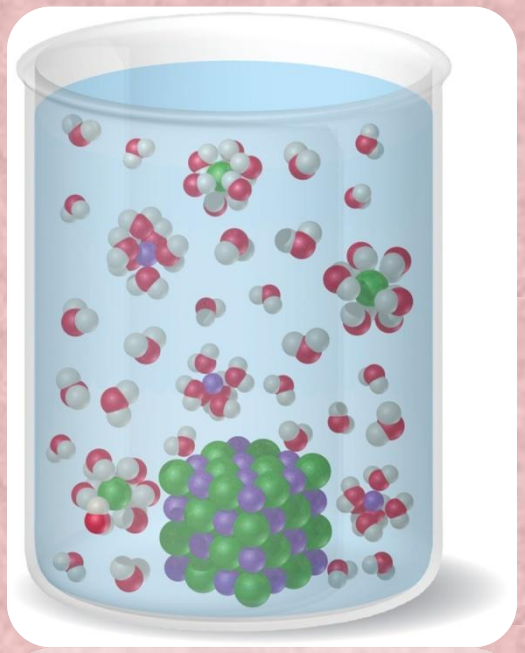


LECTURE №4

DISPERSE SYSTEMS. TRUE SOLUTION

21.02.2017

EDUCATIONAL GOALS

1) Compare and contrast:

✔ mixtures and pure substances.

✔ solutions, suspensions, and colloids.

2) Understand, compare, and contrast the terms homogeneous mixture and heterogeneous mixture. For a homogeneous mixture, explain the difference between solute(s) and solvent.

3) Predict the effect of temperature and pressure on the solubility of gases in water and the effect of temperature on the solubility of solids in water.

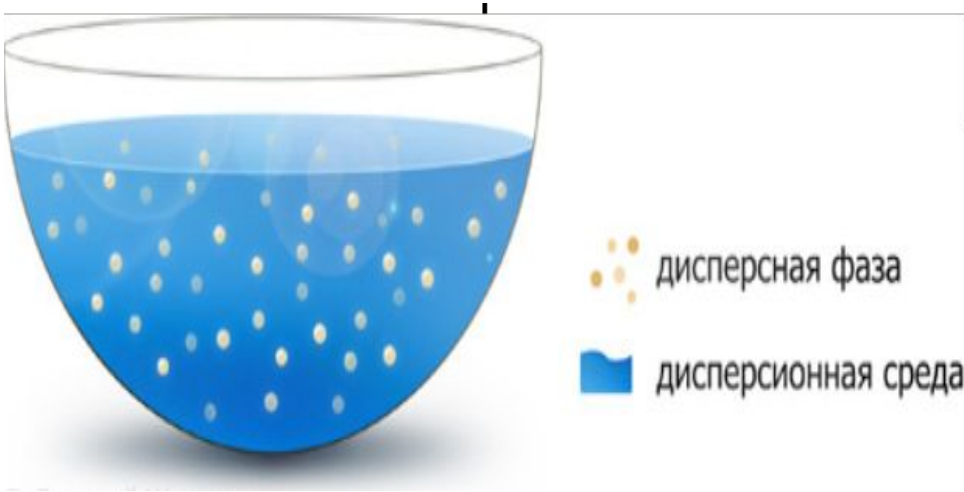
4) Be able to use the Solubility Rules Table to determine if an ionic compound will significantly dissolve in water.

5) Be able to calculate the concentration of a solution using various concentration units of measurements. (%, parts per thousand, molarity, molality, normality and titer)

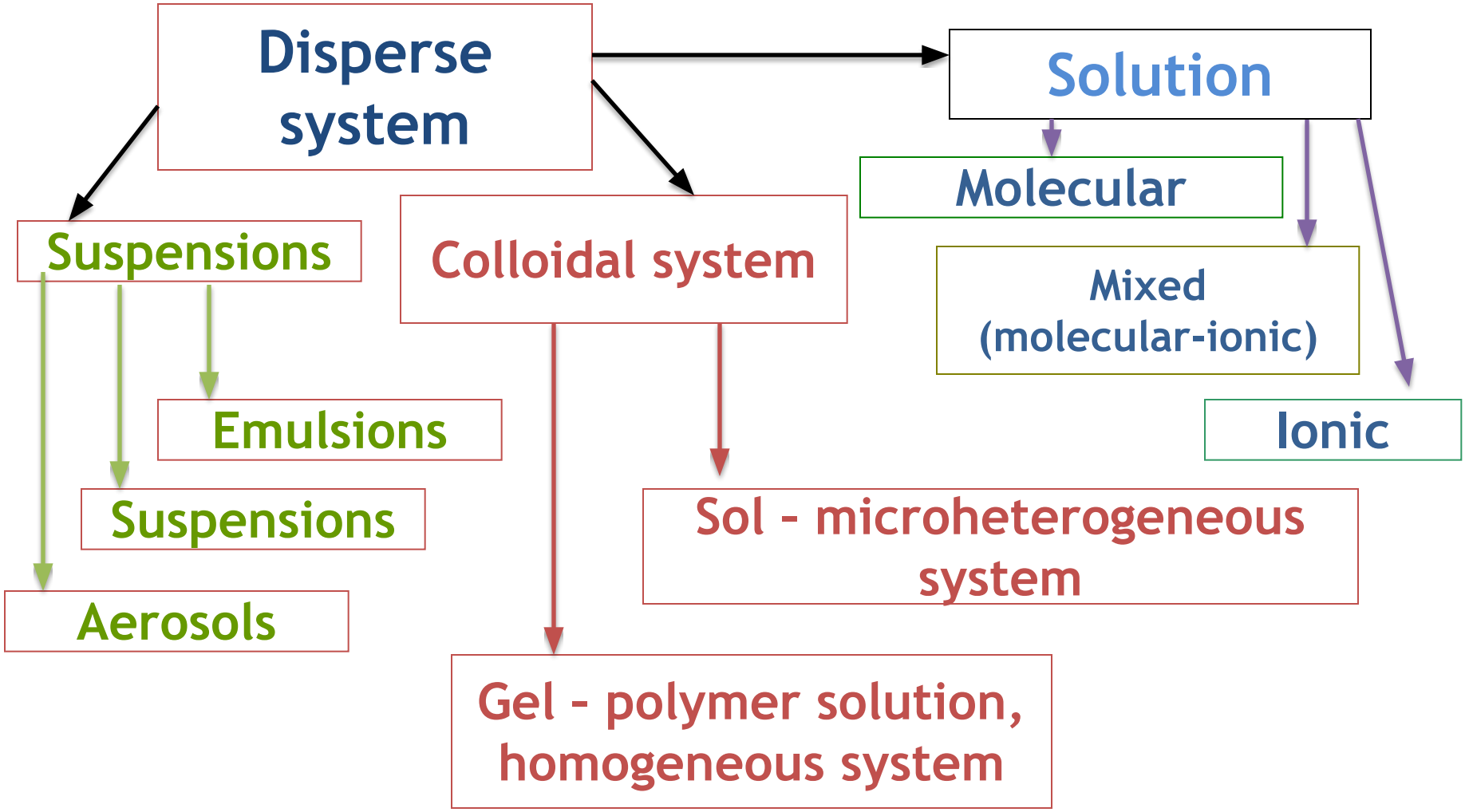
Disperse called the mixture in which one substance in the form of very small particles (in the form of droplets, dust, gas bubbles) is uniformly distributed in a medium (volume) of the other.

