CLASS : CC -AD

Revision Work-sheet Thermochemistry

Single correct

Q.1 Calculate resonance energy of $CO_{2(g)}$ from the following data.

$\Delta H_{combustion}$ of CO = –280 kJ / mole $\quad$ ΔH_f CO = –120 kJ/mol

$\Delta H_{atomisation}$ of $C_{(graphite)}$ = 720 kJ / mole $\quad$ ΔH_{BE} O = O = 500 kJ mol^{-1}

ΔH_{BE} C = O = 710 kJ /mol

(A) 200 kJ (B) 220 kJ (C) 140 kJ (D) 100 kJ

Q.2 The enthalpy of solution, of sodium and sodium oxide in large volume of water, are **–184** and **–238 kJ/mol,** respectively. If the enthalpy of formation of water is **–286 kJ/mol**, then what is the enthalpy of formation of sodium oxide? All the enthalpies are at 298 K and 1 bar pressure.

[Given : Reactions involved are

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

$$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$$ **]**

(A) +54 kJ /mol (B) –130 kJ/mol (C) –416 kJ /mol (D) +156 kJ/mol

Q.3 Calculate the amount of heat released at constant pressure when 10 moles of carbon react with 6 moles of O_2 leaving none of the reactants.

$$\Delta H_{combustion}\ C_{(graphite)} = -\ 390\ \text{kJ/mole},\ \Delta H_{Combustion}\ CO_{(g)} = -\ 250\ \text{kJ/mole}$$

(A) 1900 kJ (B) 750 kJ (C) 3900 kJ (D) 2450 kJ

Q.4 Which of the following substances will have positive value of $\Delta H_{formation}$?

(A) $Br_2(l)$ (B) $O_3(g)$ (C) ZnO(s) (D) $H^+(aq)$

Q.5 The bond enthalpies of C – C, C = C and C ≡ C bonds are 348, 610 and 835 kJ/mol, respectively at 298K and 1 bar. The enthalpy of polymerisation per mole of 2-Butyne at 298K and 1 bar, as shown below, is

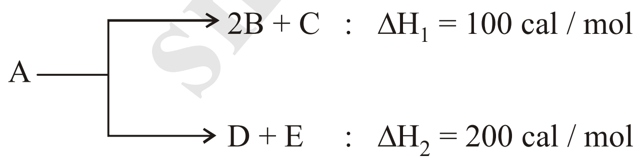
$$n\ CH_3 - C \equiv C - CH_3\ (g) \longrightarrow -(CH_2 - CH = CH - CH_2)_n - (g)$$

(A) – 123 kJ (B) – 132 kJ (C) – 139 kJ (D) – 37 kJ

Q.6 Enthalpy of neutralization of H_3PO_3 acid is –106.68 kJ/mol using NaOH. If enthalpy of neutralization of HCl by NaOH is –55.84 kJ/mol. Calculate $\Delta H_{ionization}$ of H_3PO_3 into its ions

(A) 50.84 kJ/mol (B) 5 kJ/mol (C) 2.5 kJ/mol (D) None

Q.7 For the reaction:



If initially 1 mol of A is taken & finally ratio of B & D is 8 : 1 what is total enthalpy change per mole of A reacted.

(A) $\frac{1000}{9}$ cal (B) 180 cal (C) 1000 cal (D) 120 cal

Q.8 When 100 ml 0.2 M KOH is mixed with 100 ml 0.2 M HCl, temperature of solution increases by $t_1^o C$ while when 300 ml 0.1 M KOH is mixed with 300 ml 0.1 M HCl then increase in temperature is $t_2^o C$ then which one is correct.(Assuming density as well as specific heat of final solutions are same)

(A) $t_1 = t_2$ (B) $t_1 > t_2$ (C) $t_1 < t_2$ (D) Can't be predicted

Q.9 Enthalpy for the reaction $Ag^+_{(aq.)} + Br^-_{(aq.)} \to AgBr_{(s)}$ is – 100 kJ. If magnitude of enthalpy of formation of $Ag^+_{(aq.)}$ and $Br^-_{(aq.)}$ is in the ratio of 5 : 6. While formation of $Ag^+_{(aq.)}$ is an endothermic whereas formation of Br^- is an exothermic process. Enthalpy of formation of AgBr is – 110 kJ/mole then the enthalpy of formation of $Ag^+_{(aq.)}$ in kJ/mol.

(A) 50 kJ (B) + 60 kJ (C) 100 kJ (D) 10 kJ

Q.10 Two solids A and B having molar masses 200 & 300 react to form another solid C as shown.

$$2A_{(s)} + 3B_{(s)} \longrightarrow C_{(s)}$$

If $\Delta H^o_{combustion}$ of A, B and C are –200 , –300 & –400 kJ respectively then maximum heat which can be released at constant pressure if total 2600 gm of A and B is taken is given by

(A) 200 kJ (B) 1800 kJ (C) 900 kJ (D) 450 kJ

Q.11 When 4 gm graphite is burnt in limited supply of oxygen gas at 298 K and 1 bar, 9 Kcal heat is released and no solid residue is left. The gaseous product formed is not absorbed in aqueous KOH solution. When 6 gm graphite is burnt in excess of oxygen gas at 298 K and 1 bar, 48 Kcal heat is released and no solid residue is left. The enthalpy change of the following reaction at 298 K and 1 bar will be

$$2CO_2\,(g) \longrightarrow 2CO\,(g) + O_2\,(g)$$

(A) + 69 Kcal (B) + 39 Kcal (C) +138 Kcal (D) +57 Kcal

Q.12 The standard enthalpy of atomisation of PCl_3(g) is 195 Kcal/mol. What will be the standard enthalpy of atomisation of PCl_5 (g), if the bond dissociation energies of axial P–Cl bonds in PCl_5(g) are 10% lesser and the bond dissociation energies of equatorial P–Cl bonds in PCl_5 (g) are 10% higher than the bond dissociation energies of P–Cl bonds in PCl_3(g).

