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Student Number _____

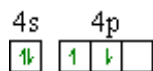
Chem 241 Section 01 - Mid-term Exam - 1¼ hours

October 22nd, 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 mark) Iodine-127 decays radioactively to give xenon-127, which then decays to give cesium-127. Which of the following statement is correct:
 - Iodine-127 decays by γ decay, and then xenon-127 decays by β decay.
 - Iodine-127 decays by α decay, and then Xenon-127 decays by β decay.
 - Both iodine-127 and xenon-127 decay by β decay.
- (1 mark) Consider the following orbitals: 3s, 4s, 5s, 3p_x, 4p_x, 5p_x, 3d_{xy}, 4d_{xy} and 5d_{xy}. Which orbital(s) feature 2 radial (spherical) nodes **and** 1 planar node?
 - 2s, 3p_x and 4d_{xy}
 - 5s, 4p_x and 3d_{xy}
 - 4p_x only
 - None of the above
- (1 mark) A copper atom (in the gas phase) has the configuration [Ar]4s¹3d¹⁰. In cuprous *compounds* (Cu⁺), the configuration of the ion is:
 - [Ar]4s²3d⁸
 - [Ar]4s²3d¹⁰
 - [Ar]4s¹3d⁹
 - [Ar]4s⁰3d¹⁰
- (1 mark) An Antimony atom has configuration: 1s²2s²2p⁶3s²3p⁶4s²3d¹⁰4p⁶5s²4d¹⁰5p³. 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?
 - 4d¹⁰5s²5p³
 - 5s²5p³5d⁰
 - 5s²5p³5d¹⁰
 - 4d¹⁰5s²5p³5d⁰


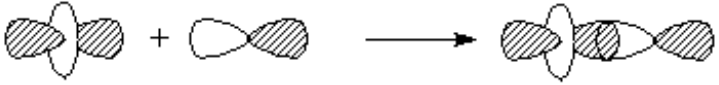
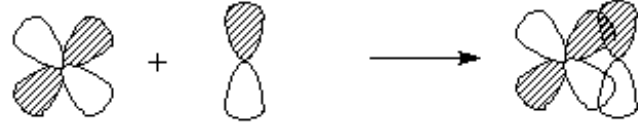
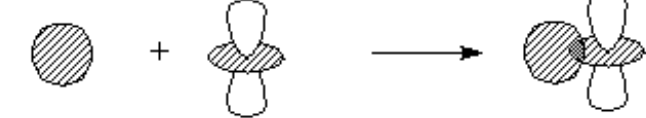

- 5) (1 mark) Several different radii can be attributed to an element. For potassium, which is the correct order for increasing radius:
- $K(\text{metallic}) < K^+(6\text{-coordinate}) < K^+(8\text{-coordinate})$
 - $K^+(6\text{-coordinate}) < K^+(8\text{-coordinate}) < K(\text{metallic})$
 - $K(\text{metallic}) < K^+(8\text{-coordinate}) < K^+(6\text{-coordinate})$
 - $K^+(8\text{-coordinate}) < K(\text{metallic}) < K^+(6\text{-coordinate})$
- 6) (1 mark) Consider the ionization of the remaining electron of He^+ . Compared with ionization from the ground state ($n = 1$), which of the following is true?
- It is 9 times more difficult to remove the last electron if, instead, it starts out in the $n = 3$ level.
 - It is 3 times more difficult to remove the last electron if, instead, it starts out in the $n = 3$ level.
 - It is 9 times easier to remove the last electron if, instead, it starts out in the $n = 3$ level.
 - It is 3 times easier to remove the last electron if, instead, it starts out in the $n = 3$ level.
- 7) (2 marks) The diagram below shows an electron configuration.



Which *two* of the following statements are true?

