THERMODYNAMICS ASSIGNMENT FOR THE SIXTH TIME

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ABSTRACT. Here is the thermodynamics assignment for the sixth time which is for the course given by professor Yuanbo Zhang. In order to practise the expertise in scientific film of physics, students need to practise using LATEXto composing their own work, even if this is only a ordinary homework.

MAIN TEXT

Given an ideal gas in the initial state p_0, V_0, S_0, calculate the entropy of any final state. Construct an invertible process:

First, isobaric expansin $(p_0, V_0) \to (p_0, V)$

$$\Delta S_1 = \int_{(p_0,V_0)}^{(p_0,V)} \frac{\mathrm{d}Q_1}{T} = \int_{(p_0,V_0)}^{(p_0,V)} \frac{\mathrm{d}A + \mathrm{d}U}{T} = \int_{(p_0,V_0)}^{(p_0,V)} \frac{p\mathrm{d}V + \nu C_V \mathrm{d}T}{T} = \int_{V_0}^{V} \frac{p\mathrm{d}V}{\frac{pV}{\nu R}} + \int_{T_0}^{T_1} \frac{\nu C_V \mathrm{d}T}{T}$$
$$= \nu R \ln \frac{V}{V_0} + \nu C_V \ln \frac{T_1}{T_0}$$

And, constant volume heating $(p_0, V) \to (p, V)$

$$\Delta S_2 = \int_{(p_0,V)}^{(p,V)} \frac{\mathrm{d}Q_2}{T} = \int_{(p_0,V)}^{(p,V)} \frac{\mathrm{d}A + \mathrm{d}U}{T} = \int_{(p_0,V)}^{(p,V)} \frac{\mathrm{d}U}{T} = \int_{(p_0,V)}^{(p,V)} \frac{\nu C_V \mathrm{d}T}{T}$$
$$= \nu C_V \ln \frac{T}{T_1}$$

As a result

$$S = S_0 + \Delta S_1 + \Delta S_2 = \nu C_V \ln \frac{T}{T_0} + \nu R \ln \frac{V}{V_0} + S_0$$

5.3.4.

(1). By the first law of thermodynamics

$$\mathrm{d}U = \mathrm{d}W + \mathrm{d}Q$$

And $\mathrm{d}Q = 0$, $W < 0$, $U = C_{V,m}T$, we can conclude

$$T < T_0$$

(2). Note that this process is actually irreversible, so there must be

$$\Delta S > 0$$

(3). We have some equation

$$W = -\frac{mg}{A}(V - V_0)$$

$$\Delta U = C_{V,m}(T - T_0) = W$$

$$\frac{mg}{A}V = RT$$

As a result

$$T = \frac{C_{V,m}T_0 + \frac{mg}{A}V_0}{C_{V,m} + R}$$

5.3.7.

(1). Gas 1 and gas 2 satisfy the ideal gas equation of state respectively, and gas 2 additionally satisfies the adiabatic equation.

$$\frac{p_0 V_0}{T_0} = \frac{2p_0 V_1}{T_1}$$

$$\frac{p_0 V_0}{T_0} = \frac{2p_0(2V_0 - V_1)}{T_2}$$

$$p_0 V_0^\gamma = 2p_0(2V_0 - V_1)^\gamma$$

$$\gamma = \frac{i+2}{i} = \frac{7}{5}$$

As a result

$$T_1 = (4 - 2^{\frac{2}{7}})T_0$$

$$T_2 = 2^{\frac{2}{7}}T_0$$

(2). By the first law of thermodynamics

$$W = \Delta U_2 = C_{V,m}(T_2 - T_0) = \frac{5}{2}(2^{\frac{2}{7}} - 1)RT_0$$

(3). By the first law of thermodynamics

$$Q = \Delta U = \Delta U_1 + \Delta U_2 = 5RT_0$$

(4). We use the express of S we just get:

$$\Delta S = \Delta S_1 + \Delta S_2 = \Delta S_1 = R \ln \frac{V_1}{V_0} + C_{V,m} \ln \frac{T_1}{T_0} = \left[\ln \left(2 - 2^{-\frac{5}{7}} \right) + \frac{5}{2} \ln \left(4 - 2^{\frac{2}{7}} \right) \right] R T_0$$

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