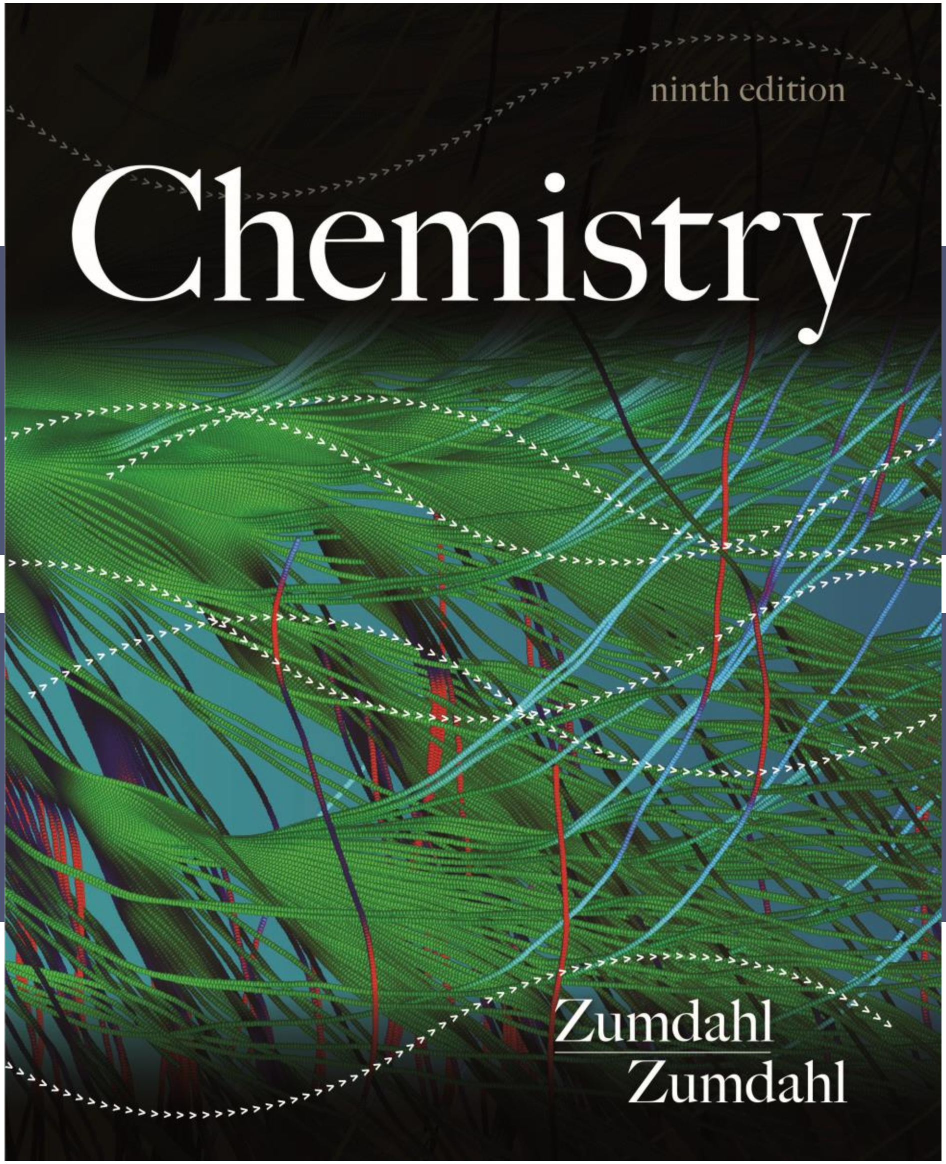


Chapter 11

Properties of Solutions

Do in your notes, compare with partner

- A solution is prepared by mixing 1.00 g ethanol (C_2H_5OH) with 100.0 g water to give a final volume of 101 mL
  - Calculate the molarity, and mole fraction of ethanol in this solution

Interactive Example 11.1 - Solution

- Molarity
  - The moles of ethanol can be obtained from its molar mass (46.07 g/mol):

$$1.00\text{ g } C_2H_5OH \times \frac{1\text{ mol } C_2H_5OH}{46.07\text{ g } C_2H_5OH} = 2.17 \times 10^{-2}\text{ mol } C_2H_5OH$$

$$\text{Volume} = 101\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}} = 0.101\text{ L}$$

Interactive Example 11.1 - Solution (Continued 1)

$$\text{Molarity of } C_2H_5OH = \frac{\text{moles of } C_2H_5OH}{\text{liters of solution}} = \frac{2.17 \times 10^{-2} \text{ mol}}{0.101 \text{ L}}$$

$$\text{Molarity of } C_2H_5OH = 0.215\ M$$

Interactive Example 11.1 - Solution (Continued 2)

- Mole fraction

$$\text{Mole fraction of } C_2H_5OH = \frac{n_{C_2H_5OH}}{n_{C_2H_5OH} + n_{H_2O}}$$

$$n_{H_2O} = 100.0 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.0 \text{ g } H_2O} = 5.56 \text{ mol}$$

$$\chi_{C_2H_5OH} = \frac{2.17 \times 10^{-2} \text{ mol}}{2.17 \times 10^{-2} \text{ mol} + 5.56 \text{ mol}} = \frac{2.17 \times 10^{-2}}{5.58} = 0.00389$$

Answer with partner, compare with another group

- You are given two aqueous solutions with different ionic solutes (Solution A and Solution B)
  - Solution A has a greater concentration than Solution B by mass percent, but Solution B has a greater concentration than Solution A in terms of molality.
    - Is this possible?
      - If not, explain why not
      - If it is possible, provide example solutes for A and B and justify your answer with calculations

