Lesson 18: Phase Diagrams, Raoult’s and Henry’s laws

what to know:
- phase diagrams (water and carbon dioxide) and related terms, §6-5
- concept of critical temperature and pressure, §6-5
- mass percentage, mole fraction and molality and interconversions with molarity, p-245-250
- ideal solutions, Raoult’s law, p-250-251,
- Henry’s law, distillation, p-262-267

questions:
1. When solid carbon dioxide (dry ice) is left open at room temperature it disappears without melting. Explain what happens and why it happens. How could you observe liquid CO₂?

2. Compare and contrast the phase diagrams for water and carbon dioxide.

3. Under what conditions do the solid, liquid and vapor phases of water coexist in equilibrium?

4. Lead is a poisonous metal that especially affects children. Lead levels of 0.250 ppm in a child cause delayed cognitive development. How many moles of lead are present in 1.00 g of the child’s blood if 0.250 ppm represent?

5. A 100 g sample of water from a lake is found to contain 1.36 x 10⁻³ mg of mercury. What is the concentration of the mercury in ppm?

6. Complete the following table for water solutions of oxalic acid, H₂C₂O₄.

<table>
<thead>
<tr>
<th>Mass Solute</th>
<th>Moles Solute</th>
<th>Volume Solution</th>
<th>Molarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 12.5 g</td>
<td></td>
<td>456 mL</td>
<td></td>
</tr>
<tr>
<td>b. _____</td>
<td>0.0375</td>
<td>_____</td>
<td>0.138</td>
</tr>
<tr>
<td>c. _____</td>
<td>_____</td>
<td>1.75 L</td>
<td>0.496</td>
</tr>
</tbody>
</table>

7. The density of a 60.0% aqueous solution of sugar is 1.290 g/mL. Molar masses are 342 for sugar and 18.0 for water.
   a. What is the molarity of the sugar solution?
   b. What is the mole fraction of water in the solution?
   c. What is the molality of the sugar solution?
   d. Which of the above expressions of concentration are temperature dependent, molarity, mole fraction or molality?

8. Explain why the solubility of a gas in a liquid always decreases with an increase in temperature.

9. At 25 °C the vapor pressure of pure benzene is 0.125 atm. What is the mole fraction of any nonvolatile solute which would result in a solution vapor pressure of 0.100 atm?

10. A mixture of hexane (C₆H₁₄) and heptane (C₇H₁₆) is 0.50 mole fraction in hexane. What can you say about the composition of the vapor above the liquid? Describe how these can be separated by distillation.

11. Relate Henry’s law to a can of soda.

12. What is an ideal solution?