1. Separate these compound into those that are polar (water soluble) and a non-polar (hydrophobic):

NaCl, NaCOOCH₃, cooking oil, HCl, CH₄, CH₃OH, CH₃CH₂OH, gasoline, N₂

<table>
<thead>
<tr>
<th>Water soluble</th>
<th>Non-polar solvent soluble</th>
</tr>
</thead>
<tbody>
<tr>
<td>NaCl, NaCOOCH₃, HCl, CH₃OH, CH₃CH₂OH</td>
<td>cooking oil, gasoline, CH₄</td>
</tr>
</tbody>
</table>

2. Rank the following substance in increasing order of vapor pressure:

NaCl, NH₃ solution, Vinegar (CH₃COOH), cooking oil, HCl, CH₄, He and H₂O.

NaCl, cooking oil, H₂O, Vinegar, HCl, NH₃ solution, CH₄, He

3. Rank the following solutes in terms of increasing solubility in the solvent:

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Solutes</th>
<th>Increasing solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>NaCl, H₂S, CH₄, NH₃</td>
<td>CH₄, H₂S, NH₃, NaCl</td>
</tr>
<tr>
<td>Hexane</td>
<td>NaCOOCH₃, cooking oil, CH₃OH, N₂</td>
<td>N₂, NaCOOCH₃, CH₃OH, cooking oil</td>
</tr>
</tbody>
</table>

4. A liquid is heated at atmospheric pressure. For each of the properties listed, predict whether they would increase or decrease in magnitude.

(a) Viscosity
   Decrease
(b) Density
   Decrease
(c) Surface Tension
   Decrease
(d) Vapor Pressure
   Increase
(e) Tendency to Evaporate
   Increase

5. Calculate the amount of heat (J) required converting 180 g of water at 10.0°C to steam at 105.0°C. Use constants found in the lecture notes for this calculation.

\[
\begin{align*}
180 \text{ g H}_2\text{O} \times (2.26 \times 10^3 \text{ J/g}) &= 4.07 \times 10^5 \text{ J} \\
180 \text{ g H}_2\text{O} \times (2.03 \text{ J/g. °C}) \times (105.0°C – 100.0°C) \times 10^5 \text{ J} &= 0.018 \times 10^5 \text{ J} \\
\text{Total heat} &= 6.77 \times 10^4 \text{ J} + 4.07 \times 10^5 \text{ J} + 0.018 \times 10^5 \text{ J} = 4.76 \times 10^5 \text{ J}
\end{align*}
\]

6. The molar heat of fusion, ΔHₜₙₜ, of Na is 2.6 kJ/mol at its melting point, 97.5°C. How much heat must be absorbed by 5.0g of solid Na at 97.5°C to melt it?

\[
5.0 \text{ g Na} \times (1 \text{ mol Na/23 g Na}) \times (2.6 \text{ kJ/1 mol Na}) = 0.57 \text{ kJ}
\]

7. How much heat would be required to convert 234.3 g of solid benzene, C₆H₆(s), at 5.5 °C into benzene vapor, C₆H₆(g), at 100.0 °C? Benzene has the following molar heat capacities: C₆H₆(l) = 136 J/mol °C, and C₆H₆(g) = 81.6 J/mol °C. The molar heat of fusion for benzene is 9.92 kJ/mol and the molar heat of vaporization for benzene is 30.8 kJ/mol. The melting point of benzene is 5.5 °C; and the boiling point of benzene is 80.1 °C. Benzene's molecular weight is 78.0 g/mol.
8. Choose the ion in each pair that would be more strongly hydrated in aqueous solution and justify your answer:
   (a) Na⁺ or Rb⁺
   (b) Cl⁻ or Br⁻
   (c) Fe³⁺ or Fe²⁺
   (d) Na⁺ or Mg²⁺
Charge density arguments explain the answers. The bigger the charge density, the more hydrated.

9. In Denver, the partial pressure of oxygen is 0.17 atm. What is the molar solubility of oxygen there at 20°C?
   Henry Law constant for oxygen at 20°C is 0.0013 mol/L atm.
   \[ S = k_H P = (0.0013 \text{ mol/L atm}) \times (0.17 \text{ atm}) = 2.21 \times 10^{-4} \text{ mol/L} \]

10. What is the molality of a solution that contains 128 g of CH₃OH in 108 g of water?
    128 g CH₃OH x 1 mol CH₃OH = 37.0 mol = 37.0 m
    \[ \frac{0.108 \text{ kg H₂O}}{32.0 \text{ g CH₃OH kg H₂O}} \]

11. (a) How many grams of H₂O must be used to dissolve 50.0 g of sucrose, C₁₂H₂₂O₁₁, to prepare a 1.25 m solution of sucrose?
    50.0 g C₁₂H₂₂O₁₁ x 1 mol C₁₂H₂₂O₁₁ = 0.146 mol C₁₂H₂₂O₁₁
    342 g C₁₂H₂₂O₁₁
    0.146 mol C₁₂H₂₂O₁₁ = 0.117 kg H₂O = 117 g H₂O
    1.25 mol C₁₂H₂₂O₁₁/ kg H₂O
    (b) Predict the boiling point of this solution; \( K_b \) for H₂O is 0.512°C/m.
    \[ \Delta T_b = (0.512 \text{ °C/m}) \times (1.25 \text{ m}) = 0.640 \text{ °C}; \text{ BP} = 100 \text{ °C} + 0.640 \text{ °C} = 100.640 \text{ °C} \]
    (c) Calculate the freezing point of this solution; \( K_f \) for H₂O is 1.86°C/m.
    \[ \Delta T_f = (1.86 \text{ °C/m}) \times (1.25 \text{ m}) = 2.32 \text{ °C} \]
    \( T_f \text{(solution)} = 0.00 \text{ °C} - 2.32 \text{ °C} = -2.32 \text{ °C} \]
    (d) What osmotic pressure would this solution exhibit at 25°C? Its density is 1.34 g/mL.
    167 g x 1 mL = 125 mL = .125 L
    1.34 g
    \[ M_{\text{sucrose}} = 0.146 \text{ mol} = 1.17 \text{ mol/L} \]
    0.125 L
    \[ \pi = MRT = (1.17 \text{ mol/L})(0.0821 \text{ L.atm/mol.K})(298 \text{ K}) = 28.6 \text{ atm} \]

