HESS LAW

H IS A STATE FUNCTION $\Rightarrow$ ΔH IS PATH INDEPENDENT

(1) $C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ $\quad \Delta H^\circ_{I}$

(2) $C(s) + O_2(g) \longrightarrow CO_2(g)$ $\quad \Delta H^\circ_{II}$

(3) $H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(l)$ $\quad \Delta H^\circ_{III}$

2 [(2)]	$2\Delta H^\circ_{II}$
− (1)	$-\Delta H^\circ_{I}$
3 [(3)]	$3\Delta H^\circ_{III}$

$2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$ $\quad \Delta H^\circ_f[C_2H_6(g)]$

$= 2\Delta H^\circ_{I} - \Delta H^\circ_{I}$
$+ 3\Delta H^\circ_{III}$

ΔH°_{rxn} INTERPRETATION $(T = 25°C)$

$$\Delta H^{\circ}_{rxn} = \sum_{\nu_p} \Delta H^{\circ}_f[P] - \sum_{\nu_R} \Delta H^{\circ}_f[R]$$

UNITS ?

ΔH°_{rxn} BALANCE BETWEEN BOND BREAKING AND BOND FORMING.

FOR ANY OTHER TEMP.

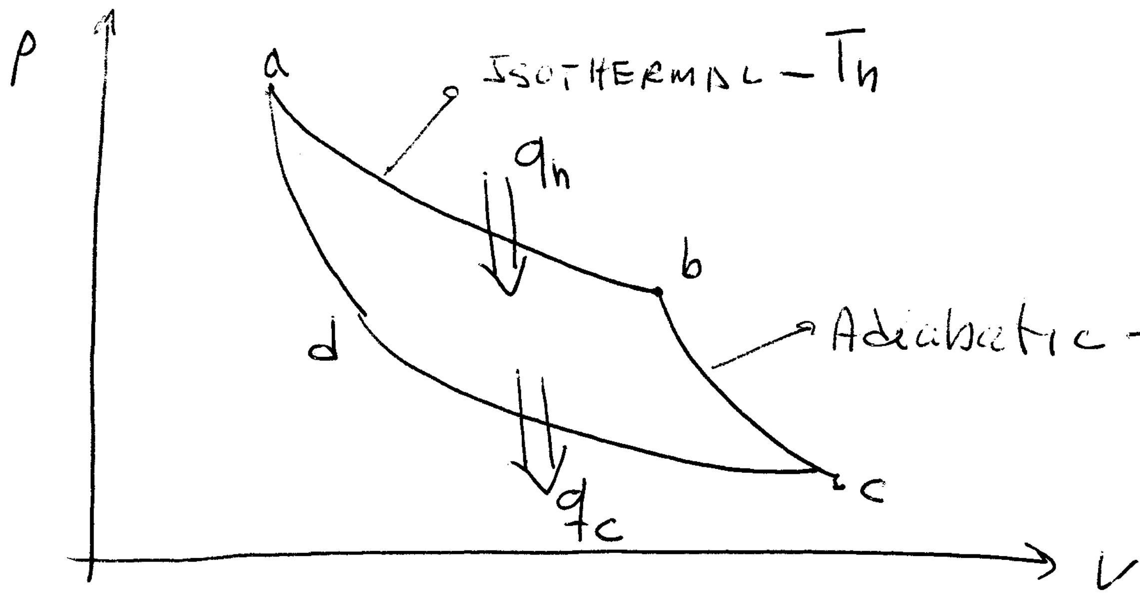
$$\begin{array}{ccc} \text{RXN} & & T \\ \big\downarrow & & \\ \text{RXN} & & T = 25°C \end{array}$$

$$
\begin{tikzcd}
\text{REACTANTS} \arrow[r] \arrow[d, "C_p(R"'] & \text{PRODUCTS} & T \\
\text{REACTANTS} \arrow[r] & \text{PRODUCTS} \arrow[u, "C_p(P)"'] & 25^\circ C
\end{tikzcd}
$$

$$\Delta H^\circ_{T\,rxn} = \Delta H^\circ_{rxn} + \int_{298.15K}^{T} \Delta C_p(T')\,dT'$$

$$\Delta C_p(T') \equiv \sum_{\nu_p} \nu_p\, C_p(\text{Prod}) - \sum_{\nu_R} \nu_r\, C_p(\text{Reac})$$

