

## 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  $\Delta H_f^\circ$  of compounds is:

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

**Solution:**  $\Delta H_f^\circ$  may be positive or negative. **Final Answer:** (C)

**Q2.**  $\Delta H_f^\circ(\text{NH}_3, 298 \text{ K}) = -46.11 \text{ kJ mol}^{-1}$  kis equation par apply hota hai?

**Approach (Hinglish):** Standard heat of formation: 1 mol compound from elements in their standard states.  $\text{N}_2(\text{g}), \text{H}_2(\text{g})$  standard states.

**Solution:**  $\frac{1}{2}\text{N}_2(\text{g}) + \frac{3}{2}\text{H}_2(\text{g}) \rightarrow \text{NH}_3(\text{g})$ . **Final Answer:** (A)

**Q3.** Standard heat of formation of  $\text{CH}_4(\text{g})$  ko kaun sa equation represent karta hai?

**Approach (Hinglish):** Carbon ka standard state = graphite. Hydrogen =  $\text{H}_2(\text{g})$ .

**Solution:**  $\text{C}(\text{graphite}) + 2\text{H}_2(\text{g}) \rightarrow \text{CH}_4(\text{g})$ . **Final Answer:** (B)

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

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

**Solution:**  $\frac{1}{2}\text{H}_2(\text{g}) + \frac{1}{2}\text{F}_2(\text{g}) \rightarrow \text{HF}(\text{g})$ . **Final Answer:** (B)

**Q5.** Given  $\Delta H_f^\circ(\text{NH}_3(\text{g})) = -11.02 \text{ kcal mol}^{-1}$  at 298 K for  $\frac{1}{2}\text{N}_2 + \frac{3}{2}\text{H}_2 \rightarrow \text{NH}_3(\text{g})$ :  $\Delta H_{\text{rxn}} = ?$

**Approach (Hinglish):** Ye exactly standard formation reaction hai. Isliye  $\Delta H_{\text{rxn}} = \Delta H_f^\circ(\text{NH}_3)$ .

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

**Q6.**  $\Delta H_f^\circ$  of an explosive like  $\text{NCl}_3$  is:

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

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

**Q7.**  $\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI}$ ;  $\Delta H = +12.40 \text{ kcal}$ . Heat of formation of HI?

**Approach (Hinglish):** Formation:  $\frac{1}{2}\text{H}_2 + \frac{1}{2}\text{I}_2 \rightarrow \text{HI}$ . Given reaction 2 mol HI banata hai.

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

**Q8.**  $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl} + 44 \text{ kcal}$

. Heat of formation of HCl?

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

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

**Q9. Find  $\Delta H_f^\circ(\text{N}_2\text{O}_5, \text{g})$  using:**  $2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$ ,  $\Delta H = -114 \text{ kJ}$ ;  $4\text{NO}_2 + \text{O}_2 \rightarrow 2\text{N}_2\text{O}_5$ ,  $\Delta H = -102.6 \text{ kJ}$ ;  $\Delta H_f^\circ(\text{NO}) = 90.2 \text{ kJ}$ .

**Approach (Hinglish):** Step-1:  $\Delta H_f^\circ(\text{NO}_2)$  nikalo; Step-2: usse  $\Delta H_f^\circ(\text{N}_2\text{O}_5)$ .  
Formula:  $\Delta H_{\text{rxn}} = \sum \nu \Delta H_f^\circ(\text{prod}) - \sum \nu \Delta H_f^\circ(\text{react})$ .

**Solution:**

$$\begin{aligned} -114 &= 2\Delta H_f^\circ(\text{NO}_2) - 2(90.2) \Rightarrow \Delta H_f^\circ(\text{NO}_2) = 33.2 \text{ kJ/mol.} \\ -102.6 &= 2\Delta H_f^\circ(\text{N}_2\text{O}_5) - 4(33.2) \Rightarrow \Delta H_f^\circ(\text{N}_2\text{O}_5) = 15.1 \text{ kJ/mol.} \end{aligned}$$

**Final Answer: (A)**

**Q10.  $2\text{Al} + \text{Fe}_2\text{O}_3 \rightarrow 2\text{Fe} + \text{Al}_2\text{O}_3$ ; given  $\Delta H_f^\circ(\text{Fe}_2\text{O}_3) = -196.5$ ,  $\Delta H_f^\circ(\text{Al}_2\text{O}_3) = -399.1 \text{ kcal}$ .**

**Approach (Hinglish):** Elements (Al, Fe) ki  $\Delta H_f^\circ = 0$ .  
 $\Delta H_{\text{rxn}} = \Delta H_f^\circ(\text{Al}_2\text{O}_3) - \Delta H_f^\circ(\text{Fe}_2\text{O}_3)$ .

