5 Energy from chemicals

Candidates should be able to:

(a) describe the meaning of enthalpy change in terms of exothermic (ΔH negative) and endothermic (ΔH positive) reactions

(b) represent energy changes by energy profile diagrams, including reaction enthalpy changes and activation energies (see 6.1(c))

(c) describe bond breaking as an endothermic process and bond making as an exothermic process

(d) explain overall enthalpy changes in terms of the energy changes associated with the breaking and making of covalent bonds

(e) describe combustion of fuels as exothermic, e.g. wood, coal, oil, natural gas and hydrogen

(f) describe hydrogen, derived from water or hydrocarbons, as a potential fuel for use in future, reacting with oxygen to generate electricity directly in a fuel cell (details of the construction and operation of a fuel cell are **not** required) and discuss the advantages and disadvantages of this

(g) name natural gas, mainly methane, and petroleum (crude oil) as sources of energy

(h) describe petroleum (crude oil) as a mixture of hydrocarbons and its separation into useful fractions by fractional distillation

(i) name the following fractions and state their uses

- *(i)* petrol (gasoline) as a fuel in cars
- *(ii)* naphtha as feedstock for the chemical industry
- *(iii)* paraffin (kerosene) as a fuel for heating and cooking and for aircraft engines
- *(iv)* diesel as a fuel for diesel engines
- *(v)* lubricating oils as lubricants and as a source of polishes and waxes
- *(vi)* bitumen for making road surfaces

(j) describe photosynthesis as the reaction between carbon dioxide and water in the presence of chlorophyll, using sunlight (energy) to produce glucose and explain how this can provide a renewable energy source.

Tuesday 11th November, 2020

Energy From Chemicals

- Every substance possesses some amount of energy called its internal energy or enthalpy (H).
- Internal energy of a substance cannot be measured.
- Energy change always takes place during chemical reactions, i.e. energy is either absorbed or evolved during chemical reactions.

Types of reactions on the basis of energy

Exothermic

exo → outside
therm → heat

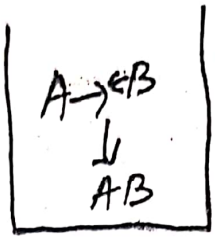
- Those reactions in which energy is released to the surroundings during reactions
- During exothermic reactions, temp of the container and surroundings is increased and they get hotter
- In exothermic reactions total energy content of the reactants is greater than that of the products

Endothermic

Endo → inside
therm → heat

- Those reactions in which energy is absorbed from the surroundings during reactions
- During endothermic reactions temp of the container and surroundings is decreased and they get colder
- In endothermic reactions total energy content of the products is greater than that of the

For exothermic ($-\Delta H$) is used



$A + B \longrightarrow AB - \Delta H$ (Exothermic)

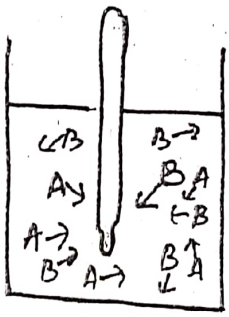
$10\,J + 5\,J \longrightarrow 12\,J$

Reactants have greater energy

$X + Y \longrightarrow XY + \Delta H$ (Endothermic)

$5J + 7J \longrightarrow 15J$

Products have greater energy



thermometer measures surrounding temp

Exothermic
Initial temp = 25°c
Change in temp = 20°c
Final temp = 5°c
= 30°c

If endothermic then

Energy released during exothermic reaction increases the temp of beaker, contents and surroundings

$\Delta H = H_2 - H_1$

↑ Products ↑ Reactants

$-\Delta H$ (If enthalpy of reactants is greater)

$\Delta H = H_2 - H_1$

↑ Products ↑ Reactants

$+\Delta H$ (If energy of the products is greater)

Some common exothermic reactions:-

1) Combustion reactions

Those reactions in which a substance burns in the presence of oxygen to produce heat

