13.2, 13.3, and 13.4

I. 13.2 – Saturated Solutions and Solubility | PART #2

Define **Saturated** – A solution in which undissolved solute and dissolved solute are in equilibrium.

The amount of solute needed to form a saturated solution in a given quantity of solvent is known as the Solubility of that solute.

Define **Solubility** – The amount of a substance that dissolves in a given quantity of solvent at a given temperature to form a saturated solution.

The Theorem of Solubility –

The solubility of a particular solute in a particular solvent is the maximum amount of the solute that can dissolve in a given amount of the solvent at a specified temperature, assuming that excess solute is present.

- For example, the solubility of NaCl in water at 0 degrees Celsius is 35.7 grams per 100 mL of water. This is the maximum amount of NaCl that can be dissolved in water to give a stable equilibrium solution at that temperature.

Define **Unsaturated** – A solution containing less solute than a saturated solution.

Define **Supersaturated** – A solution containing more solute than an equivalent saturated solution.

II. 13.3 – Factors Affecting Solubility

Solute–Solvent Interactions –

Solute–solvent interactions affect solubility in the sense that...

the stronger the attractions between solute and solvent molecules, the greater the solubility of the solute in that solvent.

- Polar liquids tend to dissolve in Polar solvents.
- Nonpolar liquids tend to dissolve in Nonpolar solvents.

This is where the saying, "like-dissolves-like" comes into play.

If you were to mix liquids and they were to mix in all proportions, you would say they are Miscible.

Define **Miscible** – Liquids that mix in all proportions.

If they don't, whereas those that do not dissolve in one another, they are Immiscible.

Define **Immiscible** – Liquids that do NOT dissolve in one another to a significant extent.

1. Predict whether each of the following substances is more likely to dissolve in the nonpolar solvent carbon tetrachloride (CCl_4) or in water: C_7H_{16}, Na_2SO_4, HCl, and I_2.

