Learning Target 9.3 **Name:** KEY **Period:**

Colligative Properties of Solutions

Physical Properties (boiling point, freezing point) of solutions can be effected by the number of particles regardless of identify of the dissolved solute particles are called colligative properties. ***Colligative properties*** can vary depending on whether the solute is an ***electrolyte*** or ***nonelectrolytes***. Boiling point elevation is directing proportional to the number of solute particles in solution regardless of the identity of those particles.

Electrolyte: Metal / non-metal
Ionic compounds will conduct electricity when dissolved in water because the elements will dissociate (separate) in water forming ions. Fore example NaCl → Na+ (aq) + Cl-(aq). Ionic (charged)

Nonelectrolyte: 2 more non-metals
A compound that will not conduct electricity when dissolved in water because it does not ionize (dissociate) like electrolytes is called nonelectrolye. The most common example includes sucrose. $C_6H_{12}O_6 \rightarrow C_6H_{12}O_6(aq)$ (covalent) Non-metal

Molar Boiling point elevation constant (K_b):

Solvent	BP (°C)	K_b (°C/m)
Water	100.0	0.512
Benzene	80.1	2.53
Carbon Tetrachloride	76.7	5.03
Ethanol	78.5	1.22
Chloroform	61.7	3.63

Molar Freezing point depression constants (k_f)

Solvent	FP (°C)	Bb (°C/m)
Water	0.0	1.86
Benzene	5.5	5.12
Carbon tetrachloride	-23	29.8
Ethanol	-114.1	1.99
chloroform	-63.5	4.68

Boiling Point Elevation:
$\Delta T_b = K_b M$

ΔT_b = new boiling point
K_b = boiling point constant
M = molarity of the solution

Freezing Point Elevation:
$\Delta T_f = K_f M$

ΔT_f = new freezing point
K_f = freezing point constant
M = molarity of the solution

Calculate the boiling point and freezing points of the following solutions.

1. What is the boiling point and freezing point of a 0.625 M aqueous solution of any nonvolatile, nonelectrolyte solute?

* 2. What are the boiling point and freezing point of a 0.40 M solution of sucrose in ethanol?

B.P.
$= 1.22(0.40) =$
$= .488 + 78.5 =$ **78.988**

F.P. $= 1.99(0.40)$
$= .796$
$= -114.1 - .796 =$ **-114.896 °C**

3. A lab technician determines the boiling point elevation of an aqueous (H_2O) solution of a nonvolatile, nonelectrolyte to be 1.12 °C. What is the solution's molality?

$\Delta T_b = K_b M$ $\quad 1.12 = 0.512\,M$

$M = \frac{1.12}{0.512} =$ **2.19 M**

solvent

4. A student dissolves 0.500 mol of a nonvolatile, nonelectrolyte solute in one kilogram of benzene (C_6H_6). What is the boiling point elevation of the resulting solution?

$\Delta T_b = 2.53(.500)$

$= 1.27$

$80.1 + 1.27 = 81.37\,^\circ C$

5. Calculate the freezing point and boiling point of 12.0 g of glucose ($C_6H_{12}O_6$) in 50.0 g water.

FP $\Delta T_f = 1.86(1.34)$

$= 2.5$

$0^\circ - 2.5 = -2.5\,^\circ C$

BP $\Delta T_b = 0.512(1.34)$

$= 0.69$

$100 + 0.69 = 100.69\,^\circ C$

$\frac{12.0\,g}{180\,g} = 0.067\,M$

$\frac{0.067\,M}{.05\,L}$

6. Calculate the freezing point and boiling point of each of the following.

a. 2.75M NaOH in water

$2.75 \times 2 = 5.5\,M$

$\Delta T_b = 0.512(5.5)$

$= 2.8$

$100 + 2.8 = 102.8\,^\circ C$

$\Delta T_f = 1.86(5.5)$

$= 10.23$

$0 - 10.23 = -10.23\,^\circ C$

b. 0.587M of water in ethanol

$\Delta T_b = 1.22(0.587)$

$= 0.716$

$87.5 + 0.716 = 88.2\,^\circ C$

$\Delta T_f = 1.99(0.587)$

$= 1.17$

$-114.1 - 1.17 = -115.27\,^\circ C$

c. 1.26M of naphthalene ($C_{10}H_8$) in benzene

$\Delta T_b = 2.53(1.26)$

$= 3.19$

$100 + 3.19 = 103.19\,^\circ C$

$\Delta T_f = 5.12(1.26)$

$= 6.45$

$0^\circ - 6.45 = -6.45\,^\circ C$

7. A rock salt (NaCl), ice, and water mixture is used to cool milk and cream to make homemade ice cream. How many grams of rock salt must be added to water to lower the freezing point 10.0 °C?

$10.0\,^\circ C = 1.86(M)$

$M = \frac{10}{1.86} = 5.4\,M$

$\frac{5.4\,mol}{1\,L} = 5.4\,mol\,NaCl \mid \frac{58.4\,g}{1\,mol\,NaCl} =$

$= 315.36\,g\,NaCl$

$\frac{315.36}{2} =$

$157.68\,g\,NaCl$

Challenge Question:

8. Calculate the freezing point and boiling point of a solution that contains 55.4 g NaCl and 42,3 g KBr dissolved in 750.3 mL of water.