國　立　清　華　大　學　命　題　紙

95 學年度 生醫工程與環境科學 系（所） 乙(環境分子科學) 組碩士班入學考試

科目 有機化學及物理化學 科目代碼 3104 共 9 頁第 1 頁 *請在【答案卷卡】內作答

一、有機化學

單一選擇題 (50%；每題二分；務必以答案卡作答；答錯不扣分)

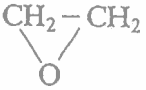
1. The structural formulas indicate that one should predict that which of the following compounds has the largest dipole moment?

(A) CCl_4
(B) $O=C=O$
(C) $(CH_3)_2C=C(CH_3)_2$
(D) *trans* $ClCH=CHCl$
(E) *cis* $ClCH=CHCl$

2. Which of the following compounds has a bond formed by overlap of $sp-sp^3$ hybrid orbitals?

(A) $CH_3-C\equiv C-H$
(B) $CH_3CH=CHCH_3$
(C) $H-C\equiv C-H$
(D) $CH_3CH_2CH_2CH_3$
(E) $CH_2=CH-CH=CH_2$

3. A tertiary alcohol is formed when excess phenylmagnesium bromide reacts with

(A) CH_3COOCH_3
(B) $HCOOCH_3$
(C) CH_3CHO
(D) H_2CO
(E) 

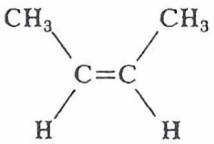
4. If one assumes that substitution could occur at any unsubstituted position, which of the following compounds could form two and only two mononitration products?

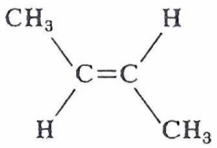
(A) Chlorobenzene
(B) 1, 3, 5-Trichlorobenzene
(C) *p*-Dichlorobenzene
(D) 1, 2, 3, 4-Tetrachlorobenzene
(E) *o*-Dichlorobenzene

5. Treatment of propionaldehyde, CH_3CH_2CHO, with dilute sodium hydroxide causes an aldol condensation and the formation of

(A) $CH_3CH_2COOCH_2CH_2CH_3$
(B) $CH_3CH_2CHOHCH(CH_3)CHO$
(C) $CH_3CH_2CHOHCH_2CH_2CHO$
(D) $CH_3CH_2COCH_2CH_2CHO$
(E) $CH_3CH_2COCH(CH_3)CHO$

6. Which of the following compounds has only a single sharp peak in its ^1H nuclear magnetic resonance spectrum?

(A) 

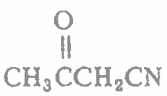
(B) 

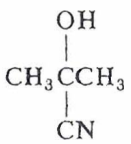
(C) $CH_3CH_2CH_2CH_3$

(D) FCH_2CH_2F

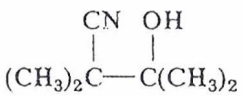
(E) $ClCH_2CH_2Cl$

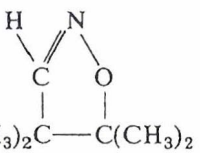
7. Which of the following is the major organic product when acetone, CH_3COCH_3, is allowed to react with hydrogen cyanide in the presence of a catalytic amount of sodium cyanide?

(A) 

(B) 

(C) $(CH_3)_2C{=}C{=}NH$

(D) 

(E) 

8. Of the following, which compound is the strongest Brönsted-Lowry acid?

(A) $CH_3-CH_2-CH_2-OH$

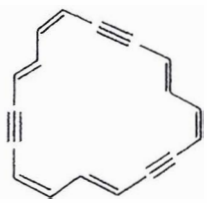
(B) $CH_3-CHBr-COOH$

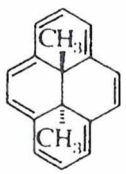
(C) $CH_3-C\equiv C-H$

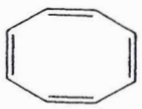
(D) CH_3-CH_2-COOH

(E) $CH_3-CH_2-SO_3H$

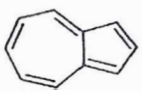
9. Which of the following molecules is NOT considered to be aromatic?

