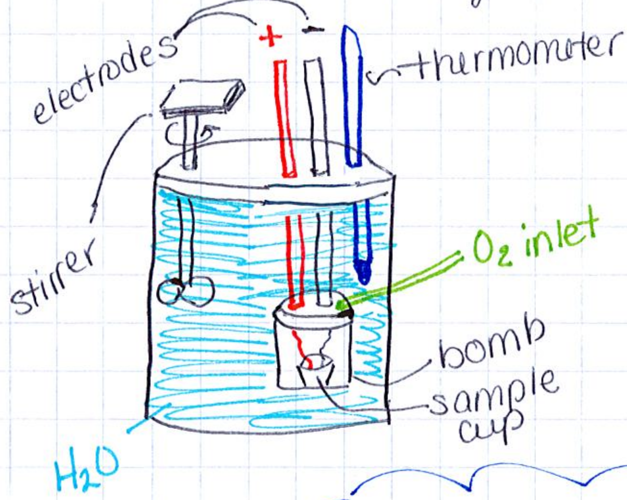
B. Constant - Volume Calorimetry (Bomb Calorimetry)
(used to study combustion reactions



- calorimeter contains a specific amount of H_2O
- due to constant V, transferred heat refers to ΔE, not ΔH
- $\Delta E \simeq \Delta H$ (most of the time

$$q_{rxn} = -C_{cal}\,\Delta T$$

Ex (13) A 0.5865 g sample of lactic acid ($HC_3H_5O_3$) is burned in a bomb calorimeter whose heat capacity is 4.812 kJ/°C. The temperature increases from 23.10°C to 24.95°C.

(A) Calculate the heat of combustion per gram

$$q_{rxn} = (-4.812\ kJ/°C)(1.85°C) = -8.90\ kJ \quad \frac{-8.90\ kJ}{.5865\ g} = -15.18\ kJ/g$$

$$\Delta T = 24.95° - 23.10° = 1.85$$

(B) " per mole.

$$.5865\ g\ HC_3H_5O_3\left(\frac{1\ mol}{90\ g}\right) = 6.52\times10^{-3}\ mol$$

$$q_{rxn} = \frac{-8.90\ kJ}{6.52\times10^{-3}\ mol} = -1367\ kJ/mol$$

Ex 14) Under constant-V conditions, the heat of combustion of glucose ($C_6H_{12}O_6$) is 15.57 kJ/g. A 2.500 g sample is burned in a bomb calorimeter & the temperature of the calorimeter increased from 20.55°C to 23.25°C.

(A) What is the heat capacity of the calorimeter?

(B) Write a balanced equation for the combustion of glucose.

(C) If the glucose sample had been twice as big, what would the temperature change be?

8. <u>Hess's Law</u> – if a reaction occurs in a series of steps, ΔH for the overall reaction will EQUAL the sum of the enthalpy changes (ΔH's) for the individual steps.

Ex (15) Using the data below, calculate the enthalpy change (ΔH) for the combustion of C to CO.

(1) $C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H_1 = -393.5\,kJ$
(2) $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H_2 = -283.0\,kJ$

$C(s) + \cancel{O_2(g)} \rightarrow \cancel{CO_2(g)}$ $\quad \Delta H_1 = -393.5\,kJ$
$\cancel{CO_2(g)} \rightarrow CO(g) + \cancel{\tfrac{1}{2}}O_2(g)$ $\quad \Delta H_2 = +283.0\,kJ$

$C(s) + \frac{1}{2}O_2(g) \rightarrow CO(g)$ $\quad \Delta H_{rxn} = -110.5\,kJ$

(16) Carbon occurs in 2 forms, graphite and diamond. Calculate ΔH for the conversion of graphite to diamond.

(1) $C_{graphite}(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H_1 = -393.5\,kJ$
(2) $C_{diamond}(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H_2 = -395.4\,kJ$

$C_{graphite}(s) + \cancel{O_2(g)} \rightarrow \cancel{CO_2(g)}$ $\quad \Delta H_1 = -393.5\,kJ$
$\cancel{CO_2(g)} \rightarrow C_{diamond}(s) + \cancel{O_2(g)}$ $\quad \Delta H_2 = +395.4\,kJ$

$C_{graphite}(s) \rightarrow C_{diamond}(s)$ $\quad \Delta H_{rxn} = +1.9\,kJ$

(17) Calculate ΔH for the reaction: $NO(g) + O(g) \rightarrow NO_2(g)$

(1) $NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$ $\quad \Delta H_1 = -198.9\,kJ$
(2) $O_3(g) \rightarrow \frac{3}{2}O_2(g)$ $\quad \Delta H_2 = -142.3\,kJ$
(3) $O_2(g) \rightarrow 2O(g)$ $\quad \Delta H_3 = +495.0\,kJ$

$NO(g) + \cancel{O_3(g)} \rightarrow NO_2(g) + \cancel{O_2(g)}$ $\quad \Delta H_1 = -198.9\,kJ$
$\cancel{\tfrac{3}{2}O_2(g)} \rightarrow \cancel{O_3(g)}$ $\quad \Delta H_2 = +142.3\,kJ$
$\tfrac{1}{2}:\ \cancel{2}O(g) \rightarrow \tfrac{1}{2}\cancel{O_2(g)}$ $\quad \Delta H_3 = \tfrac{1}{2}(-495.0\,kJ)$

$NO(g) + O(g) \rightarrow NO_2(g)$ $\quad \Delta H_{rxn} = -304.1\,kJ$

(18) Calculate ΔH for the reaction: $2C(s) + H_2(g) \rightarrow C_2H_2(g)$

(1) $C_2H_2(g) + \frac{5}{2}O_2(g) \rightarrow 2CO_2(g) + H_2O(l)$ $\Delta H_1 = -1299.6\ kJ$
(2) $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H_2 = -393.5\ kJ$
(3) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H_3 = -285.8\ kJ$

$\cancel{2CO_2(g)} + \cancel{H_2O(l)} \rightarrow C_2H_2(g) + \cancel{\frac{5}{2}O_2(g)}$ $\Delta H_1 = +1299.6\ kJ$
$2\ C(s) + \cancel{2\ O_2(g)} \rightarrow \cancel{2CO_2(g)}$ $\Delta H_2 = 2(-393.5\ kJ)$
$H_2(g) + \cancel{\frac{1}{2}O_2(g)} \rightarrow \cancel{H_2O(l)}$ $\Delta H_3 = -285.8\ kJ$

$2C(s) + H_2(g) \rightarrow C_2H_2(g)$ $\Delta H_{rxn} = +226.8\ kJ$