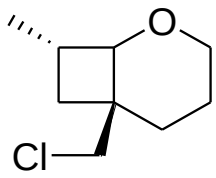
Section I. Multiple choice/Fill in the blank *(1.25 points each)*
(If there are no answers given below, you must write in the correct answer)

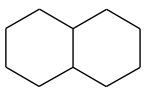
1. The molecular formula of the compound on the right is _____ .

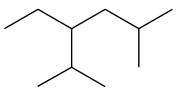


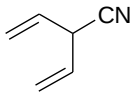
2. A compound has the molecular formula of $C_6H_9Br_2ON$. It has _____ degrees of unsaturation.
(For partial credit, show your work)

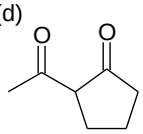
(a) 0 (b) 1 (c) 2 (d) 3 (e) 4 (f) 5
(g) none of the above is correct

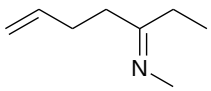
3. The compound below with the most degrees of unsaturation is compound _____ .

(a) 

(b) 

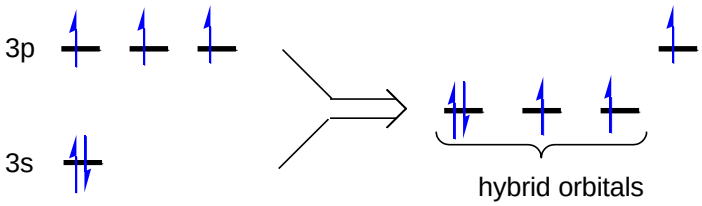
(c) 

(d) 

(e) 

4. The diagram on the right indicates a _____ .

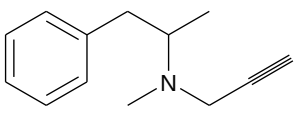
(a) sp^4 hybridized atom
(b) sp^3 hybridized atom
(c) sp^2 hybridized atom
(d) sp hybridized atom
(e) a nonhybridized atom
(f) it's going to be a long test..



5. The diagram in Question 2 would be for a(n) ____ atom with ____ π bonds.
(The first blank should be an atom, preferably one that occurs on the periodic table)

6. The compound on the right has _____π bonds.

(a) 0 (b) 1 (c) 2 (d) 3
(e) 4 (f) 5 (g) more than 5
(h) apple – yummy!!!!

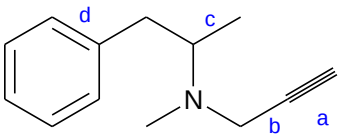


selegiline
(a MAO-B inhibitor,
used as an anti-Parkinsonian)

7. The weakest covalent bond of those below is _____ .

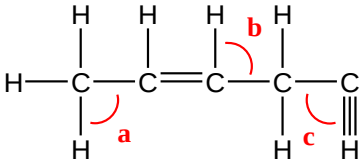
(a) C-C (b) C-Si (c) C-As (d) C=C

8. The correct order of bond lengths, from shortest to longest, is _____ .



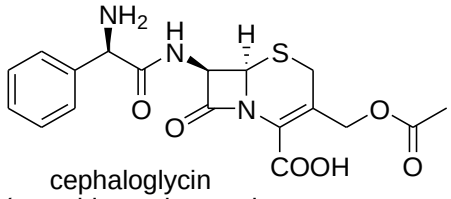
(a) b > c > d > a
(b) a > d > c > b
(c) c > b > d > a
(d) a > d > b > c
(e) none of the above
(f) extra mayo and no onions

9. Bond angle _____ in the structure that would be approximately 120°.
(Note the structure on the right was drawn by a 3rd grader and hence the bond angles you see in the structure might not be chemically correct)



(a) a (b) b (c) c
(d) none of the above

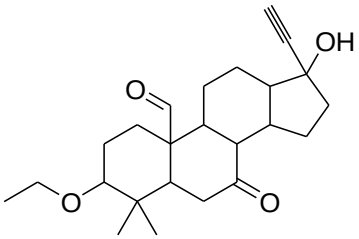
10. The compound to the right contains a _____ .
(Note there is more than one correct answer for this question, but I only want one. For partial credit, circle the group in the structure.)



cephaloglycin
(a cephlasporin, used as an antibiotic)

