

● Thermodynamics

A branch of science in which various energy changes associated with physical and chemical reaction are studied is called Thermodynamics.

The branch which studies energy changes in chemical reactions is called chemical thermodynamics.

Entire thermodynamics is constructed on the basis of zeroth law, first law, second law and third law.

Application

- (1) It can predict whether a physical or chemical reaction will occur spontaneously or not in a definite condition.
- (2) Up to what extent will a reaction occur before it achieves equilibrium and how much product will be obtained can be predicted.
- (3) Energy changes occurring during a process can be determined.
- (4) Law of active masses, phase rule etc. can be derived.

Limitation

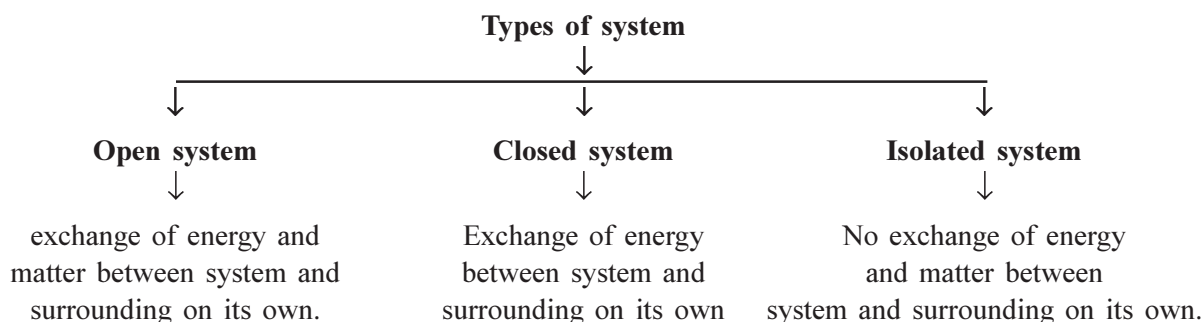
- (1) Thermodynamics can study macroscopic properties of a system. While it cannot describe the properties of free atom or molecules.
- (2) Cannot give any information of rate of reaction.
- (3) Does not give any information on mechanism of reaction. It is simply related to the initial and final state of reaction.

● System

An extremely small part of the universe which is separated from the remaining part of universe on which we note the observations of the experiments carried out by external changes is called system.

The remaining part of the universe excluding the system is called surrounding.

System + Surrounding = universe



● State function

The values of the properties of the system which depend on the state of the system but do not depend on the method how the state can be obtained are called the state function.

Extensive properties : Depends on quantity of matter.

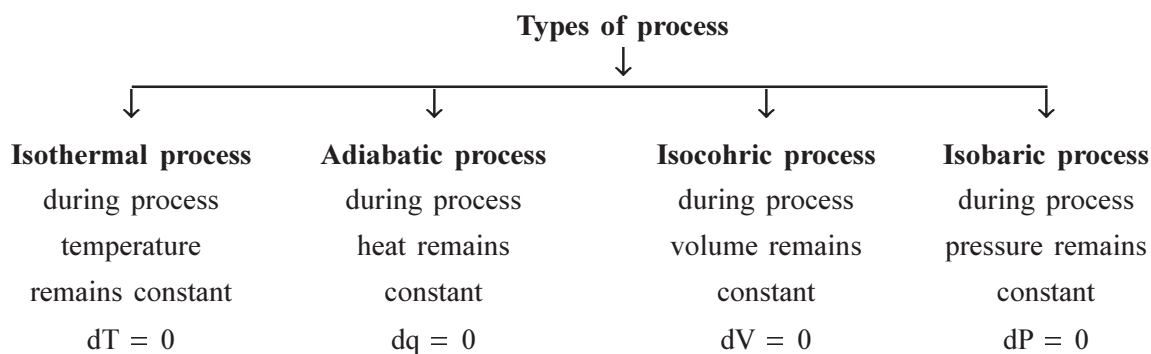
Example : quantity, mass, volume, Heat capacity, enthalpy, entropy, internal energy, free energy, pressure etc.

Intensive properties : Does not depend on quantity of matter but depend on characteristic of matter.

Example : Temperature, refractive index, viscosity, density, surface tension, specific Heat, melting point, boiling point, cell potential, pH of solution, molefraction etc.

Thermodynamical equilibrium : With change in time, if microscopic properties like temperature, pressure of system does not change, then such a system is said to be in thermodynamical equilibrium.

Thermodynamical process : If system changes its state from one equilibrium state to another equilibrium state then it is called a thermodynamical process and they are of different types as follows :



Reversible process : If the state of a system is changing with infinitesimal rate, then the difference in state function values of system and surrounding are very small and at each microscopic stage there exist an equilibrium between system and surrounding. This type of process are called reversible process.

irreversible process : If a system changes its state very fast in one step, such process is called irreversible process. In this process the system cannot be brought into initial state from final state on same path.

- Which of the following is not related to thermodynamics ?
 (A) rate of reaction (B) direction of reaction
 (C) energy changes during reaction (D) on the proportion of reaction completion
- What is the type of system if it does 20 joule work when 30 joule heat is added to the system ?
 (A) Open (B) closed (C) isolated (D) Free
- If boiling point of 1 litre water is 373 K, then boiling point of 500 ml water
 (A) decreases and becomes half (B) Increases and becomes double
 (C) will remain constant (D) Increases and becomes four times
- If fusion enthalpy of ice at 0°C is 6 KJ/mole, then what is the fusion enthalpy of 36 gm ice ?
 (A) 6 (B) 36 (C) 12 (D) 3
- What is true for adiabatic process ?
 (A) $\Delta p = 0$ (B) $\Delta v = 0$ (C) $\Delta q = 0$ (D) $\Delta T = 0$
- Adiabatic process occurs in
 (A) open system. (B) closed system. (C) isolated system. (D) given any system.
- Which of the following characteristics is not true for a reversible process ?
 (A) State of the system changes at extremely slow rate.
 (B) System passes through many stages while changing state from one to another.
 (C) Such type of process take lot of time for completion.
 (D) In such type of process, equilibrium is not established between system and surrounding in every step.

Answers : 1. (A), 2. (B), 3. (B), 4. (C), 5. (C), 6. (B), 7. (D)

Zeroth law of Thermodynamics : ‘The process of achieving thermal equilibrium between two thermally conducting bodies having different temperatures is called zeroth law.’ In other way ‘If two thermally conducting bodies are in thermal equilibrium with a third substance, then the two thermally conducting bodies are also in equilibrium with each other.’

Internal Energy (U) : In every substance definite energy is stored in it on the basis of its mass and characteristics, is called internal energy. It is the sum of different types of energies of atoms and molecules.

$$U = E_p + E_k$$

It is a state function and an extensive property.

Its absolute value cannot be measured but change (ΔU) can be measured.

$$\Delta U = U_f - U_i \text{ or } \Delta U = U_p - U_R$$

Internal energy of system can be changed in two different ways : (1) By adding or removing heat (2) By work done on the system or work done by the system.

● First law of Thermodynamics

Total energy of the universe remains constant.

Energy can neither be created nor be destroyed.

Symbolic form : $\Delta U = q + w$

U is a state function, while q and w are not state functions.

(1) If heat is added to the system, value of q is +ve and heat is released from the system, value of q is -ve.