(A) 195 Kcal / mol (B) 325 Kcal / mol (C) 331.5 Kcal / mol (D) 318.5 Kcal / mol

Q.13 Calculate change in enthalpy when 2 moles of liquid water at 1 bar and 100°C is converted into steam at 2 bar and 300°C. Assume H_2O vapours to behave ideally.

[Latent heat of vaporisation of H_2O (l) at 1 bar and 100°C is 10.8 Kcal per mole]

[R = 2 Cal / mol K]

(A) 21.6 Kcal (B) 11.8 Kcal (C) 24.8 Kcal (D) 23.6 Kcal

Q.14 One mole of magnesium in the vapour state absorbed 1300 kJ of energy. If the first and second ionization energies of Mg are 750 and 1450 kJ mol^{-1} respectively, the final composition of the mixture is

(A) 59% Mg^+ and 41% Mg^{+2} (B) 41% Mg^+ and 59% Mg^{+2}

(C) 62% Mg^+ and 38% Mg^{+2} (D) 38% Mg^+ and 62% Mg^{+2}

Comprehension :

Paragraph for question nos. 15 to 17

It is observed that when acid and bases react, some energy is released due to neutralization reaction. While in case of strong acids and bases, the energy released is greater, in case of weaker acids or bases, energy released will be lesser. The difference is attributed to energy required for ionization. From the above information and data below answer the questions that follow.

$\Delta H_{\text{neutralization SA/SB}} = -57.5$ kJ/equivalent; $\Delta H_{\text{ionization}}$ of $NH_4OH = 10$ kJ/mole;
$\Delta H_{\text{ionization}}$ of $H_2C_2O_4 = 20$ kJ/mole.

Q.15 What will be the energy released when 500 ml of 0.1M H_2SO_4 solution reacts with 1L of 0.1M NH_4OH solution if the base is 30% ionized in the given solution?
(A) 5.75 kJ (B) 4.75 kJ (C) 5.05 kJ (D) 5.45 kJ

Q.16 What will be $\Delta H_{\text{neutralization}}$ of $H_2C_2O_4$ with NaOH per mole of $H_2C_2O_4$ if acid is assumed to be completely unionized in the solution?
(A) 37.5 kJ/mole (B) – 75 kJ/mole (C) – 95 kJ/mole (D) – 37.5 kJ/mole

Q.17 What will be the final temperature attained if all the heat released in neutralization of 1L of 0.2M NH_4OH with 2L of 0.1M HCl increases the temperature of the final solution having density 0.95 gm/ml and specific heat capacity = $\frac{1}{3}$ J/gm°C if original temperature was 27°C. Assume weak base to be completely unionized.
(A) 310°C (B) 300K (C) 310 K (D) 290 K

Assertion Reason

Q.18 **Statement-1** : Assuming ideal gas behaviour of all gases involved, ΔH° for the reaction $H_{2(g)} + \frac{1}{2} O_{2(g)} \longrightarrow H_2O_{(g)}$ will be independent of the temperature at which reaction occurs.

Statement-2 : For an ideal gas, enthalpy of a fixed amount depends only on temperature.
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(C) Statement-1 is true, statement-2 is false.
(D) Statement-1 is false, statement-2 is true.

More than one correct :

Q.19 Which of the following represent(s) $\Delta H^\circ_{\text{atomization}, H_2O(s)}$?

(A) $\Delta H^\circ_{\text{sublimation}, H_2O(s)} + 2\Delta H^\circ_{\text{BE}, O-H}$ (B) $\Delta H^\circ_{\text{fusion}, H_2O(s)} + \Delta H^\circ_{\text{vapourisation}, H_2O(l)}$

(C) $-\Delta H^\circ_{\text{formation}, H_2O(s)} + \Delta H^\circ_{\text{BE}, H-H} + \frac{\Delta H^\circ_{\text{BE}, O=O}}{2}$ (D) $\Delta H^\circ_{\text{fusion}, H_2O(s)} + \Delta H^\circ_{\text{atomization}, H_2O(l)}$

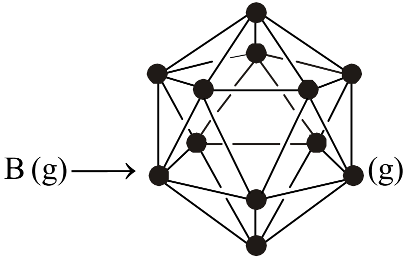
Q.20 In the thermite reaction used for obtaining energy, aluminium and ferric oxide react to form iron and aluminium oxide. From the given data identify the option(s) which is(are) **correct**:

[Given : ΔH°_f $Al_2O_3 = -390$ kJ/mol, ΔH°_f $Fe_2O_3 = -176$ kJ/mol,
Density of aluminium = 2.7 gm/ml, Density of Fe_2O_3 = 3.2 gm/ml]
(A) Maximum calorific value of the fuel can be 1000 J/gm.
(B) Maximum calorific value of the fuel can be $\frac{21.4}{7}$ kJ/ml
(C) 2.14 kg of the mixture can produce 2500 kJ of heat
(D) 140 ml of the mixture can produce 280 kJ of heat

Subjective :

Q.21 Calculate the enthalpy of ionisation of weak acid H_2A ($H_2A \rightarrow 2H^+ + A^{2-}$) in Kcal / mol, if enthalpies of neutralisation of HCl and H_2A by a strong base are 14 Kcal/eq and 11 Kcal/eq respectively.

Q.22 Boron exist in different allotropic forms. All allotropic form contains icosahedral units (icosahedral is a regular shape with 12 corners & 20 faces) with boron atoms at all 12 corners and all bonds are equivalent.



