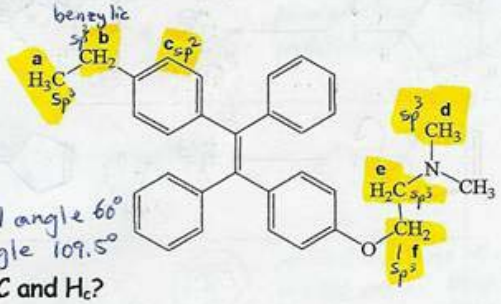
Chem 221 W08 Sect 52 Dr. C. Rogers NAME: Rogers

answers – marking scheme

INTRODUCTORY ORGANIC CHEMISTRY I --- PROBLEM SET #1

INSTRUCTIONS: ANSWER ALL QUESTIONS ON THESE PAGES. HAND IN (stapled, with no extra pages please) AT THE BEGINNING OF CLASS on Thursday Feb.14. LATE SUBMISSIONS WILL NOT BE ACCEPTED (EARLY IS FINE). ALL MATERIAL CAN ALL BE FOUND IN THE CLASS NOTES AND IN BRUICE CHAPTERS 1, 2, 3 & 7.

 # 1. Tamoxifen is a compound with activity against some breast cancer tumours (see Bruice Ch.3 #40). Answer the following questions:



a) What is the approximate bond angle of H_a-C-H_b? Typo...

acceptable answers: for H_a-C-C-H_b dihedral angle 60°
for H_a-C-H_a bond angle 109.5°

b) Which orbitals are involved in the σ-bond between C and H_c?

C $2sp^2$ — H 1s

↑ energy level

Related.

c) Which C-H_x bond should be the shortest? Why? H_c

uses sp, sp^2, sp^3 ; uses 1s } C with highest "s-character" orbital will form the shortest bond to H. So, based on sp^2 C (33% s) vs. sp^3 C (25% s), ← closer to nucleus...

H_c-C bond shortest.

Related questions.

d) What is the approximate pK_a of H_b? ~41 ← benzylic CH_2 (compared to CH_3)

* Find in similar environment, not just same bonded to C of same hybridization. See Appendix II (Bruice)

H_c? ~43 ← phenyl CH (compared to benzene alone)

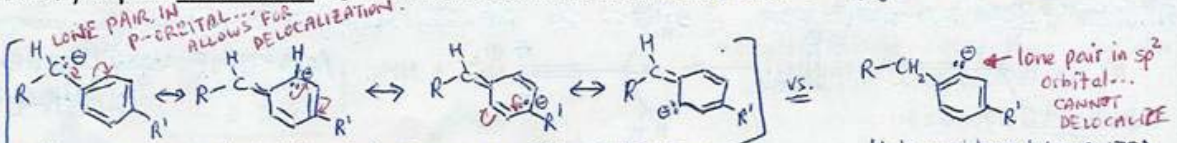
H_e? 46-60? } N is electron-withdrawing compared to C
H_f? 46-60? } O is stronger EWG than N, So $pK_a(H_f)$ a little lower than $pK_a(H_e)$

both compared to CH_3CH_3

e) Which is the most acidic H in this molecule? most acidic H has lowest pK_a (easiest to remove).

H_b (benzylic site...)

f) Briefly explain what causes H_b to be more acidic than H_c. more stable conjugate base ⇒ more acidic H.



H_b's conj. base is stabilized via resonance DELOCALIZATION.

H_c's conj. base is LOCALIZED.

Not related to the other Q's.

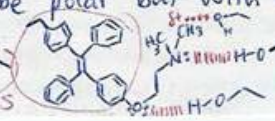
g) If you wanted to prepare a solution of this substance, would you have the best "luck" with water, ethanol or hexane as the solvent? Explain very briefly.

KNOTE: THIS QUESTION IS UNRELATED TO THE OTHERS – SIMPLY INVOLVES INTERMOLECULAR INTERACTIONS, NOT ANY BOND BREAKAGE/FORMATION...

- To dissolve: solute must interact favourably enough with solvent to draw solvent away from other solvent molecules, to surround solute molecules.

① Solute: tamoxifen = nonpolar aromatic rings + polar $-OCH_2CH_2N(CH_3)_2$

② solvent: should be polar but with nonpolar region too. = ETHANOL.

