

Name: Answer Key Last First MI

## Chemistry 233 Exam 1

Spring 2018

Dr. J. Osbourn

**Instructions:** The first 18 questions of this exam should be answered on the provided Scantron. You must use a pencil for filling in the Scantron sheet. Ensure all erasures are complete. Any questions left blank will be marked incorrect. Any question with multiple answers selected will be marked incorrect. Answer the remaining questions on the exam itself. Show all work and provide complete explanations.

**Please write your name on:**

- The first page (Exam Cover Page)
- The second page (Grading Page)
- The Scantron Sheet – Circle your Last Name

**Please bubble in your WVU Student ID Number on your Scantron sheet.**

### The Periodic Table

1 IA		2 IIA											13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA	
1 <b>H</b> 1.01		2 <b>He</b> 4.00											5 <b>B</b> 10.81	6 <b>C</b> 12.01	7 <b>N</b> 14.01	8 <b>O</b> 16.00	9 <b>F</b> 19.00	10 <b>Ne</b> 20.18	
3 <b>Li</b> 6.94	4 <b>Be</b> 9.01											11 <b>Na</b> 22.99	12 <b>Mg</b> 24.31	13 <b>Al</b> 26.98	14 <b>Si</b> 28.09	15 <b>P</b> 30.97	16 <b>S</b> 32.07	17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95
19 <b>K</b> 39.1	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.88	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.69	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.39	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.61	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.80		
37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.41	49 <b>In</b> 114.82	50 <b>Sn</b> 118.71	51 <b>Sb</b> 121.76	52 <b>Te</b> 127.6	53 <b>I</b> 126.9	54 <b>Xe</b> 131.29		
55 <b>Cs</b> 132.9	56 <b>Ba</b> 137.3	57 <b>La*</b> 138.9	72 <b>Hf</b> 178.5	73 <b>Ta</b> 180.9	74 <b>W</b> 183.9	75 <b>Re</b> 186.2	76 <b>Os</b> 190.2	77 <b>Ir</b> 192.2	78 <b>Pt</b> 195.1	79 <b>Au</b> 197.0	80 <b>Hg</b> 200.6	81 <b>Tl</b> 204.4	82 <b>Pb</b> 207.2	83 <b>Bi</b> 209	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)		
87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89 <b>Ac^</b> (227)	104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (263)	107 <b>Bh</b> (264)	108 <b>Hs</b> (265)	109 <b>Mt</b> (268)	110 <b>Ds</b> (271)	111 <b>Rg</b> (272)									

* 58 <b>Ce</b> 140.1	59 <b>Pr</b> 140.9	60 <b>Nd</b> 144.2	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.4	63 <b>Eu</b> 152.0	64 <b>Gd</b> 157.3	65 <b>Tb</b> 158.9	66 <b>Dy</b> 162.5	67 <b>Ho</b> 164.9	68 <b>Er</b> 167.3	69 <b>Tm</b> 168.9	70 <b>Yb</b> 173.0	71 <b>Lu</b> 175.0
^ 90 <b>Th</b> 232.0	91 <b>Pa</b> (231)	92 <b>U</b> 238.0	93 <b>Np</b> (237)	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)

Exams may be returned by placing them alphabetically on the table at the front of MHH G20. Your grade will not be visible as it is on the second page. If, however, you have a privacy concern, check the box below and all of your exams will be held back so that you can pick them up privately.

