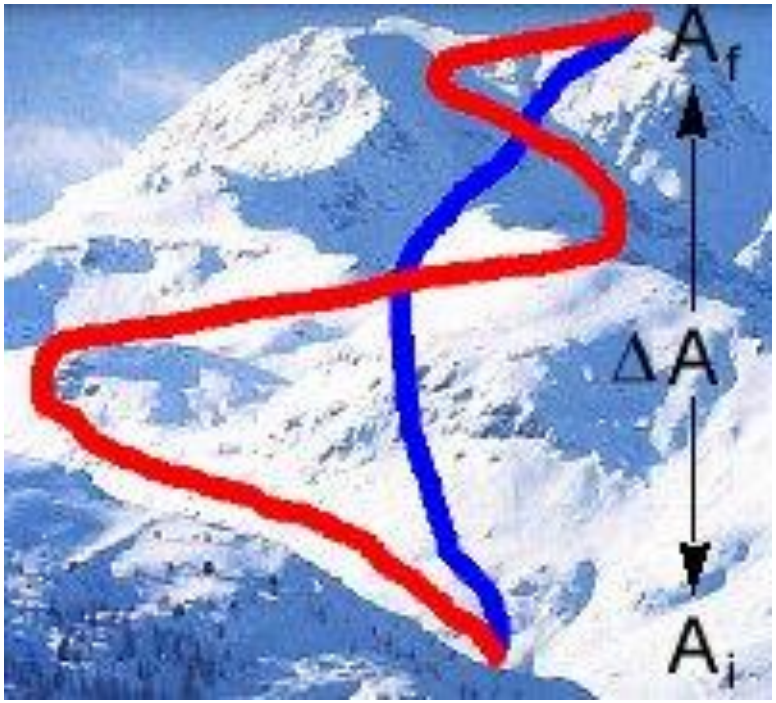
Hess's Law

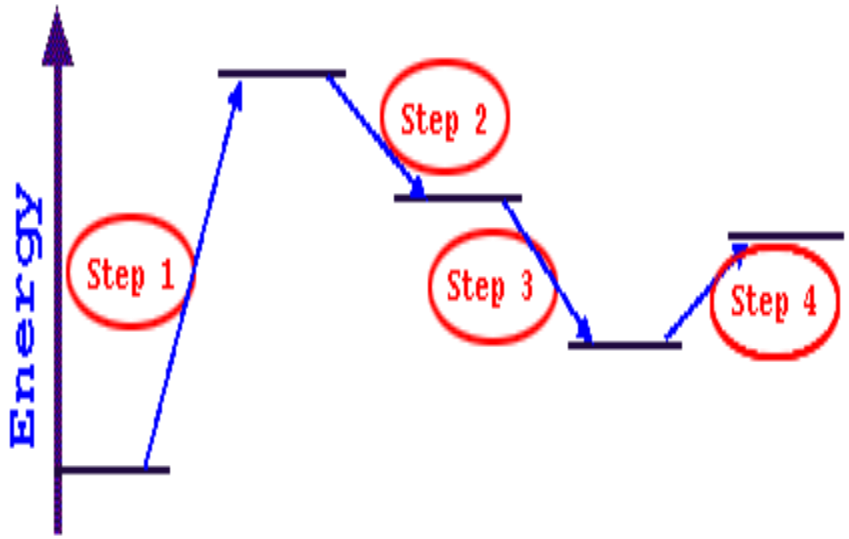
- Total enthalpy change on converting a given set of reactants to a particular set of products is constant.
- First Law of Thermodynamics
- **State Function**



Hess's Law

$\Delta H = H_{products} - H_{reactants}$

ΔH is independent of the reaction pathway.



