pts. total.) The compound below is a simple example of an azomethine imide. It has the formula  $C_2H_6N_2$ .

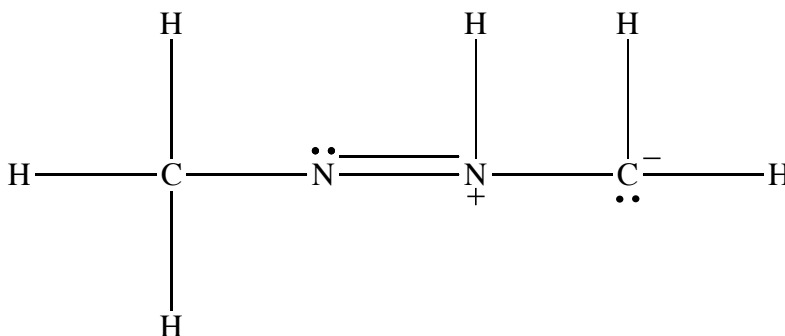
(a) (4 pts.) How many total valence electrons does the azomethine imide have?

$$2 \times 4 + 6 \times 1 + 2 \times 5 = 24$$

(b) (6 pts.) The  $\sigma$ -bond network (atom-to-atom connectivity) of the azomethine imide is sketched below. Fill in the remainder of electrons to draw the BEST resonance structure for the azomethine imide. Include all unshared pairs of electrons and any formal charges.



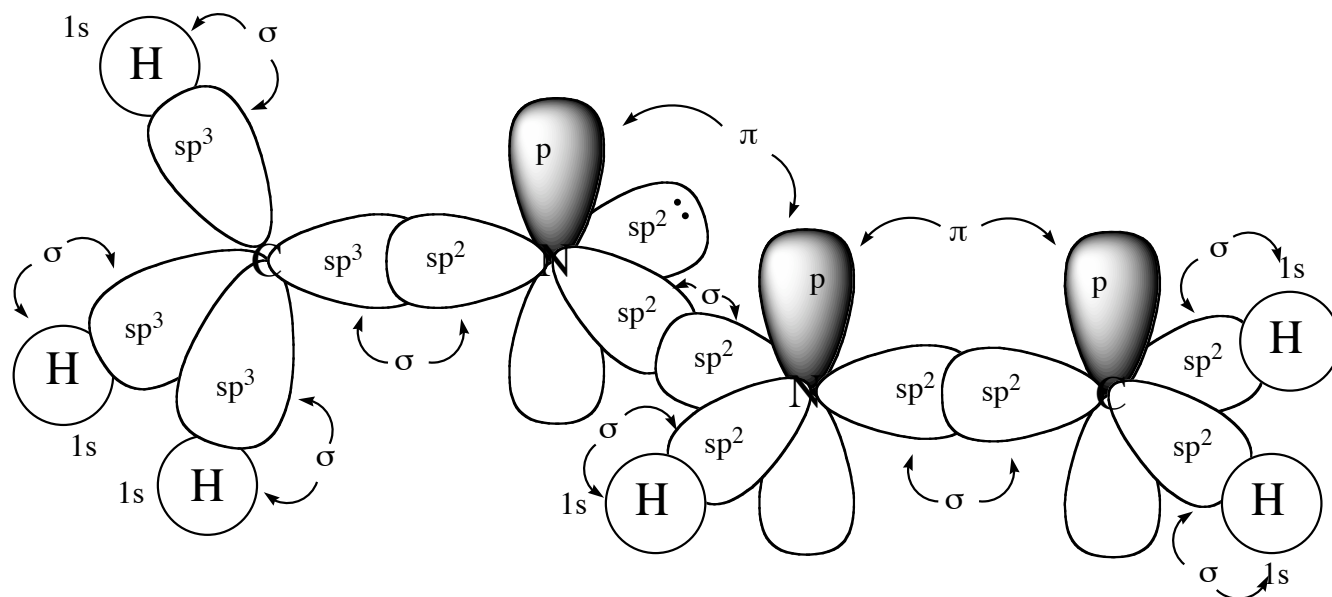
(c) (4 pts.) Draw the SECOND-BEST resonance structure for the azomethine imide. Include all unshared pairs of electrons and any formal charges.



