

CHEM 3311  
Dr. Minger

Midterm Name \_\_\_\_\_  
June 20, 2017

On your Scantron:

Bubble in your name, student ID number, and recitation section...

**GENERAL PURPOSE ANSWER SHEET**  
5 OPTIONS - 180 QUESTIONS

INSTRUCTIONS  
PLEASE USE A NO. 2 PENCIL ONLY  
MAKE HEAVY BLACK MARKS THAT FILL THE CIRCLE COMPLETELY  
DO NOT MAKE ANY STRAY MARKS ON THIS ANSWER SHEET  
MAKE ALL ERASURES CLEAN

EXAMPLES: PROPER MARK: (filled circle) IMPROPER MARKS: (partial, multiple, or stray marks)

LAST NAME FIRST MI

STUDENT ID SECTION ID

INSTRUCTOR USE ONLY  
SUBJECTIVE SCORE

TEST VERSION: A B C D E F

University of Colorado Boulder

**DO NOT WRITE OUTSIDE OF THIS BOX**

Sign your name in this box on the Scantron to acknowledge compliance with the CU Honor Code. ("I pledge on my honor as a CU student that I have neither given nor received unauthorized assistance on this exam.")

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**Recitation Sections**

- 0111 Garrett
- 0112 Mitch
- 0113 Patrick
- 0114 Jessica
- 0115 Brendan (3 pm)
- 0121 Matthew
- 0122 Alyssa
- 0123 Dayan
- 0124 Will
- 0125 Brendan (11 am)
- 0141 Rachel

Instructions continue on the next page.

# General Instructions

There are 26 questions, including one extra credit question. Be sure you have them all. Read each question carefully so that you know exactly what is being asked.

Each multiple choice question (1-26) is worth **4 points** and has **only one correct answer**. Bubble in your answers to these questions on the Scantron provided. **Only the Scantron will be graded, not anything that you write on the exam.**

At the end of the exam, turn in only your Scantron. Remember to sign the Scantron to acknowledge compliance with the Honor Code. You may keep the exam to check your answers against the key later.

Good luck!

1A 2A

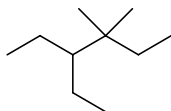
3A 4A 5A 6A 7A 8A

hydrogen 1 <b>H</b> 1.0079	beryllium 4 <b>Be</b> 9.0122																	helium 2 <b>He</b> 4.0026					
lithium 3 <b>Li</b> 6.941																		boron 5 <b>B</b> 10.811	carbon 6 <b>C</b> 12.011	nitrogen 7 <b>N</b> 14.007	oxygen 8 <b>O</b> 15.999	fluorine 9 <b>F</b> 18.998	neon 10 <b>Ne</b> 20.180
sodium 11 <b>Na</b> 22.990	magnesium 12 <b>Mg</b> 24.305																	aluminum 13 <b>Al</b> 26.982	silicon 14 <b>Si</b> 28.086	phosphorus 15 <b>P</b> 30.974	sulfur 16 <b>S</b> 32.065	chlorine 17 <b>Cl</b> 35.453	argon 18 <b>Ar</b> 39.948
potassium 19 <b>K</b> 39.098	calcium 20 <b>Ca</b> 40.078	scandium 21 <b>Sc</b> 44.956	titanium 22 <b>Ti</b> 47.867	vanadium 23 <b>V</b> 50.942	chromium 24 <b>Cr</b> 51.996	manganese 25 <b>Mn</b> 54.938	iron 26 <b>Fe</b> 55.845	cobalt 27 <b>Co</b> 58.933	nickel 28 <b>Ni</b> 58.693	copper 29 <b>Cu</b> 63.546	zinc 30 <b>Zn</b> 65.39	gallium 31 <b>Ga</b> 69.723	germanium 32 <b>Ge</b> 72.61	arsenic 33 <b>As</b> 74.922	selenium 34 <b>Se</b> 78.96	bromine 35 <b>Br</b> 79.904	krypton 36 <b>Kr</b> 83.80						
rubidium 37 <b>Rb</b> 85.468	strontium 38 <b>Sr</b> 87.62	yttrium 39 <b>Y</b> 88.906	zirconium 40 <b>Zr</b> 91.224	niobium 41 <b>Nb</b> 92.906	molybdenum 42 <b>Mo</b> 95.94	technetium 43 <b>Tc</b> [98]	ruthenium 44 <b>Ru</b> 101.07	rhodium 45 <b>Rh</b> 102.91	palladium 46 <b>Pd</b> 106.42	silver 47 <b>Ag</b> 107.87	cadmium 48 <b>Cd</b> 112.41	indium 49 <b>In</b> 114.82	tin 50 <b>Sn</b> 118.71	antimony 51 <b>Sb</b> 121.76	tellurium 52 <b>Te</b> 127.60	iodine 53 <b>I</b> 126.90	xenon 54 <b>Xe</b> 131.29						
cesium 55 <b>Cs</b> 132.91	barium 56 <b>Ba</b> 137.33	* 57-70	lutetium 71 <b>Lu</b> 174.97	hafnium 72 <b>Hf</b> 178.49	tantalum 73 <b>Ta</b> 180.95	tungsten 74 <b>W</b> 183.84	rhenium 75 <b>Re</b> 186.21	osmium 76 <b>Os</b> 190.23	iridium 77 <b>Ir</b> 192.22	platinum 78 <b>Pt</b> 195.08	gold 79 <b>Au</b> 196.97	mercury 80 <b>Hg</b> 200.59	thallium 81 <b>Tl</b> 204.38	lead 82 <b>Pb</b> 207.2	bismuth 83 <b>Bi</b> 208.98	polonium 84 <b>Po</b> [209]	astatine 85 <b>At</b> [210]	radon 86 <b>Rn</b> [222]					
francium 87 <b>Fr</b> [223]	radium 88 <b>Ra</b> [226]	* 89-102	lawrencium 103 <b>Lr</b> [262]	rutherfordium 104 <b>Rf</b> [261]	bohrium 105 <b>Db</b> [262]	seaborgium 106 <b>Sg</b> [263]	hassium 107 <b>Bh</b> [264]	meitnerium 108 <b>Hs</b> [265]	darmstadtium 109 <b>Mt</b> [266]	roentgenium 110 <b>Rg</b> [267]	unnilium 111 <b>Uun</b> [268]	ununium 112 <b>Uuu</b> [269]	unbinium 113 <b>Uub</b> [270]	ununquadium 114 <b>Uuq</b> [271]									

