Solutions and its types

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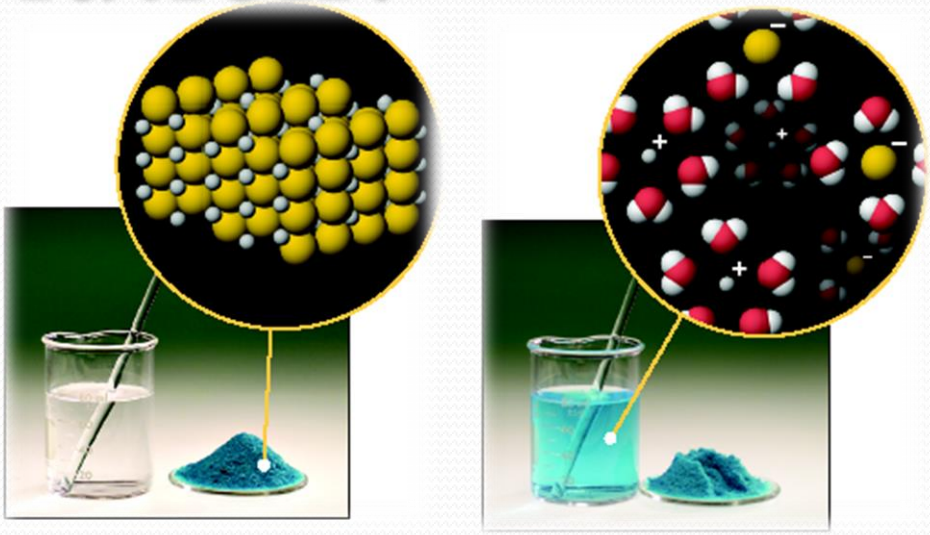
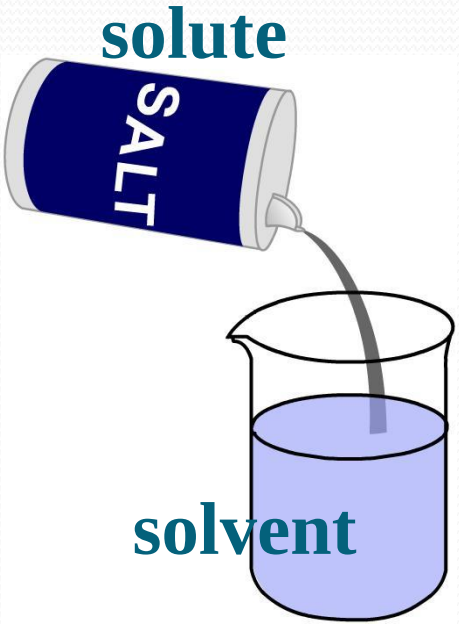
I. What is a solution?

A solution is a **homogeneous** mixture of 2 or more substances in a single phase.

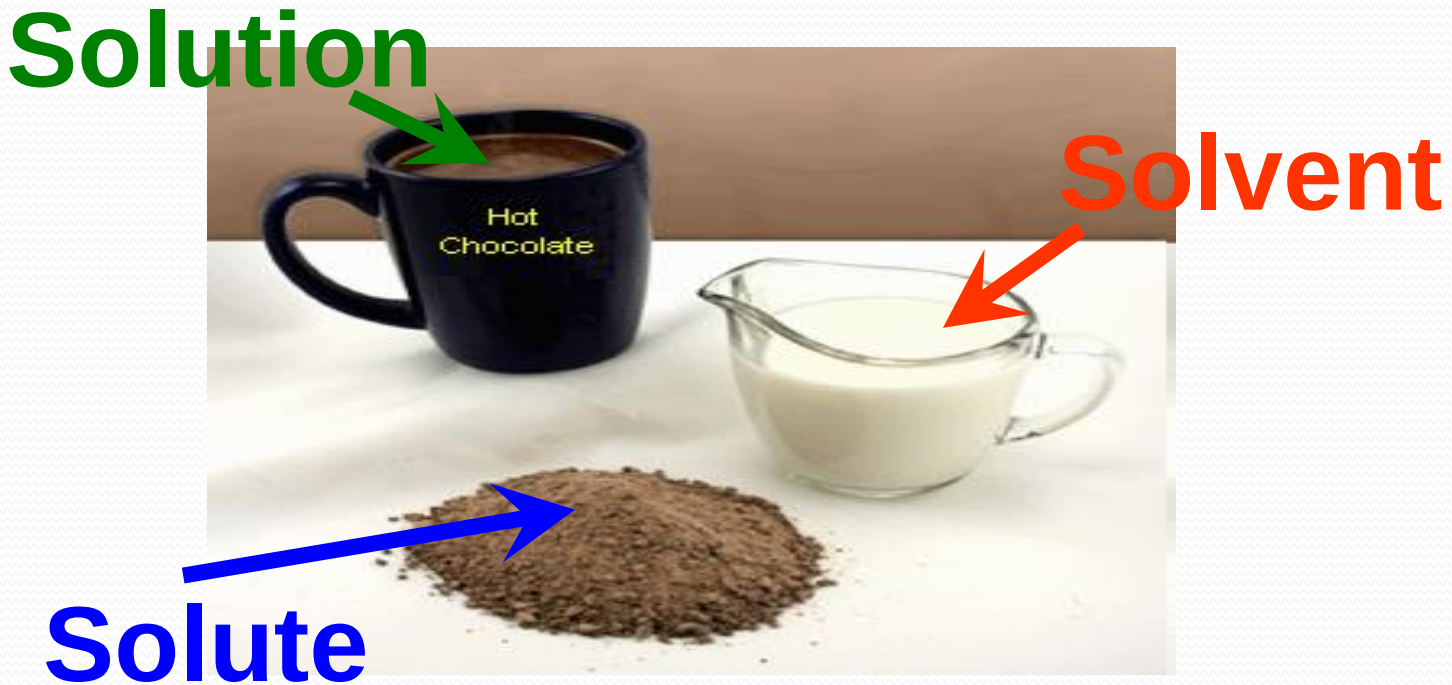


One constituent is usually regarded as the **SOLVENT** and the others as **SOLUTES**.



