

# LECTURE №4

## DISPERSE SYSTEMS. TRUE SOLUTION

21.02.2017

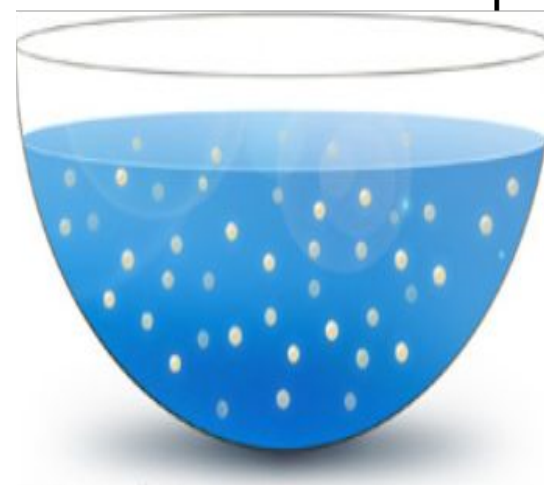
## EDUCATIONAL GOALS



- 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.***

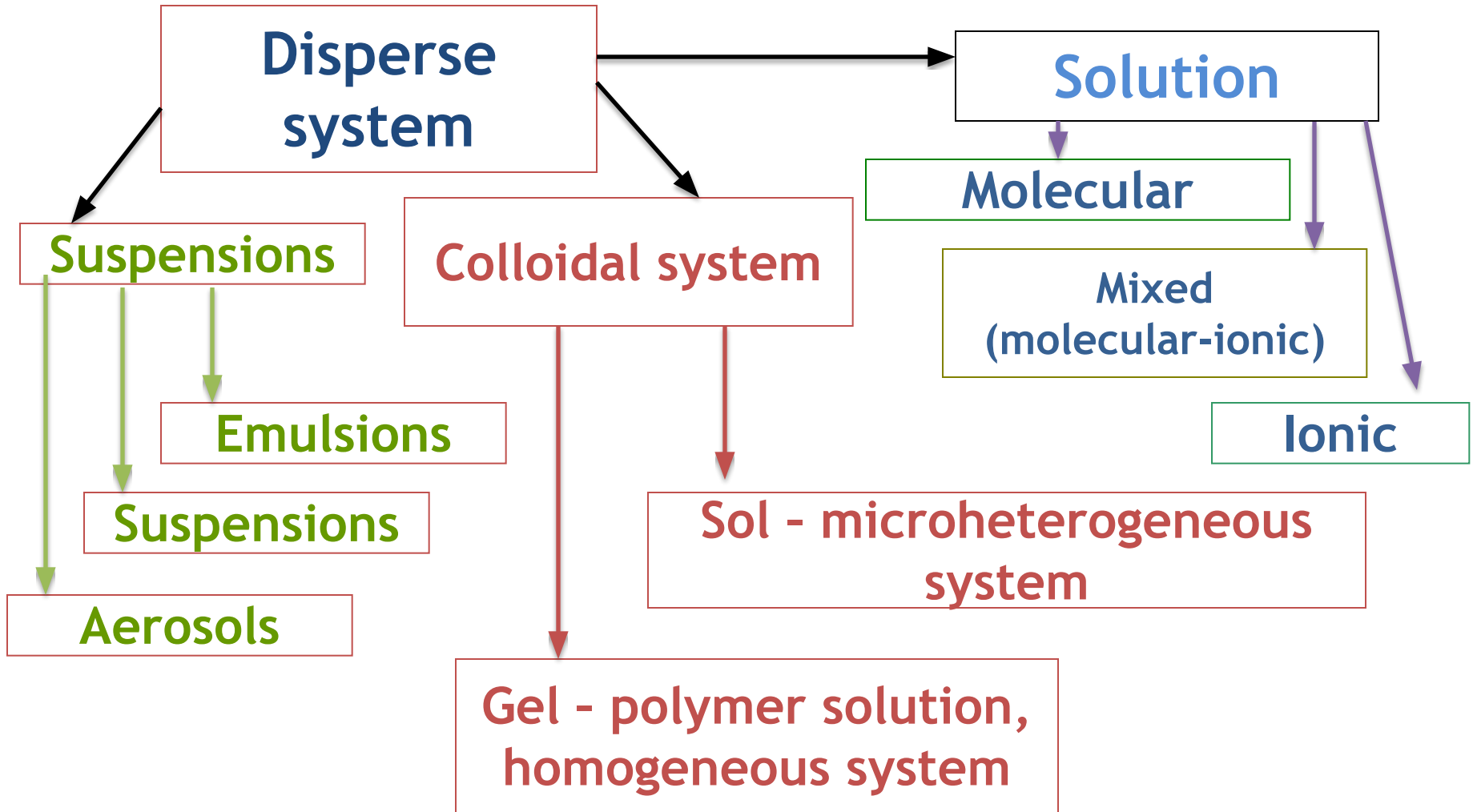
**Disperse                      System**  
**composed of:**

