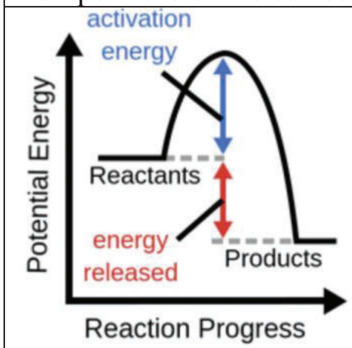
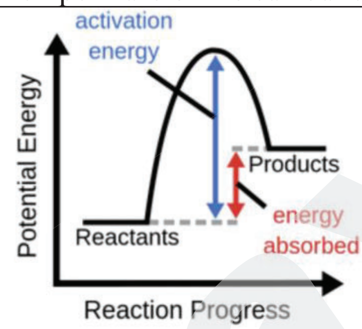
Chapter 5: Chemical Energetics

- Exothermic vs. Endothermic

Exothermic	**Endothermic**
Chemical reaction that releases energy to the surrounding	Chemical reaction that absorbs energy from the surrounding
Temperature of the surrounding increases	Temperature of the surrounding decreases
	
ΔH = negative sign	ΔH = positive sign
Bond forming	Bond breaking

- Definition table

Enthalpy Changes	**Definition**	**Equation**	**Exo/Endo**
Standard Enthalpy Change of Reaction	- Enthalpy change - The amount of reactants shown in the equation react to give products - Under standard condition		
Standard Enthalpy Change of Formation	- Enthalpy change - 1 mole of a compound is formed from its elements - Under standard conditions		
Standard Enthalpy Change of Combustion	- Enthalpy change - When 1 mole of substance is burnt in excess oxygen - Under standard condition		
Standard Enthalpy Change of Neutralisation	- Enthalpy change - When 1 mole of water is formed by the reaction of an acid with an alkali - Under standard condition		
Standard Enthalpy Change of Solution	- Enthalpy change		

	- When 1 mole of solute is dissolved in a solvent to form an infinitely dilute solution - Under standard condition		
Standard Enthalpy Change of Hydration	- Enthalpy change - When 1 mole of a hydrated salt is formed from 1 mole of the anhydrous salt - Under standard condition		
Standard Enthalpy Change of Atomisation	- Enthalpy change - When 1 mole of gaseous atoms is formed from its element - Under standard condition		
Bond Energy	- The energy required to break 1 mole of covalent bonds between 2 atoms - In gaseous state		

- Hess Law

$$\Delta H^{\ominus}_{reaction} = \sum \Delta H^{\ominus}_{f\,(products)} - \sum \Delta H^{\ominus}_{f\,(reactants)}$$

$$\Delta H^{\ominus}_{reaction} = \sum \Delta H^{\ominus}_{c\,(reactants)} - \sum \Delta H^{\ominus}_{c\,(products)}$$

Bond Energy = Bond energy (reactants) – Bond energy (products)

$Q = mc\Delta T$ (ΔT = final temperature – initial temperature)

$\Delta H = \frac{-mc\Delta T}{n}$

Enthalpy Change of Neutralisation	**Enthalpy Change of Solution**	**Enthalpy Change of Combustion**
$20cm^3$ of 0.5 M of HCl mixed with $20cm^3$, 0.5M of NaOH ΔT = 8 °C	0.5g NaOH is dissolved in $500cm^3$ of distilled water ΔT = 5 °C	5g of butanol – complete combustion To heat 200g of distilled water ΔT = 15 °C

Exercises:

Determine ΔH_r of $2\ CO_2 + 5\ H_2 \rightarrow C_2H_2 + 4\ H_2O$, given:

$\Delta H_f\ CO_2 = -393.5\ kJmol^{-1}$

$\Delta H_f\ H_2 = 0.0\ kJmol^{-1}$

$\Delta H_f\ C_2H_2 = 226.7\ kJmol^{-1}$

$\Delta H_f\ H_2O = -241.8\ kJmol^{-1}$

Determine ΔH_f of C_3H_8O, given:

$\Delta H_c\ C_3H_8O = -2010\ kJmol^{-1}$

$\Delta H_c\ C = -394\ kJmol^{-1}$

$\Delta H_c\ H_2 = -286\ kJmol^{-1}$

Past Year Topical Questions

Oct/Nov 2022 (21) Q3

(d) Sulfur, S_8, reacts with chlorine to form several different chlorides. The most common are S_2Cl_2 and SCl_2. SCl_2 forms when sulfur reacts with an excess of chlorine.

reaction **1**	$S_8(s) + 4Cl_2(g) \rightarrow 4S_2Cl_2(l)$	$\Delta H_r = -58.2\ kJ\ mol^{-1}$
reaction **2**	$S_2Cl_2(l) + Cl_2(g) \rightleftharpoons 2SCl_2(l)$	$\Delta H_r = -40.6\ kJ\ mol^{-1}$

(ii) Calculate the enthalpy change of formation, ΔH_f, of $SCl_2(l)$. You may find it useful to use Hess's Law to construct an energy cycle.

enthalpy change of formation of $SCl_2(l)$, ΔH_f = ... $kJ\,mol^{-1}$ [2]

May/June 2019 (11)

8 Two reactions and their enthalpy changes are shown.

$$2C(s) + 2H_2(g) \rightarrow C_2H_4(g) \qquad \Delta H^\ominus = +52.2\,kJ\,mol^{-1}$$

$$C_2H_2(g) + H_2(g) \rightarrow C_2H_4(g) \qquad \Delta H^\ominus = -175.8\,kJ\,mol^{-1}$$

These data can be used to calculate the enthalpy change for the reaction shown.

$$2C(s) + H_2(g) \rightarrow C_2H_2(g) \qquad \Delta H^\ominus = X$$

What is the value of X?

A $-228.0\,kJ\,mol^{-1}$

B $-123.6\,kJ\,mol^{-1}$

C $+123.6\,kJ\,mol^{-1}$

D $+228.0\,kJ\,mol^{-1}$

Chemical Properties of Group 7 elements

(i) Oxidising and reducing power

Halogen	Oxidizing Power / Reduction	Halide Ion	Reducing Power / Oxidation
F_2	-Decreases -Increasing number of electron-filled shells going down the group -Increasing shielding effect -Weaker nuclear attraction -Harder to attract electron	F^-	-Increases -Increasing number of electron-filled shells going down the group -Increasing shielding effect -Weaker nuclear attraction -Easier to lose electron
Cl_2		Cl^-	
Br_2		Br^-	
I_2		I^-	

(ii) Silver nitrate and nitric acid

Silver Halide	Colour	Reaction with Ammonia	Solubility in ammonia
AgCl	White	$AgCl(s) + 2NH_3 (aq) \rightarrow [Ag(NH_3)_2]^+ (aq) + Cl^- (aq)$	Soluble in dilute, aqueous NH_3 to give a colourless solution
AgBr	Cream	$AgBr(s) + 2NH_3 (aq) \rightarrow [Ag(NH_3)_2]^+ (aq) + Br^- (aq)$	Soluble in concentrated NH_3 only
AgI	Yellow	-	Insoluble

- Ammonia acts as a **ligand**
- A **ligand** is an ion or molecule that donates its lone pair electron through coordinate bond/dative bond to metal ion