Solutions

Mixtures

Mixture: is a combination of two or more pure substances.

Homogeneous: uniform and throughout

Air, Salt in water

Solution

Heterogeneous: nonuniform

Soup, Milk, Blood

Solutions

Gas in gas (air) solid in solid (alloys) liquid in liquid (alcohol in water)

Gas in liquid (cokes) solid in liquid (sugar in water)

Solutions

Well-mixed (uniform) – single phase

homogenous

transparent

cannot be separated by filter

cannot be separated on standing

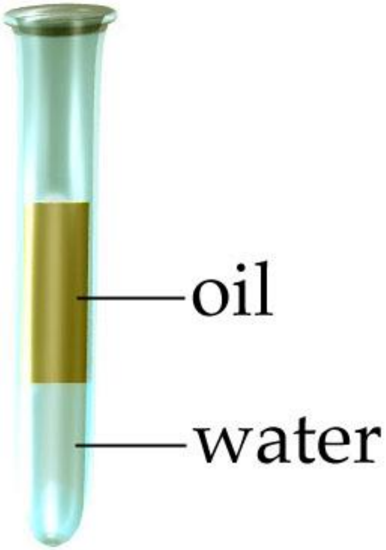
Solutions (liquid in liquid)

Solvent: greater quantity (water)

for liquid in liquid

Solute: smaller quantity (sugar)

Immiscible: two liquids do not mix.



miscible: two liquids can mix.

(in any quantities)

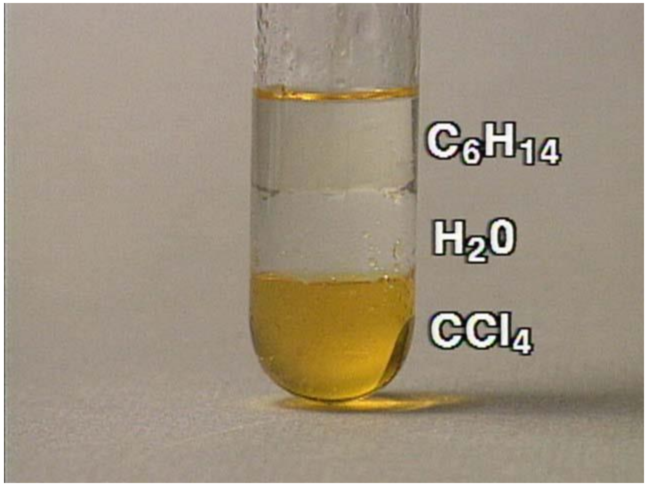
alcohol in water

Solvent and Solute

Polar dissolves polar

Nonpolar dissolves nonpolar

→ like dissolves like.



Solutions

Saturated: solvent contains or holds all the solute it can (at a given T).

maximum solute that solvent can hold (Equilibrium).

Unsaturated: solvent can hold more solute (at a given T).

Is not the maximum solute that solvent can hold.

Supersaturated: solvent holds more solute that it can normally hold (at a given T).

↓

(more than an equilibrium condition)

Temperature and Solutions

Solubility: the maximum solute that will dissolve in a given amount of a solvent (at a given T).

T ↑ ⇒ Solubility ↑

T ↓ ⇒ Crystal is formed.

Temperature and Solutions

T ↑ ⟹ Solubility ↑

Leave it to cool (T↓)

Supersaturated solution

Seeding

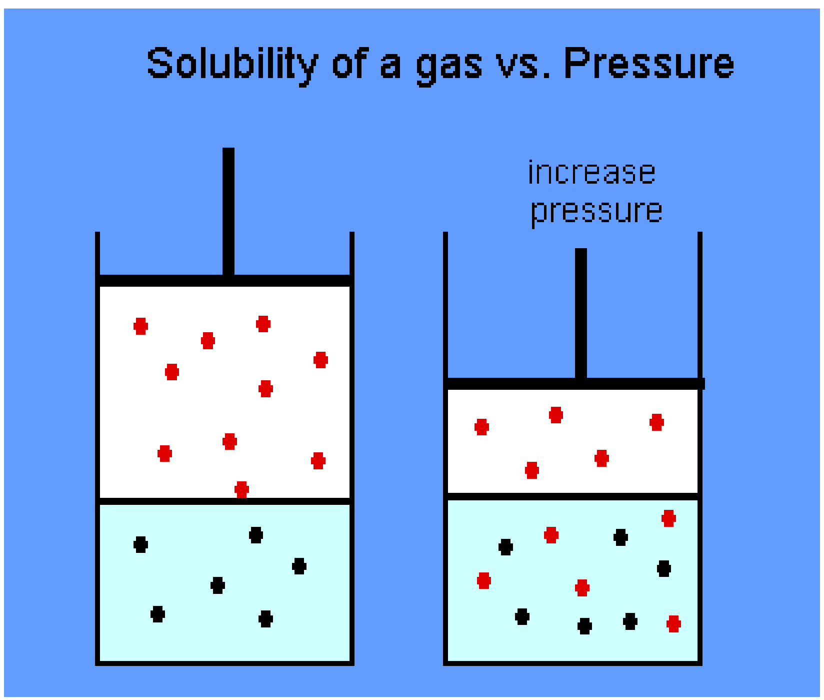
A surface on which to being crystallizing.

