一、有機化學

單一選擇題 (50%；每題 2.5 分；務必以答案卡作答；答錯不倒扣)

1) Of the following compounds, which has the greatest resonance energy?

   (A) 2-Butene
   (B) Cyclohexene
   (C) 1,3-Butadiene
   (D) 2,3-Butanedione

   (E)
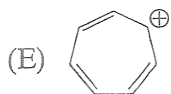
2) Which of the following compounds should be expected to have the highest boiling point?

   (A) $CH_3CH_2OCH_2CH_3$
   (B) $CH_3CH_2COCH_3$
   (C) $CH_3CH_2CH_2CH_2OH$
   (D) $CH_3CH_2CH_2COOH$
   (E) $CH_3CH_2CH_2CH_2CH_3$

3) The conversion of 1-butene to 1-butanol is accomplished in synthetically useful yield by treating the 1-butene with

   (A) HCl followed by H_2O
   (B) B_2H_6 followed by H_2O_2 and NaOH

   (C) $CH_3C\overset{O}{\underset{OOH}{}}$ followed by $LiAlH_4$
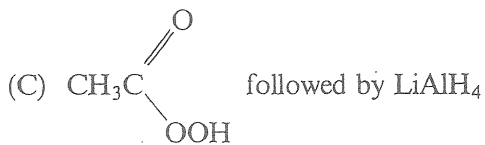
   (D) $KMnO_4$
   (E) $H_2(Pt)$ in H_2O

4) 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
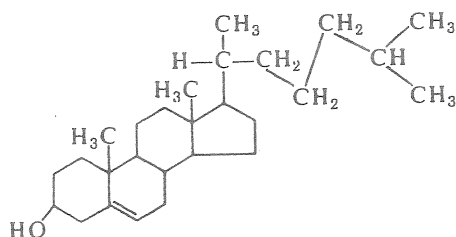
5) Secondary amines react with the nitrosonium ion to generate:

    A) diazonium salts

    B) oximes

    C) *N*-nitrosoamines

    D) imines

    E) anilines

6)

The formula above represents a member of the class of compounds known as

(A) terpenes   (B) alkaloids   (C) carbohydrates   (D) steroids
    (E) vitamins

7) Which of the following reagents should be used to convert an internal alkyne to an α–diketone?

    A) $KMnO_4$, H_2O, neutral

    B) O_3 then H_2O

    C) Sia_2BH then H_2O_2

    D) Na, NH_3
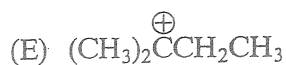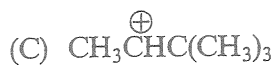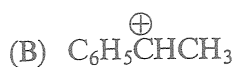
    E) $HgSO_4$, H_2SO_4

8) Both (*E*)- and (*Z*)-hex-3-ene can be subjected to a hydroboration–oxidation sequence. How are the products from these two reactions related to each other?

    A) The (*E*)- and (*Z*)-isomers generate the same products but in differing amounts.

    B) The (*E*)- and (*Z*)-isomers generate the same products in exactly the same amounts.

    C) The products of the two isomers are related as constitutional isomers.

    D) The products of the two isomers are related as diastereomers.

    E) The products of the two isomers are not structurally related.
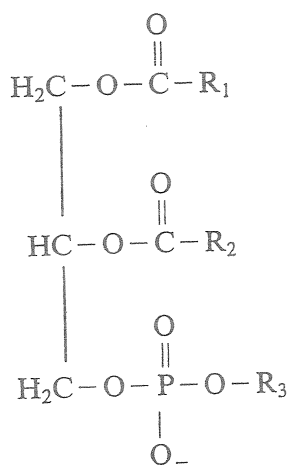
9) Which of the following carbocations would most easily undergo a 1,2-hydride shift?

(A) $(CH_3)_3C^{\oplus}$

(B) $C_6H_5\overset{\oplus}{C}HCH_3$

(C) $CH_3\overset{\oplus}{C}HC(CH_3)_3$

(D) $CH_3\overset{\oplus}{C}HCH(CH_3)_2$

(E) $(CH_3)_2\overset{\oplus}{C}CH_2CH_3$

10)

Phospholipids of the general formula shown above are arranged in lipid bilayers visualized as follows:
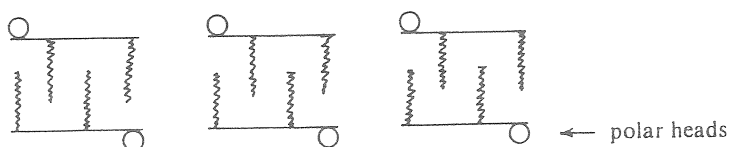
The polar heads which are exposed to an aqueous environment represent the

(A) fatty acid group R_1 only
(B) fatty acid groups R_1 and R_2
(C) phosphate diester function
(D) carbonyl function of the carboxylic acid
(E) glycerol backbone

11) The rate of a reaction typically increases as the temperature increases because:

   A) the A term in the Arrhenius equation increases.

   B) the fraction of molecules with kinetic energy greater than E_a increases.