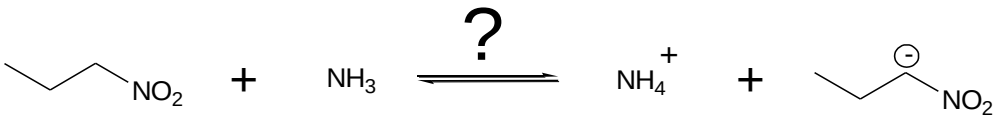
(a) alcohol (b) aldehyde (c) amide
(d) amine (e) carboxylic acid (f) ester
(g) ether (h) ketone

11. The compound to the right contains a _____ .
(Note there is more than one correct answer for this question, but I only want one. For partial credit, circle the group in the structure.)
YOU MUST CHOOSE A DIFFERENT FUNCTIONAL GROUP THAN YOU CHOSE IN QUESTION 10.



(a) alcohol (b) aldehyde (c) amide
(d) amide (e) carboxylic acid (f) ester
(g) ether (h) ketone

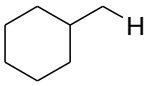
12. Given the pKa's in the table below, at equilibrium there would be _____ .

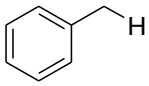


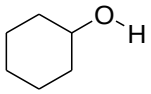
acid	pK_a
$CH_3CH_2NO_2$	10.4
$CH_3CHNO_2^{1-}$	-12
NH_3	38
NH_4	8.4

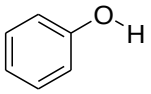
(a) about 1:1 ratio of A to B
(b) about a 2:1 ratio of A to B
(c) about a 1:2 ratio of A to B
(d) about a 10:1 ratio of A to B
(e) about a 1:10 ratio of A to B
(f) greater than a 10:1 ratio of A to B
(g) greater than 1:10 ratio of A to B

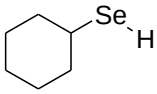
13. The strongest ACID of those listed below would be _____ .

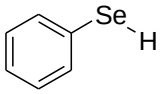
(a) 

(b) 

(c) 

(d) 

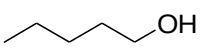
(e) 

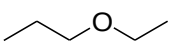
(f) 

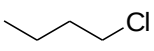
(g) you cannot determine this

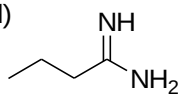
14. The strongest BASE would be made by deprotonating compound _____ in the question 13 above.

For questions 15 – 17, use the structures below

(a) 

(b) 

(c) 

(d) 

(e) 

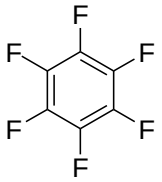
15. Compound (c) would have _____ in terms of intermolecular forces with itself.

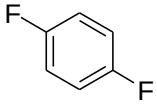
(a) dipole-dipole attractions
(b) hydrogen bonds
(c) London forces
(d) a and b
(e) a and c
(f) b and c
(g) a, b, c

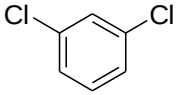
16. The compound that would be MOST soluble in water would be _____ .

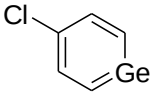
17. The compound that would be LEAST soluble in water would be _____ .

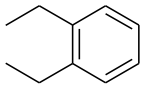
18. The MOST polar compound of those below would be _____ .

(a) 

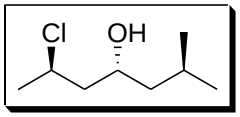
(b) 

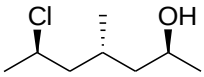
(c) 

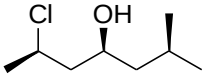
(d) 

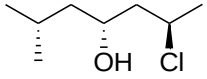
(e) 

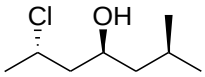
Questions 19-20 refer to the relationship of the compounds shown below to the compound shown in the box on the right.



(a) 

(b) 

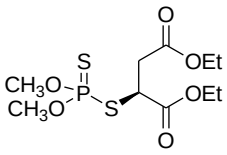
(c) 

(d) 

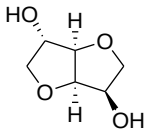
19. The enantiomer of the compound in the box is _____ .

20. An diastereomer of the compound in the box is _____ .

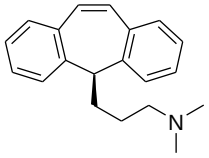
Questions 21 - 22 refer to the wily compounds caged up in the box below.



