1. Please derive that the entropy of mixing for ideal solution is

$$\Delta S_m^I = -(n_1 R \ln x_1 + n_2 R \ln x_2)$$

where n_1 and n_2 are the number of moles of their components; and x_1 and x_2 are their molar fractions. (15%)

2. Please derive the Gibbs-Duhem equation for a binary solution, i.e.,

$$n_1 d\bar{G}_1 + n_2 d\bar{G}_2 = 0$$

where n_1 and n_2 are the number of moles of their components; and $\bar{G}_1$ and $\bar{G}_2$ are their partial molar free energy. (15%)

3. Please explain why the polymer solution is never an ideal solution. (10%)

4. Please indicate at what conditions that the lower critical solution temperature (LCST) and upper critical solution temperature (UCST) in the phase diagrams are prone to occur. (10%)

5. Please explain why rubber elasticity can be predicted by thermodynamics. (10%)

6. Please explain osmotic pressure and provide at least two applications through osmotic pressure. (10%)

7. If you are asked to measure the molecular weight of polyeletrolytes, how will you do? Please explain your method in detail. (10%)

8. Show that work done on a system at constant temperature mainly increase its Helmholtz free energy. (10%)

9. Please define the terminologies of "relative viscosity", "reduced viscosity", "intrinsic viscosity", and "rheology". (10%)