Solutions

Solution Concentration

Units of Concentration

1.Molarity

2.Molality

3.Mass Percent

4.Mole Fraction

Sample Problems

1. A solution is prepared by adding 5.84 g of H_2CO to 100.0 g of water. The final volume of the solution is 104.0 mL.

a. What is the molarity of the solution?

b. What is the molality of the solution?

c. What is the mass percent of H_2CO in the solution?

d. What is the mole fraction of H_2CO in the solution?

2.The typical Hydrogen Peroxide (H_2O_2) that is used in beauty shops is 6% by mass. Calculate the mole fraction, molarity, and molality of 500 mL of H_2O_2.

What does 6% mean?

Mole Fraction

Molarity

Molality

3. The "proof" is the unit used to measure alcohol concentration in an ethanol(C_2H_5OH) in water solution. A typical hard liquor is 80.0 proof.

a. What is the mass percent of ethanol in the solution?

b. What is the molality of the solution?

c. What is the molarity of the solution?

d. What is the mole fraction of ethanol in the solution?

4. This is from the 1996 AP Exam

Concentrated sulfuric acid (18.4-molar H_2SO_4) has a density of 1.84 grams per milliliter. After dilution with water to 5.20-molar, the solution has a density of 1.38 grams per milliliter and can be used as an electrolyte in lead storage batteries for automobiles.

(a) Calculate the volume of concentrated acid required to prepare 1.00 liter of 5.20-molar H_2SO_4.

(b) Determine the mass percent of H_2SO_4 in the original concentrated solution.

(c) Calculate the volume of 5.20-molar H_2SO_4 that can be completely neutralized with 10.5 grams of sodium bicarbonate, $NaHCO_3$.

(d) What is the molality of the 5.20-molar H_2SO_4?

Henry's Law

In an Equation:

1. Diet Coke is bottled at 25° Celsius so that the liquid contains carbon dioxide at 5.0 atmospheres of pressure. The pressure of carbon dioxide in the atmosphere is $4.0x10^{-4}$ atm. What is the concentration of carbon dioxide before and after opening this culinary delight? The Henry's law constant for carbon dioxide is 3.1×10^{-2} mole/liter atm.

Vapor pressure

Molecules are in a constant state of motion and escape. Sometimes blocking the leaving area can slow them down.

Raoult's Law

Ideal Versus Non-Ideal Solutions

Ideal

Non-Ideal

What does this mean?

Now to Mixtures:
Heptane and Hexane form an almost ideal solution.

For this ideal solution only the number of molecules matter!

What if they were non-ideal solutions?

Things that bond together will experience a negative deviation from Raoult's Law. Water and acetone show significant hydrogen bonding. Ethanol and hexane are both volatile and repel each other.

The vapor, no matter what, will always be richer in the more volatile liquids!

Vapor Pressure Lowering

Picture an ideal solution. Take non-volatile, non-electrolytes and put them together.

Colligative Properties of Solutions.

What is a colligative property?

What are the four colligative properties?

1. 3.

2. 4.

Boiling Point Elevation and Freezing Point Depression:

The normal boiling point is when the vapor pressure is equal to the applied atmospheric pressure. What happens when the vapor pressure is lowered? Phase Diagrams again!

Ideally one mole of any non-volatile non-electrolytic solute in a given amount of solvent will have the same effect on colligative properties as any other substance.

Equations:

Kb	molal boiling point elevation constant	= 0.512°C mole/kilogram for water
Kf	molal freezing point depression constant	= 1.86°C mole/kilogram for water

A 1 molal aqueous solution of any non-volatile non-electrolyte boils at 100.512°C

Qualitative Effects
Cooking Noodles

Salting Highways after a snow

Anti freeze in a car radiator

Quantitative Examples

1. What is the vapor pressure of a benzene/toluene solution if the mole fraction of benzene is 0.30 and that of toluene is 0.70? The vapor pressure of benzene is 73 torr and that of toluene is 27 torr.

2.What is the mole fraction of benzene vapor in example 1?

3. A solution is prepared by mixing 1 mole of methanol (P^o = 143 torr), 2 moles of acetone (P^o = 271 torr) and 3 moles of propanol (P^o = 44.6 torr). What is the vapor pressure of the mixture? What is the composition of the vapor for each component?

4. What is the vapor pressure lowering and the vapor pressure of a solution prepared with a mole fraction of sucrose that is 0.0220 and the vapor pressure of water is 23.756 torr?

5. The molal boiling and freezing point constants for water are 0.512°C-kg/mol and 1.86°C-kg /mole respectively. We are going to discuss an ideal 0.050 molal solution of sand that does not dissociate.

a. What is the freezing point of the solution?

b. What is the boiling point of the solution?

6. A solution was prepared by dissolving 18.00 g of glucose in 150.0 g of water. It had a boiling point of 100.34°C. What is the molecular weight of glucose?

7. Ethylene glycol contains carbon, hydrogen, and oxygen. It is 38.7% carbon and 9.80% hydrogen. When 100.0 grams of it is placed in 900 grams of water the freezing point is lowered by 3.33 degrees. What is the molecular formula?

8. Solid sulfur is a molecular solid of the formula S_x. The addition of 0.24 g of sulfur to 100 g of carbon tetrachloride (K_f = 29.8°C Kg/mole) lowered its freezing point by 0.28°C. Find the value of X in sulfur's formula.

From the 1985 AP Exam

The formula and the molecular weight of an unknown hydrocarbon compound are to be determined by elemental analysis and the freezing-point depression method.

(a) The hydrocarbon is found to contain 93.46 percent carbon and 6.54 percent hydrogen. Calculate the empirical formula of the unknown hydrocarbon.

(b) A solution is prepared by dissolving 2.53 grams of p-dichlorobenzene (molecular weight 147.0) in 25.86 grams of naphthalene (molecular weight 128.2). Calculate the molality of the p-dichlorobenzene solution.

(c) The freezing point of pure naphthalene is determined to be 80.2°C. The solution prepared in (b) is found to have an initial freezing point of 75.7°C. Calculate the molal freezing-point depression constant of naphthalene.

(d) A solution of 2.42 grams of the unknown hydrocarbon dissolved in 26.7 grams of naphthalene is found to freeze initially at 76.2°C. Calculate the apparent molecular weight of the unknown hydrocarbon on the basis of the freezing-point depression experiment above.

(e) What is the molecular formula of the unknown hydrocarbon?

Osmosis

Osmotic Pressure is the external pressure exactly sufficient to oppose osmosis and stop it.

Crenation:

Hypertonic

Lysis:

Hypotonic

Electrolytes

But wait! Some of them pair up again!

What do the equations look like now?

Place the following in order by size of boiling point elevation:

Glucose
KCl
$CaCl_2$
$FeBr_3$
Acetic Acid (a weak monoprotic acid)

From the following solutions:

$C_6H_{12}O_6$(x=0.01) NaCl (x=0.01) $CaCl_2$(x=0.01)

Choose the solution with:

Highest freezing point

Lowest freezing point

Highest boiling point

Lowest boiling point

Highest osmotic pressure