# CHEM 3311 (Richardson) First Hour Exam – Sep. 26, 2017

Your Name: _____

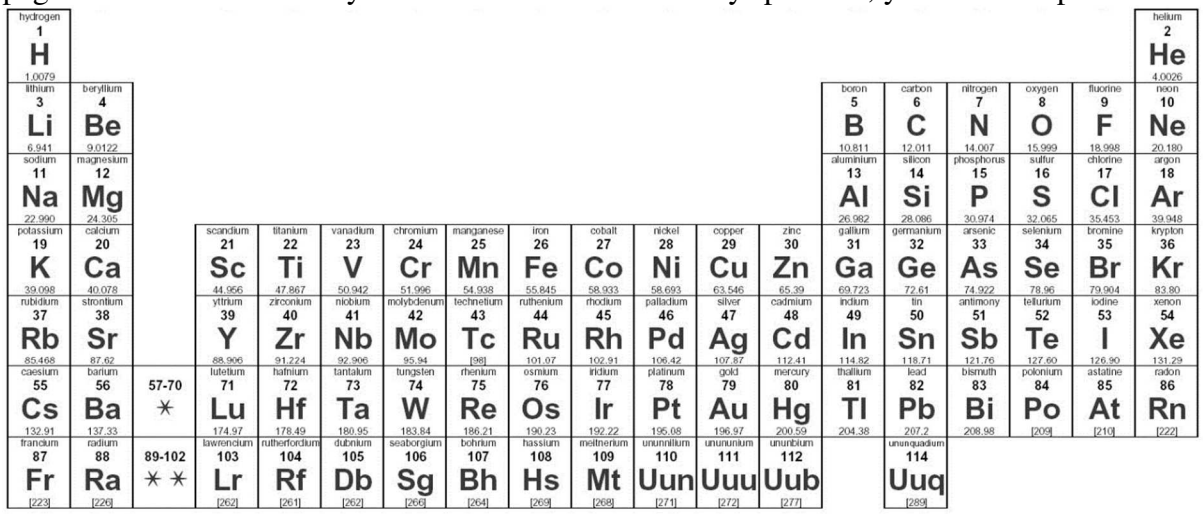
Student ID: _____

Recitation (check one)

O 8:00 Tue (Rachel Weintraub)
O 2:00 Tue (Zhenhao Chen)
O 3:00 Wed (Rachel Weintraub)
O 12:00 Thu (Patrick Li)
O 2:00 Fri (Rachel Weintraub)
O 1:00 Mon (Zhenhao Chen)
O 11:00 Tue (Patrick Li)
O 1:00 Wed (Zepeng Lei)
O 9:00 Thu (Rachel Weintraub)
O 3:00 Thu (Zepeng Lei)
O 3:00 Fri (Rachel Weintraub)

| Question | Score | Out of |
|---|---|---|
| 1 | | 18 |
| 2 | | 12 |
| 3 | | 10 |
| 4 | | 20 |
| 5 | | 16 |
| 6 | | 6 |
| 7 | | 18 |
| Total | | |

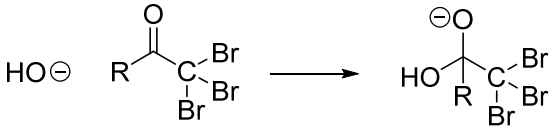
This is a closed-book exam. The use of notes, calculators, or cell phones will not be allowed during the exam. You may use models sets brought in a clear ziplock bag. Use the backs of the pages for scratch work. If your final answer is not clearly specified, you will lose points.

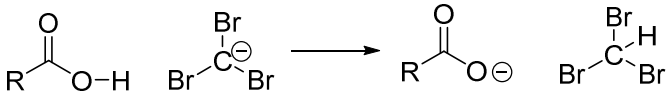


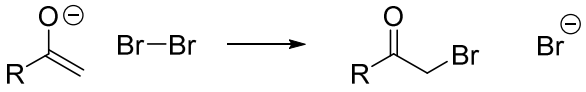

## pKa Values

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HI | -10 | $CH_3COOH$ | 4.7 | ArOH | 10 | $H_2$ | 35 |
| HBr | -8 | $HN_3$ | 4.7 | RSH | 10-12 | $NH_3$ | 36 |
| HCl | -6 | $H_2S$ | 7.0 | $H_2O$ | 15.7 | $H_2C{=}CH_2$ | 45 |
| $H_3O^+$ | -1.7 | $NH_4^+$ | 9.3 | ROH (R=alkyl) | 16-18 | $CH_4$ | 60 |
| HF | 3.2 | HCN | 9.4 | HC≡CH | 26 | | |

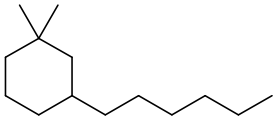
1) For the following reactions, complete these steps: (18 pts total)
   - add arrows to show the movement of electrons (2 pts per problem)
   - classify each species as either an acid, base, nucleophile, or electrophile (2 pts per problem). Please use the labels "nucleophile" and "electrophile" only for things that are NOT acting as acids/bases.
   - identify the HOMO and LUMO for each reaction (2 pts per problem). Hint for c: the HOMO is the orbital that directly attacks the other molecule.

