DPP-3 Solutions — Enthalpy of Formation

"Jo apne sapno ke liye ladte hain, unhe duniya kitni bhi baar roke... woh rukte nahin."

Q1. Since enthalpy of elements in their natural state is taken as zero, the value of ΔH_f° of compounds is:

> **Approach (Hinglish):** Elements ke standard state ki $\Delta H_f^\circ = 0$ hoti hai. Compounds ki ΔH_f° formation ke nature par depend karti hai — kabhi exothermic (negative), kabhi endothermic (positive).

Solution: ΔH_f° may be positive or negative. **Final Answer: (C)**

Q2. $\Delta H_f^\circ(\mathrm{NH_3}, 298\ \mathbf{K}) = -46.11$ **kJ mol^{-1} kis equation par apply hota hai?**

> **Approach (Hinglish):** Standard heat of formation: 1 mol compound *from elements in their standard states.* N_2(g), H_2(g) standard states.

Solution: $\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightarrow NH_3(g)$. **Final Answer: (A)**

Q3. Standard heat of formation of CH_4(g) ko kaun sa equation represent karta hai?

> **Approach (Hinglish):** Carbon ka standard state = graphite. Hydrogen = H_2(g).

Solution: C(graphite) + $2H_2(g) \rightarrow CH_4(g)$. **Final Answer: (B)**

Q4. Kaunsa reaction $\Delta H_f^{\circ\circ}$ ko define karta hai?

> **Approach (Hinglish):** 1 mol product, elements in standard states, correct physical states.

Solution: $\frac{1}{2}H_2(g) + \frac{1}{2}F_2(g) \rightarrow HF(g)$. **Final Answer: (B)**

Q5. Given $\Delta H_f^{\circ\circ}(\mathrm{NH_3(g)}) = -11.02$ kcal mol^{-1} at 298 K for $\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightarrow NH_3(g)$: $\Delta H_{\mathbf{rxn}} =$?

> **Approach (Hinglish):** Ye exactly standard formation reaction hai. Isliye $\Delta H_{\mathrm{rxn}} = \Delta H_f^{\circ\circ}(\mathrm{NH_3})$.

Solution: $\Delta H_{\mathrm{rxn}} = -11.02$ kcal mol^{-1}. **Final Answer: (A)**

Q6. $\Delta H_f^{\circ\circ}$ of an explosive like NCl_3 is:

> **Approach (Hinglish):** Highly unstable/explosive compounds usually have *positive* $\Delta H_f^{\circ\circ}$ (endothermic formation).

Solution: Positive. **Final Answer: (A)**

Q7. $H_2 + I_2 \rightarrow 2HI$; $\Delta H = +12.40$ **kcal. Heat of formation of HI?**

> **Approach (Hinglish):** Formation: $\frac{1}{2}H_2 + \frac{1}{2}I_2 \rightarrow HI$. Given reaction 2 mol HI banata hai.

Solution: Per mol HI: $+12.40/2 = +6.20$ kcal. **Final Answer: (D)**

Q8. $H_2 + Cl_2 \rightarrow 2HCl + 44$ **kcal**

. Heat of formation of HCl?

Approach (Hinglish): $\Delta H_{\text{rxn}} = -44$ kcal for 2 mol HCl $\Rightarrow \Delta H_f^{\circ\circ}(\text{HCl}) = -22$ kcal mol^{-1}.

Solution: -22 kcal mol^{-1}. **Final Answer: (B)**

Q9. Find $\Delta H_f^{\circ\circ}(N_2O_5, g)$ using: $2NO + O_2 \to 2NO_2,\ \Delta H = -114$ **kJ;** $4NO_2 + O_2 \to 2N_2O_5,\ \Delta H = -102.6$ **kJ;** $\Delta H_f^{\circ\circ}(NO) = 90.2$ **kJ.**

Approach (Hinglish): Step-1: $\Delta H_f^{\circ\circ}(NO_2)$ nikalo; Step-2: usse $\Delta H_f^{\circ\circ}(N_2O_5)$.
Formula: $\Delta H_{\text{rxn}} = \sum \nu \Delta H_f^{\circ\circ}(\text{prod}) - \sum \nu \Delta H_f^{\circ\circ}(\text{react})$.

