

國立清華大學 命題紙

九十三年學年度 原子科學 系(所) 乙 組碩士班研究生招生考試

科目 普通化學 科號 3601 共 5 頁第 1 頁 *請在試卷【答案卷】內作答

一、單一選擇題 (60%；每題兩分)

答對得該題題分；答錯倒扣 1/4 題分；未作答者，不給分亦不扣分。

1. Which of the following are incorrectly paired?

- [A] Ne, noble gas [B] Ni, transition metal [C] K, alkali metal [D] Ba, alkaline earth metal [E] O, halogen

2. An aqueous solution of ethanol, $\text{CH}_3\text{CH}_2\text{OH}$, that is 12.00 % ethanol by weight, has a density of 0.9808 g mL^{-1} at 20°C . What is the molality of ethanol in this solution?

- [A] 0.0506 [B] 0.120 [C] 1.48 [D] 2.56 [E] 2.96

3. Of energy, work, enthalpy, and heat, how many are state functions?

- [A] 0 [B] 1 [C] 2 [D] 3 [E] 4

4. How many grams of NaCl are contained in 350. mL of a 0.250 M solution of sodium chloride?

- [A] 5.11 g [B] 14.6 g [C] 41.7 g [D] 87.5 g [E] none of these

5. List the following atoms in order of increasing ionization energy: Li, Na, C, O, F.

- [A] $\text{Li} < \text{Na} < \text{C} < \text{O} < \text{F}$ [B] $\text{F} < \text{O} < \text{C} < \text{Li} < \text{Na}$ [C] $\text{Na} < \text{Li} < \text{C} < \text{O} < \text{F}$
[D] $\text{Na} < \text{Li} < \text{C} < \text{F} < \text{O}$ [E] $\text{Na} < \text{Li} < \text{F} < \text{O} < \text{C}$

6. Choose the element whose ion has the largest concentration inside a human cell.

- [A] Na [B] K [C] Ca [D] Mg [E] Fe

7. A gas sample is held at constant pressure. The gas occupies 3.62 L of volume when the temperature is 21.6°C . Determine the temperature at which the volume of the gas is 3.45 L.

- [A] 206 K [B] 294 K [C] 309 K [D] 326 K [E] none of these

8. You have two samples of the same gas in the same size container, with the same pressure. The gas in the first container has a kelvin temperature four times that of the gas in the other container. The ratio of number of collisions with the wall in the first container compared to that in the second is

- [A] 1 : 4 [B] 1 : 2 [C] 1 : 1 [D] 2 : 1 [E] 4 : 1

9. Which of the following ionic compounds has the smallest lattice energy, i.e., the lattice energy least favorable to a stable lattice?

