Redox

	reduction	oxidation
In terms of Oxygen	Lose O	gain O
In terms of Hydrogen	gain H	Lose H
oxidation state	decrease	increase

Fe in Fe_2O_3 reduced

$$Al + Fe_2O_3 \longrightarrow Fe + Al_2O_3$$

Al oxidation : gain O

Zn in ZnO reduced

$$CO + ZnO \longrightarrow CO_2 + Zn$$

C in CO oxidise

Cu in CuO reduced.

$$H_2 + CuO \longrightarrow Cu + H_2O$$

H_2 oxidised

reduction Fe in Fe_2O_3

$CO + Fe_2O_3 \longrightarrow Fe + CO_2$

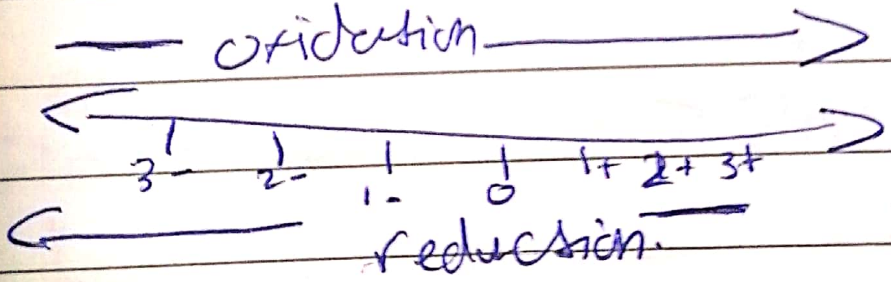
oxidised C in CO

oxidation S in H_2S

$H_2S + Cl_2 \longrightarrow HCl + S$

reduction Cl_2

Oxidation state;



$Cu^{2+} \rightarrow Cu$

$$\overset{0}{Mg} + \overset{2+}{Cu^{2+}} \longrightarrow \overset{2+}{Mg^{2+}} + \overset{0}{Cu}$$

oxidation $Mg \rightarrow Mg^{2+}$

reduction Cl_2

$$S^{2-} + \overset{0}{Cl_2} \longrightarrow 2Cl^{-} + S$$

oxidation S^{2-}

reduction H^{+}

$$\overset{0}{Na} + 2\overset{+1}{H^{+1}} \longrightarrow \overset{+1}{Na^{+1}} + \overset{0}{H_2}$$

oxidation Na

reduction $Cu^{2+} \rightarrow Cu$

$$\overset{0}{Zn} + \overset{2+}{Cu}\overset{-1}{Cl_2} \longrightarrow \overset{2+}{Zn}\overset{1-}{Cl_2} + \overset{0}{Cu}$$

oxidation $Zn \rightarrow Zn^{2+}$

reduction $Fe^{3+} \rightarrow Fe$

$$\overset{0}{Al} + \overset{3+}{Fe_2}\overset{2-}{O_3} \longrightarrow \overset{3+}{Al_2}\overset{2-}{O_3} + \overset{0}{Fe}$$

oxidation $Al \rightarrow Al^{3+}$

3) The oxidation state of (H) is (+1)
except with metals (−1)

$\overset{+1}{H_2}O$ $N\overset{+1}{H_3}$ $\overset{+1}{Na}\overset{-1}{H}$ $\overset{2+}{Ca}\overset{1-}{H_2}$ $C\overset{+1}{H_4}$ $Al\overset{-1}{H_3}$

4) The oxidation state of O is (2−)
except in peroxide : (1−)
except in (OF₂) (+2)

5) The sum of all oxidation state of all atoms in the compound = Zero
In the ion = charge of this ion

$\overset{+1}{Na}Cl$ $1 + x = 0$

$x = -1$

$C\overset{2-}{O}$ $C + (-2) = 0$

$C = +2$

$C\overset{-2}{O_2}$ $C + 2(-2) = 0$

$C - 4 = 0$

$C = +4$

$\overset{+1}{H_2}CO_3^{2-}$

$2(1)+C+3(-2)=0$

$2+C-6=0$

$C-4=0$

$C=+4$

$KMnO_4$

$1+Mn+4(-2)=0$

$1+Mn-8=0$

$Mn=+7$

NO

$N-2=0$

$N=+2$

NO_2

$N+2(-2)=0$

$N-4=0$

$N=+4$

NH_3

$N+3(1)=0$

$N+3=0$

$N=-3$

N_2O_5

$2N+5(-2)=0$

$2N-10=0$

$2N=10$

$N=+5$

NO_3^{-1}

$N + 3(-2) = -1$

$N - 6 = -1$

$N = +5$

NO_2^{-1}

$N + 2(-2) = -1$

$N - 4 = -1$

$N = +3$

$Cr_2O_7^{2-}$

$2Cr + 7(-2) = -2$

$2Cr - 14 = -2$

$2Cr = 12$

$Cr = +6$

CrO_4^{2-}

$Cr + 4(-2) = -2$

$Cr = +6$

Find the oxid. state of all underlined atoms:

$\underline{V}_2O_5$ $\boxed{+5}$

$\underline{V}O_2^{+}$ $\boxed{+5}$

$\underline{V}O^{2+}$ $\boxed{+4}$

$H_2\underline{S}$ $\boxed{-2}$

$\underline{S}O_3^{-2}$ $\boxed{+4}$

SO_2 $\boxed{+4}$

$\underline{S}O_3$ $\boxed{+6}$

$\underline{S}O_2^{2-}$ $\boxed{+2}$

$S_2O_3^{2-}$ $\boxed{+2}$

MnO_4^{-1} $\boxed{+7}$

MnO_4^{2-} $\boxed{+6}$

$$\overset{0}{Al} + \overset{3+}{Fe_2}\overset{2-}{O_3} \longrightarrow \overset{3+}{Al_2}\overset{2-}{O_3} + \overset{0}{Fe}$$

Oxidation: $Al \longrightarrow Al^{3+}$

reduction: $Fe^{3+} \longrightarrow Fe$

$$\overset{+7}{Mn}\overset{-2}{O_4^{-1}} + \overset{2+}{Fe^{2+}} + \overset{+1}{H^{+}} \longrightarrow \overset{2+}{Mn^{2+}} + \overset{3+}{Fe^{3+}} + \overset{+1}{H_2}\overset{2-}{O}$$

oxidation: $Fe^{2+} \longrightarrow Fe^{3+}$

reduction: $Mn^{7+} \longrightarrow Mn^{+2}$

$$\overset{+1}{H_2}\overset{-2}{S} + \overset{0}{Cl_2} \longrightarrow \overset{+1}{H}\overset{-1}{Cl} + \overset{0}{S}$$

oxidation: $S^{-2} \longrightarrow S$

reducsion: $Cl_2 \longrightarrow Cl^{-1}$

$$\overset{2+}{C}\overset{2-}{O} + \overset{2+}{Zn}\overset{2-}{O} \longrightarrow \overset{0}{Zn} + \overset{+4}{C}\overset{2-}{O_2}$$

Oxidation: $C^{2+} \longrightarrow C^{4+}$

reduction: $Zn^{2+} \longrightarrow Zn$

$\overset{+6}{Cr_2}\overset{-2}{O_7}^{2-} + \overset{+2}{Sn^{2+}} + \overset{+1}{H^+} \longrightarrow \overset{+3}{Cr^{3+}} + \overset{+4}{Sn^{4+}} + \overset{+1}{H_2}\overset{-2}{O}$

oxidation : $Sn^{2+} \longrightarrow Sn^{4+}$

reduction : $Cr^{6+} \longrightarrow Cr^{3+}$

$\overset{+1}{Ag}\overset{+5}{N}\overset{-2}{O_3} + \overset{+1}{Na}\overset{-1}{Cl} \longrightarrow \overset{+1}{Ag}\overset{-1}{Cl} + \overset{+1}{Na}\overset{+5}{N}\overset{2-}{O_3}$

Not Redox

$\overset{+1}{H_2}\overset{-1}{O_2} \longrightarrow \overset{+1}{H_2}\overset{-2}{O} + \overset{0}{O_2}$

oxidation : $O^{-1} \longrightarrow O_2$

reduction : $O^{-1} \longrightarrow O^{-2}$

Subject ______ Day ______

Writting half Ionic equation "Balanced"!

