

# Correction de l'examen de thermodynamique

MS 411.

## Exercice

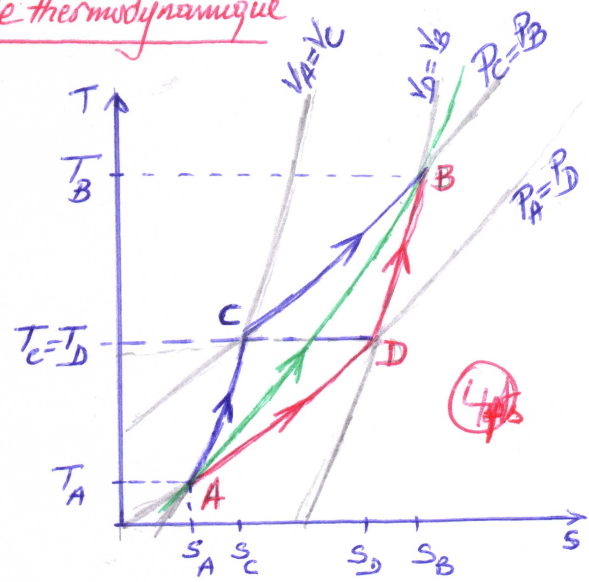
$n = 4 \text{ moles}; C_v = \frac{5}{2} R; T_A = 120^\circ\text{C} = 393\text{K}$

$P_2 = 2P_1 \text{ et } V_2 = 2V_1$

I/

1/ Diagramme entropique

2/ Calcul des températures,  $T_B, T_C$  et  $T_D$ .



\*  $P_B V_B = nRT_B \Rightarrow T_B = \frac{P_B V_B}{nR} = \frac{2P_1 \cdot 2V_1}{nR} = \frac{4P_1 V_1}{nR} = 4T_A = 4 \cdot (120 + 273) \Rightarrow T_B = 1572\text{K} = 1299^\circ\text{C}$  (0,5)

\*  $P_C V_C = nRT_C \Rightarrow T_C = \frac{P_C V_C}{nR} = \frac{2P_1 \cdot V_1}{nR} = 2T_A = 2 \cdot (120 + 273) \Rightarrow T_C = 786\text{K} = 513^\circ\text{C}$  (0,5)

\*  $P_D V_D = nRT_D \Rightarrow T_D = \frac{P_D V_D}{nR} = \frac{P_1 \cdot 2V_1}{nR} = 2T_A = 2 \cdot (120 + 273) \Rightarrow T_D = T_C = 786\text{K} = 513^\circ\text{C}$  (0,5)

## II/ Trajet (ACB)

1/ Transformation (AC)  $V_A = V_C = V_1$  et  $P_2 > P_1 \Rightarrow$  chauffage isochore (0,25) (même  $T_C > T_A$  c'est juste)

\*  $W_{AC} = 0$  car  $V_A = V_C = \text{cte} \Rightarrow dV = 0$  (0,25)

\* La chaleur  $Q_{AC} = nC_v(T_C - T_A) = 4 \cdot \frac{5}{2} \cdot 8,31 \cdot (513 - 120) \Rightarrow Q_{AC} = 32658,3 \text{ Joule}$  (0,25)

## 2/ Transformation (CB)

\*  $P_2 = P_C = P_B$  et  $V_B > V_C \Rightarrow$  (CB) refroidissement isobare (0,25) (Aussi  $T_B > T_C$  c'est juste)

\*  $W_{CB} = -P_C(V_B - V_C) = -2P_1 \cdot V_1 = -2nRT_A = -2 \cdot 4 \cdot 8,31 \cdot (120 + 273) \Rightarrow W_{CB} = -26126,64 \text{ J}$  (0,25)

\*  $Q_{CB} = nC_p(T_B - T_C) \Rightarrow Q_{CB} = n \cdot (R + C_v)(T_B - T_C) = n \cdot (R + \frac{5}{2}R)(T_B - T_C)$   
 on sait que  $C_p - C_v = R \Rightarrow C_p = R + C_v$   
 $= n \cdot \frac{7}{2} R (T_B - T_C) = 4 \cdot \frac{7}{2} \cdot 8,31 (1299 - 513) \Rightarrow Q_{CB} = 91443,24 \text{ J}$  (0,25)

