Chem 150 – Exam 4b *Name:* ______________________________
Fall 2010

Chemistry 150 Exam 4

Be sure to put your name on each page. This page can be removed from your exam so that you will have a Periodic Table handy throughout the exam, it does not need to be turned in. Show all your work for problems which require any sort of calculation, no credit will be given for answers without work shown. If you have shown a significant amount of work or multiple drawings for a problem, draw a box around what you consider your final answer.

Avogadro's Number = $6.022\text{x}10^{23}$ $^{\text{units}}/_{\text{mol}}$
32.00^{o}F = 0.000^{o}C = 273.15K
1 foot = 12 inches
1 inch = 2.54cm (exactly)
1 pound = 453.6 g = 16 ounces
1 amu = $1.6605\text{x}10^{-24}$ g
Masses of subatomic particles:
  Proton 1.00728amu = $1.6726\text{x}10^{-24}$ g
  Neutron 1.00866amu = $1.6749\text{x}10^{-24}$ g
  Electron 0.000549amu = $9.1094\text{x}10^{-28}$ g
Density of Water = $1.000\,^{g}/_{mL}$
R = 0.08206 $^{\text{L•atm}}/_{\text{mol•K}}$
PV=nRT
1 calorie = 4.184 J = 0.001Calorie

h = $6.626\text{x}10^{-34}$ Jsec
$\lambda = {}^{h}/_{mv}$
1 J = 1 kg $(^{m}/_{sec})^2$
c = $\lambda\nu$ = $3.00\text{x}10^{8}$ $^{m}/_{sec}$
$E_{photon} = h\nu$

1 **H** 1.0079																	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.066	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.88	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.847	27 **Co** 58.933	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** (98)	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	71 **Lu** 174.97	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	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** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.03	103 **Lr** (260)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Ds** (269)	111 **Rg** (272)	112 **Cn** (277)	113	114	115	116	117	118

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	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** 168.94	70 **Yb** 173.04
89 **Ac** 227.03	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (258)	101 **Md** (258)	102 **No** (259)

Score

Multiple Choice: Circle the letter of the most correct response. (6pts. per question)

1. Which of the following is ***not*** a possible set of quantum numbers for an electron?
   a. $n = 4$, $\ell = 3$, $m_\ell = -2$, $m_s = +1/2$
   b. $n = 3$, $\ell = 2$, $m_\ell = +2$, $m_s = -1/2$
   c. $n = 3$, $\ell = 1$, $m_\ell = -1$, $m_s = -1/2$
   d. $n = 2$, $\ell = 0$, $m_\ell = 0$, $m_s = +1/2$
   e. $n = 1$, $\ell = 2$, $m_\ell = +1$, $m_s = +1/2$

2. Electronegativity
   a. Is determined by assigning one electron to each atom of a bond
   b. Is the energy required to remove an electron from an atom in the gas phase
   c. Is the negative charge of an ion
   d. Is a measure of how strongly an atom attracts electrons in a covalent bond
   e. Is the energy required to remove a *pair* of electrons from an atom

3. A covalent bond:
   a. Is always polar
   b. Forms ions in solution
   c. Always contains a metal
   d. Involves sharing electrons
   e. Always has high bond energy

4. Electronegativity ***decreases***:
   a. Top to bottom on the Periodic Table
   b. Left to right across the Periodic Table
   e. In the center of the Periodic Table
   d. As the quantum number "n" decreases
   e. As atoms get smaller

5. What orbital hybridization gives a ***trigonal pyramid molecular shape***?
   a. sp
   b. sp^2
   c. sp^3
   d. sp^3d
   e. sp^3d^2

Trends: For each of the following, circle the correct response (1pts) and give a *brief* explanation of your choice (5pts).

6. Which atom is smaller? Explain:

   Al vs. Fe

   Hmm, bad choice. Using the general horizontal periodic trend, Al should be smaller. Using the general vertical Al should be smaller. Actual data from the textbook? Al = 143pm, Fe = 126pm.

