

Thermodynamics-2

1) Hess's law states that

- 1) The standard enthalpy of an overall reaction is the sum of the enthalpy changes in individual reaction.
- 2) Enthalpy of formation of compound is same as the enthalpy of decomposition of the compound into constituent elements, but with opposite sign.
- 3) At constant temperature the pressure of a gas is inversely proportional to its volume.
- 4) The mass of a gas dissolved per lit of a solvent is proportional to the pressure of the gas in equilibrium with the solution.

2) For change in entropy units are

- 1) Mol/lit
- 2) Mol. lit⁻¹ sec⁻¹
- 3) J. mol⁻¹ K⁻¹
- 4) s⁻¹

3) In standard state the non spontaneous reaction is

- 1) Melting of ice
- 2) Natural radioactivity
- 3) Freezing of water
- 4) Rusting of iron

4) The incorrect statement according to second law of thermodynamics is

- 1) Heat can't flow from colder body to a hotter body on its own.
- 2) All spontaneous processes are thermodynamically irreversible.
- 3) Heat can be converted into work completely without causing some permanent change in the system (or) surroundings.
- 4) Perpetual motion machine of second kind is not possible.

5) Incorrect statement related to an irreversible process is

- 1) Entropy of the universe goes on increasing.
- 2) Gibbs energy of the system goes on decreasing.
- 3) Total energy of the universe goes on decreasing.
- 4) Total energy of the universe remains constant.

6. Entropy of a system depends upon

- 1) Volume only
- 2) Temperature only
- 3) Pressure only
- 4) Pressure, Volume and Temperature

7. One of the following reactions involves in decrease of entropy

- 1) Sublimation of dry ice
- 2) Crystallisation of salt from brine (aq)
- 3) Burning of rocket fuel
- 4) Decomposition of gaseous N_2O_4 .

8. The least random state of H_2O system is

- 1) Ice
- 2) Liquid water
- 3) Steam
- 4) Randomness is same all.

9. Which of the following process has negative value of ΔS ?

- 1) Dissolution of sugar in water
- 2) Stretching of rubber band
- 3) Decomposition of lime stone
- 4) Evaporation of water

10. For the reaction $Iodine(g) \rightarrow Iodine(s), \Delta H = -Ve$ Then choose the correct statement/s from the following

- a) The process is spontaneous at all temperatures.
- b) The process is accompanied by an increase in entropy.
- c) The process is accompanied by a decrease in entropy.
- d) The process is accompanied by a decrease in enthalpy.

The correct statements are

- 1) Only a, b and c
- 2) Only b and d
- 3) Only c and d
- 4) Only a, c and d

11. For a spontaneous process in a reaction

- 1) $\Delta S_{total} = (\Delta S_{system} + \Delta S_{surroundings}) < 0$
- 2) $\Delta S_{total} = (\Delta S_{system} + \Delta S_{surroundings}) = 0$
- 3) $\Delta S_{total} = (\Delta S_{system} + \Delta S_{surroundings}) > 0$
- 4) $\Delta S_{sys} > 0$ Only

12. Some statements are given with regard to entropy. The incorrect statements are

A) The absolute entropy of substances cannot be determined

B) In standard state entropy of elements is always positive

C) The entropy of universe always decreases

D) In a spontaneous process, for isolated system the entropy of a system generally increases

1) A, B 2) B, C 3) A, C 4) Only C

13. For an irreversible process, the value of $[\Delta S_{\text{sys}} + \Delta S_{\text{surrounding}}]$ is

1) >0 2) <0 3) 0 4) $2\Delta S_{\text{sys}}$

14. $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$ $\Delta H = -ve$ and $\Delta G = -ve$ Then the reaction is

