

MAINS+ADVANCED

TOPIC

THERMOCHEMISTRY

SOLUTIONS

THERMOCHEMISTRY

Exercise-01

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

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

$$\Delta H_r = -67.1 \text{ kJ/mole}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

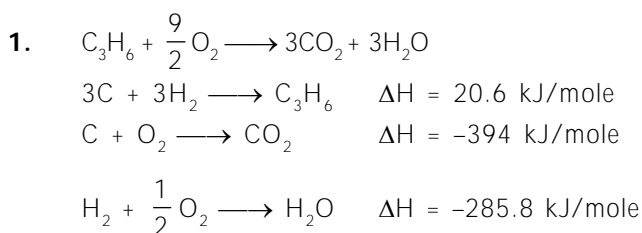
$$\text{total heat evolve from mixture (eJ.k l sepr dy m"ek)}$$

$$= 140 + 45 = 185 \text{ kJ}$$

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

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

Exercise-02



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

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

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

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

$$\Delta H_c = 34117.4 \text{ kJ/mole}$$

$$\text{energy liberated for 1 gm fat (1 xte ol k dsfy, epr)}$$

$$\Delta H_c = \frac{34117.4}{887} = 38.4 \text{ kJ/mole}$$

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

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

(3 xte dsfy, epr m"ek)

$$4. \quad \text{Heat lost copper} = \text{heat gain by gold}$$

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

$$\text{final temperature } T = 315.1 \text{ K}$$

$$T = 42.1^\circ\text{C}$$

5. Applying Hess's law.

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

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

$$\Delta H_r = 234$$

$$7. \quad \Delta H_r = [2(\Delta H_f)_{\text{CO}_2} + 3(\Delta H_f)_{\text{H}_2\text{O}} - (\Delta H_f)_{\text{C}_2\text{H}_5\text{OH}}]$$

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

$$\Delta H_r = -1234.7 \text{ kJ/mole}$$

8. Applying Hess's law,

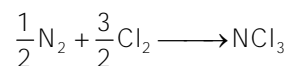
$$\Delta H_r = [2(-414) + 2(86) + 571.6]$$

$$\Delta H_r = -84.4 \text{ kJ}$$

9. Applying Hess's law,

$$\Delta H_r = [3(110.5) - 28.9 + 2(-285.8) + 3(-74.8)]$$

$$= -747.5$$



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

12. $\Delta H_r =$

$$\left[2(\Delta H_f)_{\text{N}_2\text{O}_5} + 4(\Delta H_f)_{\text{H}_3\text{PO}_3} - 4(\Delta H_f)_{\text{HNO}_3} - (\Delta H_f)_{\text{P}_4\text{O}_{10}} \right]$$

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

$$= -199.8$$

14. $\Delta H_r^\circ =$

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

$$=$$

$$[4 \times 414 + 4 \times 243 - 4 \times 331 - 4 \times 431.3]$$

$$\Delta H_r^\circ = 420$$

$$15. \quad \text{For } \Delta H_g = 0, \quad \Delta H = \Delta E$$

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

$$18. \quad \text{Heat evolve} = mC_v\Delta t = 100 \times 4.2 \times 10 = 4.2 \text{ kJ}$$

for 0.1 mole the enthalpy change = 4.2 kJ
for 1 mole the enthalpy change = 42 kJ

$$19. \quad \text{HCl} + \text{NaOH} \longrightarrow \text{NaCl} + \text{H}_2\text{O}$$

enthalpy change = $mC_v\Delta T = 100 \times 4.2 \times 3$
 $= 1.26 \text{ kJ}$

enthalpy change for 5 millimole = 1.26 kJ

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

$$\Rightarrow 2.52 \times 10^2 \text{ kJ}$$

$$22. \quad \text{C}_2\text{H}_5\text{OH} \longrightarrow \text{C}_2\text{H}_4 + \text{H}_2\text{O} \dots \text{(i)} \quad \Delta H = 45.54$$