Calculate heat evolved at constant pressure (in kJ) per mole of boron atoms undergoing above change if ΔH_{BE}(B–B) = 200 kJ/mol.

Q.23 The standard molar enthalpies of formation of IF_3 (g) and IF_5 (g) are –470 kJ and – 847 kJ, respectively. Valence shell electron-pair repulsion theory predicts that IF_5 (g) is square pyramidal in shape in which all I–F bonds are equivalent while IF_3 (g) is T-shaped (based on trigonal-bipyramidal geometry) in which I–F bonds are of different lengths. It is observed that the axial I–F bonds in IF_3 are equivalent to the I–F bonds in IF_5. Calculate the equatorial I–F bond strength (in kJ/mol) in IF_3. Some other informations given are:

$I_2 (s) \longrightarrow I_2 (g)$; $\Delta H = 62$ kJ
$F_2 (g) \longrightarrow 2F (g)$; $\Delta H = 155$ kJ
$I_2 (g) \longrightarrow 2\,I (g)$; $\Delta H = 149$ kJ

Q.24 The standard molar enthalpies of formation of $H_2O(l)$ and $H_2O_2(l)$ are – 286 and – 188 kJ/mol, respectively. Molar enthalpies of vaporisation of $H_2O(l)$ and $H_2O_2(l)$ are 44 and 53 kJ, respectively. The bond dissociation enthalpy of O_2(g) is 498 kJ/mol. Calculate the bond dissociation enthalpy (in kJ/mol) of O – O bond in H_2O_2, assuming that the bond dissociation enthalpy of O – H bond is same in both H_2O and H_2O_2.

Q.25 The heat evolved on combustion of 1 gm of starch, $(C_6H_{10}O_5)_x$, into CO_2 (g) and $H_2O(l)$ at constant pressure, is 4.00 Kcal. Standard Enthalpy of formation of CO_2 (g) and H_2O (l) are –94.00 and – 65.40 Kcal/mol. The magnitude of standard enthalpy of formation of starch (in Cal/gm) is :

Q.26 The enthalpy change for the reaction $C_3H_8(g) + H_2(g) \longrightarrow C_2H_6(g) + CH_4(g)$ at 25º C is – 55.8 kJ/mol. Calculate the enthalpy of combustion of C_2H_6(g). The enthalpy of combustion of H_2, & CH_4 are –285.8 & –890.0 kJ/mol respectively. Enthalpy of combustion of propane is –2220 kJ mol^{-1}.

Q.27 If the enthalpy of formation of HCl (g) and Cl^- (aq) are –92.3 kJ/mole and – 167.3 kJ/mol, find the enthalpy of solution of hydrogen chloride gas.

Q.28 Benzoic acid is a common standard used in Bomb calorimeters, which maintain a constant volume. If 1.22 gm of benzoic acid gives off 31.7 J of energy when burned in the presence of sufficient oxygen at an initial temperature of 24.6°C, calculate molar heat capacity at constant volume of final product mixture if final temperature is 49.6°C. Also calculate, W and ΔU for the given amount, assuming ideal gas behaviour and heat release in process is only used to rise the temperature.

Q.29 Calculate the electron gain enthalpy of fluorine atom using the following data . Make Born – Haber's cycle. All the values are in kJ mol^{-1} at 25^{o} C .

$\Delta H_{diss}(F_2) = 160$, $\Delta_f H\ (NaF(s)) = -570$, I.E. $[Na(g)] = 495$, $\Delta H_{Sub}\ [Na(s)] = 100$.

Lattice enthalpy of NaF(s) = 895

Q.30 Find the Bond enthalpy **(in kJ/mol)** of one "three centre two electron bond" in B_2H_6 $\{B\text{–}H\text{–}B \rightarrow 2B(g) + H(g)\}$ from the given data.

