Lab 1: Cell transport Mechanisms, Permeability and Osmosis

Exercise 1: Interpreting and understanding Osmolarity and Tonicity

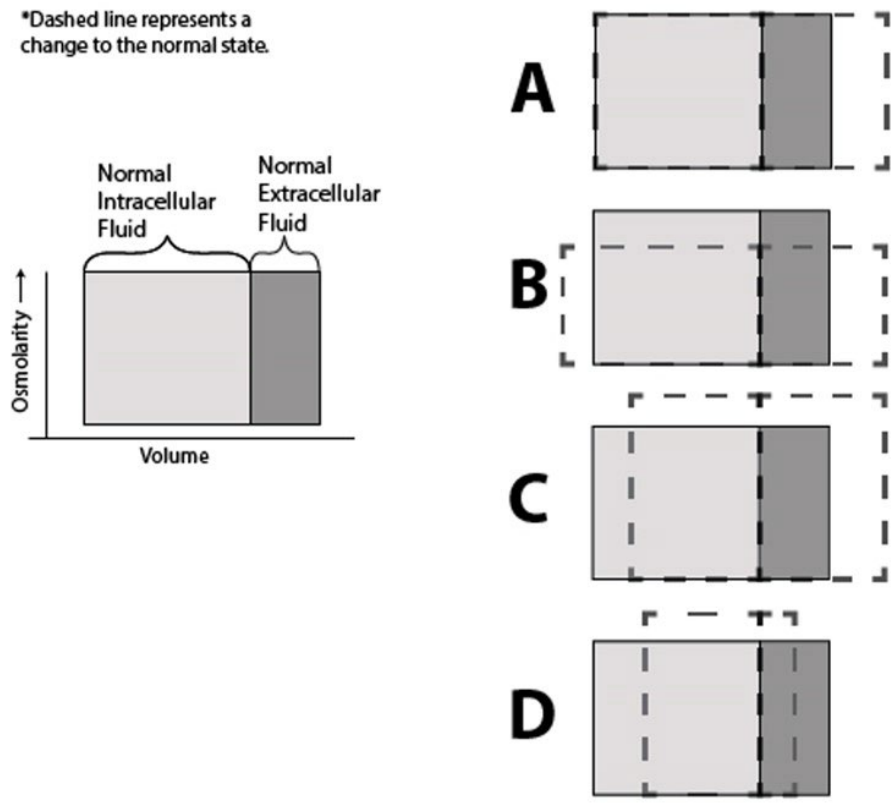
Textbook section 1.2.2

1. Complete the following table by correctly identifying the osmolarity and tonicity of the listed solutions. Use the following prefixes: iso = same, Hyper = more, Hypo = less

SOLUTION	ALSO KNOWN AS	OSMOLARITY	TONICITY
0.9% Saline	Normal saline		
5% Dextrose in 0.9% Saline	D5-normal saline		
5% Dextrose in water	D5W		
0.45% saline	Half-normal saline		
5% dextrose in 0.45% saline	D5-half normal saline		

Osmosis problems.

