

Name \_\_\_\_\_

Student Number \_\_\_\_\_

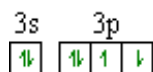
## Chem 241 Section 51 - Mid-term Exam - 1¼ hours

October 23<sup>rd</sup>, 2013

Answer all the questions on this examination paper. Use the back of the periodic table for rough work or extra space: **do not detach it.**

- 1) (1 mark) Fluorine-19 is the only stable isotope of fluorine. All other are radioactive. Which mode of decay is most likely for Fluorine-18?
  - a)  $^{18}\text{F} + \beta^- \rightarrow ^{18}\text{O}$
  - b)  $^{18}\text{F} \rightarrow ^{18}\text{Ne} + \beta^-$
  - c)  $^{18}\text{F} \rightarrow ^9\text{Be} + ^9\text{B}$
  
- 2) (1 mark) Consider the following orbitals: 4s, 5s, 6s, 4p<sub>x</sub>, 5p<sub>x</sub>, 6p<sub>x</sub>, 4d<sub>z<sup>2</sup></sub>, 5d<sub>z<sup>2</sup></sub> and 6d<sub>z<sup>2</sup></sub>. Which orbitals feature 3 radial (spherical) nodes?
  - a) 4s, 5p<sub>x</sub>, 6d<sub>z<sup>2</sup></sub>
  - b) 5s, 6p<sub>x</sub>
  - c) 4d<sub>z<sup>2</sup></sub> only
  - d) None of the above
  
- 3) (1 mark) A rhodium atom in the gas phase has the configuration [Kr]5s<sup>1</sup>4d<sup>8</sup>. In rhodium (I) compounds (Rh<sup>+</sup>), the configuration of the ion is:
  - a) [Kr]5s<sup>2</sup>4d<sup>6</sup>
  - b) [Kr]5s<sup>1</sup>4d<sup>7</sup>
  - c) [Kr]5s<sup>0</sup>4d<sup>8</sup>
  - d) [Kr]5s<sup>0</sup>4d<sup>6</sup>
  
- 4) (1 mark) A Xenon atom has configuration: 1s<sup>2</sup>2s<sup>2</sup>2p<sup>6</sup>3s<sup>2</sup>3p<sup>6</sup>4s<sup>2</sup>3d<sup>10</sup>4p<sup>6</sup>5s<sup>2</sup>4d<sup>10</sup>5p<sup>6</sup>. Which of the following represents the valence shell and atomic ground state used in describing the bonding and structure of its compounds when using valence bond theory?
  - a) 4d<sup>10</sup>5s<sup>2</sup>5p<sup>6</sup>
  - b) 5s<sup>2</sup>5p<sup>6</sup>5d<sup>0</sup>
  - c) 5s<sup>2</sup>5p<sup>6</sup>5d<sup>10</sup>
  - d) 4d<sup>10</sup>5s<sup>2</sup>5p<sup>6</sup>5d<sup>0</sup>

