

## 14 • Solutions and Their Behavior

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### STUDY QUESTIONS

- A solution of salt (molar mass  $90 \text{ g mol}^{-1}$ ) in water has a density of  $1.29 \text{ g/mL}$ . The concentration of the salt is 35% by mass.
  - Calculate the molality of the solution.
  - Calculate the molarity of the solution.
  - Calculate the total number of moles in the solution.
  - Calculate the mole fraction of the salt in the solution.
- Ethylene glycol ( $\text{C}_2\text{H}_4(\text{OH})_2$ ; 150 grams) is added to ethanol ( $\text{C}_2\text{H}_5\text{OH}$ ; 250 grams).
  - Calculate the mass % of ethylene glycol in the solution.
  - Calculate the molality of ethylene glycol in the solution.
  - Calculate the mole fraction of ethylene glycol in the solution.
- Concentrated sulfuric acid contains very little water, only 5.0% by mass. It has a density of  $1.84 \text{ g/mL}$ . What is the molarity of this acid?
- The lattice energy of a salt is  $350 \text{ kJ/mol}$  and the solvation energies of its ions add up to  $320 \text{ kJ/mol}$  for the preparation of a  $0.50 \text{ M}$  solution. In the preparation of this solution would the solution get colder or warmer? What is the driving force for this solution process?
- Addition of excess sodium nitrate to water to form a saturated solution results in the following equilibrium. The solution process is endothermic.  $\text{NaNO}_3(\text{s}) \rightleftharpoons \text{Na}^+(\text{aq}) + \text{NO}_3^-(\text{aq})$ 

How could the concentration of sodium nitrate in the solution be increased?

  - add more  $\text{NaNO}_3(\text{s})$
  - increase the pressure on the solution
  - increase the temperature
  - stir the solution more vigorously
- The value of Henry's law constant  $k_{\text{H}}$  for oxygen in water at  $24^\circ\text{C}$  is  $1.66 \times 10^{-6} \text{ M/torr}$ .
  - Calculate the solubility of oxygen in water at  $25^\circ\text{C}$  when the total external pressure is 1 atm and the mole fraction of oxygen in the air is 0.20.
  - Calculate the solubility at the same temperature with the same atmospheric composition but at an increased pressure of 2 atm.
  - What would happen to the solubility of the oxygen gas if the temperature was increased?

7. Ethanol and methanol form an almost ideal solution. If 64 g of methanol is mixed with 69 g of ethanol, what is the total vapor pressure above the solution?  
The vapor pressure of pure methanol at this temperature = 90 torr.  
The vapor pressure of pure ethanol at this temperature = 45 torr.
8. A 3.0 molal solution of naphthalene in cyclohexane boils at 89.4°C. What is the boiling point of pure cyclohexane? Although solid naphthalene is slightly volatile, assume its volatility is zero in this calculation. The constant  $k_b$  for cyclohexane is  $+2.80 \text{ K m}^{-1}$ .
9. Which of the following solutions would you expect to have the lowest freezing point? Assume that the values of  $i$  are ideal.
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|--------------------------|--------------------------------------|
| a. 0.010m NaCl           | d. 0.050m glycerol                   |
| b. 0.100m sugar          | e. 0.060m $\text{Ca}(\text{NO}_3)_2$ |
| c. 0.070m $\text{KNO}_3$ | f. 0.075m KCl                        |
10. In order to depress the freezing point of water to  $-12^\circ\text{C}$ , how much magnesium nitrate would you have to add to 500 grams of water? Assume that the van't Hoff factor  $i$  is the ideal value.  $k_f$  for water is  $-1.86 \text{ K m}^{-1}$ .

Ignore questions 11 & 12.