Answer on the question #49705, Chemistry, Physical Chemistry

Question:

Consider the dissociation of methane, CH4(g) into the elements H2(g) and C(s, graphite).
(i) Given that the enthalpy and entropy of formation of methane are –74.85 kJ mol –1 and –80.67 J K–1 mol –1 respectively at 298 K, calculate the standard Gibbs energy for the dissociation and the equilibrium constant K. [5]

(ii) Deduce the expression for the degree of dissociation α (also known as extent of reaction) for his reaction.

Answer:

(i) The reaction equation is:
$CH_4(g) = C(s, graphite) + 2H_2(g)$
The enthalpy of the reaction is equal to the negative enthalpy of the methane formation. The same way, the entropy change is negative entropy of formation change. Let's calculate the Gibbs energy change for the dissociation process:

$$\Delta G = \Delta H - T\Delta S = 74850 - 298 * 80.67 = 50.81 \frac{kJ}{mol}$$

The equilibrium constant is:

$$K = e^{-\frac{\Delta G}{RT}}$$

$$K = e^{-\frac{50.81}{8.314*298}} = 0.9796$$

(ii) The degree of dissociation can be calculated as the ratio of the methane molecules underwent the reaction amount to the initial methane molecules amount. Then the equation can be re-expressed with the use of equilibrium constant and carbon concentration.

$$\alpha = \frac{[C]}{[CH_4] + [C]} = (1 + \frac{4[C]^2}{K})^{-1}$$