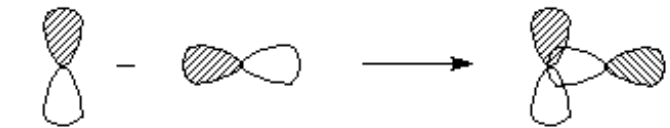
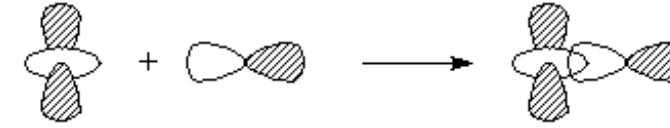
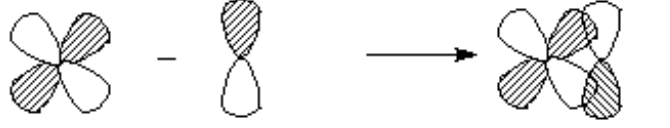
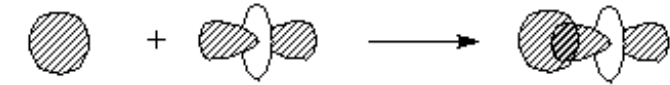
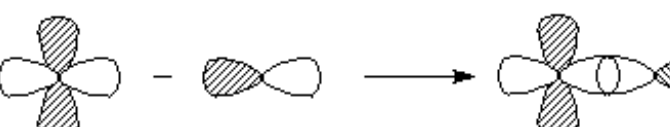
- 5) (1 mark) Several different radii can be attributed to an element. For fluorine, which is the correct order for increasing radius:
- F(covalent) < F<sup>-</sup>(4-coordinate) < F<sup>-</sup>(6-coordinate)
  - F(covalent) < F<sup>-</sup>(6-coordinate) < F<sup>-</sup>(4-coordinate)
  - F<sup>-</sup>(6-coordinate) < F<sup>-</sup>(4-coordinate) < F(covalent)
  - ~~F<sup>-</sup>(6-coordinate) < F<sup>-</sup>(4-coordinate) < F(covalent)~~
  - None of the above
- 6) (1 mark) Consider removal of the last electron from the ions Li<sup>2+</sup> and Be<sup>3+</sup>. Which of the following statements is true?
- The ionization energies for the two ions are equal.
  - Li<sup>2+</sup> is 1.33 times more difficult to ionize than Be<sup>3+</sup>
  - Be<sup>3+</sup> is 1.33 times more difficult to ionize than Li<sup>2+</sup>
  - Li<sup>2+</sup> is 1.78 times more difficult to ionize than Be<sup>3+</sup>
  - Be<sup>3+</sup> is 1.78 times more difficult to ionize than Li<sup>2+</sup>
- 7) (2 marks) The diagram below shows an electron configuration.



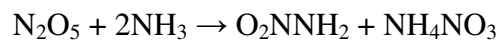
Which **two** of the following statements are true?

- The configuration is forbidden by Hund's rule
- The configuration represents an excited state as defined by Hund's rule
- The diagram could be showing the valence electrons of Se
- The configuration is not forbidden by the Pauli principle

- 8) (5 marks) Five linear combinations of atomic orbitals to make molecular orbitals are depicted below. Mark whether the resulting molecular orbital is classified as bonding, antibonding, or non-bonding, and if they are bonding or antibonding, indicate whether the molecular orbitals are  $\sigma$  or  $\pi$ . (The shading is indicative of the *relative* signs of  $\psi$ , that is, unshaded means positive  $\psi$ , shaded means negative  $\psi$  (or the reverse)).

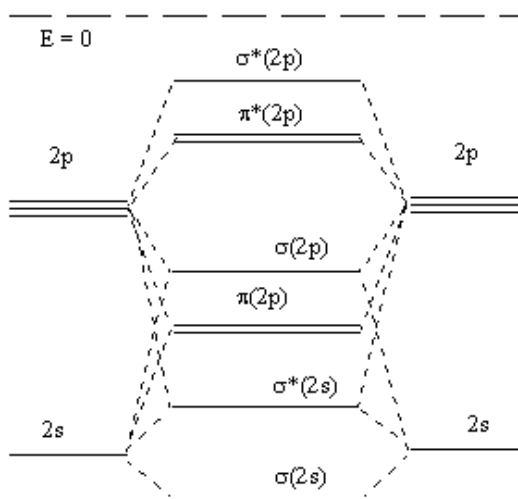
Combination	Bonding, antibonding or nonbonding?	$\sigma$ or $\pi$ ?
		
		
		
		
		

- 9) Nitramide,  $\text{NH}_2\text{NO}_2$ , an lesser-known nitrogen compound with a nitrogen – nitrogen single bond, can be made from dinitrogen pentoxide and ammonia:



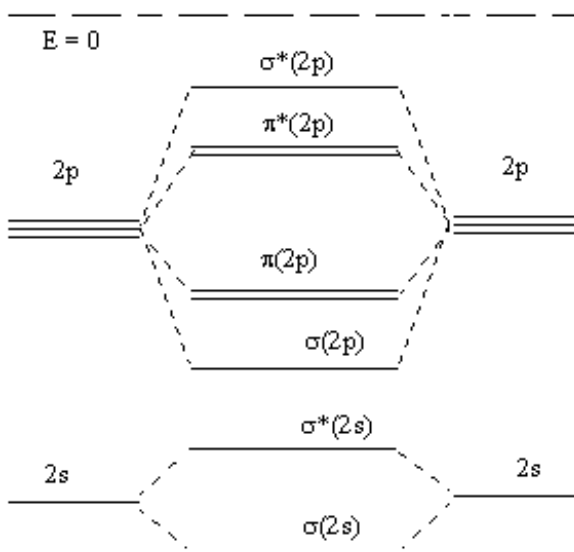
- a) (3 marks) Draw a Lewis structure for the compound, and give the geometry and hybridization at each of the nitrogen atoms.
- b) (1 mark) For your Lewis structure and any equivalent canonical (resonance) structures, what is the average nitrogen – oxygen bond order, and (average) charges on individual atoms.
- 10) (2 marks) Using box diagrams of their electron configurations, explain why the electron affinity of phosphorus is *smaller* than that of silicon, although in general, electron affinities *increase* across a period.

