CHEM 3311 **Exam #1** **Name** Key
Dr. Minger **June 9, 2014**

Please read and sign the Honor Code statement below:

I pledge that on my honor, as a University of Colorado at Boulder student, I have neither given nor received unauthorized assistance on this exam.

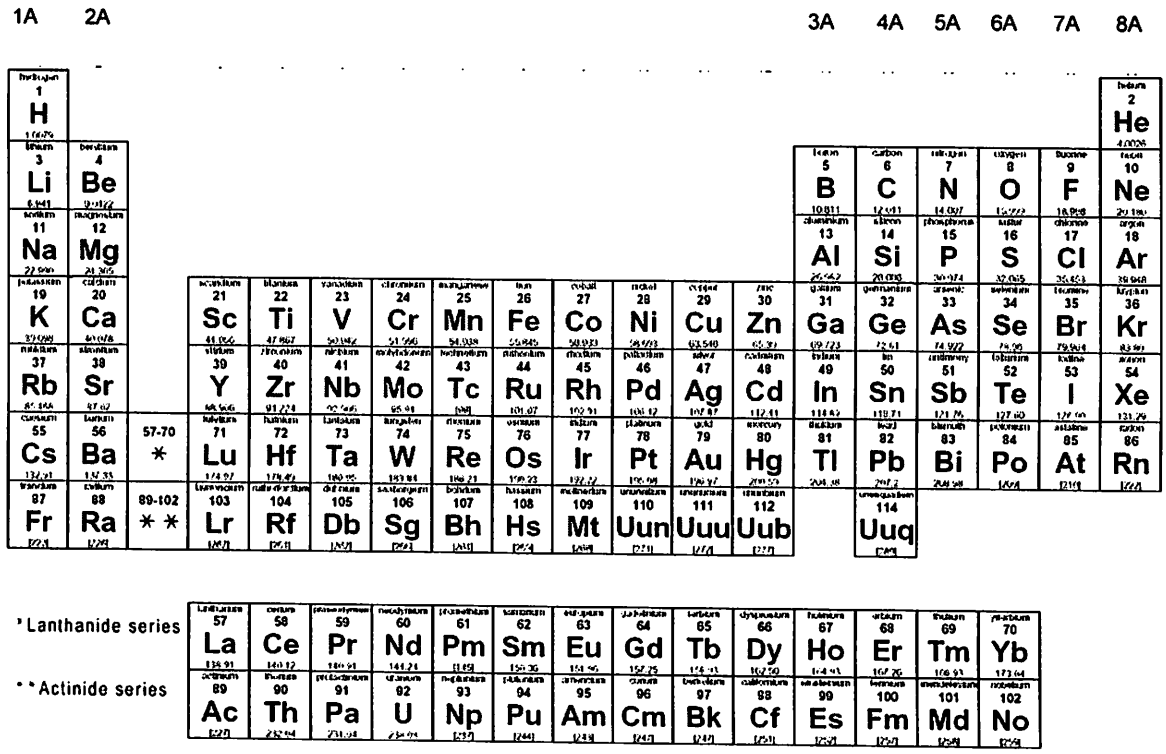
_____
Signature

General Instructions: There are 25 questions. Be sure you have them all. Read each question carefully so that you know exactly what is being asked.

Each multiple choice question (1-25) 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.**

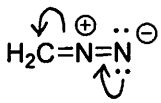
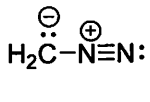
At the end of the exam, turn in your Scantron and this signed cover sheet. You may keep the rest of the exam to check your answers against the key later.

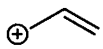
Good luck!



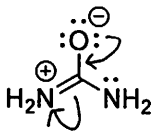
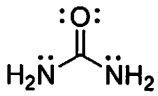
1. Which of the following pairs of structures does NOT represent a pair of resonance contributors?

