

Guide to Chapter 11. Solutions and their properties

We will spend three lecture days on this chapter. You may want to start by reviewing the concepts of heterogeneous solutions (Chapter 2)

□ Read the introductory paragraph to Chapter 11.

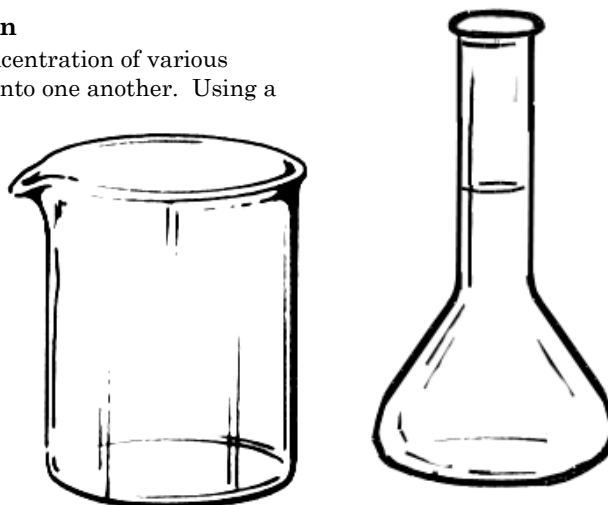
□ Read Section 11.1 Solutions and 11.2. Energy changes and the solution process.

- □ Learning Objective 1: Using your knowledge of energy terms involved in the solution process determine which solvent is best suited for a given solute.
- □ Learning Objective 2: Using the concept of intermolecular forces and the "like dissolves like" rule, determine which solvent is best suited for a given solute.
- □ Learning Objective 3: Know the definition of a suspension and a colloids.
- Do Problems 1 - 2 at the end of Section 11.2.
- Do the following end-of-chapter problems: 36, 38, 40, 42, 44

□ Read Section 11.3 Units of concentration

In this section, you will be determining the concentration of various solutions and then inter-converting them into one another. Using a sketched beaker and volumetric flask makes this job easier.

- □ Learning Objective 4: Be able to determine the concentration of a solution, taking into account whether the solute is an electrolyte or non-electrolyte. Concentration units include:
 - a. molarity
 - b. mass percent
 - c. mole fraction
 - d. molality
 - e. ppm and ppb



- □ Learning Objective 5: Know how to convert one unit of concentration measurement to another.
- Do Problems 3 – 10 at the end of the section.
- Do the following end-of-chapter problems: 48, 50, 52, 54, 58, 60, 62, 64, 66.

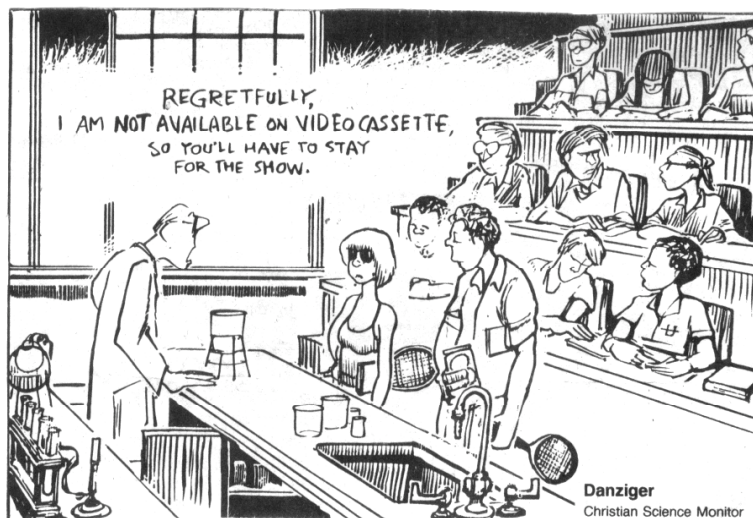
□ *Problem Club Question A. A solution is prepared by dissolving 25-g sucrose, (MM = 342) in 50-mL water. (a) Sketch the solution in a beaker. What is the (b) mole fraction of sucrose; (c) weight percent of sucrose and (d) molality of the sucrose solution? [d(H₂O) = 1.00 g/mL]*

□ *Problem Club Question B. What is the (a) mole fraction and (b) weight percent of bromine in 2.20 molal Br₂ in CH₂Cl₂ solution? Start by sketching the solution.*

□ *Problem Club Question C. How much naphthalene, C₁₀H₈ (MM = 128) must be added to 4.0-L CCl₄ (d = 1.59 g/mL) in order to form a 3.00 molal solution? Start by sketching the solution.*

□ *Problem Club Question D. Fingernail polish remover is made by mixing 50 mL acetone (propanone, d = 0.79 g/mL; MM = 58) with 50 mL ethyl acetate (ethyl ethanoate - the ethyl ester of ethanoic acid; d = 0.90 g/mL; MM = 88). Start by sketching the solution. (a) What is the mole fraction of each component? (b) What is the molality of acetone? (c) What is the weight percent of acetone?*

- **Problem Club Question E.** A 40.0-g sample of sodium fluoride, NaF ($MM = 42$) is dissolved in enough water to make 250-mL. (a) Sketch the solution. (b) Calculate the molarity of NaF. (c) How much of this solution should be used in order to prepare 100.0-mL of a 0.50 M solution? (d) How much water must be added to 100-mL of the original solution (in 'a') in order to form a 0.70 M solution?



