Freezing Point Depression & Boiling Point Elevation

Outcomes:

- Perform a lab to demonstrate freezing point depression and boiling point elevation.
- Explain freezing point depression and boiling point elevation at the molecular level (ex. Antifreeze, road salt, etc.)

Boiling Point Review:

Boiling point is the **TEMPERATURE** at which a substance changes from the **LIQUID** state to the **GAS** state.

- Boiling occurs when the **VAPOUR PRESSURE** of a liquid overcomes the **PRESSURE** of our **ATMOSPHERE**...

Pvap ≥ Patm 101.3 kPa

- So liquids with **HIGH** vapour pressures have **LOW** boiling points since it takes **LESS ENERGY** to overcome the pressure of the **ATMOSPHERE**:
  - **Ethyl Alcohol = 78°C** 60kPa
- liquids with **LOW** vapour pressures have **HIGHER** boiling points since it takes **MORE ENERGY** to overcome the pressure of the **ATMOSPHERE**:
  - **Water = 100°C** 20kPa

Boiling Point Elevation:

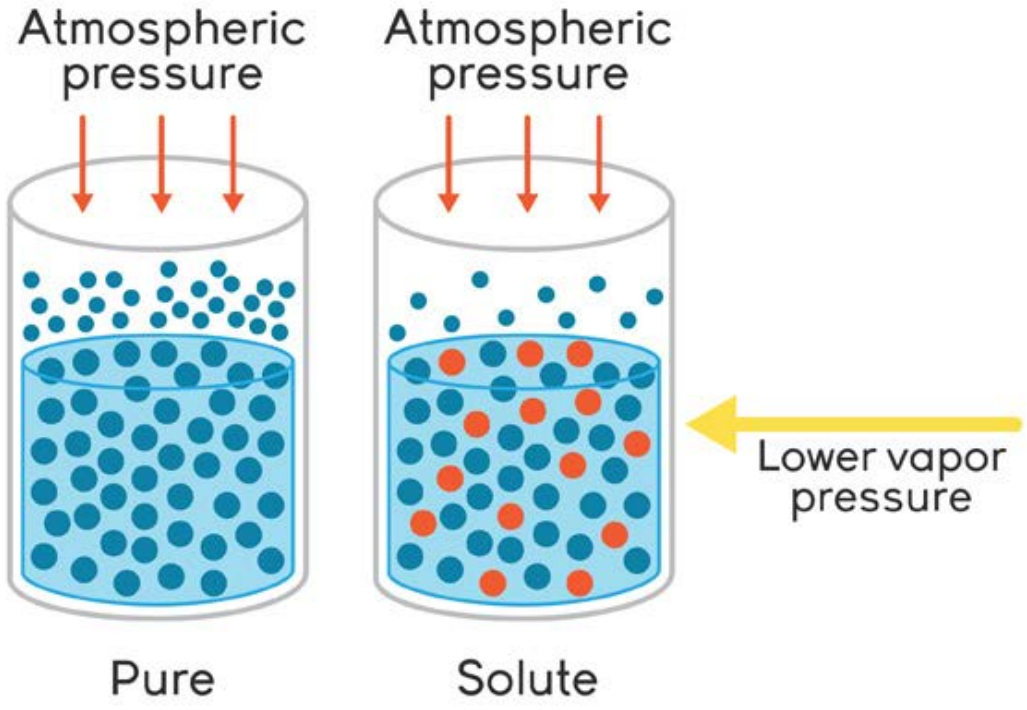
Raoult's Law:

Addition of a solute to a liquid will lower the vapour pressure

This relationship can be explained by the following considerations:

- At the **SURFACE** of the solution where **EVAPORATION** takes place, there are **FEWER** **SOLVENT** particles due to the **PRESENCE** of **SOLUTE** particles.

