KING FAHD UNIVERSITY OF PERTOLEUM & MINERALS
PHYSICS DEPARTMENT
QUIZ #5- CHAPTER 20

NAME: Key ID# SECTION#

A Carnot engine (ideal engine) absorbs heat at 527 ^{0}C and rejects heat at 127 ^{0}C. The heat absorbed produces useful mechanical work at the rate of 750 Watts.

(a) What is the efficiency of the engine?

$$\mathcal{E}_c = 1 - \frac{T_L}{T_H} = 1 - \frac{800}{400} = 0.5 \text{ or } 50\%$$

(b) What is the heat absorbed from the hot reservoir in 10 min?

$$\mathcal{E}_c = \frac{W}{Q_H} \Rightarrow \mathcal{E}_c = \frac{W/t}{Q_H/t} = \frac{P}{Q_H/t}$$

$$\Rightarrow \frac{Q_H}{t} = \frac{P}{\mathcal{E}_c} = \frac{750}{0.5} = 1500 \text{ J/s}$$

in 10 minutes $Q_H = 1500 \times 600 = 900 \text{ kJ}$

(c) What is the heat expelled to the cold reservoir in 10 min?

$$\frac{Q_H}{|Q_L|} = \frac{T_H}{T_L} \Rightarrow |Q_L| = Q_H \frac{T_L}{T_H} = 900 \text{ kJ} \times \frac{1}{2}$$

$$= 450 \text{ kJ}$$

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One mole of a monatomic ideal gas is taken from an initial state to a final state (f) as shown in figure 1. The curved line is an isotherm. Calculate the increase in entropy of the gas for this process.

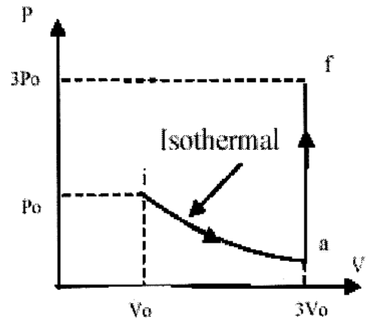

Figure 1

$i \rightarrow a$ isothermal process

$$\Delta S_{ia} = n R \ln\left(\frac{V_a}{V_i}\right)$$

$$= 1 \times 8.31 \ln\left(\frac{3V_0}{V_0}\right)$$

$$= 9.1 \text{ J/K}$$

$$\frac{P_a \cancel{V_a} = \cancel{nR} T_a}{P_f \cancel{V_f} = \cancel{nR} T_f}$$

$a \rightarrow f$ isochoric process

$$\Delta S_{af} = n C_v \ln\left(\frac{T_f}{T_a}\right) = 1 \times \frac{3}{2} R \times \ln\left(\frac{P_f}{P_a}\right)$$

$$\Delta S = 1 \times \frac{3}{2} \times 8.31 \times \ln\left(\frac{3\cancel{P_0}}{\frac{\cancel{P_0}}{3}}\right)$$

$$T_i = \frac{P_i V_i}{\cancel{nR}} = T_a = \frac{P_a V_a}{\cancel{nR}} \Rightarrow P_a = \frac{P_i V_i}{V_a} = \frac{P_0 \cancel{V_0}}{3\cancel{V_0}} = \frac{P_0}{3}$$

$$\Delta S_{af} = \frac{3}{2} \times 8.31 \ln(9) = 27.3 \text{ J/K}$$

$$\Delta S_{if} = 9.1 + 27.3 = \boxed{36.4 \text{ J/K}}$$

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You mix two samples of water, A and B. Sample A is 100 g at 20 ^{0}C and sample B is also 100 g but at 80 ^{0}C. (c_{water} = 4186 J/kg K)

(a) Calculate the equilibrium temperature of the system.

$$Q_1 + Q_2 = 0$$

$$m_A C_w (T_f - 20) + m_B C_w (T_f - 80) = 0$$

$$2T_f = 100 \Rightarrow T_f = 50^\circ C = 323\ K$$

(b) Calculate the change in the entropy of sample A.

$$\Delta S_A = m_A C_w \ln\left(\frac{T_f}{T_i}\right) = 0.1 \times 4186 \times \ln\left(\frac{323}{293}\right)$$

$$\Delta S_A = 40\ J/K \quad \left(\text{gained heat } \Delta S > 0\right)$$

(c) Calculate the change in the entropy of the sample B.

$$\Delta S_B = m_B C_w \ln\left(\frac{T_f}{T_i}\right) = 0.1 \times 4186 \ln\left(\frac{323}{353}\right)$$

$$\Delta S_B = -37\ J/K \quad \left(\text{lost heat } \Delta S < 0\right)$$

(d) Calculate the change in entropy of the system.

$$\Delta S_{system} = \Delta S_A + \Delta S_B = 40 - 37 = 3\ J/K$$