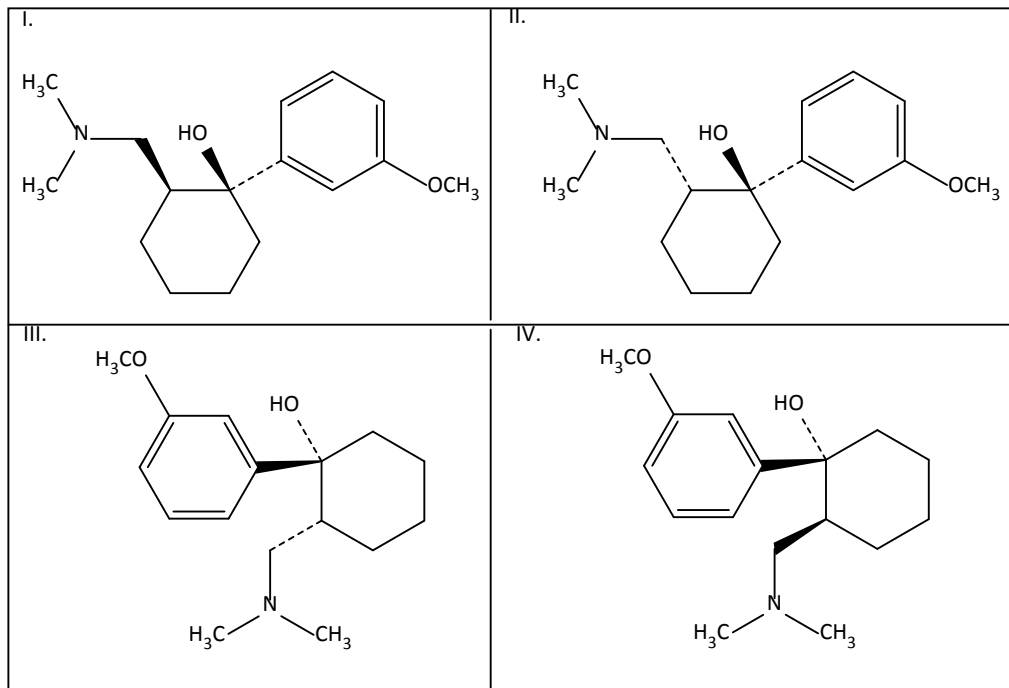
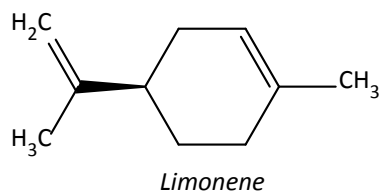


1. Tramadol is a drug that is used to treat moderate to severe pain. It contains two chiral centers and is sold as a racemic mixture. Both of the stereoisomers of the racemic mixture react with  $\text{POCl}_3$ ,  $\text{Et}_3\text{N}$  to give the same tetra-substituted alkene as the major thermodynamic product. Which of the structures below represent tramadol? **B**

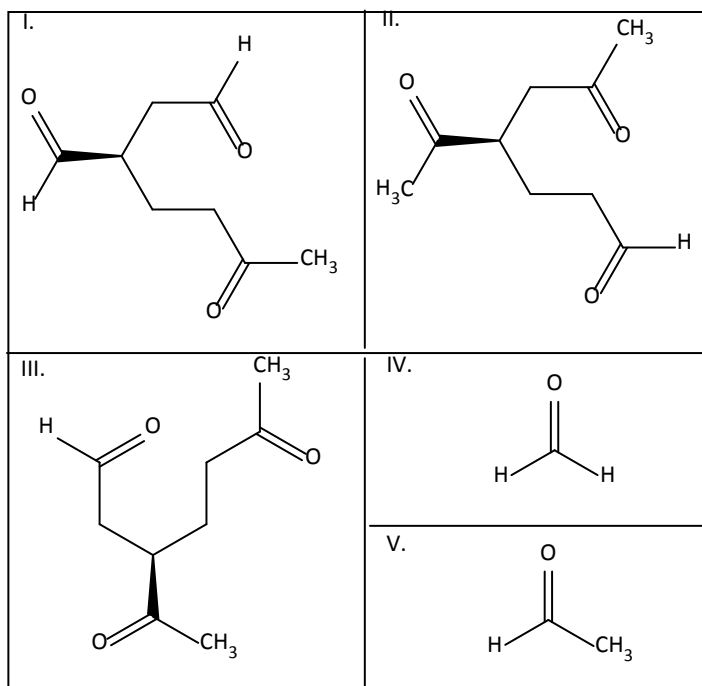


- |             |
|-------------|
| a) I & II   |
| b) I & III  |
| c) II & III |
| d) III & IV |
| e) II & IV  |

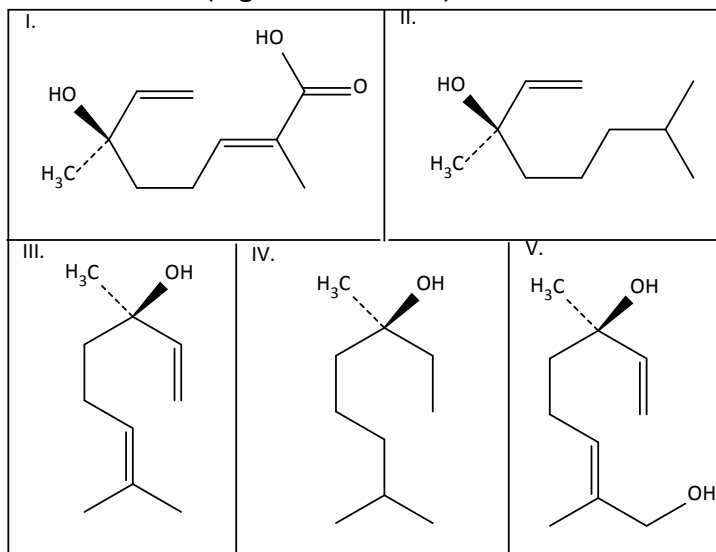
2. The products of the reaction of limonene with 1)  $\text{O}_3$  2)  $\text{Zn}$ ,  $\text{HCl}$  (assume excess reagents) are: **C**



