LAST NAME: _____

FIRST NAME: _____

Student number: _____

CHM1321 C: ORGANIC CHEMISTRY I

MIDTERM 1 - 2015

Time allowed: 80 minutes

Part	A	B	C	Bonus	Total
Points	10	20	20	2	50
Mark					
TA					

MOLECULAR MODEL KITS (IN A CLEAR PLASTIC BAG OR CONTAINER) ARE ALLOWED

CALCULATORS AND ALL OTHER AIDS ARE NOT ALLOWED

A PERIODIC TABLE IS ATTACHED AT THE END OF THE MIDTERM.

YOU MAY GENTLY REMOVE THIS PAGE AND USE IT AS SCRAP PAPER OR TO COVER YOUR WORK.

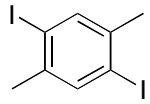
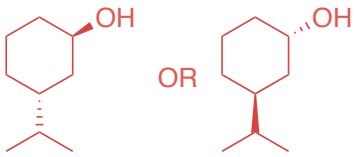
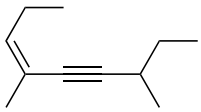
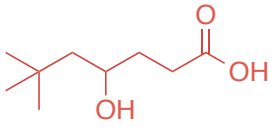
YOU MAY KEEP THIS PAGE AFTERWARDS IF YOU WISH.

YOU MAY ANSWER IN PEN OR PENCIL, AND MAY USE DIFFERENT COLOURS.

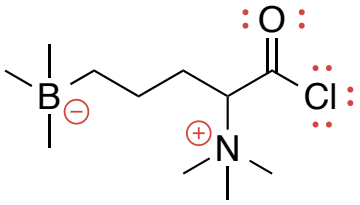
GOOD LUCK!

Part A – 1 or 2 points per question

1. (6 pts) Give the line structure or IUPAC name for the following compounds:

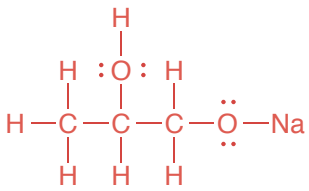
STRUCTURE	NAME
	2,5-diiodo-p-xylene
	*trans*-3-isopropylcyclohexanol
	(Z)-4,7-dimethylnona-3-ene-5-yne
	$(CH_3)_3CCH_2CHOHCH_2CH_2CO_2H$

2. (2 pts) Add lone pairs where necessary to the following structure to create full octets on all the appropriate atoms. Then add formal charges, where necessary.



3. (2 pts) Draw the full Lewis structure (including lone pairs) of $CH_3CHOHCH_2ONa$. Indicate clearly which bonds are ionic or covalent.

C–H: ΔEN = 2.5 – 2.1 = 0.4 (covalent)
C–C: ΔEN = 2.5 – 2.5 = 0 (covalent)
C–O: ΔEN = 3.5 – 2.5 = 1 (polar covalent)
O–H: ΔEN = 3.5 – 2.1 = 1.4 (polar covalent)
O–Na: ΔEN = 3.5 – 0.9 = 2.6 (ionic)

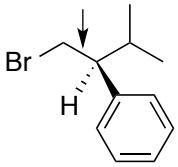


Part B

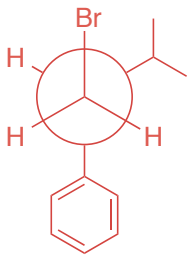
4. (6 pts) Draw the full Lewis structure of SCl_2, including lone pairs. What is the hybridization of the central atom? What is its molecular geometry? What is the approximate Cl-S-Cl bond angle? Add dipole moment arrows for the bonds in SCl_2. Is this molecule polar or non-polar?

Hybridization = sp^3
Molecular geometry = bent
Cl-S-Cl angle: slightly less than 109.5º
Molecule is POLAR.

