

科目 普通化學 類組別 A1,A6 共 5 頁第 1 頁 \*請在試卷答案卷(卡)內作答

一、選擇題 (單選; 每題 2 分, 共 40 分)

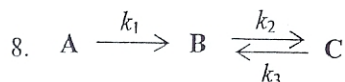
1. A specific wave function for a given electron is often called  
(1) a quantum number; (2) an operator; (3) an orbital; (4) a spectrum; (5) a Hamiltonian.
2. The observation of a diffraction pattern formed by scattered electrons from a metal surface shows that electrons  
(1) have charge; (2) have spin; (3) behave like waves; (4) have mass; (5) behave like particles.

3. If the energy levels available to the electron in the hydrogen atom is

$$E = -2.178 \times 10^{-18} \left( \frac{Z^2}{n^2} \right) \quad (\text{in joule})$$

What will be the minimum energy required to remove the electron from a hydrogen atom in its ground state?

- (1)  $2.178 \times 10^{18}$  J; (2) 0 J; (3)  $-2.178 \times 10^{18}$  J; (4)  $2.178 \times 10^{-18}$  J; (5)  $1.634 \times 10^{-18}$  J.
4. Which of the following set of quantum numbers is allowed in the hydrogen atom?  
(1)  $n = 1, l = 0, m_l = 2$ ; (2)  $n = 3, l = 2, m_l = 2$ ; (3)  $n = 4, l = 3, m_l = 4$ ; (4)  $n = 0, l = 0, m_l = 0$ ; (5)  $n = 1, l = -1, m_l = 1$ .
5. The integrated rate law for a second-order reaction is  $\frac{1}{[A]} = \frac{1}{[A]_0} + kt$  where  $[A]_0$  is the initial concentration of A. The expression for half-life is  
(1)  $0.693/k$ ; (2)  $(k[A]_0)/0.693$ ; (3)  $k/[A]_0$ ; (4)  $1/k[A]_0$ ; (5)  $0.693/(k[A]_0)$ .
6. When concentration is expressed in "moles/liter (M)", a third-order rate constant has units of  
(1)  $M^4 s^{-1}$ ; (2)  $M^3 s^{-1}$ ; (3)  $M^{-1} s^{-1}$ ; (4)  $M^{-2} s^{-1}$ ; (5)  $M^{-3} s$ .
7. The half-life for a first-order reaction involving Q is 80.0 seconds. The initial concentration of Q is 1.0 molar. The concentration of Q after 40 seconds is  
(1) 0.25 M; (2) 0.50 M; (3) 0.71 M; (4) 0.90 M; (5) 0.75 M.

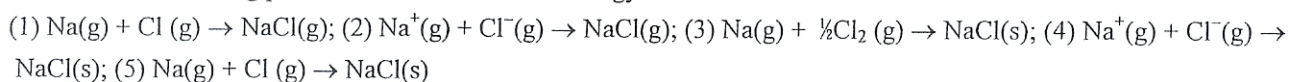


Which of the following expressions correctly represents the rate of formation of B ( $\frac{d[B]}{dt}$ ) for the mechanism shown above?

- (1)  $k_1[B] + k_2[C] + k_3[C]$ ; (2)  $k_1[A] + k_2[C] - k_3[C]$ ; (3)  $k_1[A] - k_2[B] + k_3[C]$ ; (4)  $k_1[A] - k_2[C] + k_1[B]$ ;  
(5)  $k_1[B] + k_2[C] - k_3[A]$
9. For the reaction above,  $\Delta G^0 = -163$  kilojoules at 298 K. The equilibrium constant  $K_p$  for the reaction as shown is  
 $O_3(g) \rightarrow \frac{3}{2} O_2(g)$   
1.1; (2) 0.94; (3)  $8.8 \times 10^{-19}$ ; (4)  $8.8 \times 10^{-29}$ ; (5)  $3.7 \times 10^{28}$ .
10. When the equilibrium mixture of gaseous, colorless  $N_2O_4$  and brown  $NO_2$  is heated at constant volume, which of the following description is correct about the system?  
(1) The density won't change; (2) The degree of dissociation decreased; (3) The color becomes lighter; (4) The average molar mass increases; (5) The pressure decreases
11. At constant pressure and temperature, which of the following is true for spontaneous endothermic reactions?  
(1) They sometimes have  $\Delta H > T\Delta S$ ; (2) They always have  $\Delta S > 0$ ; (3) They won't occur at high pressure; (4) They won't occur at low pressure; (5) They sometimes have  $\Delta G > 0$

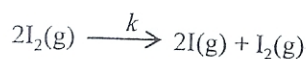
12. The quantity  $T\Delta S$  can be expressed in units of  
(1) J; (2) K; (3) J · K; (4) J · K<sup>-1</sup>; (5) L · atm · K<sup>-1</sup>.

