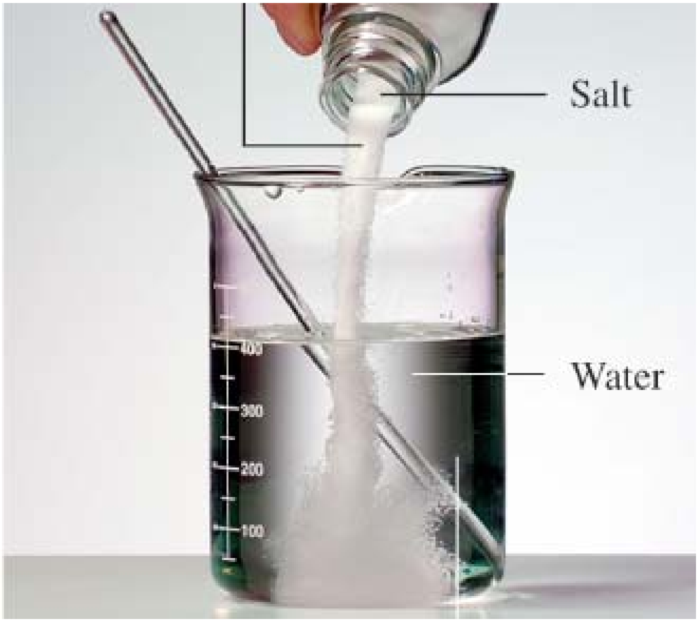
Chapter 8 Solutions



Solutions are homogeneous mixtures of two or more substances;
Solutions consist of a solvent and one or more solutes

Solutes are spread evenly throughout the solution
cannot be separated by filtration
can be separated by evaporation
are not visible but can give a color to the solution

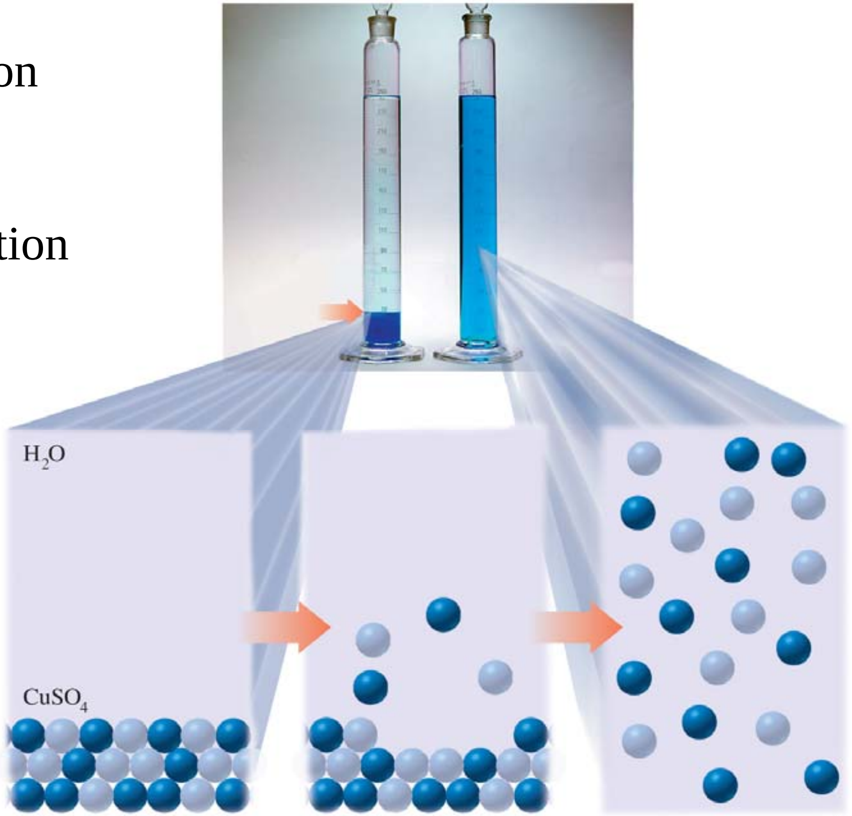


TABLE 8.1 Some Examples of Solutions

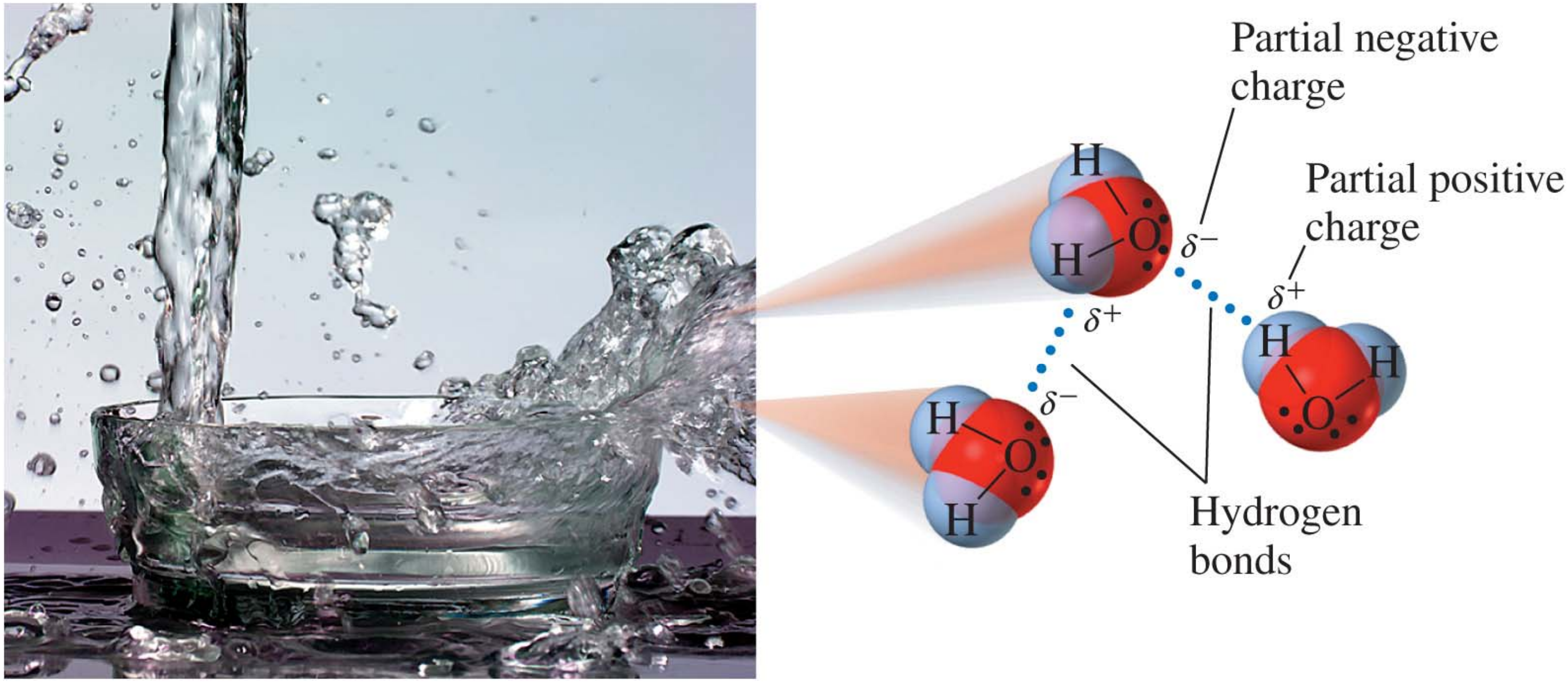
Type	Example	Primary Solute	Solvent
Gas Solutions			
Gas in a gas	Air	Oxygen (gas)	Nitrogen (gas)
Liquid Solutions			
Gas in a liquid	Soda water	Carbon dioxide (gas)	Water (liquid)
	Household ammonia	Ammonia (gas)	Water (liquid)
Liquid in a liquid	Vinegar	Acetic acid (liquid)	Water (liquid)
Solid in a liquid	Seawater	Sodium chloride (solid)	Water (liquid)
	Tincture of iodine	Iodine (solid)	Ethanol (liquid)
Solid Solutions			
Liquid in a solid	Dental amalgam	Mercury (liquid)	Silver (solid)
Solid in a solid	Brass	Zinc (solid)	Copper (solid)
	Steel	Carbon (solid)	Iron (solid)

