Water & Solutions

Aqueous solutions – water samples containing dissolved substances (solid, liquid, or gas)

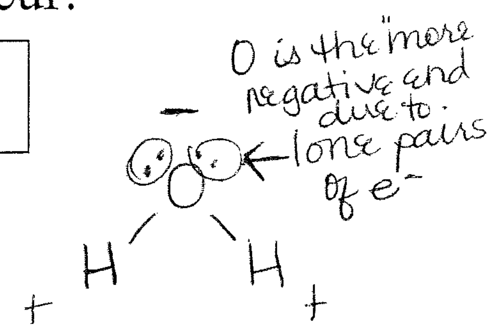
Solution has 2 parts:

1. Solvent – dissolving medium, substance in greater amount, usually liquid (H_2O is most common)
2. Solute – substance being dissolved, substance in lesser amount, usually solid

Solvation – process that occurs when a solute dissolves

Prediction of whether solubility will occur:

"like dissolves like"



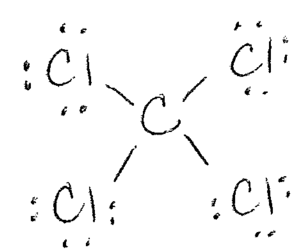
Water is a POLAR compound, so
(one end "−", one end "+")

Solute

Ionic (Metal + Nonmetal)	Polar Covalent – 2 Nonmet.	Nonpolar Covalent – 2 nonmet.
soluble* electrolyte	soluble nonelectrolyte*	insoluble nonelectrolyte

electrolyte – compound that conducts an electric current in aqueous solution or the molten state

Can an aqueous solution be made with CCl_4? ($4 + (7 \times 4) = 28$)
No – CCl_4 is nonpolar covalent; insoluble



What is solubility?

The number of grams of solute that dissolves in a given quantity of a solvent (usually 100 g) at a given temperature to produce a saturated solution

Factors affecting solubility (how much solute dissolves)

1. Temperature – generally, solubility ↑ with rise in T (gases are opposite)
2. Nature of solute or solvent
3. Pressure (for gases) – only a factor for gases, pressure ↑ results in solubility ↑ of a gas in a liquid (ex. soda pop)
   ↳ CO_2 in solution stays as long as soda is under pressure. Explains how sodas go "flat" if left open.

Factors affecting RATE of solubility (how fast solute dissolves)

1. Stirring (agitation) – more contact with surface of solute
2. Temperature – greater kinetic energy, more collisions
3. Particle size – finer particles expose more surface area so faster dissolving

Section 18.1

Properties of Solutions

<u>miscible</u> – when two liquids dissolve into each other (water and alcohol)
<u>immiscible</u> – two liquids that are not soluble in each other (water and oil)

As T ↑, can dissolve more and more solute (except gases)

1) saturated solution – contains the maximum amount of solute for a given amount of solvent at a constant T
2) unsaturated solution – contains less solute than a saturated solution
3) supersaturated solution – a solution that contains more solute than it should theoretically continue to hold at a constant T (when a saturated solution slowly cools and crystallization does not immediately occur)

