DPP - Daily Practice Problems

Chapter-wise Sheets

Date : **Start Time :** **End Time :**

CHEMISTRY (CC06)

SYLLABUS : Thermodynamics

Max. Marks : 180 **Marking Scheme :** + 4 for correct & (–1) for incorrect **Time : 60 min.**

INSTRUCTIONS : This Daily Practice Problem Sheet contains 45 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.

1. In a closed insulated container a liquid is stirred with a paddle to increase the temperature. Which of the following is true?

(a) $\Delta E = W \neq 0$ (b) $\Delta E = W, q = 0$

(c) $\Delta E = 0, W = q \neq 0$ (d) $W = 0, \Delta W = q \neq 0$

2. One mole of a non-ideal gas undergoes a change of state (2.0 atm, 3.0 L, 95 K) $\rightarrow$ (4.0 atm, 5.0 L, 245 K) with a change in internal energy, $\Delta U = 30.0$ L atm. The change in enthalpy ΔH of the process in L atm is.

(a) 40.0 (b) 42.3

(c) 44.0 (d) Not defined because pressure is not constant

3. Assuming that water vapour is an ideal gas, the internal energy change (ΔU) when 1 mol of water is vapourised at 1 bar pressure and 100°C, (given : molar enthalpy of vapourisation of water at 1 bar and 373 K = 41 kJ mol^{-1} and R = 8.3 J mol^{-1} K^{-1}) will be

(a) 41.00 kJ mol^{-1} (b) 4.100 kJ mol^{-1}

(c) 3.7904 kJ mol^{-1} (d) 37.904 kJ mol^{-1}

4. A piston filled with 0.04 mole of an ideal gas expands reversibly from 50.0 mL to 375 mL at a constant temperature of 37.0°C. As it does so, it absorbs 208 J of heat. The values of q and w for the process will be:
(R = 8.314 J/mol K) (ln 7.5 = 2.01)

(a) $q = +208\,J, w = -208\,J$ (b) $q = -208\,J, w = -208\,J$

(c) $q = -208\,J, w = +208\,J$ (d) $q = +208\,J, w = +208\,J$

5. Among the following, the intensive property is (properties are)

(a) molar conductivity (b) electromotive force

(c) resistance (d) heat capacity

6. The variation of heat of reaction with temperature is given by :

(a) Van't Hoff equation
(b) Clausius- Clapeyron equation
(c) Nernst equation
(d) Kirchoff's equation

7. The difference between heats of reaction at constant pressure and constant volume for the reaction :
$2\,C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l)$ at 25°C in kJ is

(a) –7.43 (b) +3.72

(c) –3.72 (d) +7.43

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ			

Space for Rough Work

8. The enthalpy of vapourisation of water from the following two equations is.

$$H_2(g)+\frac{1}{2}O_2(g) \dashrightarrow H_2O\ (l),\ \Delta H=-286\,kJ$$

$$H_2\ (g)+\frac{1}{2}O_2\ (g), \rightarrow H_2O\ (g),\ \Delta H=-245.5\,kJ$$

(a) 6.02 kJ (b) 40.5 kJ (c) 62.3 kJ (d) 1.25 kJ

9. For complete combustion of ethanol,

$$C_2H_5OH(l)+3O_2(g) \longrightarrow 2CO_2(g)+3H_2O(l),$$

the amount of heat produced as measured in bomb calorimeter, is 1364.47 kJ mol^{-1} at 25°C. Assuming ideality the enthalpy of combustion, $\Delta_c H$, for the reaction will be: (R = 8.314 kJ mol^{-1})

(a) −1366.95 kJ mol^{-1} (b) −1361.95 kJ mol^{-1}

(c) −1460.95 kJ mol^{-1} (d) −1350.50 kJ mol^{-1}

10. The direct conversion of A to B is difficult, hence it is carried out by the following shown path :

$$\begin{tikzcd} C \arrow[r] & D \arrow[d] \\ A \arrow[u] & B \end{tikzcd}$$

Given

$\Delta S_{(A\to C)} = 50$ e.u., $\Delta S_{(C\to D)} = 30$ e.u., $\Delta S_{(B\to D)} = 20$ e.u., where e.u. is the entropy unit, then $\Delta S_{(A\to B)}$ is

(a) +60 e.u. (b) +100 e.u. (c) −60 e.u. (d) −100 e.u.

