Name: Key

1) True/False. Write "T" if the statement is true or "F" if the statement is false (16 pts).

a. T Water is a stronger Bronsted acid than isopropyl alcohol (pK_a 17).

b. T All Bronsted bases are Lewis bases.

c. F All Lewis acids are Bronsted acids.

d. F Intermolecular forces are stronger than most covalent bonds.

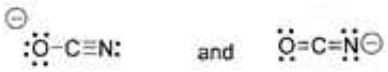
e. F Conformers can be separated from each other and isolated at room temperature.

f. F Resonance contributors can be separated from each other and isolated at room temperature.

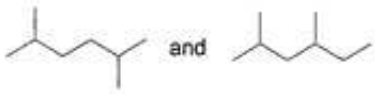
g. F A Bronsted conjugate acid-base pair differs by one electron.

h. F The more potential energy a molecule has, the more stable it is.

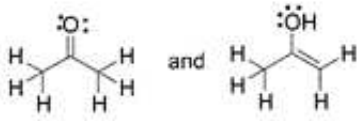
2) Indicate whether each of the following pairs of molecules are isomers, resonance structures, or conformers. (9 pts)



resonance structures



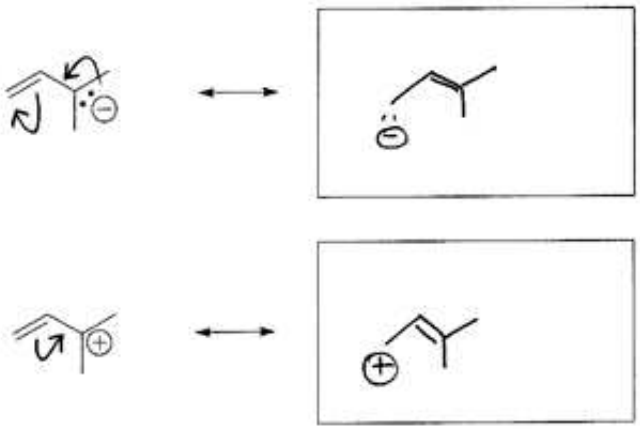
isomers



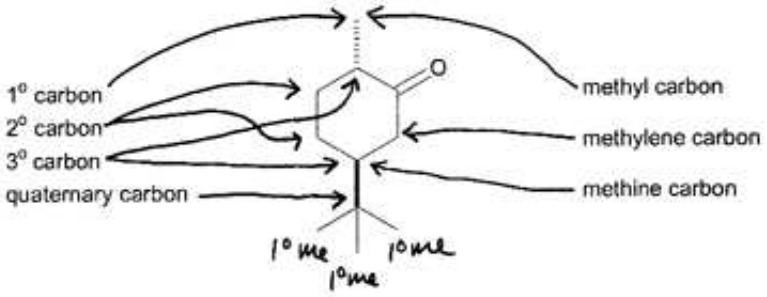
isomers

Name:_____

3) For each of these structures, draw one other stable resonance structure. Use curved arrow notation to show the flow of electrons, and include all electrons and all non-zero formal charges in your resonance structures (10 pts).

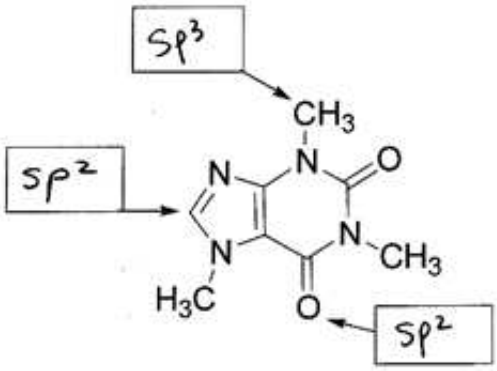


4) Draw an arrow to one of each kind of carbon in the molecule below (7 pts)

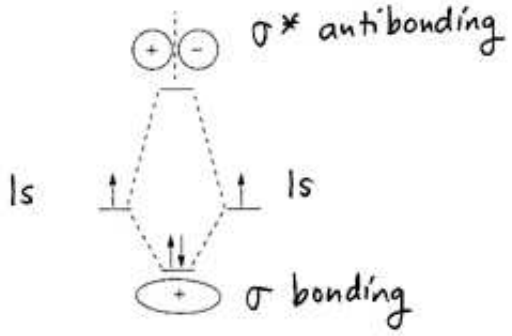


Name:_____

5) This is the structure of caffeine, a compound essential to life. What is the hybridization of each of the indicated atoms in the structure as drawn? *Hint: Not all lone pairs are shown!* (9 pts)



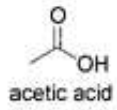
6) Below is a molecular orbital diagram for H_2. Clearly label the H_2 σ molecular orbital, the H_2 σ* molecular orbital, and all atomic orbitals shown in the diagram. Indicate which MO is bonding and which is antibonding (6 pts).