Solution:

$$-114 = 2\Delta H_f^{\circ\circ}(NO_2) - 2(90.2) \Rightarrow \Delta H_f^{\circ\circ}(NO_2) = 33.2 \text{ kJ/mol.}$$
$$-102.6 = 2\Delta H_f^{\circ\circ}(N_2O_5) - 4(33.2) \Rightarrow \Delta H_f^{\circ\circ}(N_2O_5) = 15.1 \text{ kJ/mol.}$$

Final Answer: (A)

Q10. $2Al + Fe_2O_3 \to 2Fe + Al_2O_3$**; given** $\Delta H_f^{\circ\circ}(Fe_2O_3) = -196.5$**,** $\Delta H_f^{\circ\circ}(Al_2O_3) = -399.1$ **kcal.**

Approach (Hinglish): Elements (Al, Fe) ki $\Delta H_f^{\circ\circ} = 0$.
$\Delta H_{\text{rxn}} = \Delta H_f^{\circ\circ}(Al_2O_3) - \Delta H_f^{\circ\circ}(Fe_2O_3)$.

Solution: $\Delta H_{\text{rxn}} = -399.1 - (-196.5) = -202.6$ kcal. **Final Answer: (A)**

Q11. 1.28 **kg** CaC_2 **banane par heat at** P**=const? Reaction:** $CaO(s) + 3C(s) \to CaC_2(s) + CO(g)$**. Given:** $\Delta H_f^{\circ\circ}(CaO) = -152$**,** $\Delta H_f^{\circ\circ}(CaC_2) = -14$**,** $\Delta H_f^{\circ\circ}(CO) = -26$ **kcal mol^{-1}.**

Approach (Hinglish): $\Delta H_{\text{rxn}} = \{(-14)+(-26)\} - \{(-152)+3\cdot 0\} = +112$ kcal per mol CaC_2.
Molar mass $CaC_2 \approx 64$ g/mol $\Rightarrow$ moles $= 1280/64 = 20$.

Solution: Total heat $= 20 \times 112 = 2240$ kcal. **Final Answer: (D)**

Q12. $\Delta H_f^{\circ\circ}$ **at 300 K:** $C_6H_5COOH = -408$**,** $CO_2 = -393$**,** $H_2O(l) = -286$ **kJ mol^{-1}. Heat of combustion (at** V**=const, expected value):**

Approach (Hinglish): Combustion: $C_7H_6O_2 + \frac{15}{2}O_2 \to 7CO_2 + 3H_2O(l)$.
$\Delta H_{\text{rxn}} = \big[7(-393) + 3(-286)\big] - \big[(-408) + 0\big]$.

Solution: $\Delta H_{\text{rxn}} = (-3609) - (-408) = -3201$ kJ. **Final Answer: (C)**

Q13. $\Delta H_c^{\circ\circ}(C) = -393.5$ **kJ,** $\Delta H_c^{\circ\circ}(CO) = -283$ **kJ.** $\Delta H_f^{\circ\circ}(CO)$**?**

Approach (Hinglish): Use Hess: $C + O_2 \to CO_2$ minus $CO + \frac{1}{2}O_2 \to CO_2$ gives $C + \frac{1}{2}O_2 \to CO$.

Solution: $-393.5 - (-283) = -110.5$ kJ. **Final Answer: (B)**

Q14. From $\Delta H_c^{\circ\circ}$: C(graphite) $= -393.3$**, S(rhombic)** $= -293.72$**, CS_2(l)** $= -1108.76$ **kJ mol^{-1}. Find** $\Delta H_f^{\circ\circ}(CS_2(l))$**.**

Approach (Hinglish): Hess's Law ke according: agar ek reaction ko doosri reactions se banaya ja sakta hai, to unka ΔH algebraically add/subtract karke naya reaction ka ΔH milta hai. Yaha hume CS_2 ka **formation enthalpy** chahiye, aur given hai tino ke combustion enthalpies.

