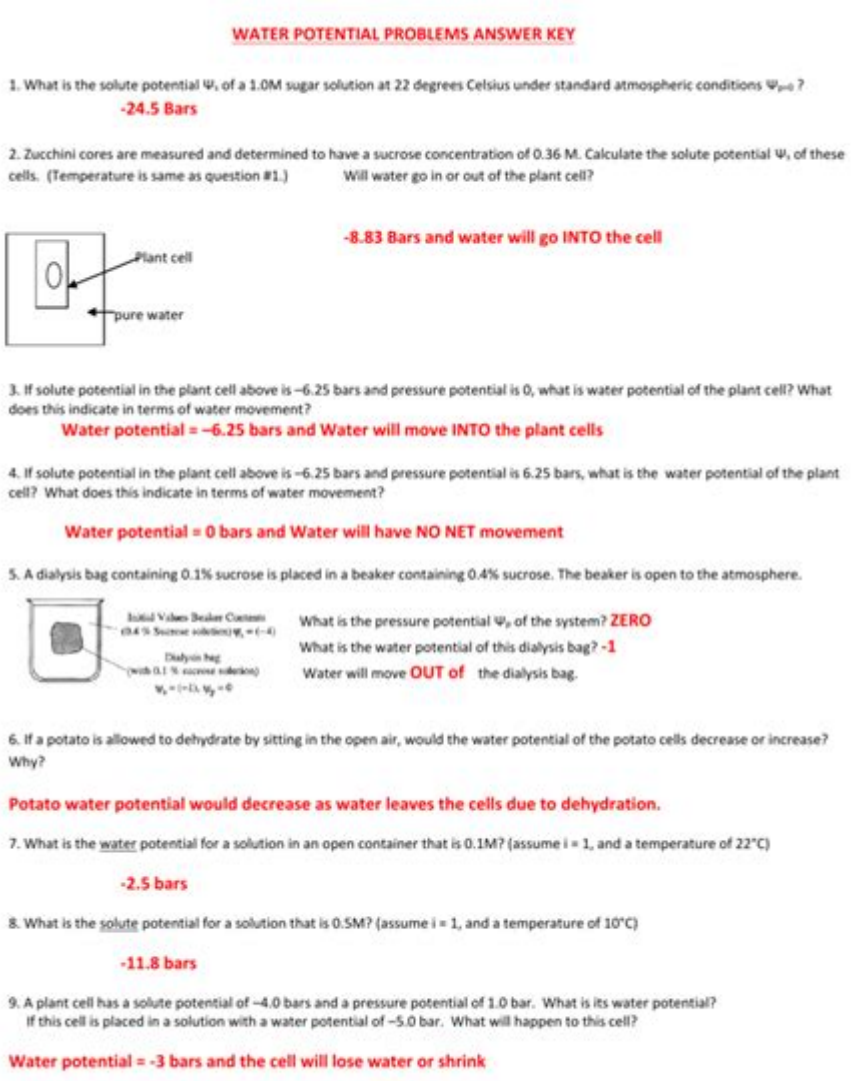
Water Potential Practice Problems Ap Biology



WATER POTENTIAL PROBLEMS ANSWER KEY

1. What is the solute potential Ψ_s of a 1.0M sugar solution at 22 degrees Celsius under standard atmospheric conditions $\Psi_{p=0}$?

-24.5 Bars

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?

-8.83 Bars and water will go INTO the cell

Plant cell

pure water

3. If solute potential in the plant cell above 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?

Water potential = –6.25 bars and Water will move INTO the plant cells

4. If solute potential in the plant cell above 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?

Water potential = 0 bars and Water will have NO NET 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.

Initial Values Beaker Contents

Dialysis bag

What is the pressure potential Ψ_p of the system? ZERO

What is the water potential of this dialysis bag? -1

Water will move OUT of 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?

Potato water potential would decrease as water leaves the cells due to dehydration.

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)

-2.5 bars

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

-11.8 bars

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?

Water potential = -3 bars and the cell will lose water or shrink

Water potential practice problems AP Biology are essential for students preparing for their Advanced Placement Biology exams. Understanding water potential is crucial in biological processes, particularly in plant physiology, as it affects how water moves through plant cells and tissues. This article will explore the concept of water potential, its components, and provide practice problems to help you grasp this important topic.

Understanding Water Potential

Water potential (Ψ) is a measure of the potential energy in water, influencing the direction of water movement. It is a crucial concept in AP Biology as it integrates fundamental ideas

in osmosis, diffusion, and plant physiology. The water potential of a system is determined by two main components:

1. Solute Potential (Ψs)

Solute potential, also known as osmotic potential, is the contribution of dissolved solutes to the overall water potential. It is always a negative value (or zero for pure water) because the addition of solutes decreases the potential energy of water. The formula to calculate solute potential is:

$$
\Psi s = -iCRT
$$

Where:
- i = ionization constant (number of particles the solute dissociates into)
- C = molar concentration of the solute
- R = pressure constant (0.0831 liter bar per mole per Kelvin)
- T = temperature in Kelvin

2. Pressure Potential (Ψp)

Pressure potential is the physical pressure on a solution. It can be positive or negative. In plant cells, pressure potential is often positive due to turgor pressure exerted by the cell wall against the cell membrane. The total water potential can be calculated using the following equation:

$$
\Psi = \Psi s + \Psi p
$$

Importance of Water Potential in Plants

Water potential plays a critical role in various physiological processes in plants, including:

- **Water Uptake:** Water moves from regions of higher water potential to lower water potential, allowing roots to absorb water from the soil.
- **Transpiration:** The loss of water vapor from plant surfaces creates a negative pressure that helps pull water upward from the roots through the xylem.
- **Cell Turgidity:** Maintaining turgor pressure is essential for plant structure and growth.
- **Photosynthesis:** Adequate water availability is crucial for photosynthesis and overall plant health.