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



 дисперсная фаза  
 дисперсионная среда

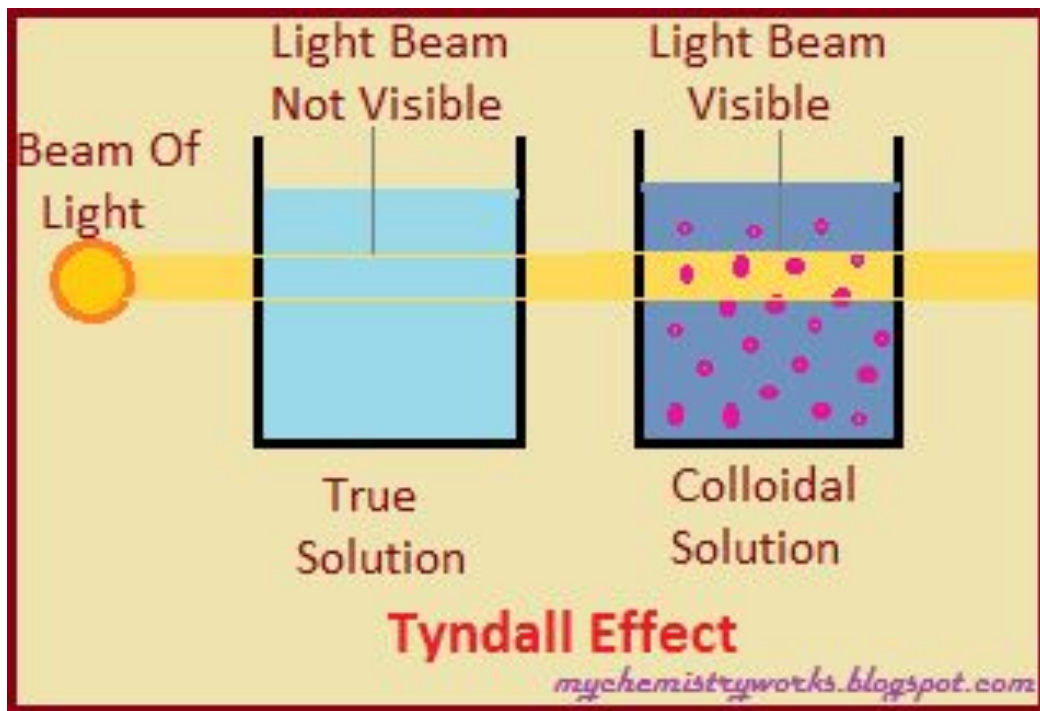
# Classification of Disperse systems and Solution



