Name:________________________________ Section (circle): 1 2 3 4 5

SAMPLE EXAM FALL 2012 MINUS Q. II.

Chemistry 11, Fall 2006
Exam II
November 16, 2006
7:30 PM – 9:30 PM

As always, full credit will not be given unless you have written down the reasoning or calculations you used to obtain the correct answer. **Work on the back of pages will not be graded!** Pay attention to significant figures. Please check now that your exam has twelve pages (including this one). A periodic table and a list of formulas are attached at the back of the exam. If you finish early, just leave your completed exam on the front desk. If you have a question, we will be up on the fifth floor. You have two hours to complete this exam.

It is against the honor code at Amherst College to either give or receive help on this exam. The work you turn in must be yours and yours alone.

Extra Credit (circle the correct answer)
Perchance you remember the stunning appearance of GN Lewis in our class last Wednesday. His words, reprinted in your powerpoint handout for that day, spoke about his attempts to have communicated the "soul of chemistry." During his speech, GN Lewis invoked the name of another, "Asmodeus", from whom he demanded a test tube. Who/What is(was) Asmodeus?

a) GN Lewis's graduate student
b) According to ancient texts, a demon who was repelled by the fumes of fish liver
c) Professor Rick Griffith's name in his former life
d) Professor O'Hara's nickname

Question	Points	Score
XC	02	
I	20	
II	24	
III	20	
IV	20	
V	16	
Total	102	

I. Atomic and Periodic Properties: Newly Synthesized Element 118 (20 points)

1. The synthesis of element 118 was reported recently by a collaborative team of 30 scientists from the US and Russia (Physical Review C, October 2006.)
   a. Write down the ground state electron configuration for the newly synthesized element. Use the abbreviation scheme in which inner core electrons are represented uisng the appropriate noble gas…for example, the electron configuration for Li is $[He]2s^1$.

   b. To which period (row) and group (column) do this new element belong?

2. Order the elements (some have yet to be synthesized) with the following atomic numbers 115, 116, 117, 118, 119, 120 from SMALLEST to LARGEST……………..

   a. Atomic radii

   b. Ionization energy

   c. Magnetic spin: (number of unpaired electrons)

3. Elements 115^{-3}, 116^{-2}, 117^{-1}, 118, 119^{+}, and 120^{+2} are isoelectronic. Arrange these elements from SMALLEST to LARGEST…………

   a. Atomic or ionic radii

   b. Ionization energy

   c. Electron Affinity (arrange from most negative to most positive)

4. Grab bag of multielectron atom questions.

   a. Which element in the fourth row (K to Kr) would have the lowest <u>second</u> ionization energy and why? Remember: 2nd Ionization Energy $Atom^{+}$ ------> $Atom^{++} + e^{-}$

   b. Which element in Group 17 (the halogens) would require the greatest energy photon to remove its 1s electron. Why?

