1, 2, 3, 4 : please see the lecture note

5.
$$\Delta S = nR \ln \frac{V_{final}}{V_{initial}} = nR \ln \frac{\frac{1}{4}}{1} = 1 \cdot mol \cdot 8.314 (J/mol \cdot K) \cdot \ln \frac{1}{4}$$
$$= -11.53 \, J/K$$

$\Delta S < 0$. It's not a spontaneous process.

6.
$$\Delta u^\circ = -RT \ln \frac{C_\beta}{C_\alpha} = -8.314 (J/mol \cdot K) \times (273+20) K \times \ln \frac{7.2}{1} = -4.81 \times 10^3 (K \cdot mol^{-1})$$

7. see lecture notes

8.

(a) Ethane, which has no dipole moment and no acid-base properties, can only have London force interaction between each other, thus resulting a low bp.

However, acetic acid does have both a dipole moment and acid properties. This gives it the ability to have London force, induction interactions, dipole-dipole interactions, and hydron bonding (acid-base interaction) with itself.

Taken together, these interactions give acetic acid a higher bp than that of ethane.

(b). $\Delta H_m = \bar{V}_i (\delta_1 - \delta_2)^2$, ΔH_m : change in enthalpy due to mixing
$\bar{V}_i$: Molar volume of solute
δ_i and δ_j : Hildebrand solubility parameters.

This means that the energy due to the change in enthalpy is unfavorable. However, ΔH_m approaches 0 (i.e. becomes less disfavored) as δ_i and δ_j become closer in value. This is the mathematical basis of the saying "Like dissolves Like".

9.

$$\bar{V_i} = \frac{M W}{density}, \quad (\alpha_i)_v = \left[3\pi N/4\right]\left[(n^2-1)/(n^2+2)\right]$$

$$E_L = C_L \bar{V_i} (\alpha_i)_v \cdot (\alpha_j)_v, \quad C_L = \text{Dispersion constant (uniform for most compounds)}$$

(a)

Compound	V_i (ml/mol)	$(\alpha_i)_v$	E_L/C_L
ethane	52.57	3.54×10^{22}	6.6×10^{46}
propane	75.36	2.57×10^{22}	4.98×10^{48}
butane	96.67	2.92×10^{23}	8.22×10^{48}
pentane	115.22	3.11×10^{23}	1.12×10^{49}
hexane	130.52	3.25×10^{23}	1.38×10^{49}
heptane	146.57	3.35×10^{23}	1.64×10^{49}
octane	162.60	3.42×10^{23}	1.9×10^{49}
CCl_4	96.94	3.89×10^{23}	1.47×10^{49}
Br_2	51.24	5.25×10^{23}	1.41×10^{49}
CS_2	60.28	5.06×10^{23}	1.54×10^{49}
H_2O	18.02	2.92×10^{23}	1.54×10^{48}
Methanol	40.49	2.89×10^{23}	3.37×10^{48}
Benzene	89.13	4.18×10^{23}	1.56×10^{49}

(b) please plot use the data above.

Reason: E_L increases with the number of atoms in n-alkanes

(c),(d) Reason: Boiling point of n-alkanes is determined by the E_L between them. The larger E_L, the higher Boiling point.

(e)

	Actual Boiling point	estimated from (d) plot.
CCl_4	76.8	76.1
Br_2	58.8	69.7
CS_2	46.2	85.3
H_2O	100.1	-76.0
Methanol	65.0	-54.7
Benzene	80.1	87.0.

CCl_4 and Benzene show good agreement, because their polarizability are [cut off]
to those of n-alkane.

H_2O and methanol show poor agreement, Because besides London force, hydroge[cut off]
exist between the molecules between them, these two compounds show higher [cut off]

For Br_2 and CS_2. the difference may be due to the charge of C_L. b[cut off]
Br_2 and CS_2 are quiet different than n-alkanes.

10.

$$\ln(X_{i,j}) = - [\bar{V}_i (\delta_i - \delta_j)^2] / RT$$

	δ_j	$|\delta_j - \delta_i|$
Water	23.4	11.4
methanol	14.5	2.5
Cyclohexane	8.6	3.8
Carbon tetrachloride	8.2	3.4

Solubility: methanol > Carbon tetrachloride > Cyclohexane > water.

11. Hint: $\ln(x_i) - [\bar{V_i}(\delta_i - \delta_j)^2]/RT$.

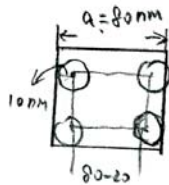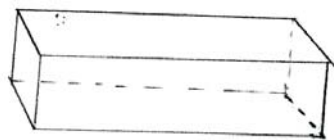12. $k = \dfrac{0.115}{1.32 \times 10^{-3}} \doteq 87.1$. is approximate to the true value of 82.6.

13. $\ln(k) = (-\bar{V_A}/RT)(\delta_{CCl_4} - \delta_{H_2O})(\delta_{CCl_4} + \delta_{H_2O} - 2\delta_A)$

$= -\left[\left(\dfrac{165}{1.25} \text{ mL/mol}\right)\Big/\left(1.987 \text{cal}/_{mol\cdot k} \cdot 298 k\right)\right][8.6 - 23.4)(8.6 + 23.4 - 2 \times 14.3)(\text{cal}/\text{mL})$

$= 11.22$ unit!

$k = 7.46 \times 10^{4}$

14.

$\ln k = -(\Delta\bar{H} - T\Delta\bar{S^0})/RT = \dfrac{\Delta S^0}{R} = \dfrac{R \ln \frac{V_1}{V_2}}{R} = \ln \dfrac{V_1}{V_2}$

$k = \dfrac{V_1}{V_2} = \dfrac{(a-d)^2}{a^2} = \dfrac{(80-20)^2}{80^2} = 0.75$

$C_{i.pore} = 1mM \times 0.75 = 0.75 \, nM$

$V_{pore} = \left[(80 \times 10^{-8})^2 \times 20 \times 10^{-5}\right]L = 1.28 \times 10^{-15} L$

$M = C_{i.pore} \cdot V_{pore} = 0.75 \times 10^{-9} M \times 1.28 \times 10^{-15} L$

$= 9.6 \times 10^{-25} \, mol$

Less than one particle! the chance for a particle in the pore is 60%.

14.

$$D\downarrow \to K\uparrow \to M\uparrow$$

15.

$$k = \exp\left[\frac{-S\hat{L}}{2}\right] = 0.123.$$