Chemistry 141 Name

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Exam 3B November 12. 2014

Multiple Choice (30 points)

Page 5 (10 points)

Page 6 (19 points)

Page 7 (23 points)

Page 8 (22 points)

Page 9 (14 points)

Total (118 points)

Chemistry Formulas and Constants

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Average Bond dissociation Energies (kJ/mol) | | | | |
| H—H 436\* | C—H 410 | N—H 390 | O—H 460 | F—F 159\* |
| H—C 410 | C—C 350 | N—C 300 | O—C 350 | Cl—Cl 243\* |
| H—F 570\* | C—F 450 | N—F 270 | O—F 180 | Br—Br 193\* |
| H—Cl 432\* | C—Cl 330 | N—Cl 200 | O—Cl 200 | I—I 151\* |
| H—Br 366\* | C—Br 270 | N—Br 240 | O—Br 210 | S—F 310 |
| H—I 298\* | C—I 240 | N—I | O—I 220 | S—Cl 250 |
| H—N 390 | C—N 300 | N—N 240 | O—N 200 | S—Br 210 |
| H—O 460 | C—O 350 | N—O 200 | O—O 180 | S—S 225 |
| H—S 340 | C—S 260 | N—S | O—S 364 |  |
|  |  |  |  |  |
| C=C 611 | C=O 732 | O=O 498\* | O=S 535 | N=O 598 |
| C≡C 837 | C≡N 891 | N≡N 946\* |  |  |
| \*Bond dissociation energies for diatomic molecules are exact. | | | | |

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





NA = 6.02 x 1023 /mol

1 kcal = 4.184 kJ h= 6.626 X 10-34 1 W = 1 J/sR = 0.0821 L atm/mol K = 62.4 L torr/mol K = 8.31 kJ/mol K

Standard Temperature and Pressure = 0oC and 1 atm

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

Multiple Choice (30 points)

1. Using periodic trends, place the following bonds in order of increasing ionic character.

Si-P Si-Cl Si-S

|  |  |  |
| --- | --- | --- |
| 1. Si-P < Si-Cl < Si-S | 1. Si-P < Si-S < Si-Cl | 1. Si-Cl < Si-S < Si-P |
| 1. Si-S < Si-Cl < Si-P | 1. Si-Cl < Si-P < Si-S |  |

1. The square of the wave function, Ψ2, represents
   1. The region is space where an electron is likely to exist
   2. The path of an electron in an atom.
   3. The size of an atom
   4. The principle quantum number of an atom
   5. The energy of an electron in an atom
2. The energy of a photon of light is \_\_\_\_\_\_\_\_\_\_ proportional to its frequency and \_\_\_\_\_\_\_\_\_\_ proportional to its wavelength.

|  |  |  |
| --- | --- | --- |
| 1. indirectly, not | 1. inversely, directly | 1. directly, inversely |
| 1. inversely, inversely | 1. directly, directly |  |

1. Determine whether each of the following is false regarding penetration and shielding. (Assume that all lower energy orbitals are fully occupied.)
2. An electron in a 3*s* orbital is more shielded than an electron in a 2*s* orbital.
3. An electron in a 3*s* orbital penetrates into the region occupied by core electrons more than electrons in a 3*p* orbital.
4. An electron in an orbital that penetrates closer to the nucleus will always experience more shielding than an electron in an orbital that does not penetrate as far.
5. An electron in an orbital that penetrates close to the nucleus will tend to experience a higher effective nuclear charge than one that does not.
6. Which statement is true about the photoelectric effect
7. The energy of the ejected electrons varied directly with the intensity of the light.
8. The number of electrons ejected varied directly with the intensity of the light.
9. The energy of the ejected electrons varied inversely with the intensity of the light.
10. The number of ejected electrons did not match.
11. The light intensity had no effect on the energy of the ejected electrons.
12. Which of the following statements are TRUE?
    1. The principal quantum number (*n*) describes the shape of an orbital.
    2. The angular momentum quantum number (*l*) describes the size and energy associated with an orbital.
    3. An orbital is the path that an electron follows during its movement in an atom.
    4. The magnetic quantum number (*ml*) describes the orientation of the orbital.
    5. All of the above are true.
13. Arrange the ions P3-, S2-, Ca2+, K+, and Cl- in order of increasing ionic radius, starting with the smallest first.

|  |  |  |
| --- | --- | --- |
| 1. Ca2+, K+, Cl-, S2-, P3- | 1. K+, Ca2+, Cl-, S2-, P3- | 1. P3-, S2-, Cl-, K+, Ca2+ |
| 1. P3-, Ca2+, S2-, K+, Cl- | 1. P3-, S2-, Ca2+, Cl-, K+ |  |

