# Biochemical Calculations

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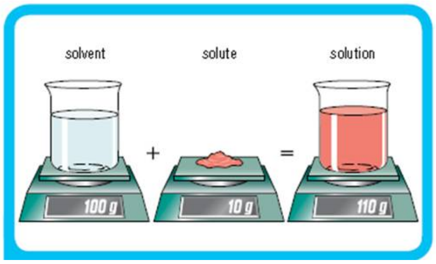
- Reference:
- Biochemical Calculation
- By Irwin Segel
- Exam dates:
- 1st
- November
- 2nd
- December

# Solution Composition

- Solute is the substance being dissolved.
- Solvent is the liquid in which the solute is dissolved.
- A solute is dissolved in a solvent.
- an aqueous solution has water as solvent.

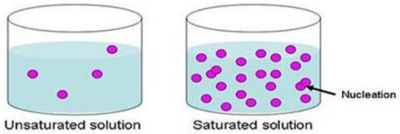



# Aqueous Solution

- The majority of reactions occur in solutions.
- There are several ways to express the concentration of a substance in a solution based on:

➢ The volume 

➢ The weight 

➢ Degree of saturation 

## Concentrations based on Volume

- Molarity(M)
- Normality (N)
- Activity (a)
- Weight/volume percent (w/v %)
- Volume/volume percent (v/v%)
- Milligram percent (mg %)
- Osmolarity

## Molarity

- *Molarity (M)* = the number of moles of solute per liter of solution
  = No. of moles of solute / $V_{(L)}$
- No. of moles = $wt_g$ /MW
- It contains Avogadro's number of molecules per liter ($6.023 \times 10^{23}$).
- Molar concentrations are usually given in square brackets.
- Example: [NaOH] = molarity of Sodium Hydroxide.

## Molarity Continue

- Example:

A solution of NaCL had 0.8 moles of solute in 2 liters of solution. What is its molarity?

- M = No. of moles / $V_{(L)}$
- M = 0.8 / 2
- M = 0.4 molar

## Molarity Continue

- Example:

How many grams of solid NaOH are required to prepared 500 ml of 0.04 M solution?

- M = No. of moles / $V_{(L)}$
- 500 ml = 500 ÷1000 = 0.5 L
- no. of moles = 0.04 ×0.5
- no. of moles = 0.02 mole
- MW of NaOH = 23 = 16 + 1 = 40 g/ mole
- wt in grams = no. of moles ×MW
- wt in grams = 0.02 ×40
- wt in grams = 0.8 grams

## Normality

- *Normality (N)* = the number of equivalents of solute per liter of solution
- = No. of equivalents / $V_{(L)}$
- No. of equivalents = $wt_g$ of solute / equivalents weight
- EW= MW of solute / n
- n represents the number of the replaceable hydrogen (in acids) or hydroxyl ions ( in bases) per molecule.
- n represents the number of electrons gained or lost per molecule (in oxidizing or reducing agents).
- *N=n*M*
- For example a 0.01 M solution of $H_2So_4$ is 0.02 N

## Normality Continue

➢ Example:

What is the normality of $H_2So_4$ solution that contains 24.5g of solute in a total volume of 100ml?

- *N=n*M*
- *n=2*
- M = No. of moles / $V_{(L)}$
- 100 ml = 100 ÷1000 = 0.1L
- No. of moles = $wt_g$/MW
- MW of $H_2So_4$ = 2 + 32 + (16*4) = 98g
- No. of moles = 24.5/ 98
- No. of moles = 0.25 mole
- M = No. of moles / $V_{(L)}$
- M=0.25/0.1 = 2.5 molar
- *N=n*M*
- *N=2*2.5 = 5 normal*

## Normality Continue

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## Osmolarity

- *Osmolarity* = the molarity of particles in a solution.
- KCl = 2 particals.
- $CaCl_2$ = 3 particals.
- The osmolarity of non dissociable substance = its molarity.
- The osmolarity of dissociable substance =n*M
- n = no. of ions produced per molecule.
- It is used when study living cells and tissues.