(d) (8 pts.) Indicate the following values for each atom:

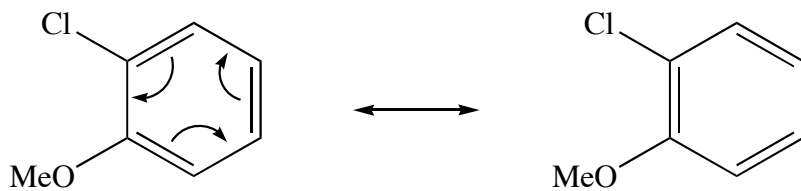
	Hybridization	Bond angles about
the C atom that bears three H's	$sp^3$	$109^\circ$
the N atom that bears no H's	$sp^2$	$120^\circ$
the N atom that bears one H	$sp^2$	$120^\circ$
the C atom that bears two H's	$sp^2$	$120^\circ$

(e) (6 pts.) Draw a diagram showing all of the atomic (hybrid and p) orbitals in the azomethine imide. Indicate which atomic orbitals overlap to form  $\sigma$  bonds, which ones overlap to form  $\pi$  bonds, and which ones hold unshared electrons. (Note: For sake of clarity, please don't draw the small back lobes [fishy tails] of the hybrid orbitals.) I've drawn in some of the orbitals to get you started.

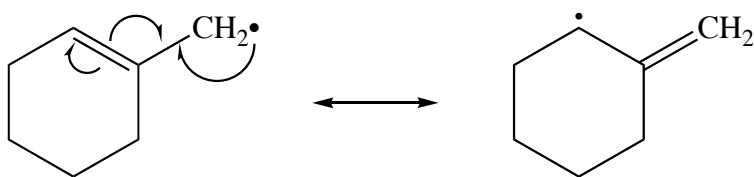


(2) (5 pts. each, 20 pts. total.) Draw the best resonance structure (other than the one that's shown) of each of the following compounds. Use the curved arrow formalism to show the movement of electrons.

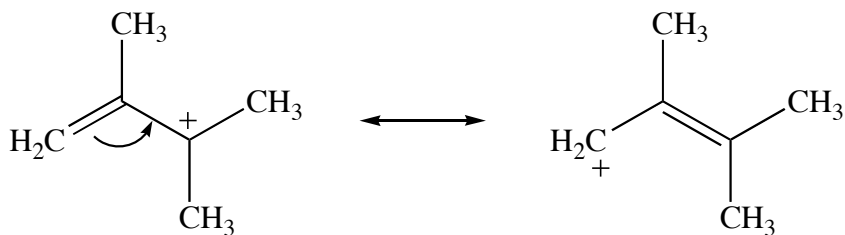
(a)



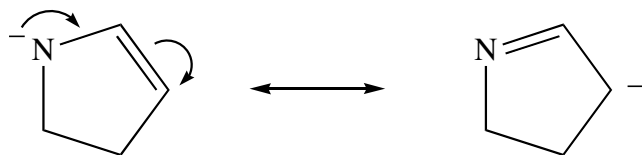
(b)



(c)

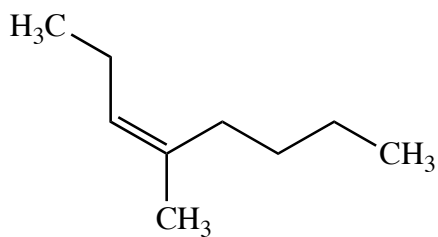


(d)



(3) (4 pts. each, 16 pts. total.)

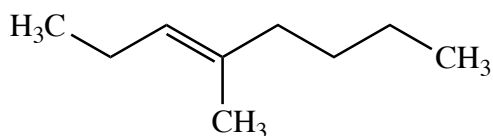
(a) Draw (Z)-4-methyl-3-octene.



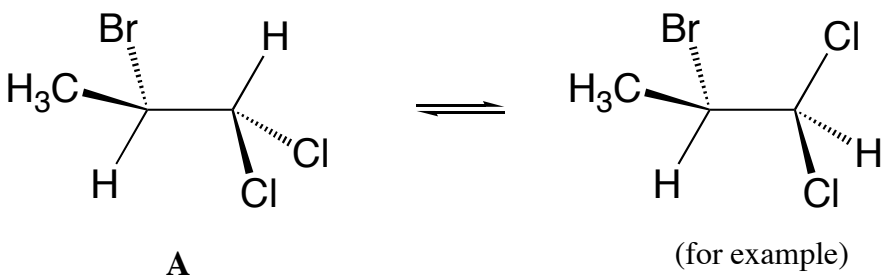
(b) Draw a *skeletal isomer* of the structure you drew in (a).

many answers possible; all must have  $C_9H_{18}$  and either one ring or one  $\pi$  bond.

(c) Draw a *configurational diastereomer* of the structure you drew in (a), or, if the structure does not have a configurational diastereomer, explain why not.

