CHEMISTRY 313-01

MIDTERM # 3 – answer key

November 17, 2005

Statistics:

- Average: **77 pts (77%)**;
- Highest: **99 pts (99%)**; Lowest: **37 pts (37%)**
- Number of students performing at or above average: **26 (57%)**
- Number of students performing at or below 55%: **3 (7%)**

1. (7 pts) Mark as true (**T**) or false (**F**) the following statements. Do not explain!
   - (**F**) Chiral molecules have only one internal mirror plane of symmetry;
   - (**F**) Enantiomers are superimposable mirror images;
   - (**F**) Diastereomers are non-superimposable mirror images;
   - (**F**) A molecule without a chirality center can never be chiral;
   - (**F**) A molecule with *n* chirality centers has *n* enantiomers;
   - (**T**) S_N2 reactions are stereospecific;
   - (**T**) S_N2 reactions are accelerated by polar aprotic solvents;

2. Circle ALL that apply:
   A. (3 pts) The specific rotation [α] will be zero in the case of:
      a. Racemic mixture;
      b. Any compound without chirality centers;
      c. Achiral compound;
      d. Any compound with one or more internal mirror planes of symmetry;

   B. (3 pts) The following reactions are stereospecific:
      a. Bromination of alkenes;
      b. S_N2 reactions;
      c. Hydroboration-Oxidation of alkenes;
      d. Acid-catalyzed hydration of alkenes;

   C. (3 pts) Circle the impossible combinations:
      a. A chiral molecule without a chirality center;
      b. An achiral molecule with one chirality center;
      c. An achiral molecule with two chirality centers;
      d. A chiral molecule with a superimposable mirror image;

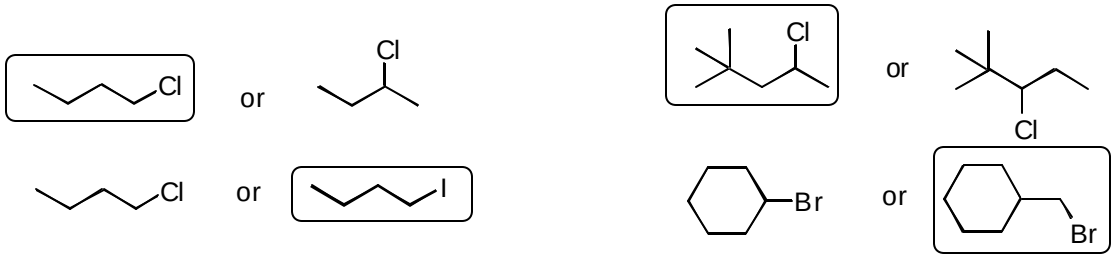
   D. (3 pts) Circle the correct statements about the S_N2 mechanism:
      a. Concerted;
      b. Reactions are fastest with tertiary substrates;
      c. Has a bimolecular rate-determining step;
      d. Is accelerated by polar protic solvents;

3. (3 pts) Assuming that each of the following processes occur by an S_N2 displacement, choose the faster reaction in each case.
   A. Reaction of a cyanide anion with 1-iodoheptane or 1-chloroheptane;

   B. Reaction of 1-bromobutane with ethanol or sodium ethoxide;

   C. Reaction of azide anion with butyl tosylate or *sec*-butyl tosylate;

4. (4 pts) In each of the following pairs, indicate the substrate with higher reactivity in S_N2 reactions. Do not explain!



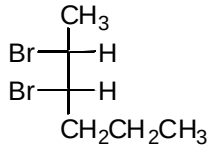
5. (6 pts) For each of the following pairs, indicate the stronger nucleophile. Do not explain!

$\boxed{^-NH_2}$ or NH_3 $\quad$ H_2O or $\boxed{CH_3COO^-}$ $\quad$ BF_3 or $\boxed{F^-}$

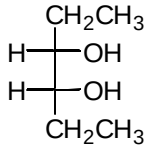
$\boxed{(CH_3)_3P}$ or $(CH_3)_3N$ $\quad$ $\boxed{I^-}$ or Cl^- $\quad$ $\boxed{CH_3SH}$ or CH_3OH

6. (8 pts) Draw an acceptable three-dimensional representation (i.e. *Fischer* projection or bald-and-dashed-wedge structure) for each of the following molecules.

