Chemistry 141 Name key

Dr. Cary Willard

Exam 3a April 14, 2011

Multiple Choice (30 points)

Page 4 (7 points)

Page 5 (16 points)

Page 6 (16 points)

Page 7 (13 points)

Page 8 (18 points)

Page 9 (10 points)

Total (110 points)

Percent (100 %)

All work must be shown to receive credit. Give all answers to the correct number of significant figures

Avogadros number = 6.022 x 1023 /mol

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) |  | |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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

Part I – Multiple Choice (30 points)

1. How many unpaired electrons does the nitride (N3–) ion have?
   1. 0
   2. 1
   3. 2
   4. 3
   5. 4
2. Which arrangement is in the correct order of decreasing radii?
   1. Sc+3 > Cr+3 > W+3
   2. Te > Sn > Si
   3. As3– > Br– > Rb+
   4. Rb+ > Cs+ >Cs
   5. N-1 > N-2 > N-3
3. Which of the following elements would you expect to have the lowest first ionization energy?
   1. F
   2. Cl
   3. Br
   4. I
   5. At

1. The first four ionization energies for an element are as shown graphically at the right. Identify the correct element from the list.
   1. Ca
   2. Al
   3. Na
   4. Te
   5. Fe
2. A covalent bond results when
   1. electrons are transferred from one atom to another atom.
   2. atoms pool their electrons to form a “sea” of electrons.
   3. atoms have outer electrons with the same principal quantum number.
   4. electrons are shared between atoms.
   5. metals bond with non-metals.
3. Indicate which of the following molecules contains a polar covalent bond.
   1. O2
   2. CO
   3. N2
   4. H2
   5. NaCl
4. Which of the following properties is typically used to predict the type of bond that forms between two elements?
   1. electronegativity
   2. atomic radius
   3. ionization energy
   4. electron affinity
   5. polarizability
5. Which of the following are listed in order of decreasing electronegativity?
   1. F, S, Na, H
   2. N, P, Si, Mg
   3. F, N, P, O
   4. F, Cl, Br, C
   5. Cl, C, N, F
6. The square of the wave function, Ψ2, represents
   1. the path of an electron in an atom.
   2. the energy of an electron in an atom
   3. the region is space where an electron is likely to exist
   4. the principle quantum number of an atom
   5. the size of an atom
7. Which of the following atoms can have an expanded octet?
   1. Te
   2. O
   3. F
   4. C
   5. He
8. Based on bond length, which of the following has the strongest bond? The number in parentheses is the bond distance.
   1. H–Br (141 pm)
   2. H–Cl (127 pm)
   3. H–I (161 pm)
   4. H–F (92 pm)
   5. cannot be determined from the data given
9. A hypothetical element can form single, double, triple, and quadruple bonds between its atoms. Which will be the shortest?
   1. single
   2. double
   3. triple
   4. quadruple
   5. bond length is not related to bond order
10. The H–X–H bond angle is larger in CH4 than in NH3,and ammonia has a larger angle than H2O. This trend is due to
    1. the effective nuclear charge’s decrease.
    2. an increase in the number of lone pairs, the lone pair repulsion causing the decrease in angle.
    3. the fact that carbon has a larger atom volume than nitrogen or oxygen.
    4. the change in polarity of the molecules.
    5. The fact that hydrogen requires more space than electrons.
11. All homonuclear diatomic molecules
    1. have polar bonds.
    2. are nonpolar.
    3. are polar.
    4. cannot vibrate.
    5. are halogens
12. Indicate which type of molecular orbital is a result of electron density building up above and below the internuclear axis.
    1. σ
    2. σ\*
    3. π
    4. π\*
    5. β\*\*

Part 2 - Problems

1. (7 points) Answer the following
   1. When n=6, what are the possible values of l?

l=5,4,3,2, or 1

* 1. When l=3, what are the possible values of ml?

ml= 3, 2, 1, 0, -1, -2, or -3

* 1. For a 3d orbital, what are the possible values of n,l,and ml?

n=3, l=2, ml = 2,1,0,-1,or -2

1. (8 points) Write the shorthand electronic configuration (as predicted by the periodic table) for the atoms/ions listed below:
   1. Fe+2

[Ar] 3d6

* 1. Mo

[Kr] 5s2 4d4

Would you expect an anomalous configuration for this atom? And if so, what would you predict and why?

Yes, I would expect one of the 5s electrons to move to the 4d sublevel giving 2 half filled shells which gives additional stability.