11. The heat of combustion of $CH_4(g)$, C (graphite), $H_2(g)$ are −20 kcal, −40 kcal −10 kcal respectively. The heat of formation of methane is

(a) −40 kcal (b) +40 kcal

(c) −80.0 kcal (d) + 80 kcal

12. From the following bond energies:

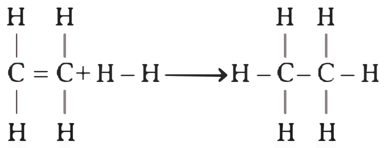
H – H bond energy: 431.37 kJ mol^{-1}

C = C bond energy: 606.10 kJ mol^{-1}

C – C bond energy: 336.49 kJ mol^{-1}

C – H bond energy: 410.50 kJ mol^{-1}

Enthalpy for the reaction,



$$H_2C=CH_2 + H-H \longrightarrow H_3C-CH_3$$

will be:

(a) −243.6 kJ mol^{-1} (b) −120.0 kJ mol^{-1}

(c) 553.0 kJ mol^{-1} (d) 1523.6 kJ mol^{-1}

13. The favourable conditions for a spontaneous reaction are

(a) $T\Delta S > \Delta H,\ \Delta H = +ve,\ \Delta S = +ve$

(b) $T\Delta S > \Delta H,\ \Delta H = +ve,\ \Delta S = -ve$

(c) $T\Delta S = \Delta H,\ \Delta H = -ve,\ \Delta S = -ve$

(d) $T\Delta S = \Delta H,\ \Delta H = +ve,\ \Delta S = +ve$

14. For which change $\Delta H \neq \Delta E$:

(a) $H_2(g)+I_2(g) \rightarrow 2HI(g)$ (b) $HCl + NaOH \rightarrow NaCl$

(c) $C(s)+O_2(g) \rightarrow CO_2(g)$ (d) $N_2(g)+3H_2(g) \rightarrow 2NH_3(g)$

15. The species which by definition has **ZERO** standard molar enthalpy of formation at 298 K is

(a) $Br_2(g)$ (b) $Cl_2(g)$ (c) $H_2O(g)$ (d) $CH_4(g)$

16. For which of the following process, ΔS is negative?

(a) $H_2(g) \rightarrow 2H(g)$

(b) $N_2(g)(1atm) \rightarrow N_2(g)(8atm)$

(c) $2SO_3(g) \rightarrow 2SO_2(g)+O_2(g)$

(d) $C_{(diamond)} \rightarrow C_{(graphite)}$

17. Given the following entropy values (in JK^{-1} mol^{-1}) at 298 K and 1 atm :

$H_2(g)$: 130.6, $Cl_2(g)$: 223.0 and HCl (g) : 186.7. The entropy change (in JK^{-1} mol^{-1}) for the reaction

$H_2(g)+Cl_2(g) \rightarrow 2HCl(g)$ is

(a) +540.3 (b) 727.0 (c) −166.9 (d) 19.8

18. In conversion of lime-stone to lime,

$CaCO_3(s) \rightarrow CaO(s)+CO_2(g)$ the values of ΔH° and ΔS° are + 179.1 kJ mol^{-1} and 160.2 J/K respectively at 298 K and 1 bar. Assuming that ΔH° and ΔS° do not change with temperature, temperature above which conversion of lime-stone to lime will be spontaneous is

(a) 1118 K (b) 1008 K (c) 1200 K (d) 845 K.

19. $(\Delta H - \Delta U)$ for the formation of carbon monoxide (CO) from its elements at 298 K is

(R = 8.314 JK^{-1} mol^{-1})

(a) −2477.57 J mol^{-1} (b) 2477.57 J mol^{-1}

(c) −1238.78 J mol^{-1} (d) 1238.78 J mol^{-1}

20. The incorrect expression among the following is :

(a) $\dfrac{\Delta G_{system}}{\Delta S_{total}} = -T$

(b) In isothermal process, $w_{reversible} = -nRT\,\ell n\dfrac{V_f}{V_i}$

(c) $\ln K = \dfrac{\Delta H^\circ - T\Delta S^\circ}{RT}$

(d) $K = e^{-\Delta G^\circ/RT}$

RESPONSE GRID

8. ⓐⓑⓒⓓ 9. ⓐⓑⓒⓓ 10. ⓐⓑⓒⓓ 11. ⓐⓑⓒⓓ 12. ⓐⓑⓒⓓ
13. ⓐⓑⓒⓓ 14. ⓐⓑⓒⓓ 15. ⓐⓑⓒⓓ 16. ⓐⓑⓒⓓ 17. ⓐⓑⓒⓓ
18. ⓐⓑⓒⓓ 19. ⓐⓑⓒⓓ 20. ⓐⓑⓒⓓ

Space for Rough Work

21. The following two reactions are known :

$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g)$; $\Delta H = -26.8$ kJ

$FeO(s) + CO(g) \longrightarrow Fe(s) + CO_2(g)$; $\Delta H = -16.5$ kJ

The value of ΔH for the following reaction

$Fe_2O_3(s) + CO(g) \longrightarrow 2FeO(s) + CO_2(g)$ is;

