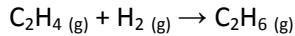
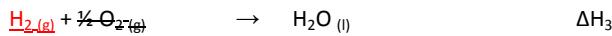
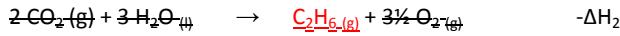
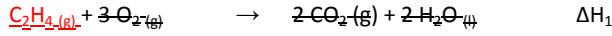
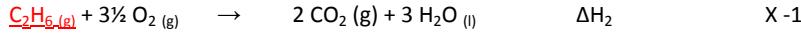
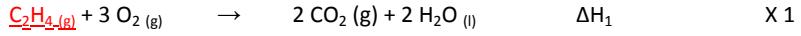
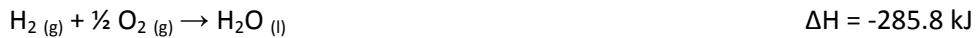
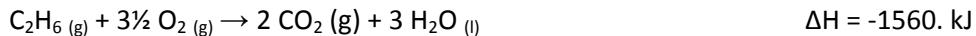


## Hess's Law Worksheet - answers

1. Calculate  $\Delta H$  for the reaction:  $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$ , from the following data.



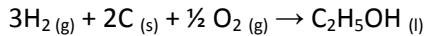
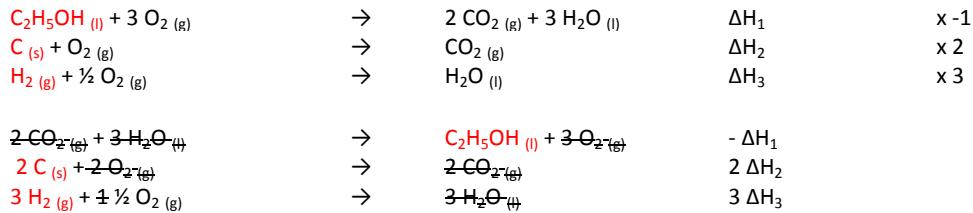
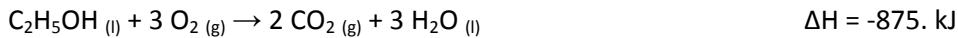
$$\Delta H = \Delta H_1 - \Delta H_2 + \Delta H_3 = -1411 + 1560 - 285.8 = -126.8 \text{ kJ}$$

2. Calculate  $\Delta H$  for the reaction  $4 NH_3(g) + 5 O_2(g) \rightarrow 4 NO(g) + 6 H_2O(g)$ , from the following data.



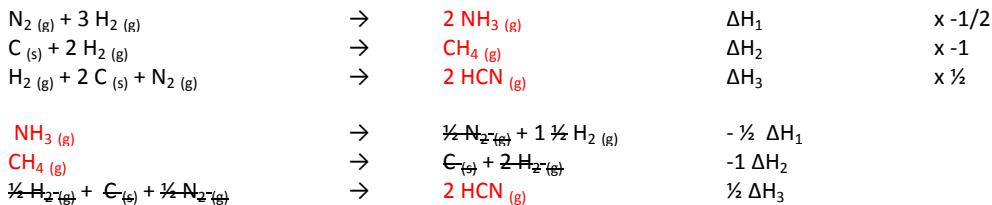
$$\Delta H = 2\Delta H_1 - 2\Delta H_2 + 3\Delta H_3 = 2(-180.5) - 2(-91.8) + 3(-483.6) = -1628.2 \text{ kJ}$$

3. Find  $\Delta H$  for the reaction  $3\text{H}_2\text{(g)} + 2\text{C}\text{(s)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{C}_2\text{H}_5\text{OH}\text{(l)}$ , using the following thermochemical data.



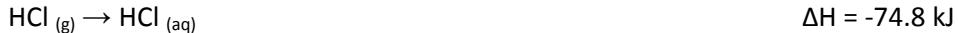
$$\Delta H = - \Delta H_1 + 2\Delta H_2 + 3\Delta H_3 = 875 + 2(-394.51) + 3(-285.8) = \mathbf{-771.4\text{ kJ}}$$

4. Calculate  $\Delta H$  for the reaction  $\text{CH}_4\text{(g)} + \text{NH}_3\text{(g)} \rightarrow \text{HCN}\text{(g)} + 3\text{H}_2\text{(g)}$ , given:

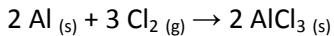


$$\Delta H = -\frac{1}{2} \Delta H_1 + -\Delta H_2 + \frac{1}{2} \Delta H_3 = -\frac{1}{2} (-91.8) - (-74.9) + \frac{1}{2} (270.3) = \mathbf{256\text{ kJ}}$$

5. Calculate  $\Delta H$  for the reaction  $2 \text{Al}_{(s)} + 3 \text{Cl}_{2(g)} \rightarrow 2 \text{AlCl}_{3(s)}$  from the data.



