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Short Notes: Form 5 Chemistry

Rate or Reaction

Calculation

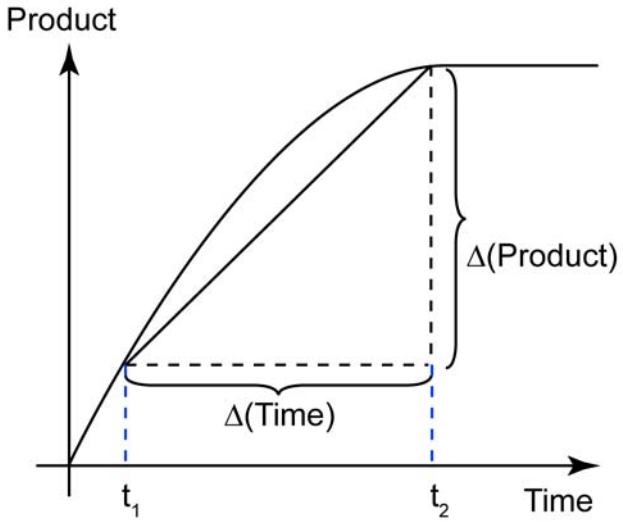
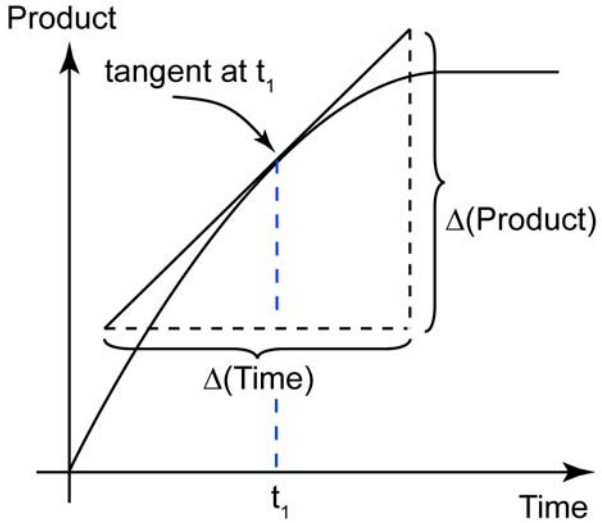
Rate of Reaction (Average Rate)

$$\text{Rates of reaction} = \frac{\text{Quantity change of reactants/products}}{\text{Total time for the reaction}}$$

If the quantity change is immeasurable

$$\text{Rates of reaction} = \frac{1}{\text{Total time for the reaction}}$$

Find the Rate From a Graph

Average Rate	Rates At an Instant
The rate of reaction is equal to the slope of the graph of quantity against time. $\text{Rate of Reaction} = \frac{\Delta(\text{Product})}{\Delta(\text{Time})}$ 	The rate of reaction at an instant, t, is equal to the slope of tangent at that instant. $\text{Rate of Reaction} = \frac{\Delta(\text{Product})}{\Delta(\text{Time})}$ 

Chemical Reaction

Precipitation of Sulphur

$$2HCl_{(aq)} + Na_2S_2O_{3(aq)} \longrightarrow 2NaCl_{(aq)} + S_{(s)} + SO_{2(g)} + H_2O_{(l)}$$

Notes:	$Na_2S_2O_3$: Sodium thiosulphate
1. Yellow precipitate (sulphur) is formed. 2. The reaction is slow.	

Potassium Dichromate (VI) with Ethanedioic Acid

$$Cr^2O_7^{2-} + 14H^+ + 3C_2O_4^{2-} \longrightarrow 6CO_2 + 7H_2O + 2Cr^{3+}$$

Notes:
1. In the reaction, the orange colour of the solution turns into green.

$Cr^2O_7^{2-}$: dichromate(VI) ion (Orange)
$C_2O_4^{2-}$: ethanedioate ion (Colourless)
Cr^{3+} : Chromium(III) ion (green)

Potassium Manganate(VII) with Ethanedioic Acid

$$2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \longrightarrow 10CO_2 + 8H_2O + 2Mn^{2+}$$

Notes:
1. Mn^{2+} is colourless
2. In the reaction, the purple colour of the solution turns into colourless.

