

WATER POTENTIAL PROBLEMS DO AT LEAST 12 OF THEM

Calculating Solute Potential

$$\Psi_s = -iCRT$$

- Variables involved: i , C , R , T

i = ionization constant: $\text{NaCl} = 2.0$ (Na^+ & Cl^-)

****for sucrose it will be 1.0 (it doesn't ionize)**

C = Molar concentration

T = Temperature: $^{\circ}\text{K}$

R = pressure constant ($R = 0.0831$ liter bars/mole K)

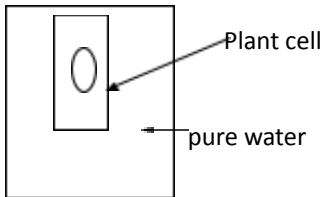
R will always be the same.

T will be given to you, but must be in $^{\circ}\text{K}$.

T = temperature in Kelvin ($273 + ^{\circ}\text{C}$)

1. What is the solute potential Ψ_s of a 1.0M sugar solution at 22 degrees Celsius under standard atmospheric conditions?

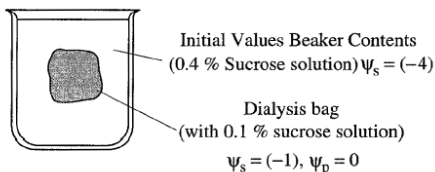
2. Zucchini cores are measured and determined to have a sucrose concentration of 0.36 M. Calculate the solute potential Ψ_s of these cells. (Temperature is same as question #1.) Will water go in or out of the plant cell?



3. If solute potential in a plant cell is -6.25 bars and pressure potential is 0, what is water potential of the plant cell? What does this indicate in terms of water movement?

4. If solute potential in the plant cell in question 3 is -6.25 bars and pressure potential is 6.25 bars, what is the water potential of the plant cell? What does this indicate in terms of water movement?

5. A dialysis bag containing 0.1% sucrose is placed in a beaker containing 0.4% sucrose. The beaker is open to the atmosphere.



What is the pressure potential Ψ_p of the system? _____

What is the water potential of this dialysis bag? _____

Water will move _____ the dialysis bag.

6. If a potato is allowed to dehydrate by sitting in the open air, would the water potential of the potato cells decrease or increase? Why?

7. What is the water potential for a solution in an open container that is 0.1M? (assume $i = 1$, and a temperature of 22°C)

8. What is the solute potential for a solution that is 0.5M? (assume $i = 1$, and a temperature of 10°C)

9. A plant cell has a solute potential of -4.0 bars and a pressure potential of 1.0 bar. What is its water potential?
If this cell is placed in a solution with a water potential of -5.0 bar. What will happen to this cell?
10. A plant cell has a solute potential of -2.0 and a pressure potential of 0.0 . What is its water potential? Show your work
It is placed in a solution with a water potential of -1.0 . What will happen to this plant cell?
11. If a cell's $\Psi_p = 2$ bars and its $\Psi_s = -3.5$ bars, what is the resulting Ψ ?
12. The cell from question #11 is placed in a beaker of sugar water with $\Psi_s = -4.0$ bars. In which direction will the net flow of water be?
13. The original cell from question # 11 is placed in a beaker of sugar water with $\Psi_s = -1.5$ bars. In which direction will the net flow of water be?
14. The value for Ψ in root tissue was found to be -3.3 bars. If you take the root tissue and place it in a 0.1 M solution of sucrose at 20°C in an open beaker, what is the Ψ of the solution, and in which direction would the net flow of water be?
15. NaCl dissociates into 2 particles in water: Na^+ and Cl^- . If the solution in question #14 contained 0.1M NaCl instead of 0.1M sucrose, what is the Ψ of the solution, and in which direction would the net flow of water be?
16. What is the solute potential Ψ_s of a 3.5M sugar solution at 22 degrees Celsius in an open beaker?
17. At 20°C , a cell containing 0.6M glucose is in equilibrium with its surrounding solution containing 0.5M glucose in an open container. What is the cell's Ψ_p ?

Fun with Water Potential!