Examples:-

i. $wood + O_2 \longrightarrow CO_2 + H_2O_{(g)} + Heat$

ii. $coke\ (C) + O_2 \longrightarrow CO_2 + Heat$

iii. $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O_{(g)} - \Delta H$

iv. $Petrol + O_2 \longrightarrow CO_2 + H_2O_{(g)} - \Delta H$

v. $H_2 + O_2 \longrightarrow H_2O_{(g)} - \Delta H$

H_1 $\qquad$ H_2

$\Delta H = H_2 - H_1$

$-\Delta H$

If $+\Delta H$ on product side, the reaction is endothermic

vi. $C_6H_{12}O_6 + O_2 \longrightarrow 6CO_{2(g)} + 6H_2O_{(g)} + Heat$ (Respiration)

2) Neutralization reaction

$NaOH + HCl \longrightarrow NaCl + H_2O - 57\ kJ/mole$

Some common endothermic reactions

⇒1 Most decomposition reactions

Decomposition reactions:

Those reactions in which one reactant decomposes (breaks up) to give two or more products.

Examples:-

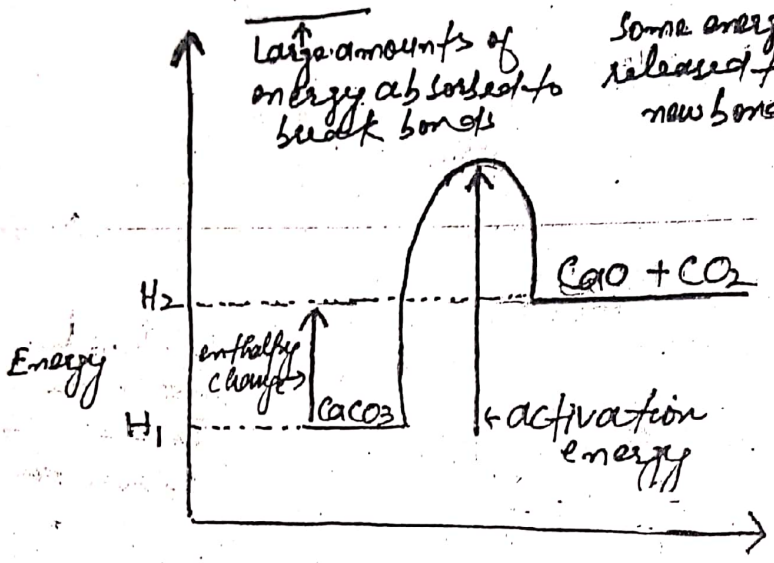
i. $CaCO_3 \xrightarrow{heat} CaO + CO_2$

ii. $MgCO_3 \longrightarrow MgO + CO_2 + \Delta H$

Energy Profile Diagram

ENDOTHERMIC REACTIONS

$CaCO_3 \xrightarrow{Heat} CaO + CO_2$



$\Delta H = H_2 - H_1$

$+ \Delta H$

$H-H \longrightarrow H + H$

Endothermic (bond breaking)

$Cl-Cl \longrightarrow Cl + Cl$

(Bond breaking) Endothermic

$H + Cl \longrightarrow H-Cl$

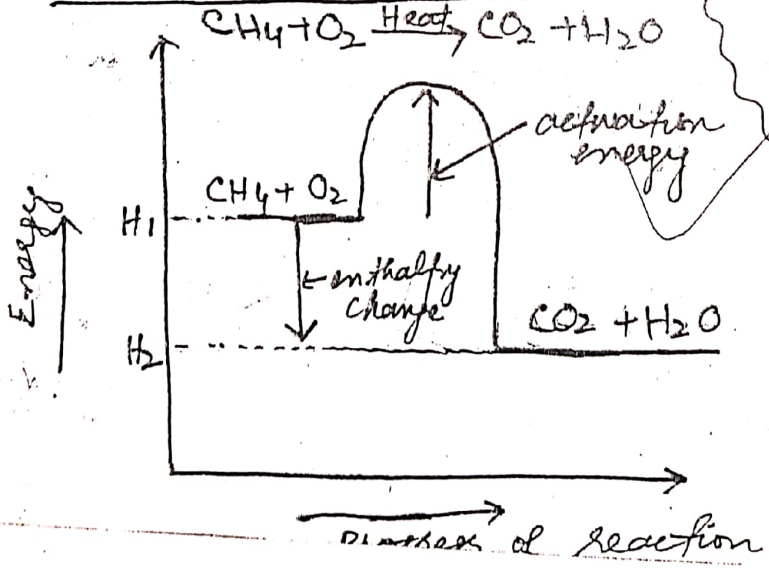
Exothermic Bond forming

$H-H + Cl-Cl \longrightarrow H-Cl$

Bond breaking endothermic

H bond form exothe

Exothermic reactions



iii. $Ca(OH)_2 + Heat \longrightarrow CaO + H_2O$

⇒ Photosynthesis

$6CO_2(g) + 6H_2O(l) \xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6O_2$

