Answer on Question #42742-Physics-Molecular Physics-Thermodynamics

Two thermally insulated vessels 1 and 2 are filled with air at temperatures (T1, T2), volume (V1, V2) and pressure (P1, P2) respectively. If the valve joining the two vessels is opened, the temperature inside the vessel at equilibrium will be?

Solution

According to the kinetic theory, the average kinetic energy (KE) per molecule f a gas is $\frac{3}{2}kT$. Let n_1 and n_2 be the number of moles of air in vessels 1 and 2 respectively.

Before mixing, the total KE of molecules in the two vessels is

$$E_1 = \frac{3}{2}n_1kT_1 + \frac{3}{2}n_2kT_2 = \frac{3}{2}k(n_1T_1 + n_2T_2).$$

After mixing, the total KE of molecules is

$$E_2 = \frac{3}{2}(n_1 + n_2)kT,$$

where T is the temperature when equilibrium is established. Since there is no loss of energy (because the vessels are insulated), $E_1 = E_2$ or

$$\frac{3}{2}k(n_1T_1 + n_2T_2) = \frac{3}{2}(n_1 + n_2)kT \rightarrow T = \frac{(n_1T_1 + n_2T_2)}{(n_1 + n_2)}.$$

Now $P_1V_1 = n_1RT_1$ and $P_2V_2 = n_2RT_2$ which gives

$$n_1 = \frac{P_1V_1}{RT_1} \ and \ n_2 = \frac{P_2V_2}{RT_2}.$$

Using these in equation for T and simplifying, we get

$$T = \frac{T_1T_2(P_1V_1 + P_2V_2)}{P_1V_1T_2 + P_2V_2T_1}.$$

Answer: $\boldsymbol{T = \frac{T_1T_2(P_1V_1+P_2V_2)}{P_1V_1T_2+P_2V_2T_1}}$.