Tonicity and Osmoregulation

Learning objectives 2.7.A Explain how concentration gradients affect the movement of molecules across membranes. 2.7.B Explain how osmoregulatory mechanisms contribute to the health and survival of organisms.

Name: Date: Period:

Use the tool **Which Way Does Water Go**. Work on the **Work out the potential** tab for Parts 1 and 2, **Put a cell in it** for Parts 3 and 4, and **Graph it** and **How organisms cope** for Part 5. Do every calculation on paper first, then use the tool to check it. Where a Part asks for a prediction, write the prediction before you use the tool to check it.

If this is your first time with the tool, watch the short demo on the tool page before you start.

watch the demo · *switch tab* · *scroll down*
predict first · *work it on paper* · *record from the tool*
sketch a graph · *score yourself*

The purple bar in the margin names the AP science practice a question uses.

Part 1 · Substitute into Ψs = −iCRT



Use the **Work out the potential** tab. It is the one showing when the tool opens.

For each row, work the calculation out on paper, then set the tool to the same values and check. **R = 0.0831 L bar/mol K** and T in kelvin is degrees Celsius plus 273.

Solution	i	C (M)	T (K)	Ψs (bars)
Sucrose, 1.0 M, 22 °C				
Sucrose, 0.5 M, 22 °C				
NaCl, 1.0 M, 22 °C				
NaCl, 0.5 M, 25 °C				
$CaCl_2$, 0.5 M, 25 °C				
Pure water, 25 °C				

SP 1 · CONCEPT EXPLANATION

1. Two rows of the Part 1 table at 22 °C have the same molarity but different values of Ψs.
(a) Identify the two rows.

(b) Explain why their values of Ψs are different.

Part 2 · What the equation will not allow

Stay on the **Work out the potential** tab and scroll down to the section headed **What the equation will not let you do**.

SP 1 · CONCEPT EXPLANATION

2. Every value of Ψs in the Part 1 table is negative or zero. Explain why solute potential can never be positive.

3. (a) Identify the water potential of pure water in an open container.

(b) Explain why this value is used as the reference point for water potential.

4. Set the tool to a 0.5 M sucrose solution at 22 °C, then set the pressure potential slider to 10 bars.
(a) Identify the values of Ψs and Ψ shown by the tool.

(b) Describe the relationship between Ψs, Ψp and Ψ.

5. Increasing the temperature makes Ψs more negative. Using the equation Ψs = −iCRT, explain why.

Part 3 · Predict the direction

Work out the potential | **Put a cell in it** | Graph it | How organisms cope

Click the **Put a cell in it** tab at the top of the tool. Keep the cell at **0.5 M** throughout.

SP 6 · ARGUMENTATION

For each row, predict the tonicity of the outside solution and the direction of water movement before you set the sliders. Then check with the tool.

Outside	**Tonicity (predict)** *circle one*	**Ψ outside**	**Ψ inside**	**Water moves** *circle one*
0.0 M	hypertonic / isotonic / hypotonic			in / out / no net movement
0.1 M	hypertonic / isotonic / hypotonic			in / out / no net movement
0.5 M	hypertonic / isotonic / hypotonic			in / out / no net movement
0.9 M	hypertonic / isotonic / hypotonic			in / out / no net movement
1.5 M	hypertonic / isotonic / hypotonic			in / out / no net movement

SP 1 · CONCEPT EXPLANATION

6. Describe the relationship between water potential and the direction of water movement.

7. Each row of the Part 3 table predicts the direction of water movement in two ways: from the tonicity and from the values of Ψ. Explain why the two methods always give the same direction.

Part 4 · Plant against animal

Stay on the Put a cell in it tab. At each tonicity, switch between the two cell types and circle what happens to each cell.

Tonicity	**Animal cell** *circle one*	**Plant cell** *circle one*
Hypotonic	swells and may burst / no net change / shrinks and shrivels	turgid / flaccid / plasmolyzed
Isotonic	swells and may burst / no net change / shrinks and shrivels	turgid / flaccid / plasmolyzed
Hypertonic	swells and may burst / no net change / shrinks and shrivels	turgid / flaccid / plasmolyzed

8. (a) Identify the tonicity of the surrounding solution in which an animal cell is healthiest.

(b) Identify the tonicity of the surrounding solution in which a plant cell is healthiest.

(c) Explain why the two cell types are healthiest in different solutions.

9. Explain why a plant cell in pure water does not burst. In your answer, refer to pressure potential.

Part 5 · Graph it, then apply it



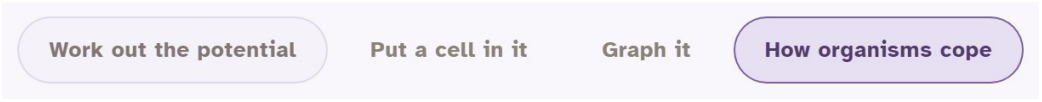
Click the **Graph it** tab at the top of the tool.

10. Construct an appropriately labeled graph that represents Ψs as a function of C for sucrose and for NaCl at 22 °C, from 0 to 2.0 M.

11. (a) Identify the slope of each line in terms of the symbols in the equation Ψs = −iCRT.

(b) Explain why the NaCl line is steeper than the sucrose line.

For question 12, click the How organisms cope tab at the top of the tool.



SP 1 · CONCEPT EXPLANATION

12. A Paramecium lives in fresh water.
(a) Describe the osmotic problem that fresh water creates for a Paramecium.

(b) Describe how a Paramecium responds to this problem.

Part 6 · Learning check self-report

Scroll down to the **Learning check** at the bottom of the tool. Type an answer to each question, check it against the rubric, and check off the points you earned. Then record your score here and, for every point you did not earn, write what the rubric asked for that your answer left out.

Question	Points possible	Points I earned	Missed opportunities (what the rubric wanted that I left out)
1	3		
2	3		
3	3		
4	2		
Total	**11**		

What the model simplifies

The cell is drawn as a simple shape whose size changes with the direction of water movement. Real cells change shape in ways that depend on the cytoskeleton and, for plant cells, on the wall.

The tool treats the cell's contents as a single solute at a single concentration. A real cytoplasm contains many solutes at once, and it is their total that sets the solute potential.

Pressure potential is set by a slider rather than emerging from the water that has entered. In a real plant cell the two are coupled: water entering raises the pressure, which then opposes more water entering.

The ionization constant is treated as a whole number. Real solutions deviate slightly from this at high concentration, which is why the equation is a very good approximation rather than an exact law.

Every equation is the CED's own, with R = 0.0831 L bar/mol K and T in kelvin taken as °C + 273.