Molality

m = moles of solute

kiligrams of solvent

1. Calculate the molality of each of the following solutions:

a) 90.0 g of Potassium Hydroxide in 2.00 x 103 g of water (dissolved)

b) 25.0 g of Ethyl Alcohol (C2H5OH) dissolved in 500. g of water

2. Calculate the number of grams of solute needed in preparing the following molal solutions:

a) 2.00 m solution of H2SO4 dissolved in 1.50 x 103 grams of water

b) 1.50 m solution of NaCldissolved in 500. grams of water

c) 4.00 m solution of NaOHdissolved in 2.00 x 103 grams of water

3. How many grams of water are needed to prepare a 1.50 m solution dissolving 40.0 grams of NaCl?

Colligative Properties

∆Tf = kf x m ∆Tb = kb x m

kf = 1.86 C kb = 0.52 C

4. Calculate the boiling point and the freezing point of each of the following solutions:

a) 62.0 grams of ethylene glycol [C2H4(OH)2] dissolved in 500. grams of water

b) 114 grams of sucrose (C12H22O11) dissolved in 750. grams of water

c) 116 grams of table salt dissolved in 1.00 x 103 grams of water

ANSWER KEY

1. Calculate the molality of each of the following solutions

*One does not have to consider whether the solute is an electrolyte or non-electrolytes when finding the molality alone because molality is moles of* ***solute*** */ kg of solvent. When calculating colligative properties, however, one needs to know the moles of particles (usually ions) in solution.*

a) 90.0 g of Potassium Hydroxide (KOH (aq)) in 2.00 x 103 g of water (dissolved)

