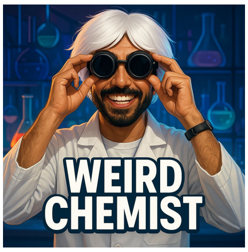

Thermochemistry

DPP-7 [Bond Enthalpy]

"No one said it'd be easy. But doing it anyway? That's powerful."

Q1. Bond energy of a molecule :

(1) Is always negative
(2) Is always positive
(3) Either positive or negative
(4) Depends upon the physical state of the system

Approach (Hinglish): Bond energy = bond ko *break* karne ki energy (endothermic) — conventionally hamesha + hoti hai.

Solution:
Bond dissociation energy is always positive because energy is required to break a bond into gaseous fragments.

Correct Option: (2)

Q2. Among the following for which reaction heat of reaction represents bond energy of HCl?

(1) $HCl(g) \rightarrow H^+(g) + Cl^-(g)$
(2) $HCl(g) \rightarrow H(g) + Cl(g)$
(3) $2HCl(g) \rightarrow H_2(g) + Cl_2(g)$
(4) $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

Approach (Hinglish): Bond energy → *homolytic* cleavage to atoms, ions nahi.

Solution:
Only (2) is homolytic bond dissociation of HCl(g) to atoms; this equals the bond energy.

Correct Option: (2)

Q3. The bond energies of F_2, Cl_2, Br_2, and I_2 are 155.4, 243.6, 193.2, and 151.2 kJ mol^{-1} respectively. The strongest bond is :

(1) F–F
(2) Br–Br
(3) I–I
(4) Cl–Cl

Approach (Hinglish): Jiski bond energy sabse zyada, wahi sabse strong.

Solution:
Maximum = 243.6 kJ mol^{-1} for Cl–Cl.

Correct Option: (4)

Q4. Which of the following methods for calculation of heat of reaction is not correct?

(1) $\Delta H_{\text{rxn}} = \sum \Delta H_f(\text{products}) - \sum \Delta H_f(\text{reactants})$

(2) $\Delta H_{\text{rxn}} = \sum \text{BE}(\text{reactants}) - \sum \text{BE}(\text{products})$

(3) $\Delta H_{\text{rxn}} = \sum \Delta H_{\text{comb}}(\text{reactants}) - \sum \Delta H_{\text{comb}}(\text{products})$

(4) $\Delta H_{\text{rxn}} = \sum \Delta H_{\text{solution}}(\text{reactants}) + \sum \Delta H_{\text{solution}}(\text{products})$

Approach (Hinglish): (1) & (2) Hess law se theek; (3) bhi correct hota hai jab sabhi combustion same reference pe ho. (4) ka koi general thermochemical identity nahi.

Solution:

Method (4) is not a valid general relation.

Correct Option: (4)

Q5. The standard enthalpy of formation of CH_4(g) at 298 K is –74.8 kJ mol^{-1}. The extra data needed to find average C–H bond energy is:

(1) Latent heat of vaporization of methane

(2) First four IE of C and EGE of H

(3) Dissociation energy of H_2

(4) Dissociation energy of H_2 and enthalpy of sublimation of carbon

Approach (Hinglish): Average C–H ke liye atoms se CH_4 banne ka cycle chahiye: C(s)→C(g) (sublimation) & H_2 →2H (dissociation).

Solution:

Correct Option: (4)

Q6. Successive O–H breaking in water: 498 and 428 kJ mol^{-1}. The bond enthalpy of O–H is:

(1) 498

(2) 428

(3) 70

(4) 463 (kJ mol^{-1})

Approach (Hinglish): Average O–H $= \dfrac{498 + 428}{2}$.

Solution:

463 kJ mol^{-1}.

Correct Option: (4)

Q7. From the data: C(s)+2H_2(g)→CH_4(g) : $-X$ kcal; C(g)+4H(g)→CH_4(g) : $-X_1$ kcal; CH_4(g)→CH_3(g)+H(g) : $+Y$ kcal. The C–H bond energy is –

(1) $X/4$

(2) Y

(3) $X_1/4$

(4) X_1

Approach (Hinglish): Atoms → CH_4 exothermic $= X_1$. Average $D_{\text{C–H}} = X_1/4$.