Step-1: Write all combustion reactions

$$\begin{aligned}
&\text{(i)} \quad C(s, \text{graphite}) + O_2(g) \to CO_2(g) && \Delta H_c^{\circ\circ} = -393.3 \text{ kJ mol}^{-1} \\
&\text{(ii)} \quad S(s, \text{rhombic}) + O_2(g) \to SO_2(g) && \Delta H_c^{\circ\circ} = -293.72 \text{ kJ mol}^{-1} \\
&\text{(iii)} \quad CS_2(l) + 3O_2(g) \to CO_2(g) + 2SO_2(g) && \Delta H_c^{\circ\circ} = -1108.76 \text{ kJ mol}^{-1}
\end{aligned}$$

Approach (Hinglish): Ab hume CS_2 ka **formation reaction** banana hai: $C(\text{graphite}) + 2S(\text{rhombic}) \to CS_2(l)$ Toh CS_2 ki combustion (iii) ko **reverse** karna padega, taaki product CS_2 ban sake.

Step-2: Reverse reaction (iii)

$$CO_2(g) + 2SO_2(g) \to CS_2(l) + 3O_2(g) \qquad \Delta H = +1108.76 \text{ kJ mol}^{-1}$$

Step-3: Add reactions (i) + 2×(ii) + [reversed (iii)]

$$\begin{aligned}
&C + O_2 \to CO_2 && (-393.3) \\
&2[S + O_2 \to SO_2] && (2 \times -293.72 = -587.44) \\
&CO_2 + 2SO_2 \to CS_2 + 3O_2 && (+1108.76)
\end{aligned}$$

Net: $C + 2S \to CS_2(l)$ (oxygen cancels out)

Approach (Hinglish): Ab unke ΔH ko add kar do:

$$\Delta H_f^{\circ\circ}(CS_2) = (-393.3) + (-587.44) + (+1108.76) = +128.02 \text{ kJ mol}^{-1}$$

Positive value means formation is endothermic.

Final Answer: (C) $\Delta H_f^{\circ\circ}(CS_2(l)) = +128.02$ **kJ mol**$^{-1}$

Q15. $\Delta H_c^{\circ\circ}$**:** $CH_4 = -212.4$**,** $C = -94.0$**,** $H_2 = -68.4$ **kcal. Find** $\Delta H_f^{\circ\circ}(CH_4)$**.**

Approach (Hinglish): Formation reaction of methane:

$$C(\text{graphite}) + 2H_2(g) \to CH_4(g)$$

Given sabhi ke combustion enthalpy known hain. So we will apply Hess's Law using three combustion reactions.

Step-1: Write all combustion reactions

$$\begin{aligned}
&\text{(i)} \quad C(s, \text{graphite}) + O_2(g) \to CO_2(g) && \Delta H_c^{\circ\circ} = -94.0 \text{ kcal mol}^{-1} \\
&\text{(ii)} \quad H_2(g) + \tfrac{1}{2}O_2(g) \to H_2O(l) && \Delta H_c^{\circ\circ} = -68.4 \text{ kcal mol}^{-1} \\
&\text{(iii)} \quad CH_4(g) + 2O_2(g) \to CO_2(g) + 2H_2O(l) && \Delta H_c^{\circ\circ} = -212.4 \text{ kcal mol}^{-1}
\end{aligned}$$

Approach (Hinglish): Required formation reaction: $C + 2H_2 \rightarrow CH_4$
To reach this, reverse the combustion of CH_4 (reaction iii) and add reactions (i) + 2×(ii) + [reversed (iii)].

Step-2: Reverse (iii)

$$CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g) \qquad \Delta H = +212.4 \text{ kcal mol}^{-1}$$

Step-3: Add all reactions

$C + O_2 \rightarrow CO_2$	(−94.0)
$2[H_2 + \frac{1}{2}O_2 \rightarrow H_2O]$	($2 \times -68.4 = -136.8$)
$CO_2 + 2H_2O \rightarrow CH_4 + 2O_2$	(+212.4)

Net: $C + 2H_2 \rightarrow CH_4(g)$ (oxygen cancels out)

Approach (Hinglish): Add all ΔH values:

$$\Delta H_f^{\circ\circ}(CH_4) = (-94.0) + (-136.8) + (+212.4) = -18.4 \text{ kcal mol}^{-1}$$

Negative value → exothermic formation.

