本試題含單選題 25 題(75 分)，及三題敘述與計算題(25 分)，總分 100 分

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

1. Considering proper number of significant figures, log(9600) =
   (A) 4 (B) 4.0 (C) 3.98 (D) 3.982 (E) None of the above

2. Considering proper number of significant figures, $0.6 \times 10.36 =$
   (A) 6.216 (B) 6.22 (C) 6.2 (D) 6 (E) None of the above

3. The chemical formula of acetic acid is?
   (A) CHCOOH (B) HCOOH (C) CH_3CH_2OH (D) CH_3COOH (E) None of the above

4. The normalized wave function for a particle in a one-dimensional box is $\psi_n(x) = \sqrt{2/L}\sin(n\pi x/L)$,
   where L is the length of the box. What is the probability that the particle will lie between $x = 0$ and
   $x = L/4$ if the particle is in its first excited state?
   (A) $\sqrt{\dfrac{2}{L}}$ (B) $\dfrac{\sqrt{2L}}{2\pi}$ (C) $\dfrac{\pi-2}{4\pi}$ (D) $\dfrac{1}{4}$ (E) None of the above

5. Given the data

   $$H_2(g) + F_2(g) \longrightarrow 2\,HF(g) \qquad \Delta H = -537\,kJ$$
   $$C(s) + 2\,F_2(g) \longrightarrow CF_4(g) \qquad \Delta H = -680\,kJ$$
   $$2\,C(s) + 2\,H_2(g) \longrightarrow C_2H_4(g) \qquad \Delta H = +52.3\,kJ$$

   what is the entropy change of the following reaction?

   $$C_2H_4(g) + 6\,F_2(g) \longrightarrow 2\,CF_4(g) + 4\,HF(g)$$

   (A) -2.49×10³ kJ (B) -2.43×10³ kJ (C) -1.95×10³ kJ (D) -1.81×10³ kJ (E) None of the above

6. At 25°C, the equilibrium constant for the reaction
   $$N_2(g) + O_2(g) \rightleftharpoons 2\,NO(g)$$
   is 4.2×10⁻³¹. Suppose a container is initially filled with nitrogen (0.41 atm), oxygen (0.59 atm), and
   nitrogen oxide (0.22 atm). What is the partial pressures of nitrogen after equilibrium is reached at 25°C?
   (R=0.082 LatmK⁻¹mol⁻¹).
   (A) 0.52 atm (B) 0.70 atm (C) 0.86 atm (D) 3.9×10⁻¹⁶ atm (E) None of the above

7. Suppose 1.000 mol of acetic acid is dissolved in enough water to give 1.000 L of solution. What is the
   pH of the solution? Acetic acid has a Ka of 1.76×10⁻⁵ at 25°C.
   (A) 1.2 (B) 2.4 (C) 3.6 (D) 4.8 (E) None of the above

8. What is the number of vibrational modes in the methane molecule?
   (A) 3 (B) 6 (C) 9 (D) 12 (E) None of the above

9. Which one of the following atoms has the highest electron affinity?
   (A) F (B) Cl (C) Br (D) I (E) At

10. The formal charge of the nitrogen atom in the nitrite ion is
    (A) -1 (B) 0 (C) +1 (D) +3 (E) +5

11. The shape of SF_4 can be characterized as
    (A) Tetrahedron (B) Pyramid (C) Seesaw (D) Trigonal bipyramid (E) None of the above

12. 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

13. What is the degeneracy of the first excited state of a particle in a two-dimensional cubic box?
    (A) 1 (B) 2 (C) 4 (D) 6 (E) None of the above

14. What is the number of radial nodes in a hydrogen $4f$ orbital?
    (A) 0 (B) 1 (C) 2 (D) 3 (E) None of the above

15. A hydrogen $4d$ orbital has an angular momentum quantum number $l = ?$
    (A) 1 (B) 2 (C) 3 (D) 4 (E) None of the above

