NAME:____________________________ Section:_____ Student Number:__________________

Spring 2014 **Chemistry 2000 Midterm #1A** ____/50 marks

INSTRUCTIONS:
1) Please read over the test carefully before beginning. You should have 7 pages of questions, a blank "overflow" page and a periodic table page.
2) If your work is not legible, it will be given a mark of zero.
3) Marks will be deducted for incorrect information added to an otherwise correct answer.
4) Calculators are not permitted.
5) You have 90 minutes to complete this test.

Confidentiality Agreement:
I agree not to discuss (or in any other way divulge) the contents of this exam until after 8:00pm Mountain Time on Tuesday, February 11th, 2014. I understand that breaking this agreement would constitute academic misconduct, a serious offense with serious consequences. The minimum punishment would be a mark of 0/50 on this exam and removal of the "overwrite midterm mark with final exam mark" option for my grade in this course; the maximum punishment would include expulsion from this university.

Signature: ____________________________ Date: ______________________________
Course: CHEM 2000 (General Chemistry II)
Semester: Spring 2014
The University of Lethbridge

Question Breakdown

Q1	/ 5
Q2	/ 24
Q3	/ 15
Q4	/ 6

Total	/ 50

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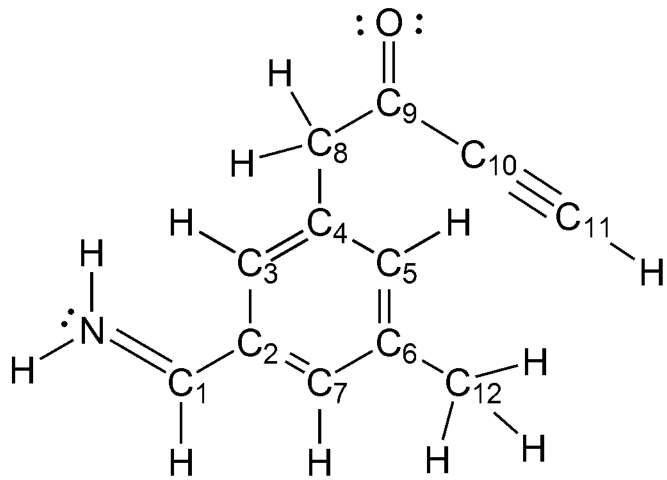
1. Consider the following molecule in accordance with valence bond theory: **[5 marks]**



(a) What is the hybridization for each of the carbon atoms in this molecule? *[3 marks]*

Carbon #	Hybrid orbital
C_1	
C_2	
C_3	
C_4	
C_5	
C_6	

Carbon #	Hybrid orbital
C_7	
C_8	
C_9	
C_{10}	
C_{11}	
C_{12}	

(b) How many σ bonds are there in this molecule? *[1 mark]*

(c) How many π bonds are there in this molecule? *[1 mark]*

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2. **[24 marks]**

(a) Construct a valence molecular orbital diagram for NO^+. Label all atomic and molecular orbitals on your diagram and include tie lines to show the linear combinations that form each molecular orbital. Place the correct number of valence electrons into the atomic orbitals as well as the molecular orbitals. It is not necessary to draw pictures of the orbitals for this part of the question. *[9 marks]*

(b) On the diagram above, clearly label the highest occupied molecular orbital(s) of NO^+ as the "HOMO"(s). In the space below, draw a picture of this/these molecular orbital(s). Clearly indicate the phase, location of the nuclei, and relative amounts of electron density on each atom. *[3 marks]*

(c) On the diagram above, clearly label the lowest unoccupied molecular orbital(s) of NO^+ as the "LUMO"(s). In the space below, draw a picture of this/these molecular orbital(s). Clearly indicate the phase, location of the nuclei, and relative amounts of electron density on each atom. *[3 marks]*

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2. continued

(d) Write the valence orbital occupancy (i.e. electron configuration) in line notation for NO^+. *[1 mark]*

(e) Provide a molecular formula for one neutral diatomic molecule that is isoelectronic with NO^+. *[1 mark]*

(f) Draw the Lewis structure for NO^+. What N–O bond order does your Lewis diagram predict? *[2 marks]*

(g) What bond order does your MO treatment predict for NO^+? Does it agree with the bond order from the Lewis diagram? *[2 marks]*