13. Which of the following processes defines the lattice energy of NaCl?



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14. If the elementary process of the collisional dissociation of  $I_2$  at high temperature is as the following:



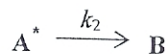
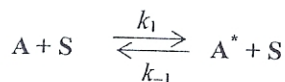
The rate of formation of  $I(g)$  should be given by

(1)  $\frac{d[I]}{dt} = 2k[I_2]^{\frac{1}{2}}$ ; (2)  $\frac{d[I]}{dt} = k[I_2]$ ; (3)  $\frac{d[I]}{dt} = 2k[I_2]^2$ ; (4)  $\frac{d[I]}{dt} = 2k \frac{[I_2]^{\frac{1}{2}}}{[I]^2}$ ; (5)  $\frac{d[I]}{dt} = 2k \frac{[I_2]^2}{[I]^2}$ .

15. For a spontaneous process in an isolated system, which of the following is true regarding to the entropy change of the system?

- (1) It is always negative; (2) It is always positive; (3) It is always zero; (4) It is negative if the process is endothermic; (5) None of the above

16. Based on the mechanism shown below for the intermediate  $A^*$ ,



the rate of formation of product B can be given by

(1)  $\frac{d[B]}{dt} = \frac{k_1 k_2 [A][S]}{(k_{-1}[S] + k_2)}$ ; (2)  $\frac{d[B]}{dt} = k_1 [A][S]$ ; (3)  $\frac{d[B]}{dt} = \frac{k_1 k_2 [A]}{[S] + k_2}$ ; (4)  $\frac{d[B]}{dt} = \frac{k_1 k_2 [A][S]}{k_{-1}[S]}$ ; (5)  $\frac{d[B]}{dt} = \frac{k_1 k_2 [A][S]}{(k_{-1}[S] + k_1)}$

17. Which of the following statement is generally true regarding to the relationship between the rate constant,  $k$ , the Arrhenius activation energy,  $E_a$ , and the temperature ( $T$ )?

- (1) A plot of  $\ln k$  vs.  $\ln 1/T$  is a straight line with slope  $E_a/R$ ; (2) A plot of  $\ln k$  vs.  $\ln T$  is a straight line with slope  $E_a/R$   
 (3) A plot of  $\ln k$  vs.  $\ln T$  is a straight line with slope  $-E_a/R$ ; (4) A plot of  $\ln k$  vs.  $\ln 1/T$  is a straight line with slope  $-E_a/R$   
 (5) A plot of  $\ln k$  vs.  $T$  is a straight line with slope  $E_a/R$

18. One mole of an ideal gas expands isothermally until its volume is doubled. What is the change in  $\Delta G$  for this process?

(1)  $e^{-2/RT}$ ; (2)  $RT \ln 2$ ; (3)  $RT \ln \frac{1}{2}$ ; (4)  $R \ln \frac{1}{2}$ ; (5)  $T \ln \frac{1}{2}$ .

19. If the elementary step  $P \rightarrow Q$  has a reaction enthalpy of  $-60$  KJ and an activation energy of  $10$  KJ, the activation energy for the reverse step is

- (1)  $0$  KJ; (2)  $-70$  KJ; (3)  $-50$  KJ; (4)  $50$  KJ; (5)  $70$  KJ.

20. If argon gas trapped in a cylinder with a movable piston undergoes an adiabatic expansion, which of the following statements is correct for the expansion? ( $q$  = heat;  $w$  = work;  $\Delta U$  = internal energy change)

- (1)  $q = w$ ; (2)  $\Delta U = q$ ; (3)  $\Delta U = 0$ ; (4)  $w = 3q$ ; (5)  $\Delta U = w$ .