(2) If work is done on the system, value of w is +ve if work is done by the system, value of w is -ve.

● Mainly two types of work are considered in Thermodynamics

(1) **Electrical work :** $W_{\text{elect}} = nFE_{\text{cell}}$

(2) **Mechanical work (Pressure volume type of work) :**

(a) **Work done when volume of system increases during an isothermal reversible process :**

$$w = -nRT \ln \frac{V_2}{V_1} = -nRT \ln \frac{P_1}{P_2}$$

(b) **Work done when volume of system decreases during an isothermal reversible process :**

$$w = nRT \ln \frac{V_2}{V_1} = nRT \ln \frac{P_1}{P_2}$$

(c) **Work done when volume of system changes at constant external pressure in an isothermal irreversible process**

$$w = -P\Delta V = -P(V_2 - V_1) = -P(V_f - V_i)$$

If volume increases $w = -ve$, and volume decreases $w = +ve$

(d) **Work done during expansion of ideal gas in vacuum in an isothermal irreversible process :**

$$w = 0$$

Unit of q and w :

with respect to q,

1 calorie = 4.184 joule

1 joule = 0.239 calorie

with respect to w,

1 joule = 1 newton meter = 1 kg m² s⁻²

1 litre bar = 101.3 joule

1 litre bar $\approx$ 100 joule

- According to first law of thermodynamics, change in energy at constant volume, $q_v = \Delta U$

Enthalpy (H) : Sum of internal energy and work energy is called enthalpy (H), Mathematically,
 $H = U + PV$

- Enthalpy is a state function and extensive property. Absolute value of H is not possible, but change in enthalpy (ΔH) can be measured.

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

and $\Delta H = q_p$

- **For system having gaseous form of matter**

$$\Delta H = \Delta U + \Delta n_{(g)}RT \quad \text{Where } \Delta n_{(g)} = n_{p(g)} - n_{r(g)}$$

or $q_p = q_v + \Delta n_{(g)}RT$ where, $R = 8.314 \text{ JK}^{-1} \text{ mole}^{-1}$

- **Process occurring at constant volume**

(1) energy is removed (Exothermic reaction)

then $q_v = \Delta U = -ve$

(2) energy is absorbed (Endothermic reaction)

then $q_v = \Delta U = +ve$

- Process occurring at constant pressure**

(1) energy is removed (Exothermic reaction)

then $q_p = \Delta H = -ve$

(2) energy is absorbed (Endothermic reaction)

then $q_p = \Delta H = +ve$

- Isothermal expansion or contraction of ideal gas,

$$\Delta H = 0 \quad \text{and} \quad \Delta U = 0$$

8. Which of the following option is correct for a system, In which 240 KJ of internal energy increased when system does 90 KJ of work ?
- (A) 330 KJ heat is added from surrounding to system.
 (B) 150 KJ heat is added from surrounding to system.
 (C) 330 KJ heat is added to surrounding from system.
 (D) 150 KJ heat is added to surrounding from system.
9. In a system having ideal gas if 607.8 joule work is done, calculate the change in volume of a system having 20 atmospheric pressure ? (1 litre atm = 101.3 joule)
- (A) 3.5 litre volume decreases (B) increases volume by 0.3 litre
 (C) Increases volume by 2.4 litre (D) decreases volume by 1.2 litre
10. Volume of ideal gas under external atmospheric pressure changes from 250 cm³ to 500 cm³. During this process if 10 joule of heat is added to the surrounding, calculate change in internal energy of the system ?
- (A) -35.32 joule (B) -15.32 joule (C) 15.32 joule (D) 35.32 joule
11. What will be the amount of work done for 3 mole of ideal gas at 27° C temperature doubling its volume during an isothermal reversible expansion ?
- (A) +8157 joule (B) -5187 joule (C) -5871 joule (D) +8751 joule

12. What will be the work done when temperature of 1 mole ideal gas under constant external pressure increases from 0°C to 100°C ?
 (A) 831.4 joule (B) -100 joule (C) 0 joule (D) -831.4 joule
13. What will be the value of $\Delta H - \Delta U$ for formation of carbon monoxide at 298 K temperature ?
 (A) -1238.78 joule mole⁻¹ (B) 1238.78 joule mole⁻¹
 (C) -2477.57 joule mole⁻¹ (D) 2477.57 joule mole⁻¹
14. Calculate ΔU for converting 72 gm of water into vapour at 100°C assume that water vapour behaves as ideal gas. Heat of vapourisation of water is 540 calorie gm⁻¹.
 (A) 35.896 K cal (B) 41.864 K cal (C) 38.88 K cal (D) 27.452 K cal
15. Calculate amount of heat released when 2.7 gm Al reacts with Fe_2O_3 ?
 $[2\text{Al} + \text{Fe}_2\text{O}_3 \rightarrow 2\text{Fe} + \text{Al}_2\text{O}_3, \Delta H^{\circ} = -852\text{KJ}]$
 (A) 852 KJ (B) 426 KJ (C) -42.6 KJ (D) +42.6 KJ
16. For which of the following reactions $\Delta H = \Delta U$?
 (A) $\text{N}_2\text{O}_{4(g)} \rightarrow 2\text{NO}_{2(g)}$ (B) $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightarrow 2\text{SO}_{3(g)}$
 (C) $\text{H}_{2(g)} + \text{Cl}_{2(g)} \rightarrow 2\text{HCl}_{(g)}$ (D) $\text{H}_{2(g)} + \frac{1}{2} \text{O}_{2(g)} \rightarrow \text{H}_2\text{O}_{(l)}$
17. For combustion of propane gas $\Delta H - \Delta U = \dots\dots\dots$
 (A) -RT (B) +RT (C) -3RT (D) +3RT
18. Calculate value of $\Delta H - \Delta U$ for formation of carbon monoxide at 298 K from its elements ?
 (A) -0.5 RT (B) 0.5 RT (C) -RT (D) +RT
19. In different open containers CaC_2 , Al_4C_3 and Mg_2C_3 are reacted with one mole water each, then which of the following options is correct for order of work done by the system ?
 (A) $\text{CaC}_2 = \text{Mg}_2\text{C}_3 < \text{Al}_4\text{C}_3$ (B) $\text{CaC}_2 = \text{Mg}_2\text{C}_3 = \text{Al}_4\text{C}_3$
 (C) $\text{CaC}_2 < \text{Al}_4\text{C}_3 < \text{Mg}_2\text{C}_3$ (D) $\text{CaC}_2 < \text{Al}_4\text{C}_3 = \text{Mg}_2\text{C}_3$
20. Calculate enthalpy of combustion of ethanol if using bomb calorimeter heat measured for combustion of 1 mole of ethanol at 25°C is 1364.47 KJ ? ($R = 8.314 \text{ joule K}^{-1} \text{ mole}^{-1}$)
 (A) -1366.95 KJmole⁻¹ (B) -1361.95 KJmole⁻¹
 (C) -1460.50 KJmole⁻¹ (D) -1350.50 KJmole⁻¹

Answers : 8. (A) , 9. (B), 10. (A), 11. (B), 12. (C), 13. (B), 14. (A) , 15. (C), 16. (C), 17. (C), 18. (B), 19. (A), 20. (A)

● Heat of reaction

$$\text{Heat of reaction } \Delta_r H^\circ = \sum \Delta_f H^\circ_{(\text{product})} - \sum \Delta_f H^\circ_{(\text{Reactant})}$$

$$\text{Standard enthalpy change} = \text{Standard energy of formation of product} - \text{Standard energy of formation of reactant}$$

(1) Enthalpy of combustion ($\Delta_c H$) : Amount of heat released when 1 mole of organic compound undergo combustion at 1 bar pressure is called enthalpy of combustion.

