

Name _____

General Instructions: Write your name in the space provided above and on the provided Scan-tron form.
Do not put your name anywhere else in this exam book.

Make sure that you read each question carefully and provide complete answers. Time limit is 55 min.

Grading: Grading will be on the basis of a highest possible score of 100 points.

- I. Multiple Choice – 2 points each, 40 points total
- II. R /S Designations – 1.5 points each, 7.5 points total
- III. Structures – 1.5 points each, 7.5 points total
- III. Reaction Products – 5 points each, 25 points total
- IV. Spectroscopy Problem – 20 points

TABLE 6.1 BOND DISSOCIATION ENERGIES (ΔH°) OF COMMON BONDS

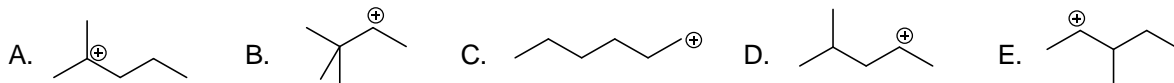
	KJ/MOL	KCAL/MOL		KJ/MOL	KCAL/MOL		KJ/MOL	KCAL/MOL	
Bonds to H			$\text{H}_2\text{C}=\text{CH}-\text{CH}_3$	385	92	$(\text{CH}_3)_2\text{CH}-\text{F}$	444	106	
$\text{H}-\text{H}$	435	104	$\text{HC}\equiv\text{C}-\text{CH}_3$	489	117	$(\text{CH}_3)_2\text{CH}-\text{Cl}$	335	80	
$\text{H}-\text{CH}_3$	435	104	Bonds to methyl			$(\text{CH}_3)_2\text{CH}-\text{Br}$	285	68	
$\text{H}-\text{CH}_2\text{CH}_3$	410	98	CH_3-H	435	104	$(\text{CH}_3)_2\text{CH}-\text{I}$	222	53	
$\text{H}-\text{CH}(\text{CH}_3)_2$	397	95	CH_3-F	456	109	$(\text{CH}_3)_2\text{CH}-\text{OH}$	381	91	
$\text{H}-\text{C}(\text{CH}_3)_3$	381	91	CH_3-Cl	351	84				
	473	113	CH_3-Br	293	70				
	356	85	CH_3-I	234	56				
	464	111	CH_3-OH	381	91	$(\text{CH}_3)_3\text{C}-\text{H}$	381	91	
	364	87				$(\text{CH}_3)_3\text{C}-\text{F}$	444	106	
$\text{H}-\text{F}$	569	136	$\text{CH}_3\text{CH}_2-\text{H}$	410	98	$(\text{CH}_3)_3\text{C}-\text{Cl}$	331	79	
$\text{H}-\text{Cl}$	431	103	$\text{CH}_3\text{CH}_2-\text{F}$	448	107	$(\text{CH}_3)_3\text{C}-\text{Br}$	272	65	
$\text{H}-\text{Br}$	368	88	$\text{CH}_3\text{CH}_2-\text{Cl}$	339	81	$(\text{CH}_3)_3\text{C}-\text{I}$	209	50	
$\text{H}-\text{I}$	297	71	$\text{CH}_3\text{CH}_2-\text{Br}$	285	68	$(\text{CH}_3)_3\text{C}-\text{OH}$	381	91	
$\text{H}-\text{OH}$	498	119	$\text{CH}_3\text{CH}_2-\text{I}$	222	53	X-X bonds			
$\text{H}-\text{OCH}_2\text{CH}_3$	435	104	$\text{CH}_3\text{CH}_2-\text{OH}$	381	91	$\text{F}-\text{F}$	159	38	
C-C bonds						$\text{Cl}-\text{Cl}$	242	58	
CH_3-CH_3	368	88	$(\text{CH}_3)_2\text{CH}-\text{H}$	397	95	$\text{Br}-\text{Br}$	192	46	
$\text{CH}_3\text{CH}_2-\text{CH}_3$	356	85				$\text{I}-\text{I}$	151	36	
$(\text{CH}_3)_2\text{CH}-\text{CH}_3$	351	84				$\text{HO}-\text{OH}$	213	51	

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I. Multiple Choice

I. Each of the following multiple choice questions has one and only one correct response. Mark the letter of the correct response to each question on the Scan-Tron form provided. A #2 pencil should be used. (Make sure to write your name on the Scan-Tron form.)

Use the following choices for questions 1-3.