(a) +6.2kJ (b) +10.3 kJ (c) –43.3 kJ (d) –10.3 kJ

22. For a particular reversible reaction at temperature T, ΔH and ΔS were found to be both +ve. If T_e is the temperature at equilibrium, the reaction would be spontaneous when

(a) $T_e > T$ (b) $T > T_e$

(c) T_e is 5 times T (d) $T = T_e$

23. The standard enthalpy of formation of NH_3 is -46.0 kJ mol^{-1}. If the enthalpy of formation of H_2 from its atoms is -436 kJ mol^{-1} and that of N_2 is -712 kJ mol^{-1}, the average bond enthalpy of N – H bond in NH_3 is

(a) -964 kJ mol^{-1} (b) $+352$ kJ mol^{-1}

(c) $+1056$ kJ mol^{-1} (d) -1102 kJ mol^{-1}

24. Standard entropy of X_2, Y_2 and XY_3 are 60, 40 and 50 J K^{-1} mol^{-1}, respectively. For the reaction,

$\frac{1}{2}X_2 + \frac{3}{2}Y_2 \rightarrow XY_3, \Delta H = -30$ kJ , to be at equilibrium, the temperature will be

(a) 1250K (b) 500K (c) 750K (d) 1000K

25. A heat engine abosrbs heat Q_1 at temperature T_1 and heat Q_2 at temperature T_2. Work done by the engine is J $(Q_1 + Q_2)$. This data

(a) violates 1st law of thermodynamics

(b) violates 1st law of themodynamics if Q_1 is –ve

(c) violates 1st law of thermodynamics of Q_2 is –ve

(d) does not violate 1st law of themodynamics.

26. The standard enthalpies of formation of $CO_2(g)$, $H_2O(l)$ and glucose(s) at 25°C are –400 kJ/mol, –300 kJ/mol and –1300 kJ/mol, respectively. The standard enthalpy of combustion per gram of glucose at 25°C is

(a) +2900 kJ (b) –2900 kJ (c) –16.11 kJ (d) +16.11 kJ

27. Using the data provided, calculate the multiple bond energy (kJ mol^{-1}) of a $C \equiv C$ bond in C_2H_2. That energy is (take the bond energy of a C – H bond as 350 kJ mol^{-1})

$2C(s) + H_2(g) \longrightarrow HC \equiv CH(g)$; $\Delta H = 225$ kJ mol^{-1}

$2C(s) \longrightarrow 2C(g)$; $\Delta H = 1410$ kJ mol^{-1}

$H_2(g) \longrightarrow 2H(g)$; $\Delta H = 330$ kJ mol^{-1}

(a) 1165 (b) 837 (c) 865 (d) 815

28. The enthalpy of neutralisation of NH_4OH and CH_3COOH is – 10.5 kcal mol^{-1} and enthalpy of neutralisation of CH_3COOH with strong base is – 12.5 kcal mol^{-1}. The enthalpy of ionisation of NH_4OH will be

(a) 3.2 kcal mol^{-1} (b) 2.0 kcal mol^{-1}

(c) 3.0 kcal mol^{-1} (d) 4.0 kcal mol^{-1}

29. The enthalpy change of formation of $CO_2(g)$ is – 393 kJ mol^{-1} and that of H_2O (l) is – 286 kJ mol^{-1}. The enthalpy of combustion of one mole of ethanol (C_2H_5OH) is –1360. The enthalpy change for the formation of one mole of ethanol form its constituent elements is

(a) –681 kJ (b) –284 kJ (c) +965 kJ (d) 1360 kJ

30. The lattice energy of solid NaCl is 180 kcal mol^{-1} and enthalpy of solution is 1 kcal mol^{-1}. If the hydration energies of Na^+ and Cl^- ions are in the ratio 3 : 2, what is the enthalpy of hydration of sodium ion ?

(a) – 107.4 kcal mol^{-1} (b) 107.4 kcal mol^{-1}

(c) 71.6 kcal mol^{-1} (d) – 71.6 kcal mol^{-1}

31. A certain reaction is non spontaneous at 298K. The entropy change during the reaction is 121 J K^{-1}. If the reaction is endothermic or exothermic, the minimum value of ΔH for the reaction is

(a) endothermic, $\Delta H = 36.06$ kJ

(b) exothermic, $\Delta H = -36.06$ kJ

(c) endothermic, $\Delta H = 60.12$ kJ

(d) exothermic, $\Delta H = -60.12$ kJ

32. Which of the following statement is incorrect ?

(a) The standard enthalpy of reaction is the enthalpy change for a reaction when all the participating substances are in their standard states.

(b) The standard state of a substance at a specified temperature is its pure form at 1 bar.