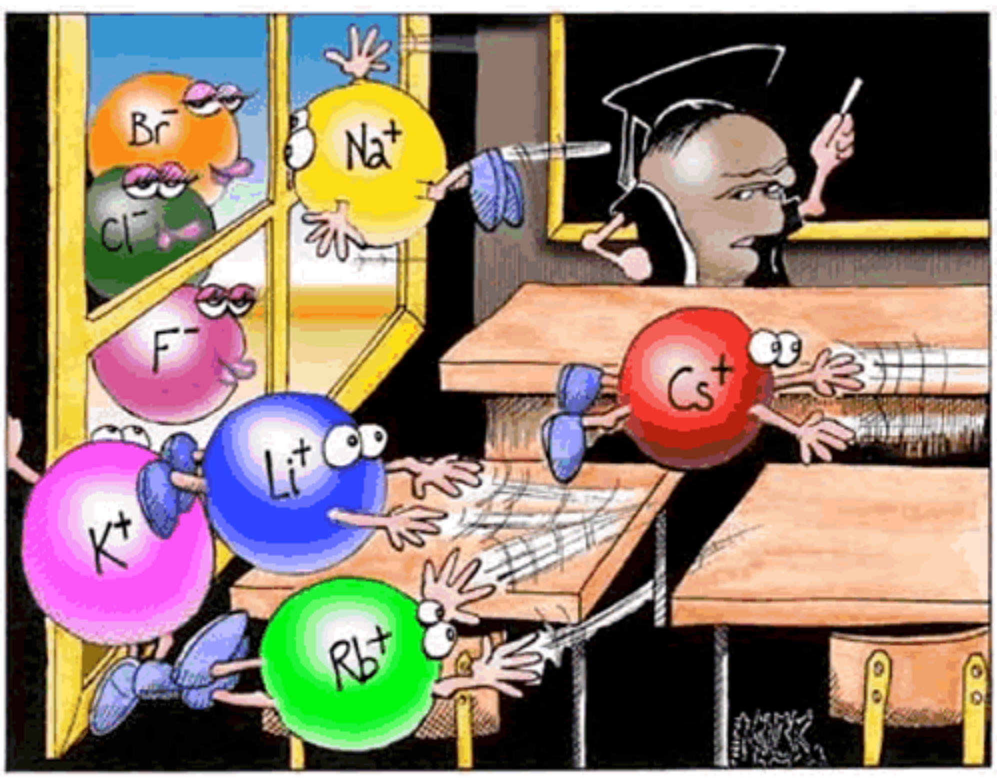
   c. Which is the first element in which the n=4 shell is COMPLETELY filled?

Question II. Lewis Structures, VSEPR, dipoles (24)

Consider the following four molecules and molecular ions : POCl (phosporus monochlorine monoxide); PH_3 (phosphine); $POCl_3$ (phosphorus trichlorine monoxide); $PFCl_4$ (phosphorus monofluorine tetrachlorine):

On the **following** page:

1. Draw the best Lewis structure clearly indicating the total number of valence electrons, all bonding and unshared electrons, and a formal charge for ALL atoms.
2. Next to the Lewis structure, sketch a VSEPR 3-D representation of the molecule. Indicate the steric number of the central P atom (steric number is the number of bonded atoms plus lone pairs), the geometry of the molecule, and the bond angles.
3. The electronegativites of P, O, Cl, H and F are 2.2, 3.4, 3.2, 2.2 and 4.0. Indicate on your VSEPR sketch both individual bond dipoles (blue pen) and molecular dipoles (red pen) for each species.



"Perhaps one of you gentlemen would mind telling me just what it is outside the window that you find so attractive...?"

Lewis Structure Val Elec ________ Formal Charges **POCl**	VSEPR Structure Steric Number _____ Geometry Name _____________
Lewis Structure Val Elec ________ Formal Charges **PH_3**	VSEPR Structure Steric Number _____ Geometry Name _____________
Lewis Structure Val Elec ________ Formal Charges **$POCl_3$**	VSEPR Structure Steric Number _____ Geometry Name _____________
Lewis Structure Val Elec ________ Formal Charges **$PFCl_4$**	VSEPR Structure Steric Number _____ Geometry Name _____________

Question III (Quantum Mechanics) 20 points

1. Write down a plausible set of four quantum numbers for each electron in the following atoms or ions. For each question, the number of electrons for which quantum numbers are requested is shown in parentheses. For some electrons, more than one correct set is possible. You need provide only one correct set for each electron. The ground state of hydrogen is done for you as an example.

   a. The ground state of Hydrogen (1) 100 + ½

   b. The lowest energy excited state of helium(2) _______ _______

   c. The ground state of lithium (3) _______ _______ _______

   d. The ground state of Li^{+2} (1) _______

   e. The valence electrons in the ground state of carbon (4)