- 11) (3 marks) Three molecular orbital energy level diagrams are shown below. Using the correct diagram for each case, show the electrons on the molecular orbital levels for  $B_2$ ,  $O_2^{2-}$ , and  $CN^-$ . Please make sure to distinguish which molecule or ion you are putting on which diagram by completing the labels below the diagrams. Give the bond order of each species.



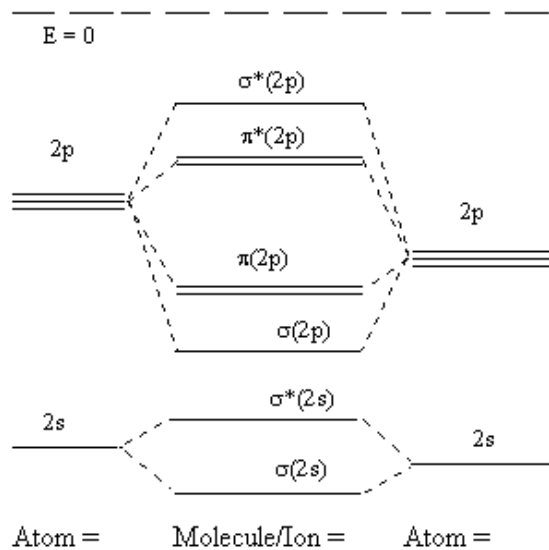
Atom =      Molecule/Ion =      Atom =

Bond Order =



Atom =      Molecule/Ion =      Atom =

Bond Order =



Bond order =

- 12) (3 marks) The H-N-H angle in ammonia is about  $107^\circ$ , and as one goes down the pnictogen group (Group 15), the equivalent angle decreases so that the H-Sb-H angle is about  $90^\circ$  in stibine,  $\text{SbH}_3$ . What effect causes this decrease in bond angle.

# Periodic Table of the Elements

1

18

1 <b>H</b> 1.008																	2 <b>He</b> 4.00	
3 <b>Li</b> 6.941	4 <b>Be</b> 9.012															9 <b>F</b> 18.998	10 <b>Ne</b> 20.18	
11 <b>Na</b> 22.99	12 <b>Mg</b> 24.31															17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95	
19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.87	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.69	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.39	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.61	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.80	
37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.94	43 <b>Tc</b> (97.91)	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.41	49 <b>In</b> 114.82	50 <b>Sn</b> 118.71	51 <b>Sb</b> 121.76	52 <b>Te</b> 127.60	53 <b>I</b> 126.90	54 <b>Xe</b> 131.29	
55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.33	<b>La-Lu</b>		72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.84	75 <b>Re</b> 186.21	76 <b>Os</b> 190.2	77 <b>Ir</b> 192.22	78 <b>Pt</b> 195.08	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.38	82 <b>Pb</b> 207.2	83 <b>Bi</b> 208.98	84 <b>Po</b> 208.98	85 <b>At</b> 209.99	86 <b>Rn</b> 222.02
87 <b>Fr</b> 223	88 <b>Ra</b> 226.03	<b>Ac-Lr</b>		104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (263)	107 <b>Bh</b> (262)	108 <b>Hs</b> (265)	109 <b>Mt</b> (266)									

57 <b>La</b> 138.91	58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.35	63 <b>Eu</b> 151.97	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.93	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.93	70 <b>Yb</b> 173.04	71 <b>Lu</b> 174.97
89 <b>Ac</b> 227.03	90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> (237)	94 <b>Pu</b> (245)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (260)