Colligative Properties Worksheet

1) If I add 45 grams of sodium chloride to 500 grams of water, what will the melting and boiling points be of the resulting solution? $K_b(H_2O) = 0.52\ ^0C/m$ and $K_f(H_2O) = 1.86\ ^0C/m$.

2) What is the vapor pressure of the solution in problem #1 at 25^0 C? The vapor pressure of pure water at 25^0C is 3.17 kPa.

3) Which solution will have a higher boiling point: A solution containing 105 grams of sucrose ($C_{12}H_{22}O_{11}$) in 500 grams of water or a solution containing 35 grams of sodium chloride in 500 grams of water?

Colligative Properties Worksheet – Answers

1) If I add 45 grams of sodium chloride to 500 grams of water, what will the melting and boiling points be of the resulting solution? $K_b(H_2O) = 0.52\ ^0C/m$ and $K_f(H_2O) = 1.86\ ^0C/m$.

To find the melting and boiling points, you'll first need to find the concentration of the solution. To find the molality, convert grams of sodium chloride to moles (it turns out to be 0.769 moles) and divide by the number of kilograms of solvent (0.500 kg H_2O). When you do this calculation, the molality is 1.54 m. Because sodium chloride breaks into two particles when it dissociates in water, the effective molality for the purposes of colligative property calculations is twice this, or 3.08 m.

From here, it's a matter of plugging the molality into the equations for freezing point depression and boiling point elevation. When you do this, you should get that the change in melting point is 5.73^0 C and the change in boiling point is 1.60^0 C.

The final answers: Melting point = -5.73^0 C, boiling point = 101.60^0 C.

2) What is the vapor pressure of the solution in problem #1 at 25^0 C? The vapor pressure of pure water at 25^0C is 3.17 kPa.

Vapor pressure = mole fraction of water x normal vapor pressure of water. The mole fraction of water in this case is equal to the number of moles of water (27.8) divided by the total number of moles of all substances in the solution (27.8 + 0.769) = 28.6 moles. The mole fraction of water is 0.972. When you multiply the mole fraction times the normal vapor pressure, you find that the vapor pressure of the solution is 3.08 kPa.

3) Which solution will have a higher boiling point: A solution containing 105 grams of sucrose ($C_{12}H_{22}O_{11}$) in 500 grams of water or a solution containing 35 grams of sodium chloride in 500 grams of water?

Using the same calculations as in question 1, you find that the boiling point of the sucrose solution is 100.32^0 C and the boiling point of the sodium chloride solution is 101.40^0 C. Clearly, the sodium chloride solution has a higher boiling point.