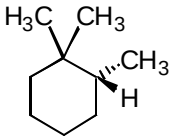
A. *(2R,3S)*-2,3-dibromohexane.



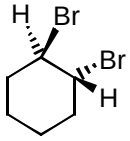
B. *meso*-3,4-hexanediol.



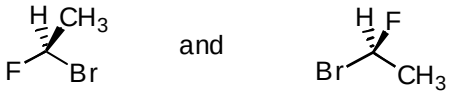
C. *(R)*-1,1,2-trimethylcyclohexane;



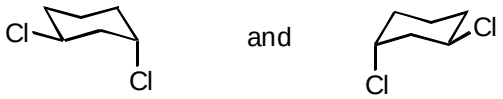
D. *(1R,2R)*-1,2-dibromocyclohexane.



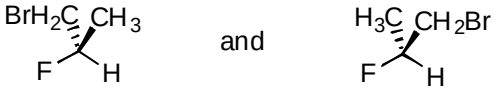
7. (14 pts) For each of the following pairs, indicate the relationship between the compounds (i.e. identical, structural isomers, enantiomers, or diastereomers). Do not explain!



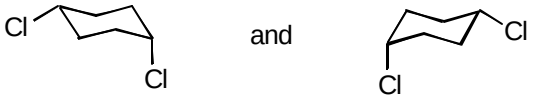
identical



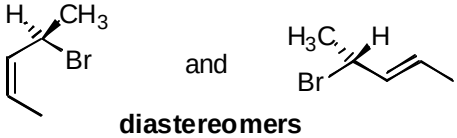
enantiomers



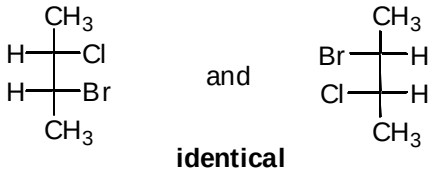
enantiomers



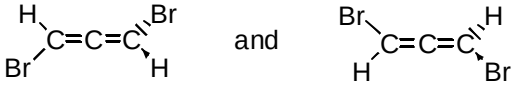
identical



diastereomers

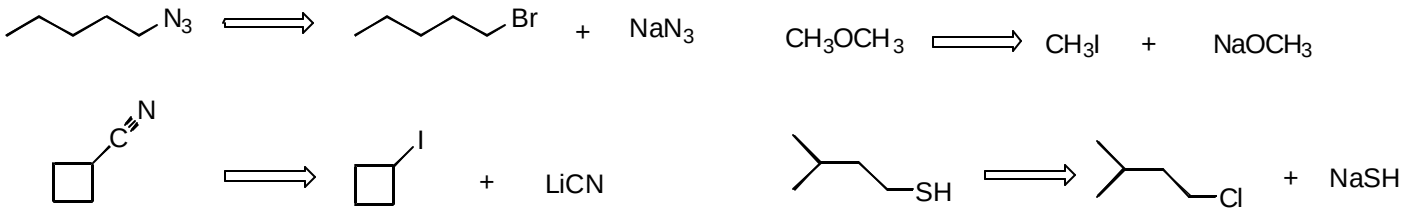


identical



identical

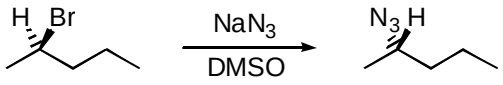
8. (8 pts) Suppose you wished to make each of the following compounds by an SN2 reaction. Identify the alkyl halide and the nucleophile you would need.



9. (4 pts) The reaction of 2-bromopentane with sodium azide (NaN_3) in DMSO was studied in order to establish if it takes place *via* S_N2 mechanism. The following experiments were performed. For each one of them, predict the observed results if the reaction occurs following S_N2 mechanism.