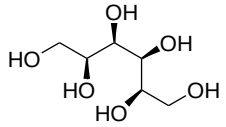
malathion
(potent insecticide)



isosorbide
(a diuretic)



protriptyline
(a tricyclic antidepressant, unique in being energizing and used for ADHD)

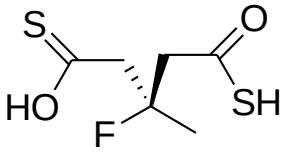


galactitol
(also known as dulcite, a sugar derivative)

21. There are _____ meso compounds in the box.
(For partial credit circle those that are meso)

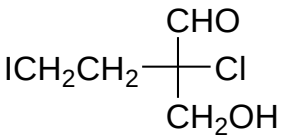
22. There are _____ chiral compounds the box.
(For partial credit put a "Y" through those that are chiral))

23. The absolute stereochemistry in the compound shown on the right is _____ .
(*For partial credit, show your rankings)*



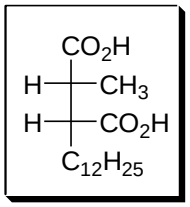
(a) *E* (b) *Z* (c) *R* (d) *S* (e) there is none

24. The absolute stereochemistry in the compound shown on the right is _____ .
(*For partial credit, show your rankings)*



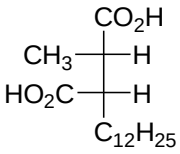
(a) *E* (b) *Z* (c) *R* (d) *S* (e) there is none

25. A compound below that is IDENTICAL to the compound on the right is _____ .

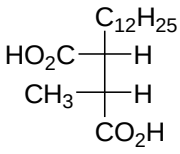


rocccellic acid (compound made by lichens to promote/inhibit plant growth)

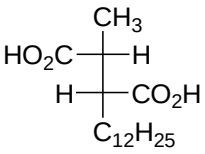
(a)



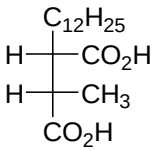
(b)



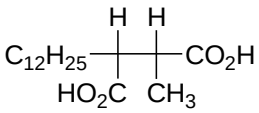
(c)



(d)



(e)



26. When discussing reactions, the ΔH can be thought of as measuring the_____, while the ΔS can be thought of as measuring the _____ .
(please use one letter below for each blank)

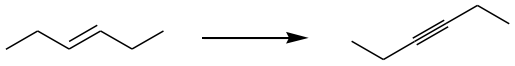
(a) spontaneity of the reaction
(b) bond strength
(c) freedom of motion of the molecules
(d) speed of the reaction

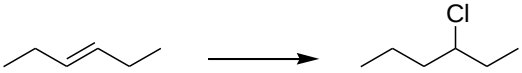
27. As the ΔG of a reactant becomes more similar in value to the ΔG of a product, the reaction will _____ .

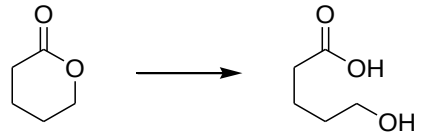
(a) go more towards the product
(b) go more towards the reactant
(c) become an equilibrium reaction
(d) you cannot predict with only this info

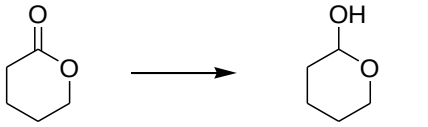
28. According to the reaction coordinate diagram on the un-left,
this reaction occurs in _____ steps and the
rate-limiting step would be going from _____ to _____ .

29. Reaction _____ below would be classified as an oxidation reaction.

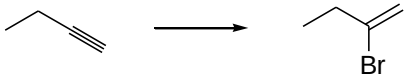
(a) 

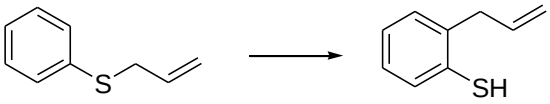
(b) 

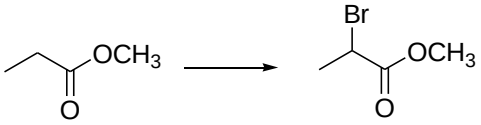
(c) 

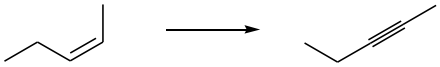
(d) 

30. A good example of a substitution reaction would be reaction _____ .
(For 1 pt extra credit, label ONE of the other reactions correctly.)