MnO_4^-: Manganate(VII) ion (Purple)
Mn^{2+}: Manganese(II) ion colourless

Decomposition of Hydrogen Peroxide

$$2H_2O_2 \xrightarrow{-} 2H_2O + O_2$$

Catalyst: manganese(IV) oxide(MnO_2), Iron(III) oxide (Fe_2O_3), silver (Ag)

Haber Process (Manufacture Ammonia)

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

(More detail in Form 4 Chapter 9)

Contact Process(Manufacture Sulphuric Acid)

$$2SO_2 + O_2 \longrightarrow 2SO_3$$

Ostwald Process (Manufacture Nitric Acid)

Stage 1

$$4NH_{3(g)} + 5O_{2(g)} \rightarrow 4NO_{(g)} + 6H_2O_{(g)}$$

Notes:
1. Temperature = 900oC
2. Pressure = 4-10 atm
3. Catalyse = Platinum (Pt)

Stage 2

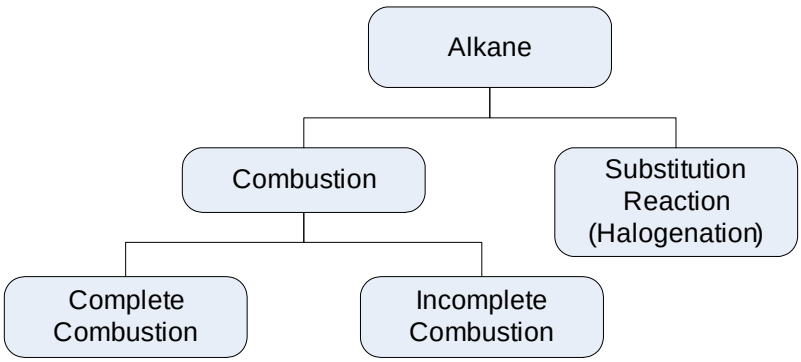
$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$$

Dissolve in water

$$3NO_{2(g)} + H_2O_{(l)} \rightarrow 2HNO_{3(aq)} + NO_{(g)}$$

Carbon Compound

Alkane



Combustion

Complete combustion

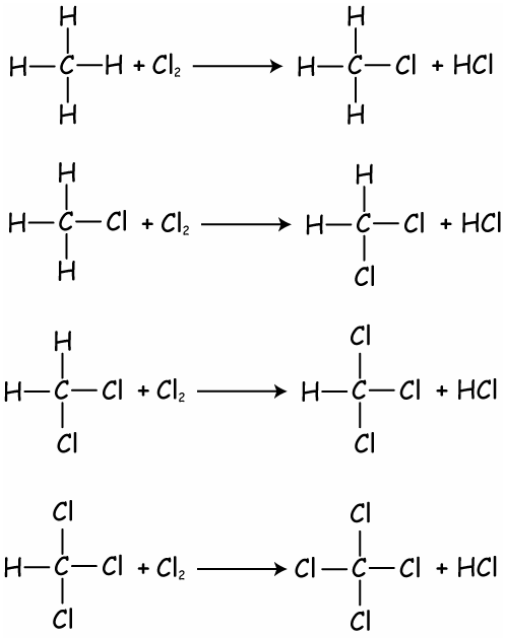
$$\mathbf{C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O}$$

Incomplete combustion

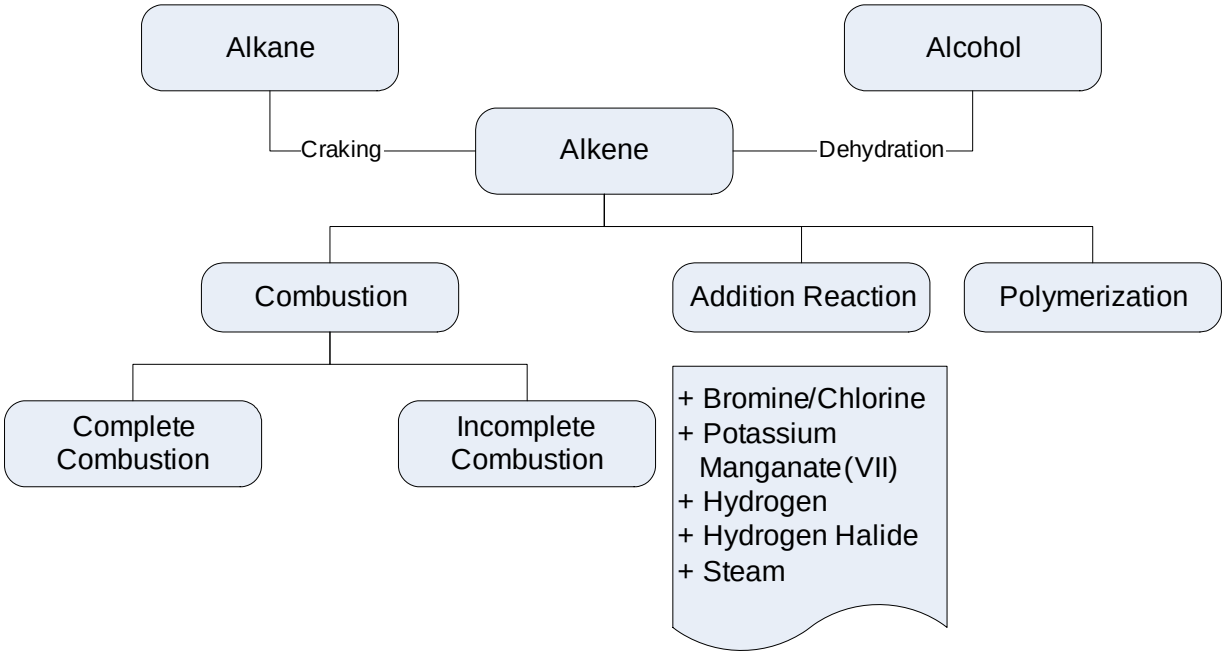
$$\mathbf{C_2H_6 + \frac{5}{2}O_2 \longrightarrow 2CO + 3H_2O}$$