(h) What is the bond order if we add an electron to NO^+ (i.e. what is the bond order in neutral NO)? *[1 mark]*

(i) Is the N–O bond strengthened or weakened in NO versus NO^+? Briefly explain why or why not. *[1 mark]*

(j) Which of the following molecules is paramagnetic: NO^+, NO, NO^-. *[1 mark]*

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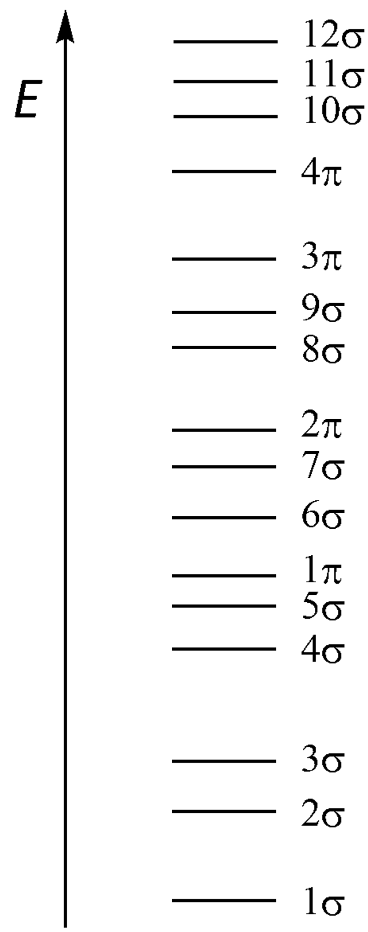
3. **[15 marks]**

The valence molecular orbital diagram for planar nitryl fluoride, NO_2F (nitrogen is the central atom) is shown below. Note that the σ or π character of each MO is indicated, but NOT the nature of the overall interaction (i.e. whether it has bonding, antibonding, or non-bonding character).



(a) Draw the Lewis structure of NO_2F. Include any possible resonance structures for this molecule. *[2 marks]*

(b) What is the bond order for NO (*hint: ignore the N–F*) in NO_2F according to your Lewis structure(s)? *[1 mark]*

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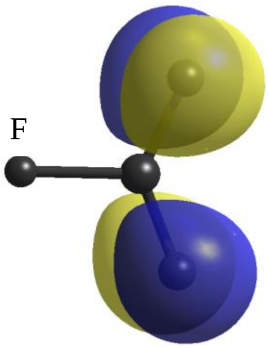
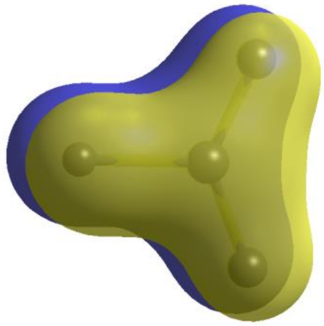
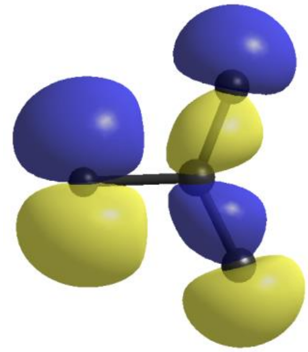
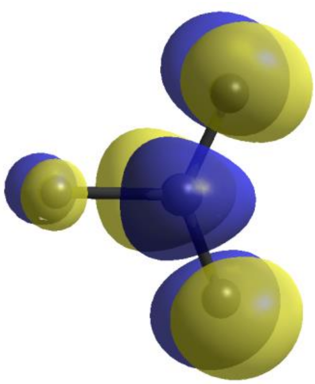
3. continued

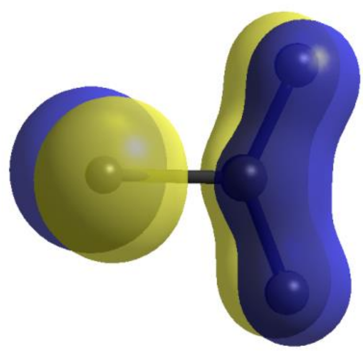
(c) Five orbital pictures for NO_2F are provided below (they are all in the same orientation). Four of them belong to π MOs, while one is a σ MO. In the space below each picture, identify the four π MOs and one σ MO, and assign the correct labels <u>for the π MOs only</u> (the sigma MO can just be labeled as σ to differentiate it from the π MOs). *[5 marks]*











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3. continued.