Disperse System composed of:

- **Dispersed phase** – substance that is distributed
- **Dispersion medium** – the continuous Phase or vehicle (acts as a solvent)



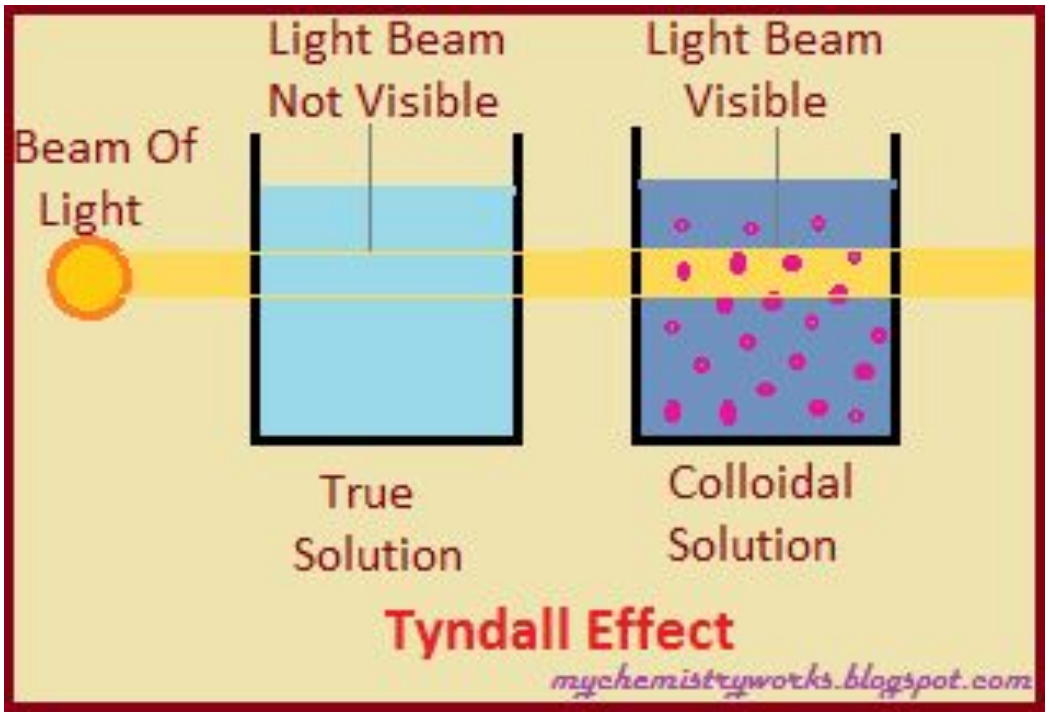
Classification of Disperse systems and Solution



Classification of Disperse Systems by Physical State

Continuous Phase / Disperse Phase	Solid	Liquid	Gas
Solid	**Solid suspensions**: glasses containing finely dispersed metals, e.g., ruby glass containing gold, pastes such as toothpaste	**Suspensions** and gels (Kaolin)	Smoke, dust
Liquid	**Solid emulsion** (mineral oil in wax), Cold cream	**Emulsions** such as milk, mayonnaise, oil in water	**Aerosol**: fog, mist, throat and nasal relief sprays
Gas	**Solid foam** (foamed plastic)	**Foams** (carbonated soft drinks)	**None**

