

& do not depend on process or pa e.a. U. H . S etc.

e.g. work, heat

### **THERMODYNAMIC PROPERTIES**

# **EXTENSIVE**

INTENSIVE

Properties which are dependent of matter (size & mass)present

e.g. Mass, volume, Internal energy heat capacity, Entropy, Enthalpy

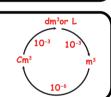
of matter(size & mass) present in

e.g. Pressure, temperature, Melting point, density, Specific heat Surface tension etc

WORK

 $\triangle W = P \triangle V = \triangle nRT$ △W =Joule <

P → Pascal 1 atm = 1.01 × 10<sup>5</sup> Pa 1 L atm = 101 J

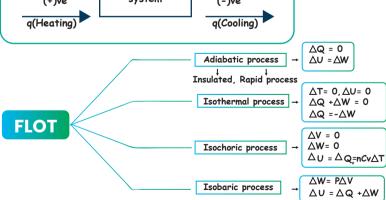


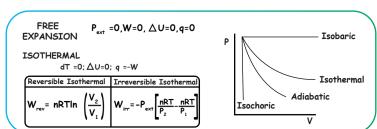
# **FIRST LAW OF THERMODYNAMICS**

(Based on Law of conservation of energy)  $\triangle U = \triangle q + \triangle W$ 

# SIGN CONVENTION







### Spontaneity

### **ENTHALPY**

 $\triangle H = \triangle U + \triangle n_a RT$ 

 $\Delta n_a = 0, \Delta H = \Delta U$ 

 $\Delta n_a > 0, \Delta H > \Delta U$  $\Delta n < 0, \Delta H < \Delta U$ 

All exothermic process are spontaneous

### **ENTROPY**



S<sub>gas</sub> > S<sub>liquid</sub> > S<sub>solid</sub>

ODYNAMIC

ERM

ENTROPY CHANGE

1) Isothermal

 $\triangle S = nR \ln \frac{V_2}{V} = nR \ln \frac{P_1}{P}$ 

2) Isochoric (PaT)

 $\Delta S = nC_v \ln \frac{T_2}{T} = nC_v \ln \frac{P_2}{P}$ 

 $\Delta S_{\text{total}} > 0$ , Spontaneous

 $\Delta S_{total} = 0$ , Equilibrium

 $\Delta S_{ ext{total}}$  < 0, Non-spontaneous

#### **GIBBS FREE ENERGY**

 $\triangle G = \triangle H - T \triangle S$ 

 $\Delta G$  < 0 Or (-)ve, Spontaneous

 $\Delta G > 0$  Or (+)ve, Non-spontaneous

 $\Delta G = 0$  , Equilibrium

#### <mark>Equilibrium Temperature</mark>

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

# **Chemical Thermodynamics** and Energetics

### 1) Heat of Reaction ( $\triangle H_{max}$ )

 $\Delta H_{ryn} = \Delta H_{products} - \Delta H_{reactants}$ 

### 2) Heat of Formation

Heat Change in formation of 1 mole of substance at 298 K and 1 atm Pressure

$$\frac{1}{2} N_2 + \frac{3}{2} H_2 \rightleftharpoons NH_3$$

$$A + B \rightleftharpoons C + C$$

 $\Delta H_{matter}$  = Heat of formation of products - Heat of formation of reactants

Standard enthalpy of formation (298 K, 1 atm) of element at it's standard state is zero e.a.  $O_2(g) = 0$   $Cl_2(g) = 0$   $Br(g) \neq 0$   $Br_2(l) = 0$ 

### 3) Enthalpy of Combustion (1 mole, 298 K)

 $A + B \rightarrow C + D$ 

Enthalpy of a b c d

CH<sub>4</sub> + 2O<sub>2</sub>→CO<sub>2</sub> + 2H<sub>2</sub>O; △H<sub>combustion</sub>

 $\Delta H_{\text{reaction}}$  = Heat of combustion of reactants - Heat of combustion of products = (a + b) - (c + d)

### 4) Heat of Neutralisation ( $\triangle H = (-)ve$ )

HCI + NaOH → NaCI + H2O ; A H\_neutralization

S.A + S.B $\rightarrow$   $\triangle$  H = -13.7 k Cal = - 57 kJ

S.A + S.B > (S.A/S.B + W.A/W.B) -> W.A+W.B (Order of  $\triangle H$  neutralisation)

# **PHYSICS** WALLAH

# **BOND ENERGY**

 $A + B \rightarrow C + D$ 

 $\Delta H_{reaction}$  = Bond energy of reactants - Bond energy of products = (a + b) - (c + d)

 $NH_3 \Rightarrow B.E = x$ B.E of N-H =  $\frac{x}{3}$ 

Bond energy: a b

 $CH_A \Rightarrow B.E = x$ B.E of C-H = x

 $A \rightarrow B ; \triangle H$ 

 $B \rightarrow C : \triangle H_2$ 

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

 $A \rightarrow B : \triangle H = x$ 

 $B \rightarrow A : \land H = -x$ 

 $A \rightarrow B : \triangle H = x$ 

 $nA \rightarrow nB : \triangle H = nx$ 

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

# **HESS' LAW OF CONSTANT HEAT SUMMATION**

