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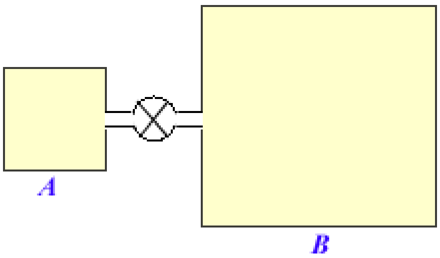
Problem 23.13 (RHK)

Container A contains an ideal gas at a pressure of $5.0\times10^{5}\ \text{Pa}$ *and a temperature of 300 K. It is connected by a thin tube to container B with four times the volume of A. B contains the same ideal gas at a pressure of* $1.0\times10^{5}\ \text{Pa}$ *and at a temperature of 400 K. The connecting valve is opened, and equilibrium is achieved at a common pressure while the temperature of each container is kept constant at its initial value. We have to find the final pressure in the system.*



Solution:

Let the initial amounts of ideal gas in the container A be n_1 mol and that in the container B be n_2 mol, respectively. Let the volume of the container A be V.

Temperature of the gas in *A* is 300 K and the pressure of the gas in *A* when it is isolated from *B* is given to be 5.0×10^5 Pa. The volume of the container *B* is 4 *V* and its temperature is 400 K and the pressure of the gas in it when it is isolated from *A* is given to be 1.0×10^5 Pa. From the ideal gas equation, we have

$$n_1 = \frac{P_A V_A}{RT_A} = \frac{5.0\times10^5\times V}{300R} = \frac{5\times10^3 V}{3R},$$

$$n_2 = \frac{P_B V_B}{RT_B} = \frac{1.0\times10^5\times 4V}{400R} = \frac{10^3 V}{R}.$$

The total amount of gas in containers A and B is therefore

$$n = n_1 + n_2 = \frac{8\times10^3 V}{3R}.$$

The connecting valve is opened and equilibrium is achieved by marinating the temperatures of *A* and *B*. Let the common pressure in the containers be P when equilibrium has been reached. Let the amount of gas in the container A at equilibrium be n_A. The amount of gas in the container B at equilibrium will be $n-n_A$. We have the following equations describing this situation:

$$PV = n_A R \times 300,$$

$$P \times 4V = \left(n - n_A\right) R \times 400,$$

or

$$n - n_A = 3n_A,$$

or

$$n_A = \frac{n}{4} = \frac{2V \times 10^3}{3R}.$$

Therefore,

$$P = 200 \text{ kPa}.$$