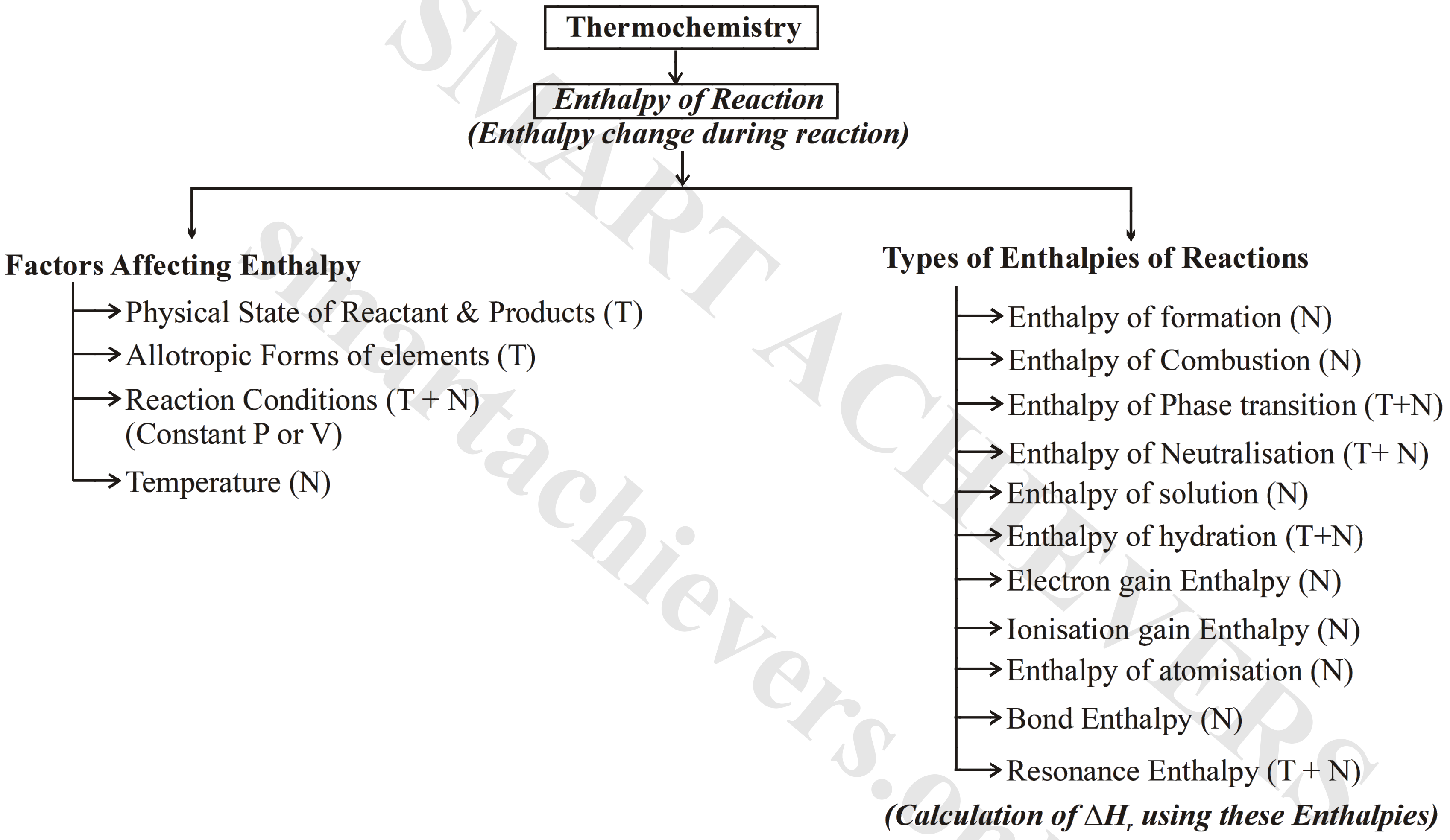
$\Delta H_f^0\ [BH_3(g)] = 100$ kJ/mol

$\Delta H_f^0\ [B_2H_6(g)] = 36$ kJ/mol

$\Delta H_{atm}\ [B(s)] = 565$ kJ/mol

$\Delta H_{atm}\ [H_2(g)] = 436$ kJ/mol

REVISION FLOW CHART



Thermochemistry

→ *Enthalpy of Reaction*

(Enthalpy change during reaction)

Factors Affecting Enthalpy

- Physical State of Reactant & Products (T)
- Allotropic Forms of elements (T)
- Reaction Conditions (T + N)
  (Constant P or V)
- Temperature (N)

Types of Enthalpies of Reactions

- Enthalpy of formation (N)
- Enthalpy of Combustion (N)
- Enthalpy of Phase transition (T+N)
- Enthalpy of Neutralisation (T+ N)
- Enthalpy of solution (N)
- Enthalpy of hydration (T+N)
- Electron gain Enthalpy (N)
- Ionisation gain Enthalpy (N)
- Enthalpy of atomisation (N)
- Bond Enthalpy (N)
- Resonance Enthalpy (T + N)

(Calculation of ΔH_r using these Enthalpies)

(G) → represents topic of graphical importance

(T) → represents topic of theoretical importance

(N) → represents topic of numerical importance

LIST OF IMPORTANT FORMULAS

(1) Relation between ΔH and ΔU

$$\Delta H = \Delta U + (\Delta n_g)RT$$

(2) Variation of ΔH_r with temperature

$$\int_{\Delta H_1}^{\Delta H_2} d(\Delta H) = \int_{T_1}^{T_2} d(\Delta C_p)_r \, dT$$

$$\frac{\Delta H_2 - \Delta H_1}{T_2 - T_1} = (\Delta C_p)_r$$

If $(C_P)_r$ is constant

(3) Calculation of $\Delta H_{reaction}$ using

(i) $\Delta_f H$: $\Delta_r H = \sum_i a_i \Delta_f H_{(Products)} - \sum_i b_i \Delta_f H_{(reactants)}$

where a_i and b_i represent the coefficients of the products and reactants in the balanced chemical equation.

(ii) $\Delta_C H$: $\Delta_r H = \sum_i b_i \Delta_C H_{(reactants)} - \sum_i a_i \Delta_C H_{(Products)}$

where a_i and b_i represent the coefficients of the products and reactants in the balanced chemical equation.

(iii) Bond Energy

In gas phase reactions, the standard enthalpy of reaction, $\Delta_r H°$, is related with the bond enthalpies of reactants and products as

$\Delta_r H° = \Sigma$ bond enthalpies (reactants) – Σ bond enthalpies (products)

(4) Relation between I.E. (Ionisation Energy) and $\Delta_i H$ (Ionisation Enthalpy) :

$$\Delta_i H \text{ (Ionisation Enthalpy)} = \text{I.E. (Ionisation Energy)} + \frac{5}{2}RT$$

(5) Relation between E.A (Electron Affinity) & $\Delta_{eg} H$ (Electron Gain Enthalpy) :

$$\Delta_{eg} H = -\text{E.A (Electron Affinity)} - \frac{5}{2}RT$$

(6) Resonance Energy :

Resonance Energy = $(\Delta_f H)_{observed} - (\Delta_f H)_{Calculated}$

NOTE: ***The reference state of commonly used elements are :***

Elements	**Reference state**
C	$C_{(graphite)}$
S	$S_{8(Rhombic)}$
P	$P_{4(white)}$
O	$O_{2(g)}$
H	$H_{2(g)}$
Br	$Br_{2(l)}$
Metal	$M_{(s)}$[except $Hg_{(l)}$]

LAST MOMENT REVIEW

THERMOCHEMISTRY

Theory : ....

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Exercise - 1 : Question ....

Exercise - 2 : Question ....

Exercise - 3 : Question ....

Exercise - 4 : Question ....

DPPs : ....

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Other Sources : ....

