

LAST NAME:

FIRST NAME:

STUDENT ID:

CHEM 221 - ORGANIC CHEMISTRY I MIDTERM EXAMINATION

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

- Check that your paper is complete: 4 pages (both sides).
- Note the (removable) reference data page: table of pK_a s, periodic table, electronegativities.
- Model kits and calculators are permitted. Cell phones & electronic dictionaries are not allowed.
- Read through the whole test quickly before starting.
- Please ask for clarification if you do not understand what a question is asking.
- You have 70 minutes to complete the test.

Mark breakdown:

Page 2. / 13 (incorrect on original)

Page 3. / 12 (incorrect on original)

Page 4. / 9

Page 5. / 9

TOTAL: / 42 (maximum ⁴³/42)

PERCENT: %

EARNED toward
FINAL GRADE: / 15

1. (6 marks) TRUE or FALSE? Circle T or F to describe the following statements.

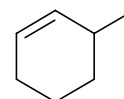
T / F In the most stable conformation of *cis*-1-bromo-2-ethylcyclohexane, the bromo group is axial.

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

T / F The carbon-carbon bond in ethene (H_2CCH_2) is longer than the one in ethyne (HCCH).

T / F When an electron pair enters a bond's σ^* orbital, the bond becomes stronger.

T / F The molecule shown here (at the right) contains one tertiary hydrogen:



T / F The carbon atom in methyl radical ($\cdot\text{CH}_3$) is sp^2 hybridized.

2. (1 mark) What is the geometry around a carbon atom that has positive formal charge?

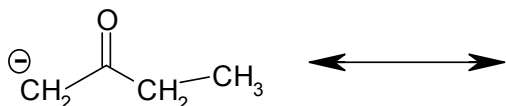
- trigonal pyramidal
- trigonal planar
- tetrahedral
- linear

3. (2 marks) Which common base below would be strong enough to deprotonate $(\text{CH}_3)_2\text{CHOH}$?

- sodium acetate: NaCH_3COO
- potassium carbonate: K_2CO_3
- calcium hydride: CaH_2
- ammonia: NH_3

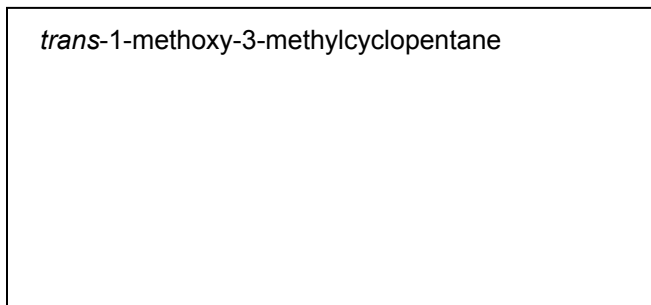
4. (2 marks) When a small amount of hexanoic acid [$\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{H}$, $\text{p}K_a \sim 4.8$] is added to a separatory funnel which contains the organic solvent diethyl ether [$(\text{CH}_3\text{CH}_2)_2\text{O}$] and water at a pH of 2.0, it is found mainly in the _____ phase as _____.

- ether; $\text{CH}_3(\text{CH}_2)_4\text{CO}_2^-$
- water; $\text{CH}_3(\text{CH}_2)_4\text{CO}_2^-$
- ether; $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{H}$
- water; $\text{CH}_3(\text{CH}_2)_4\text{CO}_2\text{H}$

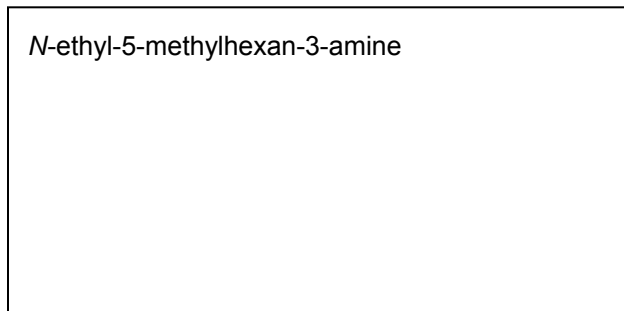
5. (2 marks) Draw the other major resonance contributor for the species shown below, then circle the structure that contributes more to the resonance hybrid. Briefly justify your choice (keywords only...).

