For any question on this exam worth three or more points, you have two choices: answer the question as written or you may write and circle the phrase "one point". If you write "one point" you will receive one point (and only one point) of credit for the question. "One point" overrides anything you have written for that question, regardless of its accuracy.

Example: (10) Briefly explain everything about organic chemistry. One point

1. (2) Circle the letter of the answer that best completes this sentence: In an S_N2 reaction, if the carbon that bears the leaving group has *R* configuration, then in the product the configuration of this same carbon ... (circle one):

   (a) ...is always *S* (b) ...is mostly *S*, rarely *R* (c) ...is sometimes *S* and sometimes *R*

   (d) ...is mostly *R*, rarely *S* (e) ...is always *R* (f) ...cannot be determined.

2. (2) The principle cause(s) of inversion in an S_N2 reaction are (circle all that apply):

   (a) steric hindrance (b) tetrahedral carbon (c) σ* orbital

   (d) *p* orbital (e) a good nucleophile (e) none of these

3. (2) The principle cause(s) of inversion in an S_N1 reaction are (circle all that apply):

   (a) steric hindrance (b) tetrahedral carbon (c) σ* orbital

   (d) *p* orbital (e) a good nucleophile (e) none of these

4. (3) DMF is (circle all that apply):

   Polar Nonpolar Protic Aprotic An ether An alcohol An amide

5. (2) Circle the best nucleophile in DMF: $CH_3CH_2O^-$ $CH_3CH_2S^-$ $CF_3CH_2O^-$ CF_3CH_2OH

6. (2) Circle the best leaving group: CH_3S^- CF_3S^- CCl_3S^- $CF_3SO_3^-$

7. (2) Using the best leaving group from the previous question, illustrate the formation of a carbocation that is 3^o with resonance. Include the appropriate curved arrows.

8. (8) Consider the effect of changing each of the following reaction aspects on the rate of ***any*** S_N2 or S_N1 reaction, when all other reaction aspects remain the same. Write one of the following in each blank: increases, decreases, no change, or cannot determine from information given.

   (a) When reaction temperature is increased, the reaction rate _____.

   (b) When [nucleophile] is increased, the reaction rate _____.

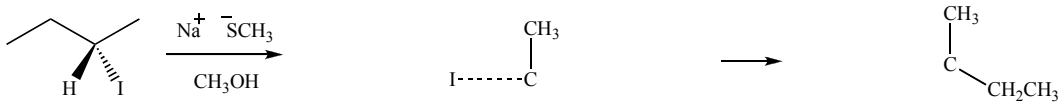
   (c) When energy of activation for one mechanism step is increased, the reaction rate _____.

   (d) When solvent ε is increased, the reaction rate _____.

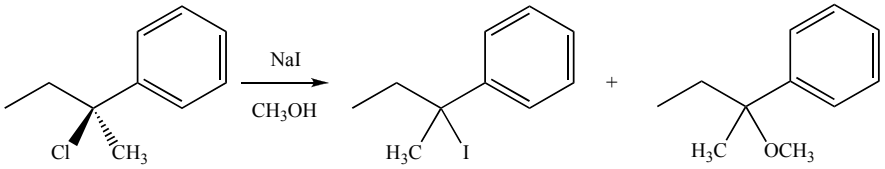
9. (2) Assign the following ε values to the solvents shown below: 25, 20, and 11.

   CH_3CH_2OH ε = _____ $(CH_3)_3COH$ ε = _____ $CH_3CH_2CH_2OH$ ε = _____

10. (8) Complete the following S_N2 reaction mechanism by adding curved arrows, and completing the partial structures.



Questions 11-15 refer to this reaction:



Product **A** Product **B**

11. (2) Circle the major product of this reaction: **A** **B**

12. (4) Write two more reasonable (but not necessarily major) products of this reaction.