Half of oxidation $\rightarrow +\acute{e}$

Half of reduction $+\acute{e} \rightarrow$

1- Balance the atoms

2- Balance the charge by adding é's to the side that has greater charge by the difference.

$$\overset{0}{Al} + \overset{+3}{Fe}\overset{-1}{Cl_3} \rightarrow \overset{+3}{Al}\overset{-1}{Cl_3} + \overset{0}{Fe}$$

oxidation: $Al \rightarrow Al^{3+} + 3\bar{e}$

reduction: $Fe^{3+} + 3\bar{e} \rightarrow Fe$

Overall reaction: $Al + Fe^{3+} \rightarrow Al^{3+} + Fe$

$\overset{0}{Al} + \overset{+1}{HCl} \longrightarrow \overset{3+}{Al}\overset{1-}{Cl_3} + \overset{0}{H_2}$

oxidation; $2Al \longrightarrow 2Al^{3+} + \overset{6}{3}é\,)\times 2$

reduction; $6\,2H^+ + \overset{6}{2}è \longrightarrow 3H_2\,)\times 3$

overall $2\,Al + 6H^+ \longrightarrow 2Al^{3+} + 3H_2$

$H^+ + \overset{+7}{Mn}\overset{+2}{O_4^-} + \overset{+2}{Fe^{2+}} \longrightarrow \overset{+2}{Mn^{2+}} + \overset{+3}{Fe^{3+}} + H_2O$

Half of oxidation; $5Fe^{2+} \longrightarrow 5Fe^{3+} + \overset{5}{1}é\,)\times$

Half of reduction; $Mn^{7+} + 5é \longrightarrow Mn^{2+}$

overall $5Fe^{2+} + Mn^{7+} \longrightarrow 5Fe^{3+} + Mn^{2+}$

$\overset{2+}{C}\overset{2-}{O} + \overset{3+}{Fe_2}\overset{2-}{O_3} \longrightarrow \overset{4+}{C}\overset{2-}{O_2} + \overset{0}{Fe}$

H.O.O $\quad 3C^{2+} \longrightarrow 3C^{4+} + \overset{6}{\cancel{2}}e^-) \times 3$

H.O.R $\quad 2Fe^{3+} + \overset{6}{\cancel{3}}e^- \longrightarrow 2Fe) \times 2$

$3C^{2+} + 2Fe^{3+} \longrightarrow 3C^{4+} + 2Fe$

OiL RiG

oxidation is lose

Reduction is Gain

To Identify which species oxidise or reduce

oxidation state

↑ oxidation

↓ reduction

To define the oxidation and reduction

OiL RiG

oxidising ad reducing agents:-

oxidising agent: The substance that itself reduced and causes the other substance to be oxidise
oxidant

reducing agent: The substance that itself oxidised and causes the other substance to be reduced.

$$\overset{0}{Al} + Fe_2O_3 \rightarrow \overset{3+}{Al}_2O_3 + Fe$$

oxidation Al reduction Fe^{3+}

reductant Al oxidant Fe_2O_3

To mention the agent if it is an ion in a compound you must mention the compound itself.

$\overset{2+}{C}\overset{2-}{O} + \overset{2+}{Zn}\overset{2-}{O} \rightarrow \overset{4+}{C}\overset{2-}{O_2} + \overset{0}{Zn}$

oxidation C^{2+} reduction Zn^{2+}

reducing agent CO oxidising agent ZnO

Most Common oxidising agent:-

① Oxygen;

$4é + O_2 \longrightarrow 2O^{2-}$

$\overset{0}{Fe} + \overset{0}{O_2} \longrightarrow \overset{3+}{Fe_2}\overset{2-}{O_3}$

$\overset{0}{S} + O_2 \longrightarrow \overset{4+}{S}O_2$

② Acidify Potassium manganate $KMnO_4$

$MnO_4^{-1} \longrightarrow Mn^{2+}$

Purple Colorless

③ Acidify Potassium dichromate K_2Cr_2O7

$\overset{+6}{Cr_2O7}^{-2} \longrightarrow \overset{+3}{Cr}^{3+}$

orange green

④ Halogens → Halides

$2\acute{e} + Cl_2 \longrightarrow 2Cl^-$

yellow green colorless

$2\acute{e} + Br_2 \longrightarrow 2Br^-$

brown Colorless

$2\acute{e} + I_2 \longrightarrow 2I^-$

brown solution colorless

black solid

purple gas

* Most common reducing agent :-

① Hydrogen:

$$H_2 \rightarrow 2H^+ + 2\acute{e}$$

$$\overset{0}{H_2} + \overset{2+}{Cu}\overset{2-}{O} \rightarrow \overset{0}{Cu} + \overset{1+}{H_2}\overset{2-}{O}$$

reducing agent

② Carbon and carbon monoxide

$$\overset{2+}{C}O + \overset{2+}{Zn}O \rightarrow \overset{0}{Zn} + \overset{4+}{C}O_2$$

reducing agent

$$C + \overset{+3}{Fe_2}O_3 \rightarrow \overset{0}{Fe} + CO$$

reducing agent.

③

- more reactive metal
- more able to lose e's
- more able to oxidise
- more able to be reducing agens.

$K \rightarrow K^{+1} + 1\acute{e}$ strongest reducing agent

$Na \rightarrow Na^{+1} + 1\acute{e}$

$Li \rightarrow Li^{+1} + 1\acute{e}$

$Ca \rightarrow Ca^{2+} + 2\acute{e}$

$Mg \rightarrow Mg^{2+} + 2\acute{e}$

$Al \rightarrow Al^{3+} + 3\acute{e}$

C, CO

$Zn \rightarrow Zn^{2+} + 2\acute{e}$

$Fe \rightarrow Fe^{3+} + 3\acute{e}$

$Pb \rightarrow Pb^{2+} + 2\acute{e}$

H

$Cu \quad Cu^{2+} + 2\acute{e}$

$Ag \rightarrow$ weakest reducing agent

$Ag^{+1} + 1\acute{e}$ → strongest oxidising agent.

* The less reactive Ion is more likely to reduce.
" to be an oxidising agent"

* The more reactive metal is more likely to oxidise.
" to be a reducing agent"

④ Potassium Iodide

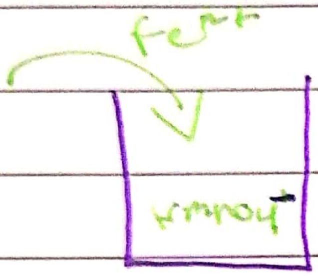
$$2I^-_{(aq)} \longrightarrow I_2 + 2e^-$$

colorless red brown

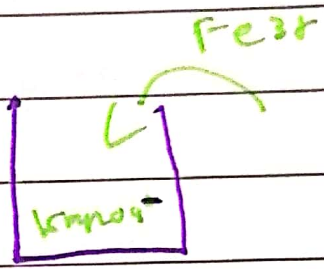
Oxidant	reductant
O_2	H_2
purple → colorless $KMnO_4/H^+$	C, CO
orage → green K_2CrO_7/H^+	metals
Halogens	Potassium Iodide

Q Fe^{2+} is a reducing agent
Fe^{3+} is an oxidising agent

write the observation in each of the followings

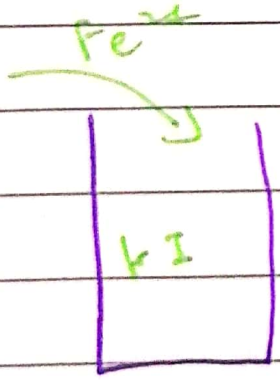


from purple
to colorless

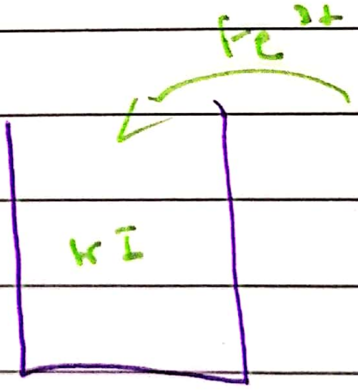


Stays Purple

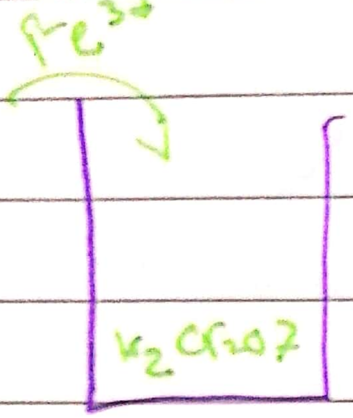
$MnO_4^{-1} \Rightarrow Mn^{+2}$
$(+7) \longrightarrow (+2)$



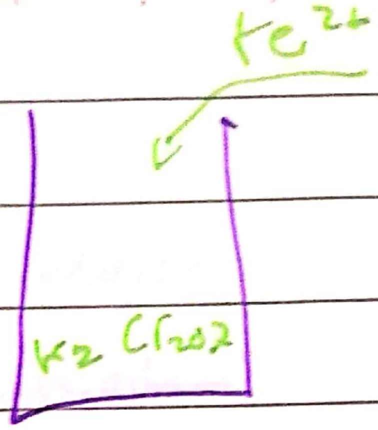
stays the
same



becomes
red brown



stay orange



from orange to green

Electrolysis

electricity

Analysis "Breaking down"

Electrolysis: Breaking down Ionic compounds "molten or ageous" by passing electricity.

