Chemistry 141 Name

Martin Larter

Exam 3A April 22, 2016

Multiple Choice (30 points)

Page 5 (16 points)

Page 6 (23 points)

Page 7 (14 points)

Page 8 (8 points)

Page 9 (12 points)

Page 10 (9 points)

Total (112 points)

Chemistry Formulas and Constants

Kinetic energy = ½ mv2

w = -PΔV

Ptotal = P1+P2+P3+…

u = (3RT/MW)½

ΔG = ΔH - TΔS

PV = nRT

Rate ∝ (MW)-½

P1=X1\*Ptotal

C = q/ΔT

Ptotal = P1 + P2 + P3 + …

M = mol/L

K = oC + 273.16

m = mol/kg solvent

Xi = moli/ moltotal



1 kcal = 4.184 kJ

NA = 6.02 x 1023 /mol R = 0.0821 L atm/mol K = 62.4 L torr/mol K = 8.31 kJ/mol K

Grossmont College

Periodic Table

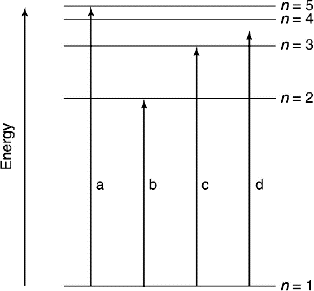
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| IA |  |  |  |  |  |  |  |  |  |  | |  |  |  |  |  | VIIA | NOBLE GASES |
| 1  **H**  1.008 | IIA |  |  |  |  |  |  |  |  |  | |  | IIIA | IVA | VA | VIA | 1  **H**  1.008 | 2  **He**  4.002 |
| 3  **Li**  6.941 | 4  **Be**  9.012 |  |  |  |  |  |  |  |  |  | |  | 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 of the following photons has the highest frequency?
   1. A photon from a Nd:YAG laser with *λ* = 1,064 nm
   2. A photon from an Ar+ laser with *λ* = 514.5 nm
   3. A photon from a Kr+ laser with *λ* = 647 nm
   4. A photon from an ArF laser with *λ* = 193 nm
2. Which of the following photons has the lowest energy?
   1. A photon from a Nd:YAG laser with *λ* = 1,064 nm
   2. A photon from an Ar+ laser with *λ* = 514.5 nm
   3. A photon from a Kr+ laser with *λ* = 647 nm
   4. A photon from an ArF laser with *λ* = 193 nm
3. If each of the following metals is exposed to light with a wavelength of 240 nm, which will emit photoelectrons with the least kinetic energy? (φ is the work function which is defined as the energy required to ionize 1 electron.)
   1. iron (φ = 7.2 × 10–19 J)
   2. palladium (φ = 8.2 × 10–19 J)
   3. platinum (φ = 9.1 × 10–19 J)
   4. sodium (φ = 4.4 × 10–19 J)
   5. nickel (φ = 8.3 × 10–19 J)
4. Which transition in a hydrogen atom will cause emission of the shortest wavelength photon?
   1. *n*1 = 4 to *n*2 = 3
   2. *n*1 = 3 to *n*2 = 1
   3. *n*1 = 4 to *n*2 = 2
   4. *n*1 = 10 to *n*2 = 9
   5. *n*1 = 3 to *n*2 = 2
5. Which of the transitions in the hydrogen atom energy-level diagram shown here is not possible?
   1. a.
   2. b.
   3. c.
   4. d.
6. In quantum mechanics, an atomic orbital \_\_\_\_\_\_\_\_
   1. Provides the position of an electron at any instant of time in the space around an atomic nucleus.
   2. Locates all the electrons in an atom.
   3. Is identical to the orbits Bohr used in his analysis of the hydrogen atom.
   4. Identifies the most probable position of an atomic nucleus.
   5. Provides the probability of finding an electron at any point in the space around an atomic nucleus.
7. Which of the following represents an *s* orbital?

