Al-Rasheed University College

Department of Dentistry

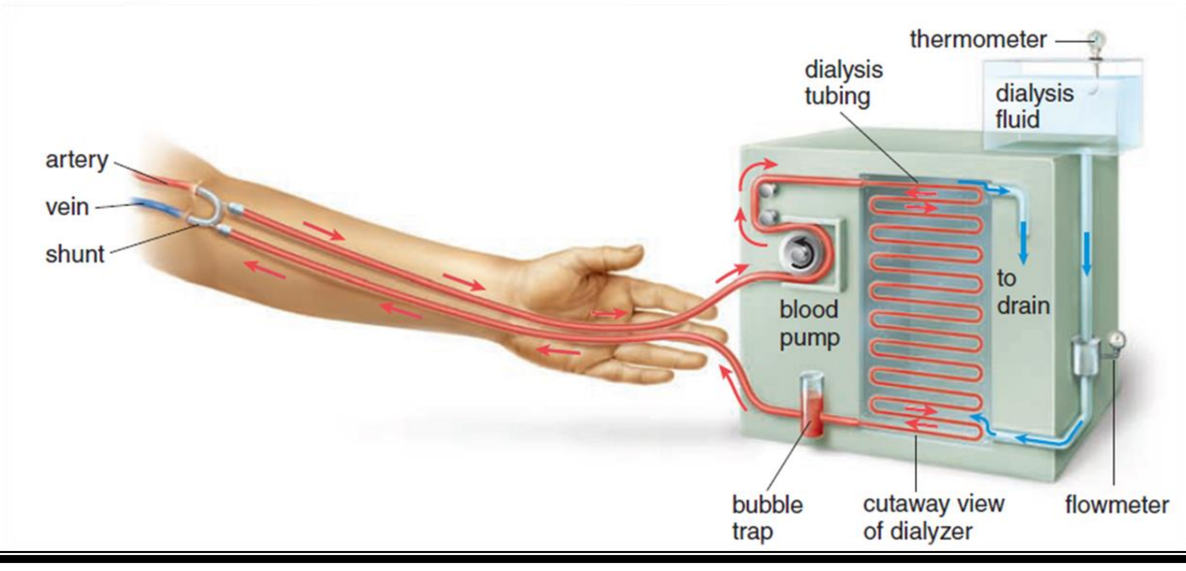
1st Stage

MEDICAL CHEMISTRY

lecture 3
Dilution, Osmosis and Dialysis

Edited By:

Lec. Dr. Haider AbdulKareem Al-Mashhadani

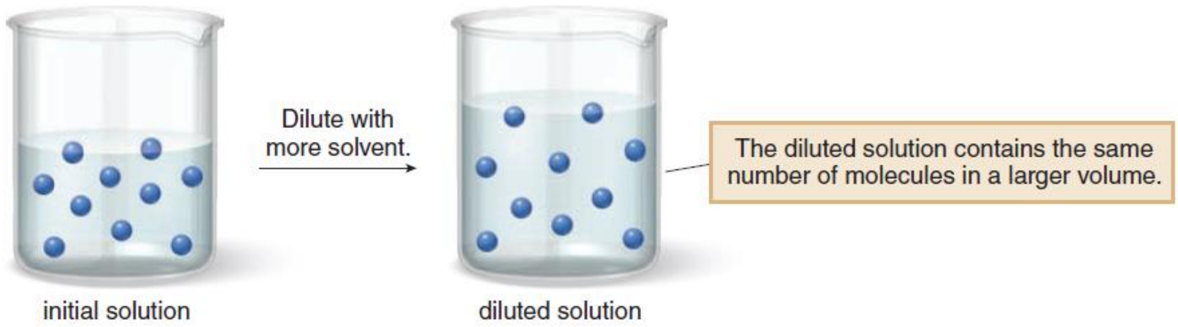


Dilution

Sometimes a solution has a higher concentration than is needed. Dilution is the addition of solvent to decrease the concentration of solute. For example, a stock solution of a drug is often supplied in a concentrated form to take up less space on a pharmacy shelf, and then it is diluted so that it can be administered in a reasonable volume and lower concentration that allows for more accurate dosing.

