

## LATENT HEAT

PUT heat into system — T constant

PHASE TRANSITIONS

$$C = \frac{Q}{\Delta T} = \frac{Q}{0} = \infty$$

HEAT required to MELT } system.  
BOIL }

$$L = \frac{Q}{m} \quad \text{mass}$$

AMBIGUOUS → IGNORES work done during process

↳ ASSUME  $P = 1 \text{ atm}$

MELTING ICE → 333 J/g

BOILING WATER → 2260 J/g = 540 cal/g

RAISING WATER is 100 cal/g  
 $0^\circ\text{C} \rightarrow 100^\circ\text{C}$

# ENTHALPY

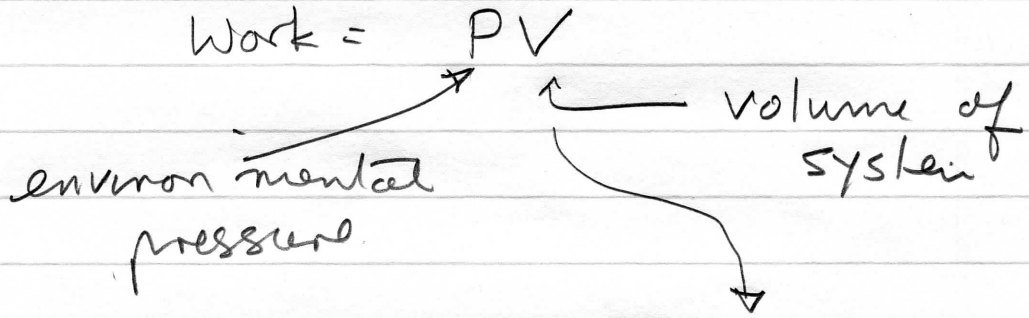
constant pressure processes → common

Can define formalism to avoid

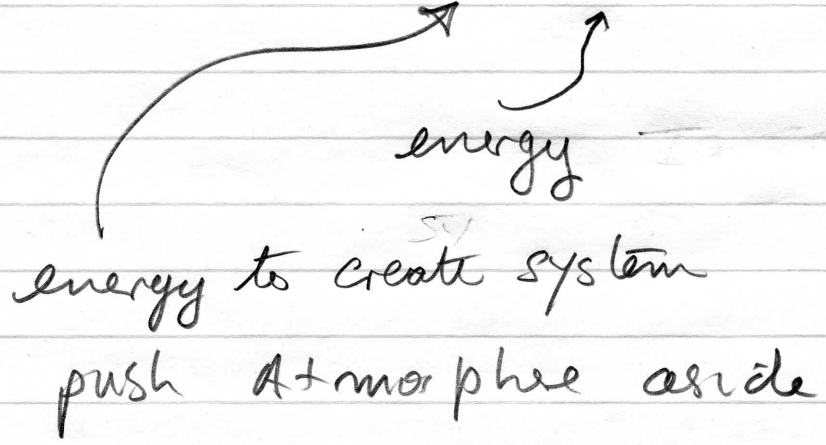
Keeping track of compression } WORK  
EXPANSION }

TAKE account of work to

CREATE SYSTEM  
(MAKE ROOM FOR IT)  
AT 1 ATMOS



ENTHALPY →  $H = U + PV$



If annihilate system

↳ Extract Energy  $u$

+

$PV$

work done as atmosphere  
collapses into space occupied  
by system.

⇒ Some change in SYSTEM, eg <sup>HEAT</sup> added

$$H + \Delta H = (u + \Delta u) + P(V + \Delta V)$$

$$= (u + PV) + (\Delta u + P\Delta V)$$

$$= H + (\Delta u + P\Delta V)$$

CHANGE in enthalpy — constant pressure

$$\Delta H = \Delta u + P\Delta V$$

$$\Delta H = \Delta U + P\Delta V$$

$\Delta$  enthalpy can come from.

$$\Delta U \text{ or } P\Delta V$$

1ST LAW  $\Delta U = Q - P\Delta V + W_{OTHER}$

$$\underbrace{\Delta U + P\Delta V}_{\Delta H} = \underset{\substack{\uparrow \\ \text{heat}}}{Q} + W_{OTHER}$$

Enthalpy only change FROM

Heat or other WORK  
during constant pressure process

→ NOT by compression / Expansion

can forget if use ENTHALPY  
→ NOT ENERGY

IF  $W_{OTHER} = 0$

ENTHALPY → how much heat added to SYSTEM

In simple case of INCREASING BODY'S TEMPERATURE

$$C_p = \left( \frac{\partial H}{\partial T} \right)_p$$

this is just the same as.

$$C_p = \left( \frac{\partial u}{\partial T} \right)_p + p \left( \frac{\partial v}{\partial T} \right)_p$$

→ DOESN'T necessarily involve HEAT TRANSFER

eg ENTHALPY increase in micro wave oven.

