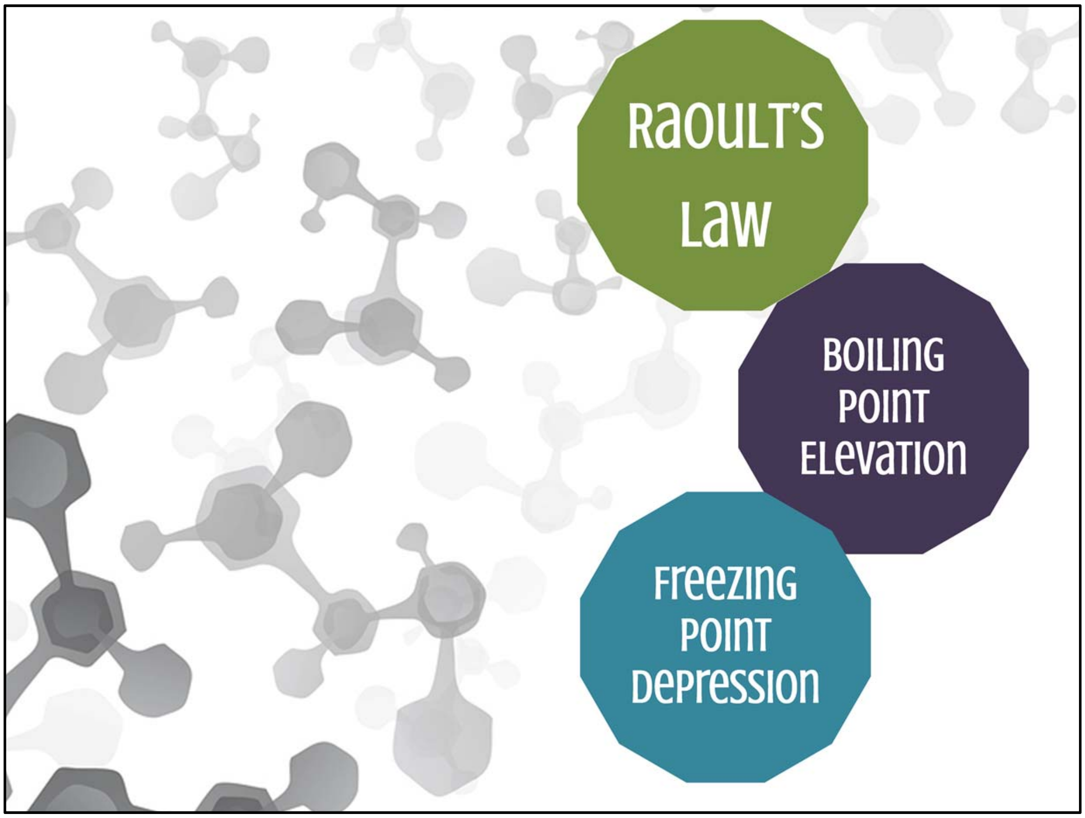
Module 10: Solutions
Topic 5 Content: Raoult's Law, Boiling Point Elevation, and Freezing Point Depression
Presentation Notes