1) Spontaneous and instantaneous 2) Spontaneous and endothermic

3) Spontaneous and slow 4) Non spontaneous and slow

15. What is necessary condition for spontaneity of a process?

1) $\Delta S > 0$ 2) $\Delta E < 0$ 3) $\Delta H < 0$ 4) $\Delta G < 0$

16. Based on the third law of thermodynamics, the entropy can be obtained using the equation.

1) $\Delta S = \frac{\Delta H}{T}$ 2) $\int_0^T T \cdot C_p^{-1} dT = S$

3) $\Delta G = T\Delta S$ 4) $\int_0^T C_p T^{-1} dT = S$

17. The process of evaporation of a liquid is accompanied by

a) Increase in enthalpy

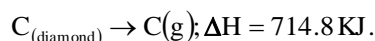
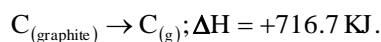
b) Increase in entropy

c) Decrease in Gibbs energy

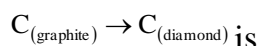
The correct statement (s) is or are

1) Only a and c 2) Only b and c 3) Only a and b 4) All

18. Given that



The ΔH for the following reaction



- 1) 1.9 KJ 2) -1.9 KJ 3) Zero 4) 714.8 KJ

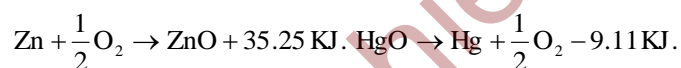
Solution: $\Delta H = \text{Equation 1} - \text{equation 2} = 716.7 - 714.8 = 1.9 \text{ KJ}$

19. At 25°C the heat of formation of $\text{H}_2\text{O} (\text{l})$ is $-285.9 \text{ KJ mole}^{-1}$ and that for $\text{H}_2\text{O} (\text{g})$ is $-242.8 \text{ KJmole}^{-1}$. The heat of vaporization of water at the same temperature is

- 1) 43.1 KJ mole^{-1} 2) 242.8 KJ mole^{-1} 3) -43.1 KJ mole^{-1} 4) -242.8 KJ mole^{-1}

Solution: $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g}), \Delta H = H_p - H_R = -242.8 - (-285.9) = +43.1 \text{ KJ}$

20. Given that



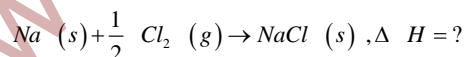
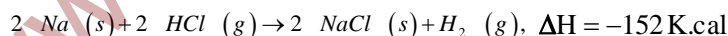
The heat of the reaction $\text{Zn} + \text{HgO} \rightarrow \text{ZnO} + \text{Hg}$ is

- 1) -26.14 KJ 2) 44.39 KJ 3) -44.39 KJ 4) 26.14 KJ

Solution: The ΔH for the reaction = $E q 1 + E q 2 = \text{Zn} + \text{HgO} \rightarrow \text{ZnO} + \text{Hg} + 26.14 \text{ KJ}$

Therefore $\Delta H = -26.14 \text{ KJ}$

21 $\text{H}_2 (\text{g}) + \text{Cl}_2 (\text{g}) \rightarrow 2 \text{HCl} (\text{g}), \Delta H = -44 \text{ K.cal}$



- 1) +108 K.cal 2) -196 K.cal 3) -98 K.cal 4) 50 K.cal

Solution: $\Delta H = 1/2 [E q 1 + E q 2] = 1/2 [-44 - 152] = -98 \text{ K.cal}$

22. If the heats of formation of CO_2 (g), H_2O (l) and CH_4 (g) are -394 kJ mol^{-1} , -286 kJ mol^{-1} and -76 kJ mol^{-1} respectively then the heat of combustion of methane is

- 1) $+1042 \text{ kJ/mole}$ 2) $+890 \text{ kJ/mole}$ 3) -890 kJ/mole 4) -1042 kJ/mole

Solution: The required equation is, $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{l}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$; $\Delta H = ?$

$$\begin{aligned} \Delta H &= \text{Heat of formation of Products} - \text{Heat of formation of Reactants} \\ &= [-394 + 2(-286)] - (-76) = -890 \text{ kJ.} \end{aligned}$$

The heat of combustion of methane = -890 kJ mol^{-1} .

