

CEM 251, Summer 2020  
Final Exam  
Wednesday, 24 June 2020, 6:00 PM  
Online (TopHat) – 2 hours



**Happy  
Summer**



ANN SWERKY

There's no subject compared to chemistry  
how it works is a total mystery  
homework is for my own mastery  
says my professor  
but all I see is my own misery

Anonymous

A question that sometimes drives me hazy:  
Am I or are the others crazy?

Albert Einstein

- 1-15. (75 pts.) \_\_\_\_\_  
16.(35 pts.) \_\_\_\_\_  
17.(30 pts.) \_\_\_\_\_  
18.(30 pts.) \_\_\_\_\_  
19.(30 pts.) \_\_\_\_\_  
20. Extra Credit (5 pts.) \_\_\_\_\_

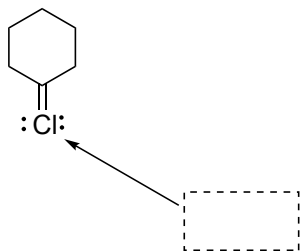
TOTAL(200 pts.) \_\_\_\_\_

Score

Note: Be sure to attempt all questions. You have 2 h to complete this exam.

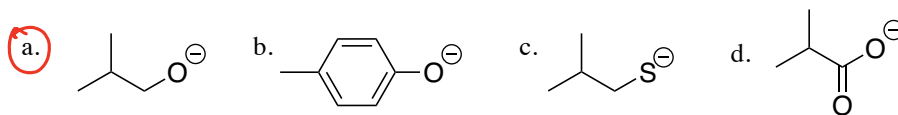
(75 pts) **Multiple choice questions:** 5 pts each for question.

1. (5 pts) What is the formal charge on the atom indicated?

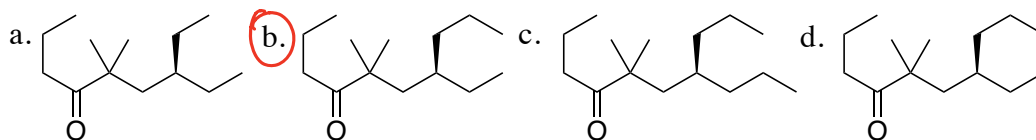


- a. -1      b. 0      **c. +1**      d. +2

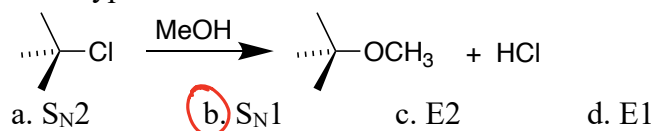
2. (5 pts) Which of the following is the strongest Bronsted-Lowry base (Hint: least stable conjugate base)?



3. (5 pts) Which of the structures below is chiral?

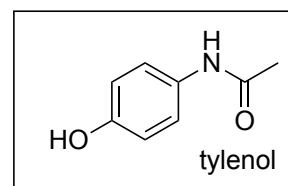


4. (5 pts) What type of reaction is shown below?

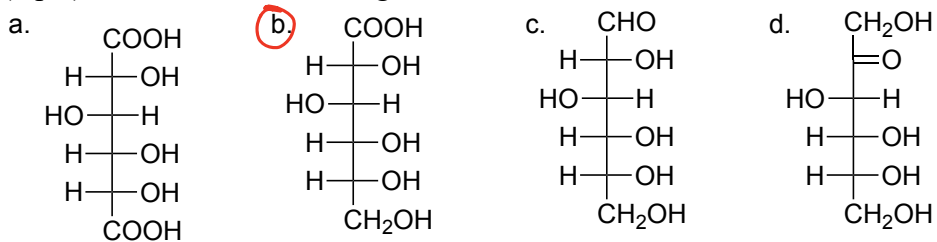


5. (5 pts) How many sp<sup>2</sup> hybridized carbon atoms are there in tylenol, shown at right?

- a. 3      b. 5      **c. 7**      d. 9



6. (5 pts) Which of the following molecules below has the formula  $C_6H_{12}O_7$ ?



D-Glucaric acid

D-Gluconic acid

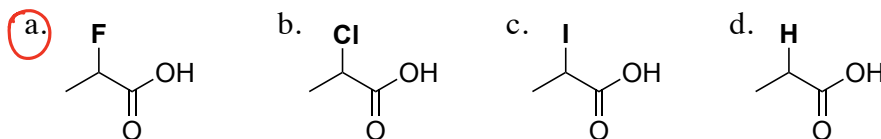
D-Glucose

D-Fructose

7. (5 pts) Which of the following alkylhalides would not undergo  $S_N2$  reaction with methanol?

