A piston and cylinder machine contains a fluid system which passes through a complete cycle of four process. During a cycle the sum of all heat transfer is -170 kJ. The system completes 100 cycles per min. Complete the following table showing the method for each item and complete the net rate of work output in kW.

process	Q (kJ/min)	W (kJ/min)	ΔU (kJ/min)
a-b	0	2170	—
b-c	21,000	0	—
c-d	$-2,100$	—	$-36,600$
d-a	—	—	—

process a-b

$Q = \Delta U + W$

$0 = \Delta U + 2170$

$\Delta U = -2170$

process b-c

$Q = \Delta U + W$

$21,000 = \Delta U + 0$

$\Delta U = 21000$ kJ/min

process c-d

$Q = \Delta U + W$

$-2100 = -36,600 + W$

$W = 36600 - 2100$

$W = 34500$ kJ/min

process d-a

$\sum_{cycle} Q = -170$ kJ

The system completes by 100 cycles/min

$Q_{ab} + Q_{bc} + Q_{cd} + Q_{da} = -17,000$ kJ/min

$0 + 21000 + (-2100) + Q_{da} = -17000$

$Q_{da} = -35,900$ kJ/min

Now $\oint \delta E = 0$ Since cyclic Integral of any property is zero

$$\Delta E_{a-b} + \Delta E_{b-c} + \Delta E_{c-d} + \Delta E_{d-a} = 0$$

$$-2170 + 21000 + (-36,600) + \Delta E_{d-a} = 0$$

$$\Delta E_{(d-a)} = 17,770 \text{ KJ/min}$$

$Q = \Delta E + W$

$$W_{d-a} = Q_{d-a} - \Delta E_{(d-a)}$$

$$= -35900 - 17770$$

$$= -53670 \text{ KJ/min}$$

Since

$$\sum_{cycle} Q = \sum_{cycle} W$$

Rate of work output $= -17,000$ KJ/min.

$$= -283.3 \text{ KW} //$$