23. The enthalpy of combustion of $\text{H}_2(\text{g})$ to give $\text{H}_2\text{O}(\text{g})$ is -249 kJ mol^{-1} and bond enthalpies of H-H and O=O are 433 kJ mol^{-1} and 492 kJ mol^{-1} respectively, the bond enthalpy of O-H is

- 1) 464 kJ mol^{-1} 2) -464 kJ mol^{-1} 3) 232 kJ mol^{-1} 4) -232 kJ mol^{-1}

Solution: Required Equation is $\text{H}_2 + 1/2 \text{ O}_2 \rightarrow \text{H}_2\text{O}$, $\Delta H = -249 \text{ kJ mol}^{-1}$

$$\begin{aligned} \Delta H &= 1(\text{H-H}) + 1/2(\text{O=O}) - 2(\text{O-H}) = -249 \text{ kJ/mol} \\ &= 433 + 1/2(492) - 2(\text{O-H}) = -249 \\ \text{O-H bond enthalpy} &= 464 \text{ kJ/mole} \end{aligned}$$

24. If at 298K the bond energies of C-H , C-C , C=C and H-H bonds are respectively 414, 347, 615 and 435 kJ mol^{-1} , the value of enthalpy change for the reaction $\text{H}_2\text{C}=\text{CH}_2(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{H}_3\text{C}-\text{CH}_3(\text{g})$ at 298 K will be

- (1) -250 kJ (2) $+125 \text{ kJ}$ (3) -125 kJ (4) $+250 \text{ kJ}$

Solution: $\text{CH}_2=\text{CH}_2(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{CH}_3-\text{CH}_3$

$$\begin{aligned} \Delta H &= 1(\text{C}=\text{C}) + 4(\text{C}-\text{H}) + 1(\text{H}-\text{H}) - 1(\text{C}-\text{C}) - 6(\text{C}-\text{H}) \\ &= 1(\text{C}=\text{C}) + 1(\text{H}-\text{H}) - 1(\text{C}-\text{C}) - 2(\text{C}-\text{H}) \\ &= 615 + 435 - 347 - 2 \times 414 = 1050 - 1175 = -125 \text{ kJ.} \end{aligned}$$

25. The enthalpies of combustion of carbon and carbon monoxide are -393.5 and -283 kJ mol^{-1} respectively. The enthalpy of formation of carbon monoxide per mole is

- (1) -676.5 kJ (2) 676.5 kJ (3) 110.5 kJ (4) -110.5 kJ

Solution: i) $\text{C} + \text{O}_2 \rightarrow \text{CO}_2, \Delta H = -393 \text{ kJ/mole}$

ii) $\text{CO} + \frac{1}{2} \text{O}_2 \rightarrow \text{CO}_2, \Delta H = -283 \text{ kJ/mole}$

After, (i) - (ii),

We have $\text{C} + \frac{1}{2} \text{O}_2 \rightarrow \text{CO} \quad \Delta H = -110.5 \text{ kJmol}^{-1}$

26. The entropy change for the conversion of 1 mole of α -tin (at 35°C , 2 atm) to 1 mole of β -tin (35°C , 2 atm) if the enthalpy of transition is $2.095 \text{ kJ mol}^{-1}$

- 1) $7.32 \text{ J mol}^{-1} \text{ K}^{-1}$ 2) $14.62 \text{ J K mol}^{-1}$ 3) $56. \text{ J mol}^{-1} \text{ K}^{-1}$ 4) $28.64 \text{ J mol}^{-1} \text{ K}^{-1}$

Solution: $\Delta S = \frac{\Delta H}{T}$, $T = 273 + 13 = 286 \text{ K}$

$$\Delta S = 2.095 \times 1000 \text{ J mol}^{-1} / 286 \text{ K} = 7.32 \text{ J mol}^{-1} \text{ K}^{-1}$$

27. ΔH (vap) for water is 40.7 kJ mol^{-1} . The entropy of vapourisation of water is

- 1) $-40.7 \text{ kJ mol}^{-1}$ 2) $407 \text{ J mol}^{-1} \text{ K}^{-1}$ 3) $109 \text{ J mol}^{-1} \text{ K}^{-1}$ 4) 722 J mol^{-1}

Solution: $\Delta S = \Delta H / T = 40.7 \times 1000 \text{ J mole}^{-1} / 373 \text{ K} = 109 \text{ J mol}^{-1} \text{ K}^{-1}$

28. The following data is known about the melting of a compound AB. $\Delta H = 9.2 \text{ kJ mol}^{-1}$ $\Delta S = 0.008 \text{ kJ K}^{-1} \text{ mol}^{-1}$. Its melting point is