$$\mathbf{C_2H_6 + \frac{3}{2}O_2 \longrightarrow 2C + 3H_2O}$$

Substitution Reaction



Alkene



Preparation of Alkene

Cracking of Alkane

$$2C_4H_{10} \longrightarrow CH_4 + C_2H_4 + C_2H_6 + C_3H_6$$

$$C_2H_5OH + \longrightarrow C_2H_4 + H_2O$$

Combustion:

Complete combustion:

$$C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$$

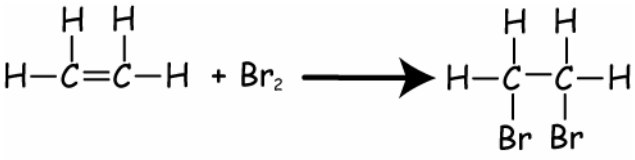
Incomplete combustion

$$C_2H_4 + 2O_2 \longrightarrow 2CO + 2H_2O$$

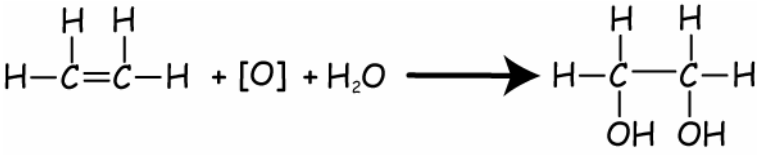
$$C_2H_4 + O_2 \longrightarrow 2C + 2H_2O$$

Addition Reaction:

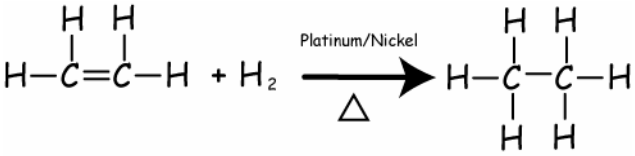
+ Bromine:



+ Potassium Manganate(VII):

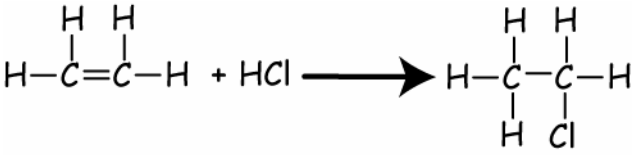


+ Hydrohen:

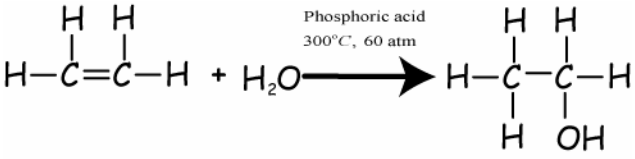


(Catalyst: platinum/nickel)

+ Hydrogen Halide:

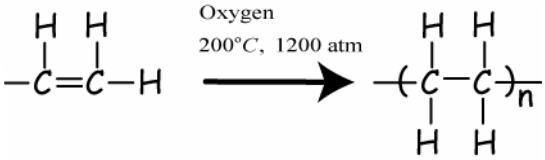


+ Steam (H_2O):