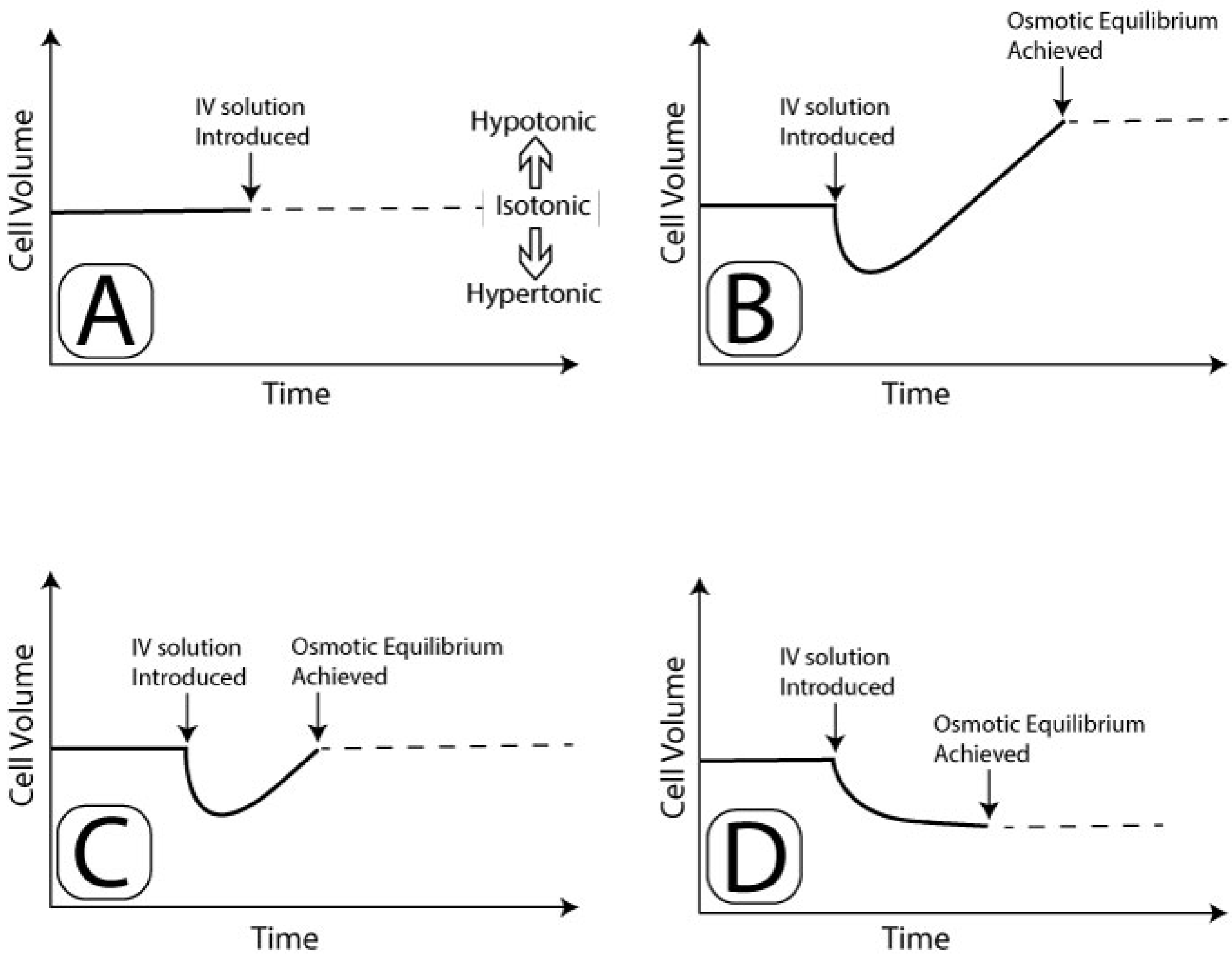
2. The diagram below represents various states of abnormal hydration. In each diagram, the normal state (dark grey and light grey) is superimposed with the abnormal state (dashed lines) to illustrate the shifts in the volume (width of rectangles) and total osmolarity (height of rectangles) of the extracellular and intracellular fluid compartments. In other words, if the dotted lines increase in height there was a change in osmolarity, if the dotted lines increase in width there was a change in volume. Look at example A. Something was added to the ECF that caused the volume to increase (ie., the dotted line moved to the right) but didn't change the osmolarity (ie, the dotted line didn't move height) and the dotted line in the ICF didn't move. Thus, an isotonic solution was added to the ECF of A increasing the volume of the ECF but did not affect the ICF volume nor osmolarity.



Which of the following CORRECTLY identifies a cause for the lettered outcomes above? In other words, this is essentially a true/false question, does the description of A (below) match the diagram labeled A (above in the picture). You may also want to try and match a description below with its correct diagram above.

(A matches A above T/F) A case of severe dehydration that has caused the loss of an excessive amount of salt and water
(B matches B above T/F) Adding a couple of liters of an Isosmotic IV solution called lactate ringers solution to the ECF. Lactate ringers solution has “non-permeable” solutes.
(C matches C above T/F) Adding a couple of liters of an IV solution that is labeled as 2.5% dextrose to the ECF.
(D matches D above T/F) A condition called diabetes insipidus that causes kidneys to excrete excessive amounts of free water (water without electrolytes) as urine (out of the body).