$\Delta H$  when Boil on mole of  $H_2O$  at 1 atmos

$$= 40,660 \text{ J}$$

one mole of water  $\approx 18 \text{ gms}$   $\left( \begin{matrix} 160 \\ 2H \end{matrix} \right)$

$$\Delta H \text{ when Boil } 1 \text{ gm. of water} = \frac{40,660 \text{ J}}{18}$$

$$= 2260 \text{ J}$$

Some number as LATENT HEAT.

— NOT ALL of 2260 J ends up in VAPORIZED water

Volume of one mole of water VAPOR

$$PV = NkT = RT$$

$\uparrow$   
in one mole

$\uparrow$   
gas constant.

$$= (8.31 \text{ J/K}) \times 373 \text{ K} = 3100 \text{ J}$$

this is only 8% of 40,660 J

It is work needed to push atmosphere away.



for each mole of water  $\rightarrow$  produce

$$\Delta H = -286 \text{ J}$$

$\uparrow$   
Enthalpy of formation

Burn a mole of Hydrogen

$\hookrightarrow$  get 286 J of heat

$\hookrightarrow$  work done by chemical thermal energy

+

work done by collapsing atmosphere into space left by reacting gases.

Go BACK TO SPECIFIC HEATS

$$C_v = \left( \frac{\partial u}{\partial \theta} \right)_v$$

IDEAL GAS SCALE  
OF TEMP

$$\theta = \frac{p}{kn}$$

$$\sqrt{\frac{N_A}{V_m}} \text{ mole}$$

$V$  constant  $dv = 0$

so in  $du = \Delta Q - p dv$

$$C_v \equiv \left( \frac{\partial Q}{\partial \theta} \right)_v = \left( \frac{\partial u}{\partial \theta} \right)_v$$

$p$  constant  $dp = 0$  in

$$dH = \Delta Q + v dp$$

$$\Delta Q = dH$$

$$C_p = \frac{dQ}{d\theta} = \left( \frac{\partial H}{\partial \theta} \right)_p$$



(9)

ideal gas -  $u$  at given temp is  
independent of  $V$

and BOYLE'S LAW  $P \propto \frac{1}{V}$  Temp.

Calc  $C_p - C_v$  for ideal gas  
↑  
K molar

$$du = \left(\frac{\partial u}{\partial \theta}\right)_v d\theta + \left(\frac{\partial u}{\partial v}\right)_\theta dv$$

$$\text{so } \left(\frac{\partial u}{\partial \theta}\right)_p = \left(\frac{\partial u}{\partial \theta}\right)_v + \left(\frac{\partial u}{\partial v}\right)_\theta \left(\frac{\partial v}{\partial \theta}\right)_p$$

for ideal gas  $u$  indep of  $V$  at  $\theta$

$$\left(\frac{\partial u}{\partial v}\right)_\theta = 0$$

$$\text{so } \left(\frac{\partial u}{\partial \theta}\right)_p = \left(\frac{\partial u}{\partial \theta}\right)_v = C_v$$

ENTHALPY  $H = U + p dV$

$$C_p = \left( \frac{\partial H}{\partial \theta} \right)_p = \left( \frac{\partial U}{\partial \theta} \right)_p + p \left( \frac{\partial V}{\partial \theta} \right)_p$$

$$= C_v + p \left( \frac{\partial V}{\partial \theta} \right)_p$$

Since  $p = n k \theta$ , for one kmole

$$\left( \frac{\partial V}{\partial \theta} \right)_p = \frac{R}{p}$$

$$\left. \begin{aligned} V = V_m &= \frac{N_A}{n} \\ &= R \theta \\ &= N_A k \end{aligned} \right\}$$

$$C_p - C_v = R$$