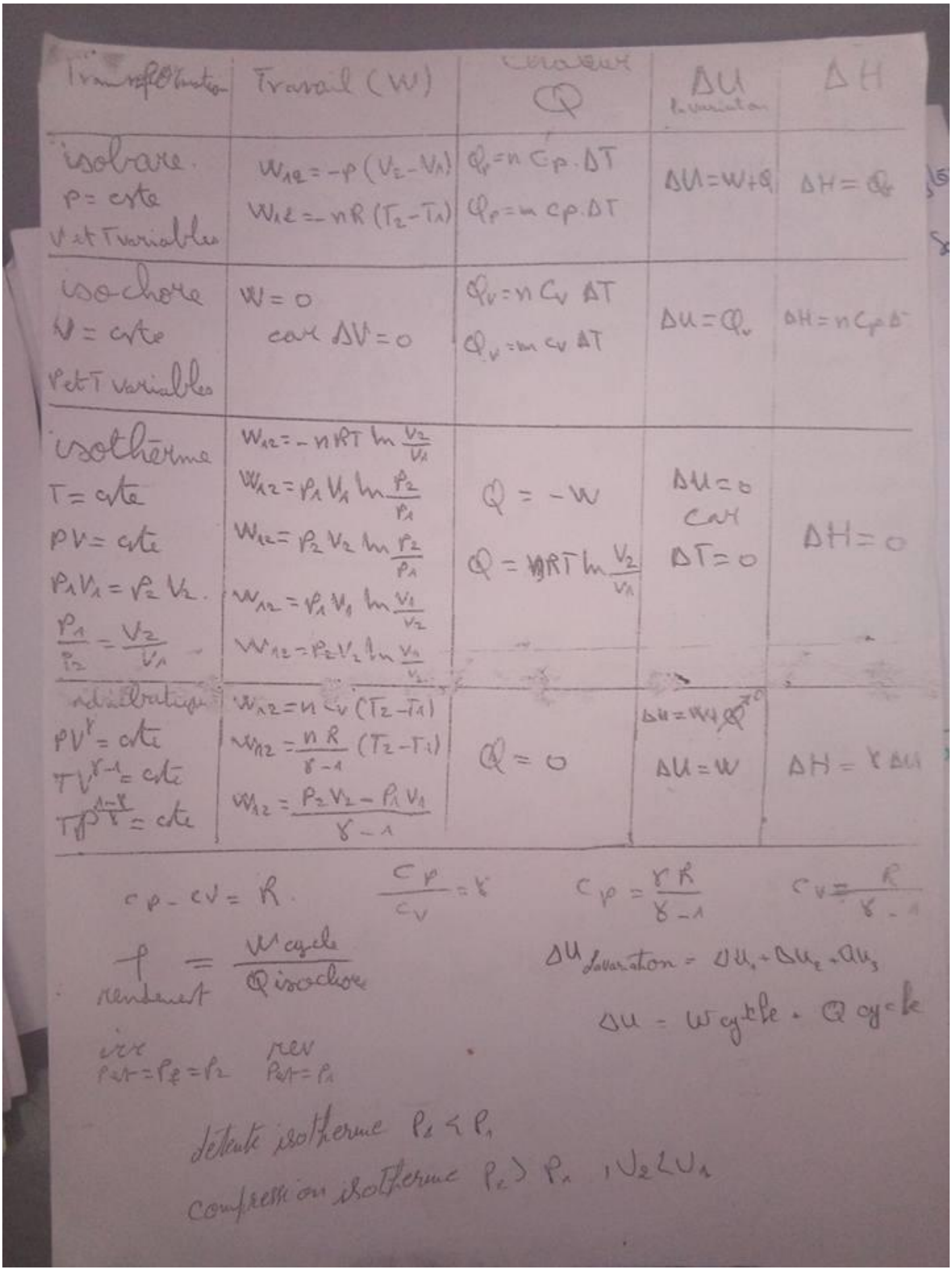
TRANSFORMATIONS DE GAZ PARFAITS

Application du 1er principe de la thermodynamique aux gaz parfaits

But : Calcul du travail (W), de la chaleur (Q), de la variation de l'énergie interne (ΔU) et de la variation de l'enthalpie (ΔH) pour un gaz parfait en l'absence de réaction chimique.

