Answer on the question #50109, Chemistry, Physical Chemistry

Question:

The dissociation equilibrium of a gas AB2 can be represented as

2AB2(g)=2AB(g)+B2(g)

The degree of dissociation is 'x' and it is small as compared to 1. The expression relating the degree of dissociation (x) with equilibrium constant Kp and total pressure P is

(1)2Kp/P

(2)2Kp/P^1/3

(3)2Kp/P^1/2

(4)Kp/P

Solution:

By definition, the degree of dissociation is the ratio between the number of moles that exhibited the reaction to the whole number of moles. Taking into account the stechiometric relations between the reagents and products, the following equation was derived:

$$x = \frac{n(AB)}{n(AB) + n(AB_2)}.$$

After some mathematical operations, with use of x<<1 condition:

$$x \cdot n(AB_2) = n(AB).$$

According to the ideal gas equation, the volume is equal to:

$$V = \frac{nRT}{P}.$$

Proceeding to the expression forK_p and its relation with moles reaction equilibrium constant n_i^{vi} :

$$K_p = \prod n_i^{\nu_i} \left.\frac{RT}{V}\right)^{\nu_i} = \frac{n_{AB}^2 \cdot n_{B_2}}{n_{AB_2}^2} \cdot \frac{RT}{V} = \frac{n_{AB}^3}{2n_{AB_2}^2} \cdot \frac{RT}{V}.$$

Calculation of the summary number of moles in the system in the equilibrium:

$$n = n_{AB} + n_{AB_2} + n_{B_2} = x \cdot n_{AB_2} + n_{AB_2} + 0.5x \cdot n_{AB_2} = (1.5x + 1) \cdot n_{AB_2} = n_{AB_2}.$$

Finally, the relation between pressure equilibrium constant K_p, pressure P and the degree of dissociation:

$$K_p = \frac{x^3 n_{AB_2}^3}{2n_{AB_2}^2} \cdot \frac{RTP}{nRT} = \frac{x^3 P}{2}$$

$$x = \sqrt[3]{\frac{2K_p}{P}}$$

Answer: (2)