$2 \text{Al}_{(s)} + 6 \text{HCl}_{(aq)}$	$\rightarrow$	$2 \text{AlCl}_{3(aq)} + 3 \text{H}_{2(g)}$	$\Delta H_1$	$\times 1$
$\text{HCl}_{(g)}$	$\rightarrow$	$\text{HCl}_{(aq)}$	$\Delta H_2$	$\times 6$
$\text{H}_{2(g)} + \text{Cl}_{2(g)}$	$\rightarrow$	$2 \text{HCl}_{(g)}$	$\Delta H_3$	$\times 3$
$\text{AlCl}_{3(s)}$	$\rightarrow$	$\text{AlCl}_{3(aq)}$	$\Delta H_4$	$\times -2$
$2 \text{Al}_{(s)} + 6 \text{HCl}_{(aq)}$	$\rightarrow$	$2 \text{AlCl}_{3(aq)} + 3 \text{H}_{2(g)}$	$\Delta H_1$	
$6 \text{HCl}_{(g)}$	$\rightarrow$	$6 \text{HCl}_{(aq)}$	$6 \Delta H_2$	
$3 \text{H}_{2(g)} + 3 \text{Cl}_{2(g)}$	$\rightarrow$	$6 \text{HCl}_{(g)}$	$3 \Delta H_3$	
$2 \text{AlCl}_{3(aq)}$	$\rightarrow$	$2 \text{AlCl}_{3(s)}$	$-2 \Delta H_4$	



$$\Delta H = \Delta H_1 + 6 \Delta H_2 + 3 \Delta H_3 - 2 \Delta H_4 = -6386.8 \text{ kJ}$$

$$9. \Delta H = \frac{1}{2} \Delta H_1 + 2 \Delta H_2 - \Delta H_3 = -813 \text{ kJ}$$

$$10. \Delta H = -\Delta H_1 - \Delta H_2 - \Delta H_3 = -96.6 \text{ kJ}$$

$$11. \Delta H = \Delta H_1 - \Delta H_2 = +98.8 \text{ kJ}$$

$$12. \Delta H = \frac{1}{3} \Delta H_1 - \frac{1}{3} \Delta H_2 = -520 \text{ kJ}$$

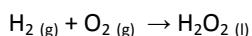
$$13. \Delta H = \Delta H_1 + \Delta H_2 - \Delta H_3 = -288.6 \text{ kJ}$$

14. Determine the heat of formation of liquid hydrogen peroxide at 25°C from the following thermochemical equations.

$\text{H}_{2(g)} + \frac{1}{2} \text{O}_{2(g)} \rightarrow \text{H}_2\text{O}_{(g)}$	$\Delta H = -241.82 \text{ kJ}$
$2 \text{H}_{(g)} + \text{O}_{(g)} \rightarrow \text{H}_2\text{O}_{(g)}$	$\Delta H = -926.92 \text{ kJ}$
$2 \text{H}_{(g)} + 2 \text{O}_{(g)} \rightarrow \text{H}_2\text{O}_{2(g)}$	$\Delta H = -1070.60 \text{ kJ}$
$2 \text{O}_{(g)} \rightarrow \text{O}_{2(g)}$	$\Delta H = -498.34 \text{ kJ}$
$\text{H}_2\text{O}_{2(l)} \rightarrow \text{H}_2\text{O}_{2(g)}$	$\Delta H = 51.46 \text{ kJ}$

Target:  $\text{H}_{2(g)} + \text{O}_{2(g)} \rightarrow \text{H}_2\text{O}_{2(l)}$

$\text{H}_{2(g)} + \frac{1}{2} \text{O}_{2(g)}$	$\rightarrow$	$\text{H}_2\text{O}_{(g)}$	$\Delta H_1$	$\times 1$
$2 \text{H}_{(g)} + \text{O}_{(g)}$	$\rightarrow$	$\text{H}_2\text{O}_{(g)}$	$\Delta H_2$	$\times -1$
$2 \text{H}_{(g)} + 2 \text{O}_{(g)}$	$\rightarrow$	$\text{H}_2\text{O}_{2(g)}$	$\Delta H_3$	$\times 1$
$2 \text{O}_{(g)}$	$\rightarrow$	$\text{O}_{2(g)}$	$\Delta H_4$	$\times -\frac{1}{2}$
$\text{H}_2\text{O}_{2(l)}$	$\rightarrow$	$\text{H}_2\text{O}_{2(g)}$	$\Delta H_5$	$\times -1$
$\text{H}_{2(g)} + \frac{1}{2} \text{O}_{2(g)}$	$\rightarrow$	$\text{H}_2\text{O}_{(g)}$	$\Delta H_1$	
$\text{H}_2\text{O}_{2(l)}$	$\rightarrow$	$\text{H}_2\text{O}_{2(l)}$	$-\Delta H_5$	
$2 \text{H}_{(g)} + 2 \text{O}_{(g)}$	$\rightarrow$	$\text{H}_2\text{O}_{2(g)}$	$\Delta H_3$	
$\text{H}_2\text{O}_{2(g)}$	$\rightarrow$	$2 \text{H}_{(g)} + \text{O}_{(g)}$	$-\Delta H_2$	
$\frac{1}{2} \text{O}_{2(g)}$	$\rightarrow$	$\text{O}_{2(g)}$	$-\frac{1}{2} \Delta H_4$	



$$\Delta H = \Delta H_1 - \Delta H_2 + \Delta H_3 - \frac{1}{2} \Delta H_4 - \Delta H_5 = -686.13 \text{ kJ}$$