

## 《化學》

I. Choose one correct answer for the following questions

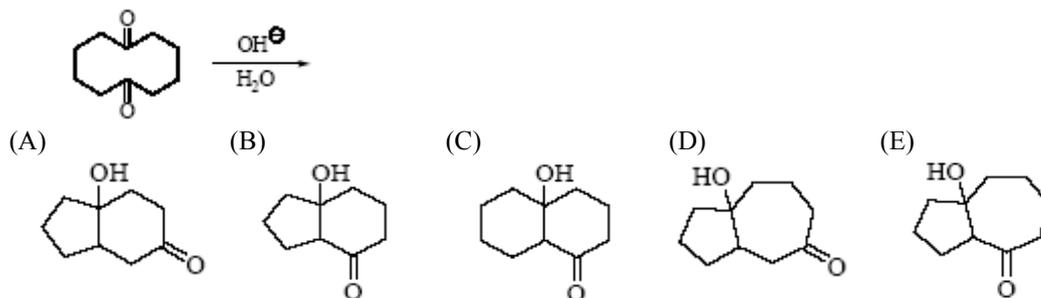
【單選題】每題 1 分，共計 60 分，答錯 1 題倒扣 0.25 分，倒扣至本大題零分為止，未作答，不給分亦不扣分。

- (A) 1. What is the carbon nucleophile which attacks molecular bromine in the acid-catalyzed  $\alpha$ -bromination of a ketone?  
 (A) an enol (B) a Grignard reagent (C) an acetylide  
 (D) a carbocation (E) an enolate

- (A) 2. What species is attacked by the alcohol's hydroxyl in the mechanism of the Swern oxidation?  
 (A) dimethylchlorosulfonium ion (B) dimethylsulfoxide (C) oxalyl chloride  
 (D) oxalium ion (E) aldehyde or ketone

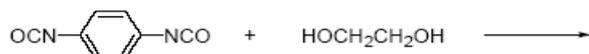
- (B) 3. When pyridine is treated with a mixture of nitric and sulfuric acids, the major product is .  
 (A) 2-nitropyridine (B) 3-nitropyridine (C) 4-nitropyridine  
 (D) 3-aminopyridine (E) 4-aminopyridine

- (E) 4. What is the major organic product of the following reaction?



- (A) 5. When (*R*)-butan-2-ol is treated with TsCl in pyridine, the product formed is .  
 (A) a single enantiomer (B) a racemic mixture  
 (C) a mixture of diastereomers (D) an achiral compound (E) none of the above

- (D) 6. What kind of polymer is produced in the following reaction?



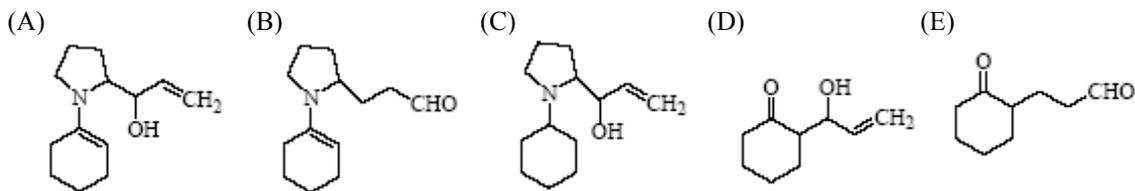
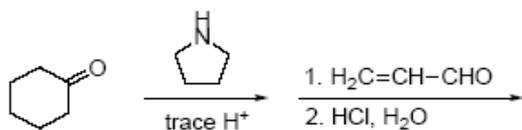
- (A) a polycarbonate (B) poly(acrylonitrile) (C) a polyester  
 (D) polyurethane (E) a synthetic rubber
- (B) 7. Which of the following reagents should be used to convert hex-3-yne to (*E*)-hex-3-ene?  
 (A)  $\text{H}_2$ , Pt (B) Na,  $\text{NH}_3$   
 (C)  $\text{H}_2$ , Lindlar's catalyst (D)  $\text{H}_2\text{SO}_4$ ,  $\text{H}_2\text{O}$  (E)  $\text{HgSO}_4$ ,  $\text{H}_2\text{O}$

- (A) 8.  $\text{S}_{\text{N}}1$  reaction usually proceed with .  
 (A) slightly more inversion than retention at the center undergoing substitution  
 (B) slightly more retention than inversion at the center undergoing substitution  
 (C) equal amounts of inversion and retention at the center undergoing substitution  
 (D) complete inversion at the center undergoing substitution  
 (E) complete retention at the center undergoing substitution

(C) 9. Peptide bonds are .

- (A) ester linkages (B) imido linkages (C) amide linkages (D) ether linkages (E) disulfide linkages

(E) 10. What is the major product of the following reaction?

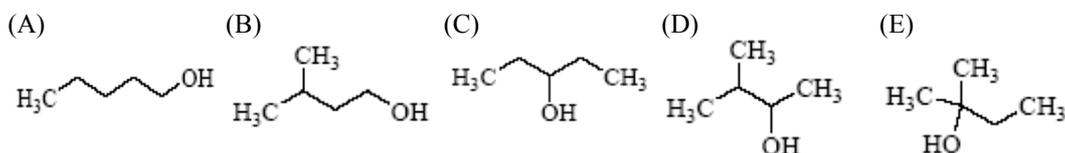


(D) 11. What compound is produced when  $(\text{CH}_3)_2\text{CHCH}_2\text{Br}$  is subjected to the following sequence of steps:

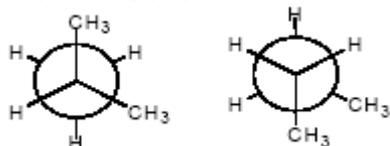
1. Mg,  $\text{Et}_2\text{O}$ , 2.  $\text{CO}_2$ , 3.  $\text{H}_3\text{O}^+$ ?