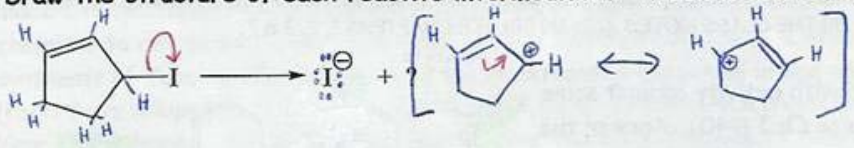


DIPOLE – INDUCED-DIPOLE + ID – ID INTERACTIONS BETWEEN N.P. REGIONS

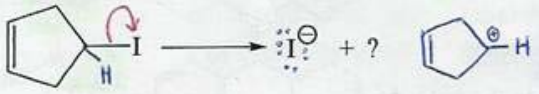
POLAR REGION CAN FORM HYDROGEN BONDS (imi) + DIPOLE-DIPOLE INTERACTIONS WITH SOLVENT MOLECULES

HINT...

 # 2. Carbocations are highly reactive, open-shell species. They exist briefly as *reactive intermediates* during the course of some common reactions of alkenes and alkyl halides. Consider the two alkyl iodides below: if the iodine atom leaves as $I^{\ominus}$, what reactive intermediate forms? Loss of $:\ddot{I}:^{\ominus}$
Draw the structure of each reactive intermediate. Which is more stable, and why?



resonance - stabilized 2° carbocation ∴MORE STABLE

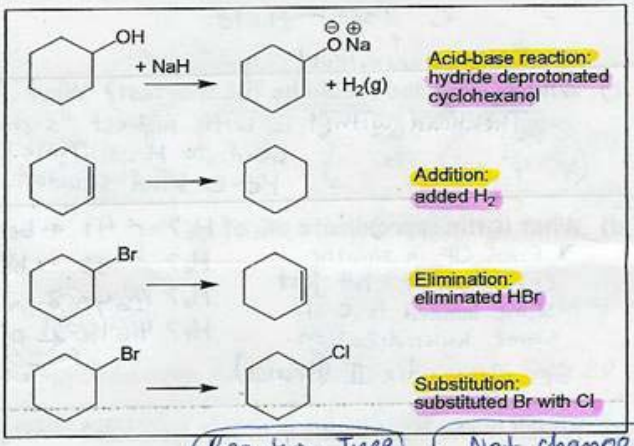


Cannot be delocalized by resonance also 2°
& cannot rearrange (H⊕ shifts here not productive since just yield other 2° C⊕)

 # 3. Shown at the right are examples of the four reaction types we will see in this course: *acid-base, addition, elimination & substitution.* We will learn how they happen in Ch.4, 8 & 9.

For reactions a-d shown below, identify the reaction type and net change that occurred during the reaction (as shown for examples).

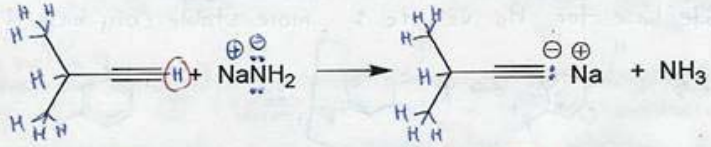
Hint: drawing the implied H-atoms & lone pairs will help.



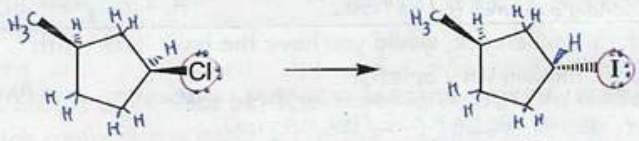
(Reaction Type) (Net change)

a) 

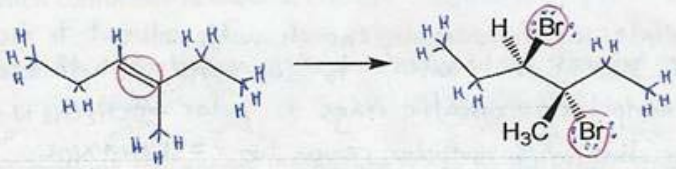
ELIMINATION: loss of H_2O

b) 

ACID-BASE: $:\ddot{N}H_2^{\ominus}$ deprotonated the R–C≡C–H unit

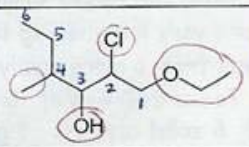
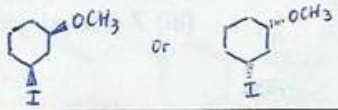
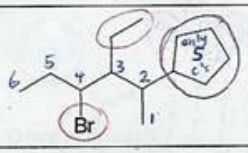
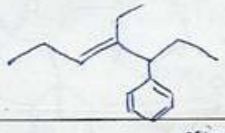
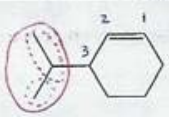
c) 