Diluted form cresol is the most widely recommended primary tooth pulpotomy medicament.

A key fact to keep in mind is that the amount of solute is constant. Only the volume of the solution is changed by adding solvent.



In using molarity as a measure of concentration in Section 4.5, we learned that the number of moles of solute can be calculated from the molarity and volume of a solution.

Moles of solute = Molarity x Volume

Thus, if we have initial values for the molarity and volume (M1 and V1), we can calculate a new value for the molarity or volume (M2 or V2), since the product of the molarity and volume equals the number of moles, a constant.

$$\underset{\text{initial values}}{M_1V_1} = \underset{\text{final values}}{M_2V_2}$$

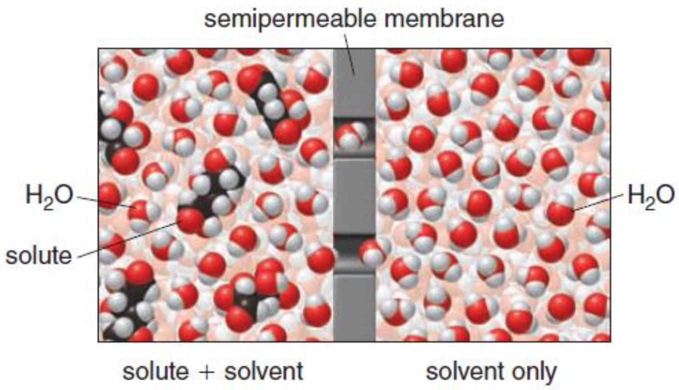
Although molarity is the most common concentration measure in the laboratory, the same facts hold in diluting solutions reported in other concentration units—

percent concentration and parts per million—as well. In general, therefore, if we have initial values for the concentration and volume (C_1 and V_1), we can calculate a new value for the concentration or volume (C_2 or V_2), since the product of the concentration and volume is a constant.

$$\underset{\text{initial values}}{C_1V_1} = \underset{\text{final values}}{C_2V_2}$$

Osmosis

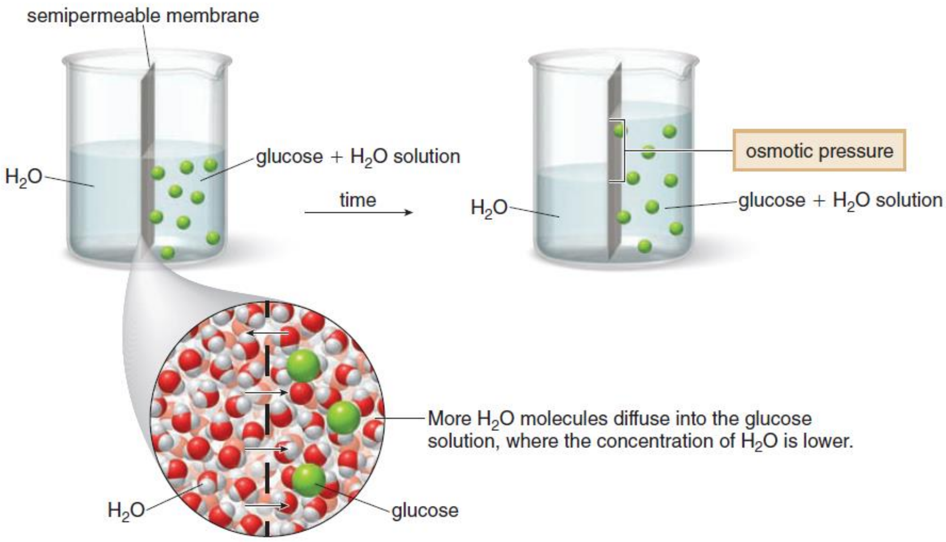
The membrane that surrounds living cells is an example of a semipermeable membrane. A membrane that allows water and small molecules to pass across, but ions and large molecules cannot.