Gas in Liquid: $T \uparrow \Rightarrow$ Solubility $\downarrow$

Global Warming

Pressure and Solutions

Henry's law P ↑ ⟹ Solubility ↑ (gas in liquid)



Concentration

Concentrated solution: large amount of solute is dissolved.

Strong Coffee

Dilute solution: small amount of solute is dissolved.

Weak Coffee

Concentration

Concentration: amount of a solute in a given quantity of solvent.

1. Percent concentration:

$$\text{Weight / volume (W / V)\%} = \frac{\text{Weight solute (g)}}{\text{Volume of solution (mL)}} \times 100$$

$$\text{Weight / Weight (W / W)\%} = \frac{\text{Weight solute (g)}}{\text{Weight of solution (g)}} \times 100$$

$$\text{Volume / volume (V / V)\%} = \frac{\text{Volume solute (mL)}}{\text{Volume of solution (mL)}} \times 100$$

Concentration

2. Molarity (M, mol/L): number of moles solute dissolved in 1 L of solution.

$$\text{Molarity (M)} = \frac{\text{moles solute (n)}}{\text{volume of solution (L)}}$$

$$\text{Molarity} \times V = \text{number of moles (n)}$$

prepare the solution: M, V → n (mol) → m (g)

Prepare the solution

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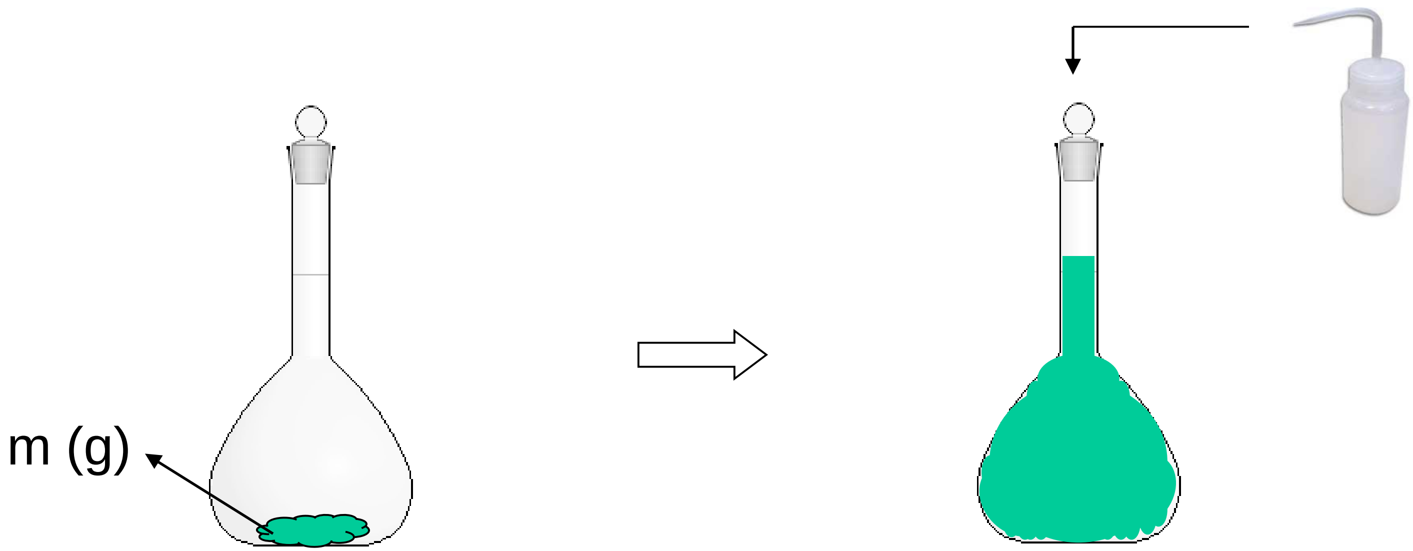


