

## PROBLEM 2.74

KNOWN: A system undergoes a power cycle consisting of four processes in series.

FIND: Complete the table of energy values provided for the cycle and evaluate the thermal efficiency.

SCHEMATIC & GIVEN DATA:

Process	$\Delta E$	$Q$	$W$
1-2	-1200	0	
2-3		800	
3-4		-200	-200
4-1	400		400

ANALYSIS:

(a) Process 1-2:  $\Delta E = Q_{12} - W_{12} \Rightarrow W_{12} = Q_{12} - \Delta E = 0 - (-1200) = +1200$

Process 3-4:  $\Delta E = Q_{34} - W_{34} \Rightarrow \Delta E = (-200) - (-200) = 0$

Process 4-1:  $\Delta E = Q_{41} - W_{41} \Rightarrow Q_{41} = \Delta E + W_{41} = 400 + 600 = 1000$

Process 2-3:

Method 1: Use  $\sum(\Delta E) = 0$  to get

$$(-1200) + (E_3 - E_2) + (0) + (400) = 0$$

$$\Rightarrow (E_3 - E_2) = 800$$

Then,  $\Delta E = Q_{23} - W_{23} \Rightarrow W_{23} = Q_{23} - \Delta E = 800 - 800 = 0$

Method 2: Use  $\sum(Q) = \sum(W)$  to get

$$\underbrace{0 + 800 + (-200) + (1000)}_{1600} = 1200 + W_{23} + (-200) + (600)$$

$$= 1600 + W_{23} \Rightarrow W_{23} = 0$$

Then  $(E_3 - E_2) = Q_{23} - W_{23} = 800$

(b) Thermal efficiency:  $\eta = \frac{W_{\text{cycle}}}{Q_{\text{in}}}$

$$W_{\text{cycle}} = (+1200) + (0) + (-200) + (600) = 1600$$

$$Q_{\text{in}} = (+800) + (+1000) = 1800$$

$$\therefore \eta = \frac{1600}{1800} = 0.889 \text{ (88.9\%)}$$