(c) The standard state of solid iron at 298 K is pure iron at 1 bar

(d) Standard conditions are denoted by adding the superscript $\ominus$ to the symbol ΔH e.g., $-\Delta H^{\ominus}$

33. Match the columns

	Column-I		**Column-II**
A.	Exothermic	I.	$\Delta H = 0, \Delta E = 0$
B.	Spontaneous	II.	$\Delta G = 0$
C.	Cyclic process	III.	ΔH is negative
D.	Equilibrium	IV.	ΔG is negative

(a) A – II; B – III; C – I; D – IV

(b) A – IV; B – I; C – III; D – II

(c) A – I; B – II; C – IV; D – III

(d) A – III; B – IV; C – I; D – II

RESPONSE GRID	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ
	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ
	31. ⓐⓑⓒⓓ	32. ⓐⓑⓒⓓ	33. ⓐⓑⓒⓓ		

34. The ΔH at 358 K for the reaction

$$Fe_2O_3(s) + 3\,H_2(g) \longrightarrow 2Fe(s) + 3\,H_2O(l)$$

given that $\Delta H_{298} = -33.29\ kJmol^{-1}$ and C_p for $Fe_2O_3(s)$, Fe(s), H_2O (l) and $H_2(g)$ and 103.8, 25.1, 75.3 and 28.8 J/K mol

(a) $-28.136\ kJmol^{-1}$ (b) $-38.3\ kJmol^{-1}$
(c) $42.5\ kJmol^{-1}$ (d) $56.2\ kJ\ mol^{-1}$

35. The enthalpy of neutralisation of a weak acid in 1 M solution with a strong base is – 56.1 kcal mol^{-1}. If the enthalpy of ionisation of acid is 1.5 kcal mol^{-1} and enthalpy of neutralisation of the strong acid with a strong base is –57.3 $kJeq^{-1}$. What is the % ionisation of the weak acid in molar solution (assume the acid is monobasic)

(a) 25 (b) 20 (c) 15 (d) 10

36. ΔH_f° of NF_3 is – 113 kJ mol^{-1} and N–F bond energy is 273.0 kJ mol^{-1}. If N≡N and F–F bond energies are in the rates 6 : 1, their magnitudes will be

(a) 780.0 kJ mol^{-1}, 130.0 kJ mol^{-1}
(b) 840 kJ mol^{-1}, 140 kJ mol^{-1}
(c) 950.0 kJ mol^{-1}, 158.3 kJ mol^{-1}
(d) 941.3 kJ mol^{-1}, 156.9 kJ mol^{-1}

37. Consider the following processes :

	ΔH (kJ/mol)
$1/2A \to B$	+150
$3B \to 2C + D$	–125
$E + A \to 2D$	+350

For $B + D \to E + 2C$, ΔH will be :

(a) 525 kJ/mol (b) – 175 kJ/mol
(c) –325 kJ/mol (d) 325 kJ/mol

38. For an isothermal reversible expansion process, the value of q can be calculated by the expression

(a) $q = 2.303nRT\log\frac{V_2}{V_1}$ (b) $q = -2.303nRT\log\frac{V_2}{V_1}$

(c) $q = -P_{exp}nRT\log\frac{V_1}{V_2}$ (d) None of these

39. Match the columns

Column-I	**Column-II**
A. $C_4H_{10} + \frac{13}{2}O_2 \to 4CO_2 + 5H_2O; \Delta H = -w$	I. Enthalpy of atomisation
B. $CH_4 \to C + 4H; \Delta H = x$	II. Enthalpy of formation
C. $H_2 + Br_2 \to 2HBr; \Delta H = y$	III. Enthalpy of combustion
D. $Na^{-}(s) \to Na(g); \Delta H = z$	IV. Enthalpy of sublimation

(a) A – IV; B – I; C – II; D – III
(b) A – II; B – III; C – I; D – IV
(c) A – III; B – I; C – II; D – IV
(d) A – I; B – II; C – IV; D – III

40. From the following data ΔH of the following reactions

$$C(s) + \frac{1}{2}O_2(g) \longrightarrow CO(g);\quad \Delta H = -110\ kJ\ \text{and}$$

$$C(s) + H_2O(g) \longrightarrow CO(g) + H_2(g);\ \Delta H = 132\ kJ$$

Calculate the mole composition of the mixture of steam and oxygen on being passes over coke at 1273 K, keeping the temperature constant.