- a) I & IV  
b) II & IV  
c) III & IV  
d) II & V  
e) III & V

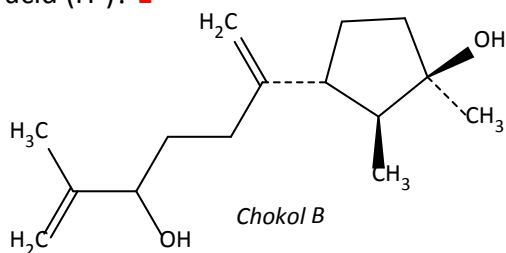


3. R-linalool (III below) is a naturally-occurring terpene that is found in sweet basil, lavender and bay laurel. It has a number of metabolites (shown below) that are generated through oxidation and reduction reactions. Rank the relative oxidation states of linalool and its metabolites from highest oxidation state to lowest oxidation state (highest >> lowest). **E**

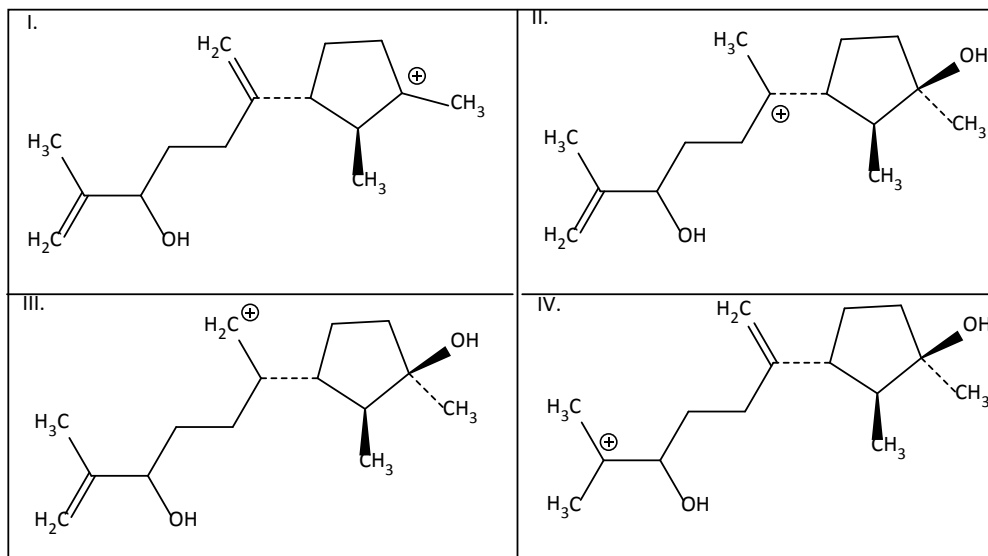


- |   |
|---|
| <p>a) I &gt; II &gt; V &gt; IV &gt; III<br/>                 b) I &gt; V &gt; II &gt; III &gt; IV<br/>                 c) I &gt; III &gt; V &gt; II &gt; IV<br/>                 d) V &gt; I &gt; III &gt; II &gt; IV<br/>                 e) I &gt; V &gt; III &gt; II &gt; IV</p> |
|---|

4. Which of the following reaction intermediates will form the *fastest* upon treatment of chokol B with strong acid ( $H^+$ )? **E**



- |  |
|--|
| <p>a) I<br/>                 b) I &amp; II<br/>                 c) I, II, &amp; III<br/>                 d) III<br/>                 e) I, II &amp; IV</p> |
|--|

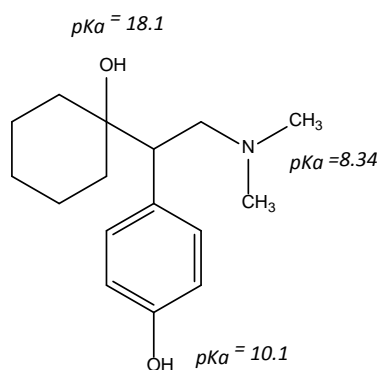


5. Which of the following alkenes will provide a mixture of enantiomers upon reaction with *m*-chloroperbenzoic acid (*m*-CPBA)? **D**

- I. *Z*-4R-methyl-2-phenyl-2-hexene
- II. *E*-3-methyl-2-phenyl-2-hexene
- III. *Z*-1-phenyl-1-hexene
- IV. 4-ethyl-3-phenyl-3-hexene

- a) I, II, III, IV
- b) II, III
- c) I, II
- d) II, III, IV
- e) I

6. Which of the following non-covalent interactions are possible for desvenlafaxine at pH = 12? **E**

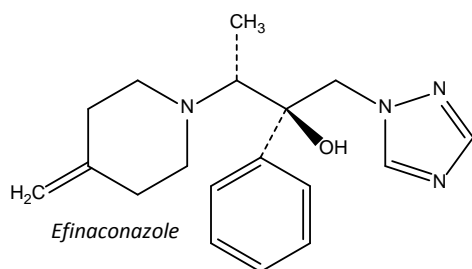


Desvenlafaxine  
(anti-depressant)

