Chem 131 **Name**_____
Exam 2, Ch 11, 12, 26 **February 29, 2012**
100 Points

Please follow the instructions for each section of the exam. Show your work on all mathematical problems. Provide answers with the correct units and significant figures. Be concise in your answers to discussion questions.

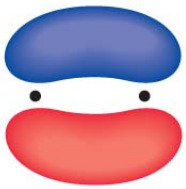
Part 0: Warmup. 4 points each

1. The compound SF_4 has a see-saw molecular geometry. How would valence bond theory describe the hybridization of the sulfur atom?

   a. sp^2
   b. sp^3
   c. sp^3d
   d. sp^3d^2
   e. sp^2d^2

   Answer _____

2. The figure below is a representation of what type of orbital?



   a. σ bonding molecular orbital
   b. σ antibonding molecular orbital
   c. π bonding molecular orbital
   d. π antibonding molecular orbital
   e. sp^3 hybrid orbital

   Answer _____

Part I: Complete all of problems 3-6

3. Define **three** of the following in a maximum of three sentences per item: (12 points)

   a. functional group:

   b. hybrid orbital:

   c. triple point:

   d. unit cell:

4. Draw the structure of any compound that contains an *amine* and an *ester* and has the molecular formula $C_4H_9NO_2$. (6 points)

5. Match each compound below to its boiling point. Clearly justify your decision; no credit will be given without a clear justification of your reasoning. (14 points)

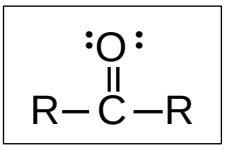
a. methyl ethyl ether ($CH_3CH_2OCH_3$), mm = 60.1 g/mol	i. 97.2^o C
b. n-propanol ($CH_3CH_2CH_2OH$), mm= 60.1 g/mol	ii. 10.8^o C
c. n-butane ($CH_3CH_2CH_2CH_3$) , mm = 58.1 g/mol	iii. -0.5^o C
d. propylamine ($CH_3CH_2CH_2NH_2$) , mm = 59.1 g/mol	iv. 48.5^o C

6. The starship *Enterprise* is powered by dilithium (Li_2). Based on *molecular orbital theory*, should Li_2 be a stable molecule? Justify your answer with a MO diagram. (10 points)

7. When drawing Lewis structures, we run into problems with compounds like ozone and benzene. With compounds like these, we have to invoke the concept of resonance and realize that the Lewis approach does provide a realistic picture of the electron distribution in these compounds. Molecular orbital theory does not have this same shortcoming. What fundamental assumption limits Lewis (and valence bond) theory and how does MO theory avoid this problem? (10 points)

Part II. Answer three (3) of problems 8-11. Clearly mark the problem you do not want graded. 14 points each.