- (A) 2-methylpropanoic acid (B) 3-methylpropanoic acid  
(C) 2-methylbutanoic acid (D) 3-methylbutanoic acid  
(E) 2-methylhexanoic acid

(E) 12. Which of the following alcohols will react most rapidly with the Lucas reagent ( $\text{HCl}$ ,  $\text{ZnCl}_2$ )?



(C) 13. The structures below are .



- (A) not isomers (B) conformational isomers (C) structural isomers  
(D) *cis-trans* isomers (E) both B and D

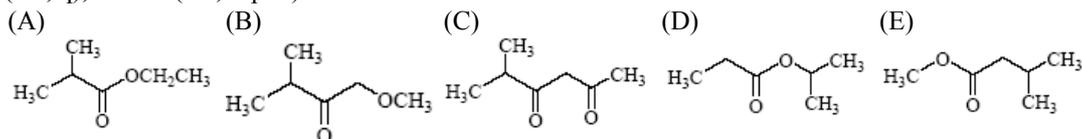
(A) 14. The Hell-Volhard-Zelinsky reaction involves .

- (A) the  $\alpha$ -bromination of carboxylic acids  
(B) the  $\alpha$ -bromination of ketones  
(C) the bromination of alcohols  
(D) the oxidation of aldehydes to acids  
(E) none of the above

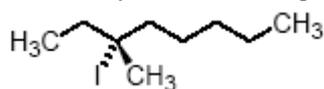
(B) 15. When indole is treated with bromine in dioxane at  $0^\circ\text{C}$ , the major organic product is .

- (A) 2-bromoindole (B) 3-bromoindole (C) 4-bromoindole (D) 5-bromoindole (E) 6-bromoindole

(D) 16. Which compound has a  $^1\text{H}$  NMR spectrum consisting of the following peaks: 0.9 (6H, d), 1.0 (3H, t), 2.2 (2H, q), and 4.0 (1H, septet)?



(E) 17. How many distinct alkene products are possible when the alkyl iodide below undergoes E2 elimination?



- (A) 1 (B) 2 (C) 3 (D) 4 (E) 5

(A) 18. Which of the following describes the compound below?



- (A) bridged bicyclic (B) fused bicyclic (C) spiro bicyclic (D) bridged tricyclic (E) fused tricyclic

(C) 19. What method will produce the transformation?

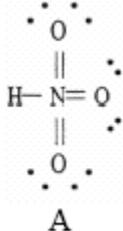


- (A) Li / ND<sub>3</sub> (B) (sia)<sub>2</sub>BD then H<sub>2</sub>O  
(C) CH<sub>3</sub>CH<sub>2</sub>MgBr then D<sub>3</sub>O<sup>+</sup> (D) (sia)<sub>2</sub>BD then D<sub>2</sub>O (E) LiAlD<sub>4</sub> then D<sub>2</sub>O

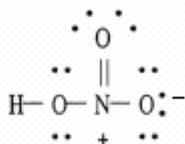
(B) 20. Energy is \_\_\_\_\_ when bonds are formed and is \_\_\_\_\_ when bonds are broken; therefore, bond dissociation energies are always \_\_\_\_\_.

- (A) released / consumed / exothermic (B) released / consumed / endothermic  
(C) consumed / released / exothermic (D) consumed / released / endothermic  
(E) consumed / released / isothermic

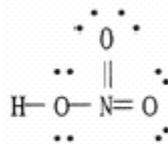
(B) 21. Which of the following are correct Lewis structures, including formal charges, for nitric acid, HNO<sub>3</sub>?



A



B



C

- (A) A only (B) B only (C) C only (D) both B and C (E) A, B, and C

(E) 22. Which of the following alkyl chlorides is least likely to undergo rearrangement during a solvolysis reaction?

- (A) *cis*-1-chloro-2-ethylcyclohexane (B) *trans*-1-chloro-2-ethylcyclohexane  
(C) 2-chloro-4-methylpentane (D) 2-chloro-3-methylpentane  
(E) 2-chloro-2-methylpentane

(A) 23. Which of the following descriptions of the nucleoside uridine does not apply to the structure of the molecule?

- (A) The uracil base is directly bonded to the 1' position of ribofuranose in the  $\alpha$  position.  
(B) The ribofuranose moiety is found in only the D configuration.  
(C) Nitrogen, at position 1 in the uracil base, is directly bonded to the ribofuranose moiety.  
(D) The 5' OH group is replaced with phosphate(s) in the nucleotide structure.  
(E) none of the above

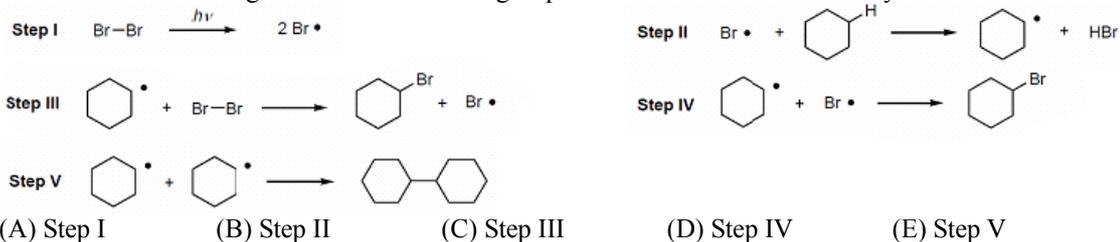
(E) 24. Which of the following is correct in order of decreasing nucleophilicity toward methyl iodide in methanol?

