

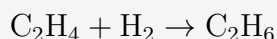
## DPP-6 – Solutions

### Other Enthalpies (Thermochemistry)

“Concept samjho, formula khud yaad ho jaayega.”

**Q1. Heat of combustion of  $C_2H_4$ ,  $C_2H_6$ , and  $H_2$  are  $-1409.5$ ,  $-1558.3$  and  $-285.6$   $\text{kJ mol}^{-1}$ . Find heat of hydrogenation of ethene.**

Ethene hydrogenates to ethane:



Apply Hess's Law using combustion data.

$$\Delta H_{\text{hydrog.}} = \Delta H_c(C_2H_6) - [\Delta H_c(C_2H_4) + \Delta H_c(H_2)]$$

$$\begin{aligned}\Delta H &= (-1558.3) - [(-1409.5) + (-285.6)] \\ &= -1558.3 - (-1695.1) = +136.8 \text{ kJ}\end{aligned}$$

**Final Answer: (1)  $-136.8$   $\text{kJ mol}^{-1}$  (exothermic).**

**Q2. Given:  $\Delta H_c$  of cyclohexane, cyclohexene,  $H_2$  are  $-3920$ ,  $-3800$ ,  $-241$   $\text{kJ mol}^{-1}$ . Find  $\Delta H_{\text{hydrog.}}$  of cyclohexene.**

Reaction:  $C_6H_{10} + H_2 \rightarrow C_6H_{12}$  By Hess's law:

$$\Delta H_{\text{hydrog.}} = \Delta H_c(C_6H_{12}) - [\Delta H_c(C_6H_{10}) + \Delta H_c(H_2)]$$

$$\Delta H = (-3920) - [(-3800) + (-241)] = -3920 - (-4041) = +121 \text{ kJ}$$

**Final Answer: (1)  $-121$   $\text{kJ mol}^{-1}$ .**

**Q3.  $Cl_2(g) \rightarrow 2Cl(g)$ . Sign of  $\Delta H$ ?**

Bond breaking process hai  $\Rightarrow$  energy absorbed  $\Rightarrow \Delta H$  positive.

**Final Answer: (1) Positive.**

**Q4. If  $H_2(g) \rightarrow 2H(g)$ ;  $\Delta H = 104$  kcal, then heat of atomisation of hydrogen is:**

1 mol H-H gives 2 atoms  $\Rightarrow$  per mole of atoms =  $\frac{104}{2} = 52$  kcal.

**Final Answer: (1) 52  $\text{kcal mol}^{-1}$ .**

**Q5.  $I(g) + I(g) \rightarrow I_2(g)$ : sign of  $\Delta H$ ?**

Bond formation releases energy exothermic  $\Delta H$  negative.

**Final Answer: (2) -ve.**

**Q6. Vaporisation process is always:**

Liquid  $\rightarrow$  gas requires energy to overcome intermolecular forces endothermic.

**Final Answer: (2) Endothermic.**

**Q7. Fusion of ice is:**

Solid  $\rightarrow$  liquid needs heat absorption endothermic.

**Final Answer: (2) Endothermic change.**

**Q8. For process  $C_{(s)} \rightarrow C_{(g)}$ , enthalpy represents:**

Solid  $\rightarrow$  gas (direct) sublimation.

**Final Answer: (4) Sublimation.**

**Q9. Heat of combustion: yellow P = -9.91 kJ, red P = -8.78 kJ. Find  $\Delta H_{\text{transition}}$  (yellow  $\rightarrow$  red).**

$$\Delta H_{\text{transition}} = \Delta H_c(\text{red}) - \Delta H_c(\text{yellow})$$

Less negative value  $\rightarrow$  less heat released  $\rightarrow$  more stable.

$$\Delta H = (-8.78) - (-9.91) = +1.13 \text{ kJ}$$

**Final Answer: (2) +1.13 kJ mol<sup>-1</sup>.**

**Q10. Graphite & diamond combustion:  $C(\text{graphite}) + O_2 \rightarrow CO_2$  ( $\Delta H = -x_1$ )  $C(\text{diamond}) + O_2 \rightarrow CO_2$  ( $\Delta H = -x_2$ ). Find  $\Delta H(\text{graphite} \rightarrow \text{diamond})$ .**

By Hess's law,



$$\Delta H = (-x_2) - (-x_1) = x_1 - x_2$$

**Final Answer: (3)  $x_1 - x_2$ .**

**Q11. For  $C(\text{diamond}) \rightarrow C(\text{graphite})$ ;  $\Delta H = -1.89$  kJ. If 6 g each burnt separately, heat in first case is:**

1 mol C = 12 g. 6 g = 0.5 mol  $\rightarrow$  difference =  $0.5 \times 1.89 = 0.945$  kJ.

Final Answer: (1) Less by 0.945 kJ.

Q12.  $\text{S}(\text{rhombic}) + \text{O}_2 \rightarrow \text{SO}_2$  ( $\Delta H = -297.5$ );  $\text{S}(\text{monoclinic}) + \text{O}_2 \rightarrow \text{SO}_2$  ( $\Delta H = -300$ ). Predict stability.

