Name: KEY

Chemistry 111
Test 2
October 27, 2004

Instructions before starting the test:

1. Your exam booklet should have **seven** pages total, with questions on pages 2-5, extra space to work on p. 6, and a periodic table of electronegativities and other reference data on p. 7. Check to see you have seven pages now. If you do not, ask for another copy of the exam.
2. You may remove the last page, which contains reference data.
3. Write your name in the space above and on the backs of pages 2-6.
4. This exam is closed-everything.
5. You may use programmable calculators, but chemical data should not be stored in them.
6. You do **not** need to justify your answers unless you are explicitly told to do so.
7. You have **90 minutes** to work on this exam. (The test should take you only 60 minutes.)

Page (Possible Points)	Your Score
Page 2 (20)	
Page 3 (27)	
Page 4 (28)	
Pages 5-6 (25)	
Total (100)	

Average of Tests 1 and 2	
Midterm Grade	

1. (20 points total) Circle the best answer to each of the following five questions. Your answers need not be justified, and no partial credit will be awarded.

A. The geometry of the CS_2 molecule is best described as $\ddot{S}=C=\ddot{S}$

(a) tetrahedral (b) linear (c) trigonal planar

(d) trigonal pyramidal (e) bent

B. Which of the following statements about molecular structure is true?

(a) The fact that NH_3 has a larger bond angle than H_2O is due to the greater repulsion between the two lone pairs on the O in H_2O. NO: lp ↔ lp acts perpendicular to H-O-H plane

(b) In PCl_5, all five P-Cl bonds are identical in length. NO r(P-Cl$_{ax}$) > r(P-Cl$_{eq}$)

(c) Experiment indicates all molecules with an even number of electrons are diamagnetic. NO: e.g. O_2

(d) It is impossible for a bonding molecular orbital to contain a node. NO - eg π_{2p}

(e) None of statements (a), (b), (c), or (d) are true.

C. Which of the following statements about molecular structure is false?

(a) The bond angle in SCl_2 will be larger than the bond angle in SBr_2. F, since $\chi(Cl) > \chi(Br)$

(b) A trigonal planar geometry can be explained by the hybridization of an *s* atomic orbital with the p_x and p_y atomic orbitals. T

(c) In NH_3, the lone pair on N occupies an sp^3 hybrid orbital. T

(d) Hybrid orbitals are used to make sigma bonds in molecules. T

(e) In BeH_2, the Be atom has two empty, unhybridized *p* orbitals. T

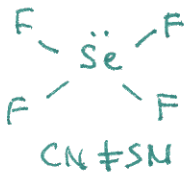
D. The valence electron configuration for a second-row diatomic molecular cation, Z_2^{2+}, is $(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^4(\pi^*_{2p})^2$. What is the identity of element Z?

(a) C (b) N (c) O (d) F (e) Ne

F_2 : 14 valence e⁻s
F_2^{2+}: 12 valence e⁻s
same as in valence e⁻ config

E. Which of the following substances is polar?

(a) CO_2 (b) BF_3 (c) SeF_4 (d) PF_5 (e) SF_6



CN ≠ SN

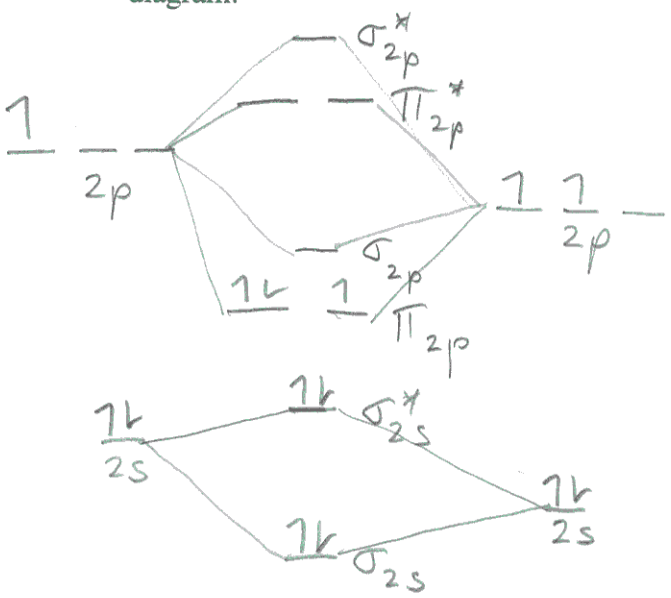
2. Lewis structures (valence bond theory) and molecular orbital theory sometimes make different predictions of the properties of novel species.

(a) (9 points) Draw the best possible Lewis structure for boron carbide (BC), and use this structure to predict BC's bond order (B. O.). Best is B≡C·

-2 if ·B=C: (possible to ↑ B.O. from 2 to 3)
-4 formal charge error -3 wrong B.O.
-5 wrong # of e⁻'s -4 separated formal charge
-5 3 unpaired e⁻'s -4 if :B–C: (very low B.O.)

B. O. = 3 (full credit if self-consistent)

(b) (14 points) Predict the bond order of BC by drawing and filling in the correct molecular orbital (MO) energy level diagram. You are required to include the atomic orbitals as part of the MO diagram. Be sure to label which atom corresponds to which side of the diagram.



-4 AO's drawn as equal in E
-4 wrong BO
-5 wrong diagram (for incorrectly drawn)
-5 wrong # of e⁻'s
-5 wrong # of AO's (eg only 1 2p AO per atom)
-5 AO's lower in E than bonding MO (-2 if diagram already penalized)

B.O. = ½(5-2) = 3/2

minimum points (if same work): 2/14

Bond Order = 1.5 (full credit if self-consistent)

(c) (4 points) Which picture on the overhead projector corresponds to boron carbide's highest occupied molecular orbital (HOMO)?

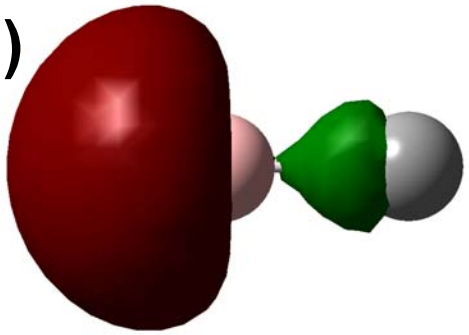
(i) σ* (ii) π (iii) π* (iv) σ

(Circle the correct answer. You do not need to justify your answer.)

Boron Carbide (BC) Molecular Orbitals

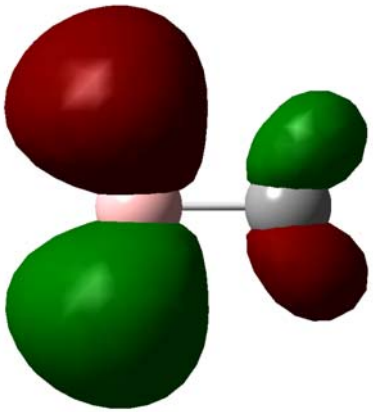
(in each case, boron is on the left and carbon is on the right)

(i)

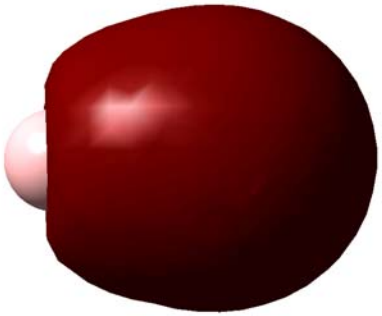


(ii)

(iii)



(iv)



incorrect
+1 something