Formation Reactions:

This reactions starts with elements only as reactants.
The reactants will form compounds as products.

elements ⇒compound

Ex. $C_{(s)} + 2H_{2(g)}$ --> $CH_{4(g)}$

The molar enthalpy symbol for a formation reaction is $\mathbf{H_f}$.

Simple Decomposition Reactions:

This reaction starts as a compound, which decomposes into its elements.
(opposite of a formation reaction)

compound ⇒elements

Ex. $CH_{4(g)}$ --> $C_{(s)} + 2H_{2(g)}$

The molar enthalpy symbol is $\mathbf{H_{SD}}$.

Combustion Reactions:

The reaction of a substance with excess oxygen to produce an oxide.

Ex. $C_{(s)} + O_{2(g)}$ --> $CO_{2(g)}$

The molar enthalpy symbol is $\mathbf{H_c}$.

(b) Molar Enthalpies
$\mathbf{H_f}$ - molar enthalpies of formation is the quantity of heat released or absorbed when one mole of a substance forms from its elements.

$\mathbf{H_c}$ - molar enthalpies of combustion is the quantity of heat released or absorbed when one mole of a substance reacts with oxygen.

$\mathbf{H^o}$ - standard molar enthalpy is the quantity of heat released or absorbed when one mole of a substance reacts at SATP

(c) ΔH_r - Enthalpy change is the quantity of heat released or absorbed when a reaction occurs. This may also be called "Heat of Reaction" or "Change in Heat".
⇒must know the number of moles of a substance reacting to determine the enthalpy change

(d) Molar enthalpy may be determined from the enthalpy change as long as the number of moles (n) are known.

⟶

COMMUNICATING ENTHALPY CHANGES

Using ΔH_r notation:
- for chemical reactions not well known, the chemical equation must accompany the enthalpy change. The molar enthalpy of reaction (or change in enthalpy) follows the equation. **For exothermic reactions the $\Delta H_r < 0$.**

Ex. $Mg_{(s)} + 1/2\ O_{2(g)}$ ==> $MgO_{(s)}$ $\Delta H_r = -601.6kJ$

The Enthalpy Change **(ΔH_r)** may be included as a term in the balanced equation:

(i) In endothermic reactions - energy is reported as a reactant and is transformed in the reaction.

$\Delta H_r = 285.8\ kJ$

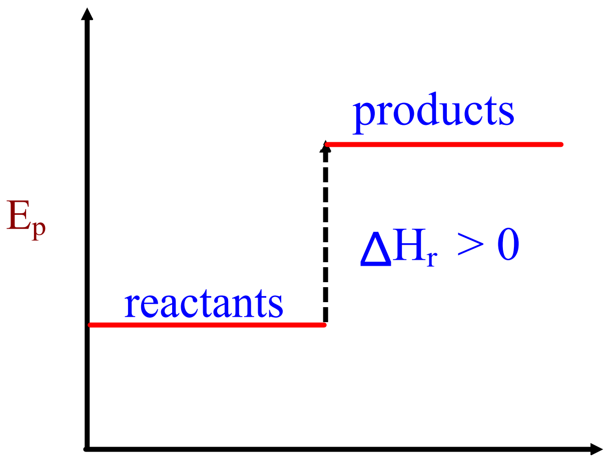
Ex. $H_2O_{(l)} + 285.8kJ \Rightarrow H_{2(g)} + \frac{1}{2} O_{2(g)}$

(ii) In exothermic reactions - energy is reported as a product since it is being produced.

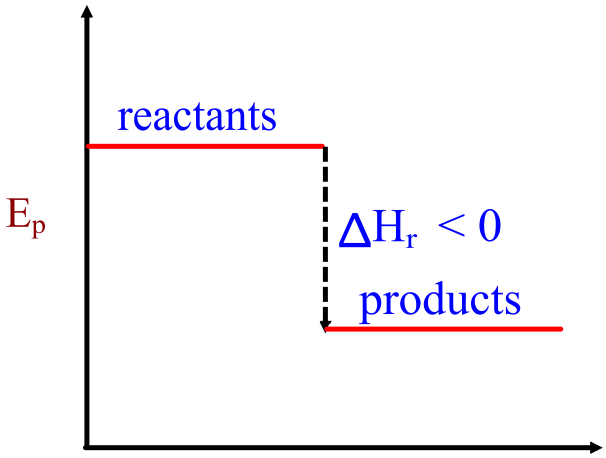
Ex. $Mg_{(s)} + 1/2\ O_{2(g)} \Rightarrow MgO_{(s)} + 601.6kJ$

POTENTIAL ENERGY DIAGRAMS
- may be used to express enthalpy change (ΔH_r)
- shows the potential energy of the reactants and products of a chemical reaction.
- shows the difference between the initial and final energies as the enthalpy change. (ΔH_r)