Parts of a Solution

- **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)
- **Solute + Solvent = Solution**

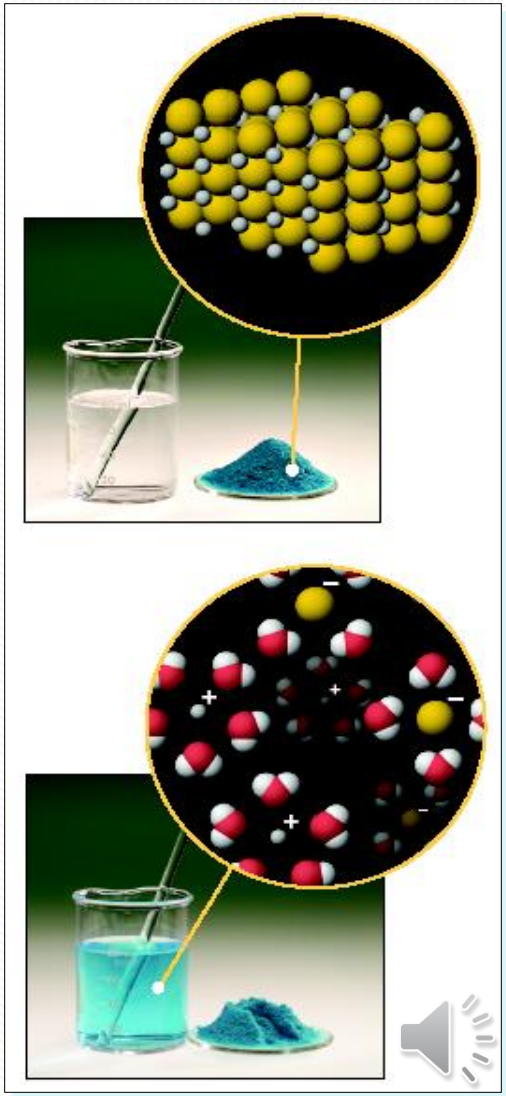


Characteristics

- A solution is a homogeneous mixture.
- The particles of solute in a solution cannot be seen by naked eye.
- A solution is stable.
- The solute from a solution cannot be separated by simple filtration.

Nature of Solutes in Solutions

- Spread evenly throughout the solution
- Cannot be separated by filtration
- Can be separated by evaporation
- Not visible, solution appears transparent
- May give a color to the solution



Soluble/Insoluble vs. Miscible/Immiscible

- **SOLUBLE** – a substance that can be dissolved.
- **INSOLUBLE** – a substance that CANNOT be dissolved
- **MISCIBLE** – a liquid substance that is <u>soluble</u> in another liquid.
- **IMMISCIBLE** – a liquid substance that is <u>insoluble</u> in another liquid.

Types of Solutions

1. Gaseous solutions
2. Liquid solutions
3. Solid solutions--alloys

TYPES OF SOLUTION

- **1.Gaseous solutions**

If the solvent is a gas, gases are dissolved under a given set of conditions. An example of a gaseous solution is air.

- **2-Liquid solutions**

If the solvent is a liquid, then gases, liquids, and solids can be dissolved.

a. Gas in liquid:

- Oxygen in water
- Carbon dioxide in water

b. Liquid in liquid:

- Alcoholic beverages are basically solutions of ethanol in water.

c. Solid in liquid:

- Sucrose (table sugar) in water

- **3-Solid solutions**

If the solvent is a solid, then gases, liquids and solids can be dissolved.

- **a. Gas in solids**:
  - Hydrogen dissolves in metals, palladium.
- **b-Liquid in solid:**
  - Mercury in gold, forming an amalgam.
- **c-Solid in solid**:
  - Steel, basically a solution of carbon atoms in a crystalline matrix of iron atoms.

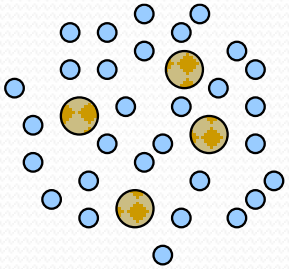
Types of Solutions

TABLE 7.1 Some Examples of Solutions

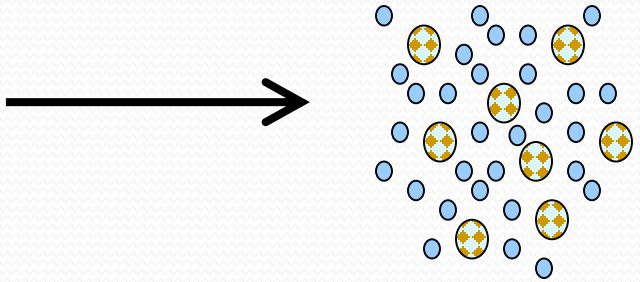
Type	Example	Solute	Solvent
Gas Solutions			
Gas in a gas	Air	Oxygen (gas)	Nitrogen (gas)
Liquid Solutions			
Gas in a liquid	Soda water	Carbon dioxide (gas)	Water (liquid)
	Household ammonia	Ammonia (gas)	Water (liquid)
Liquid in a liquid	Vinegar	Acetic acid (liquid)	Water (liquid)
Solid in a liquid	Seawater	Sodium chloride (solid)	Water (liquid)
	Tincture of iodine	Iodine (solid)	Alcohol (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)

