ANSWERS

CHM 2120A
Midterm #1
October 4, 2017

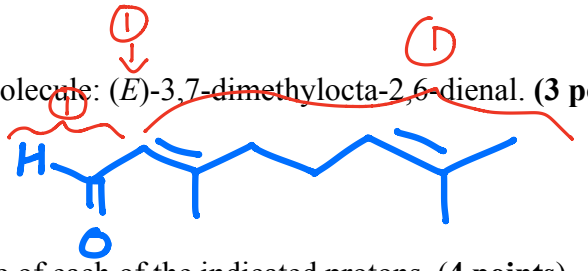
First Name: _____ Last Name: _____

Student Number: _____ Seat number: _____

Approximate total number of marks: ~~94~~ 92
The marks are given as a guide and are subject to change.
You can write in pen or in pencil.
Molecular models can be used but not shared.
Calculators or any other electronic devices may not be used for any reason.
There is a pK_a table on the last page.

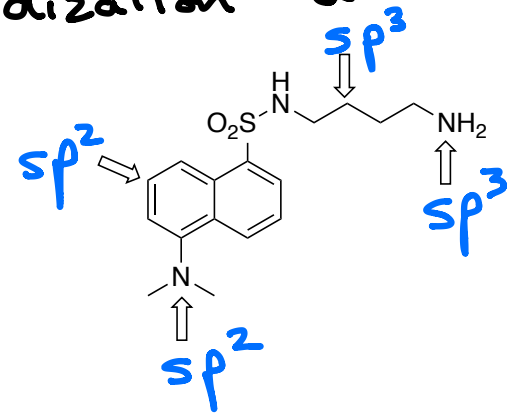
1a	2a	3b	4b	5b	6b	7b	8			1b	2b	3a	4a	5a	6a	7a	0
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Ha	106 106												

1. Draw the following molecule: (*E*)-3,7-dimethylocta-2,6-dienal. **(3 points)**



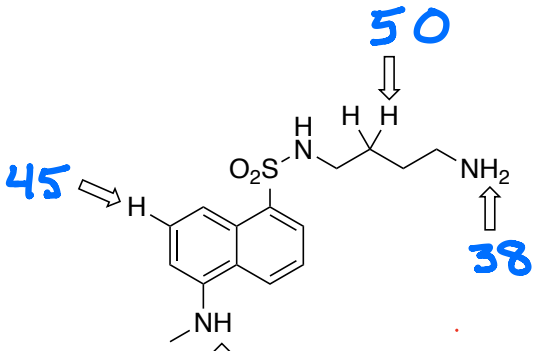
2. Estimate the ~~pK$_a$ value~~ of each of the indicated ~~protons~~ atoms **(4 points)**

hybridization



1 each

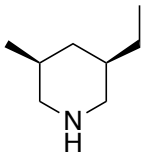
3. What is the ~~hybridization~~ pKa value of each of the indicated atoms? **(4 points)**

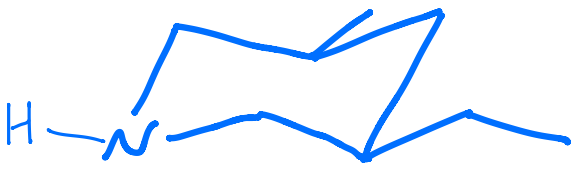


1 each

(> OH, 10 ; < NH, 38)

4. Draw the compound below in its most stable chair conformation. **(4 points)**

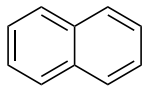




1 well drawn chair
1 correct molecule
1 most stable conf
1 H equatorial

5. Decide whether each of the following compounds is aromatic, anti-aromatic, or non-aromatic and justify your choice. Please support your answer with a drawing if you are discussing the position of electrons or orbitals in space. **(8 points)**

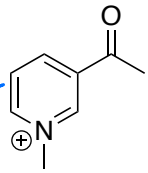
a.



(2) ✓Aromatic

✓planar
✓conjugated π system (all sp or sp^2 atoms)
✓$4n+2$ π e⁻s : 10 π e⁻s

b.