(a) 1 : 0.6 (b) 0.6 : 1 (c) 2 : 3 (d) 3 : 2

41. The heats of neutralisation of CH_3COOH, HCOOH, HCN and H_2S are – 13.2, – 13.4, –2.9 and –3.8 kcal per equivalent respectively. Arrange the acids in increasing order of strength

(a) HCOOH > CH_3COOH > H_2S > HCN
(b) CH_3COOH > HCOOH > H_2S > HCN
(c) H_2S > HCOOH > CH_3COOH > HCN
(d) HCOOH > H_2S > CH_3COOH > HCN

42. Which of the following salts should cause maximum cooling when 1 mole of it is dissolved in the same volume of water?

(a) NaCl; $\Delta H^{\circ} = 5.35\ kJmol^{-1}$
(b) KNO_3; $\Delta H^{\circ} = 53.5\ kJmol^{-1}$
(c) KOH; $\Delta H^{\circ} = -56.0\ kJmol^{-1}$
(d) HBr; $\Delta H^{\circ} = -83.3\ kJ\ mol^{-1}$

43. Read the following statements carefully and choose the correct option

(i) Internal energy U of the system is a state function.
(ii) –w shows, that work is done on the system.
(iii) +w shows, that work is done by the system

(a) (i) and (ii) are correct (b) (ii) and (iii) are correct
(c) (i) and (iii) are correct (d) Only (i) is correct

44. Consider the following reaction occurring in an automobile

$$2C_8H_{18}(g) + 25O_2(g) \longrightarrow 16CO_2(g) + 18H_2O(g)$$

the sign of Δ H, Δ S and Δ G would be

(a) +, –, + (b) –, +, –
(c) –, +, + (d) +, +, –

45. Choose the reaction with negative ΔS value.

(a) $2NaHCO_{3(s)} \to Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$
(b) $Cl_{2(g)} \to 2Cl_{(g)}$
(c) $2SO_{2(g)} + O_{2(g)} \to 2SO_{3(g)}$
(d) $2KClO_{3(s)} \to 2KCl_{(s)} + 3O_{2(g)}$

RESPONSE GRID	34. ⓐⓑⓒⓓ	35. ⓐⓑⓒⓓ	36. ⓐⓑⓒⓓ	37. ⓐⓑⓒⓓ	38. ⓐⓑⓒⓓ
	39. ⓐⓑⓒⓓ	40. ⓐⓑⓒⓓ	41. ⓐⓑⓒⓓ	42. ⓐⓑⓒⓓ	43. ⓐⓑⓒⓓ
	44. ⓐⓑⓒⓓ	45. ⓐⓑⓒⓓ			

DAILY PRACTICE PROBLEMS

CHEMISTRY SOLUTIONS

DPP/CC06

1. **(b)** In insulated system no heat or matter is exchanged, $q = 0 \therefore \Delta E = W$. The work done on the system increases internal energy.

2. **(c)** $\Delta H = H_2 - H_1 = (E_2 + P_2V_2) - (E_1 + P_1V_1)$
$= (E_2 - E_1) + (P_2V_2 - P_1V_1)$
$= 30 + 4 \times 5 - 2 \times 3 = 44\,L$ atm

3. **(d)** Given $\Delta H = 41\ kJmol^{-1} = 41000\ J\,mol^{-1}$
$T = 100°C = 273 + 100 = 373K$
$n = 1$
$\Delta U = \Delta H - \Delta nRT = 41000 - (1 \times 8.314 \times 373)$
$= 37898.88\ J\,mol^{-1} \simeq 37.9\ kJ\,mol^{-1}$

4. **(a)** Process is isothermal reversible expansion, hence $\Delta U = 0$, therefore $q = -W$.
Since $q = +208$ J, $W = -208$ J

5. **(b)** An intensive property is a physical quantity whose value does not depend on the amount of the substance for which it is measured.

6. **(d)** Kirchoff's equation, $\dfrac{\Delta H_2 - \Delta H_1}{T_2 - T_1} = \Delta C_P$

7. **(a)** Heat capacity at constant volume $(q_v) = \Delta E$
Heat capacity of constant pressure $(q_p) = \Delta H$
$\Delta H = \Delta E + \Delta nRT$ or $\Delta H - \Delta E = \Delta nRT$
Δn = no. of moles of gaseous products – no. of moles of gaseous reactants
$= 12 - 15 = -3$
$\Delta H - \Delta E = -3 \times 8.314 \times 298\ J = -7.43\ kJ.$

8. **(b)** Desired equation is $H_2O(l) \rightarrow H_2O(g)$, $\Delta H = ?$
(Equation II - Equation I)
$\Delta H = -245.5\ kJ - (-286\ kJ) = 40.5\ kJ$

9. **(a)** $C_2H_5OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(\ell)$
Bomb calorimeter gives ΔU of the reaction
Given, $\Delta U = -1364.47\ kJ\,mol^{-1}$
$\Delta n_g = -1$
$\Delta H = \Delta U + \Delta n_g RT = -1364.47 - \dfrac{1 \times 8.314 \times 298}{1000}$
$= -1366.93\ kJmol^{-1}$

10. **(a)** $\Delta S_{(A \rightarrow B)} = \Delta S_{(A \rightarrow C)} + \Delta S_{(C \rightarrow D)} - \Delta S_{(B \rightarrow D)}$
$= 50 + 30 - 20 = 60$ e.u.