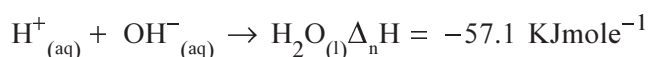
enthalpy of combustion of 1 gm substance is called calorie value.

$$\text{Calorie value} = \frac{\Delta_c H}{\text{mass}}$$

(2) Enthalpy of formation ($\Delta_f H$) : When one mole of compound is formed under standard conditions from elemental state of constituent elements, the change in enthalpy is called standard enthalpy of formation. ($\Delta_f H^\circ$)

The value of standard enthalpy of formation of any element is zero.

(3) Enthalpy of Neutralisation ($\Delta_n H$) : When one gm equivalent weight of any strong acid in its dilute solution neutralises one gm equivalent weight of any strong acid in its dilute solution, the heat produced is called enthalpy of Neutralisation.



If acid or base or both (acid, base) are weak, then value of heat of neutralisation is less than 57.1 KJ .

(4) Enthalpy of solution ($\Delta_{sol} H$) : Amount of enthalpy change when one mole solute is completely dissolved in a solvent is called enthalpy of solution.

(5) Hydration Enthalpy ($\Delta_{hyd} H$) : When 1 mole dehydrated or partly hydrated salt joins with necessary moles of H_2O the enthalpy changes is known as hydration enthalpy.

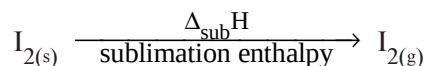
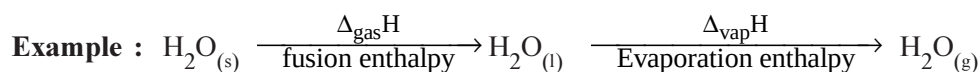
(6) Ionization Enthalpy ($\Delta_{ion} H$) : When 1 mole weak acid or weak base is completely dissociated in a solution the enthalpy changes is known as Ionisation Enthalpy.

(7) Atomisation Enthalpy ($\Delta_a H$) : When all bonds in one mole substance are broken and all atoms are separated in gaseous state the enthalpy changes is called Atomisation Enthalpy ($\Delta_a H$) .

(8) Bond enthalpy ($\Delta_{bond} H$) : minimum amount of energy required to break one mole bond and separates atoms in gaseous state is called Bond enthalpy ($\Delta_{bond} H$).

$$\Delta_r H = \text{Bond enthalpy of reactants} - \text{Bond enthalpy of products}$$

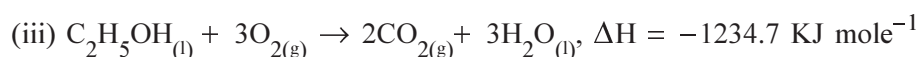
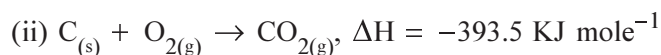
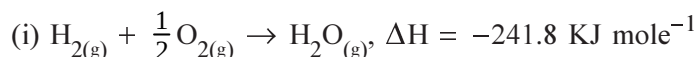
(9) Enthalpy changes during transformation in physical state



(10) Hess's law : The total change in enthalpy in a chemical reaction is equal to the algebraic sum of the changes in enthalpy occurring during different steps.

Using Hess's law enthalpy of formation, enthalpy changes during conversion of different allotropes of elements, various enthalpy of reaction can be calculated.

21. Based on the given information calculate enthalpy of formation of ethanol.



(A) $-2747.1 \text{ KJ mole}^{-1}$

(B) $-277.7 \text{ KJ mole}^{-1}$

(C) $277.7 \text{ KJ mole}^{-1}$

(D) $2747.1 \text{ KJ mole}^{-1}$

22. If standard enthalpy of combustion of ethane is $-1564.5 \text{ KJ mole}^{-1}$ then calculate standard enthalpy of formation of ethane ? Standard enthalpy of formation of $\text{CO}_{2(g)}$ and $\text{H}_2\text{O}_{(l)}$ is -395 and -286 KJmole^{-1} respectively.

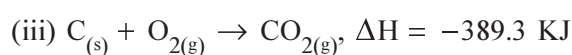
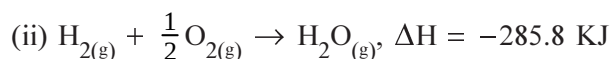
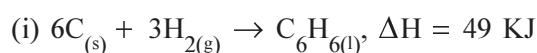
(A) $-83.5 \text{ KJmole}^{-1}$

(B) $108.5 \text{ KJmole}^{-1}$

(C) -167 KJmole^{-1}

(D) -123 KJmole^{-1}

23. Based on given information calculate enthalpy of combustion of benzene ?



(A) $-162.1 \text{ KJmole}^{-1}$

(B) $+3242.2 \text{ KJmole}^{-1}$

(C) $-3242.2 \text{ KJmole}^{-1}$

(D) $1621.1 \text{ KJmole}^{-1}$

24. Enthalpy of combustion of graphite and diamond is -393.5 and $-395.4 \text{ KJ mole}^{-1}$ respectively then calculate enthalpy changes to convert 1 mole graphite into 1 mole diamond.

(A) $+2.5 \text{ KJmole}^{-1}$

(B) -2.5 KJmole^{-1}

(C) 1.9 KJmole^{-1}

(D) -1.9 KJmole^{-1}

25. If dissociation enthalpy of CH_3COOH is $0.005 \text{ Kcalgm}^{-1}$ then calculate the energy released when 1 mole $\text{Ca}(\text{OH})_2$ is neutralised by CH_3COOH ?

(A) 27.4 Kcal

(B) 13.6 Kcal

(C) 26.8 Kcal

(D) 27.1 Kcal

26. Lattice enthalpy of $\text{NaCl}_{(s)}$ is 788 KJmole^{-1} and hydration enthalpy of $\text{NaCl}_{(s)}$ is -784 KJmole^{-1} then $\text{NaCl}_{(s)}$ solution enthalpy is

