CHM 1045 (11:15 am Lecture) **FINAL EXAM** **Name _____**
Dr. Light **April 26, 2004** **(please print)**

Check your recitation section:
___Sec. 21 5:30-6:20 pm (Popovic) **___Sec. 24 3:30-4:20 pm (Giunta)**
___Sec. 22 6:30-7:20 pm (Popovic) **___Sec. 25 4:30-5:20 pm (Giunta)**
___Sec. 23 7:30-8:20 pm (Popovic) **___Sec. 26 5:30-6:20 pm (Giunta)**

This exam consists of six pages. Make sure you have one of each. Print your name at the top of each page now. Pages 7 and 8 contain some thermochemical data, important constants, a table of electronegativities, and a periodic table. You may tear both off and use them for scratch paper.
Show your work on calculations, including unit conversions, and give answers in the correct units and appropriate number of significant figures. In problems involving molecular and formula weights, you may use values rounded to the nearest 0.1 amu.

If anything confuses you or is not clear, raise your hand and ask!

Page	**Points**
1	_____
2	_____
3	_____
4	_____
5	_____
6	_____
Total	_____

Points

(4) 1. Give the atomic symbol, including Z, A, and q in the proper location, for atoms or ions containing the following number of particles:

(a) 34 protons, 45 neutrons, 36 electrons

(b) 26 protons, 30 neutrons, 23 electrons

(6) 2. Complete and balance the equations for the following reactions, giving first the **balanced molecular equation**, then the **net ionic equation**. (Give the correct formulas for the named reactants and for the products indicated with a ?).

(a) **silver (I) nitrate + sodium sulfate ® ? + ?**

molecular equation:

net ionic equation:

(b) **sulfuric acid + lithium hydroxide ® ? + ?**

molecular equation:

net ionic equation:

3. You mix 45.0 mL of a 0.293 **M** solution of Na_3PO_4 with 65.0 mL of a 0.266 **M** solution of $BaCl_2$. Following is the balanced equation for the reaction which occurs:

$$3\ BaCl_2\ (aq) + 2\ Na_3PO_4\ (aq) \rightarrow Ba_3(PO_4)_2\ (s) + 6\ NaCl\ (aq)$$

(4) (a): How many **grams** of each reagent are mixed in the reaction?

(2) (b) Which is the limiting reagent? (Show your work in determining).

(2) (c) How many **moles** of $Ba_3(PO_4)_2$ will be formed in the reaction?

(2) (d) How many **moles** of excess reagent will remain?

(5) 4. The heat of combustion of propane (C_3H_8) is -2220 kJ/mol.
(a) Write and balance the equation for the complete combustion of propane.

(b) If enough propane is burned to produce 1.00×10^4 kJ of heat, how many grams of CO_2 would be produced?

(5) 5. A compound containing only carbon, hydrogen, and oxygen was shown by combustion analysis to consist of 57.1% C and 4.76% H. What is its empirical formula?

6. Calculate ΔH for the following reaction in two different ways, using the thermochemical data given at the end of the test:

$$C_2H_{4\,(g)} + H_2O_{(l)} \rightarrow C_2H_5OH_{(l)}$$

(3) (a) Use the bond energy data.

(3) (b) Use the heats of formation data.

(1) (c) Using the ΔH value from part (b), calculate ΔE (q at constant volume) for this reaction at 25 ^{o}C.

7. An unknown metal weighing 44.7 g is heated to a temperature of 87.2 ^{o}C and placed in an insulated cup containing 105.6 g of water at a temperature of 20.5 ^{o}C. After the metal cools, the final temperature of the metal and the water is 23.4 ^{o}C.

(3) (a) How much heat has the metal lost?

(3) (b) What is the specific heat of the metal?

(6) 8. Carbon-carbon bonds are prevalent in nearly every organic and biological molecule. The average bond energy of the C-C bond is 348 kJ/mol. Calculate the **frequency** and **wavelength** of the least energetic photon that could break a bond with this energy.

9. You purchase a tank of "purified" air containing 79.2 % mole percent nitrogen and 20.8% mole percent oxygen. At 25 ^{o}C, the tank gauge registers a pressure of 10.24 atmospheres. The volume of the tank is 6.8 L.

(3) (a) What is the partial pressure of the oxygen in the tank?

(3) (b) How many grams of oxygen are contained in the tank?

