First, graph the partial pressure of oxygen vs % saturation. This graph appears like this:

![Graph of oxygen vs % saturation](image1)

This has the form of a cooperative-binding system. Therefore you can assume N > 1. To determine N approximately, you need to graph:

\[
\log \frac{\bar{v}}{1 - \bar{v}} \text{ versus } \log P_{O_2}
\]

\(\bar{v}\) is the % saturation times 0.01. Creating this graph:

![Graph of log v/n-v vs log P O2](image2)

The slope of this ‘line’ is 1.3, therefore N ≥ 2.

7.7)
7.8) 
\[ V_1 = \chi_2 RT \Rightarrow (0.018 mL/gm)(7.6 atm) = \chi_2 (0.0821 L \cdot atm/moles \cdot K)(310 K) \]
\[ \chi_2 = 0.0054 = \frac{m}{1000 gm} \Rightarrow m = 0.30 gm/kg \]

7.10) Your concentrations are given in molality, not molarity, and you are given the mass of your solution, not its volume, so you cannot use \( \pi = c_2 RT \) directly. You need to convert your individual molalities to moles, merely by multiplying by 1 kg, so your numbers will be the same.

\[ n_{total} = 0.546 + 0.456 + 0.053 + 0.028 + 0.010 = 1.093 moles \]

Assuming 1 liter of solvent,
\[ \chi_2 = \frac{n_{solutions}}{n_{solvent} + n_{solutions}} = \frac{1.093}{55.5 + 1.093} = 0.019 \] Using the equation from the lecture notes with molar volume and mole fraction:
\[ \bar{V}_1 \pi = \chi_2 RT \Rightarrow \pi = \frac{\chi_2 RT}{\bar{V}_1} = \frac{(0.019)(0.0821 L \cdot atm/mole \cdot K)(298 K)}{(0.018 L/mole)} = 25.8 atm \]

Applied pressure would have to be greater than 26 atm.

7.11)

a) 
\[ \bar{M}_N = \chi_1 M_1 + \chi_2 M_2 = (0.5)(100,000) + (0.5)(200,000) = 150,000 \]
\[ \bar{M}_W = \frac{(100,000)}{(100,000) + (200,000)} \times 100,000 + \frac{(200,000)}{(100,000) + (200,000)} \times 200,000 = (0.33)(100,000) + (0.66)(200,000) = 166,600 \]

b) For the number-weighted average we required the mole fractions. If the masses are equal each to \( m \) then the moles can be calculated and the mole fractions...

\[ \chi_{100,000} = \frac{m}{\frac{2}{10^5} + \frac{m}{2 \times 10^5}} = 0.66 \]
\[ \chi_{200,000} = \frac{m}{\frac{m}{10^5} + \frac{m}{2 \times 10^5}} = 0.33 \]

\[ \bar{M}_N = (0.66)(10^5) + (0.33)(2 \times 10^5) = 133,300 \]
\[ \bar{M}_W = (0.50)(10^5) + (0.50)(2 \times 10^5) = 150,000 \]
7.12)
\[ \overline{M}_N = (0.33)(10,000) + (0.33)(50,000) + (0.33)(100,000) = 53,300 \text{ g/mole} \]
\[ \overline{M}_W = \frac{10,000}{160,000}(10,000) + \frac{50,000}{160,000}(50,000) + \frac{100,000}{160,000}(100,000) = 78,750 \text{ g/mole} \]

Supplementary Problem:


\[ \overline{v} \]

<table>
<thead>
<tr>
<th>[NADH] x10^-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8</td>
</tr>
<tr>
<td>3.5</td>
</tr>
<tr>
<td>3.0</td>
</tr>
<tr>
<td>2.5</td>
</tr>
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</tr>
<tr>
<td>1.5</td>
</tr>
<tr>
<td>1.0</td>
</tr>
<tr>
<td>0.5</td>
</tr>
</tbody>
</table>

From a Scatchard plot determine the number of NADH binding sites on beef heart LDH and the binding constant \( K \). Note: you do not have to plot all the data given above to obtain a Scatchard Plot, but you must plot enough data to accurately establish linear behavior. Note: the [NADH] values in the right-hand column must be multiplied by \( 10^{-7} \) when graphed.

Solution: The Scatchard equation is \( \frac{v}{[A]} = K \cdot (N - v) \) where \( K \) is the binding constant and \( N \) is the number of binding sites. Therefore the slope is \(-K\), Therefore the slope of a plot of \( v/[A] \) as a function of \( v \) is \(-K\), the y intercept is \( KN \), and the x intercept is \( N \).
The vertical axis values must be scaled by a factor of $10^7$... as noted. The slope is $-K = -0.3 \times 10^7$, approximately (best fit by linear regression is $-2.7 \times 10^6$). Therefore $K = 2.7 \times 10^6$. The y-intercept is about $1.2 \times 10^7$. Therefore $N = 4$.