(A) 4 KJmole^{-1}

(B) -4 KJmole^{-1}

(C) $-1572 \text{ KJmole}^{-1}$

(D) 1572 KJmole^{-1}

27. What is the amount of energy released when 50 ml 0.1 M $\text{HCl}_{(\text{aq})}$ is neutralised by 50 ml 0.1 M $\text{NaOH}_{(\text{aq})}$?
 (A) 57.1 KJ (B) 114.2 KJ (C) -57.1 KJ (D) 2.9 KJ
28. At 298 K if solution enthalpy of solid MgSO_4 is $-91.21 \text{ KJmole}^{-1}$ and solution enthalpy of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}_{(\text{s})}$ is $13.81 \text{ KJmole}^{-1}$ then calculate Hydration enthalpy of solid MgSO_4 ?
 (A) -91.21 (B) -105.02 (C) 105.02 (D) 91.21
29. At 298 K bond enthalpy of C-H, C - C, C = C and H - H bond is respectively 414, 347, 615 and 434 KJ mole^{-1} then calculate enthalpy changes of reaction at same temperature ?
 $\text{CH}_2 = \text{CH}_{2(\text{g})} + \text{H}_{2(\text{g})} \rightarrow \text{CH}_3 - \text{CH}_{3(\text{g})}$
 (A) 250 KJ mole^{-1} (B) $-250 \text{ KJ mole}^{-1}$ (C) 125 KJ mole^{-1} (D) $-125 \text{ KJ mole}^{-1}$
30. Enthalpy of formation of Ammonia is -45 KJ mole^{-1} and bond enthalpy of H-H and N-H is 435 KJ mole^{-1} and 390 KJ mole^{-1} , calculate bond enthalpy of $\text{N} \equiv \text{N}$?
 (A) $-872.5 \text{ KJ mole}^{-1}$ (B) $-945 \text{ KJ mole}^{-1}$ (C) $872.5 \text{ KJ mole}^{-1}$ (D) 945 KJ mole^{-1}

Answers : 21. (B), 22. (A), 23. (B), 24. (C), 25. (C), 26. (A), 27. (D), 28. (B), 29. (D), 30. (D)

● **Heat Capacity :** Heat required to raise the temperature of the substance by 1°C

● Heat capacity (C) = $\frac{q}{T_2 - T_1} = \frac{q}{\Delta T}$ (unit : joule K^{-1})

● Specific Heat Capacity (C) = $\frac{q}{m \cdot \Delta T}$ (unit : joule $\text{gm}^{-1}\text{K}^{-1}$)

Molar Heat capacity (C_m) = $\frac{q \cdot \text{Mw}}{m \cdot \Delta T}$ (unit : joule $\text{mole}^{-1}\text{K}^{-1}$)

● Heat capacity at constant volume (C_v) = $\left(\frac{\Delta U}{\Delta T}\right)_v$, Heat capacity at constant pressure (C_p) = $\left(\frac{\Delta H}{\Delta T}\right)_p$

● $C_p - C_v = R$ (For 1 mole gas)

$\therefore C_p - C_v = nR$ (For n mole gas)

(i) For monoatomic gas, $C_p = 5$ calorie $C_v = 3$ calorie

$$\therefore V = \frac{C_p}{C_v} = \frac{5}{3} = 1.67$$

(ii) For diatomic gas $C_p = 7$ calorie $C_v = 5$ calorie

$$\therefore V = \frac{C_p}{C_v} = \frac{7}{5} = 1.4$$

(iii) For triatomic gas $C_p = 8$ calorie, $C_v = 6$ calorie

$$\therefore V = \frac{C_p}{C_v} = \frac{8}{6} = 1.33$$

31. 0.1 mole of gas absorbs 41.75 joule of heat and temperature increases by 20°C, then the gas is
 (A) Triatomic (B) Diatomic (C) Polyatomic (D) Monoatomic
32. If one mole Helium gas has 1°C increase in temperature then the increase in internal energy is
 (A) 2 calorie (B) 3 calorie (C) 4 calorie (D) 5 calorie
33. For a gas at STP having 4.48 litre constant volume if 12 calorie heat is required to increase temperature by 15°C, then calculate value of C_p ?
 (A) 3 calorie (B) 4 calorie (C) 7 calorie (D) 6 calorie

Answers : 31. (B), 32. (B), 33. (D)

● Application of first law of Thermodynamics

Various types of energy changes, enthalpy changes in a chemical reaction can be determined.

● Limitation of First law of Thermodynamics

Cannot determine the direction of the reaction occurring on its own and cannot determine upto what extent reactant are converted into product.

● Second law of thermodynamics

(i) Free energy of the system in all the spontaneous processes decreases.

(ii) In all spontaneous processes, the entropy of the universe increases.

● Entropy

Measure of randomness in a system is called entropy 'S'. It is an extensive property and a state function. On increasing temperature, entropy increases. In given substance going from solid state to gaseous state entropy increases. Absolute value of entropy and change in entropy can be measured.

$$\Delta S = S_{\text{final}} - S_{\text{initial}}, \Delta S = S_p - S_R$$

$$\Delta S = \frac{q_{\text{rev}}}{T}$$

If there is a physical change in a state of a system, then entropy change can be obtained from the following formula.

$$\Delta S_{\text{fusion}} = \frac{\Delta H_{\text{Fusion}}}{T}, \Delta S_{\text{vapourisation}} = \frac{\Delta H_{\text{vapourisation}}}{T}$$

$$\Delta S_{\text{sublimation}} = \frac{\Delta H_{\text{sublimation}}}{T}$$

To determine the direction of a spontaneous reaction. $\Delta S_{\text{Total}} = \Delta S_{\text{system}} + \Delta S_{\text{surrounding}}$

If $\Delta S_{\text{Total (universe)}} > 0$, The reaction will occur in forward direction on its own

$\Delta S_{\text{total}} < 0$, the reaction will not occur in forward direction on its own

$\Delta S_{\text{total}} = 0$, The reaction will remain in equilibrium

Formula to calculate standard entropy of a substance,

$$S^\circ = 2.303C_p \log T$$

For n mole of ideal gas at constant temperature if volume changes then entropy change is,

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

34. Which of the following reaction has maximum ΔS° ?
- (A) $\text{CaCO}_{3(g)} \rightarrow \text{CaO}_{(s)} + \text{CO}_{2(g)}$ (B) $\text{Ca}_{(s)} + \frac{1}{2}\text{O}_{2(g)} \rightarrow \text{CaO}_{(s)}$
- (C) $\text{C}_{(s)} + \text{O}_{2(g)} \rightarrow \text{CO}_{2(g)}$ (D) $\text{N}_{2(g)} + \text{O}_{2(g)} \rightarrow 2\text{NO}_{(g)}$
35. Calculate boiling point of a liquid, whose enthalpy of vapourisation is 6 KJmole^{-1} and entropy change $16 \text{ joule mole}^{-1}$?
- (A) 273 K (B) 375°C (C) 375 K (D) 273°C
36. In irreversible adiabatic expansion of ideal gas increases volume from V_1 to V_2 then which of the following statement is true ?
- (A) $\Delta S_{(\text{syst})} = 0$ and $\Delta S_{(\text{surrounding})} = +\text{ve value}$ (B) $\Delta S_{(\text{syst})} = +\text{ve value}$ and $\Delta S_{(\text{surrounding})} = 0$
- (C) $\Delta S_{(\text{syst})} = 0$ and $\Delta S_{(\text{surrounding})} = 0$ (D) $\Delta S_{(\text{syst})} = +\text{ve value}$ and $\Delta S_{(\text{surrounding})} = -\text{ve value}$
37. If $\Delta S_{(A \rightarrow C)} = 50 \text{ joule K}^{-1}$, $\Delta S_{(C \rightarrow D)} = 30 \text{ joule K}^{-1}$, $\Delta S_{(B \rightarrow D)} = 20 \text{ joule K}^{-1}$, $\Delta S_{(A \rightarrow B)} = ?$
- (A) 100 joule K^{-1} (B) 60 joule K^{-1} (C) $-100 \text{ joule K}^{-1}$ (D) -60 joule K^{-1}

Answers : 34. (A) , 35. (C), 36. (A) , 37. (B)

● Free energy

Free energy of a system is an extensive property and a state function. Absolute value of free energy cannot be measured but change in free energy can be measured.

$$G = H - TS$$

$$\therefore \Delta G = \Delta H - T\Delta S$$

$$\text{or } \Delta G = G_{\text{Final}} - G_{\text{initial}}$$

$$\text{or } \Delta G = G_{(P)} - G_{(R)}$$

If value of $\Delta G < 0$, reaction will occur in forward direction on its own

If value of $\Delta G > 0$, reaction will not occur in forward direction on its own.