Electrolyte: Chemical compound that conduct electricity when "molten or ageous"

Q1 why the solid Ionic compounds don't conduct electricity.

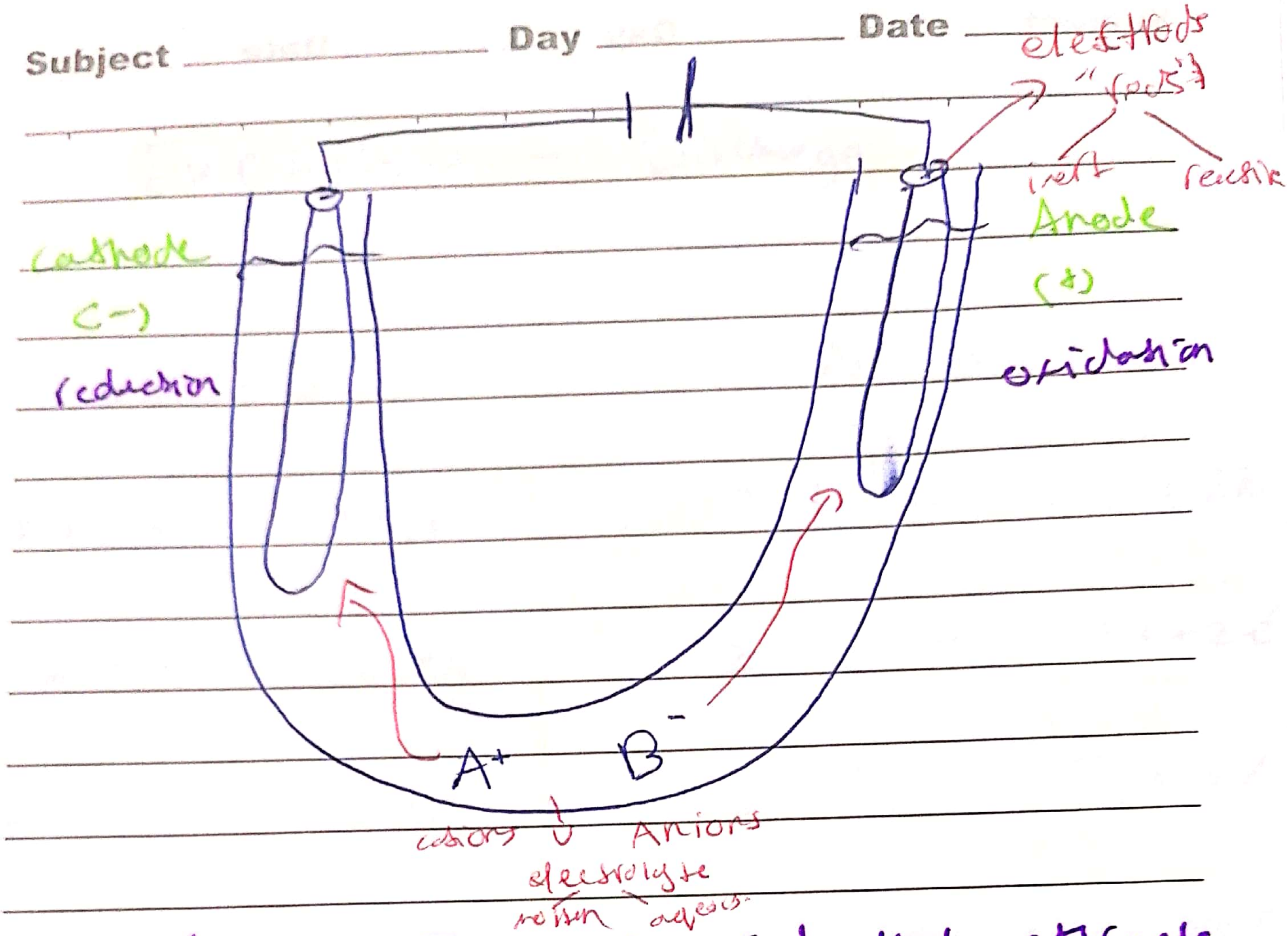
The Ions are not free to move

why the Ionic compounds conducts electricity when molten

The Ions are free to move

$NaCl_{(s)} \xrightarrow{Heat} Na^{+}_{(l)} + Cl^{-1}_{(l)}$

$NaCl_{(s)} \xrightarrow{H_2O} Na^{+}_{(aq)} + Cl^{-}_{(aq)}$



Cathode: The -ve rod that attracts +ve ions (cations) where the reduction takes place.

Anode: The +ve rod that attracts -ve ions (Anions) where the oxidation takes place.

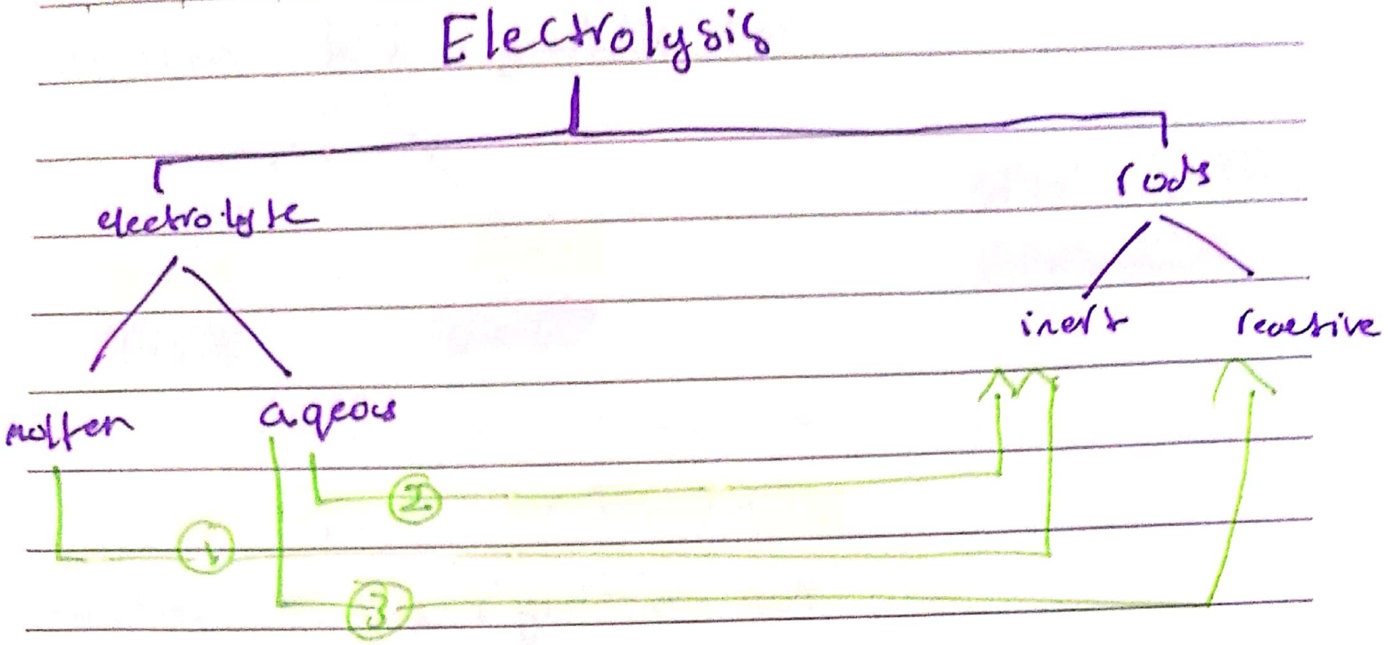
Electrolysis = Discharge

Cations	Anions
$1\acute{e} + Na^{+} \longrightarrow Na$	$2Cl^{-1} \longrightarrow Cl_2 + 2\acute{e}$ green yellow gas
$2\acute{e} + Mg^{2+} \longrightarrow Mg$	$2Br^{-1} \longrightarrow Br_2 + 2\acute{e}$ red brown liquid
$3\acute{e} + Al^{3+} \longrightarrow Al$	$2F^{-1} \longrightarrow F_2 + 2\acute{e}$ bubbles of yellow gas
$2\acute{e} + Cu^{2+} \longrightarrow Cu$	$2I^{-1} \longrightarrow I_2 + 2\acute{e}$ black solid purple gas
$2\acute{e} + H^{+} \longrightarrow H_2$ bubbles	$2O^{2-} \longrightarrow O_2 + 4\acute{e}$ colorless gas

deposite of metal

$A^{+} + 1\grave{e} \longrightarrow \underline{A}$

$2B^{-} \longrightarrow B_2 + 2\acute{e}$



Molten using inert rods.

