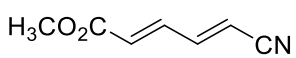
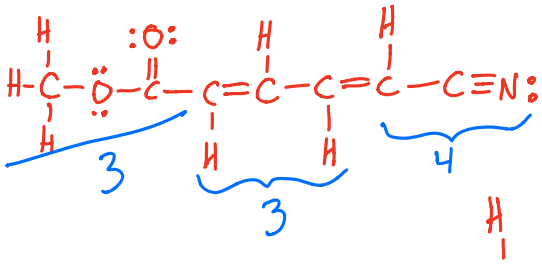
1. FUNdamentals – hybridization & structures

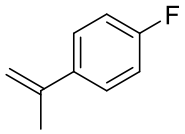
(a) (*10 points*) *Decoding* – Convert ONE of the skeletal structures below into a **Lewis structure** (choose one, X out the other). Include all bonds, atoms, and **lone pair electrons** where appropriate.

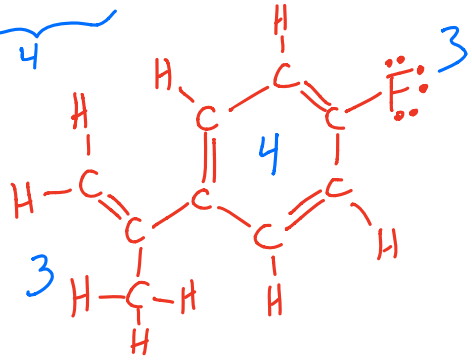
(i)





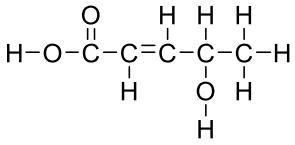
(ii)

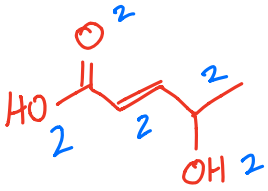




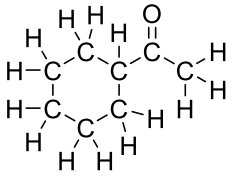
(b) (*10 points*) *Encoding* - Convert ONE of the Lewis structures below into a **skeletal structure** (choose one, X out the other).

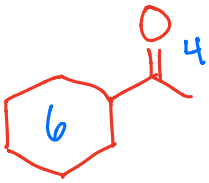
(i)





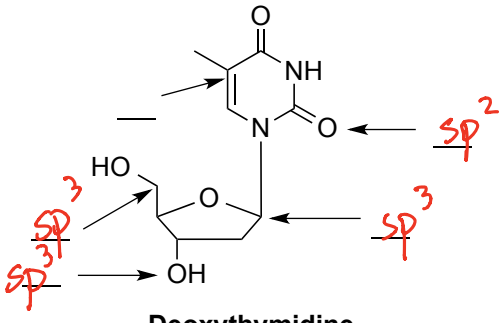
(ii)



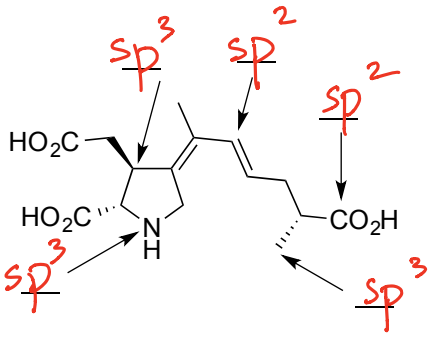


(c) *(10 points)* **Indicate the hybridization** on the indicated atoms on **biotin** and **isodihydrohistrionicotoxin**. All atoms have no formal charge. Lone pair are not shown on heteroatoms.