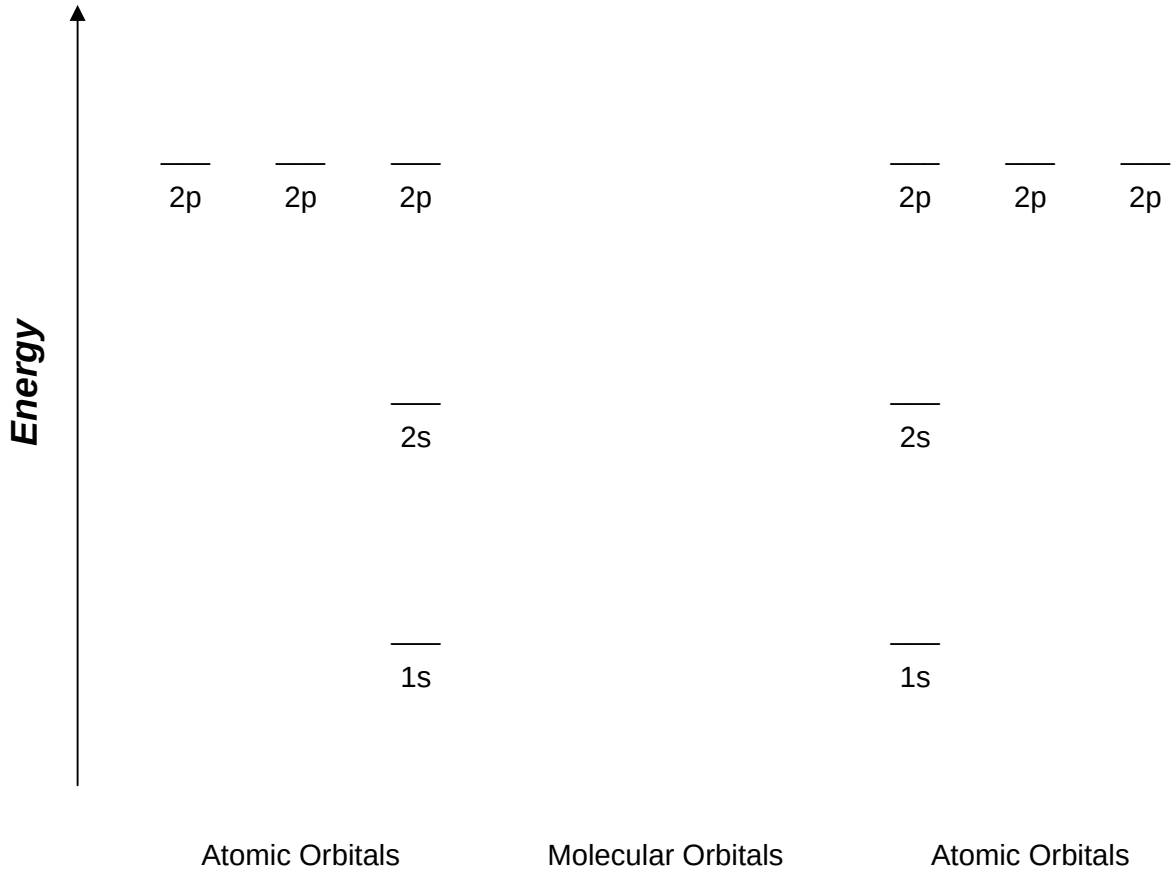
8. Many organic functional groups contain an oxygen atom double-bonded to a carbon, as shown at the right. Using *valence bond theory*, describe how the double bond is formed between the carbon and the oxygen. Indicate which orbitals on each atom participate and account for all electrons shared between the C and O atoms. Drawings may be useful in your description.



9. Silver forms a face-centered cubic structure as a solid. If the density of silver is 10.6 g/cm^3, what is the atomic radius of solid silver, in picometers (1 pm = 10^{-12} m)?

10. Answer the following questions regarding the nitric oxide, NO:

a. Complete the MO diagram below for NO. You may assume that the distribution of molecular orbitals is similar to that in O_2. (6 points)

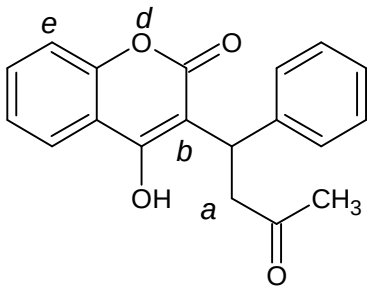


b. What is the bond order for NO? (2 points)

c. Is NO paramagnetic? Why or why not? (3 points)

d. Would you expect the NO^+ ion to be more or less stable than NO? Why? (3 points)

11. Answer the following regarding warfarin, an anticoagulant also known as coumadin. Note: the two unshared electron pairs on each oxygen have been omitted for clarity.



a. Circle <u>and name</u> three functional groups in the compound. (4 points)

b. What is the molecular formula for warfarin? (2 points)

c. How many sigma bonds are there in warfarin? (2 points)

d. How many pi bonds? (2 points)

e. Identify the hybridization of each of the atoms noted below: (4 points)

Carbon *a*: _____

Carbon *b*: _____

Oxygen *d*: _____

Carbon *e*: _____

Possibly Useful Information

$a^2 + b^2 = c^2$	$N_A = 6.02 \times 10^{23}\ mol^{-1}$	henway = 2 to 3 pounds

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9	10	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.00794																	2 He 4.00260
3 Li 6.941	4 Be 9.01218											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9898	12 Mg 24.3050											13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9381	26 Fe 55.847	27 Co 58.9332	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.757	52 Te 127.60	53 I 126.904	54 Xe 131.29
55 Cs 132.905	56 Ba 137.327	57 *La 138.906	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	89 †Ac 227.028	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (271)	111 Rg (272)							

*Lanthanide series	58 Ce 140.115	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
†Actinide series	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)