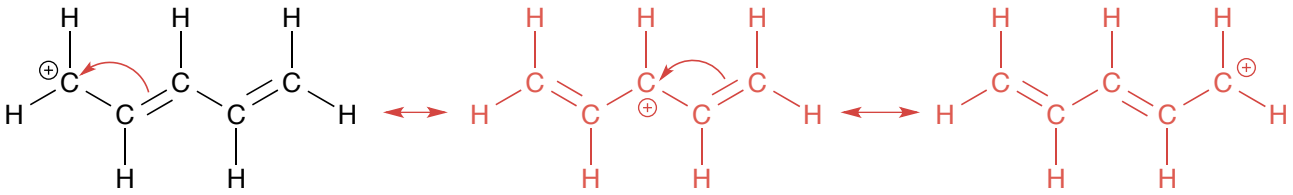
5. (3 pts) Draw and name the Newman projection for the most stable conformer of the molecule below along the C1–C2 bond (indicated with an arrow).



Br is the largest group on C1. The phenyl ring is the largest group on C2. Rotating around the C1-C2 bond gives us the most stable ANTI-STAGGERED conformer:



6. (6 pts) Draw the possible resonance structures for the following species, using electron-pushing arrows to show the conversion between resonance forms. Are these structures equivalent or non-equivalent? If they are non-equivalent, indicate the major and minor resonance contributors. Finally, draw the overall resonance hybrid.

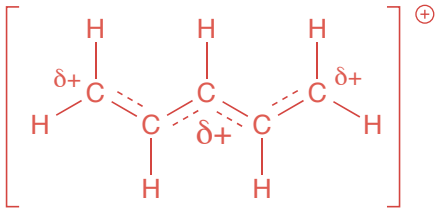


primary carbocation
MINOR

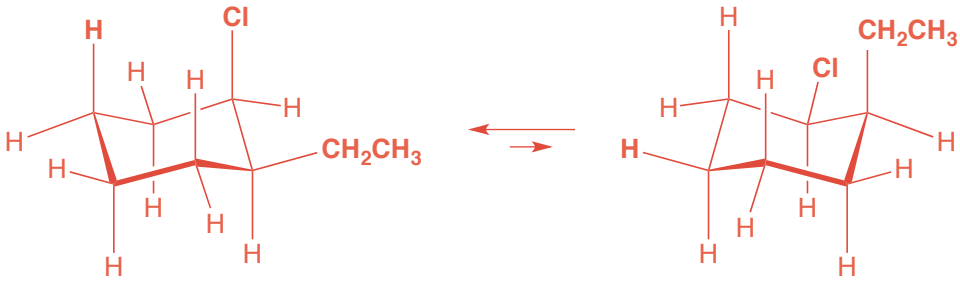
secondary carbocation
MAJOR

primary carbocation
MINOR

These are non-equivalent structures. The overall resonance hybrid is:



7. (5 pts) Draw the line structures for the two chair conformers of *cis*-1-chloro-2-ethyl-cyclohexane and label the more stable conformer.



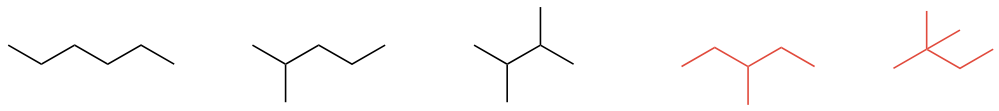
Cl is axial
CH_2CH_3 is equatorial

MORE STABLE

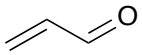
CH_2CH_3 is axial
Cl is equatorial

PART C

8. (2 pts) There are five structural isomers of the alkane C_6H_{14}. Below, draw the two missing structures.



9. (5 pts) Draw the following molecule using the LCAO method. Label all the orbitals (p, sp, sp^2, or sp^3) and the bonds (σ or π). Please include a legend if you're using different colours.

