Laying out Enthalpy Change Calculations

Here is a suggested method of laying out your enthalpy change calculations so that you are more likely to be awarded most or all the marks in a question. The most common reason why students throw marks away on enthalpy change questions is that they **cut corners** and are **not methodical.**

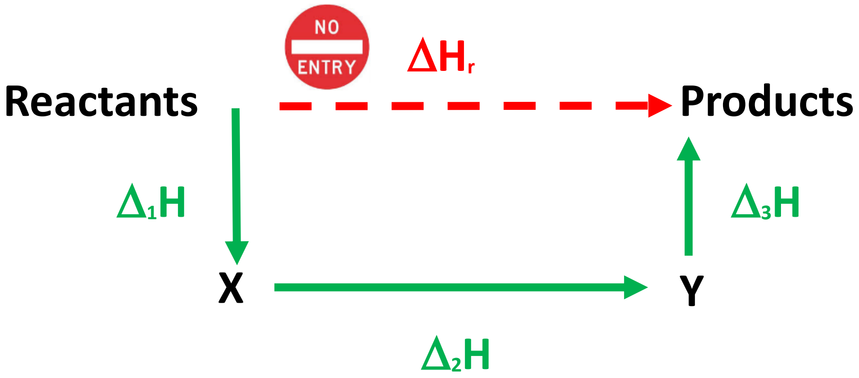
Consider example 1.

Let's assume we are being asked to calculate a value for an enthalpy change, $\Delta_r H$. This enthalpy change may be hard (or even impossible!) to obtain **directly by an experiment**. But Hess's Law tells us that we can 'travel' by an alternative route and the sum of the enthalpy changes on that alternative route will be equal to the enthalpy change $\Delta_r H$.

The arrow for $\Delta_r H$ is the dotted red line to illustrate that this is the 'blocked route' along which we can't travel directly.

But we can travel by the green route. This involves a journey of 3 legs $\Delta_1 H$, $\Delta_2 H$ & $\Delta_3 H$.

1.



Now we have drawn our Hess cycle, we need to lay out our calculation methodically.

There are **3 steps** that we should take.

1. Decide how many legs of the journey you will travel along. For each leg, draw a **pair of brackets.** The values inside all these brackets will be **added together** so always put a **+** between the sets of brackets!

$$\Delta_r H = (\qquad) + (\qquad) + (\qquad)$$

2. Now put the **enthalpy change symbols** inside the brackets

$$\Delta_r H = (\quad \Delta_1 H) + (\quad \Delta_2 H) + (\quad \Delta_3 H)$$

3. The last thing to do is to decide whether you are travelling in the direction of the arrow or travelling against the direction of the arrow. If you are travelling in the direction of the arrow, put a **+ve** sign inside the bracket and in front the enthalpy change. If you are travelling against the direction of the arrow, put a **-ve** sign inside the bracket an in front the enthalpy change.
   In this case, we are travelling in the same direction as all the arrows.

$$\Delta_r H = (+\ \Delta_1 H) + (+\ \Delta_2 H) + (+\ \Delta_3 H)$$

The next step is to rewrite this equation but insert the **actual values** of $\Delta_1 H$, $\Delta_2 H$ & $\Delta_3 H$ **taking care to add the -ve signs for exothermic processes**.

Here are the values of Δ_1H, Δ_2H & Δ_3H.

Enthalpy Change	Value/ $kJmol^{-1}$
Δ_1H	+140
Δ_2H	-2450
Δ_3H	+60

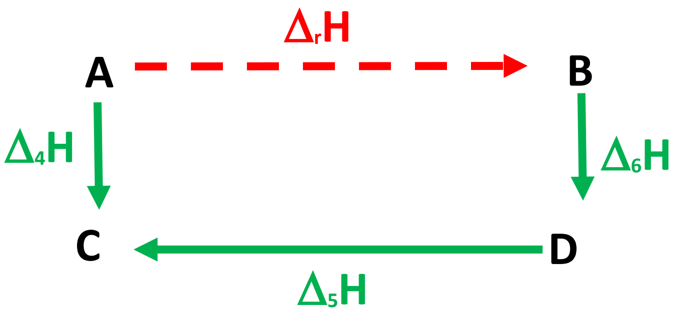
$$\Delta_rH = (+ \Delta_1H) + (+ \Delta_2H) + (+ \Delta_3H)$$

$$\Delta_rH = (+ +140) + (+ -2450) + (+ +60)$$

$$\Delta_rH = (+140) + (-2450) + (+60) = -2\,250 \ kJmol^{-1}$$

BE METHODICAL so that you can still scoop some marks even if you make a careless calculator error along the way!