* Electrolysis for molten NaCl using graphite.

$NaCl_{(l)}$

[illegible] ions

Na^{+1}

Cl^{-1}

Cathode

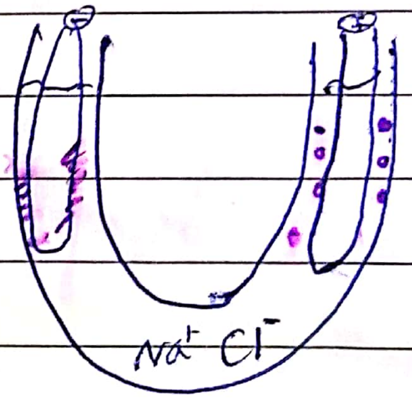
Anode

$1e^- + Na^+ \rightarrow Na$

$2Cl^- \rightarrow Cl_2 + 2e^-$

deposite of metal

bubbles of green yellow gas.



Electrolytic setup

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Molten KI / graphite rods

K^{+1} I^{-1}

Cathode Anode

electrolyte: used up

$K^{+} + 1\acute{e} \rightarrow K$ $2I^{-} \rightarrow I_2 + 2\acute{e}$

deposit of metal purple gas

Molten Al_2O_3 / graphite rods

Al^{3+} O^{2-}

Cathode anode

$Al^{3+} + 3\acute{e} \rightarrow Al$ $2O^{2-} \rightarrow O_2 + 4\acute{e}$

deposite of metal bubbles of colorless gas / relight the glowing split.

electrolyte is used up

Molten $CuCl_2$ / graphite rods

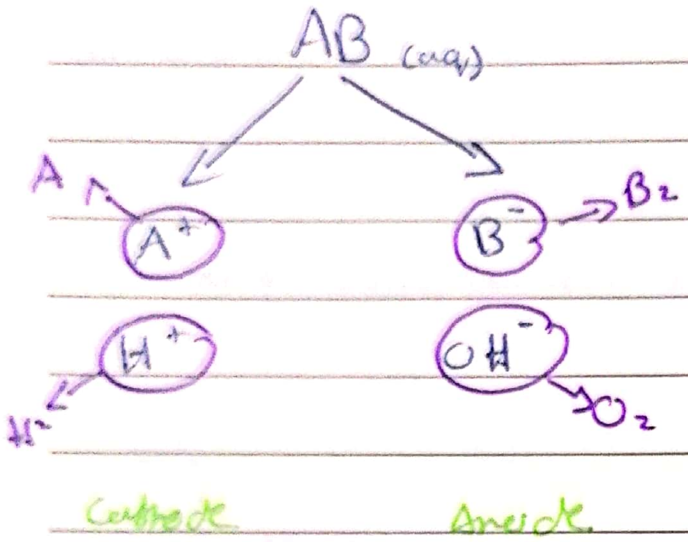
Cathode Cu^{2+} Cl^{-1} Anode

$Cu^{2+} + 2\acute{e} \rightarrow Cu$ $2Cl \rightarrow Cl_2 + 2\acute{e}$

deposite of metal bubbles of green yellow gas / bleach damp litmus paper

electrolyte: used up

Electrolysis for aqeous electrolyte using [redacted] graphite



At cathode :

The less reactive [redacted] [redacted] ion is more likely to reduce:

K^{+1}
Na^{+1}
Li^{+1}
Ca^{+1}
Mg^{+1}
Al^{+3}
Zn^{+2}
Fe^{3+}
Pb^{2+}

H
Cu^{2+}
Ag^{+1}
Au^{+3}
Pt^{+2}

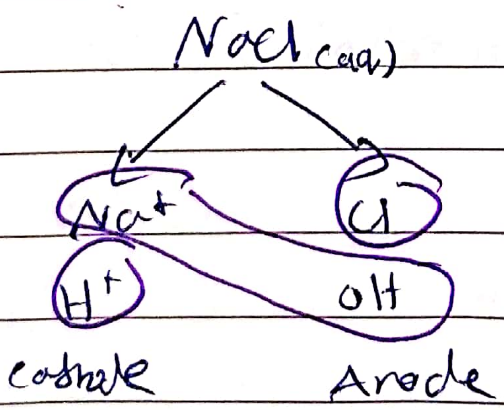
At Anode:

only concentrated halides are more likely to oxidise.

if not concentrated halide the OH^- will oxidise

$$\boxed{4OH^- \rightarrow 2H_2O + O_2 + 4e^-}$$

Example: Electrolysis for concentrated aqeous sodium chloride 'Brine'



$2H^+ + 2e^- \rightarrow H_2$

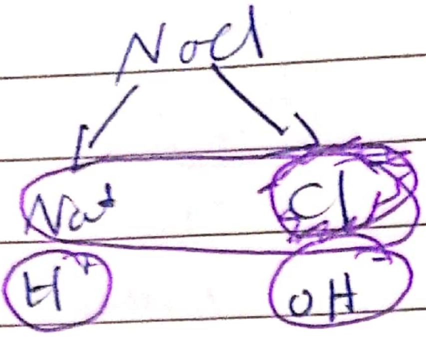
bubbles of colorless gas

$2Cl^- \rightarrow Cl_2 + 2e^-$

bubbles of green yellow gas

Electrolyte: NaOH

dilute NaCl(aq) / graphite



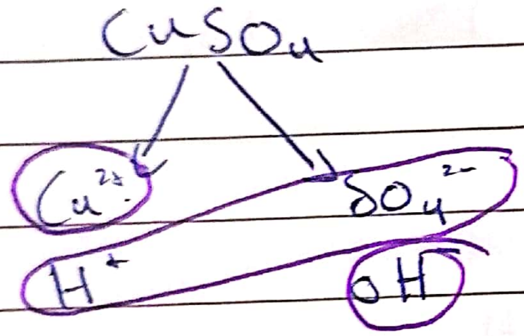
electrolyte : NaCl
more concentrated

cathode　　anode

bubbles of colorless gas　　bubbles of colorless gas

$2H^+ + 2\acute{e} \Rightarrow H_2$　　$4OH^- \rightarrow 2H_2O + O_2 + 4\acute{e}$

CuSO4 (aq) / graphite



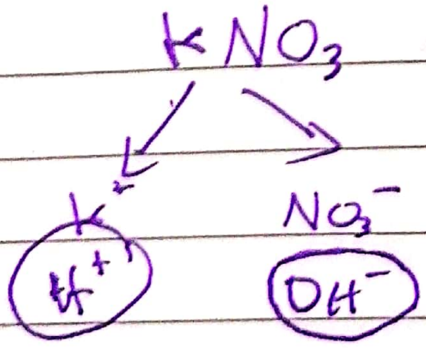
electrolyte: H_2SO_4

cathode　　anode

$2\acute{e} + Cu^{2+} \rightarrow Cu$　　$4OH^- \rightarrow 2H_2O + O_2 + 4\acute{e}$

red brown deposit of metal　　bubbles of colorless gas.

[redacted] KNO_3 (aq) / graphite



electrolyte: KNO_3
more concentrated

$4OH^- \rightarrow 2H_2O + O_2 + 4\acute{e}$
bubbles of colorless gas.

$2H^+ + 2\acute{e} \Rightarrow H_2$
bubbles of colorless

concentrated $CuCl_2(aq)$ / graphite

Cu^{2+} Cl^-

H^+ OH^-

cathode anode

$Cu^{2+} + 2e^- \rightarrow Cu$ $2Cl^- \rightarrow Cl_2 + 2e^-$

deposite of red brown metal. bubbles of green yellow gas.

electrolyte : less concentrated.

concentrated [illegible] $NaBr(aq)$ / graphite.

Na^+ Br^-

H^+ OH^-

Cathode Anode

$2H^+ + 2e^- \rightarrow H_2$ $2Br^- \rightarrow Br_2 + 2e^-$

red brown solution

electrolyte: NaOH.

