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## Solutions

Solution- homogenous mixture of two or more pure substances; composition can be varied.

One or more *solutes* are dissolved in a *solvent*.

Solute- substance dissolved in a solvent, present in smaller amount.

Solvent- substance present in greater amount, contains dissolved solute.

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## Solutions

Can be:

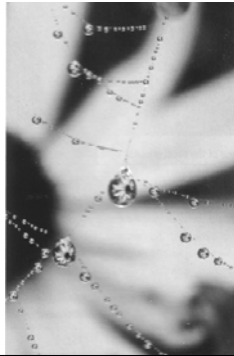
- solid dissolved in solid (alloy- brass)
- liquid dissolved in liquid (3% hydrogen peroxide)
- gas dissolved in gas (earth's atmosphere)
- solid, liquid or gas dissolved in a liquid (plethora of substances)

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## Water

Important properties of water:

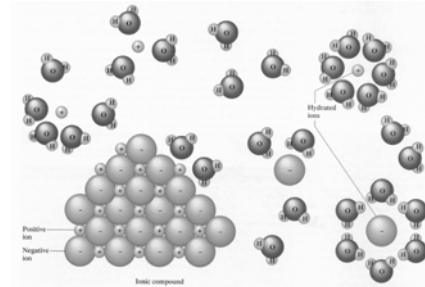
- polar
- high surface tension (Fig. 6.6 misprint)
- stores much energy in h-bonds
- excellent solvent



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## The Solution Process

Fig 8.3: Forces are important



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## Solubility is Favored By:

- Strong solvent-solute interactions
- Weak solvent-solvent interactions
- Weak solute-solute interactions

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## Solubility

- “like dissolves like”
- Ionic compounds are hard to remember - Table 7.3
  - insoluble if water can’t pull the atoms apart

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## Solubility

1. Group IA element-containing compounds are soluble.
2. Ammonium, nitrate, and acetate-containing compounds are soluble.
3. Compounds containing halogens are soluble - except Ag, Hg, and Pb.
4. Compounds containing sulfate are soluble - except Ag, Hg, and Pb, and Ca, Sr, Ba.
5. Hydroxides of IA, Ca, Ba and Sr are soluble.

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## Sample Test Question

Predict the solubility of the following compounds.

Compound	Soluble in	
	water	gasoline (C <sub>8</sub> H <sub>18</sub> )
NaCl	yes	no
KF	_____	_____
C <sub>6</sub> H <sub>12</sub>	_____	_____
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	_____	_____

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## Electrolytes Conduct Electricity

Electrolyte- chemical species that conducts electricity when liquid or when dissolved in water.

because of ions

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Solubility as a Function of Temperature

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Solubility as a Function of Temperature

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Solubility as a Function of Temperature

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### Solubility of Air in Water

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### Solubility of Gasses in Water

Increasing temp decreases sol of gas in solvent.

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### Colloids

Colloids- solutions in which the solutes are large enough that light is scattered.

$\text{Na}^+$  is  $1.53 \times 10^{-10}$  m

Milk, the prototypical colloid, has proteins such as casein, which is about  $1.41 \times 10^{-7}$  m in diameter

This causes light scattering- the *Tyndall effect*

The casein is soluble, so colloids do not settle out



Blei and Odian, GOB Fig. 7.13

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### Suspensions

An example of a suspension is muddy water.

Light \_\_\_\_\_.

The "mud" is insoluble, so over time it settles out.

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### Concentrations of Solutions

- We need a way to accurately describe how much solute is dissolved in a solvent
- Several possible units
  - Molarity
  - Normality
  - Percent solution
  - ppm
  - others

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### Molarity

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liters of solution}}$$

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## Practice Molarity Problems

What is the molarity of a solution composed of 2.85 mol solute in 0.500 L distilled water?

What is the molarity of a solution composed of 25.852 g NaCl in 1.000 L distilled water?

What is the molarity of a solution composed of 25.852 g NaCl in 750 mL distilled water?

