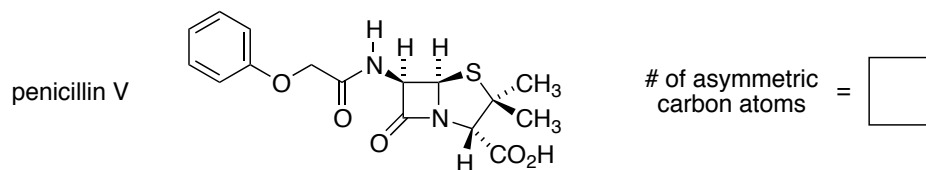
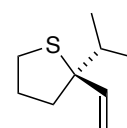
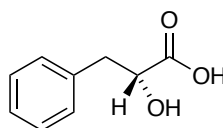
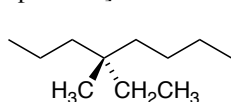


Name: \_\_\_\_\_

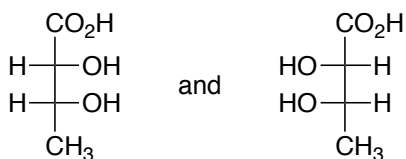
1. Indicate in the box how many asymmetric carbon atoms are present in the structure of penicillin V. [3 pts]



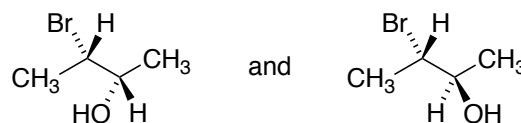
2. Indicate the stereochemical configuration, (*R*) or (*S*), for each of the following compounds in the boxes provided. [9 pts; 3 pts each]



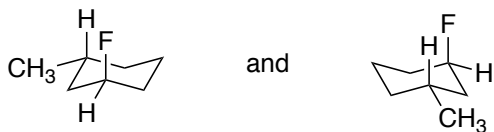
3. For each pair of stereoisomers indicate whether the two structures are identical, enantiomers or diastereomers. [12 pts; 3 pts each]