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1. The atomic radius of germanium (Z = 32) is smaller than the atomic radius of potassium (Z = 19) because of \_\_\_\_\_\_\_\_
   1. A change in the *n* quantum number.
   2. An increase in the effective nuclear charge.
   3. A decrease in the effective nuclear charge.
   4. Germanium having 32 rather than 19 electrons.
2. Resonance structures indicate that \_\_\_\_\_\_\_\_
   1. There is more than one allotropic form of a compound.
   2. More than one ionic form of a compound exists.
   3. The electronic structure is an average or superposition of the diagrams.
   4. More than one isotopic form of an element exists in the molecule.
   5. The molecule jumps back and forth between two or more different electronic structures.
3. Which statement A–D regarding formal charge is *not* correct?
   1. Formal charge on an atom in a bond is determined by the electronegativity of that atom.
   2. The formal charge of an atom in a molecule is the charge assigned to that atom.
   3. The most stable (lowest energy) Lewis structure is the one with the most formal charges equal to zero or closest to zero.
   4. Any negative formal charges should be on the more or most electronegative element.
   5. Statements A–D are all correct.
4. If an element can form single, double, triple, and quadruple bonds between its atoms. Which will be the shortest?

|  |  |  |
| --- | --- | --- |
| * 1. Single | * 1. triple | * 1. double |
| * 1. quadruple | * 1. They are all the same length |  |

1. In a chemical reaction, bonds are broken and new bonds are formed. Which one of the following statements regarding bond energies is correct?
   1. Energy is released when bonds are broken.
   2. Energy is released when bonds are broken and more stable bonds are formed.
   3. Energy is released when bonds are broken and less stable bonds are formed.
   4. Bond energies and bond lengths generally are not correlated; that is, they vary independently.
   5. Bond energies and bond order are unrelated to each other.
2. Which one of the statements A–D about electron-pair geometry and molecular geometry is *not* correct?
   1. The electron-pair geometry identifies the relative positions of the bonding regions of electrons and the lone pairs of electrons around a central atom in a molecule.
   2. The molecular geometry identifies the relative positions of the atoms around a central atom in a molecule.
   3. If there are no lone pairs, then the electron-pair geometry and the molecular geometry are the same.
   4. The molecular geometry differs from the electron-pair geometry when the number of atoms around the central atom is smaller than the number of regions of electron density.
   5. Statements A–D are all correct.
3. For the series methane, ammonia, and water, the bond angle increases in the following order: H2O < NH3 < CH4. This trend is due to \_\_\_\_\_\_\_\_
   1. A decreasing effective nuclear charge.
   2. A decrease in the number of lone pairs.
   3. An increase in atomic radius.
   4. An increase in the polarity of the molecules.
   5. An increasing effective nuclear charge.
4. Which statement regarding a pi bond between two carbon atoms is correct?
   1. The region of high electron density lies along the bond axis connecting the nuclei of the two atoms.
   2. The bond can be described by the overlap of *sp* hybrid orbitals from each atom.
   3. The bond can be described by the overlap of *sp*2 hybrid orbitals from each atom.
   4. The bond can be described by the overlap of *p* atomic orbitals from each atom.
   5. The bond can be described by the overlap of a *p* atomic orbital from one atom with a *sp*2 hybrid orbital from the other atom.

Problems (70 points)

1. (6 points)Butterflies are thought to communicate using an ultraviolet communication system. Female butterflies reflect light with a wavelength of 385 nm better than males giving males a way to identify females from a distance.
   1. What is the frequency of this reflected light?
   2. What is the energy of fifty photons of this light?
2. (6 points)The energy required to remove one electron from an atom of arsenic is 1.57 x 10−18 J.
   1. What is the minimum wavelength required to remove one electron from an atom of arsenic?
   2. What is the ionization energy (kJ/mol) for arsenic?
3. (4 points) Describe the similarities and differences in the atomic emission and absorption spectra of an atom.
4. (8 points) Which of the following sets of quantum numbers is/are acceptable for an electron of a **neutral** atom of radium (Z# = 88)? Note: This does **not** necessarily mean the **highest-energy** electron. If not acceptable state the reason why.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **n** | **l** | **ml** | **ms** | **Acceptable/ unacceptable (explain)** |
| a. | 6 | 0 | 1 | -1/2 |  |
| b. | 4 | 2 | -2 | +1/2 |  |
| c. | 5 | 3 | 0 | +1/2 |  |
| d. | 2 | 2 | -1 | -1/2 |  |

