

PROBLEM 2.72

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	ΔU	ΔKE	ΔPE	ΔE	Q	W
1-2	950	50	0	+1000 (c)	1000	0 (e)
2-3	-500 (a)	0	50	-450	0 (f)	450
3-4	-650	+50 (b)	0	-600	-600 (g)	0
4-1	200	-100	-50	+50 (d)	0	-50 (h)

ANALYSIS:

(a) For a cycle, the overall changes in U , KE , PE and E are zero:

$$\Sigma(\Delta U) = 950 + (a) - 650 + 200 = 0 \Rightarrow (a) = -500$$

$$\Sigma(\Delta KE) = 50 + 0 + (b) - 100 = 0 \Rightarrow (b) = +50$$

$$\Sigma(\Delta PE) = 0 + 50 + 0 - 50 = 0 \quad \checkmark$$

$$\Sigma(\Delta E) = (c) - 450 - 600 + (d) = 0 \Rightarrow (c) + (d) = 1050$$

For Process 1-2, $\Delta E = \Delta U + \Delta KE + \Delta PE$
 $= 950 + 50 + 0 = 1000$ kJ (c)
 So, (d) = +50

Also, for Process 1-2,
 $\Delta E = Q - W \Rightarrow W = \Delta E - Q$
 $= 1000 - 1000 = 0$ kJ (e)

For Process 2-3,
 $\Delta E = Q - W \Rightarrow Q = \Delta E + W$
 $= -450 + 450 = 0$ kJ (f)

For Process 3-4,
 $\Delta E = Q - W \Rightarrow Q = \Delta E + W$
 $= -600 + 0 = -600$ kJ (g)

For Process 4-1,
 $\Delta E = Q - W \Rightarrow W = Q - \Delta E$
 $= 0 - 50 = -50$ kJ (h)

(b) For any power cycle,

$$\eta = \frac{W_{\text{cycle}}}{Q_{\text{in}}}$$

Here, $W_{\text{cycle}} = 0 + 450 + 0 - 50 = 400$
 $Q_{\text{in}} = 1000$

$$\Rightarrow \eta = \frac{400}{1000} = 0.40 \quad (40\%)$$