- 1) 736 K 2) 1050 K 3) 1150 K 4) 1150°C

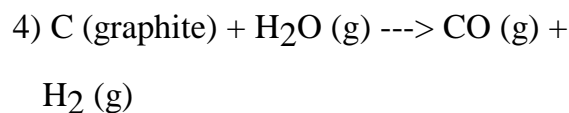
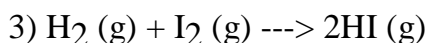
Solution: $T = (\Delta H / \Delta S) = 9.2 / 0.008 = 9200 / 8 = 1150 \text{ K}$

29. For the process $\text{CO}_2(\text{s}) \rightarrow \text{CO}_2(\text{g})$

- 1) Both ΔH and ΔS are +ve 2) ΔH is -ve, ΔS is +ve
3) ΔH is +ve, ΔS is -ve 4) Both ΔH and ΔS are -ve

30. Which of the following reaction is associated with an increase in entropy?

- 1) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$ 2) $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{l})$



31. For the reaction, $2\text{HgO}(\text{s}) \rightarrow 2\text{Hg}(\text{l}) + \text{O}_2(\text{g})$

- 1) $\Delta\text{H} > 0$ & $\Delta\text{S} < 0$ 2) $\Delta\text{H} > 0$ & $\Delta\text{S} > 0$ 3) $\Delta\text{H} < 0$ & $\Delta\text{S} < 0$ 4) $\Delta\text{H} < 0$ & $\Delta\text{S} > 0$

32. Randomness is minimum in case of

- 1) H_2 gas at 1 atm 2) H_2 gas at 5 atm
3) H_2 gas at 10 atm 4) All have same randomness

33. The value of S is negative for the process

- 1) Burning of rocket Fuel 2) Dissolution of sugar
3) Sublimation of Iodine 4) Condensation of a vapour.

34. The quantity which is not zero for an element in its standard state at 298 K is

- 1) S^0 2) H^0 3) G^0 4) Both H^0 and S^0

35. Which of the following process involves decrease in the entropy of system?

- 1) $\text{Br}_2(\text{l}) \rightarrow \text{Br}_2(\text{g})$ 2) Diamond \rightarrow graphite
3) $\text{N}_2(\text{g})$ 10atm \rightarrow $\text{N}_2(\text{g})$. 1 atm 4) Boiling of egg so that it become hard

36. In which of the following process entropy increases?

- 1) Rusting of iron 2) Vapourisation of Camphor
3) Crystallisation of sugar from syrup 4) Atomisation of di Nitrogen
1) a and b 2) b and c 3) b and d 4) Only d

37. For the spontaneous process $2\text{F}(\text{g}) \rightarrow \text{F}_2(\text{g})$, the sign of ΔH and ΔS respectively are

- 1) +ve, -ve 2) +ve, +ve 3) -ve, -ve 4) -ve, +ve

38. Entropy of a perfect crystalline solid at absolute zero is

- 1) Zero 2) Less than zero 3) Greater than zero 4) Unity

39. Which of the following has highest Entropy?

- 1) Mercury 2) Hydrogen 3) Water 4) Graphite

40. Identify the correct statement regarding a spontaneous process

- 1) Lowering of energy in the process is the only criterion for spontaneity.
- 2) For a spontaneous process in an isolated system, the change in entropy is positive.
- 3) Endothermic process are never spontaneous.
- 4) Exothermic process are always spontaneous.

41. **Assertion:** At absolute zero the entropy of a perfectly crystalline substance is taken as zero.

Reason: At absolute zero the constituent particles become completely motionless.

- 1) Both A and R are true and R is the correct explanation of A.
- 2) Both A and R are true but R is not the correct explanation of A.
- 3) A is true but R is false.
- 4) Both A and R are false.

42. **Assertion:** Decrease in free energy causes spontaneous reaction.

Reason: Spontaneous reactions are invariably exothermic reactions.

- 1) Both A and R are true and R is the correct explanation of A.
- 2) Both A and R are true but R is not the correct explanation of A.
- 3) A is true but R is false.
- 4) Both A and R are false.