Volumetric flask

Practice:

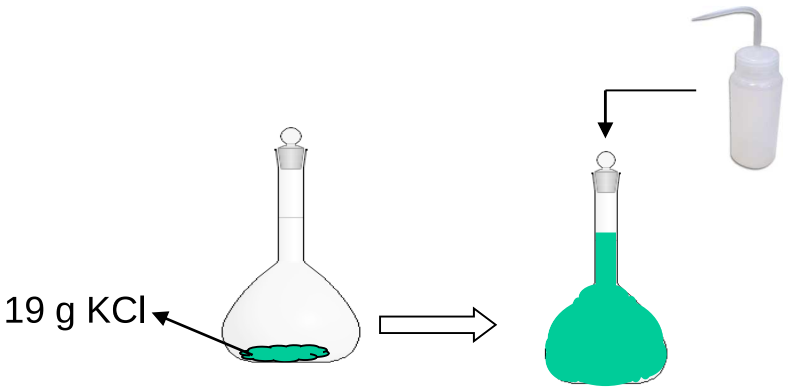
How would we make 164 mL of a 1.6 M solution of KCl in water?

$$M = \frac{\text{mol (n)}}{\text{volume (L)}}$$

$$164\ \text{mL} \times \frac{1\ \text{L}}{1000\ \text{mL}} = 0.164\ \text{L}$$

$$1.6\ \text{M} = \frac{\text{mol (n)}}{0.164\ \text{L}} \quad \Rightarrow n = 0.26\ \text{mol KCl}$$

$$0.26\ \text{mol KCl} \times \frac{74.55\ \text{g KCl}}{1\ \text{mol KCl}} = 19\ \text{g KCl}$$



Concentration

3. Parts per Million (ppm):

$$\text{ppm} = \frac{\text{g solute}}{\text{g solvent}} \times 10^6$$

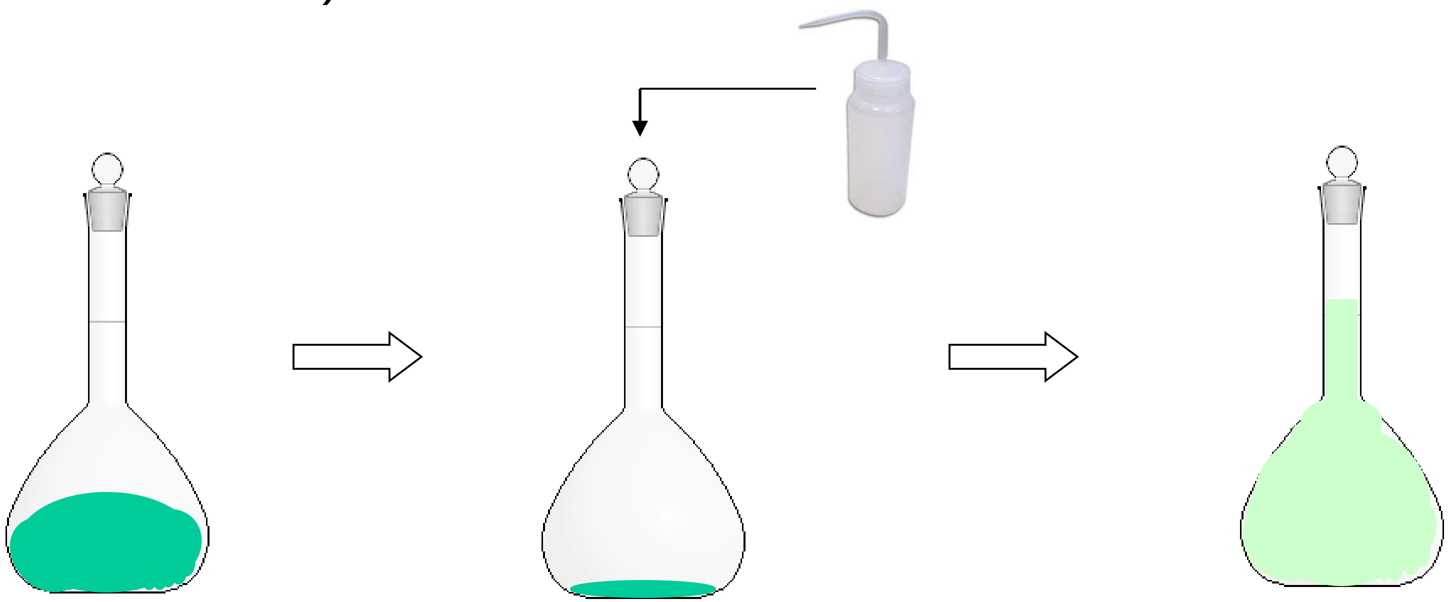
Parts per billion (ppb):

$$\text{ppb} = \frac{\text{g solute}}{\text{g solvent}} \times 10^9$$

Dilution

Concentrated solution
(Stock solution)