N°	Transformation	Travail (W)	Chaleur(Q)	Variation de l'énergie interne (ΔU)	Variation de l'enthalpie (ΔH)
1	**Isobare** P= constante V et T variables	$W_{12} = -p(V_2 - V_1)$ $W_{12} = -nR(T_2 - T_1)$	$Q_p = n\int_1^2 C_p(T)dT$ $Q_p = m\int_1^2 C_p(T)dT$	ΔU=W+Q	$\Delta H = Q_p$
2	**Isochore** V= constante Pet T variables	W=0, (dV=0)	$Q_v = n\int_1^2 C_v(T)dT$ $Q_v = m\int_1^2 C_v(T)dT$	$\Delta U = Q_v$	$\Delta H = n\int_1^2 C_p(T)dT$
3	**Isotherme** T= constante PV=constant $P_1V_1 = P_2V_2$ $\frac{P_1}{P_2} = \frac{V_2}{V_1}$	$W_{12} = -nRT\ln\frac{V_2}{V_1}$ $W_{12} =$ [illegible] $\frac{V_1}{V_2}$ $W_{12} = P_1V_1\ln\frac{P_2}{P_1}$ $W_{12} = P_2V_2\ln\frac{P_2}{P_1}$ $W_{12} = P_1V_1\ln\frac{V_1}{V_2}$ $W_{12} = P_2V_2\ln\frac{V_1}{V_2}$	$Q = -W$ $Q = nRT\ln\frac{V_2}{V_1}$	ΔU = 0 car ΔT= 0	ΔH = 0
4	**Adiabatique** $PV^{\gamma} = constant$ $TV^{\gamma-1} = constant$ $TP^{\frac{1-\gamma}{\gamma}} = constant$	$W_{12} = nC_v(T_2 - T_1)$ $W_{12} = \frac{nR}{\gamma - 1}(T_2 - T_1)$ $W_{12} = \frac{P_2V_2 - P_1V_1}{\gamma - 1}$	Q = 0 Pas d'échange de chaleur entre le système et le milieu extérieur (système isolé)	ΔU = W	$\Delta H = \gamma\,\Delta U$

Pour 1 mole $C_p - C_v = R$	$\frac{C_p}{C_v} = \gamma$	$C_p = \frac{\gamma R}{\gamma - 1}$	$C_v = \frac{R}{\gamma - 1}$



Transformation	Travail (W)	Chaleur Q	ΔU la variation	ΔH
isobare. P = cte V et T variables	$W_{12} = -P(V_2 - V_1)$ $W_{12} = -nR(T_2 - T_1)$	$Q_p = n\,C_p . \Delta T$ $Q_p = m\,c_p . \Delta T$	$\Delta U = W + Q$	$\Delta H = Q_p$
isochore V = cte P et T variables	$W = 0$ car $\Delta V = 0$	$Q_v = n\,C_v\,\Delta T$ $Q_v = m\,c_v\,\Delta T$	$\Delta U = Q_v$	$\Delta H = n C_p \Delta$
isotherme T = cte PV = cte $P_1V_1 = P_2V_2$. $\frac{P_1}{P_2} = \frac{V_2}{V_1}$	$W_{12} = -nRT \ln\frac{V_2}{V_1}$ $W_{12} = P_1V_1 \ln\frac{P_2}{P_1}$ $W_{12} = P_2V_2 \ln\frac{P_2}{P_1}$ $W_{12} = P_1V_1 \ln\frac{V_1}{V_2}$ $W_{12} = P_2V_2 \ln\frac{V_1}{V_2}$	$Q = -W$ $Q = nRT \ln\frac{V_2}{V_1}$	$\Delta U = 0$ car $\Delta T = 0$	$\Delta H = 0$
adiabatique $PV^{\gamma} = cte$ $TV^{\gamma-1} = cte$ $TP^{\frac{1-\gamma}{\gamma}} = cte$	$W_{12} = n\,C_v(T_2 - T_1)$ $W_{12} = \frac{nR}{\gamma - 1}(T_2 - T_1)$ $W_{12} = \frac{P_2V_2 - P_1V_1}{\gamma - 1}$	$Q = 0$	$\Delta U = W + \cancelto{0}{Q}$ $\Delta U = W$	$\Delta H = \gamma \Delta U$

$c_p - c_v = R$. $\frac{c_p}{c_v} = \gamma$ $c_p = \frac{\gamma R}{\gamma - 1}$ $c_v = \frac{R}{\gamma - 1}$

$\underset{\text{rendement}}{\eta} = \frac{W\,cycle}{Q\,isochore}$

$\Delta U_{la\,variation} = \Delta U_1 + \Delta U_2 + \Delta U_3$

$\Delta U = W\,cycle + Q\,cycle$

irr $P_{ext} = P_f = P_2$ rev $P_{ext} = P_1$

détente isotherme $P_2 < P_1$

compression isotherme $P_2 > P_1$, $V_2 < V_1$

La loi Dalton.

La pression Total → $\boxed{P_T} = \Sigma \boxed{p_i}$ → La pression partielle

Les données
$P_{T_1} = 200$ Kp
$n(H_2) = 6$ mol
$n(O_2) = 2$ mol

$P_i = X_i \cdot P_T$ et $\boxed{X_i} = \frac{n_i}{n_T}$

(La fraction molaire) (الكسر المولي)

n_i : كمية المادة تع العنصر الواحد (لكل واحد).

n_T : كمية المادة لعنصر الكامل

Exemple :

calculer la pression totale de chaque element.

$P_i = X_i \cdot P_T$ $\quad P(O_2) = X_{(O_2)} \cdot P_T$.