11. **(a)** $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O; \Delta H = 20\ kcal$........(1)
$C + O_2 \rightarrow CO_2; \Delta H = -40\ kcal$.....(2)
$2H_2 + O_2 \rightarrow 2H_2O\ ; \Delta H = -20\ kcal$........(3)
(2) + (3) – (1) we have, $C + 2H_2 \rightarrow CH_4$
or $\Delta H = -20 + (-40) - (-20) = -40\ kcal$

12. **(b)** Enthalpy of reaction
$= B.E_{(Reactant)} - B.E_{(Product)}$
$= \left[B.E_{(C=C)} + 4\,B.E_{(C-H)} + B.E_{(H-H)}\right] - \left[B.E_{(C-C)} + 6\,B.E_{(C-H)}\right]$
$= [606.1 + (4 \times 410.5) + 431.37)] - [336.49 + (6 \times 410.5)]$
$= -120.0\ kJ\,mol^{-1}$

13. **(a)** $\Delta G = \Delta H - T\Delta S$, ΔH + ve, ΔS is + ve; $T\Delta S > \Delta H$ for spontaneous process. It will make ΔG, –ve

14. **(d)** $\Delta H = \Delta E + \Delta nRT$ For $\Delta H \neq \Delta E$, $\Delta n \neq 0$
Where Δn = no. of moles of gaseous products – no. of moles of gaseous reactants
(a) $\Delta n = 2 - 2 = 0$
(b) $\Delta n = 0$ ($\because$ they are either in solid or liquid state)
(c) $\Delta n = 1 - 1 = 0$ ($\because$ C is in solid state)
(d) $\Delta n = 2 - 4 = -2$
$\therefore$ (d) is correct answer

15. **(b)** The species in its elemental form has zero standard molar enthalpy of formation at 298 K. At 298K, Cl_2 is gas while Br_2 is liquid.

16. **(b)** High pressure reduces volume, decreases entropy, hence ΔS negative.

17. **(d)** $\Delta S^\circ = 2S^\circ_{HCl} - (S^\circ_{H_2} + S^\circ_{Cl_2})$
$= 2 \times 186.7 - (130.6 + 223.0)$
$= 19.8\ JK^{-1}mol^{-1}$

18. **(a)** $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$
For a spontaneous reaction $\Delta G^\circ < 0$
or $\Delta H^\circ - T\Delta S^\circ < 0 \Rightarrow T > \dfrac{\Delta H^\circ}{\Delta S^\circ}$
$\Rightarrow T > \dfrac{179.1 \times 10^3}{160.2} > 1117.9K \approx 1118\,K$

19. **(d)** For the reaction, $C_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow CO$
$\Delta H = \Delta U + \Delta nRT$ or $\Delta H - \Delta U = \Delta nRT$
$\Delta n = 1 - \frac{1}{2} = \frac{1}{2}$; $\Delta H - \Delta U = \frac{1}{2} \times 8.314 \times 298$
$= 1238.78\ J\,mol^{-1}$

20. **(c)** $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$; $-RT\,\ell nK = \Delta H^\circ - T\Delta S^\circ$

$$\ell nK = -\frac{\Delta H^\circ - T\Delta S^\circ}{RT}$$

21. **(a)** $Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g)$; $\Delta H = -26.8\,kJ$ ...(i)

$FeO(s) + CO(g) \longrightarrow Fe(s) + CO_2(g)$; $\Delta H = -16.5\,kJ$ ...(ii)

eq. (i) – 2 × eq. (ii), we get

$Fe_2O_3(s) + CO(g) \longrightarrow 2FeO(s) + CO_2(g)$

$\Delta H = -26.8 + 33.0 = +6.2\,kJ$

22. **(b)** At equilibrium $\Delta G = 0$

Hence, $\Delta G = \Delta H - T_e\Delta S = 0$

$\therefore \Delta H = T_e\Delta S$ or $T_e \bullet \frac{\bullet H}{\bullet S}$

For a spontaneous reaction

ΔG must be negative which is possible only if

$\Delta H - T\Delta S < 0$

$\therefore \Delta H < T\Delta S$ or $T \bullet \frac{\bullet H}{\bullet S}$; $T_e \bullet T$

23. **(b)** $N_2 + 3H_2 \longrightarrow 2NH_3$ $\Delta H = 2 \times -46.0\ kJ\,mol^{-1}$

Let x be the bond enthalpy of N – H bond then

[**Note :** Enthalpy of formation or bond formation enthalpy is given which is negative but the given reaction involves bond breaking hence values should be taken as positive.]

