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°F = 0.000°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 = $1.000\,^{\text{g}}/_{\text{mL}}$
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	57 **La** 138.91	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	89 **Ac** 227.03	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 (269)	111 (272)	112 (277)		114		116		

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	71 **Lu** 174.97
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)	103 **Lr** (260)

Score

Multiple Choice: Circle the letter of the most correct response. (5pts. per question)

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

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

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

4. What orbital hybridization gives a ***see-saw molecular shape***?
   a. sp
   b. sp^2
   c. sp^3
   d. $\boldsymbol{sp^3d}$
   e. sp^3d^2

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

5. Which atom is larger? Explain:

   Mg vs. ***Sc***

The electron configuration for Mg is $[Ne]3s^2$ and the e^- config for Sc is $[Ar]4s^23d^1$. Since Sc has an entire extra shell of electrons, we'd expect it to be larger than Mg.

6. Which atom is smaller? Explain:

   Si vs. ***P***

Si and P both have their highest energy valence electrons in 3p orbitals. P has an additional proton in its nucleus, so the 3p electrons in P experience more attraction to the nucleus than the 3p electrons in Si. That means P should be (slightly) smaller than Si.

Score

7. Which bond is longer? Explain:

C-H vs. N-H

Using the same arguments as in #6, we'd expect N to be (slightly) smaller than C. Since bond lengths are measured from nucleus center to nucleus center, the C-H bond should be (slightly) longer than the N-H bond.

8. Which CO bond is shorter? Explain:

CO_2 vs. CH_3OH

If we look at the Lewis structures of these two molecules, the bonds in CO_2 are double bonds while the bond in CH_3OH is a single bond. Double bonds are shorter than single bonds (between the same two elements), so the CO bonds in carbon dioxide are shorter.

9. Which bond is more polar? Explain:

Si-Br vs. ***Sn-O***

The electronegativity difference is larger in Sn-O, therefore it's more polar.

10. Which has a larger first ionization energy? Explain:

Mg vs. Ca

IE is the energy required to remove an electron from a gas phase atom. Since the outermost (valence) electrons in Ca are farther from the nucleus than the valence electrons in Mg, the Ca electron should be easier to remove; it should require less energy to remove the electron from Ca so Mg should have a larger (higher) first ionization energy.

11. Which X-P-X angle is larger? Explain:

PF_3 vs. ***PBr_3***

Both of these molecules are tetrahedral electronic geometry with trigonal pyramidal molecular shape. The lone pair should repel the bonding pairs more than the bonding pairs repel the bonding pairs, so both molecules should have bond angles less than 109.5°, but because Br is larger than F, the Br atoms cannot be pushed as close together as the F atoms. Therefore, the Br-P-Br angle should be larger than the F-P-F angle.

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

12. Bismuth (At.# = 83) $1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^24d^{10}5p^66s^24f^{14}5d^{10}6p^3$ or $[Xe]6s^24f^{14}5d^{10}6p^3$

13. Aluminum (At.# = 13) $1s^22s^22p^63s^23p^1$ or $[Ne]\ 3s^23p^1$

14. Bromide ion (At.# = 35) $1s^22s^22p^63s^23p^64s^23d^{10}4p^6$ or $[Ar]4s^23d^{10}4p^6$

15. Germanium(II) ion (At.# = 32) $1s^22s^22p^63s^23p^64s^23d^{10}$ or $[Ar]4s^23d^{10}$

Score

16. What are the 3 most likely charges (+ or -) of a silicon ion (At.# = 14)? Explain your answers. (16pts)

The electron configuration of a silicon *atom* is: [Ne] $3s^2 3p^2$

Stable charges are:

-4 → Gaining 4 electrons would fill the 3p subshell [Ne] $3s^2 3p^6$
-1 → Gaining 1 electron would give a half-full 3p subshell [Ne] $3s^2 3p^3$
+2 → Losing 2 electrons would empty the 3p subshell [Ne] $3s^2$
+4 → Losing 4 electrons would completely empty the n=3 shell [Ne]

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. (16pts each)

17. $TeCl_4$

34 valence electrons, 5 regions of electron density, trigonal bipyramidal electron geometry, one lone pair on the central atom (Te), zero formal charges on all atoms, all single bonds, see-saw molecular shape, polar molecule with dipole running through the Te and pointing out between the two 120° Te-Cl bonds.

18. IF_4^-

36 valence electrons, 6 regions of electron density, octahedral electron geometry, two lone pairs on the central atom (I), zero formal charge on fluorines, all single bonds, -1 formal charge on iodine, square planar molecular shape, polar bonds but all the bond dipoles cancel each other out so it's a non-polar molecule.

19. ICl_2^+

20 valence electrons, 4 regions of electron density, tetrahedral electron geometry, two lone pairs on the central atom (I), zero formal charge on chlorines, all single bonds, +1 formal charge on iodine, bent or angular molecular shape, polar bonds, dipole runs through the central I atom, points between the two chlorine atoms.

Score