Chemistry 141 Name

Dr. Cary Willard

Exam 3A April 28, 2008

Multiple Choice (30 points)

Page 1 (30 points)

Page 2 (24 points)

Page 3 (14 points)

Page 4 (22 points)

Total (120 points)

All work must be shown to receive credit.



Grossmont College

Periodic Table

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| IA |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  | VIIA | NOBLE GASES |
| 1  **H**  1.008 | IIA |  |  |  |  |  |  |  |  |  | |  | IIIA | IVA | VA | VIA | 1  **H**  1.008 | 2  **He**  4.002 |
| 3  **Li**  6.941 | 4  **Be**  9.012 |  |  |  |  |  |  |  |  |  | |  | 5  **B**  10.81 | 6  **C**  12.01 | 7  **N**  14.01 | 8  **O**  16.00 | 9  **F**  19.00 | 10  **Ne**  20.18 |
| 11  **Na**  23.00 | 12  **Mg**  24.30 | IIIB | IVB | VB | VIB | VIIB | VIII VIII VIII | | | | IB | IIB | 13  **Al**  27.00 | 14  **Si**  28.09 | 15  **P**  30.97 | 16  **S**  32.06 | 17  **Cl**  35.45 | 18  **Ar**  39.95 |
| 19  **K**  39.10 | 20  **Ca**  40.08 | 21  **Sc**  44.96 | 22  **Ti**  47.90 | 23  **V**  50.94 | 24  **Cr**  52.00 | 25  **Mn**  54.94 | 26  **Fe**  55.85 | 27  **Co**  58.93 | 28  **Ni**  58.70 | | 29  **Cu**  63.55 | 30  **Zn**  65.38 | 31  **Ga**  69.72 | 32  **Ge**  72.59 | 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**  (99) | 44  **Ru**  101.1 | 45  **Rh**  102.9 | 46  **Pd**  106.4 | 47  **Ag**  107.9 | | 48  **Cd**  112.4 | 49  **In**  114.8 | 50  **Sn**  118.7 | 51  **Sb**  121.8 | 52  **Te**  127.6 | 53  **I**  126.9 | 54  **Xe**  131.3 |
| 55  **Cs**  132.9 | 56  **Ba**  137.3 | 57  **La**  138.9 | 72  **Hf**  178.5 | 73  **Ta**  180.9 | 74  **W**  183.9 | 75  **Re**  186.2 | 76  **Os**  190.2 | 77  **Ir**  192.2 | 78  **Pt**  195.1 | 79  **Au**  197.0 | | 80  **Hg**  200.6 | 81  **Tl**  204.4 | 82  **Pb**  207.2 | 83  **Bi**  209.0 | 84  **Po**  (209) | 85  **At**  (210) | 86  **Rn**  (222) |
| 87  **Fr**  (223) | 88  **Ra**  226.0 | 89  **Ac**  227.0 | 104  **Rf**  (261) | 105  **Db**  (262) | 106  **Sg**  (263) | 107  **Bh**  (262) | 108  **Hs**  (265) | 109  **Mt**  (266) | 110  **??**  (269) |  | |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| 58  **Ce**  140.1 | 59  **Pr**  140.9 | 60  **Nd**  144.2 | 61  **Pm**  (147) | 62  **Sm**  150.4 | 63  **Eu**  152.0 | 64  **Gd**  157.3 | 65  **Tb**  158.9 | 66  **Dy**  162.5 | 67  **Ho**  164.9 | 68  **Er**  167.3 | 69  **Tm**  168.9 | 70  **Yb**  173.0 | 71  **Lu**  175.0 |
| 90  **Th**  232.0 | 91  **Pa**  231.0 | 92  **U**  238.0 | 93  **Np**  (237) | 94  **Pu**  (244) | 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) |

Lanthanide series

Actinide series

Multiple Choice (30 points)

1. Which two ions have the same electron configuration in the ground state?
   1. Se2+ and I-
   2. Ba2+ and I-
   3. Rb+ and Cs+
   4. Fe2+ and Fe3+
   5. none of the above
2. Most of the compounds of the 2+ ions of the first row of the transition metals from Mn to Zn are colored due to absorption of visible light promoting an electron from one 3*d* orbital to another. Which of these ions should tend to form colorless compounds?
   1. Zn2+
   2. Mg2+
   3. Co2+
   4. Mn2+
   5. Cu2+
3. Indicate which is larger in each of the following two sets.