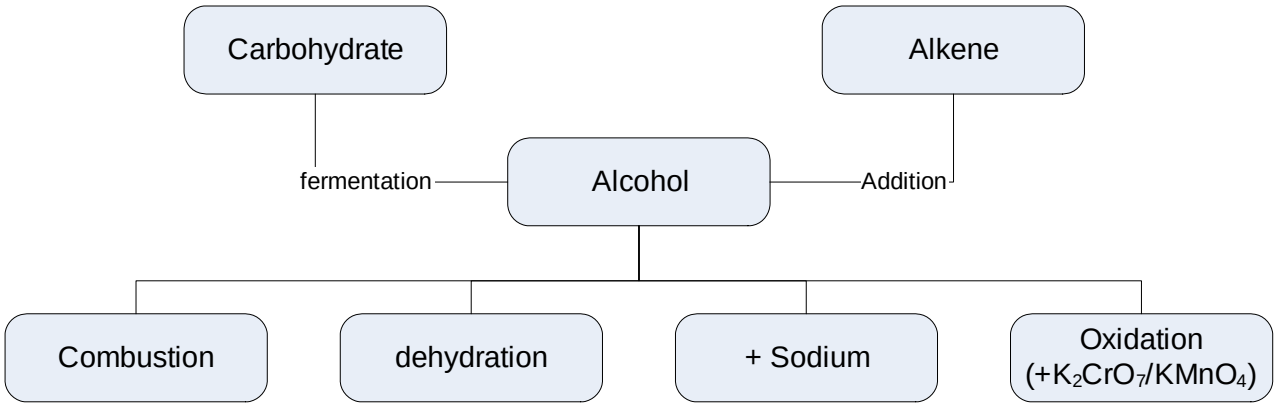
(Catalyst: phosphoric acid; Temperature: 300°C; Pressure: 60atm)

Polymerization



xygen; Temperature: 200°C; Pressure: 1200atm)

Alcohol



Preparation of alchohol

Fermentation of Carbohydrate (Glucose)

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$$

Addition of Alkene

$$C_2H_4 + H_2O \longrightarrow C_2H_5OH$$

[Catalyst:Phosphoric acid; Temperature:300^oC; Pressure: 60atm]