In a solution, the solute is uniformly distributed throughout the solvent

Water is the most common solvent

it is a polar molecule

forms hydrogen bonds between the hydrogen atom in one molecule and the oxygen atom in a different water molecule



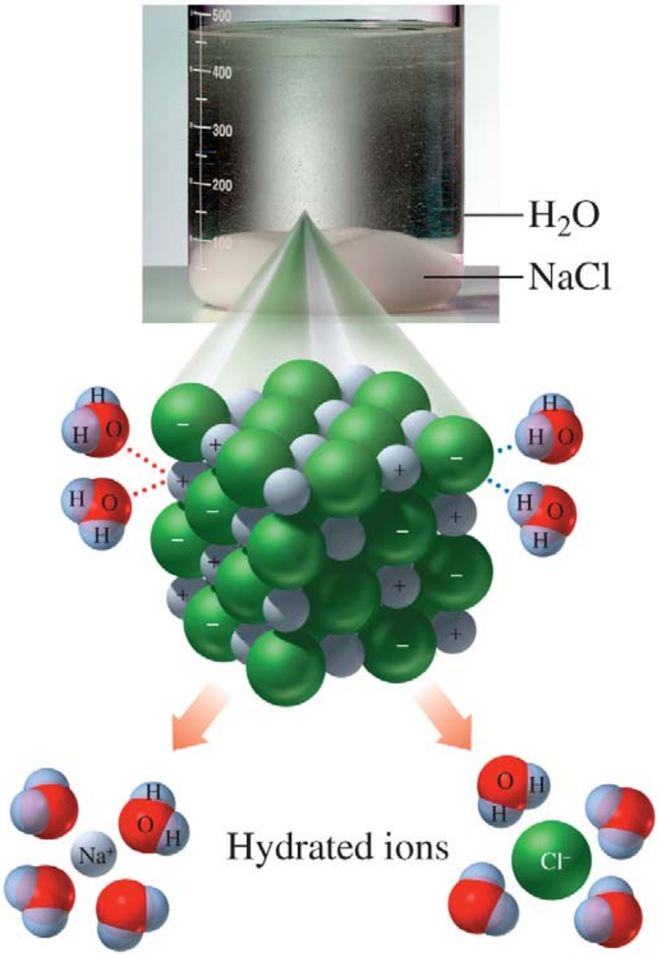
Formation of solutions

Na^+ and Cl^- ions
on the surface of a NaCl crystal are attracted to polar water molecules
are hydrated in solution by many H_2O molecules surrounding each ion

Two substances are likely to form a solution when there is an attraction between the particles of the solute and solvent;

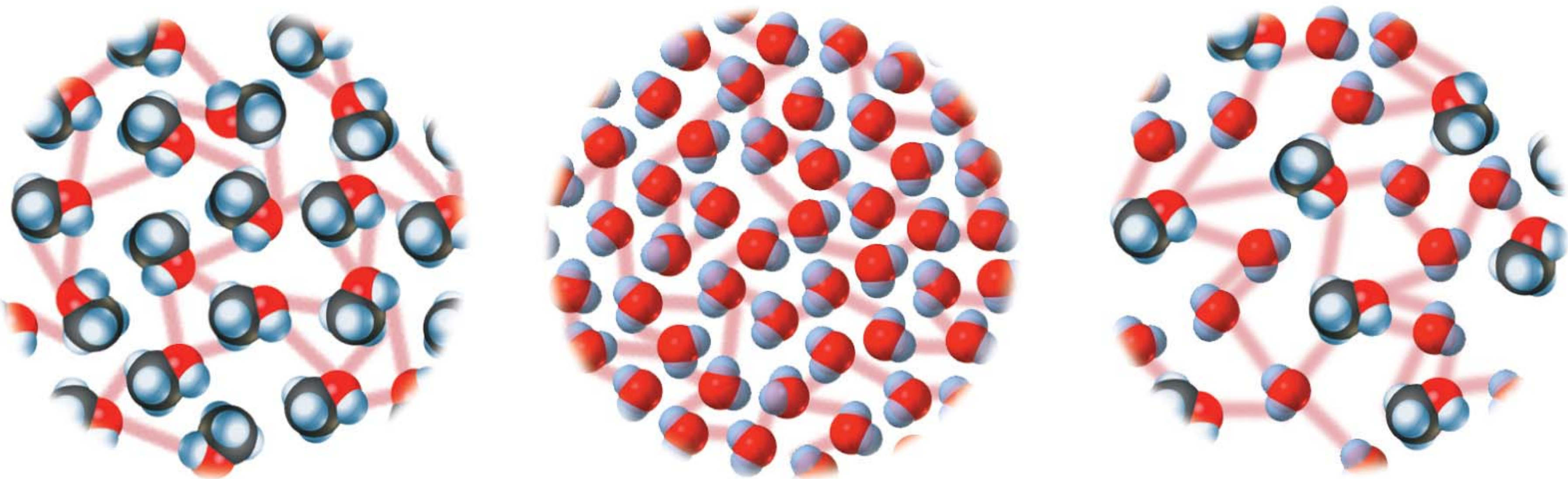
A polar solvent (such as water) dissolves polar solutes (such as sugar) and/or ionic solutes (such as NaCl)

A non-polar solvent such as hexane (C_6H_{14}) will dissolves non-polar solutes such as oil or grease



Hydrogen bonding in water and related substances

```
R-O-H····O-R
          /
         H
```