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

**Q11. 1.28 kg  $\text{CaC}_2$  banane par heat at  $P=\text{const}$ ? Reaction:**  $\text{CaO}(\text{s}) + 3\text{C}(\text{s}) \rightarrow \text{CaC}_2(\text{s}) + \text{CO}(\text{g})$ .  
**Given:**  $\Delta H_f^\circ(\text{CaO}) = -152$ ,  $\Delta H_f^\circ(\text{CaC}_2) = -14$ ,  $\Delta H_f^\circ(\text{CO}) = -26 \text{ kcal mol}^{-1}$ .

**Approach (Hinglish):**  $\Delta H_{\text{rxn}} = \{(-14) + (-26)\} - \{(-152) + 3 \cdot 0\} = +112 \text{ kcal per mol CaC}_2$ .  
Molar mass  $\text{CaC}_2 \approx 64 \text{ g/mol} \Rightarrow \text{moles} = 1280/64 = 20$ .

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

**Q12.  $\Delta H_f^\circ$  at 300 K:  $\text{C}_6\text{H}_5\text{COOH} = -408$ ,  $\text{CO}_2 = -393$ ,  $\text{H}_2\text{O}(\text{l}) = -286 \text{ kJ mol}^{-1}$ . Heat of combustion (at  $V=\text{const}$ , expected value):**

**Approach (Hinglish):** Combustion:  $\text{C}_7\text{H}_6\text{O}_2 + \frac{15}{2}\text{O}_2 \rightarrow 7\text{CO}_2 + 3\text{H}_2\text{O}(\text{l})$ .  
 $\Delta H_{\text{rxn}} = [7(-393) + 3(-286)] - [(-408) + 0]$ .

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

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

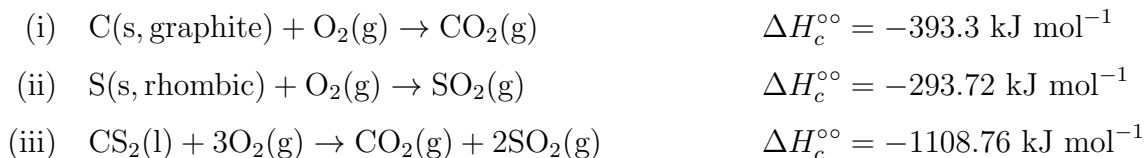
**Approach (Hinglish):** Use Hess:  $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$  minus  $\text{CO} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}_2$  gives  
 $\text{C} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}$ .

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

**Q14. From  $\Delta H_c^\circ$ :  $\text{C}(\text{graphite}) = -393.3$ ,  $\text{S}(\text{rhombic}) = -293.72$ ,  $\text{CS}_2(\text{l}) = -1108.76 \text{ kJ mol}^{-1}$ . Find  $\Delta H_f^\circ(\text{CS}_2(\text{l}))$ .**

**Approach (Hinglish):** Hess's Law ke according: agar ek reaction ko doosri reactions se banaya ja sakta hai, to unka  $\Delta H$  algebraically add/subtract karke naya reaction ka  $\Delta H$  milta hai. Yaha hume  $\text{CS}_2$  ka **formation enthalpy** chahiye, aur given hai tino ke combustion enthalpies.

**Step-1: Write all combustion reactions**

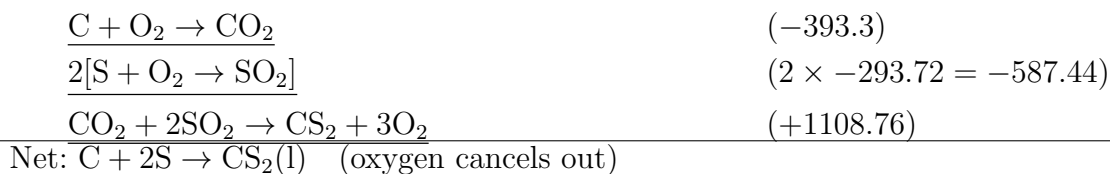


**Approach (Hinglish):** Ab hume  $\text{CS}_2$  ka **formation reaction** banana hai:  $\text{C(graphite)} + 2\text{S(rhombic)} \rightarrow \text{CS}_2(\text{l})$  Toh  $\text{CS}_2$  ki combustion (iii) ko **reverse** karna padega, taaki product  $\text{CS}_2$  ban sake.