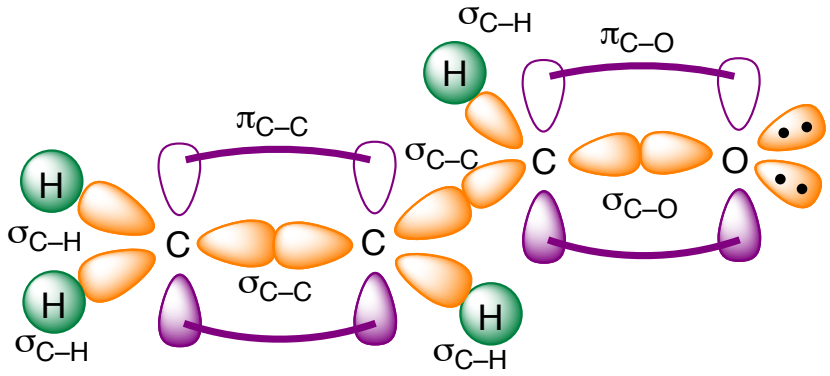


Legend

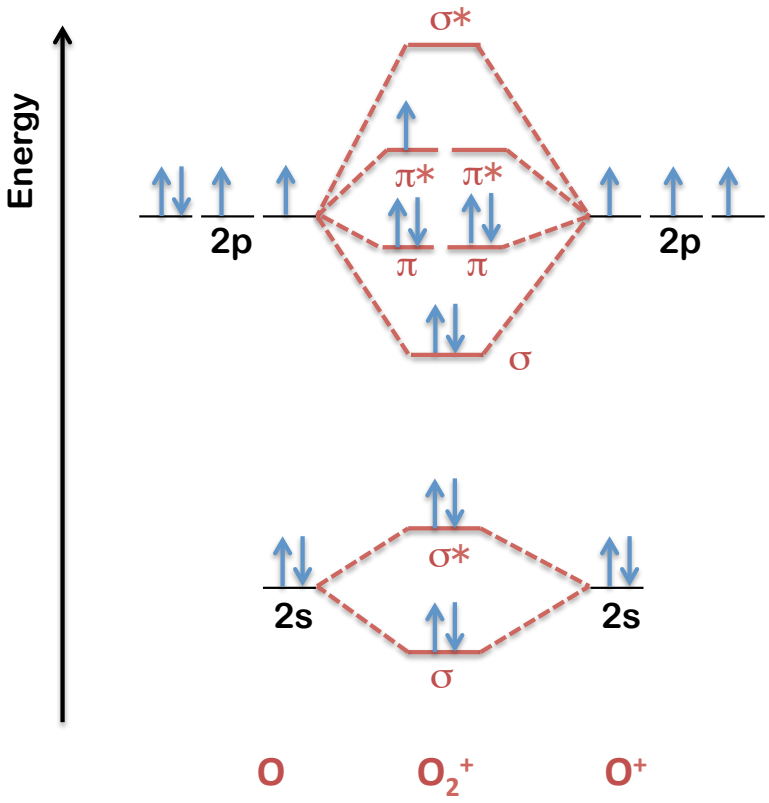
1s orbital

sp^2 orbital

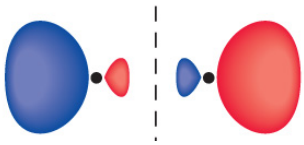
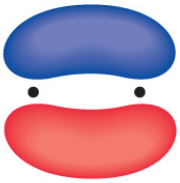
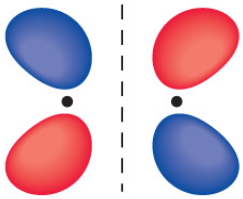
p orbital



10. Using the template below, build the molecular orbital diagram for O_2^+.



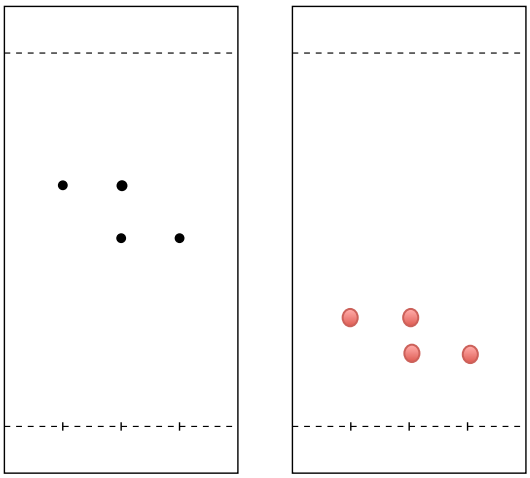
a. (4 pts) On your diagram, label all the molecular orbitals as appropriate (σ, π, σ*, or π*).
b. (4 pts) In the boxes provided below, sketch the σ, π, σ*, and π* molecular orbitals formed from mixing the 2p orbitals.