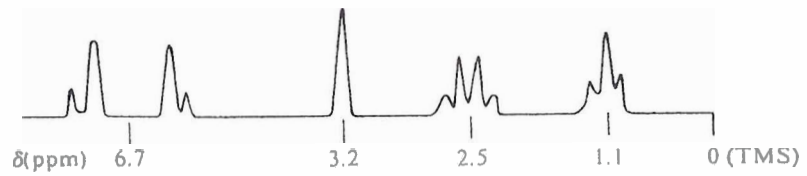
(A) 

(B) 

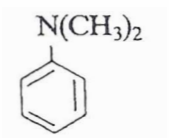
(C) 

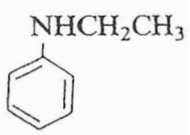
(D) 

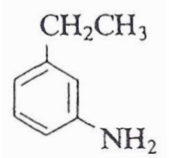
(E) 

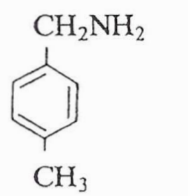


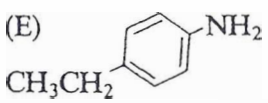
A compound with the molecular formula $C_8H_{11}N$ showed infrared absorption near 2.9 microns (3,448 cm^{-1}), ultraviolet absorption at 235 nanometers ($\epsilon = 1{,}480$), and the nuclear magnetic resonance spectrum depicted above. Which of the following structures is consistent with these data?

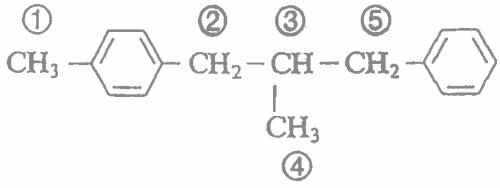
(A) 

(B) 



(D) 

(E) 

11. 

In the structural formula shown above, which of the numbered hydrogen atoms is LEAST susceptible to substitution by Cl radicals? (Assume that the reaction occurs by a free radical mechanism under reaction conditions in which substitution of hydrogen is selective.)

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

12. The concept that best explains the greater volatility of *o*-nitrophenol over *p*-nitrophenol during steam distillation of a mixture of the two compounds is

(A) hyperconjugation
(B) hydrogen bonding
(C) the *ortho*-effect
(D) resonance
(E) symmetry

13. A hexapeptide is hydrolyzed to the dipeptides Ileu-Val, Ala-Pro, and Lys-Leu. Carboxypeptidase acts on the hexapeptide to liberate valine, and 2, 4-dinitrofluorobenzene reacts with the hexapeptide to yield, after hydrolysis, 2, 4-dinitrophenylalanine. Which of the following is the amino acid sequence of the hexapeptide?

(A) Ala-Pro-Lys-Leu-Ileu-Val
(B) Val-Ileu-Lys-Leu-Pro-Ala
(C) Ileu-Val-Ala-Pro-Lys-Leu
(D) Val-Ala-Pro-Lys-Leu-Ileu
(E) Lys-Leu-Ala-Pro-Ileu-Val

14. Which of the following reactions is NOT a typical reaction of the carbonyl group ($>C=O$)?

(A) $>C=O + H_2 \xrightarrow{Pt} >CHOH$

(B) $>C=O + H_2N-OH \longrightarrow >C=N-OH + H_2O$

(C) $>C=O + CH_3Br \longrightarrow >C(Br)-O-CH_3$

(D) $>C=O + HCN \xrightarrow{OH^-} >C(CN)-OH$

(E) $>C=O + RMgBr \longrightarrow >C(R)-OMgBr$

15. Consider the compounds: butanone, pentanoic acid, hexanal, n-hexane, and n-heptanol. The boiling points of these compounds (in no specific order) are 69 °C, 80 °C, 131 °C, 176 °C, and 187 °C. Which of the following is the correct sequence of the boiling points from low to high?

