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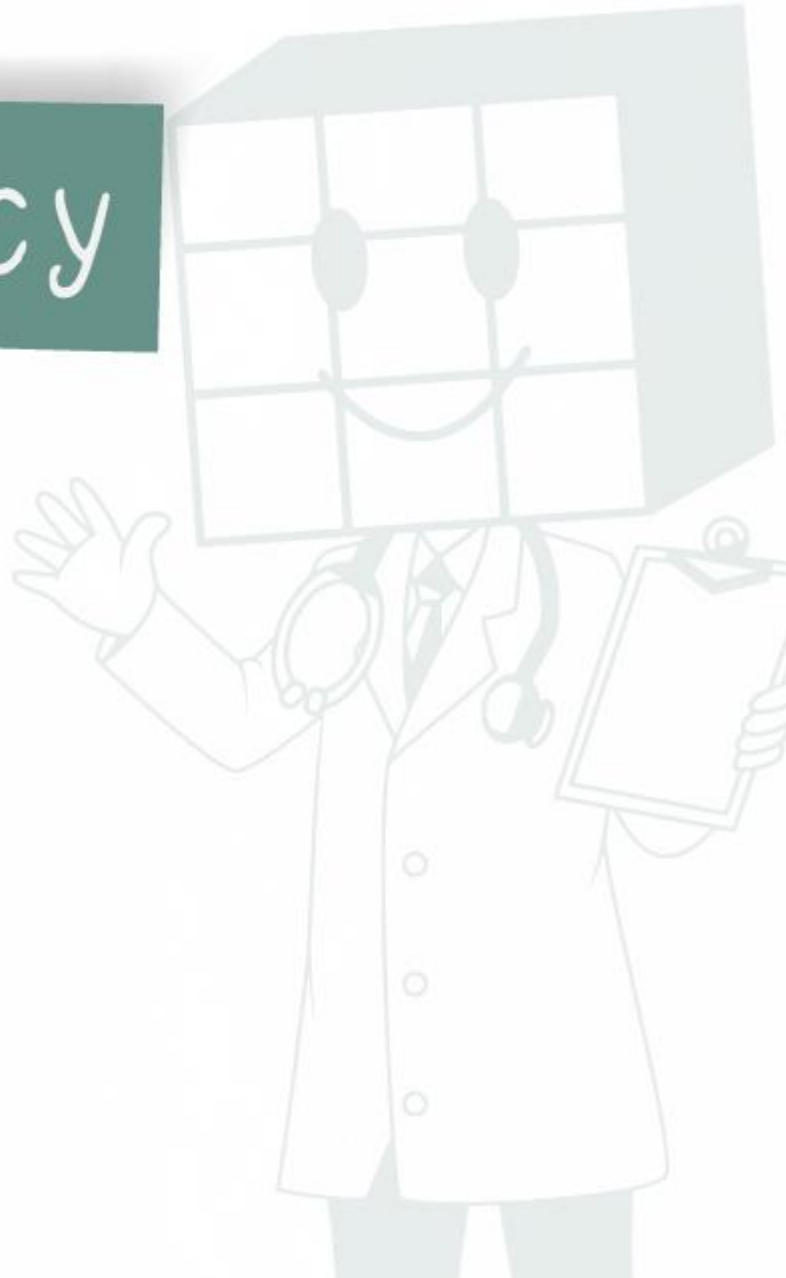
Physical Pharmacy

Electrolytes 3



Electrolytes

Ionic Strength

- It is a characteristic of an electrolyte solution , it is a measure of the intensity of the electrical field in a solution or the concentration of ions in that solution.

