

Solutions & Membranes Part 1: Solution Concentrations

Solution Concentrations

Solution Concentrations – a quantitative measure of the amount of solute dissolved in a given quantity of solution

There are a variety of concentration units. We will look at 4 main types.

1) mass/volume

2) %m/v

3) moles/volume

4) equivalents/volume

Biological Examples

Unit	Definition	Plasma concentration of NaCl	Plasma concentration of urea
percentage (w/v)	grams of solute in 100 mL of solution	0.60% (w/v)	0.025% (w/v)
mg/dL	milligrams of solute in 1 dL (100 mL) of solution	600 mg/dL	25 mg/dL
molarity	moles of solute in 1 liter of solution	0.103 M	0.0042 M
mEq/L	milliequivalents of solute in 1 liter of solution	103 mEq/L of Na ⁺ 103 mEq/L of Cl ⁻	<i>not used for nonelectrolytes</i>

mass/volume

Which solution is the **most** concentrated? Each choice refers to the same solute and solvent.

- A) 2 g solute in 25 mL solution
- B) 25 g solute in 120 mL solution
- C) 0.5 g solute in 25 mL solution
- D) 5 g solute in 75 mL solution
- E) 30 g solute in 150 mL solution

A sample of blood serum is tested and found to contain testosterone at a concentration of 575 ng/mL. How many grams of testosterone are present in 50.0 mL of this serum?

% mass/volume

Calculating %(m/v)

If 100. mL of blood serum contains 5.0 mg of thyroxine, a hormone released by the thyroid gland, what is the concentration in %(w/v)?

Potassium iodide is used to treat iodine deficiencies. What is the %(w/v) of a 75 mL solution containing 2.0 g of KI?

Using % (m/v) in Calculations

How many grams of NaCl are needed to make 750 mL of a 0.95% (w/v) solution?

How many grams of glucose ($C_6H_{12}O_6$) are needed to make 500. mL of a 5.5% (m/v) solution?

Molarity

Calculating Molarity

Folic acid ($C_{19}H_{19}N_7O_6$) is an essential vitamin and is linked to the prevention of neural tube defects in developing embryos. If 236 mL (one cup) of orange juice contains 75 μg (75 mcg) of folic acid, then what is the concentration in molarity?

Ascorbic acid, vitamin C, is a powerful antioxidant with the molecular formula $C_6H_8O_6$. It helps the body form and maintain connective tissue, including bones, blood vessels, and skin. If 236 mL (one cup) of orange juice contain 120 mg of vitamin C, then what is the concentration in molarity?

Using Molarity in Calculations

If a 0.28 M glucose ($C_6H_{12}O_6$) solution is isotonic with red blood cells, then how many grams of glucose are needed to prepare 500. mL of this solution?

There is 3.0 g of vitamin C ($C_6H_8O_6$) available to prepare a 0.0852 M solution. To what volume is the vitamin C diluted?

Equivalents: Keeping track of the charge in a solution

Eq/L: the number of charges per liter of solution

$$1 \text{ mole} = \# \text{ Eq} = X \text{ grams}$$

The concentration of electrolytes in bodily fluids is relatively low, so we use the smaller unit of milli.

$$1 \text{ mol} = \# \text{ Eq} = X \text{ grams}$$

$$1000 \text{ millimoles} = (\#)(1000) \text{ milliEquivalents} = (X)1000 \text{ milligrams}$$

$$1 \text{ mmol} = \# \text{ mEq} = X \text{ mg}$$

For example Al^{3+}

The relationship between Eq, moles, and grams

Ion and molar mass	1 equivalent = how many moles?	1 equivalent = how many grams?	1 mole = how many Eq?
Na^+ (22.99 g/mol)	1 Eq = 1 mole	$1 \text{ Eq} = \frac{22.99 \text{ g}}{1} = 22.99 \text{ grams}$	1 mole = 1 Eq
Mg^{2+} (24.31 g/mol)	1 Eq = $\frac{1}{2}$ mole	$1 \text{ Eq} = \frac{24.31 \text{ g}}{2} = 12.15 \text{ grams}$	1 mole = 2 Eq
Fe^{3+} (55.85 g/mol)	1 Eq = $\frac{1}{3}$ mole	$1 \text{ Eq} = \frac{55.85 \text{ g}}{3} = 18.62 \text{ grams}$	1 mole = 3 Eq
Cl^- (35.45 g/mol)	1 Eq = 1 mole	$1 \text{ Eq} = \frac{35.45 \text{ g}}{1} = 35.45 \text{ grams}$	1 mole = 1 Eq
CO_3^{2-} (60.01 g/mol)	1 Eq = $\frac{1}{2}$ mole	$1 \text{ Eq} = \frac{60.01 \text{ g}}{2} = 30.00 \text{ grams}$	1 mole = 2 Eq
PO_4^{3-} (94.97 g/mol)	1 Eq = $\frac{1}{3}$ mole	$1 \text{ Eq} = \frac{94.97 \text{ g}}{3} = 31.66 \text{ grams}$	1 mole = 3 Eq