(A) butanone < pentanoic acid < hexanal < n-hexane < n-heptanol

(B) butanone < pentanoic acid < n-hexane < hexanal < n-heptanol

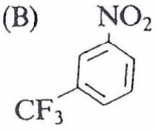
(C) n-hexane < butanone < hexanal < n-heptanol < pentanoic acid

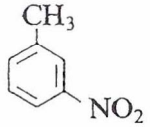
(D) n-hexane < butanone < n-heptanol < hexanal < pentanoic acid

(E) butanone < n-hexane < hexanal < pentanoic acid < n-heptanol

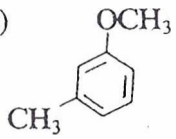
16. Which of the following compounds would be most susceptible to electrophilic attack by nitronium ions?

(A) 

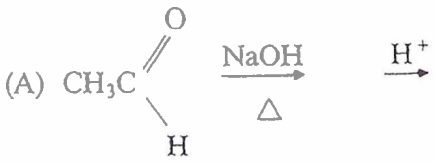
(B) 

(C) 

(D) 

(E) 

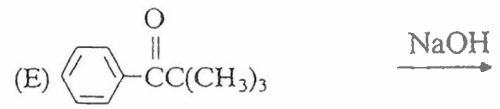
17. A carboxylic acid is formed in high yield by which of the following reactions?

(A) 

(B) 

(C) 

(D) 

(E) 

18. Which of the following is the predominant product in the reaction of HOBr with propene?

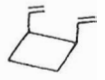
(A) 2-Bromo-1-propanol
(B) 3-Bromo-1-propanol
(C) 2-Bromo-2-propanol
(D) 1-Bromo-2-propanol
(E) 1, 2-Dibromopropane

19. The dimer formed by heating 1,3-butadiene has which of the following structures?

(A) 

(B) 

(C) 

(D) 

(E) 

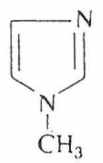
20. Which of the following reactions involves an enolate anion intermediate?

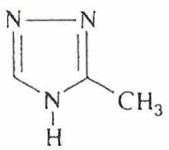
(A) Alkylation of an enamine with methyl iodide
(B) Self-condensation of acetaldehyde catalyzed by sodium hydroxide
(C) Solvolysis of *t*-butyl chloride in aqueous acetone
(D) Nucleophilic displacement of iodide from 2,4,6-trinitroiodobenzene by ethoxide ion
(E) Nitration of toluene

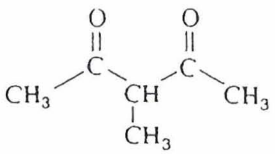
21. A laboratory preparation of pure propane involves

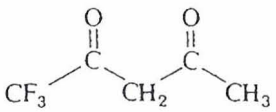
(A) the oxidation of propionic acid
(B) the action of sodium on propyl bromide
(C) the action of water on *n*-propyl magnesium bromide
(D) treating *n*-propyl alcohol with zinc and hydrochloric acid
(E) heating calcium propionate

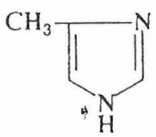
22. Which of the following compounds does NOT show tautomerism?

(A) 

(B) 

(C) 

(D) 

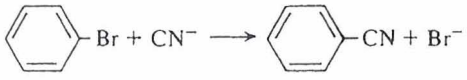
(E) 

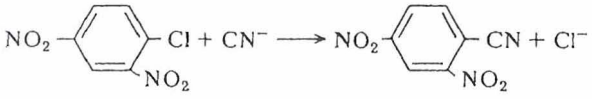
23. An unknown compound was found to react with sodium hydride with the evolution of hydrogen. The compound could not be acetylated under the normal conditions for acetylation. The compound resisted oxidation under mild conditions and under vigorous conditions yielded only products of molecular weight much smaller than the unknown. On the basis of these facts the compound is