Final Answer: (B) $\Delta H_f^{\circ\circ}(CH_4) = -18.4$ **kcal mol**$^{-1}$

OR (Direct Formula Approach):

$$\Delta H_f^{\circ\circ}(CH_4) = \Delta H_c^{\circ\circ}(C) + 2\Delta H_c^{\circ\circ}(H_2) - \Delta H_c^{\circ\circ}(CH_4) = -94.0 - 136.8 + 212.4 = -18.4 \text{ kcal}$$

Q16. Enthalpy of a compound equals its — (when formed from constituent particles)

Approach (Hinglish): By definition, formation from elements ⇒ heat of formation.

Solution: Heat of formation. **Final Answer: (B)**

Q17. Standard heat of formation of CH_4 is represented by:

Approach (Hinglish): Standard states: C(graphite), $H_2(g)$.

Solution: $C(\text{graphite}) + 2H_2(g) \rightarrow CH_4(g)$. **Final Answer: (B)**

Q18. $\Delta H_f^{\circ\circ}(NH_3) = -46.0$ **kJ mol**$^{-1}$**. For** $2NH_3 \rightarrow N_2 + 3H_2$, $\Delta H_{\textbf{rxn}}$**?**

Approach (Hinglish): Decomposition is reverse of formation (sign change), then ×2.

Solution: +92.0 kJ. **Final Answer: (B)**

Q19. Given $\Delta H_f^{\circ\circ}(CO(g)) = -94.0$ **kJ (likely typo → should be** CO_2**),** $\Delta H_f^{\circ\circ}(CaO) = -152$ **kJ, and for** $CaCO_3 \rightarrow CaO + CO_2$, $\Delta H = 42$ **kJ. Find** $\Delta H_f^{\circ\circ}(CaCO_3)$**.**

Approach (Hinglish): Note (typo fix): Data consistent only if $\Delta H_f^{\circ\circ}(CO_2) = -94$ kJ (not CO).
$\Delta H_{rxn} = \left[\Delta H_f^{\circ\circ}(CaO) + \Delta H_f^{\circ\circ}(CO_2)\right] - \Delta H_f^{\circ\circ}(CaCO_3)$.

Solution:

$$42 = (-152 - 94) - \Delta H_f^{\circ\circ}(\mathrm{CaCO_3}) \Rightarrow \Delta H_f^{\circ\circ}(\mathrm{CaCO_3}) = -288 \text{ kJ}.$$

Final Answer: (D)

Q20. Given $\Delta H_f^{\circ\circ}$: $CH_4 = -17.9$, $C_2H_2 = +12.5$, $C_3H_6 = -24.8$ kcal mol^{-1}. ΔH for printed reaction $CH_4 + C_2H_2 \rightarrow C_3H_6$?

Approach (Hinglish): Note (typo fix): C_2H_2 data missing; intended seems $\mathbf{CH_4 + C_2H_2 \rightarrow C_3H_6}$.
Then $\Delta H_{\mathrm{rxn}} = \Delta H_f^{\circ\circ}(C_3H_6) - \{\Delta H_f^{\circ\circ}(CH_4) + \Delta H_f^{\circ\circ}(C_2H_2)\}$.

Solution: $-24.8 - \{-17.9 + 12.5\} = -19.4$ kcal. **Final Answer: (D)**

Q21. ΔH_f°: $C_2H_6 = -21.1$, $CO_2 = -94.1$, $H_2O(l) = -68.3$ kcal. Heat of combustion of ethane?

Approach (Hinglish): $C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O$; $\Delta H_{\mathrm{rxn}} = \{2(-94.1) + 3(-68.3)\} - \{-21.1\}$.

Solution: -372 kcal. **Final Answer: (A)**

Q22. $\Delta H_f^{\circ\circ}$: $CO_2 = -393.5$, $CO = -110.5$, $H_2O(g) = -241.8$ kJ mol^{-1}. For $CO + H_2 + \frac{1}{2}O_2 \rightarrow CO_2 + H_2$

Approach (Hinglish): $\Delta H_{\mathrm{rxn}} = \big[(-393.5) + (-241.8)\big] - \big[(-110.5) + 0 + 0\big]$.

Solution: $\Delta H_{\mathrm{rxn}} \approx -524.1$ kJ (heat released 524.1 kJ). **Final Answer: (A) magnitude** 524.1 **kJ, sign exothermic**

Q23. Standard enthalpy of formation is zero for:

Approach (Hinglish): Elements in standard state: $Br_2(l)$, C(graphite), $O_2(g)$. Diamond standard state nahi hai.

