Hess law

Nov. 18th

- limited algebric manipulation of thermodynamic equations
- reverse order ΔH changes sign.
- multiple equation ΔH is multiplied as well.

eg. Determine the heat of formation $C_4H_{10}(g)$ given the heat of combustion of butane is -2875.9145 kJ and the heat of formation $CO_2(g)$ is -393.5 kJ. and the heat of formation of $H_2O(\ell)$ is -285.5 kJ.

Find: $4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$ $\Delta H = ?$

Given: ① $C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(\ell)$ $\Delta H = -2875.9$ kJ

② $C_{(s)} + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -393.5$ kJ

③ $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(\ell)$ $\Delta H = -285.5$ kJ

reverse ① ~~$4CO_2(g) + 5H_2O(\ell) \rightarrow C_4H_{10}(g) + \frac{13}{2}O_2(g)$~~ $\Delta H = 2875.9$ kJ

x4 ② $4C(s) + 4O_2(g) \rightarrow 4CO_2(g)$ $\Delta H = -393.5 \times 4 = -1574.0$ kJ

x5 ③ $5H_2(g) + \frac{5}{2}O_2(g) \rightarrow 5H_2O(\ell)$ $\Delta H = -285.5 \times 5 = -1427.5$ kJ

$= 4C(s) + 5H_2(g) \rightarrow C_4H_{10}(g)$ $\Delta H = -125.6$ kJ.

Determine the heat of formation of benzene $C_6H_6(\ell)$ given $\Delta H^\circ_{CO_2(g)} = -393.5$ kJ and $\Delta H^\circ_{H_2O(\ell)} = -285.5$ kJ and the combustion of 5g of benzene is able to warm 5.000 L of water from 20.000°C to 61.814°C.

--- $\Delta = mc\Delta T$, scale for 1 mol of benzene, $\Delta H = Q$

write --- Hess' Law)

$$C_6H_6(\ell) + \tfrac{15}{2}O_2(g) \rightarrow 6O_2(g) + 3H_2O(\ell) \quad \Delta H = ?$$

*substance being warmed

$Q = mc\Delta T$

$Q = ?$

**substance responsible for providing heat

$m = 5000\ L^{*} \rightarrow 5000g$

$C = 4.184\ J/g°C$

$\Delta T = 29.994 - 20.000 = 9.994°C$

$Q = 5000g \times 4.184 J/g°C \times 9.994°C$

$Q = 209075 J$

$Q = 209.075$ KJ.

$$\frac{209.075\ KJ}{5.000g^{**}} \times \frac{78.12\ g}{1\ mol} = \frac{3266.58\ KJ}{1\ mol} \qquad \Delta H = -Q$$

$\Delta H = -3266.58$ KJ.

$$C_6H_6(\ell) + \tfrac{15}{2}O_2 \rightarrow 6O_2(g) + 3H_2O(\ell) \quad \Delta H = -3266.58\ KJ.$$

Hess' law

Find $6C(s) + H_2O(g) \rightarrow C_6H_6(\ell) \quad \Delta H = ?$

Given ① $C_6H_6(\ell) + \tfrac{15}{2}O_2(g) \rightarrow 6CO_2(g) + 3H_2O(\ell) \quad \Delta H = -3266.58$ kJ

② $C(s) + O_2(g) \rightarrow CO_2(g) \quad \Delta H = -393.5$ kJ

③ $H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \quad \Delta H = -285.5$ kJ

reverse ① $6CO_2(g) + 3H_2O(\ell) \rightarrow C_6H_6(\ell) + \tfrac{15}{2}O_2(g) \quad \Delta H = 3266.58$

X6 ② $6C(s) + 6O_2(g) \rightarrow 6CO_2(g) \quad \Delta H = -2361.0$ kJ

X3 ③ $3H_2(g) + \tfrac{3}{2}O_2(g) \rightarrow 3H_2O(\ell) \quad \Delta H = -856.5$ kJ