- (A) CH<sub>3</sub>O<sup>-</sup> > CH<sub>3</sub>S<sup>-</sup> > CN<sup>-</sup> > Br<sup>-</sup> (B) CH<sub>3</sub>O<sup>-</sup> > CN<sup>-</sup> > CH<sub>3</sub>S<sup>-</sup> > Br<sup>-</sup>  
(C) CN<sup>-</sup> > CH<sub>3</sub>O<sup>-</sup> > CH<sub>3</sub>S<sup>-</sup> > Br<sup>-</sup> (D) CH<sub>3</sub>S<sup>-</sup> > Br<sup>-</sup> > CH<sub>3</sub>O<sup>-</sup> > CN<sup>-</sup>  
(E) CH<sub>3</sub>S<sup>-</sup> > CN<sup>-</sup> > CH<sub>3</sub>O<sup>-</sup> > Br<sup>-</sup>

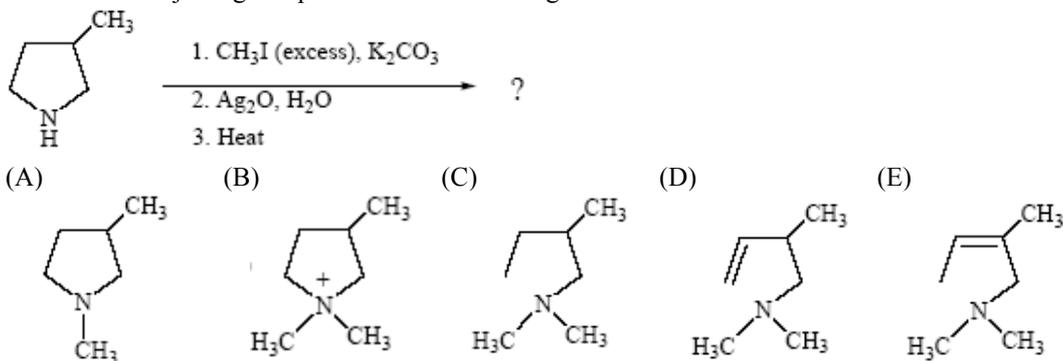
- (D) 25. Which of the following compounds will undergo  $S_N2$  reaction most readily?  
 (A)  $(CH_3)_3CCH_2I$  (B)  $(CH_3)_3CCl$  (C)  $(CH_3)_2CHI$   
 (D)  $(CH_3)_2CHCH_2CH_2CH_2I$  (E)  $(CH_3)_2CHCH_2CH_2CH_2Cl$

- (C) 26. Which of the following carbonyl compounds can be reduced by  $H_2$ /Raney Ni?  
 (A) acetic acid (B) ethyl acetate (C) acetyl chloride  
 (D) acetamide (E) *N*-methyl acetamide

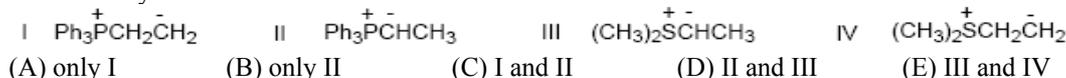
- (B) 27. Which of the following is the rate-determining step for the monobromination of cyclohexane?



- (D) 28. What is the major organic product of the following reaction?



- (D) 29. Which are ylides?

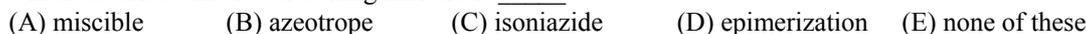


- (E) 30. Which of the following chemical reactions could be used to distinguish between a polyunsaturated vegetable oil and a petroleum oil containing a mixture of saturated and unsaturated hydrocarbons?  
 (A) addition of bromine in carbon tetrachloride (B) ozonolysis  
 (C) hydrogenation (D) lipidification (E) saponification

- (A) 31. When an alkene is subjected to treatment with  $Hg(OAc)_2$  in alcohol followed by reaction with  $NaBH_4$ , what new class of compound is formed?



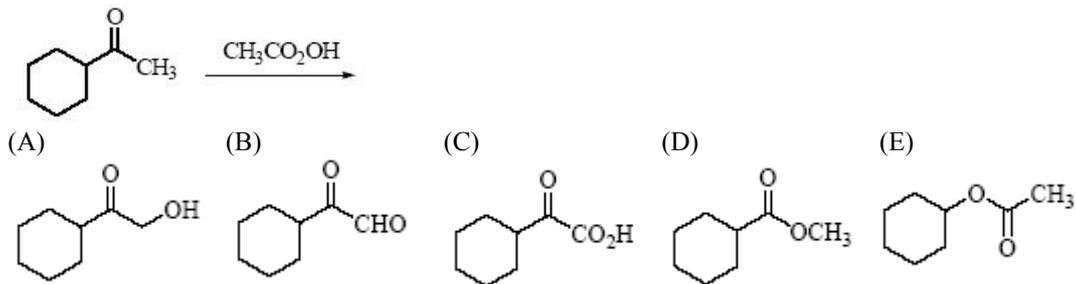
- (B) 32. Distillation of mixtures of ethanol and water cannot increase the ethanol content of the mixture above 95% because this solution boils at a lower temperature than either pure ethanol or pure water. The term which describes this lower boiling mixture is \_\_\_\_\_.



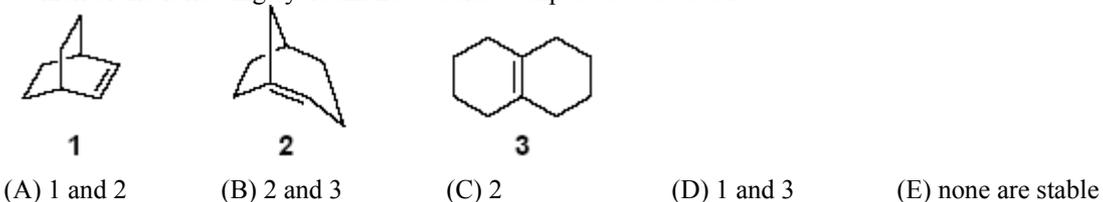
- (C) 33. The methyl ester of a carboxylic acid can be synthesized by directly using .