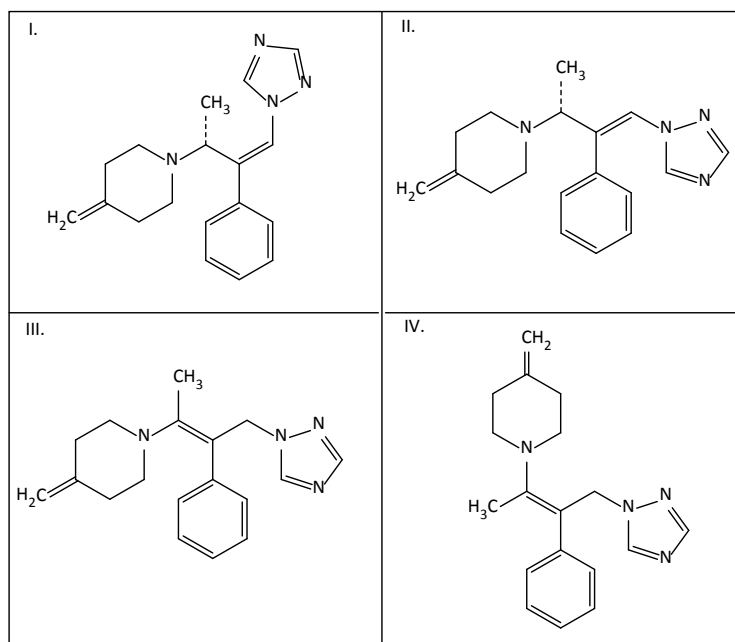
- I. Intermolecular H-bonding
- II. Intramolecular H-bonding
- III. Intermolecular Ion-Dipole
- IV. Intramolecular Ion-Dipole
- V. Intramolecular Dipole-Dipole
- VI. Intermolecular Dipole-Dipole

- a) I, III, V
- b) II, IV, VI
- c) I, II, III, IV
- d) I, II, III, IV, V, VI
- e) I, II, III, V, VI

7. Which of the following alkene(s) is (are) generated as the *major thermodynamic* product(s) in the reaction of efinaconazole with  $\text{POCl}_3$ ,  $\text{Et}_3\text{N}$ ? **B**



- a) I & II
- b) IV
- c) I, II & III
- d) III & IV
- e) III

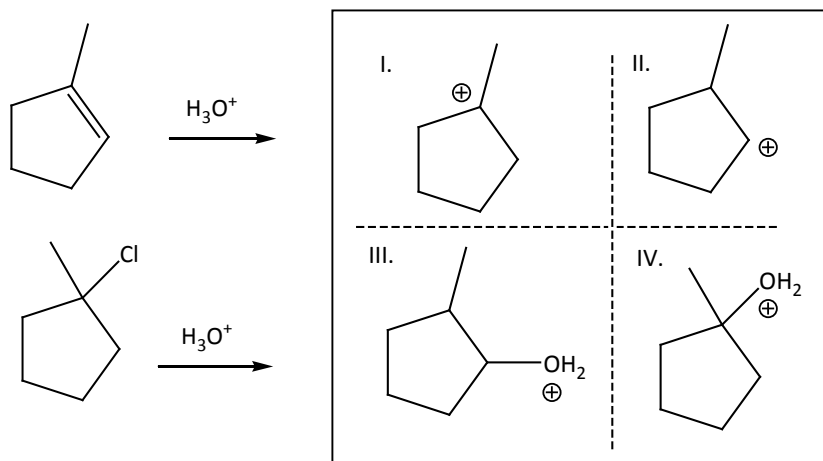


8. Which of the following compounds contains a tri-substituted alkene and a secondary alcohol? **D**

- I. 2-methylcyclopent-2-en-1-ol
- II. 1-methylcyclopent-3-en-1-ol
- III. 3-methylpent-3-en-2-ol
- IV. 2-methylpent-2-en-1-ol
- V. 4-methylcyclopent-2-en-1-ol

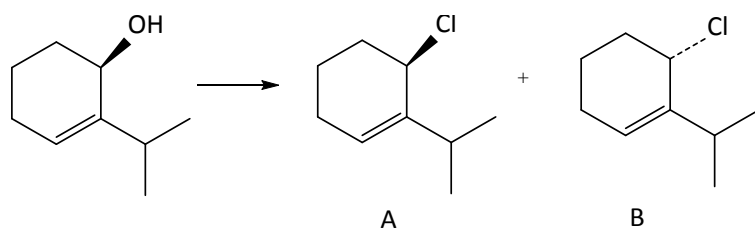
- |  |
|--|
| <ul style="list-style-type: none"> <li>a) II</li> <li>b) I, III &amp; V</li> <li>c) I, III &amp; IV</li> <li>d) I &amp; III</li> <li>e) III</li> </ul> |
|--|

9. Which of the following reaction intermediates will form in both reactions given below? **C**



- |  |
|--|
| <ul style="list-style-type: none"> <li>a) II &amp; IV</li> <li>b) I &amp; II</li> <li>c) I &amp; IV</li> <li>d) I</li> <li>e) I, II, III &amp; IV</li> </ul> |
|--|

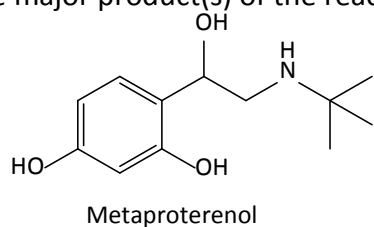
10. Which of the following statements is true regarding the transformation outlined below? **C**



