Chemistry 221 Sample Exam II Cover Sheet

Fall XXXX

Name: _____

This exam consists of twenty-five (25) multiple-choice questions and three (3) short answer questions with five points of extra credit.

A periodic table and scratch paper are available for you to use on this exam.

Before you start:

- Write your first and last name in the space above
- Sign the integrity statement below. **Failing to sign the integrity statement on this exam imparts an immediate grade of zero.**
- For multiple choice questions: clearly enter your letter answer in the appropriate location. **Circle** the letter which corresponds to your answer.
- For short answer questions: clearly **circle** your final answer, showing all work.

Point values and your exam score will be summarized on the final page

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Integrity statement:

I have neither given nor received aid on this exam.

_____

Your signature

1. Which of the following statements are CORRECT?
    1. Ionic bonds form when one or more valence electrons are transferred from one atom to another.
    2. Covalent bonds involve sharing of electrons between atoms.
    3. Ionic bond formation is always exothermic; covalent bond formation is always endothermic.

    a. 1 only
    b. 2 only
    c. 3 only
    d. 1 and 2
    e. 1, 2, and 3

Letter answer to question #1: _____

2. What is the total number of valence electrons in a carbonate ion, CO_3^{2-}?

    a. 20
    b. 22
    c. 24
    d. 26
    e. 30

Letter answer to question #2: _____

3. Which of the following species will have a Lewis structure most like that of the hydronium ion, H_3O^+?

    a. NO_3^-
    b. NH_3
    c. SO_3
    d. CO_3^{2-}
    e. H_2CO

Letter answer to question #3: _____

4. How many resonance structures can be drawn for the thiocyanate ion, SCN^{-1}? The carbon atom is in the center of this ion.

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

Letter answer to question #4: _____

5. The central atom in XeF_4 is surrounded by

    a. 3 single bonds, 1 double bond, and no lone pairs of electrons.
    b. 2 single bonds, 2 double bonds, and no lone pairs of electrons.
    c. 3 single bonds, 1 double bond, and 1 lone pair of electrons.
    d. 4 single bonds, no double bonds, and no lone pairs of electrons.
    e. 4 single bonds, no double bonds, and 2 lone pairs of electrons.

Letter answer to question #5: _____

6. Use VSEPR theory to predict the electron-pair geometry and the molecular geometry of iodine trichloride, ICl_3.

   a. The e--pair geometry is trigonal-planar, the molecular geometry is trigonal-planar.
   b. The e--pair geometry is tetrahedral, the molecular geometry is trigonal-pyramidal.
   c. The e--pair geometry is tetrahedral, the molecular geometry is trigonal-planar.
   d. The e--pair geometry is trigonal-bipyramidal, the molecular geometry is T-shaped.
   e. The e--pair geometry is trigonal-bipyramidal, the molecular geometry is trigonal-planar.

Letter answer to question #6: _____

7. What is the formal charge on each atom in a hypobromite ion, OBr^{-1}?

   a. O = -2, Br = -1
   b. O = -2, Br = +1
   c. O = -1, Br = +1
   d. O = -1, Br = 0
   e. O = 0, Br = -1

Letter answer to question #7: _____

8. Which molecule will have a triple bond?

   a. CO
   b. CO_2
   c. CH_3OH
   d. H_2CO
   e. O_3

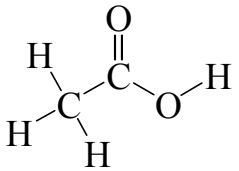
Letter answer to question #8: _____

9. All of the following statements concerning valence bond (VB) and molecular orbital (MO) bond theories are correct EXCEPT

   a. MO theory predicts that electrons are delocalized over the molecule.
   b. in VB theory, bonding electrons are localized between pairs of atoms.
   c. VB theory describes a molecular bond as the overlap between two atomic or hybrid orbitals.
   d. MO theory can describe molecular bonding in excited states.
   e. VB theory is used to predict the colors of compounds.