1. Use the bond energies provided to estimate ΔH°rxn for the reaction below.

2 Br2(l) + C2H2(g) → C2H2Br4(l) ΔH°rxn = ?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. -228 kJ | 1. -648 kJ | 1. +573 kJ | 1. -324 kJ | 1. +407 kJ |

1. The atomic radius of germanium is smaller than the atomic radius of potassium due to
   1. An increase in the effective nuclear charge.
   2. A decrease in the effective nuclear charge.
   3. The fact that *p* and *d* orbitals have the same orbital penetration.
   4. A change in the *n* quantum number.
   5. None of the above
2. How many electrons does a dsp3 orbital hold?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1. 10 | 1. 8 | 1. 6 | 1. 4 | 1. 2 |

1. Which of the following best describes the lattice energy?
   * 1. The energy required to create a 3-D lattice
     2. Energy associated with taking gaseous ions to the solid phase
     3. Energy released when ions of opposite charges come together in the gas phase and cool to form a solid ionic compound.
     4. The energy required to take elements in their natural state and forming a solid compound.
     5. All of the above
2. 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 change in polarity of the molecules.
   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 effective nuclear charge’s decrease.
   5. None of the above
3. Which statement is **false**? A sigma molecular orbital
4. May result from overlap of p atomic orbitals along the molecular axis (head-on).
5. May result from overlap of two s atomic orbitals.
6. May result from overlap of one s and one p atomic orbitals.
7. May result from overlap of p atomic orbitals perpendicular to the molecular axis (side-on).
8. May be either bonding or antibonding.
9. Which of the following statements is TRUE?
   1. The total number of molecular orbitals formed doesn't always equal the number of atomic orbitals in the set.
   2. A bond order of 0 represents a stable chemical bond.
   3. Electrons placed in antibonding orbitals stabilize the ion/molecule.
   4. When two atomic orbitals come together to form two molecular orbitals, one molecular orbital will be lower in energy than the two separate atomic orbitals and one molecular orbital will be higher in energy than the separate atomic orbitals.
   5. All of the above are true.
10. Which statement is always true according to VSEPR theory?
11. The shape of a molecule is determined by the polarity of its bonds.
12. The shape of a molecule is determined by the repulsions among all electron groups on the central atom (or interior atoms if there is more than one).
13. The shape of a molecule is determined only by repulsions among bonding electron groups.
14. The shape of a molecule is determined only by repulsions among nonbonding electron groups.
15. None of the above

Problems (points)

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

* + - How many net σ bonds?

1

* + - How many net π bonds?

1½

* 1. Is the molecule paramagnetic or diamagnetic?

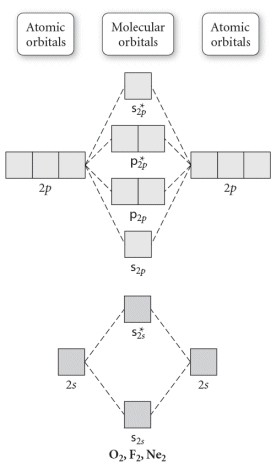
paramagnetic

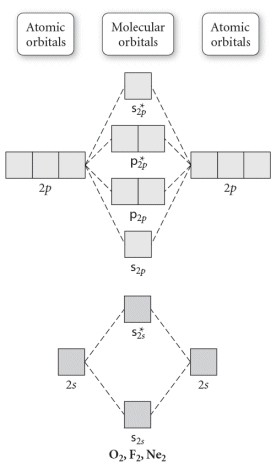
* 1. If an extra electron were added to make the cyanide ion, CN-1, would the bond order increase or decrease?

increase

* + - Would the bond get stronger or weaker?

stronger

CN CN-1



1. (12 points) The binding energy of electrons in a copper plate is 547 kJ/mol. A copper atom will emit an electron when it is struck by light with a frequency of 7.31 x 1015 Hz.
   1. Calculate the wavelength of the light from the emitted electron in nm.
   2. Calculate the binding frequency of a single electron on the copper plate
   3. What wavelength of the light in nm must be used to eject electrons from the copper plate with a kinetic energy of 7.25 x 10-19 J?

energy of light = ionization energy + kinetic energy = 7.25 x 10-19J + 9.08 x 10-19 J = 1.63 x 10-18 J

* 1. A beam of light with an intensity of 20 W is shined on a copper plate. Calculate the maximum number of electrons that can be ejected by a 4.0-second pulse of the incident light with a frequency of 7.31 x 1015 Hz .