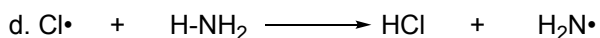
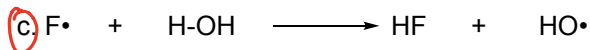
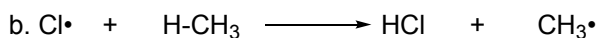
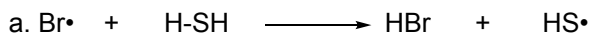
- a. 1-chlorobutane    b. 2-chlorobutane    c. 2-chloro-2-methylpropane    d. 1-chloro-2-methylpropane

8. (5 pts) Which of the carboxylic acid compounds below is the strongest acid?

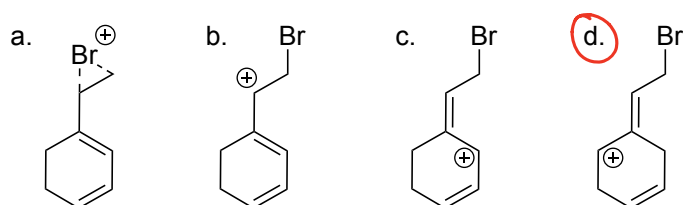
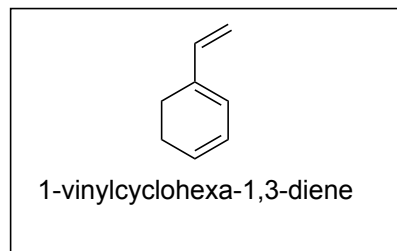


9. (5 pts) From the list of H-X bond dissociation energies (BDEs). Which reaction below is exothermic (i.e. downhill in energy)?

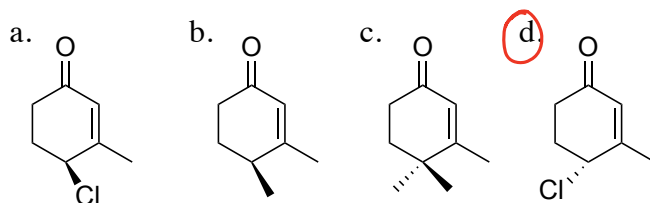
H-X	BDE	H-X	BDE
H-CH <sub>3</sub>	440	H-Cl	432
H-NH <sub>2</sub>	454	H-SH	378
H-OH	499	H-Br	366
H-F	571	H-I	298



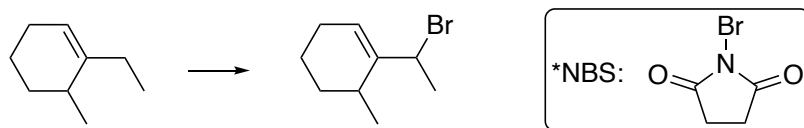
10. (5 pts) Which one of the resonance structures below does *not* represent the cation intermediate formed upon  $\text{Br}_2$  attack on the vinylic group in 1-vinylcyclohexa-1,3-diene?



11. (5 pts) Which of the following compounds has an (*R*) stereocenter?

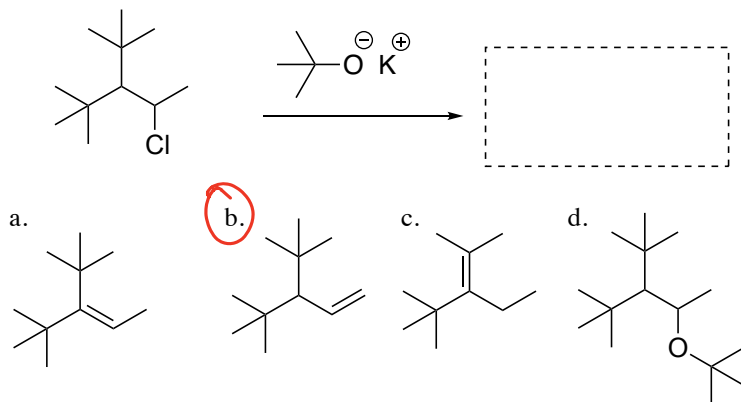


12. (5 pts) What reagent could perform the following transformation:

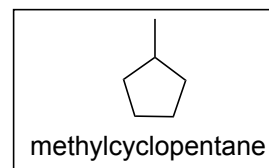


a.  $\text{Br}_2$       b.  $\text{AlBr}_3$       c.  $\text{PBr}_3$       d. N-bromosuccinimide (NBS)\*

13. (5 pts) Following E2 reaction, what would be the product for the reaction below?