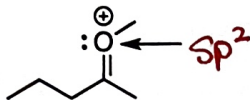
**Hold Back My Exams**

**\*Do not rip off this cover sheet\***

### Multiple Choice

Choose the one best answer for each of the following questions. Using a pencil, record this answer on the provided Scantron sheet. (2 points each)

1. In what type of orbital does the oxygen lone pair reside?



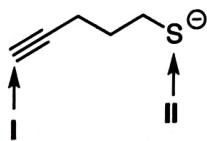
- a. sp
- b. s
- c.  $sp^2$
- d. p
- e.  $sp^3$

2. Which of the following compounds is the strongest base? Use the table of pKa values to help answer the question.

	$\text{H}_3\text{C}-\text{NH}_3^+$	$\text{H}_3\text{C}-\text{NH}_2$	$\text{H}_3\text{C}-\text{OH}_2^+$	$\text{H}_3\text{C}-\text{OH}$	$\text{H}_3\text{C}-\text{SH}$
pK <sub>a</sub>	10	35	0	16	11

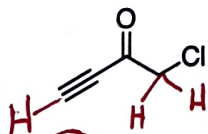
- a.  $\text{H}_3\text{C}-\text{NH}_2$
- b.  $\text{H}_3\text{C}-\text{NH}^-$
- c.  $\text{H}_3\text{C}-\text{OH}$
- d.  $\text{H}_3\text{C}-\text{O}^-$
- e.  $\text{H}_3\text{C}-\text{S}^-$

3. Carbon I contains 1 hydrogen atoms and sulfur II contains 0 hydrogen atoms.



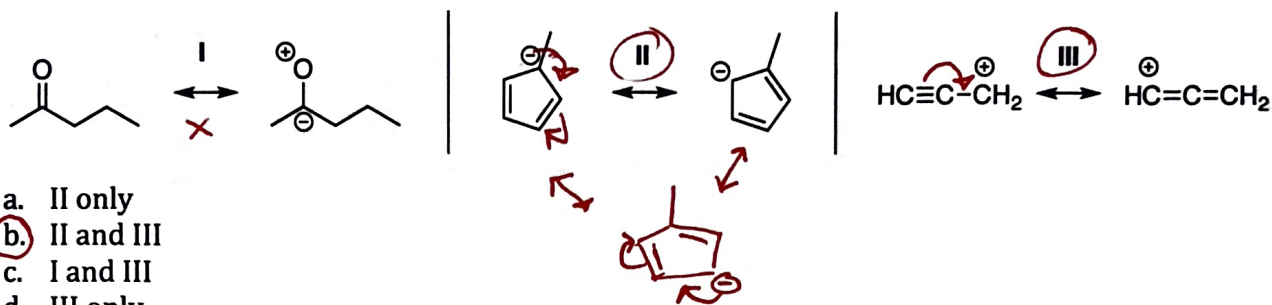
- a. 0, 0
- b. 1, 1
- c. 1, 0
- d. 2, 1
- e. 0, 1

4. The molecule shown below has 8  $\sigma$ -bonds and 3  $\pi$ -bonds. Don't forget the hydrogen!



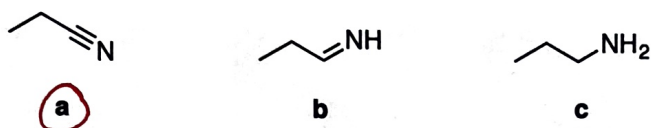
- a. 8, 3
- b. 8, 2
- c. 5, 3
- d. 3, 2
- e. 7, 3

5. Which of the following pairs of structures represent resonance structures?



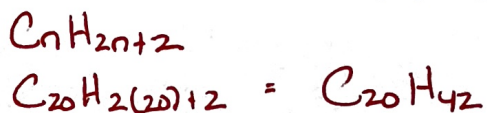
- a. II only
- b. II and III**
- c. I and III
- d. III only
- e. I and II