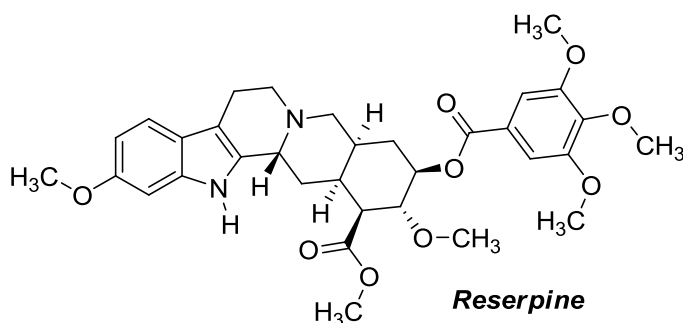
\* Lanthanide series

lanthanum 57 <b>La</b> 138.91	cerium 58 <b>Ce</b> 140.12	praseodymium 59 <b>Pr</b> 140.91	neodymium 60 <b>Nd</b> 144.24	promethium 61 <b>Pm</b> [145]	samarium 62 <b>Sm</b> 150.36	europium 63 <b>Eu</b> 151.96	gadolinium 64 <b>Gd</b> 157.25	terbium 65 <b>Tb</b> 158.93	dysprosium 66 <b>Dy</b> 162.50	holmium 67 <b>Ho</b> 164.93	erbium 68 <b>Er</b> 167.26	thulium 69 <b>Tm</b> 168.93	ytterbium 70 <b>Yb</b> 173.04
actinium 89 <b>Ac</b> [227]	thorium 90 <b>Th</b> 232.04	protactinium 91 <b>Pa</b> 231.04	uranium 92 <b>U</b> 238.03	neptunium 93 <b>Np</b> [237]	plutonium 94 <b>Pu</b> [244]	americium 95 <b>Am</b> [243]	curium 96 <b>Cm</b> [247]	berkelium 97 <b>Bk</b> [247]	californium 98 <b>Cf</b> [251]	einsteinium 99 <b>Es</b> [252]	fermium 100 <b>Fm</b> [257]	mendelevium 101 <b>Md</b> [258]	nobelium 102 <b>No</b> [259]

1. Select the correct name of this molecule.

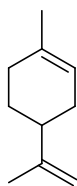


- a. 3-ethyl-4,4-dimethylhexane  
b. 4-ethyl-3,3-dimethylhexane  
c. 3,3-dimethyl-4-ethylhexane  
d. 2-methyl-2,3-diethylpentane  
e. 2,3-diethyl-2-methylpentane
2. Here is the structure of reserpine, a drug used for the treatment of high blood pressure and psychosis. (Lone pairs are omitted for simplicity.) Which carboxylic acid derivative is present in reserpine?