3/  $W_{ACB} = W_{AC} + W_{CB} = 0 + 26126,64 \Rightarrow W_{ACB} = 26126,64 \text{ J}$  (0,25)

$Q_{ACB} = Q_{AC} + Q_{CB} = 32658,3 + 91443,24 \Rightarrow Q_{ACB} = 124101,54 \text{ J}$  (0,25)

### III Trajet (ADB)

#### 1/ Transformation (AD)

\*  $P_1 = P_A = P_D$  et  $V_D > V_A \Rightarrow$  refroidissement isobare (AD) (Aussi  $T_D > T_A$  c'est juste)

\*  $W_{AD} = -P_1 (V_D - V_A) = -P_1 V_1 = -nRT_A = -4 \cdot 8,31 \cdot 393 \Rightarrow W_{AD} = -13063,32 \text{ J}$

\*  $Q_{AD} = n C_p (T_D - T_A) = n \cdot \frac{7}{2} R (T_D - T_A) = 4 \cdot \frac{7}{2} \cdot 8,31 (786 - 393) \Rightarrow Q_{AD} = 45721,62 \text{ J}$

#### 2/ Transformation (DB)

\*  $V_2 = V_D = V_B$  et  $P_B > P_D \Rightarrow$  (DB) chauffage isochore. ( $T_B > T_D$ ) idem.

\*  $V_D = V_B \Rightarrow W_{DB} = 0$

\*  $Q_{DB} = n C_v (T_B - T_D) = n \cdot \frac{5}{2} R (T_B - T_D) = 4 \cdot \frac{5}{2} \cdot 8,31 (1299 - 513) \Rightarrow Q_{DB} = 65316,6 \text{ J}$

3/  $W_{ADB} = W_{AD} + W_{DB} = -13063,32 + 0 \Rightarrow W_{ADB} = -13063,32 \text{ J}$

$Q_{ADB} = Q_{AD} + Q_{DB} = 45721,62 + 65316,6 \Rightarrow Q_{ADB} = 111038,22 \text{ J}$

### IV Trajet (AB)

1/ L'énergie interne  $U_{AB} = n C_v (T_B - T_A) = n \cdot \frac{5}{2} R (T_B - T_A) = 4 \cdot \frac{5}{2} \cdot 8,31 (1299 - 720) \Rightarrow U_{AB} = 97974,9 \text{ J}$

2/ Travail  $W_{AB} = -\int_A^B P dv$ : Calculons P?

on a de A  $\rightarrow$  B: droite sous forme de  $P = aV + b$  ce qui nous permet d'écrire.

①  $P_A = aV_A + b$

②  $P_B = aV_B + b \Rightarrow P_B - P_A = a(V_B - V_A) \Leftrightarrow 2P_1 - P_1 = a(2V_1 - V_1) \Rightarrow a = \frac{P_1}{V_1}$

①  $\Rightarrow P_A = aV_A + b \Leftrightarrow P_1 = \frac{P_1}{V_1} \cdot V_1 + b \Rightarrow b = 0$ . D'où:

$P_A = \frac{P_1}{V_1} \cdot V_A$

$P_B = \frac{P_1}{V_1} \cdot V_B$

$P = \frac{P_1}{V_1} \cdot V$

1/5

$$W_{AB} = - \int_A^B P dV = - \int_A^B \frac{P_1}{V_1} \cdot V dV = - \frac{P_1}{V_1} \int_{V_A}^{V_B} V dV = - \frac{P_1}{V_1} \cdot \frac{V^2}{2} \Big|_{V_A}^{V_B} = - \frac{P_1}{2V_1} \cdot (V_B^2 - V_A^2)$$

$$\Rightarrow W_{AB} = - \frac{3}{2} n R T_1 = - \frac{3}{2} \cdot 4 \cdot 8,31 \cdot 393 \Rightarrow W_{AB} = -19594,98 \text{ J}$$

3/ La chaleur  $Q_{AB}$ : D'après le 1<sup>er</sup> Principe de la TNDY, on a:

$$U_{AB} = W_{AB} + Q_{AB} \Rightarrow Q_{AB} = U_{AB} - W_{AB} = 97974,9 + 19594,98$$

$$\Rightarrow Q_{AB} = 117569,88 \text{ J}$$