

說明：答案一律寫在試卷上；請依序作答，並標明題號。

選擇題作答方式：將此抄錄在試卷上

1		2		3		4		5	
6		7		8		9		10	
11		12		13		14		15	
16		17		18		19		20	
21		22		23		24		25	
26		27		28		29		30	
31		32		33		34		35	

一、選擇題：(單選；1-35 每題 2 分，不倒扣，共 70 分)

- What is the correct formula for nitrous oxide?
(A) NO (B) N₂O (C) NO₃ (D) N₂O₃ (E) NO₂
- An aqueous solution of silver nitrate is added to an aqueous solution of potassium chromate and this reaction produces a solid. What is the formula for the solid?
(A) Ag₂CrO₄ (B) AgCrO₄ (C) KNO₃ (D) K₂NO₃ (E) AgK
- Four identical 1.0-L flasks contain the gases He, Cl₂, CH₄, and NH₃, each at 0°C and 1 atm pressure. For which gas do the molecules have the **smallest** average kinetic energy?
(A) He (B) CH₄ (C) NH₃ (D) Cl₂ (E) all gases the same
- Indicate the **mass action expression** for the following reaction: $2X(g) + Y(g) \rightleftharpoons 3W(g) + V(g)$
(A) $[X]^2[Y][W]^3[V]$ (B) $\frac{[W]^3[V]}{[X]^2[Y]}$ (C) $\frac{[3W][V]}{[2X][Y]}$ (D) $\frac{[X]^2[Y]}{[W]^3[V]}$ (E) $[2X]^2[Y][3W]^3[V]$
- Which reaction does **not** proceed far to the right?
(A) $HCl + H_2O \rightarrow H_3O^+ + Cl^-$ (B) $H_3O^+ + OH^- \rightarrow 2H_2O$
(C) $H_2O + HSO_4^- \rightarrow H_2SO_4 + OH^-$ (D) $HCN + OH^- \rightarrow H_2O + CN^-$
(E) $H_2SO_4 + H_2O \rightarrow H_3O^+ + HSO_4^-$
- An indicator has $K_a = 3.3 \times 10^{-6}$. What would be the approximate pH range over which it would change color?
(A) 3.5 - 4.5 (B) 3.5 - 5.5 (C) 4.5 - 6.5 (D) 5.5 - 6.5 (E) 6.5 - 8.5
- For carbonic acid (H₂CO₃), $K_{a1} = 4.30 \times 10^{-7}$ and $K_{a2} = 5.62 \times 10^{-11}$. Calculate the pH of a 0.50 M solution of Na₂CO₃.
(A) 3.03 (B) 3.33 (C) 8.31 (D) 10.67 (E) 11.97
- If the standard enthalpy of combustion of ethanol, C₂H₅OH(l) at 298 K is -1368 kJ/mol, calculate the standard enthalpy of formation (kJ/mol) of ethanol. The standard enthalpies of formation of carbon dioxide and liquid water are -393.51 and -285.83 kJ/mol, respectively.
(A) 276.5 (B) -688.7 (C) -344.3 (D) 688.7 (E) -276.5
- Which of the following compounds with the **lowest** C_p at 298 K?
(A) H₂ (B) N₂ (C) O₂ (D) Ar (E) CO₂

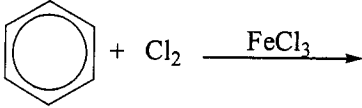
(背面仍有題目,請繼續作答)

