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國立臺北科技大學 109 學年度碩士班招生考試

系所組別：3602

化學工程與生物科技系生化與生醫工程碩士班

第一節　普通化學　試題（選考）

注意事項：

1. 本試題共 40 題，每題 2.5 分，共 100 分。
2. 不必抄題，作答時請將試題題號及答案依照順序寫在答案卷上。
3. 全部答案均須在答案卷之答案欄內作答，否則不予計分。

1. Which of the following is the hybridization of the central atom (Xe) in XeF_5^+?
   (A) *sp*
   (B) sp^2
   (C) dsp^3
   (D) d^2sp^3

2. Which statement about N_2 is **false**?
   (A) It has one sigma and two π bonds between the two atoms.
   (B) It can combine with H_2 to form NH_3.
   (C) The oxidation state is +3 on one N and –3 on the other.
   (D) It has two pairs of nonbonding electrons.

3. Which of the following has a correct bonding statement for a carbon atom with sp^3 hybridization?
   (A) four π bonds
   (B) three π bonds and one σ bond
   (C) one π bond and three σ bonds
   (D) four σ bonds

4. Consider the reaction: $aA + bB \xrightarrow{c} bB + dD + eE$, C = catalyst. The rate law is Rate = $k[A]^q[B]^r[C]^s$. Which of the following statements is **incorrect**?
   (A) The overall reaction order is $q + r + s$.
   (B) The exponents, q and r, are always equal to the coefficients a and b, respectively.
   (C) The exponent s must be determined experimentally.
   (D) The exponents, q, r, and s, are often integers.

5. The oxidation of ammonia produces nitrogen and water via the following reaction: $4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(l)$. Suppose the rate of formation of $H_2O(l)$ is 3.0 mol/(L · s). Which of the following statements is **true**?
   (A) The rate of consumption of NH_3 is 2.0 mol/(L · s).
   (B) The rate of consumption of O_2 is 2.0 mol/(L · s).
   (C) The rate of formation of N_2 is 1.3 mol/(L · s).
   (D) The rate of consumption of NH_3 is 0.50 mol/(L · s).

6. Which of the following statements is **always** true?
   (A) Exothermic reactions have lower activation energies than endothermic reactions.
   (B) The rate constant is independent of the concentrations of the reacting species.
   (C) The rate law can be determined from the stoichiometric equation.
   (D) The rate for a reaction depends on the concentrations of all the reactants.

7. A reaction that is second-order in one reactant has a rate constant of 3.8×10^{-2} L/(mol · s). If the initial concentration of the reactant is 0.280 mol/L, how long will it take for the concentration to become 0.140 mol/L?
   (A) 930 s
   (B) 180 s
   (C) 93 s
   (D) 47 s

8. Which of the following is correct about the half-life of a reaction?
   (A) Twice as long for a second-order reaction as it is for a first-order reaction.
   (B) One-half of the time the reaction will take to go to completion.
   (C) The time it takes for the amount of product formed to equal half the initial amount of reactant.
   (D) The time it takes for the reactant concentration to decrease to one-half of its initial value.

9. Nitrogen trifluoride decomposes to form nitrogen and fluorine gases according to the following equation: $2NF_3(g) \rightleftharpoons N_2(g) + 3F_2(g)$. When 2.54 mol of NF_3 is placed in a 6.00-L container and allowed to come to equilibrium at 800 K, the mixture is found to contain 0.0434 mol of N_2. What is the value of K_p at this temperature? (R = 0.0821 L · atm · mol^{-1} · K^{-1})
   (A) 4.43×10^{-7}
   (B) 1.59×10^{-5}
   (C) 1.91×10^{-3}
   (D) 1.78×10^{-2}

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10. Which of the following statements **best** describes the condition(s) needed for a successful formation for a product according to the collision model?
    (A) The energy of the incoming particles must be above a certain minimum value, and the relative orientation of the particles must allow for formation of new bonds in the product.
    (B) The relative orientation of the particles has an effect only if the kinetic energy of the particles is below some minimum value.
    (C) The relative orientation of the particles must allow for formation of the new bonds in the product.
    (D) The relative orientation of the particles has little or no effect on the formation of the product.
11. For the reaction $Br_2(g) + Cl_2(g) \rightleftharpoons 2BrCl(g)$, at equilibrium, it is found that the concentrations of Br_2, Cl_2, and BrCl are 0.484 *M*, 0.105 *M*, and 1.24×10^{-3} *M*, respectively. What is the value of K_c?
    (A) 4.12×10^{1}
    (B) 2.43×10^{-2}
    (C) 1.20×10^{-4}
    (D) 3.01×10^{-5}

12. Which of the following statements is true for the reaction: $CuO(s) + CO_2(g) \rightarrow CuCO_3(s)$?
    (A) Cu^{2+} acts as a Lewis acid and CO_3^{2-} acts as a Lewis base.
    (B) O^{2-} acts as a Lewis base and CO_2 acts as a Lewis acid.
    (C) O^{2-} acts as a Lewis base and Cu^{2+} acts as a Lewis acid.
    (D) CO_2 is the Lewis acid and $CuCO_3$ is its conjugate base.