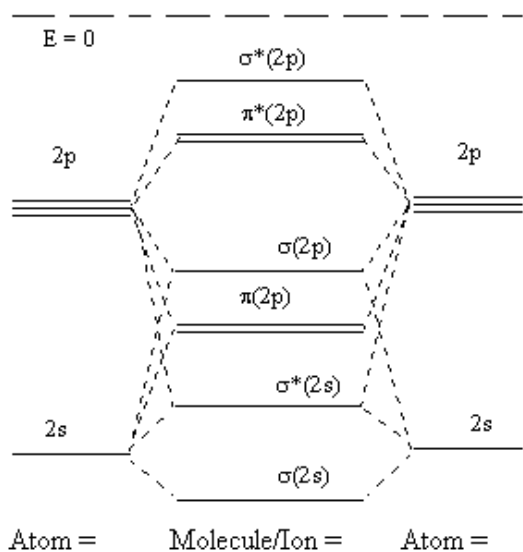
- The configuration is forbidden by Hund's rule
- The configuration represents an excited state as defined by Hund's rule
- The diagram could be showing the valence electrons of Ge
- The configuration is forbidden by the Pauli principle

- 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 neither, and if they are bonding or antibonding, indicate whether the molecular orbitals are σ or π . (The shading is indicative of the *relative* signs of ψ , that is, unshaded means positive ψ , shaded means negative ψ (or the reverse)).

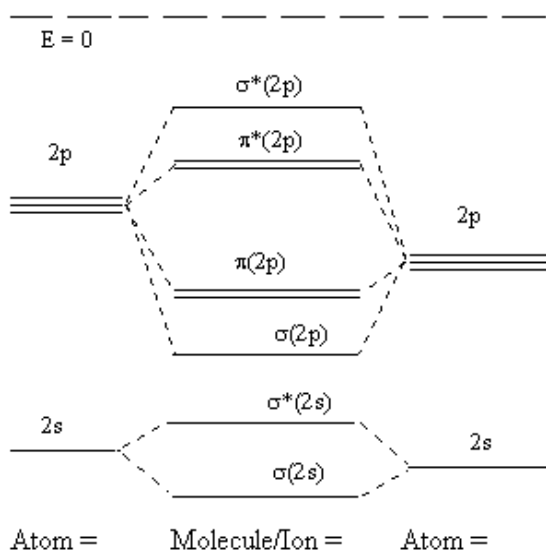
Combination	Bonding, antibonding or nonbonding?	σ or π ?
		
		
		
		
		

- 9) The chemistry of the oxy-acids and their salts of sulphur is quite complicated: be thankful we do not ask you to memorize them all! One ion is the disulphite ion, which can be isolated as $\text{Na}_2\text{S}_2\text{O}_5$. The anion contains a sulphur – sulphur single bond.
- a) (3 marks) Draw a Lewis structure for the anion, and give the geometry and hybridization at each of the sulphur atoms.
- b) (1 mark) In your Lewis structure and any equivalent canonical (resonance) structures, what are the sulphur – oxygen bond orders, and (average) charges on the individual atoms.
- 10) (2 marks) Explain the difference between the covalent radius, and the van der Waals radius of an atom.

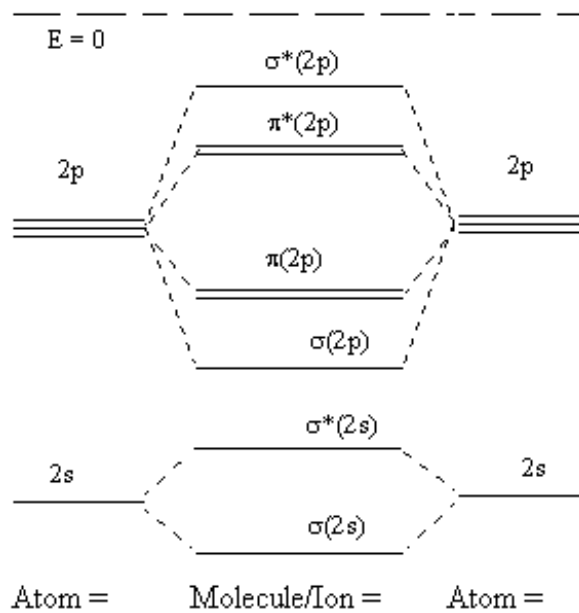
- 11) (3 marks) Three molecular orbital energy level diagrams are shown below. *Using the correct diagram for each case*, show the electrons on the molecular orbital levels for C_2 , O_2 , and NO^+ . Please make sure to distinguish which molecule or ion you are putting on which diagram by completing the labels below the diagrams. Give the bond order of each species.



Bond Order =



Bond order =



Bond order =

- 12) (3 marks) Molecular orbital theory is more successful at describing the molecule O_2 than Valence Bond (Lewis) theory. Briefly explain this statement. (You can refer to question 11 if you wish.)

Periodic Table of the Elements

1

18

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

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