Solution thermodynamics Assignment:

1. The molar volume ($cm^3.mol^{-1}$) of a binary liquid mixture at T and P is given by
   $V = 120x_1 + 70x_2 + (15x_1 + 8x_2)x_1x_2$
   a) Find expression for the partial molar volume of species 1 and 2 at T and P.
   b) Show that the expression satisfies Gibbs-Duhem equation.
   c) Show that $\left(\frac{d\widehat{v_1}}{dx_1}\right)_{x1\,=\,1} = \left(\frac{d\widehat{v_2}}{dx_1}\right)_{x1\,=\,0} = 0$
2. Find out the fugacity of the following
   a) Cyclopentane at 110 ^oC and 275 bar. At 110 ^oC VAPOUR PRESSUR OF CYCLOPENTANE IS 5.276 BAR
   b) 1-Butane AT 120 ^OC and 30 bar. Vapour pressure of 1 butane is 25.83 bar at 120 ^OC.
3. The volume change of mixing ($cm^3.mol^{-1}$) for the system ethanol (1)/methyl butyl ether (2) at 25 ^oC is given by
   $\Delta V = x_1x_2\,[- 1.026 + 0.0220(x_1 - x_2)]$
   Given that $V_1 = 58.63\ cm^3.mol^{-1}$ and $V_2 = 118.46\ cm^3.mol^{-1}$, what volume of mixture is formed when 750 cm^3 of pure species 1 is mixed with 1500 cm^3 of species 2 at 25 ^oC? What would be volume if an ideal solution were formed?
4. A 20 mol% $LiCl/H_2O$ is made by six different mixing process. Mixing is isothermal at 25 ^oC. Determine the heat effect in $J.mol^{-1}$ of the final solution for each case.
   a) Mix LiCl (s) with H_2O(l).
   b) Mix H_2O(l) with a 25 mol% $LiCl/H_2O$ solution.
   c) Mix $LiCl.H_2O$ (s) with H_2O (l).
   d) Mix LiCl (s) with a 10 mole% $LiCl/H_2O$ solution.
   e) Mix a 25 mol% $LiCl/H_2O$) with a 10 mole% $LiCl/H_2O$ solution.
   f) Mix a $LiCl/H_2O$(s) with a 10 mole% $LiCl/H_2O$ solution.

5. The following empirical two parameter expression has been proposed for correlation of excess properties of symmetric liquid mixtures:
   $$M^E = Ax_1x_2\left(\frac{1}{x_1+Bx_2} + \frac{1}{x_2+Bx_1}\right)$$
   Here, A and B are parameter that depend on T.
   Determine the expression for $\widehat{M}_1^E$ and $\widehat{M}_2^E$
   Determine the expression for ($\widehat{M}_1^E$) and $\widehat{M}_2^E$ at infinite dilution.

6. The molar enthalpy changes of mixing of methanol (1) - water (2) at a particular temperature is as follows

X_1	Δh_m (kJ/mol)	X_1	Δh_m (kJ/mol)
0.05	- 0.342	0.40	- 0.887
0.10	- 0.599	0.60	- 0.718
0.20	- 0.871	0.80	- 0.455
0.30	- 0.917	0.95	- 0.127

   Determine the difference between partial molar and pure component enthalpies for methanol and water for $X_1 = 0.35$ and $X_2 = 0.65$.

7. It is required to prepare 1 m^3 of methanol (1) water (2) solution at 25 ^oC with X_1 = 0.7779. the density of methanol (1) water (2) solution at 25 ^oC with X_1 = 0.7779 is 0.825.959 kg/m^3. The partial molar volume of water in the solution is 15.686 x 10^{-6} m^3/mol. Determine volume of methanol and water. The density of methanol at 25 ^oC is 786.846 kg/ m^3.
8. The van Laar constant A and B for a system ethanol (1) and benzene (2) at 50 ^oC are 1.7910 and 1.8262 respectively. Calculate the activity coefficient of the component in the solution containing 60 mol% ethanol.
9. Determine the bubble pressure and the composition of vapor if x_1 = 0.4 for a liquid mixture of methanol (1) – benzene (2) at 60 ^oC by using NRTL equation.

10. In a binary mixture the activity coefficient (Υ_1) of component is given by

    $$R\ln\Upsilon_1 = Ax_2^2 + Bx_2^3$$

    This equation is valid in the range of composition x_2 = 0 to x_2 = 1. Derive an expression to find out the activity coefficient of component 2.

11. The system chloroform (1) and acetone (2) form a minimum boiling azeotrope at 64.5 ^oC and 760 torr. Determine the van Laar constants and P-x-y diagram for the system at 64.5 ^oC.
12. For a particular binary system, the activity coefficients are adequately represented by

    $$\ln\Upsilon_1 = 0.5\, x_2^2 \quad \text{and} \quad \ln\Upsilon_2 = 0.5\, x_1^2$$

    the saturation pressure of the component at 80 ^oC are given by P_1^S = 900 Torr and P_2^S = 600 Torr. Is it possible to exhibit azeotrope at 80 ^oC? If so, what is the azeotropic composition and what pressure is the azeotrope likely to form?