## 二、簡答題 (共 10 分)

1. Based on the VSEPR model, describe the "molecular geometries" *in English* of the following compounds/species:

(每小題 1 分, 共 5 分)

- (1)  $XeF_4O$ ; (2)  $SiF_4$ ; (3)  $PCl_5$ ; (4)  $SeCl_6$ ; (5)  $SO_3$

2. Give the electron configurations of the following atoms: (每小題 1 分, 共 5 分)

- (1) Boron; (2) Nitrogen; (3) Neon; (4) Potassium; (5) Sulfur



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(Atomic weight; Na /23, Al /27, K /39, Ca /40, Mn /55, C /12, N /14, O /16, H /1, He /4, F /19, Cl /35.5, P /31, Br /80)  
Some useful informations

$$\ln 2 = 0.693 \quad \ln X \approx 2.303 \times \log_{10} X$$

$$\sqrt{2} = 1.414 \quad \sqrt{3} = 1.732$$

三、選擇題：請從每一題題目之下所提供的答案挑選出最接近或最合理的答案

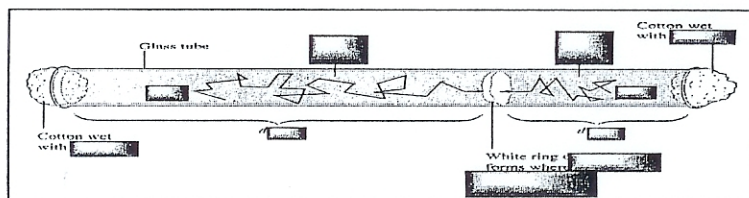
1. Match the following questions and answers: (For example: A → 5) (2 pts)

A. What is the law of multiple proportions?

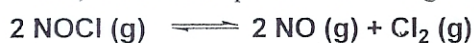
B. What is Le Chatelier's principle?

Select your answers from this following providing answers:

1. The rate of effusion of a gas is proportional to the square root of the masses of the gas particles
  2. The rate of effusion of a gas is proportional to the masses of the gas particles
  3. If a change in conditions (a "stress") is imposed on a system at equilibrium, the equilibrium position will shift in a direction that tends to enhance that change in conditions.
  4. If a change in conditions (a "stress") is imposed on a system at equilibrium, the equilibrium position will shift in a direction that tends to reduce that change in conditions.
  5. A given compound always contains exactly the same proportion of elements by mass.
  6. When two elements form a series of compounds, the ratios of the masses of the second element that combine with 1 gram of the first element can always be reduced to small whole numbers. a given compound should always contain the same combination of these atoms
2. Under what conditions, the behavior of real gases is more likely the ideal gas? (2 pts)
1. Low pressure, low temperature.
  2. High pressure, high temperature.
  3. High pressure, low temperature.
  4. Low pressure, high temperature.
3. Balance the following oxidation-reduction reactions: (2 pts)
- $$P_4 + a H_2O + b OH^- \rightarrow c HPO_3^{2-} + d PH_3$$
- Then what's the number of  $a + b + c + d = ?$
1. 4    2. 5    3. 6    4. 7    5. 8    6. 9    7. 10    8. 11    9. 12    10. 13    11. 14
4. At 25°C and 1 atm, 200 g NaN<sub>3</sub> was inflated, calculate the volume (L) of the gas released from it. (2 pts)
1. 14    2. 28    3. 56    4. 70    5. 98    6. 105    7. 112    8. 128    9. 156    10. 224
5. For the gas reaction of NH<sub>3</sub> with HBr, if no air were present in the reaction tube, calculate the ratio of these two gases (NH<sub>3</sub> : HBr) traveling distances. (2 pt)
1. 0.21    2. 0.45    3. 1.0    4. 1.6    5. 2.2    6. 2.9    7. 3.6    8. 4.8    9. 9.6



6. NOCl, which decomposes to form the gases NO and Cl<sub>2</sub>. (2 pts)



At 35°C the equilibrium constant is  $1.6 \times 10^{-5}$  mol/L. In an experiment in which 1.0 mole of NOCl is placed in a 2.0-liter flask, Calculate the equilibrium concentrations (M) of [NO].