12. What are the mole fractions of CH₃OH and H₂O in the solution described in #1? It contains 128 g of CH₃OH and 108 g of H₂O.
    128 g CH₃OH x 1 mol CH₃OH = 4.00 mol CH₃OH
    32.0 g CH₃OH
    108 g H₂O x 1 mol H₂O = 6.00 mol H₂O
    18.0 g H₂O
    \[ x_{\text{CH₃OH}} = 4 \text{ mol} = 0.400; \ x_{\text{H₂O}} = 6 \text{ mol} = 0.600 \]
    (4+6) mol (4+6) mol
13. (a) At 40°C, the vapor pressure of pure heptane is 92.0 torr and the vapor pressure of pure octane is 31.0 torr. Consider a solution that contains 1.00 mole of heptane and 4.00 moles of octane. Calculate the vapor pressure of each component and the total vapor pressure above the solution.

\[ X_{\text{heptane}} = 1 \text{ mol heptane} = 0.200; \quad X_{\text{octane}} = 1 - X_{\text{heptane}} = 0.800 \]

\[ (1 \text{ mol heptane} + 4 \text{ mol octane}) \]

\[ P_{\text{heptane}} = X_{\text{heptane}} P_0 = (0.2)(92.0 \text{ torr}) = 18.4 \text{ torr} \]

\[ P_{\text{octane}} = X_{\text{octane}} P_0 = (0.8)(31.0 \text{ torr}) = 24.8 \text{ torr} \]

\[ P_{\text{total}} = P_{\text{heptane}} + P_{\text{octane}} = 18.4 \text{ torr} + 24.8 \text{ torr} = 43.2 \text{ torr} \]

(b) Calculate the mole fractions of heptane and octane in the vapor that is in equilibrium with this solution.

\[ X_{\text{heptane}} = \frac{P_{\text{heptane}}}{P_{\text{total}}} = \frac{18.4 \text{ torr}}{43.2 \text{ torr}} = 0.426; \quad X_{\text{octane}} = \frac{P_{\text{octane}}}{P_{\text{total}}} = \frac{24.8 \text{ torr}}{43.2 \text{ torr}} = 0.574 \]

14. When 15.0 g of ethyl alcohol, \( \text{C}_2\text{H}_5\text{OH} \), is dissolved in 750 grams of formic acid, the freezing point of the solution is 7.20°C. The freezing point of pure formic acid is 8.40°C. Solve for \( K_f \) for formic acid.

\[ 15.0 \text{ g C}_2\text{H}_5\text{OH} \times 1 \text{ mol C}_2\text{H}_5\text{OH} = 0.435 \text{ } m \]

\[ 0.750 \text{ kg formic acid} \times 46.0 \text{ g C}_2\text{H}_5\text{OH} \]

\[ \Delta T_f = (T_f(\text{formic acid})) - (T_f(\text{solution})) = 8.40°C - 7.20°C = 1.20°C \]

\[ K_f = \frac{\Delta T_f}{m} = \frac{1.20°C}{2.76°C/m} = 0.435m \]

15. A 1.20 gram sample of an unknown covalent compound is dissolved in 50.0 g of benzene. The solution freezes at 4.92°C. Calculate the molecular weight of the compound. The freezing point of pure benzene is 5.48°C and \( K_f \) is 5.12°C/m.

\[ \Delta T_f = 5.48°C - 4.92°C = 0.56°C; \quad m = \Delta T_f = 0.56°C = 0.11m \]

\[ K_f 5.12°C/m \]

\[ (0.11m)(0.0500kg) = 0.0055 \text{ mol solute} \]

\[ 1.20 \text{ g solute} = 0.022 \text{ g/mol} \]

\[ 0.0055 \text{ mol solute} \]

16. 0.500 grams of a sample is dissolved in 30mL of aqueous solution. If this solution has an osmotic pressure of 8.92 torr at 27.0°C, estimate its molecular weight.

\[ \pi = MRT = (n/V)RT; \quad n = \pi V = (8.92 \text{ torr} \times 1 \text{ atm/760 torr})(0.0300L) = 0.0000143 \text{ mol} \]

\[ RT (0.0821 L-atm/mol.K)(300K) \]

\[ 0.500 g/0.0000143 \text{ mol} = 3.50 \times 10^4 \text{ g/mol} \]

17. Rank the following in terms of increasing boiling point elevation when 0.1 moles of each is placed in 1 liter of water.

\[ \text{NaCl} \quad \text{BaSO}_4 \quad \text{CaCl}_2 \quad \text{Urea (a nonionizable, water soluble organic molecule)} \]

\[ \text{BaSO}_4 < \text{urea} < \text{NaCl} < \text{CaCl}_2 \] (remember that \( \text{BaSO}_4 \) is insoluble)

18. Predict the temperature at which water boils if it has a vapor pressure of 355 torr at 80°C. The \( \Delta H^\circ_{\text{vap}} \) of water is 40.7 kJ/mol.

Use the Clausius Clapeyron equation and follow my approach in the notes. Make sure you change torr to Pa and you should get a value a little over 373 K depending on how many sig figs you use in your constants.