Name KEY

# Chemistry 121
# Test 1
# Fall 2021

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☐ ←Check here if you would like your approximate course grade when the exam is returned.
This grade includes all exams, quizzes and homework scores to this point in the semester. It should be used only as a guide to help you determine your progress in the course and is subject to change depending upon remaining scores on exams, homework, and quizzes. Approximate course grade is on the next page, upper right-hand corner.

**Read this:** Don't panic. This is a strictly timed exam. You must work quickly and accurately. You have 54 minutes to complete the exam. If the space provided is insufficient for showing your work, continue on the back of the page. Initial below the cartoon for one point. Don't forget to indicate where the work may be found. If there are questions ask the instructor not your neighbor. You may not share calculators.

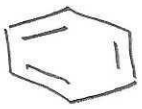
**Have fun.**

**Descriptive I:** Use only the space provided for essay/short answer questions. Brevity will be rewarded. Incorrect answers, even accompanied by correct answers, will receive a penalty.

1. (3 pts.) Strictly speaking, only 1 type of bond can be described as nearly 100% covalent. That bond is the one

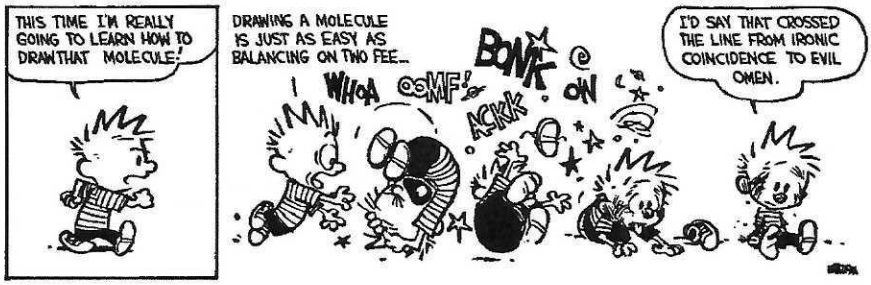
   ■ in a homonuclear diatomic molecule.
   ☐ in a heteronuclear diatomic molecule.
   ☐ between a metal and a nonmetal.
   ☐ between two nonmetals.
   ☐ between two of the same nonmetals.

2. (5 pts.) The molecule benzene has unexpected stability and equal C-C bond lengths. Draw the structure of benzene using any accepted convention.



3. (4 pts.) Different molecular structures drawn from the same molecular formula are called

   ☐ delocalization structures.
   ☐ resonance structures.
   ■ isomers.
   ☐ amphoteric structures.
   ☐ amphiprotic structures.
   ☐ impossible.
   ☐ none of these.




4. (4 pts.) Sort the following bonds in order of *increasing polarity*.

   C-Br in $CH_2Br_2$  S-S in $S_8$  Si-O in $SiO_2$  S-O in $SO_4^{2-}$  Na-Cl in NaCl

   *least polar* ____ *most polar*

   ☐ C-Br < S-S < Si-O < S-O < Na-Cl
   ☐ NaCl < S-O < Si-O < S-S < C-Br
   ☐ S-S < S-O < C-Br < Si-O < Na-Cl
   ☐ S-S < C-Br < S-O < Si-O < Na-Cl
   ■ NaCl < Si-O < S-O < C-Br < S-S

## Structure and Bonding I:

Theobromine (shown below) is found in chocolate, tea, and the kola nut. It is similar in structure to caffeine but does not have the same stimulant effect that caffeine has. It is a vasodilator and diuretic and has been used in the past to treat high blood pressure.

5. (6 pts.) The formal charge of atom 1 in theobromine is

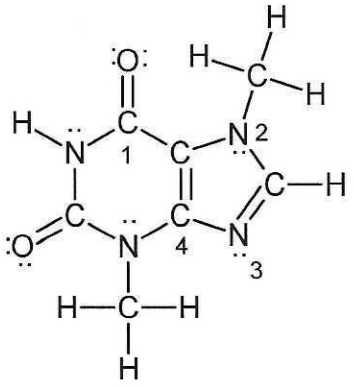
☒ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ Cannot be determined

The formal charge of atom 3 is

☒ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ Cannot be determined

6. (8 pts.) Predict the bond angle (ideal or actual) of the indicated atom group (∠ = angle) in theobromine.