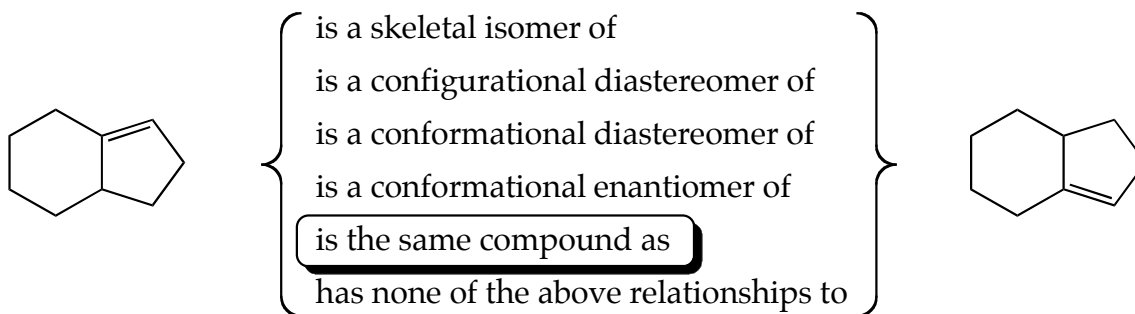


(d) Draw a *conformational stereoisomer* of structure A.

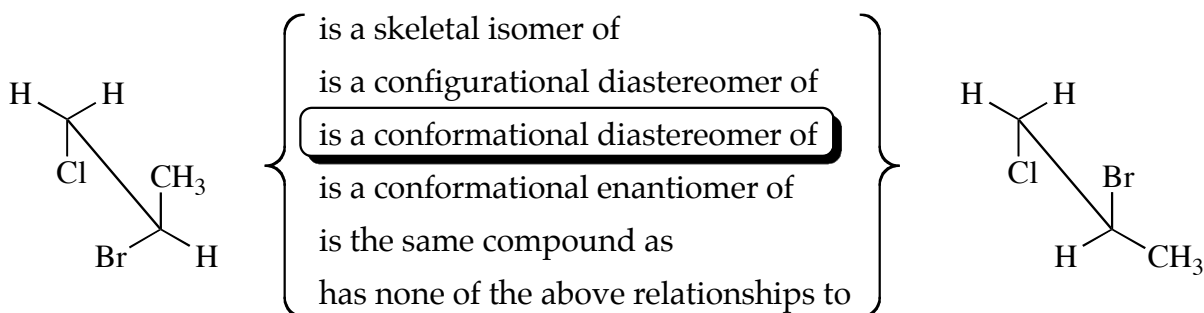


(4) (4 pts. each, 16 pts. total.) For each pair of compounds, indicate the relationship of the first compound to the second by circling the correct answer.

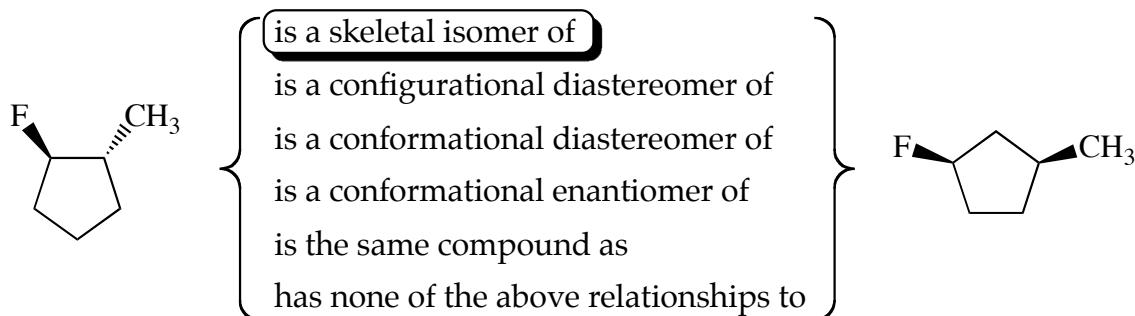
(a)



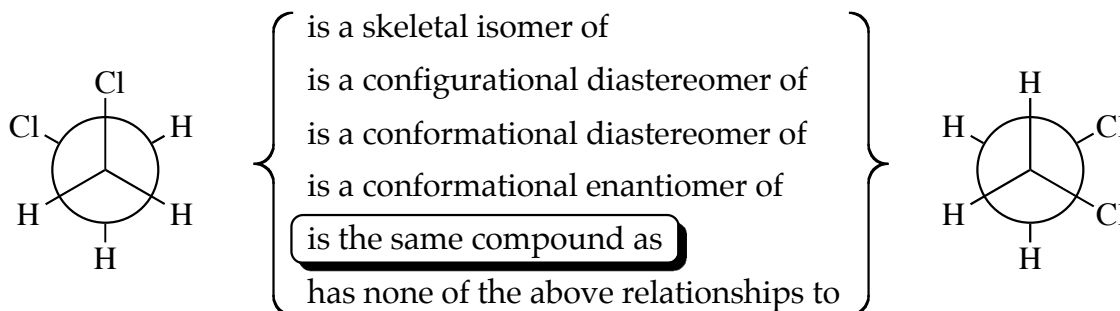
(b)