Methanol (CH_3OH) solute

Water solvent

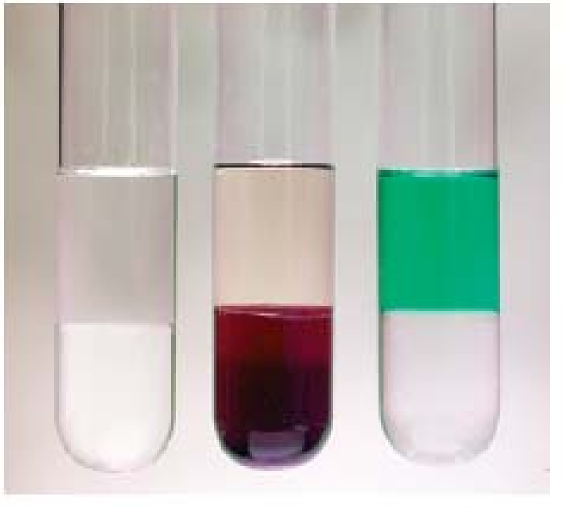
Methanol-water solution with hydrogen bonding

Water and CH_2Cl_2

a) Water (top) and methylene chloride, CH_2Cl_2 (bottom)

b) Addition of I_2 to water and methylene chloride

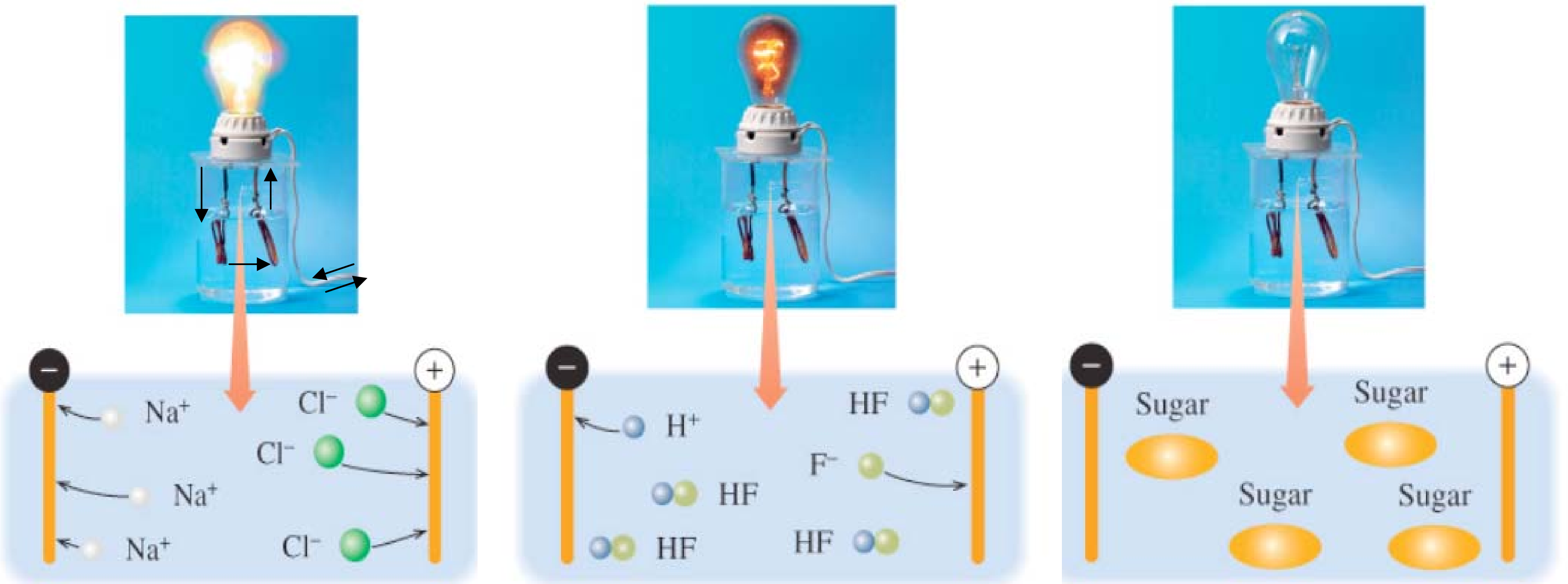
c) Addition of green $NiCl_2$ (nickel II chloride) to water and methylene chloride



(a) (b) (c)

In water, strong electrolytes produce ions and conduct an electric current
weak electrolytes produce a few ions
non-electrolytes do not produce ions even though the sugar dissolves

The movement of charge constitutes an electric current



Strong electrolyte | Weak electrolyte | Nonelectrolyte

TABLE 8.4 Classification of Solutes in Aqueous Solutions

Type of Solute	Dissociation	Particles in Solution	Conducts Electricity?	Examples
Strong electrolyte	Complete	Ions only	Yes	Ionic compounds such as NaCl, KBr, $MgCl_2$, $NaNO_3$; NaOH, KOH; HCl, HBr, HI, HNO_3, $HClO_4$, H_2SO_4
Weak electrolyte	Partial	Mostly molecules and a few ions	Yes, but poorly	HF, H_2O, NH_3, $HC_2H_3O_2$ (acetic acid)
Nonelectrolyte	None	Molecules only	No	Carbon compounds such as CH_3OH (methanol), C_2H_5OH (ethanol), $C_{12}H_{22}O_{11}$ (sucrose), CH_4N_2O (urea)

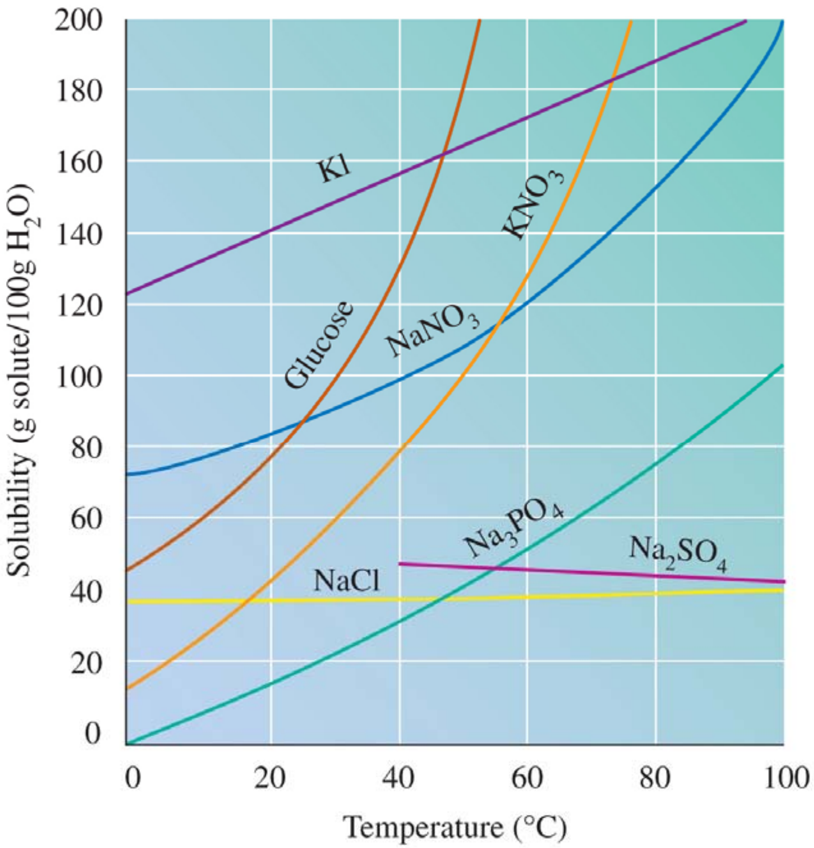
Solubility refers to the maximum amount of solute that dissolves in a specific amount of solvent, usually 100 g