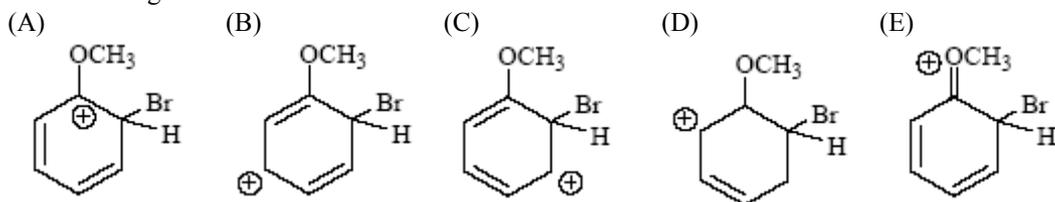
- (E) 34. What is the major product of the following reaction?



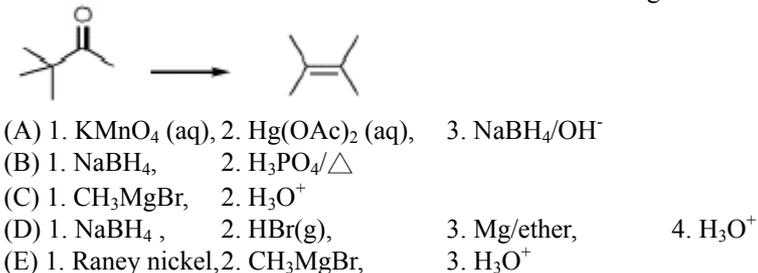
(D) 35. Which of the following cycloalkenes would be expected to be stable?



(E) 36. Which of the following structures is the most important contributor to the resonance hybrid formed when anisole undergoes *ortho*-bromination?



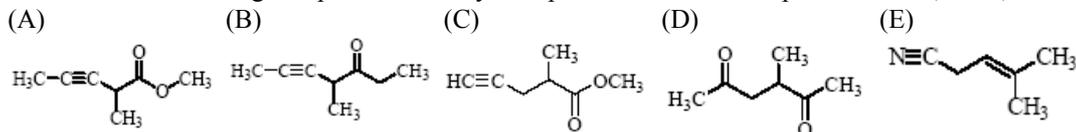
(B) 37. Which series of reactions would best facilitate the following conversion?



(D) 38. A pure sample of (*S*)-phenylalanine has a specific rotation of  $+70^\circ$ . A mixture of the two enantiomers of phenylalanine gives a specific rotation of  $-7.0^\circ$ . What are the percentages of the *S* and *R* enantiomers in the mixture?

- (A) 75 % *S*, 25 % *R* (B) 65 % *S*, 35 % *R* (C) 55 % *S*, 45 % *R*  
 (D) 45 % *S*, 55 % *R* (E) 35 % *S*, 65 % *R*

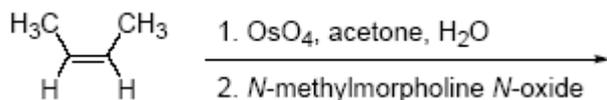
(C) 39. Which of the following compounds would you expect to show IR absorptions at  $1735$ ,  $2100$ ,  $3300\text{ cm}^{-1}$ ?



(A) 40. Which of the following compounds would most likely be used in the preparation of isobutylbenzene from benzene?

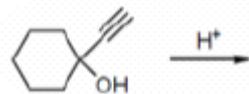
- (A)  $(\text{CH}_3)_2\text{CHCOCl}$  (B)  $(\text{CH}_3)_2\text{CHCH}_2\text{Cl}$  (C)  $(\text{CH}_3)_2\text{CHCH}_2\text{Br}$   
 (D)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Cl}$  (E)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCl}$

(D) 41. What is the product of the following reaction?



- (A) acetaldehyde  
 (B) acetic acid  
 (C) racemic (2*R*,3*R*) and (2*S*,3*S*)-2,3-butanediol  
 (D) *meso*-2,3-butanediol  
 (E) *cis*-2,3-epoxybutane

(B) 42. Provide the structure of the major organic product in the following reaction:



- (A) (B) (C) (D) (E)

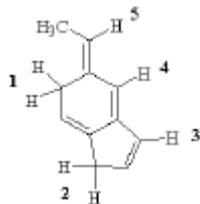
(C) 43. Which of the following describes the most stable conformation of *trans*-1-isopropyl-3-methylcyclohexane?

- (A) Both groups are equatorial.  
 (B) Both groups are axial.  
 (C) The isopropyl group is equatorial and the methyl group is axial.  
 (D) The isopropyl group is axial and the methyl group is equatorial.  
 (E) none of the above

(E) 44. Which of the following compounds will react most rapidly with HCl?

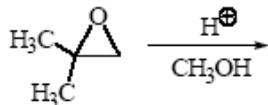
- (A) 5-methyl-1-hexene (B) 4-methyl-1-hexene  
 (C) (*E*)-5-methyl-2-hexene (D) (*E*)-2-methyl-3-hexene  
 (E) 2-methyl-2-hexene

(A) 45. Which of the labeled H atoms (1-5) in the following molecule would be predicted to be the most acidic?



- (A) 1 (B) 2 (C) 3 (D) 4 (E) 5

(B) 46. What is the major product of the following reaction?