A. Pure (R)-2-bromopentane was used as a substrate;

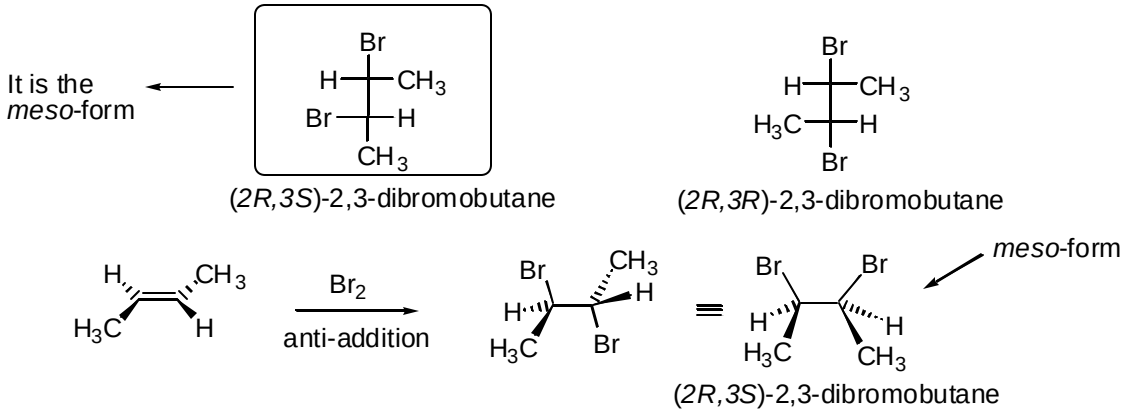
Answer: S_N2 reactions occur with inversion of configuration. Therefore the product will be (S)-2-azidopentane



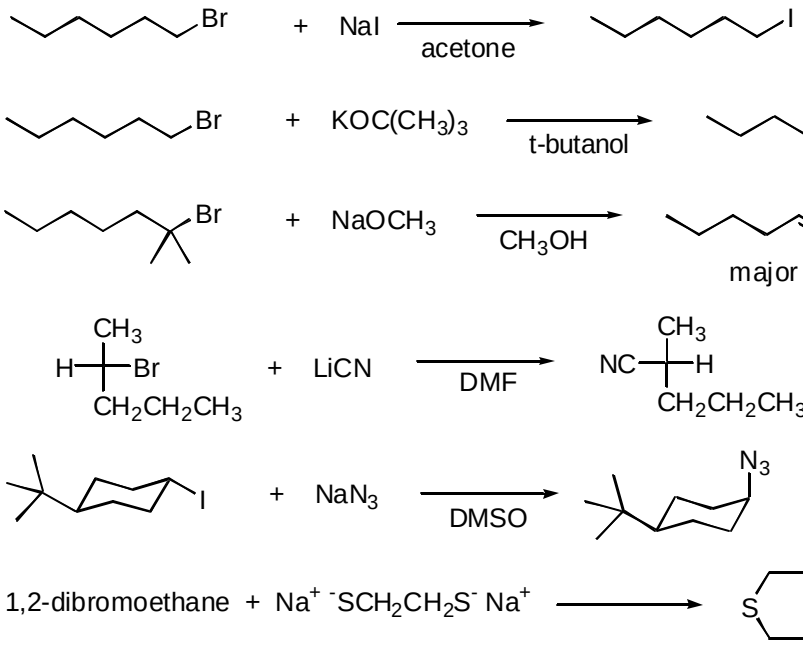
B. Ethanol was used as a solvent, instead of DMSO;

Answer: Polar protic solvents affect adversely S_N2 processes. The reaction will therefore occur at a lower rate.

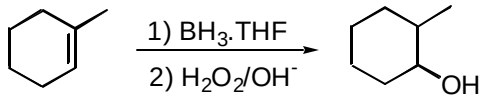
10. (4 pts) The two *Fischer* projections below correspond to two stereoisomers of 2,3-dibromobutane. Circle the structure that is formed by addition of Br_2 to *trans*-2-butene. Offer brief structural rationalization for your answer.