3. Match the graphs below to the correct IV solution



A. IV solution of .9% NaCl
B. IV solution of 1.2 % NaCl
C. IV solution of .9% NaCl + 7% Dex
D. IV solution of .45% NaCl + 5% Dex

4. What would happen if we were to add a 2L IV solution containing 5% dextrose solution to a person who has a total body water of 40 liters and an initial osmotic equilibrium of 300 mOsM. Assume that 2/3 water is found in the ICF and 1/3 in the ECF and then round to nearest decimal.   Show your work.

5. **Now let's up the ante!**

Loungella Spudinsky has decided he has had enough of being lazy and wants to start reversing the stigma associated with his last name. He decides to try joining a wrestling team and has just finished his first practice where he experienced a 10% body mass reduction! This reduction occurred through sweating and the loss of NaCl and water. Loungella's pre workout body weight was 90 kg and 50% of that weight was water. His initial ECF volume was 14 L and his pre workout osmolarity was 300 mosM but jumped to 312 mosM post work out! Note: 1 kg body fluid = 1 L. After wrestling practice, Loungella stumbled into the service station and drank 2 L of a sports drink that contained 200mM NaCl (I = 1.8) and a 5% dextrose solution (5% solution = 5g/100ml, MW of dextrose = 180 g/mol).

After equilibrium, what will be the new osmolarity and L volumes of ICF and ECF for Loungella? Show your work.

6. Describe what happened?

<u>Exercise 2: Osmolar Gap</u>

Hyperosmolar conditions in the body are serious issues and are the main cause of death in excess alcohol consumption. When someone enters the emergency room intoxicated, the attending physician should utilize a test known as the osmolar gap. The osmolar gap is a calculated parameter used in medicine to help diagnose certain toxic alcohol ingestions, such as methanol or ethylene glycol. It represents the difference between the measured serum osmolality and the calculated osmolality based on the concentrations of certain solutes in the blood, primarily sodium, glucose, and blood urea nitrogen (BUN).

The formula for calculating the osmolar gap is:

Osmolar gap = Measured serum osmolality − Calculated serum osmolality

The calculated serum osmolality is estimated using the following formula:

Calculated serum osmolality = 2 × [Na] + glucose/18 + BUN/ 2.8

Where:
[Na] is the sodium concentration in mmol/L.
Glucose is the blood glucose concentration in mg/dL.
BUN is the blood urea nitrogen concentration in mg/dL.

A normal osmolar gap is typically less than 10 mOsm/kg, but it can vary depending on the laboratory's reference range. A significantly elevated osmolar gap may indicate the presence of unmeasured osmotically active substances in the blood, such as toxic alcohols. If toxic alcohol ingestion is confirmed or strongly suspected, prompt treatment is crucial. Treatment may involve administering antidotes such as fomepizole or ethanol to inhibit the metabolism of toxic alcohols. In addition to antidote therapy, supportive care such as hydration and correction of electrolyte imbalances are needed immediately. This is why understanding tonicity and osmolarity are crucial for homeostatic maintenance.

Question 1. You are an emergency physician who has just received un unconscious patient with the following blood test values.

- Sodium concentration ([Na]): 140 mmol/L
- Blood glucose concentration: 180 mg/dL
- Blood urea nitrogen (BUN): 30 mg/dL
- Measured serum osmolality: 350 mOsm/kg