# Classification of Disperse Systems by Physical State

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

# 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 DISPERSION SYSTEMS BY PARTICLE SIZE



$10^{-9}$



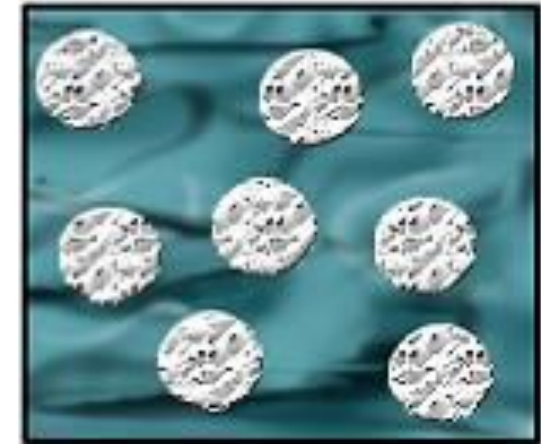
cm



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



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



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

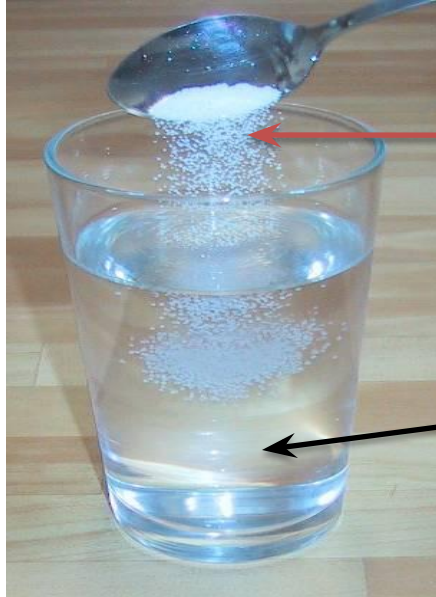
<b>System properties</b>	<b>SOLUTION</b>	<b>COLLOIDAL SYSTEM</b>	<b>SUSPENSIONS</b>
<b>Appearance</b>	Clear, transparent, homogeneous and stability	Cloudy but uniform and microheterogeneous	Cloudy, hetero-geneous, at least two substances visible
<b>Particle Size</b>	molecule or ion in size ( $10^{-7} - 10^{-9}$ cm)	10-1000 Angstroms ( $10^{-3} - 10^{-7}$ cm)	larger than 10,000 Angstroms ( $10^{-3} - 10^{-5}$ cm)
<b>Effect of Light Tyndall Effect</b>	None – light passes through, particles do not reflect light	light is dispersed by colloidal particles	variable
<b>Effect of Sedimentation</b>	None	None	particles will eventually settle out
<b>Visibility</b>	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



**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**

# CLASSIFICATION OF SOLUTION BY NATURE OF SOLUTE

**TRUE SOLUTION**

**Molecular solution:**  
non  
–electrolytes,  
e.g. organic  
substances

**Mixed  
(molecular-ionic)  
solution**

**Ionic solution:**  
soluble electrolytes solution  
– salts, bases, acids

# SOLUTE

```
graph TD; Solute[SOLUTE] --> Soluble[Soluble]; Solute --> Insoluble[Insoluble];
```

**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	$\text{NaNO}_3$	None	None
Chlorides, Bromides, and Iodides	$\text{NaCl}$	Compounds containing $\text{Ag}^+$ , $\text{Pb}^{2+}$ , or $\text{Hg}^+$ , and $\text{HgI}_2$	$\text{AgCl}$
Sulfates	$\text{K}_2\text{SO}_4$	Compounds containing $\text{Pb}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Ba}^{2+}$ , or $\text{Hg}^+$	$\text{PbSO}_4$

## Water Insoluble

Compound	Example	Exceptions	Exception Example(s)
Hydroxides	$\text{Mg}(\text{OH})_2$	Compounds containing alkali (Group I) metals <u>or</u> $\text{Ca}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Ba}^{2+}$ , $\text{NH}_4^+$	$\text{NaOH}$
Phosphates, Carbonates, and Chromates	$\text{FePO}_4$	Compounds containing alkali (Group I) metals <u>or</u> $\text{NH}_4^+$	$\text{K}_2\text{CO}_3$ , $\text{Li}_3\text{PO}_4$ , $\text{Na}_2\text{CrO}_4$

