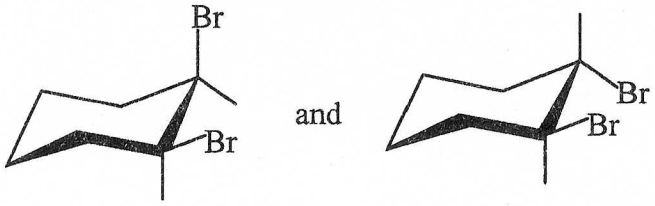
選擇題 (單選)

1. The pKa of CH_3COOH is 4.8. If the pH of an aqueous solution of CH_3COOH and CH_3COO^- is 4.8, then one knows _____.
   (A) CH_3COOH is completely ionized (B) $[CH_3COOH] > [CH_3COO^-]$
   (C) $[CH_3COOH] = [CH_3COO^-]$ (D) $[CH_3COOH] < [CH_3COO^-]$
   (D) CH_3COOH is completely unionized
2. Upon hydrogenation, which of the following alkenes releases the least heat per mole?
   (A) 3,4-dimethyl-1-hexene (B) (Z)-3,4-dimethyl-2-hexene
   (C) (E)-3,4-dimethyl-2-hexene (D) (Z)-3,4-dimethyl-3-hexene
   (E) (E)-3,4-dimethyl-3-hexene
3. Which of the following correctly describes the reaction shown below?
   $CH_2=CH_2 + HBr \rightarrow CH_3CH_2Br + heat$
   (A) $\Delta H°>0$ and $\Delta S°>0$ (B) $\Delta H°>0$ and $\Delta S°<0$ (C) $\Delta H°<0$ and $\Delta S°>0$
   (D) $\Delta H°<0$ and $\Delta S°<0$ (E) $\Delta H°= \Delta S°=0$
4. What is the relationship between the structures shown below?



   (A) enantiomers (B) diastereomers (C) configurational isomers
   (D) identical compounds (E) constitutional isomers
5. Which is the correct order of decreasing acidity in the following compounds?

H_2O	CH_3CH_3	NH_3	$CH_2=CH_2$	$HC\equiv CH$
A	B	C	D	E

   (A) A>E>C>D>B (B) A>E>D>B>C (C) E>A>C>B>D
   (D) A>C>E>D>B (E) E>D>B>A>C
6. Which of the alkyne addition reactions below involves an enol intermediate?
   (A) hydroboration/oxidation (B) treatment with $HgSO_4$ in dilute H_2SO_4
   (C) hydrogenation (D) both A and B (E) none of the above
7. An increase in conjugation is correlated with _____ in the energy of the LUMO, _____ in the energy of the HOMO, and _____ in λ_{max}.
   (A) a decrease, an increase, a decrease (B) a decrease, an increase, an increase
   (C) an increase, a decrease, a decrease (D) an increase, a decrease, an increase
   (E) an increase, an increase, a decrease

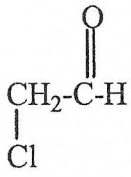
8. When (R)-2-butanol is treated with TsCl in pyridine, the product formed is:
(A) an achiral compound (B) a mixture of diastereomers
(C) a racemic mixture (D) a single enantiomer (E) none of the above

9. Which of the following functional groups typically exhibits a carbonyl stretch at the lowest frequency?
(A) amide (B) ester (C) ketone (D) aldehyde (E) ether

10. Which of the following is aromatic?
(A) cyclopentadienyl cation (B) 1,3-cyclohexadiene (C) cyclobutenyl anion
(D) 1,3,5-hexatriene (E) cycloheptatrienyl cation

11. Which of the following substituents acts as a moderate activator and o/p director in electrophilic aromatic substitution reactions?
(A) –Br (B) $-SO_3H$ (C) $-CO_2H$ (D) –NHCOR (E) –CHO

12. What is the common name for the following compound?



(A) Chloroaldehyde (B) α- Chloroacetaldehyde (C) β- Chloroacetaldehyde
(D) 2-Chloroethanal (E) α-Chloroethanal

13. Which of the following correctly reflects relative stabilities of carbocations?
(A) 3° allylic>2°>1° benzylic (B) methyl>2° benzylic>3°
(C) 3° benzylic>vinyl>1° (D) 2° allylic>2°>vinyl
(E) 1° benzylic>3°>3° allylic

14. Consider the ionic radii for the following ions. Which of the following ions possesses the smallest radius?
(A) Cr^{2+} (B) Ti^{2+} (C) Mn^{2+} (D) V^{2+}

15. Coordination Theory was first developed by whom?
(A) S. M. Jørgensen (B) L. E. Orgel (C) H. Bethe (D) A. Werner

16. Which of the following complexes may have linkage isomers?
(A) $[Co(NH_3)_4(SCN)Cl]Cl$ (B) $[Co(NH_3)_4(CN)Cl]Cl$ (C) $[Co(en)_2(OH)Cl]Cl$ (D) $[Co(en)_2(OH_2)_2]Cl_3$

17. Most of the first-row transition metals are essential for human health. Which of the following elements is an important component of hemoglobin and myoglobin?
(A) Cu (B) Zn (C) Co (D) Fe

18. Nickel can be purified by producing the volatile compound nickel tetracarbonyl, $Ni(CO)_4$. Nickel is the only metal that reacts directly with CO at room temperature. What is the

oxidation state of nickel in $Ni(CO)_4$?