   _______ _______ _______ _______

2. This question focuses properties of the fourth shell (family of orbitals with n=4).

   a. In the n=4 shell — Indicate the number of

   Orbitals ____________

   Electrons ____________

   nodes/orbital ____________

   b. Use this space to draw the radial functions and the radial probability distributions for 4s, 4p and 4d orbitals for the hydrogen atom (three graphs for each here six total). Remember to label your axes and indicate radial nodes and most probable distances on the radial distributions.

c. Use this space to sketch orbital pictures for each of the 4s, $4p_z$, and $4dx^2 - y^2$ orbitals (your answer here should show three figures, each sketched along a set of x, y, and z axes). Note phases, nodal planes, radial nodes and axial orientation if appropriate. Be sure to label your axes.

Question IV. Energy Level Diagrams…..20 points

1. The first ionization energies of helium, lithium, and carbon are 2372.3, 520.23, and 1086.4 kJ/mole.
    a. Express these ionization energies as joules/atom.

    b. Identify the orbital of the valence (highest energy) electron in these atoms (i.e. 3p or 2s)

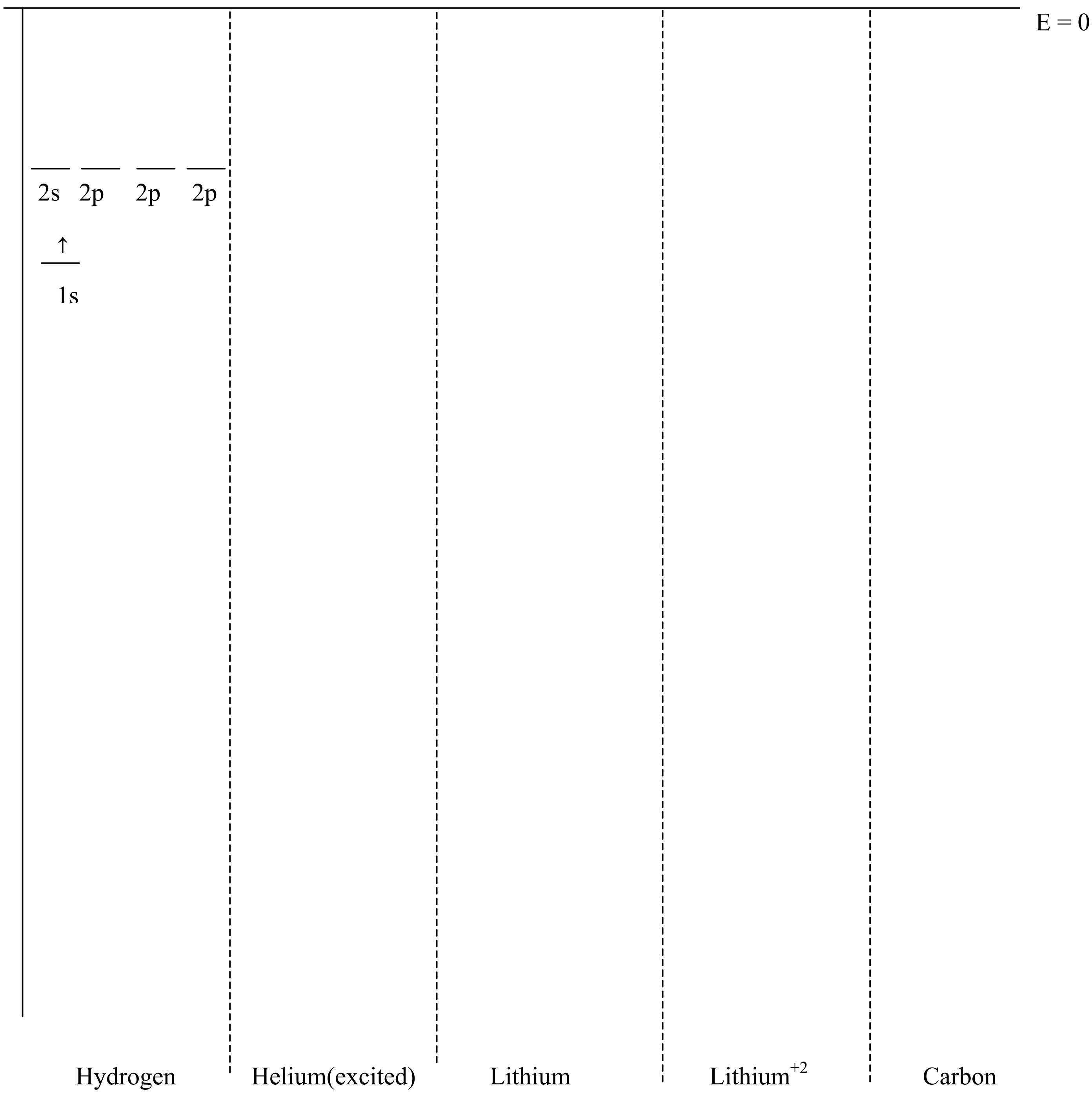
    c. What is the energy of the valence orbital in each of the atoms above?