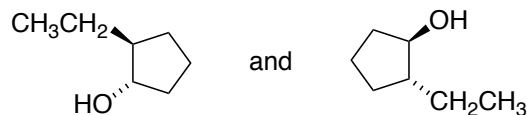
structures are \_\_\_\_\_



structures are \_\_\_\_\_

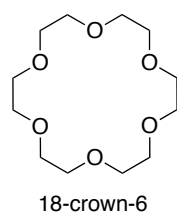


structures are \_\_\_\_\_

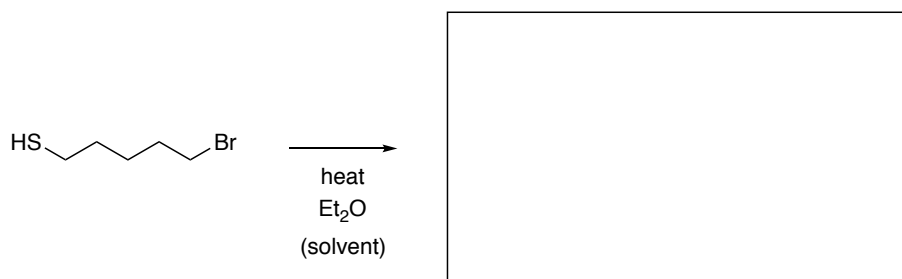
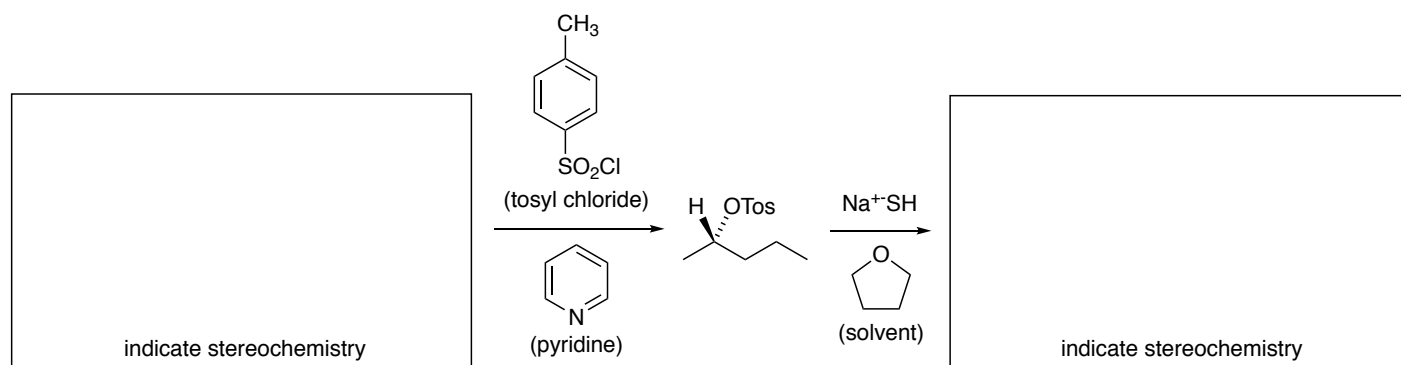
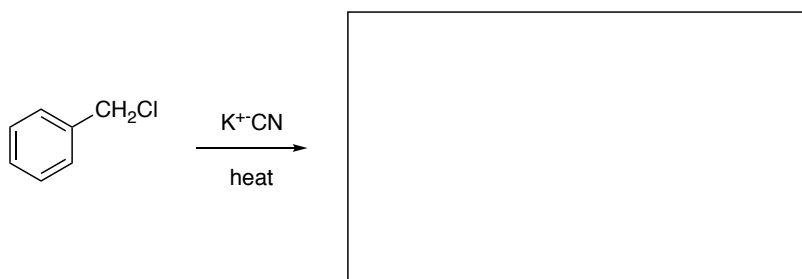
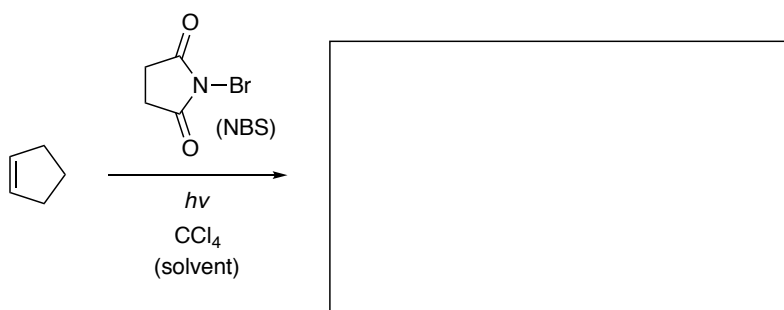
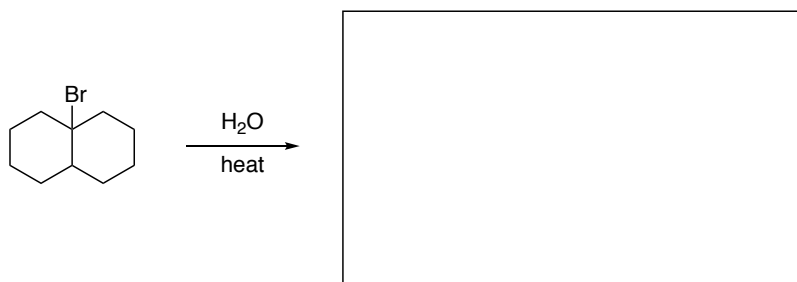


structures are \_\_\_\_\_

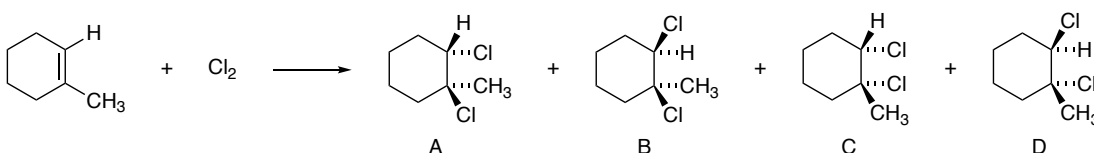
4. Crown ethers often are added to reactions to help solubilize inorganic salts in organic solvents. Crown ethers bind alkali cations selectively based on size. Circle the salt that 18-crown-6 will bind to with the highest affinity. [3 pts]



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

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

enantiomers

diastereomers

meso compound

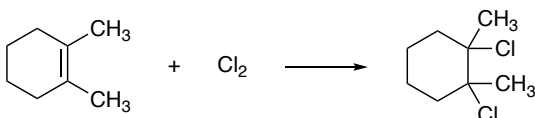
conformers

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

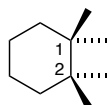
the mixture will be optically active

the mixture will be optically inactive

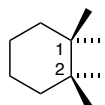
Consider reaction 2 below in which chlorine adds across the C=C double bond to form a mixture of products containing all possible stereoisomers of 1,2-dichloro-1,2-dimethylcyclohexane (shown without stereochemistry below).