1. (3 points) If all matter has wave nature, why don’t we observe the wavelength of everyday macroscopic objects?

Due to the large mass of macroscopic objects, the deBroglie wavelength is extremely small. The wavelength is so small that it is impossible to detect compared to the size of the object.

1. (4 points) An electron in the n = 7 level of the hydrogen atom relaxes to a lower energy level, emitting light of 1005 nm. What is the value of n for the level to which the electron relaxed?

Energy negative since electron is relaxing or emitting energy

1. (5 points) The valence electrons in a Niobium (Nb) atom are 5s24d3. What are the four quantum numbers for each of these five electrons?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| One of the 5s electrons: | n = 5 | l = 0 | ml = 0 | ms = 1/2 |
| The other 5s electron: | n = 5 | l = 0 | ml = 0 | ms = -1/2 |
| One of the 4d electrons: | n = 4 | l = 2 | ml = -2 | ms = 1/2 |
| The second 4d electron: | n = 4 | l = 2 | ml = -1 | ms = 1/2 |
| The third 4d electron: | n = 4 | l = 2 | ml = 0 | ms = 1/2 |

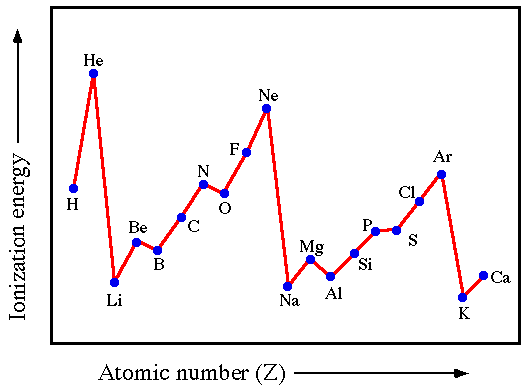
1. (6 points) Provide the ground state electron configuration:

a)  \_\_\_\_\_\_1s22s22p63s23p3\_\_\_\_\_\_\_\_\_\_\_ (Full)

b)  \_\_\_\_\_\_[Ar] 3d5 4s1\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (Short Hand)

c)  \_\_\_\_\_\_\_[Kr] 4d3\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(Short Hand)

1. (6 points) Given the following ionization energy data



* 1. Explain why there is an increase in ionization energy

from Al to Ar.

The number of protons is increasing in the nucleus hence

the effective nuclear charge is increasing but the shielding is

remaining constant which will cause stronger attraction

for valence electrons and an increase in I.E.

* 1. Explain the slight decrease in ionization energy

from P to S.

S will have a half filled p sublevel if it loses 1 electron and you removed the electron repulsion of the paired electrons. This is good therefore the ionization energy not that high. P will lose half filled shell if it loses an electron therefore the ionization energy is high.

1. (6 points) Answer the following questions about the following compounds:

KCl MgS CaF2 Rb2O LiF

* + - 1. Which compound has the *strongest* ionic bonding and why?

**magnesium sulfide**

Mg2+ and S2- ions have a greater number of charges, so they form stronger ionic bonds

(Large Charge → strong attraction → larger E)

* + - 1. Which compound has the *weakest* ionic bonding and why?

**sodium chloride**

K+ and Cl- ions have small charges and tie with Li+ and F-, smaller number of charges forms weaker ionic bonds, so the distance between ions had to be examined. Since K+ and Cl- are further apart due to larger ionic radius than Li+ and F-, KCl has the *weakest* ionic bonding (Large d → charge felt less → smaller E)

1. (10 points) Two structures may be drawn for C4H5N2Br:

Structure a Structure b

* 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\_\_\_\_\_How many pi bonds?\_\_\_3\_\_\_\_\_
  2. Which bonds are longer, the CC bonds in structure a or b? Explain.

The CC bonds in b are longer because single bonds are longer than triple bonds.

* 1. Which bonds are stronger, the CN bonds in a or b? Explain.

The CN bonds in b are stronger because double bonds are stronger than single bonds.

1. (12 points) Complete the following table make sure your structure is written so that it has minimal formal charge:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Lewis Structure | Electron pair geometry | Molecular geometry | Bond Angle | Hybridization | Polarity |
| IO43- |  | Trigonal Bipyrimidal | See-saw | 120, 90 | sp3d | polar |
| ClF3 |  | Trigonal Bipyrimidal | T-shape | 180, 90 | sp3d | polar |

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. (underlined atom central atom)

SCO OCS COS

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 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. (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

(2 points) Bonus Question: My Dog Bubba got into my Molecular Model Kit at Home and started to put the pieces together, he realized that one of the molecules he made was his favorite. Name that Molecule

\_\_\_Propane\_\_\_