# CHEM 3311 (Richardson) First Exam – Sep. 25, 2018

Your Name: Key

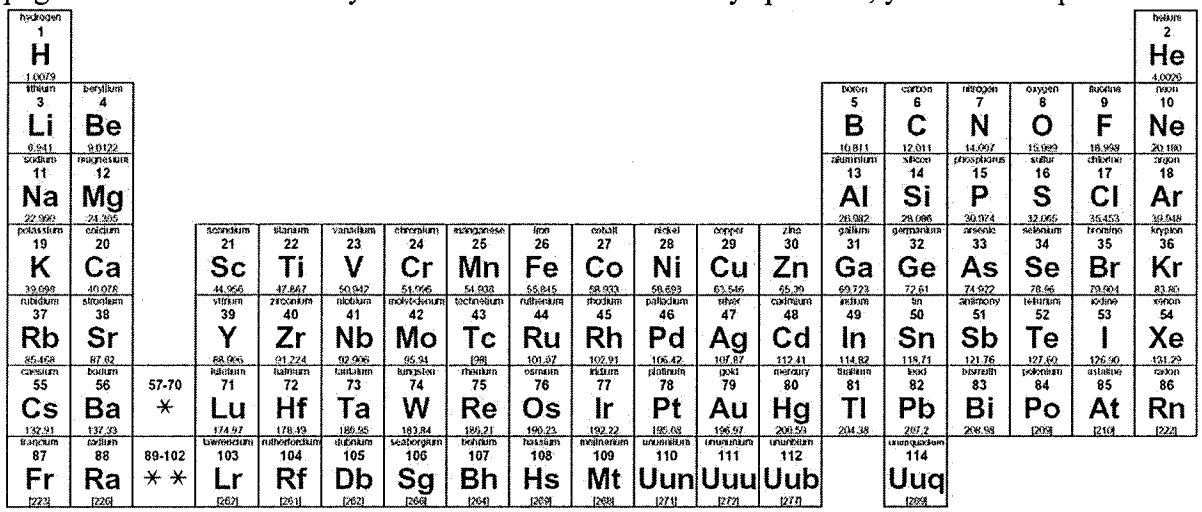
Student ID: _____

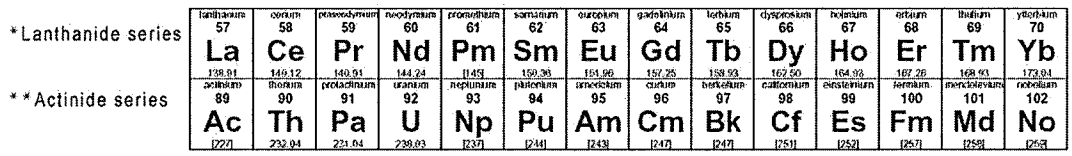
Recitation (check one)

O 11:00 Mon (Matthew Farmer)
O 2:00 Mon (Shaofeng Huang)
O 9:00 Tue (Lacey Wayment)
O 12:00 Tue (Josh Kamps)
O 3:00 Tue (Lauren Bodkin)
O 10:00 Mon (Shafer Soars)
O 1:00 Mon (Lacey Wayment)
O 3:00 Mon (Shaofeng Huang)
O 10:00 Tue (Josh Kamps)
O 2:00 Tue (Lauren Bodkin)
O 4:00 Tue (Matthew Farmer)

| Question | Score | Out of |
|---|---|---|
| 1 | | 12 |
| 2 | | 16 |
| 3 | | 24 |
| 4 | | 18 |
| 5 | | 12 |
| 6 | | 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.