C

✓ **Set 1**  and 

✓ **Set 2**  and 

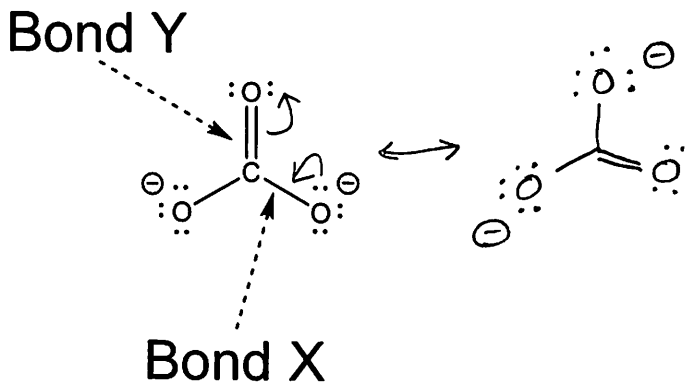
X **Set 3**  and 

✓ **Set 4**  and 

a. Set 1
b. Set 1 and Set 3
(c.) Set 3
d. Set 4
e. All of these sets represent pairs of resonance contributors

2. Here is the structure of the carbonate anion, CO_3^{2-}. Would you expect bond Y to be shorter, longer, or the same length as bond X?

C

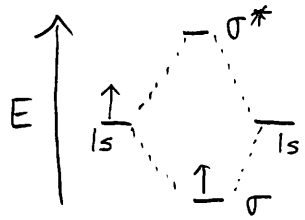


a. Shorter
b. Longer
(c.) The same length

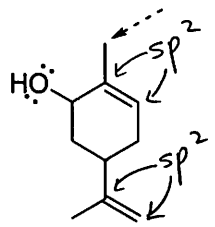
3. Consider the ion H_2^+. How many electrons are in the bonding molecular orbital for this ion?

B

a. 0
b. 1
c. 2
d. 3



Questions 4, 5 and 6 relate to carveol, a naturally occurring compound called a terpenoid that is found in many essential oils. Here is the structure of carveol. (Note that one of the carbon atoms is indicated by an arrow.)



Carveol

4. What is the hybridization of the carbon indicated by the arrow?

C

a. *sp*
b. sp^2
c. sp^3
d. The indicated carbon is not hybridized.

5. What is the approximate <u>electronic</u> geometry around the oxygen atom?

C

a. trigonal planar
b. linear
c. tetrahedral
d. octahedral
e. bent

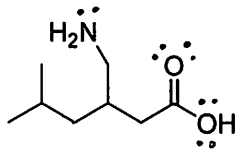
6. How many sp^2 carbon atoms are there in carveol?

C

a. 2
b. 3
c. 4
d. 5
e. 6

7. Here is the constitution of a compound called pregabalin, an anticonvulsant which is marketed under the trade name Lyrica. The lone pairs of electrons are not shown in this structure. To complete the structure, how many lone pairs of electrons must be added? (The formal charge is zero on all atoms.)

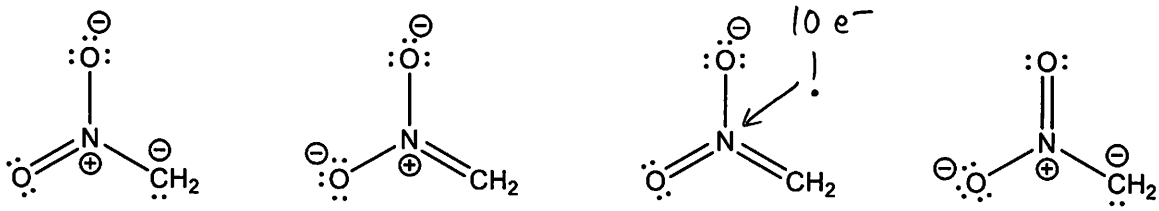
E



Pregabalin (Lyrica)

a. 1
b. 2
c. 3
d. 4
(e.) 5

8. Which of the structures is NOT an acceptable resonance contributor to the resonance hybrid represented by the others?



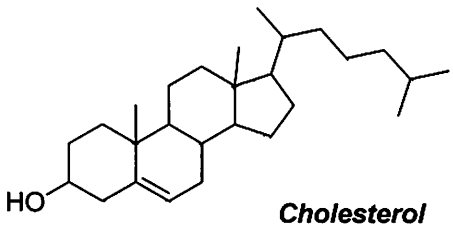
A **B** **C** **D**

C

a. A
b. B
(c.) C
d. D
e. All are acceptable resonance contributors

9. The constitution of cholesterol is shown here:

A



Cholesterol

Cholesterol can be classified as a(n):

