Answer on Question #64196, Physics / Molecular Physics | Thermodynamics

Question:

18m^3 of air having a pressure of 4 bar absolute and a temperature of 90 degrees Celsius are to be compressed together with 28m^3 of air having a pressure of 3 bar absolute and a temperature of 15 degrees Celsius, in a vessel whose volume is 22m^3. What will be the temperature of the mixture if its pressure is 7 bar absolute?

Solution:

Let's treat air as an ideal gas. Then we may apply the ideal gas law:

$PV = \frac{m}{M}RT$,

where P is the pressure of air, V — volume, m — mass, M — molar mass,
R — gas constant (8.314 J·K^{-1}·mol^{-1}), and T — absolute temperature.

We may write three equations:

$P_1V_1 = \frac{m_1}{M}RT_1$ (1)

$P_2V_2 = \frac{m_2}{M}RT_2$ (2)

$P_{tot}V_{tot} = \frac{m_1+m_2}{M}RT_{tot}$ (3)

From equations (1) and (2) we may evaluate masses and substitute them into equation (3).

$m_1 = \frac{P_1V_1}{RT_1}M$, $m_2 = \frac{P_2V_2}{RT_2}M$, $P_{tot}V_{tot} = \frac{\frac{P_1V_1}{RT_1}M+\frac{P_2V_2}{RT_2}M}{M}RT_{tot} = \left(\frac{P_1V_1}{T_1} + \frac{P_2V_2}{T_2}\right)T_{tot}$

Therefore $T_{tot} = \frac{P_{tot}V_{tot}}{\frac{P_1V_1}{T_1}+\frac{P_2V_2}{T_2}}$.

$P_1 = 4\ bar\ abs. = 4 \cdot 10^5\ Pa$, $P_2 = 3\ bar\ abs. = 3 \cdot 10^5\ Pa$, $P_{tot} = 7\ bar\ abs. = 7 \cdot 10^5\ Pa$

$T_1 = 90\ °\text{C} = 363\ K$, $T_2 = 15\ °\text{C} = 288\ K$

$V_1 = 18\ m^3$, $V_2 = 28\ m^3$, $V_{tot} = 22\ m^3$

$$T_{tot} = \frac{7 \cdot 10^5\ \cdot 22}{\frac{4 \cdot 10^5 \cdot 18}{363} + \frac{3 \cdot 10^5 \cdot 28}{288}} = 314\ K = 41\ °\text{C}$$

Answer:

41 °C