1. (12 points) Write electron configurations as predicted by the periodic table for the following atoms and ions. Answer additional questions as necessary.
   1. Cobalt (complete configuration)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   2. Would you expect cobalt to have an anomalous configuration? If so, show the configuration you would expect and explain why you predict this configuration. If not, tell why you do not expect to see an anomalous configuration.
   3. Osmium (shorthand configuration)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   4. V(III) ion (shorthand configuration)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. (3 points) Are  and  resonance structures? Why or why not?
3. (6 points) Draw Lewis Electron Dot Structures for the following species. Be sure to include all electrons! Indicate of the molecule or ion is polar or nonpolar

|  |  |
| --- | --- |
| Formic acid HCO2H | PF4− |
|  |  |

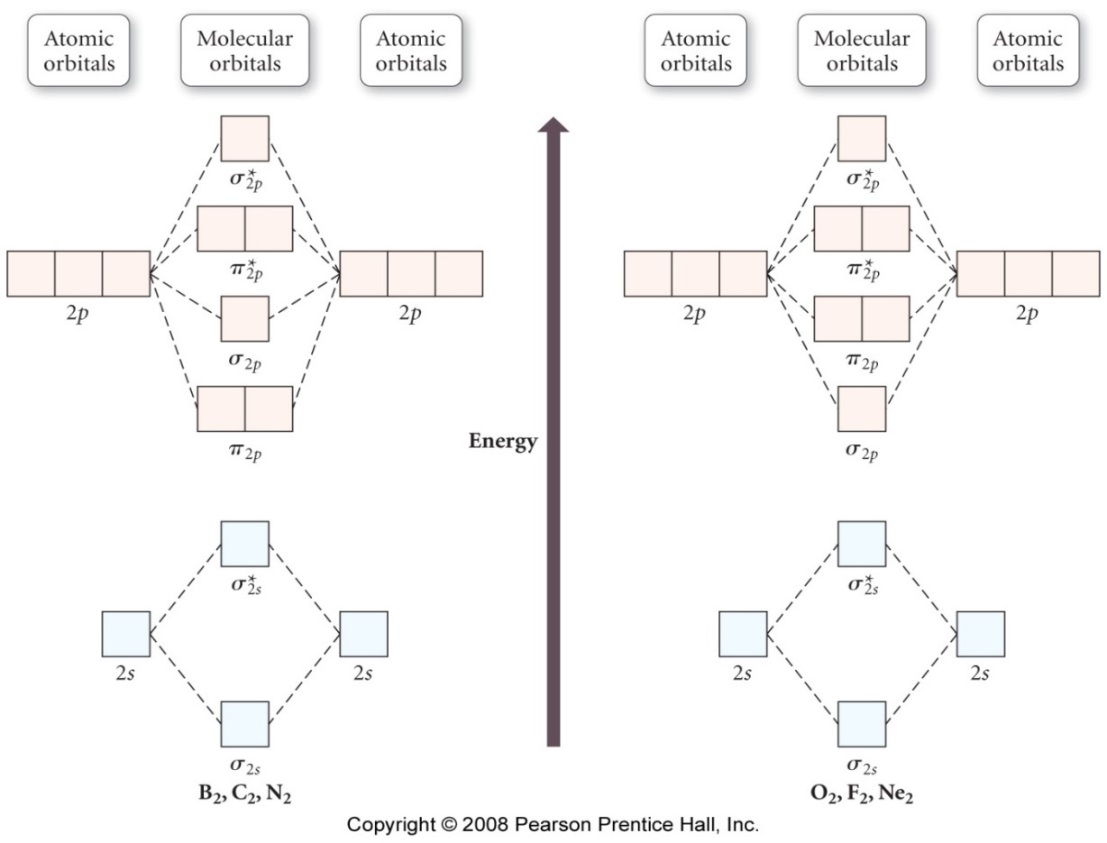
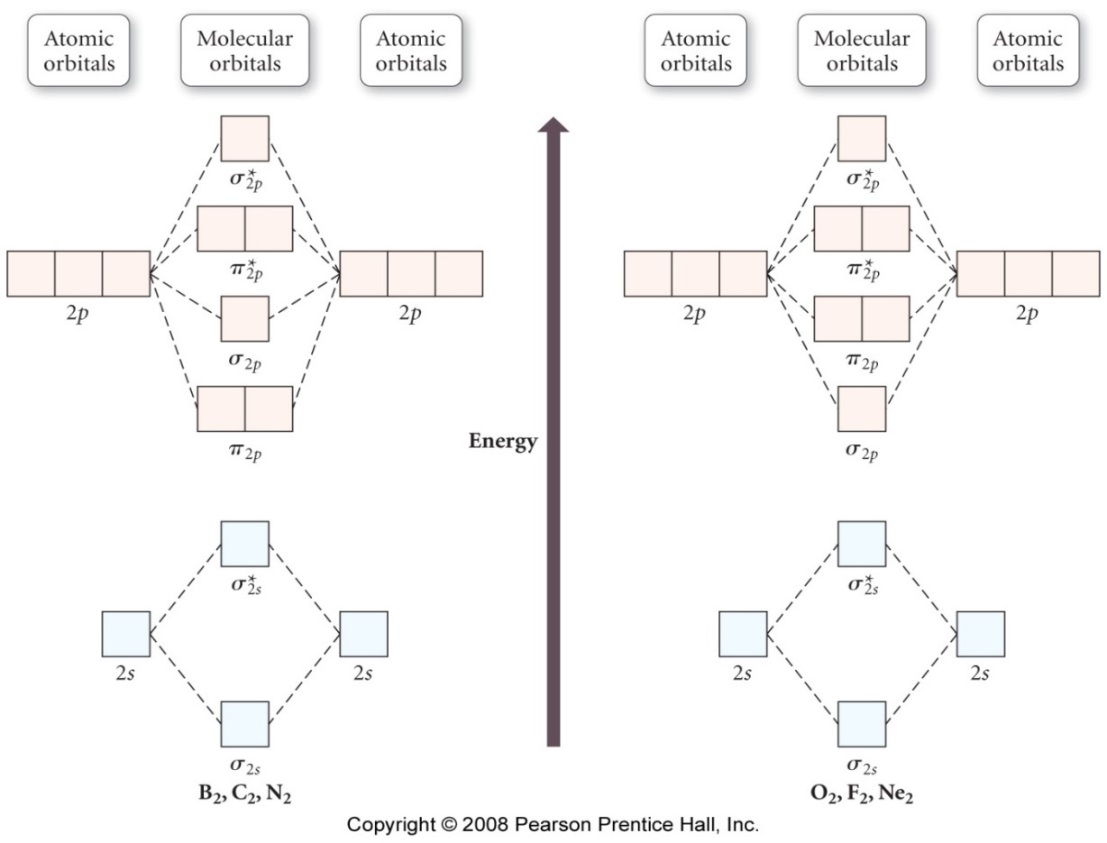
1. (8 points) Draw Lewis electron dot structures for the two possible molecules with the molecular formula HNO2. Two skeleton structures are drawn. Show all reasonable resonance structures of each and predict which of the structures is more likely to form.

