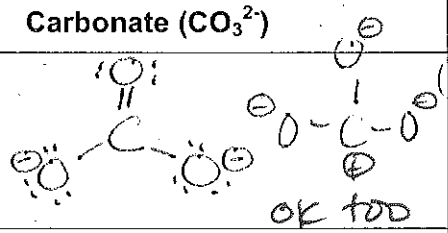
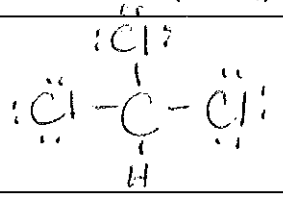
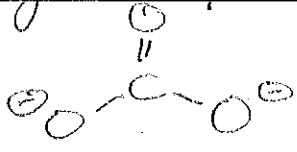
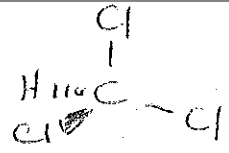
1. Fundamentals

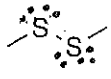
(a) (*20 points*) Draw a **Lewis structure** for each of the following molecules. Be sure to include all lone pair electrons and circle all formal charges, where appropriate.

	Carbonate (CO_3^{2-}) (10)	Chloroform ($CHCl_3$) (10)
Lewis Structure	(3)  OK too	(3) 
Hybridization of Central Atom	(2) sp^2	(2) sp^3
Geometry	(2) trigonal planar	(2) tetrahedral
3D Structure	(3) 	(3) 

(b) (*10 points*) **Fill in any nonbonding valence electrons** that are missing from the following structures.

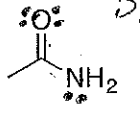
2 pts/atom (12 possible) 2 - extra

4 lp's



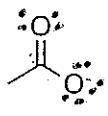
Dimethyl disulfide

3 lp's



Acetamide

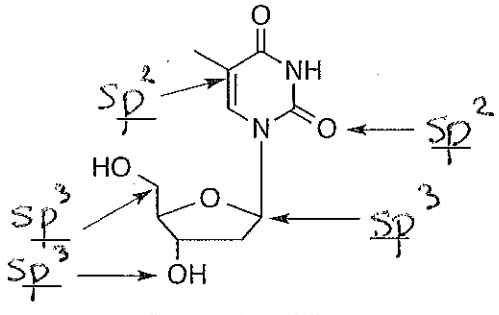
5 lp's



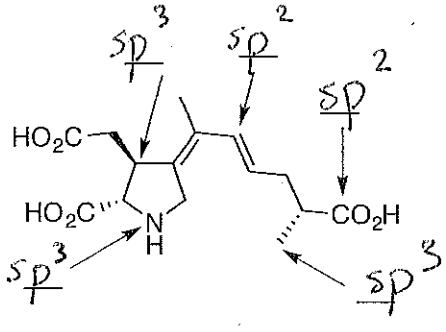
Acetate Ion

(c) *(10 points)* **Indicate the hybridization** on the indicated atoms on **Deoxythymidine** and **Isodomoic acid H.**

1pt each.

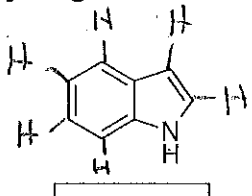


Deoxythymidine



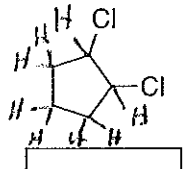
Isodomoic acid H

(d) (*10 points*) **Fill in any hydrogens** not shown and **indicate the *total* number of hydrogens** in each molecule below.



