NAME _____

ID # _____

ORGANIC CHEMISTRY I (2301)

9:05 – 9:55 am, October 8, 2014

Exam 1

If you want to pick this exam up on Friday in class (in public), please check the box on the right: ☐

If you do not check the box, I will not bring your exam to class on Thursday, and you will need to pick up your exam in private from Chemistry department staff in 115 Smith beginning Friday, October 10th at noon. Exams that are not picked up within two weeks will be disposed of.

A periodic table is attached to the back of this exam as an aid. Otherwise, you are not permitted to use any other materials (including notes, books, or electronic devices of any kind).

Right now, write your name and student ID number at the top of this page. When the exam begins, please write your name at the top of the next page.

You may use pen or pencil. However, re-grades will be considered only for exams completed in pen.

Please write your answers in the boxes/spaces provided. If your answer is not in the appropriate space (say, for example, it's on the back of the page), draw us an arrow and/or note telling us where to look.

NAME _____

Scoring: 1. _____ / 6 5. _____ / 18

2. _____ / 18 6. _____ / 20

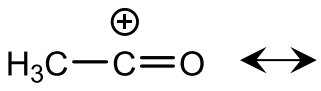
3. _____ / 14 7. _____ / 6

4. _____ / 18

Total Score: _____ / 100

1. (6 pts) **Draw Lewis dash-bond structures** for two constitutional isomers that have molecular formula **C_2H_3NO**, and that have **no formal charges** on any atom. Draw all atoms and lone pairs of electrons.

2. (18 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.



contribution:

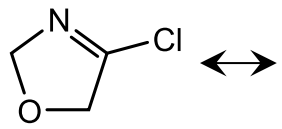
(major/minor?)

resonance structure

contribution:

(major/minor?)

resonance hybrid



resonance structure

resonance structure

contribution:

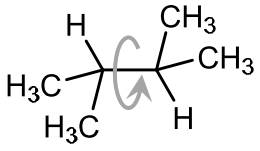
(major/minor?)

contribution:

contribution:

resonance hybrid

3. (14 pts) 2,3-Dimethylbutane (molecule **1**, shown at right) is free to rotate about its central C-C bond.

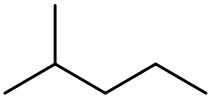


1

a. In the boxes below, draw Newman projections that illustrate the most stable, second-most stable, and least stable conformations of **1** with respect to rotation about the central C-C bond.

Newman projection for ***most stable*** *conformation*	*Newman projection for* ***second-most stable*** *conformation*	*Newman projection for* ***least stable*** *conformation*

b. Molecules **2** and **3** are isomers of **1**; like **1**, they have chemical formula C_6H_{14}.



2

3

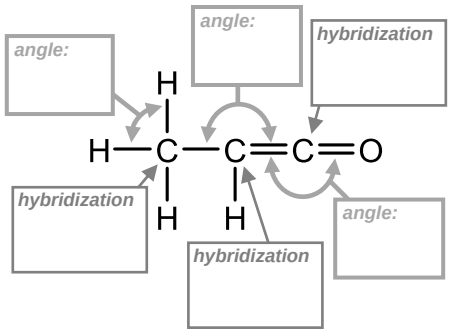
Are molecules **1**, **2**, and **3** **CONFIGURATIONAL ISOMERS**

or **STEREOISOMERS** ? *(Circle one.)*

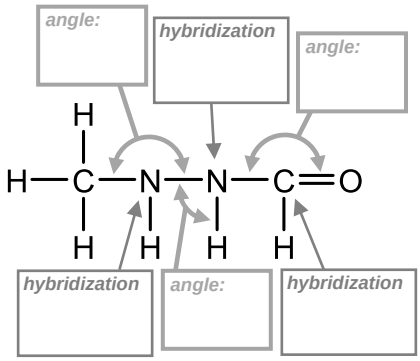
c. Each of the isomers **1-3** has its own heat of combustion (ΔH_c^0), which is the amount of energy given off when the molecule is burned to CO_2 and H_2O. Combustion is always exothermic, so ΔH_c^0 is always negative. In the boxes below, rank the molecules (**1-3**) in terms of their heats of combustion, from most exothermic to least exothermic.

most exothermic (most negative ΔH_c^0)				least exothermic (least negative ΔH_c^0)

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.