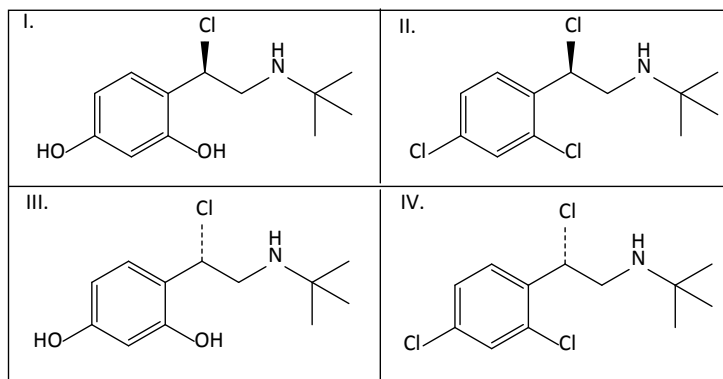
- |   |
|---|
| <ul style="list-style-type: none"> <li>a) I &amp; V</li> <li>b) II &amp; IV</li> <li>c) II &amp; V</li> <li>d) III &amp; IV</li> <li>e) I &amp; II</li> </ul> |
|---|

- |   |
|---|
| <ul style="list-style-type: none"> <li>I. Product B is an enantiomer of the starting material.</li> <li>II. Products A &amp; B are enantiomers.</li> <li>III. Products A &amp; B are diastereomers.</li> <li>IV. The reaction occurs via an <math>S_N2</math> mechanism.</li> <li>V. The reaction occurs via an <math>S_N1</math> mechanism.</li> </ul> |
|---|

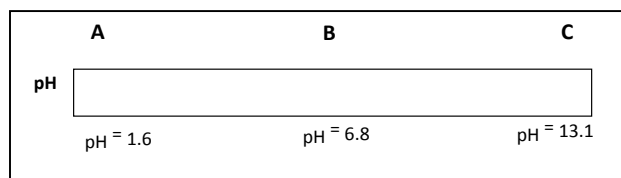
11. The major product(s) of the reaction of S-metaproterenol with excess  $\text{SOCl}_2$  is (are) : **A**



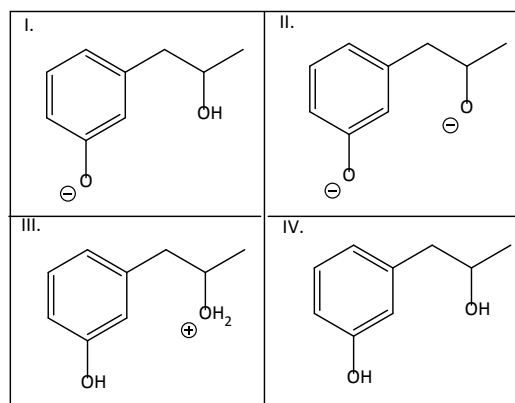
- a) I  
b) II  
c) I & III  
d) IV  
e) III



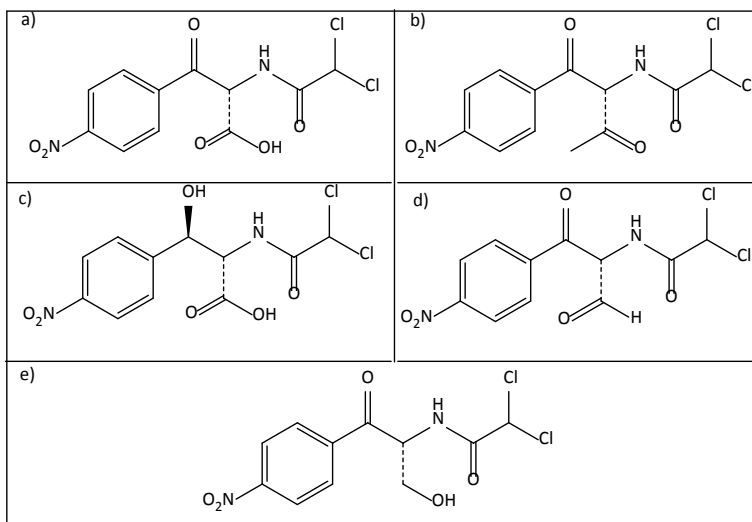
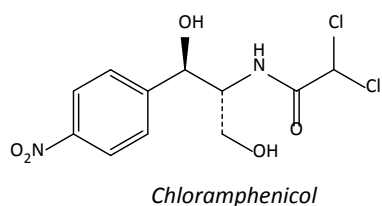
12. Identify which structure (I, II, III, IV) of 3-(2-hydroxypropyl)phenol is dominant each of the pH conditions (A, B, C) described below. (Note:  $pK_a$  of alcohol (acid) = 17;  $pK_a$  of alcohol (conjugate acid) = -2.4;  $pK_a$  of phenol = 8) **D**



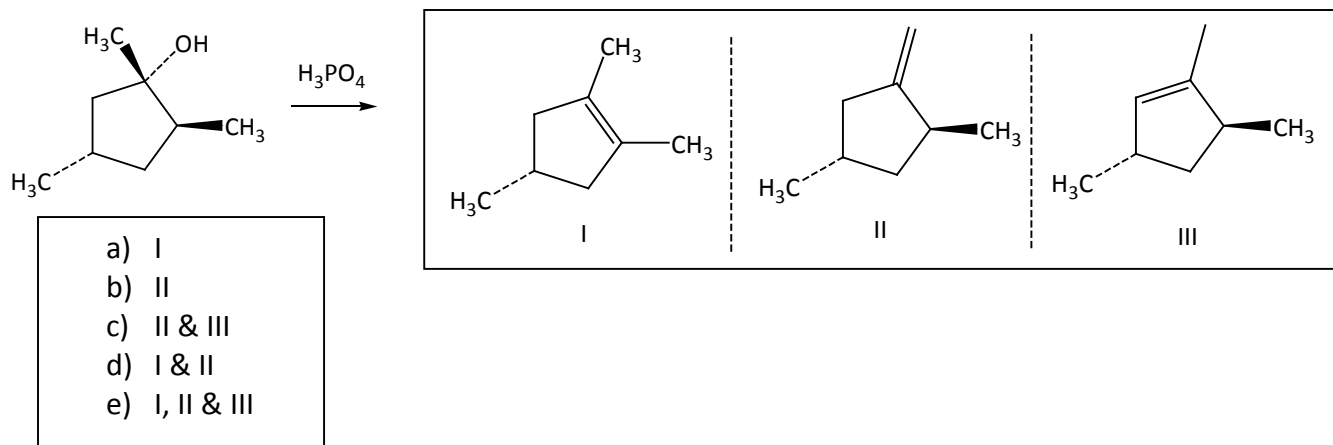
- a) A = III; B = IV; C = II  
b) A = IV; B = IV; C = IV  
c) A = III; B = IV; C = I  
d) A = IV; B = IV; C = I  
e) A = IV; B = I; C = I



