

Thermodynamics
Professor Anand T N C
Department of Mechanical Engineering
Indian Institute of Technology, Madras
Lecture No 24
Tutorial problem - Part 1

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$\oint \delta Q = \oint \delta W$
 $\sum \delta Q = \sum \delta W$
 $\sum \Delta U = 0$

The following table gives data, in kJ, for a system undergoing a thermodynamic cycle. Determine (a) the missing table entries and (b) whether the cycle is power producing or absorbing.

Process	ΔU	Q	W
1-2	610	?	-610
2-3	670	900	230
3-4	?	0	920
4-1	-360	?	0
	0	540 kJ	540 kJ

Handwritten notes:
 $dU = \delta Q - \delta W$
 $\Delta U = Q - W$
 p-v diagram showing a cycle 1-2-3-4-1.
 Summary: $\sum \Delta U = 0$, $\sum Q = 540 \text{ kJ}$, $\sum W = 540 \text{ kJ}$. *power producing*

Figure 1.

Solution of the problem in Fig. 1:

The system undergoes a cyclic process.

For the process 2-3, the first law in the integrated form is $Q - W = \Delta U$. Hence, $Q_{2-3} = 670 + 230 = 900 \text{ kJ}$.

Similarly, for the process 3-4, $\Delta U_{3-4} = Q - W = 0 - 920 = -920 \text{ kJ}$.

Similarly, for the process 4-1, $Q_{4-1} = \Delta U + W = -360 + 0 = -360 \text{ kJ}$.

For a cyclic process 1-2-3-4-1, $\Delta U = 0$, i.e. $\Delta U_{1-2} + \Delta U_{2-3} + \Delta U_{3-4} + \Delta U_{4-1} = 0$. Hence, $\Delta U_{1-2} = -670 + 920 + 360 = 610 \text{ kJ}$.

Since it is a cyclic process, according to the first law of thermodynamics, $\oint \delta Q = \oint \delta W = -610 + 230 + 920 + 0 = 540 \text{ kJ}$. Hence, $Q_{1-2} + Q_{2-3} + Q_{3-4} + Q_{4-1} = 540 \text{ kJ}$. Thus, $Q_{1-2} = 540 + 360 + 0 - 900 = 0 \text{ kJ}$.

The summation of all W values is +540 kJ. Hence, this cycle gives positive work, and it is a power producing cycle. The system also takes in 540 kJ of heat during the cyclic process.