If $\Delta G = 0$, The reaction remains in equilibrium.

For n mole of ideal gas at constant temperature, if volume changes then free energy change

$$\Delta G = nRT \ln \frac{V_1}{V_2} \text{ and } \Delta G = nRT \ln \frac{P_2}{P_1}$$

From standard free energy of formation ($\Delta_f G^\circ$) standard free energy change can be measured as

$$\Delta_r G^\circ = \sum \Delta_f G^\circ_{(P)} - \sum \Delta_f G^\circ_{(R)}$$

● Other Formulae

$$\Delta_r G^\circ = -RT \ln K_c \text{ (relation between } \Delta_r G^\circ \text{ and equilibrium constant)}$$

$$\Delta_r G^\circ = -nFE^\circ_{\text{cell}} \text{ (relation with standard cell potential)}$$

$$\Delta_r G^\circ = \Delta H^\circ - T \Delta S^\circ$$

$$\Delta G^\circ = -W_{\text{Max}}, \Delta G = \Delta G^\circ + RT \ln K$$

38. Which option is correct for process of $\text{H}_2\text{O}_{(l)} \rightarrow \text{H}_2\text{O}_{(g)}$?
 (A) $\Delta G = 0, \Delta S = 0$ (B) $\Delta G = +ve, \Delta S = 0$ (C) $\Delta G = 0, \Delta S = +ve$ (D) $\Delta G = -ve, \Delta S = +ve$
39. Partial pressure of CO_2 on heating $\text{CaCO}_{3(s)}$ at 1000K temperature is 0.003 atm. If standard free energy of formation is +27.2 calorie then calculate free energy change in the reaction ?
 $\text{CaCO}_{3(s)} \rightleftharpoons \text{CaO}_{(s)} + \text{CO}_{2(g)}$?
 (A) 12.6 Kcal (B) 15.6 Kcal (C) 13.4 Kcal (D) 14.2 Kcal
40. Which of the following statement is true for precipitation reaction of NaCl in AgNO_3 solution ?
 (A) ΔH of reaction = 0 (B) ΔH of reaction = ΔG
 (C) ΔG of reaction is -ve (D) given all
41. Value of ΔH and ΔS is positive for a reversible reaction at temperature T. If T_e is the equilibrium temperature, then for reaction to occur on its own
 (A) $T_e > T$ (B) $T > T_e$ (C) $T = T_e$ (D) $T_e = ST$
42. For reaction $\text{CaCO}_{3(s)} \rightarrow \text{CaCO}_{(s)} + \text{CO}_{2(g)}$ value of ΔH° and ΔS° are $+179.1 \text{ KJmole}^{-1}$ and $160.2 \text{ joule K}^{-1}$. If value of ΔH° and ΔS° do not change with temperature. Then above which temperature the reaction will occur in forward direction on its own ?
 (A) 1008 K (B) 1200 K (C) 845 K (D) 1118 K
43. Equilibrium constant of $P \rightleftharpoons Q$ at 298 K is If standard enthalpy change and standard entropy change for the reaction are $-54.07 \text{ KJmole}^{-1}$ and $10 \text{ joule K}^{-1} \text{ mole}^{-1}$.
 (A) 5 (B) 95 (C) 10 (D) 100
44. Standard entropy of A_2 , B_2 and AB_3 are 60, 40 and $50 \text{ JK}^{-1}\text{mole}^{-1}$ respectively. At which temperature the following reaction will achieve equilibrium ?
 $\frac{1}{2} A_2 + \frac{3}{2} B_2 \rightleftharpoons AB_3, \Delta H = -30 \text{ K joule}.$
 (A) 500 K (B) 750 K (C) 1000 K (D) 1250 K
45. On the basis of $\Delta_f G^\circ$ for the following reaction which of the following is the characteristic oxidation state of lead and Tin ?
 $\text{PbO}_2 + \text{Pb} \rightarrow 2\text{PbO}, \Delta_f G^\circ < 0$
 $\text{SnO}_2 + \text{Sn} \rightarrow 2\text{SnO}, \Delta_f G^\circ > 0$
 (A) +4, +2 (B) +2, +2 (C) +4, +4 (D) +2, +4

Answers : 38. (C), 39. (B), 40. (C), 41. (B), 42. (D), 43. (C), 44. (B), 45. (D)

46. 0.04 mole of ideal gas is filled in a cylinder. At constant temperature of 37°C this gas expands from 50 ml to 375 ml and gains 208 joule of heat. The value of q and w for this process is respectively. [$R = 8.314 \text{ joule mole}^{-1}\text{K}^{-1}$, $\ln 7.5 = 2.01$]
 (A) +208 joule, -208 joule (B) -208 joule, -208 joule
 (C) -208 joule, +208 joule (D) +208 joule, +208 joule

47. Which of the following relation is not correct ?

(A) $\frac{\Delta G_{\text{syst}}}{\Delta S_{\text{Total}}} = -T$ (B) For isothermal process $w_{\text{reversible}} = -nRT \ln \frac{V_f}{V_i}$

(C) $\ln K = \frac{\Delta H^\circ - T\Delta S^\circ}{T}$ (D) $K = e^{-\Delta G^\circ/RT}$

48. 2 moles of ideal gas during an isothermal reversible expansion increases from 10 dm³ to 100 dm³ then calculate entropy change ?

(A) 38.3 Jmole⁻¹K⁻¹ (B) 35.8 Jmole⁻¹K⁻¹ (C) 32.3 Jmole⁻¹K⁻¹ (D) 42.3 Jmole⁻¹K⁻¹

49. $4\text{NO}_{2(g)} + \text{O}_{2(g)} \rightarrow 2\text{N}_2\text{O}_{5(g)}$, $\Delta_r H = -111$ KJ. If in this reaction instead of $\text{N}_2\text{O}_{5(g)}$, $\text{N}_2\text{O}_{5(s)}$ is obtained then calculate its $\Delta_r H$? [$\Delta_{\text{sub}} H_{(\text{N}_2\text{O}_5)} = 54$ KJmole⁻¹]

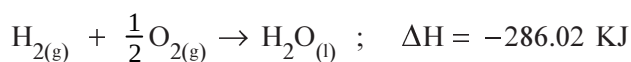
(A) -165 Kjoule (B) +54 Kjoule (C) 219 Kjoule (D) -219 Kjoule

50. At 298 K temperature standard free energy of formation of $\text{CH}_3\text{OH}_{(l)}$, $\text{H}_2\text{O}_{(l)}$ and $\text{CO}_{2(g)}$ is -166.2, -237.2 and -394.4 KJmole⁻¹ respectively and if combustion enthalpy of $\text{CH}_3\text{OH}_{(l)}$ is -726 KJmole⁻¹ what will be the efficiency of the fuel cell using CH_3OH as fuel ?

