MAINS+ADVANCED

TOPIC

THERMOCHEMISTRY

SOLUTIONS

THERMOCHEMISTRY

Exercise-01

3. $\Delta H_r = [(\Delta H_f)_{TiO_2} + 4(\Delta H_f)_{HCl} - (\Delta H_f)_{TiCl_4} - 2(\Delta H_f)_{H_2O}]$

$\Delta H_r = -944.7 - (4 \times 92.3) + 763.2 + (2 \times 241.8)$

$\Delta H_r = -67.1$ kJ/mole

4. $\Delta H_r = [3(\Delta H_f)_{CO_2} + 4(\Delta H_f)_{H_2O} - (\Delta H_C)_{C_3H_8}]$

$-2221.6 = 3 \times (-394) - 4(285.8) - (\Delta H_C)_{C_3H_8}$

$(\Delta H_C)_{C_3H_8} = -103.6$ kJ/mole

5. $\Delta H_r = [4(\Delta H_f)_{CO_2} + 2(\Delta H_f)_{H_2O} - 2(\Delta H_C)_{C_2H_2}]$

$-2601 = -4(394) - 2(285.8) - 2(\Delta H_C)_{C_2H_2}$

$(\Delta H_C)_{C_2H_2} = 226.7$

6. $\Delta H_r = [2(\Delta H_f)_{NaOH} - 2(\Delta H_f)_{H_2O}]$

$\frac{-281.9}{2} = (\Delta H_f)_{NaOH} + 285.8$

$(\Delta H_f)_{NaOH} = -426.8$ Kg

9. Heat evolve (eDr m"ek) $= \frac{1939.1}{40} \times 12 = 581.73$

12. $n_{C_2H_4} = \frac{PV}{RT}$

$V_{C_2H_4} = \frac{2}{3} \times 3.67$ | $V_{CH_4} = \frac{1}{3} \times 3.67$

$n_{C_2H_4} = \frac{1 \times 2 \times 3.67}{0.082 \times 3 \times 298}$ | $n_{CH_4} = \frac{3.67}{3 \times 0.082 \times 298}$

Heat evolve $= \frac{2 \times 3.67}{3 \times 0.082 \times 298} \times (1400)$

Heat evolve $= \frac{3.67}{3 \times 0.082 \times 298} \times 900$

total heat evolve from mixture(feJ.k l eDr dy m"ek)

= 140 + 45 = 185 kJ

13. $\frac{1}{2}H_2 + \frac{1}{2}Cl_2 \longrightarrow HCl$

$(\Delta H_f)_{HCl} = 52 + 24 - 1039 = -22$ kcal

Exercise-02

1. $C_3H_6 + \frac{9}{2}O_2 \longrightarrow 3CO_2 + 3H_2O$

$3C + 3H_2 \longrightarrow C_3H_6$ $\Delta H = 20.6$ kJ/mole

$C + O_2 \longrightarrow CO_2$ $\Delta H = -394$ kJ/mole

$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$ $\Delta H = -285.8$ kJ/mole

$(\Delta H_C)_{C_3H_6} = [3\Delta H_{CO_2} + 3\Delta H_{f(H_2O)} - \Delta H_{f(C_3H_6)}]$

$= [3 \times (-394) - 3(285.8) - 20.6]$

$(\Delta H_C)_{C_3H_6} = -2060$ kJ / mole

2. $\Delta H_C = [57(-285.8) - 52(393.5) + 7.870]$

$\Delta H_C = 34117.4$ kJ/mole

energy liberated for 1 gm fat(1 xke olk dfy, eDr

Åtk) $= \frac{34117.4}{887} = 38.4$ kJ/mole

3. $\Delta H_r = [4(90.2) - 6(241.8) + 4(46.1)]$

heat realeased for 3 gm $= \frac{905.6}{4 \times 17} \times 3 = 39.9$

(3 xke dfy, eDr m"ek)

4. Heat lost copper = heat gain by gold

$30 \times 0.385(318 - T) = 15 \times 0.129 (T - 298)$

final temperature $T = 315.1$ K

$T = 42.1°C$

5. Applying Hess's law.

6. $\Delta H_r = \left[-\frac{1}{2}(\Delta H_f)_{C_2H_2} + 2(\Delta H_f)_{CO_2} + \frac{1}{2}(\Delta H_f)_{H_2O}\right]$

