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科目：普通化學
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國立臺灣大學 112 學年度碩士班招生考試試題

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Physical constants: $m_e = 9.1 \times 10^{-31}$ kg, $h = 6.626 \times 10^{-34}$ Js, R = 0.082 LatmK⁻¹mol⁻¹=8.3 Jmol⁻¹K⁻¹, F=96500.

本份試卷含單選題 25 題(75 分)，及三大題敘述與計算題(25 分)，總分 100 分

(I). 單選題 (選出一個最適當的答案): 每題 3 分. (答案請直接填入 "選擇題作答區" 內)

1. The number log(456.1) should be reported as
   (A) 2.65906 (B) 2.6591 (C) 2.659 (D) 2.66 (E) 2.7

2. Ionic solids are often strong electrolytes that dissolve in water. Which statement in the following is correct about this process?
   (A) Water is amphiprotic and therefore is good at dissolving ionic solids.
   (B) Water is good at solvating ions because the H and O atoms in water molecules bear partial charges.
   (C) Ionic solids dissolve because the interactions between cations and anions are weaker than the interactions between ions and water molecules.
   (D) The dielectric constant of water is large, so the Coulombic interactions between the ions are reduced.
   (E) The hydrogen and oxygen bonds of water are easily broken by ionic solids.

3. Consider the 1-D particle in a box model, which statement below is true?
   (A) The zero-point energy of a hydrogen atom in a box is higher than that of an electron in the same box.
   (B) n=10 state of a He atom in a 5 nm box is higher in energy than n=4 state of a H atom in a 3 nm box.
   (C) As temperature decreases, the probability of finding the particle in the center of the box decreases.
   (D) The total energy equals the kinetic energy plus the zero-point energy.
   (E) The n=0 state is the ground state.

4. The formula of 4-ethyl-2,4-dimethylhexane is
   (A) C_9H_{18} (B) C_9H_{20} (C) $C_{10}H_{20}$ (D) $C_{10}H_{22}$ (E) $C_{11}H_{22}$

5. The two molecules on the right are
   (A) diastereomers (B) *cis-trans* isomers (C) enantiomers
   (D) rotamers (E) unrelated

6. Which ion is with charge -2 and ground-state electron configuration [Ne]$3s^2 3p^6$?
   (A) S^{2-} (B) Se^{2-} (C) P^{2-} (D) As^{2-} (E) Si^{2-}

7. What is the degeneracy of the n=3 energy level of the hydrogen atom?
   (A) 3 (B) 6 (C) 9 (D) 12 (E) 18

8. What is the number of vibrational modes in the H_2CO molecule?
   (A) 3 (B) 6 (C) 9 (D) 12 (E) 15

9. The O-H stretching frequency of a compound is 3400 cm⁻¹. What would be the frequency of the same mode when the hydrogen is changed to deuterium?
   (A) 1520 cm⁻¹ (B) 1700 cm⁻¹ (C) 1960 cm⁻¹ (D) 2400 cm⁻¹ (E) 3400 cm⁻¹

10. Which element has the largest ionization potential?
    (A) Si (B) P (C) S (D) As (E) Se

11. Which atom has the smallest atomic radius?
    (A) Si (B) P (C) S (D) As (E) Se

12. The compound XCl_4 contains 71.0% Cl by mass. What is the element X?
    (A) C (B) Ti (C) W (D) Ni (E) Pd

見背面

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13. Given a sample of ideal gas at -23 °C. In order to increase the average speed of the gas molecules by a factor of 2, to what temperature should the gas be heated?
(A) 1000 K (B) 750 K (C) 500 K (D) 354 K (E) 250 K

14. Which one is an ionic compound?
(A) CO (B) $Ni(CO)_4$ (C) NH_3 (D) CaO (E) $XeCl_4$

15. Nitrous acid is
(A) NO (B) NO_2 (C) HNO_2 (D) HNO_3 (E) HNO_4

16. The shape of SF_4 can be characterized as
(A) Trigonal pyramidal (B) Tetrahedral (C) linear (D) Square planar (E) Seesaw