Blood plasma typically contains 5.0 mEq/L of Ca^{2+} , calculate how many milligrams of Ca^{2+} are in 250 mL of blood.

How many mEq of bicarbonate are present in a 75.0 mL blood serum sample with a concentration of 25 mEq/L HCO_3^- ?

Solutions and Membranes Part 2:

Membranes, Osmosis, & Tonicity

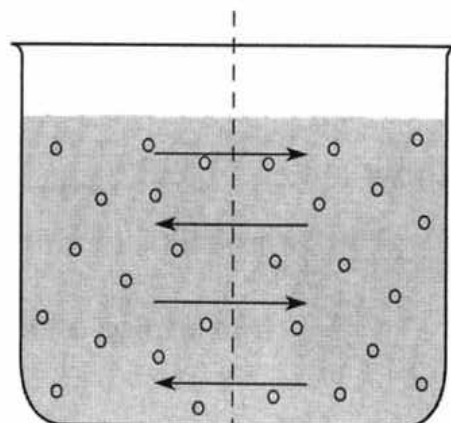
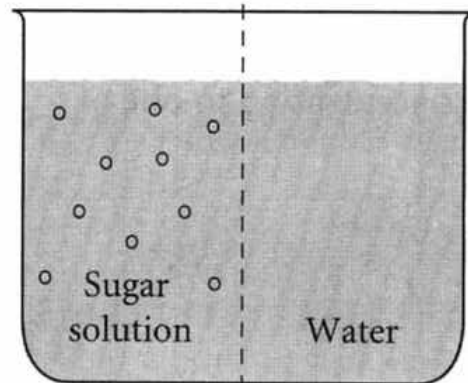
Membranes: a structure that acts as a barrier between two environments

Semi-permeable membranes: allow the passage of certain molecules and ions across the membrane while preventing the passage of larger molecules

Diffusion: spontaneous process of random motion (Brownian) causing a system to decay toward uniform conditions

Diffusion focuses on the solute.

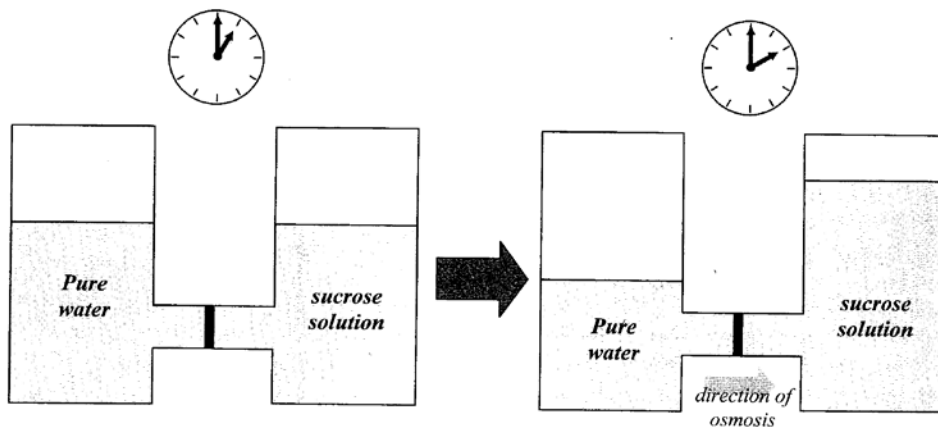
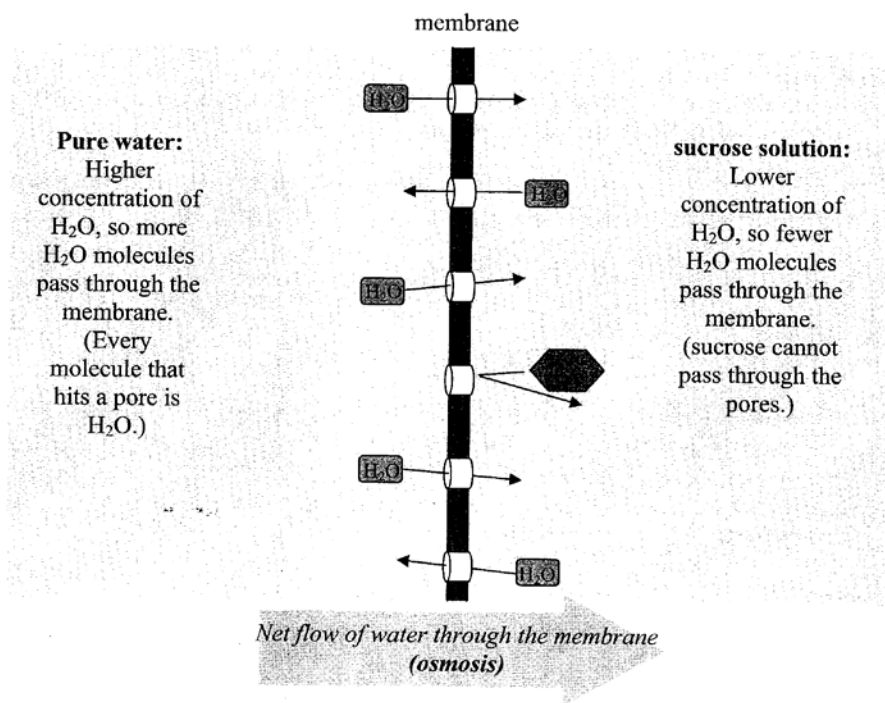
Fully Permeable Membrane