$\Delta H_r = -\frac{1}{2}(-1300) + 2(-390) - \frac{1}{2} \times 572$

$\Delta H_r = 234$

7. $\Delta H_r = \left[2(\Delta H_f)_{CO_2} + 3(\Delta H_f)_{H_2O} - (\Delta H_f)_{C_2H_5OH}\right]$

$\Delta H_r = \left[2(-393.5) - 3(241.8) + 277.7\right]$

ΔH_r = –1234.7 kJ/mole

8. Applying Hess's law,

ΔH_r = [2(–414) + 2(86) + 571.6]

ΔH_r = –84.4 kJ

9. Applying Hess's law,

ΔH_r = [3(110.5) – 28.9 + 2(–285.8) + 3(–74.8)]

= –747.5

$\frac{1}{2}N_2 + \frac{3}{2}Cl_2 \longrightarrow NCl_3$

$\Delta H_r = \left[-\Delta H_1 + \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3\right]$

12. ΔH_r =

$\left[2(\Delta H_f)_{N_2O_5} + 4(\Delta H_f)_{HPO_3} - 4(\Delta H_5)_{HNO_3} - (\Delta H_f)_{P_4O_{10}}\right]$

$\Delta H_r = \left[2(-43.1) + 4(-948.5) - 4(-174.1) - (-2984.0)\right]$

= – 199.8

14. ΔH_r° =

$\left[4\Delta H_{C-H} + 4\Delta H_{Cl-Cl} - 4\Delta H_{C-Cl} - 4\Delta H_{C-Cl}\right]$

=

$\left[4 \times 414 + 4 \times 243 - 4 \times 331 - 4 \times 4313\right]$

ΔH_r° = 420

15. For $\Delta H_g = 0$, $\Delta H = \Delta E$

$\Delta H_g \neq 0$, $\Delta H \neq \Delta E$

18. Heat evolve = $mC_V\Delta t = 100 \times 4.2 \times 10 = 4.2$ kJ

for 0.1 mole the enthalpy change = 4.2 kJ

for 1 mole the enthalpy change = 42 kJ

19. $HCl + NaOH \longrightarrow NaCl + H_2O$

enthalpy change = $mC_V dT = 100 \times 4.2 \times 3$

= 1.26 kJ

enthalpy change for 5 millimole = 1.26 kJ

enthalpy change for 1 mole $\Rightarrow \frac{1.26}{5 \times 10^{-3}}$

$\Rightarrow 2.52 \times 10^2$ kJ

22. $C_2H_5OH \longrightarrow C_2H_4 + H_2O$ ... (i) $\Delta H = 45.54$

8a 8a

$C_2H_5OH \longrightarrow CH_3CHO + H_2$ ...(ii) $\Delta H = 68.91$

a a

8a + a = 1

$a = \frac{1}{9}$

energy involve in (i) reaction

(vfHkfØ;k (i) l lEcfU/kr Åtk) = $45.54 \times \frac{8}{9}$

energy involve in (ii) reaction

(vfHkfØ;k (ii) l lEcfU/kr Åtk) = $68.91 \times \frac{1}{9}$

total involve in (i) + (ii) are $\Rightarrow$ 48.137 Kg

23. $HAuBr_4 + 4HCl \longrightarrow HAuCl_4 + 4HBr \quad \Delta H = 8.8$

% conversion (ifjoru) = $\frac{0.44}{8.8} \times 100 = 5\%$

Exercise-03

COMPREHENSION # 1

1. $\Delta H_r = \left[(\Delta H_f)_{C_2F_4} + 2(\Delta H_f)_{HCl} - 2(\Delta H_f)_{CHClF_2}\right]$

= [–658.3 + 2(–92.3) + 2(485.2)]

= 127.5 kJ/mole

2. Add eq. (i), (ii) and (iii)

$CX_4(g) \longrightarrow C(g) + 4X$

$\Delta H = -\Delta H_1 + 718 + 2D(X - X)$

X=F

$\Delta H = +679.6 + 718 + 2 \times 154.7$

$\Delta H = 1707$

Average bond energy of C – F bond = $\frac{1707}{4} = 426.75$

(C – F c/k dh vkl r c/k Åtk)

X = Cl

$\Delta H = 106.6 + 718 + 2(246.7) = 1318$

Average bond energy of C – Cl bond = 329.5 Kg

3. C – Cl bond energy = 329.5

C – H bond energy = 416.1

C – F bond energy = 426.75

Order of reactivity C – Cl > C – H > C – F

COMPREHENSION # 3

1. (i) $\Delta H = (v + w + x + y + z)$

(ii) $(\Delta H_f)_{K^+} = \frac{w}{2}$

(iii) $(\Delta H)_{EA}$ for $H = \frac{y}{2}$

(iv) $(\Delta H)_{lattice}$ for $KH = \frac{z}{2}$

2.(i) electron affinity is exothermic (byDVku cU/krk m"ek{kh g)

