CHEM 1032

Key

Solutions

How do IMF affect solutions? What do we need to take into account when deciding if a solution will form? Then we can consider how is the solution different from the pure solvent. Using the material we learn this week in lecture, work with your group to determine the properties of the two solutions:

You decide to make an aqueous CH_3OH solution (A) and an aqueous NaOH solution (B).

	Solution A	Solution B
1. Solute	CH_3OH	NaOH
2. Solute IMF	H-bonding	ion-ion
3. Solvent	H_2O	H_2O
4. Solvent IMF	H-bonding	H-bonding
5. Will a solution form?	yes	yes

Explain your reasoning for question 5.

Solution A

H-bonding + H-bonding = Like dissolves Like

Solution B

ion dipole will develop so solution favored

The 750 mL solutions are 10% by Mass (Density H_2O = 1.00 g/mL).
What is the concentration in….

750 mL = 750 g

10% solute - 75 g

90% H_2O - 675 g

Molarity:

A $75\text{ g } CH_3OH \left| \frac{1\text{ mole}}{32.042\text{ g}} \right. = \frac{2.34\text{ moles}}{0.750\text{ L}} = 3.12\text{ M}$

B $75\text{ g NaOH} \left| \frac{1\text{ mole}}{39.998\text{ g}} \right. = \frac{1.86\text{ moles}}{0.750\text{ L}} = 2.48\text{ M}$

Molality:

A $\frac{2.34\text{ moles}}{0.675\text{ Kg}} = 3.47\text{ m}$

B $\frac{1.86\text{ mole}}{0.675\text{ Kg}} = 2.76\text{ m}$

ppm: Both are the same…

$$\left(\frac{75.0\text{ g}}{750\text{ g}}\right) \cdot 10^6 = 1.0 \times 10^5\text{ ppm}$$

Mole fraction: $675\text{ g } H_2O \left| \frac{1\text{ mole}}{18.01\text{ g}} \right. = 37.5\text{ mole}$

# of particles needed

$$\chi_A = \frac{2.34\text{ mole}}{2.34 + 37.5} = 0.0587 \qquad \chi_B = \frac{1.86\text{ mole}(2)}{1.86(2) + 37.5} = 0.092$$

When you mix the solutions one feels warm and one does not feel any different. Consider the ΔH_{solu} for CH_3OH is -0.2 kJ/mol and ΔH_{solu} for NaOH is -44.46 kJ/mol. Show with calculations which solution feels warm upon mixing.

CH_3OH 2.34 mole

$$\frac{2.34 \text{ mole}}{} \left| \frac{-0.2 \text{ kJ}}{1 \text{ mole}} \right. = -0.468 \text{ kJ}$$

NaOH 1.86 mole

$$\frac{1.86 \text{ mole}}{} \left| \frac{-44.06 \text{ kJ}}{1 \text{ mole}} \right. = -82.70 \text{ kJ}$$

(−) means exothermic, so energy released, will make solution feel warm.

NaOH releases more E ... so warmer solu.
CH_3OH is a very small amount, so not much temp decrease.

Show the relationship between $|\Delta H_{solute}|$ and $|\Delta H_{hydration}|$ for both solutions.

Both solutions have a (−) ΔH value so E released. In order for $\Delta H_{solu} = \ominus$ then

$$\overset{(+)}{\Delta H_{solu}} < \overset{(-)}{\Delta H_{hydration}}$$

less E needed to pull apart

more E released

Which solution will have a higher vapor pressure at 25 °C ($P°_{vap}$ = 23.8 Torr) ?

Solution A $\quad X_{solute} = 0.0587 \therefore X_{solvent} = 0.9413$

$$P_{solu} = (0.9413)(23.8 \text{ Torr}) = 22.4 \text{ Torr}$$

Solution B $\quad X_{solute} = 0.0902 \therefore X_{solvent} = 0.9097$

$$P_{solu} = (0.9097)(23.8 \text{ Torr}) = 21.7 \text{ Torr}$$

Solution A has higher Pvap.

You decide to see how the boiling and freezing points of your solutions differ from pure water and from each other. Based on your vapor pressure calculations, hypothesize which solution will boil at a higher temp.

Since Solution B has a lower Pvap it will take more energy to reach Pext. So Solution B has highest BP... more E needed.

The important water constants are K_f = 1.86 °C/*m* and K_b = 0.512 °C/*m*. Complete the table below for each solution.

m from page 1

	Solution A	Solution B
T_f (°C)	−6.45 °C	−10.27 °C
T_b (°C)	101.78 °C	102.66 °C

A

$\Delta T_f = (3.47\,m)(1.86\,°C/m) = 6.45°C$

$0°C - 6.45°C = -6.45°C$ FP

$\Delta T_b = (3.47)(0.512\,°C/m) = 1.78°C$

$100°C + 1.78°C = 101.78°C$

B

ionic compound $= i = 2$

$\Delta T_f = (2)(2.76\,m)(1.86\,°C/m)$
$= 10.27\,°C$

$0°C - 10.27°C = -10.27°C$

$\Delta T_b = (2)(2.76\,m)(0.512\,°C/m)$
$= 2.66\,°C$

$100°C + 2.66°C = 102.66°C$

Why do the boiling/freezing points differ between the solutions if they are the same volume and same % by mass?

Because NaOH generates double the particles compared to CH_3OH... NaOH is an ionic compound. Colligative properties are dependent on number of particles not the identity of those particles.