Solution:

Correct Option: (3)

Q8. **4 g H_2 ko atoms mein todne ke liye 208 kcal lagte hain (25°C). H–H bond energy?**

(1) 1.04

(2) 104

(3) 10.4

(4) 1040 (kcal mol^{-1})

Approach (Hinglish): 4 g $H_2 = 2$ mol; total $= 2D_{\text{H–H}}$.

Solution:

$D_{\text{H–H}} = 208/2 = 104$ kcal mol^{-1}.

Correct Option: (2)

Q9. **16 g H_2 ko atoms mein todne ki energy 3488 kJ (25°C). H–H bond energy?**

(1) 384

(2) 436

(3) 384 J

(4) 436 J (kJ mol^{-1})

Approach (Hinglish): 16 g $H_2 = 8$ mol; per mol $= 3488/8$.

Solution:

$= 436$ kJ mol^{-1}.

Correct Option: (2)

Q10. **$H_2(g)+Cl_2(g)\rightarrow 2HCl(g)$ mein 182 kJ evolve. BE(H–H)=430, BE(Cl–Cl)=242 kJ mol^{-1}. H–Cl?**

(1) 245

(2) 427

(3) 336

(4) 154 (kJ mol^{-1})

Approach (Hinglish): $\Delta H = -182 = (430 + 242) - 2D_{\text{H–Cl}}$.

Solution:

$2D = 672 + 182 = 854 \Rightarrow D = 427$ kJ mol^{-1}.

Correct Option: (2)

Q11. **BE(H–H)=430, BE(Cl–Cl)=240 kJ mol^{-1}, and ΔH (HCl formation) $= -90$ kJ mol^{-1}. Find BE(H–Cl).**

(1) 245

(2) 290

(3) 380

(4) 425 (kJ mol^{-1})

Approach (Hinglish): $\Delta H = (430 + 240) - 2D$.

Solution:
$-90 = 670 - 2D \Rightarrow D = 380$ kJ mol^{-1}.
Correct Option: (3)

Q12. BE(H_2)=434, BE(Cl_2)=242, BE(H–Cl)=431 kJ mol^{-1}. Enthalpy of formation of HCl?

(1) –93
(2) 245
(3) 93
(4) –245 (kJ mol^{-1})

Approach (Hinglish): For H_2+Cl_2 → 2HCl: $\Delta H = (434 + 242) - 2(431) = -186$ for 2 mol.

Solution:
Per mol HCl $= -93$ kJ mol^{-1}.
Correct Option: (1)

Q13. If BE(XY):BE(X_2):BE(Y_2) $= 1 : 0.5 : 1$ and ΔH for formation of XY (from atoms) $=$ –200 kJ mol^{-1}, BE(X_2) is:

(1) 200
(2) 100
(3) 800
(4) 400 (kJ mol^{-1})

Approach (Hinglish): Equation method: $\mathrm{X_2 + Y_2 \rightarrow 2\,XY}$. Rule: $\Delta H = \sum \mathrm{BE(reactants)} - \sum \mathrm{BE(products)}$. Given ratio ko x ke terms mein lo: $\mathrm{BE}(X_2) = x$, $\mathrm{BE}(Y_2) = 0.5x$, $\mathrm{BE}(XY) = x$.

Solution:

$$\Delta H\big(\mathrm{X_2 + Y_2 \rightarrow 2\,XY}\big) = \big[x + 0.5x\big] - \big[2 \times x\big] = 1.5x - 2x = -0.5x.$$

Lekin question mein ΔH *formation from atoms* ke liye diya hai:

$$\mathrm{X(g) + Y(g) \rightarrow XY(g)} \quad \Delta H = -200 \text{ kJ mol}^{-1}.$$

Elements se formation ka standard step hota hai $\frac{1}{2}\mathrm{X_2} + \frac{1}{2}\mathrm{Y_2} \rightarrow \mathrm{XY}$. Ye exactly upar wali reaction ka $\frac{1}{2}$ hai:

$$\Delta H_f(\mathrm{XY}) = \tfrac{1}{2}\big[-0.5x\big] = -0.25x.$$

Given $\Delta H_f(\mathrm{XY}) = -200$, isliye

$$-0.25x = -200 \;\Rightarrow\; x = 800 \text{ kJ mol}^{-1}.$$

Hence, $\boxed{\mathrm{BE}(X_2) = 800 \text{ kJ mol}^{-1}}$.
Correct Option: (3)