Unsaturated solutions contain less than the maximum amount of solute

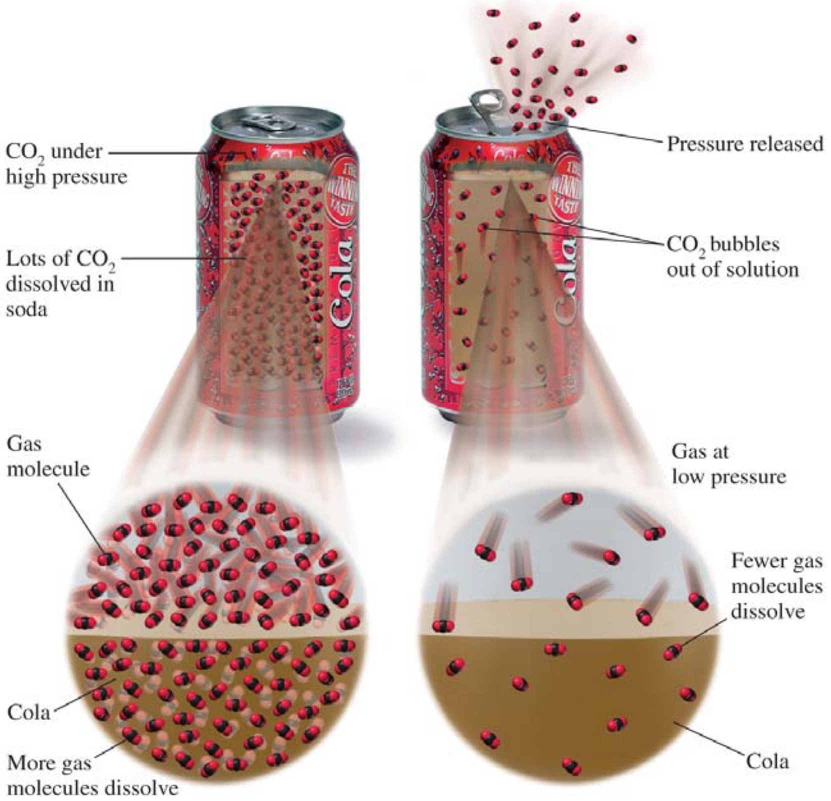
Effect of temperature on solubility

The solubility of most solids increases as temperature increases

The solubility of of gases decreases as temperature increases



The solubility of a gas in a liquid is directly related to the pressure of that gas above the liquid;
at higher pressures, more gas molecules dissolve in the liquid



Not all salts are soluble in water

Solubility is a relative measure:

Soluble salts dissolve to the extent of 1 g /100 g water or more

Sparingly soluble salts dissolve to the extent of less than 1g/100 g of water but more than 0.1 g/100 g water

Insoluble salts dissolve to less the 0.1 g/100 mL of water

$Ba(NO_3)_2 + H_2O = Ba^{+2} + 2NO_3^-$

$Na_2SO_4 + H_2O = 2Na^+ + SO_4^{-2}$

$Ba^{+2} + 2NO_3^- + 2Na^+ + SO_4^{-2} = BaSO_4\downarrow + 2NO_3^- + 2Na^+$

Results of a barium enema using X-rays

Barium is very toxic but $BaSO_4$ is very insoluble

Why is $BaSO_4$ used in this procedure?

solubility is $1*10^{-5}$ mol/liter or 0.00233 g/L

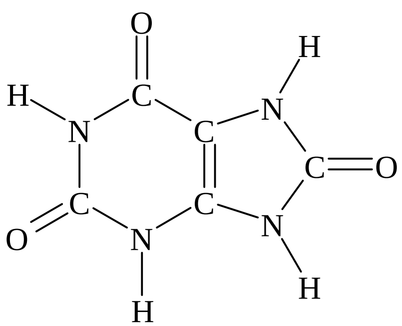
Ba 137 g/mol	137+32+64 =233g/mol
S 32 g/mol	233 g/mol*10^{-5} mol/L
O 16 g/mol	

Kidney stones are either calcium phosphate,

$Ca_3(PO_4)_2$,

calcium oxalate, CaC_2O_4

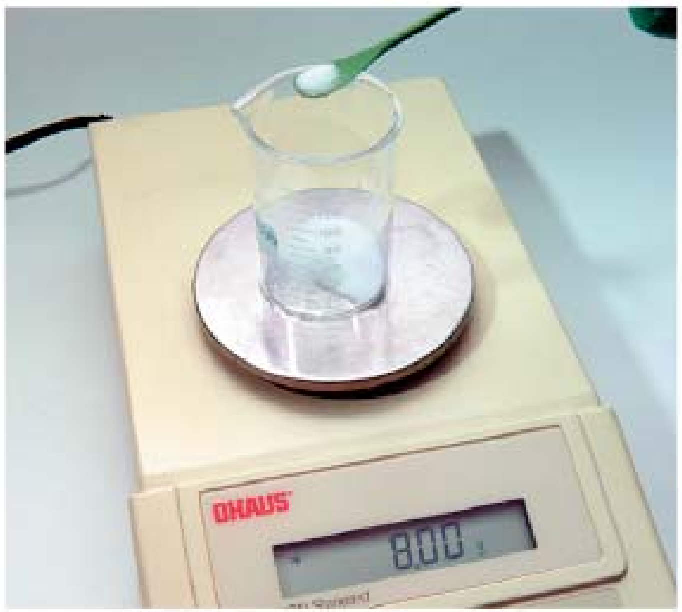
or uric acid, $C_5H_4N_4O_3$



Concentrations

The **concentration** of a solution is the amount of solute dissolved in a specific amount of solution

$$\text{concentration} = \frac{\text{amount of solute}}{\text{amount of solution}}$$



Add 8.00 g of KCl.