More exothermic combustion less stable form monoclinic less stable transition Rh  $\rightarrow$  Mono is endothermic.

Final Answer: (4)  $\Delta H$  transition  $\text{S}_R \rightarrow \text{S}_M$  endothermic.

Q13.  $\text{A}(\text{s}) \rightarrow \text{A}(\ell)$ ;  $\Delta H = x$ ;  $\text{A}(\ell) \rightarrow \text{A}(\text{g})$ ;  $\Delta H = -y$ . Heat of sublimation = ?

$\text{A}(\text{s}) \rightarrow \text{A}(\text{g}) = (\text{A}(\text{s}) \rightarrow \text{A}(\ell)) + (\text{A}(\ell) \rightarrow \text{A}(\text{g})) = x + (-y) = x - y$ .

Final Answer: (2)  $x - y$ .

Q14. Given:  $\Delta H(\text{H}_2\text{O}(\text{s}) \rightarrow \text{H}_2\text{O}(\ell)) = -285.9$ ,  $\Delta H(\text{H}_2\text{O}(\ell) \rightarrow \text{H}_2\text{O}(\text{g})) = -241.8$ . Find  $\Delta H_{\text{vap}}$  of water.

Vaporisation:  $\text{H}_2\text{O}(\ell) \rightarrow \text{H}_2\text{O}(\text{g})$ .

$$\Delta H = (-241.8) - (-285.9) = +44.1 \text{ kJ mol}^{-1}$$

Final Answer: (3)  $44.1 \text{ kJ mol}^{-1}$ .

Q15. Given:  $\text{CuSO}_4 + \text{aq} \rightarrow \text{CuSO}_4(\text{aq})$ ,  $\Delta H_1 = -66.4 \text{ kJ}$ ;  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} + \text{aq} \rightarrow \text{CuSO}_4(\text{aq})$ ,  $\Delta H_2 = +11.7 \text{ kJ}$ . Find  $\Delta H$  for  $\text{CuSO}_4 + 5\text{H}_2\text{O} \rightarrow \text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ .

Reverse (ii) and add with (i):

$$\Delta H = (-66.4) - (+11.7) = -78.1 \text{ kJ}$$

Final Answer: Enthalpy of hydration =  $-78.1 \text{ kJ mol}^{-1}$ .

Q16.  $\text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O}(\text{l}) \rightarrow \text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$ ;  $\Delta H = -x$  represents:

Solid salt combining with water molecules  $\rightarrow$  enthalpy of hydration.

Final Answer: (2) Enthalpy of hydration.

Q17. Magnitude of heat of solution on addition of solvent:

On further dilution, heat of solution decreases in magnitude (approaches constant value).

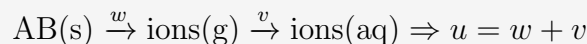
Final Answer: (1) Decreases.

Q18. Which reaction shows  $\Delta H_{\text{hydration}}$ ?

Only dissolution in water to form hydrated ions (aqueous) = hydration.

**Final Answer: (1)  $\text{CuSO}_4(\text{s}) + \text{aq} \rightarrow \text{CuSO}_4(\text{aq})$ .**

**Q19. Given  $u, v, w$  for  $\Delta H_{\text{sol}}$ ,  $\Delta H_{\text{hydr}}$ ,  $\Delta H_{\text{latt}}$ ; relation?**



**Final Answer: (2)  $u = w + v$ .**

**Q20. Enthalpy of solution of  $\text{BaCl}_2$  and  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  are  $-x, y$ . Enthalpy of hydration?**

Hydration:  $\Delta H = \Delta H_{\text{sol}(\text{anhyd})} - \Delta H_{\text{sol}(\text{hydrated})} = -x - (+y) = -(x + y)$ .

**Final Answer: (3)  $-(x + y) \text{ kJ mol}^{-1}$ .**

**Q21. Given:  $\Delta H_{\text{hydrog.}}(\text{cyclohexene}) = -119.5 \text{ kJ}$ , resonance energy of benzene =  $-150.4 \text{ kJ}$ . Find  $\Delta H_{\text{hydrog.}}(\text{benzene})$ .**

Without resonance: 3 double bonds  $3 \times (-119.5) = -358.5 \text{ kJ}$ . Actual less exothermic by resonance energy:

$$-358.5 + 150.4 = -208.1 \text{ kJ}$$

**Final Answer: (2)  $-208.1 \text{ kJ mol}^{-1}$ .**

**Q22. Use data for LiF formation to find electron gain enthalpy of F.**

By Born-Haber cycle:

$$\Delta H_f = \text{sublimation} + \text{ionisation} + \frac{1}{2} \text{bond dissoc} + \text{electron gain} + \text{lattice}$$

$$-617 = 161 + 520 + 77 + x - 1047 \Rightarrow x = -328 \text{ kJ mol}^{-1}$$

**Final Answer: (2)  $-328 \text{ kJ mol}^{-1}$ .**