or

$$C_2H_4 + H_2SO_4 \longrightarrow CH_3CH_2OSO_3H$$

$$CH_3CH_2OSO_3H + H_2O \longrightarrow CH_3CH_2OH + H_2SO_4$$

Combustion of Alcohol

$$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$

Dehydration of Alcohol

$$C_2H_5OH + \longrightarrow C_2H_4 + H_2O$$

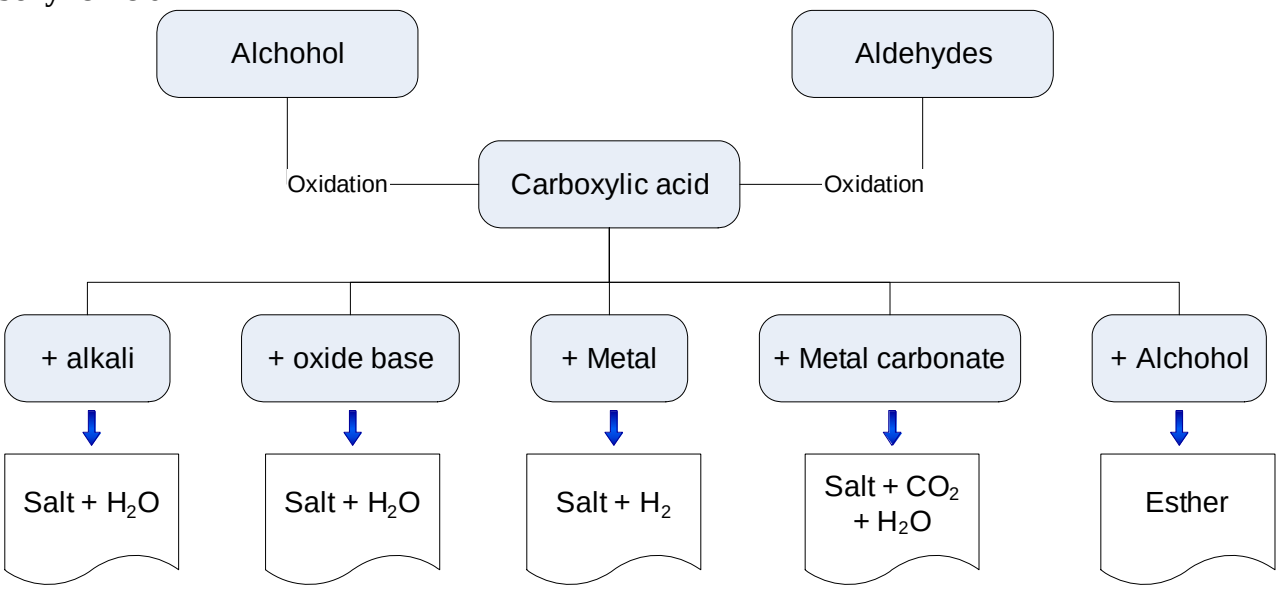
Alcohol + Sodium

$$2C_2H_5OH + 2Na \longrightarrow 2C_2H_5ONa + H_2$$

Oxidation of Alcohol

$$C_2H_5OH + 2[O] \longrightarrow CH_3COOH + H_2O$$

Carboxylic Acid



Preparation of Carboxylic acid

Oxidation of Alcohol

$$C_2H_5OH + 2[O] \longrightarrow CH_3COOH + H_2O$$

Oxidation of Aldehyde

$$C_2H_6O + [O] \longrightarrow CH_3COOH$$

Reaction

Carboxylic Acid + Alkali

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

Carboxylic Acid + Metal Oxide

$$2CH_3COOH + MgO \longrightarrow Mg(CH_3COO)_2 + H_2O$$

Carboxylic Acid + Metal

$$2CH_3COOH + Mg \longrightarrow Mg(CH_3COO)_2 + H_2$$

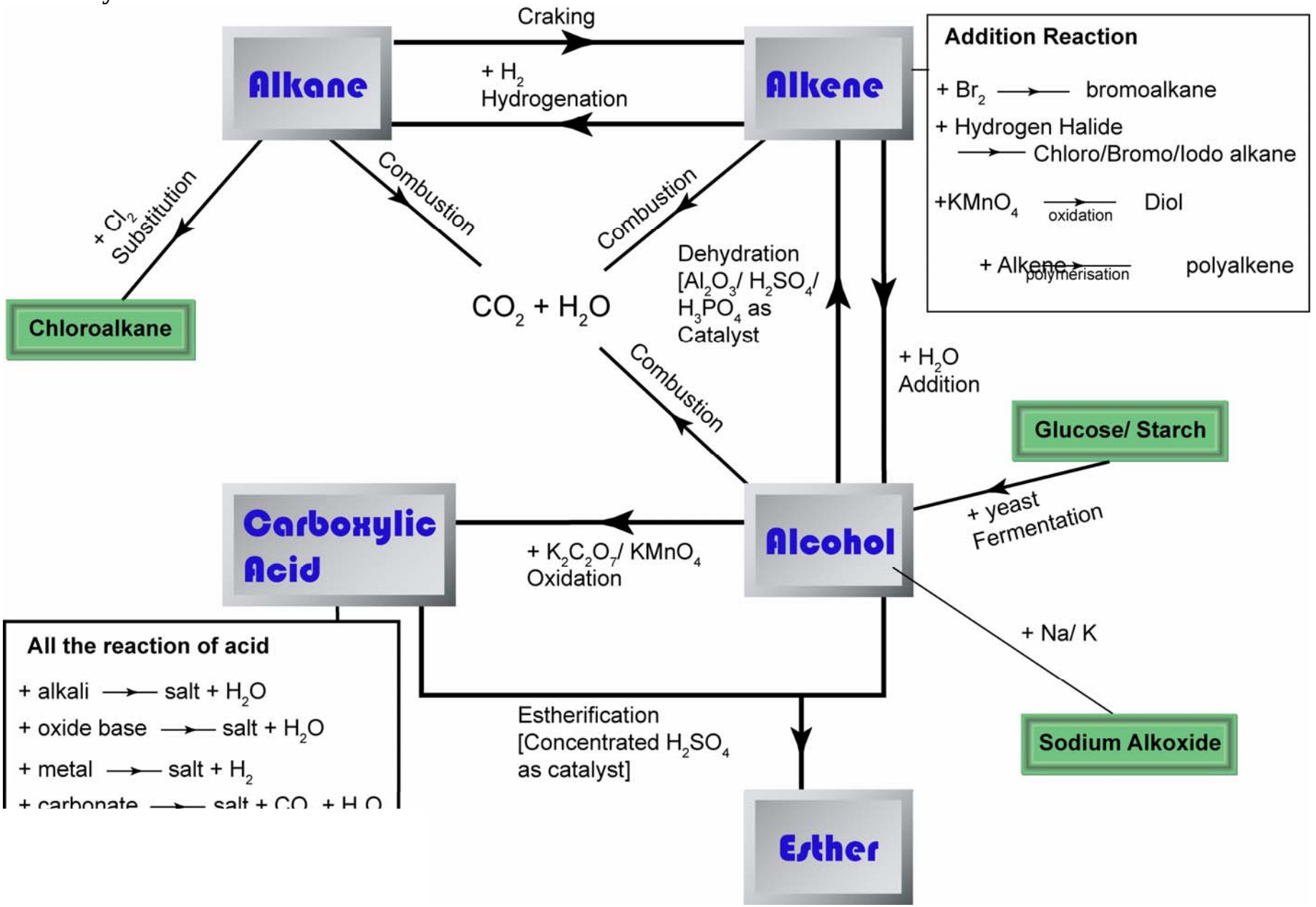
Carboxylic Acid + Metal Carbonate

$$2CH_3COOH + CaCO_3 \longrightarrow Ca(CH_3COO)_2 + CO_2 + H_2O$$

Carboxylic Acid + Alchohol

$$I + C_2H_5OH \longrightarrow CH_3COOC_2H_5 + H_2O$$

Summary of The Reaction



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Oxidation and Reduction

Iron(II) to Iron(III)