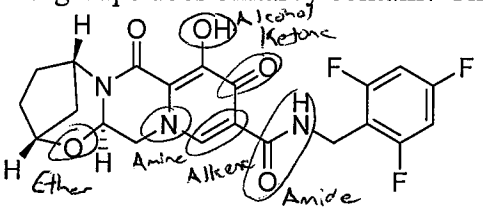




## pKa Values

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HI | -10 | $CH_3COOH$ | 4.7 | ArOH | 10 | HC≡CH | 26 |
| HBr | -8 | $HN_3$ | 4.7 | RSH | 10-12 | $H_2$ | 35 |
| HCl | -6 | $H_2S$ | 7.0 | $H_2O$ | 15.7 | $NH_3$ | 36 |
| $H_3O^+$ | -1.7 | $NH_4^+$ | 9.3 | ROH (R=alkyl) | 16-18 | $H_2C{=}CH_2$ | 45 |
| HF | 3.2 | HCN | 9.4 | O=C-CH (α H) | 9-25 | $CH_4$ | 60 |

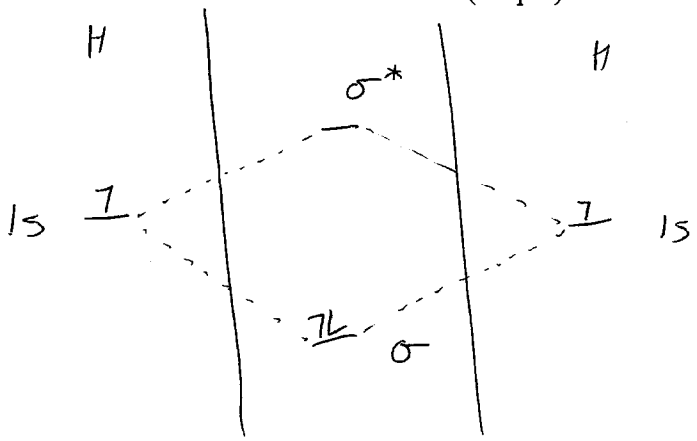
Average: 74.8
St. Dev: 16.1
Max: 98
Min: 7

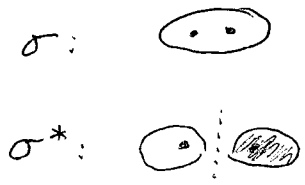
1) Biktarvy, shown below, is a new drug that is being investigated for the treatment of HIV. Which of the listed functional groups does biktarvy contain? Circle all that apply. (12 pts)



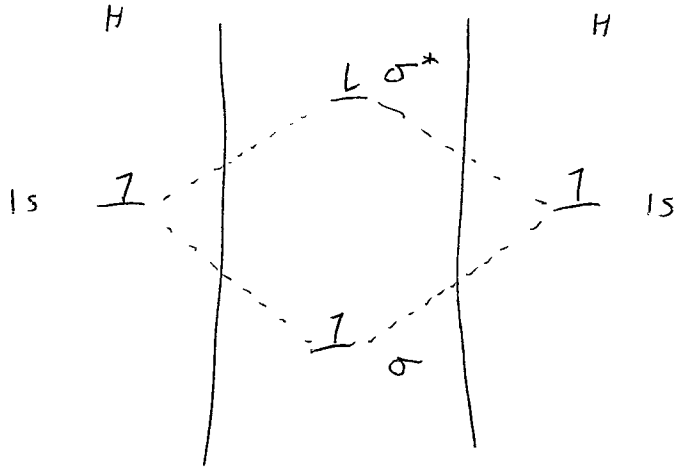

| Alcohol | Aldehyde | Alkene | Amide | Amine |
|---|---|---|---|---|
| Acid anhydride | Carboxylic acid | Ester | Ether | Ketone |

2) Molecular Orbital Diagrams (16 pts total)
   a. Draw an MO diagram for a molecule of hydrogen gas, $H_2$. Also draw the shapes of all MOs in this molecule. (10 pts)



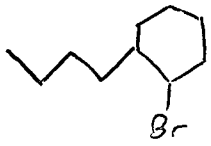

   b. When the hydrogen molecule absorbs a photon of light, an electron can jump from the bonding MO to the antibonding MO. Draw the MO diagram after this happens, and explain why this leads to the breaking of the bond between hydrogen atoms in 30 words or less. (6 pts)




Bond order is (1-1)/2 = 0, so no bond exists now.

