95 學年度 化 學 系（所） 化學、應用化學 組碩士班入學考試

科目 綜合化學 科號 0601, 0701 共 8 頁第 1 頁 *請在【答案卷卡】內作答

選擇題（單選，每題二分）

1. Which of the following statements is true concerning ideal gases?
   (A) At STP, 1.0 L of Ar(g) contains about twice the number of atoms as 1.0 L of Ne(g) since the molar mass of Ar is about twice that of Ne.
   (B) The gas particles in a sample exert attraction for one another.
   (C) The temperature of the gas sample is directly related to the average velocity of the gas particles.
   (D) A gas exerts pressure as a result of the collisions of the gas molecules with the walls of the container.
   (E) All of the above are false.
2. To increase the value of K for the exothermic reaction $2H_2(g) + O_2(g) \leftrightarrow H_2O(g)$
   (A) increase the total pressure (B) decrease the total pressure (C) increase the temperature (D) decrease the temperature (E) two of the above
3. Which of the following compounds has the lowest solubility in mol/L in water?
   (A) $PbSO_4$ $K_{sp} = 1.3 \times 10^{-8}$ (B) CdS $K_{sp} = 1 \times 10^{-28}$ (C) $Al(OH)_3$ $K_{sp} = 2 \times 10^{-32}$ (D) MgC_2O_4 $K_{sp} = 8.6 \times 10^{-5}$ (E) $Sn(OH)_2$ $K_{sp} = 3 \times 10^{-27}$
4. Given $Cu_2O(s) + (1/2)O_2(g) \rightarrow 2CuO(s)$ $\Delta H° = -144$ kJ and $Cu_2O(s) \rightarrow Cu(s) + CuO(s)$ $\Delta H° = +11$ kJ Calculate the standard enthalpy of formation of CuO(s).
   (A) –155 kJ (B) +155 kJ (C) –299 kJ (D) +299 kJ (E) –166 kJ
5. Choose the correct statement.
   (A) A reaction that exhibits a negative value of ΔS cannot be spontaneous. (B) Exothermic reactions are always spontaneous. (C) At constant pressure and temperature, a decrease in free energy ensures an increase in the entropy of the system. (D) Free energy is independent of temperature. (E) none of these
6. Which of the following is the best reducing agent?
   $Cl_2 + 2e^- \rightarrow 2Cl^-$ $E° = 1.36$ V $Mg^{2+} + 2e^- \rightarrow Mg$ $E° = -2.37$ V
   $2H^+ + 2e^- \rightarrow H_2$ $E° = 0.00$ V
   (A) Cl_2 (B) Cl^- (C) Mg (D) Mg^{2+} (E) H_2
7. Which statement about semiconductor nanoparticles such as CdSe is incorrect?
   (A) Band gap of the material may decrease due to quantum confinement. (B) Absorption band may blue-shift. (C) Emission band may blue-shift. (D) Relative intensities of the peaks in the XRD pattern may be different. (E) Widths of the peaks in the XRD pattern may become broader.
8. In which pair do both compounds exhibit predominantly ionic bonding?
   (A) Na_2SO_3 and BH_3 (B) RbCl and CaO (C) NaF and H_2O (D) PCl_5 and HF (E) KI and

O_3

9. The molecular orbital electron configuration below $(\sigma 1s)^2 (\sigma 1s^*)^2 (\sigma 2s)^2 (\sigma 2s^*)^2 (\pi 2p_x)^2 (\pi 2p_y)^2 (\sigma 2p)^2$ applies to which of the following molecules?

(A) O_2 (B) F_2 (C) NO (D) BC (E) CO

10. What is the rate law for the following reaction, given the data below? $2NO + H_2 \rightarrow N_2O + H_2O$

Experiment	Initial [NO] (mol/L)	Initial [H_2] (mol/L)	Initial Rate of Disappearance of NO (mol/L·S)
1	6.4×10^{-3}	2.2×10^{-3}	2.6×10^{-5}
2	12.8×10^{-3}	2.2×10^{-3}	1.0×10^{-4}
3	6.4×10^{-3}	4.5×10^{-3}	5.1×10^{-5}