Raoult's Law, Boiling Point Elevation, and Freezing Point Depression

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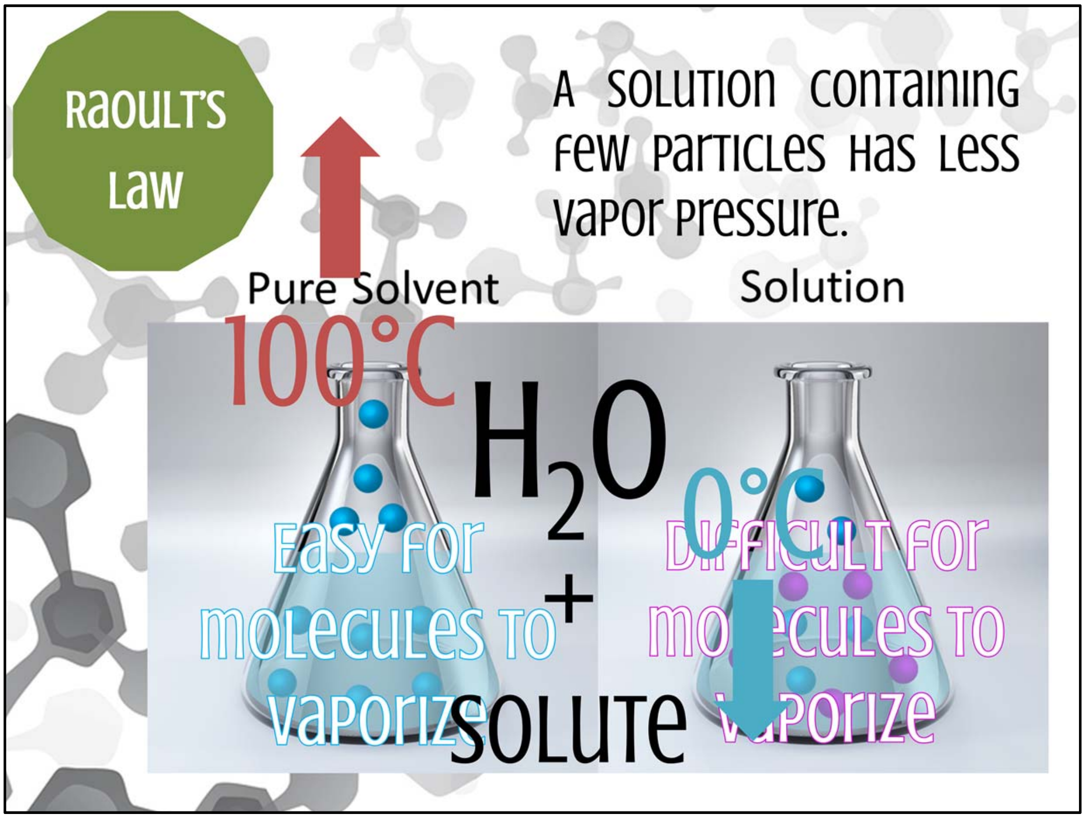
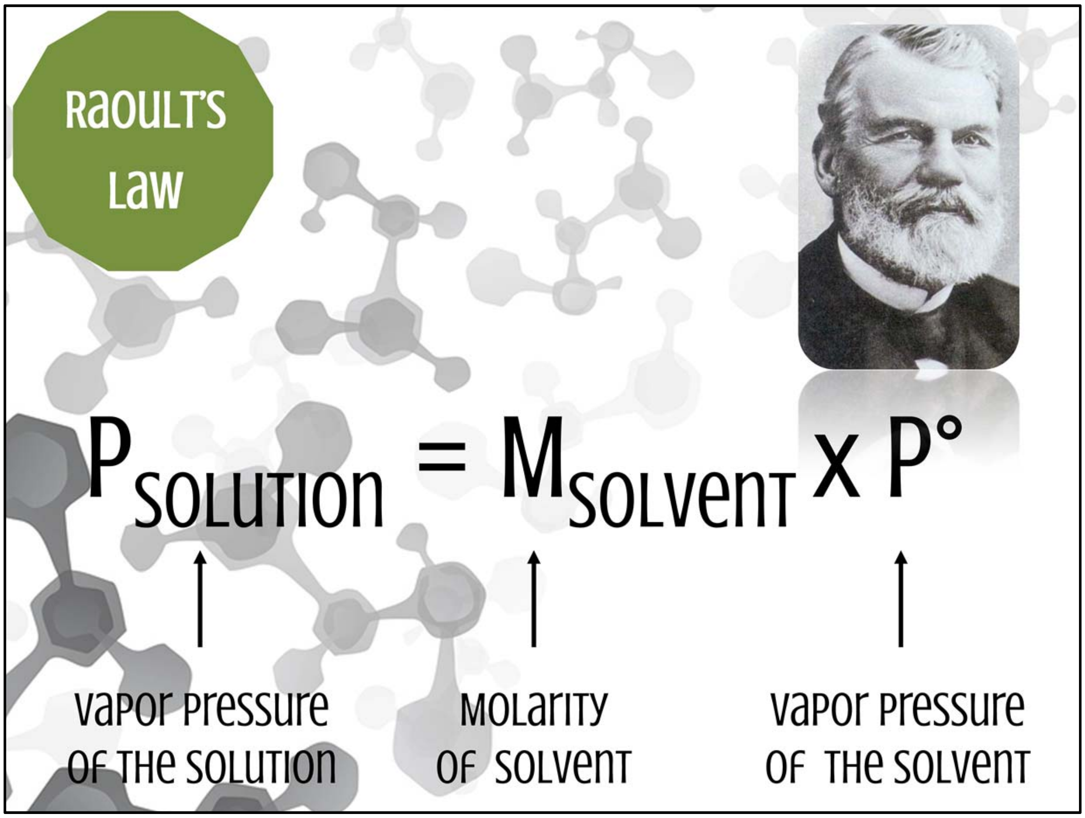