Osmosis: is the spontaneous net movement of solvent molecules through a semi-permeable membrane into a region of higher solute concentration (from a more dilute solution to a more concentrated solution.), in the direction that tends to equalize the solute concentrations on the two sides.

- What happens when water and an aqueous glucose solution are separated by a semipermeable membrane? Water flows back and forth across the membrane, but more water flows from the side that has pure solvent towards the side that has dissolved glucose. This decreases the volume of pure solvent on one side of the membrane and increases the volume of the glucose solution on the other side.
- The increased weight of the glucose solution creates increased pressure on one side of the membrane. When the increased pressure gets to a certain point, it prevents more water movement to further dilute the glucose solution. Water continues to diffuse back and forth across the membrane, but the level of the two liquids does not change any further.

Osmotic pressure is the pressure that prevents the flow of additional solvent into a solution on one side of a semipermeable membrane.



Osmotic pressure depends only on the number of particles in a solution. **The greater the number of dissolved particles, the greater the osmotic pressure**. A 0.1 M NaCl solution has twice the osmotic pressure as a 0.1 M glucose solution, since each NaCl is composed of two particles, Na^+ cations and Cl^- anions.

- ✓ If, instead of having pure water on one side of the membrane, there were two solutions of different concentrations, water would flow from the side of the less concentrated solution to dilute the more concentrated solution.

Osmosis and Biological Membranes

Since cell membranes are semipermeable and biological fluids contain dissolved ions and molecules, osmosis is an ongoing phenomenon in living cells. Fluids on both sides of a cell membrane must have the same osmotic pressure to avoid pressure buildup inside or outside the cell. Any intravenous solution given to a patient, therefore, must have the same osmotic pressure as the fluids in the body.

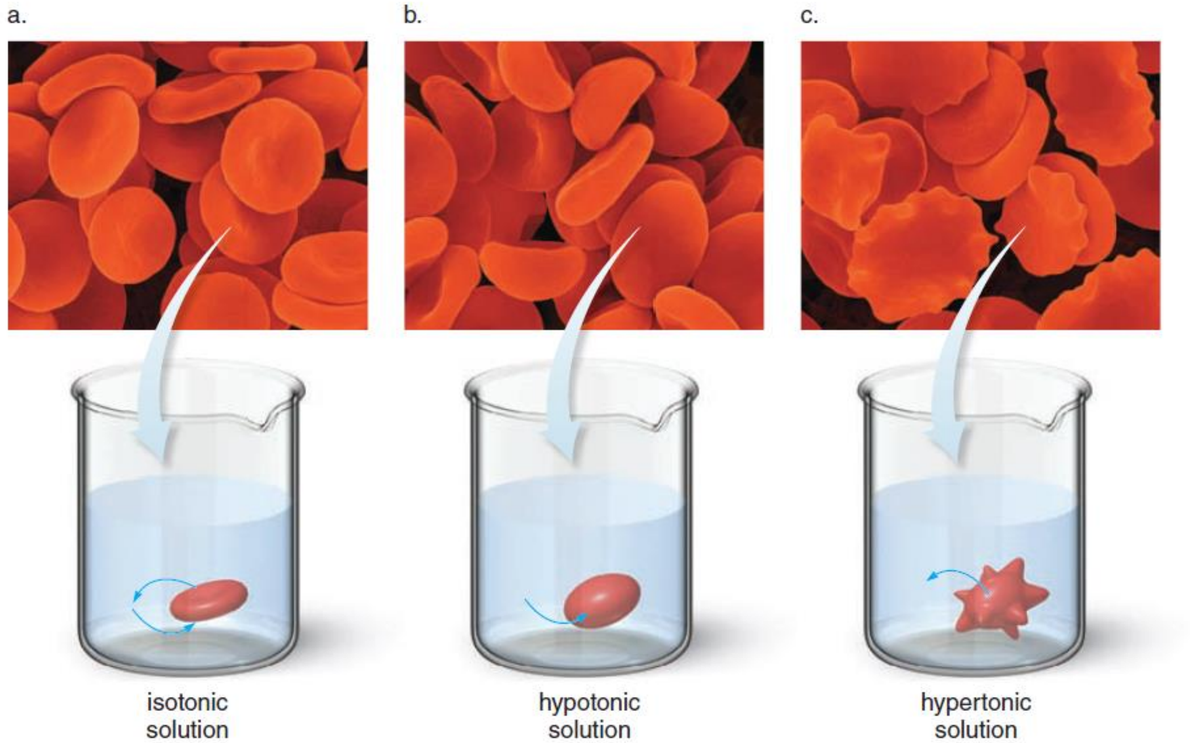
- Two solutions with the same osmotic pressure are said to be isotonic.
- A hypotonic solution has a lower osmotic pressure than body fluids.
- A hypertonic solution has a higher osmotic pressure than body fluids.