6.2) Studies of the binding of ATP to the enzyme tetrahydrofolate synthetase were conducted at $T = 293K$ and appear in the Table below. [ATP] is in molar units.

<table>
<thead>
<tr>
<th>$v$</th>
<th>0.25</th>
<th>0.50</th>
<th>1.0</th>
<th>1.5</th>
<th>2.0</th>
<th>2.5</th>
<th>3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ATP]</td>
<td>$6.67 \times 10^{-6}$</td>
<td>$1.43 \times 10^{-5}$</td>
<td>$3.33 \times 10^{-5}$</td>
<td>$6.00 \times 10^{-5}$</td>
<td>$10^{-4}$</td>
<td>$1.67 \times 10^{-4}$</td>
<td>$3 \times 10^{-4}$</td>
</tr>
</tbody>
</table>

a) Write the equation that is used to generate the Scatchard plots. From the equation, determine the value of the x intercept for the plots to the left.

Solution: From the x intercept $N = 4$
b) Assume \( \frac{K_{293}}{K_{310}} = 2 \). Using the information from the Scatchard plot calculate the standard enthalpy \( \Delta H^0 \) for the binding of ATP to tetrahydrofolate synthetase. Assume \( \Delta H^0 \) is constant between T=293K and T=310K. The y-intercepts of the plot is NK_{293} =40,000. So K_{293}=10,000. Then the ratio of the intercepts is \( \frac{K_{293}}{K_{310}} = 2 \).

\[
\ln \left( \frac{K_{293}}{K_{310}} \right) = \ln(2) = -\frac{\Delta H^0}{R} \left( \frac{1}{293K} - \frac{1}{310K} \right)
\]

\[
\Delta H^0 = -R \ln(2) \left( \frac{1}{293K} - \frac{1}{310K} \right) = -\frac{(8.31 J \cdot mole^{-1} \cdot K^{-1})(0.693)}{0.00341K^{-1} - 0.00323K^{-1}} = -\frac{5.76 J / mole}{0.00018} = -31,994 J / mole
\]

c) Calculate \( \Delta G^0 \), the standard free energy change for the binding of ATP to tetrahydrofolate synthetase at T=293K.

\[
\Delta G^0 = -RT \ln K = -(8.31 J \cdot mole^{-1} \cdot K^{-1}) (293K) \ln(K_{293}) = -2,434.8 \cdot \ln(K_{293}) J / mole
\]

\( N \cdot K_{293} = 4K_{293} = 40,000 \Rightarrow K_{293} = 10,000 \)

\( \Delta G^0 = -2434.8 \ln(K_{293}) J / mole = -2434.8 \ln(10,000) J / mole = -22,425 J / mole \)

d) Calculate \( \Delta S^0 \), the standard entropy change for the binding of ATP to tetrahydrofolate synthetase.

\[
\Delta S^0 = -\frac{\Delta H^0 - \Delta G^0}{T} = -\frac{-31,994J - (-22,425J)}{293K} = -32.65 J / K e
\]

3) Consider the two compartments, separated by a membrane that is permeable to the passage of sodium and chloride ions, but impermeable to the passage of a protein P. Assume the protein exists in solution as a monovalent anion P\(^{-}\). Initially in the left compartment \([P^-]=\left[Na^+\right]=0.02M\), and in the right compartment \([Na^+]\)=\([Cl^-]\)=0.08M. Calculate the net osmotic pressure at T=310K when the system reaches equilibrium. Hint: See Donnan Effect Notes.

Solution: x is the amount of chloride ion that moves from right to left.

\[
x = \frac{\left[Cl^-\right]_{\text{right, initial}}^2}{\left[P^-\right]_{\text{right, initial}} + 2\left[Cl^-\right]_{\text{right, initial}}} = \frac{(0.08)^2}{0.02 + 2(0.08)} = \frac{0.0064}{0.18} = 0.036 M
\]

\[
\therefore \left[Na^+\right]_{\text{left, final}} = 0.02 + x = 0.02 + 0.036 = 0.056
\]

\[
\left[Na^+\right]_{\text{right, final}} = \left[Cl^-\right]_{\text{right, final}} = 0.08 - x = 0.08 - 0.056 = 0.024 M
\]
4) Calculate the diffusion coefficient for a random coil polymer composed of 100,000 monomeric units, each unit being $4 \times 10^{-10}$ m in length. Assume the root-mean-square, end-to-end distance of the polymer can be treated as an effective hydrodynamic radius. Assume the frictional coefficient obeys Stoke’s Law. $T=293K$. Assume the viscosity of the solvent is 0.01 Poise.