(a.) alcohol
b. amide
c. ester
d. ketone
e. anhydride

10. According to valence bond theory, which orbitals are overlapping to form the C-O σ bond in cholesterol?

O sp^3 and C sp^3

E

a. *p* and *p*
b. sp^2 and sp^2
c. *p* and sp^2
d. sp^2 and sp^3
(e.) sp^3 and sp^3

11. According to valence bond theory, which orbitals are overlapping to form the C-C π bond in cholesterol?

A

(a.) *p* and *p*
b. sp^2 and sp^2
c. *p* and sp^2
d. sp^2 and sp^3
e. sp^3 and sp^3

12. Which of these molecular orbitals would you <u>not</u> expect to exist in cholesterol?

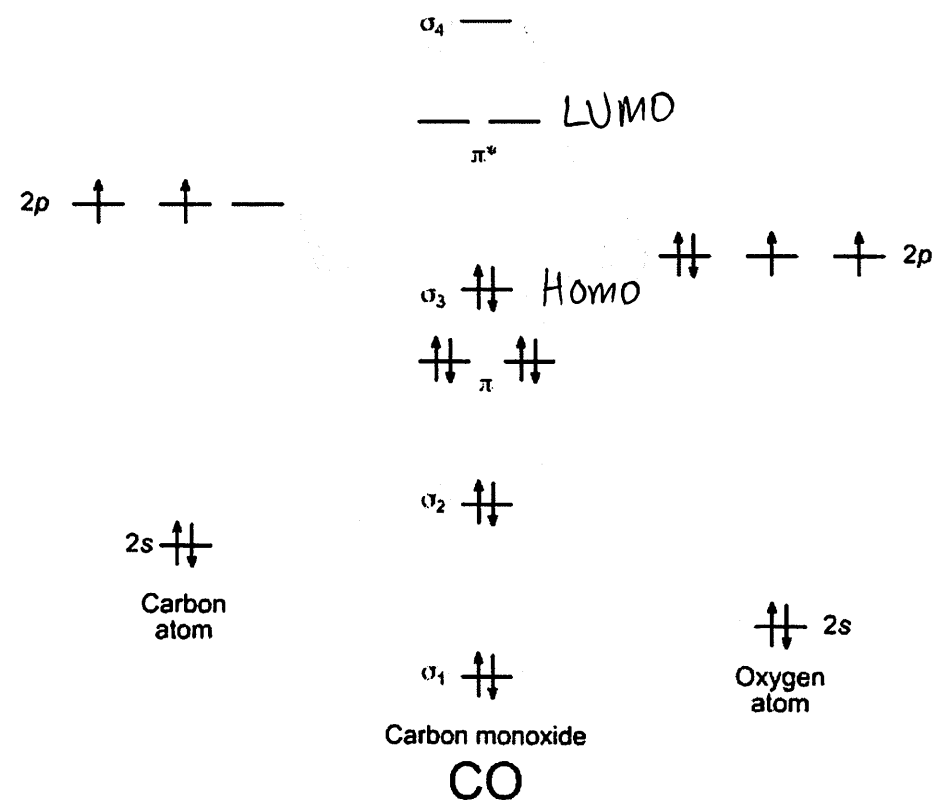
There are no C-O π bonds

C

a. C-H σ
b. C-C π*
(c.) C-O π
d. Nonbonding
e. All of these orbitals exist in cholesterol

13. Here is a molecular orbital diagram for CO, carbon monoxide. The atomic and molecular orbitals are labeled. Even though it is more complicated than the diagrams you have seen, the same principles apply.

D

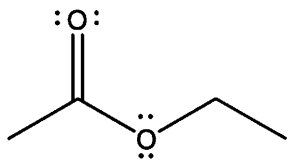


According to this diagram, what is the LUMO in CO?

a. σ^3
b. σ^4
c. $2p$
(d) π^*
e. None of these

14. Ethyl acetate is the compound shown here:

C



Ethyl acetate

To what class of compounds does ethyl acetate belong?