Types of solution on basis of the amount of solute added

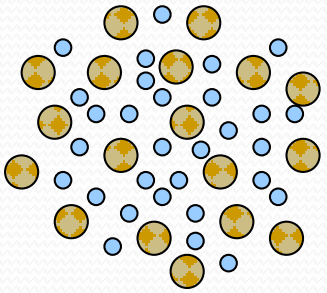
- ***Unsaturated*** - has a less than the maximum concentration of solute dissolved



- ***Saturated*** - has the maximum concentration of solute dissolved (can see solid in bottom of solution)



- ***Supersaturated*** -contains more dissolved solute than normally possible (usually requires an increase in temperature followed by cooling)



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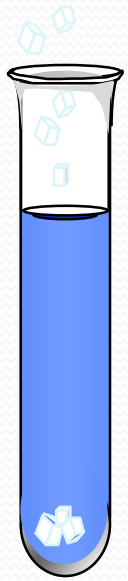
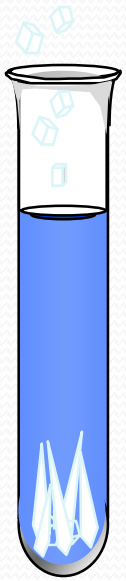
UNSATURATED SOLUTION
more solute dissolves

SATURATED SOLUTION
no more solute dissolves

SUPERSATURATED SOLUTION
becomes unstable, crystals form



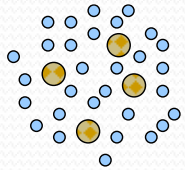


increasing concentration

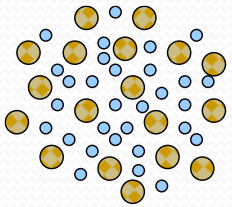
Types of solution on basis of the amount of solvent added;

- the amount of solute dissolved in a solvent at a given temperature

  •described as ***dilute*** if it has a low concentration of solute dissolved →



  •described as ***concentrated*** if it has a high concentration of solute dissolved →

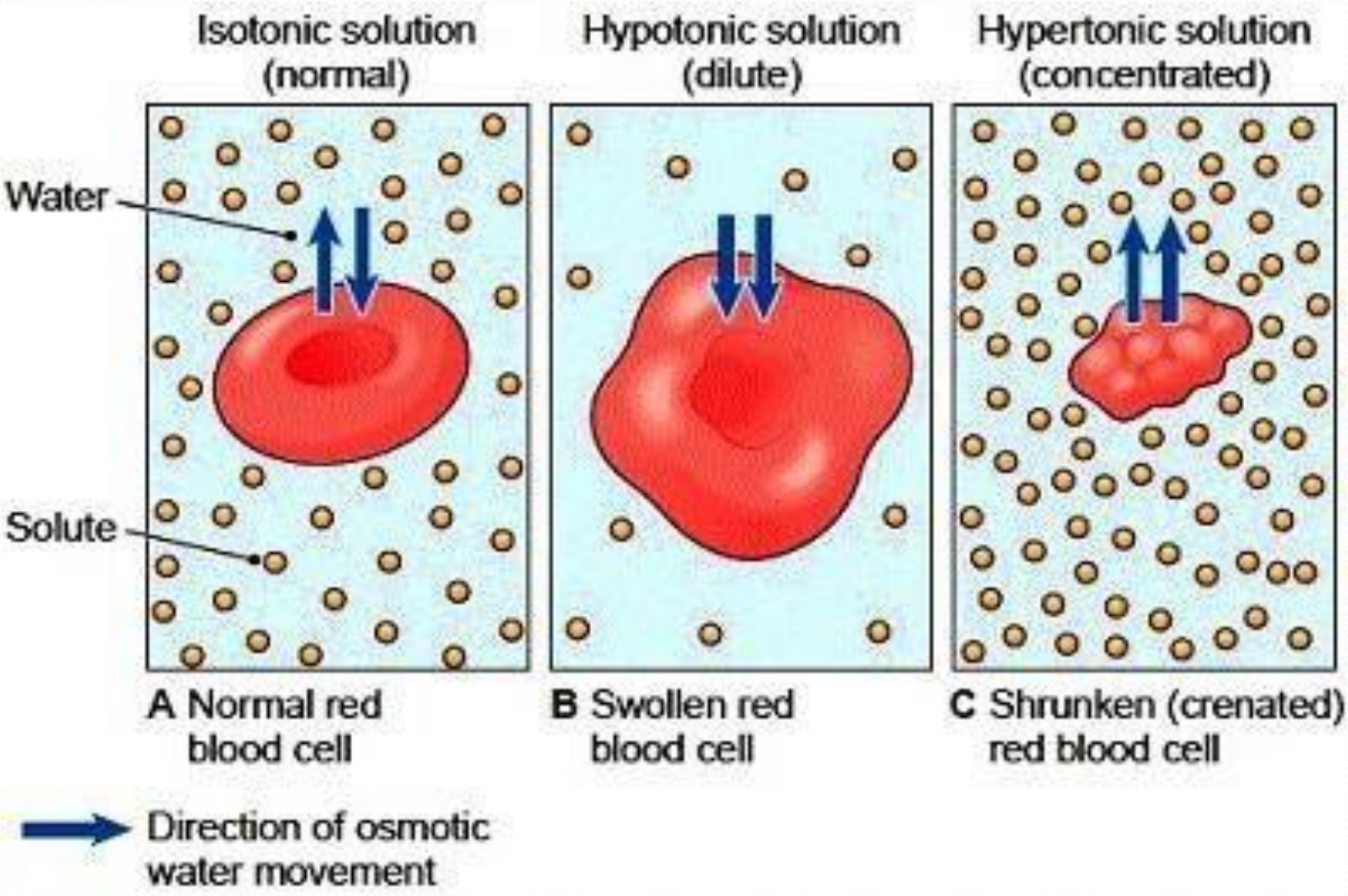


On the Basis of Concentration of Solute in Two Solutions

- Let us consider a cell placed in a solution in a beaker. Based on the concentration of solute in two solvents(in the cell and in the beaker), we can have the following types of solutions:
- **Isotonic Solution**: These solutions have the same concentration of the solute in it. Therefore, water moves across the cell from the solution in the beaker in both directions.