(3) 10. Write the abbreviated electron configuration (using the rare gas core, i.e. C = $[He]2s^2 2p^2$) for the following:

Sb **Ni^{2+}** **S**

(4) 11. For each of the following groups of three elements, circle the one with the highest first ionization energy.

(a) Na Mg K (b) F O P

(4) 12. For each of the following groups of three atoms, circle the one with the largest atomic radius.

(a) S O P (b) Ca Rb K

(4) 13. Identify the quantum number n and l associated with the following atomic orbitals:

	2s	4d	3p	6f
n =	_____	_____	_____	_____
l =	_____	_____	_____	_____

(8) 14. For the following compounds formed between bromine and fluorine, draw the Lewis dot structure. Give the electron pair geometry, the molecular geometry, and the hybridization about the central atom.

Compound	Lewis Structure	Electron pair Geometry	Molecular Geometry	Hybridization
BrF_3				
BrF_5				

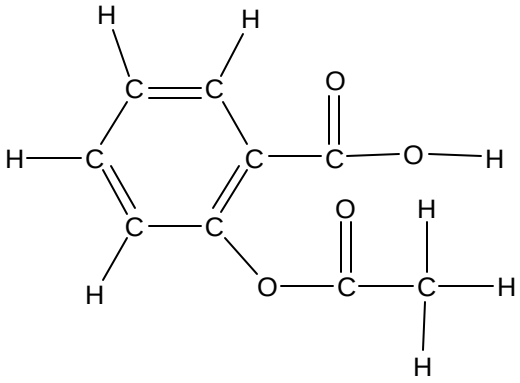
(8) 15. Acetylsalicylic acid (aspirin) is probably the most widely used medicine in the world. It has the Lewis structure on the right.

(a) How many **sigma** bonds are there in the molecule? _____

(b) How many **pi** bonds are there in the molecule? _____

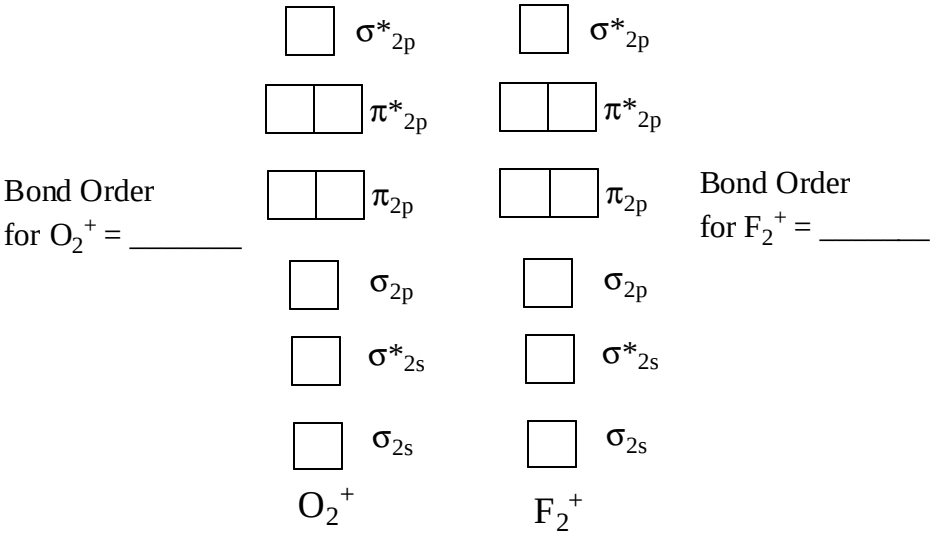
(c) How many carbon atoms in the molecule have **sp^2** hybridization? _____

(d) How many carbon atoms in the molecule have **sp^3** hybridization? _____



Acetylsalicylic Acid (aspirin)

(8) 16. Fill in the molecular orbital occupancy for the two ions O_2^+ and F_2^+ and determine the bond order for each.



Bond Order for O_2^+ = _____

Bond Order for F_2^+ = _____

(6) 17. Below is a phase diagram for water. Identify the point (A, B, C, D, or E) or region (X, Y, or Z) of the diagram that corresponds to:

(a) water vapor _____

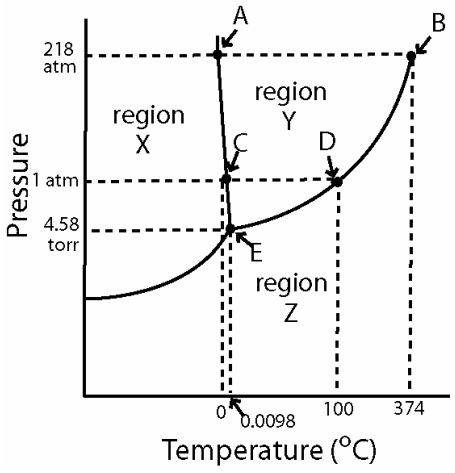
(b) liquid water _____

(c) normal melting point _____

(d) normal boiling point _____

(e) triple point _____

(f) ice _____



The following constants, equations, and tables of data may be useful to you.