7

Number of H's



8

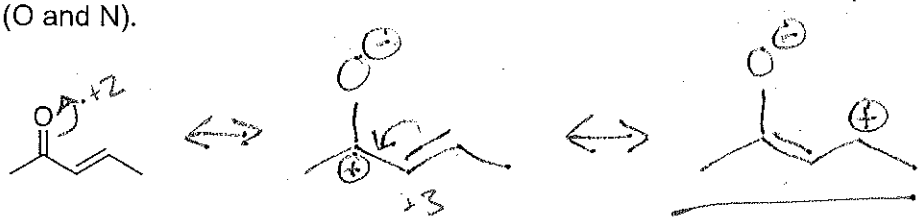
5pts 5pts

3pts - drawing H's

2pts - correct #

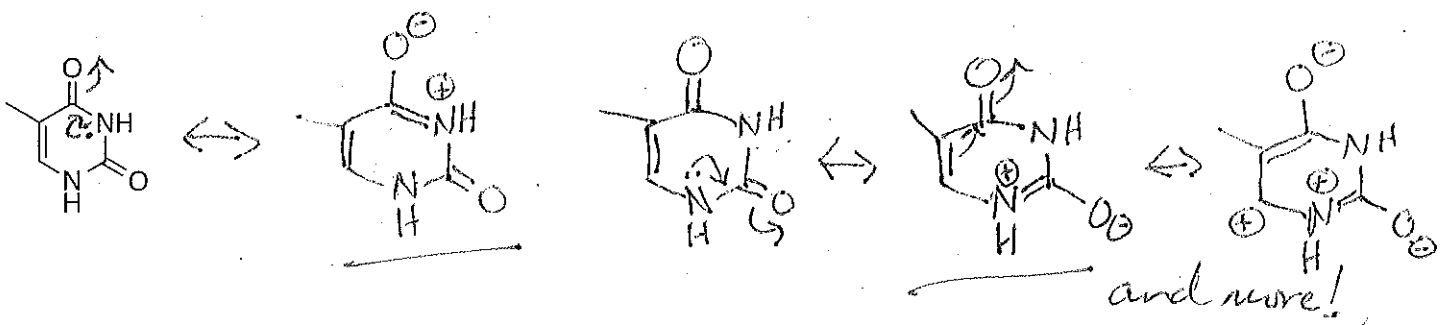
2. Resonance and Formal Charge

(a) (*20 points*) Draw two additional *non-equivalent* resonance structures for each compound below, using curved arrow notation to indicate electron movement. Lone pairs are not shown on heteroatoms (O and N).



10

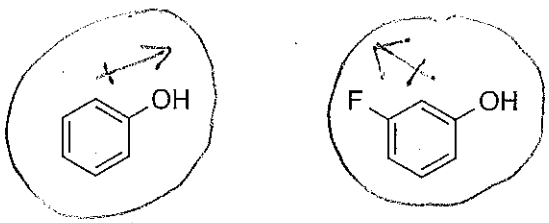
3 pts/structure (12 total)
8 pts → arrows



10

and more!

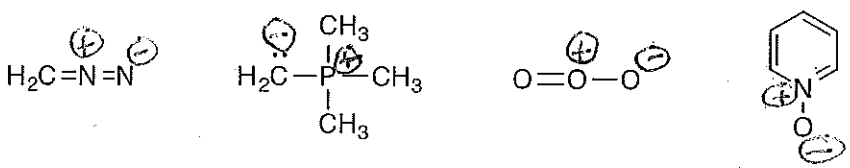
(e) (*10 points*) Circle the molecule(s) that have a dipole moment and indicated the expected direction of the net dipole.



5 5

-2 if circled

(f) (*10 points*) Add formal charges to any charged atoms below. Lone pairs are provided on carbon where applicable, but lone pairs on heteroatoms are implied (add them yourself). Circle the charge and make sure it's clear to which atom the charge belongs!



+12 if all correct

5 - 4 = +1

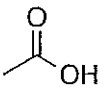
+1 for each correct charge
+½ for circling

3 4 Acidity

(a) (*15 points*) The following compounds are listed in order of acidity (most acidic on the left). Indicate the approximate **pKa value** that belongs to each compound in the boxes provided.

2pts each
16 possible
18 - extra :)

± 2 pKa
o/c

HCl	H_3O^+		NH_4^+	H_2O		NH_3	CH_4
-7	Ø	5	10	16	19	35	50

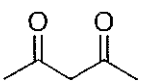
(b) (*20 points*) Rank the following sets of molecules in terms of acidity where "1" is the most acidic.

Set 1

8pts

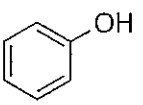
Acetone (pKa 19)

4



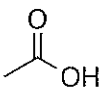
2,4-Pentanedione (pKa 9)

2



Phenol (pKa 10)

3



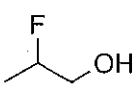
Acetic Acid (you should know this pKa!)