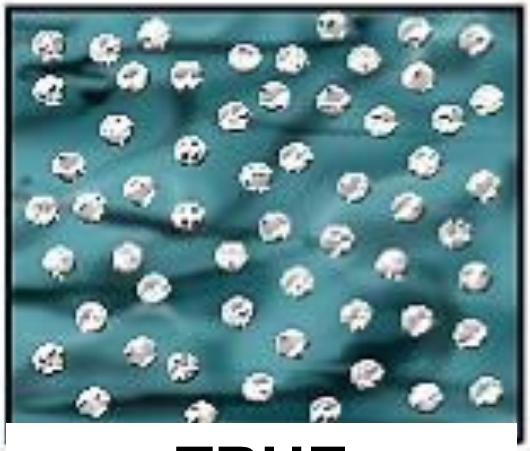
TYNDALL EFFECT IS OPTICAL PROPERTY OF SOLUTION

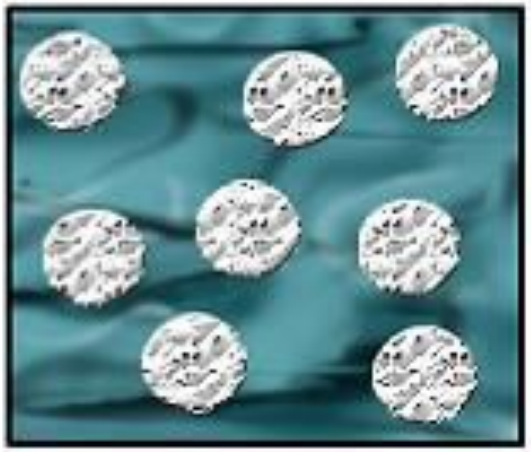


When light passes through a sol, its path becomes visible because of scattering of light by particles. It is called **Tyndall effect**.

This phenomenon was studied for the first time by Tyndall. The illuminated path of the beam is called **Tyndall cone.**

TYPES OF DISPERES SYSTEMS BY PARTICLE SIZE





TRUE SOLUTION
$D<10^{-9}$ cm

COLLOIDAL SYSTEM
$D = 10^{-7} – 10^{-9}$ cm

SUSPENSIONS
$D> 10^{-7}$ cm

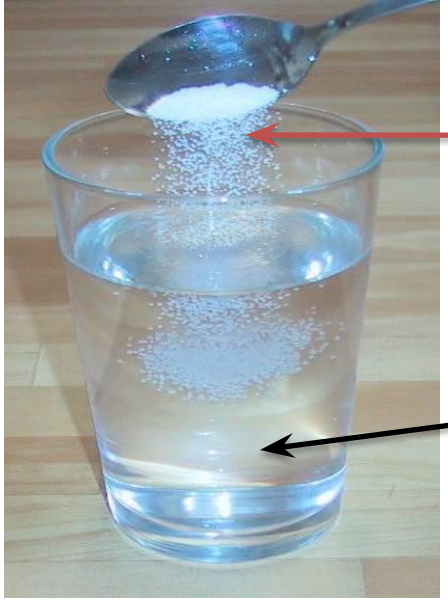
System properties	SOLUTION	COLLOIDAL SYSTEM	SUSPENSIONS
Appearance	Clear, transparent, homogeneous and stability	Cloudy but uniform and microhetero-gen eous	Cloudy, hetero-geneous, at least two substances visible
Particle Size	molecule or ion in size (10^{-7} – 10^{-9} cm)	10-1000 Angstroms (10^{-3} – 10^{-7} cm)	larger than 10,000 Angstroms (10^{-3} – 10^{-5} cm)
Effect of Light Tyndall Effect	None – light passes through, particles do not reflect light	light is dispersed by colloidal particles	variable
Effect of Sedimentation	None	None	particles will eventually settle out
Visibility	Particles non visible even under the ultramicroscope	Particles visible under ultramicroscope	Particles visible even with naked eye

QUIZ ME

1 What is it a real solution?

- a heterogeneous mixture
- a pure substances in water
- a homogeneous mixture
- compound

NEXT



SOLUTE

+

SOLVENT

= SOLUTION

A SOLUTION is a homogeneous and stable mixture of 2 or more substances in a single phase

SOLUTE – the part of a solution that is being dissolved (usually the lesser amount)

SOLVENT – the part of a solution that dissolves the solute (usually the greater amount)