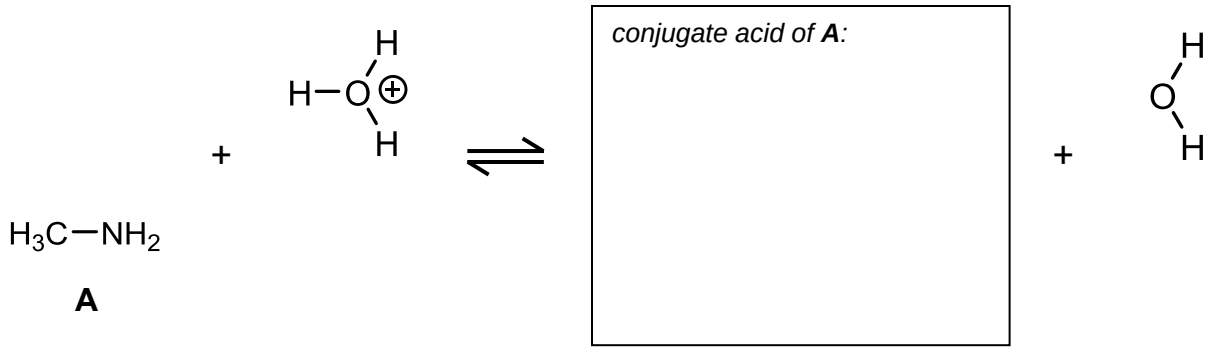


wedge/dashed-bond (3D) structure



wedge/dashed-bond (3D) structure

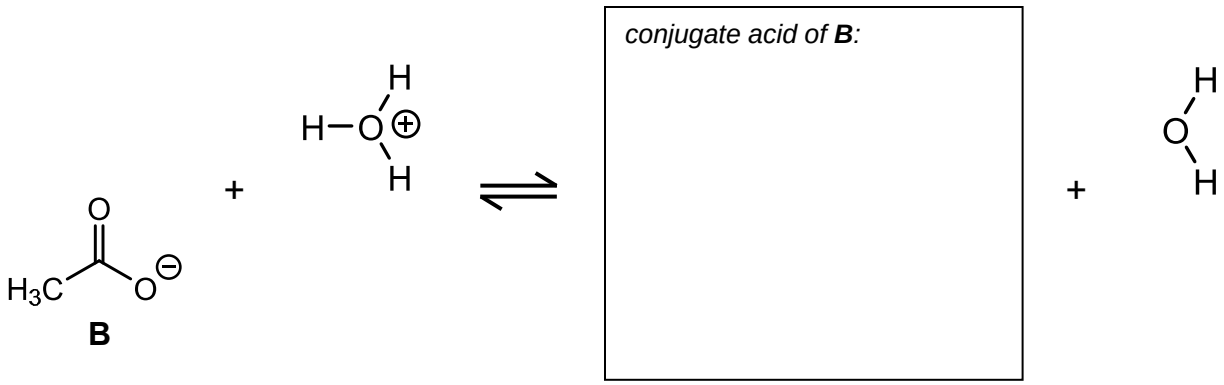
5. (18 pts) Molecules **A** and **B** below are both bases.
   - Using "electron pushing" (with double-barbed arrows), show how each base would be protonated in an acid-base reaction.
   - In the box on the right, draw the conjugate acid formed from each base.
   - Below each reaction, compare the basicity of **A**/**B** with other bases by circling the appropriate answer.



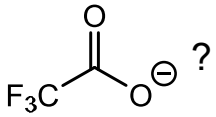
A

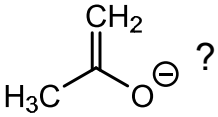
Is **A** **MORE BASIC** *or* **LESS BASIC** than H_3C-PH_2 ?

Is **A** **MORE BASIC** *or* **LESS BASIC** than H_3C-OH ?

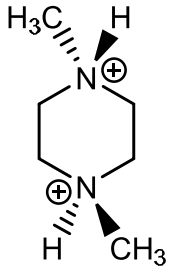


B

Is **B** **MORE BASIC** *or* **LESS BASIC** than  ?

Is **B** **MORE BASIC** *or* **LESS BASIC** than  ?

6. (20 pts) The di-cation molecule **4** exists in two equilibrating chair conformations.



