CHEM 221 - ORGANIC CHEMISTRY I
MIDTERM EXAMINATION

INSTRUCTIONS: ***PLEASE READ THIS PAGE WHILE WAITING TO START YOUR EXAM.***

This test paper includes 3 pages (both sides) plus a periodic table including electronegativity data; **note that a table of pK_a values is provided** on the back of the periodic table. Check that your paper is complete. You can remove the last page if you wish. Model kits and calculators are permitted; cell phones and electronic dictionaries are not allowed. You have the whole class (75 minutes) to complete the test. Read through the whole test quickly before starting. **GOOD LUCK!**

LAST NAME: _____ FIRST NAME: _____

STUDENT NUMBER: _____

Mark breakdown:

Page 2.	/ 12	
Page 3.	/ 17	
Page 4.	/ 10	
Page 5.	/ 12	
TOTAL:	/ 50	(maximum grade $^{51}/_{50}$)
PERCENT:	%	
EARNED toward FINAL GRADE:	/ 15	

 # 1. (__/ 7 marks) TRUE or FALSE? Circle T *or* F to describe the following statements.

T / F The C-Br bond in bromoethane can be described as involving $2sp^3$–$3sp^3$ orbital overlap.

T / F In Kekulé structures, H atoms bonded to heteroatoms are included but lone pairs are not included.

T / F Resonance delocalization can occur if two π-bonds are separated by an sp^3-hybridized C atom.

T / F Any molecule or atom described as a Brønsted base can also be described as a Lewis base.

T / F When assigning E/Z configuration, a –C≡CH group has higher priority than a $-CH(CH_3)_2$ group.

T / F At room temperature, an alkene is able to rotate about its π-bond but it cannot isomerize.

T / F The most acidic H in any molecule is the H that is held to the molecule by the weakest bond.

 # 2. (__/ 1 mark) Which of the following species are examples of tertiary amines? *Circle your choice(s):*

a) $(CH_3)_3CNH_2$
b) $(CH_3)_3N$
c) $(CH_3)_2N(CH_2CH_3)$
d) $(CH_3)_3NHCl$

 # 3. (__/ 1 mark) M.O. theory states that when two atomic orbitals overlap, two new orbitals form. They are:

a) a lower energy bonding orbital & a higher energy nonbonding orbital
b) a lower energy bonding orbital & a higher energy antibonding orbital
c) a lower energy σ orbital & a higher energy π orbital
d) a lower energy σ^* orbital & a higher energy σ orbital

 # 4. (__/ 1 mark) The larger the number of closed-shell resonance contributors that can be drawn for a species, the more _____ the species is. *Choose the correct word to complete this statement.*

a) hybrid
b) unstable
c) reactive
d) stable

 # 5. (__/ 2 marks) Which of the following bases would be strong enough to deprotonate $CH_3-C\equiv CH$?

a) $(CH_3)_3CO^-$
b) CH_3COO^-
c) $(CH_3)_2CHNH^-$
d) HCO_3^-

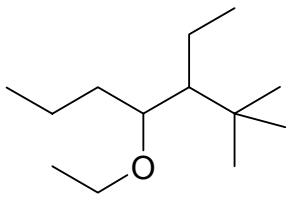
 # 6. (4 Marks) Draw a line (skeletal) structure for each of the following compounds:

a) *cis*-2-(1-methylethyl)cyclopentanol

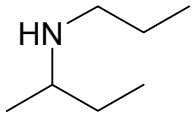
b) *(Z)*-5-bromo-3-ethylhex-2-ene

 # 7. (4 Marks) Provide a systematic IUPAC name for each of the following compounds:

a)



b)



 # 8. (__/ 9 marks) There are six isomers with the formula C_4H_8.

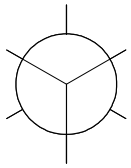
a) **(2 marks)** Calculate the number of elements (degrees) of unsaturation present in these isomers. What does this mean?

b) **(6 marks)** Draw and name all six isomers, and include E/Z descriptors where appropriate.

c) **(1 mark)** Two of the compounds in part (b) are geometric isomers of each other. Circle this pair.