$$8a \qquad \qquad 8a$$

$$\text{C}_2\text{H}_5\text{OH} \longrightarrow \text{CH}_3\text{CHO} + \text{H}_2 \dots \text{(ii)} \quad \Delta H = 68.91$$

$$a \qquad \qquad a$$

$$8a + a = 1$$

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

energy involve in (i) reaction

$$(\text{vflkf}\text{Ø}; \text{k (i) l s l Ecfllkr } \text{Å tkl}) = 45.54 \times \frac{8}{9}$$

energy involve in (ii) reaction

$$(\text{vflkf}\text{Ø}; \text{k (ii) l s l Ecfllkr } \text{Å tkl}) = 68.91 \times \frac{1}{9}$$

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

$$23. \quad \text{HAuBr}_4 + 4\text{HCl} \longrightarrow \text{HAuCl}_4 + 4\text{HBr} \Delta H = 8.8$$

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

Exercise-03

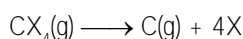
COMPREHENSION # 1

$$1. \quad \Delta H_r = [(\Delta H_f)_{\text{C}_2\text{F}_4} + 2(\Delta H_f)_{\text{HCl}} - 2(\Delta H_f)_{\text{CHClF}_2}]$$

$$= [-658.3 + 2(-92.3) + 2(485.2)]$$

$$= 127.5 \text{ kJ/mole}$$

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



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

$$\text{X} = \text{F}$$

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

$$\Delta H = 1707$$

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

(C - F cdk dh vl r cdk Å tkl)

$$\text{X} = \text{Cl}$$

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

Average bond energy of C - Cl bond = 329.5 Kg

$$3. \quad \text{C - Cl bond energy} = 329.5$$

$$\text{C - H bond energy} = 416.1$$

$$\text{C - F bond energy} = 426.75$$

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

COMPREHENSION # 3

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

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

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

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

2.(i) electron affinity is exothermic (by definition)

(ii) ionization is endothermic (by definition)

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

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

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

6. Meq. of KH = Meq. of HCl

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

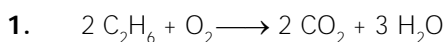
Valency factor (by definition) of K is 1 hence

$E_K = M_K$ $M_K = 39$

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

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

Exercise-4(A)



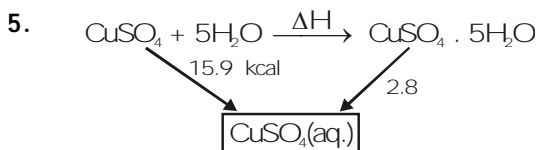
2 mol

$(\Delta H) / \text{mole} = -01560$ kJ

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

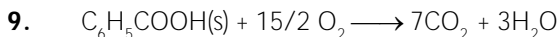
$\Delta H_f^\circ = -790 - 858 + 15 - 98$ kJ

$= -88$ kJ/mol



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

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

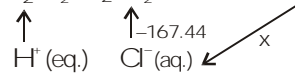
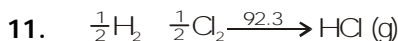


$\Delta H = q_p = 7 \times (-393) + 3 \times (-286) + 408$

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

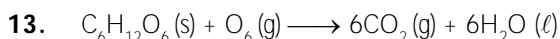
$\Delta H = \Delta U + \Delta n_g RT$

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



$-92.30 + x = -167.44$

$x = -75.14$ kJ/mol

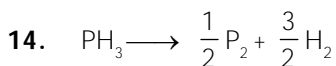


1.0 g

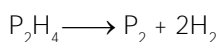
$\Delta U = m C_v dt$

$\Delta U = -10 \text{ kJ} \times 1.56 = 15.6$ kJ

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



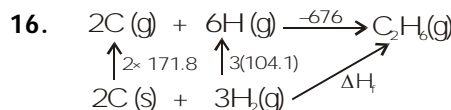
$954 = 3(P - H)$



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

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

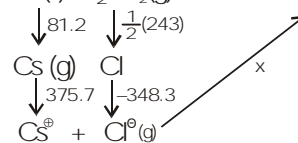
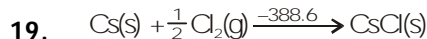
$(P - P) = -1272 + 1485 = 213$ kJ/mol