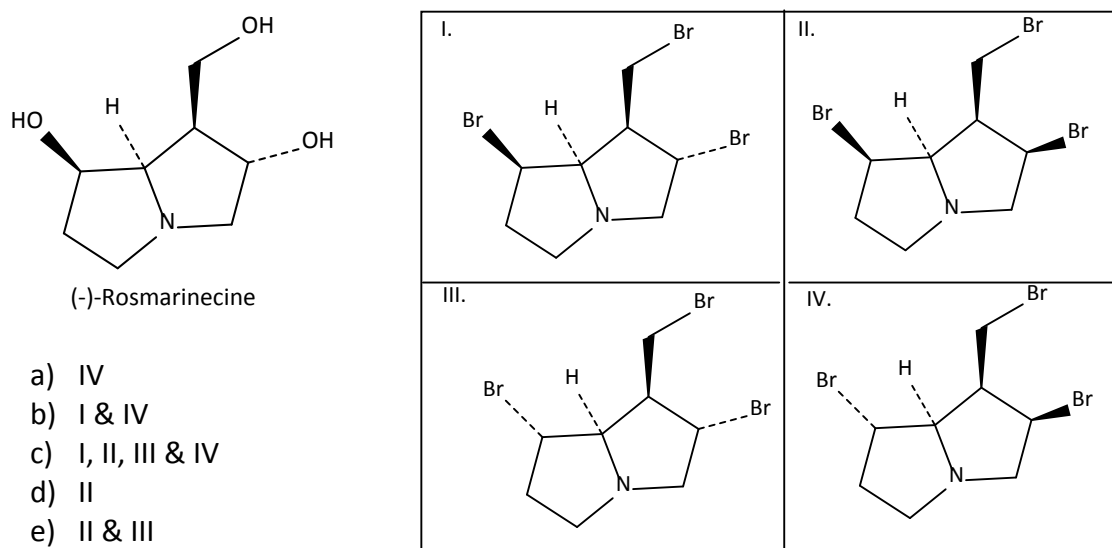
13. The product of the reaction of chloramphenicol with Jones reagent is: **A**



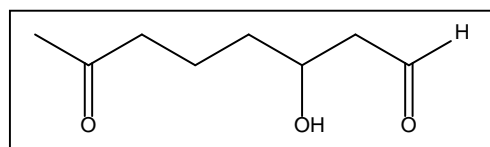
14. The major kinetic product(s) of the reaction below is (are): **E**



15. The major product(s) of the reaction of (-) rosmarinic acid with excess HBr is (are): **C**



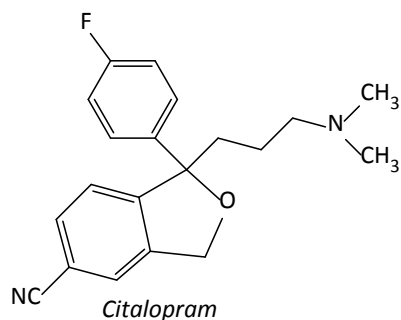
16. Which of the following reagents could be used to prepare the product below, starting with 4-methylcyclohept-3-en-1-ol? **B**



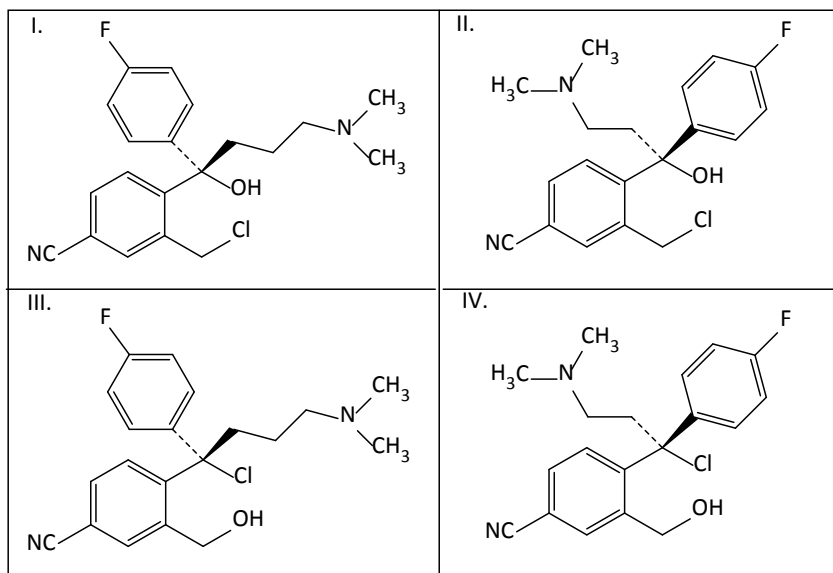
- I. 1.  $\text{O}_3$  2. Zn, HCl
- II. 1. cold, dilute  $\text{KMnO}_4$  2.  $\text{HIO}_4$
- III. PDC,  $\text{CH}_2\text{Cl}_2$
- IV.  $\text{CrO}_3$ ,  $\text{H}_2\text{SO}_4$
- V.  $\text{H}^+$ ,  $\text{KMnO}_4$ ,  $\Delta$

