

5.2. Transformation isochore (V = Cste)

$$\begin{aligned}
 SW &= -pdV & \Leftrightarrow & \boxed{W = 0} \\
 \bullet \quad dV &= 0 \\
 \bullet \quad Q &= \Delta U - W = \Delta U = \boxed{nC_v(T_2 - T_1) = Q} \\
 \bullet \quad \boxed{\Delta U = nC_v(T_2 - T_1)} \\
 \bullet \quad \Delta S &= \int \frac{SQ}{T} = \int \frac{nC_v dT}{T} = nC_v \int \frac{dT}{T} = \boxed{nC_v \ln \frac{T_2}{T_1} = \Delta S}
 \end{aligned}$$

5.3. Transformation isotherme (T=cste)

$$\begin{aligned}
 W &= \int SW = \int -p dV & PV &= nRT \\
 W &= \int \frac{-nRT}{V} & P &= \frac{nRT}{V} \\
 W &= -nRT \int dV \\
 \boxed{W} &= \boxed{-nRT \ln \frac{V_2}{V_1}}
 \end{aligned}$$

$$\begin{aligned}
 \Delta U &= nC_v \Delta T & \Delta U &= 0 \\
 \Delta T &= 0
 \end{aligned}$$

$$Q + W = \Delta U = 0$$

$$\boxed{Q = -W = nRT \ln \frac{V_2}{V_1}}$$

$$\Delta S = \int \frac{SQ}{T} = \frac{1}{T} \int SQ = \frac{Q}{T}$$

$$\boxed{\Delta S = nR \ln \frac{V_2}{V_1}}$$

5.4. Transformation adiabatique

$$\bullet \quad Q = 0 \quad (SQ = 0)$$

$$\bullet \quad \Delta S = \int \frac{SQ}{T} = 0$$

$$W = \int -p V^\gamma \frac{dV}{V^\gamma} = -P V^\gamma \int \frac{dV}{V^\gamma}$$

$$\bullet \quad = -P V^\gamma \left[V^{-\gamma+1} \right]^2$$

Isotherme $PV = cste$

$$\gamma = \frac{C_p}{C_v}$$

Adiabatique $PV^\gamma = cste$

Démo:

$$SQ = 0 = dU - SW$$

$$0 = dU - SW$$

$$0 = nC_v dT + p dV$$

$$0 = nC_v d\left(\frac{PV}{nR}\right) + p dV$$

$$0 = C_v (PdV + VdP) + PRdV$$

$$0 = C_v PdV + C_v VdP + P(C_p - C_v)dV$$

$$0 = VC_v dP + PC_p dV$$

$$0 = VdP + P\gamma dV \Rightarrow PV^\gamma = cste$$

Exercice 10 L

air $P_0 = 1 \text{ atm} = 1,013 \cdot 10^5 \text{ Pa}$

$$T_0 = 0^\circ \text{C}$$

$$M = 29 \text{ g / mole}$$

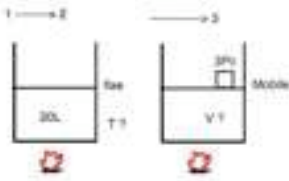
$$C_v = 708 \text{ J K}^{-1} \text{ kg}^{-1}$$

$$\gamma = 1,40$$

$$R = 8,31 \text{ J K}^{-1} \text{ mol}^{-1}$$

isochore expansion isobare

1 -----> 2 -----> 3
 on chauffe l'air jusqu'à 3 P₀ // on a triplé la pression
 on continue à chauffer jusqu'à T₃=600°C



1) Manque la question 1

2) Calcul de ΔU

$$\Delta U = nC_V \Delta T = mC_V \Delta T$$

$m?$

$$m = nM = \frac{P_0 V_0}{RT_0} M = m$$

A.N.

$$m = \frac{10^5 \times 20 \cdot 10^{-3}}{8,31 \times 273} \times 29 = 26g$$

$$\Delta U_{1-2} = mC_V \Delta T = mC_V (T_2 - T_1)$$

A.N.

$$\Delta U = 26 \cdot 10^{-3} \times 708(546)$$

$$\Delta U = 10kJ$$

3) Calcul de V_3

$$P_3 = 3P_0$$

$$T_3 = 600^\circ C$$

$$P_3 V_3 = nPT_3 \Leftrightarrow V_3 = nR \frac{T_3}{P_3} = \frac{P_0 V_0}{T_0} \frac{T_3}{P_3}$$

$$\Leftrightarrow V_3 = \frac{1T_3}{3T_0} V_0$$

A.N.

$$V_3 = \frac{1}{3} \cdot \frac{873}{273} \cdot 20 = 21,3L$$

4) Calcul de ΔU

$$\Delta U = mC_V \Delta T$$

$$\Delta U = mC_V (T_3 - T_2)$$

$$\Delta U = 26 \cdot 10^{-3} \times 708(873 - 819)$$

$$\Delta U = 0,99kJ$$

Exercice 2:

air

$$V_0 = 1m^3$$

$$T_0 = 0^\circ C$$

$$P_0 = 1atm$$

Compression

isotherme

Etat 1:

$$V_1 ?$$

$$T_1 = T_0$$

$$P_1 = 20atm$$

détente
adiabatique

$$V_1 \frac{nRT_1}{P_1} = \frac{P_0 V_0}{T_0} \frac{T_1}{P_1} = \frac{V_0}{20} = 50dm^3$$

Etat 2

$$P_2 = 1 \text{ bar}$$

$$W_{01} = \int_0^1 -p dV = \int_0^1 -\frac{nRT}{V} dV$$

$$W_{0 \rightarrow 1} = -nRT \int_0^1 \frac{dV}{V} = -nRT \ln \frac{V_1}{V_0}$$

$$W_{0 \rightarrow 1} = -P_0 V_0 \ln \frac{V_1}{V_0}$$

$$W_{01} = -10^5 \times 1 \times \ln\left(\frac{1}{20}\right) = +304 \text{ kJ}$$

$$\Delta U = 0 \Rightarrow \boxed{Q = -W = -304 \text{ kJ}}$$

V2 ?

T2 ?

$$PV^\gamma = \text{cste}$$

$$\gamma = 1,42 \text{ air}$$

$$P_1 V_1^\gamma = P_2 V_2^\gamma$$

$$V_2 = \left(\frac{P_1}{P_2}\right)^{1/\gamma} V_1$$

A.N.

$$V_2 = (20)^{\frac{1}{1,42}} \times 50 = 412 \text{ L}$$

$$T_2 = \frac{P_2 V_2}{nR} = \frac{\cancel{P_2} V_2}{\cancel{P_0} V_0} T_0 = \frac{412}{1000} \times 273 = 113 \text{ K}$$

$$P_2 = P_0$$