Exam Four CHM 203 (Dr. Mattson) 25 October 2006	***Academic Integrity Pledge:*** *In keeping with Creighton University's ideals and with the Academic Integrity Code adopted by the College of Arts and Sciences, I pledge that this work is my own and that I have neither given nor received inappropriate assistance in preparing it.* ***Signature:***

Instructions: Show all work whenever a calculation is required! You will receive credit for how you worked each problem as well as for the correct answer. This exam is worth 100 points. BOX YOUR ANSWERS!

1. (10 pts) T/F Evaluate the following statements.

T F Wavelength can have units of cm.
T F Wavelength is proportional to frequency.
T F Energy is proportional to frequency.
T F The speed of light equals energy times frequency
T F Ultraviolet electromagnetic radiation has a longer wavelength than visible light.
T F In the visible spectrum, red has the largest frequency.
T F To convert wavelength into energy with units of kJ/mol, one must use Avogadro's number
T F In quantum mechanics, energy is proportional to $-1/n^2$.
T F The lowest energy level has n = 1.
T F Whenever an electron moves from one energy level to a higher energy level, an input of energy is required.

2. In class we saw the red light that strontium makes in its flame test. The wavelength of this red light is 650 nm. Convert this wavelength into:

(a) (3 pts) Frequency

(b) (5 pts) Energy in units of kJ/mol

3. (10 pts) In class we used the hydrogen discharge tube and the view glasses to see how discrete lines of light were observed in the Balmer Series. Answer the following questions about this experiment.

(a) Were we observing light being absorbed or emitted? Circle: ABSORBED or EMITTED.

(b) You should have seen four bands of light as listed below. What electronic transitions did each band represent? (Answer should have the format of: "n = (some number) to n = (some other number)") Hint: In each case, one of the two numbers is n = 2.

red
green
blue
indigo

(c) Continuing with the previous question, what would be the first transition in the Balmer series that we could *not* see because it is not in our visible spectrum?

(d) Continuing with you previous answer, in what region of the electromagnetic spectrum does this band exist?

(e) What would be the largest energy electron transition possible within the Balmer series (not necessarily in the visible spectrum)?

4. (4 pts) Sketch an energy diagram and sketch in the energies of all orbitals up through the 5s orbital.

5. (24 pts) Answer the following questions about orbitals and quantum numbers.

(a) Populate the energy diagram in the previous problem for a ground state sulfur atom. How many unpaired electrons are present?

(b) Copy the lines you drew in Question 4 for the 3d orbits and assign values of m_l to each orbital.

(c) Sketch the shape of the following orbitals: (i) 1s; (ii) one of the 2p orbitals

(i) (ii)

(d) (i) What are the allowable values for l when n = 6?
(ii) What are they? Answer: 6s, etc.

(i)	(ii)

(e) How many orbitals all together can have n = 6?

(f) Using the periodic table, what is the largest value for n of an occupied orbital in the ground state?

(g) Which of the four quantum numbers refers only to electrons and not orbitals?

(h) Where on the periodic table does one find elements with electron configurations of $ns^2\ np^5$? Answer by giving one example.

(i) Give an example of an element with a diamagnetic ground state electron configuration

(j) Give an example of an element with a half-filled n = 1 orbital in the ground state.

6. (10 pts) Write the ground state electron configurations for the following elements. You may use the core + valence notation whenever convenient.

(a) hydrogen	
(b) lithium	
(c) phosphorus	
(d) cobalt	
(e) bromine	

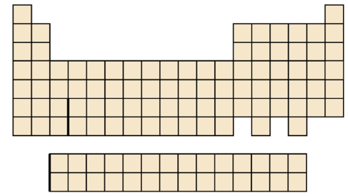
7. (8 pts) Give orbital notations for electrons in orbitals with the following quantum numbers. (For example, "1s")

(a) $n = 3, l = 1, m_l = -1, m_s = +{}^1/_2$	
(b) $n = 5, l = 3, m_l = +3, m_s = -{}^1/_2$	
(c) $n = 2, l = 0, m_l = 0, m_s = -{}^1/_2$	
(d) $n = 4, l = 2, m_l = -2, m_s = +{}^1/_2$	

8. (2 pts) The following statements are the Pauli exclusion principle and Hund's rule, not necessarily in that order. Is the first one Pauli exclusion principle or Hund's rule? Circle: PAULI or HUND

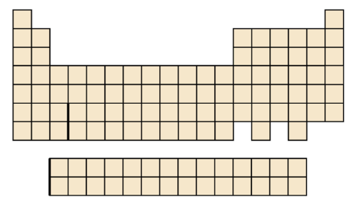
(a) No two electrons in an atom can have the same four quantum numbers.
(b) If two or more orbitals with the same energy are available, one electron goes in each until they are half full. The electrons in the half-filled orbitals all have the same value of their spin quantum number.