- a) I
- b) I & II
- c) III
- d) IV
- e) I, II & V

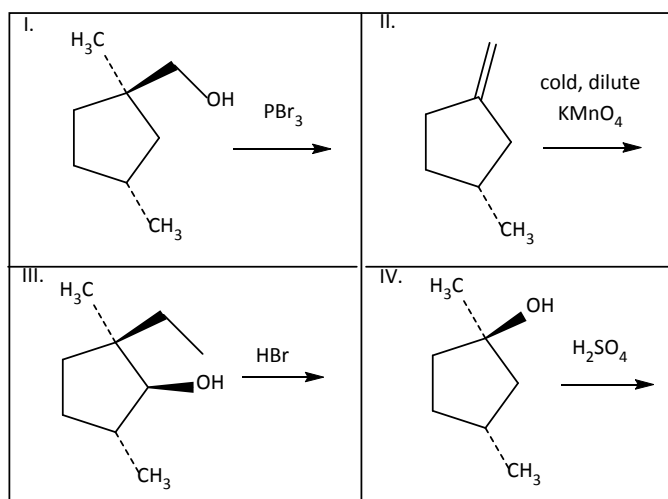
17. Citalopram is an antidepressant that is sold as a racemic mixture. However, only the *S*-enantiomer has anti-depressant activity. Citalopram can be synthesized through an *intramolecular*  $S_N2$  reaction, i.e., the reaction occurs within the same molecule. Which of the following starting materials, when reacted with NaH, would form the active enantiomer of citalopram through an intramolecular  $S_N2$  mechanism? **A**



- a) I  
b) III  
c) II  
d) IV  
e) I & III



18. Which of the following reactions will provide a mixture of diastereomers as *major products* of the reaction? **B**

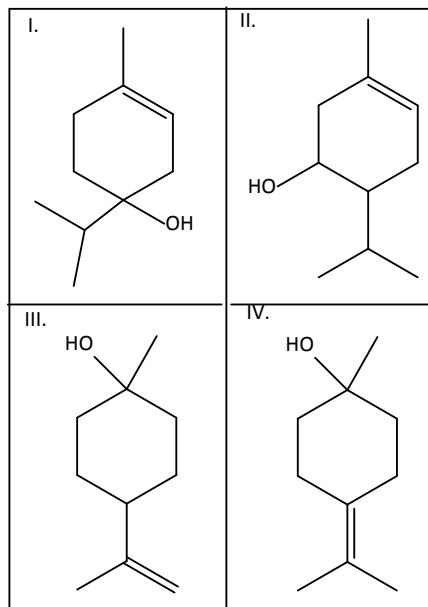


- a) I  
b) II & III  
c) III  
d) I, II & III  
e) III & IV

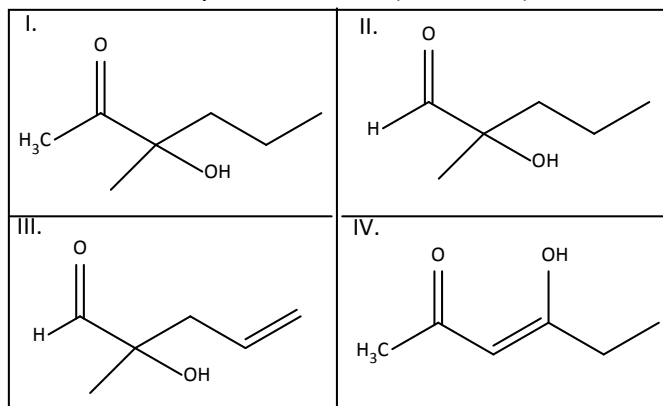
19. Terpeneols are naturally-occurring oils with mostly pleasant aromas and are used in perfumes, cosmetics and flavorings. There are four terpeneol isomers, each containing specific functional groups described and listed below as A, B, C and D. Identify which of the structures below (I, II, III, IV) corresponds to each of the terpeneol isomers. **B**

- A:  $\beta$ -Terpineol: 3° alcohol, disubstituted alkene  
 B: 4-terpineol: 3° alcohol, trisubstituted alkene  
 C:  $\gamma$ -Terpineol: 3° alcohol, tetrasubstituted alkene  
 D:  $\alpha$ -Terpineol: 2° alcohol, trisubstituted alkene

a) A = I B = II C = III D = IV	b) A = III B = I C = IV D = II	c) A = III B = IV C = I D = II
d) A = II B = I C = IV D = III		e) A = II B = IV C = I D = III