5.1–5.4 Carnot Cycle



Calculate q, w, and U FOR AN IDEAL GAS

$\boxed{a \rightarrow b \text{ ISOTHERMAL}}$

$P_a V_a T_h \longrightarrow P_b V_b T_h$

$$\Delta U_{ab} = n\bar{C}_V \Delta T = 0 = q_{ab} + w_{ab}$$

ISOTHERMAL WORK $\quad w_{ab} = -nRT_h \ln \frac{V_b}{V_a} < 0$

$$q_{ab} = w_{ab} = nRT_h \ln\left(\frac{V_b}{V_a}\right)$$

$b \to c$ Adiabatic $\Rightarrow q_{bc} = 0$

$$\Delta U_{bc} = + w_{bc}$$

$$\Delta U_{bc} = n\bar{C}_v (T_c - T_h) \quad < 0$$

$c \to d$ ISOTHERMAL $\quad \Delta U_{cd} = 0 = q_{cd} + w_{cd}$

$$w_{cd} = -nRT_c \ln\left(\frac{V_d}{V_c}\right) \quad > 0$$

$$q_{cd} = nRT_c \ln\left(\frac{V_d}{V_c}\right)$$

$d \to a$ Adiabatic $\quad q_{da} = 0$

$$\Delta U_{da} = +w_{da} + q_{da} = + w_{da}$$

$$\Delta U_{da} = n\bar{C}_v (T_h - T_c) > 0$$

$$\Delta U_{cc} = n\bar{C}_v (T_c - T_h) + n\bar{C}_v (T_h - T_c) = 0$$

$$q_{ab} = nRT_h \ln\left(\frac{V_b}{V_a}\right) \quad > 0$$

$$q_{cd} = nRT_c \ln\left(\frac{V_d}{V_c}\right) \quad < 0$$

EFFICIENCY

$$\varepsilon = \frac{|W_{cycle}|}{q_h} = \frac{|q_{ab} + q_{cd}|}{q_h} = \frac{q_h - q_c}{q_h}$$

$$\varepsilon =$$

$$W_{cc} = -nRT_h \ln\left(\frac{V_b}{V_a}\right) + \cancel{n\bar{C}_v (T_c - T_h)}$$
$$- nRT_c \ln\left(\frac{V_d}{V_c}\right) + \cancel{n\bar{C}_v (T_h - T_c)}$$

$$\varepsilon = \frac{\left| nRT_h \ln\left(\frac{V_a}{V_b}\right) \; nRT_c \ln\left(\frac{V_d}{V_e}\right) \right|}{nRT_h \ln\left(V_b/V_a\right)}$$

$$\frac{V_d}{V_c} = ?$$

Adiabat

$$V_b T_h P_b \longrightarrow V_c T_c P_c$$

$$T_h V_b^{\gamma-1} = T_c V_c^{\gamma-1}$$

$$V_a T_h P_a \longrightarrow V_d T_c P_d$$

$$T_h V_a^{\gamma-1} = T_c V_d^{\gamma-1}$$

$$V_d = \left(\frac{T_h}{T_c}\right)^{\frac{1}{\gamma-1}} V_a$$

$$V_c = \left(\frac{T_h}{T_c}\right)^{1/\gamma-1} V_b$$

$$\frac{V_d}{V_c} = \frac{V_a}{V_b}$$

$$e = \frac{T_h - T_c}{T_h} = 1 - \frac{T_c}{T_h}$$

$$\varepsilon = \frac{T_h - T_c}{T_h} = \frac{q_h + q_c}{q_h}$$

$$\Rightarrow \quad 1 - \frac{T_c}{T_h} = 1 + \frac{q_c}{q_h}$$

$$-\frac{T_c}{T_h} = \frac{q_c}{q_h}$$

$$-\frac{q_h}{T_h} = \frac{q_c}{T_c}$$

$$\frac{q_h}{T_h} + \frac{q_c}{T_c} = 0 \quad !$$