Chemistry Lecture #81: Boiling Point Elevation & Freezing Point Depression, Part 2

In this lecture we'll explain how to do two more types of problems involving boiling point elevation and freezing point depression.

21.6 g of $NiSO_4$ is added to 1.00×10^2 g of water. Find the boiling point.

Answer

We first need to find the molality, *m*, of the solution.

1 mole $NiSO_4$ = 155 g $NiSO_4$ 1000 g H_2O = 1 kg H_2O

$$\frac{21.6 \text{ g } NiSO_4}{100 \text{ g } H_2O} \times \frac{\text{mole } NiSO_4}{155 \text{ g } NiSO_4} \times \frac{1000 \text{ g } H_2O}{\text{kg } H_2O} = 1.39 \text{ } m \text{ } NiSO_4$$

$NiSO_4$ is an ionic compound that dissociates into two ions when dissolved in water

$$NiSO_4 (s) \xrightarrow{H_2O} Ni^{2+} (aq) + SO_4^{2-} (aq)$$

Since the number of solute particles has doubled, we multiply the molality by 2.

Molality = $1.39 \times 2 = 2.78$ *m*

Knowing the molality of solute particles, we can calculate the boiling point.

$\Delta T_{bp} = k_b \, m = (0.512 \text{ °C/m})(2.78 \text{ m}) = 1.42$ °C

bp = 100 + 1.42 = 101.42 °C

99.0 g of a nonionizing solute is dissolved into 669 g of water. The freezing point is -0.960 °C. What is the molecular mass of the solute?

Answer

We'll first solve for the molality of the solution, then use this to find the molecular mass of the solute.

$\Delta T_{fp} = k_f\, m$
$0.960\ °C = (1.86\ °C/m)\, m$
$0.960 = 1.86\, m$
$m = 0.516$ molal or 0.516 moles/kg H_2O

The unit of molecular mass for the solute is g solute/mole; this is the unit we want to get in the final answer. We've been given 99.0 g solute/669 g H_2O. We can convert g H_2O to kg H_2O, then use the molality to convert kg H_2O to moles.

1000 g H_2O = kg H_2O

0.516 moles/kg H_2O ⇒ 0.516 moles = kg H_2O

$$\frac{99.0\text{ g solute}}{669\text{ g } H_2O} \times \frac{1000\text{ g } H_2O}{\text{kg } H_2O} \times \frac{\text{kg } H_2O}{0.516\text{ moles}} = \frac{287\text{ g solute}}{\text{mole}}$$