   C) the activation energy decreases.

   D) the activation energy increases.

   E) the molecules make more collisions with the wall of the reaction vessel.

12) Which of the following correctly ranks the cycloalkanes in order of increasing ring strain per methylene?

   A) cyclopropane < cyclobutane < cyclohexane < cyclopentane

   B) cyclohexane < cyclopentane < cyclobutane < cyclopropane

   C) cyclohexane < cyclobutane < cyclopentane < cyclopropane

   D) cyclopentane < cyclopropane < cyclobutane < cyclohexane

   E) cyclopropane < cyclopentane < cyclobutane < cyclohexane

13) The Ka of formic acid is 1.7×10^{-4}. The pKa of formic acid is _____.

   A) 1.7   B) 4.0   C) −2.3   D) 3.8   E) 10.3

14) Which of the following is a condensation polymer?

   A) poly(ethylene terephthalate)

   B) poly(tetrafluoroethylene)

   C) polystyrene

   D) poly(vinyl chloride)

   E) poly(methyl α–methacrylate)

15) Which of the following terms best describes the compound below?

   $CH_3(CH_2)_7CH=CH(CH_2)_7CO_2H$

   A) an unsaturated fatty acid

   B) a triglyceride

   C) a synthetic detergent

   D) a micelle

   E) isoprene

16) Peptide bonds are:

   A) ester linkages.

   B) imido linkages.

   C) ether linkages.

   D) amide linkages.

   E) disulfide linkages.

17) Which of the following compounds undergoes dehydrohalogenation most rapidly in boiling ethanol by an E_1 mechanism?

   (A) $CH_3CBr=C(CH_3)_2$

   (B) $CH_3CHBrCH(CH_3)_2$

   (C) — $CHBrCH_3$

   (D) O_2N—— $CHBrCH_3$

   (E) CH_3O—— $CHBrCH_3$
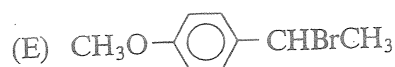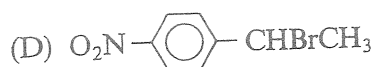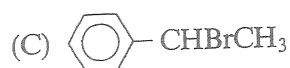
18) The reduction of cyclohexanone in isopropyl alcohol in the presence of aluminum isopropoxide can be used to prepare cyclohexanol in a good yield only if which of the following conditions is fulfilled?

   (A) The reaction is carried out at 0° C.
   (B) The reaction is irradiated with sunlight.
   (C) The acetone formed in the reaction is distilled away as the reaction is taking place.
   (D) The cyclohexanol is distilled away from the reaction mixture as the reaction is taking place.
   (E) The reaction is catalyzed with mercuric chloride.

19) Which of the following molecules is chiral?

   A) 1,2-pentadiene
   B) 2,3-pentadiene
   C) 2-methyl–2,3-pentadiene
   D) 2-chloro-4-methyl–2,3-pentadiene
   E) none of the above molecules is chiral

20) The preferred conformation of *trans*-1, 4-dimethylcyclohexane has the cyclohexane ring in the

   (A) chair form with both methyl groups equatorial
   (B) chair form with both methyl groups axial
   (C) chair form with one methyl group axial and one equatorial
   (D) boat form with the methyl groups pointing toward the center of the ring
   (E) boat form with the methyl groups pointing away from the ring

二、物理化學

計算問答題 (50%；務必作答於答案卷內)

1. Define the "entropy" and show that entropy is a state function from the first law of thermodynamics, by considering (a) an ideal gas; (b) arbitrary substance. (15%)

2. One mole of an ideal gas expands isothermally and reversibly from 90 to 300 L at 300K. (a) Calculate q, w, ΔU, ΔH and ΔS for this system. (b) If the expansion is carried out irreversibly by allowing the gas to expand into an evacuated container, what are the values of q, w, ΔU, ΔH and ΔS for this process? (20%)

3. (a) The ionization energy E_i of hydrogen atom is the energy required to remove the electron from the atom in its ground state to a position very far from the nucleus. Calculate the E_i of hydrogen atom in terms of electron volts.

$$E_n = -\frac{m_e e^4}{8\varepsilon_0^2 h^2 n^2}$$

where electron mass $m_e = 9.109\times10^{-31}$ kg; electronic charge $e = 1.602\times10^{-19}$ C; permittivity of vacuum $\varepsilon_0 = 8.854\times10^{-12}$ $C^2J^{-1}m^{-1}$; Planck constant $h = 6.626\times10^{-34}$ Js; n is the principal quantum number.

(b) Use the D_0 (spectroscopic dissociation energy) value of H_2 (4.478 eV) and the D_0 value of H_2^+ (2.651 eV) to calculate the first ionization energy of H_2 (that is, the energy needed to remove an electron from H_2).

(c) Plot the potential energy curves for the ground electronic states of H_2 and H_2^+ versus internuclear distance given that the equilibrium distance in H_2^+ is 106 pm and that of H_2 is 74.1pm. Illustrate the figure with previous data as clear as possible. (15%)