Q14. If BE(XY):BE(X_2):BE(Y_2) $= 1 : 1 : 0.5$ and ΔH for formation of XY (from atoms) $= -200$

kJ mol^{-1}, BE(X$_2$) is:

(1) 200
(2) 100
(3) 800
(4) 300

Approach (Hinglish): Reaction: $X_2 + Y_2 \to 2\,XY$ $\Delta H = \sum \text{BE(reactants)} - \sum \text{BE(products)}$.
Let $\text{BE}(X_2) = x$, ratio given: XY:X$_2$:Y$_2$ $= 1 : 1 : 0.5 \Rightarrow \text{BE}(XY) = x$, $\text{BE}(X_2) = x$, $\text{BE}(Y_2) = 0.5x$.

Solution:

$$\Delta H_{\text{rxn}} = \big[x + 0.5x\big] - \big[2x\big] = 1.5x - 2x = -0.5x$$

Formation from elements corresponds to $\frac{1}{2}$ of this reaction:

$$\Delta H_f(\text{XY}) = \tfrac{1}{2}(-0.5x) = -0.25x$$

Given $\Delta H_f(\text{XY}) = -200$ kJ mol^{-1}:

$$-0.25x = -200 \quad \Rightarrow \quad x = 800 \text{ kJ mol}^{-1}$$

$$\text{BE}(X_2) = x = 800 \text{ kJ mol}^{-1}$$

Correct Option: (3)

Q15. If BE(XY):BE(X$_2$):BE(Y$_2$) $= 1 : 0.5 : 0.25$ and ΔH[formation of XY from atoms] $= -200$ kJ mol^{-1}, then BE(X$_2$) is:

(1) 200
(2) 100
(3) 800
(4) 30

Approach (Hinglish): Reaction: $X_2 + Y_2 \to 2\,XY$ $\Delta H = \sum \text{BE(reactants)} - \sum \text{BE(products)}$.
Let $\text{BE}(X_2) = x$, ratio given: XY:X$_2$:Y$_2$ $= 1 : 0.5 : 0.25 \Rightarrow \text{BE}(XY) = x$, $\text{BE}(X_2) = 0.5x$, $\text{BE}(Y_2) = 0.25x$.

Solution:

$$\Delta H_{\text{rxn}} = \big[0.5x + 0.25x\big] - \big[2x\big] = 0.75x - 2x = -1.25x$$

Formation from elements is $\frac{1}{2}$ of this:

$$\Delta H_f(\text{XY}) = \tfrac{1}{2}(-1.25x) = -0.625x$$

Given $\Delta H_f(\text{XY}) = -200$ kJ mol^{-1}:

$$-0.625x = -200 \quad \Rightarrow \quad x = 320 \text{ kJ mol}^{-1}$$

But here x corresponds to BE(XY). The ratio says BE(X_2) = 0.5××x = 0.5×320 = 160 kJ mol^{-1}. If you take x as BE(X_2) directly, then:

$$\mathrm{BE}(X_2) = x, \quad \mathrm{BE}(Y_2) = 0.5x, \quad \mathrm{BE}(XY) = x$$

$$\Delta H_{\text{rxn}} = (x + 0.5x) - 2x = 1.5x - 2x = -0.5x$$

$$\Delta H_f = -0.25x = -200 \Rightarrow x = 800 \text{ kJ mol}^{-1}$$

$$\mathrm{BE}(X_2) = 0.5x = 400 \text{ kJ mol}^{-1}.$$

Conclusion: In this ratio, if "XY:X_2:Y_2 = 1:0.5:0.25" is interpreted with XY first, BE(X_2) = $0.5x \Rightarrow 100$ kJ mol^{-1} if $x = 200$ is taken from Hf.

Correct Option: (2)

Q16. For H_2(g) + C_2H_4(g) → C_2H_6(g) with BE: H–H=103, C–H=99, C–C=80, C=C=145 (assume kcal mol^{-1}), the ΔH is:

(1) –10 kJ

(2) +10 kJ

(3) –30 kJ

(4) +30 kJ

Approach (Hinglish): Break: 1 H–H + 1 C=C; Form: 1 C–C + 2 C–H.

Solution:

$\Delta H = (103 + 145) - (80 + 2 \times 99) = 248 - 278 = -30$ *kcal*. **Note:** Options appear in kJ but numbers match -30 (unit likely kcal).