43. **For a spontaneous reaction the ΔG , equilibrium constant (K_C) and E^0_{cell} will be respectively**

- (1) -ve, >1, -ve (2) -ve, <1, -ve (3) +ve, >1, -ve (4) -ve, >1, +ve

44. **Which of the following relationship is correct?**

- 1) $\Delta G^0 = -RT \ln K$ 2) $K = e^{-\Delta G^0/RT}$ 3) $K = 10^{-\Delta G^0/2.303RT}$ 4) All are correct

45. **Which of the following is the condition for a non spontaneous reaction at high temperature but spontaneous at low temperature**

ΔH ΔS

- 1) -ve -ve
- 2) +ve +ve
- 3) -ve +ve

4) +ve -ve

46. If $S_{\text{surroundings}} = + 959.1 \text{ JK}^{-1}\text{mol}^{-1}$

$S_{\text{system}} = -163.1 \text{ Jk}^{-1} \text{ mol}^{-1}$ Then the process is

- 1) Spontaneous 2) Non spontaneous
3) At equilibrium 4) Cannot be predicted

Solution: $S_{\text{total}} = S_{\text{sys}} + S_{\text{surr}} = +ve$. Thus the process is spontaneous.

47. ΔG^0 for conversion of oxygen to ozone, $3/2 \text{ O}_{2(\text{g})} \rightarrow \text{O}_{3(\text{g})}$ at 298K is [K_P for this conversion is 2.47×10^{-29}]

- 1) 163 j /mole 2) 163 KJ/mole 3) 16.3J/mole 4) 16.3 KJ/mole

Solution: We know $= -2.303 RT \log K_p$ and $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$.

Therefore $\Delta G^0 = -2.303(8.314 \text{ JK}^{-1} \text{ mol}^{-1}) (298 \text{ K}) (\log 2.47 \times 10^{-29}) = 163000 \text{ J mol}^{-1}$ or 163 kJ mol^{-1}

48. The standard free energy of Cu_{aq}^+ is 50 kJ mol^{-1} and that of $\text{Cu}_{\text{aq}}^{+2}$ is 66 kJ mol^{-1} . The change in free energy for the reaction, $\text{Cu}_{\text{aq}}^+ \rightarrow \text{Cu}_{\text{aq}}^{+2} + e^-$ is

- 1) 116KJ/mole 2) -16KJ/mole 3) 16KJ/mole 4) -34KJ/mole

Solution: Standard free energy change,

$$\Delta G^0 = \Delta G^0_{\text{Cu}^{+2}} - \Delta G^0_{\text{Cu}^+} = 66 \text{ kJ mol}^{-1} - 50 \text{ kJ mol}^{-1} = 16 \text{ kJ mol}^{-1}.$$

49) The entropy change for vapourisation of a liquid is $109.3 \text{ JK}^{-1}\text{mol}^{-1}$. The molar heat of vapourisation of that liquid is $40.77 \text{ kJ mol}^{-1}$. The boiling point of the liquid is

- 1) 373°C 2) 100°C 3) 100K 4) 646K

Solution: Entropy change for vapourisation, $= 109.3 \text{ JK}^{-1} \text{ mol}^{-1}$. Molal heat of vapourisation of water is $40.77 \text{ kJ mol}^{-1}$.

From the entropy change, $\Delta S = q_{\text{rev}}/T$.

Boiling point, $T = \frac{q_{\text{rev}}}{\Delta S}$ (or) $T = \frac{40.77 \times 1000}{109.3} = 373\text{K} = 373 - 273 = 100^\circ\text{C}$

50) ΔS for vapourisation of 900 g water (in KJ/K) is [$\Delta H_{\text{vap}} = 40\text{KJ/mol}$]

- 1) (900×40) 2) $(50 \times 40)/373$ 3) $(90 \times 40)/373$ 4) $(18 \times 40)/373$

KEY

1)1 2)3 3)3 4)3 5)3 6)4 7)2 8)1 9)2 10)3

11)3 12)3 13)1 14)3 15)4 16)4 17)4 18)1 19)1 20)1

21)3 22)3 23)1 24)3 25)4 26)1 27)3 28)3 29)1 30)4

31)2 32)3 33)4 34)1 35)3 36)3 37)3 38)1 39)2 40)2

41)1 42)3 43)4 44)4 45)1 46)1 47)2 48)3 49)2 50)2