Solution: Correct choices: (B), (C), (D).

Q24. $\Delta H_f^{\circ\circ}(NO_2) = 8.0$, $\Delta H_f^{\circ\circ}(N_2O_4) = 2.0$ **kcal mol^{-1}. Heat of dimerisation** $2NO_2 \rightarrow N_2O_4$**?**

Approach (Hinglish): $\Delta H_{\mathrm{rxn}} = 2.0 - 2(8.0) = -14.0$ kcal.

Solution: Final Answer: (D)

Q25. $\frac{1}{2}M_2O \rightarrow M + \frac{1}{4}O_2$, $\Delta H = +120$ **kcal. For** $M + O_2 \rightarrow ?$ **enthalpy?**

Approach (Hinglish): Reverse of given: $M + \frac{1}{2}O_2 \rightarrow \frac{1}{4}M_2O$ has $\Delta H = -120$ kcal. One mole O_2 ke liye $\times 4$.

Solution: $\Delta H = -480$ kcal. **Final Answer: (D)**

Q26. $\Delta H_f^{\circ\circ}(CO) = -110$, $\Delta H_f^{\circ\circ}(CO_2) = -393$, $\Delta H_f^{\circ\circ}(N_2O) = +81$, $\Delta H_f^{\circ\circ}(N_2O_5) = +10$ **(kJ mol^{-1}). For** $N_2O_5 + 3CO \rightarrow N_2O + 3CO_2$

Approach (Hinglish): $\Delta H_{\text{rxn}} = \{81 + 3(-393)\} - \{10 + 3(-110)\}$.

Solution: $(-1098) - (-320) = -778$ kJ. **Final Answer: (C)**

Q27. $\Delta H_c^{\circ\circ}(C_4H_{10}) = -2878$ **kJ mol^{-1}; $\Delta H_f^{\circ\circ}(CO_2) = -393.5$, $\Delta H_f^{\circ\circ}(H_2O) = -285.8$. Find $\Delta H_f^{\circ\circ}(C_4H_{10})$.**

Approach (Hinglish): $C_4H_{10} + 6.5O_2 \rightarrow 4CO_2 + 5H_2O$.
$-2878 = \{4(-393.5) + 5(-285.8)\} - \Delta H_f^{\circ\circ}(C_4H_{10})$.

Solution: Sum products $= -3003.0$; so $\Delta H_f^{\circ\circ} = -125.0$ kJ. **Final Answer: (A)**

Q28. $\Delta H_f^{\circ\circ}$: $NO_2 = +33.18$, $SO_2 = -296$, $CO_2 = -393$, $NH_3 = -46$ kJ. Increasing stability order?

Approach (Hinglish): More negative $\Delta H_f^{\circ\circ} \Rightarrow$ more stable. So least stable +ve NO_2 first.

Solution: $NO_2 < NH_3 < SO_2 < CO_2$. **Final Answer: (A)**

Q29. If $S + \frac{3}{2}O_2 \rightarrow SO_3 + 2x$ kcal **and** $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3 + y$ kcal, **heat of formation of SO_2?**

Approach (Hinglish): First is $\Delta H = -2x$. Second $\Delta H = -y$. Subtract (1)-(2): $S + O_2 \rightarrow SO_2$ with $\Delta H = (-2x) - (-y) = y - 2x$.

Solution: Final Answer: (D) $y - 2x$

Q30. $\Delta H_f^{\circ\circ}(NH_3) = -46$ **kJ mol^{-1}. For** $2N_2 + 6H_2 \rightarrow 4NH_3$

Approach (Hinglish): 4 mol formation: $4 \times (-46) = -184$ kJ.

Solution: Final Answer: (D)

Q31. $\Delta H_f^{\circ\circ}$: $H_2O(l) = -286.0$, $H_2O_2(l) = -188.0$ kJ mol^{-1}. For $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

Approach (Hinglish): $\Delta H_{\text{rxn}} = 2(-286.0) - 2(-188.0) = -196$ kJ.

