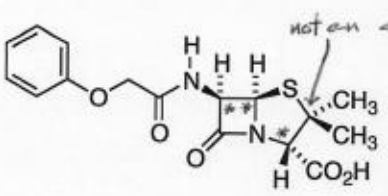
Name: Solutions

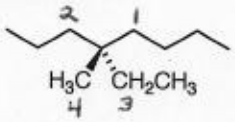
1. Indicate in the box how many asymmetric carbon atoms are present in the structure of penicillin V. [3 pts]

penicillin V

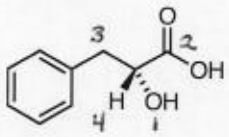



# of asymmetric carbon atoms = 3

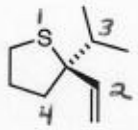
2. Indicate the stereochemical configuration, (*R*) or (*S*), for each of the following compounds in the boxes provided. [9 pts; 3 pts each]




R

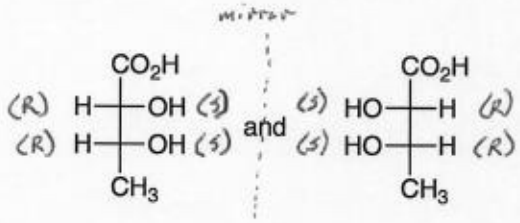



R

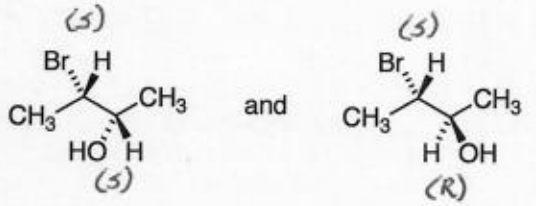



S

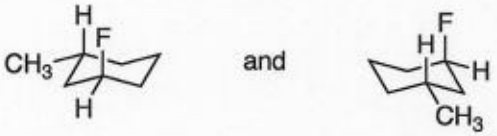
3. For each pair of stereoisomers indicate whether the two structures are identical, enantiomers or diastereomers. [12 pts; 3 pts each]



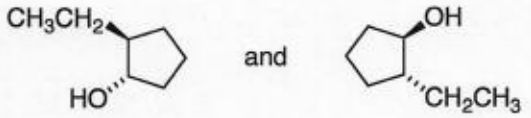

structures are enantiomers




structures are diastereomers

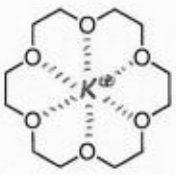



structures are identical




structures are enantiomers

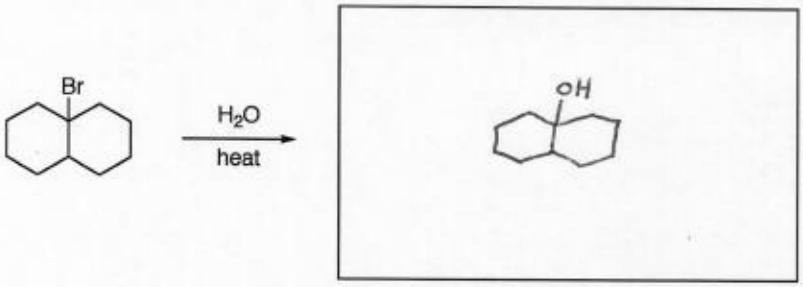
4. Crown ethers often are added to reactions to help solubilize inorganic salts in organic solvents. Crown ethers bind alkali cations selectively based on size. Circle the salt that 18-crown-6 will bind to with the highest affinity. [3 pts]