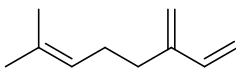


- a. Acid halide  
b. Anhydride  
c. Ester  
d. Amide  
e. None of these groups are present in reserpine
3. In the structure of reserpine shown in #2, the lone pairs are not explicitly drawn, but all atoms are neutral. How many lone pairs of electrons are there on each nitrogen atom?
- a. 0  
b. 1  
c. 2  
d. 3  
e. One billion

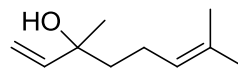
4. 2-Methylpentane is a member of a set of constitutional isomers. Which of these molecules is **not** a constitutional isomer of 2-methylpentane?
- 3-methylpentane
  - 2,2-dimethylbutane
  - 2,3-dimethylbutane
  - hexane
  - All of these molecules are constitutional isomers of 2-methylpentane.
5. Orange oil, which you will isolate from orange peels in lab, is composed of a mixture of organic compounds. Here are three examples of the compounds found in orange oil:



**Limonene**



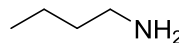
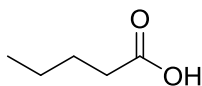
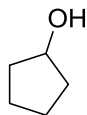
**Myrcene**



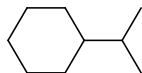
**Linalool**

- Each of these compounds contains one or more carbon-carbon double bonds. What is the percentage of *p* character for the hybrid orbitals on a carbon involved in a double bond?
- 25%
  - 33.3%
  - 50%
  - 66.7%
  - 75%
6. Referring to the structures in question #5, how many allylic carbons are there in limonene?
- 1
  - 2
  - 3
  - 4
  - 5
7. What is the approximate  $pK_a$  value of linalool?
- 5
  - 16
  - 36
  - Not enough information available

8. Arrange the three acids in order of **decreasing**  $pK_a$ . (Highest to lowest)

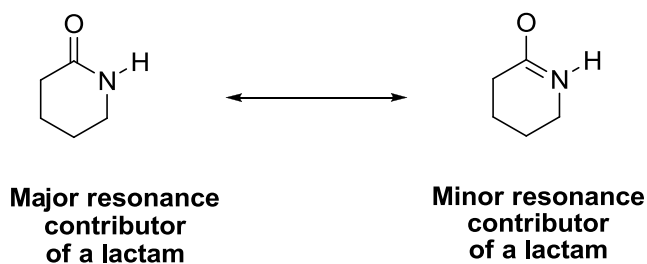


- a.  $W > X > Y$   
b.  $Y > X > W$   
c.  $Y > W > X$   
d.  $W > Y > X$   
e.  $X > Y > W$
9. Using a conjugate base stability argument, which factor is the best explanation for the difference in acidity between structures **W** and **X** in question 8?
- a. Resonance  
b. Electronegativity  
c. Charge effect  
d. Size/Polarizability
10. Using a conjugate base stability argument, which factor is the best explanation for the difference in acidity between structures **W** and **Y** in question 8?
- a. Hybridization  
b. Electronegativity  
c. Inductive effect  
d. Size/Polarizability
11. The common name for the group attached to this cyclohexane ring is



- a. isopropyl  
b. *sec*-butyl  
c. *tert*-butyl  
d. isobutyl  
e. neobutyl

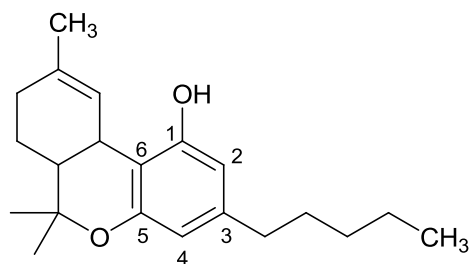
12. One of the functional groups we discussed in class was an amide. Amides can occur as cyclic structures called *lactams*. (Certain types of lactams are used as antibiotics, such as penicillin.)



In the structures above, lone pairs are not explicitly drawn and formal charges not calculated. In the major resonance contributor, all atoms are neutral. Which of the following correctly describes the formal charges in the minor resonance contributor shown above?