a. Calculate the calculated serum osmolality

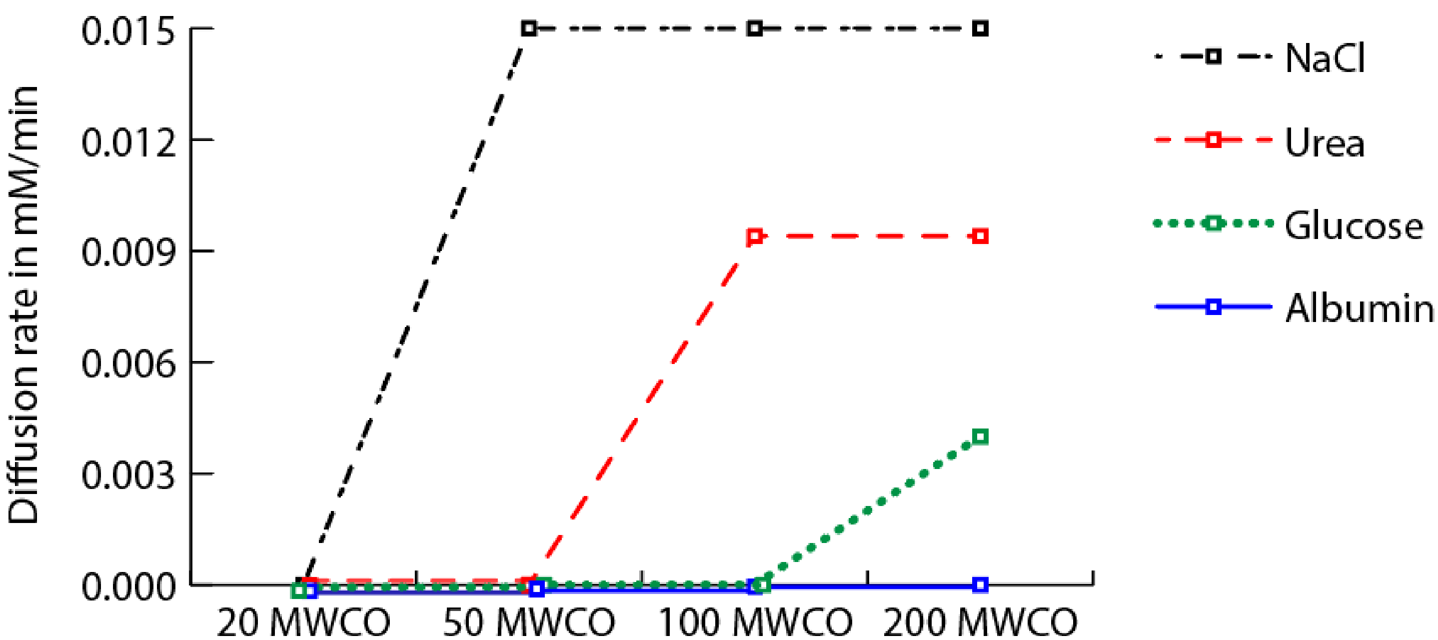
b. Determine the osmolar gap

c. Based on the osmolar gap you calculated, what do you suspect is causing the patients unconsciousness?

Exercise 3: Interpreting and Understanding Simple Diffusion

Textbook [section 1.2.3]

Consider data obtained on the diffusion rates of 9 mM solutions of the following solutes: NaCl, urea, albumin, or glucose. The data was obtained using the following system. The aquarium was filled with water and then divided into two fluid compartments by the addition of a semipermeable membrane. The semipermeable membrane design allowed for the easy exchange among membranes of varying molecular weight cut offs (MWCO) ranging in pore size of 20, 50, 100 and 200. The diffusion rates for each solution, subjected to the different MWCO membranes, were then determined by adding a solution to one side and allowing the solute to move to equilibrium (assuming the solute was able to diffuse). Once equilibrium was reached, the concentration of the solute was compared between the two sides and an average diffusion rate (mM/min) was calculated. The tank was then rinsed and prepared for the addition of another solution or different membrane until all solutions were compared against all membranes. The data obtained can be found in the following graph.