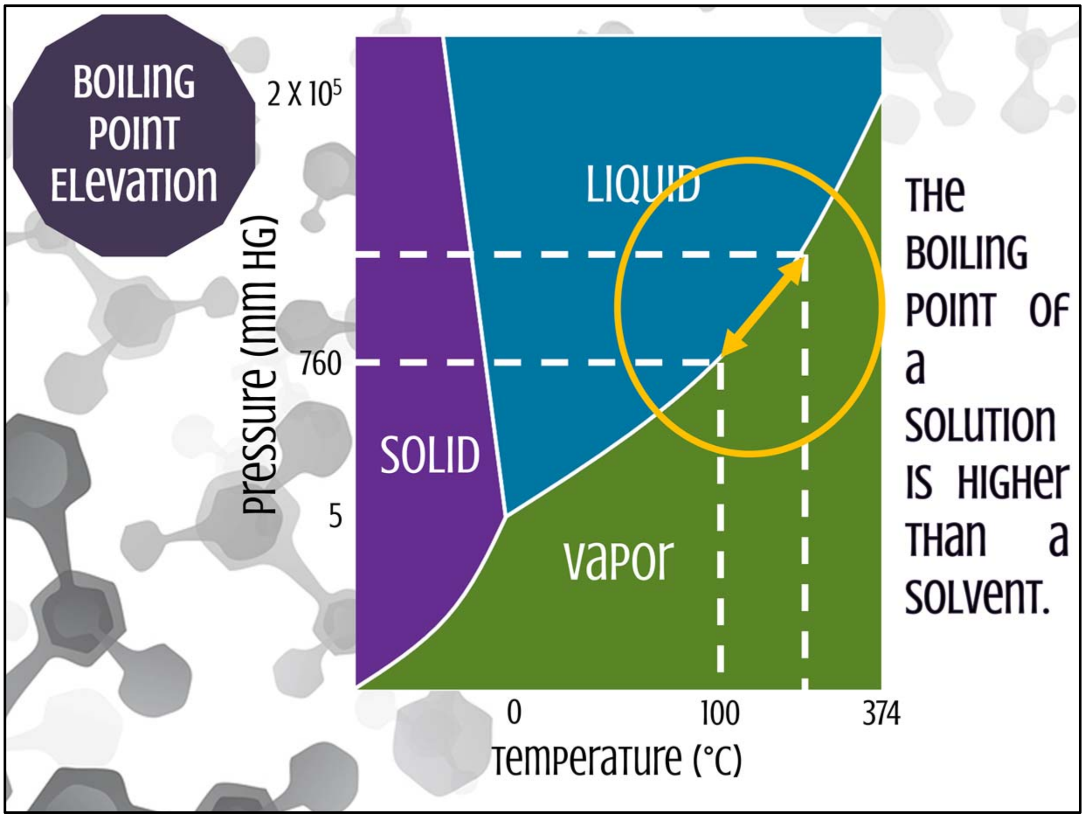
At standard temperature and pressure, water boils at 100°C and freezes at 0°C. However, if a solute like sodium chloride is placed in the water, the freezing point goes down and the boiling point goes up. When a solute is added to a solvent, the resulting solution has a lower vapor pressure than the solution of the pure solvent.

Consider two beakers: one contains pure water, and the other contains water with salt dissolved in it. As the beaker with pure water is heated, the water molecules with high kinetic energy are quite free to leave, as there is nothing to block their escape route. The other beaker contains dissolved salt ions that limit the escape of water molecules. In other words, the amount of surface area for escaping solvent molecules is reduced because some of the surface area is now occupied by solute particles. Since there are fewer particles of water becoming vapor, the vapor pressure has now been lowered. This occurs because vapor pressure is caused by collisions of particles. If fewer particles exist, then there is less pressure in the solution.