9. (6 pts) What are the two periodic trends for atomic radius? (a) Label the trends on the periodic table below.



(b) What concept explains the trend from left to right? Circle: EFFECTIVE NUCLEAR CHARGE or ENERGY DIAGRAM or INCREASED ORBITAL SIZE
(c) What concept explains the trend from top to bottom? Circle: EFFECTIVE NUCLEAR CHARGE or ENERGY DIAGRAM or INCREASED ORBITAL SIZE

10. (6 pts) What are the periodic trends for first ionization energy? (a) Label the trends on the periodic table below.



(b) What concept explains the trend from left to right? Circle one: EFFECTIVE NUCLEAR CHARGE or ENERGY DIAGRAM or INCREASED ORBITAL SIZE

(c) What concept explains the trend from top to bottom? Circle one: EFFECTIVE NUCLEAR CHARGE or ENERGY DIAGRAM or INCREASED ORBITAL SIZE

11. (4 pts) When comparing ionic vs atomic radii, which is smaller: Circle your choice in each case.

(a) a CATION or the corresponding NEUTRAL ATOM

(b) an ANION or the corresponding NEUTRAL ATOM

12. (6 pts) For the eight elements for which n = 2, which element has:

(a) the largest first ionization energy?	
(b) the largest electron affinity?	
(c) the largest atomic radius?	

13. (2 pts) Which family of elements is expected to exhibit a large jump in energy between their third and fourth subsequent ionization energies?

If you have read and signed the Academic Integrity statement, please print your name here:

Your exam score (100 possible): ________

Determine your grade:
A+ ≥ 95; A ≥ 90; B+ ≥ 85; B ≥ 80; C+ ≥ 75; C ≥ 70; D ≥ 60

Formulas, equations and constants:

$$c = \lambda \upsilon \qquad \Delta E = hc/\lambda$$

$$h = 6.626 \times 10^{-34}\ J\ s$$

$$c = 3.0 \times 10^{8}\ m/s$$

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110	111	112		114		116		118

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Answers:

1. T F T F F F T T T T

2. $4.6 \times 10^{14}\ s^{-1}$; 184 kJ/mol

3. (a) EMITTED;

(b) *red n = 3 to n = 2; green n = 4 to n = 2; blue n = 5 to n = 2; indigo n = 6 to n = 2*

(c) n = 7 to n = 2 (or n = 2 to n = 1)

(d) ultraviolet

(e) n = infinity to n = 2

4.

5s ___
4p ___ ___ ___
3d ___ ___ ___ ___ ___
4s ___
3p ___ ___ ___
3s ___

2p ___ ___ ___
2s ___

1s ___

5.

(a) (the above diagram should have been populated with electrons to make $1s^2 2s^2 2p^6 3s^2 3p^4$; two unpaired electrons

(b)

___ ___ ___ ___ ___
-2 -1 0 1 2

(c) A sphere shape and a dumb bell shape.

(d) (i) 0, 1, 2, 3, 4 and 5 (ii) 6s, 6p, 6d, 6f, 6g, and 6h

(e) 36; (f) 7; (g) m_s; (h) F; (i) Ne; (j) H

6.

H $1s^1$

Li $1s^2 2s^1$

P [Ne] $3s^2 3p^3$ or $1s^2 2s^2 2p^6 3s^2 3p^3$

Co [Ar] $4s^2 3d^7$ or $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^7$

Br [Ar] $4s^2 3d^{10} 4p^5$ or $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

7. 3p; 5f; 2s; 4d

8. PAULI

9. (a) decreases from L to R and increases from top to bottom
(b) EFFECTIVE NUCLEAR CHARGE
(c) INCREASED ORBITAL SIZE

10. (a) increases from L to R and decreases from top to bottom
(b) EFFECTIVE NUCLEAR CHARGE
(c) ENERGY DIAGRAM

11. (a) CATION; (b) NEUTRAL ATOM

12. Ne, F, Li

13. Group III