Normality (*N*)

- Measure of concentration
- Number of equivalents per liter of solution
  - Definition of an equivalent depends on the reaction that takes place in a solution

Do in your notes, compare with partner

- The electrolyte in automobile lead storage batteries is a 3.75 *M* sulfuric acid solution that has a density of 1.230 g/mL
  - Calculate the mass percent and normality of the sulfuric acid

Interactive Example 11.2 - Solution

- What is the density of the solution in grams per liter?

$$1.230 \frac{\text{g}}{\text{mL}} \times \frac{1000\text{ mL}}{1\text{ L}} = 1.230 \times 10^3\text{ g/L}$$

- What mass of H_2SO_4 is present in 1.00 L of solution?
  - We know 1 liter of this solution contains 1230 g of the mixture of sulfuric acid and water

Interactive Example 11.2 - Solution (Continued 1)

- Since the solution is 3.75 *M*, we know that 3.75 moles of H_2SO_4 is present per liter of solution
- The number of grams of H_2SO_4 present is

$$3.75 \text{ mol} \times \frac{98.0 \text{ g } H_2SO_4}{1 \text{ mol}} = 368 \text{ g } H_2SO_4$$

Interactive Example 11.2 - Solution (Continued 2)

- How much water is present in 1.00 L of solution?
  - The amount of water present in 1 liter of solution is obtained from the difference

$$1230 \text{ g solution} - 368 \text{ g } H_2SO_4 = 862 \text{ g } H_2O$$

Interactive Example 11.2 - Solution (Continued 5)

- What is the normality?
  - Since each sulfuric acid molecule can furnish two protons, 1 mole of H_2SO_4 represents 2 equivalents
  - Thus, a solution with 3.75 moles of H_2SO_4 per liter contains $2 \times 3.75 = 7.50$ equivalents per liter
    - The normality is 7.50 *N*

Steps Involved in the Formation of a Liquid Solution

1. Expand the solute (endothermic)
   - Separate the solute into its individual components
2. Expand the solvent (endothermic)
   - Overcome intermolecular forces in the solvent
3. Allow the solute and solvent to interact (exothermic)

Enthalpy (Heat) of Solution (ΔH_{soln})

- Enthalpy change associated with the formation of the solution is the sum of the ΔH values for the steps:

$$\Delta H_{soln} = \Delta H_1 + \Delta H_2 + \Delta H_3$$

  - ΔH_{soln} can have a positive sign when energy is absorbed or a negative sign when energy is released

Factors That Favor a Process

- Increase in probability of the mixed state when the solute and solvent are placed together
- Processes that require large amounts of energy tend not to occur
- Like dissolves like

Answer in your notes, compare with partner

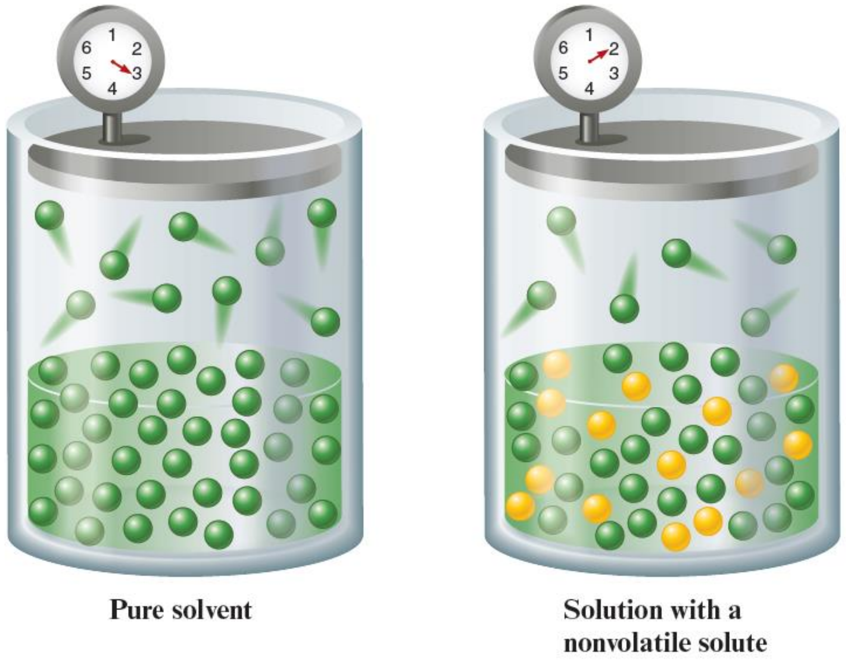
- Decide whether liquid hexane (C_6H_{14}) or liquid methanol (CH_3OH) is the more appropriate solvent for the substances grease ($C_{20}H_{42}$) and potassium iodide (KI)

Interactive Example 11.3 - Solution

- Hexane is a nonpolar solvent because it contains C—H bonds
  - Hexane will work best for the nonpolar solute grease
- Methanol has an O—H group that makes it significantly polar
  - Will serve as the better solvent for the ionic solid KI

Vapor Pressures of Solutions

- Presence of a nonvolatile solute lowers the vapor pressure of a solvent
  - Inhibits the escape of solvent molecules



The Tyndall Effect

- Scattering of light by particles
- Used to distinguish between a suspension and a true solution
  - When a beam of intense light is projected:
    - The beam is visible from the side in a suspension
    - The light beam is invisible is in a true solution

Figure 11.23 - The Tyndall Effect