- 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]



(1*S*,2*R*)



(1*R*,2*S*)

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

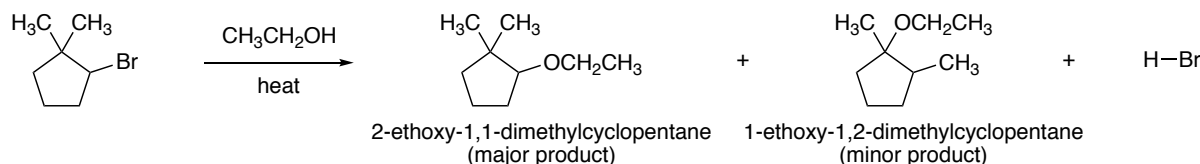
one product

two products

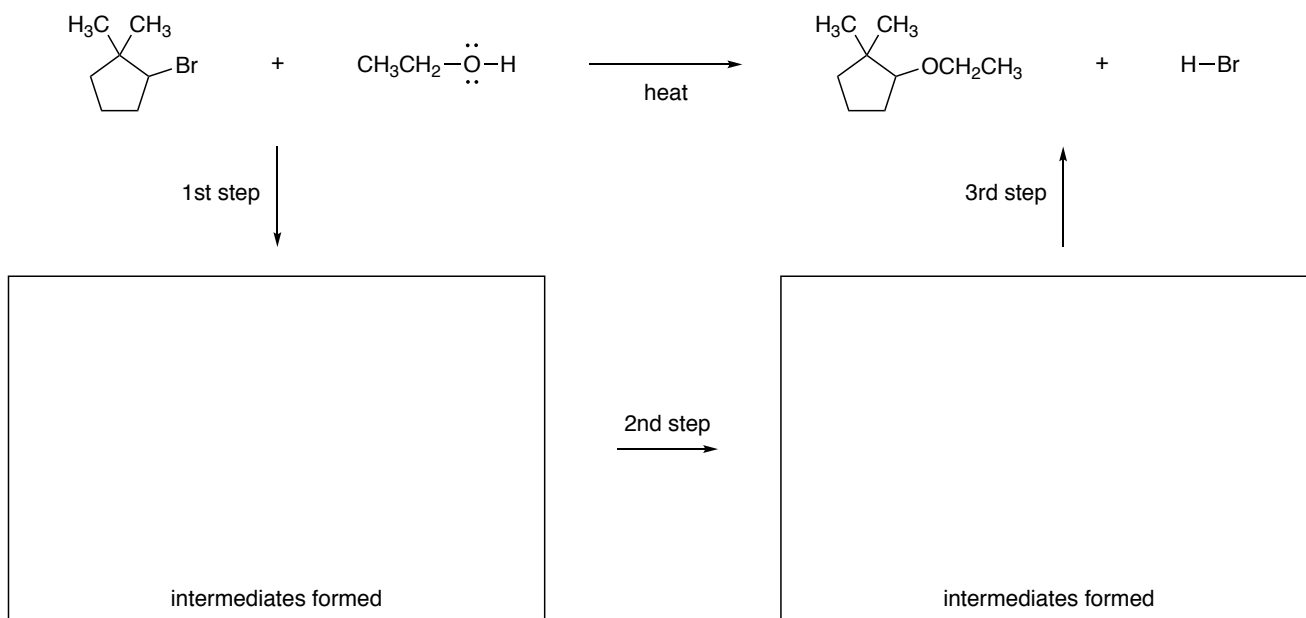
three products

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.

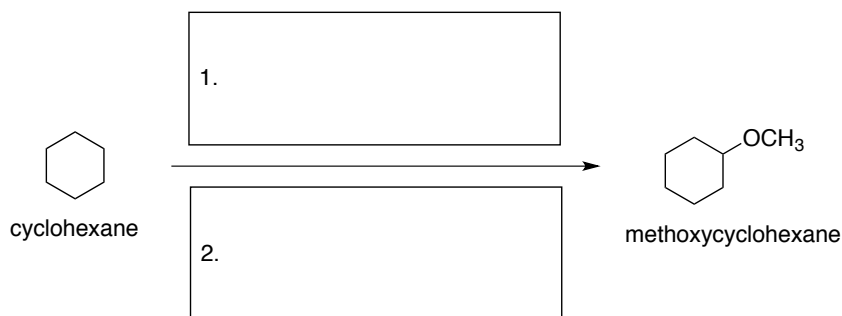


- a. Write a step-by-step reaction mechanism that shows how the major product 2-ethoxy-1,1-dimethylcyclopentane forms using the reaction template below. Your mechanism should show the intermediates that form after steps 1 and 2 in the boxes provided. Your reaction mechanism also should include *arrows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

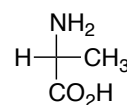
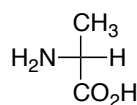
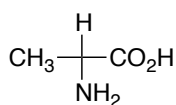
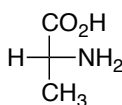


- b. How will the rate of the reaction change if the concentration of the nucleophile ethanol is increased? Circle your answer. [3 pts]
- ☐ the rate will increase                      ☐ the rate will not change                      ☐ the rate will decrease
- c. How will the rate of the reaction change 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]
- The methyl group shifts to form a more substituted carbocation intermediate that is lower in energy.
  - The methyl group shifts to allow the nucleophile to approach with less steric hinderance.
  - The methyl group shifts to reduce strain between the methyl substituents.