Add water until the mass of the solution is 50.00 g.

concentration (mass/mass (m/m)) = 8/50; = 0.16 g KCl/g solution

Types of concentration

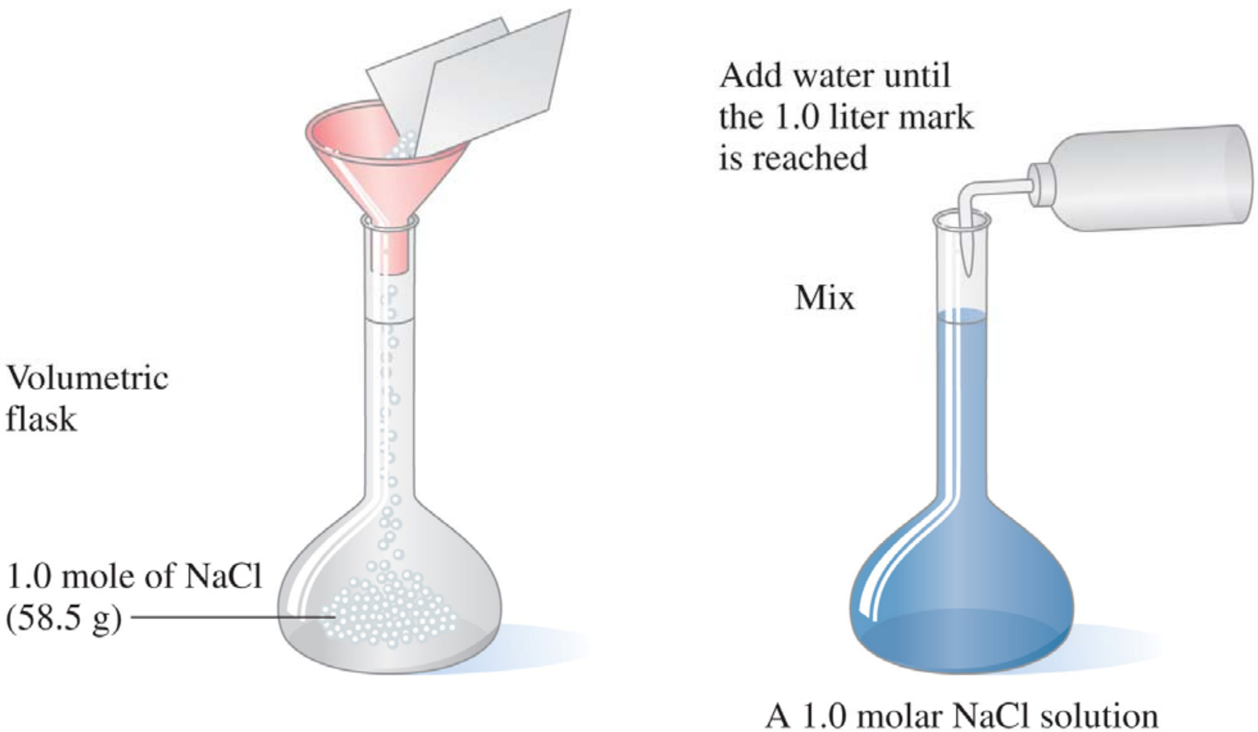
mass/mass (m/m)

mass/volume of solution (m/v)

volume/volume of solution (v/v)

Percent Concentration	Meaning
15% (m/m) KCl	There are 15 g of KCl in 100 g of solution.
5% (m/v) glucose	There are 5 g of glucose in 100 mL of solution.
12% (v/v) ethanol	There are 12 mL of ethanol in 100 mL of solution.

moles/liter **M**



Cl: 35.5 at mass

Na: 23.0 at mass

NaCl 58.5 g /mol

Solutions contain small particles (ions or molecules)
are transparent
do not separate, even by filtration or through a semipermeable membrane
do not scatter light

Colloids have medium-sized particles
cannot be separated by filtration
can be separated by semipermeable membranes
scatter light

TABLE 8.12 Examples of Colloids

	Substance Dispersed	Dispersing Medium
Fog, clouds, sprays	Liquid	Gas
Dust, smoke	Solid	Gas
Shaving cream, whipped cream, soapsuds	Gas	Liquid
Styrofoam, marshmallows	Gas	Solid
Mayonnaise, butter, homogenized milk, hand lotions	Liquid	Liquid
Cheese, butter	Liquid	Solid
Blood plasma, paints (latex), gelatin	Solid	Liquid

Suspensions

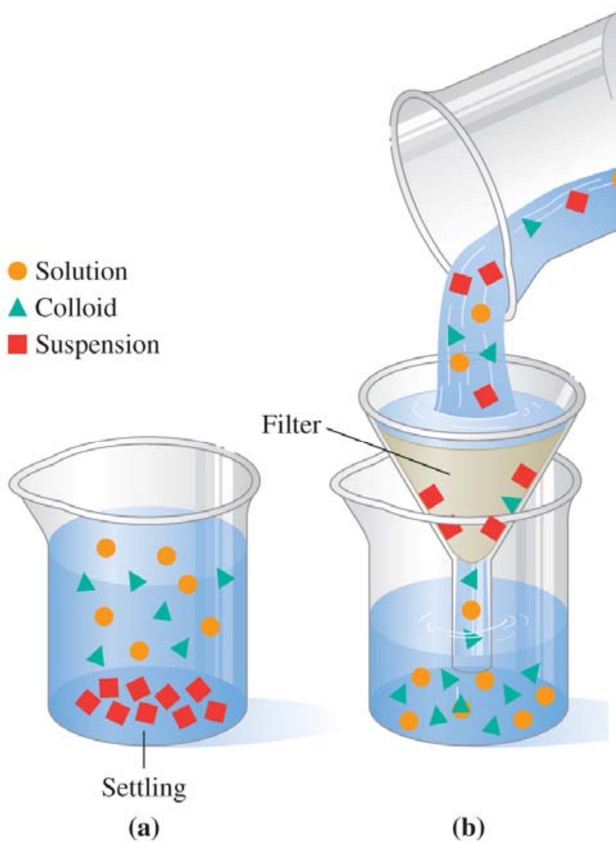
have very large particles

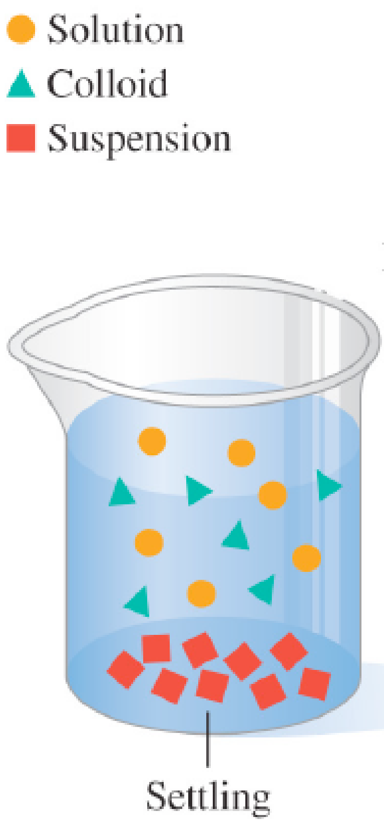
settle out

can be separated by filtration

must be stirred to stay suspended

Examples: blood platelets, muddy water, and calamine lotion





The effect of solutes on the properties of solvents

TABLE 8.14 Effect of Solute Concentration on Freezing and Boiling Points of 1000 g of Water

	Type of Solute	Moles of Solute Particles	Freezing Point	Boiling Point
Pure Water	None	0	0 °C	100 °C
Temperature change		1 mole	$\Delta T_f = 1.86$ °C	$\Delta T_b = 0.52$ °C
1 mole of ethylene glycol	Nonelectrolyte	1 mole	−1.86 °C	100.52 °C
1 mole of NaCl	Strong electrolyte	2 moles	−3.72 °C	101.04 °C
1 mole of $CaCl_2$	Strong electrolyte	3 moles	−5.58 °C	101.56 °C