5

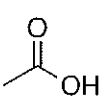
1

Set 2

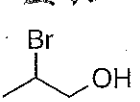
12pts



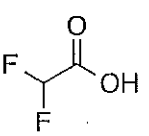
4



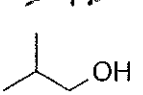
3



5



2



6

1

(d) (*10 points*) Explain the meaning of a compound's pKa in 10 words or less without equations for references to equations ("used to rank acidity" is not an acceptable answer!).

Affinity of an acid for its H^+ (proton)

out of 46

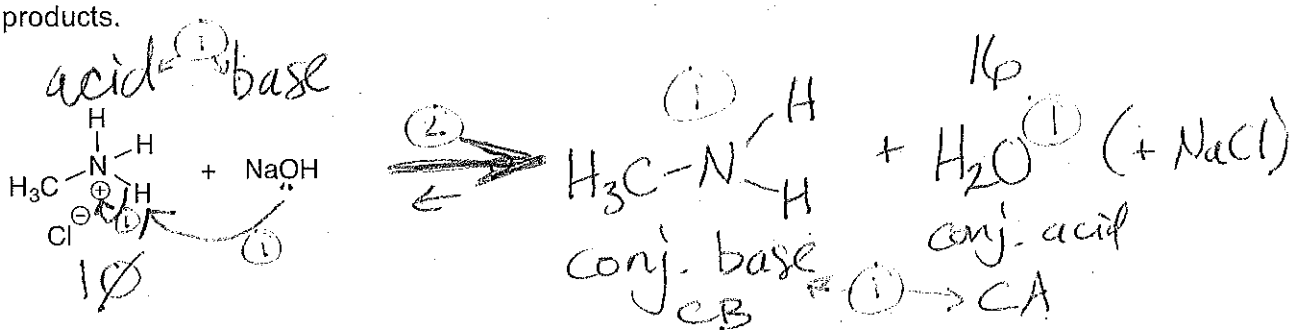
5. Acid-Base Chemistry

8 pts per part
32 possible, 2 extra ☺

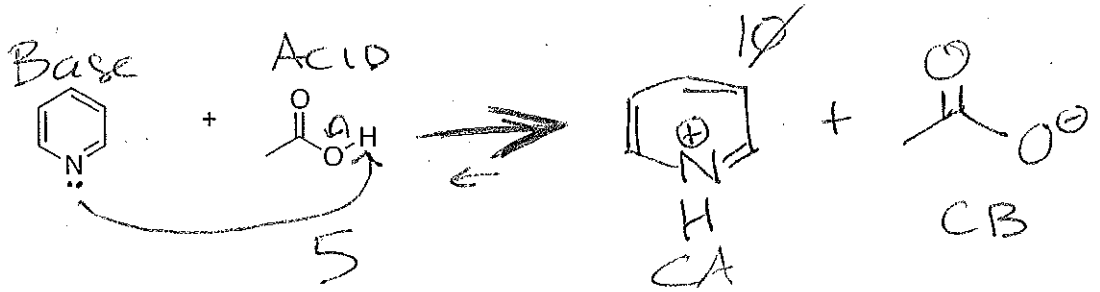
(*30 points*) For each set of reactants…

1 • **Label the acid and the base,**
2 • **Draw the products,**
1 • **Label the conjugate acid and the conjugate base,**
2 • **Use curved arrows** to indicate electron movement,
2 • **Predict the direction of the equilibrium** with an arrow pointing towards either reactants or products.

