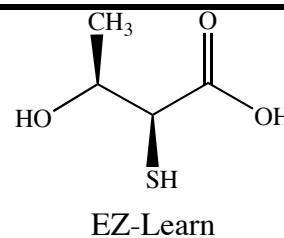
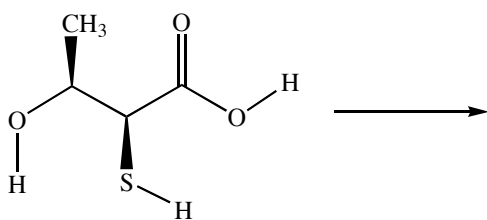


Behold EZ-Learn, a fictional pharmaceutical shown to be 110% effective in giving organic chemistry students a photographic memory. Most of the questions on this exam refer to this molecule.

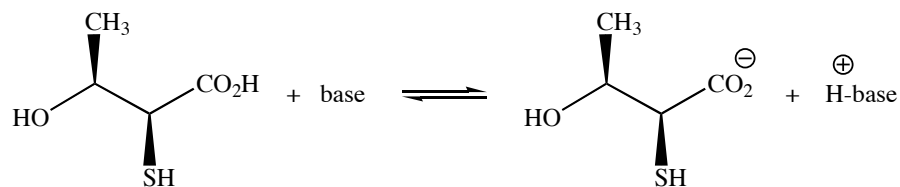


- (2 points) Circle the correct order of acidity for these functional groups of EZ-Learn.
  - ROH < RSH < RCO<sub>2</sub>H
  - ROH < RCO<sub>2</sub>H < RSH
  - RSH < ROH < RCO<sub>2</sub>H
  - RSH < RCO<sub>2</sub>H < ROH
  - RCO<sub>2</sub>H < RSH < ROH
  - RCO<sub>2</sub>H < ROH < RSH
- (8 points) Briefly explain your answer to the previous question.

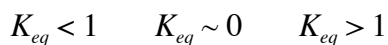
- (1 point) Circle the functional group with the lowest pK<sub>a</sub>: ROH RSH RCO<sub>2</sub>H
- (4 points) Using ammonia as the base, write a mechanism for the deprotonation of the EZ-Learn functional group with the lowest pK<sub>a</sub>. Clearly label the nucleophile and electrophile.



- (2 points) Consider this equilibrium:



The pK<sub>a</sub> of a carboxylic acid is ~ 5 and the pK<sub>a</sub> of <sup>+</sup>H-Base is ~ 10, so what can we conclude about the position of the equilibrium (circle one)?



6. (2 points) By adding, subtracting or otherwise changing at most two atoms, redraw the structure of EZ-Learn so it is obviously more acidic.

7. (5 points) Short answer: Finish each statement in ten words or less.

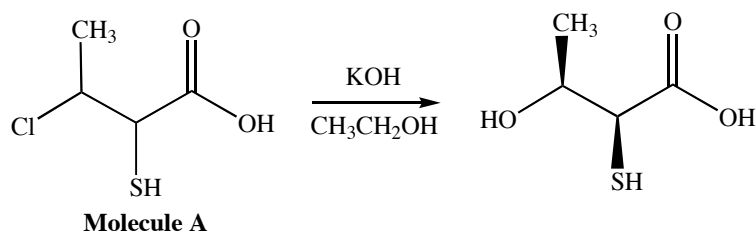
(a) The name or structure of an important ion or molecule whose  $pK_a$  is  $-1.7$  is....

(b) Water is a poorer base than ammonia because....

(c) Water is a poorer base than hydroxide ion because...

8. (2 points) Circle the weakest base:  $\text{CH}_3\text{CH}_2\text{NH}_2$     $(\text{CH}_3\text{CH}_2)_3\text{N}$     $\text{CF}_3\text{CH}_2\text{NH}_2$

Questions 9-21 (pages 2-4) refer to this  $\text{S}_{\text{N}}2$  reaction that might be used in the synthesis of EZ-Learn:



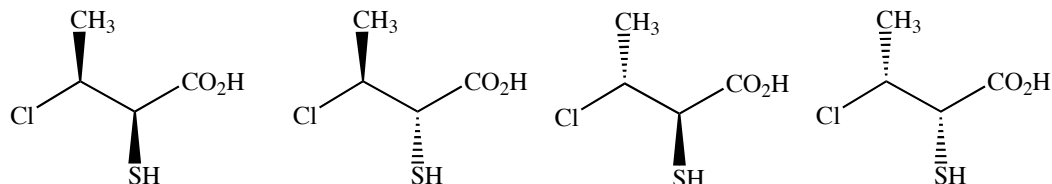
9. (4 points) Write the  $\text{S}_{\text{N}}2$  mechanism for this reaction. Include all transition states.

