

國立高雄大學 102 學年度研究所碩士班招生考試試題

科目：普通化學  
考試時間：100 分鐘

系所：應用化學系  
本科原始成績：100 分

是否使用計算機：是

**Part I.** [11 questions; **3 points** for each question; total **33 points**; select the best answer.]

- The second law of thermodynamics states that
  - the entropy of a perfect crystal is zero at 0 K.
  - the entropy of the universe is constant.
  - the energy of the universe is increasing.
  - the entropy of the universe is increasing.
  - the energy of the universe is constant.
- For a spontaneous exothermic process, which of the following must be true?
  - $\Delta G$  must be positive.
  - $\Delta S$  must be positive.
  - $\Delta S$  must be negative.
  - Two of these must be true.
  - None of these (a-c) must be true.
- The conjugate base of a weak acid is
  - a strong base
  - a weak base
  - a strong acid
  - a weak acid
  - none of these
- Identify the strongest acid.
  - HCN
  - HNO<sub>3</sub>
  - H<sub>2</sub>O
  - OH<sup>-</sup>
  - CH<sub>3</sub>OH
- Identify the strongest base.
  - CH<sub>3</sub>O<sup>-</sup>
  - CH<sub>3</sub>OH
  - CN<sup>-</sup>
  - H<sub>2</sub>O
  - NO<sub>3</sub><sup>-</sup>
- Consider the reaction  $X \rightarrow Y + Z$   
Which of the following is a possible rate law?
  - Rate =  $k[X]$
  - Rate =  $k[Y]$
  - Rate =  $k[Y][Z]$
  - Rate =  $k[X][Y]$
  - Rate =  $k[Z]$
- The hybridization of Cl in ClF<sub>2</sub><sup>+</sup> is
  - sp
  - sp<sup>2</sup>
  - sp<sup>3</sup>
  - dsp<sup>3</sup>
  - d<sup>2</sup>sp<sup>3</sup>
- Which of the following molecules has a bond order of 1.5?
  - O<sub>2</sub><sup>+</sup>
  - N<sub>2</sub>
  - O<sub>2</sub><sup>-</sup>
  - C<sub>2</sub>
  - none of these

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9. Order the intermolecular forces (dipole-dipole, London Dispersion, ionic, and hydrogen-bonding) from weakest to strongest.
- dipole-dipole, London Dispersion, ionic, and hydrogen-bonding
  - London Dispersion, dipole-dipole, hydrogen-bonding, ionic
  - hydrogen-bonding, dipole-dipole, London Dispersion, and ionic
  - dipole-dipole, ionic, London Dispersion, and hydrogen-bonding
  - London Dispersion, ionic, dipole-dipole, and hydrogen-bonding
10. On a relative basis, the weaker the intermolecular forces in a substance,
- the greater its vapor pressure at a particular temperature.
  - the greater its heat of vaporization.
  - the more it deviates from ideal gas behavior.
  - the higher its melting point.
  - none of these
11. Which of the following statements about quantum theory is *incorrect*?
- The energy and position of an electron cannot be determined simultaneously.
  - Lower energy orbitals are filled with electrons before higher energy orbitals.
  - When filling orbitals of equal energy, two electrons will occupy the same orbital before filling a new orbital.
  - No two electrons can have the same four quantum numbers.
  - All of these are correct.

**Part II.** [8 questions; **4 points** for each question; total **32 points**; select the best answer.]

12. Calculate the pKa of the conjugate acid of water,  $\text{H}_3\text{O}^+$ .
- a). -1.85      b). 1.85      c). -1.74      d). 1.74      e). 7.00
13. What is the pH of  $1.0 \times 10^{-11}$  M HI in water.
- a). 11.00      b). 3.98      c). 6.00      d). 5.50      e). 7.00

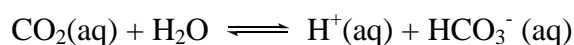
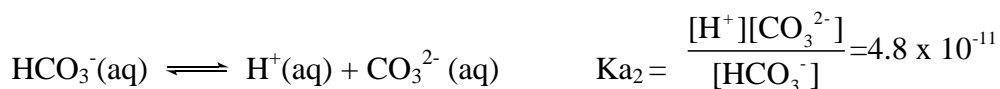
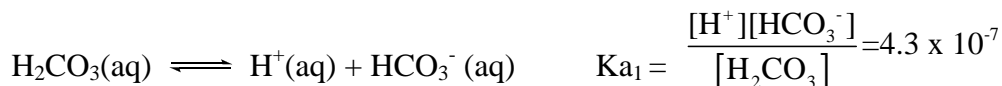
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14. Calculate the fraction of  $\text{CO}_3^{2-}:\text{HCO}_3^-$  at  $\text{pH} = 9.00$ ; Given



- a).  $4.8 \times 10^{-2}$     b).  $3.8 \times 10^{-2}$     c). 0.95    d).  $2.3 \times 10^{-3}$     e).  $4.8 \times 10^{-11}$

15. Assume a 0.100 M solution of  $\text{NH}_4\text{C}_2\text{H}_3\text{O}_2$  has a  $\text{pH}$  of 8.00.  $\text{NH}_3$  is a weak base and  $\text{C}_2\text{H}_3\text{O}_2^-$  is the anion of a weak acid. Calculate the  $K_b$  of  $\text{C}_2\text{H}_3\text{O}_2^-$ , assume that the  $K_b$  of  $\text{NH}_3 = 1.0 \times 10^{-3}$ .