$\Delta H = \Sigma$ Bond energies of reactants – Σ Bond energies of products

$2 \times -46 = 712 + 3 \times (436) - 6x$

$-92 = 2020 - 6x$

$6x = 2020 + 92$

$6x = 2112$

$x = +352\ kJ/mol$

24. **(c)** For a reaction to be at equilibrium $\Delta G = 0$. Since $\Delta G = \Delta H - T\Delta S$ so at equilibrium $\Delta H - T\Delta S = 0$ or $\Delta H = T\Delta S$

For the reaction

$\frac{1}{2}X_2 + \frac{3}{2}Y_2 \longrightarrow XY_3$; $\Delta H = -30kJ$ (given)

Calculating ΔS for the above reaction, we get

$$\Delta S = 50 - \left[\frac{1}{2}\times 60 + \frac{3}{2}\times 40\right] JK^{-1}$$

$= 50 - (30 + 60)JK^{-1} = -40JK^{-1}$

At equilibrium, $T\Delta S = \Delta H$ $[\because \Delta G = 0]$

$\therefore T \times (-40) = -30 \times 1000$ $[\because 1kJ = 1000J]$

or $T = \frac{-30 \times 1000}{-40}$ or 750K

25. **(a)** According to first law of thermodynamics energy can neither be created nor destroyed although it can be converted from one form to another.

NOTE : Carnot cycle is based upon this principle but during the conversion of heat into work some mechanical energy is always converted to other form of energy hence this data violates 1st law of thermodynamics.

26. **(c)** The standard enthalpy of the combustion of glucose can be calculated by the eqn.

$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$

$\Delta H_C = 6 \times \Delta H_f(CO_2) + 6 \times \Delta H_f(H_2O) - \Delta H_f[C_6H_{12}O_6]$

$\Delta H^\circ = 6(-400) + 6(-300) - (-1300)$

$\Delta H^\circ = -2900\ kJ/mol$

For one gram of glucose, enthalpy of combustion

$$\Delta H^\circ = -\frac{2900}{180} = -16.11\,kJ/g$$

27. **(d)** (i) $2C(s) + H_2(g) \longrightarrow H-C\equiv C-H(g)$ $\Delta H = 225\ kJ\,mol^{-1}$

(ii) $2C(s) \longrightarrow 2C(g)$ $\Delta H = 1410\ kJ\,mol^{-1}$

$C(s) \longrightarrow C(g)\ \Delta H = \frac{1410}{2} = 705kJmol^{-1}$

(iii) $H_2(g) \longrightarrow 2H(g)$ $\Delta H = 330\ kJ\,mol^{-1}$

From equation (i) :

$225 = [2 \times \Delta H_{C(s)\rightarrow c(g)} + 1 \times BE_{H-H}]$

$- [2 \times BE_{C-H} + 1 \times BE_{C\equiv C}]$

$225 = [1410 + 1 \times 330] - [2 \times 350 + 1 \times BE_{C\equiv C}]$

$225 = [1410 + 330] - [700 + BE_{C\equiv C}]$

$225 = 1740 - 700 - BE_{C=C}$

$BE_{C\equiv C} = 815\ kJmol^{-1}$

28. **(b)** ΔH_N for strong base and strong acid

$= -13.7\ kcaleq^{-1}$

$\Delta H_{ion}(CH_3COOH)$

$= -12.5 - (-13.7) = 1.2\ kcalmol^{-1}$

$\Delta H_{ion}(NH_4OH)$

$= -10.5 - (-13.7) - \Delta H_{ion}(CH_3COOH)$

$= 13.7 - 10.5 - 1.2$

$= 2\ kcalmol^{-1}$

29. **(b)** Write the proper chemical equations.

$C(graphite) + O_2(g) \rightarrow CO_2(g)$

$\Delta H = -393kJ$ ....(i)

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$

$\Delta H = -286kJ$ ....(ii)

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ $\Delta H = -1360kJ$ ....(iii)

From $(2 \times I + 3 \times II) - (III)$ we get

$$2C + 3H_2 + \frac{1}{2}O_2 \rightarrow C_2H_5OH$$

$\therefore 2(-393kJ) + 3(-286kJ) - (-1360kJ) = -284kJ$

30. **(a)** $\Delta H_{hyd.} = \Delta H_{sol.} - \Delta H_{lattice}$

$= 1 - 180 = -179\ kcalmol^{-1}$

Then $\Delta H_{hyd}(Na^+) + \Delta H_{hyd}(Cl^-) = -179$

or $\Delta H_{hyd}(Na^+) + \frac{2}{3}\Delta H_{hyd}(Na^+) = -179$

or $\Delta H_{hyd}(Na^+) = -107.4\ \text{kcalmol}^{-1}$

31. **(a)** For non spontaneous reaction

$\Delta G = +\text{ve}$

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

$\Delta S = 121\ JK^{-1}$

For $\Delta G = +\text{ve}$

ΔH has to be positive. Hence the reaction is endothermic.