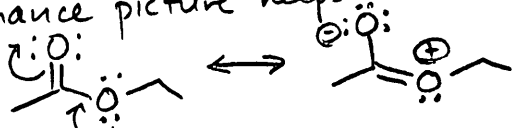
a. carboxylic acid
b. ether
(c.) ester
d. alcohol
e. anhydride

15. Ethyl acetate contains two oxygen atoms: the carbonyl oxygen, and the ester oxygen. Which of the following labels <u>best</u> describes the hybridization of the ester oxygen?

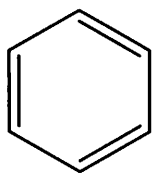
B

a. *sp*
(b.) sp^2
c. sp^3
d. The ester oxygen is not hybridized.

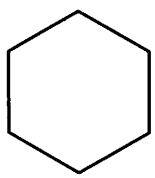
The resonance picture helps us understand this:



16. Consider the structures of benzene and cyclohexane:



benzene



cyclohexane

B

Which of these statements is true?

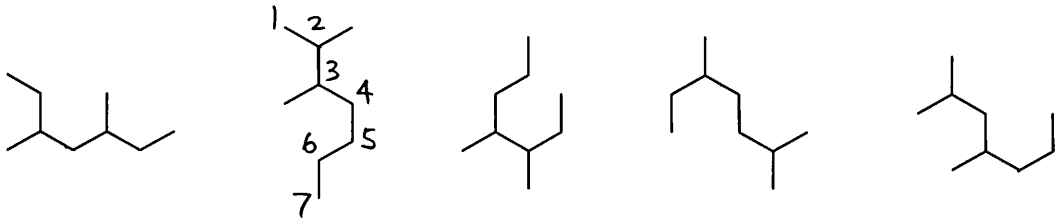
~~a.~~ Both molecules are planar (all atoms are in one plane).
(b.) Benzene is planar, but cyclohexane is not.
c. Cyclohexane is planar, but benzene is not.
d. Neither benzene nor cyclohexane is planar.

 has all sp^2 C atoms, all with trigonal planar geometry

 has all sp^3 C atoms, each with tetrahedral geometry

17. Which of these compounds is 2,3-dimethylheptane?

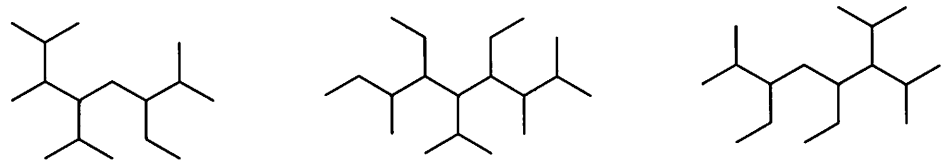
B



A ~~A~~ (B) C D E

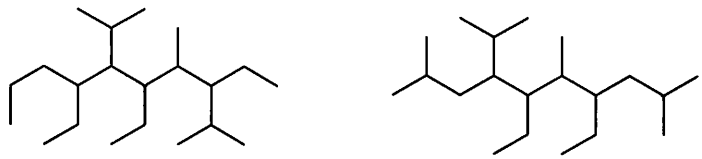
18. Which of these compounds has an isopropyl group at the 4 position?

A



(A) B C

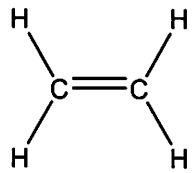
6-ethyl-4-isopropyl-2,3,7-trimethyloctane



D E

19. How many nodes are there in the C-C π* molecular orbital in ethylene?

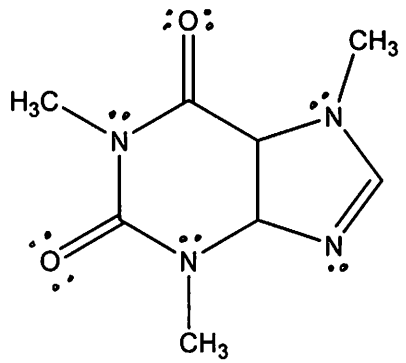
C



ethylene

a. 0
b. 1
(c.) 2
d. 3
e. Ethylene does not contain a π* orbital.