- **Problem Club Question F.** Concentrated HCl is 12 M with a density of 1.18 g/mL. (a) Sketch and label the solution. Convert this to units of (b) molality and (c) mole fraction of HCl

- **Problem Club Question G. (ACS- Style)** What mass of water is needed to dissolve 292.5 g of NaCl to produce a 0.25 m aqueous solution? [Given: Molar Mass: NaCl : 58.5 g/mol]

A. 20 kg B. 5.0 kg C. 0.80 kg D. 0.050 kg

- **Problem Club Question H. (ACS- Style)** What is the mole fraction of water in 200. g of 95% (by mass) ethanol, C_2H_5OH ? [Given: Molar Mass: C_2H_5OH : 46 $g \cdot mol^{-1}$]

A. 0.050 B. 0.12 C. 0.56 D. 0.88

□ **Read Section 11.4 Some factors affecting solubility.**

□ □ Learning Objective 6: Know the factors that have an effect on solubility.

□ □ Learning Objective 7: Use Henry's law to determine the solubility of a gas in a liquid.

□ Do Problems 11 and 12 at the end of the section.

□ Do the following end-of-chapter problems: 68, 70, 72

- **Problem Club Question I. (ACS- Style)** Air is most soluble in water at

A. high temperature and low pressure.
 B. low temperature and low pressure.
 C. high temperature and high pressure.
 D. low temperature and high pressure.

- **Problem Club Question J. (ACS- Style)** Which substance is most soluble in water?

A. C_6H_6 C. $CaCO_3$
 B. C_2H_5OH D. CO_2

- **Problem Club Question K. (ACS- Style)** Which statement correctly expresses a relation between solubility and temperature?

A. An increase in temperature increases the solubility of a gas in a liquid.
 B. The change of solubility with temperature is the same for all substances.
 C. The solubility of a liquid in a liquid is independent of temperature.
 D. The solubility of most solids in water increases with increasing temperature.
 E. The solubility of most solids in water decreases with increasing temperature.

□ Read Section 11.5. Physical behavior of solutions: Colligative properties and Section 11.6. Vapor pressure lowering of solutions: Raoult's law.

□ □ Learning Objective 8: Determine the vapor pressure of an ideal solution using Raoult's Law.

□ Do Problems 13 – 15 and 16 – 17 at the end of the section.

□ Do the following end-of-chapter problems: 34, 74, 78, 80, 86

□ *Problem Club Question L. Calculate (a) the vapor pressure lowering and (b) the vapor pressure in an aqueous solution at 90 °C [$P_{\text{vap}} = 526 \text{ mmHg}$] if the mole fraction of sucrose is 0.12.*

□ *Problem Club Question M. The vapor pressure of pure chloroform at 70.0 °C is 1.34 atm. How much iodine, I_2 [MM = 254] should be dissolved in 1.0-L of $CHCl_3$ [$d = 1.49 \text{ g/cm}^3$; MM = 119.5] to lower the vapor pressure by 100 mmHg?*

□ *Problem Club Question N. (ACS- Style) Which would have the lowest total vapor pressure at 25 °C?*

A. a 3 M aqueous solution of NaOH

B. a 3 M aqueous solution of NH_3

C. a 3 M aqueous solution of $CaCl_2$

D. a 3 M aqueous solution of ethanol

□ Read Section 11.7. Boiling point elevation and freezing point depression of solutions.

□ □ Learning Objective 9: Be able to determine the boiling or freezing point of a solution.

□ □ Learning Objective 10: Given the boiling or freezing point, be able to determine the molality of the solution.

□ Do Problems 18 – 22 at the end of the section.

□ Do the following end-of-chapter problems: 76, 82, 84, 90, 92

□ *Problem Club Question O. Calculate the freezing point and boiling point of a solution prepared by dissolving 25.0-g of propylene glycol, $C_3H_8O_2$ in 250 mL water [$d = 1.00 \text{ g/mL}$; $k_f = 1.86 \text{ deg/molal}$; $k_b = 0.52 \text{ deg/molal}$].*

□ *Problem Club Question P. How many grams of citric acid, $C_6H_8O_7$ [MM = 126], a non-electrolyte, would have to be added to 100.0-mL water to give a solution freezing at -1.50 °C ? [$k_f = 1.86 \text{ deg/molal}$]*

□ *Problem Club Question Q. When 20.25 g of lactic acid, $C_3H_6O_3$ [MM = 90] are dissolved in 250-mL acetone [$d = 0.791 \text{ g/mL}$] the resulting solution boils at 57.89 °C . If the boiling point of pure acetone is 55.95 °C , what is the boiling point constant, k_b for acetone?*