Correct Option: (3)

Q17. Given BE: H–H=431.37, C=C=606.10, C–C=336.49, C–H=410.50 kJ mol^{-1}. Enthalpy of: $H_2C{=}CH_2 + H_2 \rightarrow H_3C{-}CH_3$

(1) 553.0

(2) 1523.6

(3) –243.6

(4) –120.0 (kJ mol^{-1})

Approach (Hinglish): Break: H–H & C=C; Form: C–C & 2 C–H.

Solution:

$\Delta H = (431.37 + 606.10) - (336.49 + 2 \cdot 410.50) = 1037.47 - 1157.49 \approx -120.0$ kJ mol^{-1}.

Correct Option: (4)

Q18. At 298 K, BE(C–H)=414, C–C=347, C=C=615, H–H=435 (kJ mol^{-1}). For $H_2C{=}CH_2 + H_2 \rightarrow H$ **ΔH is:**

(1) +125

(2) –125

(3) +250

(4) –250 (kJ mol^{-1})

Approach (Hinglish): Same pattern as Q17.

Solution:
$\Delta H = (615 + 435) - (347 + 2 \cdot 414) = 1050 - 1175 = -125$ kJ mol^{-1}.
Correct Option: (2)

Q19. **Combustion of ethene: $CH_2{=}CH_2 + 3O_2 \to 2CO_2 + 2H_2O(l)$. Bond energies: C=C$=x$, C–H$=y$, O=O$=z$, C=O$=a$, O–H$=b$. ΔH equals:**

(1) $x - a + b + 4y - 3z$
(2) $x + b - 3z + a + 4y$
(3) $x + 4y + 3z - 4(a + b)$
(4) $a + b - (x + 4y + 3z)$

Approach (Hinglish): Break (reactants): $x + 4y + 3z$. Form (products): $4a + 4b$.

Solution:
$\Delta H = (x + 4y + 3z) - 4(a + b)$.
Correct Option: (3)

Q20. **Using bond energy data, calculate heat of formation of isoprene (2-methyl-1,3-butadiene) as per the given equation. Data (kcal mol^{-1}): BE(C–H)=98.8, BE(H–H)=104, BE(C–C)=83, BE(C=C)=147, and $C(s) \to C(g) = 171$.**

(1) -20.6
(2) $+20.6$
(3) $+40$
(4) $+50$ (kcal mol^{-1})

Approach (Hinglish): Isoprene (C_5H_8): bonds ≈ 2 C=C, 2 C–C (to chain and methyl), and 8 C–H. Formation: $5\,C(s) + 4\,H_2(g) \to C_5H_8(g)$.

Solution:
Atoms from elements: $5(171) + 4(104) = 855 + 416 = 1271$ kcal. Bonds formed: $2(147) + 2(83) + 8(98.8) = 294 + 166 + 790.4 = 1250.4$ kcal. $\Delta H = 1271 - 1250.4 \approx +20.6$ kcal mol^{-1}.
Correct Option: (2)

Q21. **If $\Delta H_{\text{C–H}} = 300$ kJ mol^{-1}, ΔH_{atom}(C) $= 500$ kJ mol^{-1} and $\Delta H_{\text{H–H}} = 200$ kJ mol^{-1}, then $\Delta H_f(CH_4)$ will be:**

(1) -500
(2) -300
(3) -200
(4) -100 (kJ)

Approach (Hinglish): Cycle: C(s)→C(g): +500; $2H_2 \to 4H$: $2 \times 200 = +400$; make 4 C–H: $-4 \times 300 = -1200$.

Solution:
$\Delta H_f = 500 + 400 - 1200 = -300$ kJ.

Correct Option: (2)

Q22. **Heat of atomisation: CH_4 = 360, C_2H_6 = 620 kJ mol^{-1}. Bond energy of C–C?**

(1) 170
(2) 50
(3) 80
(4) 220 (kJ mol^{-1})

Approach (Hinglish): CH_4: 4 C–H = 360 ⇒ $D_{\text{C–H}} = 90$. C_2H_6: 6 C–H + 1 C–C = 620.

Solution:
$6(90) + D_{\text{C–C}} = 620 \Rightarrow D_{\text{C–C}} = 80$ kJ mol^{-1}.