(ii) ionization is endothermic (vk;uu m"ek'kk"kh g)

3. $(\Delta H)_r = 2 \times 90 + 2 \times 418 + 436 - 2 \times 78 - 2 \times 710$

$(\Delta H)_r = -124$ kJ/mole

4. $(\Delta H_f)_{KH} = -\frac{124}{2} \Rightarrow -62$ kJ/mole

6. Meq. of KH = Meq. of HCl

$$\frac{0.1}{E_{KH}} \times 1000 = 25 \times 0.1$$

Valency factor (l;kt drk dkjd) of K is 1 hence

$E_K = M_K$ $\quad M_K = 39$

$E_{KH} = 40$ $\quad E_{KH} = E_K = E_H$

$40 = E_K + 1$ $\quad E_K \Rightarrow 39$

Exercise-4(A)

1. $2\,C_2H_6 + O_2 \longrightarrow 2\,CO_2 + 3\,H_2O$

2 mol

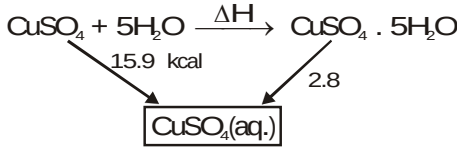
(ΔH) / mole = – 01560 kJ

$= 2(-345) + 3(286) - (\Delta H^\circ_f)_{C_2H_6}$

$\Delta H^\circ_f = -790 - 858 + 15 - 98$ kJ

$= -88$ kJ/mol

5.



Applying Hess's law $\Delta H + 2.8 = -15.9$

$\Delta H = -15.9 - 2.8$ $\quad \Delta H = 18.7$

9. $C_6H_5COOH(s) + 15/2\,O_2 \longrightarrow 7CO_2 + 3H_2O$

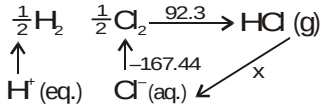
$\Delta H = q_p = 7 \times (-393) + 3(-286) + 408$

$= -2751 - 858 + 408 = -3201$

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

$\Delta U = -3201 - 8.3 \times 300 \times 0.5 = -3201 + 1.247 = -3199.75$

11.



$-92.30 + x = -167.44$

$x = -75.14$ kJ/mol

13. $C_6H_{12}O_6(s) + O_6(g) \longrightarrow 6CO_2(g) + 6H_2O(\ell)$

1.0 g

$\Delta U = m\,Cv\,dt$

$\Delta U = -10$ kJ $\times$ 1.56 = 15.6 kJ

for 1 mole = $15.6 \times 180 = -2808$ kJ

14. $PH_3 \longrightarrow \frac{1}{2}P_2 + \frac{3}{2}H_2$

$954 = 3(P - H)$

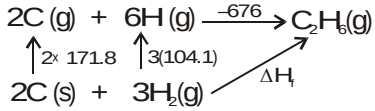
$P_2H_4 \longrightarrow P_2 + 2H_2$

$1485 = 4(P-H) + (P-P)$

$1485 = 4 \times \frac{954}{3} + (P-P)$

$(P-P) = -1272 + 1485 = 213$ kJ/mol

16.

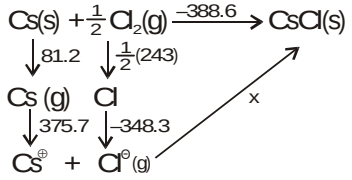


$\Delta_r H = -676 + 343.6 + 312.3 = -676 + 655.9 = 20.1$

$4(C-H) = 396$ $\quad (C-C) + 6(99) = 676$

$C - H = 99$ K $\quad (C-C) = 676 - 594 = 84$

19.