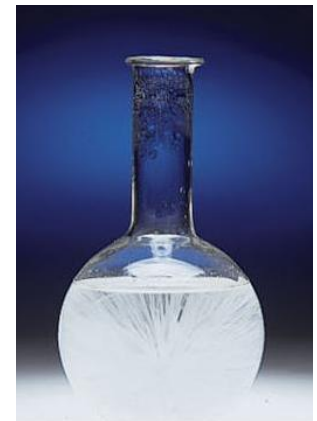


## CLASSIFICATION OF SOLUTION BY NATURE OF SOLVENT

<b>Solute</b>	<b>Solvent</b>	<b>Resulting State of Solution</b>	<b>Examples</b>
<b>gas</b>	<b>gas</b>	<b>gas</b>	air
<b>gas</b>	<b>liquid</b>	<b>liquid</b>	soda water
<b>gas</b>	<b>solid</b>	<b>solid</b>	H <sub>2</sub> gas in palladium
<b>liquid</b>	<b>liquid</b>	<b>liquid</b>	whiskey
<b>solid</b>	<b>liquid</b>	<b>liquid</b>	NaCl in water
<b>solid</b>	<b>solid</b>	<b>solid</b>	Bronze, pewter, 14K gold

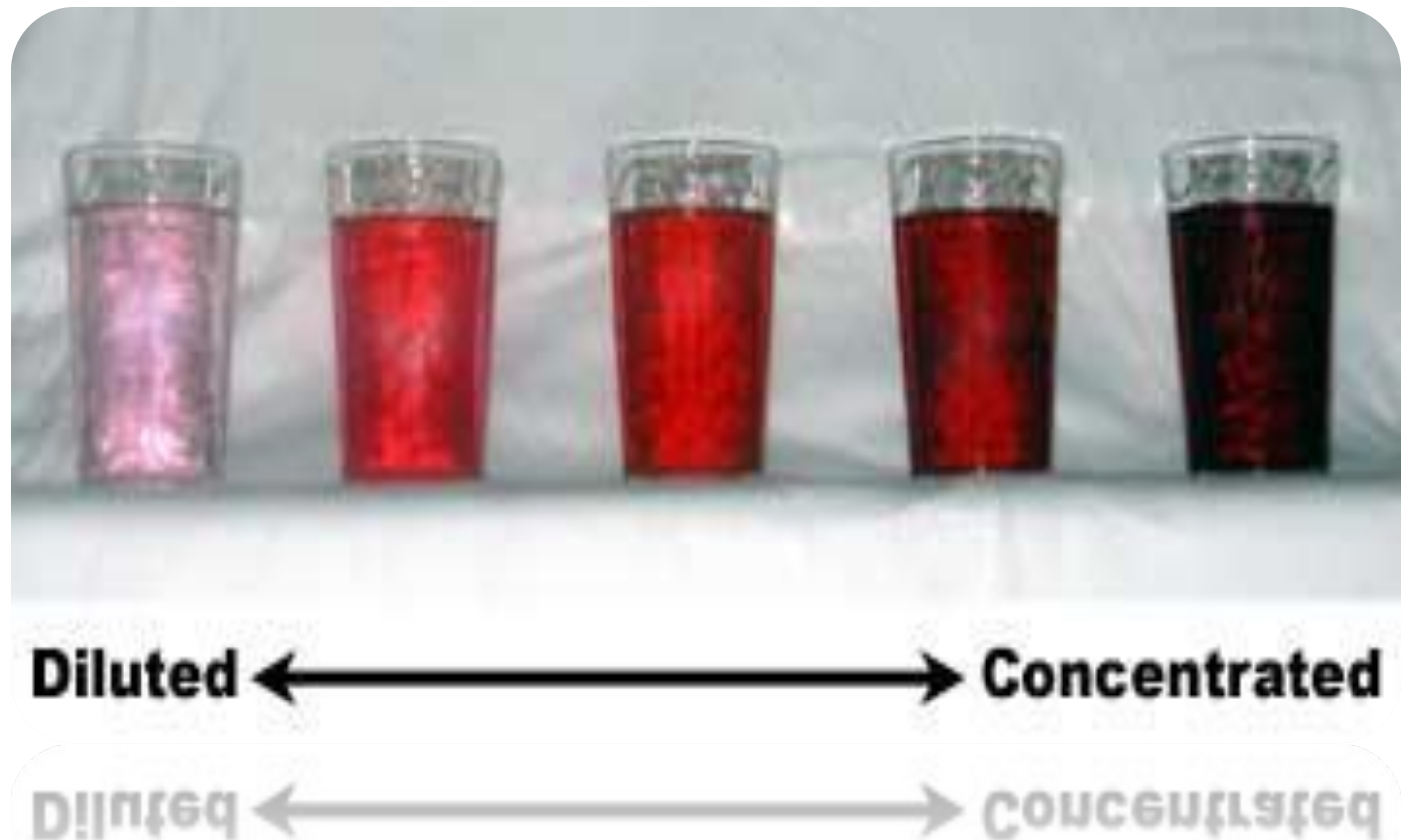
**SOLUBILITY** refers to the maximum amount of solute, expressed in grams, that can be dissolved in 100 g of water at a specific temperature and pressure.