The minimum value of ΔH can be obtained by putting

$\Delta G = 0$

$\Delta H = T\Delta S = 298 \times 121\ J$

$= 36.06\ kJ$

32. **(c)** The standard enthalpy of reaction is the enthalpy change for a reaction when all the participating substances are in their standard states. The standard state of a substance at a specified temperature is its pure form at 1 bar. For example, the standard state of liquid ethanol at 298 K is pure liquid ethanol at 1 bar. Standard state of solid iron at 500 K is pure iron at 1 bar.

33. **(d)**

34. **(a)** $\Delta C_p = 2 \times 25.1 + 3 \times 75.3 - [103.8 + 3 \times 28.8]$

$= 85.9\ JK^{-1}mol^{-1}$

$\frac{\Delta H_2 - \Delta H_1}{T_2 - T_1} = \Delta C_p$;

$\frac{\Delta H_2 - (-33290)}{358 - 298} = 85.9$

$\Delta H = -28136\ J mol^{-1}$

$= -28.136\ kJ mol^{-1}$

35. **(b)** The enthalpy of ionisation of weak acid is given by

$\Delta H_{ion(HA)}$

$= \Delta H_{N(\text{weak acid / strong base})} - \Delta H_{N(\text{strong acid / strong base})}$

$= -56.1 - (-57.3) = 1.2\ kJmol^{-1}$

$\Delta H_{(\text{ionisation})} = 1.5\ kJ mol^{-1}$

Hence % ionisation in 1 M solution

$= \frac{(1.5 - 1.2)}{1.5} \times 100 = 20$

36. **(d)** $\frac{1}{2}N_2(g) + \frac{3}{2}F_2(g) \longrightarrow NF_3$; $\Delta H = -113\ kJ$

or $\Delta H_{N\equiv N} + \frac{3}{2}\Delta H_{F-F} - 3\Delta H_{N-F} = -113\ kJ$

Let x kJ mol^{-1} be the bond energy of F – F bond then bond energy of N ≡ N bond = 6x

$\therefore \frac{1}{2} \times 6x + \frac{3}{2} \times x - 3 \times 273 = -113\ kJ$

On solving,

$x = 156.9\ kJ\ mol^{-1}$ and

N ≡ N bond energy = 6 × 156.9 = 941.4 kJ mol^{-1}

37. **(b)** Given ΔH

$\frac{1}{2}A \longrightarrow B \qquad +150 \qquad ...(1)$

$3B \longrightarrow 2C + D \qquad -125 \qquad ...(2)$

$E + A \longrightarrow 2D \qquad +350 \qquad ...(3)$

To calculate ΔH operate

2 × eq. (1) + eq. (2) – eq. (3)

$\Delta H = 300 - 125 - 350 = -175$

38. **(a)** $q = -W = 2.303nRT\log\frac{V_2}{V_1}$

39. **(c)**

40. **(a)** The first reaction is exothermic and the second reaction is endothermic. On passing the mixture of O_2 and H_2O (steam) over coke while keeping the temperature constant ΔH of both the reactions must be same.

Moles of O_2 needed to evolve 132 kJ

$= \frac{0.5 \times 132}{110} = 0.6$

Hence steam : O_2 ratio must be 1 : 0.6

41. **(a)** The greater the (negative value) of heat of neutralisation, the more is the strength of the acid. Hence,

$HCOOH > CH_3COOH > H_2S > HCN$

42. **(b)** Dissolution of KNO_3 is endothermic, hence heat is absorbed and cooling is observed.

43. **(d)** The positive sign expresses when work is done on the system. Similarly, negative sign expresses when work is done by the system.

44. **(b)** This is combustion reaction, which is always exothermic hence

$\Delta H = -\text{ve}$

As the no. of gaseous molecules are increasing hence entropy increases so $\Delta S = +\text{ve}$.

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

For a spontaneous reaction

$\Delta G = -\text{ve}$

which is possible in this case as $\Delta H = -\text{ve}$ and $\Delta S = +\text{ve}$.

45. **(c)** ΔS has negative value if number of gaseous moles decreases during a reaction, $\Delta n_g = -\text{ve}$

For the reaction

$2SO_2 + O_2 \rightarrow 2SO_3$

$\Delta n_g = 2 - 3 = -1$