Solubility Tables – provide solubility data at various T

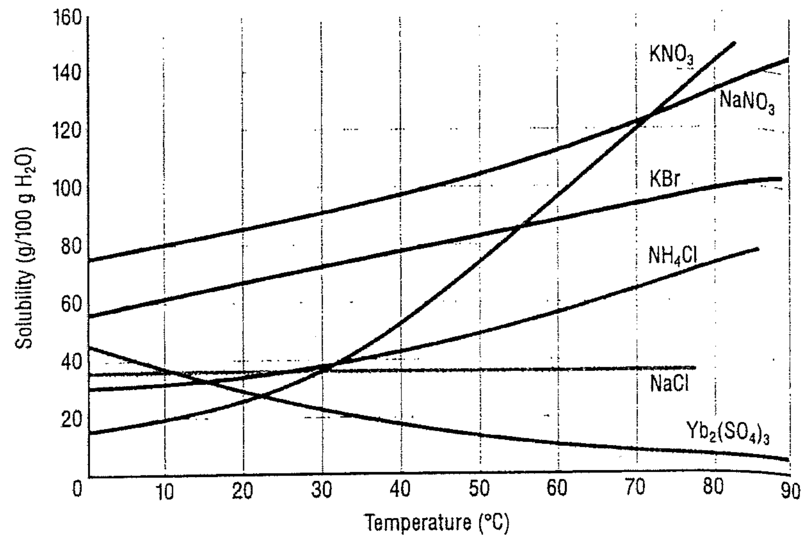
Table 18.1

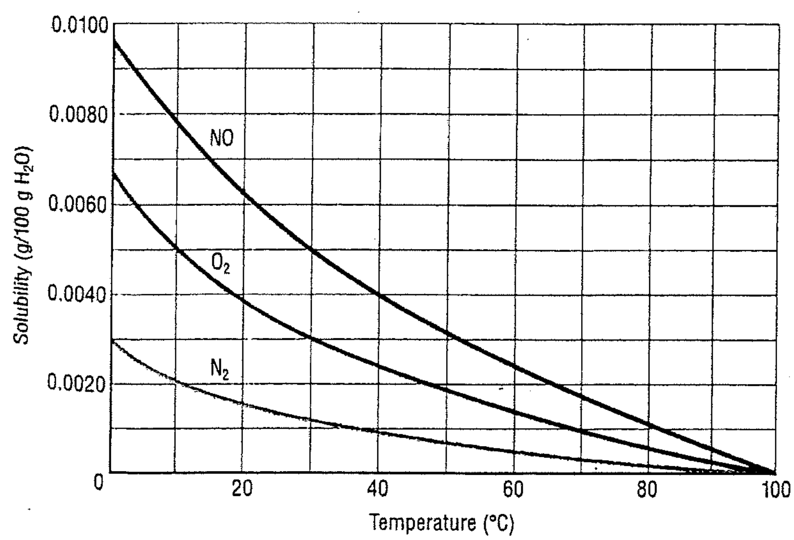
Solubilities of Some Substances in Water at Various Temperatures

Substance	Formula	Solubility (g/100 g H_2O) 0 °C	20 °C	50 °C	100 °C
Barium hydroxide	$Ba(OH)_2$	1.67	31.89	—	—
Barium sulfate	$BaSO_4$	0.00019	0.00025	0.00034	—
Calcium hydroxide	$Ca(OH)_2$	0.189	0.173	—	0.07
Lead(II) chloride	$PbCl_2$	0.60	0.99	1.70	—
Lithium carbonate	Li_2CO_3	1.5	1.3	1.1	0.70
Potassium chlorate	$KClO_3$	4.0	7.4	19.3	56.0
Potassium chloride	KCl	27.6	34.0	42.6	57.6
Sodium chloride	NaCl	35.7	36.0	37.0	39.2
Sodium nitrate	$NaNO_3$	74	88.0	114.0	182
Aluminum chloride	$AlCl_3$	30.84	31.03	31.60	33.32
Silver nitrate	$AgNO_3$	122	222.0	455.0	733
Lithium bromide	LiBr	143.0	166	203	266.0
Sucrose (cane sugar)	$C_{12}H_{22}O_{11}$	179	230.9	260.4	487
Hydrogen*	H_2	0.00019	0.00016	0.00013	0.0
Oxygen*	O_2	0.0070	0.0043	0.0026	0.0
Carbon dioxide*	CO_2	0.335	0.169	0.076	0.0

* Gas at 101 kPa total pressure

Solubility Graphs – provides saturation curve with unsaturated and supersaturated regions easily identifiable





Section 18.2 – Concentrations of Solutions

dilute solution – one that contains only a low concentration of solute

concentrated solution – one that contains a high concentration of solute

Use MOLARITY to better express concentration of solution

Molarity (M) – number of moles of solute dissolved per liter of solution

$$M = \frac{\text{moles of solute}}{\text{Liters of solution}}$$

MUST use Liters – not mL!