- **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)

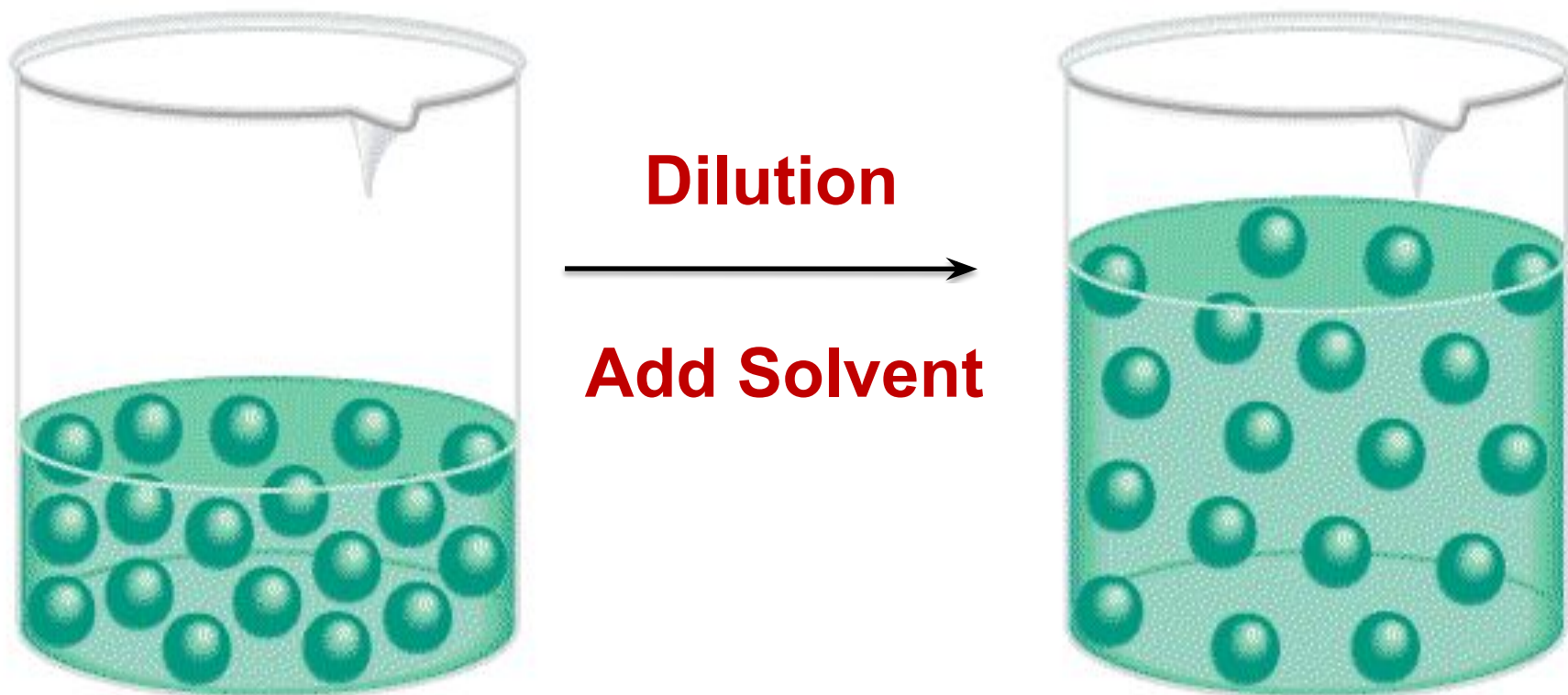


**The Diluted** is a solution in which small amount of solute dispersed in the solvent

**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

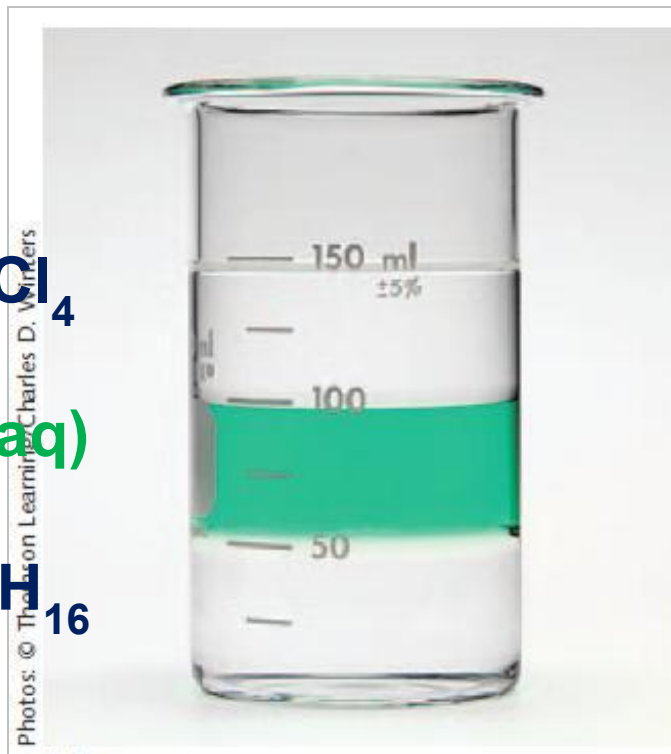
**Miscible** liquids dissolve in all proportions, e.g. ethanol and water (both H-bonded polar liquids).