Con..

- **Hypertonic Solution**: The solution kept in beaker has a higher concentration of solute in it so water comes out of the cell and into the solution in beaker causing the cell to plasmolyze/shrink.
- **Hypotonic Solution**: The solution kept in beaker has a lower concentration of solute in it so water moves into the cell causing cells to swell up and finally burst.


Isotonic solution
(normal)
Hypotonic solution
(dilute)
Hypertonic solution
(concentrated)
Water
Solute
A Normal red blood cell
B Swollen red blood cell
C Shrunken (crenated) red blood cell
Direction of osmotic water movement

On the Basis of Water as Solvent

- **Aqueous solutions**: These solutions have water as the solvent. Examples of such solutions are sugar in water, carbon dioxide in water, etc.
- **Non-Aqueous Solutions**: These solutions have a solvent that is not water. It could be ether, benzene, petrol, carbon tetrachloride etc. Common examples include sulfur in carbon disulphide, naphthalene in benzene.

Solubility

- **Solubility**: the amount (grams of solute)of the substance that will dissolve in a 100g of water or other solvent to make it a saturated solution at a given temperature is known as solubility.

- The solubility of a solute can be changed
  - by raising the temperature
  - If solute is a gas…then you can change the pressure…higher pressure of gas in a liquid increases the amount of gas that can be dissolved.
  - Shaking
  - Particle size
  - Polarity

Factors affecting solubility

Temperature

increased temperature causes solids to dissolve faster

Shaking

Shaking (agitation) causes solids to dissolve faster

Particle Size

Smaller particles dissolve Faster because they have more surface area

Pressure

Increase in pressure causes the gases to dissolve more in liquids

Note: Increasing the amount of solute DOES NOT increase the rate of dissolving

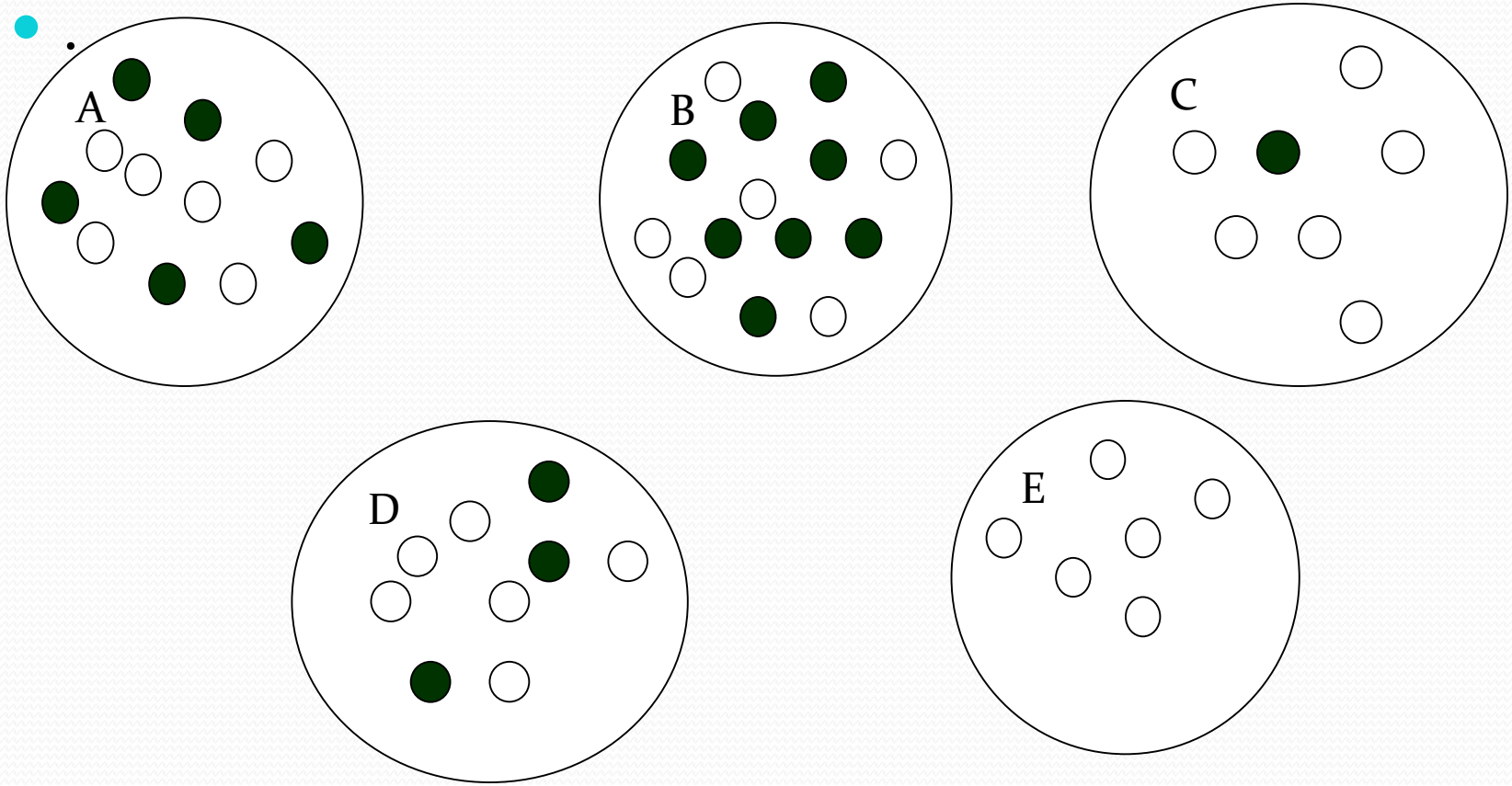
Solubility and Temperature

Solute	Increased Temperature	Decreased Temperature
Solid/liquid	Increase in solubility	Decrease in solubility
Gas	Decrease in solubility	Increase in solubility