Dilute solution



Standard solution: a solution with known concentration.

Dilution

M_1V_1 = moles(n) before dilution

Mole remains constant.

M_2V_2 = moles(n) after dilution

$$M_1V_1 = M_2V_2$$

$$\%\ V_1 = \%\ V_2$$

Practice:

- A chemist measures out 25.0 mL of a 1.00 M acid solution, and then dilutes it with water until the new total volume is 100.0 mL. What is the new concentration?

Concentrated:	Dilute:
M_1 = 1.00 M	M_2 = ? M
V_1 = 25.0 mL	V_2 = 100.0 mL

$$\mathbf{M_1V_1 = M_2V_2}$$

$$1.00 \times 25.0 = M_2 \times 100.0$$

$$M_2 = 0.250 \text{ M}$$

Ion Concentration

1.50 M Na_3PO_4 → Molarity of PO_4^{3-}?

Molarity of Na^+?

Always look at the subscripts!

Molarity of Na^+ = 3×(1.50) = 4.50 M

Molarity of PO_4^{3-} = 1×(1.50) = 1.50 M

Solution Stoichiometry

Volume A → Moles A → Moles B → Volume B

Practice 1:

$$2KI(aq) + Pb(NO_3)_2(aq) \rightarrow PbI_2(s) + 2KKNO_3(aq)$$

How much 0.115M KI solution in liters will completely precipitate the Pb^{2+} in 0.104L of 0.225M $Pb(NO_3)_2$ solution?

$$0.104\text{L } Pb(NO_3)_2 \text{ solution} \times \frac{0.225 \text{ mol } Pb(NO_3)_2}{1\text{L } Pb(NO_3)_2 \text{ solution}} \times \frac{2 \text{ mol KI}}{1 \text{ mol } Pb(NO_3)_2} \times \frac{1 \text{ L Solution KI}}{0.115 \text{ mol KI}} =$$

0.407L KI solution

Solution Stoichiometry

Practice 2:

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

How much 0.430 M NaOH solution in liters do we need to completely neutralize 0.205 L of 0.150 M H_2SO_4 solution?

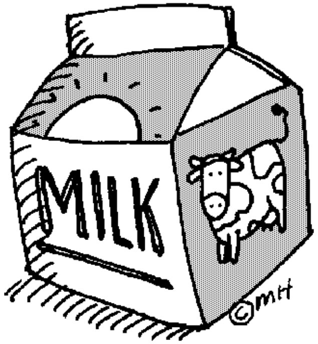
$$0.205 \text{ L } H_2SO_4 \text{ solution} \times \frac{0.150 \text{ mol } H_2SO_4}{1\text{L } H_2SO_4 \text{ solution}} \times \frac{2 \text{ mol NaOH}}{1 \text{ mol } H_2SO_4} \times \frac{1 \text{ L Solution NaOH}}{0.430 \text{ mol NaOH}} =$$

0.143L NaOH solution

Colloids

Solutions: diameter of the solute particles is under 1 nm.

Colloids: diameter of the solute particles is between 1 to 1000 nm.



non transparent, non uniform, large particles, cloudy (milky)

But it is a stable system.

Colloids

Tyndall effect:

You can see the pathway of the light passes through a colloid. (particles scatter light.)

emulsion: a mixture of immiscible substances (liquid-liquid). (milk and mayonnaise)

Brownian motion

Random motion of colloid particles.