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Revision Worksheet Thermodynamics

Single correct

Q.1 A definite amount of an ideal gas (γ =1.5) undergoes a change of state in which heat exchange is equal to work done (q = w). Molar heat capacity of the gas is :

(A) 2R (B) 3R (C*) R (D) Infinite

Q.2 When two equal sized pieces of the same metal at different temperatures T_h (hot piece) and T_c(cold piece) are brought into contact into thermal contact and isolated from it's surrounding. The total change in entropy of system is given by

(A) $C \ln \frac{T_c + T_h}{2T_c}$ (B) $C \ln \frac{T_2}{T_1}$ (C) $C \ln \frac{(T_c + T_h)^2}{2T_h.T_c}$ (D*) $C \ln \frac{(T_c + T_h)^2}{4T_h.T_c}$

Q.3 Which of the options contain correct set of parameters which are both amount and path independent parameters.

(I) Internal energy
(II) Specific enthalpy
(III) Heat exchange at constant pressure condition
(IV) Molar heat exchange at constant volume condition
(V) Temperature
(VI) Work involved

(A*) Only II, IV & V (B) All option except VI
(C) All options except III, IV & VI (D) Only II & V

Q.4 A real gas is subjected to an adiabatic process causing a change in state from (3 bar, 50 L, 500K) to (5 bar , 40 L, 600 K) against a constant pressure of 4 bar. The magnitude of enthalpy change for the process is :

(A) 4000J (B) 5000J (C*) 9000J (D) 1000J

Q.5 Pressure of 10 moles of an ideal gas is changed from 2 atm to 1 atm against constant external pressure without change in temperature. If surrounding temperature (300 K) and pressure (1 atm) always remains constant then calculate total entropy change ($\Delta S_{system} + \Delta S_{surrounding}$) for given process.
[Given : $\ell n2 = 0.70$ and R = 8.0 J/mol/K]

(A) 56 J/K (B) 14 J/K (C*) 16 J/K (D) None of these

Q.6 A system contains 1 mole of a monoatomic ideal gas. Now 1 mole of a diatomic nonreacting ideal gas is added into the system at constant volume and temperature. Due to addition of diatomic gas, choose the **incorrect** statement, regarding the new system.

(A) Enthalpy of system will increase
(B) Adiabatic coefficient ($\gamma = C_P/C_V$) of the system will decrease.
(C*) Internal energy of the system remains constant.
(D) Pressure of the system will increase.

Q.7 The enthalpy of tetramerization of X in gas phase ($4X(g) \rightarrow X_4(g)$) is – 100 kJ/mol at 300 K. The enthalpy of vaporisation for liquid X and X_4 are respectively 30 kJ/mol and 72 kJ/mol respectively. ΔS for tetramerization of X in liquid phase is – 125 J / K mol at 300 K.
What is the ΔG at 300 K for tetramerization of X in liquid phase ?
(A) –52 kJ/mol (B) –89.5 kJ/mol (C*) –14.5 kJ/mol (D) None of these

Q.8 Which of the reaction is expected to be spontaneous at low temperatures and non-spontaneous at high temperatures.
(A) Dissociation of PCl_5 to give PCl_3 and Cl_2 (B*) Formation of H_2O from $H_2(g)$ and $O_2(g)$
(C) Melting of ice (D) Vaporisation of any volatile liquid

Q.9 Calculate ΔG(kJ/mole) for the reaction at 300K.

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

at an instant where partial pressure of N_2, O_2 and NO are 10^{-1} bar, 10^{-3} bar, 10^{-3} bar. If ΔH_f° NO(g) at 300K = 90.5 kJ/mole and ΔS°_fNO(g) at 300K = 12.5J/Kmole **[2.303 × R × 300 = 5750J/mole]**
(A) 173.5 kJ/mole (B) 185 kJ/mole (C*) 162 kJ/mole (D) 84.25 kJ/mole

Q.10 Select the option which is correct regarding the following statements.
Statement-1 : Entropy of system always increases in a spontaneous process.
Statement-2 : Adiabatic process whether reversible or irreversible will not cause any change in entropy of the surroundings.
Statement-3 : CO molecule will have residual entropy at 0 K.
(A) All the statements are true. (B*) Only statement-1 is incorrect.
(C) Only statement-3 is correct. (D) Only statement-2 is correct.

Q.11 Which of the following options contain correct set of cases where **entropy of system is increasing**?
Case-I Dissociation of ammonia gas into N_2 and H_2 gases.
Case-II Polymerization process of ethene to form polythene.
Case-III Adiabatic irreversible compression of an ideal gas
Case-IV Condensation of $H_2O_{(vap)}$ to give $H_2O_{(l)}$
Case-V Isothermal free expansion of Ideal gas.
(A) All the cases (B*) Case-I, III and V only
(C) Case-I, II and V only (D) Case-I, II, III and V only

Q.12 A substance has latent heat of vaporisation (at its boiling point 300 K) = 3 kJ/gm. If molar mass of substance is 40 , then molar entropy change for condensation process will be :
(A) 10 J/K (B) 400 J/K (C*) – 400 J/K (D) – 10 J/K

Q.13 The heat capacity of a diatomic ideal gas subjected to a process such that absolute temperature is proportional to cube of its volume is given by :
(A) $\frac{5R}{2}$ (B) $\frac{7R}{2}$ (C*) $\frac{17R}{6}$ (D) $\frac{3R}{2}$

Assertion Reason

Q.14 **Statement-1 :** Adiabatic free expansion of any substance in a closed system will not cause any change in temperature of the substance.
Statement-2 : In adiabatic free expansion of any substance in a closed system internal energy will remain constant.
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(C) Statement-1 is true, statement-2 is false.

(D*) Statement-1 is false, statement-2 is true.

Assertion Reason

Q.15 **Statement-1 :** Adiabatic free expansion of any substance in a closed system will not cause any change in temperature of the substance.

