Isotonicity

Colligative Properties and E values

Isotonic solutions

Objectives

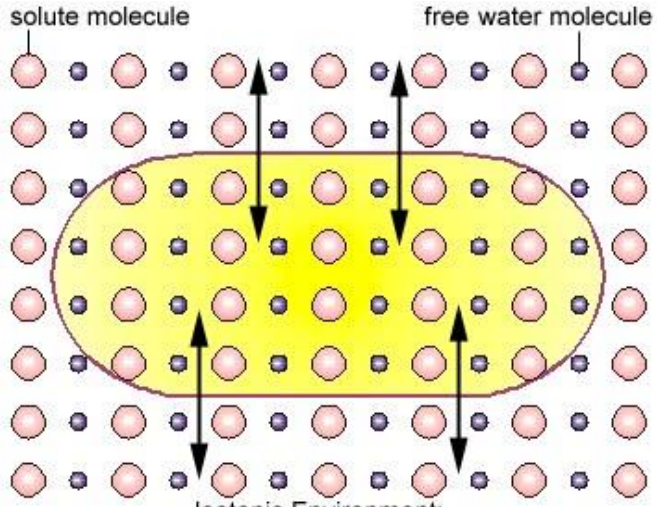
- Understand and use the dissociation factor(ι).
- Use the NaCl E value in adjusting a solution isotonicity, and performing other isotonicity related calculations (dilution and adjustment).
- Understand colligative properties and its use in adjusting solutions isotonicity.

Isotonic solutions

Why prepare isotonic solution?

Which pharmaceutical solutions are isotonic?

- Parenteral solutions?
- Nasal solutions
- Ophthalmic solutions
- Enemas



Isotonic Environment:
The solute concentration and the free water concentration are the same inside and outside the cell.
Water flows in and out of the cell at an equal rate.

http://www.eequalsmcq.com/cell%20notes.htm

Isotonicity

Name another IV isotonic solution ?

- Solutions having the same osmotic pressure as that of **0.9% NaCl** are considered isotonic.
- **NaCl equivalent E** of a substance: The amount (in grams) of NaCl with equivalent osmotic pressure as that of 1 g of the substance.

Isotonicity

You should be able to calculate the % concentration of an isotonic solution of any **substance** if you know its E

- Isotonic sodium chloride solution contains 0.9% NaCl, if a sodium chloride equivalent of boric acid is 0.52, what is the percentage strength of an isotonic solution of boric acid?

E value of Boric acid is 0.53

$$0.53g\,NaCl \approx 1g\,Boric\ acid$$

$$0.9g\,NaCl \approx Xg\,Boric\,acid$$

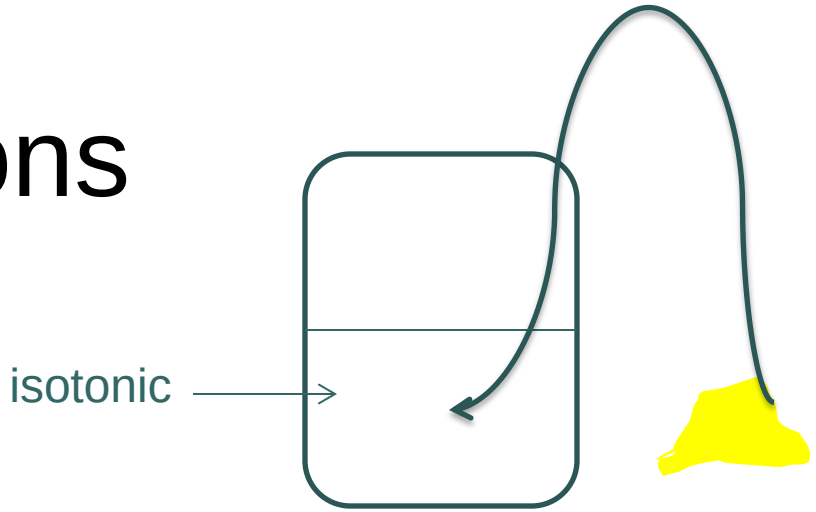
$$x = \frac{1x0.9}{0.53} = 1.7$$

A solution of 1.7 % of Boric acid is isotonic

Isotonic Solutions

- Useful equation (White Vincent)

V= w x E x 100/0.9



V= volume of the isotonic solution prepared by w (grams of the substance)

How many mL can be rendered isotonic with 1g Atropine sulfate, (E=0.13)?