- (A) (B) (C) (D) (E)

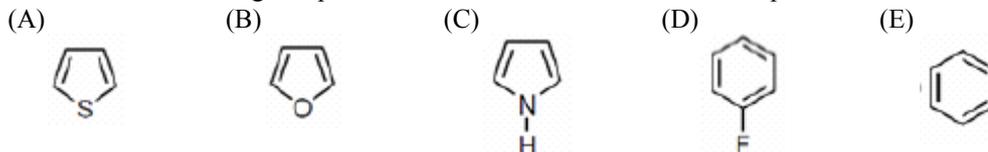
(E) 47. Which of the following compounds exhibits the pattern of  $m/z$  values shown below?

41, 43, 57, 87, 101, 116

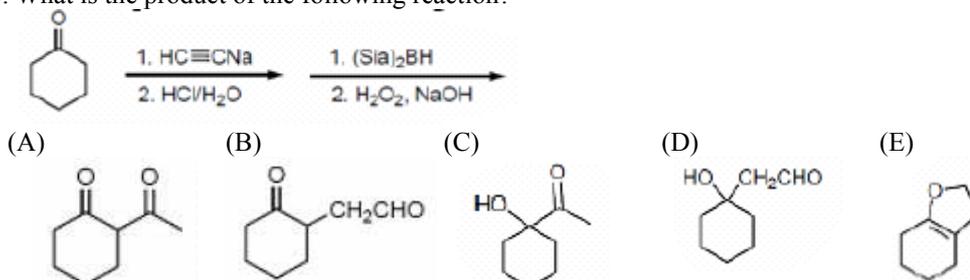
- (A) *n*-propylbromide (B) isopropyl bromide (C) 2-hexanol  
(D) 2-butanone (E) *sec*-butyl isopropyl ether

- (A) 48. Which of the following statements correctly pertains to a pair of enantiomers?  
(A) They rotate the plane of polarized light by exactly the same amounts and in opposite directions.  
(B) They rotate the plane of polarized light by differing amounts and in opposite directions.  
(C) They rotate the plane of polarized light by differing amounts and in the same directions.  
(D) They have the same specific rotation, but they have different melting points.  
(E) They have the same melting points, but they have different boiling points.

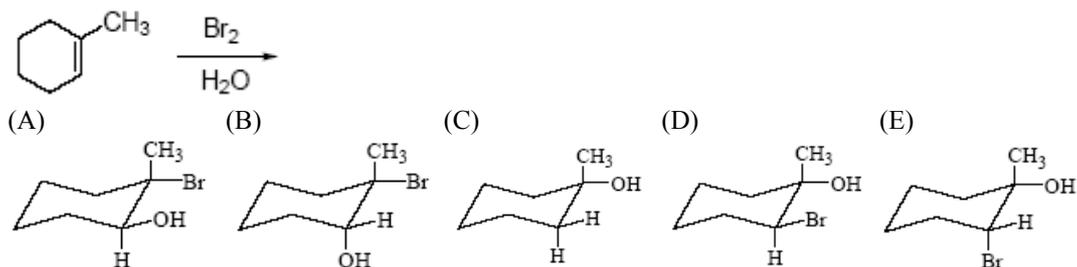
- (C) 49. Which of the following compounds is the most reactive toward electrophilic aromatic substitution?



- (D) 50. What is the product of the following reaction?



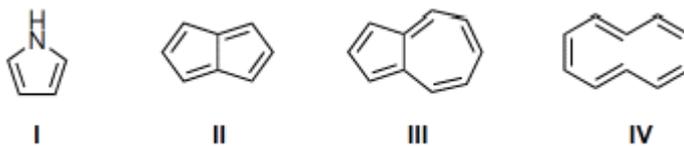
- (D) 51. What is the major product of the following reaction?



- (B) 52. Which of the following compounds has the most signals in the noise-decoupled <sup>13</sup>C NMR spectrum?

- (A) *o*-dibromobenzene (B) *m*-dibromobenzene (C) *p*-dibromobenzene  
(D) 1,3,5-tribromobenzene (E) 1,2,3,4-tetrabromobenzene

- (C) 53. Identify the aromatic compounds.

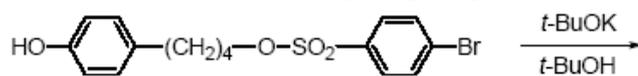


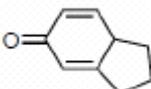
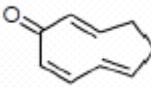
- (A) I and II (B) II and III (C) I and III (D) III and IV (E) I, III and IV

- (E) 54. Which of the following compounds has the highest melting point?

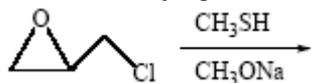
- (A) benzene (B) toluene (C) *o*-dichlorobenzene  
(D) *m*-dichlorobenzene (E) *p*-dichlorobenzene

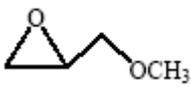
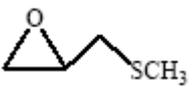
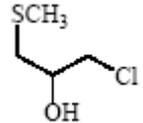
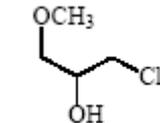
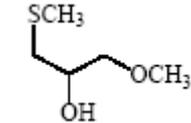
(D) 55. Provide the structure of the major organic product in the following reaction.



- (A)  (B)  (C)  (D)  (E) none of these

(B) 56. What is the major product of the following reaction?



- (A)  (B)  (C)  (D)  (E) 

(E) 57. A sample of compound X is subjected to elemental analysis and the following percentages by weight are found: 39.97% C, 6.73% H, and 53.30% O. The molecular weight of X is 90. What is the empirical formula of X?