Statement-2 : In adiabatic free expansion of any substance in a closed system internal energy will remain constant.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(C) Statement-1 is true, statement-2 is false.

(D*) Statement-1 is false, statement-2 is true.

More than one correct :

Q.16 Which of the following process must be spontaneous?

(A*) Isobaric and Isoentropic process with negative enthalpy change.

(B) Isochoric and Isothermal process with negative internal energy change.

(C) A process with constant internal energy and Isothermal with an increase in entropy of system.

(D*) An adiabatic process with constant volume condition and entropy of system increasing.

Q.17 Which of the following option(s) will show a decrease in Gibbs free energy?

(A*) Combustion of propane at 1 bar and 500K.

(B*) Vapourisation of any liquid at 1 atm and above its normal boiling point.

(C) Fusion of H_2O at 1 atm and 0°C if its normal melting point is 0°C.

(D*) Vapourisation of H_2O at 100°C and 1 bar if its normal boiling point is 100°C.

Q.18 Which of the following statements is / are incorrect.

(A*) Combustion of methane in an adiabatic rigid container will cause no change in temperature of the system.

(B*) It is possible to have both adiabatic reversible & adiabatic irreversible processes between two states.

(C*) For a reaction involving only ideal gases, occurring at constant temperature there will be no change in internal energy.

(D*) P–V work is always non zero when there is change in volume.

Q.19 Assume ideal gas behaviour for all the gases considered & vibrational degrees of freedom to be active. Separate equimolar samples of Ar, H_2, SO_2 were subjected to a two step process as mentioned. Initially all are at same state of temperature & pressure.

Step I ⟶ All undergo reversible adiabatic expansion to attain same final volume, which is double the original volume thereby causing the decreases in their temperature.

Step II ⟶ After step I all are given appropriate amount of heat isochorically to restore the original temperature.

Mark the correct option (s).

(A*) Due to step I only, the decrease in temperature will be maximum for Ar

(B*) During step II, heat given will be maximum for SO_2

(C*) There will be no net change in internal energy for any of the gas after both the steps of process are completed.

(D*) The P–V graph of Ar & H_2 will be different for overall process.

Subjective

Q.20 0.5 mole each of two ideal gases A ($C_v = \frac{3}{2}R$) and B ($C_v = \frac{5}{2}R$) are taken in a container and expanded reversibly and adiabatically from V = 1 L to V = 4 L starting from initial temperature T = 300 K. Find |ΔH| for the process in (Cal/mol).

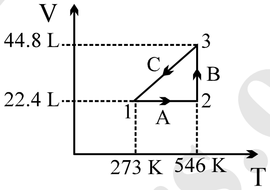
[Ans. – 900 calories]

Q.21 A system containing an ideal gas ($\gamma = 1.5$) at 10 bar, 1 L and 300K undergoes expansion upto 4L. Calculate heat exchange of the system (in J) if process is carried out at a constant external pressure of 1 bar and final pressure becomes equal to 5 bar.

Ans. 2300

Q.22 One mole of an ideal monoatomic gas is carried through the reversible cycle of the given figure consisting of step A, B and C and involving state 1,2 and 3. Fill in the blank space in the table given below assuming reversible steps.

State	P	V	T
1			
2			
3			



Step	Name of process	q	w	ΔE	ΔH
A					
B					
C					

Ans.

Table-1

State	P	V	T
1	1 atm	22.4	273
2	2 atm	22.4	546
3	1 atm	44.8	546

Step	Name of process	q	w	ΔE	ΔH
A	Isochoric	$3/2\,R(273)$	0	$3/2\,R(273)$	$5/2\,R(273)$
B	Isothermal	$546\,R\,ln2$	$-546\,R\,ln2$	0	0
C	Isobaric	$-5/2\,R(273)$	$R(273)$	$-3/2\,R(273)$	$-5/2\,R(273)$

Q.23 When 1 mole of ice melt at 0°C and at constant pressure of 1 atm. 1440 calories of heat are absorbed by the system. The molar volumes of ice and water are 0.0196 and 0.0180 litre respectively. Calculate ΔH and ΔU for the reaction.

Ans ΔH ≅ ΔU = 1440 calories

Q.24 The molar enthalpy of vaporization of benzene at its boiling point (353 K) is 30.84 $kJmol^{-1}$ What is the molar internal energy change? For how long would a 12 volt source need to supply a 0.5 A current in order to vaporise 7.8 g of the sample at its boiling point ?

Ans. $\Delta U = 27.91$ kJ mol^{-1}, t= 514 sec.

Q.25 20.0 dm^3 of an ideal gas (diatomic $C_{v,m} = 5R/2$) at 673 K and 0.7 MPa expands until pressure of the gas is 0.2 MPa. Calculate q, w, ΔU and ΔH for the process if the expansion is :

(i) Isothermal and reversible

(ii) Adiabatic and reversible. [Given : $(7/2)^{5/7} = 2.447$]

(iii) Isothermal and adiabatic

(iv) Against 0.2 MPa and adiabatic

(v) Against 0.2 MPa and isothermal.

Ans (i) $q = -w = 17.54$ kJ , $\Delta U = 0$ and $\Delta H = 0$; (ii) $q = 0$, $w = \Delta U = -10.536$ kJ and $\Delta H = -14.75$kJ (iii) $q = 0$, $w = 0$, $\Delta U = 0$ and $\Delta H = 0$ (iv) $q = 0$; $\Delta U = w = -7.14$ KJ; $\Delta H = -9.996$ KJ, (v) $q = -w = 10.0$ KJ, $\Delta U = \Delta H = 0$

Q.26 Container A containing one mole of He is connected with Container B containing 2 moles of Ne at the same temperature and pressure. Calculate ΔS_{mixing} .[**Given:** R = 2 Cal K^{-1} mol^{-1} ; ln3 = 1 ; ln2 = 0.70]
[Report your answer by multiplying it with 100] [Ans. 320]

Q.27 The equilibrium constant of the reaction $2C_3H_6(g) \rightleftharpoons C_2H_4(g) + C_4H_8(g)$ is found to fit the expression

$$\ln K_{eq} = -1.04 - \frac{1088}{T/K}$$

(where T/K is temperature expressed in Kelvin scale)

Calculate the standard reaction enthalpy and entropy at 400 K.