3) The following compounds were named incorrectly. Complete these steps for each one: (24 pts total)
   - Draw the skeletal structure (2 pts per problem)
   - Write the correct IUPAC name (4 pts per problem)
   - Write the degrees of unsaturation (2 pts per problem)

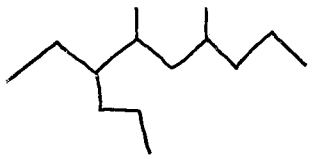
a. 1-(2-bromocyclohexyl)butane




1-bromo-2-butylcyclohexane

1 deg. unsat.

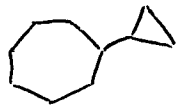
b. 4,6-dimethyl-3-propylnonane



4-ethyl-5,7-dimethyldecane

0 deg. unsat

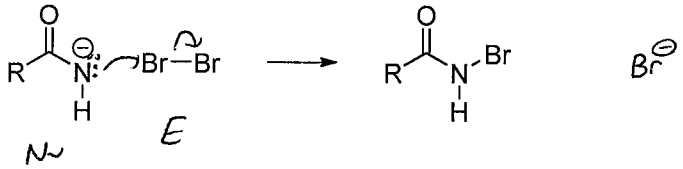
c. 1-cycloheptyl-cyclopropane



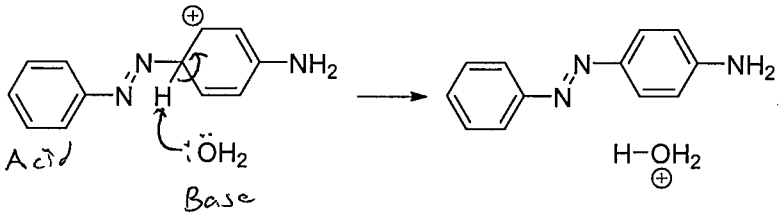
Cyclopropylcycloheptane

2 deg. unsat.

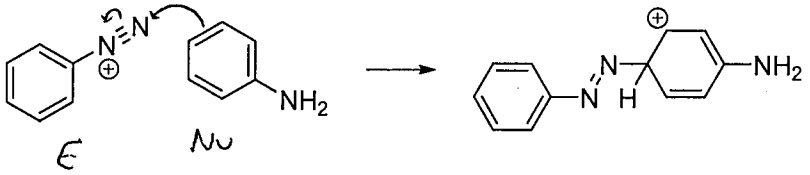
4) For the following reactions, complete these steps: (18 pts total)
   - add arrows to show the movement of electrons (2 pts per problem)
   - classify each species as either an acid, base, nucleophile, or electrophile (2 pts per problem). Please use the labels "nucleophile" and "electrophile" only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

a. 


HOMO: LP on N
LUMO: Br-Br $\sigma^*$

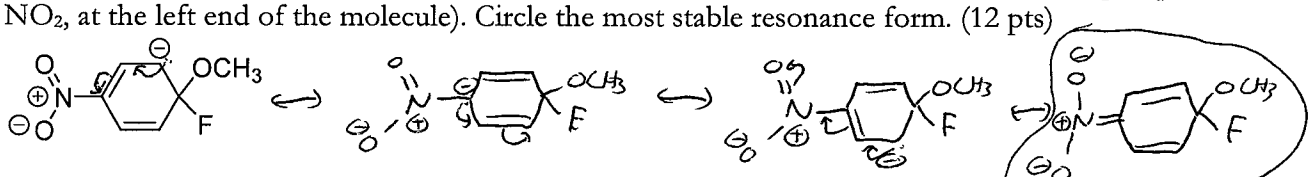
b. 


HOMO: LP on O
LUMO: H-C $\sigma^*$

c. 