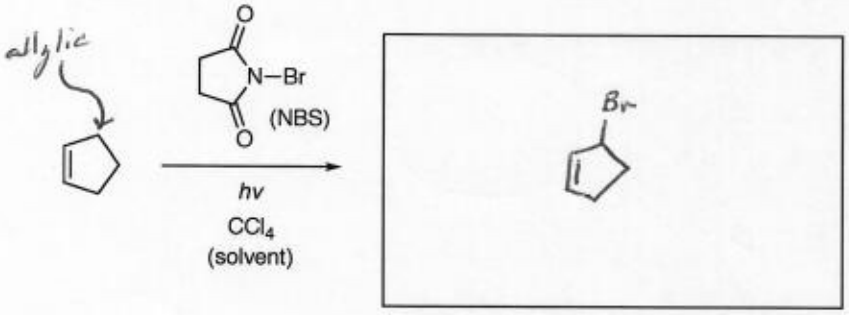


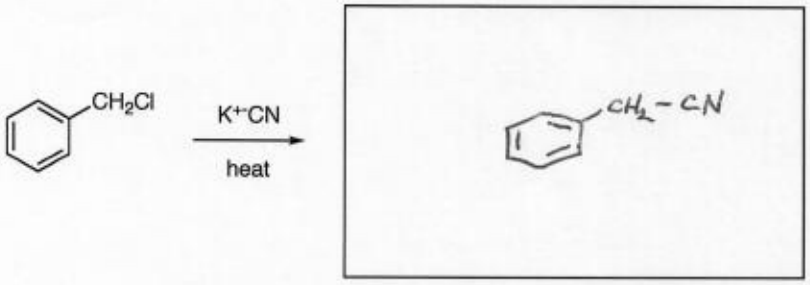

18-crown-6

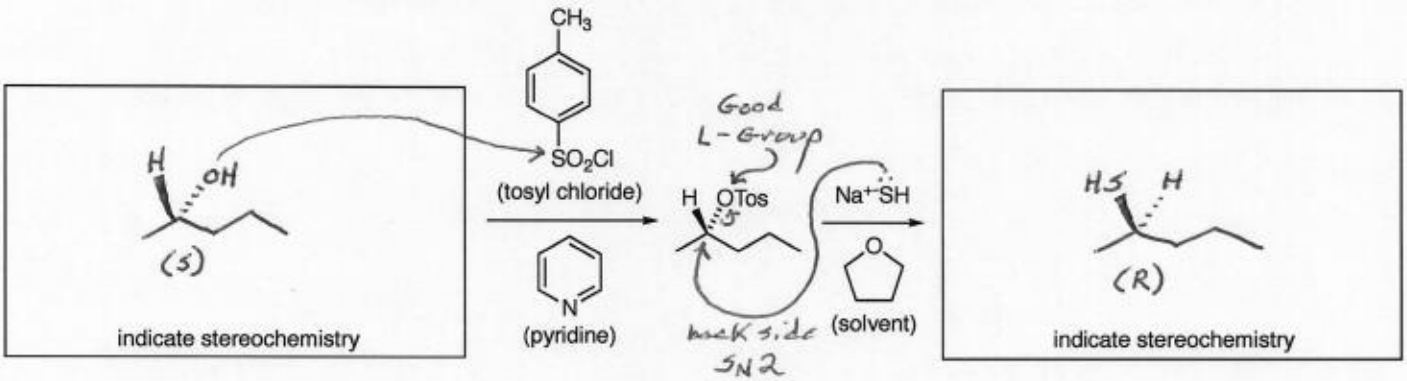
⟹ $Li^+OH^-$ $Na^+OH^-$ $K^+OH^-$ $Rb^+OH^-$

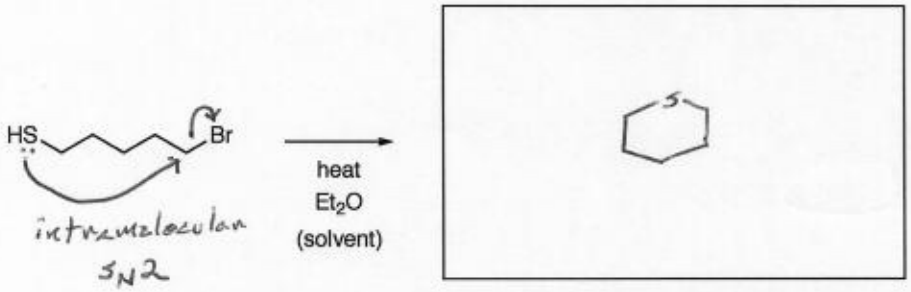
5. Provide the missing starting material or major product(s) in the reactions below. Show stereochemistry where indicated using dashed lines and wedges for compounds that have stereocenters. [24 pts; 4 pts each]