## Osmolarity Continue

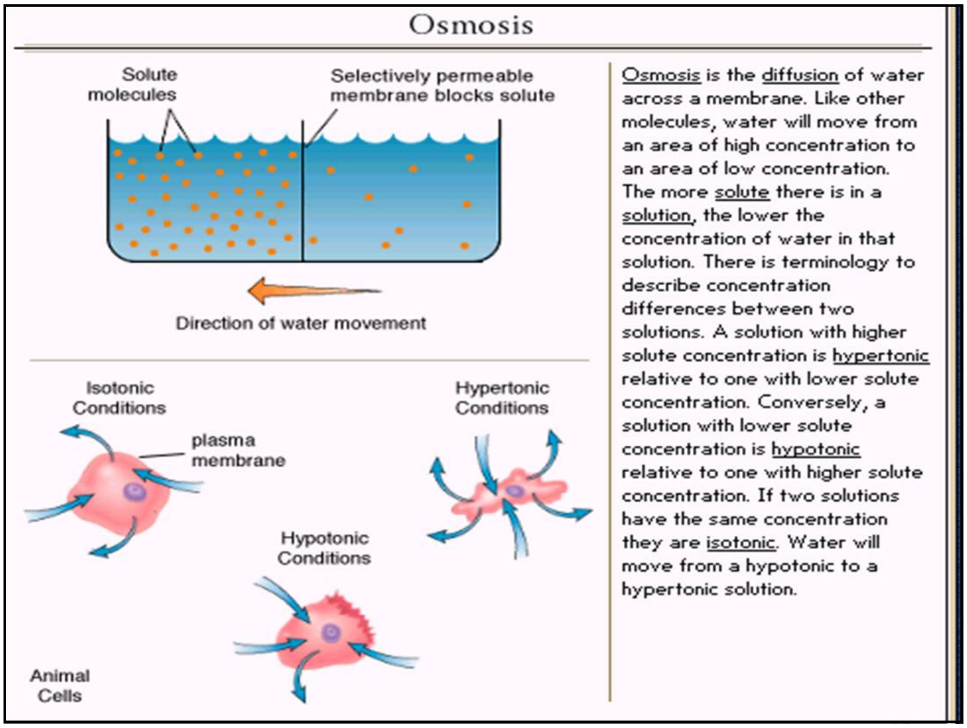
- Example:

A solution of KCl with 0.03M, what would be its osmolarity?

- The osmolarity of dissociable substance =n*M
- osmolarity = 2 * 0.03
  = 0.06 osmolar

## ISOTONIC

- ISO - means alike
- TONICITY - refers to osmotic activity of body fluids; tells the extent that fluid will allow movement of water in & out cell.
- Means that solutions on both sides of selectively permeable membrane have established equilibrium.
- Any solution put into body with the same osmolality as blood plasma.




# Osmolarity Continue

- Example:

When you want to study RBC and its osmolarity in the cytoplasm is 0.308 osmolar. What do you think the osmolarity of the invitro solution should be?

- 0.308 osmolar.

- Example:

Classify these solution in regards to the RBC osmolarity

1- 0.56 osmolar

2-0.21 osmolar

3- 0.154M NaCl

# Osmolarity Continue

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1= Hypertonic

2= Hypotonic

3= osmolarity =n*M = 2 * 0.154 = 0.308 osmolar so it is isotonic.

# Weight / volume percent

- Weight/volume percent (w / v %) = the weight in g of a solute per 100 ml of solution.

## Milligram percent

- Milligram percent ( mg%) = The weight in mg of a solute per 100 ml of solution.
- Mostly used in clinical laboratories.

➢ Example:
- Blood glucose level of 200mg/dl means there is a 200mg glucose in 100ml of blood.

## Volume / volume percent

- Volume /volume percent (v / v %) = the volume in ml of a solute per 100 ml of solution.

# Concentrations based on Weight

- Weight/Weight percent (w/w %).
- Molality.

# Weight/weight percent

- Weight/weight percent (w/w%) = the weight in g of a solute per 100 g of solution.
- The concentration of many commercial acids are given in term of w/w %.
- In order to calculate the volume of a stock solution needed for a certain preparation, we must know the density.

*ρ= density = weight/volume*

- *The following equation is usually used.*

*Wt (g) of pure substance requested = volume of stock solution needed (ml) * ρ *% as decimal of the stock solution*

- The density of water is 1gm/ml.

# Weight/weight percent Continue

- Example:

Describe the preparation of 2 liters of a 0.4M HCl solution starting with a concentrated (stock) solution of HCl with 28% w/w%, the specific gravity id 1.15?

- No. of moles of pure HCl needed = M*V

  = 0.4* 2 = 0.8 moles

MW of HCl = 1+35.5 = 36.5 g/mole

The weight in grams of pure HCl needed = no. of moles* MW

= 0.8* 36.5

= 29.2g

# Weight/weight percent Continue

- From the stock, 28 g of pure HCl in 100 grams solution

29.2g of pure HCl in ? grams solution

= (29.2 * 100) / 28

= 104.3 grams.

- $\rho$= weight/volume thus volume = weight / density
- *volume = weight / density*

  = 104.3 / 1.15

  = 90.7 ml

- so the volume of the stock HCl needed is 90.7ml and make up the volume to 2 liters with distilled water.

# Weight/weight percent Continue

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# Weight/weight percent Continue

- Since Wt (g) of pure substance requested = volume of stock solution needed (ml) * ρ * % as decimal of the stock solution thus, volume = wt / (ρ * % )
- The volume = 29.2 / ( 1.15 * 0.28)

  = 90.7 ml
- so the volume of the stock HCl needed is 90.7ml and make up

  the volume to 2 liters with distilled water.

