# LATENT HEAT

PUT heat into system — T constant

PHASE TRANSITIONS

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

HEAT required to MELT / BOIL } SYSTEM

$$L = \frac{Q}{m}$$

m ← mass

AMBIGUOUS → IGNORES work done during process

→ ASSUME P = 1 atmos

MELTING ICE → 333 J/g

BOILING WATER → 2260 J/g = 540 cal/g

RAISING WATER 0°C → 100°C is 100 CAL/g

## ENTHALPY

Constant pressure processes → common

Can define formalism to avoid

Keeping track of compression / expansion } WORK

TAKE account of work to

CREATE SYSTEM
(MAKE ROOM FOR IT)
AT 1 ATMOS

Work = PV

environmental pressure

volume of system

ENTHALPY → $H = U + PV$

energy

energy to create system

push Atmosphere aside

If annihilate system

↳ Extract Energy $U$

$+$

$PV$

work done as atmosphere collapses into space occupied by system

⇒ Some change in SYSTEM, eg HEAT 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

$\Delta U$ or/and $\Delta V$

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

$$\underbrace{\Delta U + PV}_{\Delta H} = Q + W_{OTHER}$$

$Q$ ↑ heat

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 microwave oven.

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

$$= 40,66 J$$

one mole of water $\approx$ 18gms $\begin{pmatrix} 16 O \\ 2H \end{pmatrix}$

$\Delta H$ when BOIL 1gm. of water $= \dfrac{40,660J}{18}$

$$= 2260J$$

Same number as LATENT HEAT

— NOT ALL of 2260J ends up in VAPORIZED water

Volume of one mole of water VAPOR

$$PV = NkT = RT$$

in one mole    gas constant

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

this is only 8% of 40,660J

It is work needed to push atmosphere away.

Another Example $H_2 + \frac{1}{2} O_2 \longrightarrow H_2O$

for each mole of water $\longrightarrow$ produce

$\Delta H = -286$ J

Enthalpy of formation

Burn a mole of Hydrogen

↳ get 286 J of heat

↳ work done by chemical thermal energy

+

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

GO BACK TO SPECIFIC HEATS

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

IDEAL GAS SCALE OF TEMP

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

$$n = \frac{N_A}{V_m}$$

mole

V constant $dV = 0$

so in $du = \Delta Q - p\,dV$

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

p constant $dp = 0$ in

$$dH = \Delta Q + V\,dp$$

$$\Delta Q = dH$$

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

ideal gas — $U$ at given temp is independent of $V$

and BOYLE'S LAW $p \propto n$ Tconst

Calc $C_p - C_v$ for ideal gas

↑ Kmolar

$$dU = \left(\frac{\partial U}{\partial \theta}\right)_V d\theta + \left(\frac{\partial U}{\partial V}\right)_\theta dV$$

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 $\theta$

$$\left(\frac{\partial U}{\partial V}\right)_\theta = 0$$

so $$\left(\frac{\partial U}{\partial \theta}\right)_p = \left(\frac{\partial U}{\partial \theta}\right)_V = C_V$$

ENTHALPY $H = \mathcal{U} + p\,dV$

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

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

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

$$\left(\frac{\partial V}{\partial \theta}\right)_p = \frac{R}{p} \qquad \left\{ \begin{aligned} V = V_m &= \frac{N_A}{n} \\ &= R\,\theta \\ &= N_A k \end{aligned} \right.$$

$$C_p - C_v = R$$