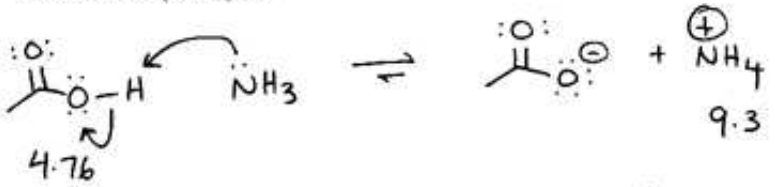
Name:_____

7a) Draw an arrow pushing mechanism for the reaction of ammonia, NH_3, with acetic acid. Show all lone pairs and non-zero formal charges. Indicate which side of the reaction is favored at equilibrium and briefly explain why (no more than two sentences!). (7 pts)

Some pK_a values:
acetic acid 4.76
ammonia 36
ammonium (NH_4^+) 9.3

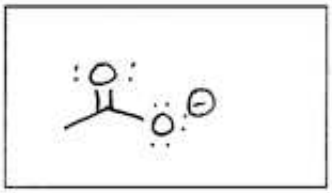


acetic acid



Right side favored – weaker acid

7b) Draw the conjugate base of acetic acid (2 pts). (Its name is "acetate".)

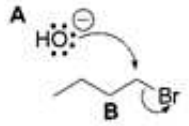


7c) Which is a stronger base, acetate or ammonia? (3 pts)

ammonia

Name:_____

8) Below is the reaction of molecule **A** (hydroxide) with molecule **B** (bromobutane).



8a) Is molecule **A** acting as a nucleophile or as an electrophile? (2 pts)

nucleophile

Explain your answer in one or two sentences (2 pts):

Has electron density available for reaction with $\delta+$ or $+$

8b) Is molecule **B** acting as a nucleophile or as an electrophile? (2 pts)

electrophile

Explain your answer in one or two sentences (2 pts):

Seeking e^- density to interact with its $\delta+$ ($\overset{+}{C}-Br$)

8c) Electrons always attack empty orbitals. What is the empty orbital being attacked in the reaction shown above? (2 pts)

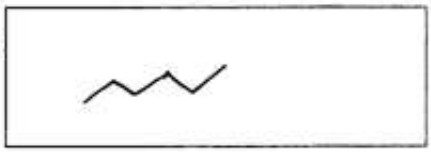
Your choices are:

C-H σ	C-C σ	C-C σ*	O-H σ	O-H σ*
O sp^3	O sp^2	C-H σ*	Br sp^3	Br sp^2
C-Br σ	C-Br σ*	C-Br π	C-Br π*	None of these

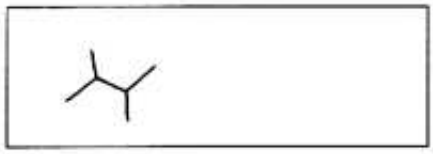
Write your answer here: C-Br σ*

Name:_____

9a) Draw a bond-line formula of *n*-hexane (2 pts).



9b) Now draw a bond-line formula of 2,3-dimethylbutane (2 pts).

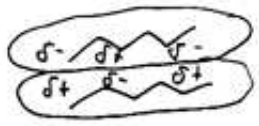


9c) Which alkane has the higher boiling point, hexane or 2,3-dimethylbutane? (1 pt)

hexane

9d) Provide a concise explanation for your answer to 10c. Your explanation should include a description of the specific forces involved in keeping the higher boiling alkane in the liquid phase, as well as the name of this type of force. Draw pictures to help you explain. (4 pts)

Both are alkanes and only have dispersion forces,* no other intermolecular forces. These forces arise from transient fluctuations in the electron clouds comprising the C-C and C-H bonds. When one alkane molecule contacts another, this transient dipole can induce a transient dipole in a second alkane molecule.



Hexane's elongated shape gives it more surface area and ∴ more points of contact for dispersion forces, vs.

More spherical shape – less points of contact

More IM forces to break ⇒ Higher bp

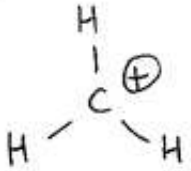
* Induced-dipole - Induced-dipole

Name: _____

10) In class and in your text, you've seen orbital pictures showing various hybridization schemes of carbon and other atoms.

Consider a chemical species called *methyl cation*, CH_3^+, and answer the following questions.

10a) Draw a Lewis structure for the cation. Be sure to include the formal charge on the appropriate atom. (2 pts)



10b) Each of the covalent C-H bonds in methyl cation is formed by the "overlap" of a/n sp^2 orbital on carbon with a/n s orbital on hydrogen. (2 pts)

Choices are: s p sp sp^2 sp^3 σ σ* π π*

10c) What is the H-C-H bond angle in methyl cation? (2 pts) 120°

10d) Is the cation a Lewis acid or a Lewis base (circle one)? (2 pts)

Lewis acid **Lewis base**

10e) Explain your answer to 10d in ONE SENTENCE. Your answer should refer to a *specific* orbital for full credit. (4 pts)

It can accept electron density in an empty p orbital