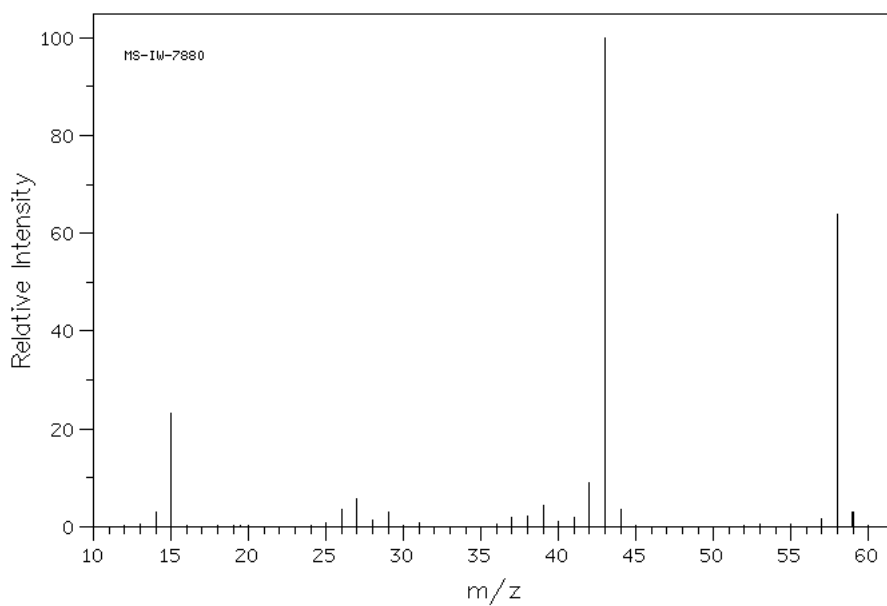


14. (5 pts) How many different signals (peaks) would be expected in a  $^1\text{H-NMR}$  spectrum of methylcyclopentane?



- a. 3      **b. 4**      c. 5      d. 6

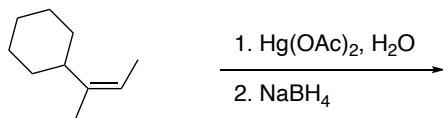
15. (5 pts) Which of the structures below best matches the mass spectrum below?



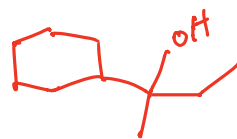
- a. butanol      **b. propanol**      c. ethanol      d. methanol

16. (35 pts) **Simple syntheses:** In the boxes provided, draw the major organic products for each of the following reactions (5 pts each).

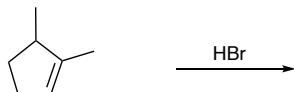
i.



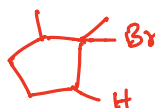
i.



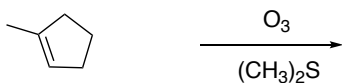
ii.



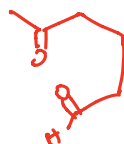
ii.



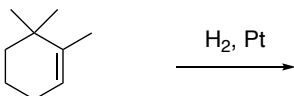
iii.



iii.



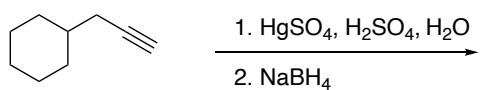
iv.



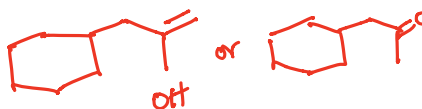
iv.



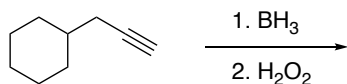
v.



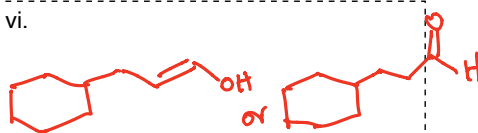
v.



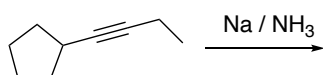
vi.



vi.



vii.