4

a. In the boxes below, draw the less stable chair conformer of molecule **4** on the left, and the more stable one on the right. **Draw every hydrogen attached to the six-membered ring.**

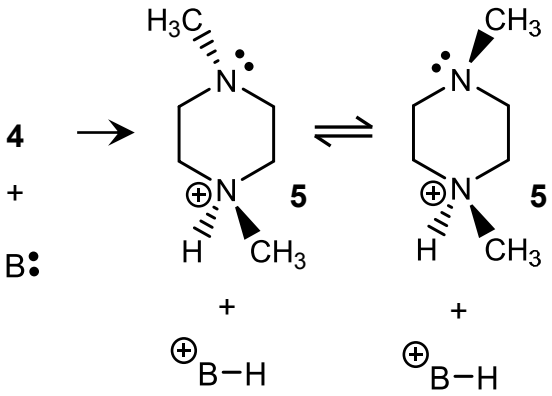
b. In one of the two conformers, the molecule experiences de-stabilizing 1,3-diaxial (steric) interactions. **Illustrate one of these interactions with a double-headed arrow** on the appropriate conformer.

.

less*-stable chair conformation of **4***	***more****-stable chair conformation of **4***

c. Are the methyl groups in **4** oriented ***cis-*** or ***trans-*** ? (Circle one.)

d. When molecule **4** is exposed to enough base to remove just one proton, the result is cation **5**, in which one of the methyl groups is free to switch faces: The most stable conformation of **5** is actually not a chair, but a <u>boat</u>. Draw the most stable boat conformation of **5** in the box below. Feel free to omit H atoms attached to carbon.

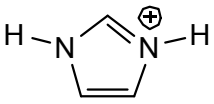
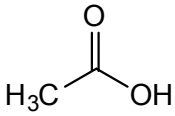


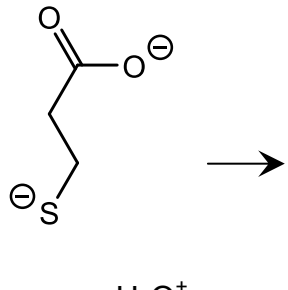
*most stable boat conformation of **5***

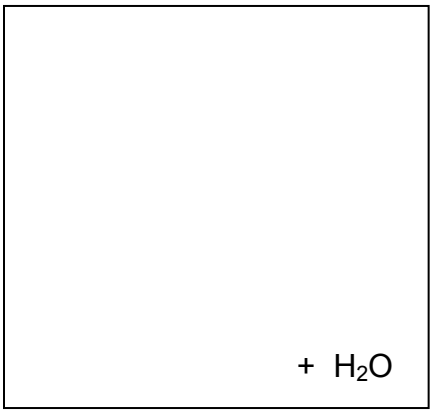
e. The boat conformation of **5** is stabilized by a hydrogen bond. **Illustrate that hydrogen bond with a double-headed arrow** in your drawing on the previous page.

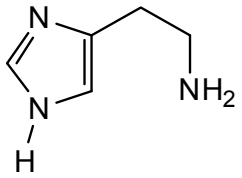
f. Both molecules **4** and **5** have 2 C-C bonds; each of these bonds is associated with a σ bonding orbital and a σ* anti-bonding orbital. What do these orbitals look like? In the space on the right, illustrate these two molecular orbitals with lobes, and shade in those lobes according to their phase.

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 <u>one</u> molecule of H_3O^+. Make sure your equation is balanced.

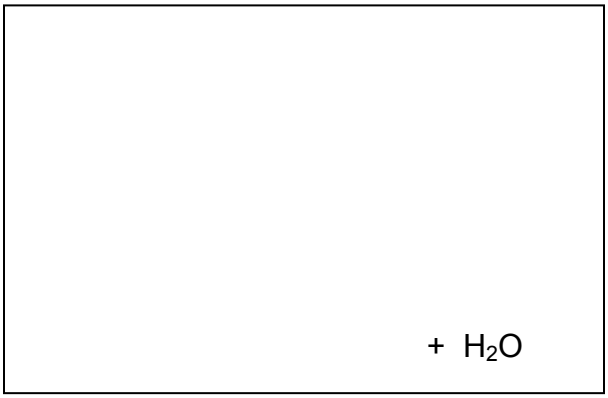
	pK_a
$H_3C-\overset{\oplus}{N}H_3$	10.6
H_3C-SH	10.6
	7.0
	4.7