(air) (soil)

⇒3 Lightning

$N_2 + O_2 \xrightarrow{\text{light}} 2NO$

⇒4 Formation of hydrogen Iodide

$H_2 + I_2 \rightarrow 2HI + 1310 KJ/mol$

Activation Energy

- It is the additional amount of energy required by the reactants to be converted into products.
- It is the amount of energy which activates the reactants in order to undergo a chemical reaction.
- Greater the activation energy slower will be the reaction

Energy Profile Diagram

To determine the energy changes of a reaction

Why some reactions are exothermic and others endothermic

- $H-H + Cl-Cl \longrightarrow H-Cl + H-Cl \quad -\Delta H$

Bond breaking — Endothermic

Bond forming — Exothermic

Exothermic

This reaction is exothermic because energy absorbed during bond breaking is lesser than energy released during bond forming. More energy is released during bond forming than is absorbed during bond breaking.

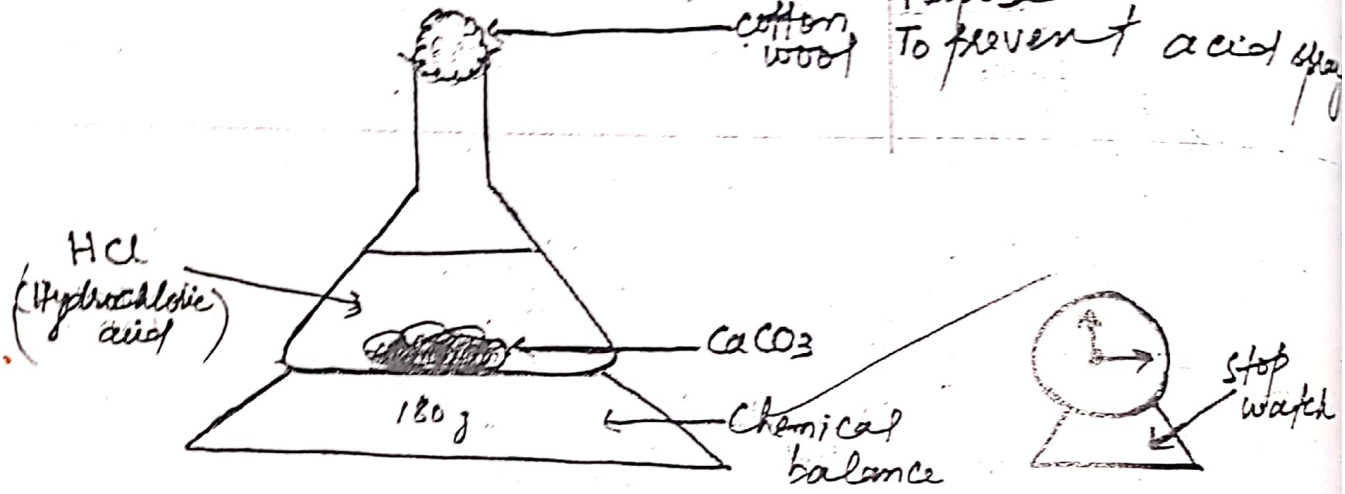
Calculation of enthalpy or overall energy of chemical reaction

See next page →

Rate of Reaction

- Fast: rate cannot be measured e.g; Bomb explosion
- Slow: ripening of fruits, rusting of iron
- Moderately slow: acid + carbonate
  acid + metal

Measurement of rate of reaction by measuring



Time/min	Mass of flask + contents/g	Total decrease in mass/g	Decrease in mass per minute/g
0	180g	00	00
1	172g	08	08
2	168g	12	04
3	166g	14	02
4	165g	15	01
5	165g	15	00
6	165g	15	00

Conc. of reacting particles decreases as the reaction proceeds therefore rate of reaction decreases so as the volume of CO_2