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

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

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

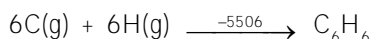
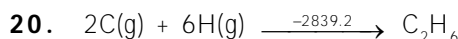


$81.2 + 375.7 + 121.5 - 348.3 + x = -388.5$

$578.4 - 348.3 + 388.5 = -x$

$-x = 966.9 - 348.3$

$x = -618.6$



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

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

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

$-5482.3 + RE = 0.5506$

$RE = -23.68$ kJ/mol

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

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

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

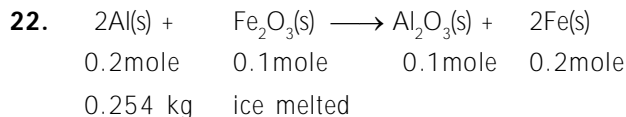
$$5/2 (T - 300) = - \left(\frac{T_f - 300}{2} - \frac{300}{5} \right)$$

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

$$3T = 810 \quad T = 270 \text{ K}$$

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

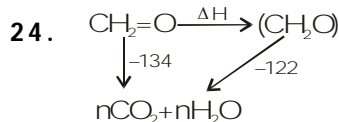
$$\Delta H = -150 R + 2 R(-30) = -210R = -1745.9 \text{ J}$$



$$\Delta H = \frac{-254 \times 1.436}{18} = 20.26 \text{ kcal}$$

Heat liberated for 0.1 mole = 20.26 kcal

Heat liberated for 1 mole = -202.6 kcal

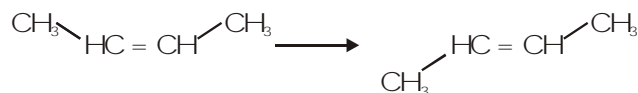


applying Hess law

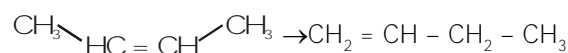
$$\Delta H - 122 = -134 \quad \Delta H = 12 \text{ Kcal}$$

Exercise-4(B)

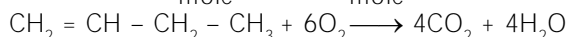
1. Given



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

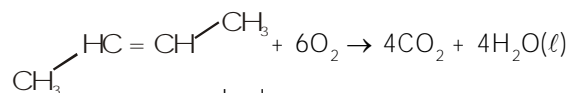


$$\Delta H_2 = +1771 \frac{\text{cal}}{\text{mole}} = 1.771 \frac{\text{kcal}}{\text{mole}} \quad \dots(\text{ii})$$

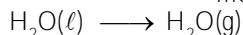


$$\Delta H_3 = -649.8 \frac{\text{kcal}}{\text{mole}} \quad \dots(\text{iii})$$

$$(\text{ii}) + (\text{iii}) - (\text{i})$$

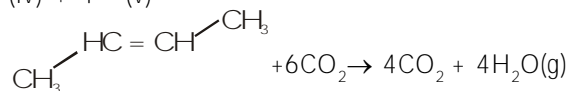


$$\Delta H = -647.079 \frac{\text{kcal}}{\text{mole}} \quad \dots(\text{iv})$$



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

$$(\text{iv}) + 4 \times (\text{v})$$

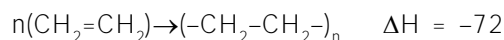


$$\Delta H = -603.079$$

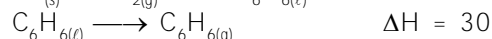
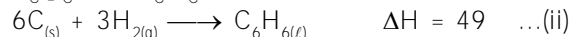
$$[2 B_{\text{C}-\text{C}} + B_{\text{C}=\text{C}} + 8 B_{\text{C}-\text{H}}] + 6B_{\text{O}=\text{O}} - 8 B_{\text{C}=\text{O}} - 8B_{\text{O}-\text{H}} = -603.079$$