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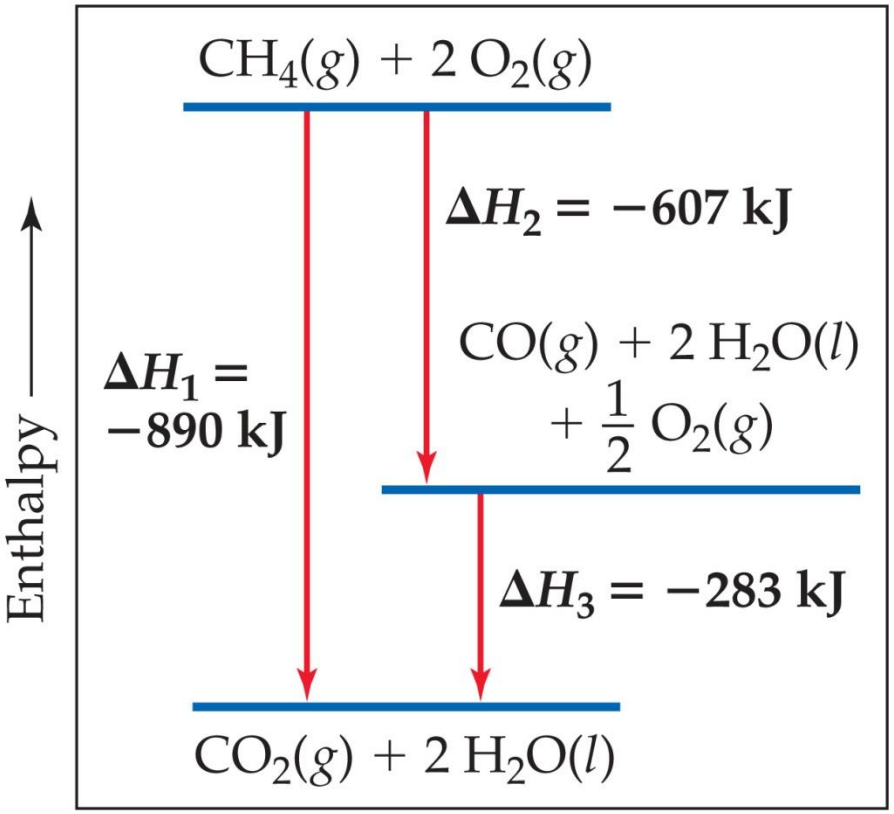
Hess's Law



ΔH for an overall reaction is equal to the sum of the enthalpy changes for the individual steps.

$\Delta H_1 = \Delta H_2 + \Delta H_3$

$CH_4\,(g) + 2O_2\,(g) \rightarrow CO_2\,(g) + 2H_2O\,(l)$

$\Delta H = -890$ KJ

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Example

- **Overall Reaction**

$NaHCO_3\ (s) + HCl\ (aq) \rightarrow NaCl\ (aq) + CO_2\ (g) + H_2O\ (l)$ $\quad \Delta H_1 = ?$

- **Steps**

$2NaHCO_3\ (s) \rightarrow Na_2CO_3\ (aq) + CO_2\ (g) + H_2O\ (l)$ $\quad \Delta H_2 = +90\ kJmol^{-1}$

$Na_2CO_3\ (aq) + 2HCl\ (aq) \rightarrow 2NaCl\ (aq) + CO_2\ (g) + H_2O\ (l)$ $\quad \Delta H_3 = -370\ kJmol^{-1}$

Sample Problem 2

- Given the following steps

$C\ (s) + O_2\ (g) \rightarrow CO_2\ (g)$ $\Delta H = -395$ KJ

$H_2\ (g) + \frac{1}{2}\ O_2\ (g) \rightarrow H_2O\ (l)$ $\Delta H = -287$ KJ

$C_2H_4\ (g) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 2H_2O\ (l)$ $\Delta H = -1416$ KJ