- [A] NaCl [B] BaO [C] CsI [D] LiF [E] MgO

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10. If $\Delta G_r^\circ(\text{HI, g}) = +1.7 \text{ kJ}$, what is the equilibrium constant at 25°C for the reaction: $2 \text{ HI(g)} = \text{H}_2(\text{g}) + \text{I}_2(\text{s})$
 [A] 24 [B] 3.9 [C] 2.0 [D] 0.50 [E] 0.25
11. Which of the following statements about the spontaneous reaction occurring in a galvanic cell is true?
 [A] $\Delta E_{\text{cell}}^\circ > 0$, $\Delta G^\circ < 0$, and $Q < K$ [B] $\Delta E_{\text{cell}}^\circ > 0$, $\Delta G < 0$, and $Q < K$
 [C] $\Delta E_{\text{cell}}^\circ > 0$, $\Delta G^\circ > 0$, and $Q > K$ [D] $\Delta E_{\text{cell}}^\circ > 0$, $\Delta G < 0$, and $Q > K$
 [E] $\Delta E_{\text{cell}}^\circ > 0$, $\Delta G^\circ > 0$, and $Q < K$
12. A solution of 8.0 M formic acid (HCOOH) is 0.47% ionized. What is the K_a of formic acid?
 [A] 3.8×10^{-2} [B] 1.8×10^{-4} [C] 6.9×10^{-6} [D] 3.4×10^{-8} [E] need more data
13. How many possible sequences can be made for a polypeptide with six different amino acids?
 [A] 720 [B] 64 [C] 36 [D] 6 [E] none of these (a-d)
14. A salt, MY , crystallizes in a body-centered cubic structure with a Y^- anion at each cube corner and an M^+ cation at the cube center. Assuming that the Y^- anions touch each other and the M^+ cation at the center, and the radius of Y^- is $1.50 \times 10^2 \text{ pm}$, the radius of M^+ is:
 [A] 34 pm [B] 62 pm [C] 110 pm [D] 220 pm [E] non of these
15. The density of a liquid is determined by successively weighing 25, 50, 75, 100, and 125 mL of the liquid in a 250-mL beaker. If volume of liquid is plotted along the horizontal axis, and total mass of beaker plus liquid is plotted on the vertical axis:
 [A] the x, or horizontal, intercept is the negative value of the weight of the beaker. [B] the slope of the line is independent of the identity of the liquid. [C] the line will pass through the origin. [D] the slope of the line is 1.0. [E] the y, or vertical, intercept is the weight of the empty beaker.
16. The number of half-lives needed for a radioactive element to decay to about 6% of its original activity is (choose nearest number):
 [A] 2 [B] 3 [C] 4 [D] 5 [E] 6
17. Which of the following statements about quantum theory is *incorrect*?
 [A] When filling orbitals of equal energy, two electrons will occupy the same orbital before filling a new orbital.
 [B] No two electrons can have the same four quantum numbers.
 [C] Lower energy orbitals are filled with electrons before higher energy orbitals.
 [D] The energy and position of an electron cannot be determined simultaneously.
 [E] All of these are correct.

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18. The electron pair in a C-F bond could be considered
- [A] closer to F because fluorine has a higher electronegativity than carbon.
 [B] closer to C because carbon has a larger radius and thus exerts greater control over the shared electron pair.
 [C] an inadequate model since the bond is ionic.
 [D] closer to C because carbon has a lower electronegativity than fluorine.
 [E] centrally located directly between the C and F.
19. Vitamin A has a molar mass of 286.4 g and has a general molecular formula of C_xH_yE , where E is an unknown element. If Vitamin A is 83.86% C and 10.56% H by mass, what is the molecular formula of vitamin A?
- [A] $C_{10}H_{15}S_5$ [B] $C_{12}H_{18}N_9$ [C] $C_{14}H_{21}N_7$ [D] $C_{20}H_{30}O$ [E] $C_{20}H_{30}S$
20. Consider the reaction $3O_2(g) \leftrightarrow 2O_3(g)$. At 175 °C and a pressure of 128 torr, an equilibrium mixture of O_2 and O_3 has a density of 0.168 g/L. Calculate K_p for the above reaction at 175 °C.
- [A] 0.002 atm^{-1} [B] 0.42 atm^{-1} [C] 317 atm^{-1} [D] 522 atm^{-1} [E] non of these
21. The solubility of benzoic acid is 0.34 g/100 mL in water at 25 °C and 10.0 g/100 mL in benzene (C_6H_6) at 25 °C. For a 1.0 molal solution of benzoic acid in benzene ($K_f = 5.12 \text{ }^\circ\text{C kg/mol}$ for benzene.), the measured freezing-point depression would be
- [A] less than 5.12 °C [B] equal to 5.12 °C [C] between 5.12 °C and 10.24 °C [D] equal to 10.24 °C
 [E] greater than 10.24 °C
22. Which of the followings is extensive property of a system?
- [A] entropy [B] refractive index [C] temperature [D] pressure [E] density
23. Calculate the most probable value of r (r_{mp}) that an electron described by a hydrogen atomic 1s wave function will be found?
- $$\Psi_{100} = \frac{1}{\sqrt{\pi}} \left(\frac{1}{a_0}\right)^{3/2} e^{-(r/a_0)}$$
- [A] 0 [B] $0.3a_0$ [C] $0.5a_0$ [D] a_0 [E] $1.5a_0$
24. If a steady current of 15.0 A is passed through an aqueous solution of $CuSO_4$, how long will it take to deposit 0.250 mol of Cu at the cathode, assuming 100% efficiency?
- [A] $3.22 \times 10^3 \text{ min}$ [B] $1.61 \times 10^3 \text{ min}$ [C] 53.6 min [D] 26.8 min [E] 0.893 min

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25. Which of the following favors the solubility of an ionic solid in a liquid solvent?

