Question # 82385

For the reaction 2A (aq) <---> B (aq) + C (aq), the standard free enthalpy change is 1.49 kJ at 25 degrees Celsius. The initial concentration of A is 0.527 M, the initial concentration of B is 0.314 M, and the initial concentration of C is 0.204 M. At equilibrium (we are still at 25 degrees Celsius), what will be the concentration of A (aq) (in mol / L)?

Solution:

If the system is in equilibrium, the free energy change is equal to 0 ($\Delta G=0$). But ΔG^0 is not equal to 0 in this case, so:

$$\Delta G^0 = -RTlnK_c$$

As it is nothing about standard entropy change in conditions of the task, it is possible to assume that $\Delta S=0$. In this case, the free energy change is equal to the free enthalpy change:

$$K_c = e^{-\frac{\Delta H}{RT}} = e^{-\frac{1490}{8.314*298}} = 0.6014$$

, where $K_c = \frac{C_B * C_C}{{C_A}^2}$.

So, it is possible to calculate the change of concentrations of components in a chemical reaction:

$$\frac{[B]*[C]}{[A]^2} = 0.6014$$

$$[B]*[C] = 0.6014*[A]^2$$

$$(0.314 + x)*(0.204 + x) = 0.6014*(0.527 - x)^2$$

$$0.064056 + 0.518*x + x^2 = 0.167026 - 0.6338756*x + 0.6014x^2$$

$$0.3986*x^2 + 1.151876*x - 0.10297 = 0$$

$$x = \frac{-1.151876 + \sqrt{1.151876^2 - 4*0.3986*(-0.10297)}}{2*0.3986} = \frac{-1.151876 + 1.221063}{2*0.3986} = 0.087$$

Consequently, the concentration of A at equilibrium is equal to:

$$[A] = 0.527 - 0.087 = 0.440\frac{mol}{l}$$

Answer:

The concentration of A at equilibrium is 0.440 mol/l.