Ans. $\Delta H° = 9.04$ kJ/mol; $\Delta S° = -8.64$ J/mol^{-1}K^{-1}

Q.28 A substance undergoes a change represented as shown $\mathbf{A_{(l)}}$ **[1 bar, 300 K]** $\longrightarrow$ $\mathbf{A_{(s)}}$ **[1 bar, 300 K]**. From the given information, calculate magnitude of change in internal energy (in Joules) when 1 moles of A(l) solidifies.

Information :

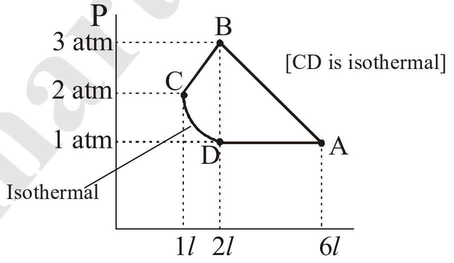
(i) Standard melting point of A(s) is 300 K.

(ii) Latent heat of fusion of A is 0.01 kJ/gm.

(iii) Specific volume of A(s) is 100 ml/g and A(l) is 120 ml/gm.

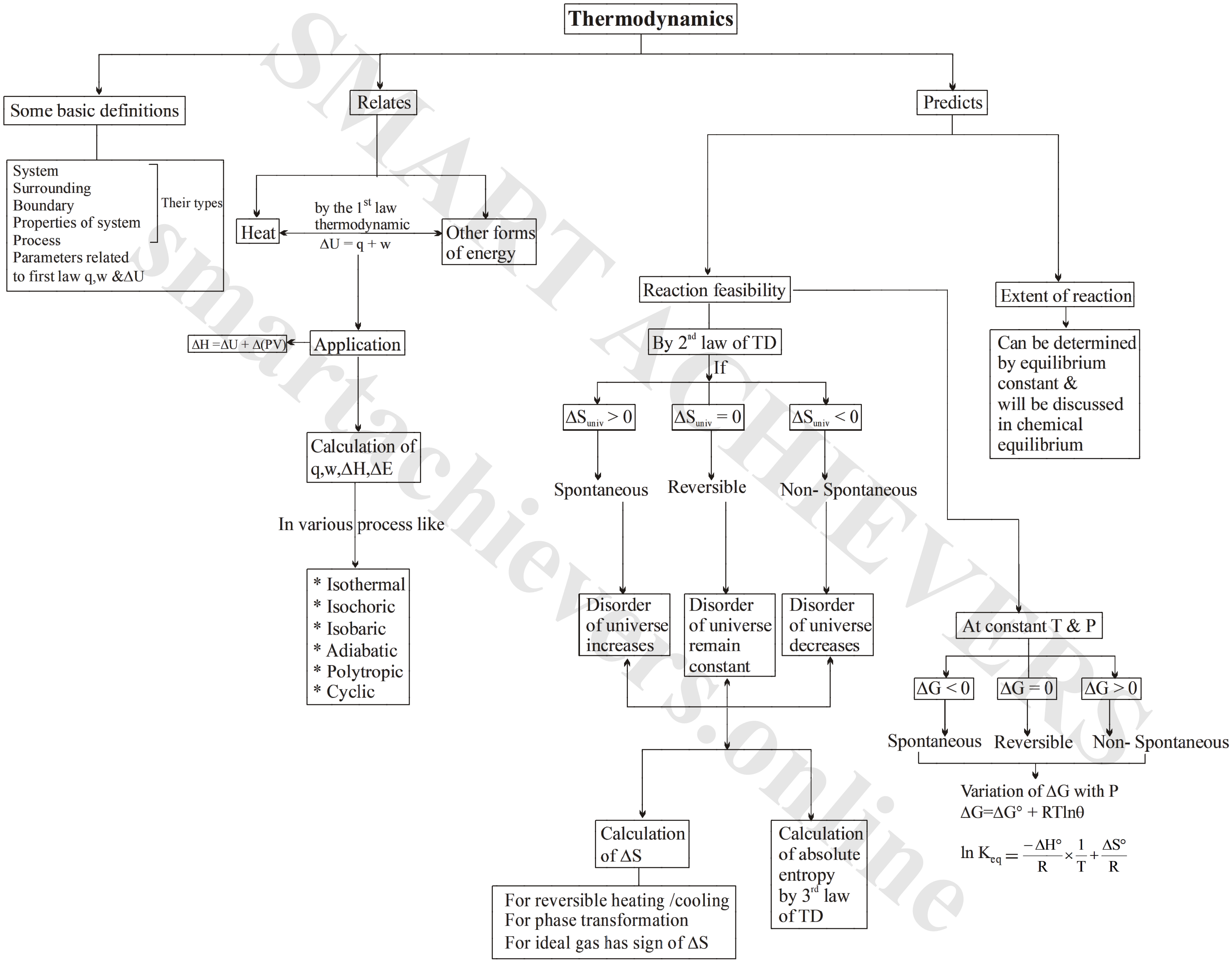
(iv) Molar mass of A is 50 gm / mole. [Ans. 0400]

Q.29 One mole of a monoatomic ideal gas is subjected to a process as shown. Calculate the maximum temperature obtained during the process (in Kelvin)



[If $T_{max} = \frac{X}{R}$, then fill X in the OMR sheet.] [Ans. 0008]