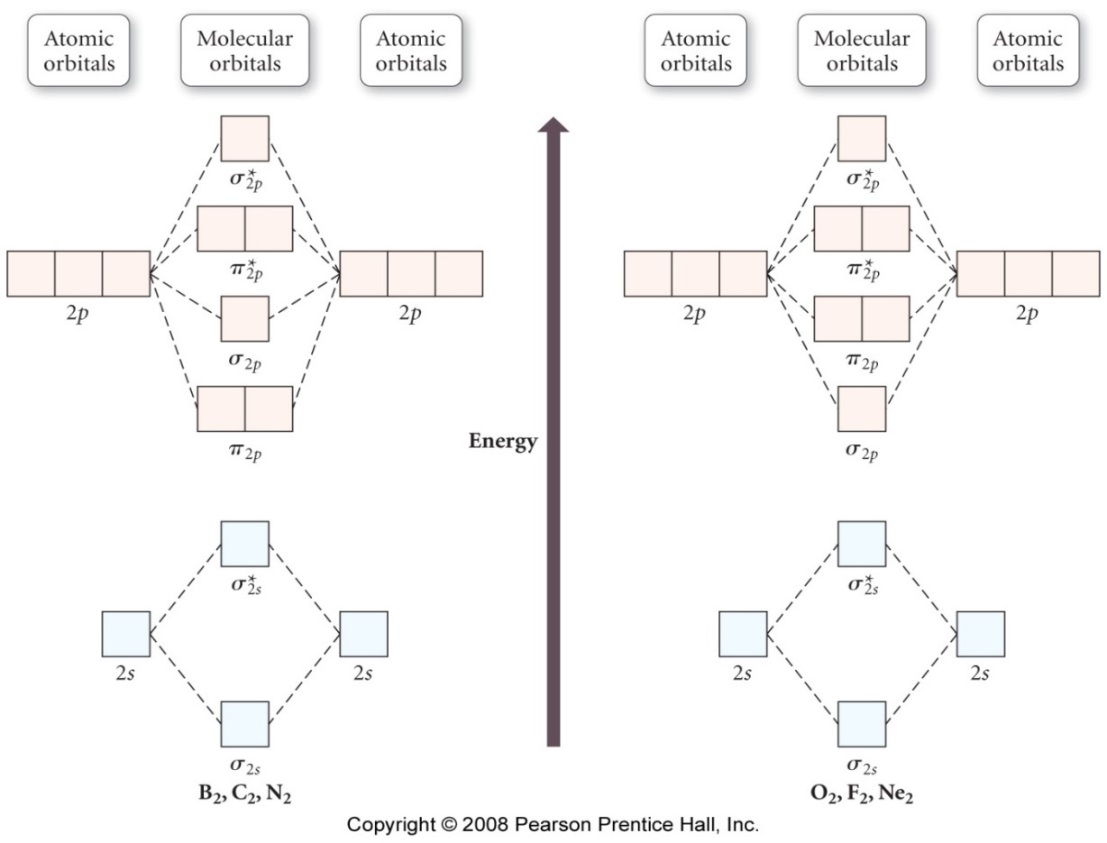
|  |  |  |
| --- | --- | --- |
| Skeleton | Lewis Electron Dot Structures | Evaluation of Structures |
|  |  |  |
|  |  |  |