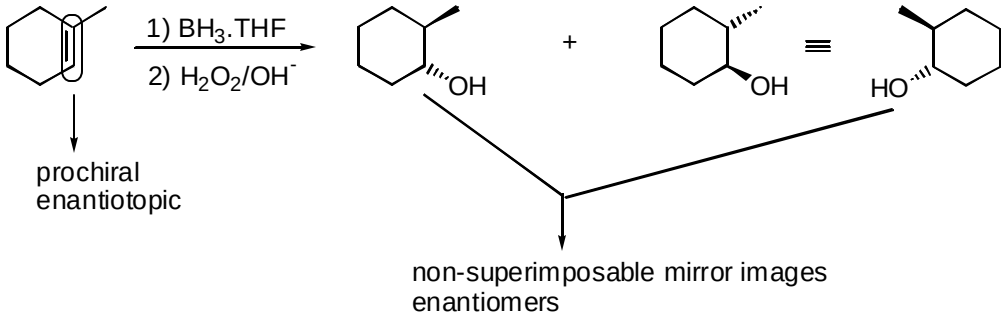
11. (12 pts) Predict the principal organic product in each of the following reactions. If a mixture is formed, indicate the expected major product. Indicate explicitly stereochemistry/regiochemistry, wherever applicable.



12. (2 pts) For the reaction below, identify the prochiral atom or functional group and label it as enantiotopic or diastereotopic.

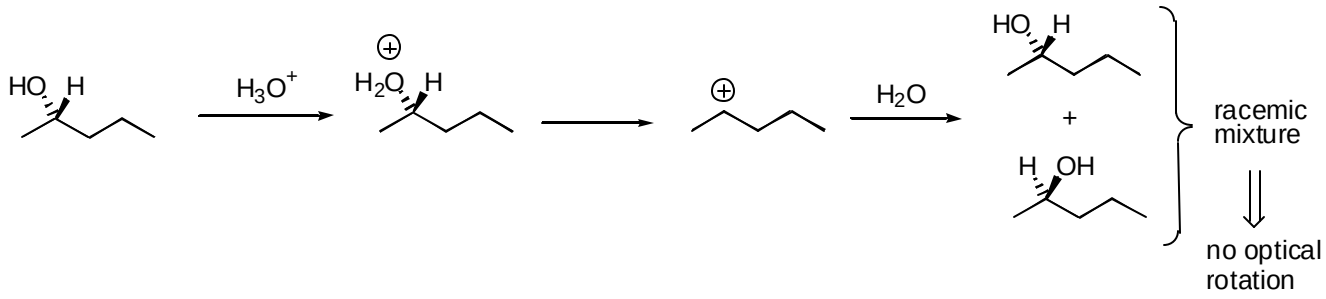


Hydroboration - oxidation is a stereospcific, syn-addition process. In the present case it will lead to the generation of a pair of enentiomers.

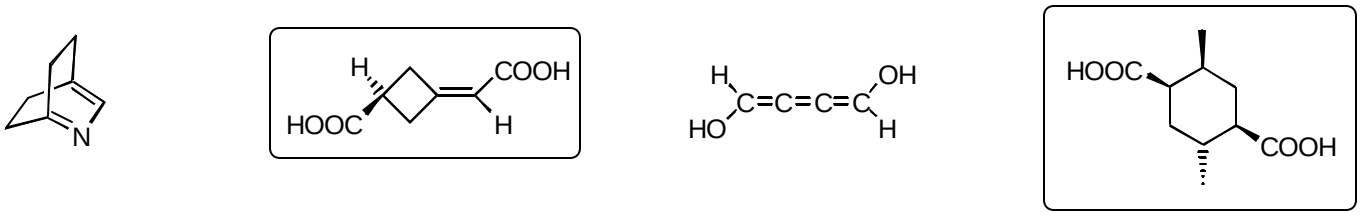


13. (4 pts) When allowed to stand in the presence of small amounts of dilute aqueous acid, pure (S)-2-butanol slowly loses its optical activity. Propose a mechanism to account for this fact.