1pt each



Deoxythymidine

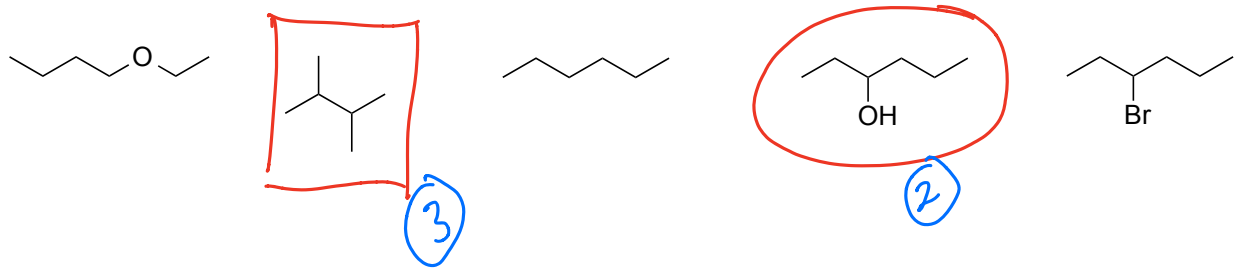


Isodomoic acid H

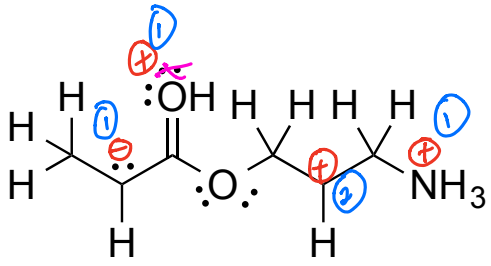
Take 3 slow deep breaths

2. Molecular Structure

(a) (*5 points*) *Circle the compound with the* ***highest boiling point*** and draw a box around the compound with the **lowest boiling point**.

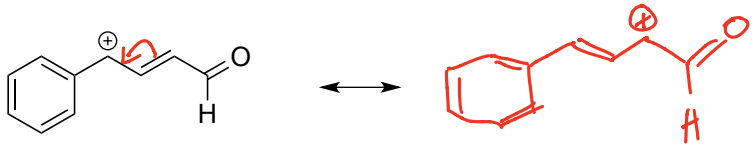


(b) (*5 points*) The fictional molecule below has several charged atoms. All lone pair electrons and bonds to hydrogens are explicitly shown. **Add circled formal charges** to all appropriate atoms.

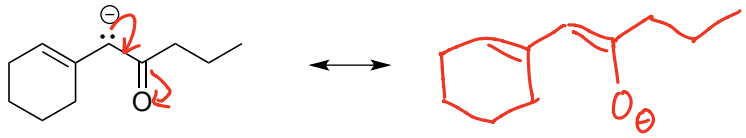


(c) (*20 points*) **Draw one resonance structure** for BOTH compounds below, using **curved arrow notation** to indicate electron movement.

(i)



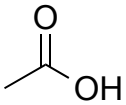
(ii)



5pts-structure
- no credit if charge is missing
5pts-arrow set
* start & end points of arrows matter!

3. Acid-Base Chemistry

(a) (*10 points*) List the **pKa** of each compound in the boxes provided. -1 per incorrect pKa

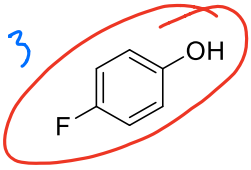
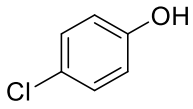
HCl	NH_4^+		H_2O	H_3O^+	CH_4		NH_3
-7	10	19	16	0	50	5	35

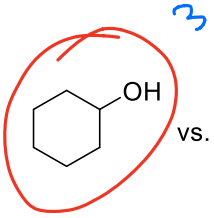
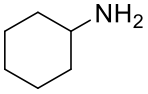
±2pKa units OK

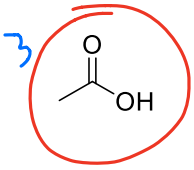
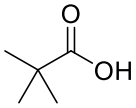
-2

(b) (*10 points*) **Circle the more acidic compound** in each pair.