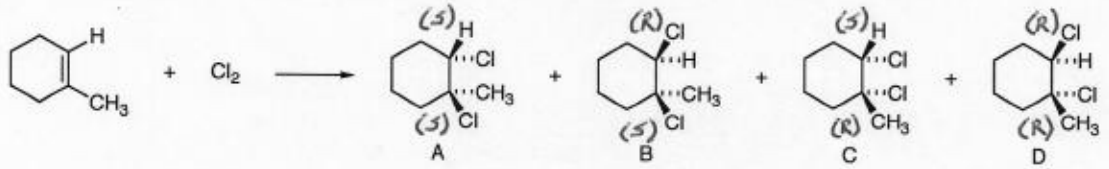



6. Consider reaction 1 below in which chlorine adds across the C=C bond to form a mixture of all possible stereoisomers of 1,2-dichloro-1-methylcyclohexane (A-D).




a. Which product is (1*S*,2*R*)-1,2-dichloro-1-methylcyclohexane. Write the letter in the box. [3 pts]

B

b. Which product is the enantiomer of product A? Write the letter in the box. [3 pts]

D

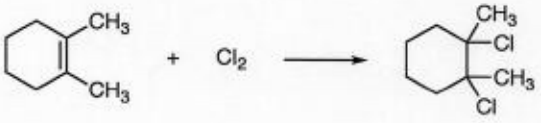
c. What is the stereochemical relationship between products C and D? Circle your answer. [3 pts]

enantiomers (diastereomers) meso compound conformers

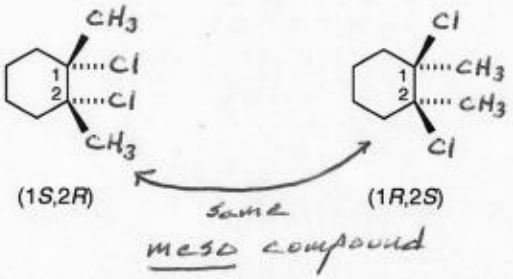
d. Will a pure sample of compound C be optically active or inactive in a polarimeter? Circle your answer. [3 pts]

(the mixture will be optically active) the mixture will be optically inactive

Consider reaction 2 below in which chlorine adds across the C=C double bond to form a mixture of products containing all possible stereoisomers of 1,2-dichloro-1,2-dimethylcyclohexane (shown without stereochemistry below).



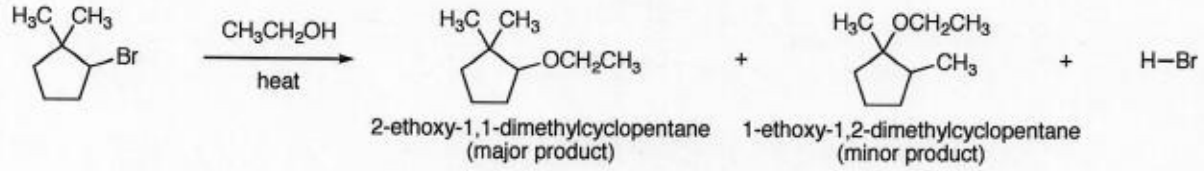

e. Draw the structures of (1*S*,2*R*)- and (1*R*,2*S*)-1,2-dichloro-1,2-dimethylcyclohexane below using the templates provided. [4 pts]




f. How many unique stereoisomers form as products in reaction 2? Circle your answer. [3 pts]