HOMO: C=C $\pi$
LUMO: N=N $\pi^*$

5) Draw all reasonable resonance forms for this molecule, including valid arrow-pushing to convert each form into the next. (Ignore any forms where the **only** difference is within the nitro group, $NO_2$, at the left end of the molecule). Circle the most stable resonance form. (12 pts)

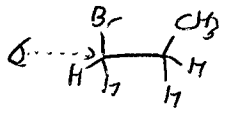


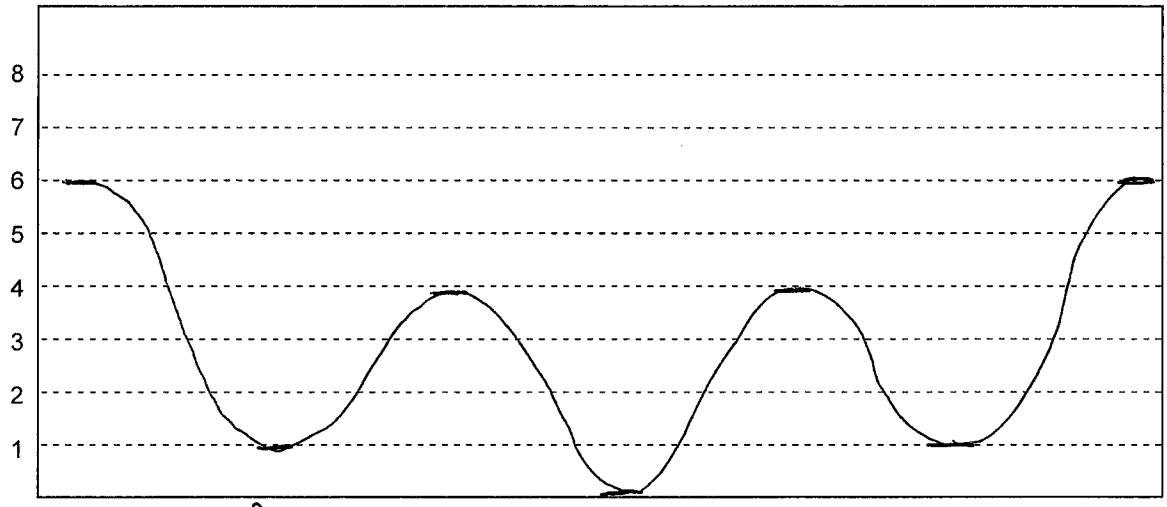

Most stable

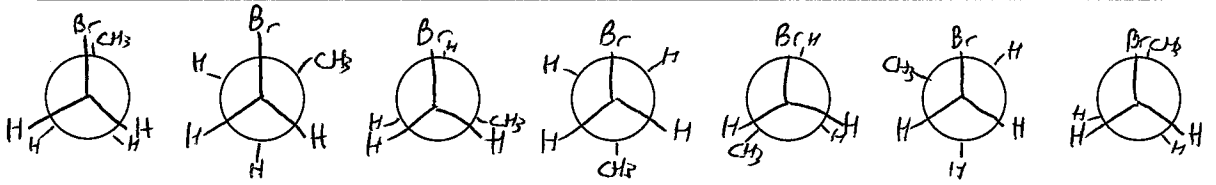
(⊖ on O, not C)

6) Draw the structure of 1-bromopropane. Sighting along the bond between carbon 1 and carbon 2 (as numbered by IUPAC), show a Newman projection for the molecule's conformations for dihedral angles in increments of 60°, starting with both the bromine and carbon 3 pointed directly up. **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. (18 pts)

| Interaction | Energy (kcal/mol) |
|---|---|
| H/H eclipsed | 1 |
| Me/H eclipsed | 1.15 |
| Br/H eclipsed | 1.75 |
| Br/Me eclipsed | 4 |
| Me/Br gauche | 1 |



| Interactions: | Interactions: | Interactions: | Interactions: | Interactions: | Interactions: | Interactions: |
|---|---|---|---|---|---|---|
| Br - Me eclipsed<br>2x H-H eclipsed | Br-Me gauche | Br-H eclips.<br>Me-H eclips.<br>H-H eclips. | – | Br-H eclip.<br>Me-H eclip.<br>H-H eclip. | Br-Me gauche | Br-Me eclip.<br>2 x H-H eclipsed |
| 6 kcal/mol | 1 | 3.9 | 0 | 3.9 | 1 | 6 |