REVISION FLOW CHART



LIST OF IMPORTANT FORMULAS

Heat Capacity : $C = \dfrac{\theta}{\Delta T}$ $\Rightarrow C_{p,m} - C_{v,m} = R$ and $r = \dfrac{C_{p,m}}{C_{V,m}}$

$C_{v,m} = \left(\dfrac{f_t}{2} + \dfrac{f_R}{2} + f_{vib}\right) \times R$ $(f \rightarrow \text{degree of freedom})$

$dH = n \int C_{p,m} dT \quad \Rightarrow \quad dU = n \int C_{v,m} dT \quad \Rightarrow \quad W = -\int P_{ext} dV$

Enthalpy Calculation :

$\Delta H = \Delta U + \Delta(PV) = \Delta U + (P_2V_2 - P_1V_1)$

$\Delta H = \Delta U + \Delta n_g RT$

$$(W_{iso})_{reversible} = -nRT\ln\frac{V_2}{V_1} = -nRT\ln\frac{P_1}{P_2}$$

$$(W_{iso})_{reversible} = -P_{ext}(V_2 - V_1) = -P_{ext}\left[\frac{nRT}{P_2} - \frac{nRT}{P_1}\right]$$

$$W_{adiabatic} = \frac{P_2V_2 - P_1V_1}{\gamma - 1} = nC_{v,m}dT = \frac{nR}{\gamma - 1}(T_2 - T_1)$$

$$\left.\begin{aligned} &PV^{\gamma} = \text{constant} \\ &TV^{\gamma-1} = \text{constant} \\ &P^{\gamma-1}T^{\gamma} = \text{constant} \end{aligned}\right\} \text{applicable for reversible process only}$$

For Polytropic process :

$$W = \frac{P_2V_2 - P_1V_1}{x - 1} = \frac{nR(T_2 - T_1)}{x - 1} \quad \Rightarrow \quad C_m = C_{v,m} + \frac{R}{1 - x}$$

Second Law of Thermodynamics :

Efficiency of Carnot Cycle $= 1 /0 \dfrac{T_L}{T_H}$

Calculation of Entropy Change :

(a) **For reversible heating / Cooling of liquids / solids**

$$\Delta S = nC_m \ln\frac{T_f}{T_i}$$

(b) **For Real Gas :** $\Delta S = nC_{p,m} \ln\dfrac{T_f}{T_i}$ (isobaric) $\Rightarrow$ $\Delta S = nC_{v,m} \ln\dfrac{T_f}{T_i}$ (isochoric)

(c) **For Phase Transformation:** $\Delta_{vap} S = \dfrac{\Delta_{vap} H}{T_{BP}}$ $\quad \Delta_{fus} S = \dfrac{\Delta_{fus} H}{T_{MP}}$

(d) For Ideal Gas undergoing any process

$$\Delta S = nC_{v,m}\ln\frac{T_f}{T_i} + nR\ln\frac{V_f}{V_i}$$

$$\Delta S = nC_{p,m}\ln\frac{T_f}{T_i} + nR\ln\frac{V_i}{V_f}$$

$$\Delta S_{total} = \Delta S_{system} + \Delta S_{surrounding}$$

Third Law of Thermodynamics :

$$\Delta S_m^0 \ (TK) = \int_0^{mp} \frac{C_{p,m}dT}{T} + \frac{\Delta_{fus}H}{T_{mp}} + \int_{mp}^{BP} \frac{C'_{p,m}dT}{T} + \frac{\Delta_{vap}H}{T_{BP}} + \int_{BP}^{TK} \frac{C''_{p,m}dT}{T}$$

(a) For Chemical Reaction :

$$aA + bB \rightleftharpoons cC + dD$$

$$\Delta_{reaction} S = \Sigma(x_iS_i)_{product} - \Sigma(x_iS_i)_{reac\tan t}$$

(b) Variation of **ΔS with Temperature:**

$$\Delta S_{T_2} = \Delta S_{T_1} + \Delta_{reaction}C_p \ln\left(\frac{T_f}{T_i}\right)$$

(c) Variation of ΔS with Pressure

$$\Delta S_{P_2} = \Delta S_{P_1} + \Delta n_g R \ln\left(\frac{P_1}{P_2}\right)$$

Variation of Enthalpy with Temperature :

$$\Delta H_{T_2} = \Delta H_{T_1} + \int_{T_1}^{T_2} \Delta_{rxn}C_p dT$$

$$\Delta U_{T_2} = \Delta U_{T_1} + \int_{T_1}^{T_2} \Delta_{rxn}C_V dT$$

Gibbs Free Energy :

$U = H - TS$

$\Delta G = -\, T\Delta S_{total}$

$\Delta G = \Delta H - T\Delta S$ (at constant P and T)

$\Delta G = VdP - SdT$

Variation of ΔG with P at constant temperature (dT = 0) :

$\Delta G = nRT \ln \dfrac{P_2}{P_1}$ (For ideal gas)

$\Delta G = V(P_2 - P_1)$ (For solids and liquids)

$\Delta G = \Delta G^\circ + RT \ln\theta$

$$\ln K_{eq} = -\frac{\Delta H^\circ}{R} \times \frac{1}{T} + \frac{\Delta S^\circ}{R}$$

$$\underset{\underset{Y}{\downarrow}}{\ln K_{eq}} = -\underset{\underset{m}{\downarrow}}{\frac{\Delta H^\circ}{R}} \times \underset{\underset{x}{\downarrow}}{\frac{1}{T}} + \underset{\underset{C}{\downarrow}}{\frac{\Delta S^\circ}{R}} \text{ (Its graph)}$$

$$\log \frac{K_2}{K_1} = \frac{\Delta H^\circ}{2.303R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

LAST MOMENT REVIEW

THERMODYNAMICS

Theory : ....

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Exercise - 1 : Question ....

Exercise - 2 : Question ....

Exercise - 3 : Question ....

Exercise - 4 : Question ....

DPPs : ....

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Other Sources : ....

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