Oxidising agent: Chlorine or Bromine

$$Fe^{2+} \longrightarrow Fe^{3+} + e$$
$$+ \quad Cl_2 + 2e \longrightarrow 2Cl^-$$
$$2Fe^{2+} + Cl_2 \longrightarrow 2Fe^{3+} + 2Cl^-$$

Observation:
1. The green colour of Fe^{2+}solution turns brown

$$Fe^{2+} \longrightarrow Fe^{3+} + e$$
$$+ \quad Br_2 + 2e \longrightarrow 2Br^-$$
$$2Fe^{2+} + Br_2 \longrightarrow 2Fe^{3+} + 2Cl^-$$

Observation:
1. The green colour of Fe^{2+} solution turn brown
2. The brown colour of bromine water turns into colourless.

Oxidising agent: Potassium Permanganate(VII)

$$Fe^{2+} \longrightarrow Fe^{3+} + e$$
$$+ \quad MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H_2O$$
$$5Fe^{2+} + MnO_4^- + 8H^+ \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$$

Observation:
1. The green colour of solution Fe^{2+} turns brown
2. The purple colour of the MnO_4^- solution turns into colourless

Oxidising agent: Potassium Dichromate(VI)

$$Fe^{2+} \longrightarrow Fe^{3+} + e$$
$$+ \quad Cr_2O_7^{2-} + 14\,H^+ + 6e \longrightarrow \quad 2Cr^{3+} + 7H_2O$$
$$6Fe^{2+} + MnO_4^- + 8H^+ \longrightarrow 6Fe^{3+} + Mn^{2+} + 4H_2O$$

Observation:
1. The green colour of solution Fe^{2+} turns brown.
2. The orange colour of the $Cr_2O_7^{2-}$ solution turns green.

Oxidising agent: Hidrogen Peroxide

$$Fe^{2+} \longrightarrow Fe^{3+} + e$$
$$+ \quad H_2O_2 + 2H^+ + 2e \longrightarrow \quad 2H_2O$$
$$2Fe^{2+} + H_2O_2 + 2H^+ \longrightarrow 2Fe^{3+} + 2H_2O$$

Observation:
1. The green colour of solution Fe^{2+} turns brown

Oxidising agent: Concentrated Nitric Acid

$$Fe^{2+} \longrightarrow Fe^{3+} + e$$
$$+ \quad NO_3^- + 4H^+ + 3e \longrightarrow NO + 2H_2O$$
$$3Fe^{2+} + NO_3^- + 4H^+ \longrightarrow 3Fe^{3+} + NO + 2H_2O$$

$^{2+}$ turns brown

Iron(III) to Iron(II)

Reducing Agent: More reactive Metal

$$Fe^{3+} + e \longrightarrow Fe^{2+}$$
$$+ \quad Zn \longrightarrow Zn^{2+} + 2e$$
$$2Fe^{3+} + Zn \longrightarrow 2Fe^{2+} + Zn^{2+}$$

Observation:
1. The brown colour of the iron(III) solution turn green.
2. Zinc powder dissolve in the solution.

Reducing Agent: Sulphur Dioxide

$$Fe^{3+} + e \longrightarrow Fe^{2+}$$
$$+ \quad SO_2 + 2H_2O \longrightarrow SO_4^{2-} + 4H^+ + 2e$$
$$2Fe^{3+} + SO_2 + 2H_2O \longrightarrow 2Fe^{2+} + SO_4^{2-} + 4H^+$$

Observation:
1. The brown colour of the iron(III) solution turn green.

Reducing Agent: Hydrogen Sulphide

$$Fe^{3+} + e \longrightarrow Fe^{2+}$$
$$+ \quad H_2S \longrightarrow 2H^+ + S + 2e$$
$$2Fe^{3+} + H_2S \longrightarrow 2Fe^{2+} + 2H^+ + S$$

Observation:
1. The brown colour of the iron(III) solution turn green.
2. Yellow precipitate forms in the solution.