Notice that the effect depends on the number of particles that form in solution

ethylene glycol (antifreeze) unchanged in water: 1 mol lowers the freezing temperature 1.86° C

An equivalent amount of NaCl that forms Na^+ and Cl^- ions in water doubles the effect

1 mol of $CaCl_2$ which forms Ca^{+2} and 2 Cl^- triples the effect

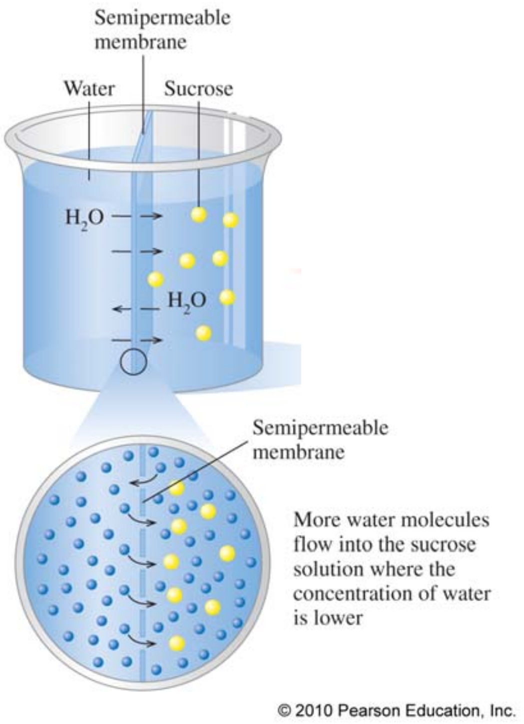
Osmosis

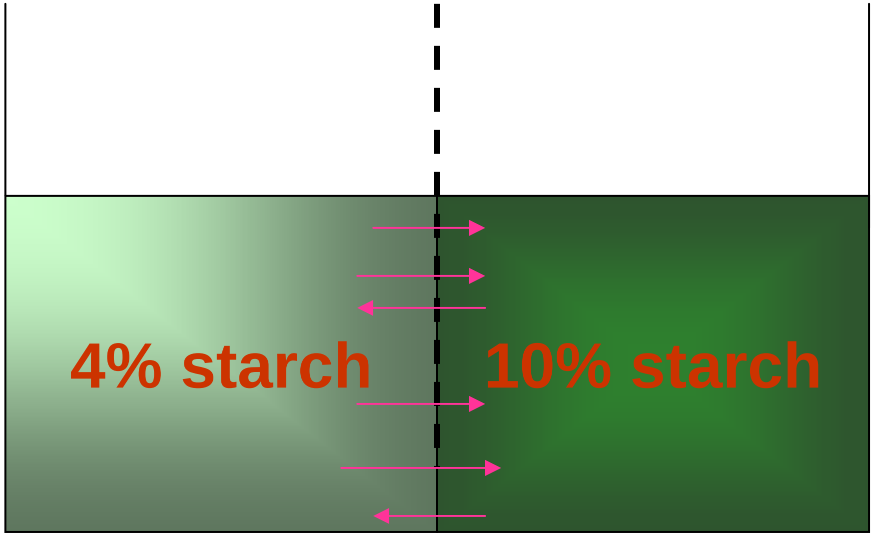
In **osmosis**, water (solvent) flows from the lower solute concentration into the higher solute concentration;

the level of the solution with the higher solute concentration rises;

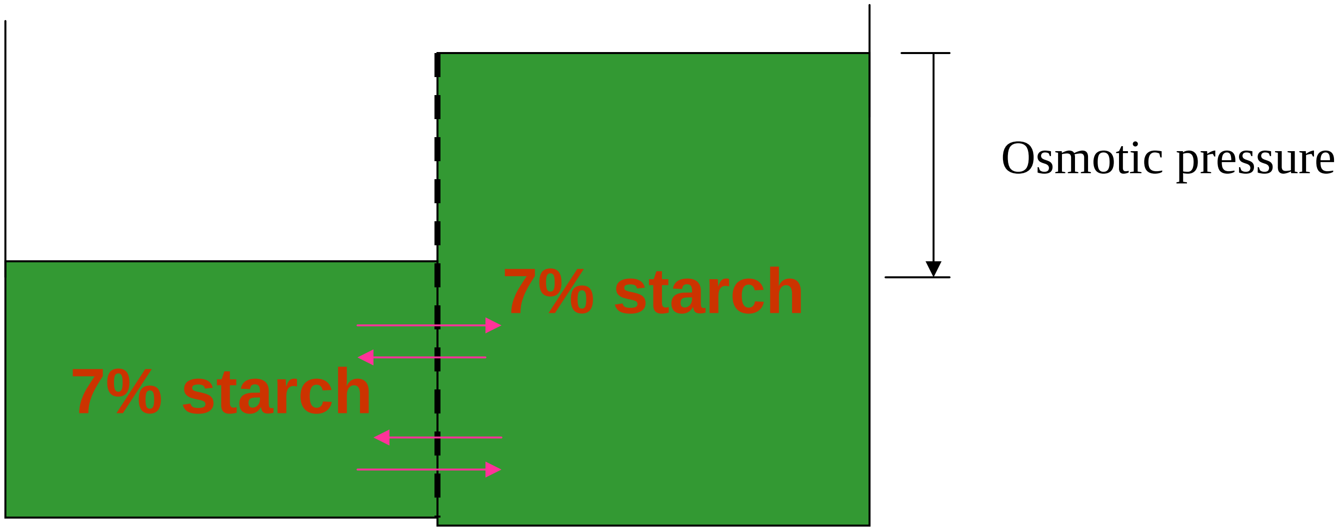
at equilibrium, when the levels of the two solutions don't change anymore with time, the amount of water flowing between the two sides is equal because of the greater pressure generated by the two unequal levels

Osmotic pressure is the pressure generated by the two unequal levels





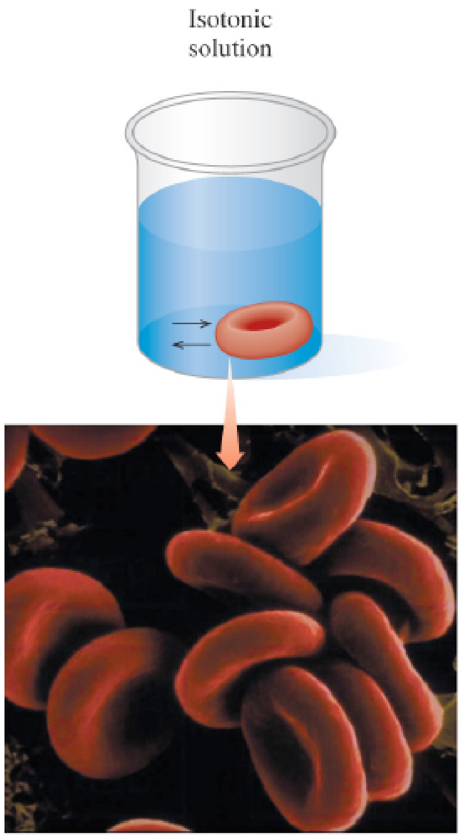
A semipermeable membrane separates a 4% starch solution from a 10% starch solution. Starch cannot pass through the membrane, but water can. What happens?



