

**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.

$$\text{Avogadro's Number} = 6.022 \times 10^{23} \text{ units/mol}$$

$$32.00^\circ\text{F} = 0.000^\circ\text{C} = 273.15\text{K}$$

$$1 \text{ foot} = 12 \text{ inches}$$

$$1 \text{ inch} = 2.54\text{cm (exactly)}$$

$$1 \text{ pound} = 453.6 \text{ g} = 16 \text{ ounces}$$

$$1 \text{ amu} = 1.6605 \times 10^{-24} \text{ g}$$

Masses of subatomic particles:

$$\text{Proton } 1.00728\text{amu} = 1.6726 \times 10^{-24} \text{ g}$$

$$\text{Neutron } 1.00866\text{amu} = 1.6749 \times 10^{-24} \text{ g}$$

$$\text{Electron } 0.000549\text{amu} = 9.1094 \times 10^{-28} \text{ g}$$

$$\text{Density of Water} = 1.000 \text{ g/mL}$$

$$R = 0.08206 \text{ L}\cdot\text{atm/mol}\cdot\text{K}$$

$$PV = nRT$$

$$1 \text{ calorie} = 4.184 \text{ J} = 0.001 \text{ Calorie}$$

$$h = 6.626 \times 10^{-34} \text{ Jsec}$$

$$\lambda = h/mv$$

$$1 \text{ J} = 1 \text{ kg (m/sec)}^2$$

$$c = \lambda\nu = 3.00 \times 10^8 \text{ m/sec}$$

$$E_{\text{photon}} = h\nu$$

1 <b>H</b> 1.0079																	2 <b>He</b> 4.0026				
3 <b>Li</b> 6.941	4 <b>Be</b> 9.0122															5 <b>B</b> 10.811	6 <b>C</b> 12.011	7 <b>N</b> 14.007	8 <b>O</b> 15.999	9 <b>F</b> 18.998	10 <b>Ne</b> 20.180
11 <b>Na</b> 22.990	12 <b>Mg</b> 24.305															13 <b>Al</b> 26.982	14 <b>Si</b> 28.086	15 <b>P</b> 30.974	16 <b>S</b> 32.066	17 <b>Cl</b> 35.453	18 <b>Ar</b> 39.948
19 <b>K</b> 39.098	20 <b>Ca</b> 40.078	21 <b>Sc</b> 44.956	22 <b>Ti</b> 47.88	23 <b>V</b> 50.942	24 <b>Cr</b> 51.996	25 <b>Mn</b> 54.938	26 <b>Fe</b> 55.847	27 <b>Co</b> 58.933	28 <b>Ni</b> 58.69	29 <b>Cu</b> 63.546	30 <b>Zn</b> 65.39	31 <b>Ga</b> 69.723	32 <b>Ge</b> 72.61	33 <b>As</b> 74.922	34 <b>Se</b> 78.96	35 <b>Br</b> 79.904	36 <b>Kr</b> 83.80				
37 <b>Rb</b> 85.468	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.906	40 <b>Zr</b> 91.224	41 <b>Nb</b> 92.906	42 <b>Mo</b> 95.94	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.41	49 <b>In</b> 114.82	50 <b>Sn</b> 118.71	51 <b>Sb</b> 121.76	52 <b>Te</b> 127.60	53 <b>I</b> 126.90	54 <b>Xe</b> 131.29				
55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.33	71 <b>Lu</b> 174.97	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.84	75 <b>Re</b> 186.21	76 <b>Os</b> 190.23	77 <b>Ir</b> 192.22	78 <b>Pt</b> 195.08	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.38	82 <b>Pb</b> 207.2	83 <b>Bi</b> 208.98	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)				
87 <b>Fr</b> (223)	88 <b>Ra</b> 226.03	103 <b>Lr</b> (260)	104 <b>Rf</b> (261)	105 <b>Db</b> (262)	106 <b>Sg</b> (263)	107 <b>Bh</b> (262)	108 <b>Hs</b> (265)	109 <b>Mt</b> (266)	110 <b>Ds</b> (269)	111 <b>Rg</b> (272)	112 <b>Cn</b> (277)	113	114	115	116	117	118				