- (A)  $\text{C}_6\text{H}_8\text{O}$  (B)  $\text{C}_2\text{H}_4\text{O}_2$  (C)  $\text{C}_4\text{H}_{10}\text{O}_2$  (D)  $\text{C}_3\text{H}_6\text{O}_3$  (E)  $\text{CH}_2\text{O}$

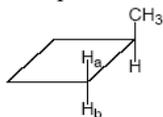
(E) 58. Which of the following conditions will drive the equilibrium of the Fischer esterification towards ester formation?

- (A) addition of water (B) removal of water as it is formed  
(C) addition of an inorganic acid as a catalyst (D) addition of alcohol  
(E) both B and D

(B) 59. The Wittig reaction involves .

- (A) formation of carboxylic acids  
(B) formation of alkenes  
(C) formation of  $\alpha, \beta$ -unsaturated carboxylic acids  
(D) formation of  $\beta$ -ketoesters  
(E) formation of alcohols

(C) 60. The protons marked  $\text{H}_a$  and  $\text{H}_b$  in the molecule below are \_\_\_\_\_.

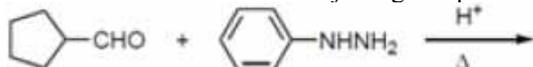


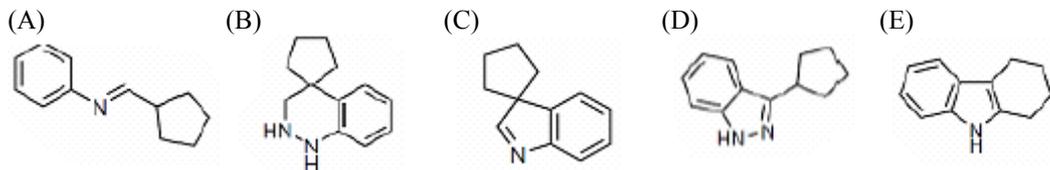
- (A) chemically equivalent (B) enantiotopic (C) diastereotopic  
(D) endotopic (E) none of the above

II. Choose one correct answer for the following questions

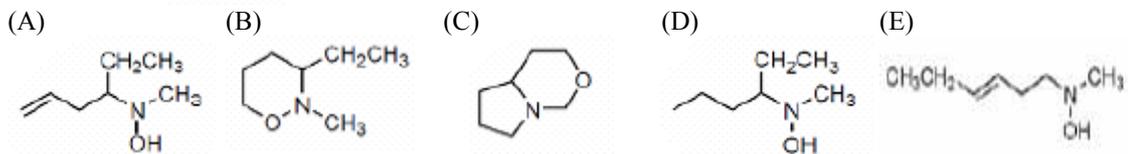
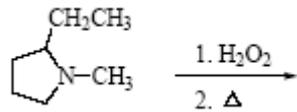
【單選題】每題 2 分，共計 40 分，答錯 1 題倒扣 0.5 分，倒扣至本大題零分為止，未作答，不給分亦不扣分。

(E) 61. Provide the structure of the major organic product in the following reaction.

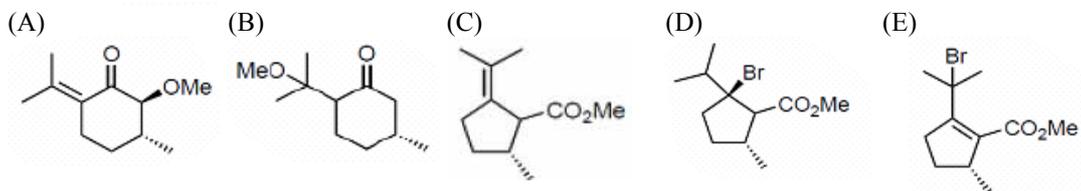
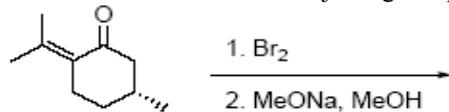




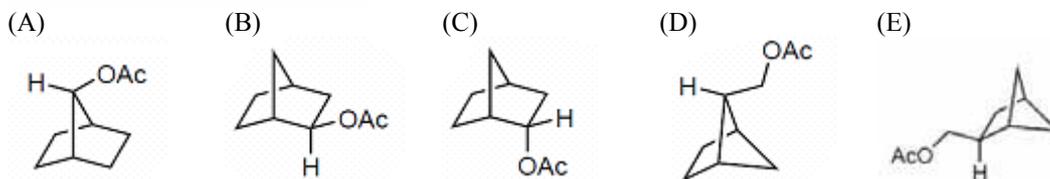
(A) 62. Provide the structure of the major organic product in the following reaction.



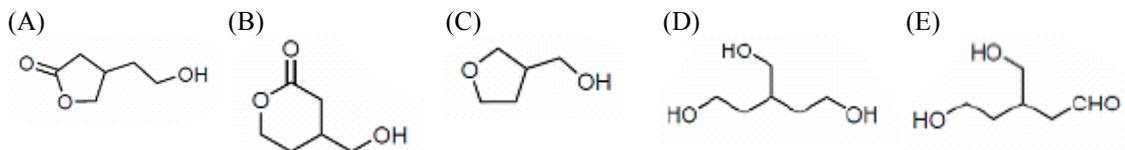
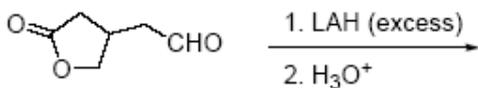
(C) 63. Provide the structure of the major organic product in the following reaction.



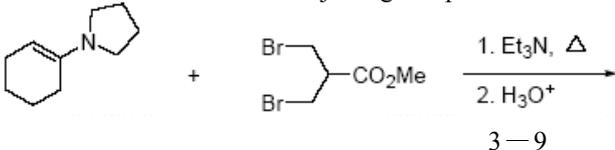
(B) 64. Provide the structure of the major organic product in the following reaction.