6. Which carbon-nitrogen bond is the strongest?

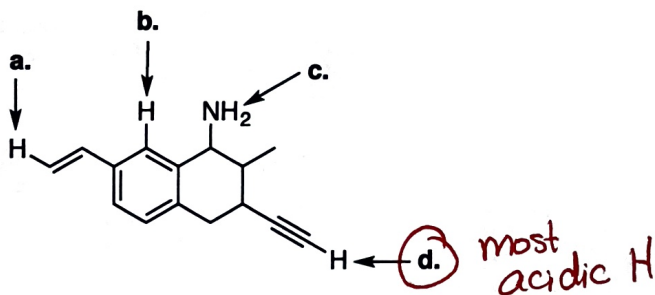


7. A saturated alkane with 20 carbon atoms will have how many hydrogen atoms?

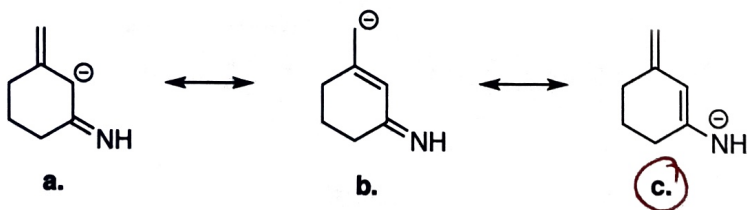
- a. 20
- b. 40
- c. 44
- d. 42**
- e. It cannot be determined



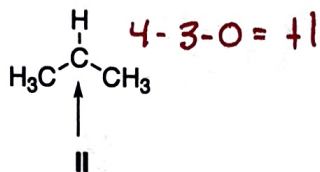
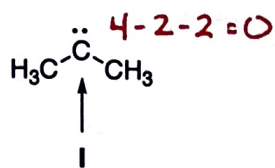
8. If the molecule below were reacted with a strong base, which proton would the base react with preferentially?



9. Consider the three resonance structures shown below. Which would be the major contributor to the resonance hybrid?

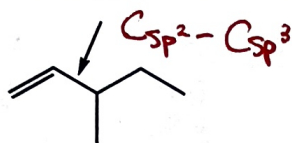


10. What is the formal charge on carbons I and II, respectively? *All atoms and lone pairs have been drawn in!*



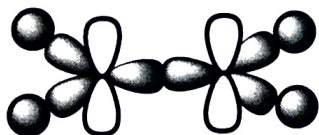
- a. -1, +1
- b. -1, 0
- c. 0, +1**
- d. 0, -1
- e. +1, +1

11. What type of orbital overlap is present in the indicated bond?



- a.  $Csp^3-Csp^3$
- b.  $Csp^2-Csp^2$
- c.  $Csp^2-Csp^2$  and  $Cp-Cp$
- d.  $Csp^2-Csp^3$**
- e.  $Csp^2-Csp^3$  and  $Cp-Cp$

12. In the following orbital picture, how many  $\pi$ -bonds are present?



- a. zero
- b. one**
- c. two
- d. cannot be determined

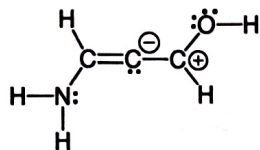
13. Which of the indicated covalent bonds is the most polar?