- It depends on the total number of ionic charges and not on the specific properties of the salt present in the solution.

$$\mu = \frac{1}{2}(c_1 z_1^2 + c_2 z_2^2 + c_3 z_3^2 + \cdots + c_j z_j^2)$$

$$\mu = \frac{1}{2}\sum_{1}^{j} c_i z_i^2$$

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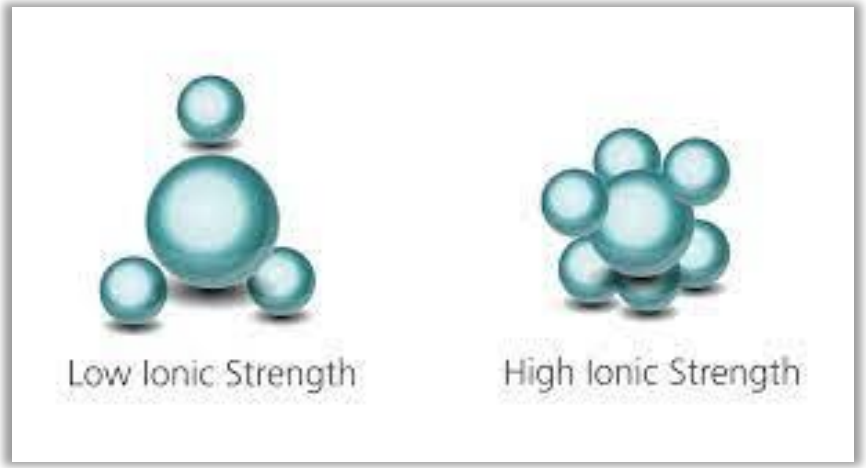
Electrolytes

Ionic Strength

- Where the summation symbol indicates that the product of $\mathbf{cz^2}$ terms for all the ionic species in the solution, from the first one to the j^{th} species, is to be added together.

- The terms:- ci is the concentration in moles/liter of any of the ions zi is its valence.



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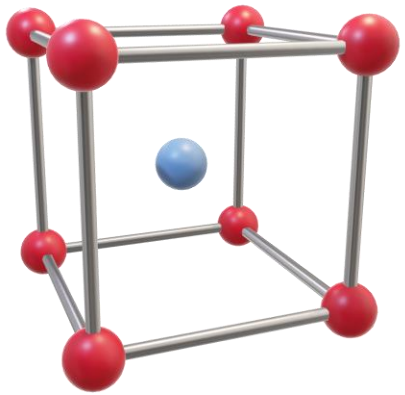
Electrolytes

Ionic Strength

- The sum is divided by 2 because positive ion-negative ion pairs contribute to the total electrostatic interaction, whereas we are interested in the effect of each ion separately

- OR we can say that since such a salt has two constituents, each constituent contributes half of the total ionic strength



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Electrolytes

Example 6-11

What is the ionic strength of (a) 0.010 M KCl, (b) 0.010 M $BaSO_4$, and (c) 0.010 M Na_2SO_4, and (d) what is the ionic strength of a solution containing all three electrolytes together with salicylic acid in 0.010 M concentration in aqueous solution ($K_a = 1.06 \times 10^{-3}$) ? Solution :

$\mu = 1/2 \; \Sigma \; c_i \; z_i^2$

Answer : a

KCl :

$$KCl \longrightarrow K^+ + Cl^-$$

0.01 0.01 0.01

$\mu = 1/2 \; (0.01 \times 1^2) + (0.01 \times -1^2)$

$= 1/2(0.02)$

$= 0.01$

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Electrolytes

Example 6-11

What is the ionic strength of (a) 0.010 M KCl, (b) 0.010 M BaSO4, and (c) 0.010 M Na2SO4, and (d) what is the ionic strength of a solution containing all three electrolytes together with salicylic acid in 0.010 M concentration in aqueous solution (Ka= 1.06×10^{-3}) ? Solution :

$\mu = 1/2 \Sigma c_i z_i^2$

Answer : b

BaSO4

$$\underset{0.01}{BaSO_4} \longrightarrow \underset{0.01}{Ba^{+2}} + \underset{0.01}{So_4^{-2}}$$

