Exercise 1: Dilute Solution

1.1.
(a) You are on a safari in Kenya when you come across a rhinoceros with mass $M_R = 10^3$ kg with 7 red oxypecker birds on her back each with mass $M_B = 100$g.

(i) calculate the number-average mass of the multi-creature system.

(ii) calculate the weight-average mass of the multi-creature system.

(iii) calculate the polydispersity index (PDI) of the multi-creature system.

(iv) Which number would you be interested in when considering the damage the multi-creature system could cause your safari vehicle if you were to crash into it?

(b) You have the following collection of polymer chains:
　　　　100 chains with degree of polymerization 10^2
　　　　100 chains with degree of polymerization 10^3
　　　　and 10 chains with degree of polymerization 10^4.
Each monomer has a molar mass $m_{mon} = 100$ g mol^{-1}.

　　　　(i) calculate the number-average mass M_n of the population.
　　　　(ii) calculate the weight-average mass M_w of the population.
　　　　(iii) calculate the polydispersity index (PDI) of the population.

1.2. 200g of polystyrene is added to 900 mL of xylene to yield a solution, which has a total volume of 1L. Calculate the enthalpy of mixing of this solution using the solubility parameters (PS: $\delta = 9.1$ (cal/cm^3)$^{1/2}$, xylene: $\delta = 8.8$ (cal/cm^3)$^{1/2}$) for each component.

1.3. On a "chess-field" containing 64 squares, you distribute
　　a) 16 small solute molecules and 48 solvent molecules (which each use 1 square of space).
　　b) 1 polymer molecule of a length of 16 (each segment of the chain using 1 square of space) and 48 solvent molecules (using one square of space)
$k_B = 1.38 \times 10^{-23}$ J/K

What is the entropy of mixing in both cases? Which system has the higher entropy?

1.4. You prepare a 5% (by volume) solution of polyethylene oxide with a molecular weight of 250.000 g/mol in water at 25°C. The Flory-Huggins parameter at this temperature is 0.4. The density of polyethylenoxide is 1130 kg/m^3 and the density of water is 1000 kg/m^3. Calculate the free energy of mixing per cm^3 ! Will the polymer dissolve in this solvent under the given conditions?

1.5. Three reported theta systems are
- Polyisoprene in dioxane at 34°C
- Poly(methyl methacrylate) in carbon tetrachloride at 27°C
- Poly (vinyl acetate) in ethanol at 19°C

Estimate for each of these cases the interaction parameter χ , using following equation:

$$\chi = \frac{V_1}{RT}\left(\delta_1 - \delta_2\right)^2$$

R = 1.987 cal/K mol;
dioxane: M = 88 g/mol, ρ =1.03 g/cm³, δ = 10.0 (cal/cm³)^1/2
carbon tetrachloride: M = 154 g/mol, ρ = 1.59 g/cm³, δ = 8.6 (cal/cm³)^1/2
ethanol: M = 46 g/mol, ρ = 0.79 g/cm³, , δ = 12.7 (cal/cm³)^1/2

polyisoprene: δ = 8.1 (cal/cm³)^1/2
poly(methyl methacrylate): δ = 9.2 (cal/cm³)^1/2
poly(vinyl acetate): δ = 9.4 (cal/cm³)^1/2