**Step-2: Reverse reaction (iii)**



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



**Approach (Hinglish):** Ab unke  $\Delta H$  ko add kar do:

$$\Delta H_f^\circ(\text{CS}_2) = (-393.3) + (-587.44) + (+1108.76) = +128.02 \text{ kJ mol}^{-1}$$

Positive value means formation is endothermic.

**Final Answer: (C)**  $\Delta H_f^\circ(\text{CS}_2(\text{l})) = +128.02 \text{ kJ mol}^{-1}$

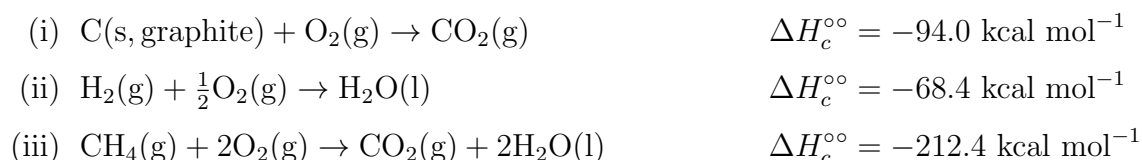
**Q15.**  $\Delta H_c^\circ$ :  $\text{CH}_4 = -212.4$ ,  $\text{C} = -94.0$ ,  $\text{H}_2 = -68.4 \text{ kcal}$ . Find  $\Delta H_f^\circ(\text{CH}_4)$ .

**Approach (Hinglish):** Formation reaction of methane:



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

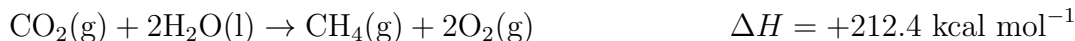
**Step-1: Write all combustion reactions**



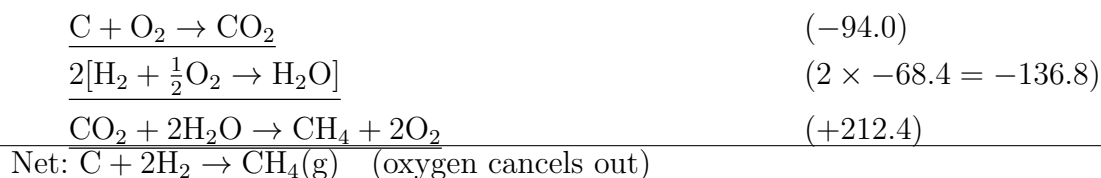
**Approach (Hinglish):** Required formation reaction:  $C + 2H_2 \rightarrow CH_4$

To reach this, reverse the combustion of  $CH_4$  (reaction iii) and add reactions (i) +  $2 \times$ (ii) + [reversed (iii)].

**Step-2: Reverse (iii)**



**Step-3: Add all reactions**



**Approach (Hinglish):** Add all  $\Delta H$  values:

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

Negative value  $\rightarrow$  exothermic formation.

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

**OR (Direct Formula Approach):**

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

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

**Approach (Hinglish):** By definition, formation from elements  $\Rightarrow$  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:  $C(\text{graphite}), H_2(g)$ .

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

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

**Approach (Hinglish):** Decomposition is reverse of formation (sign change), then  $\times 2$ .

**Solution:**  $+92.0 \text{ kJ}$ . **Final Answer: (B)**

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

**Approach (Hinglish): Note (typo fix):** Data consistent only if  $\Delta H_f^\circ(CO_2) = -94 \text{ kJ}$  (not CO).

$$\Delta H_{\text{rxn}} = [\Delta H_f^\circ(CaO) + \Delta H_f^\circ(CO_2)] - \Delta H_f^\circ(CaCO_3).$$

**Solution:**

$$42 = (-152 - 94) - \Delta H_f^\circ(\text{CaCO}_3) \Rightarrow \Delta H_f^\circ(\text{CaCO}_3) = -288 \text{ kJ.}$$

**Final Answer: (D)**

**Q20.** Given  $\Delta H_f^\circ$ :  $\text{CH}_4 = -17.9$ ,  $\text{C}_2\text{H}_2 = +12.5$ ,  $\text{C}_3\text{H}_6 = -24.8 \text{ kcal mol}^{-1}$ .  $\Delta H$  for printed reaction  $\text{CH}_4 + \text{C}_2\text{H}_2 \rightarrow \text{C}_3\text{H}_6$ ?