(A) 80 % (B) 87 % (C) 90 % (D) 97 %

51. From the given information of a thermodynamic reaction calculate $\Delta_f H^\circ_{(\text{OH})}$ at 298 K.

$[\Delta_f H^\circ_{(\text{H}^+_{\text{aq}})} = 0]$



(A) -22.88 KJ (B) -228.88 KJ (C) 228.88 KJ (D) -343.52 KJ

52. If $\Delta_{\text{diss}} H^\circ_{(\text{Cl}_2)} = 240$ KJ mole⁻¹, $\Delta_{\text{eg}} H^\circ_{\text{Cl}} = -349$ KJ mole⁻¹, $\Delta_{\text{hyd}} H^\circ_{(\text{Cl}^-)} = -381$ KJmole⁻¹.

Calculate change in enthalpy for $\frac{1}{2}\text{Cl}_{2(g)} \rightarrow \text{Cl}^-_{(\text{aq})}$?

(A) 152 KJmole⁻¹ (B) -850 KJmole⁻¹ (C) -610 KJmole⁻¹ (D) +120 KJmole⁻¹

53. Calculate the change in internal energy to convert 1 mole water into 1 mole vapour at 1 bar pressure and 100°C temperature ? Assume water vapour behaves as ideal gas and enthalpy of vapourisation of water at 370 K and 1 bar pressure is 41 KJmole⁻¹.

(A) 4.100 KJmole⁻¹ (B) 3.7904 KJmole⁻¹ (C) 37.904 KJmole⁻¹ (D) 41.00 KJmole⁻¹

54. Which of the following statement is true for a reaction occurring on its own ?

(A) Change in entropy is positive for a reaction occurring on its own in an isolated system.

(B) Endothermic reactions never occur on their own.

(C) Exothermic reactions always occur on their own.

(D) Decrease in energy during a reaction is the only measure of its spontaneity.

55. If ratio of enthalpy of formation of $\text{CO}_{2(g)}$ and $\text{SO}_{2(g)}$ is 4:3 and enthalpy of formation of CS_2 is 26 KJmole^{-1} , then for the following reaction calculate enthalpy of formation of $\text{SO}_{2(g)}$?
- $$\text{CS}_{2(l)} + 3\text{O}_{2(g)} \rightarrow \text{CO}_{2(g)} + 2\text{SO}_{2(g)}$$
- (A) $-88.6 \text{ Kcal mole}^{-1}$ (B) $-52.5 \text{ Kcal mole}^{-1}$ (C) $-71.7 \text{ Kcal mole}^{-1}$ (D) $-47.8 \text{ Kcal mole}^{-1}$
56. Ratio of bond enthalpy of XY, X_2 and Y_2 is 1:1 : 0.5 and $\Delta_f H_{(xy)} = -200 \text{ KJmole}^{-1}$ then calculate bond enthalpy of X_2 ?
- (A) 100 KJmole^{-1} (B) 300 KJmole^{-1} (C) 800 KJmole^{-1} (D) 400 KJmole^{-1}
57. Calculate the energy released when 500 cm^3 of 0.1 M HCl solution is mixed with 200 cm^3 of 0.2 M NaOH solution ?
- (A) $2.292 \text{ KJmole}^{-1}$ (B) $1.292 \text{ KJmole}^{-1}$ (C) $0.292 \text{ KJmole}^{-1}$ (D) $3.392 \text{ KJmole}^{-1}$
58. Which of the following thermodynamic relation is true ?
- (A) $dG = VdP - SdT$ (B) $dE = PdV + TdS$ (C) $dH = VdP + TdS$ (D) $dG = VdP + SdT$
59. If molar heat capacity of Al is 25 KJmole^{-1} , calculate the heat required to raise temperature of 54 gm Al from 30°C to 50°C ? [$M_{\text{Al}} = 27 \text{ gm/mole}$]
- (A) 1.5 KJ (B) 0.5 KJ (C) 1.0 KJ (D) 2.5 KJ
60. If combustion enthalpy of carbon and methane is $-x \text{ KJmole}^{-1}$ and $+z \text{ KJmole}^{-1}$ and formation enthalpy of water is $-y \text{ KJ mole}^{-1}$ then calculate enthalpy of formation of methane ?
- (A) $(-x - y + z) \text{ KJ}$ (B) $(-z - x + 2y) \text{ KJ}$ (C) $(-x - 2y - z) \text{ KJ}$ (D) $(-x - 2y + z) \text{ KJ}$
61. Standard enthalpy of formation of $\text{CO}_{2(g)}$, $\text{H}_2\text{O}_{(l)}$ and glucose at 25°C temperature is -400 KJmole^{-1} , -300 KJmole^{-1} and $-1300 \text{ KJmole}^{-1}$ respectively then calculate enthalpy of combustion of 1 gm glucose at 25°C temperature and 1 bar pressure ?
- (A) 2900 KJ (B) -2900 KJ (C) -16.11 KJ (D) 16.11 KJ
62. Calculate molar heat capacity of a monoatomic ideal gas in a reaction where ratio of P and V is 1 ?
- (A) $\frac{4R}{2}$ (B) $\frac{3R}{2}$ (C) $\frac{5R}{2}$ (D) 0
63. In an adiabatic reversible process a sample of Argon gas at 1 atmosphere and 27°C temperature increases its volume from 1.25 dm^3 to 2.50 dm^3 Calculate enthalpy changes during a reaction ? $C_v = 12.49 \text{ KJmole}^{-1}$ for Argon.
- (A) $+22.32 \text{ J}$ (B) $+2.232 \text{ J}$ (C) -11.64 J (D) -11.64 J
64. For which of the following $\Delta H = \Delta U$?
- (A) $\text{PCl}_{5(g)} \rightarrow \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$ (B) $2\text{CO}_{(g)} + \text{O}_2 \rightarrow 2\text{CO}_{2(g)}$
- (C) $\text{H}_{2(g)} + \text{Br}_{2(g)} \rightarrow 2\text{HBr}_{(g)}$ (D) $\text{C}_{(s)} + 2\text{H}_2\text{O}_{(g)} \rightarrow 2\text{H}_{2(g)} + \text{CO}_{2(g)}$