(d) Of the four π MOs shown: *[4 marks]*
Which should be considered as bonding π MOs? Justify your answer.

Which should be considered as antibonding π MOs? Justify your answer.

Which should be considered as non-bonding π MOs? Justify your answer.

(e) Fill in the valence electrons for the MO diagram of nitryl fluoride. How many electrons are in σ MOs? How many are in π MOs? *[2 marks]*

(f) How many normal modes of vibration should NO_2F have? *[1 mark]*

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4. **[6 marks]**

Provide definitions for the following terms, and where appropriate give an example of each.

(a) intrinsic semiconductor

(b) extrinsic semiconductor

(c) ultraviolet photoelectron spectroscopy

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Overflow Page

If you use this page for any answers, please clearly indicate which question is being answered and make sure you note on the page for the question itself that the answer continues here.

Chem 2000 Standard Periodic Table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.0079 **H** 1																	4.0026 **He** 2
6.941 **Li** 3	9.0122 **Be** 4											10.811 **B** 5	12.011 **C** 6	14.0067 **N** 7	15.9994 **O** 8	18.9984 **F** 9	20.1797 **Ne** 10
22.9898 **Na** 11	24.3050 **Mg** 12											26.9815 **Al** 13	28.0855 **Si** 14	30.9738 **P** 15	32.066 **S** 16	35.4527 **Cl** 17	39.948 **Ar** 18
39.0983 **K** 19	40.078 **Ca** 20	44.9559 **Sc** 21	47.88 **Ti** 22	50.9415 **V** 23	51.9961 **Cr** 24	54.9380 **Mn** 25	55.847 **Fe** 26	58.9332 **Co** 27	58.693 **Ni** 28	63.546 **Cu** 29	65.39 **Zn** 30	69.723 **Ga** 31	72.61 **Ge** 32	74.9216 As 33	78.96 **Se** 34	79.904 **Br** 35	83.80 **Kr** 36
85.4678 **Rb** 37	87.62 **Sr** 38	88.9059 **Y** 39	91.224 **Zr** 40	92.9064 **Nb** 41	95.94 **Mo** 42	(98) **Tc** 43	101.07 **Ru** 44	102.906 **Rh** 45	106.42 **Pd** 46	107.868 **Ag** 47	112.411 **Cd** 48	114.82 **In** 49	118.710 **Sn** 50	121.757 **Sb** 51	127.60 **Te** 52	126.905 **I** 53	131.29 **Xe** 54
132.905 **Cs** 55	137.327 **Ba** 56	**La-Lu**	178.49 **Hf** 72	180.948 **Ta** 73	183.85 **W** 74	186.207 **Re** 75	190.2 **Os** 76	192.22 **Ir** 77	195.08 **Pt** 78	196.967 **Au** 79	200.59 **Hg** 80	204.383 **Tl** 81	207.19 **Pb** 82	208.980 **Bi** 83	(210) **Po** 84	(210) **At** 85	(222) **Rn** 86
(223) **Fr** 87	226.025 **Ra** 88	**Ac-Lr**	(261) **Rf** 104	(262) **Db** 105	(263) **Sg** 106	(262) **Bh** 107	(265) **Hs** 108	(266) **Mt** 109	(281) **Dt** 110	(283) **Rg** 111							

138.906 **La** 57	140.115 **Ce** 58	140.908 **Pr** 59	144.24 **Nd** 60	(145) **Pm** 61	150.36 **Sm** 62	151.965 **Eu** 63	157.25 **Gd** 64	158.925 **Tb** 65	162.50 **Dy** 66	164.930 **Ho** 67	167.26 **Er** 68	168.934 **Tm** 69	173.04 **Yb** 70	174.967 **Lu** 71
227.028 **Ac** 89	232.038 **Th** 90	231.036 **Pa** 91	238.029 **U** 92	237.048 **Np** 93	(240) **Pu** 94	(243) **Am** 95	(247) **Cm** 96	(247) **Bk** 97	(251) **Cf** 98	(252) **Es** 99	(257) **Fm** 100	(258) **Md** 101	(259) **No** 102	(260) **Lr** 103

Developed by Prof. R. T. Boeré