Electrolysis of Brine solution $NaCl_{(aq)}$ concentrated

$NaCl_{(aq)}$

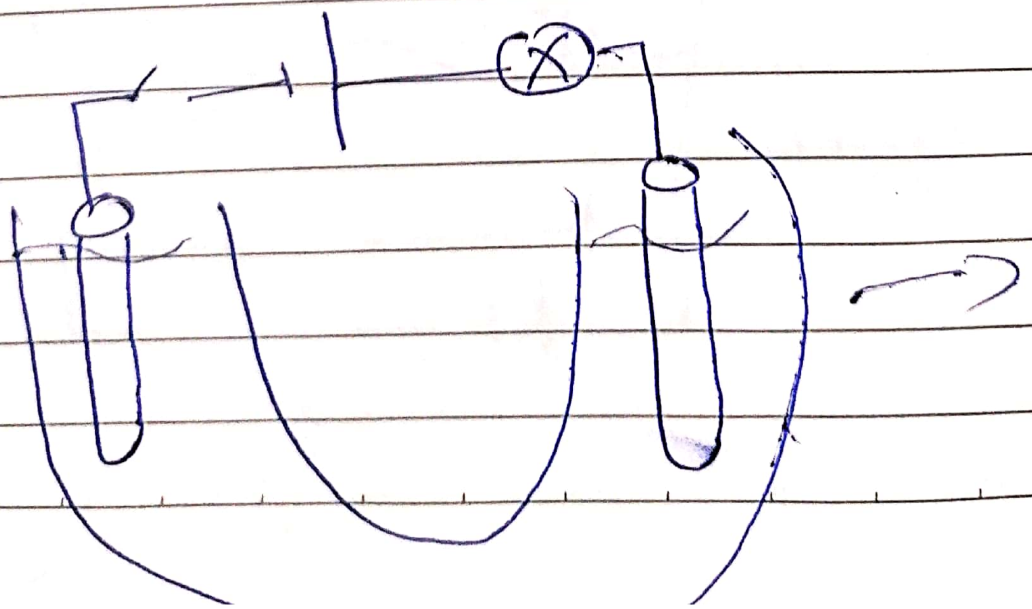
Na^+ Cl^-

H^+ OH^-

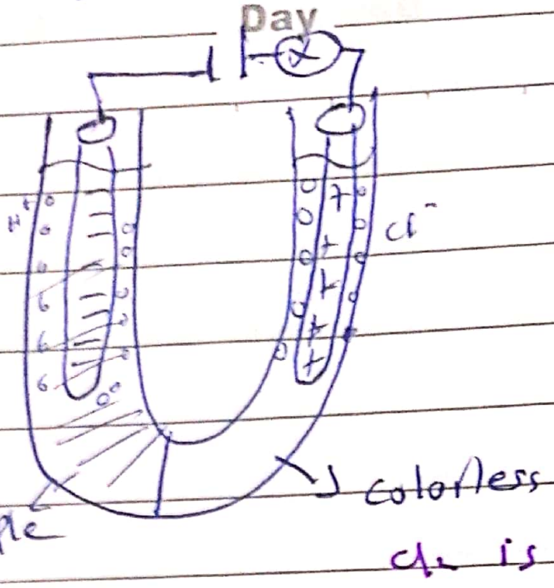
cathode:	Anode
$2H^+ + 2e^- \rightarrow H_2$	$2Cl^- \rightarrow Cl_2 + 2e^-$
bubbles of colorless gas	bubbles of green yellow gas

electrolyte: NaOH

Brine + universal indicator



Brine + universal indicator



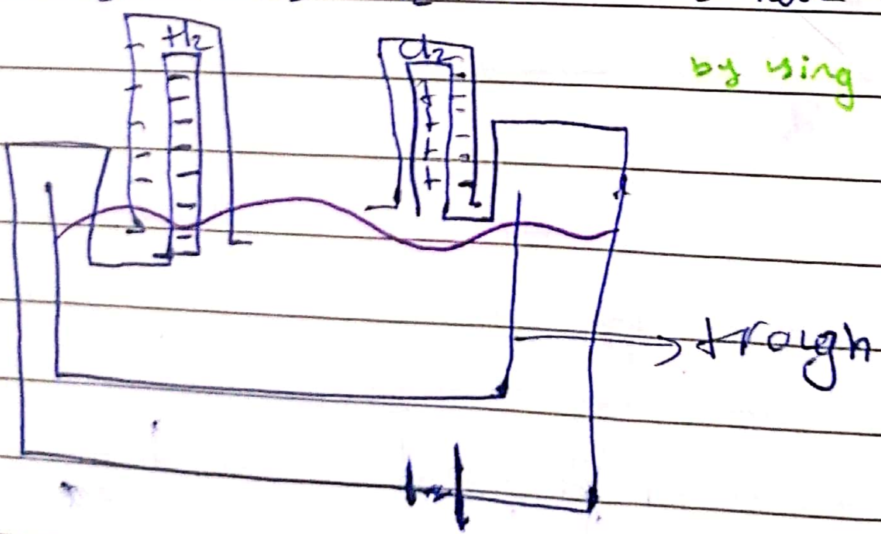
NaOH is a alkali

Cl_2 is a bleaching agent.

Cl_2 delay in its appearence. some Cl_2 reacts with NaOH.

How to collect and measure their volume, the two gases H_2 - Cl_2 on the cathode and anode;

by using inverted measuring.



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H_2SO_4

H^+ SO_4^{-2}

H^+ OH^-

cathode anode

$2H^+ + 2\acute{e} \rightarrow H_2$ $4OH^- \rightarrow 2H_2O + O_2 + \boxed{4\acute{e}}$

$4H^+ + 4\acute{e} \rightarrow 2H_2$

$4OH^- \rightarrow 2H_2O + O_2 + 4\acute{e}$

$4H^+ + 4OH^- \rightarrow 2H_2O + \underline{2H_2} + \underline{O_2}$

2 : 1

Electrolysis for aqueous electrolyte using active rod.

* The active rod made from the same metal ion in the electrolyte.

$CuSO_{4(aq)} \xrightarrow{using} Cu$ rod

$AgNO_{3(aq)} \xrightarrow{using} Ag$ rod

$CuSO_{4(aq)}$

↙ ↘

Cu^{2+} SO_4^{2-}

H^+ OH^-

Neither the OH^- nor SO_4^{2-} oxidise

The anode itself will oxidise

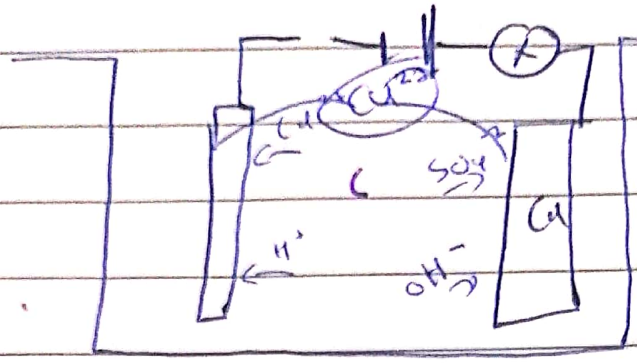
cathode anode

$Cu^{2+} + 2e \rightarrow Cu$

$Cu \rightarrow Cu^{2+} + 2e$

deposite of red brown solid

mass ↑



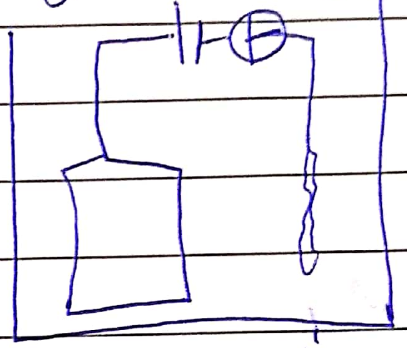
anode oxidise

to cathode through wires

$Cu \rightarrow Cu^{2+} + 2\acute{e}$

$Cu^{2+} + 2\acute{e} \rightarrow Cu$

To cathode through electrolyte



cathode mass ↑
as Cu deposite

Always
* overall:
The electrolyte stays the
same because the anode
oxidise and Replaced the
Cu^{2+} in the electrolyte with
the same rate

Anode:
mass decreases
Cu oxidise and
lose e's

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Applications on electrolysis

- Molten / inert ⇒ Extraction of Al
- aqeous / inert ⇒ Prepare solution
  - conc. $NaCl_{(aq)}$
    - Na^+ , Cl^-
    - H^+ , OH^-
  - NaOH
- aqeous / active ⇒
  - ① electroplating
  - ② Refining / purifying metals.