$\mu = 1/2 (0.01 \times 2^2) + (0.01 \times -2^2)$

$= 1/2(0.08)$

$= 0.04$

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Electrolytes

Example 6-11

What is the ionic strength of (a) 0.010 M KCl, (b) 0.010 M BaSO4, and (c) 0.010 M Na2SO4, and (d) what is the ionic strength of a solution containing all three electrolytes together with salicylic acid in 0.010 M concentration in aqueous solution ($Ka = 1.06 \times 10^{-3}$) ? Solution :

$\mu = 1/2 \; \Sigma \; ci \; zi^2$

Answer : c

Na2 SO4

$$\underset{0.01}{Na_2SO_4} \longrightarrow \underset{2(0.01)}{2Na^{+1}} + \underset{0.01}{So_4^{-2}}$$

$\mu = 1/2 \; (\; 2(0.01) \times 1^2) + (0.01 \times -2^2)$

$= 1/2(0.06)$

$= 0.03$

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Electrolytes

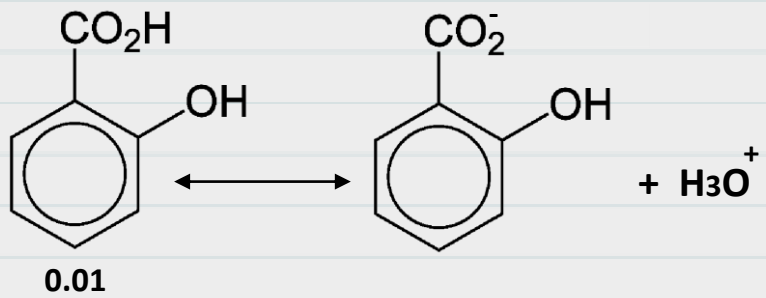
Example 6-11

What is the ionic strength of (a) 0.010 M KCl, (b) 0.010 M BaSO4, and (c) 0.010 M Na2SO4, and (d) what is the ionic strength of a solution containing all three electrolytes together with salicylic acid in 0.010 M concentration in aqueous solution ($Ka = 1.06 \times 10^{-3}$) ? Solution :

$\mu = 1/2 \Sigma c_i z_i^2$

Answer : d

Salicylic acid



$[H_3O^+] = \sqrt{Ca\ Ka}$

$= \sqrt{0.01 \times 1.06 \times 10^{-3}} = 0.003$

$\mu = 1/2 (0.003 \times -1^2) + (0.003 \times 1^2)$

0.003

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Electrolytes

Example 6-11

What is the ionic strength of (a) 0.010 M KCl, (b) 0.010 M BaSO4, and (c) 0.010 M Na2SO4, and (d) what is the ionic strength of a solution containing all three electrolytes together with salicylic acid in 0.010 M concentration in aqueous solution ($K_a = 1.06 \times 10^{-3}$) ? Solution :

$\mu = 1/2 \Sigma c_i z_i^2$

Answer :

$\mu_{Total} = 0.01 + 0.04 + 0.03 + 0.003 = 0.083$

It will be observed in Example 6-11 that :

μ of a 1:1 electrolyte such as KCl is the same as the molar concentration

μ of a 1:2 electrolyte such as Na2SO4 is three times the concentration

μ for a 2:2 electrolyte is four times the concentration as in BaSO4

μ for weak electrolyte (salicylic acid) is much lower than its conc.

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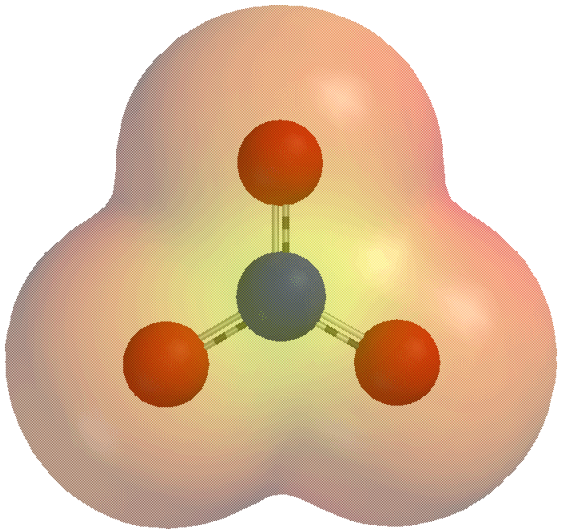
Electrolytes