- a).  $1.0 \times 10^{-9}$     b).  $1.0 \times 10^5$     c).  $1.0 \times 10^{-5}$     d).  $1.0 \times 10^9$     e).  $1.0 \times 10^{-3}$

16. Classify each of the following as a strong acid, weak acid, strong base, or a weak base in aqueous solution.

- i.  $\text{HNO}_2$     ii.  $\text{HNO}_3$     iii.  $\text{CH}_3\text{NH}_2$     iv.  $\text{NaOH}$     v.  $\text{NH}_3$   
 vi.  $\text{HF}$     vii.  $\text{HCO}_2\text{H}$     viii.  $\text{Ca}(\text{OH})_2$     ix.  $\text{H}_2\text{SO}_4$

- a). strong acid or base: ii, iv, viii, ix;    weak acid or base: i, iii, v, vi, vii  
 b). strong acid or base: i, ii, iii, v, vii;    weak acid or base: iv, vi, viii, ix  
 c). strong acid or base: ii, iv, vi, ix;    weak acid or base: i, iii, v, vii, viii  
 d). strong acid or base: ii, iv, vi, vii, ix;    weak acid or base: i, iii, v, viii  
 e). strong acid or base: ii, iv, vi, viii, ix;    weak acid or base: i, iii, v, vii

17. At  $40^\circ\text{C}$  the value of  $K_w$  is  $2.92 \times 10^{-14}$ . If the hydroxide ion concentration in a solution is 0.10 M, what is the  $\text{pH}$  at  $40^\circ\text{C}$ ?

- a).  $\text{pH} = 11.53$     b).  $\text{pH} = 7.00$     c).  $\text{pH} = 10.34$   
 d).  $\text{pH} = 12.53$     e).  $\text{pH} = 6.77$

18. How much volume of concentrated (12 M)  $\text{HCl}$  into 1600 mL of water, to get a  $\text{pH} = 1.50$  solution?

- a). 5.0 mL    b). 4.2 mL    c). 4.7 mL    d). 6.3 mL    e). 1.2 mL

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19. In a two bulb system (separated by a valve) with total  $n$  particles, the probability of finding all the molecules of gas in the left bulb after opening the valve is defined as

a).  $\frac{1}{2^n} = \left(\frac{1}{2}\right)^n$

b).  $\frac{1}{3^n} = \left(\frac{1}{3}\right)^n$

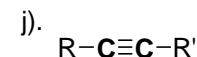
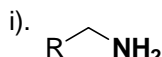
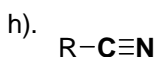
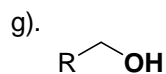
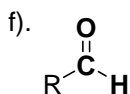
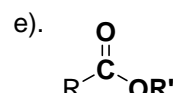
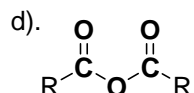
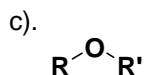
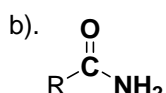
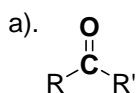
c).  $\left(\frac{1}{3}\right)^{6 \times 10^{23}}$

d).  $\frac{1}{2} \log(10)^{6 \times 10^{23}}$

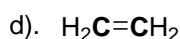
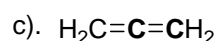
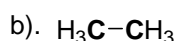
e).  $\frac{1}{2} \ln^{6 \times 10^{23}}$

**Part III.** [6 questions; total 35 points.]

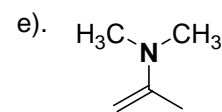
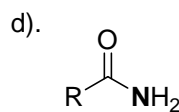
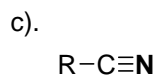
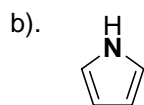
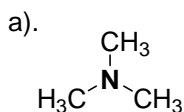
20. For the following compounds, write down the corresponding **English names** of following organic functional groups. **10 points**



21. Give the ranking of **carbon-carbon bond length**, starting from the longest one. **4 points**



22. Which **nitrogen atoms (N)** of following compounds are  $sp^2$  hybridized? **3 points**



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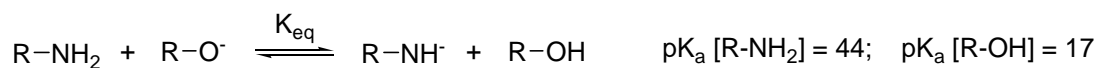
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23. **Diazo compound** ( $R_2C=N_2$ ) has two linked nitrogen atoms (azo) as a terminal functional group. Write down the Lewis structure with resonances. **5 points**

24. For the following acid-base reaction, calculate the  $K_{eq}$  value and determine which direction of equilibrium is more favored. **5 points**



25. Give the **English names** of the following alkyl groups. **8 points**