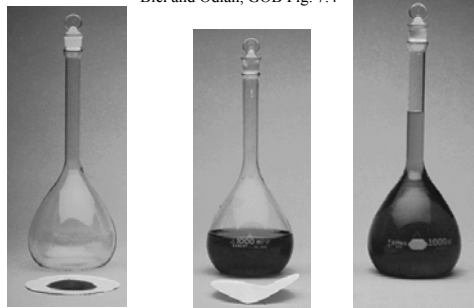
How many grams NaCl are in 0.15 L of 3.2 M NaCl?

How many grams of sucrose (molar mass 342) are required to make 500.0 mL of 0.26 M sucrose?

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## Preparing Solutions

Blei and Odian, GOB Fig. 7.4



1. Weigh out the amount of solute needed
2. Dissolve in a portion of water
3. Dilute to final volume

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## Normality

$$\text{Normality} = \frac{\text{equivalents of solute}}{\text{liters of solution}}$$

Normality =  $M \cdot X$ , where  $X$  is number ions of interest

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## Practice Normality Problems

What is the normality of a solution if 1.652 g oxalic acid dihydrate are dissolved in 250.00 mL deionized water?

How many g NaOH did we use to prepare 8.0 L of 2 N NaOH for experiment 140?

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## Dilution in Solutions

$$(C_D)(V_D) = (C_F)(V_F)$$

What is the final concentration of HCl if 53.0 mL concentrated (11.6 M) is diluted to 1.00 L?

What volume of 11.6 M HCl would you dilute to 1.0 L if you wanted a solution of 4.5 M?

What volume of 18 M  $\text{H}_2\text{SO}_4$  would you dilute to 1.0 L if you wanted a solution of 4.5 N?

$$(N_A)(V_A) = (N_B)(V_B)$$

If I titrate 200.0 mL of NaOH to neutrality with 24.96 mL of 1.00 M HCl, what is the concentration of the NaOH?

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## Percent solution

$$\text{Percent solution (w/v)} = \frac{\text{g solute}}{100 \text{ mL of solution}}$$

$$\text{Percent solution (v/v)} = \frac{\text{mL solute}}{100 \text{ mL of solution}}$$

What is the percent solution (w/v) if 58.5 g NaCl is dissolved in 250.0 mL water?

What is the percent solution (v/v) if 500.0 mL pure alcohol is dissolved in punch to a final volume of 14.0 L?

What is the percent solution (v/v) if 500.0 mL pure alcohol is dissolved in 14.0 L punch?

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## Parts per Million (ppm)

$$\text{ppm} = \frac{\text{g of solute}}{1,000,000 \text{ g of solution}}$$

How many ppm is a solution if 50.0 g NaCl is dissolved in a  $5.6 \times 10^2$  L water?

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## Colligative Properties

Colligative properties- changes in the behavior of a solvent based on containing a solute

- Decreased melting point
- Increased boiling point
- Increased osmotic pressure

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## Colligative Properties-Osmotic Pressure

*Osmosis* is movement of water

*Dialysis* is an important application of this concept

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## Colligative Properties-bp

For water, 1 mol particles/kg water  $\left( K_{bc} = \frac{0.51^\circ\text{C kg}}{\text{mol}} \right)$  raises bp by  $0.51^\circ\text{C}$

How much would the boiling point increase if 3.25 mol  $\text{CH}_3\text{Cl}$  were dissolved in 251 g water?

How much would the boiling point increase if 27.5g NaCl were dissolved in 657 mL water?

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## Colligative Properties-mp

For water, 1 mol particles/kg water  $\left( K_f = \frac{1.86^\circ\text{C kg}}{\text{mol}} \right)$  lowers mp by  $1.86^\circ\text{C}$

How much would the melting point decrease if 113g  $\text{CH}_3\text{CH}_2\text{OH}$  were dissolved in 1750 mL water?

How much would the melting point decrease if 36 g  $\text{CaCl}_2$  were dissolved in 432 mL water?

The melting point of 1.00 kg of water changes by  $3.26^\circ\text{C}$  when 25.0 g of a covalent compound is added. What is the molar mass of the compound?

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## Practice Problems: Colligative Properties

The melting point of 1.00 kg of water changes by  $1.86^\circ\text{C}$  when 75.0 g of an ionic compound (molar mass 300.0 g/mol) is added. How many ions does this molecule dissociate into?