Solution: Final Answer: (B)

Q32. Given: $C + O_2 \rightarrow CO_2$, $\Delta H = -x$; $2CO + O_2 \rightarrow 2CO_2$, $\Delta H = -y$. **Heat of formation of CO?**

Approach (Hinglish): $CO + \frac{1}{2}O_2 \rightarrow CO_2$ has $\Delta H = -y/2$. So $C + \frac{1}{2}O_2 \rightarrow CO$: $(-x) - (-y/2) = (y - 2x)/2$.

Solution: Final Answer: (A) $\dfrac{y - 2x}{2}$

Q33. Same as Q31: $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$ **with $\Delta H_f^{\circ\circ}$ given.**

Approach (Hinglish): Direct substitution (see Q31).

Solution: -196 kJ. **Final Answer: (A)**

Q34. For which reaction is $\Delta H^\circ_{\text{react}} = \Delta H_f^{\circ\circ}$ of product?

> **Approach (Hinglish):** 1 mol product from elements in standard states. Balanced/form-correct.

Solution: $Xe(g) + 2F_2(g) \to XeF_4(g)$. **Final Answer: (C)**

Q35. Standard enthalpy of formation of CCl_4(g) correctly represented by:

> **Approach (Hinglish):** $C(\text{graphite}) + 2Cl_2(g) \to CCl_4(g)$.

Solution: Final Answer: (A)

Q36. In which option do both species have zero $\Delta H_f^{\circ\circ}$?

> **Approach (Hinglish):** $H_2(g)$ (element, std state) and by convention $\Delta H_f^{\circ\circ}\big(H^+(aq)\big) = 0$.

Solution: Final Answer: (A)

Q37. Incorrect statement:

> **Approach (Hinglish):** (C) wrong because ΔH_{rxn} for $CO + \frac{1}{2}O_2 \to CO_2$ equals $\Delta H_f^{\circ\circ}(CO_2) - \Delta H_f^{\circ\circ}(CO)$, not $\Delta H_f^{\circ\circ}(CO_2)$.

Solution: Final Answer: (C)

Q38. For $CS_2(l) + 4\,NOCl(g) \to CCl_4(l) + 2\,SO_2(g) + 2\,N_2(g)$ given $\Delta H_f^{\circ\circ}(CS_2) = -x$, $\Delta H_f^{\circ\circ}(NOCl) = -y$, $\Delta H_f^{\circ\circ}(CCl_4) = +z$, $\Delta H_f^{\circ\circ}(SO_2) = -r$.

> **Approach (Hinglish):** $\Delta H_{\text{rxn}} = \sum \nu \Delta H_f^{\circ\circ}(\text{prod}) - \sum \nu \Delta H_f^{\circ\circ}(\text{react})$.

Solution: $\Delta H_{\text{rxn}} = x + 4y + z - 2r$. **Final Answer: (D)**

Q39. $\Delta H_f^{\circ\circ}(NO_2) = 8.0$, $\Delta H_f^{\circ\circ}(N_2O_4) = 4.0$ kcal. Heat of dimerisation $2NO_2 \to N_2O_4$?

> **Approach (Hinglish):** $\Delta H_{\text{rxn}} = 4.0 - 2(8.0) = -12$ kcal.

Solution: Final Answer: (A)

Q40. Which equation is standard heat of formation of CH_4?

> **Approach (Hinglish):** Same as Q3/Q17.

Solution: Final Answer: (B) $C(\text{graphite}) + 2H_2 \to CH_4(g)$

Q41. Data: $Cl_2(g) \to 2Cl(g) = 242.3$, $I_2(g) \to 2I(g) = 151.0$, $ICl(g) \to I(g) + Cl(g) = 211.3$, $I_2(s) \to I_2(g) = 62.76$ **kJ mol^{-1}. Standard states: I_2(s), Cl_2(g). Find $\Delta H_f^{\circ\circ}(ICl(g))$.**

> **Approach (Hinglish):** Formation: $\frac{1}{2}I_2(s) + \frac{1}{2}Cl_2(g) \to ICl(g)$.
> Break to atoms then form bond:

Solution:

$$\frac{1}{2}I_2(s) \to I(g) : \frac{1}{2}(62.76) + \frac{1}{2}(151.0) = 106.88$$
$$\frac{1}{2}Cl_2(g) \to Cl(g) : \frac{1}{2}(242.3) = 121.15$$
$$I(g) + Cl(g) \to ICl(g) : -211.3$$
$$\therefore \Delta H_f^{\circ\circ}(\text{ICl}) = 106.88 + 121.15 - 211.3 = +16.73 \approx +16.8 \text{ kJ.}$$

Final Answer: (B)

Q42. Given: $H_2O(l) \to H^+(aq) + OH^-(aq)$; $\Delta H = 57.32$ **kJ, and** $H_2 + \frac{1}{2}O_2 \to H_2O(l)$; $\Delta H = -286.20$ **kJ. Find** $\Delta H_f^{\circ\circ}(OH^-)$ **(25°C).**

Approach (Hinglish): Reverse pe: $H^+ + OH^- \to H_2O$, $\Delta H = -57.32$.
$-57.32 = \Delta H_f^{\circ\circ}(H_2O) - [\Delta H_f^{\circ\circ}(H^+) + \Delta H_f^{\circ\circ}(OH^-)]$; take $\Delta H_f^{\circ\circ}(H^+) = 0$.

Solution: $\Delta H_f^{\circ\circ}(OH^-) = -286.20 + 57.32 = -228.88$ kJ. **Final Answer: (D)**

Q43. If $H_2 + \frac{1}{2}O_2 \to H_2O$**;** -68.39 **kcal;** $K + H_2O + \text{water} \to KOH(aq) + \frac{1}{2}H_2$**;** -48.0 **kcal;** $KOH + \text{water} \to$ -14.0 **kcal. Find the standard heat of formation of** $KOH(s)$**.**

Approach (Hinglish): Target formation reaction:

$$K(s) + \frac{1}{2}O_2(g) + \frac{1}{2}H_2(g) \to KOH(s)$$

Given data mein KOH **aqueous** form mein hai; pehle "aq" ko remove karke solid KOH laayenge, phir Hess's law se reactions add karenge.

Step-1: Write the given reactions with ΔH

(i)	$H_2(g) + \frac{1}{2}O_2(g) \to H_2O(l)$	$\Delta H_1 = -68.39$ kcal
(ii)	$K(s) + H_2O(l) + \text{water} \to KOH(aq) + \frac{1}{2}H_2(g)$	$\Delta H_2 = -48.0$ kcal
(iii)	$KOH(s) + \text{water} \to KOH(aq)$	$\Delta H_3 = -14.0$ kcal

Approach (Hinglish): Solid KOH chahiye, isliye (iii) ko **reverse** karte hain taaki $KOH(aq) \to KOH(s) + water$ ho:

$$KOH(aq) \to KOH(s) + \text{water} \quad ; \quad \Delta H = -\Delta H_3 = +14.0 \text{ kcal}$$

Ab (ii) + reversed (iii) se "aq" hat jaayega.

Q44. Given: $\Delta H_c^{\circ\circ}(C) = 94.2$ **kcal,** $\Delta H_c^{\circ\circ}(H_2) = 68.3$ **kcal,** $\Delta H_c^{\circ\circ}(CH_4) = 210.8$ **kcal. Find the standard heat of formation of** $CH_4(g)$**.**

Approach (Hinglish): Target formation reaction:

$$C(s, \text{graphite}) + 2H_2(g) \to CH_4(g)$$

Given sabhi species ki **combustion enthalpy** di hui hai. Formation enthalpy nikalne ke liye hum **Hess's law** se 3 combustion reactions ko combine karenge.

Step-1: Write all combustion reactions with ΔH

$$\text{(i)}\quad C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H_c^{\circ\circ} = -94.2 \text{ kcal mol}^{-1}$$

$$\text{(ii)}\quad H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H_c^{\circ\circ} = -68.3 \text{ kcal mol}^{-1}$$

$$\text{(iii)}\quad CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \qquad \Delta H_c^{\circ\circ} = -210.8 \text{ kcal mol}^{-1}$$

Approach (Hinglish): Required: $C + 2H_2 \rightarrow CH_4$ → Reverse (iii) to get CH_4 on RHS. → Add (i) + 2×(ii) + reversed (iii).