20. Match the compounds below (I, II, III, IV) with the results of the tests (A, B, C, D) listed in the table. **A**

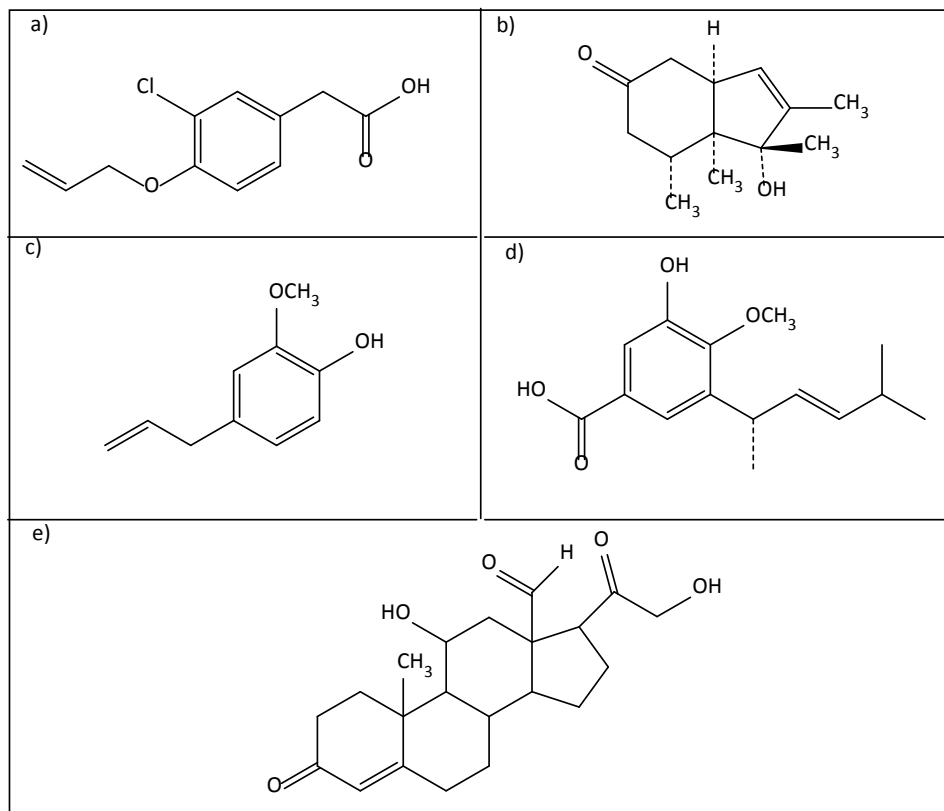


Test	A	B	C	D
	Result	Result	Result	Result
Jones Tests	+	-	+	-
Iodoform Test	-	+	-	+
Bromine/Water	-	+	+	-
Lucas Test	+	-	+	+
KMnO <sub>4</sub>	-	+	+	-

a) I = D II = A III = C IV = B	b) I = B II = C III = A IV = D
c) I = B II = A III = C IV = D	
d) I = C II = B III = A IV = D	
e) I = D II = C III = A IV = B	



21. Alclofenac is an analgesic, anti-pyretic and anti-inflammatory agent. It reacts with  $\text{KMnO}_4$ , but not PCC or Jones reagent. Treatment of alclofenac with *m*-CPBA results in formation of a mixture of enantiomers. At  $\text{pH} = 7$ , alclofenac can form *intermolecular* ion-dipole interactions, but not *intramolecular* ion-dipole interactions. Which of the following compounds is alclofenac? **A**

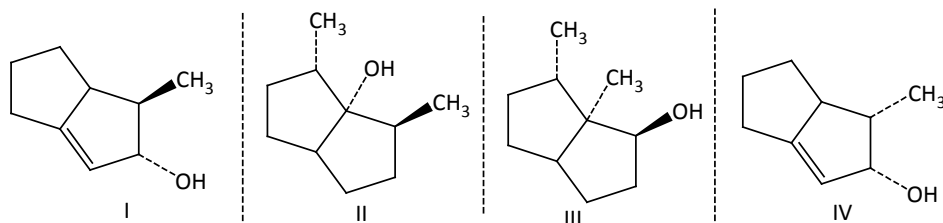


22. Which of the following alcohols will form a chiral 2° alkyl bromide upon reaction with  $\text{PBr}_3$ ? **B**

- |   |
|---|
| <p>a) I &amp; II<br/>b) II<br/>c) III<br/>d) II &amp; IV<br/>e) I</p> |
|---|