13. Which of the following solutes, dissolved in 1.0 kg of water, would be expected to provide the fewest particles and to **freeze** at the **highest** temperature?
    (A) 0.10 mol $HClO_3$
    (B) 0.10 mol HClO
    (C) 0.10 mol $HClO_4$
    (D) 0.10 mol HCl

14. A 0.10 *M* solution of a weak monoprotic acid has a pH of 3.40 at 25°C. What is the acid-ionization constant, K_a, for this acid?
    (A) 1.2×10^{-8}
    (B) 1.8×10^{-7}
    (C) 1.6×10^{-6}
    (D) 3.4×10^{-5}

15. At a temperature of 25°C, an initially 0.011 *M* solution of a weak monoprotic acid is 2.9% ionized once equilibrium has established. What is the acid-ionization constant, K_a, for this acid? (assume $C_a/K_a \geq 10^2$)
    (A) 1.5×10^{-7}
    (B) 9.3×10^{-6}
    (C) 7.6×10^{-5}
    (D) 6.2×10^{-4}
16. The autoionization of water, as represented by the equation below, is known to be endothermic. Which of the following correctly states what occurs as the temperature of water is raised?
    $H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$.
    (A) The pH of the water decreases, and the water remains neutral.
    (B) The pH of the water increases, and the water remains neutral.
    (C) The pH of the water decreases, and the water becomes more acidic.
    (D) The pH of the water does not change, and the water remains neutral.

17. Which of the following ones is a true statement about Avogadro's law?
    (A) The volume of a fixed amount of gas is inversely proportional to its pressure at constant temperature.
    (B) Equal amounts of gases occupy the same volume at constant temperature and pressure.
    (C) The total pressure of a mixture of gases is the simple sum of the partial pressure of all of the gaseous compounds.
    (D) The rates of effusion of gases are inversely proportional to the square roots of their molar masses.

18. Which of the following is ***not*** an assumption of the kinetic molecular theory for a gas?
    (A) Gases are made up of tiny particles in constant chaotic motion.
    (B) The average velocity of the gas particles is directly proportional to the absolute temperature.
    (C) Gas particles collide with the walls of their container in elastic collisions.
    (D) Gas particles are very small compared to the average distance between the particles.

19. Which of the following is included as a postulate in the kinetic molecular theory of an ideal gas?
    (A) All collisions between molecules are elastic.
    (B) The distance between gas molecules is small compared with the size of the molecule.
    (C) In an average collision between molecules, both molecules have the same kinetic energy.
    (D) All molecules move randomly in zigzag directions.

20. Aqueous solutions of potassium sulfide and copper(II) chloride are mixed together. Which statement is correct?
(A) Both KCl and CuS precipitate from solution.
(B) No reaction will occur.
(C) CuS will precipitate from solution.
(D) A gas is released.

21. Iron is biologically important in the transport of oxygen by red blood cells from the lungs to the various organs of the body. In the blood of an adult human, there are approximately 2.63 $\times 10^{13}$ red blood cells with a total of 2.90 g of iron. On the average, how many iron atoms are present in each red blood cell? (molar mass Fe = 55.85g/mol)
(A) 1.19×10^{9}
(B) 2.63×10^{13}
(C) 3.13×10^{18}
(D) 6.16×10^{22}

22. You take an aspirin tablet (a compound consisting solely of carbon, hydrogen, and oxygen) with a mass of 1.00 g, burn it in air, and collect 2.20 g of carbon dioxide and 0.400 g water. The molar mass of aspirin is between 170 and 190 g/mol. What is the molecular formula of aspirin? (C = 12, H = 1, O = 16)
(A) $C_6H_8O_5$
(B) $C_8H_{10}O_5$
(C) $C_9H_8O_4$
(D) $C_{10}H_6O_4$

23. For the reaction $2\mathbf{A} + 4\mathbf{B} \rightarrow 2\mathbf{C} + 2\mathbf{D}$, at a particular instant in time, the rate of the reaction is 0.0352 *M*/s. What is the rate (*M*/s) of change of **B**?
(A) 0.0088
(B) –0.0088
(C) –0.141
(D) –0.0352

24. Order the intermolecular forces (dipole-dipole, London dispersion, ionic, and hydrogen-bonding) from the weakest to strongest.
(A) dipole-dipole, London dispersion, ionic, and hydrogen-bonding.
(B) London dispersion, dipole-dipole, hydrogen-bonding, and ionic.
(C) dipole-dipole, ionic, London dispersion, and hydrogen-bonding.
(D) London dispersion, ionic, dipole-dipole, and hydrogen-bonding.