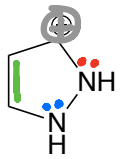


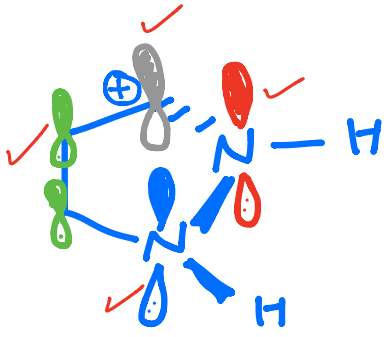
(2) ✓Aromatic

✓planar
✓conjugated π system (all sp or sp^2 atoms)
✓$4n+2$ π e⁻s : 10 π e⁻s
(C=O and ⊕ have no effect on aromaticity)

(4) ✓c. Aromatic

✓6 π e⁻s
π bond (2)
+ 2 pairs of non-bonding e⁻s

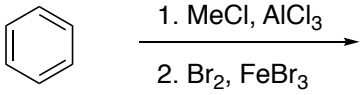




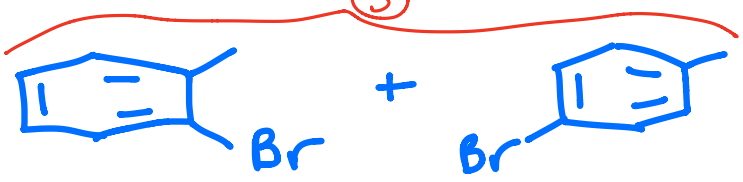
✓planar
✓conjugated π system: yes- overlapping p orbitals

6. Draw the major organic product(s) for the following reactions. **(3 points each; total 6 points)**

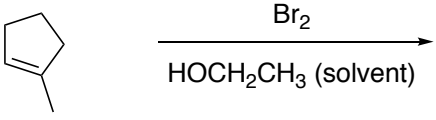
a.



(3)

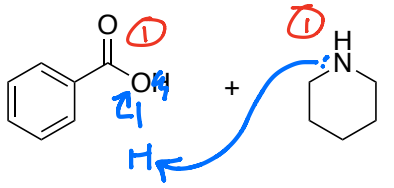


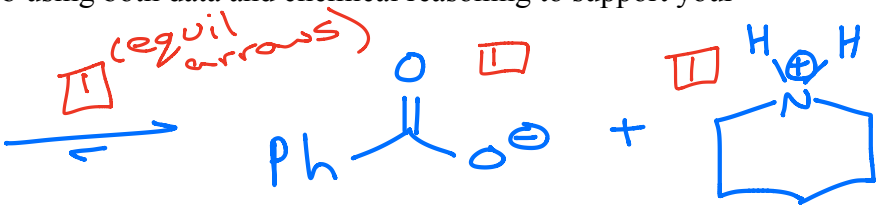
b.



(1) structure
(1) regiochem
(1) stereochem

7. For the following reaction:
   a. Draw the mechanism and products. **(5 points)**
   b. Determine the direction of the equilibrium. **(1 point)**
   c. Justify your answer in part b using both data and chemical reasoning to support your answer. **(3 points)**





(values) pKa ~ 5

Acid

Base

conjugate base

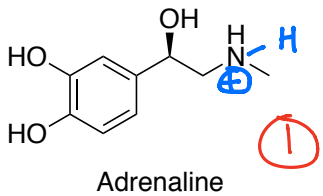
pKa ~ 10

conj. acid

- more stable base (despite ⊖)
  - stabilized by O (more electronegative than N)
  - resonance (no resonance in the base)
  - inductive effect (carbonyl and Ph are e- withdrawing groups

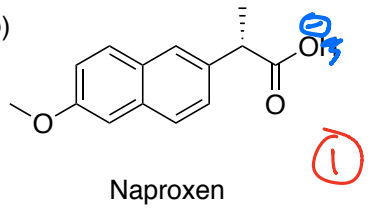
8. Draw the predominant form of each of the following compounds in a solution at pH 7. ~~(3 points)~~ 2

a)



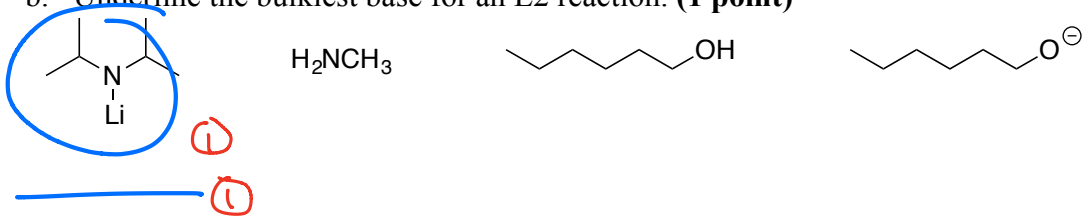
Adrenaline

b)