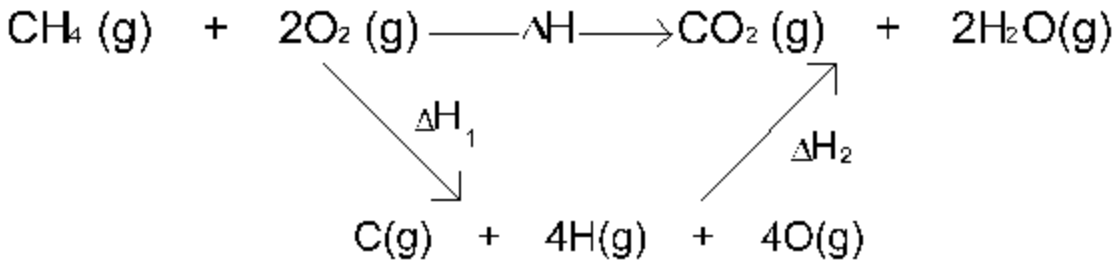
Calculate ΔH for

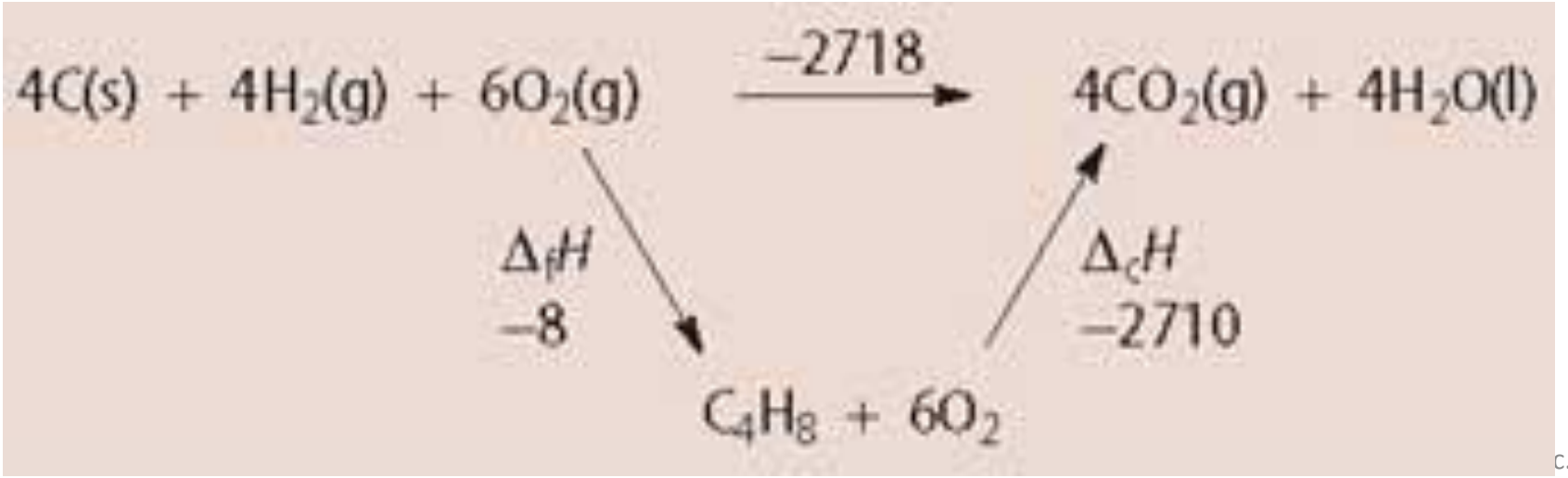
$2C\ (s) + 2H_2\ (g) \rightarrow C_2H_4\ (g)$

Bonds and Enthalpy Cycles

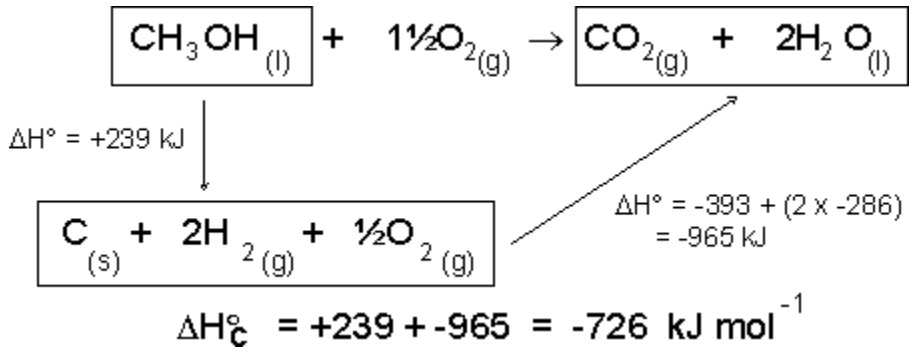
The bond-breaking and bond-making can be represented in an enthalpy cycle.

Enthalpy Cycles





Using an Enthalpy Cycle



The **Enthalpy Cycle** provides an alternative route for the combustion of 1 mole of methanol. The methanol is first converted to the elements from which it was formed (the reverse of the enthalpy of formation), and these are then burned to form the products (enthalpy of combustion).

Ms. Hall's Example

Clockwise arrows must equal counterclockwise arrow

Construct a Hess Cycle

	ΔH°_c (kJ mol^{-1})
$C_6H_6(l)$	-3267
C(s)	-394
$H_2(g)$	-286

Want to form benzene (C_6H_6) from C and H**.**