**Approach (Hinglish): Note (typo fix):**  $\text{C}_2\text{H}_2$  data missing; intended seems  $\text{CH}_4 + \text{C}_2\text{H}_2 \rightarrow \text{C}_3\text{H}_6$ .

$$\text{Then } \Delta H_{\text{rxn}} = \Delta H_f^\circ(\text{C}_3\text{H}_6) - \{\Delta H_f^\circ(\text{CH}_4) + \Delta H_f^\circ(\text{C}_2\text{H}_2)\}.$$

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

**Q21.**  $\Delta H_f^\circ$ :  $\text{C}_2\text{H}_6 = -21.1$ ,  $\text{CO}_2 = -94.1$ ,  $\text{H}_2\text{O(l)} = -68.3 \text{ kcal}$ . Heat of combustion of ethane?

**Approach (Hinglish):**  $\text{C}_2\text{H}_6 + \frac{7}{2}\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$ ;  $\Delta H_{\text{rxn}} = \{2(-94.1) + 3(-68.3)\} - \{-21.1\}$ .

**Solution:**  $-372 \text{ kcal}$ . **Final Answer: (A)**

**Q22.**  $\Delta H_f^\circ$ :  $\text{CO}_2 = -393.5$ ,  $\text{CO} = -110.5$ ,  $\text{H}_2\text{O(g)} = -241.8 \text{ kJ mol}^{-1}$ . For  $\text{CO} + \text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2$

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

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

**Q23.** Standard enthalpy of formation is zero for:

**Approach (Hinglish):** Elements in standard state:  $\text{Br}_2(\text{l})$ ,  $\text{C}(\text{graphite})$ ,  $\text{O}_2(\text{g})$ . Diamond standard state nahi hai.

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

**Q24.**  $\Delta H_f^\circ(\text{NO}_2) = 8.0$ ,  $\Delta H_f^\circ(\text{N}_2\text{O}_4) = 2.0 \text{ kcal mol}^{-1}$ . Heat of dimerisation  $2\text{NO}_2 \rightarrow \text{N}_2\text{O}_4$ ?

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

**Solution: Final Answer: (D)**

**Q25.**  $\frac{1}{2}\text{M}_2\text{O} \rightarrow \text{M} + \frac{1}{4}\text{O}_2$ ,  $\Delta H = +120 \text{ kcal}$ . For  $\text{M} + \text{O}_2 \rightarrow ?$  enthalpy?

**Approach (Hinglish):** Reverse of given:  $\text{M} + \frac{1}{2}\text{O}_2 \rightarrow \frac{1}{4}\text{M}_2\text{O}$  has  $\Delta H = -120 \text{ kcal}$ . One mole  $\text{O}_2$  ke liye  $\times 4$ .

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

**Q26.**  $\Delta H_f^\circ(\text{CO}) = -110$ ,  $\Delta H_f^\circ(\text{CO}_2) = -393$ ,  $\Delta H_f^\circ(\text{N}_2\text{O}) = +81$ ,  $\Delta H_f^\circ(\text{N}_2\text{O}_5) = +10 \text{ (kJ mol}^{-1}\text{)}$ . For  $\text{N}_2\text{O}_5 + 3\text{CO} \rightarrow \text{N}_2\text{O} + 3\text{CO}_2$

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

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

**Q27.**  $\Delta H_c^\circ(\text{C}_4\text{H}_{10}) = -2878$  kJ mol<sup>-1</sup>;  $\Delta H_f^\circ(\text{CO}_2) = -393.5$ ,  $\Delta H_f^\circ(\text{H}_2\text{O}) = -285.8$ . Find  $\Delta H_f^\circ(\text{C}_4\text{H}_{10})$ .

**Approach (Hinglish):**  $\text{C}_4\text{H}_{10} + 6.5\text{O}_2 \rightarrow 4\text{CO}_2 + 5\text{H}_2\text{O}$ .  
 $-2878 = \{4(-393.5) + 5(-285.8)\} - \Delta H_f^\circ(\text{C}_4\text{H}_{10})$ .