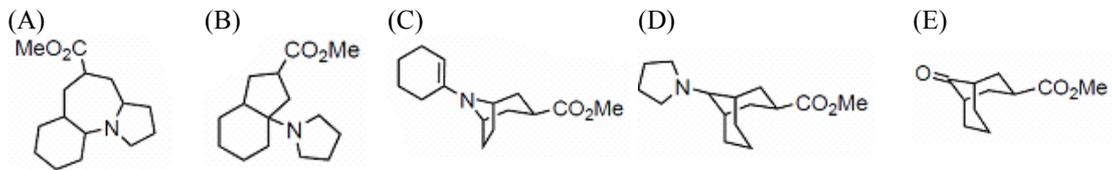


(D) 65. Provide the structure of the major organic product in the reaction below.

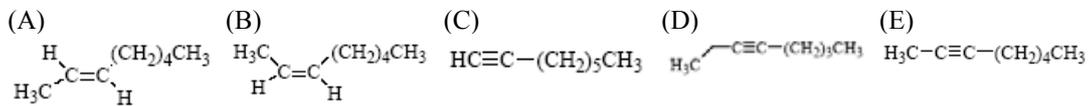
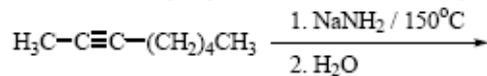


(E) 66. Provide the structure of the major organic product in the following reaction.





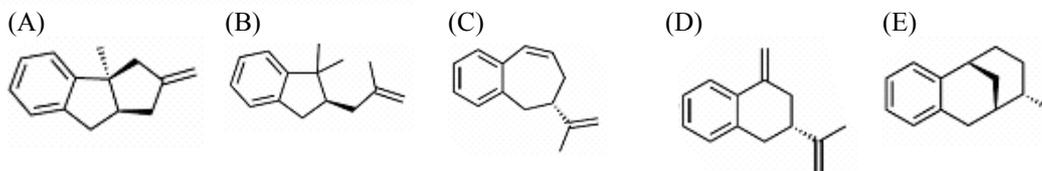
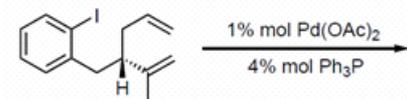
(C) 67. What is the major product of the following reaction?



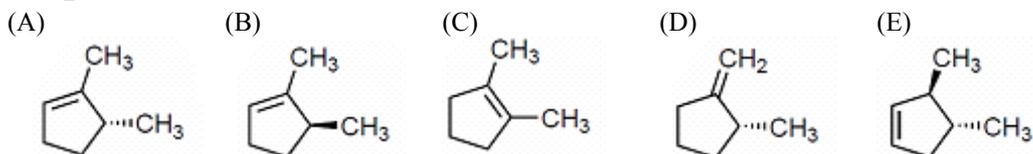
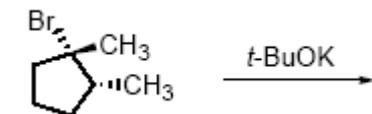
(C) 68. What is the major organic product resulted from tetrahydrofuran being reacted with excess HBr?

- (A) 1,2-dibromobutane (B) 1,3-dibromobutane (C) 1,4-dibromobutane  
(D) 4-bromobutan-1-ol (E) 3-bromobutan-1-ol

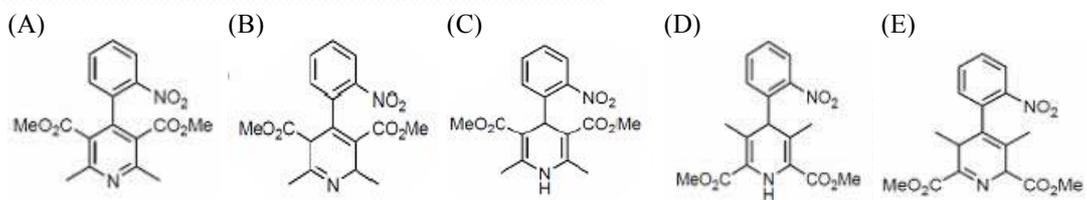
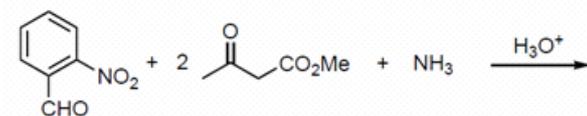
(A) 69. Provide the structure of the major organic product in the following reaction.



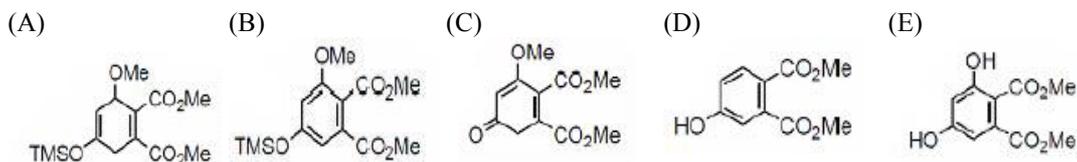
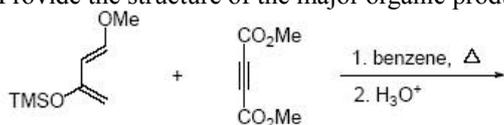
(D) 70. Identify the major product of the reaction below.



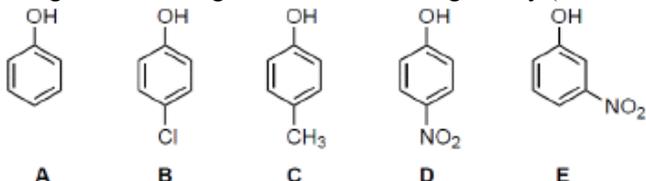
(C) 71. Provide the structure of the major organic product in the following reaction.