Isotonic solutions used in hospitals include 0.92% (w/v) NaCl solution (or 0.15 M NaCl solution) and 5.0% (w/v) glucose solution. Although these solutions do not contain exactly the same ions or molecules present in body fluids, they exert the same osmotic pressure.

- If a red blood cell is placed in an isotonic NaCl solution, called physiological saline solution, the red blood cells retain their same size and shape because the osmotic pressure inside and outside the cell is the same (Figure 7.7a). What happens if a red blood cell is placed in a solution having a different osmotic pressure?

- In a hypotonic solution, the concentration of particles outside the cell is lower than the concentration of particles inside the cell. In other words, the concentration of water outside the cell is higher than the concentration of water inside the cell, so water diffuses inside (Figure 7.7b). As a result, the cell swells and eventually bursts. This swelling and rupture of red blood cells is called hemolysis.

- In a hypertonic solution, the concentration of particles outside the cell is higher than the concentration of particles inside the cell. In other words, the concentration of water inside the cell is higher than the concentration of water outside the cell, so water diffuses out of the cell (Figure7.7c). As a result, the cell shrinks. This process is called crenation.

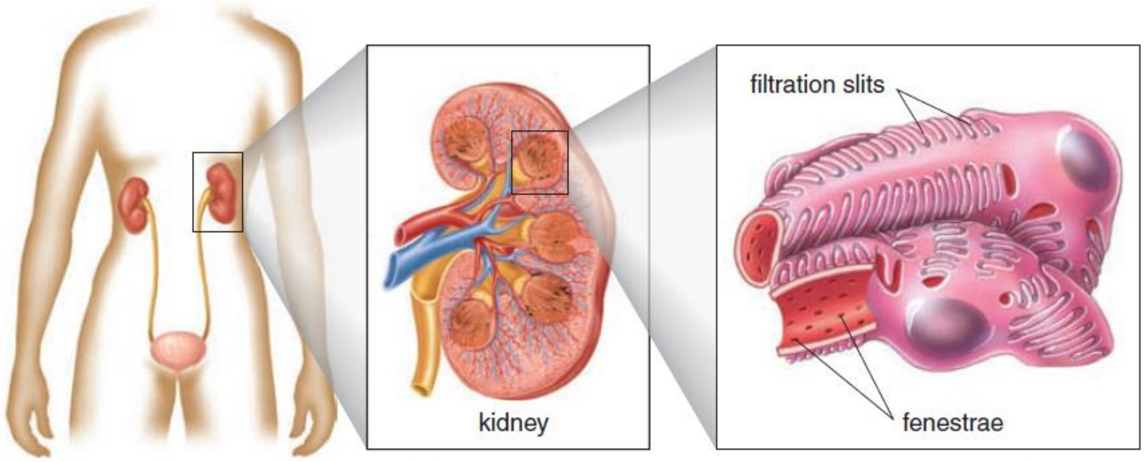


(a) In an isotonic solution, the movement of water into and out of the red blood cell occurs to an equal extent and the red blood cell keeps its normal volume. (b) In a hypotonic solution, more water moves into the cell than diffuses out, so the cell swells and eventually it can rupture (hemolysis). (c) In a hypertonic solution, more water moves out of the cell than diffuses in, so the cell shrivels (crenation).