14. Which compound below would you expect to be the strongest base?

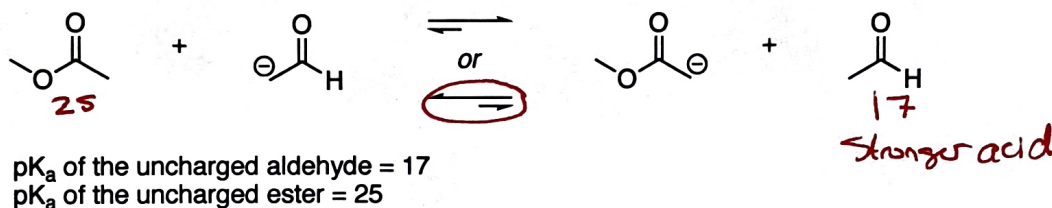


15. Evaluate the legitimacy of the Lewis structure shown below.



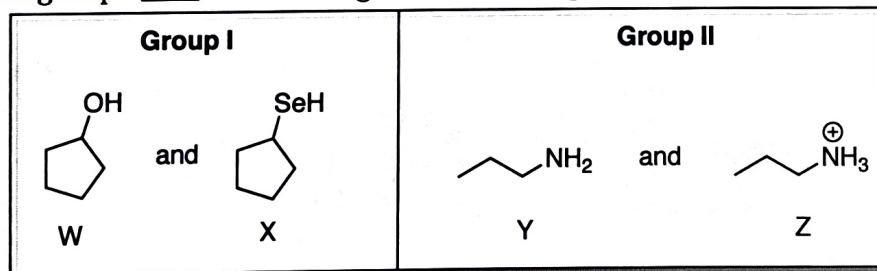
- The structure is legitimate.
- The structure is not legitimate because the oxygen does not have an octet.
- The structure is not legitimate because the formal charges are not correct.
- The structure is not legitimate because the middle carbon lacks an octet.
- The structure is not legitimate because the rightmost carbon lacks an octet.

16. Consider the following acid base reaction and the given  $pK_a$  values. In what direction does the reaction lie?



- The reaction lies to the right
- The reaction lies to the left

17. In group I X is the strongest acid and in group II Z is the strongest acid.



- W, Y
- W, Z
- X, Y
- X, Z

18. What effect is used to qualitatively differentiate the acidity in the two molecules shown below?



- Atom Effect - Electronegativity
- Atom Effect - Size
- Inductive Effect
- Resonance
- Hybridization

## Completion Section

Answer the remaining questions in the spaces provided. Show all work and provide complete explanations.

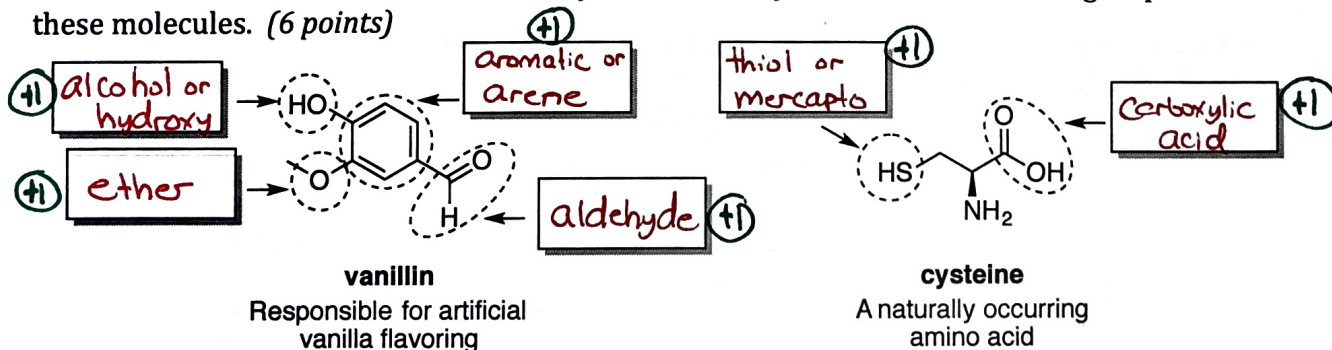
19. Provide the name and skeletal (bond-line) structure for the straight chain alkanes corresponding to the molecular formulas provided (2 points each)

Formula	Name	Skeletal Structure
$C_3H_8$	Propane (+1)	(+1)
$C_7H_{16}$	heptane (+1)	(+1)

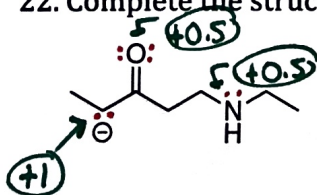
20. For each compound shown below, complete the table by drawing the missing skeletal or condensed structure. (2 points each)

	Condensed Structure	Skeletal Structure
a	$(CH_3)_2C(OH)(CH_2)_3NHCH_3$	(+2)
b	$CH_3CH_2CH(CH_3)(CH_2)_2CHO$ must be CHO! (+2)	(+2)
c	$H_2C=CHCH(CH_2CH_3)CH_2OH$	(+2)