(A) 1− (B) 0 (C) 1+ (D) 2+

19. When nitric acid is added to a solution of sodium sulfide, elemental sulfur forms. What type of reaction is this?

(A) Electrolysis (B) Acid-Base (C) Oxidation-Reduction (D) Recrystallization

20. Which of the following hydrogen halides is the strongest acid?

(A) HI (B) HBr (C) HCl (D) HF

21. What is the molecular geometry of carbon suboxide C_3O_2?

(A) Pentagonal plane (B) Trigonal bipyramid (C) Square pyramid (D) Linear

22. Which of the following combinations is an n-type semiconductor?

(A) Gallium is added as an impurity to silicon.

(B) A small fraction of silicon atoms is replaced by germanium atoms.

(C) A small fraction of silicon atoms is replaced by arsenic atoms.

(D) A silicon crystal is doped with boron.

23. A substance is said to be amphoteric if it can behave either as an acid or as a base. Which of the following substances is not amphoteric?

(A) H_2O (B) Ga_2O_3 (C) $Al(OH)_3$ (D) In_2O_3

24. Although the Xe−F bond is polar, XeF_4 has no dipole moment. What is the molecular geometry of XeF_4 based on the VSEPR model?

(A) Tetrahedral (B) Square planar (C) Seesaw (D) Octahedral

25. Which of the following ions has noble gas electron configurations?

(A) Cu^{2+} (B) Ag^{+} (C) Sc^{3+} (D) Hg^{2+}

26. Lithium aluminum hydride $LiAlH_4$ is a powerful reducing agent used in the synthesis of organic compounds. What is the summation of oxidation states of three atoms Li, Al and H?

(A) 0 (B) 1 (C) 2 (D) 3

27. Which of the following compounds possesses the so called "three-center bond"?

(A) Solid $BeCl_2$ (B) PCl_3 (C) Solid BeH_2 (D) PH_3

28. What is the maximum mass (g) of Cu that is produced by the reaction of 30.0g of CuO and 20.0 g of CH_4?

$4CuO + CH_4 \rightarrow 2H_2O + 4Cu + CO_2$,

(A) 24.0, (B) 95.9, (C) 30.0, (D) 20.0

29. Which produces the greatest number of ions when one mole dissolves in water?

(A) NaCl, (B) NH_4NO_3, (C) NH_4Cl, (D) Na_2SO_4

30. Which of the following is wrong with Material Safety Data Sheet?

(A) It is designed to provide both workers and emergency personnel with the proper procedures for handling or working with a particular substance.

(B) It is designed for consumers to educate themselves on the hazards of consumer products.

(C) It includes information such as physical data (melting point, boiling point, flash point, etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill/leak procedures.

(D) It needs to be updated every three years by law.

31. Ammonium nitrate (NH_4NO_3) dissolves readily in water even though the dissolution is endothermic by 26.4 kJ/mol. The solution process is spontaneous because (A) of the increase in enthalpy upon dissolution of this strong electrolyte, (B) osmotic properties predict this behavior, (C) of the increase in disorder upon dissolution of this strong electrolyte, (D) the vapor pressure of the water decreases upon addition of the solute.

32. A 0.100 m solution of which one of the following solutes will have the lowest vapor pressure?
(A) sucrose, (B) $Ca(ClO_4)_2$, (C) NaCl, (D)$Al(ClO_4)_3$

33. Of the concentration units below, only _____ is temperature dependent.
(A) molarity, (B) molality, (C) mass %, (D) ppb

34. What compound in limestone and marble is attacked by acid rain?
(A) potassium hydroxide, (B) hydroxyapatite, (C) calcium carbonate, (D) gypsum.

35. Which one of the following was generally produced by anaerobic bacteria decomposing biodegradable waste?
(A) hydrogen sulfide, (B) nitrate, (C) carbon dioxide, (D) toluene

36. Which one of the following types of elements is most likely to be a good oxidizing agent?
(A) alkali metals, (B) transition elements, (C) lanthanides, (D) halogens.

37. Which of the following extraction technique usually uses the least amount of solvent to extract organic substance?
(A) Soxhlet extraction, (B) Microwave assisted extraction, (C) solid phase microextraction, (D) Sonication assisted extraction.

38. Four identical 1.0-L flasks contain the gases He, Cl_2, CH_4, and NH_3, each at 0°C and 1 atm pressure. Which gas sample has the greatest number of molecules?
(A) He (B) Cl_2 (C) CH_4 (D) NH_3 (E) all gases the same

39. Consider the following gas samples:

Sample A	**Sample B**
$S_2(g)$	$O_2(g)$
$n = 1$ mol	$n = 2$ mol
$T = 800$ K	$T = 400$ K
$P = 0.20$ atm	$P = 0.40$ atm

Which one of the following statements is *false*?
(A) The volume of sample A is twice the volume of sample B.
(B) The average kinetic energy of the molecules in sample A is twice the average kinetic

energy of the molecules in sample B.