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

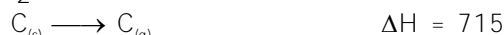
2. Given



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



$$\text{R.E. of } \text{C}_6\text{H}_6 = -152$$



$$(6 \times 715 + 6 \times 218) - (3B_{\text{C}-\text{C}} + 3B_{\text{C}=\text{C}} + 6 \times 415 - \text{RE}) = 79$$

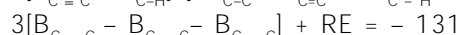
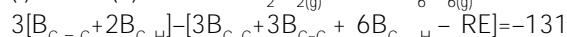
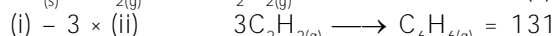
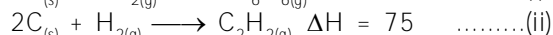
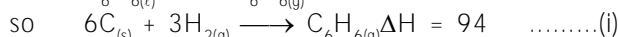
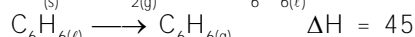
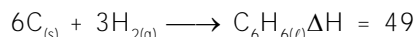
$$B_{\text{C}-\text{C}} + B_{\text{C}=\text{C}} = 959 \quad \dots(\text{iii})$$

from equation (i) and (iii)

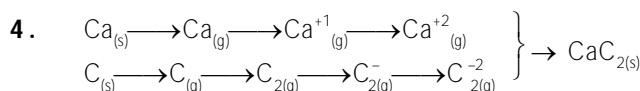
$$B_{\text{C}-\text{C}} = 343.66$$

$$B_{\text{C}=\text{C}} = 615.33$$

3. Given



$$\text{RE} = -131 + 99 = -32$$



$$-60 = [179 + 590 + 1143 + 718 \times 2 - 614 - 315 + 410 + \text{L.E.}]$$

$$\text{L.E.} = -2889 \text{ kJ/mole}$$

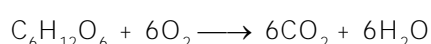
5. O_2 consumed by body in 1 hr.

$$= 20 \times 60 \times 200 (0.2 - 0.1) = 24000 \text{ mL.}$$

so volume of O_2 at 273K is let V then

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

$$V = 21135.48 \text{ mL} \quad \text{moles of } \text{O}_2 = 0.9435$$



$$\Delta H = -2880 \text{ kJ/mol}$$

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

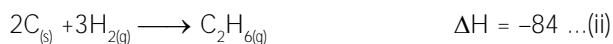
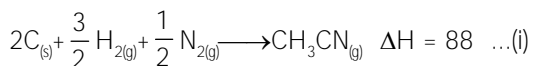
$$\text{Heat released} = \frac{2880 \times 0.9435}{6} = 452.9 \text{ kJ}$$

Heat used for muscular work

$$= 452.9 \times 0.25 = 113.22 \text{ kJ}$$

so distance = 1.132 km

6. Given :



$$B_{\text{C-H}} = 410$$

from equation (i)

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

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

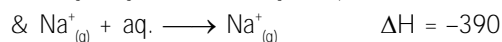
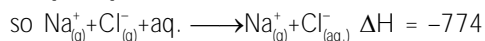
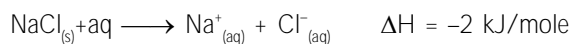
from equation (ii)

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

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

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

7. Given :



so enthalpy of hydration of $\text{Cl}^- = -384$

similarly enthalpy of hydration of $\text{I}^- = -307$