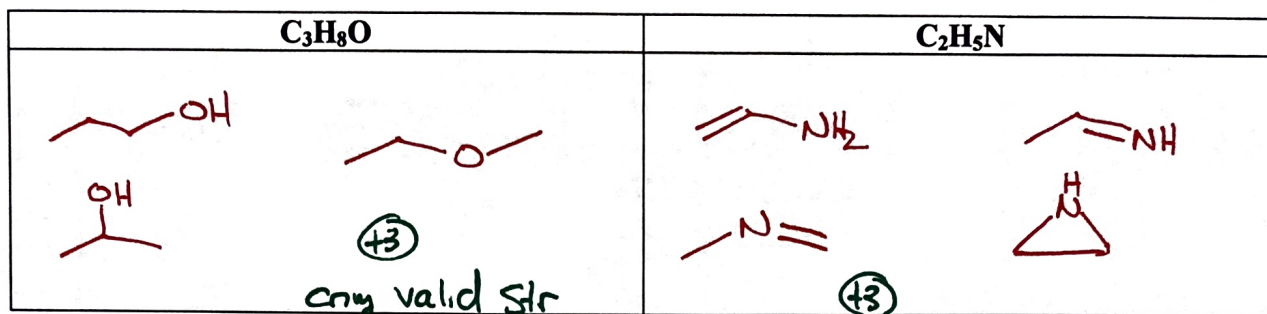
21. Below are the structures of vanillin and cysteine. Identify the circled functional groups in each of these molecules. (6 points)



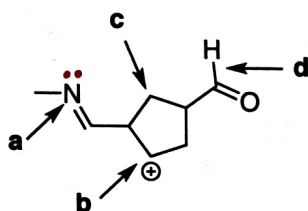
22. Complete the structure below by adding all lone pair electrons. (2 points)



23. Draw a valid Lewis structure or skeletal structure for each compound below. (3 points each)



24. Use the molecule shown below to answer the following questions. (2 points each)



a. What is the hybridization of nitrogen a?

$sp^2$  (2)

b. What is the geometry at carbon b?

trigonal planar (2)

c. What is the approximate bond angle at carbon c?

$109.5^\circ$  (2)

d. What is the orbital overlap involved in bond d?

$H_s - C_{sp^2}$  (2)

25. Draw the orbital picture for the methyl cation ( $CH_3^+$ ). Draw in and label every orbital (i.e  $sp^3$ ). (3 points)



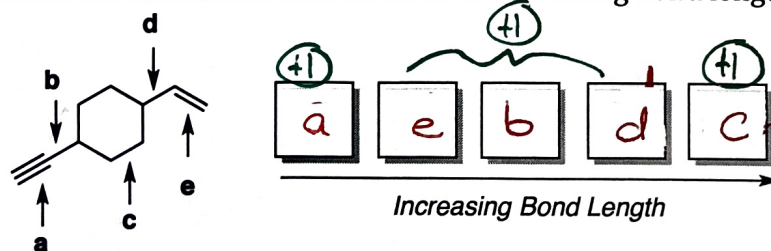
(3)