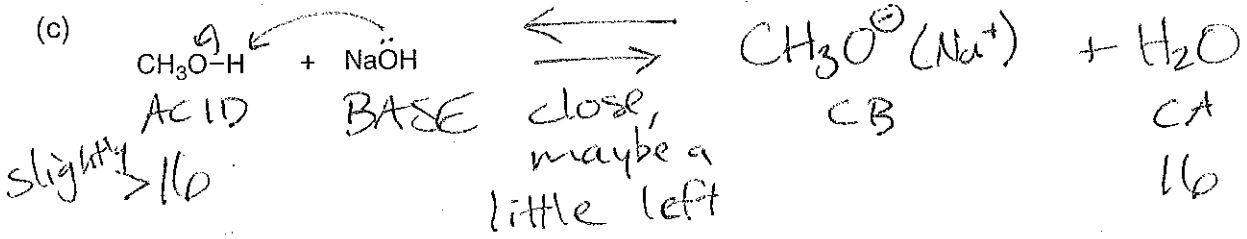
(a)



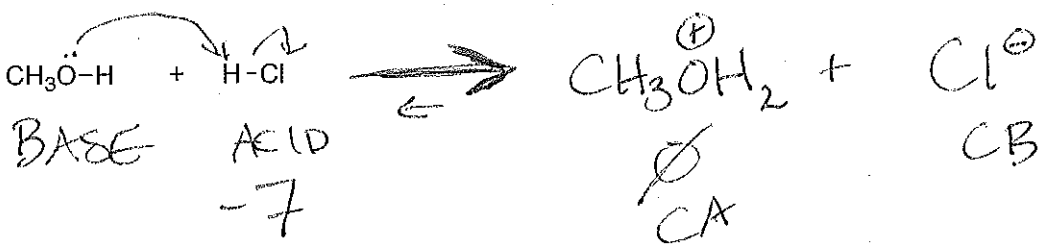
(b)



(c)



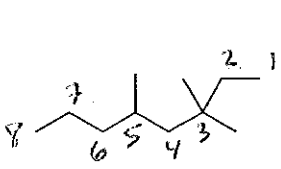
(d)



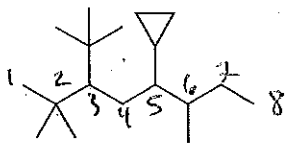
5

3. Nomenclature and Functional Groups

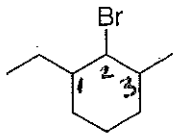
(a) (15 points) Provide **names for any three** following compounds. Write the letter (**i-iv**) of the molecule you are choosing in the parentheses next to the blank line for full credit.



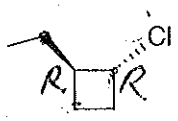
(i)



(ii)



(iii)



(iv)

5pts each

(i) 3,3,5-Trimethyloctane

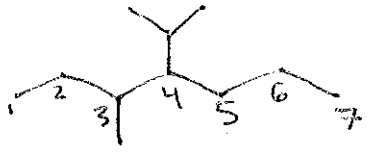
(ii) 2,2,6-Trimethyl-3-tert-butyl-5-cyclopropyloctane

(iii) 1-Ethyl-2-bromo-3methylcyclohexane

(iv) (1R, 2R)-1-chloro-2-ethylcyclobutane

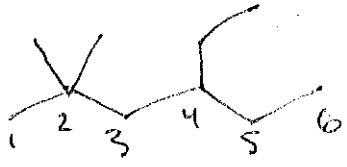
(b) *(10 points)* **Draw** the structures of...