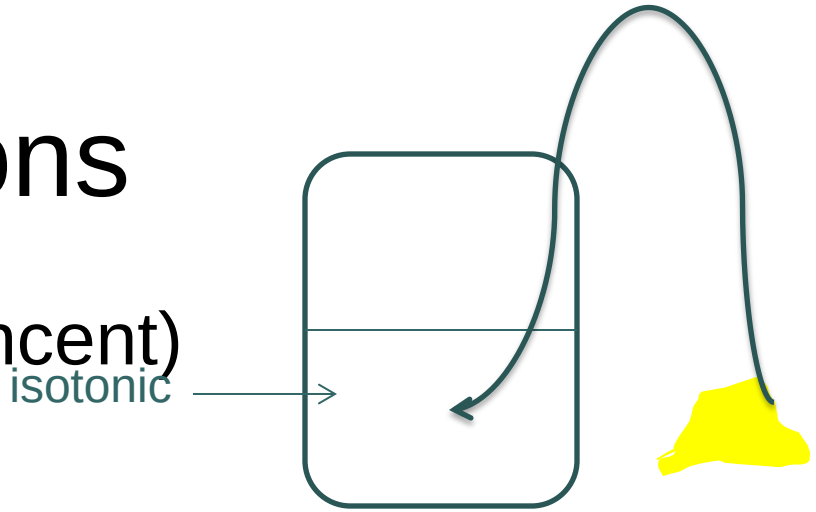
What is the concentration of the isotonic solution of Atropine sulfate? (what is the % strength of an isotonic solution of Atropine?)

How can you prepare 1% isotonic Atropine sulfate solution?

Isotonic Solutions

- Useful equation (White Vincent)

$V = w \times E \times 100/0.9$



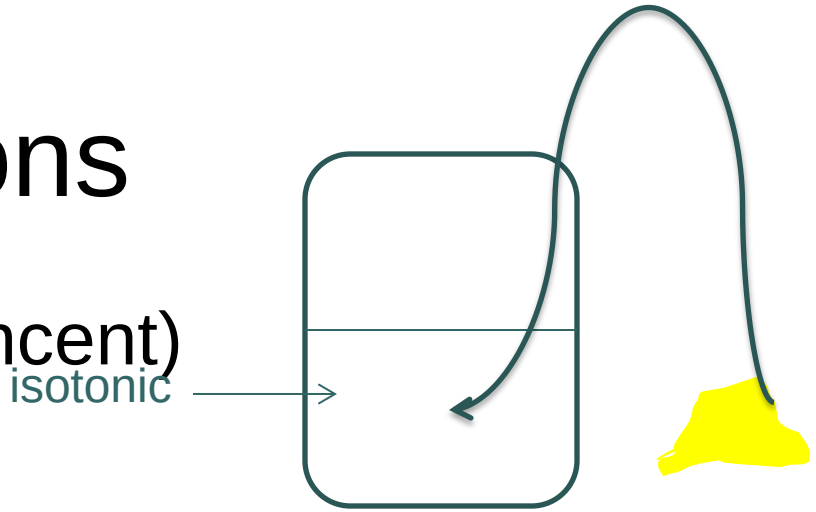
How many mL can be rendered isotonic with 1g Atropine sulfate, (E=0.13)?

$V = 1g \times 0.13 \times 100/0.9 = 14.4$ mL

Isotonic Solutions

- Useful equation (White Vincent)

$V = w \times E \times 100/0.9$



What is the concentration of the isotonic solution of Atropine sulfate? (what is the % strength of an isotonic solution of Atropine?)