Naproxen

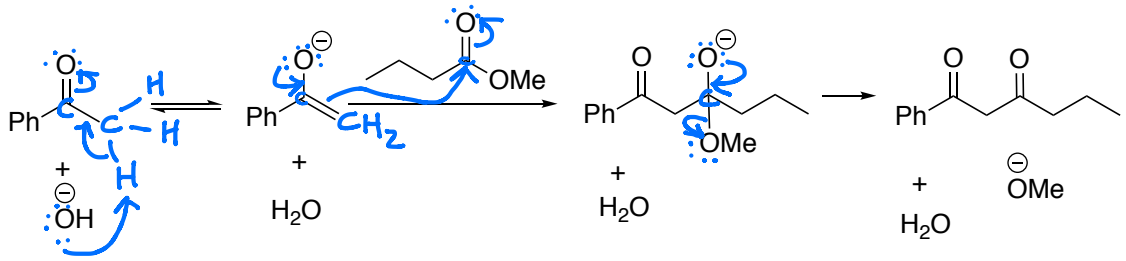
9. For the following compounds:
   a. Circle the strongest base for an E2 reaction. **(1 point)**
   b. Underline the bulkiest base for an E2 reaction. **(1 point)**



10.

a. Expand all the atoms involved in the mechanism below to reveal the implicit atoms (C, H) and electrons. **(2 points)**

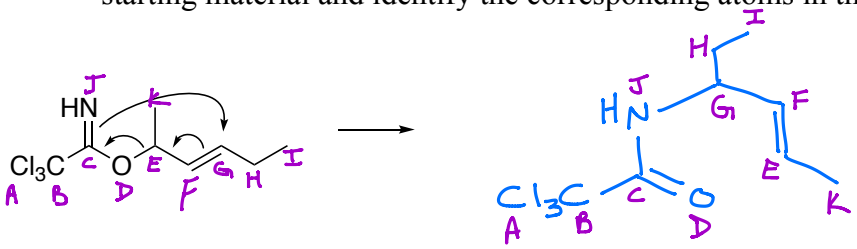
b. Add curved arrows to describe the mechanism for the following. All reagents and intermediates have already been shown. **(8 points)** (1) per arrow



11.

a. Draw the product of the reaction steps shown below. **(3 points)** −1 per error

b. Map all the atoms between starting materials and products (*i.e.*, label the atoms in the starting material and identify the corresponding atoms in the products). **(2 points)**

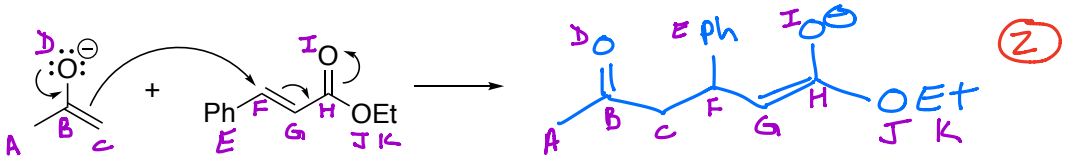


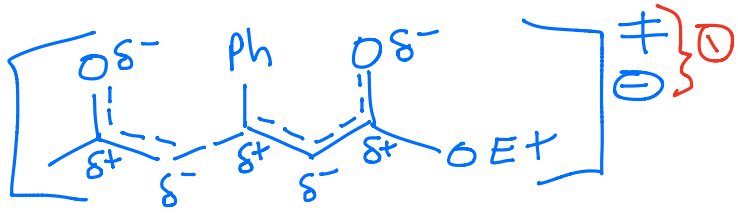
12.

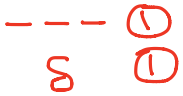
a. Draw the product of the reaction step shown below. **(2 points)**