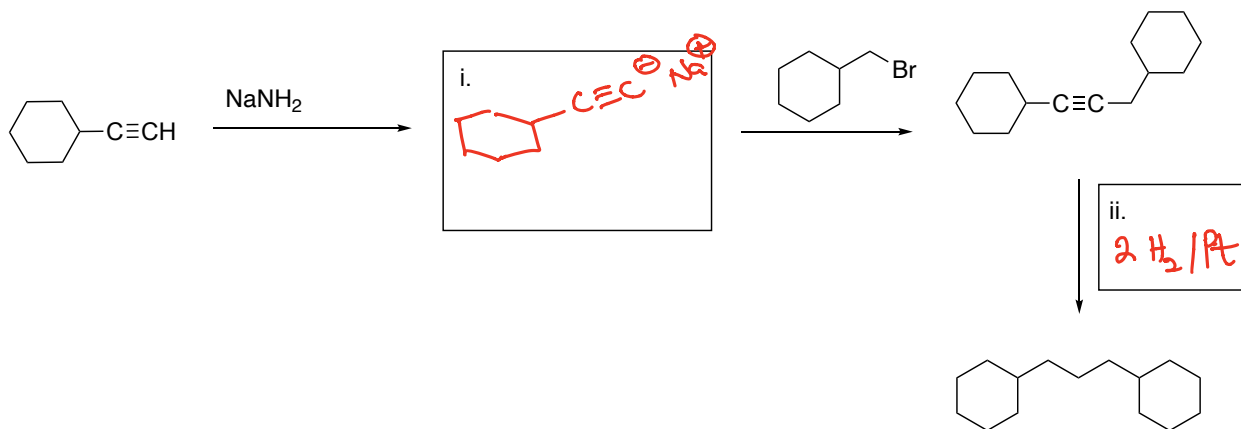


vii.

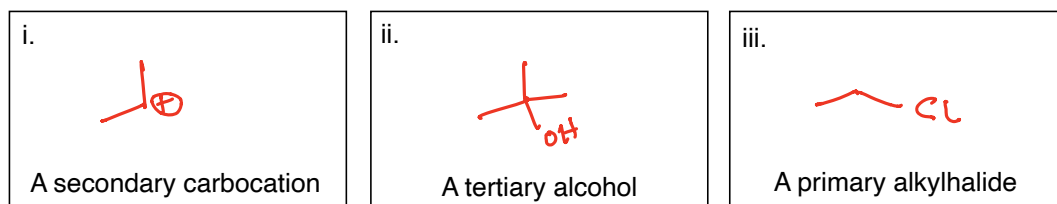


17. (30 pts):

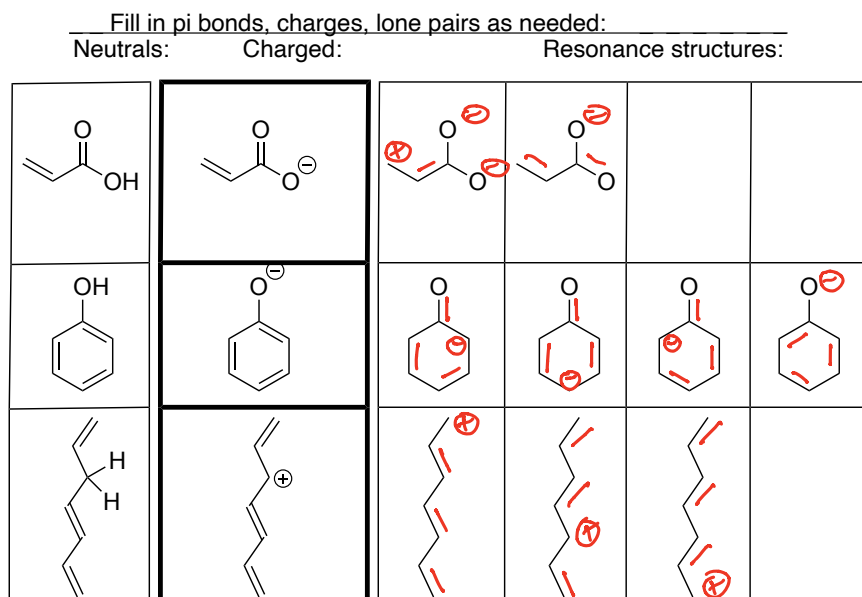
- (a) (6 pts) In the boxes, draw the (i) intermediate (3 pts) in the first step and provide the (ii) reagent(s) (3 pts) in the final step:



- (b) (6 pts) In the boxes, draw simple examples of the requested compound types (2 pts each):

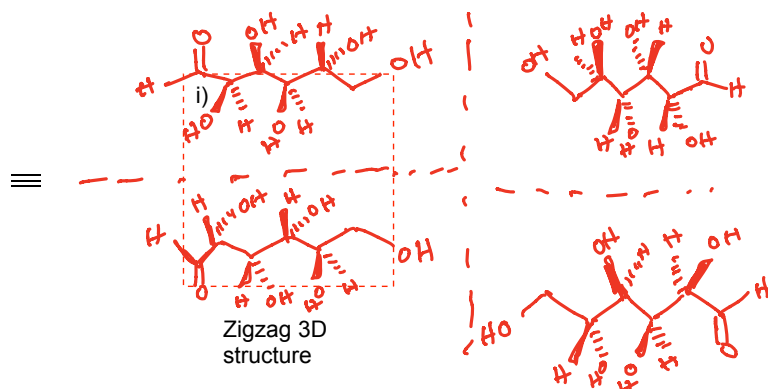
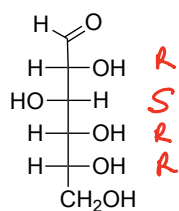


- (c) (16 pts) Consider the structures below and complete the resonance structures (2 pts each) to the right the charged species.

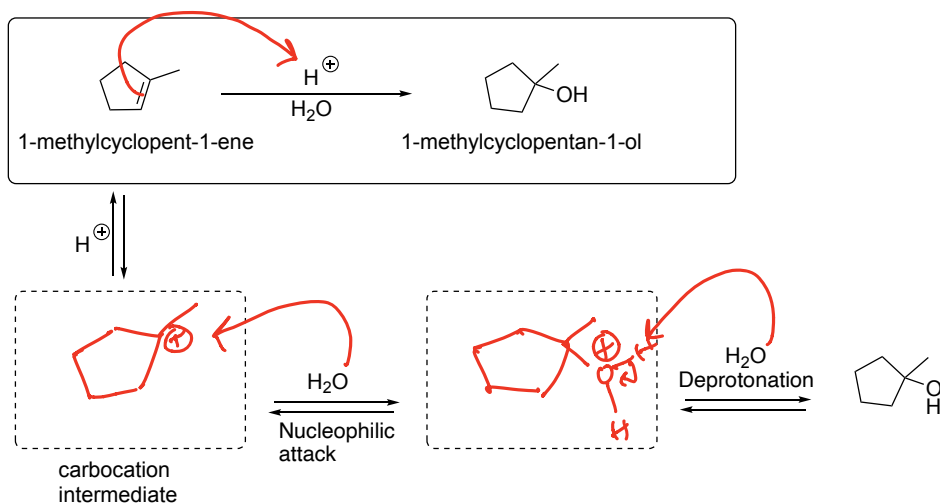


18. (30 pts):

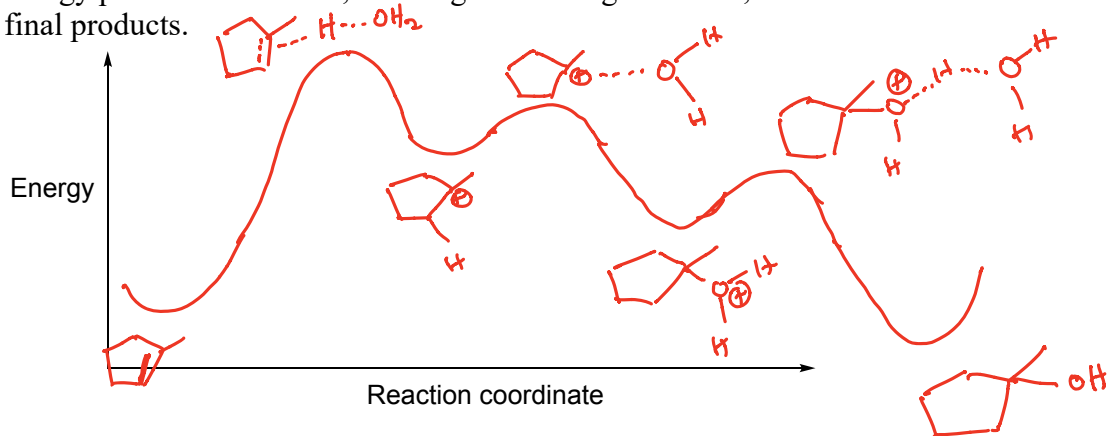
i) (10 pts) Assign R and S to all the chiral centers (8 pts) in the structure below and convert it to the zigzag 3D form (2-points).