(C) The fraction of molecules in sample A having a kinetic energy greater than some high fixed value is larger than the fraction of molecules in sample B having kinetic energies greater than that same high fixed value.

(D) The mean square velocity of molecules in sample A is twice as large as the mean square velocity of molecules in sample B.

(E) Assuming identical intermolecular forces in the two samples, sample A should be more nearly ideal than sample B.

40. For a particular process q = 20 kJ and w = 15 kJ. Which of the following statements is true?
(A) Heat flows from the system to the surroundings.
(B) The system does work on the surroundings.
(C) ΔE = 35 kJ.
(D) All of the above are true.
(E) None of the above are true.

41. One mole of an ideal gas at 25°C is expanded isothermally and reversibly from 125.0 L to 250.0 L. Which statement is correct?
(A) $\Delta S_{gas} = 0$ (B) $\Delta S_{gas} = R\ln 2$ (C) $\Delta S_{surr} = 0$ (D) $\Delta S_{univ} = 0$ (E) $\Delta S_{gas} = \Delta S_{surr}$

42. Consider the following portion of the energy-level diagram for hydrogen:

$n = 4$ -0.1361×10^{-18} J
$n = 3$ -0.2420×10^{-18} J
$n = 2$ -0.5445×10^{-18} J
$n = 1$ -2.178×10^{-18} J

For which of the following transitions does the light emitted have the longest wavelength?
(A) $n = 4$ to $n = 3$ (B) $n = 4$ to $n = 2$ (C) $n = 4$ to $n = 1$ (D) $n = 3$ to $n = 2$
(E) $n = 2$ to $n = 1$

43. Which of the following is *not* determined by the principal quantum number, n, of the electron in a hydrogen atom?
(A) the energy of the electron
(B) the minimum wavelength of the light needed to remove the electron from the atom.
(C) the size of the corresponding atomic orbital(s)
(D) the shape of the corresponding atomic orbital(s)
(E) All of the above are determined by n.

44. For which of the following elements does the electron configuration for the lowest energy state show a partially filled d orbital?
(A) Ti (B) Rb (C) Cu (D) Ga (E) Kr

45. Which statement is correct?
(A) H_2O is linear.
(B) The molecule ClO_2 cannot be accurately described by a Lewis structure consistent with the octet rule.

(C) The diatomic molecule Cl_2 is an example of a polar molecule.
(D) The bonds in LiF have more covalent character than those in F_2.
(E) none of these

46. Given the following information:

$Li(s) \rightarrow Li(g)$	heat of sublimation of Li(s) = 166 kJ/mol
$HCl(g) \rightarrow H(g) + Cl(g)$	bond energy of HCl = 427 kJ/mol
$Li(g) \rightarrow Li^+(g) + e^-$	ionization energy of Li(g) = 520. kJ/mol
$Cl(g) + e^- \rightarrow Cl^-(g)$	electron affinity of Cl(g) = -349 kJ/mol
$Li^+(g) + Cl^-(g) \rightarrow LiCl(s)$	lattice energy of LiCl(s) = -829 kJ/mol
$H_2(g) \rightarrow 2H(g)$	bond energy of H_2 = 432 kJ/mol

calculate the net change in energy for the reaction $2Li(s) + 2HCl(g) \rightarrow 2LiCl(s) + H_2(g)$

(A) 363 kJ (B) -562 kJ (C) -179 kJ (D) -73 kJ (E) None of these

47. Which charge(s) of O_2 would give a bond order of 2.5?

(A) +1 (B) -1 (C) -2 (D) 2 (E) 0

48. The reaction $A \rightarrow B + C$ is known to be zero order in A with a rate constant of 5.0×10^{-2} mol/L · s at 25° C. An experiment was run at 25°C where $[A]_0 = 1.0 \times 10^{-3}$ M.

The integrated rate law is

(A) $[A] = kt$ (B) $[A] - [A]_0 = kt$ (C) $\frac{[A]}{[A]_0} = kt$ (D) $\ln \frac{[A]}{[A]_0} = kt$

(E) $[A]_0 - [A] = kt$

49. The rate law for a reaction is found to be Rate = $k[A]^2[B]$. Which of the following mechanisms gives this rate law?

I. $A + B \rightleftharpoons E$ (fast)
$E + B \rightarrow C + D$ (slow)

II. $A + B \rightleftharpoons E$ (fast)
$E + A \rightarrow C + D$ (slow)

III. $A + A \rightarrow E$ (slow)
$E + B \rightarrow C + D$ (fast)

(A) I (B) II (C) III (D) I and II (E) none of the above

50. At a given temperature, you have a mixture of benzene (vapor pressure of pure benzene = 745 torr) and toluene (vapor pressure of pure toluene = 290 torr). The mole fraction of benzene in the vapor above the solution is 0.590. Assuming ideal behavior, calculate the mole fraction of toluene in the solution.

(A) 0.213 (B) 0.778 (C) 0.641 (D) 0.359 (E) 0.590