Botanists use the term water potential when predicting the movement of water into and out of plant cells. Remember, the movement of water across a semi-permeable membrane as it follows its own concentration gradient is osmosis. But plants are a unique case because they have a cell wall which prevents a plant cell from bursting if it takes on too much water. If a plant cell is placed in a hypotonic environment, it will take on water UNTIL water pressure inside the cell builds up to a point that it cannot take on any more. This increase in water pressure will actually push water molecules back out of the cell against water's concentration gradient until the amount of water moving *in* due to solute difference is equal to the water moving *out* due to water pressure—this is a dynamic equilibrium!

Water potential is a measure of how likely water is to move from one location (say outside the cell) to another (inside the cell). For example, in the case above....a plant cell placed in a hypotonic solution.....water has a higher potential (tendency) to move INTO the cell than it does to move OUT of it. Therefore, water potential is GREATER outside the cell than inside the cell because the water outside the cell has the GREATER POTENTIAL TO MOVE. Just like any solute will diffuse DOWN its concentration gradient—from high to low concentration, water will always move from an area of greater water potential to an area of lesser water potential.

Water potential is made up of 2 parts---solute potential and pressure potential. Add both together to get the total water potential. See below.

Note: (we use the greek letter “psi” or “ Ψ ” to represent water potential.)

$$\text{Solute potential} + \text{Pressure potential} = \text{Water potential}$$

$$\Psi_s + \Psi_p = \Psi$$

- **Solute potential**—(Ψ_s)—the greater the concentration of a solute, the lower the water potential.—an inverse relationship. Think of it this way: if you place a plant cell in very salty water, water will leave the cell for the environment it's in. Water had a greater tendency to move OUT than in (the cell). Therefore, water potential was lower in the environment than in the cell. This means that the water in the environment had low tendency to move (into the cell) than the other way around. Said another way, water that was in the cell had a greater potential to move (OUT) than the other way around. In summary, solute potential is the effect that solutes have on a solution's overall water potential. (always a negative value- the more negative, the less likely that there is free water that can move the CLOSER TO 0 the better, more free water to move).

- **Pressure potential**—(Ψ_p)—physical pressure increases water potential—a direct relationship. If you have a syringe filled with water and you press down on the plunger (increasing pressure), water will leave the syringe through the needle (the only opening). Plant cells work the same way, if water pressure increases inside the cell, that pressure will drive water back out. The cell wall will not break, but it is a little bit elastic and will bulge outward. This is called TURGOR. The water pressure that causes turgor is called TURGOR PRESSURE. Lack of turgor is called WILTING! (this can be positive or negative)

The solute potential (ψ_s) = $-iCRT$, where i is the ionization constant, C is the molar concentration, R is the pressure constant ($R = 0.0831$ liter bars/mole-K), and T is the temperature in K ($273 + ^\circ\text{C}$).

Example #1: A 0.15 M solution of sucrose at atmospheric pressure ($\psi_p = 0$) and 25°C.

$$(\psi_s) = -iCRT$$

$$C = 0.15 \text{ M}$$

$$T = (273 + 25)$$

$$R = 0.0831$$

$$I = 1 \text{ (this is because sucrose does not dissociate in water)}$$

$$\psi_s = - (1)(0.15)(0.0831)(273+25) = -3.7 \text{ bars}$$

This example has an solute potential of -3.7 bars

$$\Psi_s + \Psi_p = \Psi$$

$$\Psi = 0 + -3.7 \text{ bars}$$

$$= -3.7 \text{ bars}$$

Example #2: A 0.15 M NaCl solution contains 2 ions, Na^+ and Cl^- ; therefore $i = 2$. Room Temp = 25°C.

$$(\psi_s) = -iCRT$$

$$I = 2$$

$$C = 0.15 \text{ M}$$

$$R = 0.0831$$

$$T = (273 + 25)$$

$$(\psi_s) = -(2)(0.15)(0.0831)(298) = -7.4 \text{ bars}$$

$$\Psi = 0 + -7.4 \text{ bars} = -7.4 \text{ bars}$$

Careful when answering these questions:

Which of the answers above has MORE water potential? #1

Which of the answers above is MORE concentrated? #2