b. Draw the transition state for that step. **(3 points)**

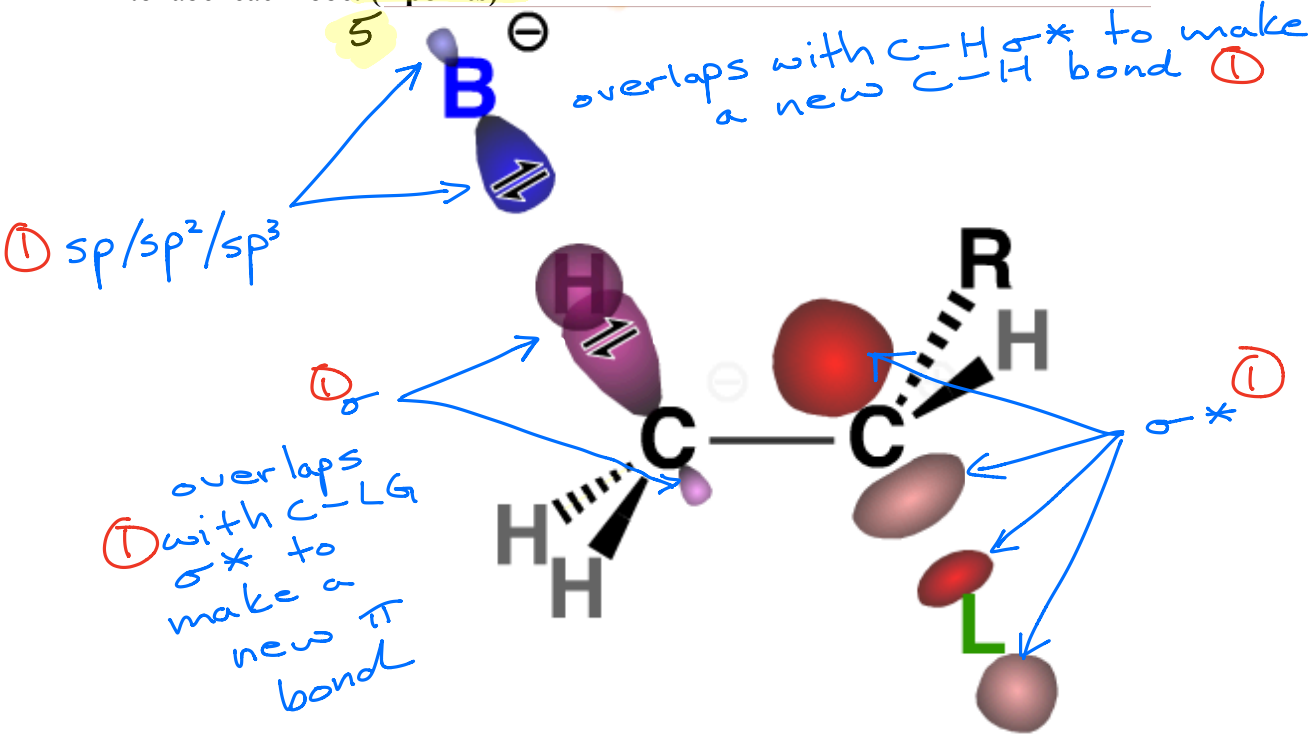
c. Map each of the atoms between starting materials and products (*i.e.*, label the atoms in the starting material and identify the corresponding atoms in the products). **(2 points)**







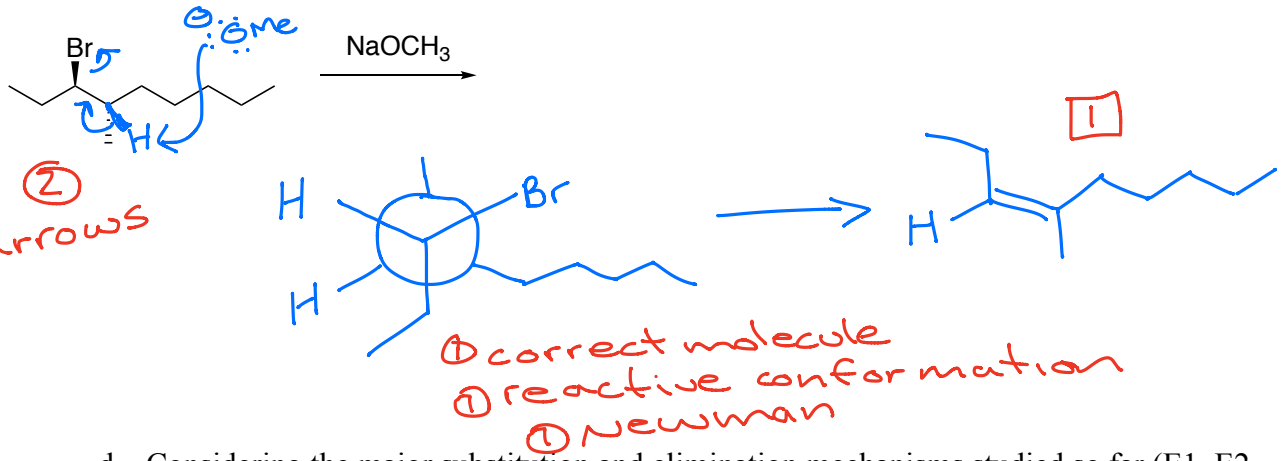
13. The following images represent the orbitals involved in an E2 reaction. Label each orbital and describe how each orbital is involved in the reaction. If an orbital has more than one lobe, be sure to label each lobe. ~~(7 points)~~