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

colorless  $\text{CCl}_4$

green  $\text{NiCl}_2(\text{aq})$

colorless  $\text{C}_7\text{H}_{16}$



Photos: © Thomson Learning/Charles D. Wilkins



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

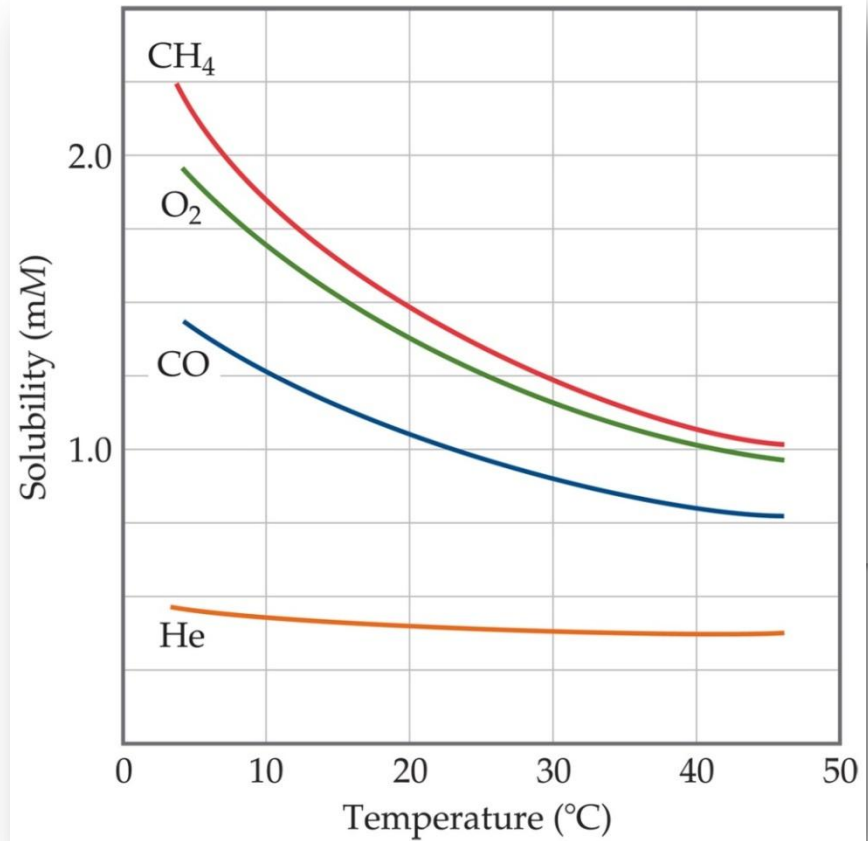
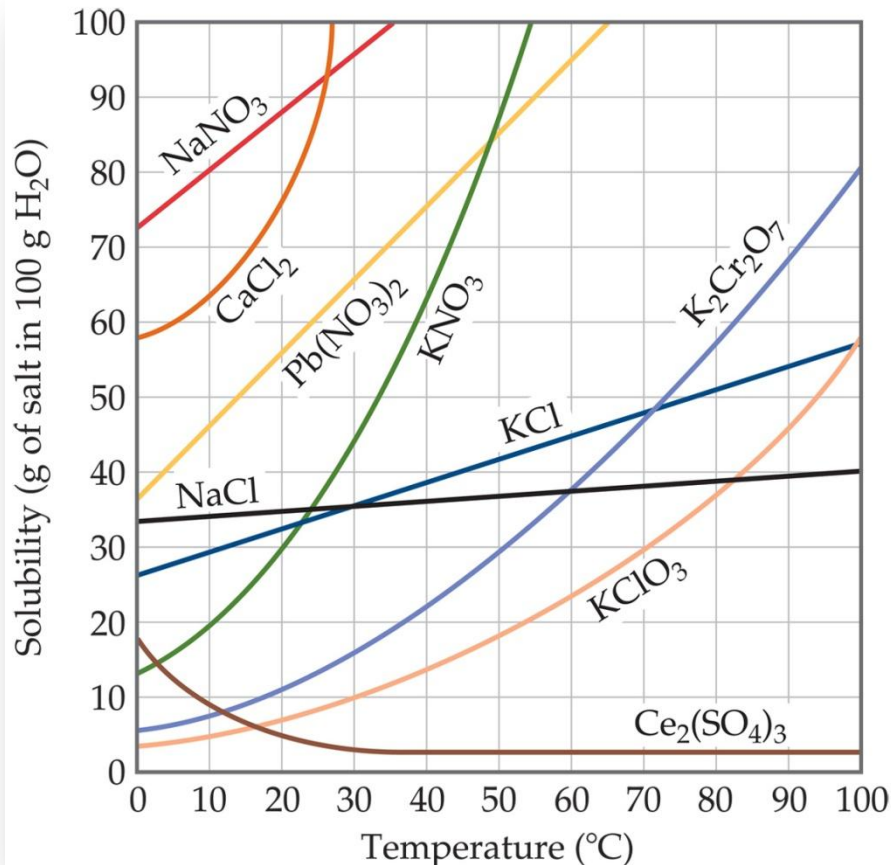
3) **Pressure** – for gas solution solubility increases with the  $P$