$n_T = n_{O_2} + n_{H_2}$
$n_T = 2 + 6 = 8$ mol

et $X_{O_2} = \frac{n_{O_2 i}}{n_{O_2 T}} = \frac{2}{8} = \frac{1}{4} = \boxed{0{,}25}$

$P_i = 0{,}25 \times 200 = \frac{n_{H_2}}{n_T} = \frac{6}{8} =$

$\boxed{P_{i\,O_2} = 50}$

$P_{i\,(H_2)} = \frac{6}{8} \times 200 =$

La loi d'equilibre

Resumé Chimie II

La loi de Gaz parfait ⇒ قانون الغاز المثالي

Définition : Le Gaz parfait il neglige les interaction qui se trouve entre les molicule.

V = cst

$$PV = nRT \Rightarrow P/T = \frac{nR}{V} = cst.$$

$$\frac{P}{T} = cst \text{ Alors } \frac{P_1}{V_1} = \frac{P_2}{V_2}.$$

T = cst.

$$P.V = \overset{cst}{\boxed{nRT}} \Rightarrow P_1.V_1 = P_2.V_2.$$

P = cst.

$$PV = nRT \Rightarrow \overset{cst}{\boxed{\frac{P}{nR}}} = \frac{T}{V} , \frac{T_1}{V_1} = \frac{T_2}{V_2}.$$

$$R = \frac{\ell.atm}{K.mol} \Rightarrow \underline{P = atm} , \underline{V = \ell}$$

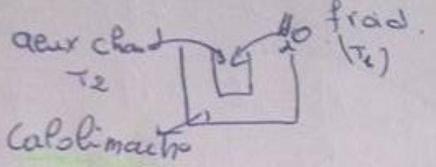
$$R = \frac{J}{K.mol} \Rightarrow \underline{P = pascal} \text{ et } \underline{V = m^3}$$

$1\ell \rightarrow 10^3\ dm^3$

$1m^3 \rightarrow 10^3\ell.$

La loi D'equilibre $\sum \varphi = 0$

avec $\varphi = m \cdot C \cdot \Delta T$



$Q = T_{eq} = ??$

$\sum \varphi_i = 0.$

$mc = C = u.$

$\varphi_{cal} + \varphi_{eau\,f} + \varphi_{eau\,ch} = 0.$

$m \cdot C \cdot \Delta T + m_1 \cdot C_1 \cdot \Delta T_1 + m_2 \cdot C \cdot \Delta T_2 = 0$

$C(T_{eq} - T_1) + m_1 \cdot C_1 (T_{eq} - T_1) + m_2 \cdot C_2 (T_{eq} - T_2) = 0$

[illegible]

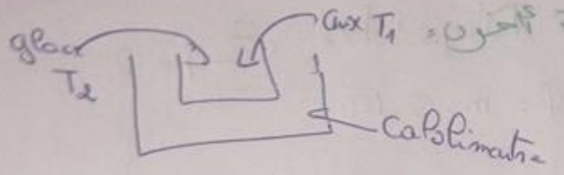
[illegible]

[illegible]

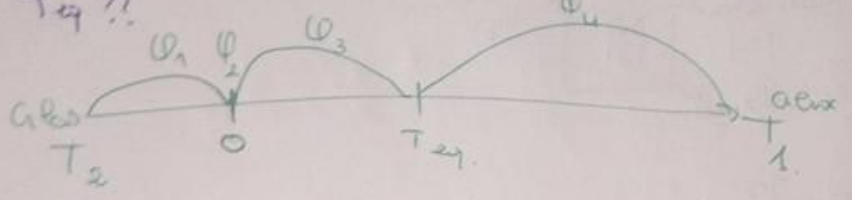
$C T_{eq} - C T_1 + m_1 C_1 T_{eq} + \ldots$

بالنشر و التبسيط نستخرج T_{eq}.

حالة أخرى :



T_{eq} ??



$Q_1 = m_g \cdot c_g \, (0 - T_1)$

$Q_2 = m_{(g)} \cdot L_f$

$Q_3 = m_{(g)} \, c_g \, (T_{eq} - 0)$

$Q_4 = m \cdot c \, (T_{eq} - T_1)$

$Q_5 = Q_{cal} = C \, (T_{eq} - T_1)$

$Q_1 + Q_2 + Q_3 + Q_4 + Q_c = 0$

بتعويض بالنشر و التبسيط نستخرج :Teq

thermodynamique.

toujours on'a une transformation de l'Etat (A) a l'Etat B.

$$\boxed{\begin{matrix} T_1 & V_1 \\ P_1 & \end{matrix}} \longrightarrow \boxed{\begin{matrix} T_2. & V_2 \\ P_2. & \end{matrix}}$$

les lois.

* $P \cdot V = nRT$

* $\Delta U = Q + W$

* $DU = n C_p . \Delta T$

$DH = n C_v . \Delta T$

$R = C_p - C_V$.