Dialysis

Dialysis is also a process that involves the selective passage of substances across a semipermeable membrane, called a dialyzing membrane. In dialysis, however, water, small molecules, and ions can travel across the membrane; only large biological molecules like proteins and starch cannot.

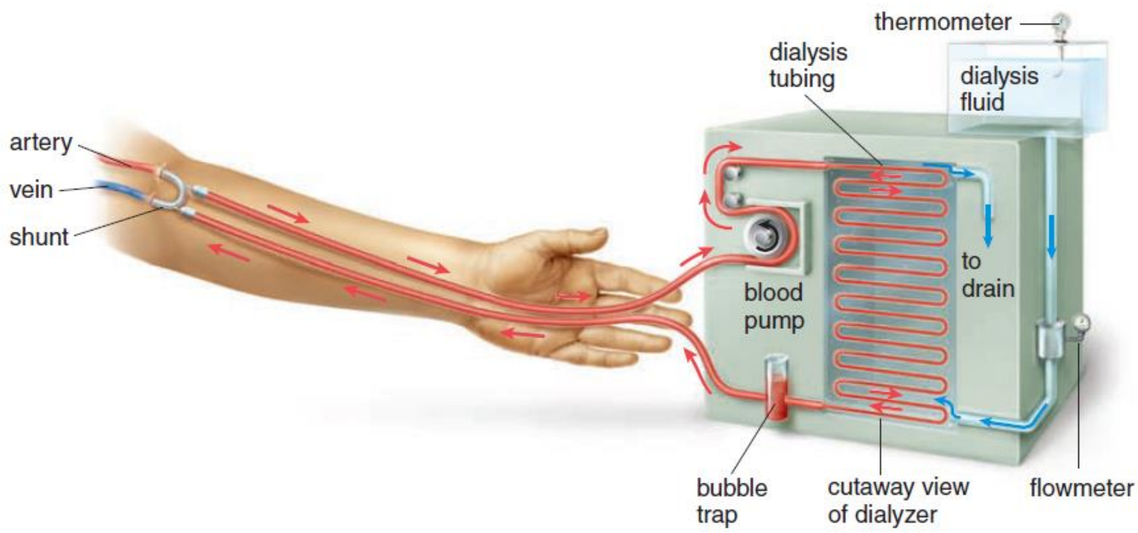
In the human body, blood is filtered through the kidneys by the process of dialysis. Each kidney contains over a million nephrons, tube like structures with filtration membranes. These membranes filter small molecules—glucose, amino acids, urea, ions, and water—from the blood. Useful materials are then reabsorbed, but urea and other waste products are eliminated in urine.



Body fluids are dialyzed by passage through the kidneys, which contain more than a million nephrons that filter out small molecules and ions from the blood. Useful materials are then reabsorbed while urea and other waste products are eliminated in urine.

When an individual's kidneys are incapable of removing waste products from the blood, hemodialysis is used (Figure bellow). A patient's blood flows through a long tube connected to a cellophane membrane suspended in an isotonic solution that contains NaCl, KCl, $NaHCO_3$, and glucose.

Small molecules like urea cross the membrane into the solution, thus removing them from the blood. Red blood cells and large molecules are not removed from the blood because they are too big to cross the dialyzing membrane.



When a patient's kidneys no longer function properly, periodic dialysis treatments are used to remove waste products from the blood. Blood is passed through a dialyzer, which contains a membrane that allows small molecules to pass through, thus acting as an artificial kidney. Each treatment takes several hours. Patients usually require two to three treatments per week.