Red blood cells have cell membranes that are semipermeable

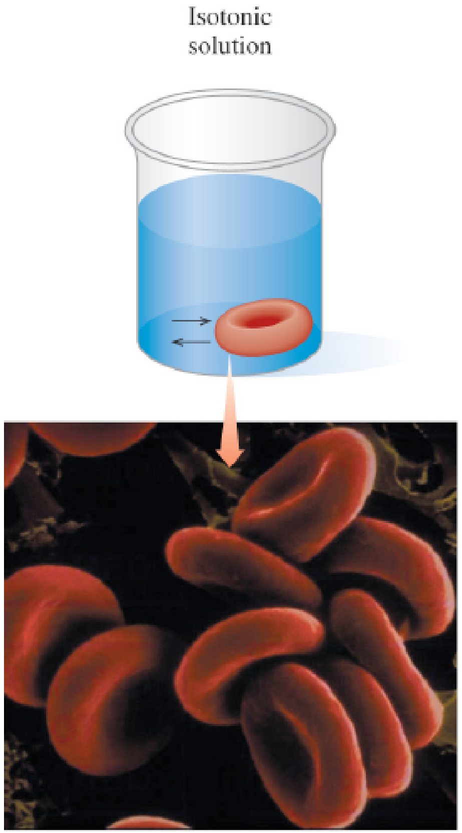
they maintain an osmotic pressure that cannot change without damage occuring

they must maintain an equal flow of water between the cell and its surrounding environment



An **isotonic solution** exerts the same osmotic pressure as red blood cells

5.0% (m/v) glucose or 0.9% (m/v) NaCl is used medically because each has a solute concentration equal to the osmotic pressure equal to red blood cells



A **hypotonic solution**
has a lower osmotic pressure than red blood cells (RBCs)

containes fewer dissolved particles than blood serum

causes water to flow into RBCs

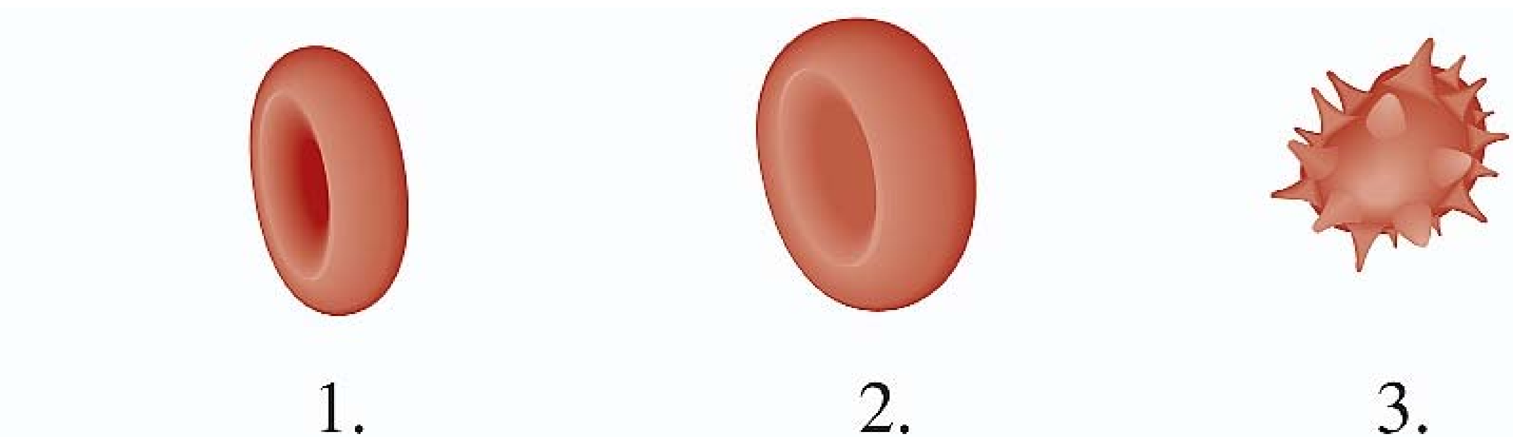
causes *hemolysis* (RBCs swell and may burst)

A **hypertonic solution**
has a higher osmotic pressure than RBCs

containes more dissolved particles than blood serum

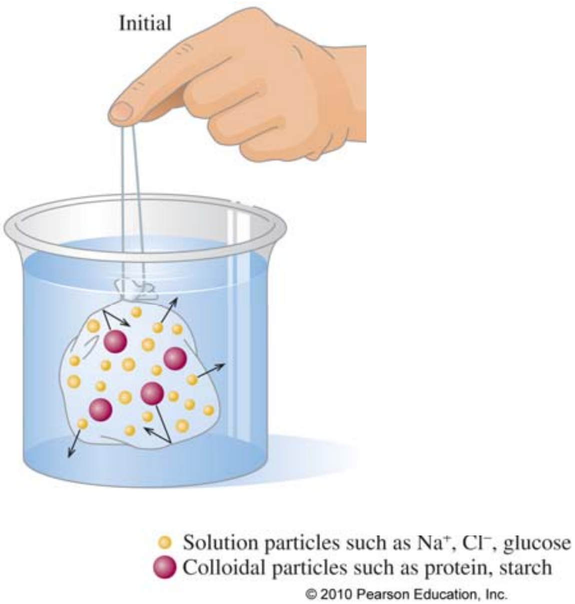
causes water to flow out of RBCs

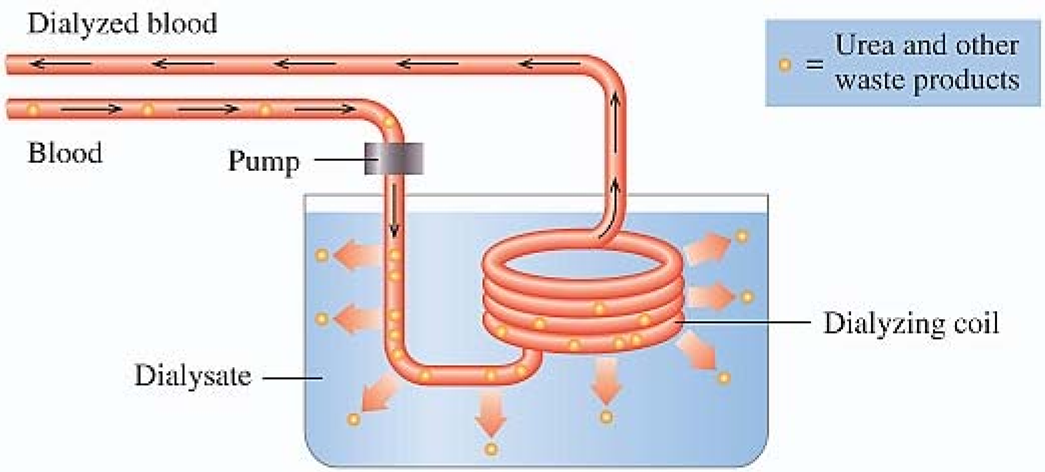
causes *crenation* (RBCs shrink in size)