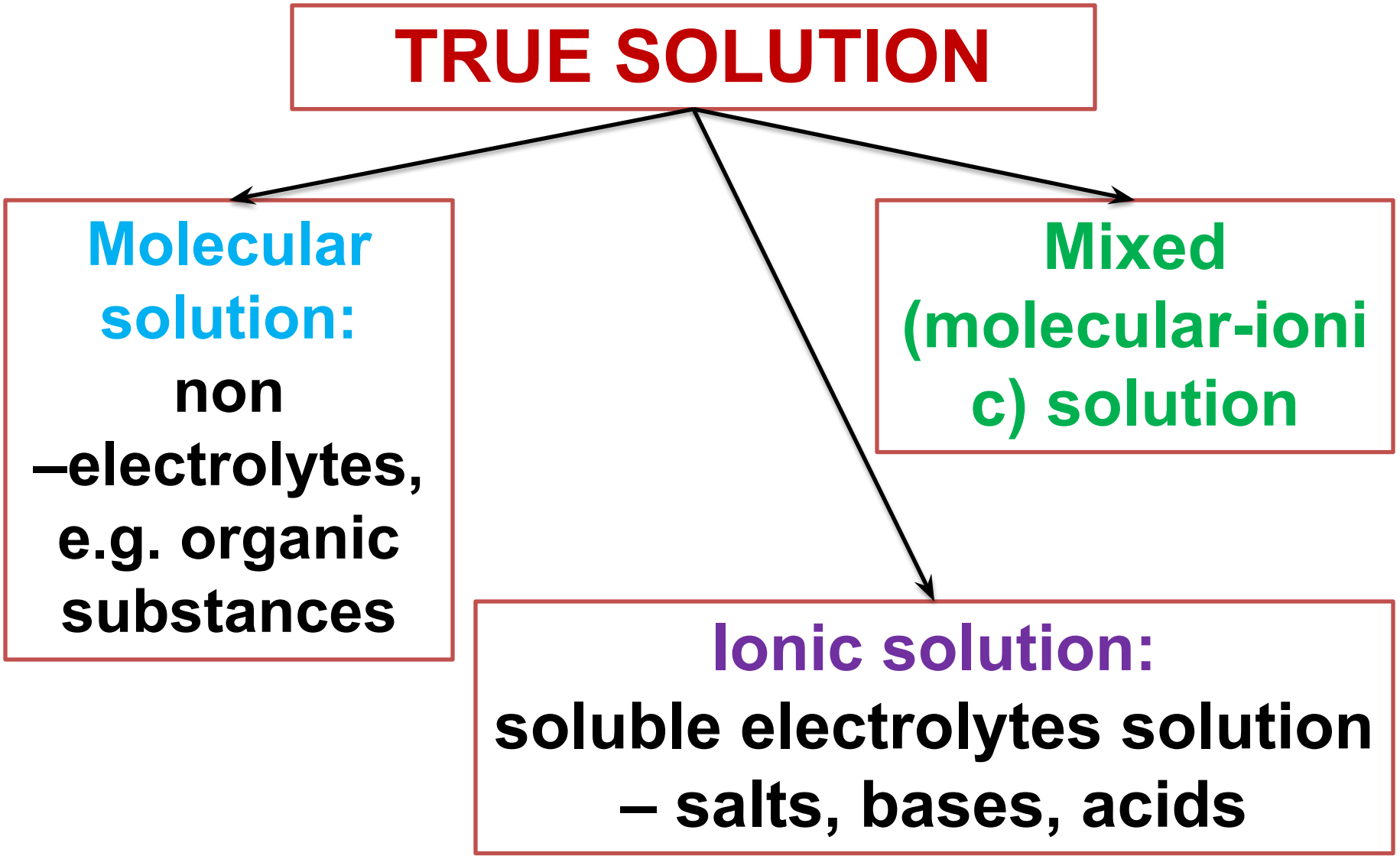
QUIZ ME

2 A solution consists of two parts. One part is the substance that is dissolved. What is the name of this part of a solution?

- solution
- solvent
- solute
- vehicle

NEXT

CLASSIFICATION OF SOLUTION BY NATURE OF SOLUTE



SOLUTE

Soluble – a substance that dissolves in a solvent

Insoluble – a substance that does not dissolve in a solvent

Solvation (dissolution) – the process of surrounding solute particles with solvent particles to form a solution

Water Soluble			
Compound	**Example**	**Exceptions**	**Exception Example**
Nitrates	$NaNO_3$	None	None
Chlorides, Bromides, and Iodides	NaCl	Compounds containing Ag^+, Pb^{2+}, or Hg^+, and HgI_2	AgCl
Sulfates	K_2SO_4	Compounds containing Pb^{2+}, Sr^{2+}, Ba^{2+}, or Hg^+	$PbSO_4$
Water Insoluble			
Compound	**Example**	**Exceptions**	**Exception Example(s)**
Hydroxides	$Mg(OH)_2$	Compounds containing alkali (Group I) metals *or* Ca^{2+}, Sr^{2+}, Ba^{2+}, NH_4^+	NaOH
Phosphates, Carbonates, and Chromates	$FePO_4$	Compounds containing alkali (Group I) metals *or* NH_4^+	K_2CO_3, Li_3PO_4, Na_2CrO_4

