1. Please define the following terms with a <u>mathematical formula</u>, explain clearly the symbols you use in the formula: (A) The first law of Thermodynamics, (B) Chemical potential of i species in a mixture at constant temperature and pressure, (C) Instantaneous reaction rate of B in the reaction A + 2B → 3C + 4D, (D) Clapeyron equation, (E) Time-independent Schrodinger equation. (20%)

2. The barometric pressure decrease with height above sea level in the Earth's atmosphere as

    $$P_i = P_i^0 e^{-\frac{M_i g z}{RT}}$$ where P_i is the partial pressure at the height z, P_i^0 is the partial pressure of component gas i at sea level, g is the acceleration of gravity, and R is the gas constant. (20%)

    (A) Derive the barometric pressure formula.

    (B) Consider an atmosphere that has the composition $X_{N_2} = 0.70$ and $X_{CO_2} = 0.30$ and that

      T = 300 K. The total pressure near sea level is 1.00 atm. Calculate the mole fractions of the two components at a height of 50 km.

3. Figure 1 below depicts that a system consists of n mol of ideal gas going through a change of state from (V_i, T_i) to (V_f, T_f) by path I. Use what is suggested in Figure 1 show that the internal energy, U, of the system is a <u>state function</u>. (20%)
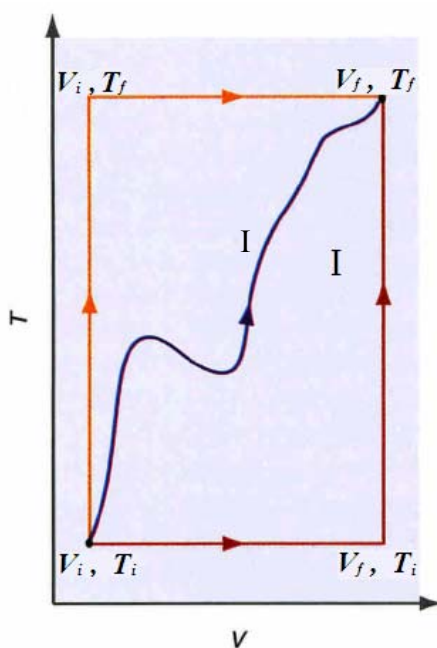

Figure 1

4. Some of the following elementary reactions have a linear integrated rate law with their slope equal to –k. What type of reactions are they? You need to prove your answer. (20%)

   (A) zero order reaction

   (B) 1st order reaction

   (C) 2nd order reaction ($C_{A,0} = C_{B,0}$)

   (D) 2nd order reaction ($C_{A,0} \neq C_{B,0}$)

   (E) 3rd order reaction ($C_{A,0} = C_{B,0} = C_{C,0}$)

5. This is a question about "the particle in a box" in quantum chemistry. What is the probability for finding the particle in the central third of the box if it is in its ground state?

   Given that $\int \sin^2 bx \, dx = x/2 - (\sin 2bx)/4b$. (20%)