Electroplating: Coating a metal with another metal using electricity.

why: ① to prevent rusting
② more attractive.

How to electroplate a metal spoon with Ag?

1- Clean the metal spoon from any impurities as oxide layer to ensure a well sticking.

2- Make the metal spoon the cathode

3- The anode must be Ag

4- the electrolyte must has Ag^+ eg $AgNO_3$

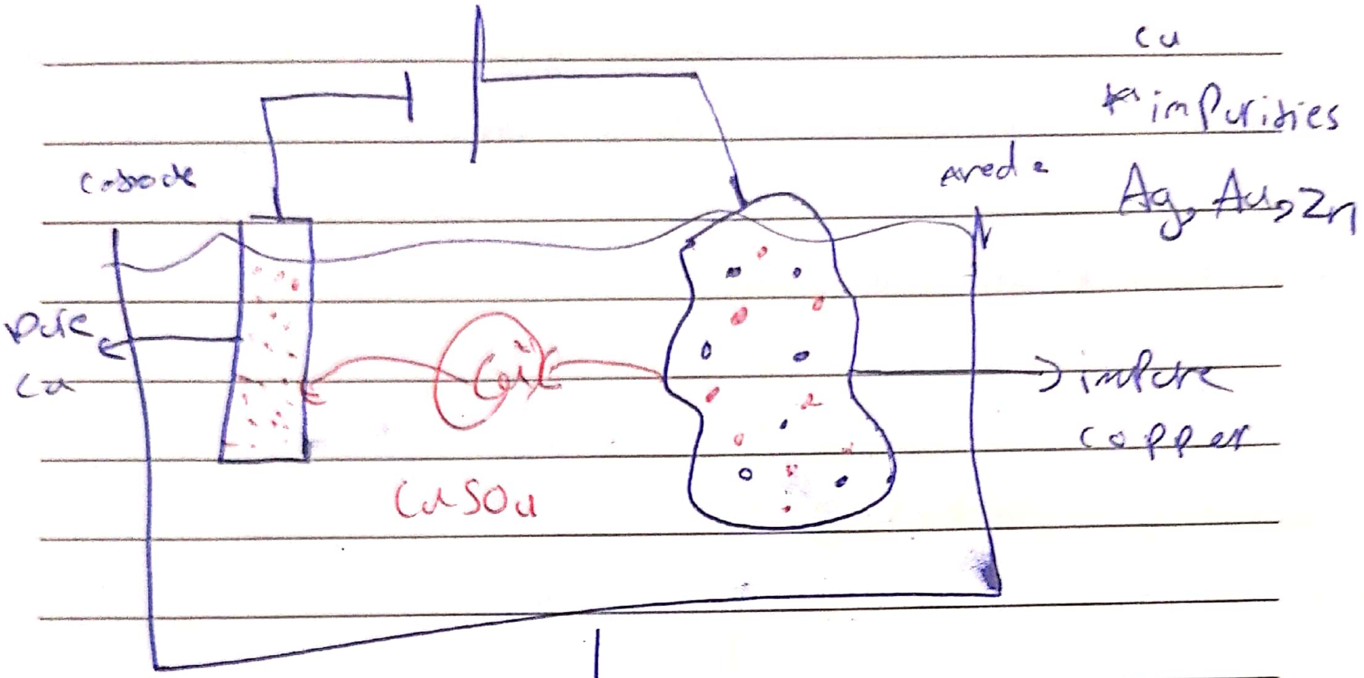
5- switch on the circuit

6- rotate the metal spoon to ensure an equal distribution.

7- rinsed with distilled water.

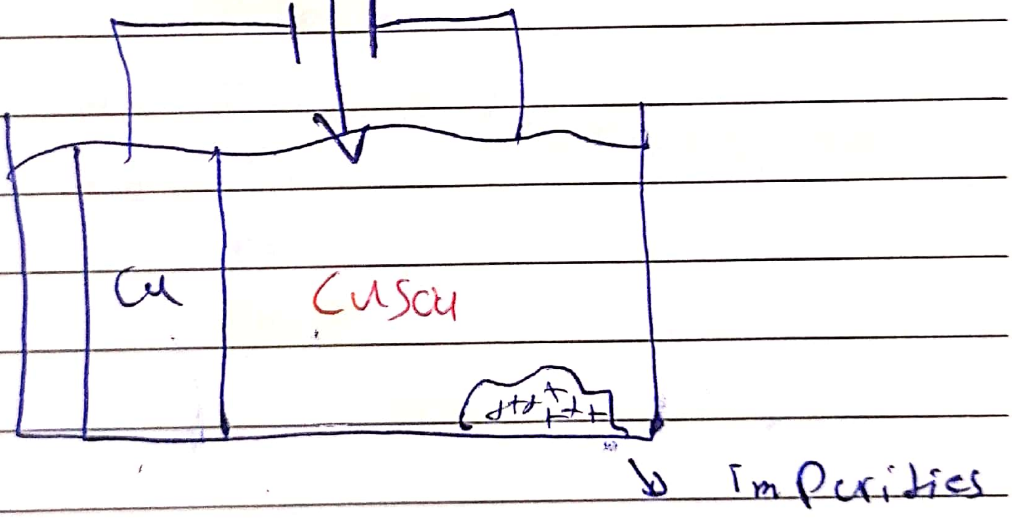
8- dry in oven.

Refining copper / Purifying



$Cu^{2+} + 2e^- \rightarrow Cu$

$Cu \rightarrow Cu^{2+} + 2e^-$



Ag, Au: settle down
They are less reactive than Cu

Zn: displace Cu from $CuSO_4$

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Extraction of metals:

* The methode of extraction the metal from its ore depends on the Position of this metal in the reactivity series.

ore : main rock that the metal comes from.

K
Na
Li
Ca
Mg
Bauxite Al_2O_3 ← Al

] Electrolysis / Molten / gra

C, Co

Zinc blende ZnS ← Zn
Hematite Fe_2O_3 ← Fe

] reduction by C, CO

Pb

H

copper sulfide CuS ← Cu] reduction by H

Ag
Au

Extraction of Al

ore: Bauxite Al_2O_3

method: Electrolysis for molten ore using graphite

* the M.P of Al_2O_3 is 2000°C

So we dissolve Al_2O_3 in molten cryolite Na_3AlF_6, why?

1- to lower the M.P to 900°C so less cost

2- to increase the electrical conductivity

$$\begin{tikzcd}
 & Al_2O_3(l) \arrow[dl] \arrow[dr] & \\
Al^{3+} & & O^{2-}
\end{tikzcd}$$

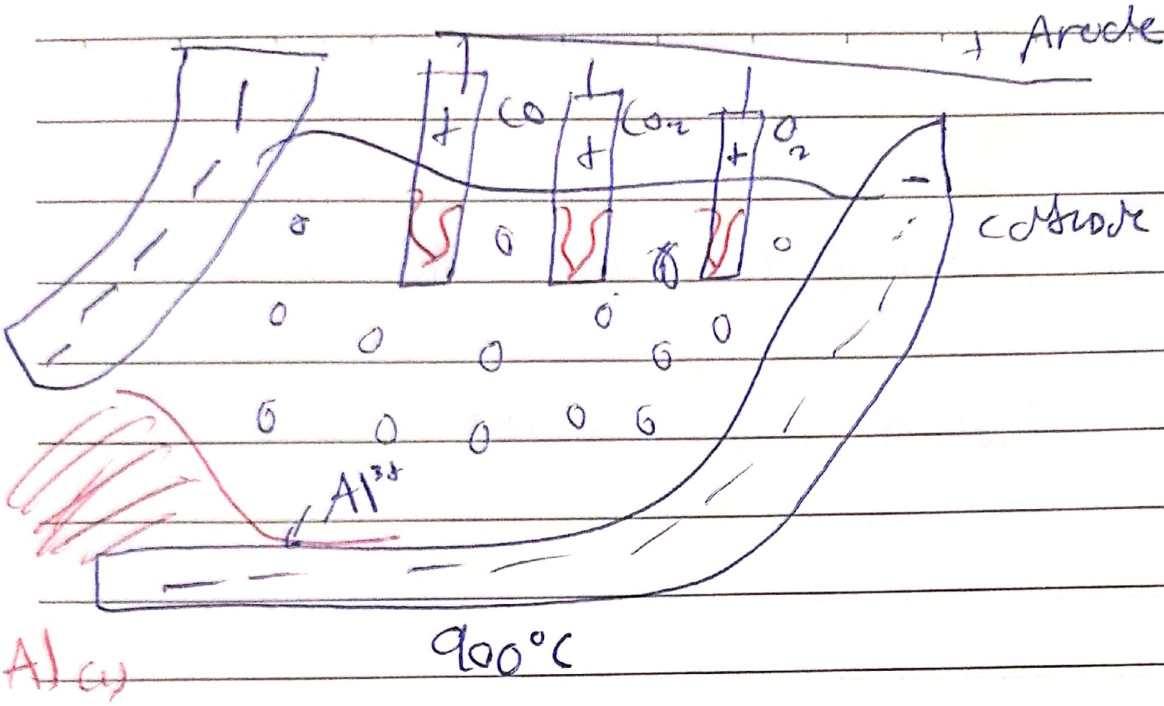
cathode anode

$2O^{2-} \rightarrow O_2 + 4e^-$

bubbles of gas

$Al^{3+} + 3e^- \rightarrow Al$

deposite of metal



gases produced at anode

1- O_2

2 - CO_2

3 - CO

(CO_2 and CO:) reaction of anode with O_2 so we must Replace the Anode Periodically