(i) 4-Isopropyl-3-methylheptane

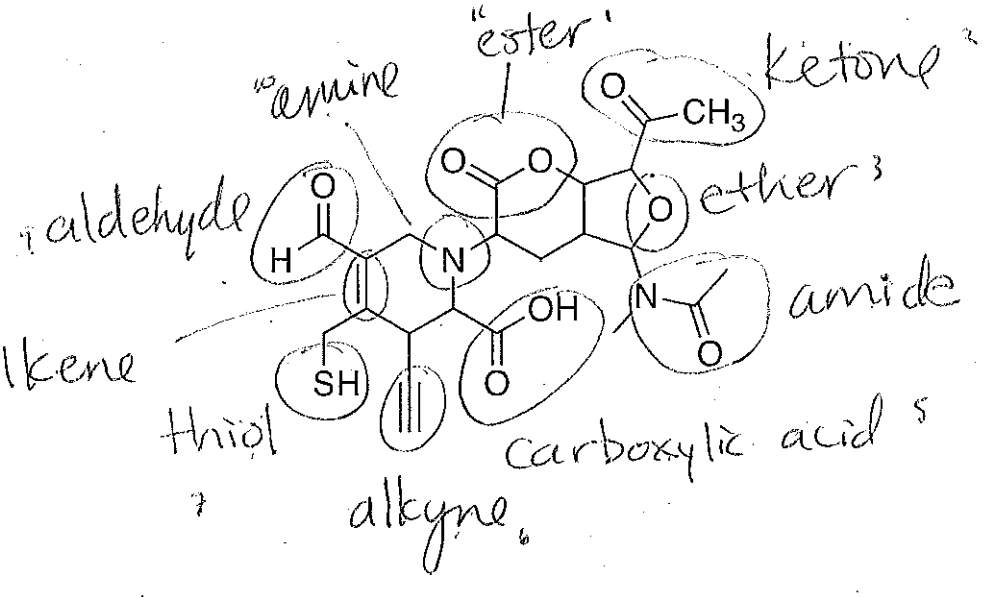


5pts ea

(ii) 4-Ethyl-2,2-dimethylhexane



(d) (*20 points*) **Circle and identify all the functional groups** in the fictitious molecule below.

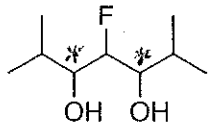


2pts each. 22 possible 2 extra

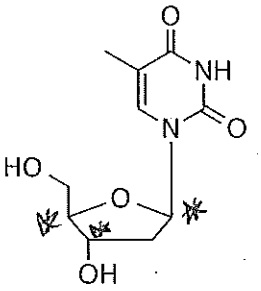
6. Stereochemistry

(a) (*18 points*) Chiral centers are of great importance in recognition by cell receptors and enzyme active sites. Indicate the chiral centers (AKA stereocenters) in each compound with a star (*) then indicate the maximum number of stereoisomers for each compound on the lines below.

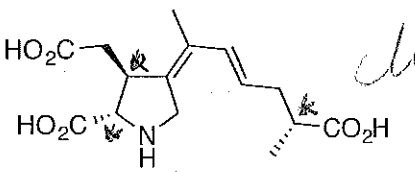
RR
SS
SR
RS
meso



1,6-Dimethyl-4-fluoro-3,5-heptanediol



Deoxythymidine



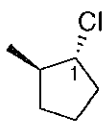
Isodomoic acid H

16 pts - chiral ctrs
2 pts ea.

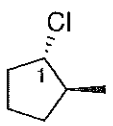
Max # stereoisomers:

3 8 8 3 pts

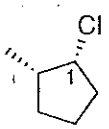
(b) (*11 points*) Designate each chiral center as *R* or *S* on the lines below each structure. If the indicated atoms are not chiral, leave the line blank.



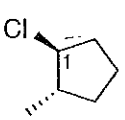
A



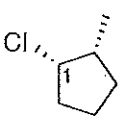
B



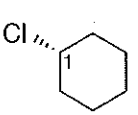
C



D



E



F

1 pt each

A: 1 R, 2 R B: 1 S, 2 S C: 1 R, 2 S D: 1 S, 2 S E: 1 S, 2 R F: 1 —

(b) *(8 points)* Indicate whether the following pairs of compounds are enantiomers, diastereomers, constitutional isomers, the same compound, or not related.

1 pt each

A & B enantiomers
A & C diastereomers
C & D diastereomers
C & E enantiomers
C & F const. isomers
D & E diastereomers
D & F const. isomers
E & F const. isomers

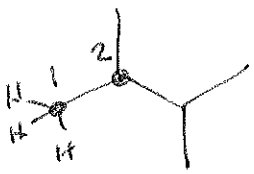
(c) (*3 points*) Briefly define the term 'racemic mixture.' Give an example of a racemic mixture using the compounds above.