7. Which ion is smaller? Explain:

   Mn^{2+} vs. **Mn^{3+}**

   Both ions have the same number of protons in the nucleus. Mn^{3+} has fewer electrons so each electron "feels" more of the nuclear charge, which should draw the electrons closer, making Mn^{3+} smaller than Mn^{2+}.

Score

8. Which bond is longer? Explain:

C-S vs. C-O

S has another shell of electrons, so S should be bigger than O, therefore the C-S bond should be longer than the C-O bond.

9. Which CO bond is longer? Explain:

CO_2 vs. **CO_3^{-2}**

Drawing proper Lewis structures, both CO bonds in CO_2 are double bonds while the average bond order in CO_3^{-2} is 1.33 (two singles and a double, average to 4/3), so the CO bonds in CO_2 should be shorter.

10. Which element is less electronegative? Explain:

Se vs. **Sb**

Se is smaller, so the bonding electrons are closer to the nuclear charge, Se should be more electronegative. OR Se is closer to F, F is most electronegative, so Se is more electronegative than Sb.

11. Which bond is more polar? Explain:

N-S vs. **P-O**

O is more electronegative than S, and P is less electronegative than N, so the difference in electronegativity is greater for P-O, therefore the P-O bond is more polar.

For each of the following, write out a correct electron configuration. You may use noble gas shorthand notation for species below the 2nd row of the Periodic Table. (6pts each)

12. Aluminum (At.# = 13) **$1s^2 2s^2 2p^6 3s^2 3p^1$**

13. Strontium (At.# = 38) **$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2$**

14. Sulfide ion (At.# = 16) **$1s^2 2s^2 2p^6 3s^2 3p^6$**

"sulfide ion" has a -2 charge

15. Chromium(III) ion (At.# = 24) **$1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$**

"chromium(III) ion" has a +3 charge, 4s electrons are lost first

16. What are the 3 most likely charges (+ or -) of a germanium ion (At.# = 32)? Explain your answers. (15pts)

Starting with the electron configuration of a germanium ***atom***, we need to add or remove electrons to get to (relatively) stable electron configurations.

Ge	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^2$	
Ge^{-1}	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^3$	half-filled 4p subshell should be relatively stable
Ge^{-4}	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$	full shell noble gas configuration is stable
Ge^{+2}	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$	all subshells are full
Ge^{+4}	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$	all subshells are full, the entire n=3 set of orbitals is full
$\cancel{Ge^{+3}}$	$\cancel{1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}}$	half-filled 4s subshell DOES NOT make this very stable

Score

For each of the following, draw a correct Lewis Structure, determine the formal charge on each atom, name the electronic geometry, draw an appropriate VSEPR structure, name the molecular shape, and show the dipole moment of any polar molecules/ions. (15pts each)

17. IF_3

7 + 3(7) = 28 valence electrons	
Lewis Structure:	3 single bonds, 2 extra lone pairs on the central atom
Formal Charge:	0 on all atoms
Electron Geometry:	5 regions of electron density, trigonal bipyramidal
VSEPR Structure:	T-shaped molecule (TBP with 2 lone pairs)
Dipole Moment:	along the middle I-F bond pointing at the F

18. NO_2^-

5 + 2(6) + 1 = 24 valence electrons	
Lewis Structure:	1 single bond, 1 double bond, 1 extra lone pair on the central atom
Formal Charge:	0 on N and double-bonded oxygen, -1 on single-bonded oxygen
Electron Geometry:	3 regions of electron density, trigonal planar
VSEPR Structure:	Bent (trigonal planar with 1 lone pair)
Dipole Moment:	Through N, bisecting O-N-O angle, pointing away from N

19. $TeCl_4$

6 + 4(7) = 34 valence electrons	
Lewis Structure:	4 single bonds, 1 extra lone pair on the central atom
Formal Charge:	0 on all atoms
Electron Geometry:	5 regions of electron density, trigonal bipyramidal
VSEPR Structure:	See-saw-shaped molecule (TBP with 1 lone pairs)
Dipole Moment:	Through the Te, bisecting the equatorial Cl-Te-Cl angle, pointing away from Te

Score