SUBSTITUTION: I replaced Cl

d) 

ADDITION: added Br_2 across C=C

 # 4. Complete the following table.

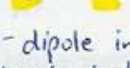
Systematic (IUPAC) name	Line (skeletal) structure
Acceptable names: 3-chloro-1-ethoxy-4-methylhexan-3-ol 3-chloroethoxy-4-methyl-3-hexanol 3-chloro-1-ethoxy-4-methyl-3-hexanol	 principal Gp: OH ⇒ -ol principal chain: hexane (+OH) substituents: ① chloro (3-) ② ethoxy (1-) ③ methyl (4-)
cis-1-iodo-3-methoxycyclohexane ↑ same side; I; -OCH3	In any orientation on page: 
4-bromo-2-cyclopentyl-3-ethylhexane	 principal Gp: none ⇒ -ane principal chain: most sub'd hexane substituents: ① bromo (-4-) ② ethyl (-3-) ③ cyclopentyl (-2-
—CH2CH3; C=C between C3–C4 *E*-4-ethyl-5-phenyl-3-heptene ↑ trans-like; 7 C's; C=C	
Mixed name: 3-isopropylcyclohexene Fully systematic name: 3-(1-methylethyl)cyclohexene	 principal Gp: none but C=C ⟩ -ene principal chain: cyclohex (+ C=C) substituents: isopropyl (-3-)

can include -1- here but not needed (implied if not mentioned 1)

 # 5. Which is more soluble in water: ethyl propyl amine *OR* ethyl dimethyl amine (common names)? Your explanation should include structural diagrams showing which regions of the molecules would be involved in each type of intermolecular force.

ethyl propyl amine = 2° amine vs. ethyl dimethyl amine = 3° amine

Note: solubility higher if have stronger interactions with water.



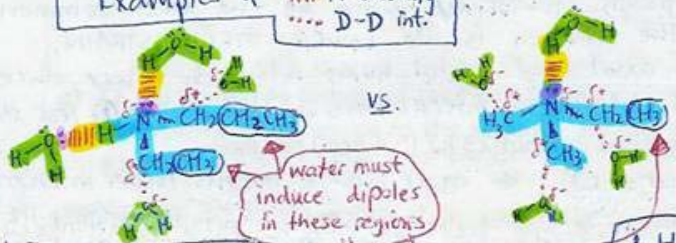
- Hydrogen-bond donor + acceptor
- Dipole-dipole interactions are also important, but less so than H-bonding because H-bonding is stronger (per interaction).
- The 2 amines would have different nonpolar regions to be hydrated (compare polarity):

  1 $\overset{\delta+}{C}H_2CH_3$ vs. 2 $\overset{\delta+}{C}H_3$

  1 $\overset{\delta+}{C}H_2CH_2CH_3$ vs. 1 $\overset{\delta+}{C}H_2CH_3$

  dipole won't extend this far in chain...

Examples of H-bonding ···· D-D int.



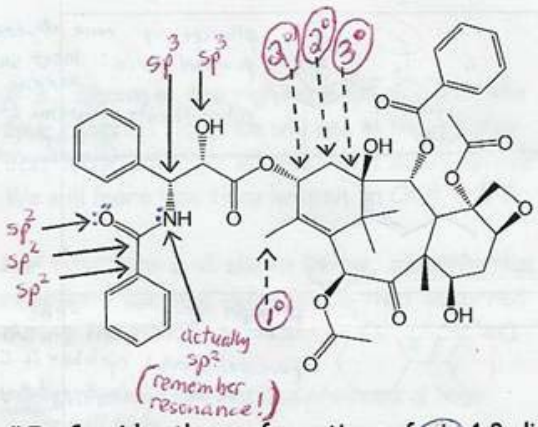
Net: 2 H-bond (strong), 2 D-D (medium), 3 ID-D needed → LONDON DISPERSION FORCES (WEAK) ← 1 H-bond (strong), 3 D-D (medium), 1 ID-D needed

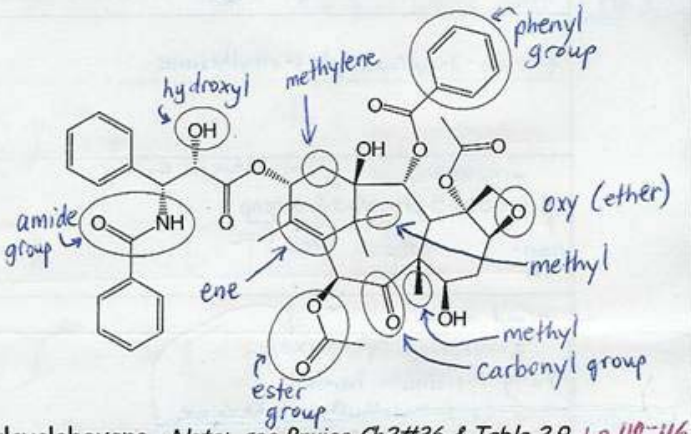
⇒ Conclusion: very similar.