(i) HF vs. HI 1

(ii)  vs.  3

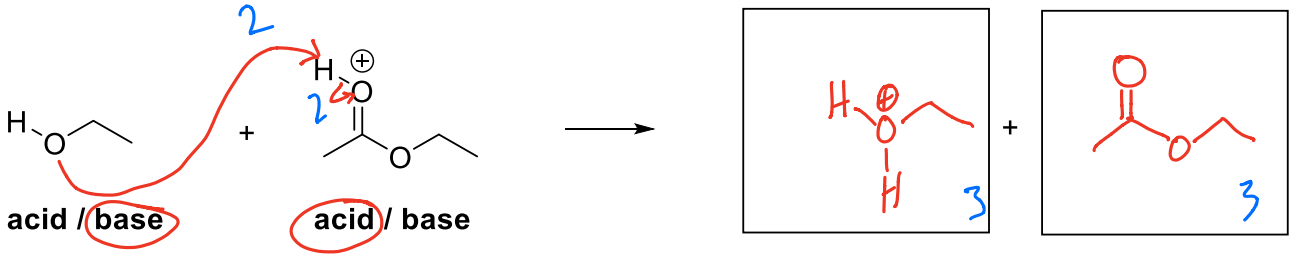
(iii)  vs.  3

(iv)  vs.  3

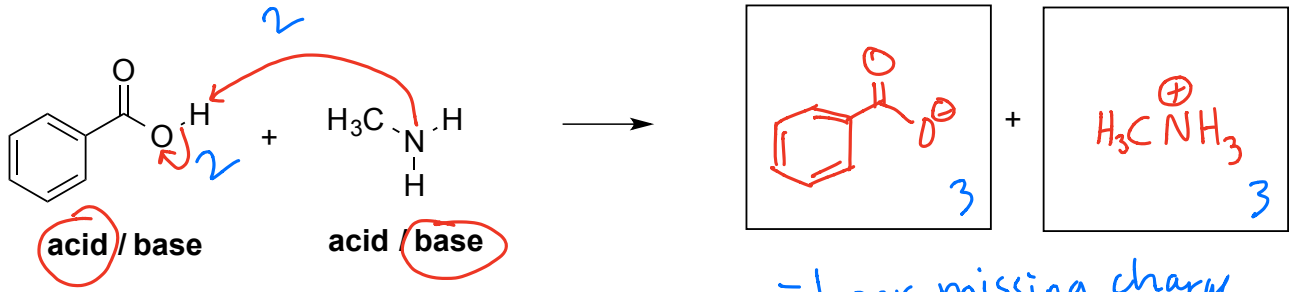
(c) (*10 points*) Choose ONE reaction below (X out the other)…

- **Indicate (circle) which is the acid and the base**
- **Use curved arrows** to indicate electron movement in starting materials (reactants).
- **Draw the products**, including circled formal charges where appropriate.

(i)



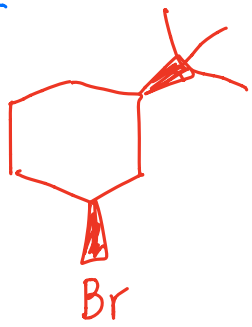
(ii)