## Molality

- *Molality* = the number of moles of solute per 1000 grams of solvent.

- Solution = solvent + solute.

➢ Example:

Calculate the molality of a concentrated HCl stock solution which has a 28% w/w%, S.G= 1.15?

- Since the weight of solution = weight of solvent + weight of solute.

  Thus, the weight of solvent = weight of solution - weight of solute.

  = 100g – 28 g

  = 72g

MW of HCl = 1+35.5 = 36.5 g/mole

No. of moles of solute = 28 / 36.5

= 0.77 mole

## Molality Continue

0.77 mole of solute in 72 g of solvent

? mole of solute in 1000 g of solvent

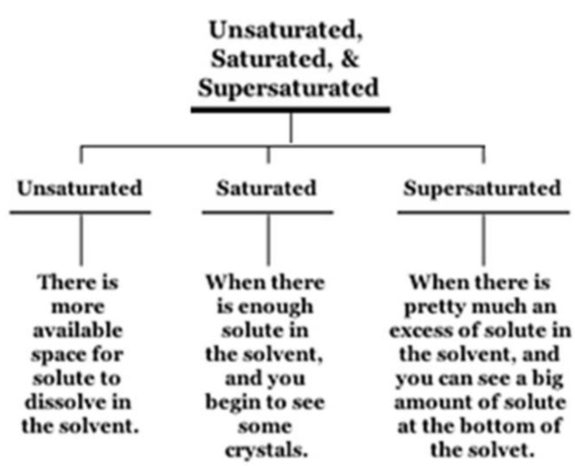
- No. of moles of solute 1000 g of solvent = ( 0.77 * 1000) / 72

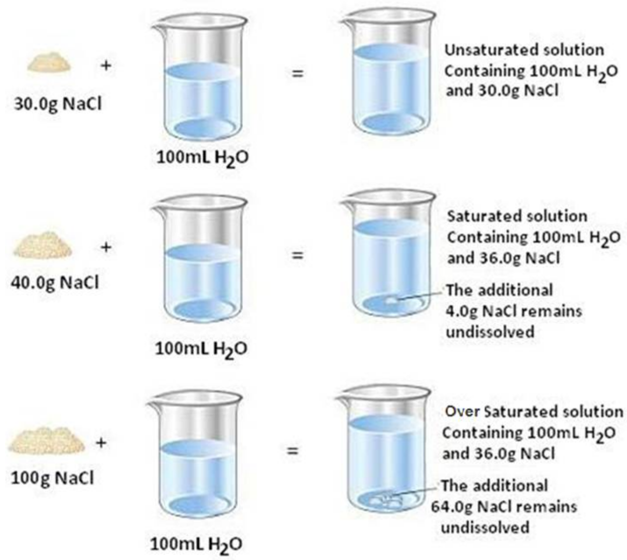
  = 10.69 moles

- The molality is 10.69

# Saturation Degree

- Saturated solution is one where the concentration is at a maximum - no more solute is able to dissolve at a given temperature.
- A saturated solution represents an equilibrium: the rate of dissolving is equal to the rate of crystallization.
- Unsaturated Solution :less than the maximum amount of solute for that temperature is dissolved in the solvent.
- No solid remains in flask.
- Supersaturated
- Solvent holds more solute than is normally possible at that temperature.






# Concentrations based on Saturation Degree

- Percent saturation= the concentration of salt in solution as a percent of the maximum concentration possible at a given temperature.

$$\text{Volume (ml)} = \frac{100\,(S2-S1)}{1-S2}$$

- At the equation above:
- Volume is the volume of the saturated salt needed.
- S1 is the initial low saturation ( used as a decimal).
- S2 is the final high saturation ( used as a decimal).
- This is to the volume to be added to 100 ml at saturation S1.

# Concentrations based on Saturation Degree Continue

➢ Example:

How many ml of a saturated ammonium sulfate solution must be added to 40ml of a 20% saturated solution to reach a final solution of 70%?

- Volume (ml) = ( 100 * (S2-S1)) / (1-S2)
  = ( 100 * (0.7-0.2)) / (1-0.7)
  = ( 100 * 0.5) / (0.3)
  = 50 / 0.3
  **= 166.6 ml**
- Since 100 ml of solution need 166.6 ml saturated solution
- 40 ml of solution need ? ml
- The volume needed is (40* 166.6) / 100 = 66.64ml of saturated solution needed to be added to 40 ml of 20% saturated ammonium sulfate solution to reach a final solution of 70%.

# Units Conversion

| Prefix | Symbol | $10^n$ |
|---|---|---|
| Deci | d | $10^{-1}$ |
| Centi | c | $10^{-2}$ |
| Milli | m | $10^{-3}$ |
| Micro | µ | $10^{-6}$ |
| Nano | n | $10^{-9}$ |
| Pico | p | $10^{-12}$ |
| Femto | f | $10^{-15}$ |