10. Which of the following has the **highest** entropy at 298 K?
 (A) $\text{H}_2\text{O}(\text{l})$ (B) $\text{Kr}(\text{g})$ (C) $\text{CaO}(\text{s})$ (D) $\text{CH}_3\text{OH}(\text{l})$ (E) $\text{N}_2\text{O}_5(\text{g})$
11. Estimate the ΔS° (J/Kmol) of process $\text{M}(\text{s}) \rightarrow \text{M}(\text{l})$, if the molar heat of melting is 213 kJ/mol, and melt at 1060°C at 1 atm.
 (A) 201 (B) 160 (C) 108 (D) 71 (E) 0
- For 12-14. Consider 2.0 mole of a monatomic ideal gas that is taken from state A ($P_A = 2$ atm, $V_A = 5$ L) to state B ($P_B = 1$ atm, $V_B = 20$ L) by different pathways.
 Path 1: state A ($P_A = 2$ atm, $V_A = 5$ L) to state C ($P_C = 2$ atm, $V_C = 20$ L) to state B ($P_B = 1$ atm, $V_B = 20$ L)
 Path 2: state A ($P_A = 2$ atm, $V_A = 5$ L) to state D ($P_D = 1$ atm, $V_D = 5$ L) to state B ($P_B = 1$ atm, $V_B = 20$ L)
12. Calculate q (kJ) of path 1 and path 2
 (A) $q_1 = 3.04$, $q_2 = 2.48$ (B) $q_1 = 1.62$, $q_2 = 4.56$ (C) $q_1 = 6.27$, $q_2 = 2.45$
 (D) $q_1 = 4.56$, $q_2 = 3.04$ (E) $q_1 = 2.56$, $q_2 = 4.24$
13. Calculate w (kJ) of path 1 and path 2
 (A) $w_1 = -3.04$, $w_2 = -1.54$ (B) $w_1 = -2.74$, $w_2 = -3.62$ (C) $w_1 = -2.52$, $w_2 = -3.57$
 (D) $w_1 = -3.04$, $w_2 = -2.24$ (E) $w_1 = -3.62$, $w_2 = -2.74$
14. Calculate ΔE (kJ) between state B and state A
 (A) 2.53 (B) -1.52 (C) -2.53 (D) 1.52 (E) -3.04
15. An excess of finely divided iron is stirred up with a solution that contains Cu^{2+} ion, and the system is allowed to come to equilibrium. The solid materials are then filtered off and electrodes of solid copper and solid iron are inserted into the remaining solution. What is the value of the ratio $[\text{Fe}^{2+}]/[\text{Cu}^{2+}]$ at 25°C ?
 (A) 3.4×10^{-27} (B) 0 (C) 1 (D) 2.2×10^{26} (E) 4.4×10^{-27}
16. Concerning the hydrogen atom, what information do we get from the values of **angular** momentum quantum number?
 (A) energy of orbital (B) velocity of electron (C) wavelength of electron
 (D) direction of orbital (E) shape of orbital
17. What is the maximum number of electrons in an atom that can have the quantum number $n = 4$, $m_l = 2$?
 (A) 4 (B) 6 (C) 8 (D) 10 (E) 12
18. Which of the following has a **zero** dipole moment?
 (A) HCN (B) NO_2 (C) SO_2 (D) PF_5 (E) NF_3
19. For which of the following can we **not** draw a stable Lewis structure?
 (A) PCl_5 (B) OCl_6 (C) SCl_6 (D) XeF_2 (E) NF_3
20. Calculate the formal charge on carbon in COCl_2
 (A) +2 (B) +1 (C) 0 (D) -1 (E) -2
21. What type of molecular structure does the ICl_5 molecule have?
 (A) square pyramid (B) tetrahedron (C) trigonal bipyramid (D) trigonal plan (E) octahedron
22. The molecular orbital electron configuration, $(\sigma 1s)^2 (\sigma 1s^*)^2 (\sigma 2s)^2 (\sigma 2s^*)^2 (\pi x)^2 (\pi y)^2 (\sigma 2p)^2$, applies to which of the following molecules?
 (A) BC (B) CO (C) NO (D) O_2 (E) F_2
23. The vibrational transition requires photons of energy in which region of the spectrum?
 (A) ultraviolet (B) visible (C) infrared (D) microwave (E) radio wave