Dust

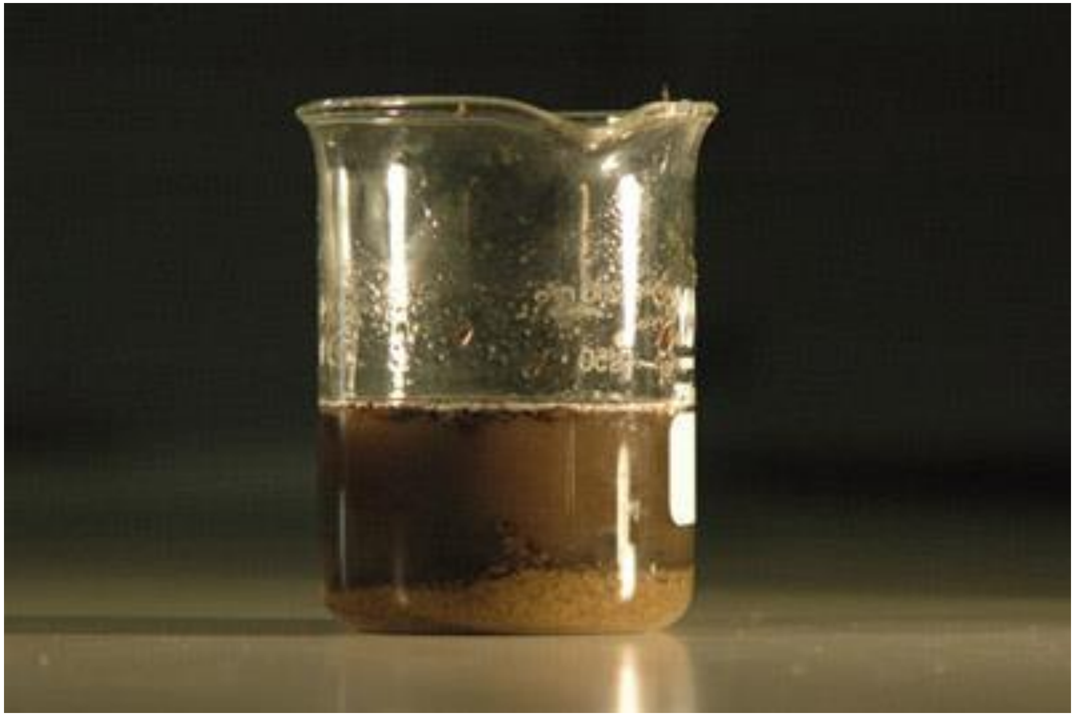
Why do colloidal particles remain in solution and do not stick together?

1. Surrounding water molecules prevent colloidal molecules from touching and sticking together.

2. A charged colloidal particle encounters another particle of the same charge, they repel each other.

Suspension

suspension: system does not stays stable and settle (> 1000 nm).
(sand in water)



But it is not a stable system.

Freezing and boiling point

If we dissolve a solute in a solvent: ➡ bp ↑ fp ↓

$\Delta T = mk$

ΔT: change of bp or fp (T_2 - T_1)
K: constant (depend on solvent) – K_b K_f
m: Molality

$$m = \frac{\text{Moles solute}}{\text{Kg solvent}}$$

Kg solvent → not solution

Freezing and boiling point

Practice 1:

If 13.7 g of glucose ($C_6H_{12}O_6$) dissolved in 0.86 kg of water, calculate the boiling point of this solution (k_b for water is 0.512 ºCkg/mol).