CLASSIFICATION OF SOLUTION BY NATURE OF SOLVENT

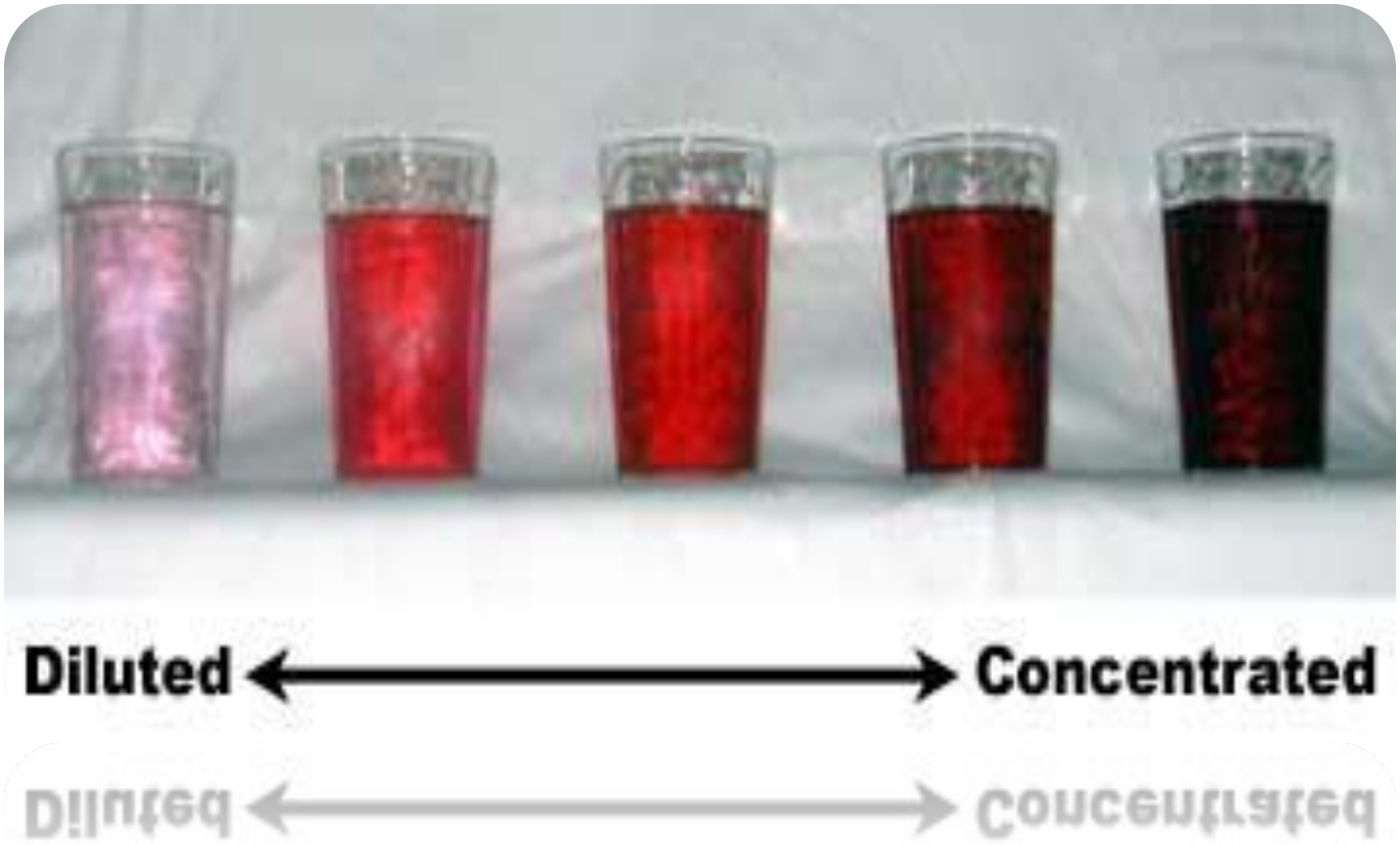
Solute	Solvent	Resulting State of Solution	Examples
gas	gas	gas	air
gas	liquid	liquid	soda water
gas	solid	solid	H_2 gas in palladium
liquid	liquid	liquid	whiskey
solid	liquid	liquid	NaCl in water
solid	solid	solid	**Bronze, pewter, 14K gold**

SOLUBILITY refers to the maximum amount of solute, expressed in grams, that can be dissolved in 100 g of water at a specific temperature and pressure.

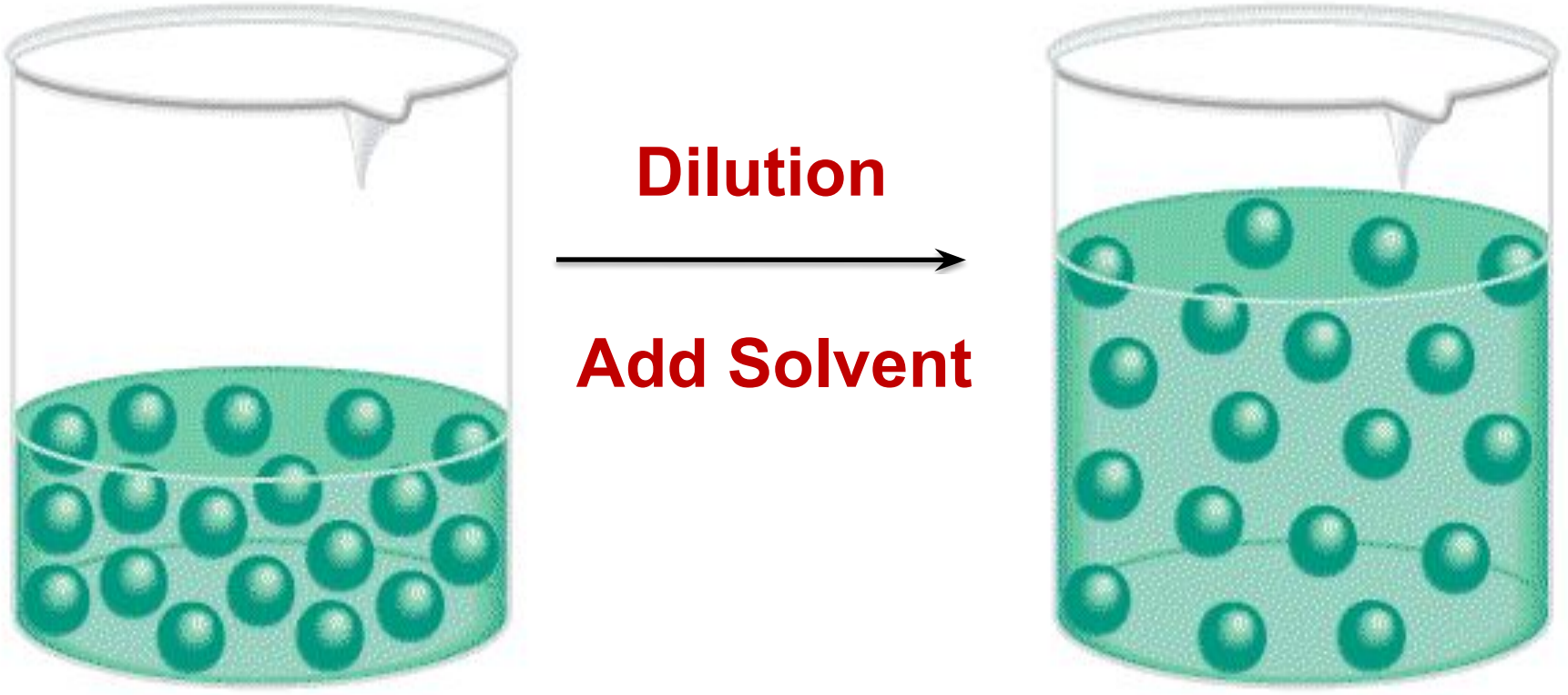
- **UNSATURATED – a solution that contains less dissolved solute**
- **SATURATED – a solution that contains the maximum amount of dissolved solute**
- **SUPERSATURATED – a solution that contains more dissolved solute than a saturated solution at the same temperature (**as result solute will usually precipitate out of solution**)**