(I) Cr3+ or Cr (II) Se2- or Se

* 1. Cr is larger than Cr3+ and Se2- is larger than Se.
  2. Cr3+ is larger than Cr and Se is larger than Se2-.
  3. Cr is larger than Cr3+ and Se is larger than Se2-.
  4. Cr3+ is larger than Cr and Se2- is larger than Se.
  5. unable to determine which is larger

1. Of the following, which element has the highest first ionization energy?
   1. sodium
   2. lithium
   3. boron
   4. beryllium
   5. potassium
2. Which of the following represents the change in electronic configuration that is associated with the first ionization energy of magnesium?
   1. [Ne]3*s2* 🡪 [Ne]3*s1*3*p1*
   2. [Ne]3*s2* 🡪 [Ne]3*s1* + e-
   3. [Ne]3*s2* + e- 🡪 [Ne]3*s2*3*p1*
   4. [Ne]3*s1*3*p1* 🡪 [Ne]3*s1* + e-
   5. None of the above
3. Covalent bonding is a
   1. loss of electrons.
   2. gain of electrons.
   3. sharing of electrons.
   4. transfer of electrons.
   5. none of the above
4. Of the following elements, which has the lowest electronegativity?
   1. Ca
   2. Br
   3. Mg
   4. Cl
   5. O
5. Which chemical process is associated with the lattice energy for sodium chloride? (For this problem we are defining lattice energy as a positive value)
   1. NaCl(*g*) 🡪 Na+(*g*) + Cl-(*g*)
   2. NaCl(*s*) + H2O(*l*) 🡪 Na+(*aq*) + Cl-(*aq*)
   3. Na(*s*) + 1/2 Cl2(*g*) 🡪 NaCl(*s*)
   4. Na(*g*) + Cl (*g*) 🡪 NaCl(*s*)
   5. NaCl(*s*) 🡪 Na+(*g*) + Cl-(*g*)
6. Which bond should have the highest bond dissociation energy?
   1. N-N
   2. N=N
   3. N≡N
   4. All three bonds should have about the same dissociation energy.
   5. unable to determine
7. The greater the electronegativity difference between two bonded atoms, the
   1. greater the bond order.
   2. more unstable the bond.
   3. greater the covalent character of the bond.
   4. greater the ionic character of the bond.
   5. unable to determine.
8. Which element can expand its valence shell to accommodate more than eight electrons?
   1. P
   2. C
   3. O
   4. He
   5. Li
9. What geometric arrangement of charge clouds is expected for an atom that has five charge clouds?
   1. square planar
   2. tetrahedral
   3. square pyramidal
   4. octahedral
   5. trigonal bipyramidal
10. Which of the following is **not** true?
    1. An *sp3* hybrid orbital may form a sigma bond by overlap with an orbital on another atom.
    2. An *sp3* hybrid orbital may form a pi bond by overlap with an orbital on another atom.
    3. An *sp3* hybrid orbital may hold a lone pair of electrons.
    4. The *sp3* hybrid orbitals are degenerate.
    5. All of the above are true.
11. A triple bond is generally composed of
    1. three  bonds.
    2. three  bonds.
    3. two  bonds and one  bond.
    4. one  bond and two  bonds.
    5. one  bond, one  bond and one  bond
12. Compare the energies of molecular orbitals of homonuclear diatomic molecules with the energies of the atomic orbitals with which they correlate.
    1. Both bonding and antibonding molecular orbitals lie lower in energy than the atomic orbitals.
    2. Bonding orbitals are higher and antibonding orbitals are lower in energy than the atomic orbitals.
    3. Both bonding and antibonding molecular orbitals are higher in energy than the atomic orbitals.
    4. Bonding orbitals are lower and antibonding orbitals are higher in energy than the atomic orbitals.
    5. Bonding and antibonding energies are not related to atomic orbital energy levels.

