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

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^{2-2} ?

- 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. NO3-
- b. NH₃
- c. SO₃
- d. CO₃²⁻
- e. H₂CO

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 XeF₄ 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, ICl₃.
 - 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. CO₂
- c. CH₃OH
- d. H₂CO
- e. O₃

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
 - $b.\quad sp^2$
 - c. sp³
 - d. sp³d
 - e. sp³d²

Letter answer to question #11:

- 12. In which of the following molecules and ions does the central carbon atom have sp hybridization: Cl₂CO, CH₂Br₂, CO₂, and OCN⁻¹?
 - a. Cl₂CO only
 - b. Cl₂CO and CH₂Br₂
 - c. CH_2Br_2 and CO_2
 - d. CH₂Br₂ and OCN-1
 - e. CO₂ and OCN⁻¹

Letter answer to question #12:

13. What is the molecular geometry around a central atom that is sp² 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?



e. 1, 2, and 3

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

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. H₂²⁻
- b. He₂
- $c. \quad Li_2$
- d. Li₂²⁻
- e. Be₂

Letter answer to question #17:

18. According to molecular orbital theory, what is the bond order of superoxide, O₂-1?

- 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. C₂-2
- b. O₂
- c. NO
- d. N₂-1
- e. B₂-1

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] $(\sigma_{2s})^2 (\sigma_{2p})^2 (\pi_{2p})^4$
- 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?



d. C_2

a.

b.

 N_2 e.

Letter answer to question #21:

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

- Р a.
- b. Ne
- c. F
- d. Li
- e. Ν

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
- Li and F e.

Letter answer to question #23:

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

a. O = -2, Br = -1b. 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) ICl₃

b) TeBr₂

c) XeF₄

d) BrF₂-1

e) I₃-1

2. Draw molecular orbital energy diagrams for N₂, N₂¹⁺ and N₂²⁻. 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:

Grade	Percentage	Points on This Exam
А	89% - 100%	115 - 130
В	78% - 88%	101 - 114
С	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
- 24. D

25. B

Part II: Short Answer / Calculation.

- 1. Lewis structures:
 - a. ICl3: trigonal bipyramid EPG, T-shape MG, dsp3, polar
 - b. TeBr₂: tetrahedral EPG, bent MG, sp³, polar
 - c. XeF4: octahedral EPG, square planar MG, *d*²*sp*³, nonpolar
 - d. BrF₂-1: trigonal bipyramid EPG, linear MG, *dsp*³, nonpolar
 - e. I₃-1: trigonal bipyramid EPG, linear MG, *dsp*³, nonpolar
- 2. Molecular orbitals:

N₂: [core electrons] $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\sigma_{2p})^2$ bond order = 3, diamagnetic, shortest bond length N₂⁺¹: [core electrons] $(\sigma_{2s})^2 (\sigma_{2s}^*)^2 (\pi_{2p})^4 (\sigma_{2p})^1$ bond order = 2.5, paramagnetic N₂⁻¹: [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 sp³d