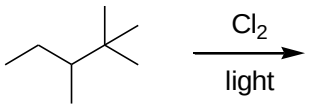
(a) 

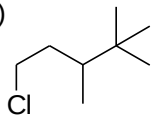
(b) 

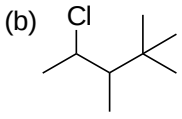
(c) 

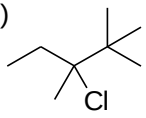
(d) 

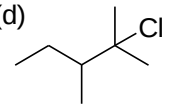
31. The MAJOR free radical halogenation product of the reaction below would be _____ .

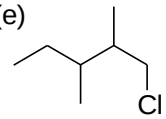


(a) 

(b) 

(c) 

(d) 

(e) 

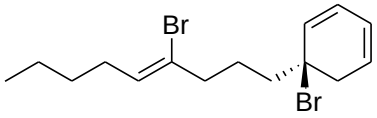
32. The best part of this class is _____ . *(Note: no answer will be marked wrong on this one)*

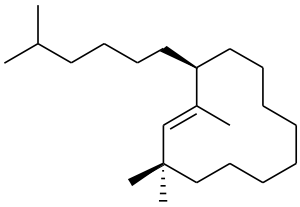
(a) dodging the chalk that somehow seems to be flying around in the room
(b) the really short and easy exams that don't cut into your social life at all
(c) the stares you get when you play with the models in the library
(d) the fact that it is over for 4 months

Section II. Nomenclature.

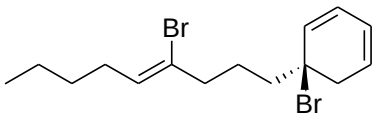
33. (*12 points*) For ONE of the compounds below..

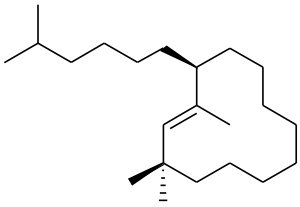
(a) Circle all the stereocenters (both sp^3 and sp^2 in the compound)





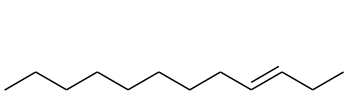
(b) Now provide an acceptable name for this compound, including any depicted stereochemistry. (Note that these are the same compounds as above, just redrawn fresh for this part of the question).



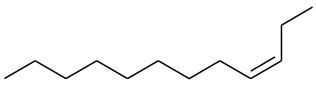


Section III. Short answer.

34. (*7 points*) Rank the following compounds based on increasing boiling point, with 1 being the lowest boiling point compound and 5 being the highest boiling point compound.

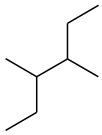


$C_{12}H_{24}$ ____

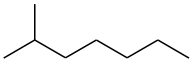


$C_{12}H_{24}$ ____

C_3H_8 ____



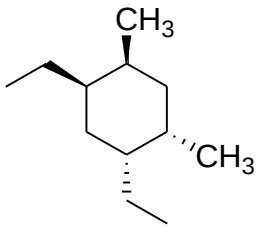
C_8H_{18} ____

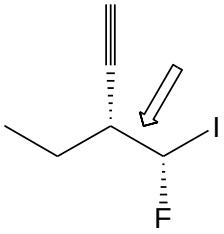


C_8H_{18} ____

34. (*9 points*) Note that you should only do parts (b) and (c) for ONE of the compounds below.

(a) Draw ONE Newman projection underneath the compound on the right, and ONE chair form underneath the compound on the left.





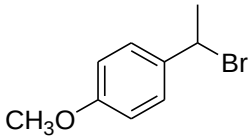
(b) Now EITHER draw 3 more Newman projections, or the other chair conformer, AND rank them according to their relative energy, with 1 being the lowest energy conformer.

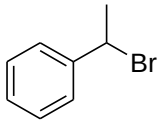
(Did you remember to rank them?)

37. (*8 points*) (a) Throughout the semester I've stressed three principles that we can use to explain differences between compounds and reactions, or at least tried to. List them below.
(Hint: one begins with an "i", one begins with a "r", and one begins with a "s")

(b) Now explain ONE of the following using ONE of the concepts above. Note that sometimes you can help explain things by drawing structures in addition to words.