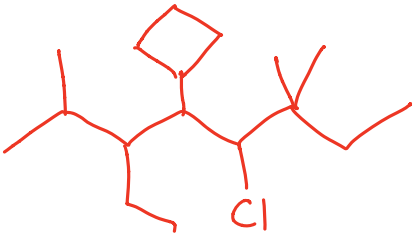
-1 per missing charge

4. Nomenclature and Functional Groups

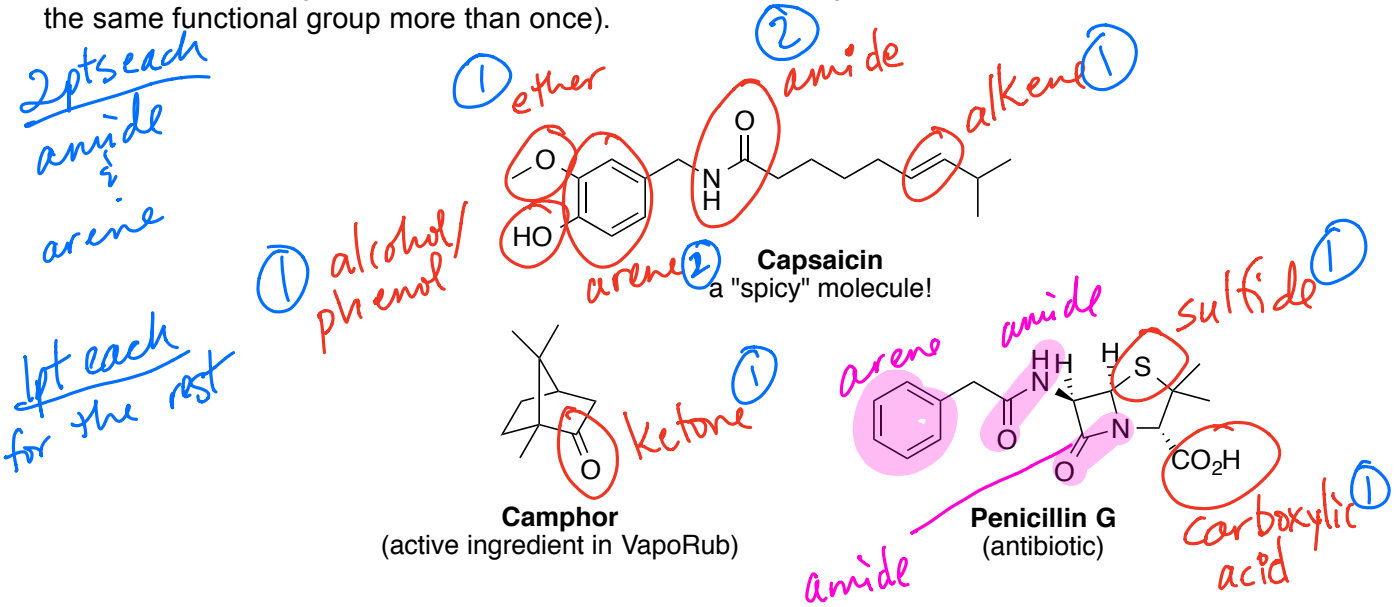
(a) *(10 points)* **Draw** the structure of ***cis*-3-bromo-1-*tert*-butylcyclohexane**.



(b) *(10 points)* **Draw** the structure of **4-cyclobutyl-3-ethyl-5-chloro-2,6,6-trimethyloctane.**



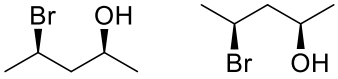
(c) (*10 points*) **Circle and identify the ten unique functional groups in the molecules below**. Alkanes don't count as functional groups in this context and the functional groups must be different for credit (do not indicate the same functional group more than once).



5. Stereochemistry

(a) (*10 points*) Indicate the relationship of each pair of compounds: **not isomers, same compound, constitutional isomers, enantiomers, or diastereomers.**

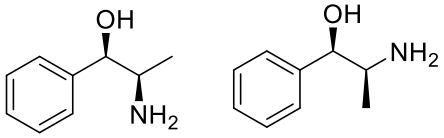
(i)



enantiomers

4

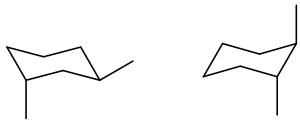
(ii)



diastereomers

4

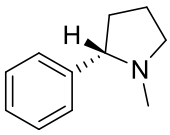
(iii)



constitutional isomers

2

(b) (*10 points*) Below is the structure of nicotine, the addictive component in tobacco. Assign the configuration of the chiral center in nicotine (**circle *R* or *S***), then **draw its enantiomer**.

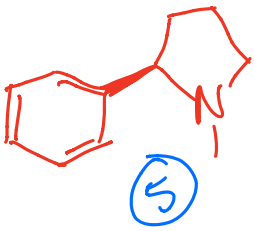


Nicotine

R / **S** (circle one)

5

Enantiomer of nicotine:

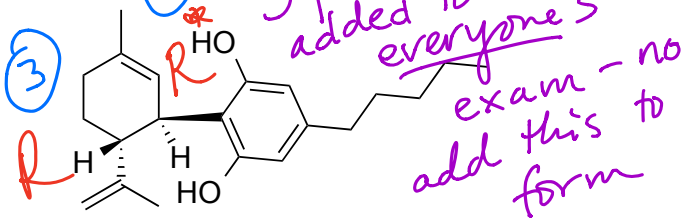


5

(c) (*10 points*) Cannabidiol (CBD) is present in certain strains of marijuana and has different activity than THC. **Assign both chiral centers in CBD as *R* or *S*** (draw an arrow to clearly indicate which assignment goes to which carbon), then **draw a diastereomer of CBD**.

