ECC classnotes L2

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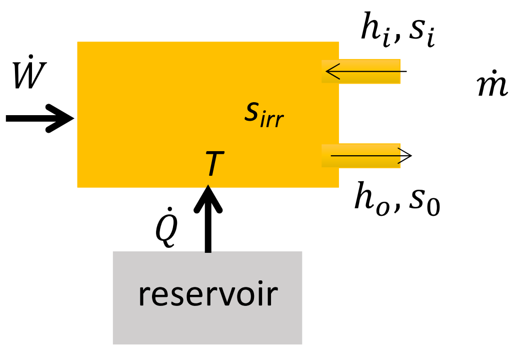
First law for OPEN systems :
Flow of fluid at a constant rate through a device. **NOTE: mass flow rate is conserved**



Energy balance (**steady case**)

$$\dot{Q} + \dot{W} = \dot{m}(h_o - h_i)$$

Entropy balance

$$\frac{\dot{Q}}{T} + \dot{m}s_i + s_{irr} = \dot{m}s_o$$

unsteady case

$$\dot{Q} + \dot{W} - \dot{m}h_o + \dot{m}h_i = \frac{dE}{dt}$$

$$\frac{\dot{Q}}{T} + \dot{m}s_i + s_{irr} - \dot{m}s_o = \frac{dS}{dt}$$

Minimum work performed by a compressor

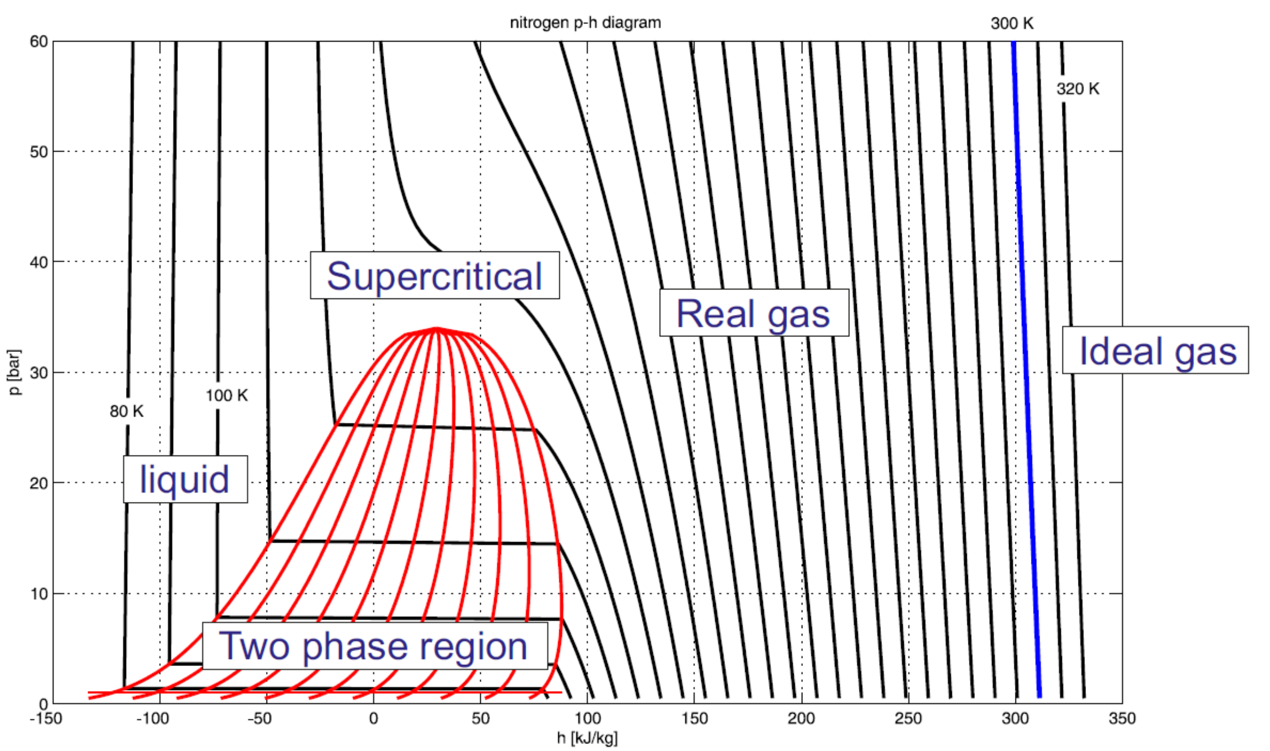
Energy balance (**steady case**)

$$\dot{Q} + \dot{W} = \dot{m}(h_o - h_i)$$

Entropy balance

$$\frac{\dot{Q}}{T_r} + \dot{m}s_i + s_{irr} = \dot{m}s_o$$

$$\dot{W} = \dot{m}([h_o - T_r s_o] - [h_i - T_r s_i]) + T_r s_{irr}$$



Thermodynamics toolkit – part I

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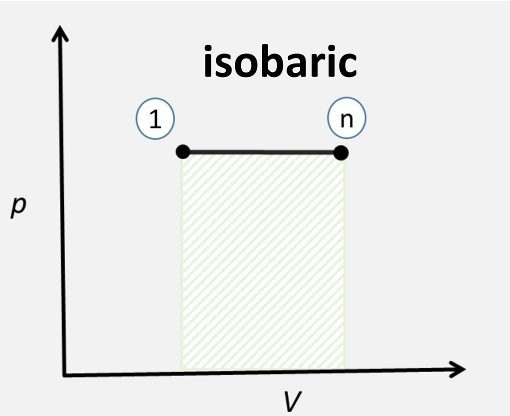


