

1. Please explain the second law of thermodynamics in detail. (10%)
2. Please explain the ideal solution in detail. (10%)
3. Please explain the Henry's law in detail. (10%)
4. Please explain the Nernst distribution law in detail. (10%)
5. Please explain the osmotic pressure in detail. (10%)
6. Use the first law of thermodynamics and other relevant definitions to derive the following expression for  $c_V$

$$c_V = - \left( \frac{\partial E}{\partial V} \right)_T \left( \frac{\partial V}{\partial T} \right)_E \quad (15\%)$$

where  $E$  is the internal energy.

7. For any gas that obeys van der Waals equation of state, show that

$$\left( \frac{\partial E}{\partial V} \right)_T = \frac{a}{V^2} \quad (20\%)$$

where  $E$  is the internal energy.

(Hint: The van der Waals equation of state is  $\left( p + \frac{a}{V^2} \right) (V - b) = RT$  )

8. The activity coefficient  $\gamma_2$  (on the mole fraction scale) of the solute in a certain dilute solution is given by  $\gamma_2 = e^{Ax_2^2}$ , where  $A$  is a constant at constant temperature. Obtain an expression in terms of  $A$  and  $x_2$  for the activity coefficient  $\gamma_1$  (on the mole fraction scale) of the solvent in this solution.

(15%)