- [A] a large polarity of the solvent [B] a large magnitude of the solvation energy of the ions
[C] a small magnitude of the lattice energy of the solute [D] all of these [E] none of these

26. How many electrons can be contained in all of the orbitals with $n = 4$?

- [A] 2 [B] 8 [C] 10 [D] 18 [E] 32

27. An automobile tire is filled with air at a pressure of 30 lb/in² at 25°C. A cold front moves through and the temperature drops to 5°C. Assuming no change in volume, what is the new tire pressure?

- [A] 4.0 lb/in² [B] 6.0 lb/in² [C] 20.0 lb/in² [D] 28.0 lb/in² [E] 32.0 lb/in²

28. Consider the following reduction potentials:

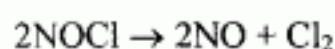


For a galvanic cell employing the Cu, Cu²⁺ and Pb, Pb²⁺ couples, calculate the maximum amount of work that would accompany the reaction of one mole of lead under standard conditions.

- [A] No work can be done. The system is at equilibrium.
[B] 40.5 kJ [C] 45.3 kJ [D] 90.7 kJ [E] none of these

29. The questions below refer to the following information:

The rate constant k for the reaction shown below is $2.6 \times 10^{-8} \text{ L}/(\text{mol s})$ when the reaction proceeds at 300.0 K. The activation energy is 98000 J/mol. (The universal gas constant (R) is 8.314 J/(mol K))



If the temperature changed to 310 K the rate constant k would change. The ratio of k at 310 K to k at 300.0 K is closest to what whole number?

- [A] 1 [B] 2 [C] 3 [D] 4 [E] 5

30. Given the heats of the following reactions:

	<u>ΔH° (kJ)</u>
I. $\text{P}_4(\text{s}) + 6\text{Cl}_2(\text{g}) \rightarrow 4\text{PCl}_3(\text{g})$	-1225.6
II. $\text{P}_4(\text{s}) + 5\text{O}_2(\text{g}) \rightarrow \text{P}_4\text{O}_{10}(\text{s})$	-2967.3
III. $\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{PCl}_5(\text{g})$	-84.2
IV. $\text{PCl}_3(\text{g}) + (1/2)\text{O}_2(\text{g}) \rightarrow \text{Cl}_3\text{PO}(\text{g})$	-285.7

Calculate the value of ΔH° for the reaction below:



- [A] 7555.0 kJ [B] 2682.2 kJ [C] 610.1 kJ [D] 110.5 kJ [E] None of these is within 5% of the correct answer.

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二、問答題 (40%)

- (10%) When the galleon *Atocha* was destroyed on a reef by a hurricane in 1622, it was bound for Spain carrying about 47 tons of copper, gold, and silver from the New World. The bulk of the treasure was silver bars and coins packed in wooden chests. When treasure hunter Mel Fisher salvaged the silver in 1985, corrosion and marine growth had transformed the shiny metal into something that looked like coral. Write down all possible chemical reactions in wooden chests that had occurred in 350 years of being submerged in the ocean and propose effective procedures to restore the silver to its original condition.
- (10%) What is the degree of degeneracy of an energy level? For the particle in a cubic box with dimension l , what is the degree of degeneracy of the energy levels with the following values of $8ml^2E/h^2$? (a) 12; (b) 14
- (20%) Usually 10 minutes is required to hardboil an egg at 100 °C on the ground. On the top of a mountain 2500 m above sea level, it takes 12 hours to hardboil the egg. This dramatic change in rate with temperature is far beyond the chemist's rule of thumb. **Assume** that the temperature is constant at 27 °C both on the ground and on the top of the mountain. Air is a single gas with molar mass 0.028 kg/mol. The molar enthalpy change of vaporization of water is independent of temperature and equal to 40.7 kJ/mol.
 - What is the atmospheric pressure on the top of the mountain?
 - What is the boiling point of water on the top of the mountain?
 - Estimate the activation energy of the reaction.
 - Propose a reason why the dramatic change in rate with temperature occurs in hardboiling of eggs.