The Diluted is a solution in which small amount of solute dispersed in the solvent

The Concentrated is a solution in which large amount of solute is dissolved in the solvent



Dilution is the procedure for preparing a less concentrated solution from a more concentrated solution.



Solute-Solvent Interactions

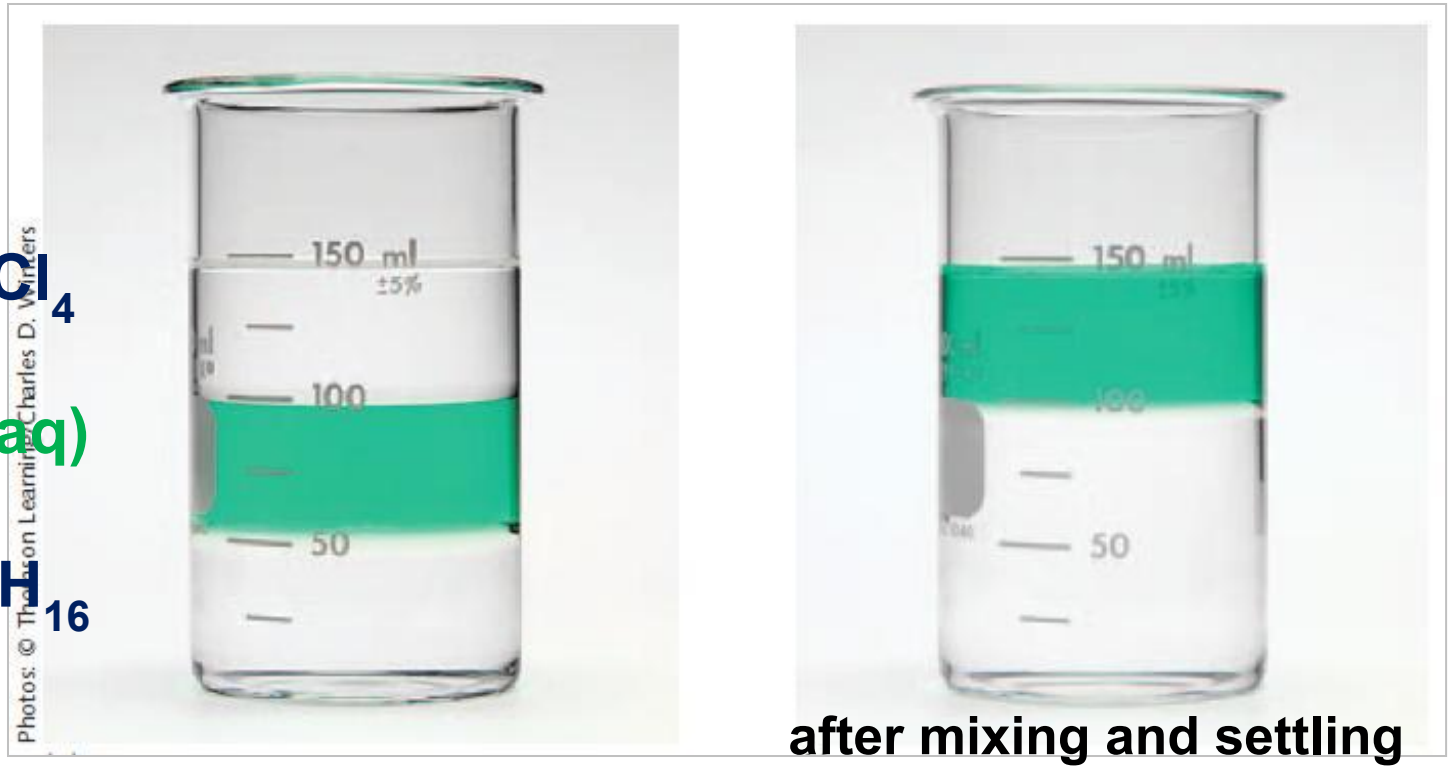
Miscible liquids dissolve in <u>all proportions</u>, e.g. ethanol and water (both H-bonded polar liquids).