□ *Problem Club Question R. (ACS- Style) A 0.10 m aqueous solution of HF shows a freezing point of -0.198 °C . What is the percent dissociation of HF? [Molal Freezing Point Constant K_f for water = $1.86 \text{ °C}\cdot\text{m}^{-1}$]*

A. 6.4%

B. 10%

C. 20%

D. 98%

□ *Problem Club Question S. (ACS- Style) Which formula is possible for a completely ionized salt if an aqueous 0.10 M solution of that salt has a freezing point of -0.74 °C ? [Molal Freezing Point Constant K_f for water = $1.86 \text{ °C}\cdot\text{m}^{-1}$]*

A. MX

B. M_2X

C. M_2X_3

D. MX_3

□ *Problem Club Question T. (ACS- Style) If we have three different solutions, A, B, and C, each containing 100 g of water, plus respectively 34.2 g of sucrose, 4.6 g of ethanol, and 4.0 g of sodium hydroxide, which statement is true?*

	<i>Molar Masses</i>
<i>sucrose, C₁₂H₂₂O₁₁</i>	<i>342 g·mol⁻¹</i>
<i>ethanol, C₂H₅OH</i>	<i>46 g·mol⁻¹</i>
<i>NaOH</i>	<i>40 g·mol⁻¹</i>

- A. A, B, and C will all have the same freezing points.*
- B. A and C have the same boiling point, but B has a lower one.*
- C. C has the lowest freezing point in the group.*
- D. A, B, and C all have different freezing points.*
- E. The boiling point of C is lower than that of A or B.*

□ *Problem Club Question U. (ACS- Style) Which water solution has the lowest freezing point?*

- A. 0.1 m Na₂SO₄*
- B. 0.1 m NaCl*
- C. 0.1 m KNO₃*
- D. 0.1 m C₁₂H₂₂O₁₁ (sugar)*
- E. 0.1 m HC₂H₃O₂*

□ *Problem Club Question V. (ACS- Style) The addition of a non-volatile solute to water will always*

- A. increase the boiling point.*
- B. increase the freezing point.*
- C. increase the temperature of the solution.*
- D. increase the vapor pressure at a specific temperature.*
- E. increase the total volume relative to the sum of the volumes of the components.*

□ **Read Section 11.8. Osmosis and osmotic pressure.**

- □ **Learning Objective 11:** Explain the process called osmosis. Define the terms: i. semipermeable membrane; ii. Isotonic; iii. reverse osmosis; and iv. osmotic pressure
- □ **Learning Objective 12:** Given the molarity (or the necessary information to determine it), be able to determine the osmotic pressure of a solution.
- □ **Learning Objective 13:** Given the osmotic pressure, be able to determine the molarity of the solution.
- **Do Problems 23 – 24** at the end of the section.
- **Do the following end-of-chapter problems:** 94, 96

□ *Problem Club Question W. Calculate the osmotic pressure of an aqueous solution at 25 °C containing 50.0-g urea, CO(NH₂)₂ [MM = 60] per liter of solution*

From “Ask Dr. Science”

*Dear Dr. Science,
What is reverse osmosis?*

from James Ayers of Apache Junction, AZ

For an oz to mose, it must have both the impulse to mose, as well as a direction in mind. A directionless oz is like a bored teenager wandering a shopping mall. Not only will it fail to permeate the membrane, it will probably max out its parents' credit card in a futile attempt to satiate a spiritual hunger that comes from deep at the bottom of the container, or psyche. Talk about clueless! For an oz to reverse its mosis, it must not only be unmotivated by a sense of purpose, but genuinely in the grip of evil. In scientific terms, its entropic state must equal or exceed its molecular weight. That's why reverse osmosis is against the law in most states.

Answers:

Question A. (b) 0.0256 (c) 33.3% (d) 1.46 molal

Question B. (a) 0.158 (b) 26%

Question C. 2442 g naphthalene

Question D. (a) $X_{\text{acetone}} = 0.57$ and $X_{\text{ethyl acetate}} = 0.43$ (b) 15.1 molal (c) 46%

Question E. (a) must show volumetric flask (b) 3.81 M (c) 13.1 mL (d) add 444 mL

Question F. (a) use volumetric flask (b) 16.2 molal (c) 0.225

Question G. A

Question H. B

Question I. D

Question J. B

Question K. D

Question L. (a) 63 mmHg (b) 463 mmHg

Question M. 344 g

Question N. C

Question O. freezing point = $-2.45\text{ }^{\circ}\text{C}$ and normal boiling point = $100.68\text{ }^{\circ}\text{C}$

Question P. 10.1 g

Question Q. 1.71 deg/molal

Question R. A

Question S. D

Question T. C

Question U. A

Question V. A

Question W. 20.4 atm

Question X. B

Question Y. MM = 169

Question Z. D

Question AA. E

Question BB. B