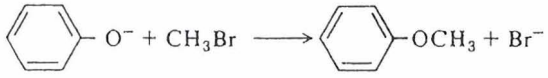
(A) a primary alcohol
(B) an aldehyde
(C) a secondary alcohol
(D) a tertiary alcohol
(E) a secondary amine

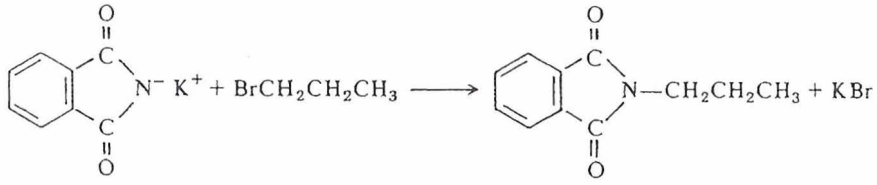
24. Which of the following reactions does NOT represent a practical method for nucleophilic displacement of a halide ion from an organic halide?

(A) $CH_3CH_2CH_2CH_2Br + CN^- \longrightarrow CH_3CH_2CH_2CH_2CN + Br^-$

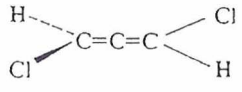
(B) 

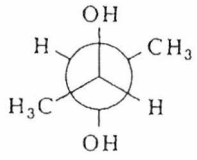
(C) 

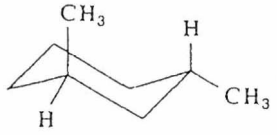
(D) 

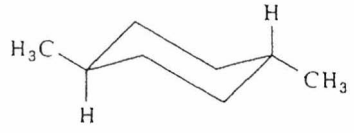
(E) 

25. Compounds that are incapable of optical activity include which of the following?

I. 

II. 

III. 

IV. 

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

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95 學年度 生醫工程與環境科學 系（所） 乙(環境分子科學) 組碩士班入學考試

科目 有機化學及物理化學 科目代碼 3104 共 9 頁第 9 頁 *請在【答案卷卡】內作答

二、物理化學

計算問答題 (50%；每題十分；務必作答於答案卷內)

1. The internal energy of a perfect monatomic gas relative to its value at T = 0 K is (3/2)nRT. Calculate (a) $(\partial P/\partial V)_T$ (b) $(\partial U/\partial P)_T$ (c) $(\partial H/\partial V)_T$ (d) $(\partial U/\partial T)_P$ (e) C_P-C_V (10%)

2. The vapor pressure of mercury at 536K is 103 torr. Estimate the normal boiling point of mercury. The enthalpy of vaporization of $Hg_{(l)}$ is 58.7 kJ/mol. (Hg: 200.59 g/mol) (10%)

3. For heating α mol of liquid water from T_{in} to T_{final} K ($T_{final} < 373K$) at a constant pressure of 1 atm, the system and the surroundings are connected only by a hot thin rod. Assume that the surroundings (consider the hot thin rod only) remain at T_{hot} ($T_{hot} > 373$ K) as the system warms up. The heat capacity of water at constant pressure is C_p (J/mol K). Calculate the entropy change of the process and show that this process is spontaneous. (10%)

4. A possible mechanism for $C_2H_6+H_2 \rightarrow 2CH_4$ is

(1) $C_2H_6 \rightleftharpoons 2CH_3$ K (equilibrium constant)

(2) $CH_3 + H_2 \rightarrow CH_4+H$ k_1 (rate constant)

(3) $H + C_2H_6 \rightarrow CH_4 + CH_3$ k_2 (rate constant)

(a) Derive the rate law assuming that the first reaction is at equilibrium, and the H atom concentration is small.

(b) Which one is the rate-determining step? (10%)

5. Consider an electron confined to some finite system. The state of the electron is described by the wavefunction $\psi = \sqrt{2}\sin(k\pi x)$, where k is some constant. Assume that the potential energy is zero, or $V(x) = 0$. What is the energy of the electron? (10%)