Physical constants and equations:

Rydberg constant = $1.097 \times 10^{7}\ m^{-1}$
$1/\lambda = 1.097 \times 10^{7}\ m^{-1}\ (1/n_1^2 - 1/n_2^2)$
Planck's constant, $h = 6.626 \times 10^{-34}$ J-s
(or $kg\text{-}m^2/s$)
Speed of light, $c = 3.00 \times 10^{8}$ m/s = $\lambda\nu$
Energy of 1s orbital in the hydrogen atom = -2.18×10^{-18} J (also = Rydberg constant x hc)
$\lambda = h/mv$
$\Delta x \cdot m\Delta v \geq h/4\pi$
$E = h\nu$
$N = 6.022 \times 10^{23}$ entities/mol
R = 0.08206 L-atm/mol-K
(or 8.314 J/mol-K)

?H of fusion of ice = 6.008 kJ/mol;
?H of vaporization of water = 40.67 kJ/mol;
Specific heat of ice = 2.092 J/g-K
Specific heat of water = 4.184 J/g-K;

Heats of Formation:

Substance	ΔH_f^o **kJ/mol**	**Substance**	ΔH_f^o **kJ/mol**
CO(g)	-110.5	CaO(s)	-635.1
CO_2(g)	-393.5	$CaCO_3$(s)	-1207.1
CH_3OH(l)	-238.6	$Ca(OH)_2$(s)	-986.1
C_2H_5OH(l)	-277.7	Mg(g)	147.1
H_2O(l)	-285.8	Mg^{2+}(g)	2335.1
H_2O(g)	-241.8	Mg^{+}(g)	885.1
C_2H_6(g)	-84.7	MgO(s)	-601.7
C_2H_4(g)	52.3	Li(g)	159.3
C_2H_2(g)	226.7	Cl(g)	121.7
C_6H_6(l)	49.0	F(g)	80.0
C_4H_{10}(g)	-124.7	LiCl(s)	-408.3
CH_2O(g)	-117.0	Li^{+}(g)	685.7
CH_3COOH(l)	-484.1	Cl^{-}(g)	-227
$C_6H_{12}O_6$(s)	-1273.3	F^{-}(g)	-252

Average Bond Energies (kJ/mol)

Single Bonds:

C-H	413	N-H	391	O-H	463	F-F	155
C-C	348	N-N	163	O-O	146		
C-N	293	N-O	201	O-F	190	Cl-F	253
C-O	358	N-F	272	O-Cl	203	Cl-Cl	242
C-F	485	N-Cl	200	O-I	234		
C-Cl	328	N-Br	243			Br-F	237
C-Br	276			S-H	339	Br-Cl	218
C-I	240	H-H	436	S-F	327	Br-Br	193
C-S	259	H-F	567	S-Cl	253		
		H-Cl	431	S-Br	218	I-Cl	208
Si-H	323	H-Br	366	S-S	266	I-Br	175
Si-Si	226	H-I	299			I-I	151
Si-C	301						
Si-O	368						

Multiple Bonds:

C=C	614	N=N	418	O_2	495
C≡C	839	N≡N	941		
C=N	615			S=O	523
C≡N	891			S=S	418
C=O	799				
C≡O	1072				

Some Electronegativities

H 2.1	(2A)	(3A)	(4A)	(5A)	(6A)	(7A)
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8
	[Transition Metals 1.0-2.4]					
Rb 0.8					Te 2.1	I 2.5
Cs 0.7					Po 2.0	At 2.2

1A												3A	4A	5A	6A	7A	8A
1 H 1.008	2A																2 He 4.003
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3B	4B	5B	6B	7B	|------	8B	------|	1B	2B	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	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 183.85	75 Re 186.21	76 Os 190.2	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 (263)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (269)	109 Mt (268)	110 Uun (272)	111 Uuu	112 Uub	113	114 Uuq	115	116 Uuh	117	118 Uuo

*Lanthanides	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97

** Actinides	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 (254)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)