+ H_3O^+ ⟶



Periodic Table of the Elements

Chemistry Reference Sheet

California Standards Test

	1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1	1 **H** Hydrogen 1.01	2 2A																2 **He** Helium 4.00
2	3 **Li** Lithium 6.94	4 **Be** Beryllium 9.01											5 **B** Boron 10.81	6 **C** Carbon 12.01	7 **N** Nitrogen 14.01	8 **O** Oxygen 16.00	9 **F** Fluorine 19.00	10 **Ne** Neon 20.18
3	11 **Na** Sodium 22.99	12 **Mg** Magnesium 24.31	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 **Al** Aluminum 26.98	14 **Si** Silicon 28.09	15 **P** Phosphorus 30.97	16 **S** Sulfur 32.07	17 **Cl** Chlorine 35.45	18 **Ar** Argon 39.95
4	19 **K** Potassium 39.10	20 **Ca** Calcium 40.08	21 **Sc** Scandium 44.96	22 **Ti** Titanium 47.87	23 **V** Vanadium 50.94	24 **Cr** Chromium 52.00	25 **Mn** Manganese 54.94	26 **Fe** Iron 55.85	27 **Co** Cobalt 58.93	28 **Ni** Nickel 58.69	29 **Cu** Copper 63.55	30 **Zn** Zinc 65.39	31 **Ga** Gallium 69.72	32 **Ge** Germanium 72.61	33 **As** Arsenic 74.92	34 **Se** Selenium 78.96	35 **Br** Bromine 79.90	36 **Kr** Krypton 83.80
5	37 **Rb** Rubidium 85.47	38 **Sr** Strontium 87.62	39 **Y** Yttrium 88.91	40 **Zr** Zirconium 91.22	41 **Nb** Niobium 92.91	42 **Mo** Molybdenum 95.94	43 **Tc** Technetium (98)	44 **Ru** Ruthenium 101.07	45 **Rh** Rhodium 102.91	46 **Pd** Palladium 106.42	47 **Ag** Silver 107.87	48 **Cd** Cadmium 112.41	49 **In** Indium 114.82	50 **Sn** Tin 118.71	51 **Sb** Antimony 121.76	52 **Te** Tellurium 127.60	53 **I** Iodine 126.90	54 **Xe** Xenon 131.29
6	55 **Cs** Cesium 132.91	56 **Ba** Barium 137.33	57 **La** Lanthanum 138.91	72 **Hf** Hafnium 178.49	73 **Ta** Tantalum 180.95	74 **W** Tungsten 183.84	75 **Re** Rhenium 186.21	76 **Os** Osmium 190.23	77 **Ir** Iridium 192.22	78 **Pt** Platinum 195.08	79 **Au** Gold 196.97	80 **Hg** Mercury 200.59	81 **Tl** Thallium 204.38	82 **Pb** Lead 207.2	83 **Bi** Bismuth 208.98	84 **Po** Polonium (209)	85 **At** Astatine (210)	86 **Rn** Radon (222)
7	87 **Fr** Francium (223)	88 **Ra** Radium (226)	89 **Ac** Actinium (227)	104 **Rf** Rutherfordium (261)	105 **Db** Dubnium (262)	106 **Sg** Seaborgium (266)	107 **Bh** Bohrium (264)	108 **Hs** Hassium (269)	109 **Mt** Meitnerium (268)									

58 **Ce** Cerium 140.12	59 **Pr** Praseodymium 140.91	60 **Nd** Neodymium 144.24	61 **Pm** Promethium (145)	62 **Sm** Samarium 150.36	63 **Eu** Europium 151.96	64 **Gd** Gadolinium 157.25	65 **Tb** Terbium 158.93	66 **Dy** Dysprosium 162.50	67 **Ho** Holmium 164.93	68 **Er** Erbium 167.26	69 **Tm** Thulium 168.93	70 **Yb** Ytterbium 173.04	71 **Lu** Lutetium 174.97
90 **Th** Thorium 232.04	91 **Pa** Protactinium 231.04	92 **U** Uranium 238.03	93 **Np** Neptunium (237)	94 **Pu** Plutonium (244)	95 **Am** Americium (243)	96 **Cm** Curium (247)	97 **Bk** Berkelium (247)	98 **Cf** Californium (251)	99 **Es** Einsteinium (252)	100 **Fm** Fermium (257)	101 **Md** Mendelevium (258)	102 **No** Nobelium (259)	103 **Lr** Lawrencium (262)

Key

11 — Atomic number
Na — Element symbol
Sodium — Element name
22.99 — Average atomic mass*

* If this number is in parentheses, then it refers to the atomic mass of the most stable isotope.

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