Endothermic Rxn



Exothermic Rxn



see Fig 11-8 p 373 (also 11-15,16,17)

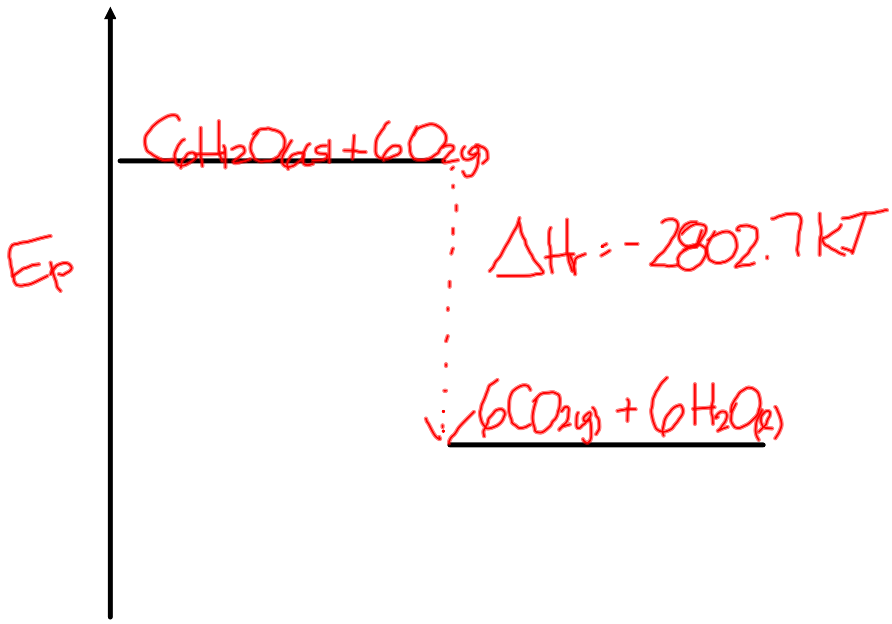
For the following reaction:

(a) rewrite the equation including the enthalpy change as a term

(b) draw a potential energy diagram

(i) $C_6H_{12}O_{6(s)} + 6O_{2(g)} \longrightarrow 6CO_{2(g)} + 6H_2O_{(l)}$ $\Delta H_r^o = -2802.7kJ$

a) $C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_{(l)} + 2802.7kJ$



Predicting Energy Changes using Hess' Law

Hess' Law - (Heat of Summation)
- allows for the determination of the enthalpy change of a reaction with direct use of calorimetry.

Rules:

- if a chemical equation is reversed, then the sign of the ΔH_r changes
- if the coefficients of a chemical equation are altered by multiplying

or dividing by a constant factor, then the ΔH_r is altered in the same way

Ex. $C_{(s)} + O_{2(g)} \Rightarrow CO_{2(g)}$ $\Delta H = -393.5$ kJ

Example

$$H_2O\,(g) + C\,(s) \rightarrow CO\,(g) + H_2\,(g)$$

$\Delta H = ?$

Steps (found using calorimetry):

① $H_2\,(g) + 1/2\,O_2\,(g) \rightarrow H_2O\,(g) \quad \Delta H = -242.0\text{ kJ}$

② $2CO\,(g) \rightarrow 2\,C\,(s) + O_2\,(g) \quad \Delta H = +221.0\text{ kJ}$

Rev ①

③ $H_2O_{(g)} \rightarrow H_{2(g)} + \frac{1}{2}O_{2(g)}$ $\quad \Delta H = 242.0\text{ kJ}$

Rev ② ÷2

④ $C_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{(g)}$ $\quad \Delta H_r = -110.5\text{ kJ}$

③ + ④

$H_2O_{(g)} + C_{(s)} \longrightarrow H_{2(g)} + CO_{(g)}$ $\quad \boxed{\Delta H_r = 131.5\text{ kJ}}$

$$4 + y + \cancel{x} = 3 - 4y + \cancel{x}$$

Calculate the heat released by the burning of sulfur in oxygen given the following steps:

$$2S(s) \quad + \quad 3O_2(g) \quad \rightarrow \quad 2SO_3(g) \qquad \Delta H = ?$$

Evidence:

Step 1	$S(s)$	+	$O_2(g)$	$\rightarrow$	$SO_2(g)$	$\Delta H = -297$ kJ
Step 2	$2SO_2(g)$	+	$O_2(g)$	$\rightarrow$	$2SO_3(g)$	$\Delta H = -198$ kJ

① x 2

③ $2S_{(s)} + 2O_{2(g)} \rightarrow 2SO_{2(g)}$ $\Delta H_r = -594$ kJ

② + ③

$2S_{(s)} + 3O_{2(g)} \rightarrow 2SO_{3(g)}$ $\Delta H_r = -792$ kJ

Worksheet