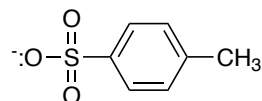
8. Propose a two-step synthesis (i.e., two separate sequential reactions) to convert cyclohexane into methoxycyclohexane by providing in the missing reagents/conditions on the boxes provided below. [3 pts; 1.5 pts each]



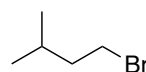
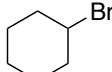
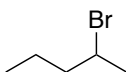
9. Circle the Fischer projection in which the asymmetric carbon atom has (S) stereochemical configuration. [3 pts]



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



11. Circle the compound below that will react at the fastest rate in an  $\text{S}_\text{N}2$  reaction. [3 pts]



Periodic Table

Key: These numbers appearing within brackets are the mass numbers of common isotopes. Those elements underlined are radioactive.

Legend:   
 □ element is a gas   
 □ element is a liquid   
 □ element is a solid

1 1.0 H Hydrogen	2 4.0 He Helium																
3 6.9 Li Lithium	4 9.0 Be Beryllium																
5 23.0 Na Sodium	6 24.3 Mg Magnesium																
7 39.1 K Potassium	8 40.1 Ca Calcium	9 45.0 Sc Scandium	10 47.9 Ti Titanium	11 50.9 V Vanadium	12 52.0 Cr Chromium	13 54.9 Mn Manganese	14 55.8 Fe Iron	15 58.9 Co Cobalt	16 58.7 Ni Nickel	17 63.5 Cu Copper	18 65.4 Zn Zinc	19 69.7 Ga Gallium	20 72.6 Ge Germanium	21 74.9 As Arsenic	22 79.0 Se Selenium	23 79.9 Br Bromine	24 83.8 Kr Krypton
19 85.5 Rb Rubidium	20 87.6 Sr Strontium	21 88.9 Y Yttrium	22 91.2 Zr Zirconium	23 92.9 Nb Niobium	24 95.9 Mo Molybdenum	25 (99) Tc Technetium	26 101.1 Ru Ruthenium	27 102.9 Rh Rhodium	28 106.4 Pd Palladium	29 107.9 Ag Silver	30 112.4 Cd Cadmium	31 114.8 In Indium	32 118.7 Sn Tin	33 121.8 Sb Antimony	34 127.6 Te Tellurium	35 126.9 I Iodine	36 131.3 Xe Xenon
37 132.9 Cs Cesium	38 137.3 Ba Barium	39 138.9 La Lanthanum	40 178.5 Hf Hafnium	41 181.0 Ta Tantalum	42 183.9 W Tungsten	43 186.2 Re Rhenium	44 190.2 Os Osmium	45 192.2 Ir Iridium	46 195.1 Pt Platinum	47 197.0 Au Gold	48 200.6 Hg Mercury	49 204.4 Tl Thallium	50 207.2 Pb Lead	51 209.0 Bi Bismuth	52 (210) Po Polonium	53 (210) At Astatine	54 (222) Rn Radon
55 (223) Fr Francium	56 (226) Ra Radium	57 Ac Actinium	58 (227) Th Thorium	59 (227) Pa Protactinium	60 (227) U Uranium	61 (227) Np Neptunium	62 (227) Pu Plutonium	63 (227) Am Americium	64 (227) Cm Curium	65 (227) Bk Berkelium	66 (227) Cf Californium	67 (227) Es Einsteinium	68 (227) Fm Fermium	69 (227) Md Mendelevium	70 (227) No Nobelium	71 (227) Lr Lawrencium	
* 58-71 Lanthanide series Ce (140.1) Pr (140.9) Nd (144.2) Pm (147) Sm (150.4) Eu (152.0) Gd (157.3) Tb (158.9) Dy (162.5) Ho (164.9) Er (167.3) Tm (168.9) Yb (173.0) Lu (175.0) † 90-103 Actinide series Th (232.0) Pa (231) U (238.1) Np (237) Pu (244) Am (243) Cm (247) Bk (247) Cf (251) Es (252) Fm (257) Md (258) No (259) Lr (260)																	

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