(A) Rate = k[NO] (B) Rate = k[NO]^2 (C) Rate = k[NO]^2[H_2] (D) Rate = k[NO][H_2] (E) Rate = k[NO][H_2]^2

11. In the unit cell of sphalerite, Zn^{2+} ions occupy half the tetrahedral holes in a face-centered cubic lattice of S^{2-} ions. The number of formula units of ZnS in the unit cell is

(A) 1 (B) 2 (C) 3 (D) 4 (E) 8

12. A solution of two liquids, A and B, shows a negative deviation from Raoult's law. This means that (A) molecules of A interact strongly with other A-type molecules. (B) molecules of A interact weakly, if at all, with B molecules. (C) the molecules of A hinder the strong interaction between B molecules. (D) the two liquids have a positive heat of solution. (E) molecules of A interact more strongly with B than with A or B with B.

13. The color of a transition metal complex results from:

(A) nuclear magnetic resonance. (B) transition of an electron between d orbitals. (C) bending vibration. (D) stretching vibrations. (E) transition of an electron between an S and a p orbital.

14. Which of the following is the strongest acid?

(A) CH_3OH (B) $CH_3OH_2^+$ (C) H_2N^- (D) CH_3NH_2 (E) $CH_3NH_3^+$

15. 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^-]

(E) CH_3COOH is completely unionized

16. Assuming roughly equivalent molecular weights, which of the following would have the highest boiling point?

(A) a tertiary amine (B) a quaternary ammonium salt (C) an alcohol

(D) an ether (E) an alkyl chloride

17. Which of the following best explains the relative stabilities of the eclipsed and staggered forms of ethane? The _____ form has the most _____ strain.

(A) eclipsed; steric (B) eclipsed; torsional (C) staggered; steric

(D) staggered; torsional

18. Which of the following has two equatorial alkyl substituents in its most stable conformation?

(A) 1,1-dimethylcyclohexane (B) *cis*-1,2-dimethylcyclohexane

(C) *cis*-1,3-diethylcyclohexane (D *cis*-1,4-diethylcyclohexane

(E) all of the above

19. Which of the following correctly describes the reaction shown?

$CH_2{=}CH_2 + HBr \rightarrow CH_3CH_2Br$ + 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) $\Delta H° = \Delta S° = 0$

20. Which of the following compounds will react most 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

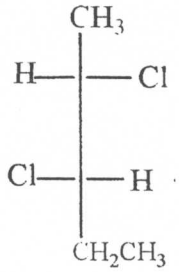
21. Upon hydrogenation, which of the following alkenes releases the least heat per mole?

(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

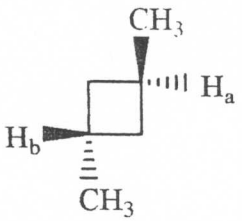
22. What is the configuration of the following compound?



(A) 2*S*, 3*R* (B) 3*R*, 3*S* (C) 2*S*, 3*S* (D) 2*R*, 3*R*

(E) Can't do *R* and *S*; the compound is achiral.

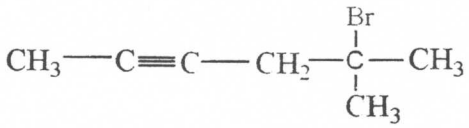
23. What term properly describes the stereochemical relationship between hydrogens H_a and H_b in the compound below?



(A) homotopic (B) enantiotopic (C) diastereotopic (D) meso

(E) *syn*

24. What is the IUPAC name for the following alkyne?



(A) 5-Bromo-2-heptyne (B) 3-Bromo-5-heptyne

(C) 2-Bromo-2-methyl-4-hexyne (D) 5-Bromo-5,5-dimethylhexyne

(E) 5-Bromo-5-methyl-2-hexyne

25. Which is the correct order of decreasing acidity in the following compounds?

H_2O	CH_3CH_3	NH_3	$CH_2=CH_2$	HC≡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

26. 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

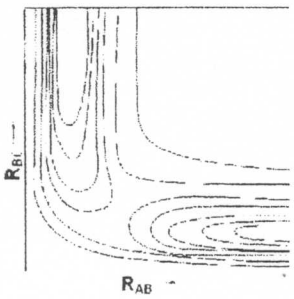
(B) a decrease, an increase, an increase

(C) an increase, a decrease, a decrease

(D) an increase, a decrease, an increase

(E) an increase, an increase, a decrease

27. Given a potential surface for the reaction: AB + C → A + BC.



Which one of the following statements is *true*?