(i) the **S_N1** reaction of the compound on the left (←) occurs much faster than the same reaction on the compound in the right

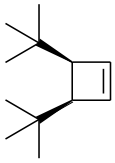


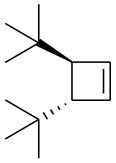


(ii) the free-radical chlorination of fluoromethane (CH_3F) occurs much more readily than the chlorination of methane (CH_4)

(Note: a fluorine atom is roughly the same size as a hydrogen atom)

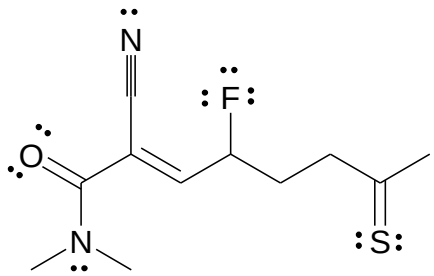
(iii) the catalytic hydrogenation of the compound on the left (←) occurs much faster than the hydrogenation of the compound on the right

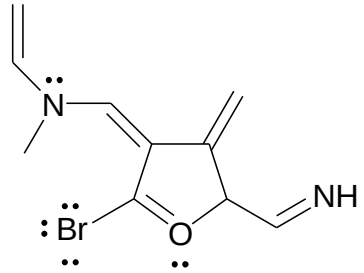




38. (*14 points*) Resonance

(a) Draw in any and all formal charges in ONE of the compounds below.



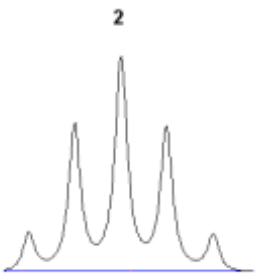


(b) Now draw two REASONABLE resonance structures for this compound, being sure to show any formal charges in these structures AS WELL AS arrows to show how to convert one resonance contributor into another. Note that your second resonance contributor must be derived from your first contributor for full credit.

(c) Circle the lowest energy and put an "X" through the highest energy conformers, and briefly explain your answer.

(d) So what does each resonance contributor structure represent, in terms of the real structure of the compound?

39. (*11 points*) Spectroscopy



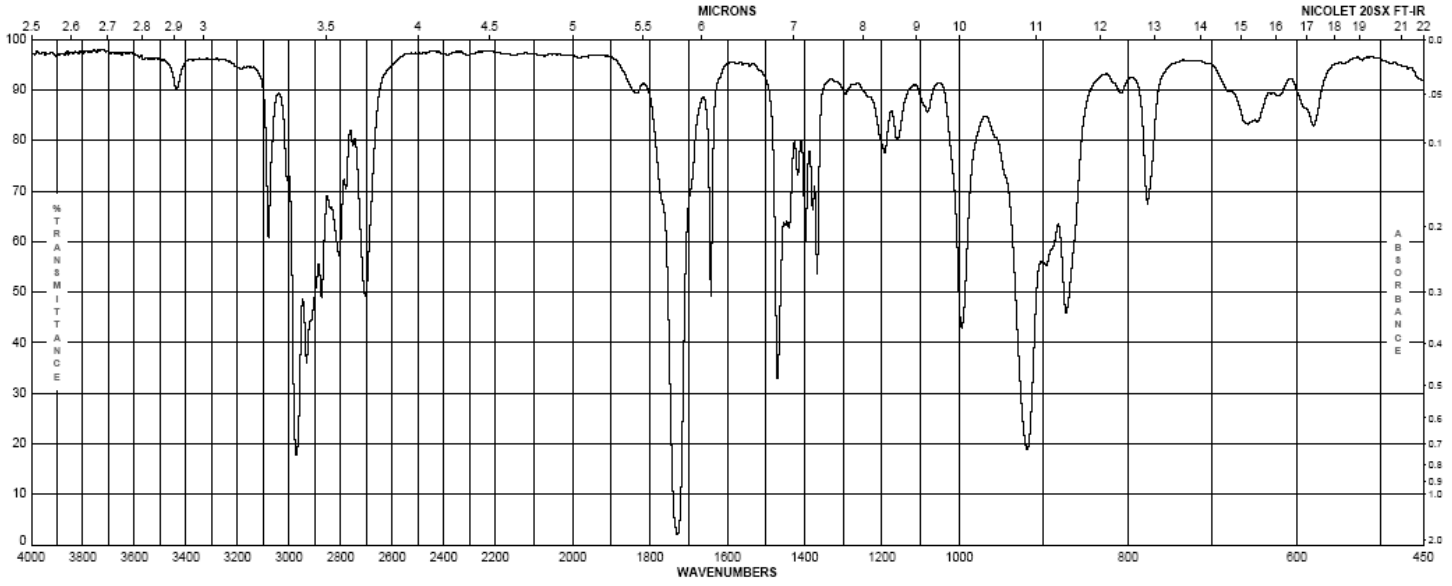
(a) Consider the ^{1}H NMR signal shown on the right. Is this signal from a CH, a CH_2, a CH_3, 2 CH_2's, 2CH_3's, or none of the above?