(D) 72. Provide the structure of the major organic product in the following reaction.

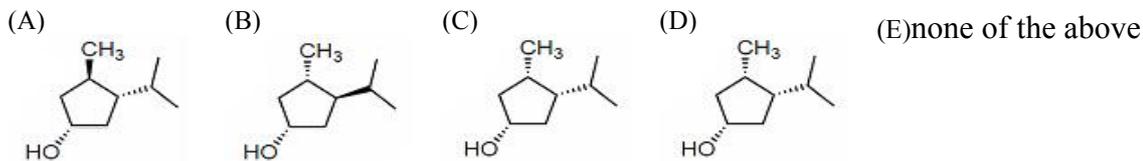
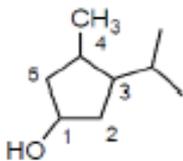


(B) 73. Arrange the following in order of increasing acidity (least acidic first).



- (A)  $B < C < A < D < E$       (B)  $C < A < B < E < D$       (C)  $C < A < E < B < D$   
 (D)  $E < C < A < B < D$       (E) none of these

(C) 74. Based on the structure shown below, choose the stereoisomer having a configuration of (1R,3S,4S) in a perspective structure.

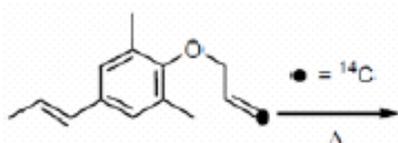


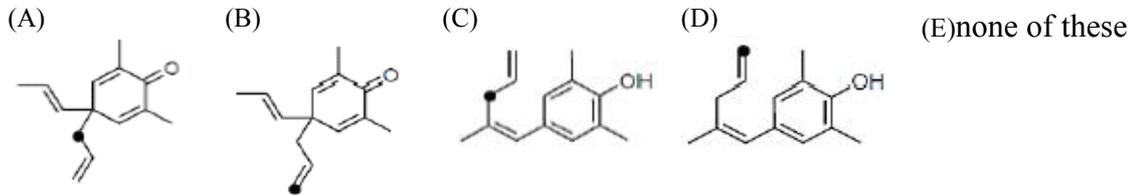
(E) 75. Deduce the identity of the compound from the data provided.

$C_8H_{13}Br$ ,  $^1H$  NMR  $\delta$  (splitting, integral): 3.5 (t, 2H), 1.8 (t, 2H), 0.9 (s, 9H);  $^{13}C$  NMR: 6 signals.

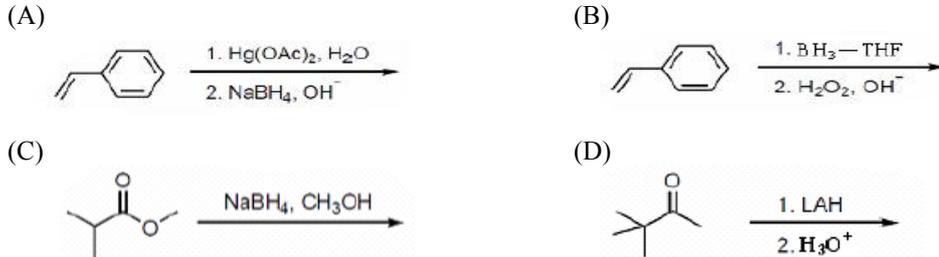
- (A) 5-bromo-2,2-dimethylhex-3-yne      (B) 6-bromo-4,4-dimethylhex-1-yne  
 (C) 3-bromo-1,2-dimethylcyclohexene      (D) 4-bromo-1,2,4-trimethylcyclopentene  
 (E) 1-bromo-5,5-dimethylhex-3-yne

(C) 76. Provide the structure of the major organic product in the following reaction.





(E) 77. Which of the following reactions will result in the formation of a secondary alcohol(s) in good yield?



(E) both (A) and (D)

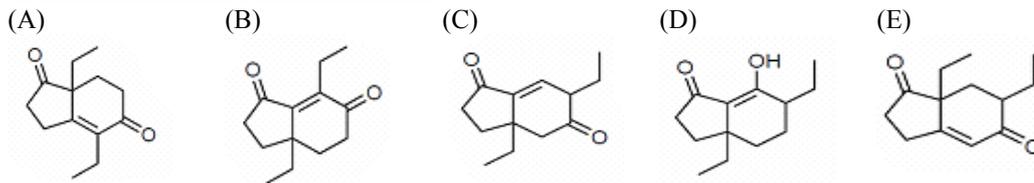
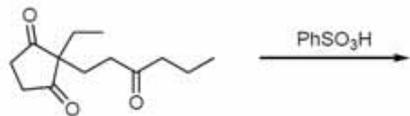
(D) 78. Arrange the following reactions in order for preparing 1,4-diaminobutane from cyclohexene.

I.  $\text{NH}_3$  II.  $\text{KMnO}_4, \text{H}_3\text{O}^+$  III.  $\text{Br}_2, \text{NaOH}/\text{H}_2\text{O}$  IV.  $\text{SOCl}_2$

(A) I  $\rightarrow$  IV  $\rightarrow$  II  $\rightarrow$  III (B) II  $\rightarrow$  III  $\rightarrow$  I  $\rightarrow$  IV (C) IV  $\rightarrow$  II  $\rightarrow$  III  $\rightarrow$  I

(D) II  $\rightarrow$  IV  $\rightarrow$  I  $\rightarrow$  III (E) none of these

(A) 79. Provide the structure of the major organic product in the following reaction.



(B) 80. Provide the structure of the major organic product in the following reaction.

