1. (60%) 每題三分，只有一個正確答案，答錯倒扣一分。

(1-1). One atmosphere is (a) 76.0 mm Hg, (b) 1.01325 bar, (c) 1.01325 Pa, (d) 1.0 N·m⁻².

(1-2). Consider the van der Waals equation,

\[(P + a n^2/V^2)(V - nb) = nRT\]

the value of constant \(a\) reflects (a) how strongly gas molecules attract each other, (b) the size of the molecules, (c) both of the above, (d) none of the above.

(1-3). The value of the electronic partition function q for oxygen atom at room temperature is (a) 0, (b) 1, (c) 2, (d) 3.

(1-4). For an adiabatic process, (a) \(q = 0\), (b) \(\Delta T = 0\), (c) \(\Delta U = 0\), (d) all of the above.

(1-5). Which of the followings is correct? (a) \(dS = \delta q/T\), (b) \(\Delta S > 0\) for a spontaneous process, (c) \(\int dS = 0\), (d) all of the above.

(1-6). The Boltzmann formula for entropy is \(S = k_B \ln W\), where \(W\) is related to the (a) work, (b) work function, (c) wavefunction, (d) most probable configuration of the system.

(1-7). Arrange the following reactions according to increasing values of \(\Delta_r S^\circ\).

a. \(S(s) + O_2(g) \rightarrow SO_2(g)\)
b. \(H_2(g) + O_2(g) \rightarrow H_2O(l)\)
c. \(C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)\)

(a) \(a < b < c\), (b) \(a < c < b\), (c) \(b < a < c\), (d) \(b < c < a\).

(1-8). For which one of the following substances is \(\Delta G^\circ\) zero? (a) \(H_2O(g)\), (b) \(H_2O(l)\), (c) \(O_2(g)\), (d) \(H_2(g)\).

(1-9). What can be said about a chemical system that has reached a minimum free energy? (a) it is at absolute zero, (b) its entropy is zero, (c) it is at equilibrium, (d) the reaction is complete.

(1-10). Given the Arrhenius equation \(k = A \exp(-E/RT)\), (a) \(k\) is the Boltzmann constant, (b) \(k\) is the equilibrium constant, (c) \(E\) is the reaction enthalpy, (d) none of the above.
(1-11). Dissolving ammonium chloride in water lowers the temperature of the system. For this dissolving process the signs of $\Delta H$, $\Delta S$, and $\Delta G$ would be: (a) $+, +, +$, (b) $+, +, -, (c) -, -, +$, (d) $-, -, -$.

(1-12). The vapor pressure of benzene can be expressed by the empirical formula $\ln(P/\text{torr}) = -(3884 \text{ K/T}) + 17.63$. The boiling point of benzene is (a) $67^\circ\text{C}$, (b) $167^\circ\text{C}$, (c) $67 \text{ K}$, (d) $167 \text{ K}$ when the atmospheric pressure is 500 torr.

(1-13). When a nonvolatile solute is added to a solvent to form an ideal solution, (a) the enthalpy of solution is negative, (b) the entropy of the liquid is lowered, (c) the free energy of the solvent decreases, (d) the vapor pressure of the solvent stays the same.

(1-14). The vapor pressure of a mixture of ethanol and benzene shows a positive deviations from Raoult’s law. (a) the mixing process is exothermic, (b) the ethanol-benzene interactions are more repulsive than either ethanol-ethanol or benzene-benzene interactions, (c) the boiling point of the mixture is higher than that predicted by Raoult’s law, (d) all true.

(1-15). Consider the reaction described by $\text{N}_2\text{O}_4(g) = 2\text{NO}_2(g)$, for which $\Delta G^\circ = 4.729 \text{ kJ/mol}$ at $298.15 \text{ K}$. (a) the decomposition of $\text{N}_2\text{O}_4(g)$ is nonspontaneous, (b) the decomposition of $\text{N}_2\text{O}_4(g)$ is exothermic, (c) $K_p = 1.48$, (d) $K_p$ increases with temperature.