(b) Draw TWO different but possible 3-carbon fragments of a structure that would give this signal, considering both the integration and the splitting.

Extra credit question (1 point)
Why would it NOT make chemical sense if this signal was found at 4.1 ppm?

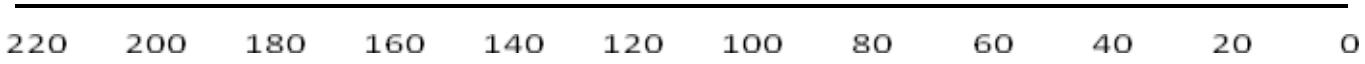
(c) The compound also had the signal on the right. What does this suggest?

(d) Now circle AND LABEL all the identifiable peaks in the IR spectrum below.



(e) So draw a structure for a compound of a compound with the formula $C_9H_{16}O_2$ that would give all the above fragments in the spectrum.

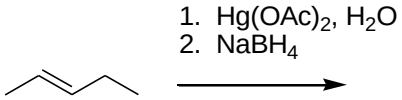
(f) Now label each carbon in your structure, and indicate where it would appear in the ^{13}C NMR spectrum below.

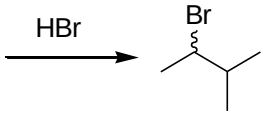


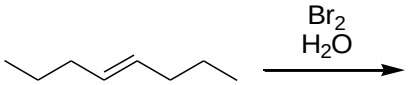
Section IV. Reactions

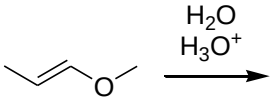
41. (*17.5 points*) Alkenes

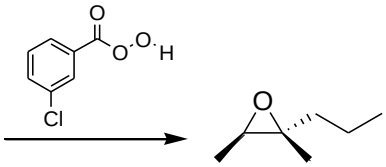
Draw the MAJOR product(s) / MISSING starting material for **FIVE** of the reactions shown below, being sure to carefully consider issues of regio- and stereo-selectivity. At LEAST ONE reaction must be from the next page (rxns j-m).

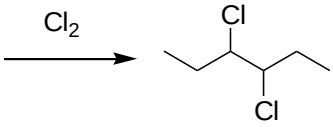
(a) 

(b) 

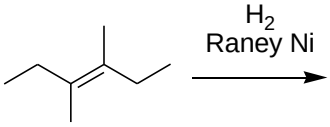
(c) 

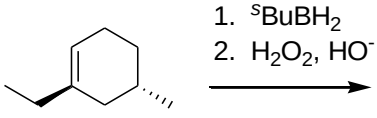
(d) 

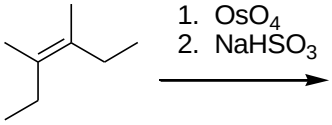
(e) 

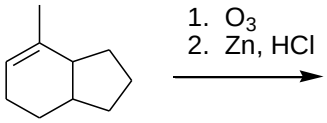
(f) 

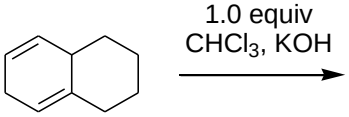
meso

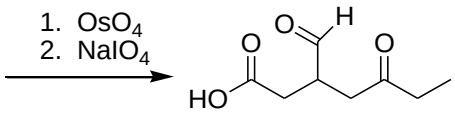
(g) 

(h) 

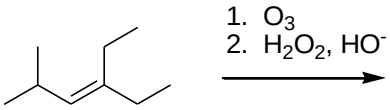
(i) 