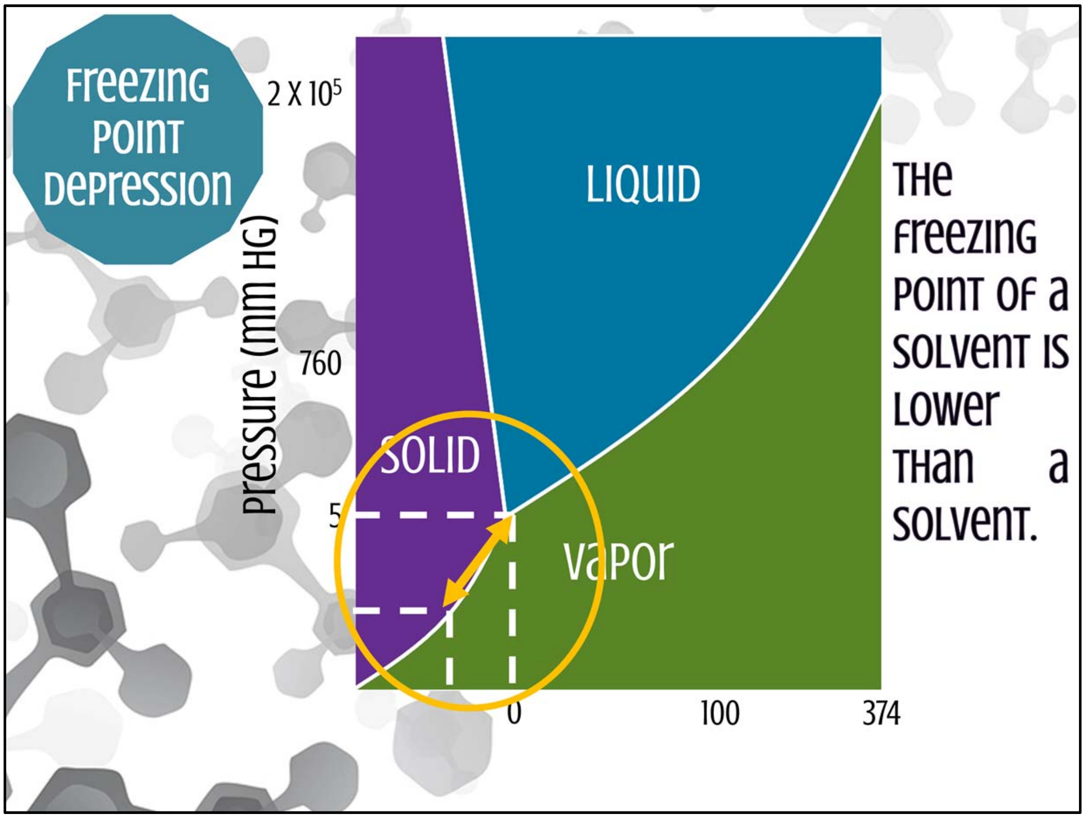


It was French chemist Francois Raoult who mathematically described the lowering vapor pressure of solutions. Raoult's Law states that the vapor pressure of a solution is equal to the amount of moles of solvent times the pressure of the solvent.

In this equation, $P_{solution}$ is the vapor pressure of the solution, $M_{solvent}$ is the molarity of the solvent, and $P°_{solvent}$ is the vapor pressure of the pure solvent. This law works for ideal mixtures only. When using this equation, the vapor pressure will either be positive or negative. A positive vapor pressure indicates that the solvent molecules have an easy escape from the solution to the gas phase. A negative vapor pressure indicates the opposite. Negative vapor pressure shows that the gasses are having difficulty escaping the solution. Any solution that follows Raoult's Law is referred to as an ideal solution because the solution has behaved as expected. However, very few solutions actually behave as expected, making the majority of solutions non-ideal.



As a result of Raoult's Law, the boiling point of a solution is greater than the boiling point of the pure solvent. Boiling occurs when vapor pressure equals atmospheric pressure. If the vapor pressure has been lowered, then more heat will be required to raise the vapor pressure to equal the atmospheric pressure. Therefore, the boiling point of a solution is higher than the boiling point of the pure solvent. The boiling point elevation is the numerical difference between the boiling point of the solution with the solute in it and the boiling point of the pure solvent. This relationship is best viewed on a phase diagram showing both the solution and pure solvent.



The freezing point of a solution also lowers when compared to that of a pure solvent. This is known as freezing point depression. In order to understand the freezing point depression, you must consider the actual freezing process. A liquid freezes by achieving a very orderly state of atoms. If there are impurities in the liquid, the solution is less ordered and has more difficultly when freezing. This relationship is best viewed on a phase diagram showing both the solution and pure solvent.