 # 9. (__/ 5 marks) Think about the conformation of 1-chloropropane in which the Cl and CH_3 groups are *anti* .

a) **(1 mark)** Complete the Newman projection of this conformer (down C1-C2 bond):

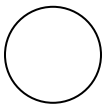


b) **(0.5 marks)** What is the dihedral angle between the Cl and CH_3?

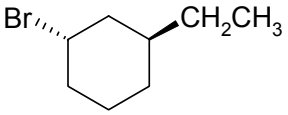
c) **(0.5 marks)** How many bonds are eclipsed in this conformation?

d) **(3 marks)** Imagine the molecule rotates 120° about its C1-C2 bond. Draw the new conformation's Newman projection (*use the circle below*) and complete the following statements (*circle your choices*):

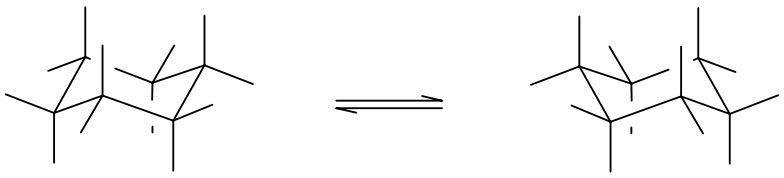
The amount of steric strain is:	higher,	lower,	the same
The amount of torsional strain is:	higher,	lower,	the same
This conformer's potential energy is:	higher,	lower,	the same
The Cl-CH_3 dihedral angle is:	larger,	smaller,	the same



 # 10. (__/ 5 marks) Shown below is an incomplete drawing of the ring-flipping equilibrium for *trans*-1-bromo-3-ethylcyclohexane (structure shown at the right).



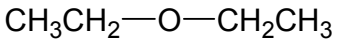
a) **(1 mark)** Complete the structures of the conformers by adding the hydrogens and substituents.
b) **(1 mark)** Label the substituents as axial ("ax") or equatorial ("eq") in each conformer.
c) **(1 mark)** Identify the important steric interactions in each conformer. Circle the substituents involved.



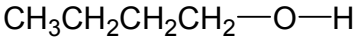
d) **(1 mark)** Briefly describe the relative stability of this compound's two chair conformers.

e) **(1 mark)** Imagine a molecule of another compound "B" collides with a molecule of *trans*-1-bromo-3-ethylcyclohexane in a sample at room temperature. Which conformation of *trans*-1-bromo-3-ethylcyclohexane will molecule "B" most likely bump into?

 # 11. (__/ 6 marks) Diethyl ether and 1-butanol are isomers with similar solubilities in water but very different boiling points.



diethyl ether, bp 35°C
8.4mL dissolves in 100mL H_2O

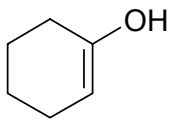


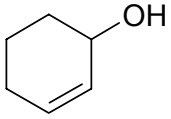
1-butanol, bp 118°C
9.1mL dissolves in 100mL H_2O

a) **(3 marks)** What causes these two isomers to have such different boiling points? Explain.

b) **(3 marks)** What causes these two isomers to have similar solubilities in water? Explain.

 # 12. (__/ 6 marks) Two isomeric cyclohexenyl alcohols are shown here:





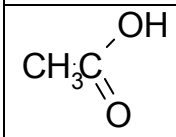
a) **(2 marks)** Which is the most acidic H in each molecule? Why?

b) **(4 marks)** Which of the two compounds has the lower pK_a? Explain your choice, and include relevant structures to support your arguments.

EXTRA SPACE FOR ROUGH WORK

POTENTIALLY USEFUL INFORMATION

TABLE OF pK_a VALUES

Compound	**pK_a**
$CH_3CH_2CH_2CH_3$	>51
CH_4	51
$H_2C{=}CH_2$	44
CH_3NH_2	40
NH_3	38
$HC{\equiv}CH$	25
$(CH_3)_3COH$	19
CH_3CH_2OH	17
CH_3OH	15.5
H_2O	15.7
RNH_3^+	9
H_2CO_3	6.4
	4.7
HF	3.2
$CH_3CH_2OH_2^+$	-2.4
H_2SO_4	-5.2
HCl	-7
HI	-9