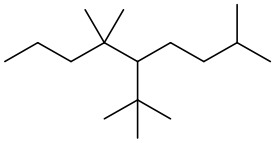
a. 

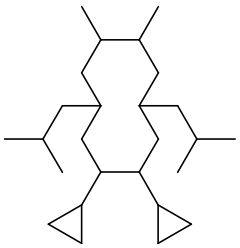

b. 

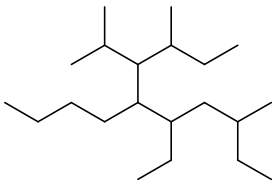

c. 

2) Give the IUPAC names for the following structures. (12 pts total)

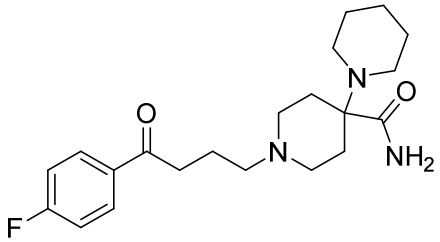
a. 

c. 

b. 

d. 

3) Pipamperone, shown below, is an antipsychotic used for the treatment of schizophrenia. Which of the listed functional groups does pipamperone contain? Circle all that apply. (10 pts)




| | | | | |
|---|---|---|---|---|
| Alcohol | Aldehyde | Alkene | Amide | Amine |
| Aromatic ring | Ester | Ether | Alkyl/aryl halide | Ketone |

4) Lewis structure and Molecular Orbitals (20 pts total)
   a. Draw a Lewis structure for acetylene, $C_2H_2$. (4 pts)

   b. What is the hybridization of each carbon atom in this structure? (2 pts)

   c. How many σ and how many π bonds are there between the two carbon atoms? (2 pts)

   d. Generate an MO diagram for the C-C triple bond in acetylene, given that any π orbitals will be at the same energy level as each other. Ignore the atomic orbitals and electrons used for bonding to hydrogen atoms, and do not show 1s orbitals. (10 pts)

   e. What is the bond order between the two carbons, according to the MO diagram? (2 pts)

5) Cyclopentadiene, shown below, is surprisingly acidic for an organic compound. It loses a proton very easily from its $sp^3$-hybridized carbon. (16 pts total)

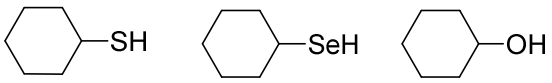
a. Draw the conjugate base of cyclopentadiene. (2 pts)

b. Show all the major resonance forms of the conjugate base (starting with the structure you drew for part a.), using arrow-pushing to move from one form to the next. (8 pts)

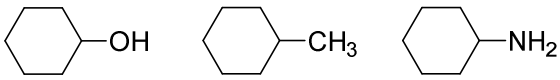
c. What is the average charge on each carbon atom? (3 pts)

d. What is the average C-C bond order? (3 pts)

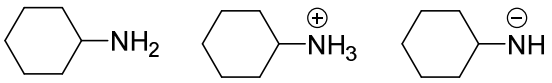
6) For each set of compounds shown below, rank them by acidity (1=highest pKa, 3 = lowest pKa) and explain your reasoning in twenty words or less per explanation. (6 pts)

a. 

Reason:

b. 

Reason:

c. 

Reason:

7) Draw the structure of 2-methylpentane. Sighting along the bond between carbon 2 and carbon 3 (as numbered by IUPAC), show a Newman projection for the molecule's conformations for dihedral angles in increments of 60°. **Keep the front atom stationary and rotate the back atom clockwise**. For each conformation, plot these energy levels and create a conformational energy diagram. You do not need to calculate the exact energy for each level – a rough estimate is acceptable, so long as the relative ordering of levels is correct. If the energy of a particular interaction is not shown in this table, assume it is zero. (18 pts)

| Interaction | Energy (kcal/mol) |
|---|---|
| H/H eclipsed | 1 |
| Me/H eclipsed | 1.15 |
| Et/H eclipsed | 1.25 |
| Me/Me eclipsed | 3.6 |
| Me/Et eclipsed | 3.9 |
| Me/Me gauche | 0.67 |
| Me/Et gauche | 0.75 |