σ 	σ* 
π 	π* 

c. (1 pt) What is the bond order in O_2^+?

$$\text{Bond Order} = \frac{8-3}{2} = 2.5$$

11. You wish to separate a mixture of cyclohexanone and cyclohexanol. At left is a test TLC on silica gel using a 1:1 mixture of hexanes:ethyl acetate as the developing solvent. Lanes 1 and 3 are the reference spots for the two compounds and Lane 2 is a co-spot.



a. (1 pt) Match the lanes to the analyte compounds:

LANE 1 → CYCLOHEXANONE

LANE 3 → CYCLOHEXANOL

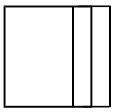
b. (1 pt) On the TLC plate at right, add spots corresponding to the expected result if the separation was redone in a 3:1 mixture of hexanes:ethyl acetate.

c. (2 pts) In one or two sentences, explain your reasoning for part b.

Changing the solvent mixture from 1:1 to 3:1 hexanes:ethyl acetate represents a significant drop in the polarity of the mobile phase. As a result, polar substrates will experience a larger preference for the polar stationary phase (greater intermolecular forces). Thus, the upward movement of the sample through the TLC is reduced and the R_f values decrease.

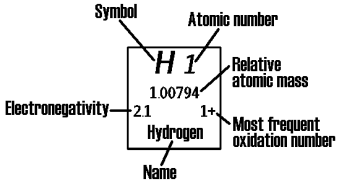
Bonus:

The molecule shown at right has never been successfully isolated by organic chemists. Name this molecule, and briefly explain why it is so unstable.



This is cyclobutyne. It is impossible to isolate because of its extraordinarily high RING STRAIN. The two carbon atoms in the triple bond are sp hybridized, and thus require bond angles of 180º. However, in the 4-membered ring, the bond angles must squeezed to 90º! This is HALF of the desired angles – resulting in enormous instability.

