

**Exercice 1 :**

Supposons l'air comme un gaz parfait, on a :

$$P_1 v_1 = \frac{m}{M} R T_1$$

$$v_1 = \frac{R T_1}{M P_1} = 0,6451 \text{ m}^3 \cdot \text{kg}^{-1} \text{ car } m = 1 \text{ kg}$$

$$\text{Evolution isentropique} \Rightarrow \frac{P_1}{P_2} = \left( \frac{v_2}{v_1} \right)^{1,4} = \left( \frac{T_1}{T_2} \right)^{\frac{1,4}{1,4-1}}$$

$$v_2 = \left( \frac{P_1}{P_2} \right)^{\frac{5}{7}} v_1 = 1,736 \text{ m}^3 \cdot \text{kg}^{-1}$$

$$T_2 = \left( \frac{P_1}{P_2} \right)^{\frac{-1,4+1}{1,4}} T_1 = 605,75 \text{ K}$$

$$\frac{\text{kg}}{\text{s}} = \frac{m}{s} \cdot \frac{\text{m}^2}{\text{m}^3} \cdot \text{kg} = \frac{m}{s} \cdot \left( \frac{\text{m}^3}{\text{kg}} \right)^{-1} \cdot \text{m}^2$$

$$\dot{m} = c_2 \frac{1}{v_2} A_2 = 0,346 \text{ kg} \cdot \text{s}^{-1}$$

$$W_{t,s} = \Delta U = \frac{R}{M} \frac{1}{1,4-1} (T_2 - T_1) = -211 \text{ kJ} \cdot \text{kg}^{-1}$$

$$v_{2,r} = \frac{R T_{2,r}}{M P_2} = 1,8 \text{ m}^3 \cdot \text{kg}^{-1}$$

$$\Delta S = c_v \ln \left( \frac{T_{2,r}}{T_1} \right) + \frac{R}{M} \ln \left( \frac{v_{2,r}}{v_1} \right)$$

$$\Delta S = 9 \text{ J} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$$

$$\text{avec } c_v = 0,71 \text{ kJ} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$$

L'irréversibilité est plus importante que les pertes de chaleur.

**Exercice 2 :**

AB : évolution isentropique  $\Rightarrow$

$$\frac{P_A}{P_B} = \left( \frac{V_B}{V_A} \right)^{1,4} = \left( \frac{T_A}{T_B} \right)^{\frac{1,4}{1,4-1}}$$

$$P_B = P_A \left( \frac{T_A}{T_B} \right)^{\frac{1,4}{1-1,4}} = 10 \text{ bar}$$

$$V_B = V_A \left( \frac{P_A}{P_B} \right)^{\frac{1}{1,4}} = 80 \text{ cm}^3$$

BC : évolution isotherme réversible  $\Rightarrow P_C V_C = P_B V_B$

$$P_C = P_B \frac{V_B}{V_A} = 1,93 \text{ bar} \text{ avec } V_A = V_C$$

$$W_{AB} = \frac{nR}{\gamma-1} (T_B - T_A) \quad nR = \frac{P_A V_A}{T_A}$$

$$W_{AB} = \frac{P_A V_A}{T_A} \frac{1}{\gamma-1} (T_B - T_A) = 96,33 \text{ J}$$

$$Q_{AB} = 0$$

$$W_{BC} = -P_B V_B \ln \left( \frac{V_C}{V_B} \right) = -131,47 \text{ J}$$

$$Q_{BC} = -P V_B \ln \left( \frac{V_C}{V_B} \right) = 131,47 \text{ J}$$

$$\text{CA : évolution isochore} \Rightarrow \frac{P_A}{T_A} = \frac{P_C}{T_C}$$

$$W_{CA} = 0$$

$$Q_{CA} = \frac{nR}{\gamma-1} (T_A - T_C) \quad T_C = \frac{P_C}{P_A} T_A$$

$$Q_{CA} = \frac{P_A V_A}{T_A} \frac{1}{\gamma-1} \left( 1 - \frac{P_C}{P_A} \right) T_A = -96,33 \text{ J}$$

$$W_{\text{cycle}} = W_{AB} + W_{BC} + W_{CA} = 96,33 - 131,47$$

$$W_{\text{cycle}} = -35,14 \text{ J}$$

$$Q_{\text{cycle}} = Q_{AB} + Q_{BC} + Q_{CA} = 131,47 - 96,33$$

$$Q_{\text{cycle}} = -35,14 \text{ J}$$

$$\Delta U_{\text{cycle}} = 0 : 1^{\text{er}} \text{ principe vérifié}$$

$$\Delta S_{BC} = nR \ln \left( \frac{V_C}{V_B} \right) \quad nR = \frac{P_B V_B}{T_B} \quad V_C = V_A$$

$$\Delta S_{BC} = \frac{P_B V_B}{T_B} \ln \left( \frac{V_A}{V_B} \right) = 0,472 \text{ J} \cdot \text{K}^{-1}$$

$$\Delta H_{CA} = n C_p (T_A - T_C) \quad C_p = \frac{R \gamma}{\gamma-1}$$

$$\Delta H_{CA} = \frac{P_A V_A}{T_A} \frac{\gamma}{\gamma-1} \left( 1 - \frac{P_C}{P_A} \right) T_A = -134,86 \text{ J}$$

**Exercice 3 :**

$$\text{Evolution isochore} \Rightarrow \frac{P_1}{P_2} = \frac{T_1}{T_2}$$

$$Q_{12} = C_v (T_2 - T_1) \quad C_v = \frac{3}{2} R \quad T_2 = \frac{P_2}{P_1} T_1$$

pour rappel, l'hélium est un gaz monoatomique

$$Q_{12} = \frac{3}{2} R \left( \frac{P_2}{P_1} - 1 \right) T_1 = 12 \text{ kJ}$$

$$\text{avec } P_1 = 200; P_2 = 800; T_1 = 323,15$$