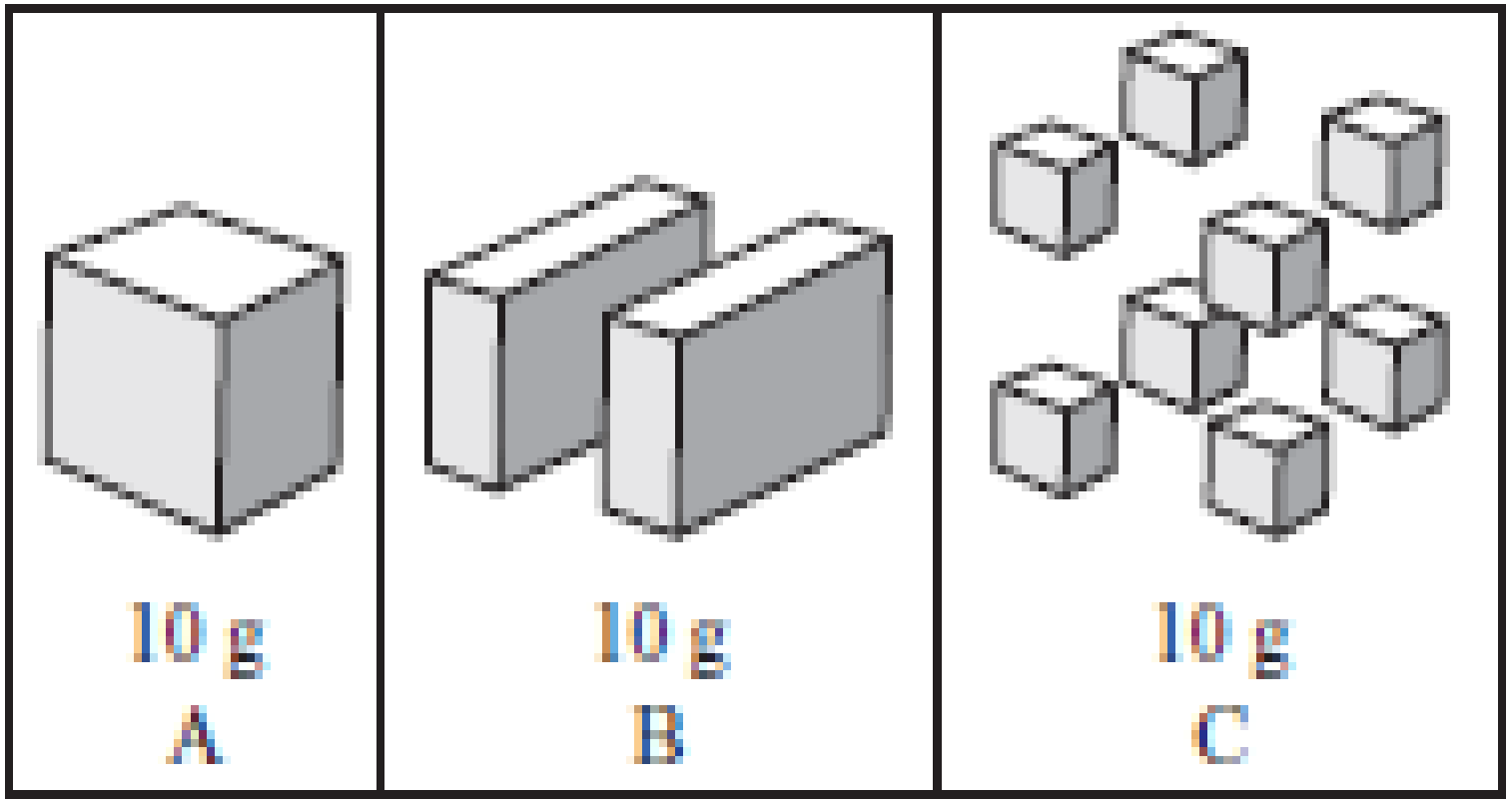
Solubility and Pressure

Solute	Increased Pressure	Decreased Pressure
Solid/liquid	No effect on solubility	No effect on solubility
Gas	Increase in solubility	Decrease in solubility

Which solution has the greatest, the least and no concentration of solute?



Which of these sugar cubes will dissolve the fastest and how do you know?



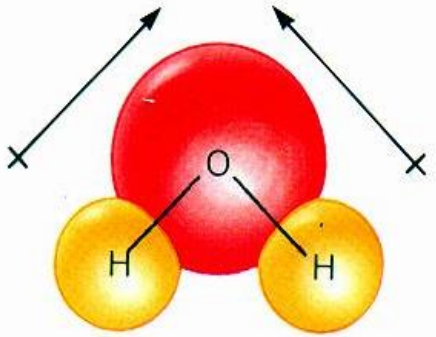
Water is the universal solvent

- because more substances dissolve in water than in any other chemical.

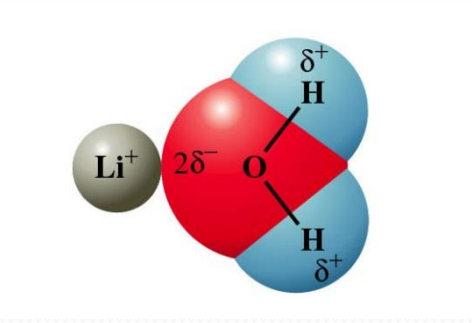
- This has to do with the polarity of each water molecule.

