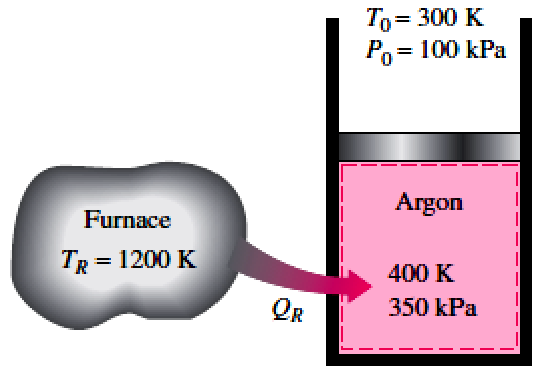
King Saud University

Department of Mechanical Engineering
ME 374: Thermodynamics -II- 1st Midterm Exam
Saturday, 01.12.1433 (17.10.2012); 09:00 am – 10:00 am

Question 1 (20 points)

A frictionless piston–cylinder device, as shown in the figure, initially contains 0.01 m^3 of argon gas at 400 K and 350 kPa. Heat is now transferred to the argon from a furnace at 1200 K, and the argon expands isothermally until its volume is doubled. No heat transfer takes place between the argon and the surrounding atmospheric air, which is at T_0 =300 K and P_0 =100 kPa. Determine (*a*) the useful work output, (*b*) the exergy destroyed, and (*c*) the reversible work for this process.



Question 2 (20 points)

Air is compressed steadily by a reversible compressor from an inlet state of 100 kPa and 300 K to an exit pressure of 900 kPa. Determine the compressor work per unit mass for (*a*) isentropic compression with k = 1.4, (*b*) polytropic compression with n =1.3, (*c*) isothermal compression, and (*d*) ideal two stage compression with intercooling with a polytropic exponent of n =1.3.
Draw a P-V and T-S diagrams for the two stage compression process. **For air R=0.287 kJ/kg.k**

Useful Relations

$$\underbrace{S_{in} - S_{out}}_{\substack{\text{Net entropy transfer}\\ \text{by heat and mass}}} + \underbrace{S_{gen}}_{\substack{\text{Entropy}\\ \text{generation}}} = \underbrace{\Delta S_{system}}_{\substack{\text{Change}\\ \text{in entropy}}}$$

$$\underbrace{X_{in} - X_{out}}_{\substack{\text{Net exergy transfer}\\ \text{by heat, work, and mass}}} - \underbrace{X_{destroyed}}_{\substack{\text{Exergy}\\ \text{destruction}}} = \underbrace{\Delta X_{system}}_{\substack{\text{Change}\\ \text{in exergy}}}$$

$$\Delta X = X_2 - X_1 = m(\phi_2 - \phi_1) = (E_2 - E_1) + P_0(V_2 - V_1) - T_0(S_2 - S_1)$$
$$= (U_2 - U_1) + P_0(V_2 - V_1) - T_0(S_2 - S_1) + m\frac{V_2^2 - V_1^2}{2} + mg(z_2 - z_1)$$

Isentropic compression with k = 1.4:

$$w_{comp,in} = \frac{kRT_1}{k-1}\left[\left(\frac{P_2}{P_1}\right)^{(k-1)/k} - 1\right]$$