$$m = \frac{\text{Moles solute}}{\text{Kg solvent}}$$

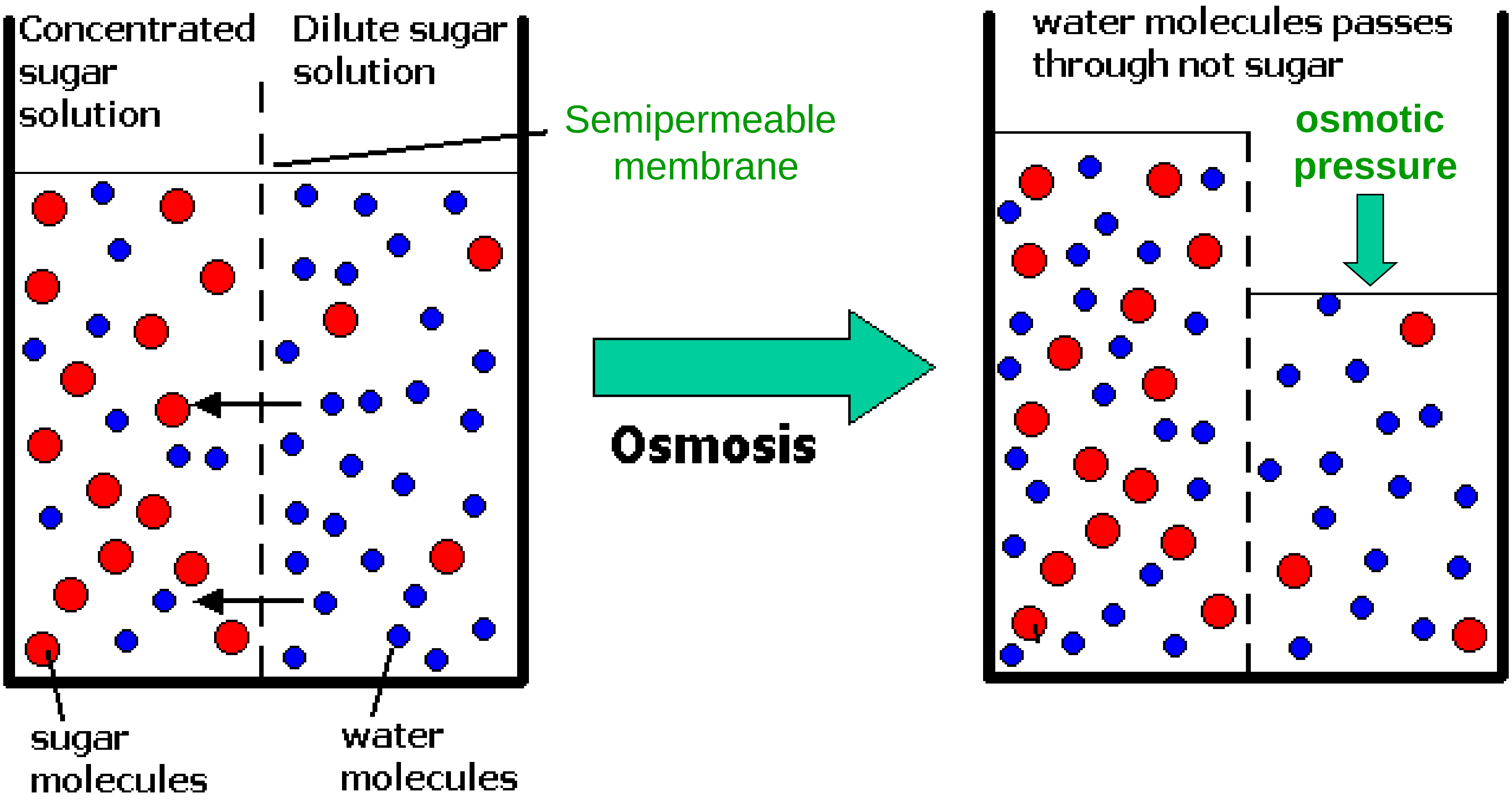
$$13.7\text{g } C_6H_{12}O_6 \times \frac{1 \text{ mol } C_6H_{12}O_6}{180 \text{ g } C_6H_{12}O_6} = 0.0761 \text{ mol } C_6H_{12}O_6$$

$$m = \frac{0.0761 \text{ mol } C_6H_{12}O_6}{0.86 \text{ kg } H_2O} = 0.088 \text{ m}$$

$$\Delta T = T_2 - T_1 = mk_b$$

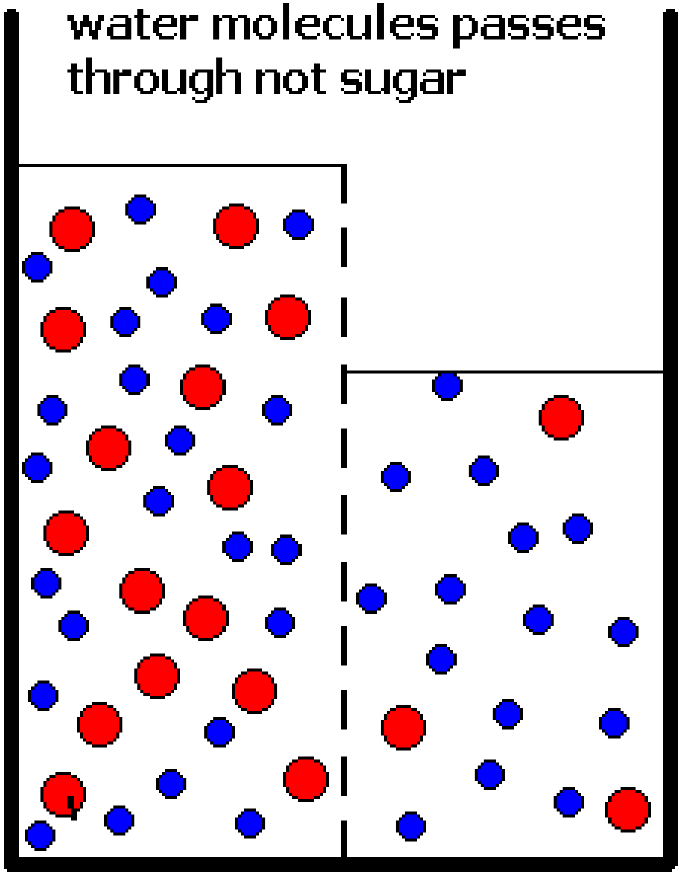
$$T_2 - 100.00 = 0.088 \times 0.512$$
$$T_2 - 100.00 = 0.045$$
$$T_2 = 100.00 + 0.045$$
$$T_2 = 100.05^{o}\text{C}$$