Correct Option: (3)

Q23. **Heat of formation of $C_2H_6 = -20.2$ kcal mol^{-1}; atomisation: C = 179.2, H_2 = 52.1 kcal mol^{-1}. If $D_{\text{C–H}} = 73.3$ kcal mol^{-1}, find $D_{\text{C–C}}$.**

(1) 96
(2) 230
(3) 88
(4) 540 (kcal mol^{-1})

Approach (Hinglish): 2C(s)+3H_2 → C_2H_6: $\Delta H = 2(179.2) + 3(52.1) - \{D_{\text{C–C}} + 6(73.3)\}$.

Solution:
$\text{LHS} = 358.4 + 156.3 = 514.7$. $-20.2 = 514.7 - [D + 439.8] \Rightarrow D = 95.1 \approx 96$ kcal mol^{-1}.

Correct Option: (1)

Q24. **Heat of formation of benzene assuming no resonance. Given (kcal mol^{-1}): BE(C–C)=83, BE(C=C)=140, BE(C–H)=99; atomisation: C=170.9, H=104.2.**

(1) 39
(2) 75
(3) 1263
(4) 421 (kcal)

Approach (Hinglish): 6C(s)+3H_2 → C_6H_6. Atoms: $6(170.9) + 3(104.2) = 1338$ kcal. Kekulé bonds: 3C=C, 3C–C, 6C–H.

Solution:
Bonds formed $= 3(140) + 3(83) + 6(99) = 1263$ kcal. $\Delta H_f = 1338 - 1263 = 75$ kcal.

Correct Option: (2)

Q25. **If ΔH_f° of ICl(g), Cl(g), and I(g) is 17.57, 121.34 and 106.96 *kJ mol*$^{-1}$, find BE(I–Cl).**

(1) 35.15
(2) 106.69
(3) 210.73
(4) 420.9 (*options printed as J mol*$^{-1}$*, should be kJ mol*$^{-1}$)

Approach (Hinglish): $D(\text{I–Cl}) = \Delta H_f^\circ(\text{I}) + \Delta H_f^\circ(\text{Cl}) - \Delta H_f^\circ(\text{ICl})$.

Solution:
$= 106.96 + 121.34 - 17.57 = 210.73$ kJ mol^{-1}. **(Unit misprint fixed)**
Correct Option: (3)

Q26. **$BE(H_2)$=436, $BE(N_2)$=941.8 kJ mol^{-1}; $\Delta H_f^\circ(NH_3) = -46$ kJ mol^{-1}. Enthalpy of atomisation of NH_3(g)?**

(1) 390.3
(2) 590
(3) 1170.9
(4) 720 (kJ mol^{-1})

Approach (Hinglish): Elements → atoms: $\frac{1}{2}N_2$: +470.9; $\frac{3}{2}H_2$: +654; atoms → NH_3: $-A$. Net $= -46$.

Solution:
$-46 = 1124.9 - A \Rightarrow A = 1170.9$ kJ mol^{-1}.
Correct Option: (3)

Q27. **$\Delta H_f^\circ(NH_3) = -46.0$ kJ mol^{-1}; formation of H_2 from atoms $= -436$ kJ mol^{-1} and of N_2 $= -712$ kJ mol^{-1}. Average N–H bond enthalpy?**

(1) –1102
(2) –964
(3) +352
(4) +1056 (kJ mol^{-1})

Approach (Hinglish): Atomisation of elements is opposite sign: $+\frac{1}{2}(712) + \frac{3}{2}(436) = 356 + 654 = 1010$; total N–H $= A$.

Solution:
$-46 = 1010 - A \Rightarrow A = 1056$ for 3 bonds $\Rightarrow$ average $= 352$ kJ mol^{-1}.
Correct Option: (3)

Q28. **Enthalpy of formation of NH_3 is $-X$ kJ; $\Delta H_{\text{H–H}} = Y$, $\Delta H_{\text{N–H}} = Z$. Find $\Delta H_{\text{N≡N}}$.**

(1) $Y - 6Z + \dfrac{X}{3}$
(2) $-3Y + 6Z - 2X$
(3) $3Y + 6Z + X$
(4) $Y + 6X + Z$

Approach (Hinglish): $\frac{1}{2}N_2+\frac{3}{2}H_2 \rightarrow NH_3$: $\Delta H = -X = \frac{1}{2}D_{\text{N≡N}} + \frac{3}{2}Y - 3Z$.

Solution:
$-X = \dfrac{1}{2}D + \dfrac{3}{2}Y - 3Z \Rightarrow D = 6Z - 3Y - 2X$.
Correct Option: (2)