Problems

1. (9 points) Write the electron configurations for the following atoms or ions as predicted by the periodic table
   1. Si (complete configuration)

1s2 2s2 2p6 3s2 3p2

* 1. Ta (shorthand configuration)

[Xe] 6s2 5d3 4f14

* 1. Nb +2 (shorthand configuration)

[Kr] 4d3

1. (6 points) Arrange the following atoms in order of increasing atomic radius
   1. Br, Se, Te. Justify your choices.

Br<Se<Te

Br is smaller than Se because atomic sizes decrease as you move across the periodic table to the right. Se is smaller than Te because atomic sizes increase as you go down a column.

1. (5 points) How are atomic size and first ionization energy related? Explain this relationship. (i.e. why does it make sense that these two properties are related?)

Atoms with smaller atomic sizes have larger ionization energies. This is because the smaller an atom is, the more closely its electrons are held and the more difficult it is to take them away. As electrons get far from the nucleus the attractive forces becomes weaker

1. (5 points) If energy is required to form monatomic ions from metals and nonmetals, why do ionic compounds exist?

Although energy is required to form monatomic ions, the amount of energy recovered when these atoms come together to form an ionic crystal is significantly more favorable resulting in an overall favorable process.

1. (5 points) Explain how sigma and pi bonds differ.

Sigma bonds have overlap between the atoms and pi bonds have overlap above and below the atoms.

1. (18 points) Write reasonable Lewis Electron Dot Structures for the following molecules or ions (Central atom is listed first). Tell the orbital and molecular geometry for each molecule/ion. Show formal charges for all non-zero charges. If resonance structures exist, show them.

|  |  |  |
| --- | --- | --- |
| POCl3  P is central atom |  | orbital geometry  tetrahedral  molecular geometry  tetrahedral |
| SF2 |  | orbital geometry  tetrahedral  molecular geometry  bent |
| ICl2-1  (one iodine two chlorines!) |  | orbital geometry  trigonal bipyramidal  molecular geometry  linear |

1. (6 points) Although I3-1 is known, F3-1 is not. Using Lewis structures, explain why F3-1 does not form.

I3-1 and F3-1 both require an expanded octet on the central atom. Iodine has available d orbitals so that it can expand its octet. Fluorine’s outermost electrons are in the 2p orbitals and there are no 2d orbitals in which to place extra electrons.



1. (8 points) Two structures can be drawn for cyanuric acid:



* 1. Are these two resonance structures of the same molecule? Explain.

These are different molecules because they have different skeleton structures. Resonance structures must have the same skeleton structure!

* 1. How many sigma bonds are in structure a?

12

* 1. How many pi bonds are in structure a?

3

* 1. Which bonds are longer, the CO bonds in structure a or b? Explain.

The CO bonds in b are longer because single bonds are longer than double bonds.

1. (6 points) Look at the compound pictured below. Explain the bonding in terms of valence bond theory. That is show the atomic orbitals on the N atom, describe any electron promotion and hybridization necessary, and show the orbitals involved in both sigma and pi bonding as well as the orbital holding the lone pair of electrons



1. (16 points) Answer the following questions for the structure below:



|  |  |
| --- | --- |
| What is the orbital geometry of I (arrow a)?  Trigonal bipyramidal | What is the hybridization of Kr (arrow g)?  sp3d2 |
| What is the formal charge of Rn (arrow c)?  +2 | What is the hybridization of C (arrow h)?  sp2 |
| What is the orbital geometry of N (arrow e)?  linear | What is the formal charge on Sb (arrow j)?  -3 |
| What is the molecular geometry of P (arrow f)?  Trigonal pyramidal | What is the molecular geometry of Br (arrow i)?  Square pyramidal |

1. (6 points)Determine the electron configurations for CN+1, CN, and CN-1. Calculate the bond order for each, and indicate which ones are paramagnetic. Predict which one would be most stable based on your determinations. (Use the MO splitting diagrams on the front page to help you answer the question.)

|  |  |  |
| --- | --- | --- |
| Molecule / ion | Bond order | Magnetic character |
| CN+1 | 2 | Paramagnetic |
| CN | 2.5 | Paramagnetic |
| CN-1 | 3 | Diamagnetic |

Which of these species do you predict to be the most stable and why?

CN-1 would be the most stable because it has the highest bond order.