13. (2) Which of the following species is present in the reaction and the best nucleophile? Circle one:

I^- Cl^- Na^+ CH_3OH CH_3O^-

14. (4) Circle 'poor' or 'good', then complete the statement ***using fifteen words or less***: The principle reason why iodide ion is a poor / good nucleophile is...

15. (4) Circle 'S_N2' or 'S_N1', then complete the statement in ***fifteen words or less***: The principle reason why this reaction occurs by the S_N2 / S_N1 mechanism is...

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16. (2) Circle the letter of the slowest S_N2 reaction.

(a) CH_3I and NaF in DMF (c) CH_3I and NaCl in DMF

(b) CH_3I and NaF in CH_3OH (d) CH_3I and NaCl in CH_3OH

17. (4) Circle the letter of the slowest S_N1 reaction, the write the product of this slowest reaction in the space below.

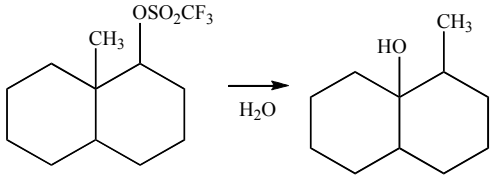
(a) $(CH_3)_3C–I$ and NaF in H_2O (c) $(CH_3)_3C–Cl$ and NaF in CH_3OH

(b) $(CH_3)_3C–I$ and NaCl in H_2O (d) $(CH_3)_3C–Cl$ and NaCl in CH_3CH_2OH

Product of slowest reaction:

18. (3) Draw the most stable carbocation you can that consists of exactly four carbons, any number of hydrogens, and no additional elements.

Questions 19 and 20 refer to this reaction:



19. (10) Write the mechanism for the reaction shown above. Unambiguously label each step that involves a carbocation with the name of the carbocation fate it illustrates. If no carbocations are involved, then no labels are necessary.

20. (4) Using any structure drawn in the reaction mechanism in the previous question, illustrate all carbocation fates *not included* in the mechanism. Include the corresponding curved arrows in this illustration.

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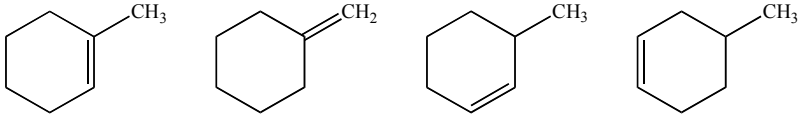
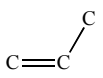
21. (2) Circle the most stable alkene:

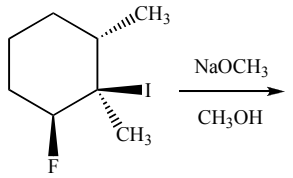


22. (2) Complete this drawing to make an alkene that has both cis and *E* configuration. Your answer can have no atoms with nonzero formal charges, no more than four carbon atoms, but you may use any number of atoms of any other elements. If this is not possible, write "not possible".

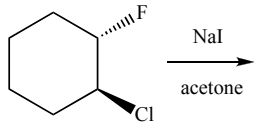


23. (6) Write a *realistic* example of an E2 reaction, including all reactants, products, and mechanism. The example may not include any halogen atoms, and must clearly illustrate Zaitsev's Rule. Transition states do not have to be included.

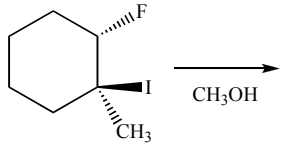
24. (16) For each reaction circle the most likely mechanism, then write the major reaction product in the box. If two or more products are formed in roughly equal amounts, draw all the products.

(a) 

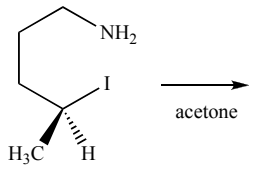
S_N2 S_N1 E2

(b) 

S_N2 S_N1 E2

(c) 

S_N2 S_N1 E2

(d) 

S_N2 S_N1 E2

25. (2) Provide concise yet precise definition for 'leaving group':