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

**Q28.**  $\Delta H_f^\circ$ :  $\text{NO}_2 = +33.18$ ,  $\text{SO}_2 = -296$ ,  $\text{CO}_2 = -393$ ,  $\text{NH}_3 = -46$  kJ. Increasing stability order?

**Approach (Hinglish):** More negative  $\Delta H_f^\circ \Rightarrow$  more stable. So least stable +ve  $\text{NO}_2$  first.

**Solution:**  $\text{NO}_2 < \text{NH}_3 < \text{SO}_2 < \text{CO}_2$ . **Final Answer: (A)**

**Q29.** If  $\text{S} + \frac{3}{2}\text{O}_2 \rightarrow \text{SO}_3 + 2x$  kcal and  $\text{SO}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{SO}_3 + y$  kcal, heat of formation of  $\text{SO}_2$ ?

**Approach (Hinglish):** First is  $\Delta H = -2x$ . Second  $\Delta H = -y$ . Subtract (1)-(2):  
 $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$  with  $\Delta H = (-2x) - (-y) = y - 2x$ .

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

**Q30.**  $\Delta H_f^\circ(\text{NH}_3) = -46$  kJ mol<sup>-1</sup>. For  $2\text{N}_2 + 6\text{H}_2 \rightarrow 4\text{NH}_3$

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

**Solution: Final Answer: (D)**

**Q31.**  $\Delta H_f^\circ$ :  $\text{H}_2\text{O}(\text{l}) = -286.0$ ,  $\text{H}_2\text{O}_2(\text{l}) = -188.0$  kJ mol<sup>-1</sup>. For  $2\text{H}_2\text{O}_2(\text{l}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$

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

**Solution: Final Answer: (B)**

**Q32.** Given:  $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ ,  $\Delta H = -x$ ;  $2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$ ,  $\Delta H = -y$ . Heat of formation of CO?

**Approach (Hinglish):**  $\text{CO} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}_2$  has  $\Delta H = -y/2$ . So  $\text{C} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}$ :  $(-x) - (-y/2) = (y - 2x)/2$ .

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

**Q33.** Same as Q31:  $2\text{H}_2\text{O}_2(\text{l}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$  with  $\Delta H_f^\circ$  given.

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

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

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

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

**Solution:**  $\text{Xe(g)} + 2\text{F}_2\text{(g)} \rightarrow \text{XeF}_4\text{(g)}$ . **Final Answer:** (C)

**Q35.** Standard enthalpy of formation of  $\text{CCl}_4\text{(g)}$  correctly represented by:

**Approach (Hinglish):**  $\text{C(graphite)} + 2\text{Cl}_2\text{(g)} \rightarrow \text{CCl}_4\text{(g)}$ .

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

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

**Approach (Hinglish):**  $\text{H}_2\text{(g)}$  (element, std state) and by convention  $\Delta H_f^{\circ}(\text{H}^+(\text{aq})) = 0$ .

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

**Q37.** Incorrect statement:

**Approach (Hinglish):** (C) wrong because  $\Delta H_{\text{rxn}}$  for  $\text{CO} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}_2$  equals  $\Delta H_f^{\circ}(\text{CO}_2) - \Delta H_f^{\circ}(\text{CO})$ , not  $\Delta H_f^{\circ}(\text{CO}_2)$ .

**Solution:** **Final Answer:** (C)

**Q38.** For  $\text{CS}_2\text{(l)} + 4\text{NOCl(g)} \rightarrow \text{CCl}_4\text{(l)} + 2\text{SO}_2\text{(g)} + 2\text{N}_2\text{(g)}$  given  $\Delta H_f^{\circ}(\text{CS}_2) = -x$ ,  $\Delta H_f^{\circ}(\text{NOCl}) = -y$ ,  $\Delta H_f^{\circ}(\text{CCl}_4) = +z$ ,  $\Delta H_f^{\circ}(\text{SO}_2) = -r$ .

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

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

**Q39.**  $\Delta H_f^{\circ}(\text{NO}_2) = 8.0$ ,  $\Delta H_f^{\circ}(\text{N}_2\text{O}_4) = 4.0$  kcal. Heat of dimerisation  $2\text{NO}_2 \rightarrow \text{N}_2\text{O}_4$ ?