ii) (10 pts) Draw the intermediates (3 pts each) in the dotted boxes below and arrows (1pt each) to show the mechanism acid-catalyzed hydration. (Redraw all structures in your answer sheet)



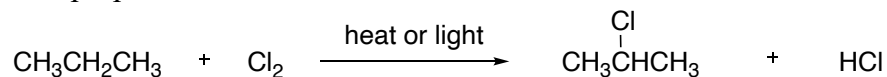
iii) (10 pts) The acid catalyzed reaction above is an exothermic reaction. Draw an energy plot of the reaction, showing the starting materials, transition states and the final products.





19. (30 pts):

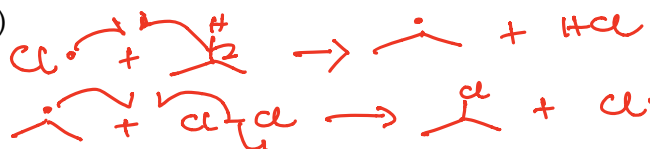
a) (12 pts) Give the mechanism of the radical chlorination of propane to give 2-chloropropane.



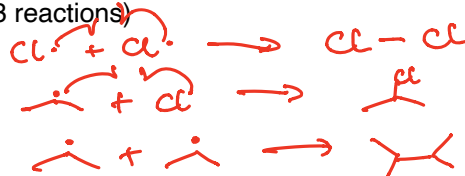
i. (2 pts) Initiation (1 reaction)



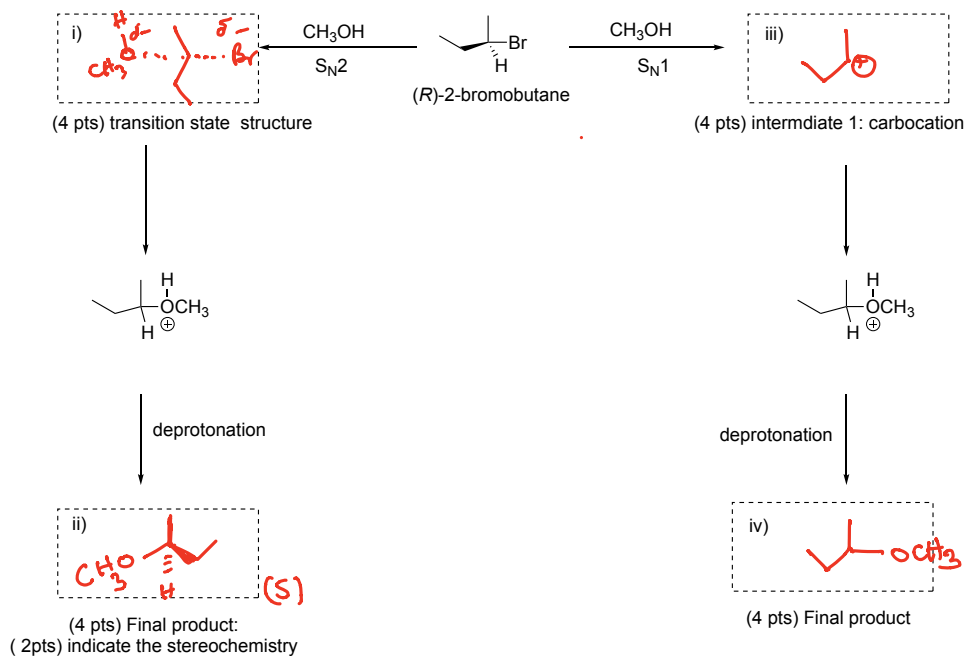
ii. (4 pts) Propagation (2 reactions)



iii. (6 pts) Termination (3 reactions)



b) (18 pts) Draw the intermediates, transition state and the final products of the  $\text{S}_{\text{N}}1$  and  $\text{S}_{\text{N}}2$  pathways below. Be sure to indicate the stereochemistry of the  $\text{S}_{\text{N}}2$  final product.



20. (5 pts. extra credit)

Write a poem (rhyme) about something chemical that we've learned in this class. The poem must have not less that 5 lines.