   C_7H_{16} - CCl_4 HCl - water
   Na_2SO_4 - water I_2 - CCl_4

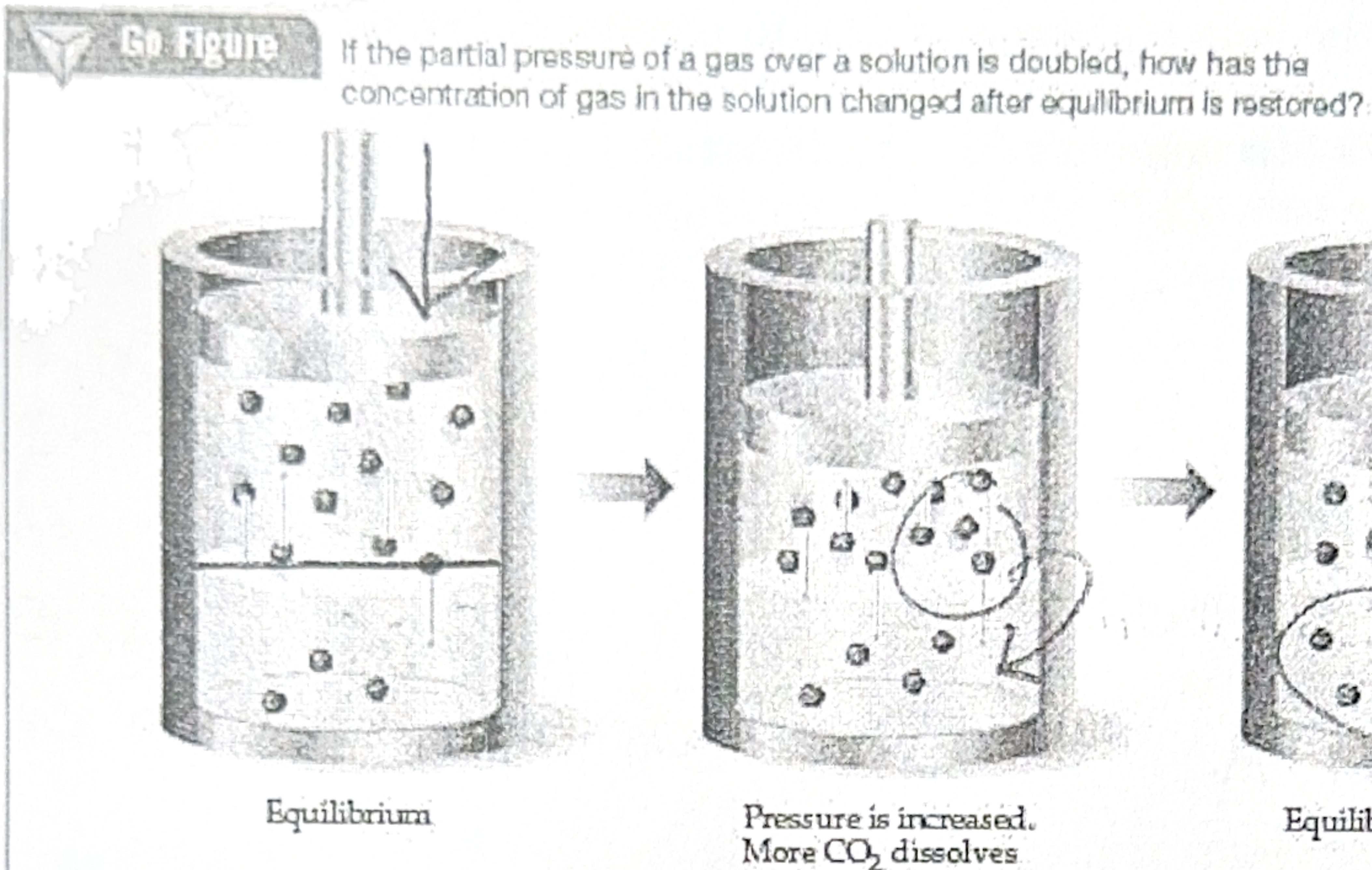
Pressure Effects – GAS

The "Theorem" of Pressure Effects on a Gas's Solubility –

The solubility of a gas in any solvent is increased as the partial pressure of the gas above the solvent increases.

Thus, we can formulate the general understanding that...

the solubility of a gas in a liquid solvent increases in DIRECT PROPORTION to the partial pressure of the gas above the solution.



▲ Figure 13.12 Effect of pressure on gas solubility.

- I increased the pressure; I essentially pushed more gas to be forced into the solvent. More gas becomes dissolved in solution because I increased the pressure.

The relationship between pressure and solubility is expressed by Henry's Law.

$$S_g = kP_g$$

- S_g - The solubility of the gas in the solvent (usually expressed as molarity)
- k - The proportionality constant known as the Henry's law constant.
  - The value of k depends on the solute, solvent, and temperature.
- P_g - The partial pressure of the gas over the solution.

Don't forget about SIG-FIGS!

2. Calculate the concentration of CO_2 in a soft drink that is bottled with a partial pressure of CO_2 of 4.0 atm over the liquid at 25 degrees Celsius. The Henry's law constant for CO_2 in water at this temperature is 3.4E–2 mol/L–atm.

$S_g = KP_g$

$S_g = (3.4E{-2}\ \frac{mol}{L \cdot atm})(4.0\ atm)$

$S_g = 0.136\ mol/L$

$S_g \doteq 0.14\ M$

The solubility is expressed in the same units as concentration, so $S_g \doteq 0.14\ M$ is THE concentration.

Temperature Effects –

- The solubility of most solid solutes in water Increase as the solution temperature Increases.
  - Of course, there are exceptions to this rule. (Who cares)
- The solubility of gases in water Decrease with Increase temperature.

Therefore, for temperature effects, the solubility of solid and gaseous solutes are inverse.

III. 13.4 – Expressing Solution Concentration | PART #1

Calculation of Mass–Related Concentrations: ppm – and [illegible]

3. (a) A solution is made by dissolving 13.5 g of glucose into 0.100 kg of water. What is the mass percentage of solute in this solution? (b) Then, a 2.5 g sample of groundwater was found to contain 5.4 micrograms of zinc ions. What is the concentration of the zinc ions in parts per million?

a.) We want mass percent.

13.5g solute

0.100kg solvent → 100g solvent

$\%(w/w) = \frac{\text{Solute in (g)}}{\text{SOLUTION in (g)}} \times 100\%$

$\%(w/w) = \frac{13.5g}{(13.5g + 100g)} \times 100\%$

$\%(w/w) = 11.89427313\%$

$\%(w/w) \doteq 11.9\%$

b.) We want ppm

2.5g of solvent

5.4ug of solute

$\%(w/w) = \frac{\text{Solute in (g)}}{\text{Solution in (g)}} \times 10^6$

$\%(w/w) = \frac{(5.4ug)}{5.4ug + 2.5g} \times 10^6$

$= 2.2\ ppm$

Calculation of Molality: *m* –

4. A solution is made by dissolving 4.35 g of glucose in 25.0 mL of water at ~~25~~ degrees Celsius. Calculate the molality of glucose in the solution. Water has a density of 1.00 g/mL.

$$\text{Molality} = \frac{\text{mol solute}}{\text{Kg solvent}}$$

$$\frac{4.35\text{ g } C_6H_{12}O_6}{} \times \frac{1\text{ mol } C_6H_{12}O_6}{180.16\text{ g } C_6H_{12}O_6} = 0.0241452043\text{ mol}$$

Density as a conversion factor.

$$\frac{25.00\text{ mL } H_2O}{} \times \frac{1.00\text{ g } H_2O}{1.00\text{ mL } H_2O} = 25.00\text{ g } H_2O \rightarrow 2.500 \times 10^{-2}\text{ kg}$$

$$\text{Molality } (m) = \frac{0.0241452043\text{ mol}}{2.500 \times 10^{-2}\text{ kg}}$$

$$m = 0.965808170\text{5 molal}$$

$$m = \boxed{0.966\text{ molal}}$$