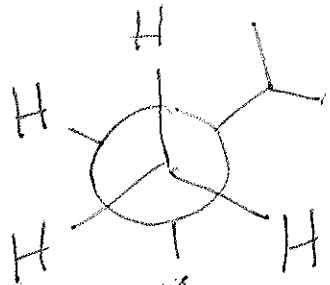
2 pts → 50:50 mixture of enantiomers

1 pt → 50% A : 50% B (or C : E, A : D)

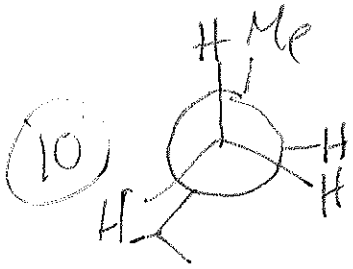
7. Conformational Analysis

(a) (*20 points*) Consider the rotation around the *C1-C2* bond of **2,3-dimethylbutane.**
Draw the least stable and most stable conformations of this compound as Newman projections.





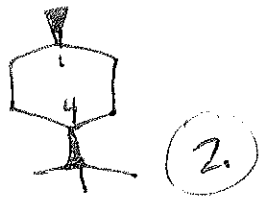
(10) staggered most stable



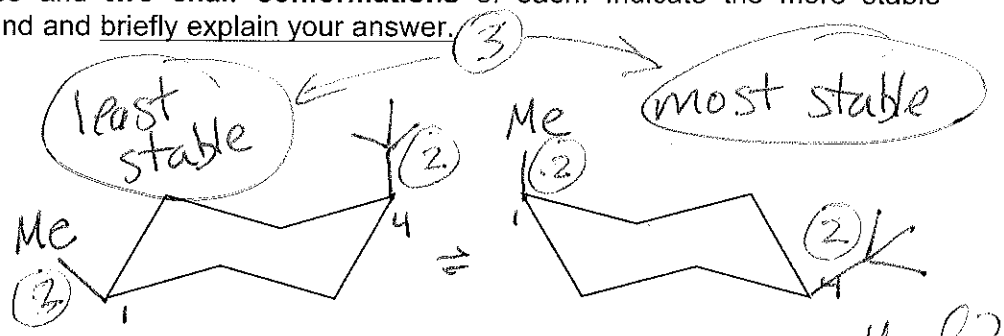
(10) eclipsed least stable

(b) (*30 points*) Consider the following compounds:
***cis*-1-Methyl-4-*tert*-butylcyclohexane** and ***trans*-1-Methyl-4-*tert*-butylcyclohexane**.
Draw the **skeletal structures** and **two chair conformations** of each. Indicate the more stable conformation of each compound and briefly explain your answer.

***cis*-1-Methyl-4-*tert*-butyl-cyclohexane**

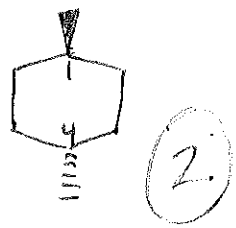


(2)

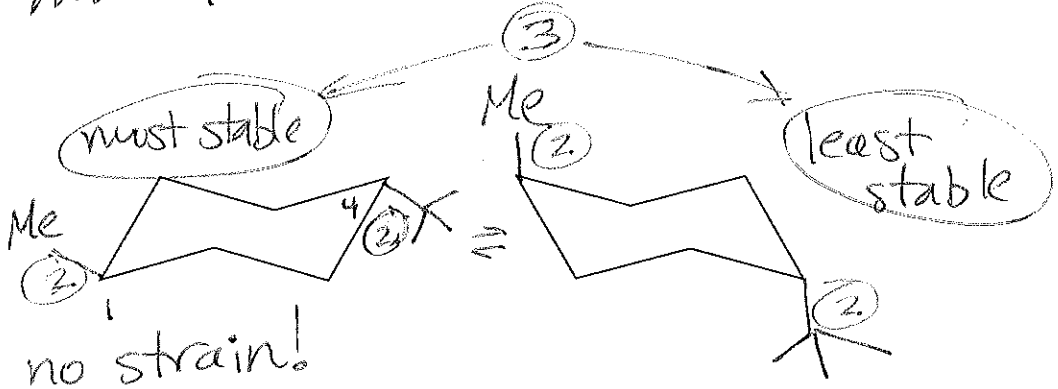


t-Butyl is larger than methyl
more 1,3-diaxial interactions (2)

***trans*-1-Methyl-4-*tert*-butyl-cyclohexane**



(2)



no strain!

(2) → lots of 1,3-diaxial interactions