○ : arrows, features
□ : structure

14.

a. What is the major mechanism type for the reaction below? **(1 point)** E2
b. Draw the starting material in the Newman structure of its reactive conformation. **(3 points)**
c. Draw the mechanism and the major organic product. **(3 points)**

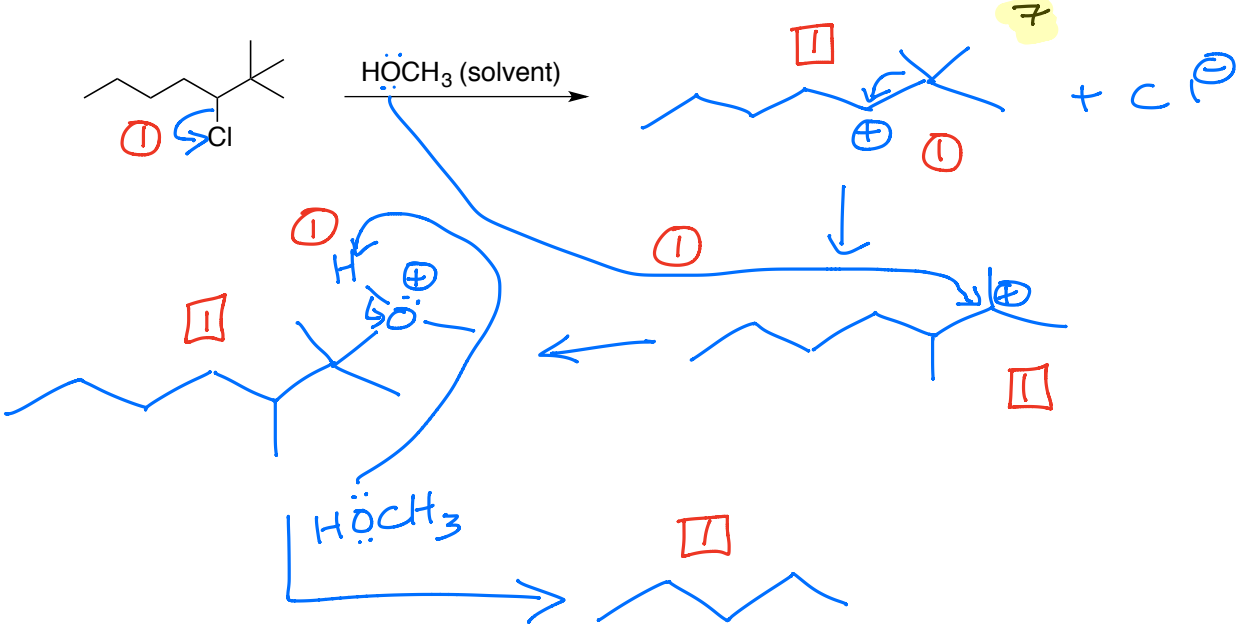


② arrows
① correct molecule
① reactive conformation
① Newman
①

d. Considering the major substitution and elimination mechanisms studied so far (E1, E2, S_N1), justify the choice of mechanism you proposed and include a comparison to a mechanism you did not propose. **(3 points)**

Base is sufficiently strong/reactive ① to react immediately rather than going through a high E carbocation ① intermediate (such as E1 or S_N1). Leaving ① group is good enough (i.e., stable enough when it leaves) for any of the rxns

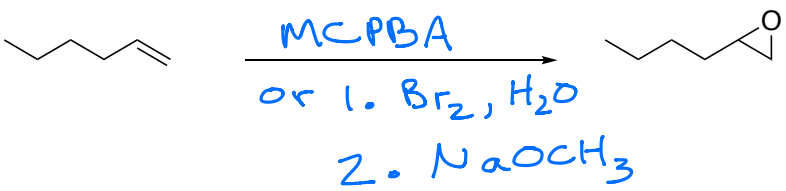
15. Draw the mechanism and substitution product of the reaction below. ~~(6 points)~~ 7



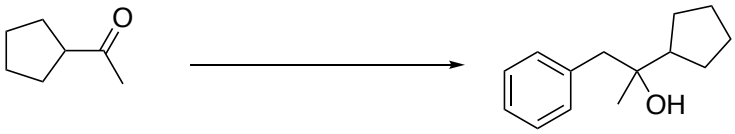
① ① ① ① ① ① ①

16. Add the appropriate reagents to effect the following transformations: **(3 points)**

a.



b.