Osmosis – the movement of solvent molecules from a dilute solution to a more concentrated solution across a semi-permeable membrane.

Osmosis focuses on the SOLVENT because the movement of the solute is restricted by a selectively permeable membrane (similar to our cell membranes).

Osmotic pressure – amount of pressure required to counteract osmosis. Osmosis can NOT continue indefinitely because gravity prevents the differences in the levels from becoming too great. Eventually the process of osmosis stops.



To the solvent ALL solutes are the same.

Solute concentrations are determined from the total number of dissolved particles: cations, anions and covalent molecules.

How many moles of solutes are found in one liter of a 0.20M $\text{Ca}(\text{HCO}_3)_2$?

How many moles of solutes are found in one liter of a 0.20M CH_3OH ?

Which solution has the greatest solute concentration?

A) 0.7 M CH_3OH

B) 0.25 M AlCl_3

C) 0.50 M KF

D) 0.35 M CaBr_2

E) 0.40 M KNO_3

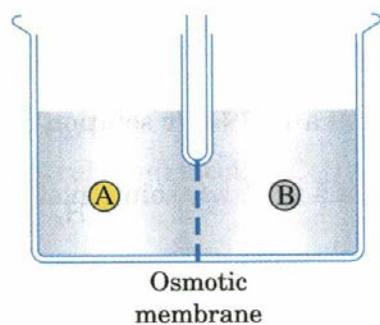
Predict which side rises (A or B) and EXPLAIN why. The solvent is water.

Compartment A.

contains 0.4 M CaCl_2

Compartment B

contains 0.5 M MgSO_4 .



Osmotic pressure is very important to the health of our cells.

The total solute concentration of red blood cells is 0.28 M.

Tonicity is the relationship between the overall concentration of a solution and the normal solute concentration of red blood cells.

Hypertonic: a solution with a higher solute concentration than our cells

Isotonic: a solution with a solute concentration the same as our cells

Hypotonic: a solution with a lower solute concentration than our cells

What happens to red blood cells if they are exposed to a hypotonic solution?

What happens to red blood cells if they are exposed to a hypertonic solution?

Dilution Calculations

$$C_1V_1 = C_2V_2$$

How many liters of a 0.025% (m/v) KCl solution can be prepared from 200. mL of a 4.5% (m/v) stock solution?

Hydrocortisone is used as an anti-inflammatory for localized pain. You need to prepare a 50 mg/mL solution of hydrocortisone for an injection. You have 5 mL of a 200 mg/mL stock solution of hydrocortisone available. How many mL of the 50 mg/mL solution can you prepare?

Intravenous sodium lactate solutions contain 1.72 % (w/v) sodium lactate in water. If you have 120 mL of 5.00 % (w/v) sodium lactate, what must the final volume be? How much water will you add?

If you mix 125 mL of water with 25 mL of 4.45 % (m/v) glucose, what will be the resulting concentration of the glucose solution?