

Lesson 3 For Book 1Review Question 1 --- Some implications of “electronic configuration”

When Fe^{2+} (aq) and Mn^{3+} (aq) are mixed together, there is a spontaneous reaction.

- a) State the electronic configuration of Fe^{2+} and Mn^{3+} .
- b) By considering the electronic configuration, explain the **spontaneity** of the reaction:
$$\text{Fe}^{2+} + \text{Mn}^{3+} \rightarrow \text{Fe}^{3+} + \text{Mn}^{2+}$$
- c) State the oxidizing agent and the reducing agent. (5M)

→ Actually, by considering the electronic configuration of ions/ atoms, the spontaneity of a R_____ reaction can be predicted to some extent.

Energetics → Thermochemistry

- When there is a energy d_____ between reactants and products, a reaction can be said to be going to happen. First, we must know that energy flow must be from the “h_____ side to l_____ side”, that is, from higher potential to lower potential.
- When a reaction happens, there will be energy transfer and usually it is in the form of h_____. if the reaction is exo_____, the system r_____ heat to the surroundings; if the reaction is endo_____, the system a_____ heat from the surroundings. The study of such heat changes in chemical reactions is known as **thermochemistry**.
- Two important energy terms = **Internal energy change and Enthalpy change**
→ Internal energy change = the measurement of the heat change of a system is carried out at constant v_____ i.e. inside a rigid container.
→ Enthalpy change = the measurement of the heat change of a system is carried out at constant p_____ e.g. under atmospheric pressure.
But, we will encounter the study of ENTHALPY CHANGE only.

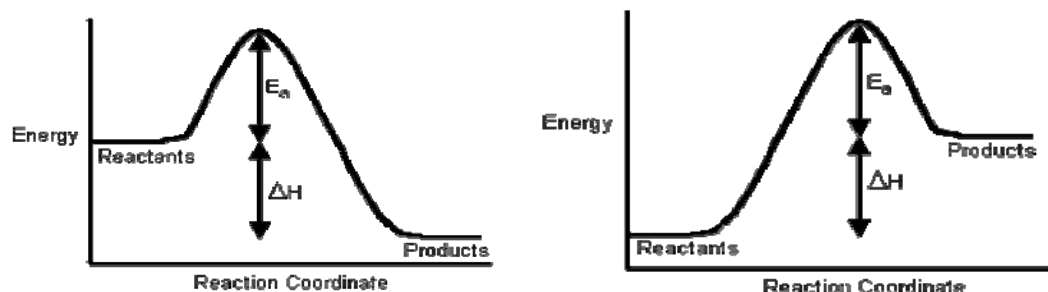
Exercise 1 --- Exothermic or Endothermic? → Energy profile

Please draw a one-step energy profile for the combustion of ethane.

(Hint = To draw an energy profile, we need to know the axis, the position of the starting and end points, and also the species involved at each stages.)

Standard Enthalpy change

- That is, $\Delta H^\ominus = H_{\text{final}} - H_{\text{initial}}$, under the standard conditions, including the temperature = 298K, the pressure = 1 bar, elements or compound in their normal physical states... (REMEMBER to add a $^\ominus$ sign)
- Two basic but useful graphs: **Exo and Endo and E_a and ΔH of a reaction**



- REMEMBER ALL TYPES of enthalpy change
- 1) Standard enthalpy change of Combustion $\Delta H^\ominus C$ is the enthalpy change when _____ mole of a substance is burnt completely in oxygen under _____ conditions.
e.g. please write down the respective equation for the combustion of hydrogen.

→ Practically, we use calorimeter to measure the $\Delta H^\ominus C$ of a compound / fuel, under some assumptions e.g. there is _____ heat loss to the _____.
→ A “_____” sign is always required.
 - 2) Standard enthalpy change of neutralization $\Delta H^\ominus \text{neut}$ is the enthalpy change when one mole of water is formed from the n _____ of an acid and an alkali under standard conditions.
i.e. $H^+ + OH^- \rightarrow H_2O$, where the ions are in a _____ state.
→ A “_____” sign is always required.
 - 3) Standard enthalpy change of solution $\Delta H^\ominus \text{soln}$ is the enthalpy change when one mole of a s _____ is completely dissolved in a relatively large volume of s _____ (usually water) to form an infinity dilute solution under standard conditions.
e.g. $NaCl(s) + aq \rightarrow Na^+(aq) + Cl^-(aq)$
→ The sign is unknown this time.
 - 4) *** Standard enthalpy change of formation $\Delta H^\ominus f$ is the enthalpy change of the reaction when one mole of a substance is formed from its constituent elements in their standard states under standard conditions.
Please write down the $\Delta H^\ominus f$ of $CaI_2(s)$ with correct state.

→ The sign of the $\Delta H^\ominus f$ can indicate the **thermal s** _____ of an (ionic) compound, that is, if the formation is e _____, the compound is **stable**.

