

國立交通大學 104 學年度碩士班考試入學試題

科目：普通化學(6523)

考試日期：104 年 2 月 7 日 第 1 節

系所班別：加速器光源科技與應用碩士學位學程

第 1 頁, 共 5 頁

【可使用計算機】*作答前請先核對試題、答案卷(試卷)與准考證之所組別與考科是否相符!!

Potentially useful information (including periodic table, some formulae and constants):

PERIODIC TABLE OF THE ELEMENTS

| 1A | 2A | 3B | 4B | 5B | 6B | 7B | 8B | 8B | 8B | 1B | 2B | 3A | 4A | 5A | 6A | 7A | 8A | | | | | | | | | | | | | | |
|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| 1 H 1.008 | | | | | | | | | | | | | | | | | 2 He 4.003 | | | | | | | | | | | | | | |
| 3 Li 6.941 | 4 Be 9.012 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 Na 22.99 | 12 Mg 24.31 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 K 39.10 | 20 Ca 40.08 | 21 Sc 44.96 | 22 Ti 47.88 | 23 V 50.94 | 24 Cr 52.00 | 25 Mn 54.94 | 26 Fe 55.85 | 27 Co 58.93 | 28 Ni 58.71 | 29 Cu 63.55 | 30 Zn 65.39 | 31 Ga 69.72 | 32 Ge 72.61 | 33 As 74.92 | 34 Se 78.96 | 35 Br 79.90 | 36 Kr 83.80 | | | | | | | | | | | | | | |
| 37 Rb 85.47 | 38 Sr 87.62 | 39 Y 88.91 | 40 Zr 91.22 | 41 Nb 92.91 | 42 Mo 95.94 | (98) | 101.1 | 102.9 | 106.4 | 107.9 | 112.4 | 114.8 | 118.7 | 121.8 | 127.6 | 126.9 | 131.3 | | | | | | | | | | | | | | |
| 55 Cs 132.9 | 56 Ba 137.3 | 57 La 138.9 | 58 Ce 140.1 | 59 Pr 140.9 | 60 Nd 144.2 | 61 Pm (145) | 62 Sm 150.4 | 63 Eu 151.9 | 64 Gd 157.3 | 65 Tb 158.9 | 66 Dy 162.5 | 67 Ho 164.9 | 68 Er 167.3 | 69 Tm 168.9 | 70 Yb 173.0 | 71 Lu 175.0 | 72 Hf 178.5 | 73 Ta 180.9 | 74 W 183.8 | 75 Re 186.2 | 76 Os 190.2 | 77 Ir 192.2 | 78 Pt 195.1 | 79 Au 197.0 | 80 Hg 200.6 | 81 Tl 204.4 | 82 Pb 207.2 | 83 Bi 209.0 | 84 Po (209) | 85 At (210) | 86 Rn (222) |
| 87 Fr (223) | 88 Ra (226) | 89 Ac (227) | 90 Th (232) | 91 Pa (231) | 92 U (238) | 93 Np (237) | 94 Pu (244) | 95 Am (243) | 96 Cm (247) | 97 Bk (247) | 98 Cf (251) | 99 Es (252) | 100 Fm (257) | 101 Md (258) | 102 No (259) | 103 Lr (262) | 104 Rf (261) | 105 Db (262) | 106 Sg (266) | 107 Bh (264) | 108 Hs (277) | 109 Mt (268) | 110 Ds (271) | 111 Rg (272) | 112 Cn (285) | 113 Nh (286) | 114 Fl (289) | 115 Mc (290) | 116 Lv (293) | 117 Ts (294) | 118 Og (294) |

Formulae

- $t_{1/2} = (\ln 2/k)$, $\ln 2 = 0.693$
- $\nu = R(1/n_1^2 - 1/n_2^2)$, $R = 3.29 \times 10^{15} \text{ Hz}$
- $nFE = RT \ln K$
- $\Delta E^\circ = E^\circ(\text{cathode}) - E^\circ(\text{anode})$
- $\Delta G^\circ = -nFE^\circ$
- $\Delta E = \Delta E^\circ - (0.05916/n) \log Q$