25. 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, what is the mole fraction of toluene **in the solution**?
(A) 0.878
(B) 0.776
(C) 0.641
(D) 0.213

26. A solution contains 1 mole of liquid A and 3 moles of liquid B. This solution has a vapor pressure of 314 torr at 25°C. At 25°C, liquid A has a vapor pressure of 265 torr and liquid B has a vapor pressure of 355 torr. Which of the following is **true**?
(A) This solution exhibits a positive deviation from Raoult's Law.
(B) This solution is ideal.
(C) More information is needed to answer this question.
(D) This solution exhibits a negative deviation from Raoult's Law.

27. Many classic experiments have given us indirect evidence of the nature of the atom. Which of the experiments listed below did not give the results described?
(A) The electric discharge tube proved that electrons have a negative charge.
(B) The Rutherford experiment proved the Thomson "plum-pudding" model of the atom to be essentially correct.
(C) Millikan's oil-drop experiment showed that the charge on any particle was a simple multiple of the charge on the electron.
(D) The Rutherford experiment was useful in determining the nuclear charge on the atom.

28. It is observed that 7.53 mmol of BaF_2 will dissolve in 1.0 L of water. What is the value of K_{sp} for barium fluoride?
(A) 1.1×10^{-4}
(B) 4.3×10^{-5}
(C) 1.7×10^{-6}
(D) 2.3×10^{-7}

29. Which of the following is the correct name of $CH_3C \equiv CCH_2CH_2Cl$?
(A) 1-chloro-3-pentyne
(B) 5-chloro-2-pentene
(C) 1-chloro-3-pentene
(D) 5-chloro-2-pentyne

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30. Why does octane have a higher boiling point than ethane, 126°C versus –89°C?
(A) Octane exhibits hydrogen bonding and ethane does not.
(B) Octane has a higher vapor pressure than ethane.
(C) Octane contains more double bonds than ethane.
(D) Octane has stronger London dispersion forces than ethane.

31. Silver chromate, Ag_2CrO_4, has a K_{sp} of 8.97×10^{-12}. Which of the following ones is the solubility in mol/L of silver chromate?
(A) 1.31×10^{-4}
(B) 1.65×10^{-4}
(C) 1.50×10^{-6}
(D) 2.08×10^{-4}

32. Which one of the following pairs **cannot** be mixed together to form a buffer solution?
(A) NH_3, NH_4Cl
(B) $NaC_2H_3O_2$, HCl ($C_2H_3O_2^-$ = acetate)
(C) RbOH, HBr
(D) KOH, HF

33. In which one of the following solutions is silver chloride the most soluble?
(A) 0.200 M HCl
(B) 0.0150 M NH_3
(C) 0.750 M $LiNO_3$
(D) 0.185 M KCl

34. Which of the following Lewis structures would be an incomplete octet?
(A) NF_3
(B) SO_2
(C) BCl_3
(D) CF_4

35. Which one of the following processes produces a decrease of the entropy of the system?
(A) dissolving oxygen in water
(B) sublimation of naphthalene
(C) dissolving sodium chloride in water
(D) boiling of alcohol

36. For the reaction: $C_2H_6\ (g) \rightarrow C_2H_4\ (g) + H_2\ (g)$. $\Delta H°$ is +137 kJ/mol and $\Delta S°$ is +120 J/K · mol. Which one of the following is correct for this reaction?
(A) nonspontaneous at all temperatures
(B) spontaneous only at high temperature
(C) spontaneous at all temperatures
(D) spontaneous only at low temperature

37. The equilibrium constant for the following reaction is 3.0×10^8 at 25 °C.
$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$. What is the $\Delta G°$ in kJ/mol for this reaction?
(A) 22
(B) –4.1
(C) –22
(D) –48

38. In which one of the following solutions is the statement of the second law of thermodynamics?
(A) $\Delta S = q_{rev}/T_{\text{at constant temperature}}$
(B) $\Delta H°_{rxn} = \Sigma\, n\Delta H°_f$ (products) - $\Sigma\, m\Delta H°_f$ (reactants)
(C) for any spontaneous process, the entropy of the universe increases
(D) the entropy of a pure crystalline substance is zero at absolute zero

39. The normal boiling point of $C_2Cl_3F_3$ is 47.6 °C and its molar enthalpy of vaporization is 27.49 kJ/mol. What is the change in entropy in the system in J/K when 28.6 grams of $C_2Cl_3F_3$ vaporizes to a gas at the normal boiling point?
(A) 27.5
(B) 13.1
(C) 4.19
(D) –4.19

40. Which of the following atoms involves with a ground-state electron configuration of $[Ar]4s^23d^1$?
(A) Sc
(B) Mn
(C) Cr
(D) Fe