Two Ways to Find ΔH° for a Reaction

1. Experimental Data

2. Previously Determined ΔH° values (Heat's of Formation)

$$\Delta H^{\circ}$$

as composed to
25°C, 1 atmosphere pressure (SATP)

Change in   enthalpy (change in chemical potential energy)

Eg. 2 g of C_5H_{12} is reacted with oxygen in a combustion reaction. Determine ΔH° for this reaction given that heat produced by the combustion warms 500 mL water from 20,000°C to 46.457°C (p.299)

Step:

① Q = ? $C_5H_{12}(l) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$ ΔH° = ?   mL ↔ g

m = 500 mL → 500 g.   Written per mol
                                                          of reactant.
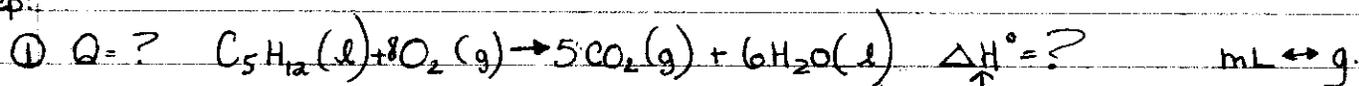
* C = 4.184 J/g°C

ΔT = 46.457°C - 20,000°C = 26.457°C

$Q = mc\Delta T$

$Q = 500g \times 4.184 J/g°C \times 26.457°C$

$Q = 55348 J \rightarrow 55.348 kJ$

② Conversions

$$\frac{55.348 \text{ kJ}}{2.00 g \ C_5H_{12}} \times \frac{72.17g}{1 \text{ mol } C_5H_{12}} = \frac{1997.23 \text{ kJ}}{1 \text{ mol } C_5H_{12}}$$

③ ΔH = -Q

ΔH = -1997.23 kJ/mol C_5H_{12}

④ ∴ $C_5H_{12}(l) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$
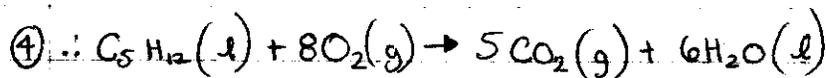
ΔH° = -1997.23 kJ

Given that $\Delta H° = -1997.23$ kJ for the combustion of C_5H_{12}.
Determine the final temperature of 500 mL of water at 20,000°C if
warmed by the combination of 200 g of pentane.

① $C_5H_{12}(\ell) + 8O_2 \rightarrow 5CO_2(g) + 6H_2O(\ )$, $\Delta H = -1997.23$ kJ
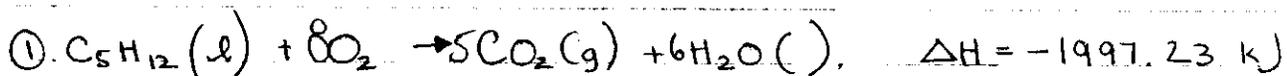
② $Q = -\Delta H$
$Q = 1997.23$ kJ / mol C_5H_{12}

③ Conversions (scale → size)

$200 g\ C_5H_{12} \times \dfrac{1\ mol\ C_5H_{12}}{72.17g\ C_5H_{12}} \times \dfrac{1997.23\ kJ}{1\ mol\ C_5H_{12}} = 55.348$ kJ

④ $Q = 55.348$ kJ → 55348 J. $\Delta T = \dfrac{Q}{mc}$ $\Delta T = T_F - T_i$
   $m = 500$ mL → 500 g. $T_F = \Delta T + T_i$
   $C = 4.184$ J/g°C $\Delta T = \dfrac{55348\ J}{500 g \times 4.184\ J/g°C}$ $T_F = 26.457°C + 20000°C$
   $\Delta T = ?$ $T_F = 46.457°C$
                              $\Delta T = 26.457°C$

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* Schlenker's mistake $\Delta H \neq -1997.23$ for the combustion of pentane.
  Find $\Delta H°$ for a reaction using heats of formation.
  $C_5H_{12}(\ell) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(\ell)$ $\Delta H° = ?$
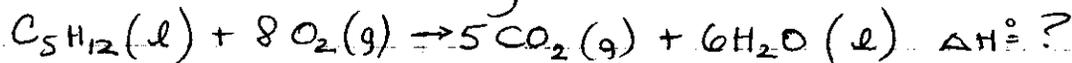
  $\Delta H° = [5\Delta H°_{CO_2} + 6\Delta H°_{H_2O(\ell)}] - [\Delta H°_{C_5H_{12}} + 8\Delta H°_{O_2}]$ (p.799)
             \underbrace{}   \underbrace{}   \underbrace{}   \underbrace{}
             pot.energy   pot.energy   pot.energy   pot.energy
             of CO_2 of H_2O C_5H_{12} of O_2 *

  $\Delta H° = [5(-393.5\ kJ) + 6(-285.8\ kJ)] - [(-173.5\ kJ) + 8(0^*)]$

  $\Delta H° = -3508.8$ kJ

   * all elements in their natural state at SATP have been assigned $\Delta H° = 0$