6. (3 marks) Draw a line (skeletal) structure for the following compounds:

a) *trans*-1-methoxy-3-methylcyclopentane

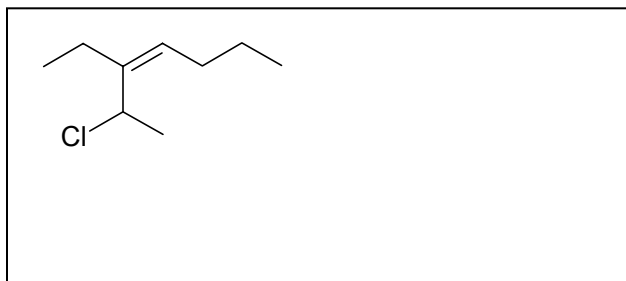


b) *N*-ethyl-5-methylhexan-3-amine

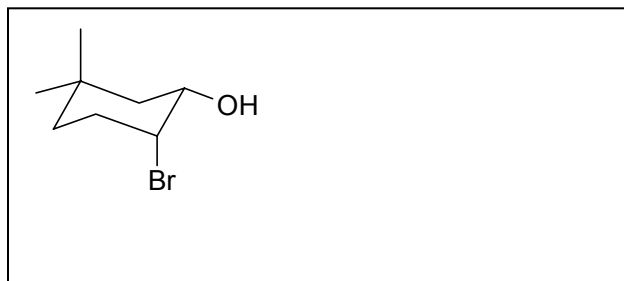


7. (3 marks) Provide a systematic name (with *E/Z*/*cis*/*trans* if applicable) for the following compounds:

a)

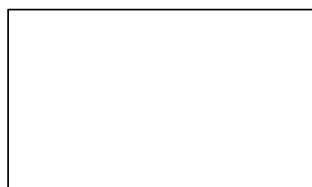
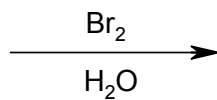
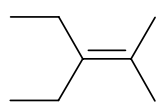


b)

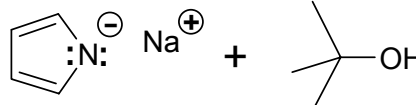
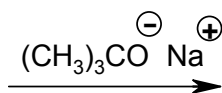


8. (6 marks) Fill in the boxes: draw the missing reactant or major product OR
list the missing conditions: reagent, catalyst, solvent (if critical for reaction)

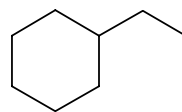
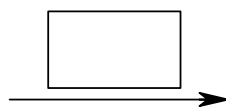
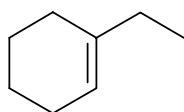
a)



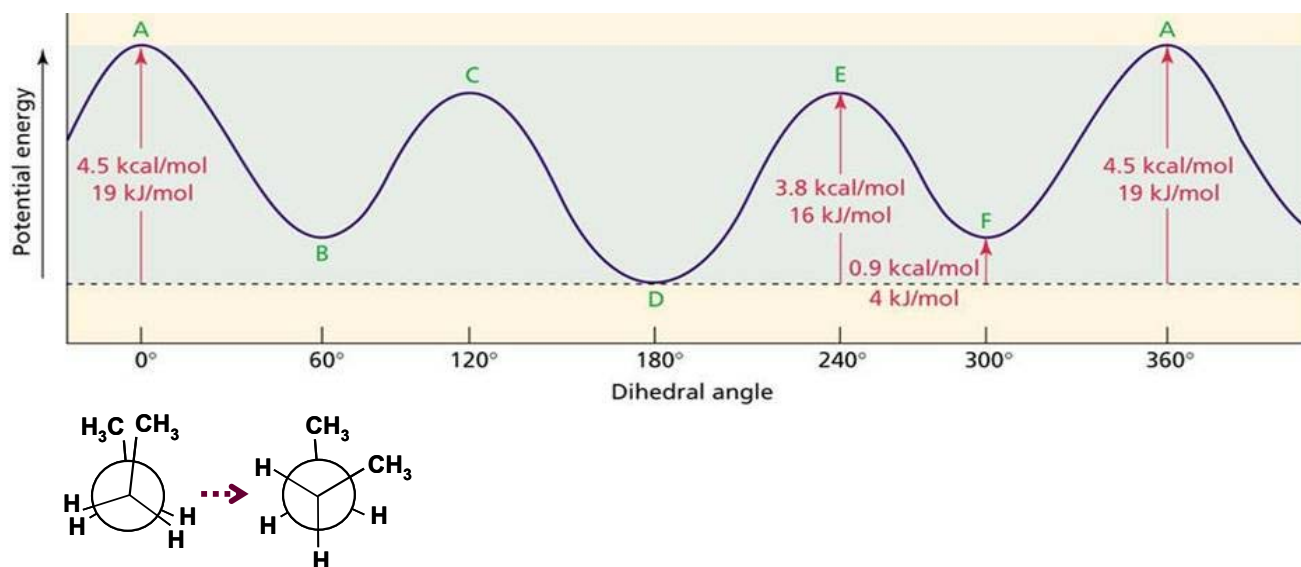
b)