16. Which one is an ionic compound?
    (A) B_2H_6 (B) NH_3 (C) Sc_2O_3 (D) H_2O (E) None of the above

17. Which one of the following diatomic molecules has the highest bond order?
    (A) O_2 (B) O_2^+ (C) F_2 (D) C_2 (E) C_2^+

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18. Which one of the following conjugated molecule is aromatic?
    (A) Benzene (B) Cyclopentadienyl cation (C) Ethylene (D) Hexatriene (E) All of the above
19. What is the number of chiral centers in 4-ethyl-2,4-dimethylhexane?
    (A) 0 (B) 1 (C) 2 (D) 3 (E) 4
20. The van der Waals equation of gas state is $\left(P + a\dfrac{n^2}{V^2}\right)(V - nb) = nRT$. What is the coefficient b related to?
    (A) Strength of intermolecular interactions (B) Density of gas (C) Temperature (D) Excluded volume of the molecule (E) None of the above
21. If 1.25 L of a carbonated beverage is bottled under a CO_2 pressure of 5.0 atm at 25°C, what is the number of moles of carbon dioxide dissolved in water? Use 1.00 g cm^{-3} as the density of water and $1.65×10^3$ atm as the Henry's law constant for carbon dioxide in water.
    (A) 0.21 (B) 0.42 (C) 0.17 (D) 0.34 (E) None of the above
22. The order of the elementary reaction $CH_3Cl + F \rightarrow CH_3F + Cl$ is?
    (A) 0 (B) 1 (C) 2 (D) 3 (E) None of the above
23. If 6.00 mol argon in a 100-L vessel initially at 300 K is compressed adiabatically until a temperature of 450 K is reached, what is the work done on the gas? (The gas constant R=8.314 $JK^{-1}mol^{-1}$).
    (A) 7.5 kJ (B) -7.5 kJ (C) 11.2 kJ (D) -11.2 kJ (E) None of the above
24. Which technique allows us to accurately determine three-dimensional molecular structures?
    (A) Nuclear magnetic resonance (B) X-ray diffraction (C) Scanning tunneling microscopy (D) Transmission electron microscopy (E) All of the above
25. Which one of the following statements is true?
    (A) If something is reduced, it is formally losing electrons.
    (B) A reducing agent gets oxidized as it reacts.
    (C) An oxidizing agent is needed to convert CO_2 into CO.
    (D) If there are no changes in the charge state of the reactants or products of a particular reaction, that reaction is not a redox reaction.
    (E) An acid-base reaction cannot be a redox reaction.

(II). 敘述與計算題 (共 25 分): ※ 注意：請於答案卷內之「非選擇題作答區」作答，並應註明作答之題號。

26. The standard hydrogen electrode is very important in electrochemistry. Answer the following questions concisely; either in Chinese or English is fine.
    (26A) (4%) Give the balanced half-reaction that occurs at a hydrogen electrode in acidic aqueous solution when it serves as the cathode of a voltaic cell.
    (26B) (4%) Write the half-reaction that occurs at a hydrogen electrode in acidic aqueous solution when it serves as the anode of a voltaic cell.
    (26C) (4%) What is *standard* about the standard hydrogen electrode?

27. An ice cube with a mass of 20 g at -20 °C is dropped into a cup that holds 500 mL of hot water, initially at 83 °C. The density of liquid water is 1.00 g/mL; the specific heat capacity of ice is 2.03 J/g-C; the specific heat capacity of liquid water is 4.184 J/g-C; the enthalpy of fusion of water is 6.01 kJ/mol.
    (27A) (3%) What is the final temperature in the cup?
    (27B) (5%) What is ΔS of the process?

28. (5%) The reaction between nitric oxide and hydrogen,
    $2NO(g) + H_2(g) \rightarrow N_2O\ (g) + H_2O(g)$
    may proceed via the following mechanism:

    $NO(g) + NO(g) \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} N_2O_2(g)$

    $N_2O_2(g) + H_2(g) \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} N_2O(g) + H_2O(g)$

    Give the rate law for the overall reaction if the second step is the rate-determining step.

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