one product two products (three products) four products

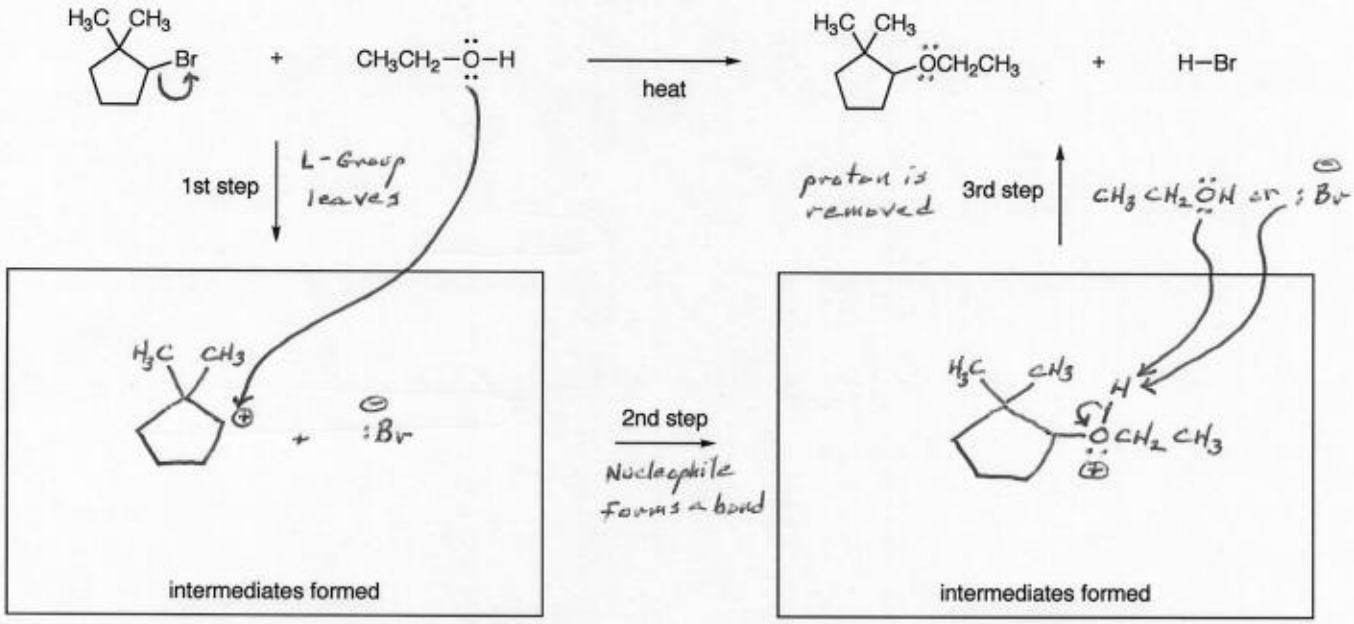
7. You react 2-bromo-1,1-dimethylcyclopentane with ethanol to synthesize 2-ethoxy-1,1-dimethylcyclopentane (major product) via $S_N1$ solvolysis. Analysis shows the reaction gives a mixture of two products, as shown below.




2-ethoxy-1,1-dimethylcyclopentane (major product)

1-ethoxy-1,2-dimethylcyclopentane (minor product)

a. Write a step-by-step reaction mechanism that shows how the major product 2-ethoxy-1,1-dimethylcyclopentane forms using the reaction template below. Your mechanism should show the intermediates that form after steps 1 and 2 in the boxes provided. Your reaction mechanism also should include *arrows that show the movement of lone pairs and bonding pairs of electrons* at each step where bonds are broken or formed. [9 pts]




b. How will the rate of the reaction change if the concentration of the nucleophile ethanol is increased? Circle your answer. [3 pts]

the rate will increase **(the rate will not change)** the rate will decrease

$S_N1$ rxn

c. How will the rate of the reaction change if the substrate and nucleophile (i.e., 2-bromo-1,1-dimethylcyclopentane and ethanol) are placed in a polar aprotic solvent such as diethyl ether (Et-O-Et) instead of using ethanol as both the nucleophile and solvent (i.e., a solvolysis reaction)? Circle your answer. [3 pts]

