Answer on Question #52511-Physics-Other

Two tanks are connected by a valve. One tank contains 2 kg of CO2 at 77°C and 0.7 atm. The other tank has 8 kg of the same gas at 27°C and 1.2 atm. The valve is opened and gases are allowed to mix while receiving energy by heat transfer from the surroundings. The final equilibrium temperature is 42°C.

Using ideal gas model, determine:

a) the final equilibrium pressure

b) the heat transfer for the process.

Solution

a) The final pressure can be found from ideal gas equation of state:

$$P_f = \frac{m_f R T_f}{V_1 + V_2} = \frac{(m_1 + m_2) R T_f}{V_1 + V_2}$$

For tank 1 and 2, we can write: $V_1 = \frac{m_1 R T_1}{P_1}$ and $V_2 = \frac{m_2 R T_2}{P_2}$. Thus, the final pressure, P_f becomes:

$$P_f = \frac{(m_1 + m_2) R T_f}{\frac{m_1 R T_1}{P_1} + \frac{m_2 R T_2}{P_2}} = \frac{(m_1 + m_2) T_f}{\frac{m_1 T_1}{P_1} + \frac{m_2 T_2}{P_2}}.$$

$$P_f = \frac{(10kg)(315K)}{\frac{(2kg)(350K)}{0.7\ atm} + \frac{(8kg)(300K)}{1.2\ atm}} = 1.05\ atm.$$

b) The heat transfer can be found from an energy balance:

$$\Delta U = Q - W$$

With $W = 0$,

$$Q = U_f - U_i$$

where initial internal energy is: $U_i = m_1\, u(T_1) + m_2\, u(T_2)$

The final internal energy is: $U_f = (m_1 + m_2) u(T_f)$

The energy balance becomes:

$$Q = m_1\, [u(T_f) - u(T_1)] + m_2\, [u(T_f) - u(T_2)]$$

Since the specific heat Cv is constant

$$Q = m_1 C_v\, [T_f - T_1] + m_2 C_v\, [T_f - T_2]$$

$$Q = (2kg)\left(0.745 \frac{kJ}{kgK}\right)(315K - 350K) + (8kg)\left(0.745 \frac{kJ}{kgK}\right)(315K - 300K) = 37.25\ kJ.$$

The plus sign indicates that the heat transfer is into the system.