Letter answer to question #9: _____

10. How many sigma (σ) bonds and pi (π) bonds are in acetic acid?



   a. six σ and one π
   b. six σ and two π
   c. seven σ and one π
   d. eight σ and zero π
   e. eight σ and one π

Letter answer to question #10: _____

11. What is the hybridization of the sulfur atom in SF_4?

    a. sp
    b. sp^2
    c. sp^3
    d. sp^3d
    e. sp^3d^2

Letter answer to question #11: _____

12. In which of the following molecules and ions does the central carbon atom have sp hybridization: Cl_2CO, CH_2Br_2, CO_2, and OCN^{-1}?

    a. Cl_2CO only
    b. Cl_2CO and CH_2Br_2
    c. CH_2Br_2 and CO_2
    d. CH_2Br_2 and OCN^{-1}
    e. CO_2 and OCN^{-1}

Letter answer to question #12: _____

13. What is the molecular geometry around a central atom that is sp^2 hybridized, has three sigma bonds, and has one pi bond?

    a. trigonal-planar
    b. trigonal-pyramidal
    c. trigonal-bipyramidal
    d. linear
    e. tetrahedral

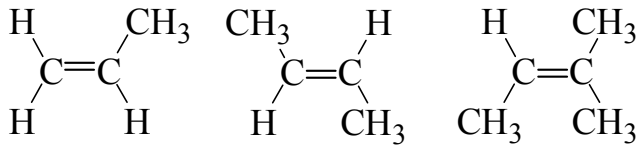
Letter answer to question #13: _____

14. Carbon dioxide reacts with an aqueous solution of sodium hydroxide to form carbonate ion. What change in the hybridization of carbon occurs in this reaction?

    a. sp to sp^2
    b. sp^2 to sp^3
    c. sp^3 to sp^3d
    d. sp^3 to sp^3d^2
    e. no change

Letter answer to question #14: _____

15. For which of the following compounds is it possible for isomers to exist?



(1) (2) (3)

    a. 1 only
    b. 2 only
    c. 3 only
    d. 1 and 2
    e. 1, 2, and 3

Letter answer to question #15: _____

16. Atomic orbitals combine most effectively to form molecular orbitals when

    a. electrons in the orbitals have no spins.
    b. electrons in the orbitals have the same spin.
    c. the atomic orbitals are hybridized.
    d. the atomic orbitals have similar energies.
    e. metals combine with nonmetals.

Letter answer to question #16: _____

17. According to molecular orbital theory, which of the following species is the most likely to exist?

    a. H_2^{2-}
    b. He_2
    c. Li_2
    d. Li_2^{2-}
    e. Be_2

Letter answer to question #17: _____

18. According to molecular orbital theory, what is the bond order of superoxide, O_2^{-1}?

    a. 1
    b. 3/2
    c. 2
    d. 5/2
    e. 3

Letter answer to question #18: _____

19. Use molecular orbital theory to predict which ion is diamagnetic.

    a. C_2^{-2}
    b. O_2
    c. NO
    d. N_2^{-1}
    e. B_2^{-1}

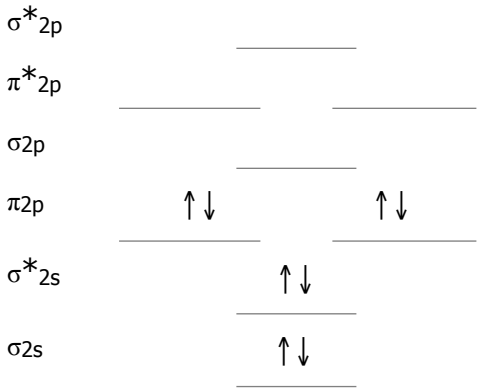
Letter answer to question #19: _____

20. What is the molecular orbital configuration of CO?

    a. [core electrons] $(\sigma_{2s})^2 (\sigma^*_{2s})^2 (\pi_{2p})^4$
    b. [core electrons] $(\sigma_{2s})^2 (\sigma^*_{2s})^2 (\pi_{2p})^2 (\sigma_{2p})^2 (\pi^*_{2p})^2$
    c. [core electrons] $(\sigma_{2s})^2 (\sigma^*_{2s})^2 (\pi_{2p})^4 (\sigma_{2p})^2$
    d. [core electrons] $(\sigma_{2s})^2 (\sigma^*_{2s})^2 (\sigma_{2p})^2 (\pi_{2p})^4$
    e. [core electrons] $(\sigma_{2s})^2 (\sigma^*_{2s})^2 (\pi_{2p})^2$