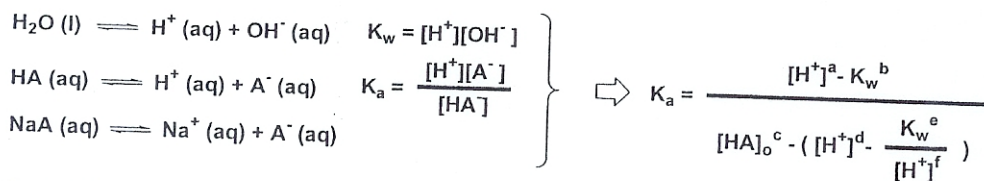
1. 0.01    2. 0.02    3. 0.04    4. 0.08    5. 0.1    6. 0.2    7. 0.4    8. 0.8    9. 1.0    10. 2.0

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7. The product is colorless in the dimerization of yellow  $\text{NO}_2$  gas. If it was found that as the reaction temperature increase, the color of the mixture is getting darker. (2 pts)
- A. Is this dimerization reaction an endothermic or exothermic reaction?  
 B.  $K$  (equilibrium constant) become smaller or bigger as temperature decrease?  
 Select your answer from this following providing answers :  
 1. A. endothermic B. smaller; 2. A. exothermic B. smaller; 3. A. endothermic B. Larger; 4. A. exothermic B. Larger
8. Pick up two that are not state function: (2 pts)  
 1. Energy 2. Enthalpy 3. Heat 4. Height 5. Pressure 6. Temperature 7. Volume 8. Work 9. Entropy
9. Arrange the following species,  $\text{H}_2\text{O}$ ,  $\text{A}_1^-$ ,  $\text{Cl}^-$ , and  $\text{A}_2^-$ , according to their strength as bases: (2 pts)  
 $(K_a : \text{HA}_1 = 9 \times 10^{-4}$  and  $\text{HA}_2 = 4 \times 10^{-10})$   
 1.  $\text{A}_1^- > \text{A}_2^- > \text{H}_2\text{O} > \text{Cl}^-$  2.  $\text{A}_2^- > \text{A}_1^- > \text{Cl}^- > \text{H}_2\text{O}$  3.  $\text{A}_2^- > \text{H}_2\text{O} > \text{A}_1^- > \text{Cl}^-$  4.  $\text{A}_1^- > \text{H}_2\text{O} > \text{A}_2^- > \text{Cl}^-$   
 5.  $\text{Cl}^- > \text{A}_2^- > \text{A}_1^- > \text{H}_2\text{O}$  6.  $\text{A}_2^- > \text{A}_1^- > \text{H}_2\text{O} > \text{Cl}^-$  7.  $\text{A}_2^- > \text{A}_1^- > \text{Cl}^- > \text{H}_2\text{O}$  8.  $\text{A}_2^- > \text{Cl}^- > \text{A}_1^- > \text{H}_2\text{O}$
10. Estimate the pH of a 0.10 M  $\text{NH}_4\text{Cl}$  solution. The  $K_b$  value for  $\text{NH}_3$  is  $1.8 \times 10^{-5}$ . (2 pts)  
 1. 4.1 2. 5.1 3. 6.1 4. 7.1 5. 8.1 6. 9.1 7. 10.1 8. 11.1
11. (2 pts)  
 A. A 1.0 M  $\text{NH}_3$  solution was added some  $\text{NH}_4\text{Cl}$ , how the pH change? (smaller or bigger or ?)  
 B. A 1 M HF solution was added some NaF, how the percent dissociation change? (smaller or bigger or ?)  
 Select your answer from this following providing answers :  
 1. A. smaller B. smaller 2. A. smaller B. bigger 3. A. bigger B. smaller  
 4. A. bigger B. bigger 5. A. No Change B. No Change 6. A. No Change B. Smaller
12. In the titration of the triprotic ( $\text{H}_3\text{A}$ ) acid with NaOH, in some stages the solution will contain amphoteric anions as the Only major species (such as  $\text{H}_2\text{A}^-$  or  $\text{HA}^{2-}$ ). Estimate the pH of a 1.0 M solution of  $\text{NaH}_2\text{A}$ , if  $\text{H}_3\text{A}$ , with  $K_{a1} = 1 \times 10^{-3}$ ;  $K_{a2} = 1 \times 10^{-8}$ ;  $K_{a3} = 1 \times 10^{-13}$  (2 pts)  
 1. 3.0 2. 4.5 3. 5.5 4. 6.5 5. 7.5 6. 8.0 7. 8.5 8. 9.5 9. 10.5 10. 11.5
13. Estimate the equilibrium concentrations of the species  $\text{HPO}_4^{2-}$  in a 5.0 M  $\text{H}_3\text{PO}_4$  solution, (2 pts)  
 If  $\text{H}_3\text{PO}_4$  with  $k_{a1} = 7 \times 10^{-3}$ ,  $k_{a2} = 7 \times 10^{-8}$ ,  $k_{a3} = 7 \times 10^{-13}$   
 1.  $7 \times 10^{-2}$ ; 2.  $7 \times 10^{-3}$ ; 3.  $7 \times 10^{-4}$ ; 4.  $7 \times 10^{-5}$ ; 5.  $7 \times 10^{-6}$ ; 6.  $7 \times 10^{-7}$ ; 7.  $7 \times 10^{-8}$ ; 8.  $7 \times 10^{-9}$ ; 9.  $7 \times 10^{-10}$ ; 10.  $7 \times 10^{-11}$
14. Calculate the solubility of solid AgCl in a 1.0 M  $\text{NH}_3$  solution. (4 pts)  
 $\text{AgCl (s)} \rightleftharpoons \text{Ag}^+ \text{(aq)} + \text{Cl}^- \text{(aq)} \quad K_{sp} = 1.0 \times 10^{-10}$   
 $\text{Ag}^+ \text{(aq)} + \text{NH}_3 \text{(aq)} \rightleftharpoons \text{Ag(NH}_3\text{)}^+ \text{(aq)} \quad K_1 = 1.0 \times 10^3$   
 $\text{Ag(NH}_3\text{)}^+ \text{(aq)} + \text{NH}_3 \text{(aq)} \rightleftharpoons \text{Ag(NH}_3\text{)}_2^+ \text{(aq)} \quad K_2 = 1.0 \times 10^3$   
 1. 0.5 2.  $1 \times 10^{-1}$  3.  $5 \times 10^{-2}$  4.  $1 \times 10^{-2}$  5.  $5 \times 10^{-3}$  6.  $1 \times 10^{-3}$  7.  $1 \times 10^{-4}$  8.  $1 \times 10^{-5}$  9.  $1 \times 10^{-6}$  10.  $1 \times 10^{-7}$