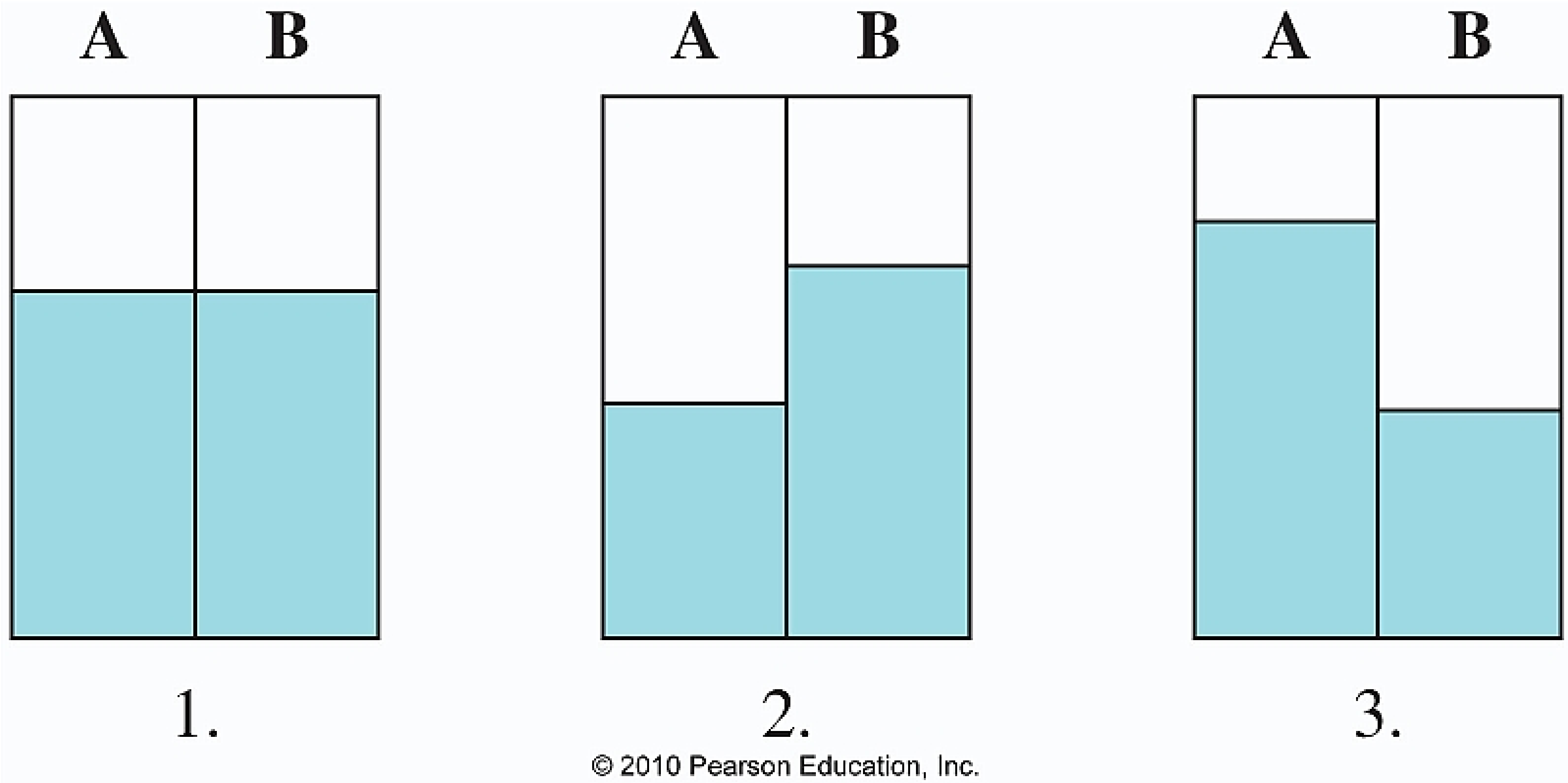


Normal red blood cell

In **dialysis**,
solvent and small solute particles pass through an artificial membrane;
large particles are retained inside;
waste particles such as urea from blood are removed using hemodialysis (artificial kidney)







A semipermeable membrane separates two compartments, A and B. If the levels of solutions in A and B are equal initially, select the diagram that illustrates the final levels for each of the following:

	A	B
a.	2% (m/v) starch	8% (m/v) starch
b.	1% (m/v) starch	1% (m/v) starch
c.	5% (m/v) sucrose	1% (m/v) sucrose
d.	0.1% (m/v) sucrose	1% (m/v) sucrose

Explain what happened to the coke bottle in the polycarbonate bottle

An **isotonic** 0.9% (m/v) **NaCl solution of** exerts the same osmotic pressure as red blood cells

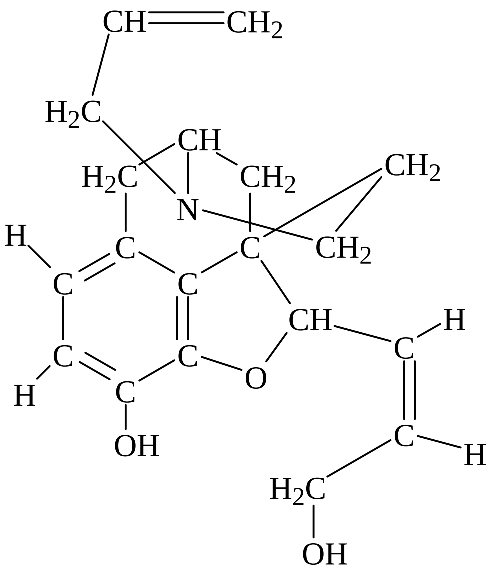
What is the concentration of this solution in moles /liter (**M**)?

0.9% (m/v) means there are 0.009g/mL solution; How much NaCl would be in 1 L of solution?

0.009g/mL*1000mL = 9 g of NaCl; How many moles is this?

Na = 23 g/mol; Cl = 35.5 g/mol Cl; MW = 23+35.5; MW = 58.5 g/mol

9g/58.5 g/mol = 0.154 moles/liter of solution; The solution is 0.154 **M**



Nalorphine ($C_{19}H_{21}NO_3$), a relative of morphine, is used to combat withdrawal symptoms in narcotics users. How many mL of a $1.0*10^{-3}$ M solution are needed to administer a dose of 3.11 mg?

MW Nalorphine =	19*12	=	228
	21*1	=	21
	14*1	=	14
	16*3	=	48
			311

How many moles of Nalorphine are in a 3.11 mg sample?

0.00311g /311g/mol = $1*10^{-5}$ moles

$1.0*10^{-3}$ moles/L*V(L) = $1.0*10^{-5}$moles

V = $1.0*10^{-5}$ moles/ $1.0*10^{-3}$ moles/L

V = $1*10^{-2}$ L * 1000mL/L = 10 mL