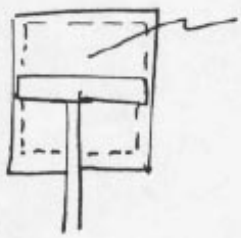
10.213 Problem #2 Solution



1 kg Argon
300 K = T_1
1 bar = P_1

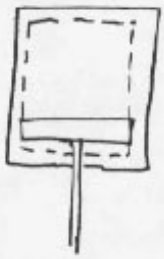
condition (1)

$V_1^t = 0.624\ m^3$
$T_1 = 300K$
$P_1 = 1\ bar$
} 1 kg Ar

$+Q = 104.2\ kJ$
ISOBARIC EXPANSION

CLOSED SYSTEM

condition (2)



$V_2^t = 1.041\ m^3$
$T_2 = 500K$
$P_2 = 1\ bar$
} 1kg Ar

Now, in general: for a reversible process

$$W = -\int_{V_1}^{V_2} P_{op}\, dV^t \quad \begin{pmatrix} S+VN \\ 1.3 \end{pmatrix}$$

$$P_{op} = P_{system} = P$$

so,

$$W_{rev} = -\int_{V_1}^{V_2} P\, dV^t$$

for constant P,

$$W_{rev} = -P\int_{V_1}^{V_2} dV^t \quad \text{—— (1)}$$

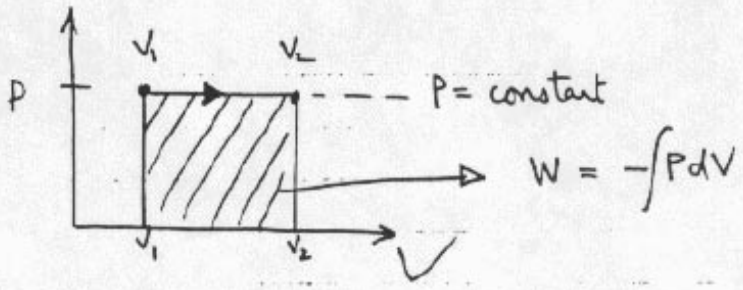
(a) From (1),

$$\boxed{W_{rev} = -P\int_{V_1}^{V_2} dV^t = -P\Delta V^t}$$

$$= (-1\ \cancel{bar})(1.041 - 0.624)\ m^3 \left(\frac{10^5\ Pa}{1\ \cancel{bar}}\right)$$

$$= -41,700\ J$$

$$W_{rev} = \underline{-41.7\ kJ} \Longrightarrow$$



(b) Work = $-41.7\ kJ < 0$

Because work is done by system on surroundings during expansion.

(c) First law:

$$\boxed{\Delta U^t = Q + W} \qquad \text{(S+VN 2.3)}$$

$$\Delta U^t = (104.2\ kJ) + (-41.7\ kJ)$$
$$= +62.5\ kJ \Rightarrow$$

(d) From definition of H,

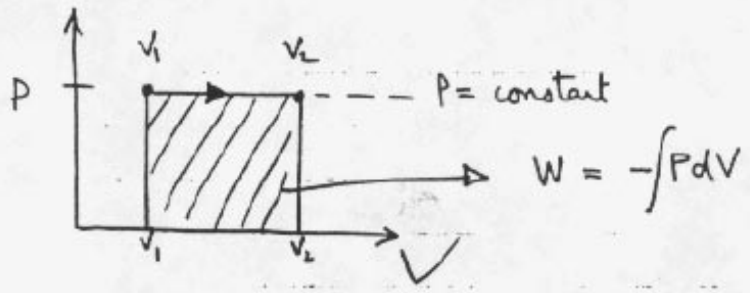
$$\boxed{H^t \equiv U^t + PV^t} \qquad \text{(S+VN 2.5)}$$

so,
$$\Delta H^t = \Delta U^t + \Delta(PV^t) \qquad \text{(S+VN 2.7)}$$
$$= \Delta U^t + P\Delta V^t + V^t \Delta P$$
$$= \Delta U^t + (-W) \qquad (= 0 \text{ for const. P})$$
$$= (+62.5\ kJ) - (-41.7\ kJ)$$

$$\therefore \Delta H^t = 104.2\ kJ \Rightarrow$$

(note: $\Delta H^t = Q$ for isobaric process + reversible)

(a) $\boxed{\Delta H = \Delta H^t / n}$



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$$= (+62.5\ kJ) - (-41.7\ kJ)$$