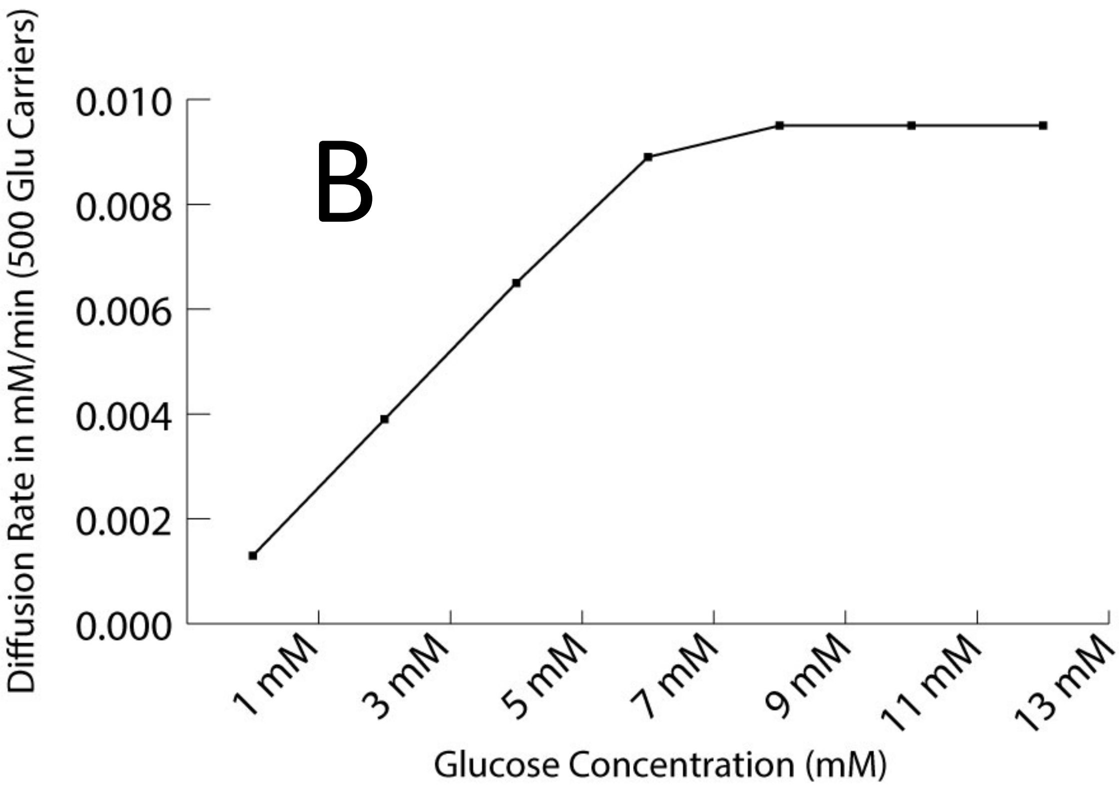
Questions (Exercise 3)

1. Rank the relative size of each molecule.

2. Rank the diffusion rates of the molecules and explain the observed differences. How does this correlate with Fick's 1st Law of Diffusion?
3. Why does the diffusion rate not change for NaCl with an increase in MWCO from 50 to 100 to 200?

Exercise 4: Interpreting and Understanding Facilitated Diffusion

In **graph B**, data was collected from the same system but with a fixed number of glucose carriers (500) but with varying mM concentrations of glucose (1,3,5,7,9,11 and 13). Diffusion rates were measured in mM/min.



Question (Exercise 4)

1. What happens to the rate of diffusion as the concentration gradient is increased? Explain (Graph B)

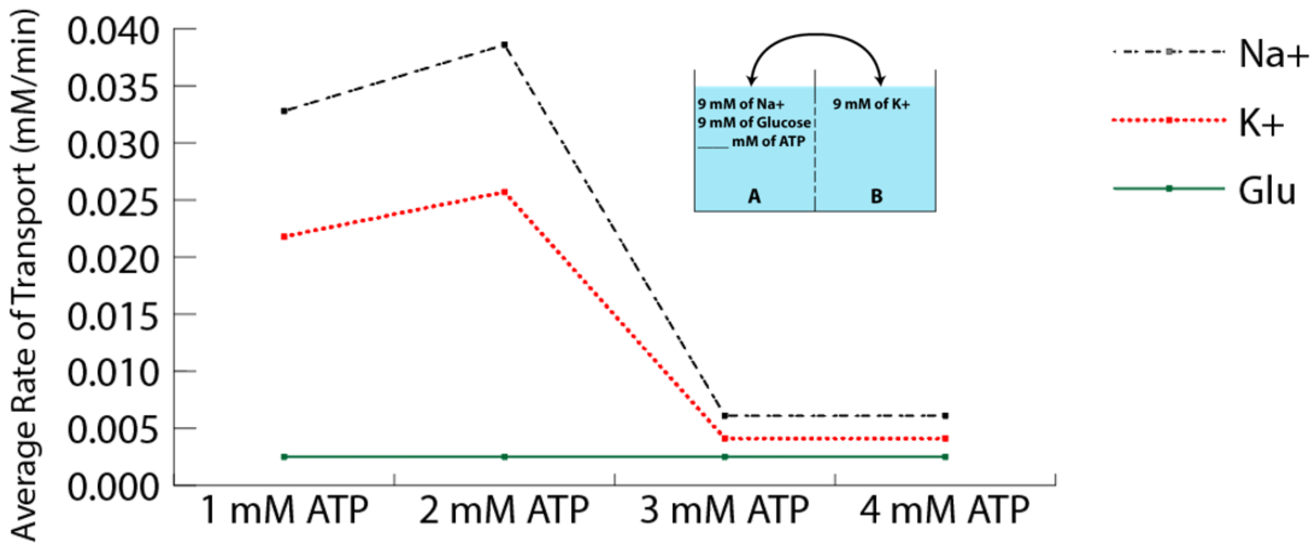
Exercise 5: Interpreting and Understanding Active Transport