$\gamma = \frac{C_P}{C_V}$.

$$W = -\int_{V_1}^{V_2} P\,dv. = -\frac{nRT}{V} \cdot \ln\left(\frac{v_2}{V_2}\right).$$

$$= -\frac{nRT}{V} \cdot \ln\left(\frac{P_1}{P_2}\right).$$

IRREVERSIBLE

$1 \rightarrow 2$

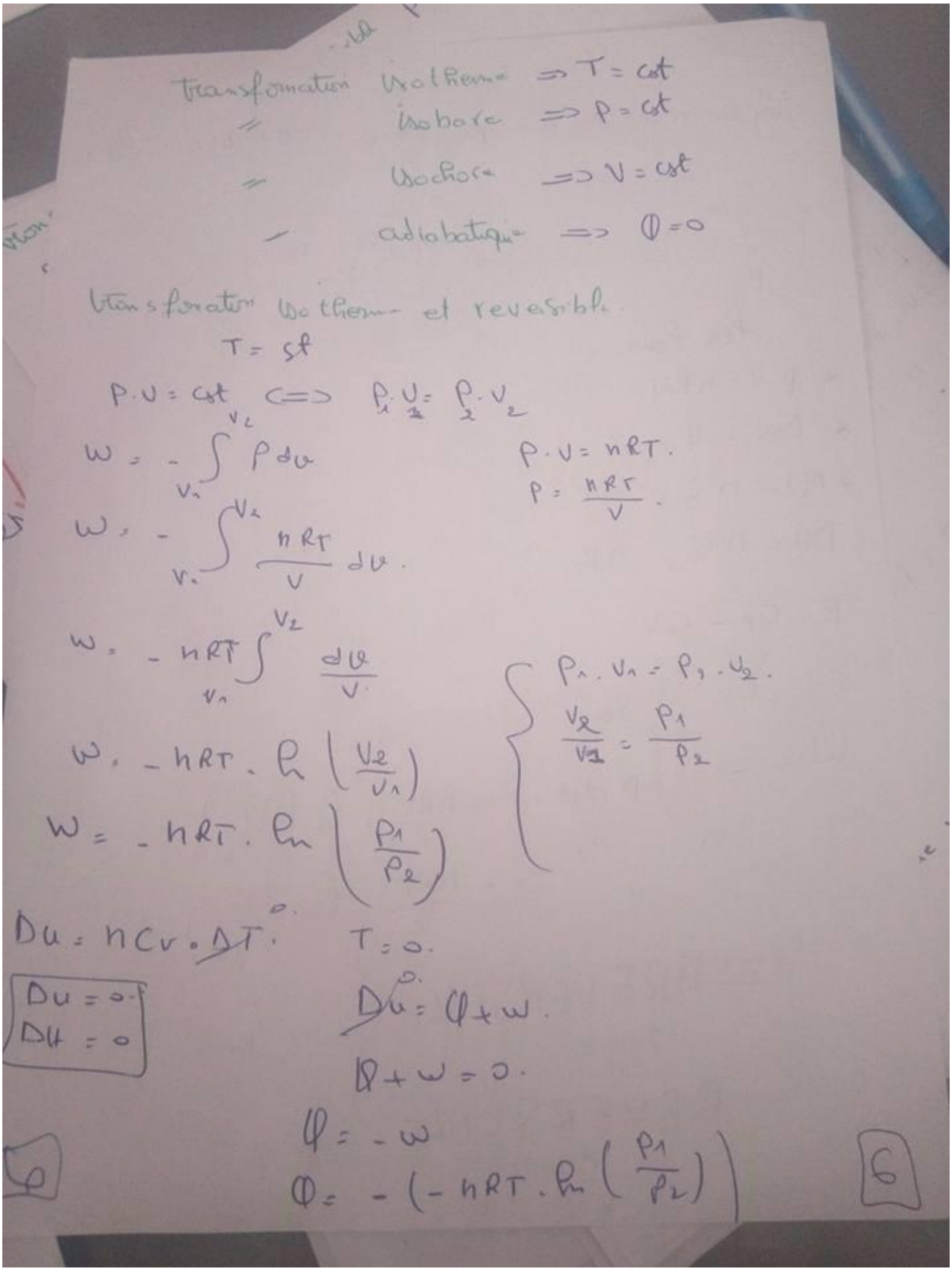
التفاعل في اتجاه
واحد

REVERSIBLE

التفاعل في اتجاهين

$1 \longrightarrow 2$

$1 \longleftarrow 2$



transformation isotherme $\Rightarrow T = cst$

" isobare $\Rightarrow P = cst$

" isochore $\Rightarrow V = cst$

" adiabatique $\Rightarrow Q = 0$

transformation isotherme et reversible.