	Nitrogen	Carbonyl oxygen	Carbonyl carbon
<b>A</b>	+	-	0
<b>B</b>	-	+	0
<b>C</b>	0	-	+
<b>D</b>	0	+	-
<b>E</b>	None of the answer choices A-D is correct.		

13. Tetrahydrocannabinol (THC) is the major psychoactive component in cannabis. Some of the carbon atoms are numbered in the structure for reference. Lone pairs are not explicitly drawn, but all atoms are neutral.

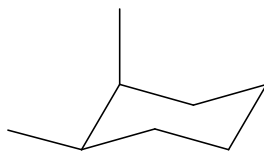


**Tetrahydrocannabinol**

According to valence bond theory, what orbitals are overlapping to form the  $\pi$  bond between C5 and C6?

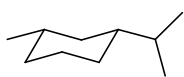
- $sp$  and  $sp$
- $sp^2$  and  $sp^2$
- $sp^3$  and  $sp^3$
- $p$  and  $p$

14. How many gauche butane interactions are there in this structure?

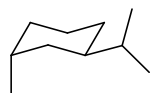


- a. 0 (none)  
b. 1  
c. 2  
d. 3  
e. 4
15. A C-C  $\pi^*$  represents an out of phase combination of two  $p$  orbitals. How many nodes are there in a C-C  $\pi^*$  orbital?

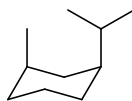
- a. 0  
b. 1  
c. 2  
d. 3  
e. One billion
16. There are several isomers of 1-isopropyl-3-methylcyclohexane. Chair conformations of some of them are shown here. Which of these chair conformations represents the lowest energy structure?



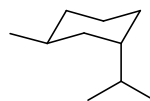
**A**



**B**



**C**

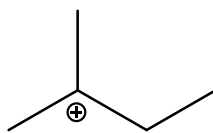


**D**

All the structures have the same energy

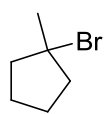
**E**

17. How many unhybridized  $p$  orbitals are there in this structure?

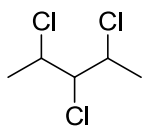


- a. 0  
b. 1  
c. 2  
d. 3  
e. Some other number; e.g. one billion

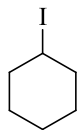
18. Which of these structures is a tertiary alkyl halide?



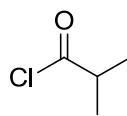
A



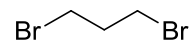
B



C

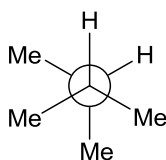


D

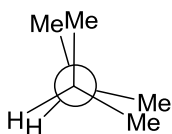


E

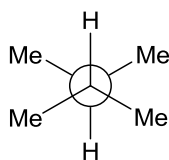
19. Which of these Newman projections shows the least stable conformation of 2,3-dimethylbutane looking down the C2-C3 bond?



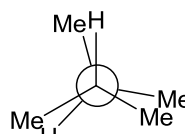
A



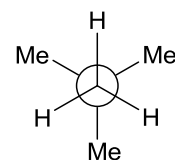
B



C

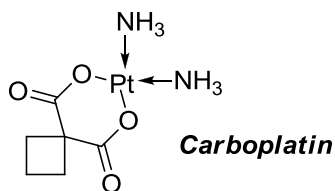


D



E

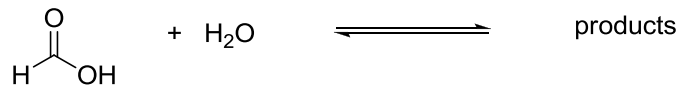
20. In lecture, we discussed the types of strain present in cyclobutane. A compound based on cyclobutane is called carboplatin. Carboplatin is used to treat various types of cancer. (The ammonia molecules “coordinate” to the platinum atom, and this interaction is represented by arrows in the structure. However, you should just focus on the four-membered ring.) What types of strain do you expect to be present in carboplatin?