Example – 2.5 M HCl means $\frac{\text{2.5 mols HCl}}{\text{1 Liter solution}}$

Problem 1: Find the molarity of a solution that is made by dissolving 0.35 moles of ammonium iodide in 100 mL of solution.

convert to L… 0.1 L

$$M = \frac{0.35 \text{ mol } NH_4I}{0.1 \text{ L}} = 3.5 \text{ M } NH_4I$$

100 mL = 0.1 L

$$\frac{100 \text{ mL}}{} \Big| \frac{1 \text{ L}}{1000 \text{ mL}} = 0.1 \text{ L}$$

Problem 2: Find the molarity of a solution that is made by dissolving 53.0 g of potassium chloride in 500.0 mL of solution.

→ convert to L ... 0.5 L

① $\frac{53.0\ g\ KCl}{} \left| \frac{1\ mol\ KCl}{74.55\ g\ KCl} \right. = 0.71\ mol\ KCl$

② $M = \frac{0.71\ mol\ KCl}{0.5\ L} = \boxed{1.42\ M\ KCl}$

Problem 3: How many grams of sodium chloride are needed to make 1.500 L of a 2.00 M solution?

① $2.00\ M = \frac{mol\ NaCl}{1.5\ L} \rightarrow 3\ mol\ NaCl$

② $\frac{3\ mol\ NaCl}{} \left| \frac{58.44\ g\ NaCl}{1\ mol\ NaCl} \right. = \boxed{175.32\ g\ NaCl}$

Problem 4: What volume of 1.25 M sodium hydroxide can be prepared using 60.0 grams of sodium hydroxide?

do ②nd → $1.25\ M\ NaOH = \frac{1.5\ mol\ NaOH}{x\ L\ NaOH}$

$= \boxed{1.20\ L\ NaOH}$

do ①st → $\frac{60.0\ g\ NaOH}{} \left| \frac{1\ mol\ NaOH}{40.00\ g\ NaOH} \right. = 1.5\ mol\ NaOH$

Dilutions

When diluting, moles of solute DO NOT change!

A solution is diluted by simply adding more solvent.

$$M_1 V_1 = M_2 V_2$$

M_1 = molarity (mols/L) of initial solution
V_1 = volume (mL or L) of initial solution
M_2 = molarity of new solution
V_2 = volume of new solution

Problem 1: How would you prepare 100 mL of 0.40 M magnesium sulfate from an initial solution of 2.0 M magnesium sulfate

$$M_1 V_1 = M_2 V_2$$

$$(2.0\ M) V_1 = (0.40\ M)(0.1\ L)$$

$$\boxed{V_1 = 0.02\ L \text{ or } 20\ mL}$$

Problem 2: If you dilute 20.0 mL of a 3.5 M solution to make 100.0 mL of solution, what is the molarity of the dilute solution?

$$M_1 V_1 = M_2 V_2$$

$$(3.5\ M)(0.02\ L) = M_2 (0.1\ L)$$

$$\boxed{M_2 = 0.7\ M}$$

(or you can use mL)

$$(3.5\ M)(20.0\ mL) = M_2 (100.0\ mL)$$

$$\boxed{M_2 = 0.7\ M}$$

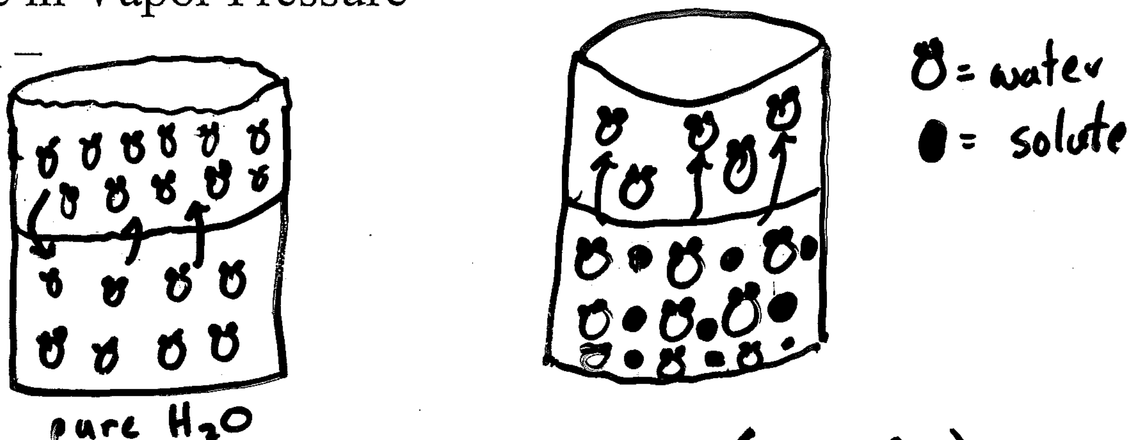
Section 18.3 – Colligative Properties of Solutions