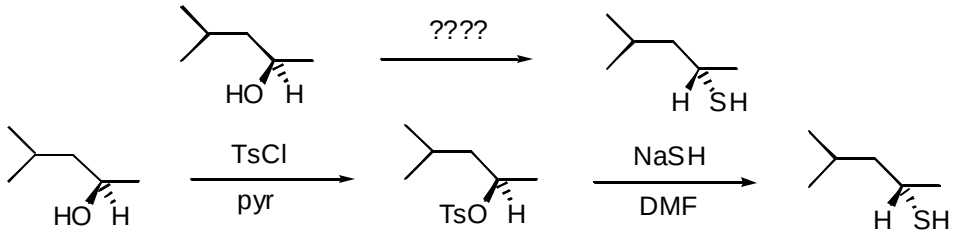
An alcohol, in the presence of acid, will be protonated and form a carbocation. The carbocation presents a planar (achiral) environment and subsequent addition of water will lead to the generation of a racemic mixture.



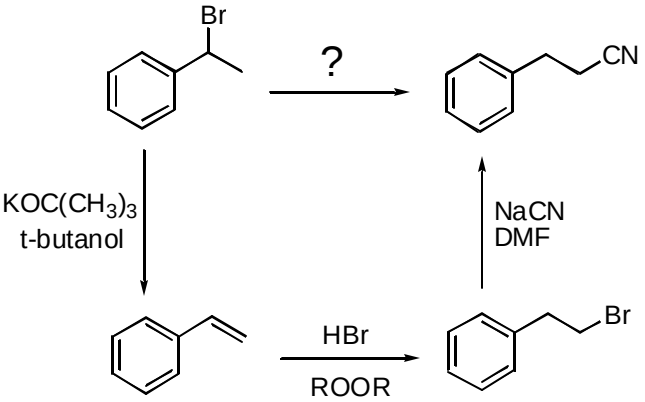
14. (4 pts) Circle the chiral molecules among the structures below. Do not explain!



15. (4 pts) Propose a synthetic sequence to accomplish the following transformation.

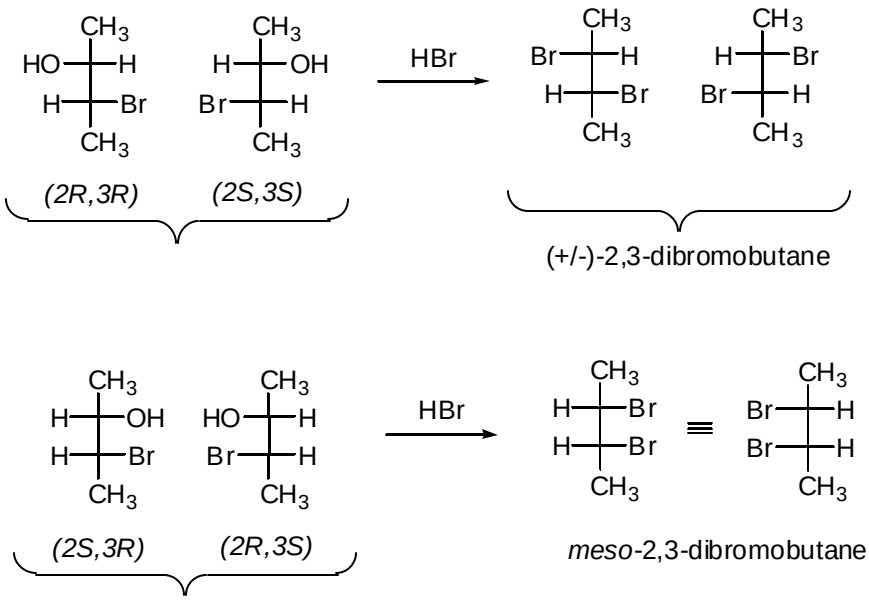


16. (4 pts) Outline a plausible synthetic sequence for the following transformation:



17. (3 pts) **BONUS PROBLEM (In order to receive credit for this problem, it has to be solved entirely!!).** On treatment with HBr, a racemic mixture of *(2R,3R)*-3-bromo-2-butanol and its enantiomer is converted to *(+/-)*-2,3-dibromobutane. In the same conditions, the racemic mixture of *(2S,3R)*-3-bromo-2-butanol and its enantiomer is converted to *meso*-2,3-dibromobutane.

A. Provide the Fischer projections for the starting materials and products.



B. Do the reactions occur with inversion or retention of configuration at the chiral center?

RETENTION