**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  $\text{CH}_4$ ?

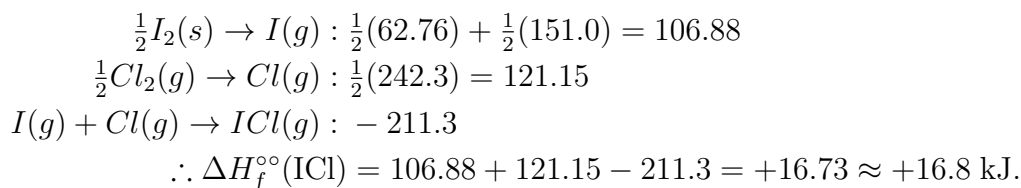
**Approach (Hinglish):** Same as Q3/Q17.

**Solution:** **Final Answer:** (B)  $\text{C(graphite)} + 2\text{H}_2 \rightarrow \text{CH}_4\text{(g)}$

**Q41. Data:**  $\text{Cl}_2\text{(g)} \rightarrow 2\text{Cl(g)} = 242.3$ ,  $\text{I}_2\text{(g)} \rightarrow 2\text{I(g)} = 151.0$ ,  $\text{ICl(g)} \rightarrow \text{I(g)} + \text{Cl(g)} = 211.3$ ,  $\text{I}_2\text{(s)} \rightarrow \text{I}_2\text{(g)} = 62.76$  kJ mol<sup>-1</sup>. **Standard states:**  $\text{I}_2\text{(s)}$ ,  $\text{Cl}_2\text{(g)}$ . **Find**  $\Delta H_f^{\circ}(\text{ICl(g)})$ .

**Approach (Hinglish):** Formation:  $\frac{1}{2}\text{I}_2\text{(s)} + \frac{1}{2}\text{Cl}_2\text{(g)} \rightarrow \text{ICl(g)}$ .  
Break to atoms then form bond:

**Solution:**



**Final Answer: (B)**

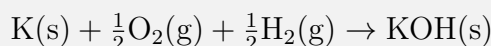
**Q42. Given:**  $H_2O(l) \rightarrow H^+(aq) + OH^-(aq)$ ;  $\Delta H = 57.32 \text{ kJ}$ , and  $H_2 + \frac{1}{2}O_2 \rightarrow H_2O(l)$ ;  $\Delta H = -286.20 \text{ kJ}$ . Find  $\Delta H_f^\circ(OH^-)$  ( $25^\circ C$ ).

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

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

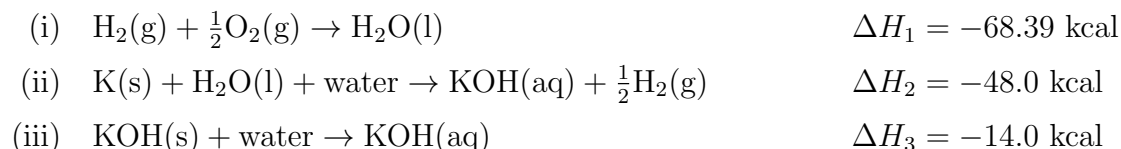
**Q43. If**  $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$ ;  $-68.39 \text{ kcal}$ ;  $K + H_2O + \text{water} \rightarrow KOH(aq) + \frac{1}{2}H_2$ ;  $-48.0 \text{ kcal}$ ;  $KOH + \text{water} \rightarrow -14.0 \text{ kcal}$ . Find the standard heat of formation of  $KOH(s)$ .

**Approach (Hinglish):** Target formation reaction:

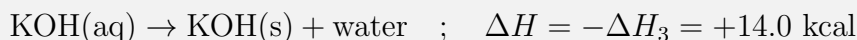


Given data mein  $KOH$  aqueous form mein hai; pehle "aq" ko remove karke solid  $KOH$  laayenge, phir Hess's law se reactions add karenge.

