Answer on Question#45939 - Chemistry - Inorganic Chemistry

Question:

the freezing point of a solution containing 0.2 gram of actic acid in 20 gram of benzene is lowered by 0.45 celsuis. calculate molar mass of actic acid and van hoff factor.

Answer:

The decrees in freezing temperature of the solution comparing with pure solvent is due to the dissolved substance. In this case, acetic acid CH_3COOH was disdolved in benzene C_6H_6. One molecule of acetic acid has the following molecular structure:

The decrees in freezing temperature is defined by the followin formula (Raul's second law):

$$\Delta T = iK_f C_m$$

where i is for van't hoff coefficient, K_f is for freezing constant and C_m is for molarity. Therefore, decrees in freezing piont is proportional to molarity of the solution. Molarity is defined as the amount of moles of dissolved substance (A) per one kilogram of solvent (B):

$$C_m = \frac{n(A) * 1000}{m(B)} = \frac{m(A) * 1000}{M(A) * m(B)}$$

For benzene, freezing constant Kf = 5.089 ^oC kg mol^{-1}. Considering this, one can calculate van't hoff coefficient i. I shows, how much particles dissolved substance creates while dissociation. There are three cases possible:

1. i > 1, dissolved substance dissociates into two or more particles in the solution;

2. i = 1, dissolved substance doesn't dissociate or associate, so, technically, it produces only one particle;

3. i < 1, dissoved substance associates - produces one molecule (associate) from two or more particles.

We will find out the value of i and make conclusions based on this value.

Firstly, molar mass of one molecule of acetic acid must be calculated:

$$M(CH_3COOH) = 12 * 2 + 4 + 16 * 2 = 60 \frac{g}{mol}$$

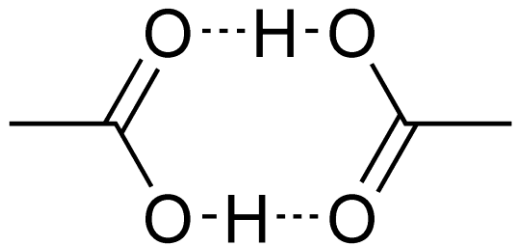
Now we can calculate molality of the final solution:

$$C_m = \frac{n(A) * 1000}{m(B)} = \frac{m(A) * 1000}{M(A) * m(B)} = \frac{0.2g * 1000}{60 \frac{g}{mol} * 20g} = 0.167 \frac{mol}{kg}$$

And, finally, van't hoff coefficient can be calculated:

$$\Delta T = iK_f C_m 0.45^oC = i * 5.089 * 0.167 \frac{mol}{kg} \Rightarrow i = \frac{0.45}{5.089 * 0.167} = 0.53$$

It is less than 1, so acetic acid associates in benzene, producing dimere:



The molar mass of this dimere molecule is *M(dimer) = 2*M(monomer) = 60*2 = 120 g/mol*