Property of Al	use of Al
malleable	window frame, cooking utensils
low density	Aircraft bodies
form non toxic oxide layer	food cans
conduct electricity ductile	electrical wire.

Rusting:

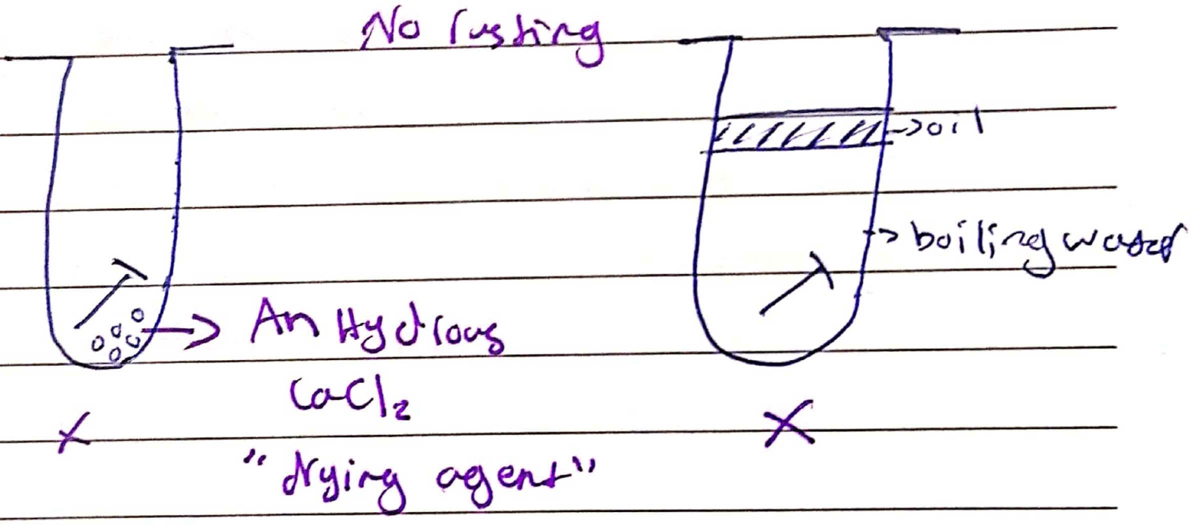
slow reaction

reaction of Iron with both H_2O and O_2

$$\overset{0}{Fe} + O_2 \xrightarrow{H_2O} \overset{+3}{Fe_2}O_3 \cdot nH_2O$$

oxidation

No rusting



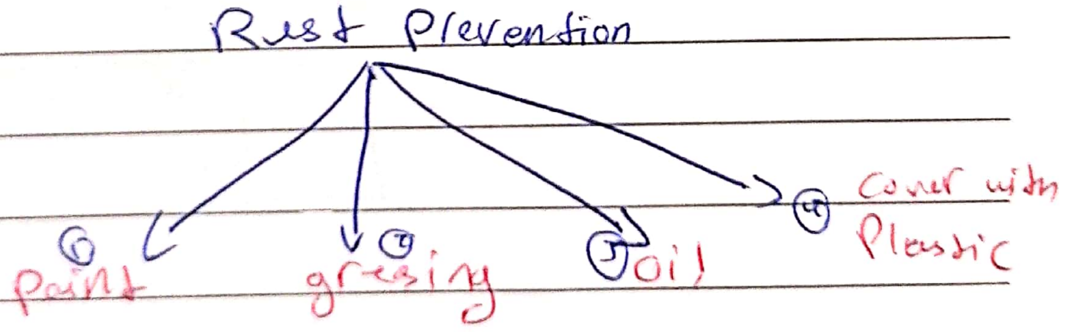
NO H_2O

NO O_2

Two rust Prevension solutions A and B

Plan an exp to show which Brand is better.

- take a known mass of Iron nail
- apply a known volume of solution A
- add them to a known volume of water for 1week
- dry the iron nail
- measure the mass
- repeat the exp using Solution B
- the exp which case less increase in mass is the better solution.



(Prevent H_2O and O_2 from reaching Fe)

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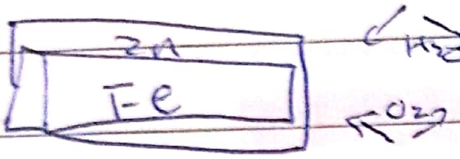
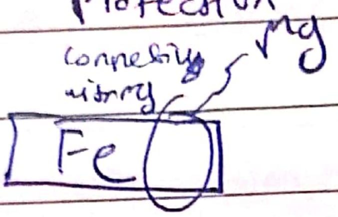
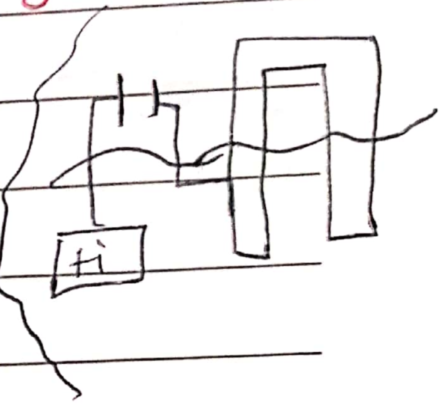
Rust prevention

- Galvanizing
- Sacrificial Protection
- Electro Plating
- Cathodic Protection

Coating with Zn



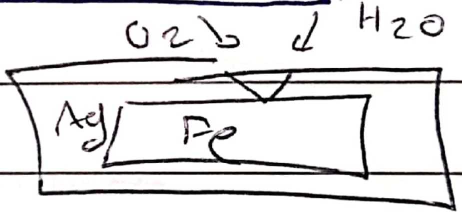


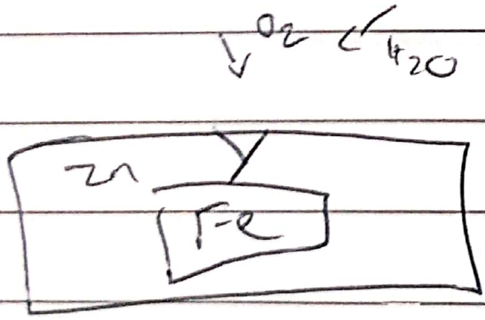


Zn and Mg are more reactive then Fe

They are more likely to oxidise

So Fe is less likely to rust (oxidation)

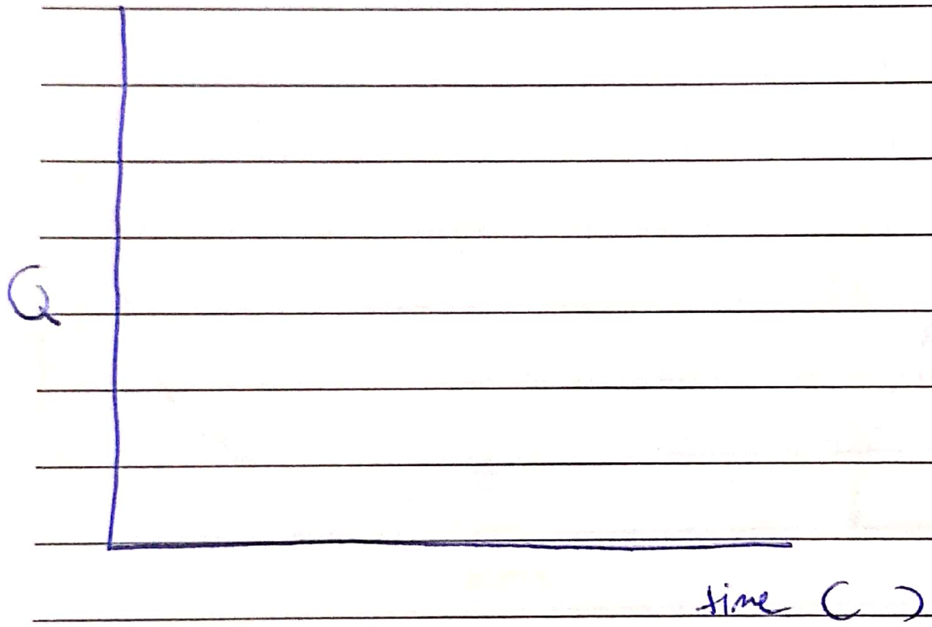




Zn is better.