57 <b>La</b> 138.91	58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.36	63 <b>Eu</b> 151.97	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.93	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.94	70 <b>Yb</b> 173.04
89 <b>Ac</b> 227.03	90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> 237.05	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (258)	101 <b>Md</b> (258)	102 <b>No</b> (259)

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

- Which of the following is **not** a possible set of quantum numbers for an electron?
  - $n = 4, \ell = 3, m_\ell = -2, m_s = +1/2$
  - $n = 3, \ell = 2, m_\ell = +2, m_s = -1/2$
  - $n = 3, \ell = 1, m_\ell = -1, m_s = -1/2$
  - $n = 2, \ell = 0, m_\ell = 0, m_s = +1/2$
  - $n = 1, \ell = 2, m_\ell = +1, m_s = +1/2$
- Electronegativity
  - Is determined by assigning one electron to each atom of a bond
  - Is the energy required to remove an electron from an atom in the gas phase
  - Is the negative charge of an ion
  - Is a measure of how strongly an atom attracts electrons in a covalent bond**
  - Is the energy required to remove a *pair* of electrons from an atom
- A covalent bond:
  - Is always polar
  - Forms ions in solution
  - Always contains a metal
  - Involves sharing electrons**
  - Always has high bond energy
- Electronegativity **decreases**:
  - Top to bottom on the Periodic Table**
  - Left to right across the Periodic Table
  - In the center of the Periodic Table
  - As the quantum number “n” decreases
  - As atoms get smaller
- What orbital hybridization gives a **trigonal pyramid molecular shape**?
  - sp
  - sp<sup>2</sup>
  - sp<sup>3</sup>**
  - sp<sup>3</sup>d
  - sp<sup>3</sup>d<sup>2</sup>

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

6. Which atom is larger?

Al vs. Fe

Explain:

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.

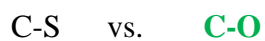
7. Which ion is larger?

**Mn<sup>2+</sup>** vs. Mn<sup>3+</sup>

Explain:

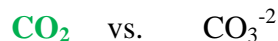
Both ions have the same number of protons in the nucleus. Mn<sup>3+</sup> has fewer electrons so each electron “feels” more of the nuclear charge, which should draw the electrons closer, making Mn<sup>3+</sup> smaller than Mn<sup>2+</sup>.

8. Which bond is shorter? Explain:



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 shorter?



Explain:

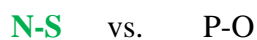
Drawing proper Lewis structures, both CO bonds in CO<sub>2</sub> are double bonds while the average bond order in CO<sub>3</sub><sup>2-</sup> is 1.33 (two singles and a double, average to 4/3), so the CO bonds in CO<sub>2</sub> should be shorter.

10. Which element is more electronegative? Explain:



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 less polar? Explain:



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 2<sup>nd</sup> row of the Periodic Table. (6pts each)

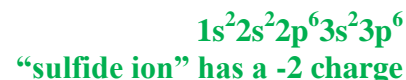
12. Aluminum (At.# = 13)



13. Strontium (At.# = 38)



14. Sulfide ion (At.# = 16)

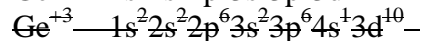
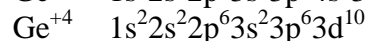
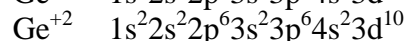
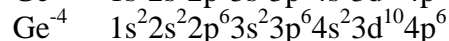
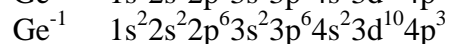
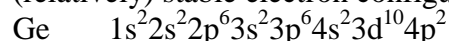


15. Chromium(III) ion (At.# = 24)



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.



half-filled 4p subshell should be relatively stable

full shell noble gas configuration is stable

all subshells are full

all subshells are full, the entire n=3 set of orbitals is full

half-filled 4s subshell DOES NOT make this very stable

Fall 2010

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.  $\text{IF}_3$  $7 + 3(7) = 28$  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.  $\text{NO}_2^-$  $5 + 2(6) + 1 = 24$  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.  $\text{TeCl}_4$  $6 + 4(7) = 34$  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 pair)

Dipole Moment: Through the Te, bisecting the equatorial Cl-Te-Cl angle, pointing away from Te