$T = cst$

$P.V = cst \iff P_1.V_1 = P_2.V_2$

$$W = -\int_{V_1}^{V_2} P\,dV \qquad P.V = nRT. \qquad P = \frac{nRT}{V}.$$

$$W = -\int_{V_1}^{V_2} \frac{nRT}{V}\,dV.$$

$$W = -nRT\int_{V_1}^{V_2} \frac{dV}{V}$$

$$W = -nRT.\ln\left(\frac{V_2}{V_1}\right)$$

$$W = -nRT.\ln\left(\frac{P_1}{P_2}\right)$$

$$\left\{\begin{array}{l} P_1.V_1 = P_2.V_2. \\ \frac{V_2}{V_1} = \frac{P_1}{P_2} \end{array}\right.$$

$\Delta U = nCv.\overset{0}{\cancel{\Delta T}}.$ $\quad T = 0.$

$\boxed{\begin{array}{l} \Delta U = 0. \\ \Delta H = 0 \end{array}}$

$\overset{0}{\cancel{\Delta U}} = Q + W.$

$Q + W = 0.$

$Q = -W$

$Q = -\left(-nRT.\ln\left(\frac{P_1}{P_2}\right)\right)$

transformation isobar et reversible $P = cst$.

$PV = nRT$

$$\frac{T}{V} = \boxed{\frac{P}{nR}} = cst. \iff \boxed{\frac{T_1}{V_1} = \frac{T_2}{V_2}}$$

$$W = -\int_{V_1}^{V_2} P\,dv \Rightarrow -P\int_{V_1}^{V_2} dv.$$

$$\Rightarrow \boxed{-P\left[V_2 - V_1\right]}$$

$$V = \frac{nRT}{P}$$

$$W = -\cancel{P}\left[\frac{nRT_2}{\cancel{P}} - \frac{nRT_1}{P}\right]$$

$$\boxed{W = -nR\left[T_2 - T_1\right]}$$

$$Q = Q_P = nC_P.\Delta T = nC_P(T_2 - T_1).$$

$Q_P =$

⋮

3/ isochore et reversible.

$V = cst$.

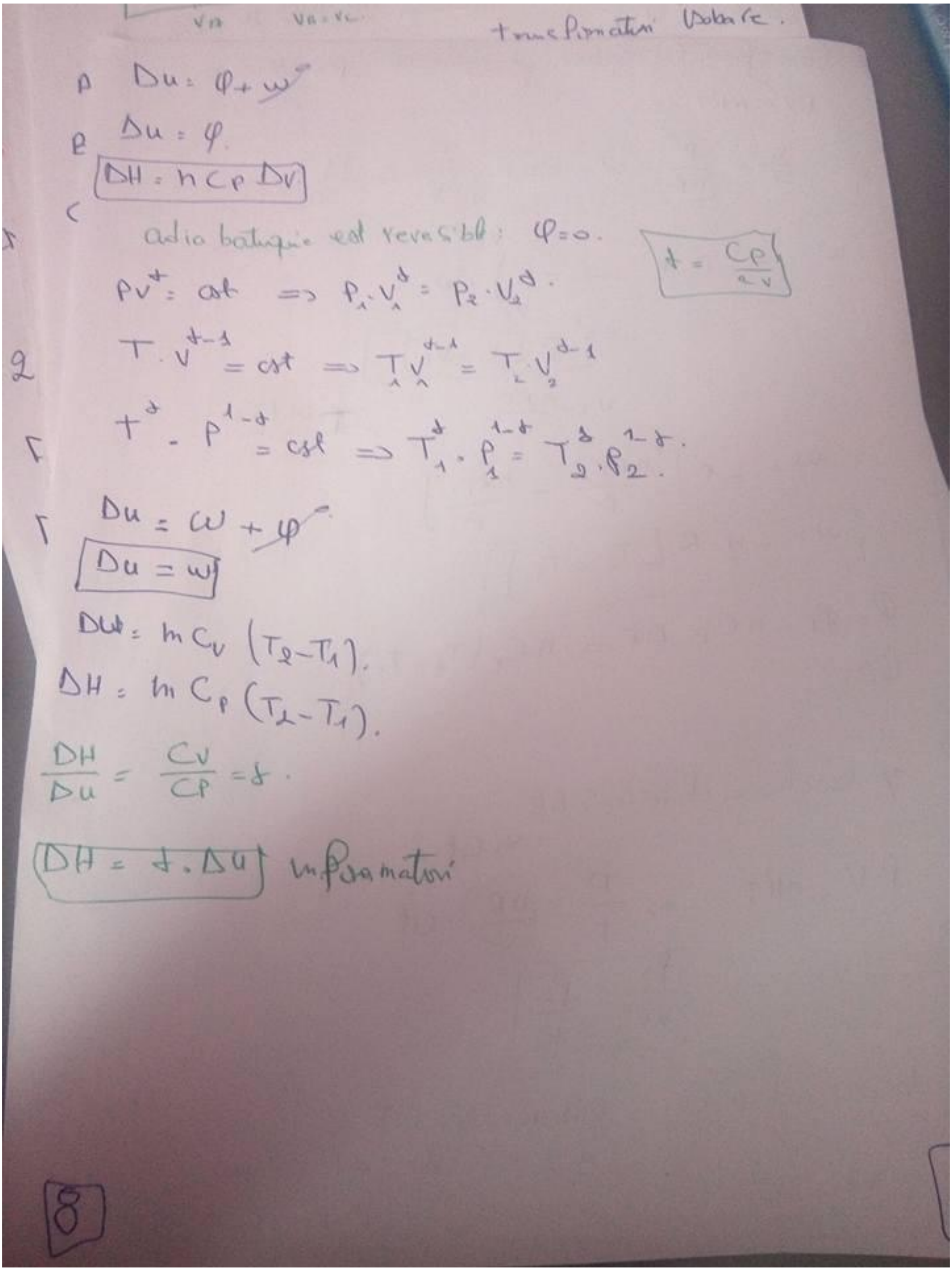
$$P.V = nRT \Rightarrow \frac{P}{T} = \boxed{\frac{nR}{V}} = cst$$