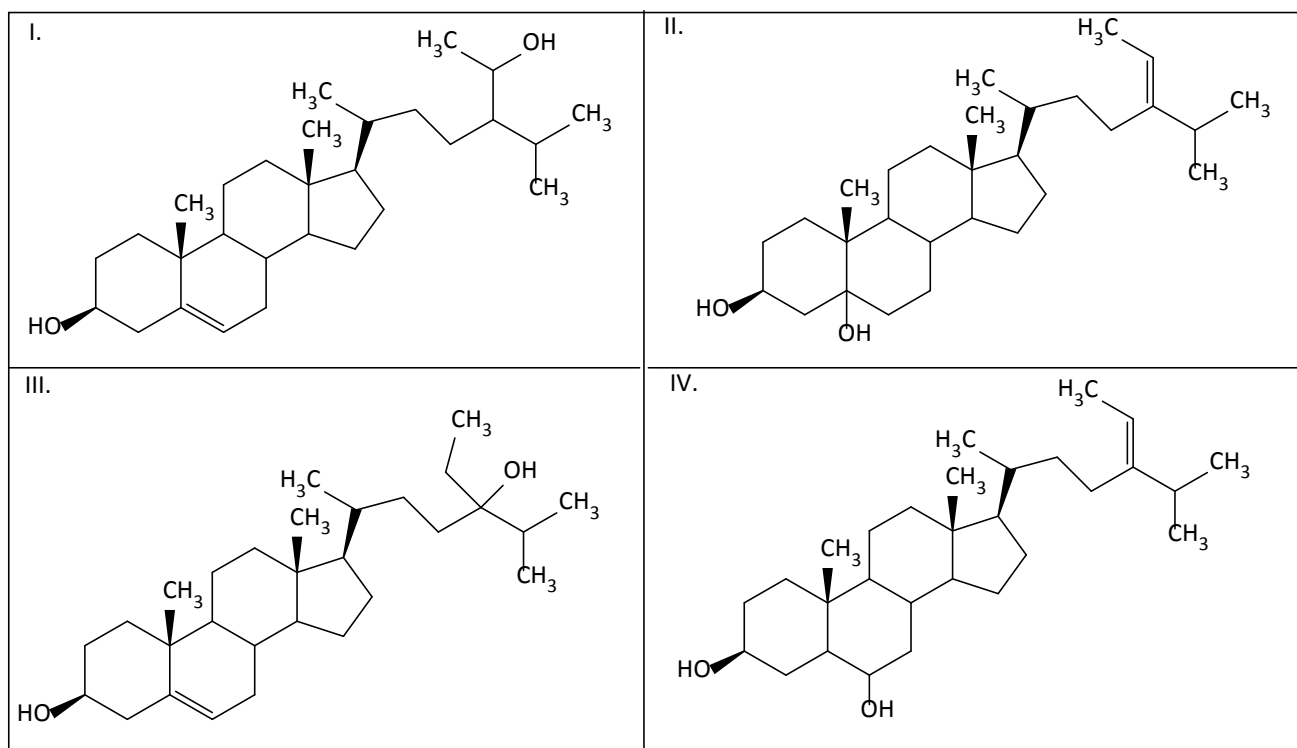
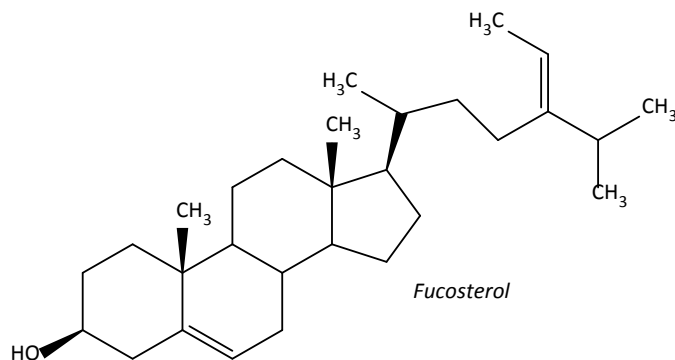
- |  |
|--|
| <p>I. 3R, 4S-3,4-dimethyl-3-hexanol<br/>II. 3R-2,2-dimethyl-3-hexanol<br/>III. 3-methyl-3-pentanol<br/>IV. 3S-3,5-dimethyl-3-hexanol</p> |
|--|

23. Which of the following compounds cannot undergo reaction with  $\text{POCl}_3$ ,  $\text{Et}_3\text{N}$ ? **E**



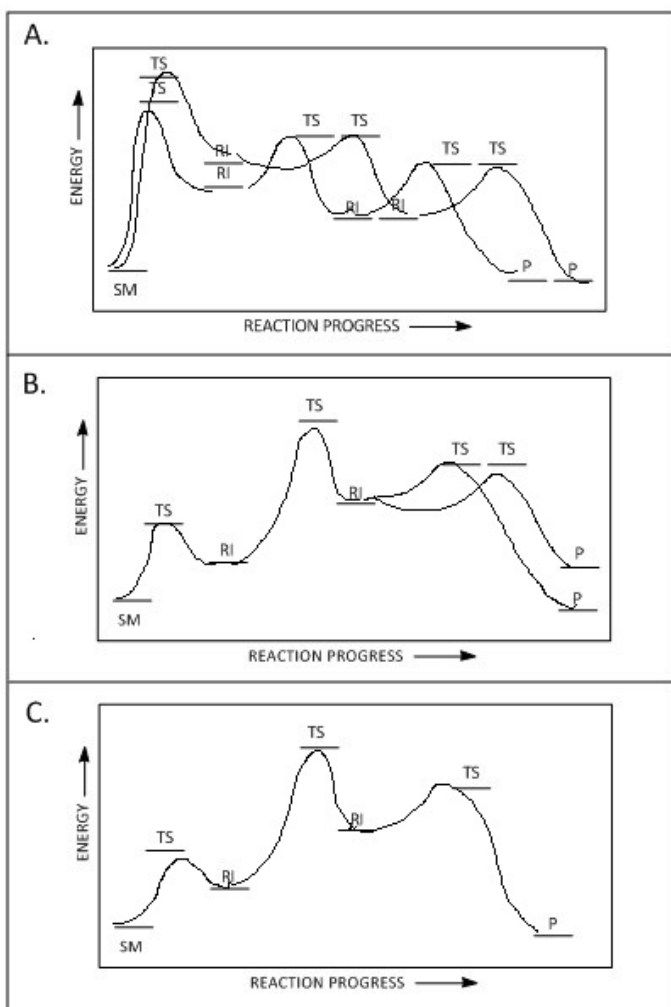
- |   |
|---|
| <p>a) I &amp; IV<br/>b) II &amp; IV<br/>c) I &amp; II<br/>d) III<br/>e) I</p> |
|---|

24. Which alcohol(s) would form the fastest in the reaction of fucosterol with one equivalent of  $\text{H}_3\text{O}^+$  (i.e., only one alkene reacts)? **C**



- a) I
- b) I & III
- c) II & III
- d) IV
- e) III

25. Match the reaction energy diagrams to each of the reactions given below. **E**  
(Assume no rearrangements occur in any reactions)



**REACTIONS**

- I. 1-methylcyclopentanol + HCl  $\rightarrow$
- II. 1-methylcyclopentene +  $\text{H}_3\text{O}^+$   $\rightarrow$
- III. 1-methylcyclopentanol +  $\text{H}_2\text{SO}_4$   $\rightarrow$

- a) A = I ; B = II ; C = III
- b) A = II ; B = I ; C = III
- c) A = III ; B = I ; C = II
- d) A = III ; B = II ; C = I
- e) A = II ; B = III ; C = I