What is a colligative property? – a property of solutions that depends ONLY on the number of solute particles dissolved and NOT the identity of the solute

There are 3 colligative properties of solutions:

1) Decrease in Vapor Pressure

Diagram –



Explanation – less water molecules (on surface) available to change to a gas

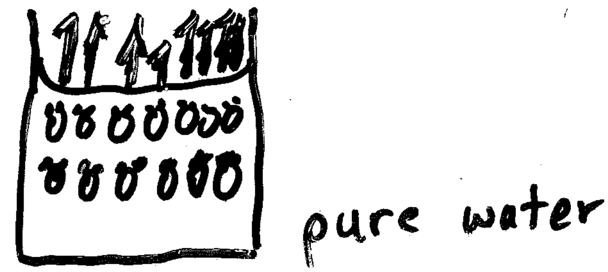
Decrease in vapor pressure is proportional to the number of particles:

sucrose	1 particle (covalent)	$C_{12}H_{22}O_{11}$
NaCl	2 particles (ionic)	Na^+ Cl^-
$CaBr_2$	3 particles (ionic)	Ca^{+2} Br^- Br^-

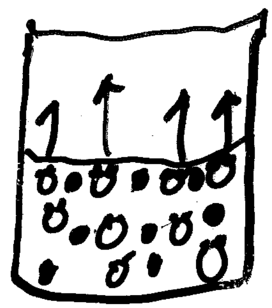
Solutions of equal molarity of KI and MgF_2 are compared. Which would have a lower vapor pressure and why?

$K^+ I^-$ (2)

Mg^{+2} F^- F^- (3)



2) Boiling-Point Elevation
Explanation:



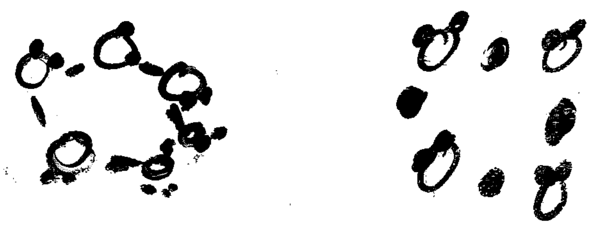
less H_2O exposed to surface

Examples:

anti-freeze

3) Freezing-Point Depression
Explanation:

Solute does not allow water to form crystal



Examples:

anti-freeze
ice-cream

Solutions of equal molarity of KI and MgF_2 (2) are compared. Which would have a higher boiling point and why?

Mg^{+2} F^- F^-

Which would have a lower freezing point and why?

MgF_2

Tyndalleffect - scattering of visible light in all direction

Comparison
Solutions, Colloids, and Suspensions

Property	Solution	Colloid	Suspension
Uniformity	Homogeneous	Borderline	Heterogeneous
Solute particle type	Ions atoms small molecules	Large molecules or particles	Large particles or aggregates or clumps or Cement units of matter
Particle size	0.1-1nm	1-100nm	100nm and Larger
Effect of light	no scattering	exhibits Tyndall effect	exhibits Tyndall effect
Effect of gravity	Stable does not Separate	Stable does not Separate	unstable Sediment forms
Filtration	Particles not retained on filter	Particles not retained on filter	Particles retained on filter
Examples		Glue Paint Marshmallow Gas Solid	Muddy water

Suspension are mixtures from which particles settle out upon standing

colloids are heterogeneous mixtures containg Particles that are intermidat in size between those of suspension and true solutions