3

mistake in key, 3 points added to everyone's exam - no need to add this to exam correction form



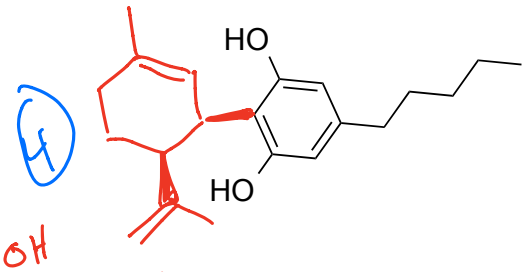
3

R

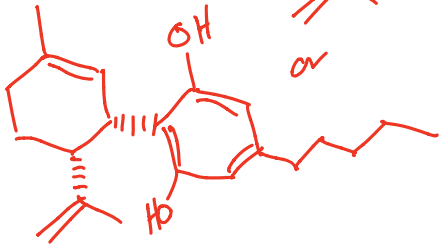
Cannabidiol (CBD)

Assign R / S to both chiral centers

Draw a <u>diastereomer</u> of CBD, building on the core structure given:



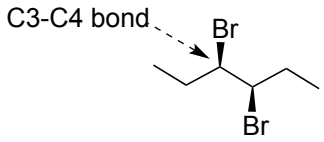
4



or

6. Conformational Analysis: Newman Projections

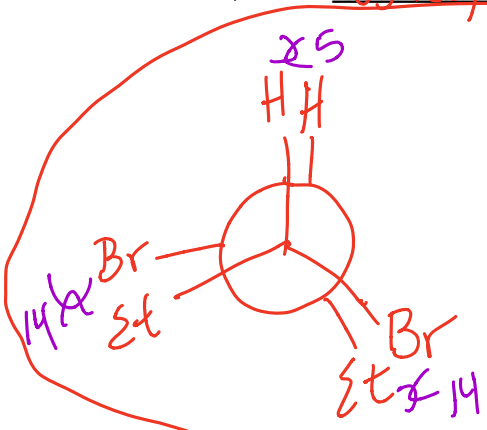
(*25 points*) Consider the rotation around the *C3-C4* bond of **(3*R*,4*R*)-3,4-dibromohexane.**



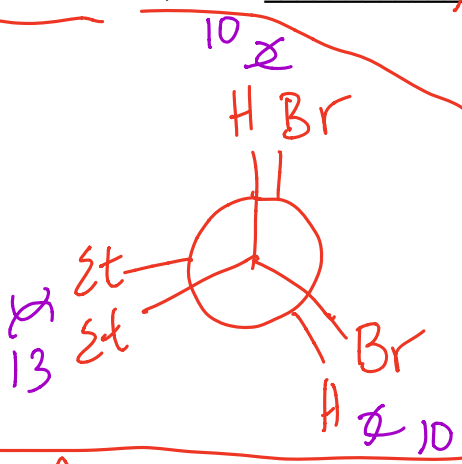
Draw all three eclipsed Newman projections, in no particular order. **Calculate the total strain** associated with each conformation using the table below, **enter on the provided line, and identify the <u>least stable conformation (Circle it)</u>**. Briefly **explain your assignment of the least stable conformation** – including which specific types of steric strain are involved. Short phrases are great – complete sentences not required!

	H-H	H-Ethyl (Et)	H-Br	Et-Et	Et-Br	Br-Br
Gauche	0	0	0	6	8	11
Torsional	5	8	10	13	14	16

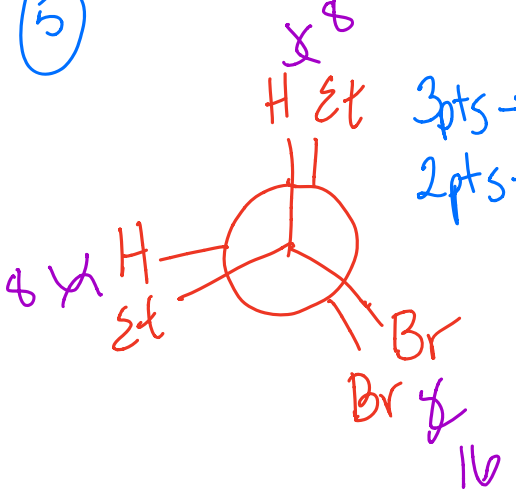
(5) Newman 1, Strain 33 kJ/mol



(5) Newman 2, Strain 33 kJ/mol



Newman 3, Strain 32 kJ/mol (5)