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15. When a buffered solution has a pH value close to 7, you need to calculate the  $[H^+]$  contribution from  $H_2O$ . Using the following equations to derive the exact treatment of the  $[H^+]$  for a buffered solution ( $K_a$  = equilibrium constant of HA,  $[HA]_0$  = the initial concentration of HA,  $[NaA]_0$  = the initial concentration of NaA, assume the value of  $K_w$ ;  $K_a$ ;  $[HA]_0$ ;  $[NaA]_0$  is known). (4 pts)



Then what's the number of  $a + b + c + d + e + f = ?$

1. 4    2. 5    3. 6    4. 7    5. 8    6. 9    7. 10    8. 11    9. 12    10. 13

四、填充題：請製表後再將答案置入表內

16. A system with 1 mol of a monatomic ideal gas that is taken from state A ( $P_A = 5 \text{ atm}$ ,  $V_A = 10 \text{ L}$ ) to state B ( $P_B = 5 \text{ atm}$ ,  $V_B = 40 \text{ L}$ ) at a constant pressure process: Calculate the  $q$ ,  $w$ ,  $\Delta E$  and  $\Delta H$  (Gas constant  $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$  or  $0.08206 \text{ L atm K}^{-1}\text{mol}^{-1}$ , make sure their signs ( $\pm$ ) is considered from the system's point of view) (8 pts)



State	w	q	ΔE	ΔH
A → B	2 pts (kJ)	2 pts (kJ)	2 pts (kJ)	2 pts (kJ)

17. Name the elements or compounds in English: For example: H → Hydrogen. (8 pts)

1. K → 2 pts	3. O <sub>2</sub> F <sub>2</sub> → 2 pts
2. Mo → 2 pts	4. HClO <sub>2</sub> → 2 pts