(j) 

(k) 

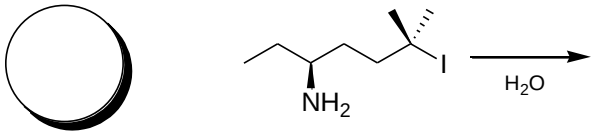
(l) 

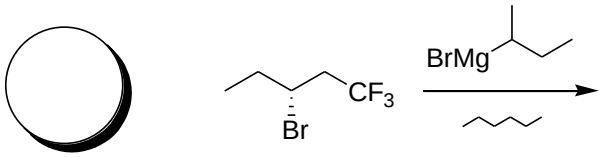
(note: the starting material contains a carbonyl group in it already)

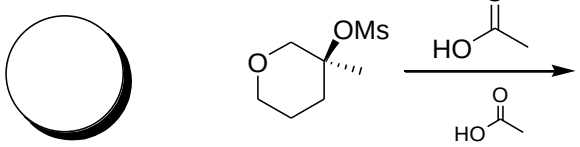
(m) 

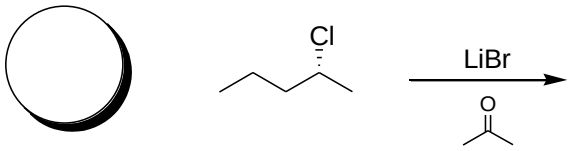
40. (*14 points*) Alkyl halides.

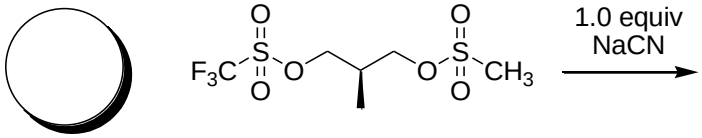
For **FOUR** of the reactions shown below, fill in the oval with the correct reaction type(s) (S_N1, S_N2, E1, or E2), and draw the major product(s) for the reaction.

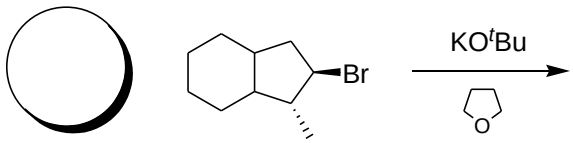
(a) 

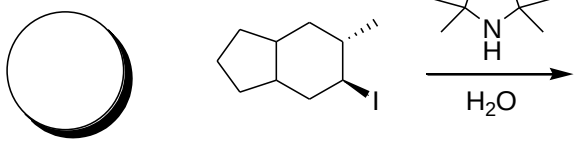
(b) 

(c) 

(d) 

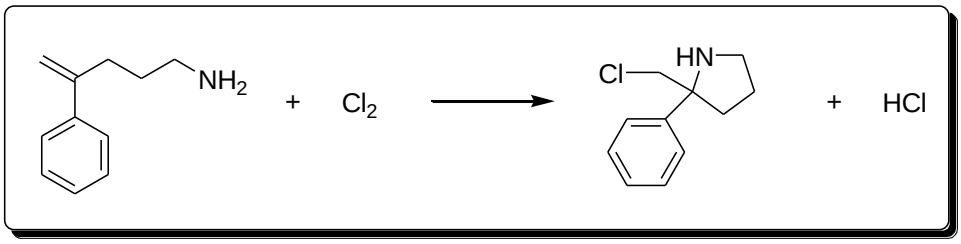
(e) 

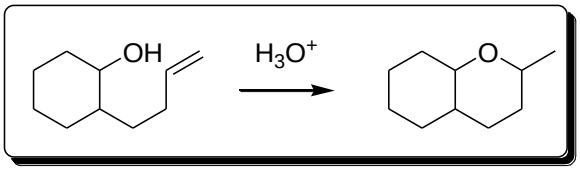
(f) 

(g) 

Section V. Mechanisms.

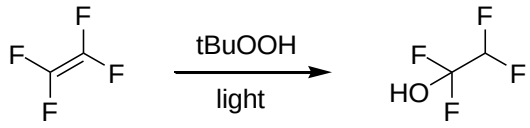
42. (*11 points*) Using curved arrow formulism, provide a reasonable mechanism for ONE of the reactions shown below.