1. (8 points) The odd electron molecule ClO is implicated in the atmospheric chemistry of fluorocarbons. Draw the molecular orbital diagram for ClO as well as the orbital diagram of the ions that would form if the odd electron were either lost or gained. Blank MO templates are available at the bottom of the page.
   1. What are the bond orders of the three species?

ClO ClO− ClO+

* 1. Which of the species has the strongest bond? Explain your choice.
  2. Are any of the species diamagnetic? If so, which ones?





1. (12 points) Given the molecule of martindane shown below, answer the questions in the table.



|  |  |
| --- | --- |
| Bond angle(s) around sulfur (a) |  |
| Hybridization of phosphorous (b) |  |
| Molecular geometry around xenon (c) |  |
| Orbital geometry around phosphorous (d) |  |
| Molecular geometry around phosphorous (d) |  |
| Hybridization of nitrogen (e) |  |
| Molecular geometry around nitrogen (e) |  |
| Bond angle(s) around nitrogen (e) |  |
| Molecular geometry around bromine (f) |  |
| Orbital geometry around bromine (f) |  |
| Hybridization of iodine (g) |  |
| Orbital geometry around iodine (g) |  |

1. (5 points) Cl2O2 is thought to play a role in ozone depletion in the atmosphere. Given the Lewis structure below, explain the bonding in terms of valence bond theory. That is show the atomic orbitals on the Cl atom, describe any electron promotion and hybridization necessary, and label the orbitals involved in both sigma and pi bonding as well as the orbital holding the lone pair of electrons on Cl. You do not need to draw a 3D representation of the orbitals.



1. (4 points) Use bond dissociation data to determine the energy of the reaction

2 NH3 + Cl2 🡪 N2H4 + 2 HCl

The structures of the atoms involved are shown below:

