Organic Chemistry: Chem 210

Practice Exam 1A

There are **30** questions on this exam. Check that you have done all of the problems and filled in the first **30** bubbles on the scantron. Most questions are worth 4 points; there are several two-point questions clearly labeled in the text. The maximum score on this exam is 100 points.

Instructions

Answer sheet

1) On the scantron, you need to clearly fill:
   • your **name** and your **student number**,
   • **section number**: (it is 001)
   • **test form** (white = test form A; yellow = test form B).
2) Use a #2 pencil

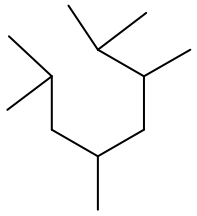
Exam policy

1) No electronic devices of any kind, such as calculators, cell phones, or even more advanced digital watches, are allowed. Possession of such devices during the exam, whether in use or not, is grounds for awarding a zero on the exam.
2) Molecular models are allowed (no instruction pages are permitted, however).
3) There are some blank pages at the end of the test that can be used as scratch paper.
4) Relevant tables, including the periodic table, are attached at the end of this exam.
5) Numerical values given in one question apply only to that question, and should not be used in other questions, unless there is a specific instruction to do so. If necessary, the values from the provided tables should be used, even if they differ from values that you may remember from different sources.
6) The exam results are based strictly on scantron's marks. No extraneous information is used to adjust the scores. Mark your choices with extra care.
7) Feel free to take this copy of the exam with you. The answer key will be posted on the web after the exam (under "News").

Hints

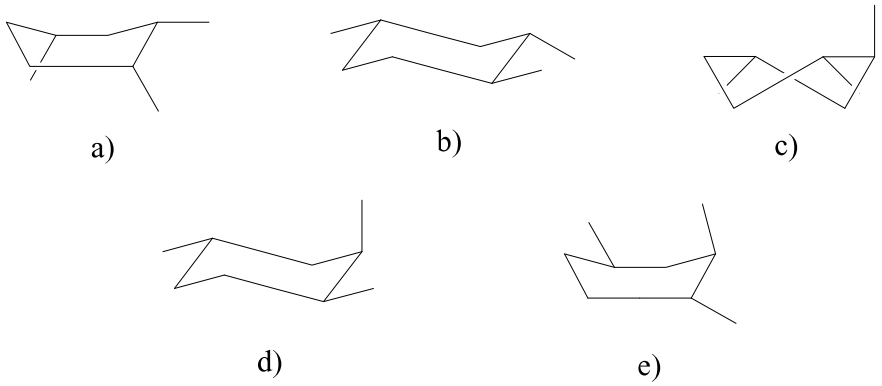
1) As you read the question, underline or circle key words to highlight them for yourself.
2) Questions have only one correct answer, unless indicated otherwise. No partial credit will be given.
3) There is no penalty for guessing.

1. (4 pts) What is the IUPAC name for the following molecule?



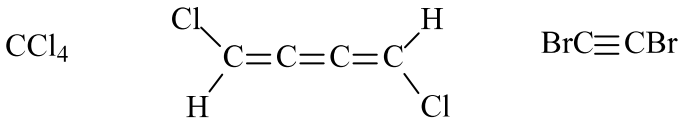
a) 2,4,5,7-tetramethylnonane
b) 1,1,3,5,6-pentamethylheptane
c) 3,5-dimethyl-isobutylhexane
d) 2,3,5,7-tetramethyloctane
e) 2,4,6,7-tetramethyloctane

2. (4 pts) Of the trimethylcyclohexanes shown below, which is lowest in energy?



a) b) c) d) e)

3. (4 pts) Which of the following molecules has a dipole moment?



a) CCl_4

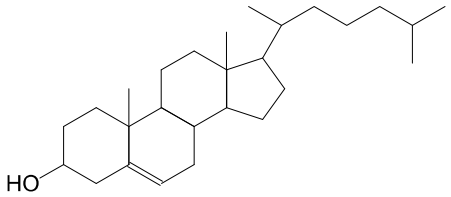
b)

c) $BrC{\equiv}CBr$

d) CH_2Cl_2

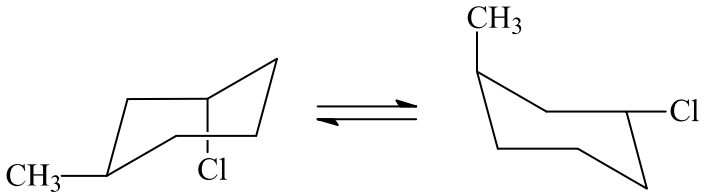
e)

4. (4 pts) The carbon attached to the –OH functional group in cholesterol would be correctly classified as a _____ carbon.



a) primary
b) secondary
c) tertiary
d) quaternary
e) penitentiary

5. (4 pts) What is the energy difference between these two conformers of *trans*-3-chloro-1-methylcyclohexane? A positive value means that the structure on the left is more stable.



a) 1.8 kJ/mol
b) 3.8 kJ/mol
c) 5.6 kJ/mol
d) –1.8 kJ/mol
e) –3.8 kJ/mol
f) –5.6 kJ/mol

6. (4 pts) A carbon atom forms four bonds to the unspecified number of other atoms. To form these bonds, the carbon atom uses a combination of hybrid and/or atomic orbitals. Which of the following combinations of orbitals **is not** possible?

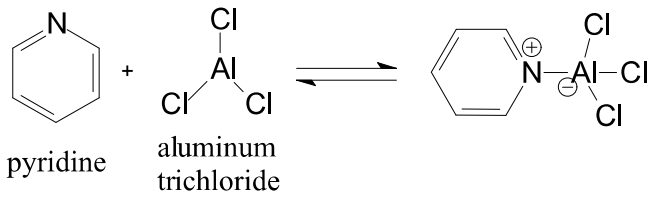
a) sp^2, sp^2, sp^2, sp^5
b) sp^2, sp^2, sp^5, sp^5
c) sp^3, sp^3, sp, p
d) sp^3, sp^3, sp^2, sp^5
e) sp^2, sp^2, sp^2, p

7. (4 pts) Which of the underlined atoms in the molecules shown below have *sp* hybridization?

A. $\underline{C}H_2CHCH_3$
B. $CH_2\underline{C}CHCl$
C. $CH_3\underline{C}H_2^+$
D. $H\underline{C}CCH_3$
E. $CH_3\underline{C}N$
F. $(CH_3)_2C\underline{N}NH_2$

a) D and F
b) D, E, and F
c) A, C, and D
d) B, D, and E
e) A, B ,C, and F

8-9. Consider the following acid-base reaction:



pyridine aluminum trichloride

8. (4 pts) Identify the critical HOMO in the reactants:

a) a π orbital of pyridine
b) a p orbital of aluminum trichloride
c) a non-bonding orbital on nitrogen
d) a σ orbital of aluminum trichloride

9. (4 pts) Identify the critical LUMO in the reactants:

a) a p orbital of aluminum trichloride
b) a non-bonding orbital on nitrogen
c) a π* orbital of aluminum trichloride
d) a π* orbital of pyridine

10. (4 pts) How do the two highest-energy occupied molecular orbitals of acetylene (HCCH) differ?

a) One is a σ molecular orbital with both *s* and *p* character, and the other is a π bond constructed from p-orbitals.
b) They are both constructed out of p-orbitals, with one forming a σ bond and the other forming a π bond.
c) They are both formed from p-atomic orbitals that are 120° apart.
d) One is bonding and the other is antibonding.
e) They are both π-bonding orbitals of the same energy and oriented 90° from each other.

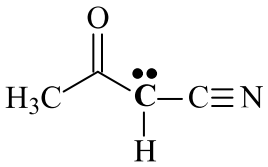
11. (4 pts) In allene ($H_2C=C=CH_2$), the terminal carbons are sp^2 hybridized. Each of the terminal H_2C groups marks, therefore, a plane, and the two "terminal" planes are 90° from each other. Other compounds with double bonds on successive carbons may also exist. They are called cumulenes. What is the relationship between the two terminal H_2C groups in a cumulene containing three consecutive double bonds ($H_2C=C=C=CH_2$)?

a) They are in perpendicular planes.
b) They are in two planes 60° from each other.
c) They are in the same plane.
d) They are in two planes 120° from each other.
e) They are in two planes 109° from each other.

12. (4 pts) What is the respective formal charge on the oxygen, the carbon (in bold), and the nitrogen in the molecule shown below?

Consider only the resonance structure that is shown below; lone pairs on oxygen and nitrogen are not drawn.

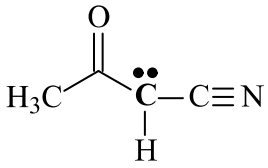
	O	C	N
a)	-1	0	+1
b)	0	-1	0
c)	0	0	0
d)	0	-1	+1
e)	-1	+1	0



13. (4 pts) What is the hybridization of the oxygen and the carbon (in bold) in the molecule shown below.

Consider all important resonance contributors; lone pairs on oxygen and nitrogen are not drawn.

	O	C
a)	sp^2	sp^2
b)	sp^3	sp^3
c)	sp	sp
d)	sp^2	sp^3
e)	sp^3	sp^2

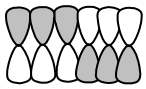


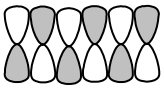
14. (4 pts) What is the energy difference between the highest and the lowest-energy conformations of 2,3-dimethylbutane?

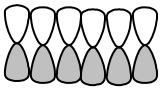
a) 26 kJ/mol
b) 33 kJ/mol
c) 7.6 kJ/mol
d) 18.4 kJ/mol
e) 4.4 kJ/mol

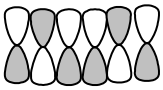
15-18. (2 pts each) A schematic representation of π-type molecular orbitals for 1,3,5-hexatriene (built out of six p atomic orbitals on carbon atoms) is shown below. The orbitals are shown in a random order.

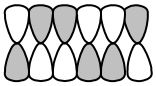
1,3,5-hexatriene

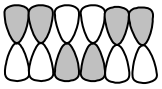
a) 

b) 

c) 

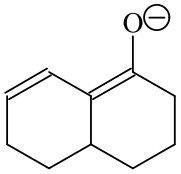
d) 

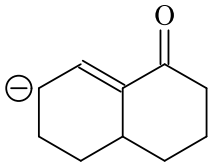
e) 

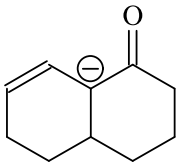
f) 

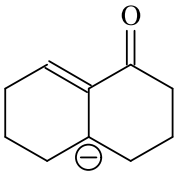
15. Which orbital corresponds to the HOMO of 1,3,5-hexatriene?
16. Which of the π orbitals have 2 nodal planes (in the bonding sense)?
17. Which of the π orbitals has the highest energy?
18. If an extra electron was added to the π-system of 1,3,5-hexatriene, which orbital would it occupy?

19. (4 pts) Which of the following is not a resonance structure of the others?

a) 

b) 

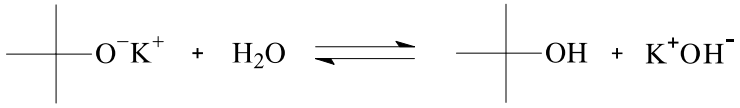
c) 

d) 

20. (4 pts) How many **constitutional** isomers are there for the alkyl halide $C_5H_{11}Cl$?

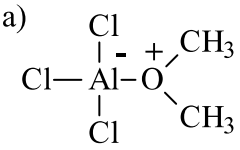
a) 6 b) 7 c) 8 d) 9 e) 10

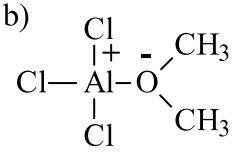
21. (4 pts) Which statement about the following equilibrium is true?

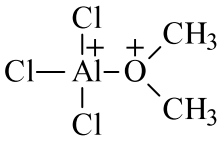


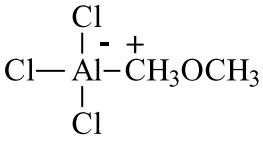
a) The equilibrium favors the products.
b) *t*-Butoxide is the dominant anionic species in the equilibrium.
c) Water is the weaker acid.
d) *t*-Butoxide is stabilized by resonance.