(5) Explanation for the least stable conformation:

both have same amount of torsional strain — groups repel each other

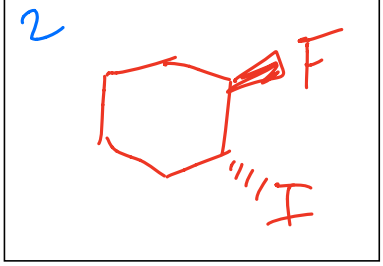
7. Conformational Analysis: Chairs

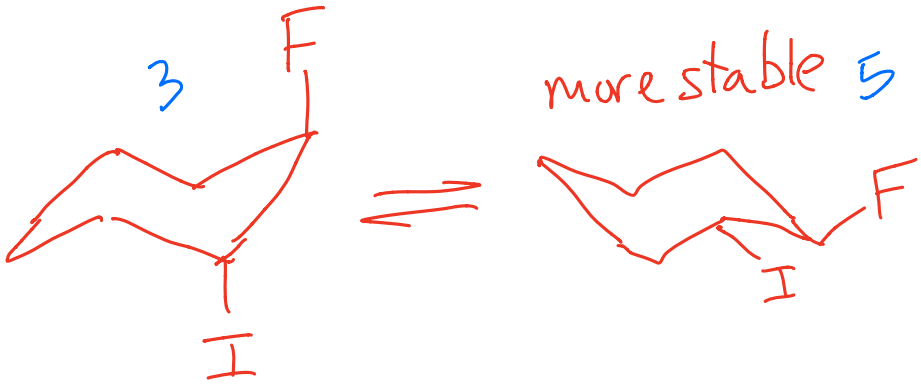
(*25 points*) Consider the following compounds:

***trans*-1-Fluoro-2-iodocyclohexane** and ***cis*-1-Fluoro-2-iodocyclohexane**

Draw the **skeletal structures** and **two chair conformations** of each. Chair templates are provided for the *cis* compound. Redraw your own chairs for the *trans* compound. Circle the more stable conformation of each compound and briefly explain your selections below each pair, including the specific types of steric strain involved. Short phrases are great – complete sentences not required!

***trans*-1-Fluoro-2-iodocyclohexane**

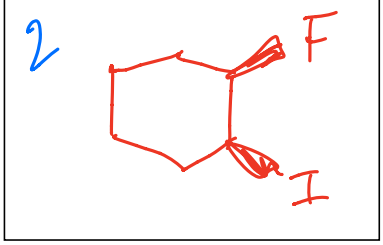


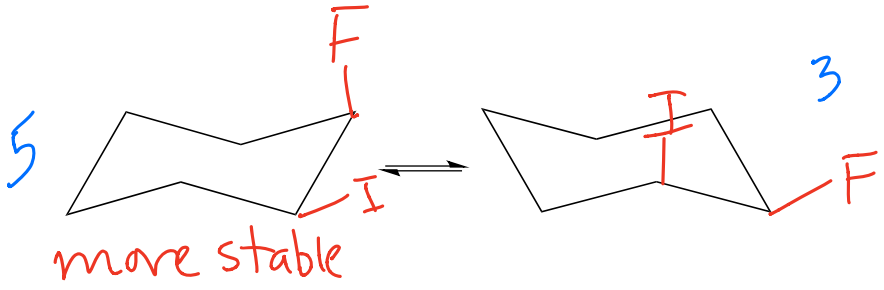


explanation for more stable conformation:

no 1,3-diaxial interactions, 2
all equatorial, no strain

***cis*-1-Fluoro-2-iodocyclohexane**





explanation for more stable conformation:

smaller F ax, bigger I eq, 3
less 1,3-diaxial interactions