- Which is the least stable carbocation?
- Which is the most stable?
- Which carbocation is expected to undergo a 1,2-hydride shift?
- Which of these correctly describes the overall reaction $a \rightarrow e$? (See Figure 1)
 - non-concerted, exothermic
 - non-concerted, endothermic
 - concerted, exothermic
 - concerted, endothermic

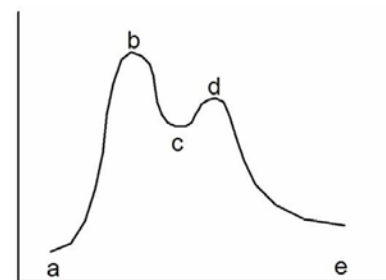


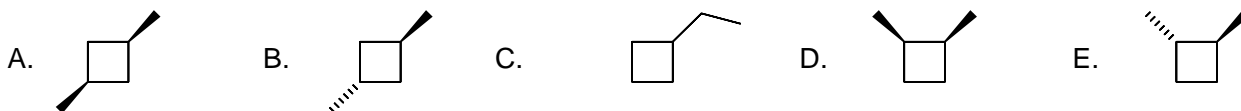
Figure 1 - PE Diagram for Questions 4-6

- Which of the following reactions is the fastest? (See Figure 1)
 - $a \rightarrow c$
 - $c \rightarrow e$
 - $c \rightarrow a$
 - $e \rightarrow c$
- What points on the graph represent transition states? (See Figure 1)
 - c only
 - b and d
 - b, c, and d
 - c and e
- Use the table of BDEs on the front page to predict the ΔH of the following hypothetical reaction.

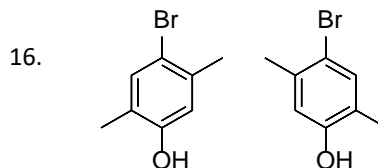
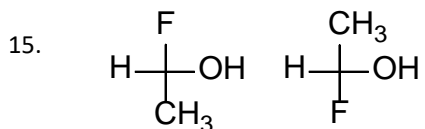
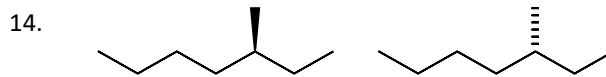
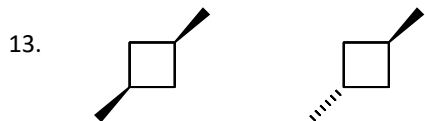
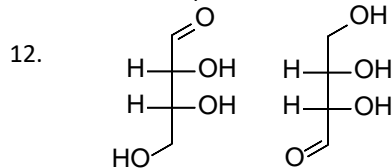
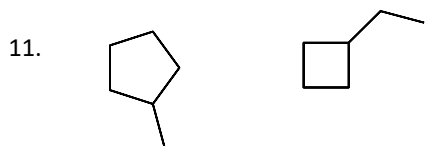
$$\text{CH}_3\text{CH}_2\text{Br} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{HBr}$$
 - +8 kcal/mol
 - 8 kcal/mol
 - +5 kcal/mol
 - 5 kcal/mol

- Morphine is a natural product isolated from opium poppies. It can be reacted with H_2SO_4 to form morphine sulfate which is used as an oral pain reliever. The $[\alpha]_D$ of pure morphine sulfate is -110° . If 10 morphine sulfate caplets are dissolved in 5.0 mL H_2O and the solution is measured on an automatic 1-dm polarimeter to give an observed rotation of $\alpha_{\text{obs}} = -22.0^\circ$ what is the average mass (in mg) of the caplets?
 - 20
 - 25
 - 80
 - 100
 - 1500
- The optical purity of a research compound was measured by polarimetry to be 50%. Which of these statements correctly describes the compound?
 - It is a mixture of enantiomers in a 4:1 ratio
 - It is a mixture of enantiomers in a 3:1 ratio
 - It is a mixture of diastereomers in a 4:1 ratio
 - It is a mixture of diastereomers in a 3:1 ratio.
 - It is a racemic mixture

- Which of the following cycloalkanes is chiral?

