Assignment 11

09 April 2022 03:30

Kartik Choudhary [B20CS025]
Thermodynamics [MEL2020]

1. After the partition is removed, the gas expands freely.

for a free expansion,

$$dU = 0$$

$$mc_v \Delta T = 0$$

$$\Delta T = 0$$

$$T = C \quad \text{[isothermal process]}$$

$$P_1 V_1 = P_2 V_2$$

$$P_1 V_1 = P_2 (2V_1) \quad [\because \text{2 equal parts}]$$

$$P_1 = 2P_2$$

$$250 = 2P_2$$

$$P_2 = 125 \text{ kPa}$$

Calculating the total entropy change in the process,

$$\Delta S = N\left[C_p \ln\left(\frac{T_2}{T_1}\right) - \bar{R}\ln\left(\frac{P_2}{P_1}\right)\right]$$

$$\Delta S = 5\left[C_p \ln\left(\frac{T_2}{T_1}\right) - 8.314\ln\left(\frac{125}{250}\right)\right]$$

$$\Delta S = 5\left[0 - 8.314\ln\left(\frac{125}{250}\right)\right]$$

$$\boxed{\Delta S = 28.81 \text{ kJ/K}}$$

$$\boxed{\Delta S = 28.81\,kJ/K}$$

3. Entropy of mixing is $= -R \sum x_i \ln(x_i)$

$$= -R\left[0.5\ln(0.5) + 0.5\ln(0.5)\right]$$

work $= T\Delta S$

work required $= T\left[-R\ln(0.5)\right]$

$$= -RT\ln(0.5)$$

$$= RT\ln(2)$$

2. mass of air in tank $m = 5kg$

temperature of air in tank $T_1 = 327°C = 600K$

Pressure of air in tank $P_1 = 100kPa$

Temperature of surrounding $T_2 = 27°C = 300K$

a) Entropy change of air in tank $\Delta s_{air} = mc_v \ln\left(\frac{T_2}{T_1}\right)$

Specific heat of air $c_v = 0.718\,kJ/kgK$

$\Delta s_{air} = (5kg)(0.718\,kJ/kgK)\ln\left(\frac{300K}{\;}\right)$

$600K]$

$\Delta S_{air} = -2.488 \, KJ/K$

Entropy change of the air in the tank during the process $\boxed{\Delta S_{air} = -2.488 \, KJ/K}$

(b) from energy balance

$Q_{out} = m C_v (T_2 - T_1)$

$Q_{out} = (5kg)(0.718 \, KJ/kgK)(327 - 27)K$

$Q_{out} = 1077 \, KJ$

Entropy change of surroundings

$\Delta S_{surr} = \frac{1077 \, KJ}{300 \, K}$

$\Delta S_{surr} = 3.59 \, KJ/K$

net entropy change of the universe due to the process

$\Delta S_{total} = \Delta S_{air} + \Delta S_{surr}$

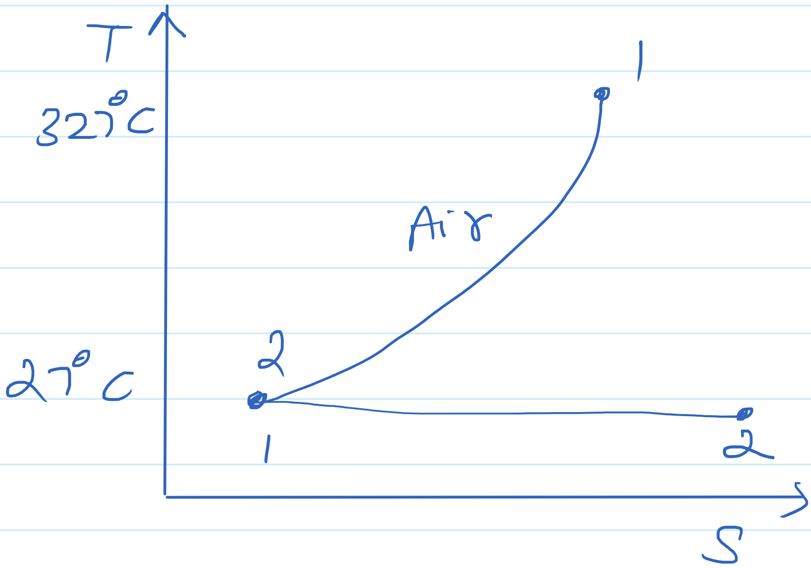
$\Delta S_{total} = -2.488 + 3.59$

$\Delta S_{total} = 1.10 \, KJ/K$

Entropy change of the universe due to this process

$$\boxed{\Delta S_{total} = 1.10\ kJ/K}$$

(c) Air in the tank and surroundings on a single T–S diagram:



(4) Entropy of mixing

$$\delta S = \frac{\delta q_{rev}}{T}$$

$$= \frac{1}{T}\left[\frac{nRT}{V}\,dV\right]$$

$$\delta S = \frac{nR}{V}\,dV$$

$$\delta S = \frac{nR}{V}\,dV$$

$$\Delta S = \int \frac{nR}{V}\,dV$$

$$\boxed{\Delta S = nR\ln\left[\frac{V_F}{V_i}\right]}$$

$$\Delta S_A = n_A R \ln\left[\frac{V_{Total}}{V_A}\right]$$

$$\Delta S_B = n_B R \ln\left[\frac{V_{total}}{V_B}\right]$$

$$\Delta S_{mix} = n_A R \ln\left[\frac{V_{Total}}{V_A}\right] + n_B R \ln\left[\frac{V_{Total}}{V_B}\right]$$

$$\downarrow V = \frac{nRT}{P}$$

$$\Delta S_{mix} = n_A R \ln\left[\frac{n_{total}\frac{RT}{P}}{n_A\frac{RT}{P}}\right] + n_B R \ln\left[\frac{n_{total}}{n_B}\right]$$

$$\frac{\Delta S_{mix}}{n_{total}} = \frac{n_A}{n_{total}} R \ln\left[\frac{n_{total}}{n_A}\right] + \frac{n_B}{n_{total}} R \ln\left[\frac{n_{total}}{n_B}\right]$$

$$X = \frac{n_i}{n_{total}}$$

$$\frac{\Delta S_{mix}}{n_{total}} = x_A R \ln\left[\frac{1}{x_A}\right] + x_B R \ln\left[\frac{1}{x_B}\right]$$

$$\Delta S_{mix} = -n_{total} R \left[x_A \ln(x_A) + x_B \ln(x_B)\right]$$

$$\boxed{\Delta S_{mix} = -n_{total} R \sum_i x_i \ln(x_i)}$$