(1-16). The collision frequency of a single nitrogen molecule in nitrogen at $25^\circ\text{C}$ and one bar is (a) $7.3 \times 10^9 \text{ s}^{-1}$, (b) $7.3 \times 10^{19} \text{ s}^{-1}$, (c) $7.3 \times 10^9 \text{ s}^{-1} \text{ cm}^3$, (d) $7.3 \times 10^{19} \text{ s}^{-1} \text{ cm}^3$.

(1-17). The bimolecular reaction $\text{H(g)} + \text{Br}_2(g) \rightarrow \text{HBr(g)} + \text{Br(g)}$ is exothermic by 173 kJ/mol. (a) it has second-order kinetics, (b) its molecularity is 2, (c) it is a homogeneous reaction, (d) all the above are correct.

(1-18). The rate constant for the reaction $2\text{HI(g)} \rightarrow \text{H}_2(g) + \text{I}_2(g)$ is $1.22 \times 10^{-6} \text{ dm}^3\cdot\text{mol}^{-1}\cdot\text{s}^{-1}$ at $575 \text{ K}$ and $2.50 \times 10^{-8} \text{ dm}^3\cdot\text{mol}^{-1}\cdot\text{s}^{-1}$ at $716 \text{ K}$. The activation energy is (a) 185 kcal/mol, (b) 185 cal/mol, (c) 185 kJ/mol, (d) 185 J/mol.

(1-19). The freezing point of a 0.20-molal solution of sucrose ($\text{C}_{12}\text{H}_{22}\text{O}_{11}$) in water is 272.78 K. The freezing point of a 0.20-molal solution of NaCl in water is (a) 272.78 K, (b) 272.41 K, (c) 273.06 K, (d) do not have enough information to estimate.
1. (20%) Each question counts 4 points, only one correct answer, wrong answers are penalized.

(2-1). A monolayer of N₂ molecules (effective area 0.165 nm²) is adsorbed on the surface of 1.00 g of an Fe/Al₂O₃ catalyst at 77 K. Upon warming, the nitrogen occupies 2.86 cm³ at 0°C and 760 torr. What is the surface area of the catalyst? (a) 12.8 m², (b) 12.8 cm², (c) 12.8 mm², (d) 12.8 μm², (e) 12.8 mm².

(2-2). Consider the attractive interactions between gaseous HCl molecules, (a) they have a r⁶ dependence, (b) the London (dispersion) interaction contributes most, (c) the dipole-dipole interactions are the strongest, (d) they are temperature-independent, (e) none of the above is correct.

(2-3). The diffusion coefficient of I₂ in hexane at 25°C is 4.05 × 10⁻⁹ m²·s⁻¹. The time required for an iodine molecule to have a root mean square displacement of 1.0 cm is (a) 1.2 day, (b) 1.2 hr., (c) 1.2 min., (d) 3.4 day, (e) 3.4 hr.

(2-4). The rate law for the reaction N₂O₄(g) → 2 NO(g) is first order in [N₂O₄] with a rate constant k. The expression for the time-dependent behavior of concentration of NO is [NO] = (a) [N₂O₄]₀(1 – e⁻ᵏᵗ), (b) [N₂O₄]₀(1 – e⁻²ᵏᵗ), (c) 2[N₂O₄]₀(1 – e⁻ᵏᵗ), (d) [N₂O₄]₀(e⁻ᵏᵗ – 1), (e) 2[N₂O₄]₀(e²ᵏᵗ – 1).

(2-5). A solution containing 2.20 g of a polymer in 300 mL of the solution has an osmotic pressure of 7.45 torr at 20°C. The molecular mass of the polymer is (a) 540,000, (b) 180,000, (c) 54,000, (d) 18,000, (e) 5,400.

3. (8%) An ideal gas undergoes a reversible isothermal expansion from an initial volume of V₁ to a final volume 10V₁ and thereby does 10 kcal of work. The initial pressure was 100 atm. (a) Calculate V₁. (b) If there were 2 moles of gas, what must its temperature have been?

4. (12%) E°₂₉₈K is –0.627 V for the cell Ag/Ag₂SO₄(s)/H₂SO₄(m)/H₂(1 atm)/Pt.
(a) Write the cell reaction (and each electrode reaction).
(b) Calculate E₂₉₈K if m = 0.2 (neglect activity coefficients).
(c) Repeat the calculation in (b), but take the mean activity coefficient of 0.1 m H₂SO₄ to be 0.70.