Immiscible liquids form distinct separate phases, e.g. gasoline (non-polar) and water (polar).

colorless CCl_4

green $NiCl_2(aq)$

colorless C_7H_{16}



after mixing and settling

Factors affecting solubility

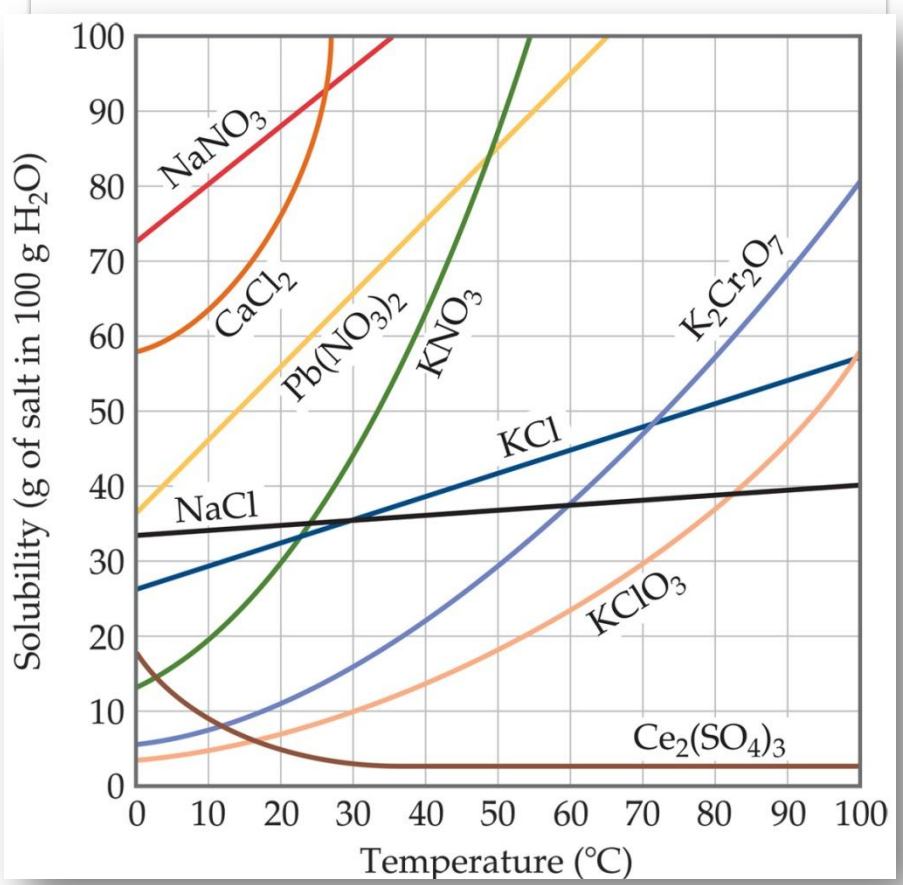
1) **The nature of the solute and solvent:**
   - Polar substances tend to dissolve in polar solvents.
   - Non-polar substances tend to dissolve in non-polar solvents.

2) **Temperature** – solubility usually increases as *T* increases

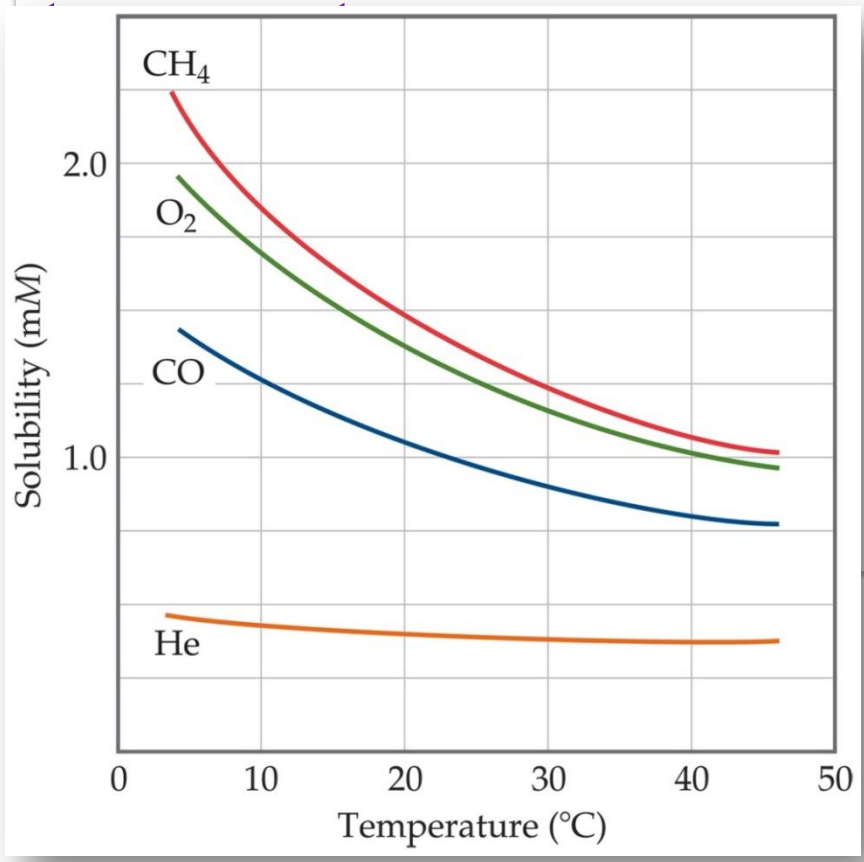
3) **Pressure** – for gas solution solubility increases with the P