$$\boxed{\frac{P_1}{V_1} = \frac{P_2}{V_2}}$$

$W = -\int P\,dv$ puisque $V = cst$

$dv = 0.$

$$\boxed{W = 0}$$



VA   VB = VC   transformation Isobare.

A $\Delta U = Q + \cancel{W}$

B $\Delta U = Q$

$$\boxed{\Delta H = n C_p \Delta V}$$

C

adiabatique est reversible : $Q = 0$.

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

$PV^{\gamma} = cst \Rightarrow P_1 \cdot V_1^{\gamma} = P_2 \cdot V_2^{\gamma}$.

2 $T \cdot V^{\gamma-1} = cst \Rightarrow T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$

F $T^{\gamma} \cdot P^{1-\gamma} = cst \Rightarrow T_1^{\gamma} \cdot P_1^{1-\gamma} = T_2^{\gamma} \cdot P_2^{1-\gamma}$.

Γ $\Delta U = W + \cancel{Q}$

$$\boxed{\Delta U = W}$$

$\Delta U = m C_v (T_2 - T_1)$.

$\Delta H = m C_p (T_2 - T_1)$.

$$\frac{\Delta H}{\Delta U} = \frac{C_v}{C_p} = \gamma.$$

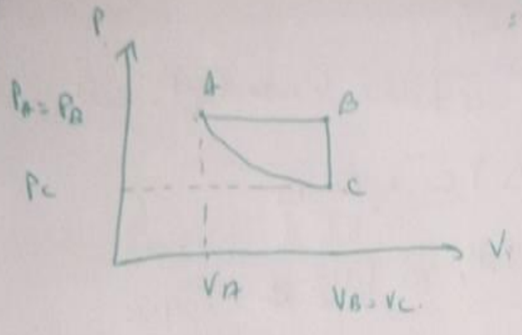
$\boxed{\Delta H = \gamma \cdot \Delta U}$ transformation

8

une pression de 1atm.
st plongé dans 1L d'eau à 20 °C. La température finale est de 30,

inium ?

نقرأه من المخطط:

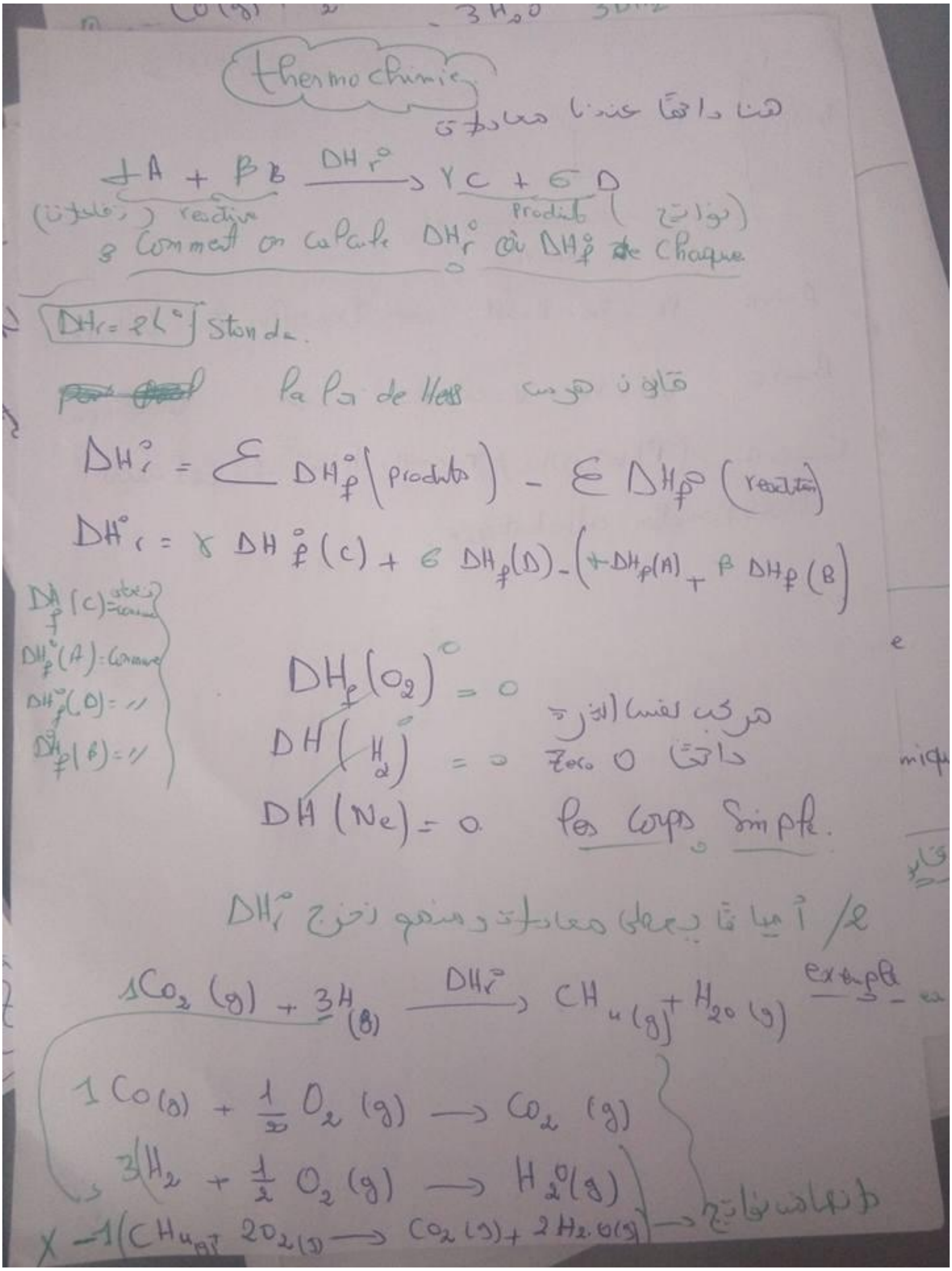


A → B $P_A = P_B = P = cst$. ⟹ transformation isobare.

B → C $V_A = V_C = V = cst$ ⟹ // isochore

C → A ليس لها حل ثابت لا بالحجم و لا بالضغط (P)

transformation adiabatique.



thermochimie

هنا داقما عندنا معادلة

$$\underbrace{\alpha A + \beta B}_{\text{reactive}} \xrightarrow{\Delta H_r^\circ} \underbrace{\gamma C + \sigma D}_{\text{Produit}}$$

(متفاعلات) reactive — Produit (نواتج)

3 Comment on calcule ΔH_r° où ΔH_f° ~~de~~ chaque

$\boxed{\Delta H_r = 25^\circ}$ standa.

~~[illegible]~~ La Loi de Hess قانون هيس

$$\Delta H_r^\circ = \Sigma \Delta H_f^\circ(\text{produits}) - \Sigma \Delta H_f^\circ(\text{reactifs})$$

$$\Delta H_r^\circ = \gamma \Delta H_f^\circ(C) + \sigma \Delta H_f(D) - (\alpha \Delta H_f(A) + \beta \Delta H_f(B))$$

$\Delta H_f(C)$ = معطاة = connue
$\Delta H_f^\circ(A)$ = connue
$\Delta H_f^\circ(D)$ = //
$\Delta H_f(B)$ = //

$\Delta H_f(O_2)^\circ = 0$
$\Delta H(H_2)^\circ = 0$
$\Delta H(Ne) = 0$

مركب نفسه الذرة
داتما Zero 0
Les corps simple.