the rate will increase the rate will not change **(the rate will decrease)**

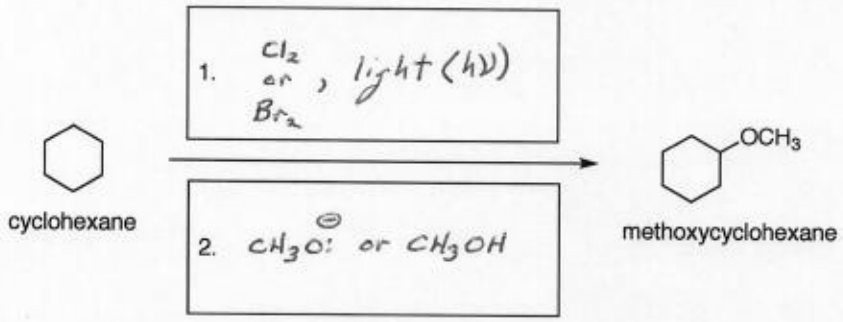
d. The reaction produces a minor amount of 1-ethoxy-1,2-dimethylcyclopentane as an unwanted side product due to rearrangement, where a methyl group shifts from carbon 1 to carbon 2 during the reaction. Circle the most reasonable explanation for why the methyl shift occurs. [3 pts]

**I. The methyl group shifts to form a more substituted carbocation intermediate that is lower in energy.**

II. The methyl group shifts to allow the nucleophile to approach with less steric hinderance.

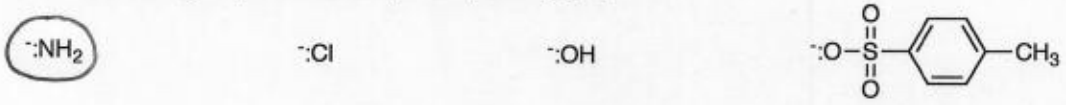
III. The methyl group shifts to reduce strain between the methyl substituents.

8. Propose a two-step synthesis (i.e., two separate sequential reactions) to convert cyclohexane into methoxycyclohexane by providing in the missing reagents/conditions on the boxes provided below. [3 pts; 1.5 pts each]

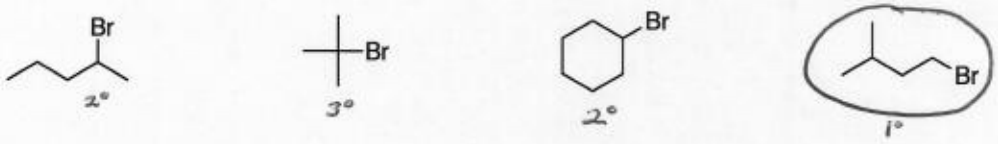


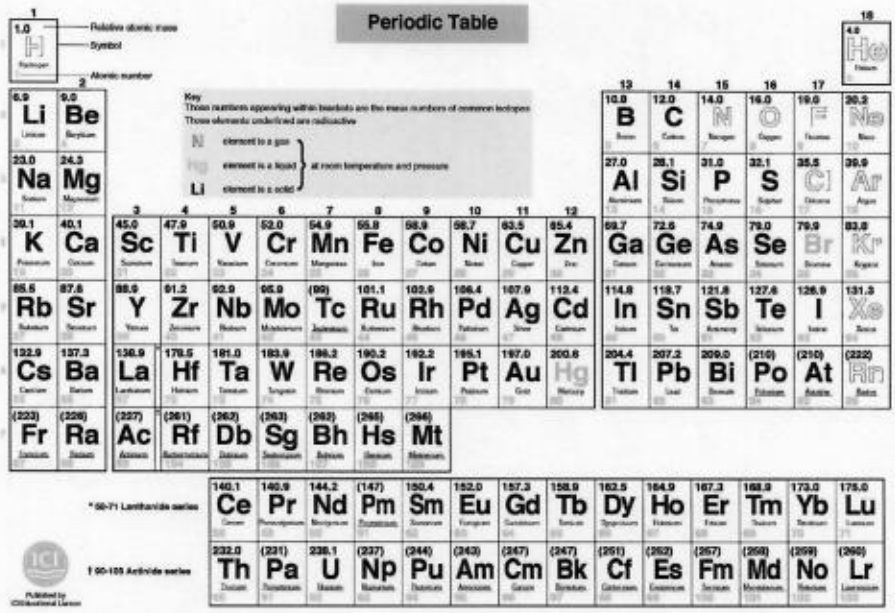

9. Circle the Fischer projection in which the asymmetric carbon atom has (S) stereochemical configuration. [3 pts]


10. Circle the strongest (most reactive) nucleophile. [3 pts]




11. Circle the compound below that will react at the fastest rate in an $S_N2$ reaction. [3 pts]




Score: _____/100