2. Helium can be excited from its ground state to its first excited state with an electric discharge (see problem III1b). When this excited state helium relaxes back down to the ground state it can emit a photon of wavelength 125 nm.

    a. What is the energy of a photon with that wavelength?

    b. What does the energy of this photon represent with regards to the energies of the orbitals in Helium.

3. Consider the atoms in Question III, 1a: the hydrogen atom, a helium atom in its lowest energy excited state, the ground states of lithium and the lithium^{+2} ion, and finally, a ground state carbon atom. The energy level diagram for the energy levels in **hydrogen** up to n=2 is shown below with its electron in the proper orbital. In the columns adjacent to the diagram for hydrogen, draw your own energy level diagrams for the n=1 and n=2 levels for **helium**, **lithium**, **lithium^{+2}**, and **carbon** as accurately as you can, and then populate those orbitals with the appropriate number of electrons. It is possible to **calculate the exact energies for eight of these levels** from information in this exam.



V Baker's Street Dozen Lab (16 points)

You have signed up to be a TA next semester, and Professor Sanborn gives you the answer key to the Baker's Street Half-Dozen lab. The six solutions are labeled in lab only as A-F. Your answer key tells you that A is silver nitrate, B is sodium chloride, C is sodium hydroxide, D is nitric acid, E is hydrochloric acid, and F is sodium carbonate, and each is 0.1 M.

1. Write out the chemical formulas of the six solutions

2. Predict the approximate pH of each solution.

3. Fill out the reactivity chart so that you'll be ready for your students. Record what your students will observe i.e. "milky white precipitate or "bubbles formed." Write "NR" if no reaction occurs.

	B	C	D	E	F
A					
B					
C					
D					
E					

Write out an explanation for how the identification is made for each unknown to help you explain to your students.

A.

B.

C.

D.

E.

F.

Assorted Equations, Constants, and Conversion Factors

Wavelength, frequency, speed relation for waves: $\lambda\nu = c$

Photon energy: $E_{photon} = h\nu = \frac{hc}{\lambda}$

Photoelectric effect: $E_{kinetic\ (ejected\ e^-)} = E_{photon} - \Phi = h\nu - h\nu_o$

Kinetic energy: $E_{kinetic} = \frac{1}{2}mv^2$

deBroglie wavelength: $\lambda = \frac{h}{p} = \frac{h}{mv}$

Heisenberg's uncertainty principle: $\Delta p \times \Delta x \geq \frac{h}{4\pi}$ or $m\Delta v \times \Delta x \geq \frac{h}{4\pi}$

Energy levels of a one-electron atom: $E_n = \left(-2.178 \times 10^{-18}\ J\right)\left(\frac{Z^2}{n^2}\right)$

$$\Delta E = \left(-2.178 \times 10^{-18}\ J\right)\left(Z^2\right)\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