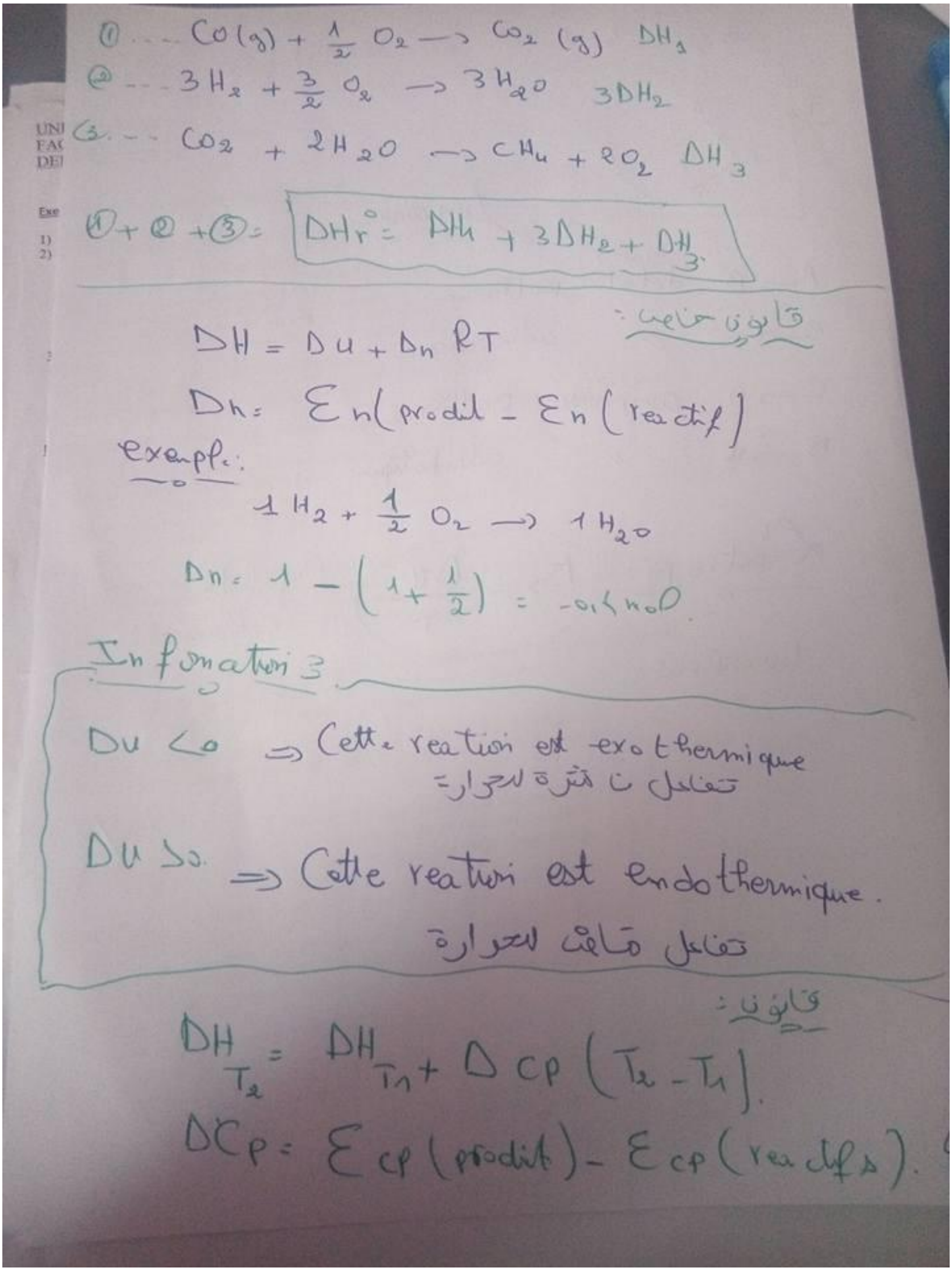
2/ أحيانا تا يعطيو معادلات ومنهم نخرج ΔH_r°

$$1CO_2(g) + 3H_{2(g)} \xrightarrow{\Delta H_r^\circ} CH_{4(g)} + H_2O(g)$$ exemple

$$1\,CO_{(g)} + \frac{1}{2}O_2(g) \longrightarrow CO_2(g)$$

$$3\,H_2 + \frac{1}{2}O_2(g) \longrightarrow H_2O(g)$$

$$\times -1\,(CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_2(g) + 2H_2O(g)) \longrightarrow$$ كنلاحظ نواتج



① ... $CO(g) + \frac{1}{2} O_2 \rightarrow CO_2(g)$ ΔH_1

② ... $3H_2 + \frac{3}{2} O_2 \rightarrow 3H_2O$ $3\Delta H_2$

③ ... $CO_2 + 2H_2O \rightarrow CH_4 + 2O_2$ ΔH_3

① + ② + ③ = $\boxed{\Delta H_r^\circ = \Delta H_1 + 3\Delta H_2 + \Delta H_3}$

قانون هام :

$$\Delta H = \Delta U + \Delta n RT$$

$\Delta n = \Sigma n($prodit $- \Sigma n($reactif$)$

exemple :

$$1 H_2 + \frac{1}{2} O_2 \rightarrow 1 H_2O$$

$$\Delta n = 1 - \left(1 + \frac{1}{2}\right) = -0{,}5 \text{ mol}.$$

Information :

$\Delta U < 0$ ⇒ Cette reation est exothermique

تفاعل ناشر للحرارة :

$\Delta U > 0$ ⇒ Cette reation est endothermique.

تفاعل ماص للحرارة

قانون :

$$\Delta H_{T_2} = \Delta H_{T_1} + \Delta Cp \left(T_2 - T_1\right).$$

$\Delta Cp = \Sigma cp($prodit$) - \Sigma cp($reactifs$)$.

le Cycle de Carnot

toujours:

A → B détente isotherme (تمدد)

B → C " adiabatique

C → D compression isotherme (تقلص)

D → A " adiabatique

L'entropie : $\boxed{\Delta s = \frac{\Delta Q}{T}}$ l'égalité Clausius

$\Delta u = Q + w$.