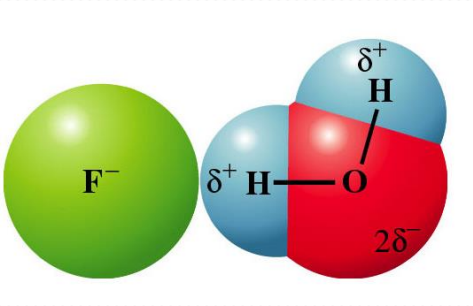
Water Molecules

- Are polar because O is more electronegative than H
  - Gives O a partial negative charge.
- Form strong intermolecular hydrogen bonds.
- Water molecules are attracted to one another better than other molecules.



Polar bonds

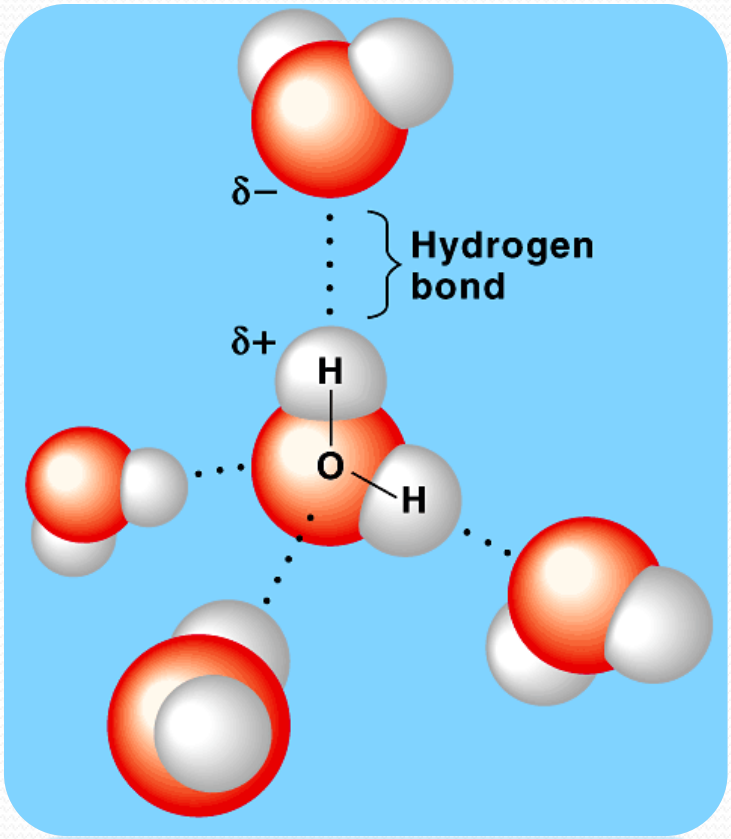




Hydrogen bonding

Hydrogen bonding occurs because of polarity

One water molecule bonds to another.



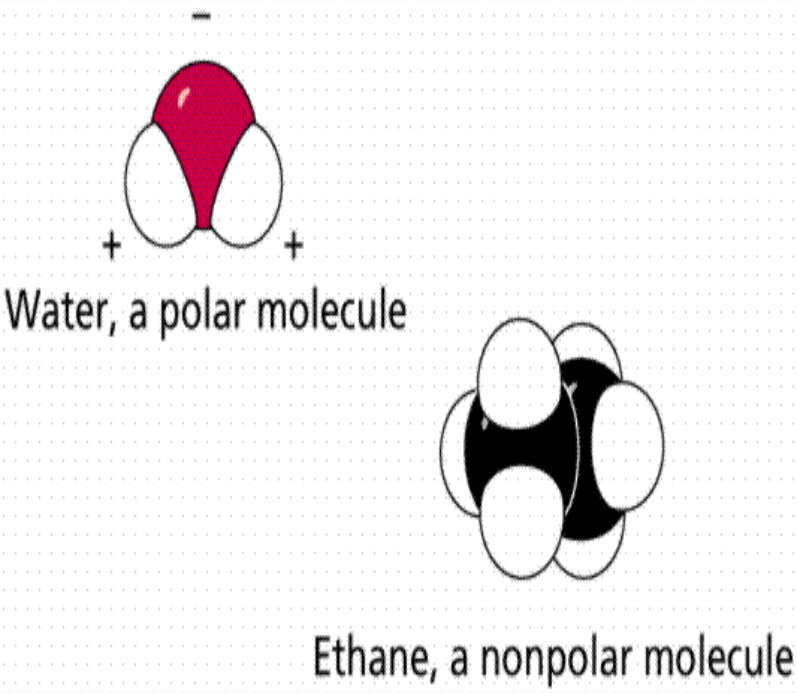
What is, or is not, soluble in H_20?