c)

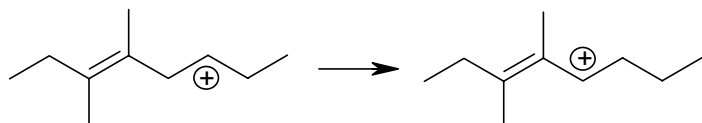


9. Consider the potential energy diagram for rotation about the C2-C3 bond in butane. Fig. 2.5 Bruice 4th Ed. © Prentice Hall, 2004

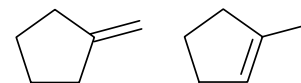


- a) **(2 marks)** The molecule's conformation at points A & B are represented by the two Newman projections above. What type(s) of strain is/are relieved by this 60° rotation about the C2-C3 bond? _____
 What is the name of the relative orientation of the CH₃ groups in conformer B? _____
- b) **(3 marks)** Draw the Newman projection for the molecule's conformation at point D (*draw it up near the others*). What is the name of the relative orientation of the CH₃ groups in conformer D? _____
 What causes conformer D to be more stable than conformer B? (*keywords only*)

10. (4 marks) Explain, in detail, both HOW and WHY the following carbocation rearrangement occurs:



11. Which alkene shown undergoes acid-catalyzed hydrolysis more quickly? Why?



Your explanation must include:

(2 marks) • a balanced chemical equation for the reaction of each alkene (e.g., for reaction with H₂SO₄ / H₂O)

(4 marks) • full arrow-pushing mechanisms for the reaction of each alkene

(3 marks) • written comments and/or diagrams to explain what causes the difference

EXTRA SPACE FOR ROUGH WORK

POTENTIALLY USEFUL INFORMATION**TABLE OF pK_a VALUES**

Representative Compound	pK_a
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$	>51
CH_4	51
$\text{H}_2\text{C}=\text{CH}_2$	44
CH_3NH_2	40
NH_3	38
H_2	35
$\text{HC}\equiv\text{CH}$	25
$(\text{CH}_3)_3\text{COH}$	19
$\text{CH}_3\text{CH}_2\text{OH}$	17
CH_3OH	15.5
H_2O	15.7
HCO_3^-	10.2
NH_4^+	9.4
RNH_3^+	9
H_2CO_3	6.4
$\begin{array}{c} \text{OH} \\ \\ \text{CH}_3\text{C} \\ \\ \text{O} \end{array}$	4.7
HF	3.2
H_3O^+	-1.7
$\text{CH}_3\text{CH}_2\text{OH}_2^+$	-2.4
H_2SO_4	-5.2
$\begin{array}{c} \text{OH} \\ \\ \text{CH}_3\text{C} \\ \\ \text{O}^+\text{H} \end{array}$	-6.5
HCl	-7
HI	-9

Periodic Table of the Elements

1 H 1.008																	2 He 4.00
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	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 65.39	31 Ga 69.72	32 Ge 72.61	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 (97.91)	44 Ru 101.07	45 Rh 102.91	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	La-Lu	72 Hf 178.49	73 Ta 180.95	74 W 183.84	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 208.98	85 At 209.99	86 Rn 222.02
87 Fr 223	88 Ra 226.03	Ac-Lr	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (262)	108 Hs (265)	109 Mt (266)									

57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.35	63 Eu 151.97	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
89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (245)	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 (260)

Electronegativity Values of the Elements

H 2.1																	He
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.9	Ni 1.9	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe
Cs 0.7	Ba 0.9	La-Lu	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.9	Bi 1.9	Po 2.0	At 2.2	Rn