20. The structure of caffeine is shown. Lone pairs are not explicitly drawn, but all atoms are neutral (formal charge = zero).



D

Caffeine

How many nonbonding molecular orbitals are there in caffeine?

a. 2
b. 4
c. 6
(d.) 8
e. Millions

21. There are three methyl groups in caffeine. What is the percentage of *p* character for the orbitals on a carbon in a methyl group?

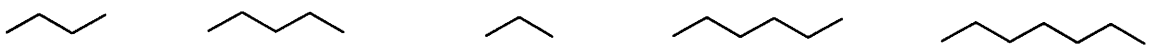
a. 25%
b. 33.3%
c. 50%
d. 66.7%
(e.) 75%

E

sp^3 is 25% s, 75% p

22. Which of these compounds is pentane?

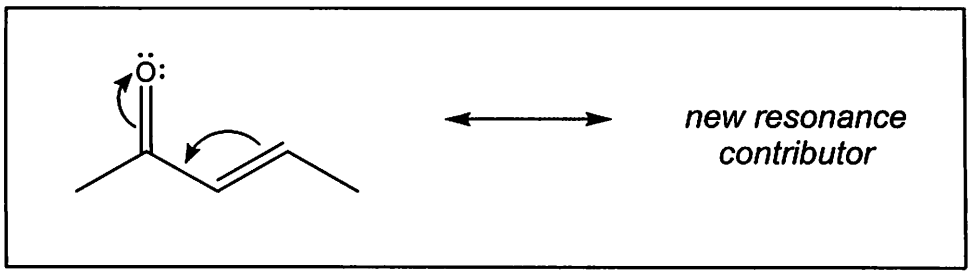
B

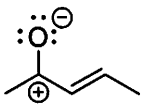


A (B) C D E

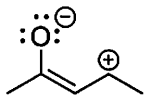
23. Curved arrows are used to convert one resonance contributor (resonance structure) to another. Examine the curved arrows shown on the structure below. Which of the choices is the resonance structure that would result from those arrows?

B

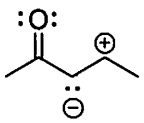




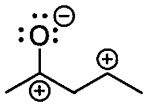
A



(B)



C



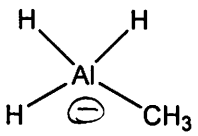
D

None of these structures

E

24. What is the formal charge on aluminum in this structure?

B

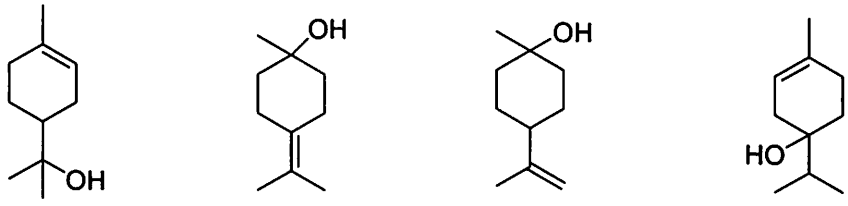


$3 - (4 + 0) = -1$

a. 1+
(b.) 1−
c. 0
d. 2+
e. 2−

25. Recently, tabloids reported that there was a heated altercation between Solange and Jay Z in an elevator in a New York hotel. While the exact nature of this argument has not been revealed, insiders claim that Solange became furious with Jay Z because he kept insisting that the four compounds shown below were constitutional isomers:

A



Solange claimed, loudly, that the four were resonance structures contributing to the same resonance hybrid. She then physically attacked Jay Z. Witnesses indicate that during the attack she screamed "You can't call yourself an organic chemist!"

Who was correct, Jay Z or Solange?

Same formula, different connectivity

(a.) Jay Z. The four compounds are constitutional isomers.

b. Solange. The four compounds are contributors to the same resonance hybrid.

c. Neither Jay Z nor Solange were correct. The four compounds have no relationship to one another.

d. Both Jay Z and Solange were correct. The four compounds are constitutional isomers AND resonance contributors to the same hybrid.