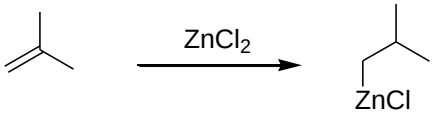


43. (*5 points*) Polymerization reactions..

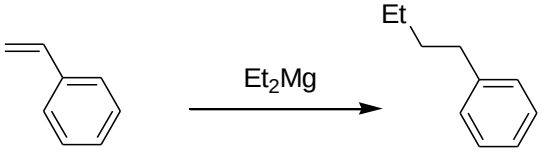
(a) Choose ONE polymerization initiation step below, and write in the box if it occurs by an anionic, cationic, or free radical mechanism



teflon



polyisobutylene
(used in basketball,
roofing, and gas masks)

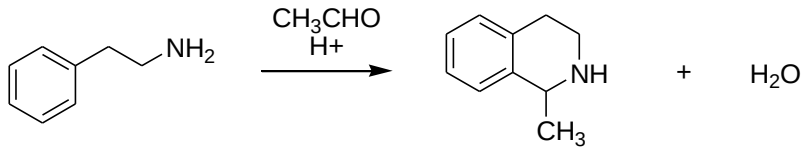


polystyrene
(used in styrofoam,
as well as many other things)

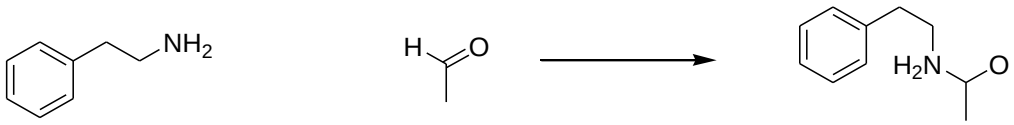
(b) Now for the reaction you chose, complete the structure of the intermediate shown above (to make it an anion, a cation, or a free radical)

(c) Finally, use curved arrows to show the mechanism of how two more monomer units would add to this intermediate to give a 3-unit polymer.

44. (*7 points*) The Mannich reaction is a very useful method for the synthesis of amines and biosynthesis of alkaloids, and an example is shown below.



The presumed first step is shown below:

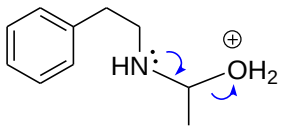


(a) For the step above, draw in any and all lone pairs on the heteroatoms in the starting materials. Note they are both neutral compounds.

(b) Now draw a curved arrow to show the movement of electrons in this process, and show any and all lone pairs AND charges in the product.

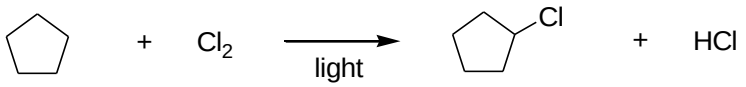
(c) Now label the nucleophile and electrophile in this step.

(d) A little bit further on in the mechanism the following step is proposed. Draw the structure of the compound(s) that would result from the arrow pushing shown.

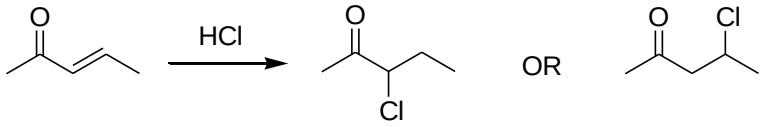


Extra credit.

A. (4 points) Using curved arrow formulism, provide a reasonable mechanism for the reaction shown below.



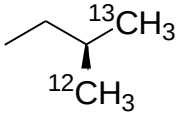
B. (1.5 points) Which product below would be the major product, and why? (Hint: consider resonance in the starting material).



product A product B

C. (6 points) Provide the remaining steps for the Mannich reaction in Question 43. (Hint: there are two steps after the one shown in part (d), and one or two steps (depending how you do it) to get from product of first step to compound shown in part (d))

D. (1 point) Is there a stereocenter in the compound on the right? If so, show your rankings and assign the appropriate stereochemistry for the compound.



CONGRADULATIONS – YOU'RE DONE !!!!!!

I hope you have a fantastic summer (minus the sunburn) and I thank you for your hard work and perseverance over the semester. And I look forward to picking this up again with you in Org. II in the fall…. (he he he…)

For those of you who are transferring out of EIU / graduating / joining a monastery, it was nice having you in class and good luck with your future endeavors..