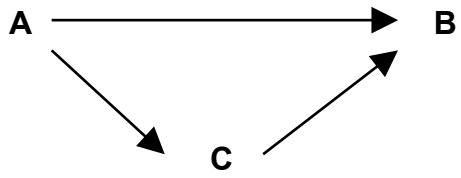
HESS'S LAW 2 - COMBUSTION

Hess's Law: The enthalpy change for a reaction is independent of the route taken

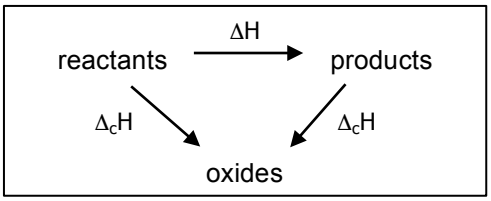


e.g. the enthalpy change to go from A → B direct is the same as going from A → C → B

- This method is for questions involving enthalpies of combustion (some people called these "type 2 questions").

Best method for most students (uses a cycle)

- Questions that involve enthalpies of combustion can usually be done using the cycle shown below.
- The reaction involved across the top is often an enthalpy of formation (from elements to a compound).
- The sum of the clockwise arrows equals the sum of the anticlockwise arrows.
- Be careful when drawing your cycle to ensure that arrows are going in the right direction and the number of moles is correct.



- If you use a cycle like this, there is no need to worry about getting the number of oxygen molecules in the downward arrows.

Simpler method if you are struggling

- This is a simpler method that works for most simple questions.

ΔH = [SUM of $\Delta_c H$ reactants] – [SUM $\Delta_c H$ products]

- Note that this is *reactants – products* which is the opposite of the equation that uses enthalpies of formation.

Example 1

Calculate the enthalpy of formation of ethanol (C_2H_5OH) given the following enthalpies of combustion.

$\Delta_c H$ C(s) = -393, $H_2(g)$ = -286, $C_2H_5OH(l)$ = -1371 kJ/mol

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Example 2

Calculate the enthalpy change for this reaction given the following data. $C(s) + 2\ H_2(g) \rightarrow CH_4(g)$

$\Delta_c H$ $C(s) = -393$, $H_2(g) = -286$, $CH_4(g) = -890$ kJ/mol

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1) Calculate the enthalpy of combustion of propane, $C_3H_8(g)$, given the following enthalpy changes.

$\Delta_c H$: $C(s)$ -393; $H_2(g)$ -286 kJ mol^{-1}, $\Delta_f H$: $C_3H_8(l)$ -103 kJ mol^{-1}

2) Calculate the enthalpy change for the following reaction using the enthalpies of combustion given.

$$C(graphite) \rightarrow C(diamond)$$

$\Delta_c H$: C(graphite) -393; C(diamond) -395 kJ mol^{-1}

3) Calculate the enthalpy change during the fermentation of glucose using the enthalpies of combustion given.

$$C_6H_{12}O_6(s) \rightarrow 2\ C_2H_5OH(l) + 2\ CO_2(g)$$

$\Delta_c H$: $C_6H_{12}O_6(s)$ -2820; $C_2H_5OH(l)$ -1368 kJ mol^{-1}

4) Calculate the enthalpy of formation of pentane, $C_5H_{12}(l)$, given the following enthalpies of combustion.

$\Delta_c H$: $H_2(g)$ -286; $C(s)$ -393; $C_5H_{12}(l)$ -3509 kJ mol^{-1}

5) Calculate the enthalpy of combustion of propanone, $CH_3COCH_3(l)$, given the information below.

$\Delta_c H$: $H_2(g)$ -286; $C(s)$ -393 $\Delta_f H$: $CH_3COCH_3(l)$ -217 kJ mol^{-1}

6) Calculate the enthalpy of combustion of $CS_2(l)$ given the following enthalpy changes.

$\Delta_c H$: $C(s)$ -393; $S(s)$ -297 kJ mol^{-1}, $\Delta_f H$: $CS_2(l)$ +88 kJ mol^{-1}

7) Calculate the standard enthalpy change for the following reaction using the enthalpy changes given.

$$SO_2(g) + 2\ H_2S(g) \rightarrow 3\ S(s) + 2\ H_2O(l)$$

$\Delta_c H$: $S(s)$ -297 kJmol^{-1} $\Delta_f H$: $H_2O(l)$ -286; $H_2S(g)$ -20 kJ mol^{-1}