Entalpia

$H = U + PV$

funzione di stato

gas ideale $PV = nRT$

es: GAS IDEALE

k!

$U = f(T)$; $PV = nRT \rightarrow PV = g(T) \Rightarrow H = f(T)$

↳ diff $dH = dU + d(PV) = nC_v dT + nR dT = nC_p dT$

GAS PERFETTO $nC_v dT$

$d(nRT)$

$C_p = C_v + R$ (Mayer)

$$\Delta H = n\int_{T_a}^{T_b} C_p dT \qquad Q = \Delta H$$

EQUAZIONI TDS

- consideriamo una trasformazione internamente reversibile in un sistema comprimibile

non sono funzioni di stato

$$(\delta Q)_{int,rev} = dU - (\delta W)_{int,rev}$$

$(\delta Q)_{int,rev} = TdS$ $\qquad$ $(\delta W)_{int,rev} = -PdV$

Q ↓ $\boxed{+}$ ← W

calore e lavoro entranti = positivi

$\boxed{TdS = dU + PdV}$ → I eq del TdS

- $H := U + PV$ $\qquad dH = dU + d(PV) = \underbrace{dU + dPV}\; + \underbrace{PdV}$

→ $dU + PdV = dH - dPV$

$\boxed{TdS = dH - dPV}$ → II eq del TdS

ΔS per un GAS IDEALE

$dU = C_v dT$
$dH = C_p dT$
$PV = nRT$
→ GAS IDEALE

I eq TdS : $TdS = dU + PdV$ generica

$TdS = C_v dT + PdV$ $\qquad \frac{R}{V}$

$dS = C_v \frac{dT}{T} + \left(\frac{P}{T}\right) dV \longrightarrow dS = C_v \frac{dT}{T} + \frac{R}{V} dV$

$1 \rightarrow 2$

$$\boxed{S(T_2, V_2) - S(T_1, V_1) = \int_{T_1}^{T_2} C_v(T)\frac{dT}{T} + R \ln \frac{V_2}{V_1}}$$

GAS IDEALE

II eq TdS:

$$TdS = dH - VdP$$

$$dS = c_p \frac{dT}{T} - \frac{V}{T} dP \qquad PV = nRT$$

$$dS = c_p \frac{dT}{T} - \frac{R}{P} dP$$

$$\boxed{S(T_2, P_2) - S(T_1, P_1) = \int_{T_1}^{T_2} c_p(T) \frac{dT}{T} - R \ln \frac{P_2}{P_1}}$$

GAS IDEALE

Cv, Cp costanti

$$\left.\begin{aligned} S_2(T_2, V_2) - S_1(T_1, V_1) &= c_v \ln T_2/T_1 - R \ln \frac{V_2}{V_1} \\ S_2(T_2, P_2) - S_1(T_1, P_1) &= c_p \ln T_2/T_1 - R \ln P_2/P_1 \end{aligned}\right\} \left[\frac{J}{mol K}\right] \text{ x G.P.}$$

$$\Delta S = c_v \ln \frac{T_2 V_2^{(\gamma-1)}}{T_1 V_1^{(\gamma-1)}} \qquad \gamma = \frac{c_p}{c_v} \qquad \Delta S = c_p \ln \frac{T_2 P_2^{(\gamma-1)}}{T_1 P_1^{(\gamma-1)}} \longrightarrow \Delta S = c_v \ln \frac{P_2 V_2^\gamma}{P_1 V_1^\gamma}$$

TRASFORMAZIONE ISOENTROPICA $S_2 = S_1 \Rightarrow$ ADIABATICA REVERSIBILE

$$0 = c_v \ln \frac{P_2 V_2^\gamma}{P_1 V_1^\gamma} \Rightarrow P_2 V_2^\gamma = P_1 V_1^\gamma \qquad PV^\gamma = \text{cost}$$

POLITROPICA CON INDICE $\gamma = c_p/c_v = n$

adiabatica reversibile

ΔS FLUIDO INCOMPRIMIBILE ρ = costante $c_v = c(T)$

densità $[kg/m^3]$

$$dS = c(T)\frac{dT}{T} + \frac{P\,dV}{T} \qquad P\,dV = 0 \text{ (incomprimibile)}$$

$$\longrightarrow dS = c(T)\frac{dT}{T}$$

es GAS IDEALE

$$PV = \frac{R}{mm} T$$

$P \to [Pa]$ $V \to [m^3/kg]$

massa molare $\frac{kg}{kmol}$

$\frac{R}{mm} \to R^*$ J/kgK

$T \to K$