Practice Problems on Water Potential

To solidify your understanding of water potential, let’s dive into some practice problems. Ensure you have a calculator handy to solve these problems.

Problem 1: Calculating Solute Potential

A solution has a concentration of 0.5 M of NaCl at 25°C. Calculate the solute potential (Ψs).

Solution:
1. Determine the ionization constant (i) for NaCl, which dissociates into 2 ions (Na^+ and Cl^-). Thus, i = 2.
2. Convert the temperature to Kelvin: 25°C + 273 = 298 K.
3. Use the formula:

$$
\Psi s = -iCRT = -2 \times 0.5 \times 0.0831 \times 298
$$

Calculating gives:

$$
\Psi s = -24.8 \, \text{bars}
$$

Problem 2: Total Water Potential

A plant cell has a solute potential of -0.8 MPa and a pressure potential of 0.5 MPa. What is the total water potential (Ψ)?

Solution:
Use the equation:

$$
\Psi = \Psi s + \Psi p
$$

Substituting the values gives:

$$
\Psi = -0.8 + 0.5 = -0.3 \, \text{MPa}
$$

Problem 3: Water Movement Direction

A cell has a water potential of -0.5 MPa. It is placed in a solution with a water potential of -1.0 MPa. In which direction will water move?

Solution:
Water moves from areas of higher water potential to areas of lower water potential. Since -0.5 MPa is greater than -1.0 MPa, water will move out of the cell into the solution.

Problem 4: Pressure Potential Calculation

A plant cell has a water potential of -0.6 MPa and a solute potential of -0.4 MPa. What is the pressure potential (Ψp) of the cell?

Solution:
Using the equation:

$$
\Psi = \Psi s + \Psi p
$$

Rearranging gives:

$$
\Psi p = \Psi - \Psi s = -0.6 - (-0.4) = -0.2 \, \text{MPa}
$$

Problem 5: Effect of Solute Concentration

You have a beaker containing pure water ($\Psi = 0$ MPa) and a beaker with a 1.0 M sugar solution (assume $i = 1$, $R = 0.0831$, $T = 298$). Calculate the solute potential of the sugar solution and determine the direction of water movement when the two solutions are separated by a selectively permeable membrane.

Solution:
1. Calculate solute potential:

$$
\Psi s = -iCRT = -1 \times 1.0 \times 0.0831 \times 298 = -24.6 \, \text{MPa}
$$

2. Compare potentials:
- Pure water: $\Psi = 0$ MPa
- Sugar solution: $\Psi = -24.6$ MPa

Water will move from the pure water (higher potential) to the sugar solution (lower potential).

Conclusion

In summary, understanding water potential is crucial for AP Biology students, as it underpins many biological processes in plants. By solving practice problems, students can grasp the concepts of solute potential, pressure potential, and their implications on water movement. Mastery of water potential not only aids in exam preparation but also enhances comprehension of plant physiology and water relations, critical for a well-rounded understanding of biology.

Frequently Asked Questions

What is water potential and why is it important in AP Biology?

Water potential is a measure of the potential energy in water, influencing the movement of water in plants and cells. It is crucial for understanding processes like osmosis and transpiration in AP Biology.

How do you calculate water potential using solute potential and pressure potential?

Water potential (Ψ) is calculated using the formula $\Psi = \Psi s + \Psi p$, where Ψs is the solute potential and Ψp is the pressure potential. Solute potential can be calculated using the equation $\Psi s = -iCRT$, where i is the ionization constant, C is the molar concentration, R is the pressure constant, and T is the temperature in Kelvin.

What is the significance of a negative water potential value?

A negative water potential value indicates that the water has a lower potential energy compared to pure water (which has a potential of 0), meaning it is more likely to move towards areas of higher solute concentration or lower water potential.

How does pressure potential affect water movement in plant cells?

Pressure potential, which can be positive in turgid plant cells, helps maintain cell structure and drives water movement into the cell. When pressure potential is high, it can counteract solute potential, allowing for water uptake and nutrient transport.

What happens to water potential when a plant cell is placed in a hypertonic solution?

When a plant cell is placed in a hypertonic solution, water moves out of the cell, resulting in a decrease in turgor pressure and a more negative water potential, which can lead to plasmolysis.

Can you provide an example of calculating water potential in a potato cell with a known solute concentration?

Sure! If a potato cell has a solute concentration corresponding to a solute potential of -0.5 MPa and the pressure potential is 0.5 MPa, the water potential would be Ψ = Ψs + Ψp = -0.5 MPa + 0.5 MPa = 0 MPa.

Why is understanding water potential essential for predicting plant responses to environmental changes?

Understanding water potential is essential because it helps predict how plants will respond to changes in water availability, soil salinity, and drought conditions, impacting their growth, nutrient uptake, and overall health.

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