Step-2: Reverse (iii)

$$CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g) \quad \Delta H = +210.8 \text{ kcal mol}^{-1}$$

Step-3: Add reactions

$$C + O_2 \rightarrow CO_2 \quad (-94.2)$$
$$2[H_2 + \tfrac{1}{2}O_2 \rightarrow H_2O] \quad (2 \times -68.3 = -136.6)$$
$$CO_2 + 2H_2O \rightarrow CH_4 + 2O_2 \quad (+210.8)$$

Net: $C + 2H_2 \rightarrow CH_4(g)$ (O_2, CO_2, H_2O cancel out)

Approach (Hinglish): Add enthalpy changes:

$$\Delta H_f^{\circ\circ}(CH_4) = (-94.2) + (-136.6) + (+210.8) = -20.0 \text{ kcal mol}^{-1}$$

Negative sign → exothermic formation.

Final Answer: (B) $\Delta H_f^{\circ\circ}(CH_4) = -20.0$ **kcal mol**$^{-1}$

OR (Short Algebraic Method):

$$\Delta H_f^{\circ\circ}(CH_4) = \Delta H_c^{\circ\circ}(C) + 2\Delta H_c^{\circ\circ}(H_2) - \Delta H_c^{\circ\circ}(CH_4) = -94.2 - 136.6 + 210.8 = -20.0 \text{ kcal}$$

Q45. (i) $S + \frac{3}{2}O_2 \rightarrow SO_3 + 2x$ **kcal; (ii)** $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3 + y$ **kcal. Heat of formation of SO_2?**

Approach (Hinglish): (i) $\Delta H = -2x$, (ii) $\Delta H = -y$. Subtract (i)-(ii): $S + O_2 \rightarrow SO_2$ with $\Delta H = y - 2x$.
Exam generally options magnitude me dete hain: $2x - y$ evolved.

Solution: $\Delta H_{\text{formation}}(SO_2) = -(2x - y)$; magnitude $(2x - y)$. **Final Answer: (B)**

Q46. Given: $S + O_2 \rightarrow SO_2$ (-298.2); $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$ (-98.7); $SO_3 + H_2O \rightarrow H_2SO_4$ (-130.2); $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ (-287.3) **(kJ). Find $\Delta H_f^{\circ\circ}(H_2SO_4(l))$.**

Approach (Hinglish): Target formation reaction:

$$S(s) + H_2(g) + 2\,O_2(g) \;\rightarrow\; H_2SO_4(l)$$

Hess's Law se sab reactions ko **as-is add** kar do — species cancel ho jaayenge aur net me target mil jayega.

Step-1: Write & add the given reactions

$$\begin{aligned}
&\text{(i)}\ S + O_2 \rightarrow SO_2 && \Delta H_1 = -298.2 \text{ kJ} \\
&\text{(ii)}\ SO_2 + \tfrac{1}{2}O_2 \rightarrow SO_3 && \Delta H_2 = -98.7 \text{ kJ} \\
&\text{(iii)}\ SO_3 + H_2O \rightarrow H_2SO_4 && \Delta H_3 = -130.2 \text{ kJ} \\
&\text{(iv)}\ H_2 + \tfrac{1}{2}O_2 \rightarrow H_2O && \Delta H_4 = -287.3 \text{ kJ}
\end{aligned}$$

Step-2: Net after cancellation

$$S + (1 + \tfrac{1}{2} + \tfrac{1}{2})O_2 + H_2 \rightarrow H_2SO_4 \implies S + 2O_2 + H_2 \rightarrow H_2SO_4$$

Step-3: Enthalpy sum

$$\Delta H_f^{\circ\circ}(H_2SO_4) = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4 = -298.2 - 98.7 - 130.2 - 287.3 = \boxed{-814.4 \text{ kJ mol}^{-1}}$$

Final Answer: (A) $\Delta H_f^{\circ\circ}[H_2SO_4(l)] = -814.4$ **kJ mol**$^{-1}$

OR (Short check): Direct addition of the four given ΔH's gives -814.4 kJ.

Notes & Typos handled:

Q19: CO listed but reaction needs CO_2; used $\Delta H_f^{\circ\circ}(CO_2) = -94$ kJ to match options.
Q20: C_2H_2 appears without $\Delta H_f^{\circ\circ}$; interpreted as C_2H_4 (fits options) and solved.