1. (10%) The general rate equation for simple kinetics \( nA \rightarrow \text{products} \) is

\[
R = k[A]^n,
\]

with \( n \) = order of reaction.

Assume \( t_{1/2} \) and \( t_{3/4} \) are the time for 50% and 75% of reaction to occur, respectively.

(a) Show that the ratio \( t_{1/2}/t_{3/4} \) is a function only of \( n \) (\( n \neq 1 \)).

(b) For a reaction the ratio \( t_{1/2}/t_{3/4} \) is 1/3, what is the order of the reaction.

2. (10%) For the reaction: \( \text{Me}_3\text{CCl} + \text{OH}^- \rightarrow \text{Me}_3\text{COH} + \text{Cl}^- \), with \( \text{Me} = \text{CH}_3 \), it is first-order with respect to \( \text{Me}_3\text{CCl} \) and does not dependent on the concentration of \( \text{OH}^- \). The reaction is \( 10^4 \text{ times faster in 90\% water-10\% acetone solution than in 10\% water-90\% acetone solution} \). Give a reasonable explanation about these behavior.

3. (10%) Using the critical conditions for van der Waals gases, show that the van der Waals constants

(a) \( a = \frac{27bRT_c}{8} \)  
(b) \( b = \frac{RT_c}{8p_c} \)

4. (10%) A concentration cell is assembled using two silver metal electrodes. One electrode dips into a 0.050 M \( \text{Ag}^+ \) solution, and the other electrode, coating in \( \text{AgBr} (s) \), dips into a 0.010 M \( \text{Br}^- \) solution. If the cell voltage is 0.53 V, what value does this give for the \( K_{sp} \) of \( \text{AgBr} (s) \).

5. (10%) The first and the second ionization energies of the He atom are 2372 kJ mol\(^{-1}\) and 5251 kJ mol\(^{-1}\), respectively. Find

(a) the effective nucleus charge \( (Z_{\text{eff}}) \) of the He atom.

(b) the electronic repulsion energy in the He atom.

Given: the ionization energy of \( \text{H} \) atom is 1312 kJ mol\(^{-1}\)

the average value of \( E_{1s} \) of He atom: \( E_{1s} \) (in kJ mol\(^{-1}\)) \( \approx Z_{\text{eff}}^2 \times 1312 \)
6. (10%) A piston exerting a pressure of 1.0 atm rests on the surface of water at 25°C. The pressure was reduced infinitesimally when 10.0 g of water was evaporated with 22.2 kJ of heat being absorbed. Calculate (a) the work done on the system (w); (b) the internal energy change of the system (ΔU); (c) the enthalpy change of the system (ΔH).

7. (10%) The vapor pressure (P) of a compound as a function of temperature (T) may be described by the Clausius-Clapeyron equation. Assuming the enthalpy of vaporization (ΔH_{vap}) is constant, the empirical expression was found to be \( \log(P/\text{Torr}) = 7.96 - 1780 \ (T/\text{K}) \). Calculate (a) ΔH_{vap}; (b) the normal boiling point of the molecule.

8. (10%) The vapor pressure of pure liquid A at 300 K is 600 Torr and that of pure liquid B is 400 Torr. Consider the equilibrium composition of a mixture in which the mole fraction of A in the vapor is 0.35, calculate (a) the total pressure of the vapor; (b) the composition of the liquid mixture. Assuming these two compounds form ideal solution and the vapor follows ideal gas law.

9. (10%) Estimate how much time does a CCl₄ molecule in heptane take to jump through about one molecular diameter (i.e., two effective molecular radii which is approximately the fundamental jump length for translational motion). At 25°C, the diffusion coefficient of CCl₄ is 3.17×10⁻⁹ m² s⁻¹ and that the viscosity of heptane is 0.6 cP. (Hint: the Einstein-Smoluchowski equation is expressed as \( D = \frac{kT}{6\pi \eta r} \) and the jump distance can be obtained by use of the Stokes-Einstein equation, \( D = kT/(6\pi \eta r) \))

10. (10%) A thermally insulated container is divided by a partition into two compartments with identical volume V. The left part contains \( n_1 \) mol of ideal gas at temperature T and pressure P whereas the right part contains \( n_2 \) mol of ideal gas at temperature T and pressure P'. The partition is now removed. Calculate (a) the final pressure of the gas mixture in terms of \( n_1 \), \( n_2 \), and P; (b) the total change of entropy if the gases are different; (c) the total change of entropy if the gases are identical.