1. ∠NCO 120 2. ∠CNC 109.5 3. ∠CNC 120 4. ∠NCN 120

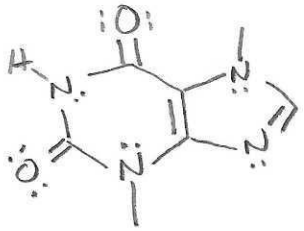


**Theobromine**

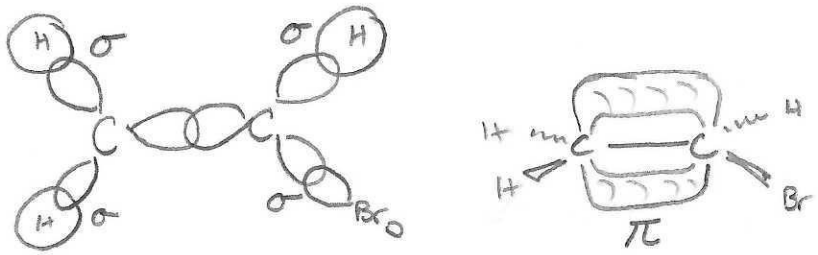
7. (8 pts.) Predict the hybridization of the indicated atoms in theobromine.

1. $sp^2$ 2. $sp^3$ 3. $sp^2$ 4. $sp^2$

8. (5 pts.) Draw the theobromine molecule using conventional structural shorthand. Neatness counts.

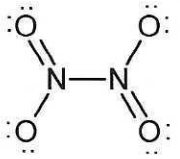


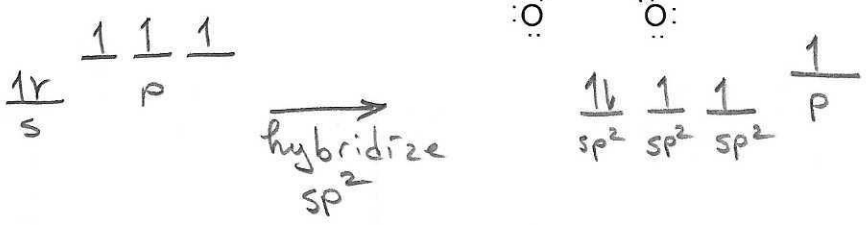
9. (8 pts.) Using your best artistry, draw the valence bond picture (showing orbitals, not just lines) of bromoethylene, $C_2H_3Br$. Indicate the type of each orbital used in bonding. Like was done in lecture, multiple pictures, if necessary or to improve the clarity of your answer, are permitted. If lone-pairs are present, do not show those orbitals.



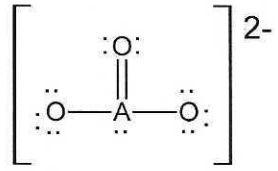

**Descriptive II:** Use only the space provided. Incorrect answers, even accompanied by correct answers, will receive a penalty.

10. (4 pts.) Show with a simple energy level diagram what is happening to the atomic orbitals of nitrogen to form the hybrid molecular orbitals in one of the nitrogen atoms in $N_2O_4$.




11. (3 pts.) Atom A is a row 4 element. O is oxygen. Identify the element based on the Lewis structure of the oxo-anion of A.




A = Se

12. (6 pts.) Consider the following molecules and ions:

$NO_3^-$ $CN^-$ $CO_2$ $BF_3$ $[ONO]^+$ HCN

Answer the following questions based on these. Check all that apply in each question.

Which molecules or ions *require* a non-zero formal charge on one or more atoms?

■ $NO_3^-$ ■ $CN^-$ ☐ $CO_2$ ☐ $BF_3$ ☐ $[ONO]^+$ ☐ HCN ☐ none

Which will require an expanded valence for their Lewis structure?

☐ $NO_3^-$ ☐ $CN^-$ ☐ $CO_2$ ☐ $BF_3$ ☐ $[ONO]^+$ ☐ HCN ■ none

Which of the species will not be linear?

■ $NO_3^-$ ☐ $CN^-$ ☐ $CO_2$ ■ $BF_3$ ☐ $[ONO]^+$ ☐ HCN ☐ none

## Structure and Bonding II: (24 pts.)

1. a. Draw the correct Lewis structures of the following compounds and ions. (2 pt. each)
   b. Based on the Lewis structure drawn, identify the electronic and molecular geometries and indicate if the molecule or ion possesses a permanent dipole moment (*i.e.* is polar). (1 pt. each)
   c. Determine the hybridization on any hybridized atoms (also indicate which atom or atoms are hybridized). (1 pt. each)

Scoring on this section is hierarchal: Part (a) will be graded first, with the remaining parts graded based on the structures and geometries assigned.