Mokeur's Periodic table of the elements



	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIII	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	H 1 1.00794 2.1 1+ Hydrogen																	He 2 4.002602 - - Helium
2	Li 3 6.941 1.0 1+ Lithium	Be 4 9.012182 1.5 2+ Beryllium											B 5 10.811 2.0 3+ Boron	C 6 12.011 2.5 4+,4- Carbon	N 7 14.00674 3.0 3+,3- Nitrogen	O 8 15.9994 3.5 2- Oxygen	F 9 18.9984032 4.0 1- Fluorine	Ne 10 20.1797 - - Neon
3	Na 11 22.989768 0.9 1+ Sodium	Mg 12 24.3050 1.2 2+ Magnesium											Al 13 26.981539 1.5 3+ Aluminum	Si 14 28.0855 1.8 4+ Silicon	P 15 30.973762 2.1 5+ Phosphorus	S 16 32.066 1.8 4+ Sulfur	Cl 17 35.4527 3.0 1- Chlorine	Ar 18 39.948 - - Argon
4	K 19 39.0983 0.8 1+ Potassium	Ca 20 40.078 1.0 2+ Calcium	Sc 21 44.955910 1.3 3+ Scandium	Ti 22 47.88 1.5 4+ Titanium	V 23 50.9415 1.6 5+ Vanadium	Cr 24 51.9961 1.6 3+ Chromium	Mn 25 54.93805 1.5 2+ Manganese	Fe 26 55.847 1.8 3+ Iron	Co 27 58.9332 1.8 2+ Cobalt	Ni 28 58.6934 1.8 2+ Nickel	Cu 29 63.546 1.9 2+ Copper	Zn 30 65.39 1.6 2+ Zinc	Ga 31 69.723 1.6 3+ Gallium	Ge 32 72.61 1.6 4+ Germanium	As 33 74.92159 2.0 3+,3- Arsenic	Se 34 78.96 2.4 4+ Selenium	Br 35 79.904 2.8 1- Bromine	Kr 36 83.80 - - Krypton
5	Rb 37 85.4678 0.8 1+ Rubidium	Sr 38 87.62 1.0 2+ Strontium	Y 39 88.90585 1.3 3+ Yttrium	Zr 40 91.224 1.4 4+ Zirconium	Nb 41 92.90638 1.6 5+ Niobium	Mo 42 95.94 1.8 6+ Molybdenum	Tc 43 98.9063 1.9 7+ Technetium	Ru 44 101.57 2.2 3+,4+ Ruthenium	Rh 45 102.9055 2.2 3+ Rhodium	Pd 46 106.42 2.2 2+ Palladium	Ag 47 107.8682 1.9 1+ Silver	Cd 48 112.411 1.7 2+ Cadmium	In 49 114.82 1.7 3+ Indium	Sn 50 118.71 1.8 4+ Tin	Sb 51 121.757 1.9 3+,3- Antimony	Te 52 127.60 2.1 4+ Tellurium	I 53 126.90447 2.5 1- Iodine	Xe 54 131.29 - - Xenon
6	Cs 55 132.90543 0.7 1+ Cesium	Ba 56 137.327 0.9 2+ Barium	La 57 138.9055 1.1 3+ Lanthanum	Hf 72 178.49 1.3 4+ Hafnium	Ta 73 180.9479 1.5 5+ Tantalum	W 74 183.85 1.7 6+ Tungsten	Re 75 186.207 1.9 7+ Rhenium	Os 76 190.2 2.2 4+ Osmium	Ir 77 192.22 2.2 4+ Iridium	Pt 78 195.08 2.2 4+ Platinum	Au 79 196.96654 2.4 3+ Gold	Hg 80 200.59 1.9 2+ Mercury	Tl 81 204.3833 1.8 1+ Thallium	Pb 82 207.2 1.8 2+ Lead	Bi 83 208.98037 1.9 3+ Bismuth	Po 84 208.9824 2.0 2+ Polonium	At 85 209.9871 2.2 1- Astatine	Rn 86 222.0176 - - Radon
7	Fr 87 223.0197 0.7 1+ Francium	Ra 88 226.0254 0.9 2+ Radium	Ac 89 227.0278 1.1 3+ Actinium	Rf 104 261.11 - - Rutherfordium	Db 105 262.11 - - Dubnium	Sg 106 263.12 - - Seaborgium	Bh 107 262.12 - - Bohrium	Hs 108 264 - - Hassium	Mt 109 266.1378 - - Meitnerium	Uun 110 269 - - Ununnilium	Uuu 111 272 - - Unununium	Uu 112 277 - - Ununbium		Uuq 114 289 - - Ununquadium		Uuh 116 289 - - Ununhexium		Uuo 118 293 - - Ununoctium

6	Ce 58 140.115 1.1 3+ Cerium	Pr 59 140.90765 1.1 3+ Praseodymium	Nd 60 144.24 1.1 3+ Neodymium	Pm 61 144.9127 1.1 3+ Promethium	Sm 62 150.36 1.2 3+ Samarium	Eu 63 151.965 1.2 3+ Europium	Gd 64 157.25 1.2 3+ Gadolinium	Tb 65 168.92534 1.2 3+ Terbium	Dy 66 162.50 1.2 3+ Dysposium	Ho 67 164.93032 1.2 3+ Holmium	Er 68 167.26 1.2 3+ Erbium	Tm 69 168.93421 1.2 3+ Thulium	Yb 70 173.04 1.1 3+ Ytterbium	Lu 71 174.967 1.2 3+ Lutetium
7	Th 90 232.0381 1.3 4+ Thorium	Pa 91 231.03588 1.5 5+ Protactinium	U 92 238.0289 1.4 6+ Uranium	Np 93 237.082 1.3 5+ Neptunium	Pu 94 244.0642 1.3 4+ Plutonium	Am 95 243.0614 1.3 3+ Americium	Cm 96 247 1.3 3+ Curium	Bk 97 247.0703 1.3 3+ Berkelium	Cf 98 251.0796 1.3 3+ Californium	Es 99 252.03 1.3 - Einsteinium	Fm 100 257.0951 1.3 - Fermium	Md 101 258.01 1.3 - Mendelevium	No 102 259.1009 1.3 - Nobelium	Lr 103 260.1053 - - Lawrencium