Practice #2: Intermolecular Forces and Colligative Properties of Solutions

1. An aqueous solution is 40.00% ethylene glycol ($C_2H_6O_2$) by mass.
The density of the solution is 1.050 g/mL.
Calculate the following:
a) molality (m)
b) molarity (M)
c) mole fraction (X)

2. Explain why, in terms of Henry's Law, a bottle of coke fizzes when you open it.

3. What is a solution? A colloid? A suspension? An aerosol? A dispersion? A gel?
How can the Tyndall effect be used to distinguish differences between these media?
Give examples of each medium.

Practice #2 Answers:

1. a) molality = $\frac{\text{moles solute}}{\text{kg solvent}}$ So, assuming 1.00 Liter . . .

$1.00\text{L} \times \frac{1000\text{mL}}{1.00\text{L}} \times 1.050\ \text{g/mL}$ = total mass of 1050 g

(0.4000)(1050 g) = g ethylene glycol = 420.0 g $C_2H_6O_2$ So, mass of water =1050 -420 = 630 g

or 0.630 kg. Moles of $C_2H_6O_2$ are $420.0\text{g} \times \frac{1\ \text{mole}}{62.26\text{g}}$ = 6.746 moles $C_2H_6O_2$

$m = \frac{6.746\ \text{moles}\ C_2H_6O_2}{0.630\ \text{kg water}} = 10.7\ \text{m}$

b) Molarity = $\frac{\text{moles solute}}{\text{total volume of solution}}$ As per part a, assume 1.00 L.

$\frac{6.746\ \text{moles}\ C_2H_6O_2}{1.00\ \text{Liter}} = 6.746\ \text{M}$

c) mole fraction (X) = $\frac{\text{moles of}\ C_2H_6O_2}{\text{total moles}}$

moles H_2O = $630\ \text{g}H_2O \times \frac{1\ \text{mol}\ H_2O}{18.02\ \text{g}} = 35.0$

$X_{C_2H_6O_2} = \frac{6.746\ \text{moles}\ C_2H_6O_2\ \text{(part a)}}{6.746\ \text{n}\ C_2H_6O_2 + 35.0\ \text{n}\ H_2O} = 0.162$

2. Henry's Law states c = kP, The concentration (c) of the dissolved gas is directly proportional to the partial pressure (P) of the gas above it. When soda is bottled, an additional amount of CO_2 is added above the surface of the liquid in order to maintain the solubility of the CO_2 as the bottle sits on a shelf. When opened this additional CO_2 escapes to the lower pressure atmosphere, resulting in less soluble CO_2 and a "fizzing" noise. This is why the soda gets "flatter and flatter" after each successive opening (think of a 2 Liter soda bottle).

3. Solutions

A solution is a homogeneous mixture of two or more components. The dissolving agent is the solvent. The substance, which is dissolved, is the solute. The components of a solution are atoms, ions, or molecules, which makes them 10^{-9} m or smaller in diameter.

Example: Sugar and Water, Salt and Water

Suspensions

The particles in suspensions are larger than those found in solutions. Components of a suspension can be evenly distributed by a mechanical means, like by shaking the contents, but the components will settle out.

Example: Oil and Water

Colloids

Particles intermediate in size between those found in solutions and suspensions can be mixed such that they remain evenly distributed without settling out. These particles range in size from 10^{-8}m to

10^{-6} m in size and are termed colloidal particles or colloids. The mixture they form is called a colloidal dispersion. A colloidal dispersion consists of colloids in a dispersing medium.

Example: Milk, silty or muddy water

More Dispersions

Liquids, solids, and gases all may be mixed to form colloidal dispersions.

Aerosols: solid or liquid particles in a gas.
Examples: Smoke is a solid in a gas. Fog is a liquid in a gas.

Sols: solid particles in a liquid.
Example: Milk of Magnesia is a sol with solid magnesium hydroxide in water.

Emulsions: liquid particles in liquid.
Example: Mayonnaise is oil in an aqueous vinegar (acetic acid) solution.

Gels: liquids in solid.
Examples: gelatin is protein in water. Quicksand is sand in water.

Telling Them Apart

You can tell suspensions from colloids and solutions because the components of suspensions will eventually separate. Colloids can be distinguished from solutions using the Tyndall effect. A beam of light passing through a true solution, such as air or salt water, is not visible. Light passing through a colloidal dispersion, such as smoky or foggy air, will be reflected by the larger particles and the light beam will be visible. This is why it is impossible to see in the fog with your high beams on. The water droplets in the air are directing the light away from what it is you are trying to see. [Usually they are directing the light back into your face!]