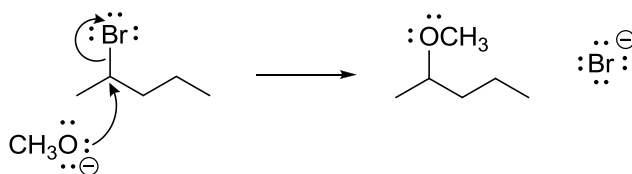
- Torsional
- Steric
- Angle
- Torsional and steric
- All three types of strain



21. Identify the LUMO in the reaction between formic acid and water.



- OH  $\sigma$  in  $\text{H}_2\text{O}$
  - OH  $\sigma^*$  in formic acid
  - $sp^3$  on O in  $\text{H}_2\text{O}$
  - s in formic acid
  - nMO (nonbonding molecular orbital) in  $\text{H}_2\text{O}$
22. A gauche butane interaction is
- an example of torsional strain
  - an example of steric strain
  - present only in butane
  - present only in acyclic molecules
  - described or defined by more than one of the choices a-d
23. Calculate the bond order for the ion  $\text{H}_2^-$ .
- 0
  - $\frac{1}{2}$
  - 1
  - $1\frac{1}{2}$
  - 2
24. Identify the HOMO in the reaction between methoxide ion, a nucleophile, and 2-bromopentane, an electrophile. Spectator ions are omitted from the mechanism for clarity.

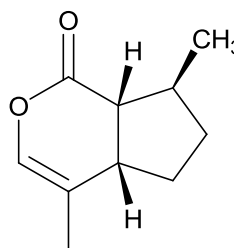
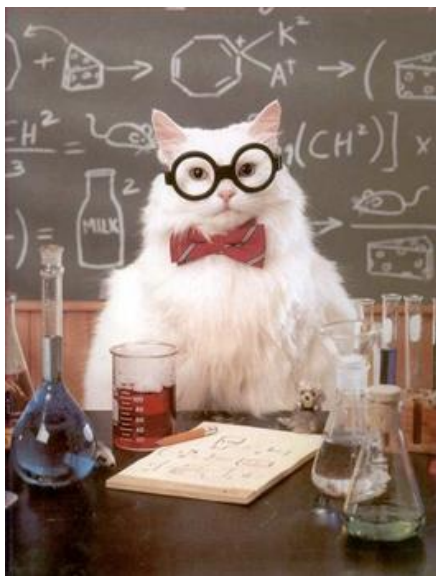


- C-O  $\sigma$
- C-O  $\sigma^*$
- C-Br  $\sigma^*$
- nMO (nonbonding molecular orbital) in methoxide
- nMO in 2-bromopentane

25. Recently at a concert, Justin Bieber was asked to sing the song “Despacito”. This song is currently #1 on the Billboard Hot 100, and Bieber himself recorded it with two other musicians. According to the news report, when Bieber stated that he couldn’t sing the song because he didn’t know it, “...that didn't go over well as someone threw a bottle at him from the audience, which he ducked.”

It is believed that someone placed a substance in Bieber’s energy drink that resulted in his dramatic memory loss. The prime suspect is the Chemistry Cat, shown below. Authorities suspect that the Chemistry Cat secretly spiked Bieber’s drink with a massive dose of nepetalactone, the active ingredient in catnip, and that Bieber had an unfavorable reaction to this compound.

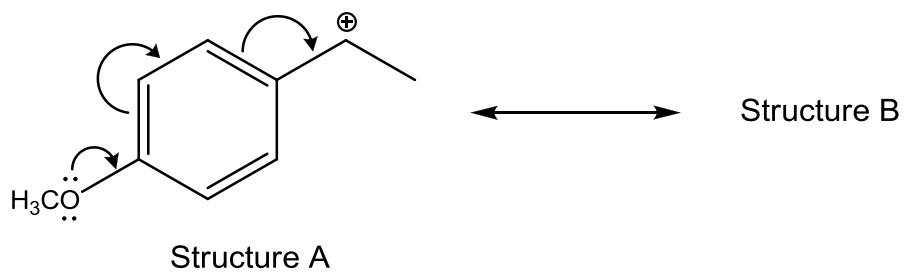
Which statement best describes the hybridization of the oxygen atoms in nepetalactone? (Lone pairs are not explicitly drawn, but all atoms are neutral.)



**nepetalactone**

- Both are  $sp^2$  hybridized
- Both are  $sp^3$  hybridized
- The carbonyl oxygen is  $sp^2$  and the ester oxygen is  $sp^3$
- The carbonyl oxygen is  $sp^3$  and the ester oxygen is  $sp^2$

26. **Extra credit.** Structure A and Structure B are related as resonance contributors. Using the curved arrows on A, determine the structure of B. Then choose which of the two structures is the major contributor.



The major contributor is

- Structure A
- Structure B
- Neither A nor B. The structures are equivalent.