(A) The reaction has early barrier.

(B) At the transition state, R_{AB} is shorter than R_{BC}.

(C) Reactants with sufficient vibrational energy are favored for the reaction.

(D) The potential surface produces vibrationally excited products.

28. In a one-dimensional box with a length of L, what is the probability of finding a particle in this box in energy level n = 4 between x = L/4 and x = L/2?

(A) 50% (B) 37.5% (C) 12.5% (D) 25%

29. The experimental rate law for the decomposition of nitrous oxide (N_2O) to N_2 and O_2 is rate = $k[N_2O]^2$. Two mechanisms are proposed:

I. $N_2O \rightarrow N_2 + O$

$N_2O + O \rightarrow N_2 + O_2$

II. $2N_2O \rightleftharpoons N_4O_2$

$N_4O_2 \rightarrow 2N_2 + O_2$

Which of the following could be a *correct* mechanism?

(A) Two of the above could be correct.

(B) Mechanism I with the first step as the rate-determining step.

(C) Mechanism II with the second step as the rate-determining step.

(D) Mechanism I with the second step as the rate-determining step.

30. Which statement is *true* of a process in which one mole of a gas is expanded from state A to state B?

(A) The amount of work done in the process must be the same, regardless of the path.

(B) The amount of heat released in the process will depend on the path taken.

(C) The final volume of the gas will depend on the path taken.

(D) When the gas expands from state A to state B, the surroundings are doing work on the system.

31. Consider the reaction: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ at constant temperature. Initially a container is filled with pure $SO_3(g)$ at a pressure of 2 atm, after which equilibrium is allowed to be reached. If y is the partial pressure of O_2 at equilibrium, the value of K_p is:

(A) $\dfrac{(2-y)^2}{(y^2)(y/2)}$ (B) $\dfrac{(2-2y)^2}{(2y)^2(y)}$ (C) $\dfrac{(2-2y)^2}{(y^2)(2y)}$ (D) $\dfrac{(2-y)^2}{(2y)^2(y)}$

32. For the dissociation reaction of the acid

HF: $HF(aq) \rightleftharpoons H^+(aq) + F^-(aq)$

Why is ΔS negative?

(A) The ions are hydrated.

(B) The reaction is expected to be endothermic and thus ΔS should be negative.

(C) The reaction is expected to be exothermic and ΔS thus should be negative.

(D) Each HF molecule produces two ions when it dissociates.

33. Consider the hydrogen–oxygen fuel cell where

$H_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons H_2O(l) \quad \Delta G^\circ = -237.18$ kJ per mole of H_2

Which of the following statements is *true*?

(A) At standard conditions, the maximum work the fuel cell could do on the surroundings is 237.18 kJ/mol.

(B) In the real world, the actual amount of useful work the cell can do is less than 237.18 kJ.

(C) More energy is dissipated as waste heat in the fuel cell than in the reversible pathway.

(D) All three statements are true.

34. What is the total number of electrons that can be accommodated in the level corresponding to n = 5 (n : the principal quantum number)?

(A) 8 (B) 18 (C) 32 (D) 50

35. Which is *true* about the vapor pressures of methane (CH_4) and ammonia (NH_3)?

(A) The vapor pressure of ammonia is greater than the vapor pressure of methane because ammonia is polar and methane is non-polar.

(B) The vapor pressure of ammonia is less than the vapor pressure of methane because ammonia is non-polar and methane is polar.

(C) The vapor pressure of methane is greater than the vapor pressure of methane because methane has more hydrogen bonding than ammonia.

(D) None of the above statements are true.

36. A solute added to a solvent raises the boiling point of the solution because

(A) the solute increases the volume of the solution, and an increase in volume requires an increase in the temperature to reach the boiling point (derived from $PV = nRT$).

(B) the solute particles lower the solvent's vapor pressure, thus requiring a higher temperature to cause boiling.

(C) the solute particles raise the solvent's vapor pressure, thus requiring a higher temperature to cause boiling.