-1 for not labeling orbitals

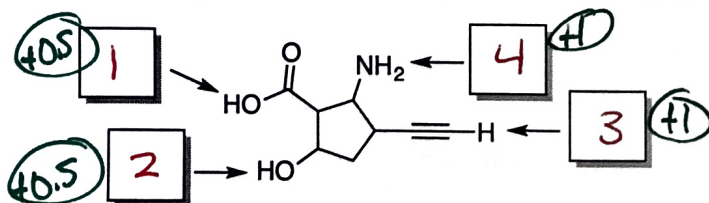
-1 missing p-orbital

-1 not including  $H_s$  orbitals

26. Rank the indicated bonds in order of increasing bond length. (3 points)

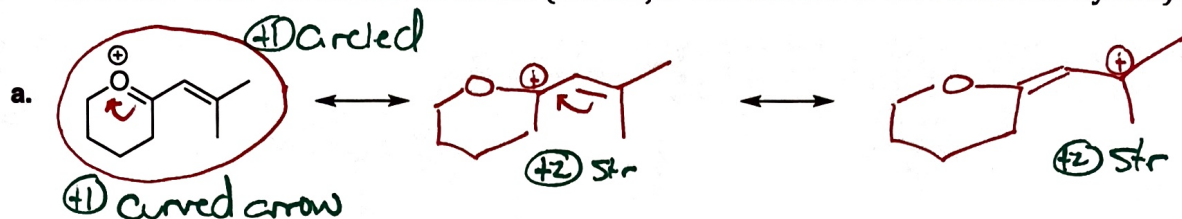


27. Rank the protons in the molecule below from most acidic (1) to least acidic (4). (3 points)

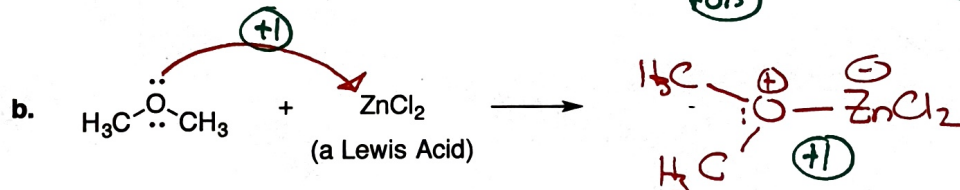
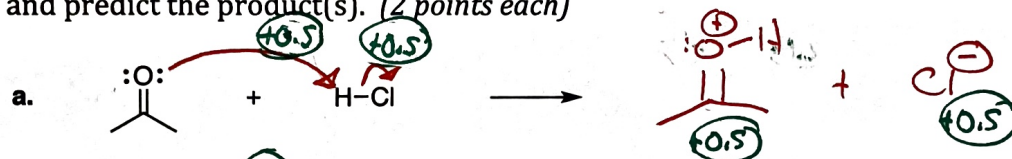


28. For each structure shown below, complete the following: (12 points)

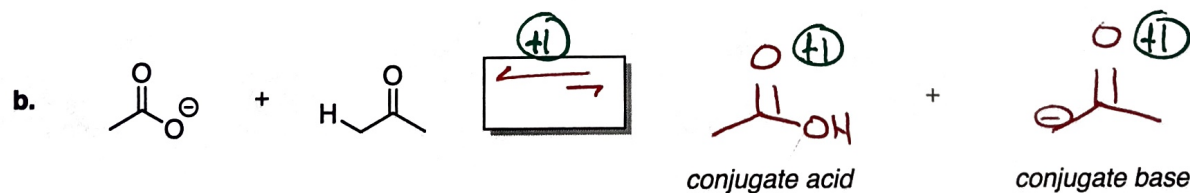
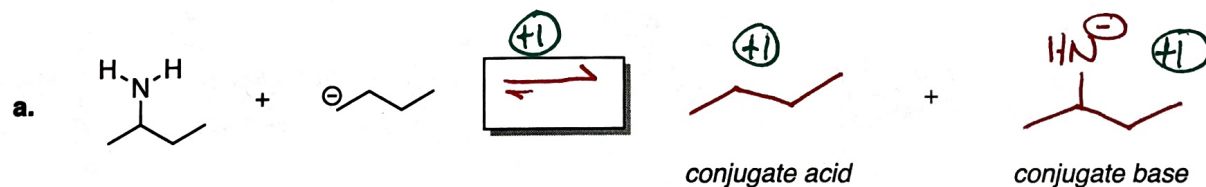
- Draw all relevant resonance structures. (2 pts each structure)
- Use curved arrows to show electron flow. (1 pt)
- Circle the "best" resonance structure (the major contributor to the resonance hybrid). (1 pt)



29. For each reaction shown below, draw in curved arrows in the reactants to show electron flow and predict the product(s). (2 points each)



30. For each acid/base reaction below: I. Draw the correct products; II. Draw in the appropriate equilibrium arrow to show the direction in which the reaction lies. (3 points each)



31. What is the formal charge on the oxygen in the molecule below? (1 point)