K 1 x 39.1 = 39.1

O 1 x 16.0 = 16.0 GFM = 56.1 g/mole

H 1.00 x 1 = 1.00

90.0 g x 1 mole/56.1 g = 1.60 moles 2.00 x 103 g = 2.00 kg

X moles / 1.00 kg = 1.60 moles / 2.00 kg

0.80 moles/kg = 0.80 molal = 0.800 m or 8.00 x 10-1 m

* *KOH(aq) is an electrolyte*

b) 25.0 g of Ethyl Alcohol (C2H5OH) dissolved in 500. g of water

C 2 x 12.0 = 24.0

H 6 x 1.00 = 6.0 GMM = 46.0 g/mole

O 1 x 16.0 = 16.0

25.0 g x 1 mole/46.0 g = 0.540 moles 500. g = 0.500 kg

X moles / 1.00 kg = 0.540 moles / 0.500 kg

1.08 moles/kg = 1.08 molal = **1.08 m**

* *Ethyl Alcohol is a non-electrolyte*

2. Calculate the number of grams of solute needed in preparing the following molal solutions:

a) 2.00 m solution of H2SO4 dissolved in 1.50 x 103 grams of water

2.00 m = 2.00 moles / kg

2.00 moles / 1.00 kg = X moles / 1.50 kg

X = 3.00 moles 1.50 x 103 grams = 1.50 kg

H 2 x 1.00 = 2.00

S 1 x 32.0 = 32.0 GMM = 98.0 g/mole

O 4 x 16.0 = 64.0

3.00 moles x 98.0 g/mole = **294 g**

* *H2SO4(aq) is an electrolyte*

b) 1.50 m solution of NaCldissolved in 500. grams of water

1.50 m = 1.50 moles / kg

1.5 moles / 1.00 kg = X moles / 0.500 kg

X = 0.750 moles 500. g = 0.500 kg

Na 1 x 23.0 = 23.0

Cl 1 x 35.0 = 35.5 GFM = 58.5 g/mole

0.750 moles x 58.5 g/mole = **43.9 g**

* *NaCl(aq) is an electrolyte*

c) 4.0 m solution of NaOHdissolved in 2.00 x 103 grams of water

4.0 m = 4.0 moles / kg

4.0 moles / 1.00 kg = X moles / 2.00 kg

X = 8.0 moles 2.00 x 103 g = 2.00 kg

Na 1 x 23.0 = 23.0

O 1 x 16.0 = 16.0 GMM = 40.0 g/mole

H 1 x 1.00 = 1.00

8.0 moles x 40.0 g/mole = **320 g**

* *NaOH(aq) is an electrolyte*

3. How many grams of water are needed to prepare a 1.50 m solution dissolving 40.0 grams of NaCl?

Na 1 x 23.0 = 23.0

Cl 1 x 35.5 = 35.5 GFM = 58.5 g/mole

40.0 g x 1 mole/58.5 g = 0.684 moles of NaCl

1.50 moles / 1.00 kg = 0.684 moles / X g

X = 0.456 kg = **456 g** of water

Freezing Point Boiling Point

∆Tf = kf x m ∆Tb = kb x m

kf = -1.86 C kb = 0.52 C

4. Calculate the boiling point and the freezing point of each of the following solutions:

a) 62.0 grams of ethylene glycol [C2H4(OH)2] dissolved in 500. grams of water

C 2 x 12.0 = 24.0

H 6 x 1.00 = 6.00 GMM = 62.0 g/mole

O 2 x 16.0 = 32.0

62.0 g x 1 mole/62.0 g = 1.00 mole 500. g = 0.500 kg

X moles / 1.00 kg = 1 mole / 0.500 kg

X = 2.00 moles, therefore, a 2.00 m solution

∆Tf = kf x m ∆Tb = kb x m

∆Tf = (-1.86 C/m) x 2.00 m = -3.72 C ∆Tb = (0.52 C/m) x 2.00 m = 1.04 C

∆Tf = 0.00 C + (-3.72 C) = **-3.72 C** ∆Tb = 100. C + 1.04 C = **101.04 C**

* *ethylene glycol is a non-electrolyte*

b) 114 grams of sucrose (C12H22O11) dissolved in 750. grams of water

C 12 x 12.0 = 144

H 22 x 1.0 = 22.0 GMM = 342 g/mole

O 11 x 16.0 = 176

114 g x 1 mole/342 g = 0.330 moles 750. g = 0.750 kg

X moles / 1.00 kg = 0.330 moles / 0.750 kg

X = 0.44 moles, therefore, a 0.440 m solution

∆Tf = kf x m ∆Tb = kb x m

∆Tf = (-1.86 C/m) x 0.440 m =- 0.82 C ∆Tb = (0.52 C/m) x 0.440 m = 0.23 C

∆Tf = 0.00 C + (-0.82 C) = **-0.82 C** ∆Tb = 100. C + 0.23 C = **100.23 C**

* *sucrose (table sugar) is a non-electrolyte*

c) 116 grams of table salt dissolved in 1.00 x 103 grams of water

Na 1 x 23.0 = 23.0

Cl 1 x 35.0 = 35.5 GFM = 58.5 g/mole

116 g x 1 mole/58.5 g = 1.98 moles 1.00 x 103 g = 1.00 kg

X moles / 1.00 kg = 1.98 moles / 1.00 kg

X = 1.98 moles, therefore, a 1.98 m solution

* NaCl is an electrolyte which dissociates into ions in solution, therefore:

NaCl (aq) 🡪 Na+ (aq) + Cl- (aq)

* For every 1 mole of NaCl (aq), 2 moles of ions are produced, so the molality must be multiplied by 2.

X = 1.98 moles 🡪 2 moles of ions/compound, therefore, a 3.96 m solution

∆Tf = kf x m ∆Tb = kb x m

∆Tf = (-1.86 C/m) x 3.97 m = -7.38 C ∆Tb = (0.520 C/m) x 3.97 m = 2.06 C

∆Tf = 0.00 C + (-7.38 C) = **-7.38 C** ∆Tb = 100. C + 2.06 C = **102.06 C**