**Step-1: Write the given reactions with  $\Delta H$**



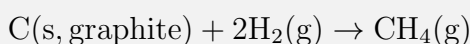
**Approach (Hinglish):** Solid  $KOH$  chahiye, isliye (iii) ko reverse karte hain taaki  $KOH(aq) \rightarrow KOH(s) + \text{water}$  ho:



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

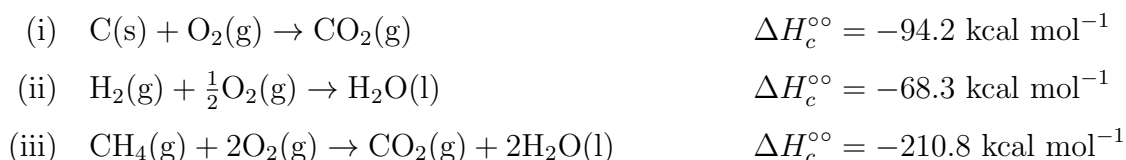
**Q44. Given:**  $\Delta H_c^\circ(C) = 94.2 \text{ kcal}$ ,  $\Delta H_c^\circ(H_2) = 68.3 \text{ kcal}$ ,  $\Delta H_c^\circ(CH_4) = 210.8 \text{ kcal}$ . Find the standard heat of formation of  $CH_4(g)$ .

**Approach (Hinglish):** Target formation reaction:



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  $\Delta H$**

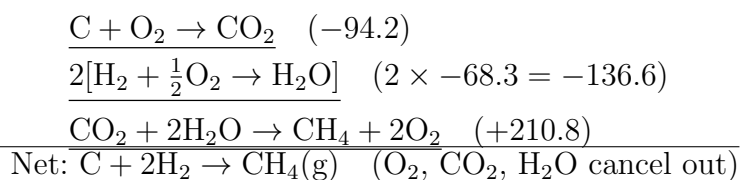


**Approach (Hinglish):** Required:  $C + 2H_2 \rightarrow CH_4$  → Reverse (iii) to get  $CH_4$  on RHS. → Add (i) +  $2 \times$ (ii) + reversed (iii).

**Step-2: Reverse (iii)**



**Step-3: Add reactions**



**Approach (Hinglish):** Add enthalpy changes:

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

**Negative sign → exothermic formation.**

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

**OR (Short Algebraic Method):**

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

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

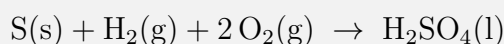
**Approach (Hinglish):** (i)  $\Delta H = -2x$ , (ii)  $\Delta H = -y$ . Subtract (i)-(ii):  $S + O_2 \rightarrow SO_2$  with  $\Delta H = y - 2x$ .

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)**

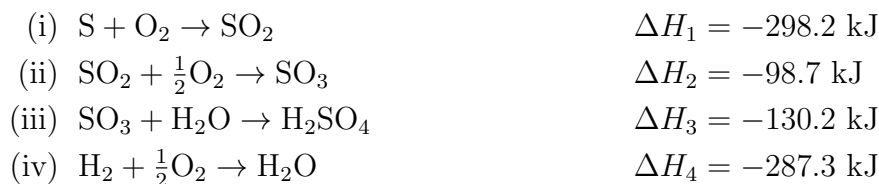
**Q46. Given:**  $S + O_2 \rightarrow SO_2$  ( $-298.2$ );  $SO_2 + \frac{1}{2}O_2 \rightarrow SO_3$  ( $-98.7$ );  $SO_3 + H_2O \rightarrow H_2SO_4$  ( $-130.2$ );  $H_2 + \frac{1}{2}O_2 \rightarrow H_2O$  ( $-287.3$ ) (**kJ**). **Find  $\Delta H_f^\circ(H_2SO_4(l))$ .**

**Approach (Hinglish):** Target formation reaction:



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**



**Step-2: Net after cancellation**



**Step-3: Enthalpy sum**

$$\Delta H_f^{\circ}(\text{H}_2\text{SO}_4) = \Delta H_1 + \Delta H_2 + \Delta H_3 + \Delta H_4 = -298.2 - 98.7 - 130.2 - 287.3 = \boxed{-814.4 \text{ kJ mol}^{-1}}$$

**Final Answer: (A)  $\Delta H_f^{\circ}[\text{H}_2\text{SO}_4(\text{l})] = -814.4 \text{ kJ mol}^{-1}$**

**OR (Short check):** Direct addition of the four given  $\Delta H$ 's gives  $-814.4 \text{ kJ}$ .

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**Notes & Typos handled:**

Q19: CO listed but reaction needs  $\text{CO}_2$ ; used  $\Delta H_f^{\circ}(\text{CO}_2) = -94 \text{ kJ}$  to match options.

Q20:  $\text{C}_2\text{H}_2$  appears without  $\Delta H_f^{\circ}$ ; interpreted as  $\text{C}_2\text{H}_4$  (fits options) and solved.