(D) the temperature to cause boiling must be great enough to boil not only the solvent but also

the solute.

37. The following data were collected for the decay of HO_2 radicals:

Time	$[HO_2]$	Time	$[HO_2]$
0 s	1.0×10^{11} molec/cm^3	14 s	1.25×10^{10} molec/cm^3
2 s	5.0×10^{10} molec/cm^3	30 s	6.225×10^{9} molec/cm^3
6 s	2.5×10^{10} molec/cm^3		

Which of the following statements is *true*?

(A) The rate of the reaction increases with time.

(B) A plot of $\ln[HO_2]$ versus time is linear with a slope of $-k$.

(C) The half-life of the reaction is 2 ms.

(D) A plot of $1/[HO_2]$ versus time gives a straight line.

38. The bond order in the NO molecule is

(A) 2.5 (B) 1.5 (C) 3 (D) 2

39. What statement about molecular spectroscopy is *false*?

(A) Vibrational transitions in molecules typically require energies that correspond to the visible region of the electromagnetic spectrum.

(B) Rotational changes are produced by radiation in the microwave region of the electromagnetic spectrum.

(C) The majority of electron transitions in molecules occur in the UV region of the electromagnetic spectrum.

(D) Nuclear spin transitions typically require energies that correspond to the radiofrequency region of the electromagnetic spectrum.

40. An adequate amount of HCl was added into a mixture containing MCO_3 and $M(HCO_3)$. After the reaction is completed, the molar ratio of H^+ reactant used and the CO_2 product generated is 6:5. What is the molar ratio of MCO_3 to $M(HCO_3)$?

(A) 1:1 (B) 1:2 (C) 1:3 (D) 1:4

41. Under intensive heating, $(NH_4)_2SO_4$ will be decomposed into NH_3, SO_2, and H_2O. What is the molar ratio of oxidized product to reduced product?

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

42. Which of the following reaction is a spontaneous one?

(A) $F_2 + 2Cl^- \rightarrow 2F^- + Cl_2$ (B) $2Ag + Cu^{2+} \rightarrow 2Ag^+ + Cu$

(C) $Mg^{2+} + Zn \rightarrow Mg + Zn^{2+}$ (D) $Fe \rightarrow Fe^{3+} + 3e^-$

43. An aliquot of 0.4000 g of organic acid (M.W. = 200 g/mol) was dissolved in water and titrated. At the end point of titration, 40.00 mL , 0.1000 M NaOH was used. What is the number of H^+ being ionized per molecule of the organic acid?

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

44. Which of the following chemical compound is more appropriate matrix for MALDI analysis of proteins?

(A) 2,5-dihydroxybenzoic acid (B) picolinic acid (C) sinapinic acid

(D) porphyrin

45. Which of the following chemical compound has the highest impact of green house gas per molecule?

(A) carbon dioxide (B) sulphur hexafluoride (C) perfluorocarbons

(D) hydrofluorocarbons

46. The limit of quantitation is usually defined as the amount of analyte which would generate a signal n times to that of the blank. What is the n value?

(A) 10 (B) 6 (C) 5 (D) 3

47. Which is the most abundant noble gas in the atmosphere?

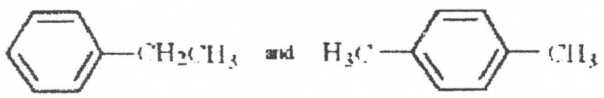
(A) He (B) Ar (C) Ne (D) Kr

48. Which of the following reactions contributes to the reason why CFC's are most damaging to the ozone layer?

(A) $NO + O_3 \rightarrow NO_2 + O_2$ (B) $O_2 + O\bullet \rightarrow O_3$ (C) $Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$

(D) $O_3 + h\nu \rightarrow O_2 + O\bullet$

49. Which type of spectroscopy would be the most useful in distinguishing the following pair of compounds?



(A) IR (B) UV-Vis (C) NMR (D) MS

50. Determine the number of electrons transferred in the following reaction.

$2Mn^{2+}(aq) + 5Cl_2(g) + 8H_2O \rightarrow 2MnO_4^-(aq) + 16H^+(aq) + 10Cl^-(aq)$

(A) 5 (B) 6 (C) 8 (D) 10