Affecting Temperature on Solubility

Generally, the solubility of *solid* solutes in liquid solvents increases

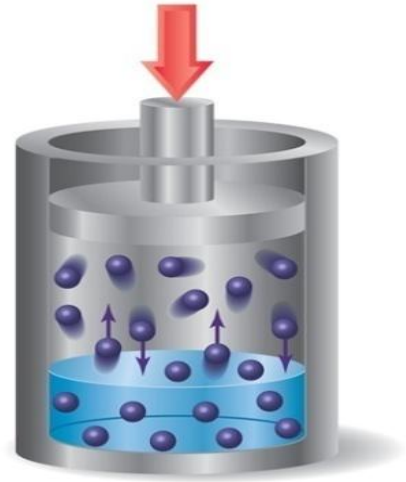


The solubility of *gas* solutes in liquid solvents decreases with increasing

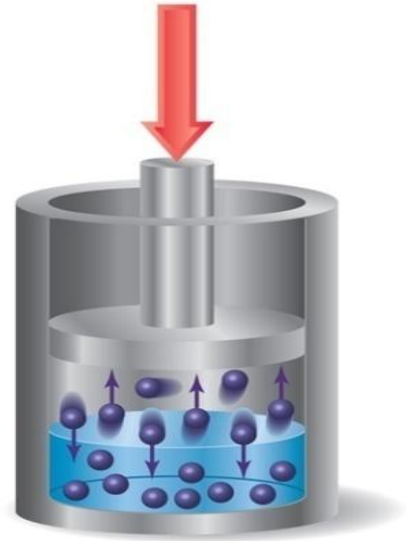


Gases in Solution

Increasing pressure above solution forces more gas to dissolve.



(a)



(b)

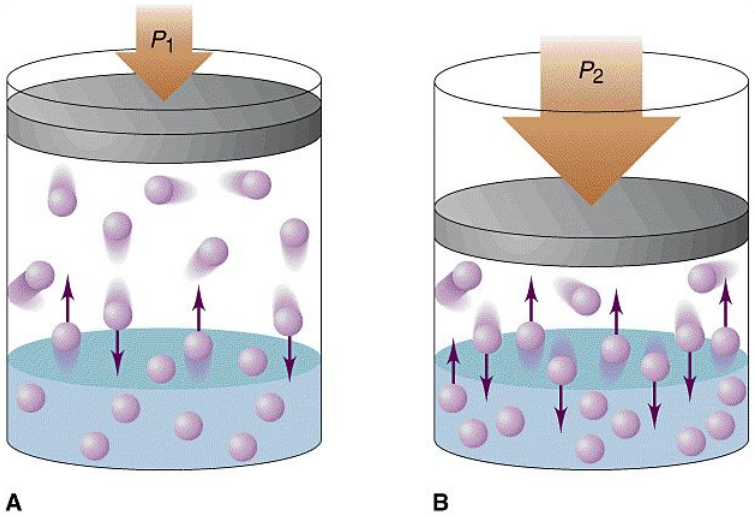
(p)

The solubility of ***liquids*** and ***solids*** does not change appreciably with pressure.

But, the solubility of a ***gas*** in a liquid is directly proportional to its pressure.

Pressure and Solubility of Gases

The solubility of a gas in a liquid is proportional to the partial pressure of the gas over the solution (*Henry's law*).



$$c = k \bullet P$$

c is the concentration (*mol*) of the dissolved gas
P is the partial pressure of the gas over the solution
k is a constant (mol/L•atm) that depends only on temperature

The solubility product constant, K_{sp}, is the equilibrium constant for a solid substance dissolving in an aqueous solution. It represents the level at which a solute dissolves in solution:

$$K_xA_y \Leftrightarrow xK^{+n} + yA^{-m}$$

$$K_{sp(K_xA_y)} = [K^{+n}]^x \cdot [A^{-m}]^y$$

$$Ca_3(PO_4)_2 \Leftrightarrow 3Ca^{2+} + 2PO_4^{3-}$$

$$K_{sp} = [Ca^{2+}]^3 \cdot [PO_4^{3-}]^2$$

QUIZ ME

3 The amount of a solute dissolved in a given amount of solvent is represented by the …

- Mass of the solution
- Volume of the solution
- Mass of the solute
- Concentration of the solute

NEXT

Concentration Units

The *concentration* of a solution is the amount of solute present in a given quantity of solvent or solution.

There are many different units for this purpose, including:

- **Percent by weight or volume,**
- **Molarity,**
- **Normality,**
- **Molality,**
- **Titer.**

1) **Percent composition by mass** is the mass of the solute divided by the mass of the solution, multiplied by 100 (%):

$$C_{\%} = \frac{m_{solute}}{m_{s\ln}} \cdot 100\% = \frac{m_{solute}}{m_{solute} + m_{solvent}} \cdot 100\% = \frac{m_{solute}}{V_{s\ln} \cdot \rho} \cdot 100\%$$

2) **Molarity** is the number of moles of solute per liter of solution (*mol/l*):

$$C_M = \frac{\nu}{V} = \frac{m_{solute}}{M \cdot V_{s\ln}}$$

3) **Normality** is equal to the gram equivalent weight of a solute per 1 liter of solution (*mol*eq/l*):

$$C_N = \frac{m_{solute}}{Eq \cdot V_{sln}}$$

4) **Molality** is the number of moles of solute per 1 kilogram of solvent (*mol/kg*):

$$C_m = \frac{\nu_{moles} \cdot 1000}{m_{solvent(g)}} = \frac{m_{solute} \cdot 1000}{M_{solute} \cdot m_{solvent}}$$

5) **Titer** is equal to the gram of a solute per 1 milliliter of solution (*g/ml*):

$$T = \frac{m_{solute}}{Vs\,\ln\ (ml)} = \frac{C_N \cdot Eq}{1000}$$

Steps involved in the preparation of a standard solution