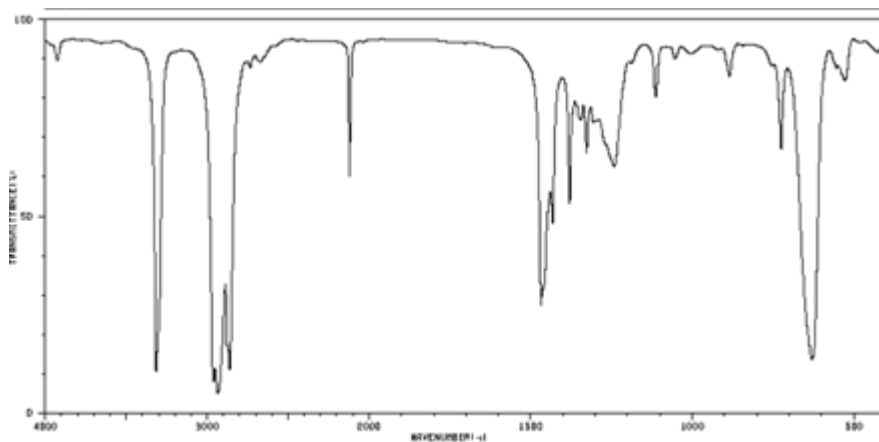


For Questions 11-16 identify the relationship between the two structures shown. Use the following choices:
 A. enantiomers B. diastereomers C. constitutional isomers D. same compound E. different compounds, not isomers



17. Which compound gives the IR spectrum shown at right?

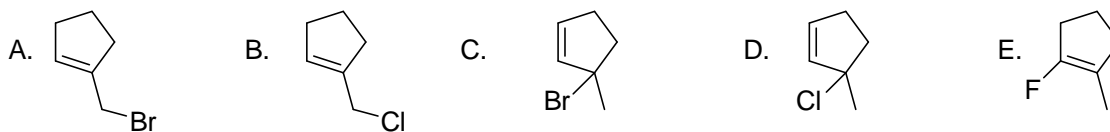
- A. 1-Octene
- B. 2-Octene
- C. 1-Octyne
- D. 2-Octyne
- E. 1-Octanol



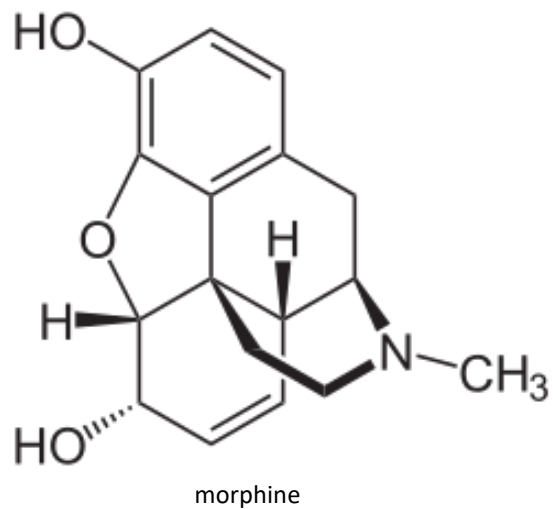
18. What are the expected peak multiplicities in the ^1H NMR spectrum of ?
 A. q, t, t, m, s B. s, t, t, d, m C. t, q, m, t, d D. t, q, d, m, d E. q, t, t, m, q

19. What are the expected peak multiplicities in the ^1H NMR spectrum of ?
 A. q, t, t B. s, s, s C. t, m, t C. s, s, s E. d, d, q

20. Which of the following substrates gives the **fastest** $\text{S}_{\text{N}}2$ reactions?



- II. (a) Label all chirality centers in morphine as *R* or *S* as appropriate. Show priorities of all groups around each chirality center.
(b) How many stereoisomers are theoretically possible form morphine?



III. Give the structure of each of the following:

TMS

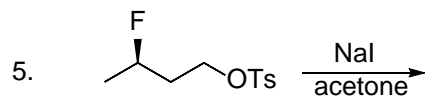
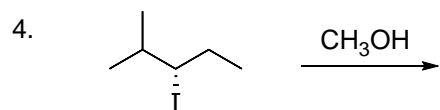
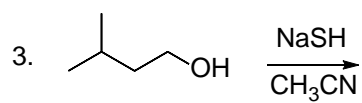
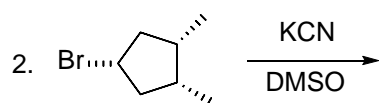
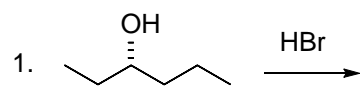
(*S*)-3-chloro-1-hexene

DMSO

meso-3,4-dimethylhexane

TsCl

IV. Predict the product of each of the following nucleophilic substitution reactions. If no reaction is expected to occur then write N.R. and explain your reasoning.



V. A compound with molecular formula $C_4H_8O_2$ displays the following IR and 1H NMR spectra. Propose a structure for this compound. Explain your reasoning by labeling all key peaks in the spectra.