Reducing Agent: Sodium Sulphite

$$Fe^{3+} + e \longrightarrow Fe^{2+}$$
$$+ \quad SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e$$
$$2Fe^{3+} + SO_3^{2-} + H_2O \longrightarrow 2Fe^{2+} + SO_4^{2-} + 2H^+$$

Observation:
1. The brown colour of the iron(III) solution turn green.

Reducing Agent: Tin(II) Chloride

$$Fe^{3+} + e \longrightarrow Fe^{2+}$$
$$+ \quad Sn^{2+} \longrightarrow Sn^{4+} + 2e$$
$$2Fe^{3+} + Sn^{2+} \longrightarrow 2Fe^{2+} + Sn^{4+}$$

Observation:
1. The brown colour of the iron(III) solution turn green.

Displacement of Metal

[A more reactive metal can displace a less reactive ion of metal from its compound.]

Example:

$$Mg + PbCl_2 \longrightarrow MgCl_2 + Pb$$
$$3Zn + Fe_2O_3 \longrightarrow 3ZnO + 2Fe$$
$$Al + CuSO_4 \longrightarrow Al_2(SO_4)_3 + Cu$$

Electrochemical Series

More electropositive
←
K, Na, Ca, Mg, Al, Zn, Fe, Sn, Pb, H, Cu, Ag

Kalau Nak Cari Makanan Ada Zat Ferum Seperti Papaya Harus Cari di Argentina

Reactivity Series

More reactive
←
K, Na, Ca, Mg, Al, **C**, Zn, **H**, Fe, Sn, Pb, Cu, Ag

Displacement of Halogen

[A more reactive halogen can displace a less reactive halide from its compound.]

Example:

$$Cl_2 + KBr \longrightarrow KCl + Br_2$$
$$Br_2 + NaI \longrightarrow NaBr + I_2$$
$$F_2 + KI \longrightarrow KF + I_2$$

Reactivity of Halogen

More reactive
←
$F_2 > Cl_2 > Br_2 > I_2 > At_2$

Colour of Halogen and Halide

Halogen	Colour in water	Colour in CCl_4
Chlorine (Cl_2)	Pale Yellow	Pale Yellow
Bromine (Br_2)	Brown/Orange/	Brown/Orange/
	Yellow	
	Purple	

Halogen	Colour in water	Colour in CCl_4
Chloride (Cl^-)	Colourless	Colourless
Bromide (Br^-)	Colourless	Colourless
Iodide (I^-)	Colourless	Colourless

The Oxidising Agent and Reducing Agent

Oxidising Agent (Reduction)	Redusing Agent (Oxidation)
Halogen $Cl_2 + 2e \longrightarrow 2Cl^-$ $Br_2 + 2e \longrightarrow 2Br^-$ $I_2 + 2e \longrightarrow 2I^-$	**Metal** $Mg \longrightarrow Mg^{2+} + 2e$ $Zn \longrightarrow Zn^{2+} + 2e$ $Al \longrightarrow Al^{3+} + 2e$
Metal Ion $Mg^{2+} + 2e \longrightarrow Mg$ $Pb^{2+} + 2e \longrightarrow Pb$ $Sn^{2+} + 2e \longrightarrow Sn$	**Halide Ion** $2Cl^- \longrightarrow Cl_2 + 2e$ $2Br^- \longrightarrow Br_2 + 2e$ $2I^- \longrightarrow I_2 + 2e$
Fe^{3+} $Fe^{3+} + e \longrightarrow Fe^{2+}$	**Fe^{2+}** $Fe^{2+} \longrightarrow Fe^{3+} + e$
Potassium Manganate(VII) $MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H_2O$	**Sulphur Dioxide** $SO_2 + 2H_2O \longrightarrow SO_4^{2-} + 4H^+ + 2e$
Potassium Dicromate(VI) $Cr_2O_7^{2-} + 14\ H^+ + 6e \longrightarrow 2Cr^{3+} + 7H_2O$	**Hydrogen Sulphide** $H_2S \longrightarrow 2H^+ + S + 2e$
Hydrogen Peroxide $H_2O_2 + 2H^+ + 2e \longrightarrow 2H_2O$	**Sodium Sulphite Aqueous** $SO_3^{2-} + H_2O \longrightarrow SO_4^{2-} + 2H^+ + 2e$
Concentrated Nitric Acid $NO_3^- + 4H^+ + 3e \longrightarrow NO + 2H_2O$	**Tin(II) Chloride Aqueous** $Sn^{2+} \longrightarrow Sn^{4+} + 2e$