# Affecting Temperature on Solubility

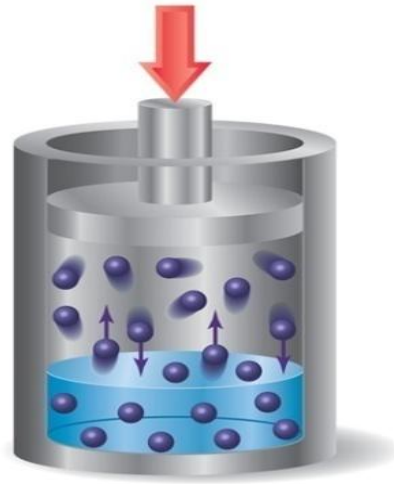
Generally, the solubility of solid solutes in liquid solvents increases

The solubility of gas solutes in liquid solvents decreases with increasing

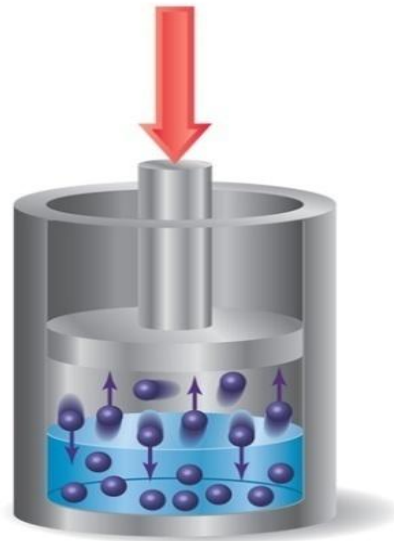


# Gases in Solution

Increasing pressure above solution forces more gas to dissolve.