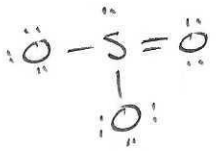
$SO_3^{2-}$

electronic geometry: Tetrahedral

molecular geometry: Trigonal pyramidal

Polar (yes) no

hybridization $sp^3$ on S



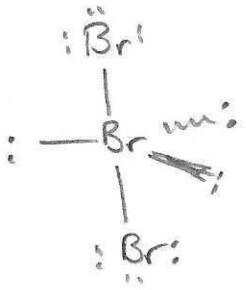
$Br_3^-$ (tribromide ion)

electronic geometry: Trigonal bipyramidal

molecular geometry: linear

Polar yes (no)

hybridization $sp^3d$ on Br



$COBr_2$

electronic geometry: Trigonal planar

molecular geometry: Trigonal planar

Polar (yes) no

hybridization $sp^2$ on C

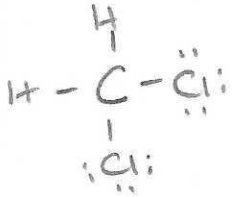
$CH_2Cl_2$

electronic geometry: Tetrahedral

molecular geometry: Tetrahedral

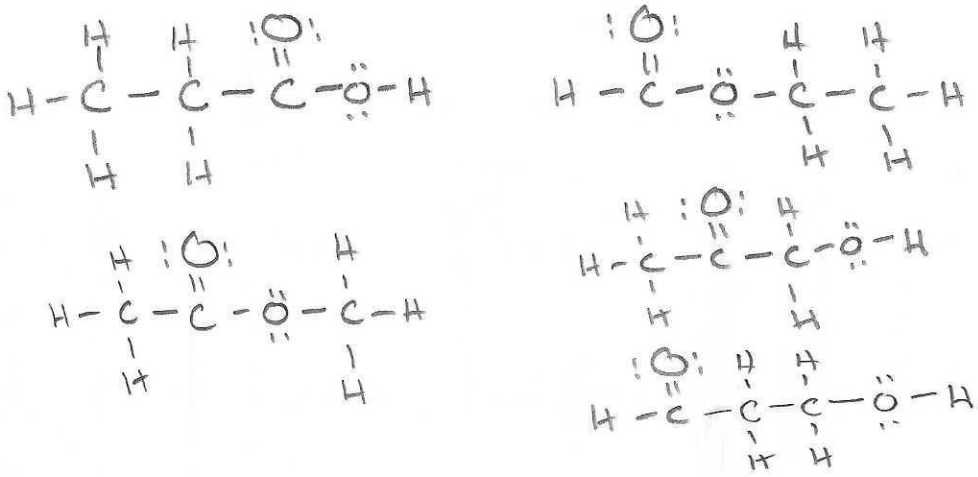
Polar (yes) no

hybridization $sp^3$ on C



**Pick either 2a or 2b. Notice that 2b has a small amount of extra credit. If you attempt both, put an X through the problem you do not wish to be graded. If you do not indicate which you would like graded, 2a will be scored.**

2a. (6 pts.) Draw 2 different possible and chemically acceptable structures for molecules with the formula $C_3H_6O_2$.

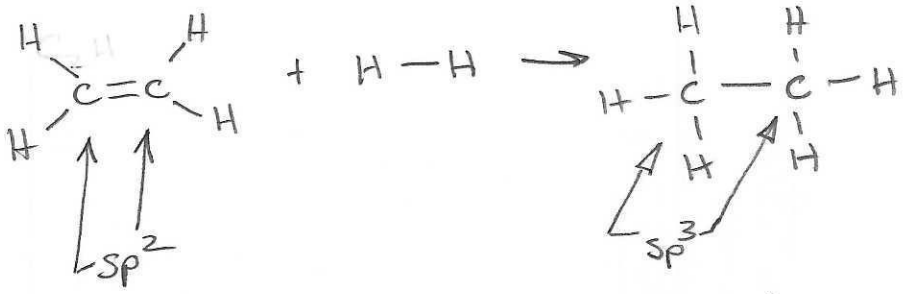


2b. (11 pts.) Draw 3 different possible and chemically acceptable structures for molecules with the formula $C_5H_6O_2$. One of the structures must contain a closed ring of atoms. There are no requirements on the other 2 structures.

3. A. (1 pt.) Write the reaction of ethylene gas ($C_2H_4$) with hydrogen gas ($H_2$) to form ethane gas ($C_2H_6$).

   B. (2 pts.) Show with 3-dimensional pictures (VSEPR diagrams, not VB orbital diagrams) what is taking place at the molecular level. You may combine (A) and (B) into one equation if you would like.

   C. (3 pts.) Beneath each reactant and product, describe any geometric and hybridization changes encountered along the reaction path.




Trigonal planar on each C

Tetrahedral for each C