Constants

- $R = 8.314 \text{ J / (K}\cdot\text{mol)}$
 $= 8.206 \times 10^{-2} \text{ atm}\cdot\text{L / (K}\cdot\text{mol)}$
- $1 \text{ atm} = 760 \text{ Torr}$
 $= 1.01 \times 10^5 \text{ Pa}$
 $= 0.0821 \text{ L atm / (K}\cdot\text{mol)}$
 $= 8.314 \text{ L kPa / (K}\cdot\text{mol)}$
- $e = 1.60 \times 10^{-19} \text{ C}$
- $c = 2.99 \times 10^8 \text{ m/s}$
- $h = 6.63 \times 10^{-34} \text{ J}\cdot\text{s}$
- $\hbar = 1.05 \times 10^{-34} \text{ J}\cdot\text{s}$
- $F = 96,500 \text{ Coulombs/mole}$

(Question 1~16: total 32%, 2% for each)

(單選題共 16 題，每題答對得 2 分，未作答或答錯不給分。請用答案卡作答。)

1. The lowest-frequency line in the Lyman series for H is $2.47 \times 10^{15} \text{ Hz}$. What is the frequency of the radiation emitted by He^+ from $n = 2$ to $n = 1$?

- A) $4.94 \times 10^{15} \text{ Hz}$
- B) $9.88 \times 10^{15} \text{ Hz}$
- C) $2.67 \times 10^{16} \text{ Hz}$
- D) $5.34 \times 10^{16} \text{ Hz}$

2. For dinitrogen monoxide, which of the following statements is not true?

- A) The most stable arrangement of atoms is NON.
- B) $\text{N}=\text{N}=\text{O}$ and $\text{N}=\text{O}=\text{N}$ are not resonance structures.
- C) In the structure $\text{N}=\text{O}=\text{N}$, the formal charge on the central O atom is +2.
- D) In the structure $\text{N} \equiv \text{N}-\text{O}$, the formal charge on the central N atom is +1.

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3. For a one-dimensional particle in a box, which of the following statements is not true?

- A) The lowest possible energy > 0 .
- B) For $n = 1$, the wavelength is equal to the length of the box.
- C) As the mass of the particle becomes heavier, the lowest possible energy decreases.
- D) The probability of finding the particle in a region is proportional to the square of wavefunction (Ψ^2)

4. Hydrogen has a strong emission line at 6563 Å. What is the energy difference between the energy levels in hydrogen that are involved in this transition?

- A) 0.16 eV
- B) 1.89 eV
- C) 3.03 eV
- D) 4.57 eV
- E) 15.2 eV

5. Which of the following is not a valid resonance structure for N_3^- ?

- (A) $[\ddot{N}=\ddot{N}-\ddot{N}]^-$ (B) $[\ddot{N}\equiv N-\ddot{N}]^-$ (C) $[\ddot{N}-N\equiv N:]^-$
- (D) $[\ddot{N}=N=\ddot{N}]^-$ (E) all are correct

6. 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) Gas particles are very small compared to the average distance between the particles.
- C) Gas particles collide with the walls of their container in elastic collisions.
- D) The average velocity of the gas particles is directly proportional to the absolute temperature.
- E) All of the above are assumptions of the kinetic molecular theory.

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7. Of the following sets of four quantum numbers $\{n, l, m_l, m_s\}$, identify the one that is allowed for an electron in an atom.

- A) $\{2, 2, 0, +1/2\}$
- B) $\{3, 1, -1, 0\}$
- C) $\{4, 0, 1, +1/2\}$
- D) $\{4, 2, -2, -1/2\}$

8. Which of the following statements is true?

- A) Fluorescence never occurs in gas phase.
- B) Mechanical shock to a crystal may cause luminescence.
- C) In fluorescence, the wavelength of the emitted light is always longer than the exciting light.
- D) In phosphorescence, the excited state is a doublet state that has longer life-time than a singlet state.
- E) Because of the short life-time of the excited state, an excited fluorescent molecule never transfers its energy and excites another fluorescent molecule.

9. A sample of O_2 gas takes 400 s to effuse through a porous plug at 400 K. It takes 800 s for the same number of molecules of an unknown gas to effuse at 300 K. What is the molar mass of this unknown gas?