Like Dissolves Like

- "Polar solvents dissolve ionic compounds and polar molecules
  - Water is polar therefore it can dissolve
    - NaCl
    - Copper (II) sulfate
    - NaOH
- Nonpolar solvents dissolve nonpolar compounds
- Oil is nonpolar, which is why oil and water separate

Solubility depends on Molecular Structure

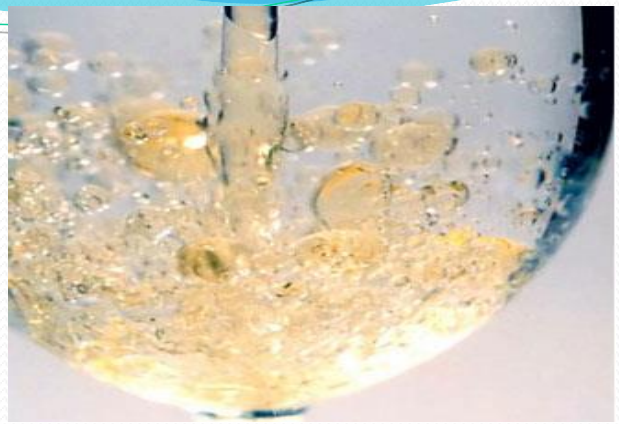
- When a substance dissolves, its molecules (covalent bonds) or ions (ionic bonds) separate from one another and become evenly mixed with molecules of the solvent



www.emc.maricopa.edu

- Water contains polar covalent bonds.
  - Negative region (O)
  - Positive region (H)

Polar and Nonpolar



www.historyforkids.org

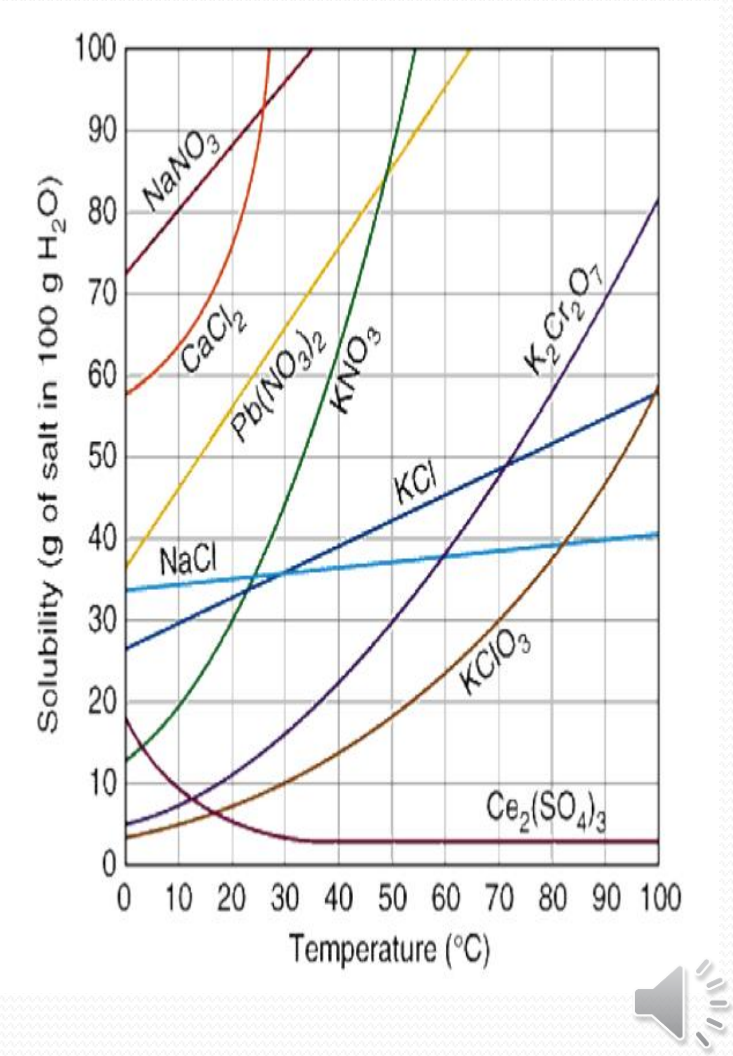
- Water and oil do not mix
  - Water is polar…negative and positive regions
  - Oil is nonpolar…no charge
  - Molecules are not attracted to each other (opposite charges attract each other) so they do not mix.
- Water and sugar or salt mix
  - Water is polar
  - Salt and sugar are also polar
  - Opposite charged molecules are attracted to each other.

Solubility Curves

Solubility indicates the amount of solute that will dissolve in a given amount of solvent at a specific temperature. (solid and gaseous solutes dissolved in 100 grams of water)

For this curve,

- X-Axis
  - Temperature
- Y-Axis
  - How Much Solute Dissolves in 100g of Water
- Various Lines
  - Each line represents a different solute.



Solution Concentrations

Expressed as a ratio of the amount of solute to the total amount of solution:

$$\text{Concentration} = \frac{\text{Amount of solute}}{\text{Total amount of solution}}$$

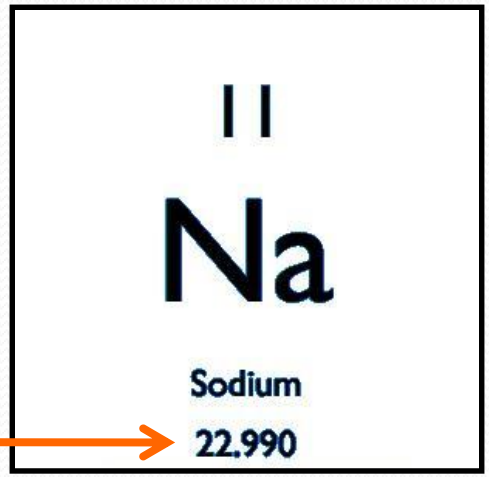
moles

Liter

(molarity, ***M***)

Units of Concentration

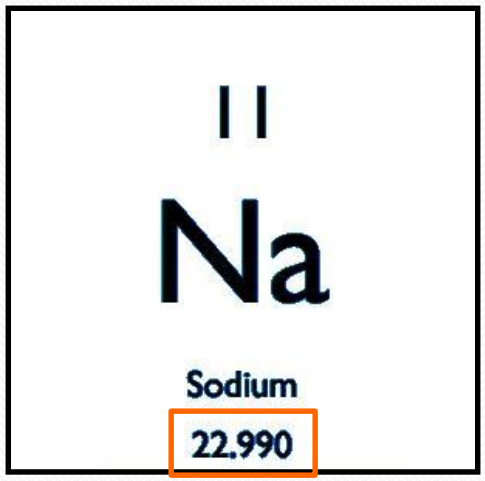
- A mole is the SI unit of number of particles and can be used as an expression of the molecular weight of a substance.