[Kr] 5s1 4d5

* 1. Db

[Rn] 7s2 6d3 5f14

Would you expect an anomalous configuration for this atom? And if so, what would you predict and why?

No, there is no advantage to moving electrons--



1. (8 points) Below is a molecule of diaminomaleonitrile, or DAMN for short.
   1. How many sigma bonds are in the structure \_\_\_11\_\_\_\_\_How many pi bonds?\_\_\_\_5\_\_\_\_
   2. Which bonds are longer, the C2—C5  or the C2—C3 bond? Explain.

The C2—C3 bonds is longer because single bonds are longer than double bonds.

* 1. Which bonds are stronger, the C2—N1  or the N4—C3 bond? Explain.

The N4—C3 bond is stronger because triple bonds are stronger than single bonds.

1. (8 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.

|  |  |
| --- | --- |
| SOCl2  S is central atom |  |
| BrF3 |  |

1. (4 points) Phosphorus forms two compounds with chlorine, PCl3 and PCl5, but nitrogen forms only one, NCl3. Explain.

In order to form PCl5, the phosphorus must expand its valence. Because phosphorus has available d orbitals it is able to do this, but nitrogen has no 2d orbitals so it can not expand its valence to form NCl5.

1. (4 points) Explain how sigma and pi bonds differ. (Give a complete answer!)

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

1. (8 points) Give the orbital geometry, molecular geometry, hybridization, and formal charge for each of the highlighted atoms below:



|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| atom | orbital geometry | molecular geometry | hybridization | formal charge |
| Bromine (a) | Octahedral | Square planar | sp3d2 | -1 |
| Phosphorus (b) | Tetrahedral | Trigonal pyramidal | sp3 | 0 |
| Xenon (c) | Trigonal bipyramidal | See saw | sp3d | +2 |
| Carbon(d) | linear | linear | sp | 0 |

1. (5 points) Arrange the following in order of increasing Cl—X—Cl bond angle. Explain your reasoning.



SiCl4<PCl3<SCl2

As the number of electrons on the central atom increases the bond angles decrease because lone pairs of electrons require more space than bonds.

1. (8 points) Using formal charge arguments, determine the best formula for a compound with formula COS. Draw all possible skeleton structures and identify the best structure.

|  |  |  |
| --- | --- | --- |
|  |  |  |
| No!  Electronegative sulfur has a positive charge in all structures and carbon has a negative charge. Helps if we expand octed on sulfur, but still not enough to fix problems | No!  Electronegative oxygen will not have a +2 charge! Nor will carbon take a high negative charge | Good!  1st structure has no formal charge. Others have negative charge on electronegative atoms. Not great, but OK. |

1. (4 points) Explain the difference between resonance structures and isomers. Draw examples to help show the difference.

Resonance structures are structures with the same molecular formula and the same connectivity of atoms. Isomers have the same molecular formula, but different atom connectivity.



Structures a and b are resonance structures and structure c is an isomer of both structure a and b

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 Br 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

hybridization of bromine atom



1. (10 points) The CN molecule has been found in interstellar space. Assuming the electronic structure of the molecule can be described using the molecular orbital energy level diagrams at the bottom of the page, answer the following questions.
   1. What is the bond order of the molecule?

2.5

* + 1. How many net σ bonds?

1

* + 1. How many net π bonds?

½

* 1. Is the molecule paramagnetic or diamagnetic?

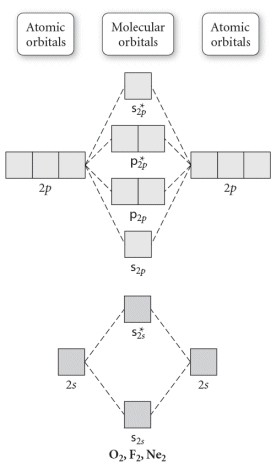
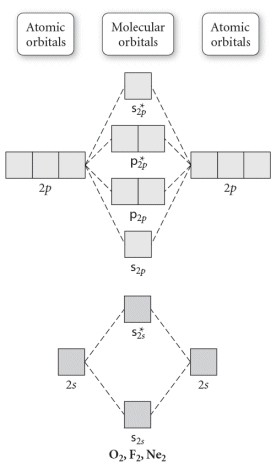
paramagnetic

* 1. If an extra electron were added to make the cyanide ion, CN-1, would the bond order increase or decrease?

increase

* + 1. Would the bond get stronger or weaker?

stronger

CN CN-1