- A) 48.0 g/mol
- B) 55.5 g/mol
- C) 72.0 g/mol
- D) 96.0 g/mol

10. Molecular crystals are held in lattice sites by

- A) covalent bonds.
- B) ionic bonds.
- C) intermolecular forces.
- D) large molecular orbitals that span many lattice sites.

11. What is the molecular shape of white phosphorus P_4 , and is this molecule polar or nonpolar?

- A) linear, polar.
- B) saw tooth, nonpolar
- C) tetrahedron, nonpolar
- D) square planar, nonpolar
- E) trigonal pyramidal, polar

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12. Which of the following reaction is referred to the second ionization energy of calcium?

- A) $\text{Ca}_{(g)}^+ \rightarrow \text{Ca}_{(g)}^{2+} + e^-$
- B) $\text{Ca}_{(aq)}^+ \rightarrow \text{Ca}_{(aq)}^{2+} + e^-$
- C) $\text{Ca}_{(g)} \rightarrow \text{Ca}_{(g)}^{2+} + 2 e^-$
- D) $\text{Ca}_{(s)} \rightarrow \text{Ca}_{(aq)}^{2+} + 2 e^-$
- E) $\text{Ca}_{(s)} \rightarrow \text{Ca}_{(g)}^{2+} + 2 e^-$

13. The small, but important, energy differences between $3s$, $3p$, and $3d$ orbitals are due mainly to

- A) the number of electrons they can hold
- B) their principal quantum number
- C) the Heisenberg uncertainty principle
- D) the penetration effect
- E) Hund's rule

14. Which of the following statements is true?

- A) The exact location of an electron can be determined if we know its energy.
- B) An electron in a $2s$ orbital can have the same n , l , and m_l quantum numbers as an electron in a $3s$ orbital.
- C) Ni has two unpaired electrons in its $3d$ orbitals.
- D) In the buildup of atoms, electrons occupy the $4f$ orbitals before the $6s$ orbitals.
- E) Only three quantum numbers are needed to uniquely describe an electron.

15. Which of the following species has a trigonal bipyramid structure?

- (A) NH_3 (B) IF_5 (C) I_3^- (D) PCl_5 (E) none of these

16. Consider an atom traveling at 1% of the speed of light. The de Broglie wavelength is found to be 4.15×10^{-3} pm. Which element is this?

- (A) He (B) S (C) F (D) Cu (E) P

17. (10%) Explain how solar cells and artificial photosynthesis harvest solar energy?

18. (10%) In the titration of 100.0 ml of a 0.050 M H_3A solution ($K_{a1} = 1.0 \times 10^{-3}$, $K_{a2} = 5.0 \times 10^{-8}$, $K_{a3} = 2.0 \times 10^{-12}$), calculate the volume of 1.00 M NaOH required to reach pH= 9.50 and 4.00.

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19. (13%) The concentration of CO in the air is 300 ppmv when the atomic pressure and temperature are 628 torr and 0 °C, respectively.

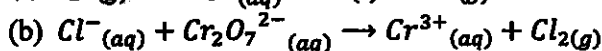
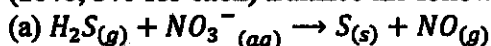
(a) Define ppmv for gases. (3%)

(b) What is the partial pressure of CO? (5%)

(c) What is the concentration of CO in molecules per cubic centimeter? (5%)

(1 atm = 760 torr = 1.013×10^5 Pa)

20. (10%, 5% for each) Balance the following two equations occurring in acidic solution.



21. (8%) Consider the two reduction half-reactions:

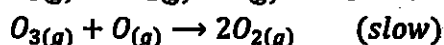
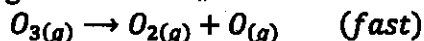


(a) Calculate the standard electrode potential E°_{cell} for zinc acting as the anode (oxidation) and copper acting as the cathode (reduction).

(b) Calculate the ΔG° for the reaction, where $\Delta G^\circ = -nFE^\circ_{cell}$. ($F = 96500 \frac{\text{Coulombs}}{\text{mole}}$)

22. (10%) Write the structural formulas for all isomers of C_6H_{14} and name all these isomers.

23. (7%) Consider the following mechanism:



(a) Write the overall balanced chemical equation.

(b) Identify any intermediates within the mechanism.

(c) What is the reaction order with respect to each reactant?