

One kilogram of a fluid is compressed according to the relation  $(Pv = 0.25)$  where  $P$  is in bars and  $v$  in  $m^3/kg$ . The final volume is  $1/4$  the initial volume. Calculate the work done on the fluid and sketch the process on a  $P-V$  diagram.

\*\*\* solution \*\*\*

∴ For closed system

$$W_{1-2} = \int P \cdot dv$$

as this fluid is compressed according to the relation  $Pv = 0.25$

but  $\rightarrow P$  (bars) &  $v \rightarrow \frac{m^3}{kg}$   
 $\therefore Pv = 0.25 \times 100 = 25 \frac{kJ}{kg}$

$\therefore P v_0 = 25 \frac{kJ}{kg} \rightarrow P = \frac{25}{v_0} \text{ kPa}$

$$W_{1-2} = \int \frac{25}{v} \cdot dv$$

$$W_{1-2} = 25 \int \frac{dv}{v}$$

$$W_{1-2} = 25 [\ln v]_{v_1}^{v_2}$$

$$= 25 [\ln(v_2) - \ln(v_1)]$$

$$W_{1-2} = 25 \ln\left(\frac{v_2}{v_1}\right)$$

$\therefore v_2 = \frac{1}{4} v_1 \rightarrow \frac{v_2}{v_1} = \frac{1}{4}$   
 $\therefore W_{1-2} = 25 \ln\left(\frac{1}{4}\right) = -34.66 \text{ kJ}$   
 → which is the specific work done on the system

\*\*\* To get work

$$W = m \cdot w_{1-2} = 1 \text{ kg} \times (-34.66) \text{ kJ/kg}$$

$$\therefore W_{1-2} = -34.66 \text{ kJ}$$

(-ve) → work done on the system



2.2 A gas contained within a piston-cylinder assembly expands from an initial volume  $V_1 = 0.15 \text{ m}^3$  to a final volume of  $V_2 = 0.36 \text{ m}^3$  where the pressure remains constant at  $0.5 \text{ MPa}$ . Calculate the work, in kJ.

\*\*\* solution \*\*\*

For closed system shown :-

$$W_{1-2} = \int P \cdot dv$$

→ For constant Pressure Process  $P_1 = P_2 = P$

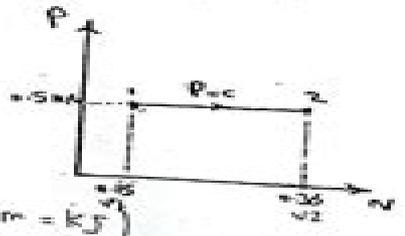
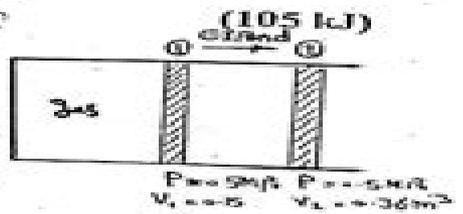
$$\therefore W_{1-2} = P \int dv = P [v]_{v_1}^{v_2}$$

$$= W_{1-2} = P (v_2 - v_1)$$

$$\therefore W_{1-2} = 0.5 \times 10^6 \text{ (kPa)} (0.36 - 0.15) \text{ m}^3$$

$$= 105 \text{ kJ} \quad \left( \text{kPa} \cdot \text{m}^3 = \frac{\text{kJ}}{\text{m}^3} \cdot \text{m}^3 = \text{kJ} \right)$$

(+ve) → work done by the system.



# Engineering Thermodynamics Solved Problems

**Michael Hoelscher**



## **Engineering Thermodynamics Solved Problems:**

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