$81.2 + 375.7 + 121.5 - 348.3 + x = -388.5$

$578.4 - 348.3 + 388.5 = -x$

$-x = 966.9 - 348.3$

$x = -618.6$

20. $2C(g) + 6H(g) \xrightarrow{-2839.2} C_2H_6$

$2C(g) + 4H(g) \xrightarrow{-2275.2} C_2H_4$

$6C(g) + 6H(g) \xrightarrow{-5506} C_6H_6$

$(C-C) + 6(C-H) = -2839.2 \Rightarrow C - C = 373.98$

$(C=C) + 4(C-H) = -2275.2 \Rightarrow C = C = 637.72$

$-6(410.87) + 3(373.98) + 3(631.72) + RE = -5506$

$-5482.3 + RE = 0.5506$

$RE = -23.68$ kJ/mol

21. $q = 0$ $\quad \Delta U = w$

$$n\,Cv\,\Delta T = P_{avg.}\left(\frac{nRT_f}{P_f}-\frac{nRT_i}{P_i}\right)$$

$$n\times\frac{5}{2}R\,\Delta T = -P_{avg}\left(\frac{nRT_f}{P_f}-\frac{nRT_i}{P_i}\right)$$

$$5/2\,(T-300) = -\left(\frac{T_f}{2}-\frac{300}{5}\right)$$

$$5/2\,T - 750 - \frac{T_f}{2}+60$$

$3T = 810$ $\qquad T = 270$ K

$$\Delta U = w = 2\times\frac{5}{2}R(-300) = -150R = -1247.1J$$

$\Delta H = -150\,R + 2\,R(-30) = -210R = -1745.9J$

22. $2Al(s) + Fe_2O_3(s) \longrightarrow Al_2O_3(s) + 2Fe(s)$

0.2mole 0.1mole 0.1mole 0.2mole

0.254 kg ice melted

$$\Delta H = \frac{-254\times1.436}{18} = 20.26 \text{ kcal}$$

Heat liberated for 0.1 mole = 20.26 kcal

Heat liberated for 1 mole = –202.6 kcal

24. $CH_2{=}O \xrightarrow{\Delta H} (CH_2O)$

$\downarrow -134$ $\qquad \swarrow -122$

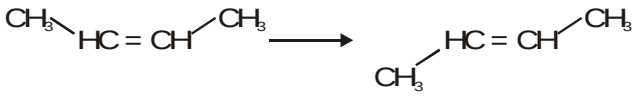
$nCO_2 + nH_2O$

applying Hess law

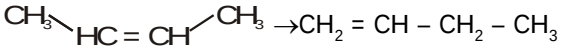
$\Delta H - 122 = -134$ $\qquad \Delta H = 12$ Kcal

Exercise-4(B)

1. Given



$$\Delta H_1 = -950\frac{cal}{mole} = -0.95\frac{kcal}{mole} \quad ...(i)$$

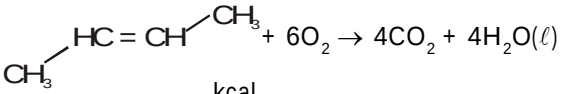


$$\Delta H_2 = +1771\frac{cal}{mole} = 1.771\frac{kcal}{mole} \quad ...(ii)$$

$CH_2 = CH - CH_2 - CH_3 + 6O_2 \longrightarrow 4CO_2 + 4H_2O$

$$\Delta H_3 = -649.8\frac{kcal}{mole} \quad ...(iii)$$

(ii) + (iii) – (i)

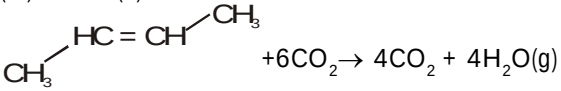


$$\Delta H = -647.079\frac{kcal}{mole} \quad ...(iv)$$

$H_2O(\ell) \longrightarrow H_2O(g)$

$$\Delta H_4 = 11\frac{kcal}{mole} \quad ...(v)$$

(iv) + 4 × (v)



$\Delta H = -603.079$

$[2\,B_{C-C} + B_{C=C} + 8\,B_{C-H}]$

$+ 6B_{O=O} - 8\,B_{C=O} - 8B_{O-H} = -603.079$

$B_{C=C} = 192.921$ kcal/mole

2. Given

$n(CH_2{=}CH_2) \rightarrow (-CH_2-CH_2-)_n \quad \Delta H = -72$

i.e., $B_{C=C} - 2\,B_{C-C} = -72$ ...(i)

$6C_{(s)} + 3H_{2(g)} \longrightarrow C_6H_{6(\ell)} \quad \Delta H = 49$ ...(ii)

$C_6H_{6(\ell)} \longrightarrow C_6H_{6(g)} \quad \Delta H = 30$

R.E. of $C_6H_6 = -152$

$\frac{1}{2}H_2 \longrightarrow H \quad \Delta H = 218$

$C_{(s)} \longrightarrow C_{(g)} \quad \Delta H = 715$

$B_{C-H} = 415$ for equation (2)

