4.

XXX~~8~~XX

(a)

Conservation of mass: $\dot{m}_{20} + \dot{m}_{55} = 12$ (1)

Conservation of energy: $\dot{m}_{20} \times 20 = \dot{m}_{55} \times 15$ (2)

(1) and (2): $\dot{m}_{55} = 48/7$

Power = $\frac{48}{7} \times 4180 \times (55 - 20)/60 = 16720$ W

Alternatively,

$$(0.5)(36/7)(4180)(35 - T) = (36/7)(4180)T - 20)$$
$$T = 25°C$$

$$P = C\frac{\Delta m}{\Delta t} \cdot \Delta T = (4180)(12/60)(40 - \cancel{25}\ 20) = \cancel{12.54\text{ kW}}$$ XXXXXX 16720 W

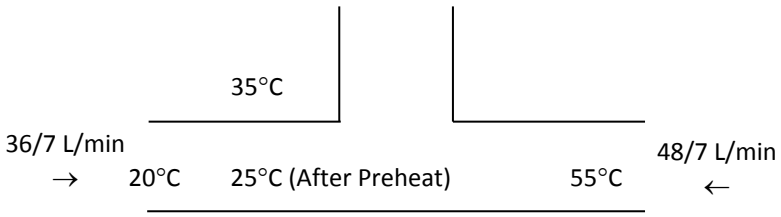
(b)

Entropy produced in heating up the water:

$$= 12 \times 4180 \times \ln\left(\frac{40 + 273.15}{20 + 273.15}\right) = 3310$$

$$\Delta S_{\text{Tot}} = 3310 \times 5 \times 4 \times 365 = 24 \text{ MJ/K}$$

(c)



$$(0.5)(36/7)(4180)(35 - T) = (36/7)(4180)(T - 20)$$
$$T = 25°C$$

Power Saved = $(36/7)/60 \times (4180)(25 - 20) = 1.79\,\text{kW}$

Required Power = 16.72 – 1.79 = 14.93 kW

(d)

Delta S = 12 x 4180 x ln[(40+273.15)/(25+273.15)] x 5 x 4 x 365 = 17.97 MJ/K
Reduction in Entropy = (24 - 18) MJ/K = 6 MJ/K