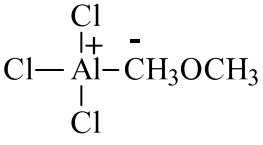
22. (4 pts) Which of the following is the product of the reaction between $AlCl_3$ and CH_3OCH_3?

a) 

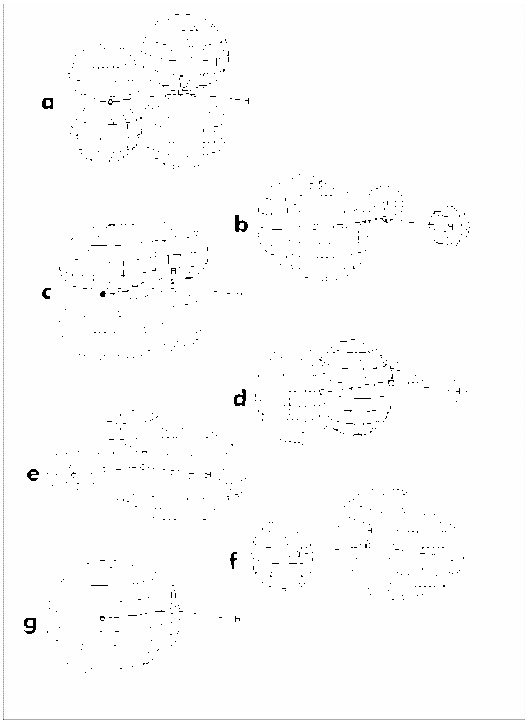
b) 

c) 

d) 

e) 

23-28. (2 pts each) The molecular orbitals for formaldehyde ($O{=}CH_2$) are shown on the right. They are arranged in the order of decreasing energy, from the highest at the top (a) to the lowest at the bottom (g).



23. Which orbital corresponds to the highest-energy nonbonding electrons on oxygen?

24. Which orbital holds bonding π electrons?

25. Which orbital would be the most important in the reaction of formaldehyde with hydride (H^-)?

26. Which picture represents the lowest-energy σ-type orbital?

27. Which orbital can be designated as π*?

28. Which orbital represents the C-O σ bond?

29-30. (4 pts each) Each of the following molecules or ions contains at least one C-N bond. The following two questions are based on the Lewis structures of these species.

Remember to consider resonance structures, where appropriate. Please note that lone pairs on nitrogen atoms are not shown explicitly.

a) H_2CNCH_3 b) H_3CCN c) $(H_3C)_4N^+$ d) $(H_2N)_3C^+$ e) $(H_2C)_2N^+$

29. Which molecule or ion has the longest C-N bond?

30. Which molecule or ion has the shortest C-N bond?

End of the exam

Total Strain Energies in Cycloalkanes		
ring size	kJ/mol	kcal/mol
3	115	27.6
4	110	26.4
5	27	6.5
6	0	0
7	26	6.3
8	40	8.6

Energy Costs for Interactions in Alkane Conformers		
Interaction	kJ/mole	kcal/mole
H-H eclipsed	4.0	1.0
H-CH_3 eclipsed	6.0	1.4
CH_3-CH_3 eclipsed	11.0	2.6
CH_3-CH_3 gauche	3.8	0.9

Steric Strain Due to 1,3-Diaxial Interactions

Y	*Strain of one H–Y 1,3-diaxial interaction* (kcal/mol)	(kJ/mol)
—F	0.12	0.5
—Cl	0.25	1.0
—Br	0.25	1.0
—OH	0.5	2.1
—CH_3	0.9	3.8
—CH_2CH_3	0.95	4.0
—$CH(CH_3)_2$	1.1	4.6
—$C(CH_3)_3$	2.7	11.3
—C_6H_5	1.5	6.3
—COOH	0.7	2.9
—CN	0.1	0.4

MAIN GROUPS												MAIN GROUPS					
1A																	8A
1																	18
1 H 1.008	2A 2											3A 13	4A 14	5A 15	6A 16	7A 17	2 He 4.003
3 Li 6.941	4 Be 9.012					TRANSITION METALS						5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.066	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.867	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.992	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc [98]	44 Ru 101.07	45 Rh 102.90	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	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 183.84	75 Re 186.21	76 Os 190.23	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]	89 Ac** [227]	104 Rf [261]	105 Db [262]	106 Sg [266]	107 Bh [264]	108 Hs [265]	109 Mt [268]	110 [269]	111 [272]	112 [277]		114 [285]		116 [289]		118 [293]

* LANTHANOIDS	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 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
** ACTINOIDS	90 Th 232.04	91 Pa 321.04	92 U 238.03	93 Np [237]	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]