2. Here is another example.



Enthalpy Change	Value/ $kJmol^{-1}$
Δ_4H	+410
Δ_5H	-760
Δ_6H	-110

$$\Delta_rH = (+ \Delta_4H) + (- \Delta_5H) + (+ \Delta_6H)$$

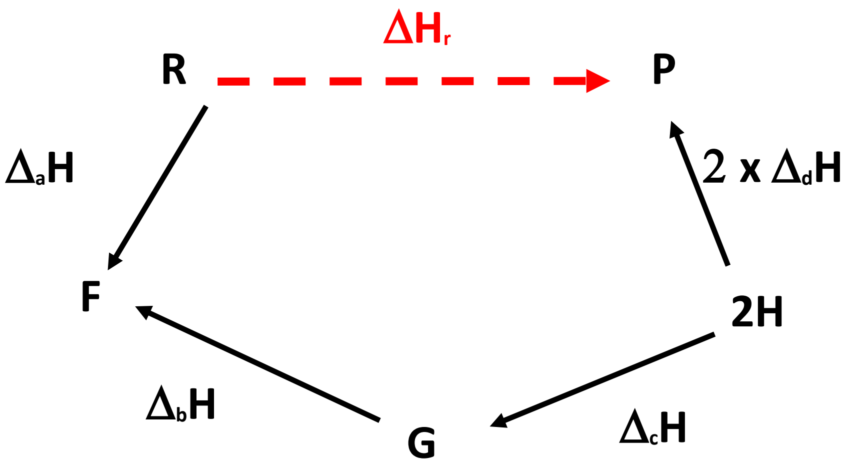
$$\Delta_rH = (+ +410) + (- -760) + (+ -110)$$

$$\Delta_rH = (+410) + (+760) + (-110) = +1\,280 \ kJmol^{-1}$$

Have a go at the next examples. Follow the 3 steps shown above. **DO NOT CUT CORNERS!**

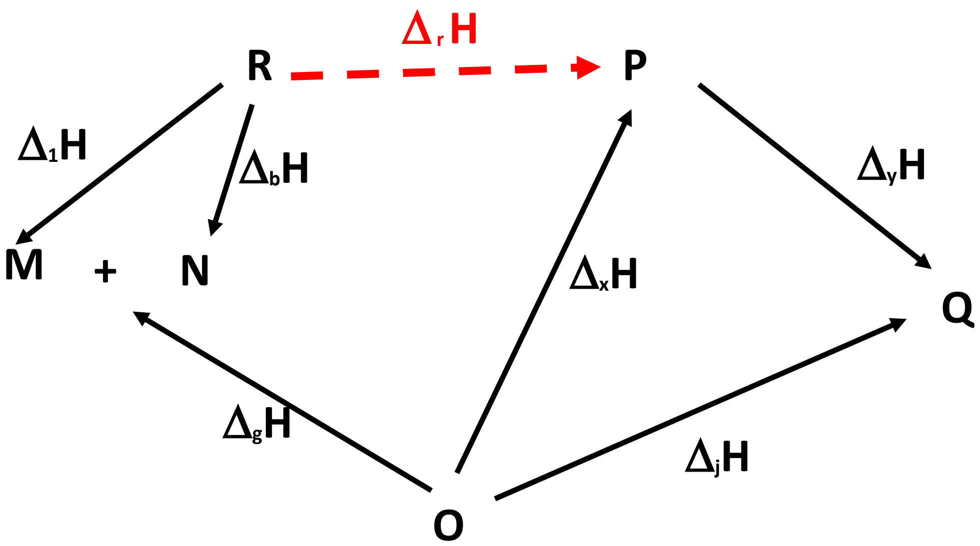
All the values for the enthalpy changes are shown in the table below.

3.



$\Delta_r H =$

4.



$\Delta_r H =$

Alternatively you could also write it as;

$\Delta_r H =$

Now try to write an equation that would represent the **simplest** combination of enthalpy changes for the conversion of **O into P** if the enthalpy change $\Delta_x H$ can't be obtained directly by experiment.

Hint; find the **S**tart and **E**nd of this 'enthalpy journey' and write '**S**' and '**E**' on the appropriate ends of the relevant reaction arrow. Then go via the alternative route.

$\Delta H_x =$

- Go back and **calculate** values for $\Delta_r H$ for each of the examples using the data below. Layout your calculation under the expression with symbols.

Enthalpy Change	Value/ $kJmol^{-1}$	Enthalpy Change	Value/ $kJmol^{-1}$
$\Delta_1 H$	+140	$\Delta_a H$	+81
$\Delta_2 H$	-2450	$\Delta_b H$	-390
$\Delta_3 H$	+60	$\Delta_c H$	+1565
$\Delta_4 H$	+410	$\Delta_d H$	+8
$\Delta_5 H$	-760	$\Delta_g H$	-95
$\Delta_6 H$	-110	$\Delta_h H$	+28
$\Delta_x H$	-to be calculated	$\Delta_j H$	-884
		$\Delta_y H$	+29

Finally, calculate a value for $\Delta_x H$ **from the data.**

Answers

1. **ΔH_r = -2 250**
2. **ΔH_r = +1 280**
3. **ΔH_r = -1 078**
4. **ΔH_x = -913**

   ΔH_r = -1 068