31.21 $500\frac{lb_m}{hr}$ **of** $300psia$, $800°F$ **steam is mixed with** $1200\frac{lb_m}{hr}$ **of** $300psia$ **steam with quality 50%. What is the quality of the resulting mixture?**

A. 0.69

B. 0.73

C. 0.77

D. 0.81

Refer to the two streams as State 1 and State 2, respectively. Let State 3 be the conditions after mixing. Start by using the Properties of Superheated Steam table to find the enthalpy at State 1.

$$P_1 = 300psia$$

$$T_1 = 800°F$$

$$\dot{m}_1 = 500\frac{lb}{hr}$$

$$h_1 = 1421.3\frac{Btu}{lb}$$

Use the Properties of Saturated Water and Steam by pressure table to look up h_f and h_{fg} at $300psia$ and use the quality to find the enthalpy at State 2.

$$P_2 = 300psia$$

$$\chi_2 = 0.5$$

$$\dot{m}_2 = 1200\frac{lb}{hr}$$

$$h_f = 393.93\frac{Btu}{lb}$$

$$h_{fg} = 809.42\frac{Btu}{lb}$$

$$h_2 = h_f + \chi_2 h_{fg} = h_f = 393.93\frac{Btu}{lb} + 0.5\left(809.42\frac{Btu}{lb}\right) = 798.64\frac{Btu}{lb}$$

For Steady-Flow Systems, consider the mass balance and energy balance. The mass flow rate at State 3 is simply the sum of States 1 and 2.

$$\dot{m}_1 + \dot{m}_2 = \dot{m}_3$$

$$\dot{m}_3 = \dot{m}_1 + \dot{m}_2 = 500\frac{lb}{hr} + 1200\frac{lb}{hr} = 1700\frac{lb}{hr}$$

Only enthalpy needs to be considered in the energy balance. Solve for h_3.

$$\dot{m}_1 h_1 + \dot{m}_2 h_2 = \dot{m}_3 h_3$$

$$h_3 = \frac{\dot{m}_1 h_1 + \dot{m}_2 h_2}{\dot{m}_3} = \frac{\left(500\frac{lb}{hr}\right)\left(1421.3\frac{Btu}{lb}\right) + \left(1200\frac{lb}{hr}\right)\left(798.64\frac{Btu}{lb}\right)}{1700\frac{lb}{hr}} = 981.8\frac{Btu}{lb}$$

Determine the quality using the enthalpy at State 3.

$$\chi_3 = \frac{h_3 - h_f}{h_{fg}} = \frac{981.8\frac{Btu}{lb} - 393.93\frac{Btu}{lb}}{809.42\frac{Btu}{lb}} = 0.726$$

Answer B