(c)

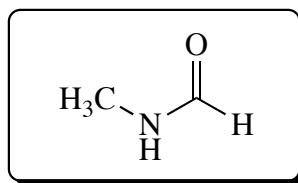
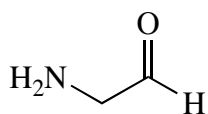


(d)



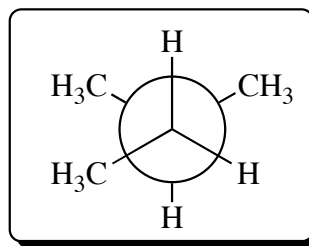
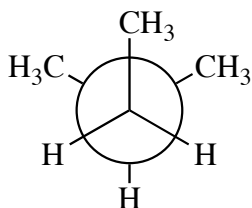
(5) (4 pts. each, 20 pts. total.)

(a) Circle the compound that is lower in energy, and explain your answer.



because one can draw a second resonance structure in which everyone has its octet. The more low-energy resonance structures, the lower in energy the compound.

(b) Circle the structure that is lower in energy, and explain your answer.



because the compound on the left has two gauche interactions, but the one on the right has only one.

(c) The reaction of  $\text{CH}_3\text{CH}_2^-$  with  $\text{H}^+$  to give  $\text{CH}_3\text{CH}_3$  is much stronger (more rapid, more exothermic) than the reaction of  $\text{HC}\equiv\text{C}^-$  with  $\text{H}^+$  to give  $\text{HC}\equiv\text{CH}$ . Explain why.

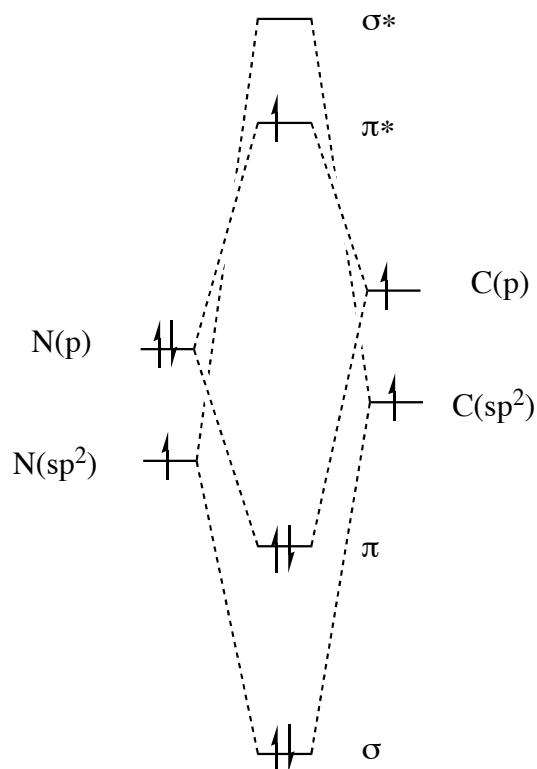
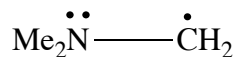
because the lone pair in  $\text{HC}\equiv\text{C}^-$  is in a lower-energy  $\text{sp}$  orbital, and the lone pair in  $\text{CH}_3\text{CH}_2^-$  is in a higher-energy  $\text{sp}^3$  orbital. The higher the energy of the lone pair, the more reactive the compound is.

(d) The carbocation on the left is a little *higher* in energy than the one on the right. The difference derived from the ability of the bonds indicated by the arrows to share their electrons with the positively charged C. Explain why the indicated bond in the compound on the right is able to share its electrons more easily than the indicated bond in the compound on the left.



because the bond on the left is made up of  $\text{C}(\text{sp}^3)$  and  $\text{C}(\text{sp}^2)$ , whereas the one on the right is made up of  $\text{C}(\text{sp}^3)$  and  $\text{C}(\text{sp}^3)$ , so the bond on the right is higher in energy, so it's more readily shared with the electron-deficient C atom by hyperconjugation.

(e) A C-based radical is lower in energy if it is adjacent to an atom that has a lone pair, as in the compound below. Use an orbital interaction diagram of the bonding between N and C in the compound below *and words* to explain why. I've started the diagram for you. Assume that both the lone pair on N and the unshared electron on C are in p orbitals.



When the filled N(p) orbital overlaps with the half-filled C(p) orbital, two electrons go down in energy into the  $\pi$  orbital, and one goes up in energy into the  $\pi^*$  orbital. The overall result is a decrease in energy.