E value of Atropine acid is 0.13

$$0.13g\,NaCl \approx 1g\,Atropine$$

$$0.9g\,NaCl \approx Xg\,Atropine$$

$$x = \frac{1x0.9}{0.13} = 6.9$$

A solution of 6.9% of atropine is isotonic

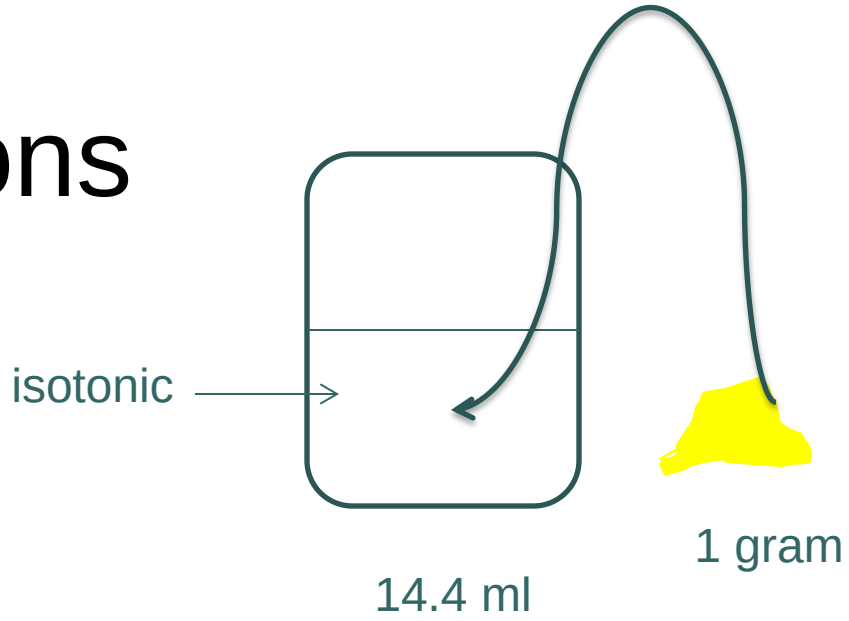
V= w x E x 100/0.9

100= w x 0.13 x 100/0.9 = 6.7 g

Isotonic Solutions

- Useful equation (White Vincent)

V= w x E x 100/0.9



How can you prepare 1% isotonic Atropine sulfate solution?

V= 1g x 0.13 x 100/0.9=14.4 ml

What about the rest of the 100 ml?

We can add NaCl or another substance to adjust the isotonicity.

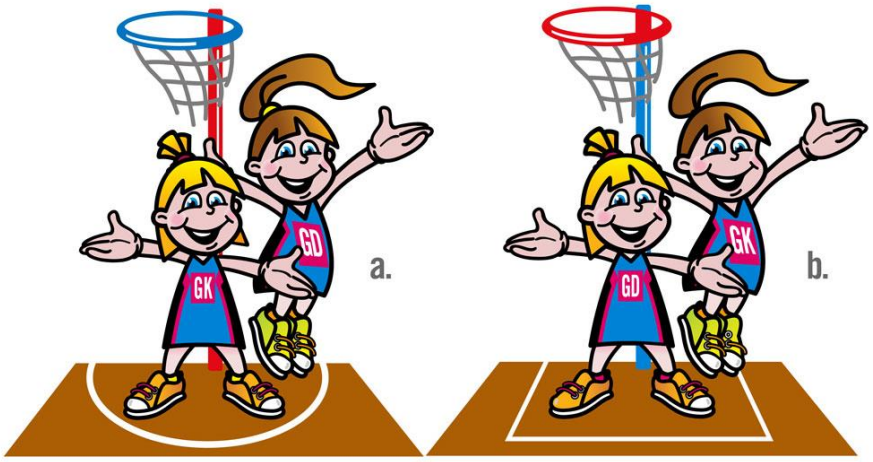
We have 100-14.4 = 85.6 ml to adjust its isotonicity

If we use NaCl the 0.9% of the 85.4 ml = 0.77 g

Isotonicity

Naphazoline HCl (E=0.27)		1%
NaCl		qs
Water	qsad	30 ml
Dispense isotonic sol		

Naphazoline HCl (E=0.27)		1%
NS [normal saline]		qs
Water	qsad	30 ml
Dispense isotonic sol		



Isotonicity

Sometimes we need to adjust the isotonicity using another agent other than NaCl. Why?

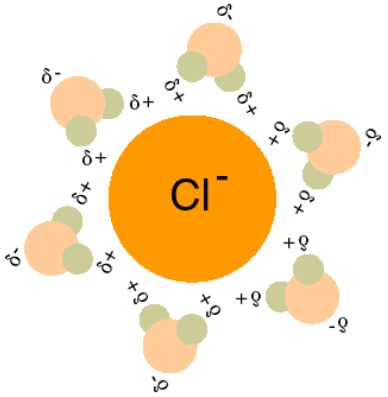
		E
Phenacaine HCl	1%	0.2
Chlorobutanol	0.5%	0.24
Boric acid	qs	0.52
Purified water	qs 60 mL	