24. Predict which substance in each of the following pairs would have **stronger** intermolecular force.
 CO₂ or OCS PF₃ or PF₅ SF₂ or SF₆ SO₃ or SO₂
 (A) CO₂, PF₅, SF₆, SO₂ (B) CO₂, PF₃, SF₆, SO₃ (C) OCS, PF₃, SF₂, SO₃
 (D) OCS, PF₅, SF₆, SO₃ (E) OCS, PF₃, SF₂, SO₂
25. The compound ZrI₄ can be described as cubic closest packed anions (I⁻) with the cations (Zr⁺⁴) in tetrahedral holes. What **fraction** of the tetrahedral holes is occupied?
 (A) 1 (B) 1/2 (C) 1/4 (D) 1/8 (E) 1/16
26. A solution is prepared by mixing 20 mL of pentane (C₅H₁₂, d = 0.63 g/cm³) with 50 mL of hexane (C₆H₁₄, d = 0.66 g/cm³). (C=12, H=1) Assuming that the volumes add on mixing, calculate the **molality** of this pentane solution.
 (A) 0.175 (B) 2.50 (C) 5.30 (D) 0.313 (E) 0.384
27. Consider the following aqueous solutions:
 Which solution would have the **highest** vapor pressure at 28°C?
 (A) 0.010 *m* Na₃PO₄ (B) 0.020 *m* CaBr₂ (C) 0.020 *m* KCl (D) 0.020 *m* HF (E) 0.020 *m* FeCl₃
28. Rank the following compounds according to increasing values (disorder) of ΔS⁰_{soln} (J K⁻¹ mol⁻¹) for LiF, NaCl, KCl, and CaS dissolving in water.
 (A) LiF < NaCl < KCl < CaS (B) CaS < LiF < NaCl < KCl (C) CaS < KCl < NaCl < LiF
 (D) NaCl < KCl < CaS < LiF (E) KCl < CaS < LiF < NaCl
29. Which of the following molecules display **optical** activity?
 I: *trans*-[Cr(en)₂Br₂]⁻; II: *cis*-[Cr(en)₂Br₂]⁻; III: [Co(edta)]⁻;
 IV: [Co(en)₃]³⁺; V: *cis*-[Pt(NH₃)₂Cl₂]; VI: [CrCl₂Br₂]²⁻(tetrahedral)
 (A) II, IV, V (B) II, III, IV (C) II, IV, VI (D) II, III, IV, V (E) II, IV, V, VI
30. Which of the following complex ions will absorb light with the **shortest** wavelength?
 (A) [Cr(NH₃)₆]Cl₃ (B) [Cr(NH₃)₅Cl]Cl₂ (C) [Cr(NH₃)₄(H₂O)₂]Cl₃
 (D) [Cr(H₂O)₆]Cl₃ (E) [Cr(H₂O)₅Cl₂]Cl
31. Specify the number of **unpaired** electrons for the following ions.
 Cr(H₂O)₆²⁺, Fe(CN)₆³⁺, CoF₆³⁻, Co(NH₃)₆³⁺, NiCl₄²⁻, PdCl₄²⁻
 (A) 2, 5, 0, 4, 2, 2 (B) 4, 5, 0, 4, 2, 0 (C) 2, 1, 4, 0, 2, 2 (D) 4, 1, 4, 0, 2, 0 (E) 4, 5, 4, 0, 2, 2
32. Special stability is associated with certain magic number. The numbers are 2, 8, 20, 28, 50, 82 and 126. To what subatomic particles do these numbers refer?
 (A) neutrons (B) electrons (C) positrons (D) quarks (E) protons
33. What fraction of ³⁸K remains after 2.00 hours? The half-life of ³⁸K is 7.71 minutes.
 (A) 1.03 × 10⁻³ (B) 4.10 × 10⁻⁴ (C) 2.07 × 10⁻⁵ (D) 4.75 × 10⁻⁵ (E) 2.05 × 10⁻⁶
34. What is the number of possible isomers for C₄H₈?
 (A) 2 (B) 3 (C) 4 (D) 5 (E) 6
35. One strand of a DNA molecule contains the base sequence as this, 5'-ACTTGCGA-3'. What is the DNA complement of this base sequence?
 (A) 3'-TGAACGCT-5' (B) 5'-TGAACGCT-3' (C) 3'-UGAACGCU-5'
 (D) 5'-UGAACGCU-3' (E) 5'-AGCGTTCA-3'

(背面仍有題目,請繼續作答)

二、非選擇題 (共 30 分，計算題務必列出計算過程，只寫答案不計分。)

1. Calculate the pH of a solution that contains 3.25 M HCN ($K_a = 6.2 \times 10^{-10}$), 1.00 M NaOH and 1.50 M NaCN. 4%
2. A galvanic cell is constructed with copper electrodes and Cu^{2+} in each compartment. In one compartment, the $[\text{Cu}^{2+}] = 1.0 \times 10^{-3}$ M and in the other compartment, the $[\text{Cu}^{2+}] = 2.0$ M. Calculate the potential for this cell at 25°C. The standard reduction potential for Cu^{2+} is +0.34 V. 4%
3. What is the probability of finding an electron in a small region of an atom 1s orbital $\Psi_{1s} = e^{-2r/a_0}$ at a distance a_0 from the nucleus **relative** to the probability of finding it in the same small region located at $3a_0$ from the nucleus? 4%
4. A second-order reaction $2A \rightarrow B + C$, give the $[A]_0 = 0.06 \text{ mol L}^{-1}$ and that after 100 second the concentration of [B] rises to 0.02 mol L^{-1} . Calculate the rate constant of reaction. 4%
5. The enthalpy of vaporization for water is 40.7 kJ/mol at 1 atm (760 torr), then what is the boiling point of water at 475 torr? ($T_b = 100^\circ\text{C}$, $R = 8.3145 \text{ J/K mol}$) 4%
6. The osmotic pressure of a solution saturated with a salt M_3X_2 is 2.64×10^{-2} atm at 25°C. Calculate K_{sp} value for M_3X_2 , assuming ideal behavior. ($R = 0.08206 \text{ L atm / K mol}$) 4%
7. Draw the structure of major product for the following reactions.
 - a.  2%
 - b. $\text{CH}_3\text{CH}_2\text{CH}_3 + \text{MnO}_4^- \rightarrow$ 2%
 - c. $\text{CH}_3\text{CH}_2\underset{\text{OH}}{\text{CH}}\text{CH}_2\text{CH}_3 + \text{H}_2\text{SO}_4 \xrightarrow{\Delta}$ 2%