

STATE FUNCTION

Properties which depend only on initial and final state of system & do not depend on process or path
e.g. U, H, S etc.

PATH FUNCTION

Depends on path or process, as well as initial and final state of the system
e.g. work, heat

THERMODYNAMIC PROPERTIES

EXTENSIVE

Properties which are dependent of matter (size & mass) present in system
e.g. Mass, volume, Internal energy, heat capacity, Entropy, Enthalpy etc.

INTENSIVE

Properties which are independent of matter (size & mass) present in system
e.g. Pressure, temperature, Melting point, density, Specific heat, Surface tension etc.

WORK

$\Delta W = P \Delta V = \Delta nRT$
 $\Delta W = \text{Joule}$
 $P \rightarrow \text{Pascal}$
 $V \rightarrow \text{m}^3$
 $1 \text{ atm} = 1.01 \times 10^5 \text{ Pa}$
 $1 \text{ L atm} = 101 \text{ J}$
 $\text{dm}^3 \text{ or L}$
 10^{-3} m^3
 10^{-6} m^3

FIRST LAW OF THERMODYNAMICS

(Based on Law of conservation of energy)

$\Delta U = \Delta q + \Delta W$

SIGN CONVENTION

W(Compression)

(+)ve

q(Heating)

system

W(Expansion)

(-)ve

q(Cooling)

FLOT

Adiabatic process
Insulated, Rapid process
 $\Delta Q = 0$
 $\Delta U = \Delta W$

Isothermal process
 $\Delta T = 0, \Delta U = 0$
 $\Delta Q + \Delta W = 0$
 $\Delta Q = -\Delta W$

Isochoric process
 $\Delta V = 0$
 $\Delta W = 0$
 $\Delta U = \Delta Q = nC_v \Delta T$

Isobaric process
 $\Delta W = P \Delta V$
 $\Delta U = \Delta Q + \Delta W$

FREE EXPANSION

$P_{\text{ext}} = 0, W = 0, \Delta U = 0, q = 0$

ISOTHERMAL

$dT = 0; \Delta U = 0; q = -W$

Reversible Isothermal

$W_{\text{rev}} = nRT \ln \left(\frac{V_2}{V_1} \right)$

Irreversible Isothermal

$W_{\text{irr}} = -P_{\text{ext}} \left[\frac{nRT}{P_1} - \frac{nRT}{P_2} \right]$

Isobaric

P

Isothermal

P

Isochoric

P

Adiabatic

P

Spontaneity

ENTHALPY

$\Delta H = \Delta U + \Delta n_g RT$
 $\Delta n_g = 0, \Delta H = \Delta U$
 $\Delta n_g > 0, \Delta H > \Delta U$
 $\Delta n_g < 0, \Delta H < \Delta U$
All exothermic process are spontaneous

ENTROPY

$S_{\text{gas}} > S_{\text{liquid}} > S_{\text{solid}}$

ENTROPY CHANGE

1) Isothermal
 $\Delta S = nR \ln \frac{V_2}{V_1} = nR \ln \frac{P_1}{P_2}$

2) Isochoric ($P \propto T$)
 $\Delta S = nC_v \ln \frac{T_2}{T_1} = nC_v \ln \frac{P_2}{P_1}$

3) Isobaric
 $\Delta S = nC_p \ln \frac{T_2}{T_1} = nC_p \ln \frac{V_2}{V_1}$

$\Delta S_{\text{total}} > 0$, Spontaneous
 $\Delta S_{\text{total}} = 0$, Equilibrium
 $\Delta S_{\text{total}} < 0$, Non-spontaneous

GIBBS FREE ENERGY

$\Delta G = \Delta H - T \Delta S$
 $\Delta G < 0$ Or (-)ve, Spontaneous
 $\Delta G > 0$ Or (+)ve, Non-spontaneous
 $\Delta G = 0$, Equilibrium

Equilibrium Temperature

$T_e = \frac{\Delta H}{\Delta S}$

ΔH	ΔS	$\Delta G = \Delta H - T \Delta S$	Spontaneity.
(-)	(+)	Always Negative	Spontaneous at all temp
(+)	(-)	Always Positive	Non-spontaneous at all temperature.
(+)	(+)	+ve @ low temp. -ve @ high temp.	Non spontaneous at low temperature Spontaneous at high temperature
(-)	(-)	-ve @ low temp. +ve @ high temp.	Spontaneous at low temperature, $T < T_e$ Non spontaneous at high temperature

THERMODYNAMICS

THERMOCHEMISTRY

1) Heat of Reaction (ΔH_{rxn})
 $\Delta H_{\text{rxn}} = \Delta H_{\text{products}} - \Delta H_{\text{reactants}}$

2) Heat of Formation
Heat Change in formation of 1 mole of substance at 298 K and 1 atm Pressure (standard enthalpy of formation)
 $\frac{1}{2} \text{N}_2 + \frac{3}{2} \text{H}_2 \rightleftharpoons \text{NH}_3$
 $A + B \rightleftharpoons C + D$
 $\Delta H_{\text{reaction}} = \text{Heat of formation of products} - \text{Heat of formation of reactants}$
 $= (c + d) - (a + b)$
Standard enthalpy of formation (298 K, 1 atm) of element at its standard state is zero e.g.,
 $\text{O}_2(\text{g}) = 0$ $\text{Cl}_2(\text{g}) = 0$ $\text{Br}(\text{g}) \neq 0$ $\text{Br}_2(\text{l}) = 0$

3) Enthalpy of Combustion (1 mole, 298 K)
(standard enthalpy of combustion)
 $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}; \Delta H_{\text{combustion}}$
 $A + B \rightarrow C + D$
Enthalpy of combustion:
 $\Delta H_{\text{react}} = \text{Heat of combustion of reactants} - \text{Heat of combustion of products}$
 $= (a + b) - (c + d)$

4) Heat of Neutralisation ($\Delta H = (-)\text{ve}$)
 $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}; \Delta H_{\text{neutralisation}}$
 $S.A + S.B \rightarrow \Delta H = -13.7 \text{ k Cal} = -57 \text{ kJ}$
 $S.A + S.B > (S.A / S.B + W.A / W.B) > W.A + W.B$ (Order of ΔH neutralisation)

PHYSICS WALLAH

BOND ENERGY

$A + B \rightarrow C + D$
Bond energy: a b c d
 $\Delta H_{\text{reaction}} = \text{Bond energy of reactants} - \text{Bond energy of products}$
 $= (a + b) - (c + d)$
 $\text{NH}_3 \Rightarrow \text{B.E} = x$
 $\text{B.E of N-H} = \frac{x}{3}$
 $\text{CH}_4 \Rightarrow \text{B.E} = x$
 $\text{B.E of C-H} = \frac{x}{4}$

$A \rightarrow B; \Delta H_1$

$B \rightarrow C; \Delta H_2$

$A \rightarrow C; \Delta H_3 = \Delta H_1 + \Delta H_2$

$A \rightarrow B; \Delta H = x$

$B \rightarrow A; \Delta H = -x$

$A \rightarrow B; \Delta H = x$

$nA \rightarrow nB; \Delta H = nx$

HESS' LAW OF CONSTANT HEAT SUMMATION

A

ΔH_1

B

ΔH

D

ΔH_2

C

ΔH_3

$\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$