65. Calculate combustion enthalpy of cyclopropane at 298 K from the given information ?
 $\Delta_f H^\circ_{\text{CO}_2} = -300 \text{ KJmole}^{-1}$, $\Delta_f H^\circ_{\text{H}_2\text{O}} = -250 \text{ KJmole}^{-1}$
 $\Delta_f H^\circ_{\text{propane}} = -50 \text{ KJmole}^{-1}$,
 Cyclopropane $\rightarrow$ propane, $\Delta H = -30 \text{ KJmole}^{-1}$.
 (A) $-1470 \text{ KJmole}^{-1}$ (B) $-1730 \text{ KJmole}^{-1}$ (C) $-1670 \text{ KJmole}^{-1}$ (D) $-1530 \text{ KJmole}^{-1}$
66. H_2 , cyclohexene and cyclohexane have enthalpy of combustion -241 , -3800 and $-3920 \text{ KJmole}^{-1}$. Calculate Hydrogenation enthalpy of cycloHexene ?
 (A) -121 KJmole^{-1} (B) $+121 \text{ KJmole}^{-1}$ (C) $+242 \text{ KJmole}^{-1}$ (D) -242 KJmole^{-1}
67. If combustion enthalpy of methane and ethane is $-210 \text{ K cal mole}^{-1}$ and $-368 \text{ K cal mole}^{-1}$ respectively. Calculate combustion enthalpy of Decane ?
 (A) -158 Kcal (B) -1632 Kcal
 (C) -1700 Kcal (D) incomplete information
68. $A_{(l)} \xrightarrow{1 \text{ atm}} A_{(g)}$, $\Delta H_{\text{vap}} = 460.6 \text{ Kcalmol}^{-1}$, Boiling point = 50 K . Calculate its boiling point at 10 atm ?
 (A) 150 K (B) 75 K (C) 100 K (D) 200 K
69. Hydrogenation enthalpy of ethene is x_1 and hydrogenation enthalpy of benzene is x_2 . Calculate resonance energy of benzene ?
 (A) $x_1 - x_2$ (B) $x_1 + x_2$ (C) $3x_1 - x_2$ (D) $x_1 - 3x_2$
70. Enthalpy of neutralisation of oxalic acid with strong base is $-25.4 \text{ Kcalmole}^{-1}$. Enthalpy of neutralisation of a strong acid and a strong base is $-13.7 \text{ Kcalequivalent}^{-1}$ then calculate ionization enthalpy of $\text{H}_2\text{C}_2\text{O}_4$?
 (A) 1 Kcalmole^{-1} (B) 2 Kcalmole^{-1} (C) $18.55 \text{ Kcalmole}^{-1}$ (D) $11.7 \text{ Kcalmole}^{-1}$
71. Value of ΔU and q is respectively for 1 mole ideal at 27°C temperature undergoing reversible isothermal expansion from 2 atmosphere to 10 atmosphere ? ($R = 2 \text{ calorie}$)
 (A) 0, -965.84 cal (B) -965.84 cal , -865.58 cal
 (C) -865.84 cal , -865.58 cal (D) $+965.84 \text{ cal}$, $+865.58 \text{ cal}$
72. What will be the value of ΔH and ΔS at any temperature for a reaction occurring on its own ?
 (A) ΔH and ΔS both have +ve value. (B) ΔH and ΔS both have -ve value
 (C) ΔH +ve and ΔS -ve value. (D) ΔH -ve and ΔS +ve value.
73. If 0.1 mole ideal gas at constant pressure absorbs 41.75 joule and increase temperature by 20°C then the gas is
 (A) diatomic (B) monoatomic (C) triatomic (D) polyatomic
74. Which of the following reaction will have entropy change positive ?
 (A) $\text{H}_{2(g)} + \text{I}_{2(g)} \rightleftharpoons 2\text{HI}_{(g)}$ (B) $\text{HCl}_{(g)} + \text{NH}_{3(g)} \rightleftharpoons \text{NH}_4\text{Cl}_{(s)}$
 (C) $\text{NH}_4\text{NO}_{3(s)} \rightleftharpoons \text{N}_2\text{O}_{(g)} + 2\text{H}_2\text{O}_{(g)}$ (D) $\text{MgO}_{(s)} + \text{H}_{2(g)} \rightleftharpoons \text{Mg}_{(s)} + \text{H}_2\text{O}_{(l)}$
75. When a 1 mole of monoatomic ideal gas at $T \text{ K}$ temperature and 1 bar pressure due to isothermal expansion change volume from 1 litre to 2 litre, then calculate its temperature in K ?
 (A) $\frac{T}{2^3}$ (B) $T + \frac{2}{3 \times 0.0821}$ (C) T (D) $T - \frac{2}{3 \times 0.0821}$

76. Calculate the change in entropy on heating 200 gm water at constant pressure and increasing temperature from 10°C to 20°C ? (at constant pressure, molar heat capacity is 75.3 joule K⁻¹.mole⁻¹)
 (A) 29.0 joule K⁻¹ (B) 227.0 joule K⁻¹ (C) -227.0 joule K⁻¹ (D) -29.0 joule K⁻¹
77. At 298 K temperature, value of bond enthalpy for C – H, C – C, C = C and H – H is 414, 347, 615 and 434 KJmole⁻¹ respectively then calculate hydrogenation enthalpy of ethene ?
 (A) +250 KJ (B) -250 KJ (C) +125 KJ (D) -125 KJ
78. Based on the given bond enthalpy values, calculate enthalpy of formation of N₂H_{4(g)} ?

$$\begin{array}{ll} \text{N} - \text{N} \rightarrow 159 \text{ KJ mole}^{-1} & \text{H} - \text{H} \rightarrow 436 \text{ KJ mole}^{-1} \\ \text{N} = \text{N} \rightarrow 418 \text{ KJ mole}^{-1} & \text{N} - \text{H} \rightarrow 389 \text{ KJ mole}^{-1} \\ \text{N} \equiv \text{N} \rightarrow 941 \text{ KJ mole}^{-1} & \end{array}$$

 (A) +711 KJ mole⁻¹ (B) +98 KJ mole⁻¹ (C) -98 KJ mole⁻¹ (D) -711 KJ mole⁻¹
79. Calculate standard enthalpy change for the given reaction

$$\text{Na}_2\text{O}_{(s)} + \text{SO}_{3(g)} \rightarrow \text{Na}_2\text{SO}_{4(s)}$$

 (i) $\text{Na}_{(s)} + \text{H}_2\text{O}_{(l)} \rightarrow \text{NaOH}_{(s)} + \frac{1}{2} \text{H}_{2(g)}$ $\Delta H^\circ = -146 \text{ KJ mole}^{-1}$
 (ii) $\text{Na}_2\text{SO}_4 + \text{H}_2\text{O}_{(l)} \rightarrow 2\text{NaOH}_{(s)} + \text{SO}_{3(g)}$ $\Delta H^\circ = + 418 \text{ KJ mole}^{-1}$
 (iii) $2\text{Na}_2\text{O}_{(s)} + 2\text{H}_{2(g)} \rightarrow 4\text{Na}_{(s)} + 2\text{H}_2\text{O}_{(l)}$ $\Delta H^\circ = + 259 \text{ KJ mole}^{-1}$
 (A) +823 KJ (B) -581 KJ (C) -435 KJ (D) +531 KJ
80. Enthalpy of formation of SF_{6(g)}, S_(g) and F_(g) are -1100, 275 and 80 KJmole⁻¹ respectively. Calculate average bond enthalpy of S – F bond ?
 (A) 301 KJmole⁻¹ (B) 220 KJmole⁻¹ (C) 309 KJmole⁻¹ (D) 280 KJmole⁻¹

Answers : 46. (A), 47. (C), 48. (A), 49. (A), 50. (D), 51. (B), 52. (B), 53. (C), 54. (A), 55. (C), 56. (C), 57. (A), 58. (A), 59. (C), 60. (D), 61. (C), 62. (A), 63. (C), 64. (C), 65. (B), 66. (A), 67. (B), 68. (A), 69. (C), 70. (B), 71. (A), 72. (D), 73. (B), 74. (C), 75. (B), 76. (A), 77. (D), 78. (C), 79. (B), 80. (C)