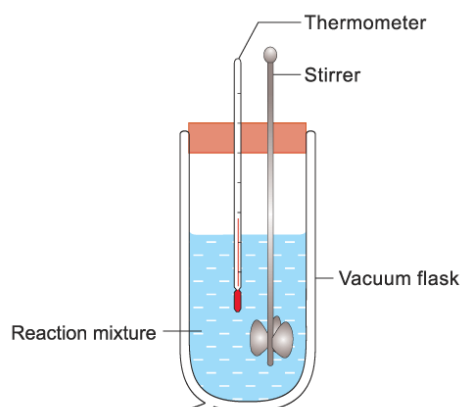
Exercise 1 Determination of ΔH^\ominus_c by using Calorimetry

A student used a calorimeter to determine the enthalpy change of combustion of methanol, an **organic fuel**. In the experiment, 1.60 g of methanol was used and 50 g of water was heated up, raising the temperature by 33.2°C . Given that the specific heat capacities of water and copper calorimeter are $4200 \text{ J kg}^{-1}\text{K}^{-1}$ and $2100 \text{ J kg}^{-1}\text{K}^{-1}$

Respectively and the mass of the calorimeter is 400 g, calculate the enthalpy change of combustion of methanol.

Hint = We can use the formula "Heat change = $(m_1c_1 + m_2c_2) \Delta T$ " and thus

$$\Delta H^\ominus_c = \text{heat change} / \text{no of mole of methanol used.} \quad (-697.2 \text{ kJ mol}^{-1})$$



Calculations by using Hess's Law \rightarrow Born-Haber Cycle

- Hess's Law of constant heat summation states that the total enthalpy change accompanying a chemical reaction is independent of the route by which the chemical reaction takes place.

\rightarrow The ΔH^\ominus_r is governed by the initial state and the _____ state only, at constant p_____.

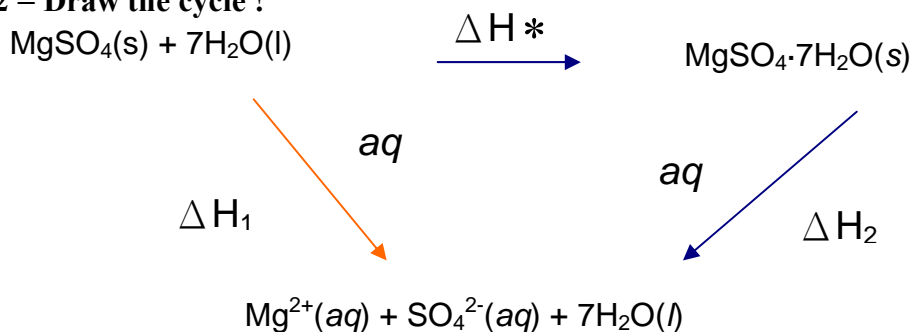
- When we are dealing with such question, we need to make clear of the definition of every ΔH^\ominus . That is, we need to know the underlying equation of every ΔH^\ominus .

SKILL : Put the equation representing the **target ΔH^\ominus** on the **top** on the cycle.

Illustration: Enthalpy change of **hydration** of $\text{MgSO}_4(\text{s})$ to form $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$

Step 1 = Target equation = _____

Step 2 = Draw the cycle !



ΔH^* = enthalpy of hydration of $\text{MgSO}_4(\text{s})$

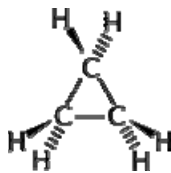
ΔH_1 = molar enthalpy change of solution of anhydrous magnesium sulphate(VI)

ΔH_2 = molar enthalpy change of solution of magnesium sulphate(VI)-7-water

SO, we have $\Delta H^* = \Delta H_1 - \Delta H_2$

Exercise 2

The table below lists the standard enthalpy changes of combustion of three substances.

Substance	$\Delta H^{\ominus} C$ (kJ mol ⁻¹)
C(graphite)	-394
H ₂ (g)	-286
C ₃ H ₆ (g)	-2090
Cyclopropane	

i) Calculate the $\Delta H^{\ominus} f$ of cyclopropane. (+50 kJ mol⁻¹)

ii) Explain the **sign** of the $\Delta H^{\ominus} f$ of cyclopropane.

→ Cyclopropane is not energetically s_____ since it has high **ring strain**.

Enthalpy Change, Entropy Change and Free Energy

● Entropy Change ΔS = the change of the **degree of disorder** of a system after a r_____ happened.

→ a measure of energy actually --- ΔS has the unit of **J K⁻¹**

→ if the species of the system have a **higher** K.E. or P.E after a reaction happened, the ΔS should be have the sign “p_____”.

→ if there is **more gaseous species** in the system after a reaction happened, the ΔS should be have the sign “p_____”.

● $\Delta S = S_{\text{final}} - S_{\text{initial}}$

● **Free energy** = A measure of the **spontaneity** of a reaction at constant temperature and constant **p**_____ .

● For a reaction (reversible),

$\Delta G = \Delta H - T\Delta S < 0$ when the reaction **can** take place spontaneously.

> 0 when the reaction **cannot** take place spontaneously but can take place spontaneously in the opposite way

→ Actually, high temperature favors many reactions.

Further Thinking

i) Regarding the formation of dry ice, is there any bonds forming or breaking?

ii) Regarding the formation of dry ice, will it be exo or endo ?

iii) Regarding the formation of dry ice, will the entropy change pos or neg ?

iv) Can you speed up the formation by increasing the temp?