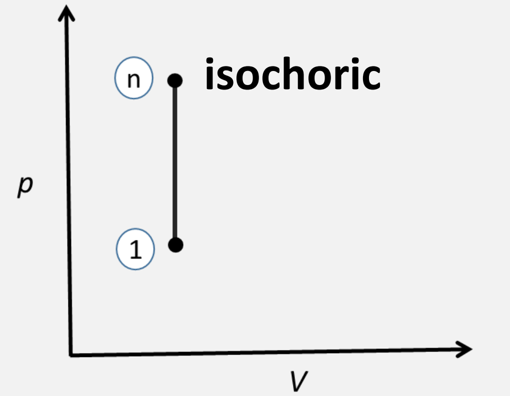
$$W = -p_1(V_n - V_1)$$

$$\Delta U = nc_v(T_n - T_1)$$

$$Q = nc_p(T_n - T_1)$$

$$\Delta S = nc_p \ln\frac{T_n}{T_1}$$

Note:
- Only quasistatic processes can be shown on a property diagram
- Any process, $\Delta U = nc_v\Delta T$
- If volume increases in a process, W is negative



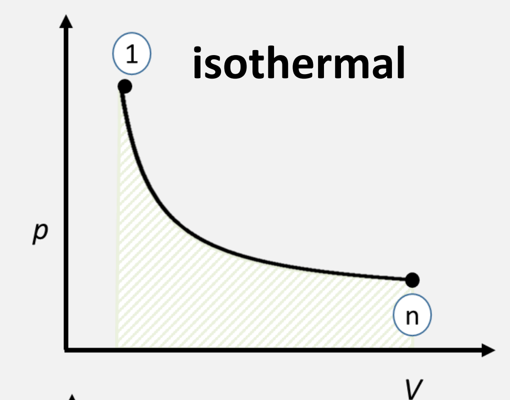
$$W = 0$$

$$\Delta U = nc_v(T_n - T_1)$$

$$Q = nc_v(T_n - T_1)$$

$$\Delta S = nc_v \ln\frac{T_n}{T_1}$$

Note:
- Practice plotting T-s diagrams of these processes.

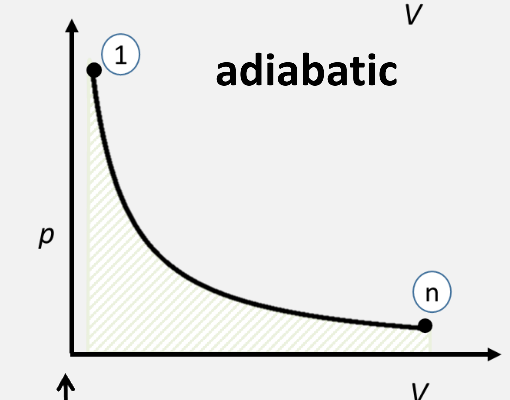


$$W = -nRT_1 \ln\frac{V_n}{V_1}$$

$$\Delta U = 0$$

$$Q = -W$$

$$\Delta S = nR \ln\frac{V_n}{V_1}$$



$$W = -p_1V_1^{\gamma}\frac{1}{1-\gamma}(V_2^{1-\gamma} - V_1^{1-\gamma})$$

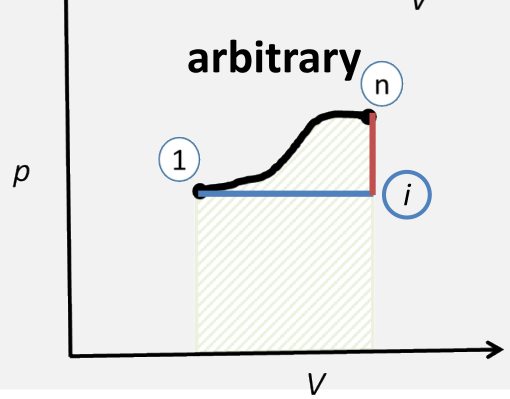
$$\Delta U = nc_v(T_n - T_1)$$

$$Q = 0$$

$$\Delta S = 0$$

If temperatures are given and n and f are know calculate ΔU, which is equal to W.

If p, V and f are given calculate ΔU, which is equal to W.



$$W = -\int_{V_1}^{V_n} pdV$$

$$\Delta U = nc_v(T_n - T_1)$$

$$Q = \Delta U - W$$

$$\Delta S_{1n} = \Delta S_{1i} + \Delta S_{in} \qquad \Delta S_{1n} = nc_p \ln\frac{T_i}{T_1} + nc_v \ln\frac{T_n}{T_i}$$

Check if you can calculate ΔU and then W. Apply first law to calculate Q.