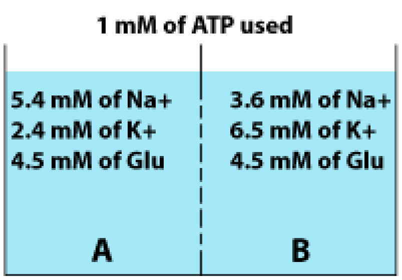
Textbook [Section 1.2.4]

The graph represents data obtained from a two-chamber system separated by a membrane containing Na/K ATPase pumps (primary active transport proteins). Each side is filled with either a 9mM NaCl solution or a 9mM KCl solution. The membrane can be altered to contain various numbers of Na/K ATPase pumps and the amount of ATP can be altered from 1mM up to 10mM. The data is displayed as rate of transport.

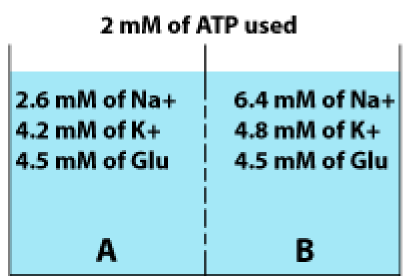
The graph below represents the average rate of Na+, K+, and Glucose transport over a period of time that it takes for all transport to come to completion. 4 experiments were performed where side "A" started with 9 mM of Na+ and Glucose and side "B" started with 9 mM of K+. Each experiment used a different amount of ATP introduced to side A. The experiment was allowed to run until all transport of all solutes stopped.

The images below the graph shows the concentrations of solutes after transport has completed and the time it takes to complete all transport is shown below the images.

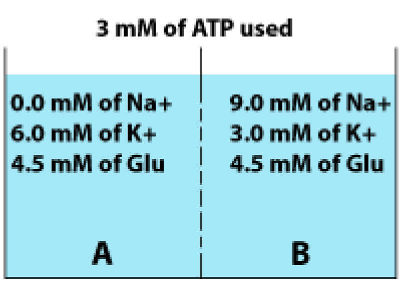




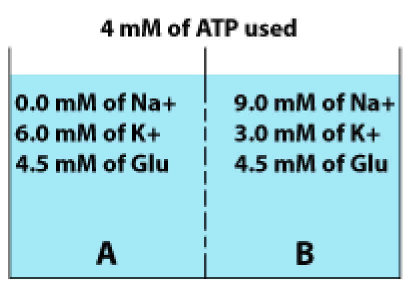
Na+ transport finished in 2 min
K+ transport finished in 2 min
Glu transport finished in 60 min



Na+ transport finished in 5 min
K+ transport finished in 5 min
Glu transport finished in 60 min



Na+ transport finished in 50 min
K+ transport finished in 50 min
Glu transport finished in 60 min



Na+ transport finished in 50 min
K+ transport finished in 50 min
Glu transport finished in 60 min

Questions (Exercise 5)

1. As each run progressed with varying amounts of ATP (mM), the concentrations of the solutes changed in between side A and Side B. The rate also slowed down markedly even stopping before completion. Why?