17.

a. Circle the fixed mindset questions in the following list, even if they are not true for you: **(2 points)**

½ pt each

- My ability in this subject is something I cannot change
- I don't like to ask questions because it shows what I don't know
- I'm not an organic chemistry person
- I feel smart when I don't make mistakes

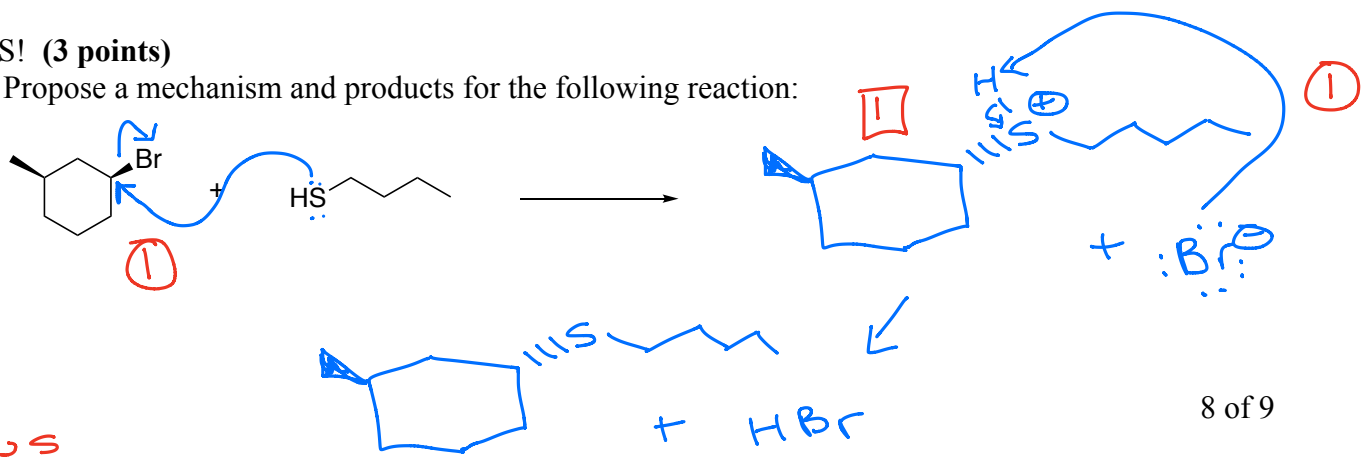
b. Rewrite one of the fixed mindset statements from the list above into a growth mindset statement. (**1 point**)

examples: Mistakes help me learn

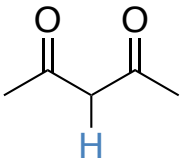
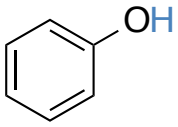
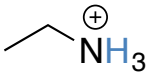
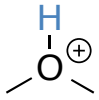
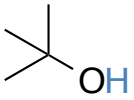
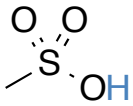
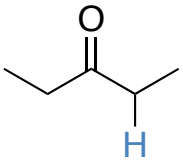
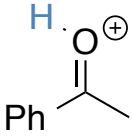
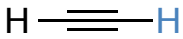
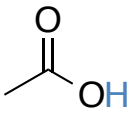
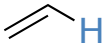
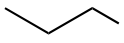
My ability can improve if I seek help and work hard

BONUS! **(3 points)**

Propose a mechanism and products for the following reaction:



O-arrows
□-structure

Acid	pK_a value (H_2O solvent)	Acid	pK_a value (H_2O solvent)
HI	-10		9
H_2SO_4	-3		
HBr	-9		9.9
HNO_3	-1.3		
HCl	-8		10.6
HF	3.17		
		H_2O	15.7
	-3.8		17
	-2.6		20
	-6.2		
			24
H_3O^+	-1.7	H_2	36
$CH_3OH_2^+$	-2.2	NH_3	38
	4.76		50
			51