(a)



(b)

(P)

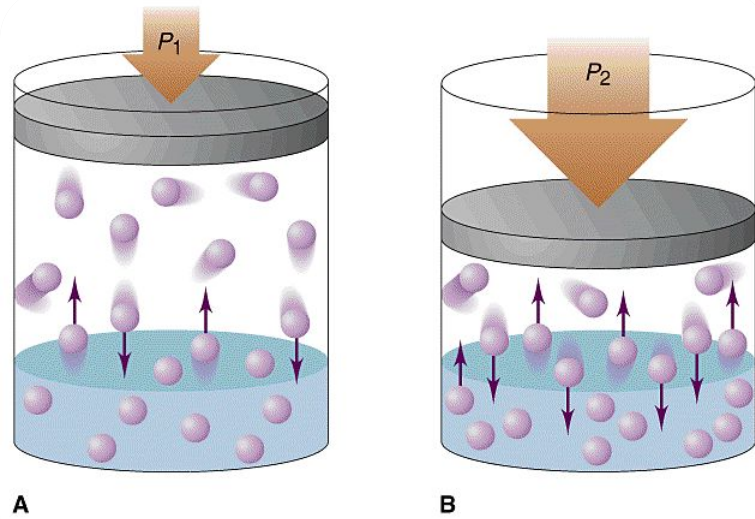
The solubility of *liquids* and *solids* does not change appreciably with pressure.

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*).



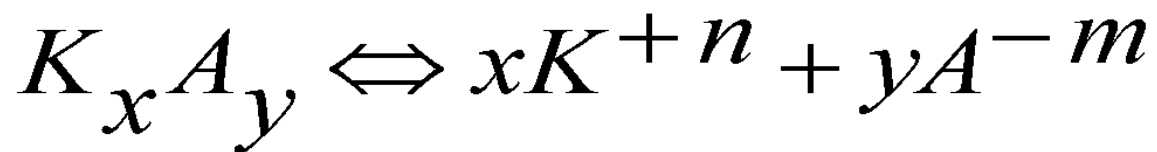
$$c = k \cdot P$$

**c** is the concentration (*mol*) of the dissolved gas

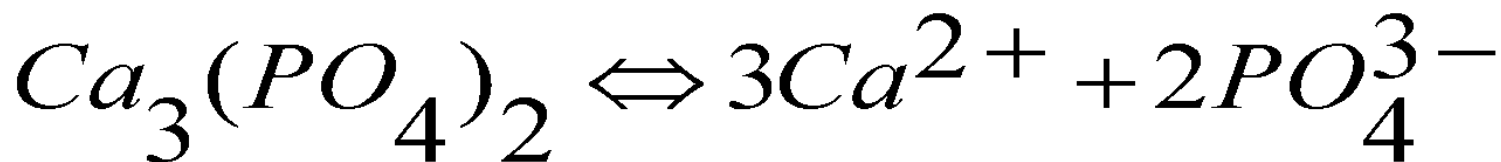
**P** is the partial pressure of the gas over the solution

**k** is a constant ( $\text{mol/L} \cdot \text{atm}$ ) 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:**



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



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

# 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

# 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 (%):

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

2) **Molarity** is the number of moles of solute per liter of solution ( $\text{mol/l}$ ):

$$C_M = \frac{v}{V} = \frac{m_{\text{solute}}}{M \cdot V_{\text{soln}}}$$

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

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

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

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

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

$$T = \frac{m_{\text{solute}}}{V_{\text{soln}} \text{ (ml)}} = \frac{C_N \cdot Eq}{1000}$$

# Steps involved in the preparation of a standard solution