Prepare isotonic solution

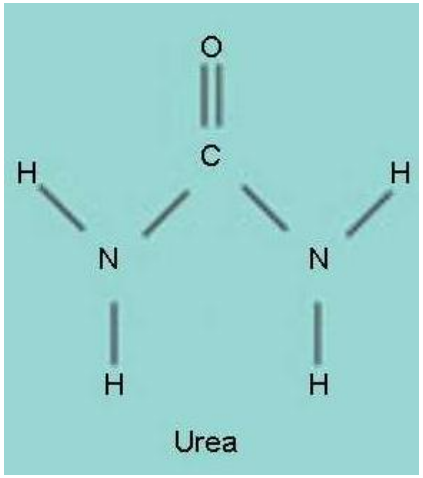
Extra problem

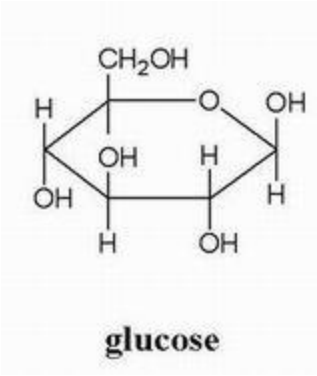
- How many milligrams of NaCl are required to prepare the following prescription . Note: Epinephrine solution is isotonic.
- Atropine Sulfate (E = 0.14) 1%
- Epinephrine solution 1:2000 8 mL
- Purified water Qs 30 mL

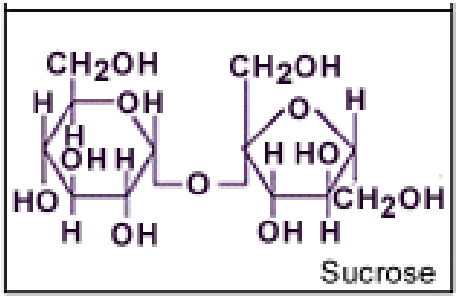
Physical Properties of solutions: Colligative Properties



- Definition: Properties that depend on the concentration of the solute molecules or ions, not the identity of the solute.

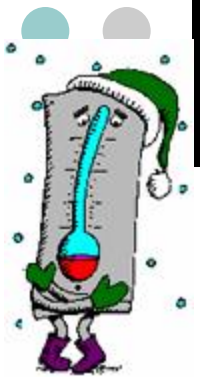






Colligative Properties

- Elevation of boiling point
- Depression of the vapor pressure
- **Depression of freezing point**
- **Osmotic pressure**



Freezing Point Depression

- Definition: It is the point at which the liquid and the solid phases coexist in equilibrium at one atmosphere.
- Freezing points of a pure solvent is higher than the freezing points of a solution.
- The depression of the freezing point depends on the molal concentration of the solute.

Freezing Point Depression

- $\Delta T_f = 1.86 \times m$

For water K_f ***= 1.86*** $\frac{\deg}{kg.mole}$

(in diluted solutions m=M).

What does this equation mean?

It means, but adding one mole of particles the freezing point of the 1 kilogram solvent (water) drops by 1.86°C.

Freezing Point Depression

- If you have 0.1 M solution of dextrose will result in $\Delta T_f = 0.1 \times 1.86 = 0.186\ ^{O}$.

- 0.1 M solution of NaCl will result in $\Delta T_f = \iota \times 0.1 \times 1.86$. If $\iota = 1.9$ then $\Delta T_f = 0.353$.

Calculate the ι of solution of Na_2SO_4 (the dissociation percentage is 85%).

Can you find ΔT_f for 0.1 Na_2SO_4?

Isotonic Solutions

- Freezing point depression,
  - An isotonic solution has a freezing point of -0.52 ^{O}C .

The isotonicity of parenteral fluids can be adjusted with NaCl or glucose till the solution acquires freezing point of -0.52 ^{O}C .

(Zatz Pharmaceutical Calculations book pg 244)

Preparation of isotonic solution

$$w = \frac{0.52 - a}{b}$$

0.52 is the ΔT_f of isotonic solutions

w = weight% of the adjusting solution

a= freezing point **(depression)** of the solution to be adjusted.

b=ΔTf of 1% of the adjusting solution

Problem

- Calculate the NaCl needed to adjust the isotonicity of a 50 mL solution of 0.5% lidocaine HCl
- 1% lidocaine HCl causes a ΔTf of 0.13 ^{O}C.
- 1% NaCl causes a ΔTf of 0.576 ^{O}C.

References

- Amiji Applied Physical Pharmacy book
- Physical Pharmacy by Martin
- www.chemguide.co.uk
- Physicochemical Principles of Pharmacy Alexander Florence Chapter 2 and 3.