Answer on Question#39963 - Chemistry - Physical Chemistry

Question:

a) Calculate the translation energy/molecule at 300K for the nitrogen molecule?
b) Calculate the translation energy/mole at 300K for the nitrogen molecule?
c) Calculate the Number Density at 298.2K for the nitrogen molecule?
d) Calculate the Concentration at 298.2K for the nitrogen molecule?

Answer:

a) Every molecule has 3 translational degrees of freedom. Each translational degree of freedom contains 1/2kT energy per molecule. Hence the total translational energy can be calculated as following:

$E_T(N_2)_{molecule} = 1/2kT \cdot 3 = 3/2kT = 3/2 \cdot 1.381 \cdot 10^{-23} \cdot 300 = 6.21 \cdot 10^{-21}$ J

b) The translational energy per mole can be calculated multiplying the energy per molecule by Avogadro's number:

$E_T(N_2)_{mole} = 3/2kT \cdot N_A = 3/2RT = 3740$ J/mol

c) The number density v is defined as the number of molecules per unit of volume:

$v = N/V$; $N = n \cdot N_A$

The volume can be obtained from the ideal gas law:

$pV = nRT$; $V = nRT/p$

Substituting the equation for volume into the expression for number density we can obtain the final expression:

$$\nu = \frac{nN_A p}{nRT} = \frac{N_A p}{RT}$$

The specific pressure data was not given, so we will use the atmospheric pressure for calculations.

$$\nu = \frac{N_A p}{RT} = \frac{6.022 \cdot 10^{23} mol^{-1} \cdot 101325\ Pa}{8.3145 \frac{J}{mol \cdot K} \cdot 298.2\ K} = 2.46 \cdot 10^{25}\ m^{-3} = 2.46 \cdot 10^{22}\ l^{-3}$$

d) The concentration is the number of moles per unit of volume.

$c = n/V$

$pV = nRT$ => $p = cRT$; $c = p/RT$

$$c = \frac{101325\ Pa}{8.3145\ \frac{J}{mol \cdot K} \cdot 298.2\ K} = 40.87 \frac{mol}{m^3} = 40.87 \frac{mol}{m^3} = 0.04087 \frac{mol}{l^3}$$