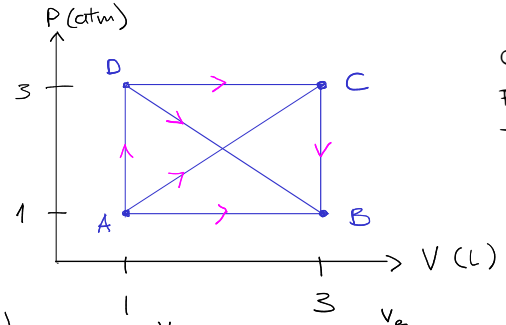
Problem 1: (11-03-28)



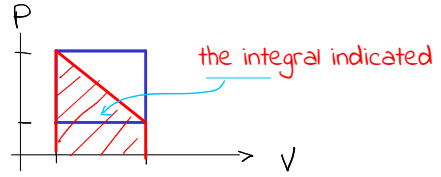
Quasi-static processes
Find w done by the gas
The type of gas is not specified

a) $W_{AB} = \int_{V_A}^{V_B} p\,dV = p_A \int_{V_A}^{V_B} dV$ as p is constant

$= p_A (V_B - V_A) = 1.013 \cdot 10^5 \text{ Pa} \cdot 2 \cdot 10^{-3} \text{ m}^3$

$= 1.013 \cdot 10^5 \frac{\text{N}}{\text{m}^2} \cdot 2 \cdot 10^{-3} \text{ m}^3 = 203 \text{ Nm} = \underline{203 \text{ J}}$

b) $W_{ADB} = \underbrace{W_{AD}}_{=0 \text{ as } dV=0} + W_{DB} = W_{DB}$

$W_{DB} = \int_{V_D}^{V_B} p\,dV$ "=" 

$= 2 \cdot W_{AB} = \underline{406 \text{ J}}$

c) $W_{ACB} = W_{AC} + \underbrace{W_{CB}}_{=0 \text{ as } dV=0} = W_{AC} = W_{DB} = 406 \text{ J}$ Similar integral as in b)

d) $W_{ADCB} = \underbrace{W_{AD}}_{=0 \text{ as } dV=0} + W_{DC} + \underbrace{W_{CB}}_{=0 \text{ as } dV=0} = W_{DC} = 3 W_{AB}$

$= \underline{609 \text{ J}}$

Problem 2: (11-03-76)

a) Adiabatic

$V_i = 2.0 \cdot 10^{-3} \text{ m}^3$, $T_i = 300 \text{ K}$, $p_i = 5.0 \cdot 10^5 \text{ Pa}$

$V_f = 2.5 \cdot 10^{-3} \text{ m}^3$

Find T_f and p_f $\gamma = 5/3$

$pV^\gamma = \text{Const.}$ (3.12)

$p^{1-\gamma} T^\gamma = \text{Const.}$ (3.13)

$TV^{\gamma-1} = \text{Const.}$ (3.14)

$\rightarrow p_f V_f^\gamma = p_i V_i^\gamma \rightarrow$ $p_f = p_i \left(\frac{V_i}{V_f}\right)^\gamma$

$= 5.0 \cdot 10^5 \text{ Pa} \cdot \left(\frac{2.0}{2.5}\right)^{5/3}$

$\approx \underline{3.45 \cdot 10^5 \text{ Pa}}$

$T_f V_f^{\gamma-1} = T_i V_i^{\gamma-1} \rightarrow$ $T_f = T_i \left(\frac{V_i}{V_f}\right)^{\gamma-1}$

$= 300 \text{ K} \left(\frac{2.0}{2.5}\right)^{\frac{5}{3}-1} \approx \underline{260 \text{ K}}$

b) isothermal

Find T_f and p_f

$T_f = T_i = 300 \text{ K}$

$pV = nRT$, $T = \text{Const.} \rightarrow p_f V_f = p_i V_i$

$\rightarrow p_f = p_i \left(\frac{V_i}{V_f}\right)$ $= 5.0 \cdot 10^5 \text{ Pa} \left(\frac{2.0}{2.5}\right)$

$= \underline{4.0 \cdot 10^5 \text{ Pa}}$

Problem 3: (11-04-50)

Ideal gas — Isothermal reversible expansion

$n = 1$ mol

$V_f = 2V_i$

a) Find ΔS_{gas}, $pV = nRT$, $E_{int} = \frac{3}{2}nRT$

$\Delta E_{int} = 0$

$\Delta E_{int} = Q - W = 0 \rightarrow W = Q$

$$W = \int_{V_i}^{V_f} p\,dV = nRT \int_{V_i}^{V_f} \frac{dV}{V} = nRT \ln\left(\frac{V_f}{V_i}\right) = nRT \ln(2)$$

$\rightarrow Q = nRT\ln(2)$

isothermal $\rightarrow$ $\Delta S = \frac{Q}{T} = nR\ln(2)$

$= 1\,\text{mol} \cdot 8.314 \frac{J}{K \cdot \text{mol}} \ln(2) = 5.76 \frac{J}{K}$

b) isothermal $\rightarrow T_f = T_i$

This is thus not a proper question

Problem 4: (11-04-64)

Carnot engin: $e = 1 - \frac{T_c}{T_h}$

$e_i = 0.60 \rightarrow e_f = 0.55$ as $T_c^i \rightarrow T_c^f$

$T_h^f = T_h^i$

a) Find $T_h^i = T_h^f$

$e_i = 1 - \frac{T_c^i}{T_h^i}$

$\rightarrow e_i - 1 = -\frac{T_c^i}{T_h^i}$

$\rightarrow \frac{T_c^i}{T_h^i} = 1 - e_i$

$\rightarrow \boxed{T_h^i = \frac{T_c^i}{1 - e_i}} = \frac{(27 + 273)\,K}{1 - 0.6}$

$= 750\,K = 477\,^\circ C$

b) $e_f = 1 - \frac{T_c^f}{T_h^f} = 1 - \frac{T_c^f}{T_h^i}$

$\rightarrow \frac{T_c^f}{T_h^i} = 1 - e_f$

$\rightarrow T_c^f = T_h^i (1 - e_f) = \left(\frac{T_c^i}{1 - e_i}\right)(1 - e_f)$

$= 750 \cdot (1 - 0.55)\,K$

$\simeq 338\,K \simeq 64.5\,^\circ C$