Physical Constant	Symbol, Value and Unit
Gas constant:	$R = 0.08206$ atm dm^3 mole^{-1} K^{-1} $= 8.315$ J mole^{-1} K^{-1}

Note: $I_n = \int_0^\infty e^{-ar} r^n dr = \frac{n!}{a^{n+1}}$ $\quad ln2 = 0.6931$

1. (30%) For an enzyme catalysis reaction $E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} E + P$, where E is the enzyme with initial concentration $[E]_0$, S is the substrate with initial concentration $[S]_0$, ES is the enzyme-substrate complex, and P is the product. k_1, k_2, k_{-1} and k_{-2} are the rate constants. Assume K_i is the equilibrium constant of the first reaction and k_2 is evaluated as k_i at temperature T_i, and K_j is the equilibrium constant of the first reaction and k_2 is evaluated as k_j at temperature T_j. (a) Using steady-state approximation, find the initial rate of the reaction in terms of rate constants k_1, k_2, k_{-1}, $[S]_0$ and $[E]_0$. (b) Express the standard thermodynamic enthalpy ($\Delta H°$) for the formation of ES and the activation energy E_a for k_2 in terms of k_i, T_i, K_i, k_j, T_j, and K_j.

2. (30%) The wavefunction of 1s orbital for the hydrogen atom is $\Psi_{1s} = C(\frac{1}{a_0})^{3/2} e^{-r/a_0}$ (a) Find the value of C that normalizes the orbital (b) Calculate the average distance $< r >$ between the nucleus and electron in terms of a_0. (c) Calculate the most probable distance r to find the electron in terms of a_0.

3. (10%) The Hamiltonian for "the particle in a box problem" along the x direction is defined as $\hat{H} = -\frac{\hbar^2}{2m}\frac{d^2}{dx^2}$. Apply the variation method with trial function $\Psi = \sin(\frac{\pi x}{a})$ to calculate an energy for a particle of mass m moving in an one-dimensional box of length a.

4. (10%) Consider a three-dimensional cubic box of length d, containing eight non-interacting electrons with each mass as m. Given that the energy levels for electrons in three-dimensional box are $E_{nml} = (n^2+m^2+l^2)(h^2/8md^2)$, where n, m, and l are quantum number. (a) Calculate the energy of the ground state of this system in terms of h, d, and m. (b) Calculate the energy of the first excited state of this system in terms of h, d, and m.

5. (20%) A sample of 1.00 mol of a monoatomic perfect gas, initially at 298 K and 10 liters, is expanded isothermally and reversibly, to a final volume of 20 liters with surroundings maintained at 298 K. Calculate ΔS, ΔU, ΔH, ΔA, and ΔG for this case.