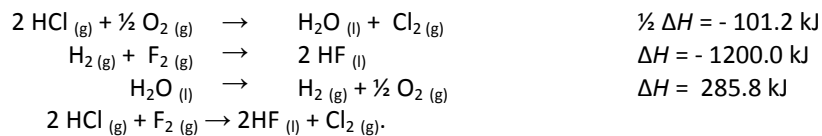
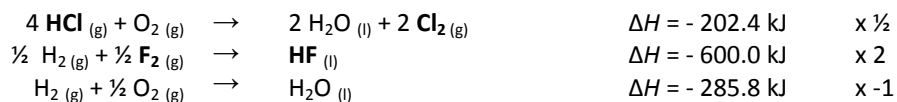


## Hess's Law and Standard Enthalpy of Formation Practice Questions – Answers

1.

- (a)  $\text{Ca}_{(s)} + \text{O}_{2(g)} + \text{H}_{2(g)} \rightarrow \text{Ca(OH)}_{2(s)}$   $\Delta H = -981.6 \text{ kJ}$   
 (b)  $6 \text{C}_{(s)} + 3 \text{H}_{2(g)} \rightarrow \text{C}_6\text{H}_6(l)$   $\Delta H = +49.0 \text{ kJ}$   
 (c)  $2 \text{Na}_{(s)} + \text{C}_{(s)} + 3/2 \text{O}_{2(g)} \rightarrow \text{Na}_2\text{CO}_3(s)$   $\Delta H =$   
 (d)  $\text{Ca}_{(s)} + \text{F}_{2(g)} \rightarrow \text{CaF}_2(s)$   $\Delta H =$   
 (e)  $1/4 \text{P}_4(s) + 3/2 \text{H}_2(g) \rightarrow \text{PH}_3(g)$   $\Delta H =$   
 (f)  $3 \text{C}_{(s)} + 4 \text{H}_2(g) \rightarrow \text{C}_3\text{H}_8(g)$   $\Delta H =$   
 (g)  $1/8 \text{S}_8(s) \rightarrow \text{S}(g)$   $\Delta H =$

2. Target:  $2 \text{HCl}_{(g)} + \text{F}_{2(g)} \rightarrow 2\text{HF}_{(l)} + \text{Cl}_{2(g)}$ .

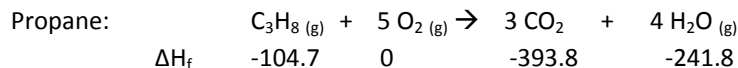


$$\Delta H = 1/2 \Delta H_1 + 2 \Delta H_2 + -\Delta H_3 = -1015.4 \text{ kJ}$$

3.  $\Delta H = -\Delta H_1 + -\Delta H_2 + -\Delta H_3$   $\Delta H = -96.6 \text{ kJ}$   
 4.  $\Delta H = \Delta H_1 - \Delta H_2$   $\Delta H = 98.8 \text{ kJ}$   
 5.  $\Delta H = 1/3 \Delta H_1 - 1/3 \Delta H_2$   $\Delta H = -312 \text{ kJ}$

6. and

7.



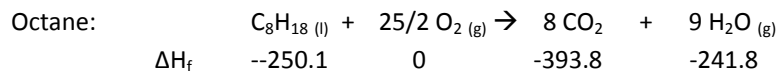
$$\begin{aligned} \Delta H &= \sum n \Delta H_f \text{ prod} - \sum n \Delta H_f \text{ react} \\ &= [(3 \text{ mol CO}_2)(-393.8 \text{ kJ/mol CO}_2) + (4 \text{ mol H}_2\text{O})(-241.8 \text{ kJ/mol H}_2\text{O})] - \\ &\quad [(1 \text{ mol C}_3\text{H}_8)(-104.7 \text{ kJ/mol C}_3\text{H}_8) + (5 \text{ mol O}_2)(0 \text{ kJ/mol O}_2)] \\ &= -2043 \text{ kJ} \end{aligned}$$

$$\Delta H_{\text{rxn}} = \Delta H/n \text{ frpm balanced equation } n = 1 \text{ mol C}_3\text{H}_8$$

$$\Delta H_{\text{rxn}} = -2043 \text{ kJ/mol C}_3\text{H}_8$$

$$\Delta H_{\text{rxn}} = -2043 \text{ kJ/mol C}_3\text{H}_8 \div (44.11 \text{ g C}_3\text{H}_8/\text{mol C}_3\text{H}_8) = -46.32 \text{ kJ/g C}_3\text{H}_8$$

$$\text{Propane: } \Delta H_{\text{rxn}} = \mathbf{-46.32 \text{ kJ/g C}_3\text{H}_8}$$