Ethyl dimethyl amine is likely more soluble, even though it has less H-bonding. Remember that 2° amines usually are more soluble than 3° amines, but this example was complicated by a difference in C-chains ~~too~~ (they are not isomers). NOTE: if you gave good explanations, either answer is fine!!

 # 6. Paclitaxel, known as Taxol® (shown below – both same), is a very potent anti-cancer drug. It is a naturally occurring substance discovered in extracts of the bark of the Pacific Yew tree. The extremely low yields of Taxol from yew bark, and the resulting decline of the yew population, quickly made the synthesis of Taxol the target of many research laboratories. It took over a decade for chemists to devise even a very low yielding total synthesis of Taxol. Currently, the large-scale semi-synthesis of Taxol starts from a more easily extracted compound in the yew tree's needles.
[Facts from Wikipedia] To see a 3D view of Taxol, go to: *http://www.3dchem.com/molecules.asp?ID=34#*

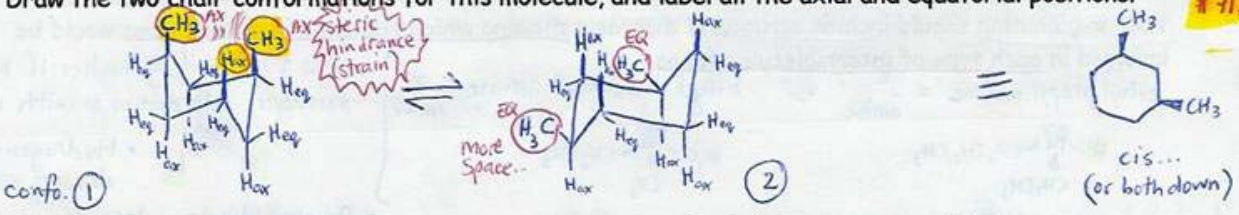
Your tasks here: **(i) 6 solid arrows:** give the hybridization of the non-H atom indicated
(ii) 4 dashed arrows: label the indicated C atom as 1°, 2°, 3° or 4°
(iii) 7 circled groups: name the alkyl group or functional group indicated
NOT compound class
label each as a "substituent" if possible





 # 7. Consider the conformations of (cis)-1,3-dimethylcyclohexane. *Note: see Bruice Ch2#36 & Table 2.9* +p.110-116 (+37...) +Ch2#67

a) Draw the two chair conformations for this molecule, and label all the axial and equatorial positions. #71!

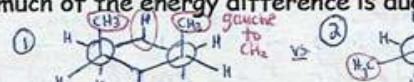


b) Which conformer would predominate in an equilibrium sample of this substance? Why?
Conformer (2) (both methyl groups equatorial) would be the most common conformation for this molecule. The reason is its LOWER STERIC STRAIN. In conformer (1), the CH_3's are both axial and would bump into each other since they are positioned 1,3 ⇒ called 1,3-diaxial interactions. This makes (1) less stable.

c) The energy difference between these conformations is about 23 kJ (5.4 kcal) per mole.
Which conformer is lower in energy? Conformer (2) ← more stable means lower in energy.

p.111 NOTE: 1 CH_3-CH_3 gauche interaction causes 3.6 kJ/mol strain (the WHY behind H,CH_3 1,3-diaxial interaction)

How much of the energy difference is due to the torsional energy of gauche relationships?



(1) CH_3-CH_2 gauche = 3.6 kJ/mol
× 2 CH_3/molecule = 7.2 kJ/mol
BUILD MODEL TO SEE

Build models to prove to yourself (see p.112 top)

How much of this energy difference is due to the steric strain of the 1,3-diaxial interaction? (most)

- Note: the above calculation is the same as treating two H-CH_3 1,3-diaxial int's (see p.115)
- So, the CH_3-CH_3 diaxial int'n strain can be calculated by difference

$23\ \frac{kJ}{mol} - 7.2\ \frac{kJ}{mol} = 15.8\ \frac{kJ}{mol}$ due to CH_3-CH_3 steric repulsion (1,3-diaxial)

+see Ch2#67, 71