$(6\times715+6\times218) - (3B_{C-C}+3B_{C=C}+6\times415 - RE) = 79$

$B_{C-C} + B_{C=C} = 959$ ...(iii)

from equation (i) and (iii)

$B_{C-C} = 343.66$ $\qquad B_C = C = 615.33$

3. Given

$6C_{(s)} + 3H_{2(g)} \longrightarrow C_6H_{6(\ell)} \Delta H = 49$

$C_6H_{6(\ell)} \longrightarrow C_6H_{6(g)} \quad \Delta H = 45$

so $6C_{(s)} + 3H_{2(g)} \longrightarrow C_6H_{6(g)} \Delta H = 94$ .....(i)

$2C_{(s)} + H_{2(g)} \longrightarrow C_2H_{2(g)} \quad \Delta H = 75$ .....(ii)

(i) – 3 × (ii) $\qquad 3C_2H_{2(g)} \longrightarrow C_6H_{6(g)} = 131$

$3[B_{C\equiv C}+2B_{C-H}] - [3B_{C-C}+3B_{C=C} + 6B_{C-H} - RE] = -131$

$3[B_{C\equiv C} - B_{C-C} - B_{C=C}] + RE = -131$

$RE = -131 + 99 = -32$

4. $\left.\begin{matrix} Ca_{(s)} \longrightarrow Ca_{(g)} \longrightarrow Ca^{+1}_{(g)} \longrightarrow Ca^{+2}_{(g)} \\ C_{(s)} \longrightarrow C_{(g)} \longrightarrow C_{2(g)} \longrightarrow C^{-}_{2(g)} \longrightarrow C^{-2}_{2(g)} \end{matrix}\right\} \rightarrow CaC_{2(s)}$

$-60 = [179+590+1143+718\times2-614-315+410+ L.E.]$

L.E. = – 2889 kJ/mole

5. O_2 consumed by body in 1 hr.

$= 20 \times 60 \times 200\,(0.2 - 0.1) = 24000$ mL.

so volume of O_2 at 273K is let V then

$$\frac{V}{273} = \frac{24000}{310}$$

V = 21135.48 mL $\qquad$ moles of $O_2 = 0.9435$

$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$

$\Delta H = -2880$ kJ/mol

moles of glucose $\longrightarrow \frac{0.9435}{6}$

Heat released = $\frac{2880 \times 0.9435}{6}$ = 452.9 kJ

Heat used for muscular work

= 452.9 × 0.25 = 113.22 kJ

so distance = 1.132 km

6. Given :

$2C_{(s)} + \frac{3}{2} H_{2(g)} + \frac{1}{2} N_{2(g)} \longrightarrow CH_3CN_{(g)}$ $\Delta H = 88$ ...(i)

$2C_{(s)} + 3H_{2(g)} \longrightarrow C_2H_{6(g)}$ $\Delta H = -84$ ...(ii)

$C_{(s)} \longrightarrow C_{(g)}$ $\Delta H = 717$

$N_{2(g)} \longrightarrow 2N_{(g)}$ $\Delta H = 946$

$H_{2(g)} \longrightarrow 2H_{(g)}$ $\Delta H = 436$

$B_{C-H} = 410$

from equation (i)

$(2 \times 717 + 1.5 \times 436 + 0.5 \times 946) - (3 \times 410 + B_{C-C} + B_{C \equiv N}) = 88$

$B_{C-C} + B_{C \equiv N} = 1243$ ...(iii)

from equation (ii)

$(2 \times 717 + 3 \times 436) - (B_{C-C} + 6 \times 410) = -84$

$B_{C-C} = 366$ kJ/mole from equation (iii)

$B_{C \equiv N} = 877$ kJ/mole

7. Given :

$NaCl_{(s)} + aq \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)}$ $\Delta H = -2$ kJ/mole

$Na^+_{(g)} + Cl^-_{(g)} \longrightarrow NaCl(s)$ $\Delta H = -772$ kJ/moles

so $Na^+_{(g)} + Cl^-_{(g)} + aq. \longrightarrow Na^+_{(g)} + Cl^-_{(aq.)}$ $\Delta H = -774$

& $Na^+_{(g)} + aq. \longrightarrow Na^+_{(g)}$ $\Delta H = -390$

so enthalpy of hydration of Cl^- = –384

similarly enthalpy of hydration of I^- = –307