  → ***Lower P_{vap} so boiling point goes up***



https://www.learner.org/courses/chemistry/images/lrg_img/VaporPressure.jpg

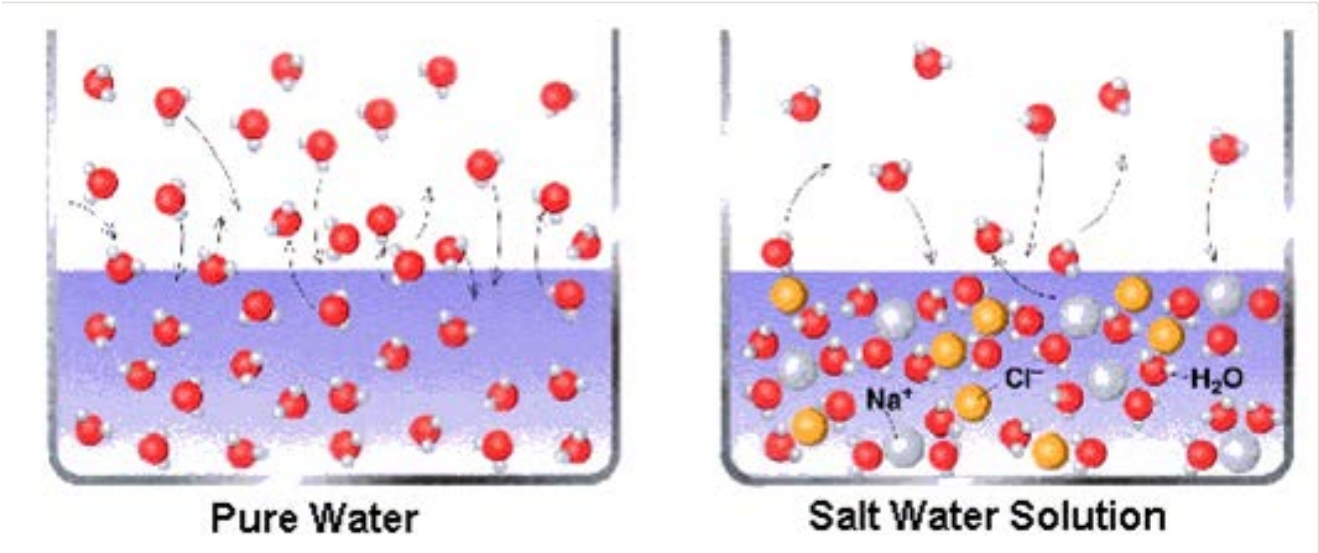
Boiling Point Elevation:

- The **SOLUTE** particles **ABSORB** energy and therefore **REDUCES** the energy available to **EVAPORATE** the **SOLVENT** particles

  → ***Lower P_{vap} so boiling point goes up***

- **ENERGY** is required to overcome the **I.M.F.'S** between the **SOLUTE** and **SOLVENT** particles.

  → ***Lower P_{vap} so boiling point goes up***



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Boiling Point Elevation:

Recall:

Boiling point is the temperature at which $P_{vap} = P_{atm}$

So, if the **VAPOUR PRESSURE** is lowered, it will take **MORE** energy to reach P_{atm}, so the **BOILING POINT** will be **HIGHER**.

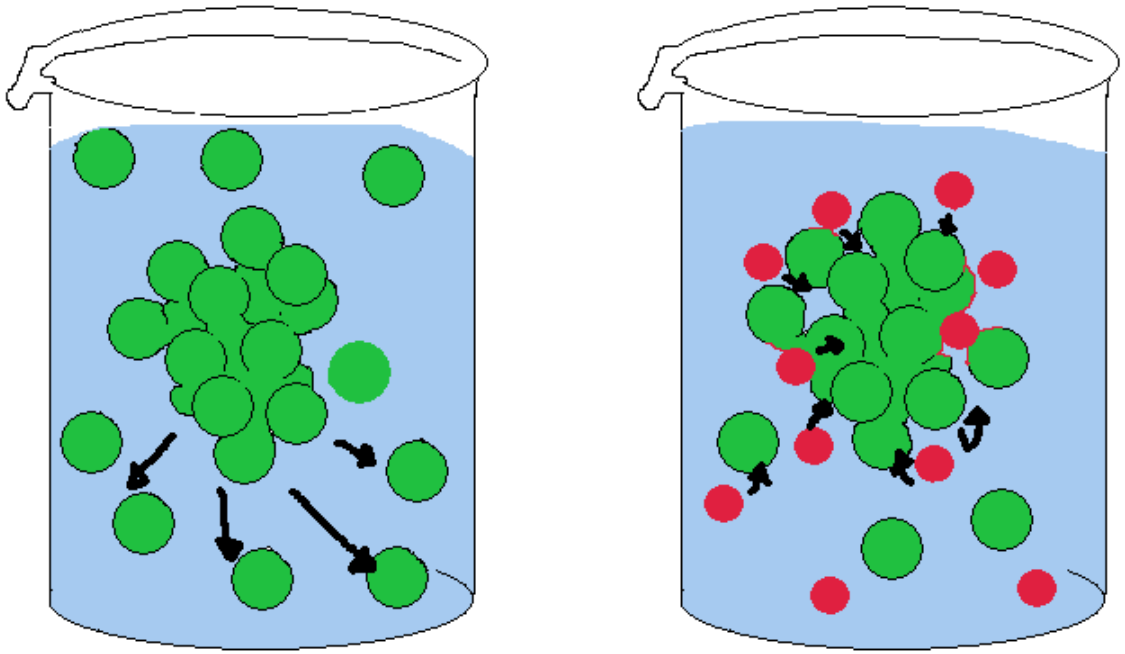
Therefore:

Addition of a solute raises the boiling point of a solvent.

Freezing Point Depression:

- For a liquid to **SOLIDIFY**, it must form a very **ORDERED CRYSTAL STRUCTURE**.
- If there are **IMPURITIES** (solute) in the liquid, then the liquid is **LESS ORDERED**, making it **DIFFICULT** to freeze.
- **SOLUTE** particles interfere with crystal **FORMATION**, so **MORE** kinetic energy must be **LOST**.

  → ***Lower freezing point***



https://www.powsciencetoys.com/v/vspfiles/assets/images/fpdepression.png

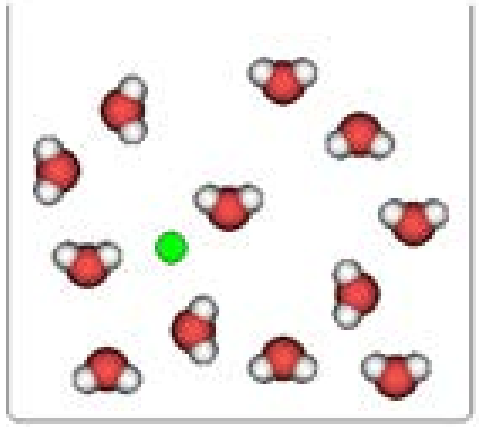
Freezing Point Depression:

Effect of different solutes:

- The **MORE PARTICLES** released by a **SOLUTE**, the more the freezing point will be **DEPRESSED**!
  → There are **MORE** particles to **INTERFERE** with freezing!

Examples:

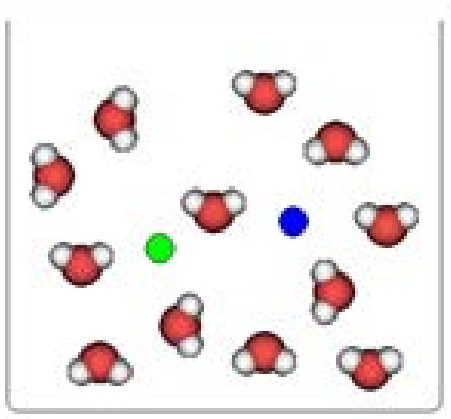
Sugar Solution: $C_6H_{12}O_{6\,(s)} \rightarrow C_6H_{12}O_{6\,(aq)}$



One molecule of sugar will create one

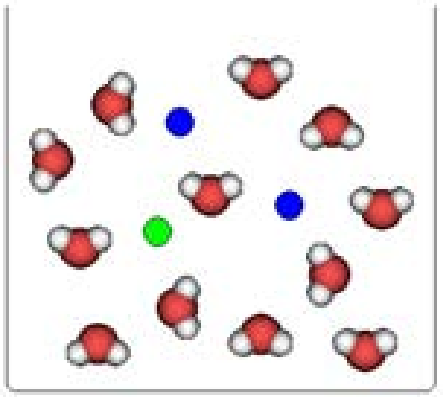
Freezing Point Depression:

NaCl Solution: $NaCl_{(s)} \rightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$



One molecule of NaCl will create two dissolved particles

$CaCl_2$ Solution: $CaCl_{2(s)} \rightarrow Ca^{2+}_{(aq)} + 2Cl^{-}_{(aq)}$



One molecule of $CaCl_2$ will create three dissolved particles