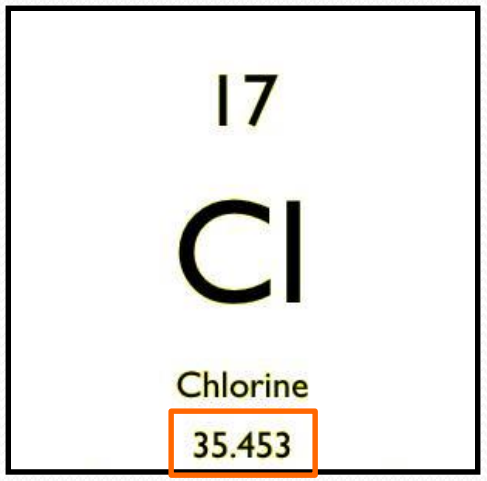


The formula weight of an element is expressed as grams/mole

Units of Concentration

- The molar mass of a compound can be calculated by adding the molar mass of the individual elements.





22.99 + 35.45 = 58.44 g/mol

Making Solutions

- You just calculated the molar mass of sodium chloride to be 58.44 g/mol.
- To determine how to make a stock solution of sodium chloride, use the formula:

$$g = M \times L \times \text{molar mass}$$

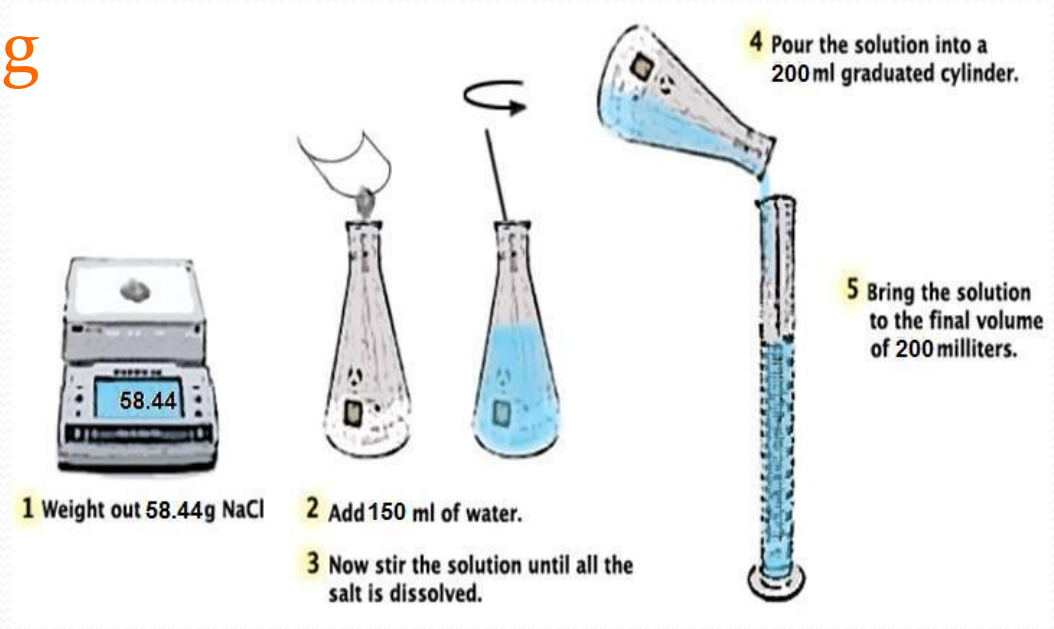
Making Solutions

- How many grams of NaCl would you need to prepare 200.0 mL of a 5 M solution?

g = M x L x molar mass

g = (5mol/L) (0.2L) (58.44g/mol)

g = 58.44 g



Diluting Solutions

- Often once you have made a stock solution, you need to dilute it to a working concentration.
- To determine how to dilute the stock solution, use the formula:

$$C_1V_1 = C_2V_2$$

C_1 – concentration of stock
C_2 - concentration of diluted solution
V_1 – volume needed of stock
V_2 – final volume of dilution

Solution Concentrations

Expressed as a ratio of the amount of solute to the total amount of solution:

$$\text{Concentration} = \frac{\text{Equivalent weight of solute}}{\text{Total amount of solution}}$$

Molecular wt/valency

Liter

(Normality, ***N***)

Solution Concentrations

Expressed as a ratio of the amount of solute to the total amount of solution:

$$\text{Concentration} = \frac{\text{moles of solute}}{\text{mass of solvent (in kilograms) in the solution}}$$

(Molality, m)

Solution Concentrations

Expressed as a ratio of the amount of solute to the total amount of solution:

$$\text{Concentration} = \frac{\text{Amount of solute}}{\text{Total amount of solution}}$$

mg

dL

(mg %/v)

Solution Concentrations

Expressed as a ratio of the amount of solute to the total amount of solution:

concentration of solutions by various methods

$$\text{Concentration} = \frac{\text{Amount of solute}}{\text{Total amount of solution}}$$

grams

mL

(%, *w/v*)

Solution Concentrations

Expressed as a ratio of the amount of solute to the total amount of solution:

$$\text{Concentration} = \frac{\text{Amount of solute}}{\text{Total amount of solution}}$$

mass (grams)

mass unit (grams)

(%, *w/w*)

Solution Concentrations

Expressed as a ratio of the amount of solute to the total amount of solution:

$$\text{Concentration} = \frac{\text{Amount of solute}}{\text{Total amount of solution}}$$

(%, *v/v*)

(mL)

(100 mL)

THANK YOU