● **Questions having one or more than one option correct :**

81. Which of the following is a state function ?
 (A) internal energy (B) irreversible expansion work
 (C) reversible expansion work (D) molar enthalpy
82. Which of the following acid base have enthalpy of neutralisation -53.7 KJ ?
 (A) HCN and NaOH (B) HNO₃ and NaOH (C) HCl and KOH (D) HCl and NH₄OH
83. Which of the following thermodynamic condition is responsible for a spontaneous reaction at 300 K temperature ?
 (A) $\Delta G^\circ = -400 \text{ KJmole}^{-1}$
 (B) $\Delta H^\circ = 200 \text{ KJmole}^{-1}$, $\Delta S^\circ = -4 \text{ joule K}^{-1}\text{mole}^{-1}$
 (C) $\Delta H^\circ = -200 \text{ KJmole}^{-1}$, $\Delta S^\circ = 4 \text{ joule K}^{-1}\text{mole}^{-1}$
 (D) $\Delta H^\circ = -200 \text{ Jmole}^{-1}$, $\Delta S^\circ = 40 \text{ joule K}^{-1}\text{mole}^{-1}$
84. Which of the following is extensive property ?
 (A) Elevation in Boiling point (B) Boiling point
 (C) E.M.F. of the cell (D) Standard cell potential

85. In standard conditions, if the reaction is at equilibrium then,
 (A) equilibrium constant $K = 0$ (B) equilibrium constant $K = 1$
 (C) $\Delta H^\circ = T\Delta S^\circ$ (D) $\Delta H^\circ - T\Delta S^\circ < 0$
86. For which of the following reaction $\Delta H > \Delta U$?
 (A) $\text{H}_{2(g)} + \text{I}_{2(g)} \rightarrow 2\text{HI}_{(g)}$ (B) $\text{PCl}_{5(g)} \rightarrow \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$
 (C) $2\text{H}_2\text{O}_{2(l)} \rightarrow 2\text{H}_2\text{O}_{(l)} + \text{O}_{2(g)}$ (D) $\text{C}_{(s)} + \text{O}_{2(g)} \rightarrow \text{CO}_{2(g)}$
87. Which of the following is not correct at 298 K ?
 (A) $\Delta_f G^\circ_{(\text{graphite})} = 0$ (B) $\Delta S^\circ_{(\text{graphite})} = 0$ (C) $\Delta_f H^\circ_{(\text{graphite})} = 0$ (D) $\Delta_f H^\circ_{\text{CO}_2} = 0$

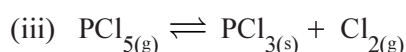
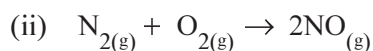
Answers : 81. (A), (D), 82. (B), (C), 83. (A), (C), (D), 84. (A), (C) 85. (B), (C), 86. (B), (C), 87. (B), (D)

88. Which type of enthalpy is related to Born Haber cycle ?
 (A) $\Delta_{\text{sub}} H$ (B) $\Delta_i H$ (C) $\Delta_D H$ (D) $\Delta_U H$
89. In which reaction entropy increases ?
 (A) dissolution of salt in water
 (B) evaporation of camphor
 (C) crystallisation of sugar from its aqueous solution
 (D) at constant temperature increase in pressure from 1 bar to 10 bar
90. Enthalpy change for $\text{C}_{(\text{graphite})} \longrightarrow \text{C}_{(g)}$ is
 (A) vapourisation enthalpy. (B) sublimation enthalpy
 (C) enthalpy of conversion of allotropes (D) atomisation enthalpy
- Each of the following questions have two statements. In which (A) statement of Assertion and second (R) statement of reason studying the statements carefully on the basis of the given instructions select the correct option.
- (A) both statements are correct and reason (B) is correct explanation of (A).
 (B) both statements are correct, but reason (B) is not the explanation of (A).
 (C) Statement (A) is correct and reason (B) wrong.
 (D) Statement (A) is wrong and reason (B) correct.
91. **Assertion (A) :** During isothermal expansion of ideal gas the absorbed heat is zero.
Reason (B) : volume occupied by ideal gas molecule is zero.
92. **Assertion (A) :** For all chemical reactions standard free energy of reaction is zero.
Reason (B) : At constant temperature and pressure decrease in free energy of system favours spontaneous reaction.
93. **Assertion (A) :** Enthalpy of formation of $\text{H}_2\text{O}_{(l)}$ is more than Enthalpy of formation of $\text{H}_2\text{O}_{(g)}$.
Reason (B) : Enthalpy value is -ve for $\text{H}_2\text{O}_{(g)} \longrightarrow \text{H}_2\text{O}_{(l)}$.
94. **Assertion (A) :** Enthalpy of reaction of KOH and HClO_4 and enthalpy of reaction of KOH and HCl is same.
Reason (B) : HClO_4 and HCl both are strong acids.
95. **Assertion (A) :** Entropy of elements is zero at zero kelvin temperature.
Reason (B) : All elements have standard entropy value more than 1.

Answers : 88. (A), (B), (C), (D) 89. (A), (B) 90. (B), (C), 91. (B), 92. (D), 93. (A), 94. (A), 95. (B)

● Column type questions

96. Column : I



Column : II

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

(q) $\Delta H = \Delta U$

(r) $\Delta H = \Delta U - 2RT$

(s) $\Delta H < \Delta U$

Answers : (i) $\rightarrow$ (q), (ii) $\rightarrow$ (q), (iii) $\rightarrow$ (p), (iv) $\rightarrow$ (r), (s)

97. Column : I

(i) (Theoretical enthalpy of formation)
(practical enthalpy of formation)

(ii) (reactant bond enthalpy)
(product bond enthalpy)

(iii) $C_p \Delta T$

(iv) $C_v \Delta T$

Column : II

(p) enthalpy of reaction

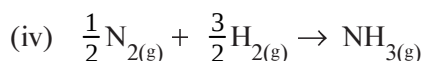
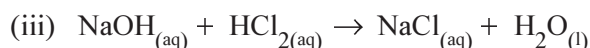
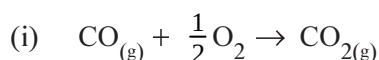
(q) Resonance energy

(r) ΔU

(s) ΔH

Answers : (i) $\rightarrow$ (q), (ii) $\rightarrow$ (p), (s) (iii) $\rightarrow$ (p), (s) (iv) $\rightarrow$ (r)

98. Column : I



Column : II

(p) Hydrogenation enthalpy

(q) enthalpy of formation

(r) combustion enthalpy

(s) Neutralisation enthalpy

Answers : (i) $\rightarrow$ (r), (ii) $\rightarrow$ (p), (iii) $\rightarrow$ (s), (iv) $\rightarrow$ (q)

● Integer type Questions

99. Value of specific heat ratio is 1.66 for AX gas, then value of X can be ?

Answers : 1

100. $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightarrow 2\text{NH}_{3(g)}$ reaction heat capacity at constant volume is XRT more than heat capacity at constant pressure then calculate value of X ?

Answers : 2

101. For Melting point of a solid substance P is $1.502 \text{ KJmole}^{-1}$ enthalpy change for converting 1 mole liquid P to solid is -5.5 JK^{-1} , then at what temperature in celcius can liquid p be solified ?

Answers : 0