Avogadro's number: $N_A = 6.022 \times 10^{23}\ mol^{-1}$

Speed of light: $c = 2.9979 \times 10^8\ m\ s^{-1}$

Planck's constant: $h = 6.626 \times 10^{-34}\ J\ s$

Fundamental charge: $e = 1.60218 \times 10^{-19}\ C$

Proton mass: $m_p = 1.673 \times 10^{-27}\ kg$

Neutron mass: $m_n = 1.675 \times 10^{-27}\ kg$

Electron mass: $m_e = 9.109 \times 10^{-31}\ kg$

$1\ kg = 10^3\ g$

$1\ nm = 10^{-9}\ m$

$1\ J = 1\ N\ m = 1\ kg\ m^2\ s^{-2}$

$1\ kJ = 10^3\ J$

WebElements: the periodic table on the world-wide web

http://www.webelements.com/

Key:

element name atomic number **symbol** atomic weight (mean relative mass)

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
hydrogen 1 **H** 1.0079																		helium 2 **He** 4.0026
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.0122												boron 5 **B** 10.811	carbon 6 **C** 12.011	nitrogen 7 **N** 14.007	oxygen 8 **O** 15.999	fluorine 9 **F** 18.998	neon 10 **Ne** 20.180
sodium 11 **Na** 22.990	magnesium 12 **Mg** 24.305												aluminium 13 **Al** 26.982	silicon 14 **Si** 28.086	phosphorus 15 **P** 30.974	sulfur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.948
potassium 19 **K** 39.098	calcium 20 **Ca** 40.078		scandium 21 **Sc** 44.956	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.942	chromium 24 **Cr** 51.996	manganese 25 **Mn** 54.938	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.933	nickel 28 **Ni** 58.693	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.39	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.922	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.80
rubidium 37 **Rb** 85.468	strontium 38 **Sr** 87.62		yttrium 39 **Y** 88.906	zirconium 40 **Zr** 91.224	niobium 41 **Nb** 92.906	molybdenum 42 **Mo** 95.94	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.91	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.87	cadmium 48 **Cd** 112.41	indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.76	tellurium 52 **Te** 127.60	iodine 53 **I** 126.90	xenon 54 **Xe** 131.29
caesium 55 **Cs** 132.91	barium 56 **Ba** 137.33	57-70 *	lutetium 71 **Lu** 174.97	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.22	platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	89-102 **	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [261]	dubnium 105 **Db** [262]	seaborgium 106 **Sg** [266]	bohrium 107 **Bh** [264]	hassium 108 **Hs** [269]	meitnerium 109 **Mt** [268]	darmstadtium 110 **Ds** [281]	roentgenium 111 **Rg** [272]	ununbium 112 **Uub** [285]	ununtrium 113 **Uut** [284]	ununquadium 114 **Uuq** [289]	ununpentium 115 **Uup** [288]	ununhexium 116 **Uuh** [292]		

*lanthanoids	lanthanum 57 **La** 138.91	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.96	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.93	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.93	erbium 68 **Er** 167.26	thulium 69 **Tm** 168.93	ytterbium 70 **Yb** 173.04
**actinoids	actinium 89 **Ac** [227]	thorium 90 **Th** 232.04	protactinium 91 **Pa** 231.04	uranium 92 **U** 238.03	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]

Symbols and names: the symbols and names of the elements, and their spellings are those recommended by the International Union of Pure and Applied Chemistry (IUPAC - http://www.iupac.org/). Names have yet to be proposed for the most recently discovered elements 111–112 and 114 so those used here are IUPAC's temporary systematic names. In the USA and some other countries, the spellings **aluminum** and **cesium** are normal while in the UK and elsewhere the common spelling is **sulphur.**
Group labels: the numeric system (1–18) used here is the current IUPAC convention.
Atomic weights (mean relative masses): Apart from the heaviest elements, these are the IUPAC 2001 values and given to 5 significant figures. Elements for which the atomic weight is given within square brackets have no stable nuclides and are represented by the element's longest lived isotope.