Osmotic Pressure



Higher concentration → Higher osmotic pressure

Osmotic Pressure



Water flows from
low concentration
to
high concentration.

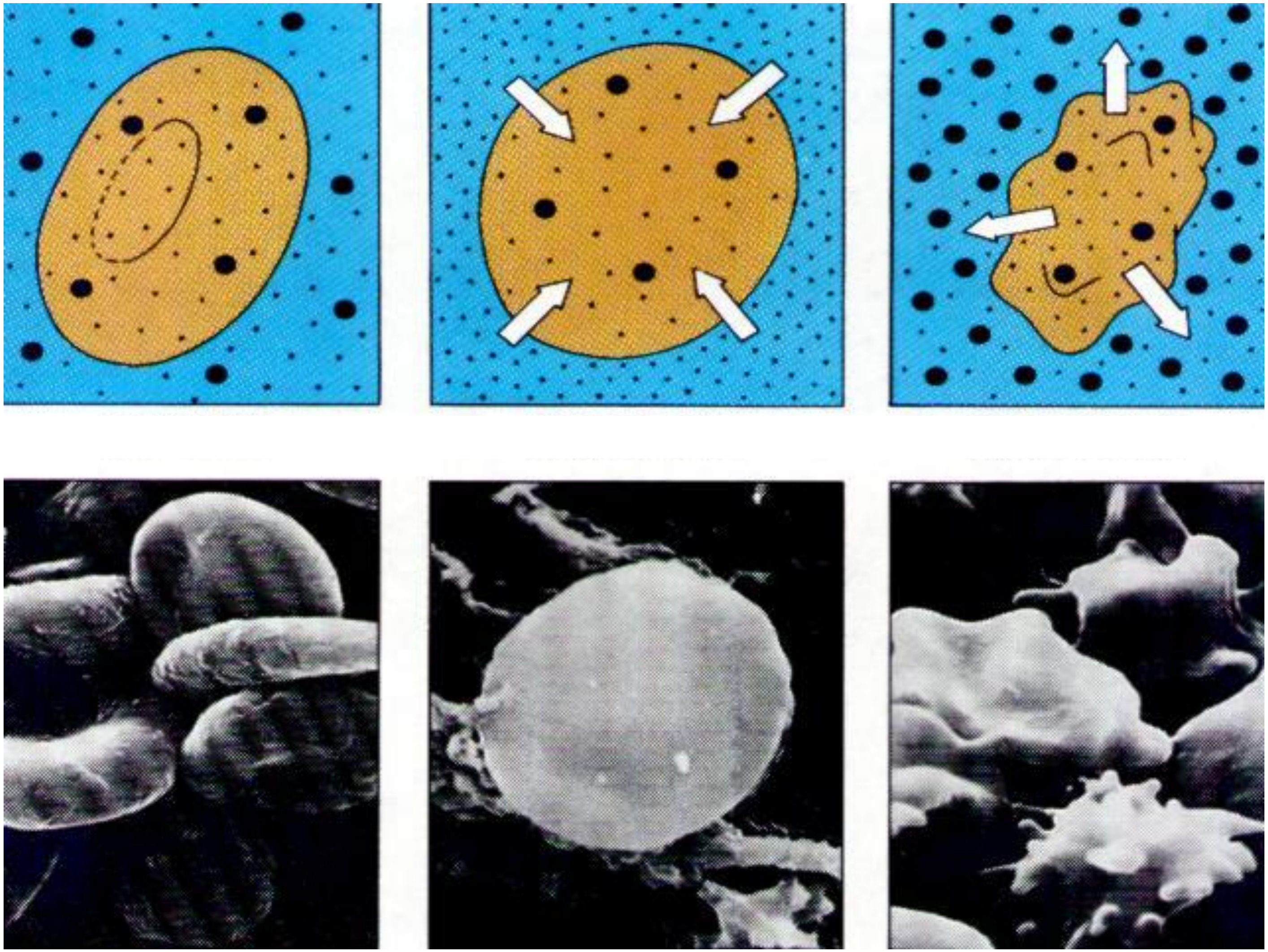
Osmotic Pressure

Osmolarity (osmol) = M × i

M: molarity
i: number of particles

Osmolarity ↑ → Osmotic pressure ↑

Isotonic solution **Hypotonic solution** **Hypertonic solution**



Hemolysis Crenation