10. (4 points) Short answer: Complete each statement in ten words or less.

(a) Along the reaction coordinate for any mechanism step, the transition state has the highest....

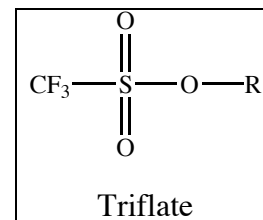
(b) This is because...

11. (2 points) Circle the stereoisomer of molecule A necessary to produce EZ-Learn.



12. (2 points) If the R-Cl portion of molecule A is changed to triflate the  $S_N2$  reaction rate is (circle one):

Increased    Decreases    Almost unchanged



13. (6 points) Give two concise but specific reasons for your answer to the previous question.

Reason #1:

Reason #2:

14. (2 points) If KOH is changed to water the reaction rate (circle one):

Increases    Decreases    Does not change much

15. (2 points) Draw the molecular structure of DMF. Include all lone pairs.

16. (2 points) If  $\text{CH}_3\text{CH}_2\text{OH}$  is changed to DMF the reaction rate (circle one):

Increases    Decreases    Does not change much

17. (6 points) Give two concise but specific reasons for your answer to the previous question.

Reason #1:

Reason #2:

18. (4 points) By adding, subtracting or otherwise changing at most four atoms, redraw the structure of molecule A so that it is a primary alkyl chloride.

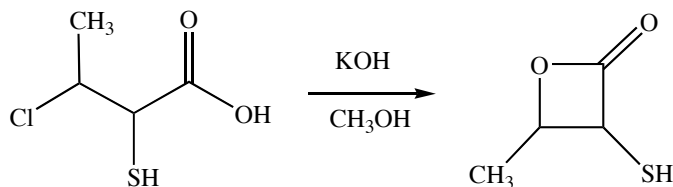
Circle the correct statement about the  $S_N2$  reaction rates of your primary chloride versus molecule A.

Molecule A <  $1^\circ$  chloride    Rates about equal    Molecule A >  $1^\circ$  chloride

19. (4 points) By adding, subtracting or otherwise changing at most four atoms, redraw the structure of molecule A so that it cannot undergo an  $S_N2$  reaction.

Finish this statement in ten words or less: The modified molecule A cannot undergo an  $S_N2$  reaction because....

Here is a possible side reaction that might occur when molecule A is treated with KOH:



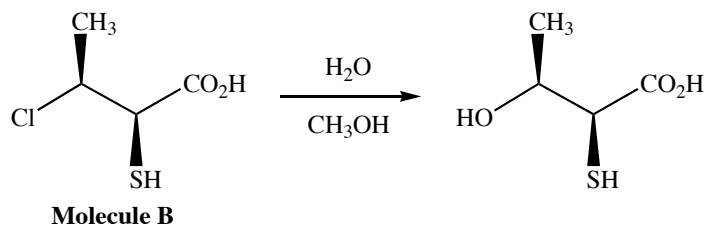
20. (4 points) Write the most reasonable mechanism for this reaction. Do not include any transition states.

21. (6 points) Give two factors that disfavor this side reaction from occurring.

Factor #1:

Factor #2:

Questions 22-25 on this page refer to this  $S_N1$  reaction:



22. (7 points) Write a complete  $S_N1$  mechanism for this reaction. Label the rate-determining step as “rds” but do not include any transition states.
23. (6 points) Give two significant and different reasons why this reaction probably does not occur by the  $S_N2$  mechanism.
- Reason #1:
- Reason #2:
24. (3 points) Give one additional  $S_N1$  product not shown that might be expected to occur in this reaction.
25. (2 points) By adding, subtracting or otherwise changing at most four atoms, redraw the structure of molecule B so its  $S_N1$  reaction is obviously faster.

26. (2 points) Draw the structure of a carbocation that has exactly two carbons (and any other atoms that you want) but is more stable than a primary carbocation.
27. (2 points) Write the mathematical equation that relates reaction rate and energy of activation.
28. (4 points) Hard question! Circle the better nucleophile in DMF: LiOH CsOH  
Briefly explain your reasoning. (Think carefully! Right answer with wrong reasoning will not earn any credit.)