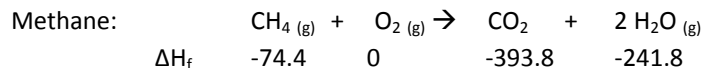
$$\begin{aligned} \Delta H &= \sum n \Delta H_f \text{ prod} - \sum n \Delta H_f \text{ react} \\ &= [(8 \text{ mol CO}_2)(-393.8 \text{ kJ/mol CO}_2) + (9 \text{ mol H}_2\text{O})(-241.8 \text{ kJ/mol H}_2\text{O})] - \\ &\quad [(1 \text{ mol C}_8\text{H}_{18})(-250.1 \text{ kJ/mol C}_8\text{H}_{18}) + (25/2 \text{ mol O}_2)(0 \text{ kJ/mol O}_2)] \\ &= -5074 \text{ kJ} \end{aligned}$$

$$\Delta H_{\text{rxn}} = \Delta H/n \text{ frpm balanced equation } n = 1 \text{ mol C}_8\text{H}_{18}$$

$$\Delta H_{\text{rxn}} = -5074 \text{ kJ/mol C}_8\text{H}_{18}$$

$$\Delta H_{\text{rxn}} = -5074 \text{ kJ/mol C}_8\text{H}_{18} \div (114.24 \text{ g C}_8\text{H}_{18}/\text{mol C}_8\text{H}_{18}) = -44.42 \text{ kJ/g C}_8\text{H}_{18}$$

$$\text{Octane: } \Delta H_{\text{rxn}} = \mathbf{-44.42 \text{ kJ/g C}_8\text{H}_{18}}$$



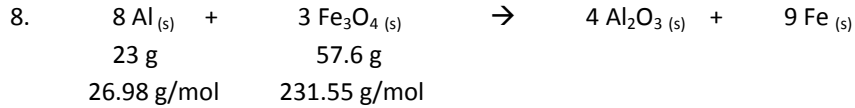
$$\begin{aligned} \Delta H &= \sum n \Delta H_f \text{ prod} - \sum n \Delta H_f \text{ react} \\ &= [(1 \text{ mol CO}_2)(-393.8 \text{ kJ/mol CO}_2) + (2 \text{ mol H}_2\text{O})(-241.8 \text{ kJ/mol H}_2\text{O})] - \\ &\quad [(1 \text{ mol CH}_4)(-74.4 \text{ kJ/mol CH}_4) + (1 \text{ mol O}_2)(0 \text{ kJ/mol O}_2)] \\ &= -802.7 \text{ kJ} \end{aligned}$$

$$\Delta H_{\text{rxn}} = \Delta H/n \text{ frpm balanced equation } n = 1 \text{ mol CH}_4$$

$$\Delta H_{\text{rxn}} = -802.7 \text{ kJ/mol CH}_4$$

$$\Delta H_{\text{rxn}} = -802.7 \text{ kJ/mol C}_3\text{H}_8 \div (16.05 \text{ g CH}_4/\text{mol CH}_4) = -50.01 \text{ kJ/g CH}_4$$

$$\text{Propane: } \Delta H_{\text{rxn}} = \mathbf{-50.01 \text{ kJ/g CH}_4}$$



let Al be limiting:

$$\begin{aligned}
 m \text{ Fe}_3\text{O}_4 &= m \text{ Al} / M \text{ Al} \times \text{mol ratio} \times M \text{ Fe}_3\text{O}_4 \\
 &= (23 \text{ g Al}) / (26.98 \text{ g/mol}) \times (3 \text{ mol Fe}_3\text{O}_4 / 8 \text{ mol Al}) \times (231.55 \text{ g Fe}_3\text{O}_4 / \text{mol Fe}_3\text{O}_4) \\
 &= 74.02 \text{ g}
 \end{aligned}$$

$m \text{ Fe}_3\text{O}_4 \text{ req'd} > m \text{ Fe}_3\text{O}_4 \text{ have}$ , therefore  $\text{Fe}_3\text{O}_4$  is limiting

$$\Delta H_{\text{rxn}} = \Delta H / n = -3350 \text{ kJ} / 3 \text{ mol Fe}_3\text{O}_4 = -1117 \text{ kJ} / \text{mol Fe}_3\text{O}_4$$

$$\begin{aligned}
 \Delta H &= n\Delta H_{\text{rxn}} = (57.6 \text{ g Fe}_3\text{O}_4) / (231.55 \text{ g Fe}_3\text{O}_4 / \text{mol Fe}_3\text{O}_4) \times (-1117 \text{ kJ} / \text{mol Fe}_3\text{O}_4) \\
 &= -272.2 \text{ kJ}
 \end{aligned}$$



$$\begin{aligned}
 \Delta H &= \sum n\Delta H_{f \text{ prod}} - \sum n\Delta H_{f \text{ react}} \\
 -3350 \text{ kJ} &= [(4 \text{ mol Al}_2\text{O}_3)(-1675.7 \text{ kJ/mol Al}_2\text{O}_3) + (9 \text{ mol Fe})(0 \text{ kJ/mol Fe})] - \\
 &\quad [(8 \text{ mol Al})(0 \text{ kJ/mol Al}) + (3 \text{ mol Fe}_3\text{O}_4)(x \text{ kJ/mol Fe}_3\text{O}_4)] \\
 x &= -1117.6 \text{ kJ/mol Fe}_3\text{O}_4
 \end{aligned}$$

$$9. \quad \Delta H = 1.55 \times 10^5 \text{ kJ} \qquad \Delta H_f = 226.7 \text{ kJ/mol C}_2\text{H}_2$$

$$10. \quad \Delta H_f = -64.6 \text{ kJ/mol SiC}$$