17. Which one of the following bonds is the most polar?
(A) N-C (B) N-N (C) N-O (D) N-Cl (E) N-H

18. If 6.00 mol argon in a 73.8 L vessel initially at 300 K is compressed adiabatically and irreversibly to reach a temperature of 450 K, what is the work done on the gas.
(A) -22.4 kJ (B) -11.2 kJ (C) 0 (D) 11.2 kJ (E) 22.4 kJ

19. Given that $\Delta H_{fussion}$ for ice is 6.01 kJ/mol, what is ΔS when 36 g of ice melts at 273 K and 1 atm?
(A) 44 J/K (B) 22 J/K (C) 0 (D) -22 J/K (E) -44 J/K

20. Which compound would you expect to have the highest standard molar entropy at 1 atm and 300K?
(A) $H_2(g)$ (B) $He(g)$ (C) $N_2O_4(g)$ (D) $CH_4(g)$ (E) $C_{12}H_{24}(l)$

21. Which one of the following statements is incorrect?
(A) The higher the temperature, the broader the distribution of molecular speeds in a gas (B) In a spontaneous process, the energy of the system is conserved (C) In a spontaneous process, the free energy of the system decreases (D) Work is not a state function (E) Entropy is extensive

22. A cell has a standard cell potential of +0.111 V at 300 K. If the equilibrium constant for the redox reaction is $K=5.4×10^3$, then what is the number of electrons transferred in the reaction?
(A) $n=1$ (B) $n=2$ (C) $n=3$ (D) $n=4$

23. When 50.0 mL of 0.1 M NaOH is mixed with a 50.0 mL 0.200 M weak acid solution at 25°C, the pH is 4.00. What is the K_a of the weak acid?
(A) 10^{-2} (B) $5×10^{-3}$ (C) 10^{-3} (D) $5×10^{-4}$ (E) 10^{-4}

24. Which one in the following is not affected by a catalyst?
(A) Rate of the reaction (B) Free energy of the transition state (C) The ratio of total forward and reverse rates (D) Entropy of the reaction (E) Reaction mechanism

25. 50.0 mL of a 0.05 M solution of $Pb(NO_3)_2$ is mixed with 50.0 mL of a 0.20 M solution of $NaIO_3$ at 25°C. What is $[Pb^{2+}]$ in the solution (choose closest number)? At 25°C, Ksp for $Pb(IO_3)_2$ is $2.5×10^{-13}$.
(A) $1×10^{-10}$ (B) $5×10^{-11}$ (C) $2.5×10^{-11}$ (D) $5×10^{-12}$ (E) $2.5×10^{-12}$

(II). 敘述與計算題 (共 25 分，計算與推導需寫出過程):

26. (8%) Benzene is an aromatic compound.
(26a) The aromaticity of benzene arises because of what special properties of its π-electrons?
(26b) Benzene molecule is planar and does not undergo addition reaction. Explain the observations.

27. The mechanism of a chemical reaction is shown on the right.
(27a) (2%) What is the total reaction?
(27b) (5%) Give the rate law that corresponds to the mechanism.

$$A + B \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} C + D \quad \text{(fast equilibrium)}$$

$$C + E \overset{k_2}{\longrightarrow} F \quad \text{(slow)}$$

28. Phthalic acid (H_2Ph) is a doprotic acid with $pK_{a1}=2.90$ and $pK_{a1}=5.52$.
(28A) (6%) If 25.0 mL of a 0.2 M H_2Ph solution is titrated against 0.1 M NaOH solution, what are the pH value at the first and second equivalence points, respectively?
(28B) (4%) Describe how one can make 100 mL buffer solution with pH=3 by using 0.2 M H_2Ph solution and 0.1 M NaOH solution. Give the volume required for each solution.

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