Ionic Strength

- **The main difference between ionic strength and electrolyte conc, is that:**

a) The ionic strength is higher than the concentration if some of the ions are highly charged and fully dissociated (μ for four times the concentration as in BaSO4)

b) The ionic strength reflects the conc. of free ions some times as in weak electrolytes(salicylic acid) which is partially dissociated , the ionic strength much lower than



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Electrolytes

Ionic Strength

- **The importance of the principle of ionic strength**

a. **In biochemistry**: In the study of the influence of pH on biologic action,

b. **In preparation of buffer:**- The buffer should be adjusted to a constant ionic strength in each experiment, since addition of neutral salts to buffers changes the pH of the solution .

c. **The total ionic concentration** in solution will affect important properties such as the dissociation constant or the solubility of different salts.

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Electrolytes

Ex : 12

A buffer contains 0.3 mole of K2HPO4 and 0.1 mole of KH2PO4 per liter of solution , Calculate the ionic strength of the solution.

Answer :

$$K_2HPO_4 \longrightarrow 2K^{+} + HPO_4^{-2}$$

$$KH_2PO_4 \longrightarrow K^{+} + H_2PO_4^{-}$$

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Electrolytes

Q19/

A solution contains 0.003 M of sodium phenobarbital together with a buffer consisting 0.2M sodium acetate and 0.3M acetic acid (ka 1.75×10^{-5}) What is the ionic strength of this solution? $\mu = 1/2\ \Sigma\ ci\ zi$

Answer : 0.003 M of sodium phenobarbital

$$\underset{0.003}{\text{Sodium phenobarbital}} \longrightarrow \underset{0.003}{Na^{+1}} + \underset{0.003}{\text{Phenoparbital}^{-1}}$$

$$\mu = 1/2\ (0.003 \times 1^{2}) + (0.003 \times -1^{2})$$

$$0.003$$

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Electrolytes

Q19/

A solution contains 0.003 M of sodium phenobarbital together with a buffer consisting 0.2M sodium acetate and 0.3M acetic acid (ka 1.75×10^{-5}) What is the ionic strength of this solution? $\mu = 1/2\ \Sigma\ ci\ zi$

Answer : 0.2M sodium acetate

$$\underset{0.2}{CH_3COONa} \qquad \underset{0.2}{CH_3COO^{-1}} + \underset{0.2}{Na^{+1}}$$

Since $^{+}$it is 1:1 electrolyte

μ= conc. = 0.2

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Electrolytes

Q19/

A solution contains 0.003 M of sodium phenobarbital together with a buffer consisting 0.2M sodium acetate and 0.3M acetic acid (ka 1.75×10^{-5}) What is the ionic strength of this solution? $\mu = 1/2 \Sigma c_i z_i$

Answer : 0.3M acetic acid (ka 1.75×10^{-5})

$$CH_3COOH \longleftrightarrow CH_3COO^{-1} + H_3O^{+1}$$

0.3

$[H_3O^+] = \sqrt{Ca\ Ka}$

$= \sqrt{0.3 \times 1.75 \times 10^{-5}}$

$= 0.0022$

$\mu = 1/2\ ((0.0022 \times -1^2) + (0.0022 \times 1^2)$

0.0022

μ Total = 0.003 + 0.2+0.0022= 0.2052

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Electrolytes

Q20/

A solution contains 0.05 M AlCl3 and 0.2M Na2HPO4 , What is the ionic strength of this solution

Answer :

$$AlCl_3 \longrightarrow Al^{+3} + 3\,Cl^{-}$$

$$Na_2HPO_4 \longrightarrow 2\,Na^{+} + HPO_4^{-2}$$

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Thank You !

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