7.72 Water vapor at 6 MPa, 600°C enters a turbine operating at steady state and expands adiabatically to 10 kPa. The mass flow rate is 2 kg/s and the isentropic turbine efficiency is 94.7%. Kinetic and potential energy effects are negligible. Determine

(a) the power developed by the turbine, in kW.
(b) the rate at which exergy is destroyed within the turbine, in kW.
(c) the exergetic turbine efficiency.

Let $T_o = 298$ K, $p_o = 1$ atm.

7.81 Saturated water vapor at 1 bar enters a direct-contact heat exchanger operating at steady state and mixes with a stream of liquid water entering at $25^\circ$C, 1 bar. A two-phase liquid–vapor mixture exits at 1 bar. The entering streams have equal mass flow rates. Neglecting heat transfer with the surroundings and the effects of motion and gravity, determine for the heat exchanger

(a) the rate of exergy destruction, in kJ per kg of mixture exiting.
(b) the exergetic efficiency given by Eq. 7.29.

Let $T_o = 20^\circ$C, $p_o = 1$ bar.

**SP-10**

A turbine operating at steady state with steam entering at $p_1 = 30$ bar, $T_1 = 350^\circ$C and a mass flow rate of 10 kg/s. A half of the stream is extracted at $p_2 = 5$ bar, $T_2 = 200^\circ$C. The remaining steam exits at $p_3 = 0.15$ bar, $x_3 = 0.90$. Neglect the heat loss from the turbine to the environment at $T_o = 25^\circ$C and $p_o = 1$ bar. Determine:

(a) The total work produced by the turbine, in kW.
(b) The exergy destruction, in kW.
(c) The second-law effectiveness (or exergetic efficiency) for the turbine.

<table>
<thead>
<tr>
<th>State</th>
<th>$p$ (bar)</th>
<th>$T$ ($^\circ$C)</th>
<th>$h$ (kJ/kg)</th>
<th>$s$ (kJ/kg·K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>350</td>
<td>3115.3</td>
<td>6.7428</td>
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<tr>
<td>2</td>
<td>5</td>
<td>200</td>
<td>2855.4</td>
<td>7.0592</td>
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<tr>
<td>3</td>
<td>0.15</td>
<td>53</td>
<td>2361.7</td>
<td>7.2831</td>
</tr>
</tbody>
</table>

$p_1 = 30$ bar
$T_1 = 350^\circ$C
$m_1 = 10$ kg/s

$p_2 = 5$ bar
$T_2 = 200^\circ$C
$m_2 = 5$ kg/s

$p_3 = 0.15$ bar
$x_3 = 0.90
$m_3 = 5$ kg/s

Answers: (c) 0.798
**12.16 WP** A mixture having a molar analysis of 60% N₂ and 40% CO₂ enters an insulated compressor operating at steady state at 1 bar, 30°C with a mass flow rate of 1 kg/s and is compressed to 3 bar, 147°C. Neglecting kinetic and potential energy effects, determine

- **a.** the power required, in kW.
- **b.** the isentropic compressor efficiency.
- **c.** the rate of exergy destruction, in kW, for T₀ = 300 K.

**12.24 WP** Argon (Ar), at 300 K, 1 bar with a mass flow rate of 1 kg/s enters the insulated mixing chamber shown in Fig. P12.24 and mixes with carbon dioxide (CO₂) entering as a separate stream at 575 K, 1 bar with a mass flow rate of 0.5 kg/s. The mixture exits at 1 bar. Assume ideal gas behavior with k = 1.67 for Ar and k = 1.25 for CO₂. For steady-state operation, determine

- **a.** the molar analysis of the exiting mixture.
- **b.** the temperature of the exiting mixture, in K.
- **c.** the rate of entropy production, in kW/K.

**SP-11**

An insulated, rigid tank initially contains 2.2 lb-mol of argon (Ar) at 80°F, 14.5 psia. The tank is connected by a valve to a large vessel containing nitrogen (N₂) at 440°F, 58 psia. A quantity of nitrogen flows into the tank, forming an Ar-N₂ mixture at temperature T and pressure p. Plot T, in °F, and p, in psia, versus the amount of N₂ within the tank, in 0 to 20 lb-mol. Also, find the pressure when 0.2 lb-mol of N₂ entered the tank.

Note: Please include your EES code, parametric tables, and plots. Assumptions, basic equation(s), system sketch can be either submitted separately or included within the EES code. EES code should contain variable definitions, comments, etc.