The most typical isotonic solutions

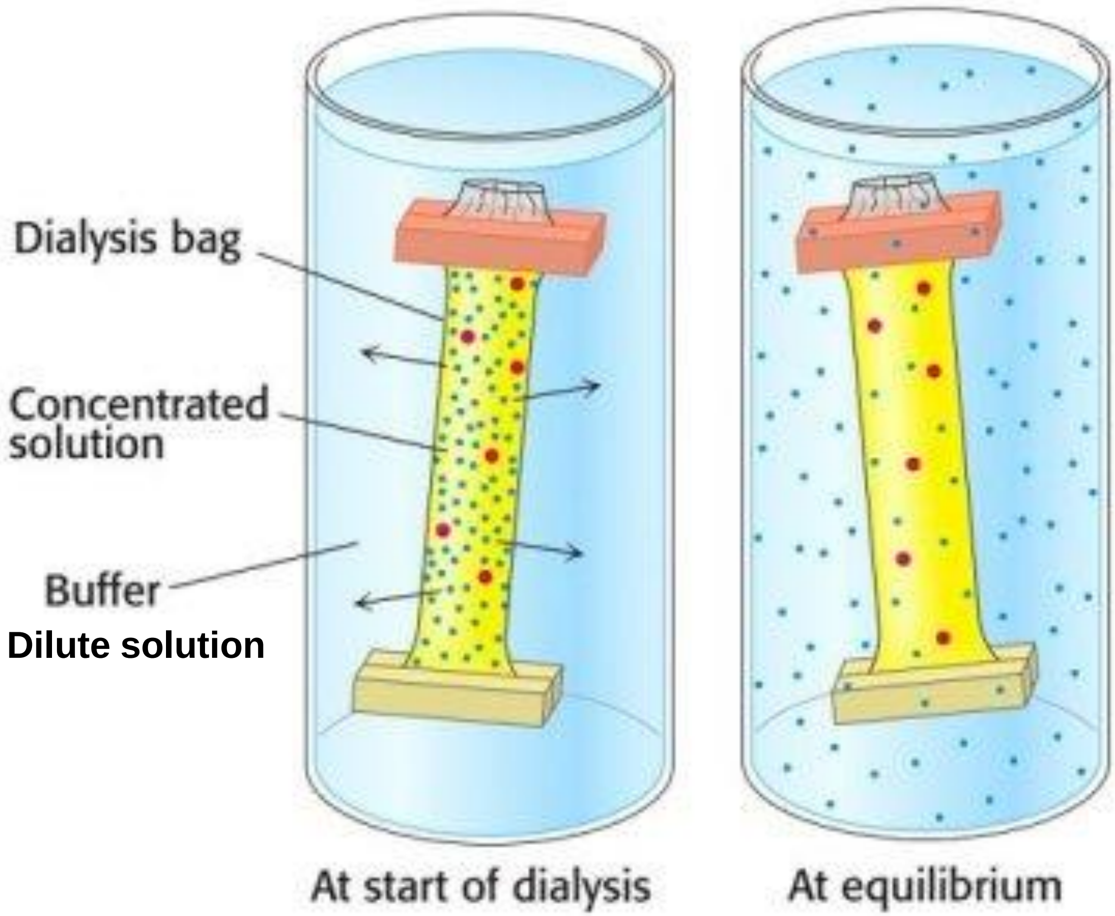
0.9% (m/v) NaCl ⟶ 0.9 g NaCl/100 mL of solution

5% (m/v) Glucose ⟶ 5 g glucose/100 mL of solution

Higher than these numbers → Hypertonic solution

Lower than these numbers → Hypotonic solution

Dialysis


Dialysis bag
Concentrated solution
Buffer
Dilute solution
At start of dialysis
At equilibrium