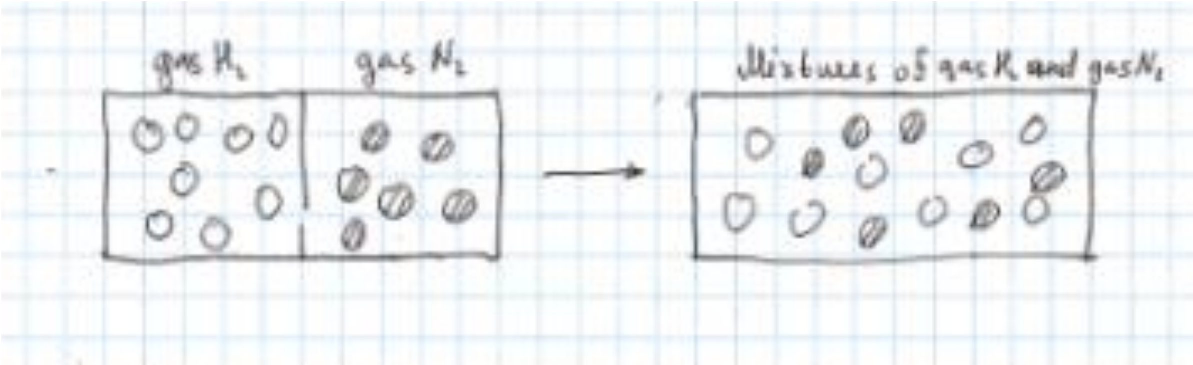
Calculate the entropy of mixing when 2.00 mol of H2 are mixed with 3.00 mol of N2 assuming that no chemical reaction occurs between them.

Solution. According to the second law of thermodynamics, gas will always go to such a state as to occupy free volume, that is, it always goes from the state of least probable entropy to the state of greater probability. Express this with the formula: $S=k_B \ln W$.
Imagine a situation where two spaces with gases occupying corresponding volumes, V_{H2} (right) and V_{N2}(left). Open the partition. We get a mixture of gases occupying the volume $V=(V_{H2}+V_{N2})$.
In the figure it looks like this:



For hydrogen, we can write the change in entropy as follows: $\Delta S_{H_2}=n_{H_2} R\ln(\frac{V_{H_2}+V_{N_2}}{V_{H_2}})$.

For nitrogen, we can write the change in entropy as follows: $\Delta S_{N_2}=n_{N_2} R\ln(\frac{V_{H_2}+V_{N_2}}{V_{N_2}})$.

The entropy of the mixture will then be expressed by the formula: $\Delta_{mix}S=\Delta S_{H_2}+\Delta S_{N_2}=n_{H_2} R\ln(\frac{V_{H_2}+V_{N_2}}{V_{H_2}})+ n_{N_2} R\ln(\frac{V_{H_2}+V_{N_2}}{V_{N_2}})$.

At the same time, the law of Mendeleev-Clapeyron is known: pV=nRT, Then the entropy of the mixture we can write: $\Delta_{mix}S=\Delta S_{H_2}+\Delta S_{N_2}=n_{H_2} R\ln(\frac{n_{H_2}+n_{N_2}}{n_{H_2}})+ n_{N_2} R\ln(\frac{n_{H_2}+n_{N_2}}{n_{N_2}})$.

Then we calculate the entropy change of the mixture, substituting the relevant data:
$\Delta_{mix}S=\Delta S_{H_2}+\Delta S_{N_2}=n_{H_2} R\ln(\frac{n_{H_2}+n_{N_2}}{n_{H_2}})+ n_{N_2} R\ln(\frac{n_{H_2}+n_{N_2}}{n_{N_2}})=2\times 8.31\times \ln(\frac{2+3}{2})+3\times 8.31\times \ln(\frac{2+3}{3})=$
$=15.229+12.735=27.964 \frac{J}{K}$.

Answer: $\Delta_{mix}S= 27.964 \frac{J}{K}$.

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