

**Nature of science:**

Hypotheses—based on the conservation of energy and atomic theory, scientists can test the hypothesis that if the same products are formed from the same initial reactants then the energy change should be the same regardless of the number of steps. (2.4)

**Understandings:**

- The enthalpy change for a reaction that is carried out in a series of steps is equal to the sum of the enthalpy changes for the individual steps.

**Applications and skills:**

- Application of Hess's Law to calculate enthalpy changes.
- Calculation of  $\Delta H$  reactions using  $\Delta H_f^\circ$  data.
- Determination of the enthalpy change of a reaction that is the sum of multiple reactions with known enthalpy changes.

**Guidance:**

- Enthalpy of formation data can be found in the data booklet in section 12.
- An application of Hess's Law is  $\Delta H_{\text{reaction}} = \Sigma(\Delta H_f^\circ \text{products}) - \Sigma(\Delta H_f^\circ \text{reactants})$ .

**International-mindedness:**

- Recycling of materials is often an effective means of reducing the environmental impact of production, but varies in its efficiency in energy terms in different countries.

**Theory of knowledge:**

- Hess's Law is an example of the application of the Conservation of Energy. What are the challenges and limitations of applying general principles to specific instances?

**Utilization:**

- Hess's Law has significance in the study of nutrition, drugs, and Gibbs free energy where direct synthesis from constituent elements is not possible.

**Syllabus and cross-curricular links:**

Physics topic 2.3—conservation of mass-energy

**Aims:**

- Aim 4:** Discuss the source of accepted values and use this idea to critique experiments.
- Aim 6:** Experiments could include Hess's Law labs.
- Aim 7:** Use of data loggers to record temperature changes.

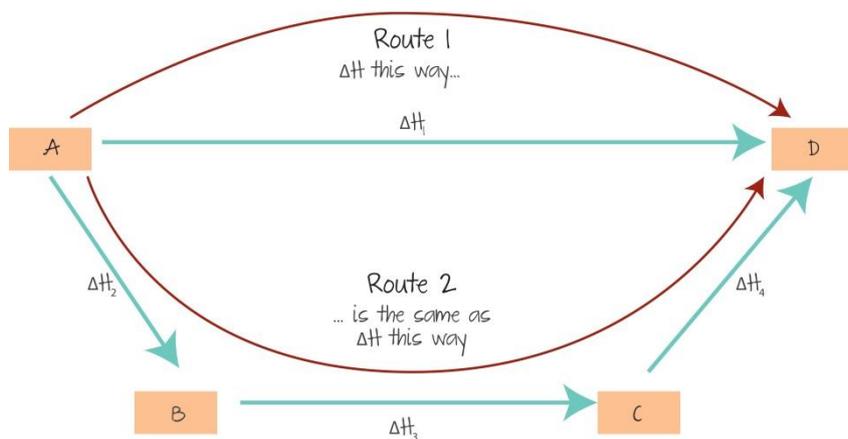
# UNIT 5.2 – HESS'S LAW

**First law of thermodynamic:** The conservation of energy law

**Second law of thermodynamic:** Heat flows spontaneously from hotter to colder places

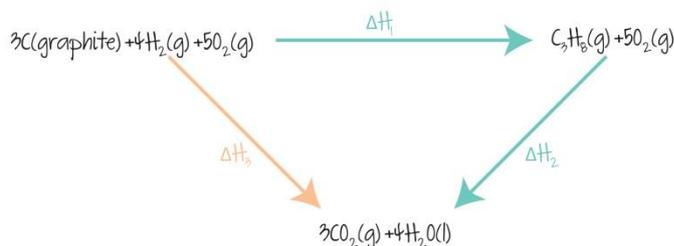
**Hess's Law:** The total enthalpy change in a chemical reaction is independent of the route by which the chemical reaction takes place, as long as the initial and final conditions are the same.

## ENTHALPY CYCLES



*Enthalpy change for Route 1 =  
enthalpy change for Route 2*

$$\Delta H_1 = \Delta H_2 + \Delta H_3 + \Delta H_4$$



$$\Delta H_1 = \Delta H_2 - \Delta H_3$$

When we reverse a reaction, the sign of  $\Delta H$  changes whereas the numerical value remains the same.

## ENTHALPIES OF FORMATION

With Hess's law we can calculate the enthalpy of any reaction, provided we know the enthalpies of formation of all the reaction and products.

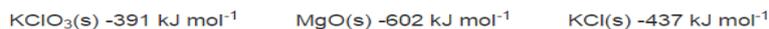
The standard enthalpy change of formation ( $\Delta H_f^\ominus$ ) is the enthalpy change when one mole of a compound is formed from its elements under standard conditions.

Enthalpy of change of a reaction		Sum of enthalpies of formation of products		Sum of enthalpies of formation of reactants
=		=		-
$\Delta H$		$\Sigma \Delta H_f^\ominus$ [products]		$\Sigma \Delta H_f^\ominus$ [reactants]

The following reaction used to be used in flash photography:



Relevant enthalpy changes of formation values,  $\Delta H_f^\ominus$ , are shown here:



What is the enthalpy change, in kJ, of this reaction?

+1760

#1

-648

#2

+740

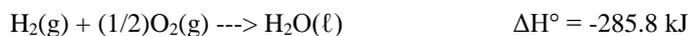
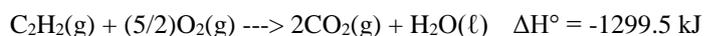
#3

-1852

#4

## WORKING OUT $\Delta H$ FROM MANY EQUATIONS

When given multiple equations we most likely need to rearrange some so our final  $\Delta H$  is true.



1. The first step is to rearrange each equation so the reactant and the products are on the right side.  
This is shown in **red**
2. The second step is to figure out if you need to multiply any equations in order to cancel out or have the right number of reactant/products.  
This is shown in **green**
3. The last step is simply to check if everything cancels out right and gives you a straightforward enthalpy.  
This is shown in **purple**