Rusting

Step 1: Formation pf Ion

Anode:

$$Fe \longrightarrow Fe^{2+} + 2e$$

Cathode:

$$O_2 + H_2O \longrightarrow 4OH^- + 4e$$

Step 2: Corrosion of Iron

$$Fe^{2+} + 2OH^- \longrightarrow Fe(OH)_2$$

Step 3: Formation of iron(III) hydroxide

$$4Fe(OH)_2 + H_2O + O_2 \longrightarrow 4Fe(OH)_3$$

Step 4: Formation of Hydrated Iron(III) Oxide

$$Fe(OH)_3 \longrightarrow Fe_2O_3{\cdot}xH_2O$$

$$e + 3O_2 + xH_2O \longrightarrow 2Fe_2O_3\ xH_2O$$

Preparation of Oxygen Gas

Decomposition of Potassium Manganate (VII)

$$2KMnO_4 \longrightarrow K_2MnO_4 + MnO_2 + O_2$$

Decomposition of Potassium Chlorate (V)

$$2KClO_3 \longrightarrow 2KCl + 3O_2$$

[Manganese(IV) Oxide as catalyst]

Decomposition of Potassium Nitrate

$$2KNO_3 \longrightarrow 2KNO_2 + O_2$$

Extraction of Iron From Its Ore

Production of Carbon Dioxide

$$C + O_2 \longrightarrow CO_2$$

Production of Carbon Monoxide

$$CaCO_3 \longrightarrow CaO + CO$$

Reduction of Iron Ore to Iron

Upper Section of the Ballast Furnace

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

$$Fe_3O_4 + 4\ CO \longrightarrow 3Fe + 4CO_2$$

Lower Section of the Ballast Furnace

$$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$$

$$Fe_3O_4 + 4\ C \longrightarrow 3Fe + 4CO_2$$

Removal of Impurities

$$CaO + SiO_2 \longrightarrow CaSiO_3$$

Thermochemistry

Calculation

Heat of Reaction

$$\Delta H = \frac{\text{Thermal Energy Change}}{\text{Number of Mole}}$$

Thermal Energy Change

$$Q = mc\Delta\theta$$

m = mass of solution = volume of solution
c = specific heat capacity of solution

Number of Mole

For solution $n = \frac{MV}{1000}$	For gas (When volume is given) $n = \frac{\text{Volume of gas}}{\text{Molar volume of gas } (22.4\text{dm}^3 \text{ at stp} / 24\text{dm}^3 \text{ at rtp})}$
	For solid, liquid or gas (When mass is given) $n = \frac{\text{mass}}{\text{Molar mass (RAM/RMM)}}$

Chemical Reaction

Exothermic Reaction

Dissolving Alkali or Acid

$$NaOH \xrightarrow{H_2O} Na^+ + OH^-$$

$$H_2SO_4 \xrightarrow{H_2O} H^+ + SO_4^{2-}$$

Dissolving of Anhydrous Salt

$$CuSO_4 \xrightarrow{H_2O} Cu^{2+} + SO_4^{2-}$$

$$Na_2CO_3 \xrightarrow{H_2O} 2Na^+ + CO_3^{2-}$$

Combustion of Fuel

Example:

Combustion of Carbon

$$C + O_2 \longrightarrow CO_2$$

Combustion of Hydrogen

$$2H_2 + O_2 \longrightarrow 2H_2O$$

Combustion of Ethane

$$C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O$$

Reaction of Acid

Neutralisation

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

$$2HNO_3 + CaO \longrightarrow Ca(NO_3)_2 + H_2O$$

Acid + Reactive Metal

$$H_2SO_4 + Zn \longrightarrow ZnSO_4 + H_2$$

Acid + Carbonate Acid

$$HCl + CaCO_3 \longrightarrow CaCl_2 + CO_2 + HCl$$

Displacement Reaction

$$Zn + CuSO_4 \longrightarrow ZnSO_4 + Cu$$

Endothermic Reaction

Dissolving of Ammonium Chloride, Ammonium Nitrate and Ammonium Sulphate

$$NH_4Cl \xrightarrow{H_2O} NH_4^+ + Cl^-$$

$$NH_4NO_3 \xrightarrow{H_2O} NH_4^+ + NO_3^-$$

$$(NH_4)SO_4 \xrightarrow{H_2O} 2NH_4^+ + SO_4^{2-}$$

Dissolving of Hydrated Salt

$$CuSO_4 \bullet xH_2O \longrightarrow Cu^{2+} + SO_4^{2-} + xH_2O$$

$$Na_2CO_3 \bullet xH_2O \longrightarrow 2Na+ + CO_3^{2-} + xH_2O$$

Thermal Decomposition of salts

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$Ca(NO_3)_2 \longrightarrow 2CaO + 4NO_2 + O_2$$