Letter answer to question #20: _____

21. Which molecule will have the following valence molecular orbital level energy diagram?



a. Li_2
b. Be_2
c. B_2
d. C_2
e. N_2

Letter answer to question #21: _____

22. Which of the following elements is most likely to form compounds with an expanded valence shell?

a. P
b. Ne
c. F
d. Li
e. N

Letter answer to question #22: _____

23. Which of the following combinations is most likely to produce an ionic bond?

a. Cl and Br
b. P and S
c. N and O
d. B and O
e. Li and F

Letter answer to question #23: _____

24. What is the formal charge on each atom in a hypobromite ion, OBr^{-1}?

a. O = -2, Br = -1
b. O = -2, Br = +1
c. O = -1, Br = +1
d. O = -1, Br = 0
e. O = 0, Br = -1

Letter answer to question #24: _____

25. Use VSEPR theory to predict the molecular geometry of HCN.

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

Letter answer to question #25: _____

Part II: Short Answer / Calculation, 30 points total with 5 points extra credit. *Show all work!*

1. For each of the following molecules or ions, (15 points)
   i) draw the Lewis structure
   ii) give the hybridization of the central atom
   iii) predict the electron pair *and* molecular shape of the molecule, and
   iv) state if the molecule is polar or nonpolar

a) ICl_3 **b)** $TeBr_2$ **c)** XeF_4 **d)** BrF_2^{-1} **e)** I_3^{-1}

2. Draw molecular orbital energy diagrams for N_2, N_2^{1+} and N_2^{2-}. Determine the bond order and indicate if each molecule is paramagnetic or diamagnetic. Indicate which of the molecules will have the shortest bond length. (15 points)

3. Complete the sentences below with the appropriate word or phrase. (5 points)

- The **molecular geometry** of a molecule whose central atom has four single bonds and two lone pairs of electrons is _____.

- In valence bond theory, a π bond is described as the sideways overlap of two unhybridized _____ orbitals.

- In molecular orbital theory, the bond order is defined as 1/2(the number of electrons in bonding orbitals - the number of electrons in _____ orbitals).

- Mixing six atomic orbitals together should create _____ molecular orbitals (i.e. a number.)

- Hybridization of a T-shaped molecular geometry structure would be described as _____.

CH 221 Exam II Point Distribution Sheet

*Avoid a point penalty - do **not** write on this page!*

Multiple choice questions:

_____ X *4 points per question* = _____ points
number of multiple choice questions correct

Short answer questions:

_____ points

Total points on this exam: _____ points

Grade	***Percentage***	***Points on This Exam***
A	89% - 100%	115 - 130
B	78% - 88%	101 - 114
C	65% - 77%	84 - 100
D	55% - 64%	71 - 83
F	0% - 54%	0 - 70

Part I: Multiple Choice Questions

1. D
2. C
3. B
4. C
5. E

6. D
7. D
8. A
9. E
10. C

11. D
12. E
13. A
14. A
15. B

16. D
17. C
18. B
19. A
20. D

21. D
22. A
23. E
24. D

25. B

Part II: Short Answer / Calculation.

1. Lewis structures:
   a. ICl_3: trigonal bipyramid EPG, T-shape MG, dsp^3, polar
   b. $TeBr_2$: tetrahedral EPG, bent MG, sp^3, polar
   c. XeF_4: octahedral EPG, square planar MG, d^2sp^3, nonpolar
   d. BrF_2^{-1}: trigonal bipyramid EPG, linear MG, dsp^3, nonpolar
   e. I_3^{-1}: trigonal bipyramid EPG, linear MG, dsp^3, nonpolar

2. Molecular orbitals:
   N_2: [core electrons] $(\sigma_{2s})^2 (\sigma^*_{2s})^2 (\pi_{2p})^4 (\sigma_{2p})^2$ *bond order* = 3, diamagnetic, *shortest bond length*
   N_2^{+1}: [core electrons] $(\sigma_{2s})^2 (\sigma^*_{2s})^2 (\pi_{2p})^4 (\sigma_{2p})^1$ *bond order* = 2.5, paramagnetic
   N_2^{-1}: [core electrons] $(\sigma_{2s})^2 (\sigma^*_{2s})^2 (\pi_{2p})^4 (\sigma_{2p})^2 (\pi^*_{2p})^1$ *bond order* = 2.5, paramagnetic

3. Short answer:
   square planar
   p (2p, 3p, etc. ok)
   antibonding
   six
   sp^3d