Rate of Reaction

$$\text{Rate: } \frac{\text{Change in a Quantity}}{\text{change in time}} = \frac{\Delta Q}{\Delta T}$$



$$\frac{\Delta \text{PH}}{\Delta \text{time}} = \frac{1}{s} \qquad \frac{\Delta \text{light intensity}}{\Delta \text{Time}} = \frac{1}{s} \qquad \frac{\Delta \text{temp}}{\Delta \text{time}} = \frac{C^\circ}{s}$$

$$\frac{\Delta \text{volume gas}}{\Delta \text{time}} = \frac{cm^3}{s} \qquad \frac{\Delta \text{Mass}}{\Delta \text{time}} = \frac{g}{s} \qquad \frac{\Delta \text{elec cond.}}{\Delta \text{Time}} = \frac{1}{s}$$

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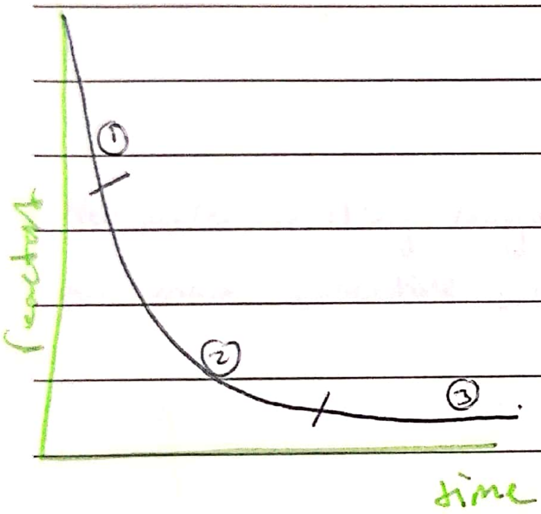
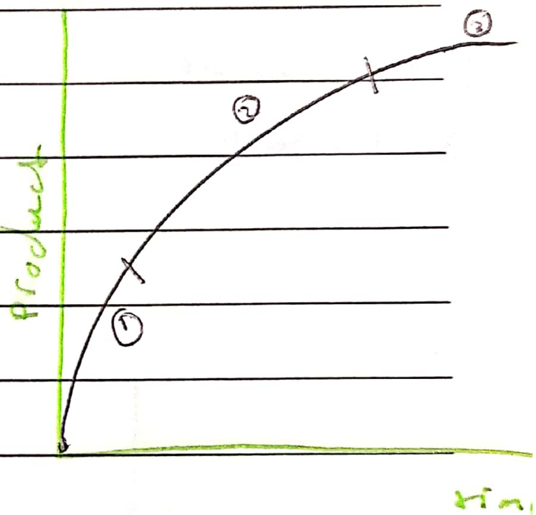
To measure the rate of reaction

measure how fast the reactants consumed per unit time

measure how fast the product produced per unit time





region ①: the rate is the highest → from the curve: steepest, high gradient

more Reactants

so more Particles

so more effective collisions Per unit time.

Region (2). The rate is slower; From the curve; less steep lower gradient.

Less reactants

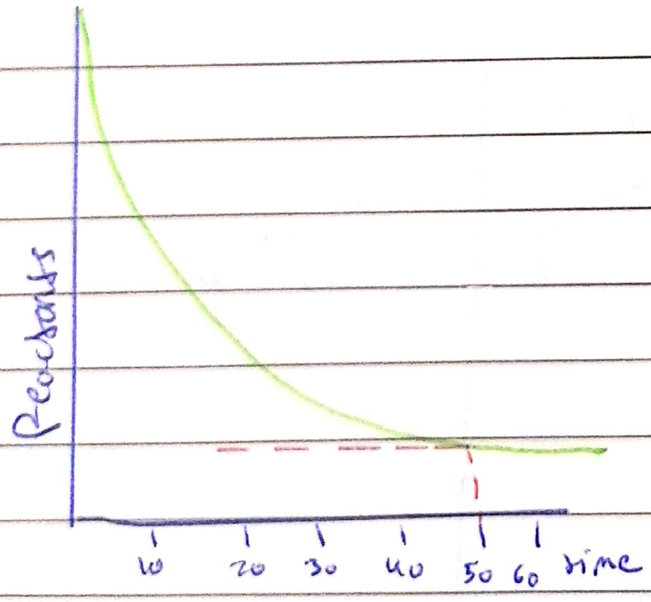
Less Particles

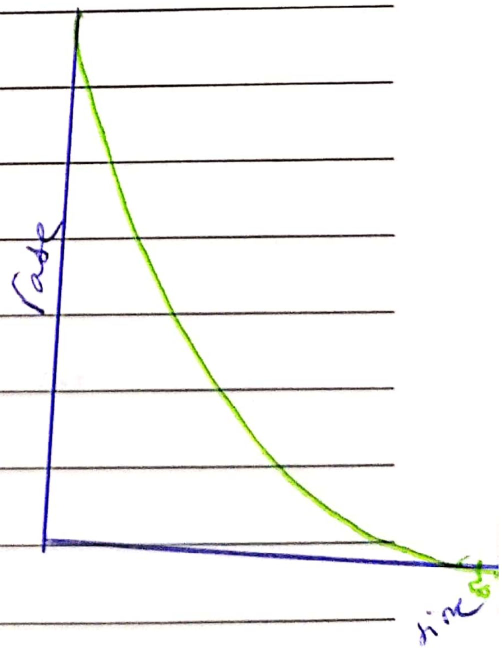
so less effective collisions per unit time

Region (3). The rate is over; From the curve; horizontal line gradient = 0

No more limitting reagent

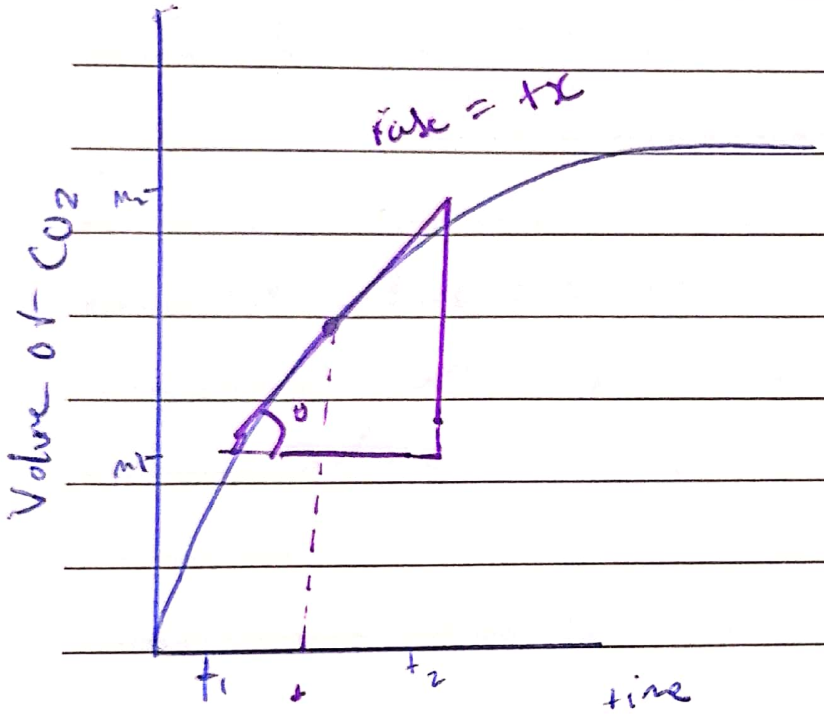
no more effective collisions.

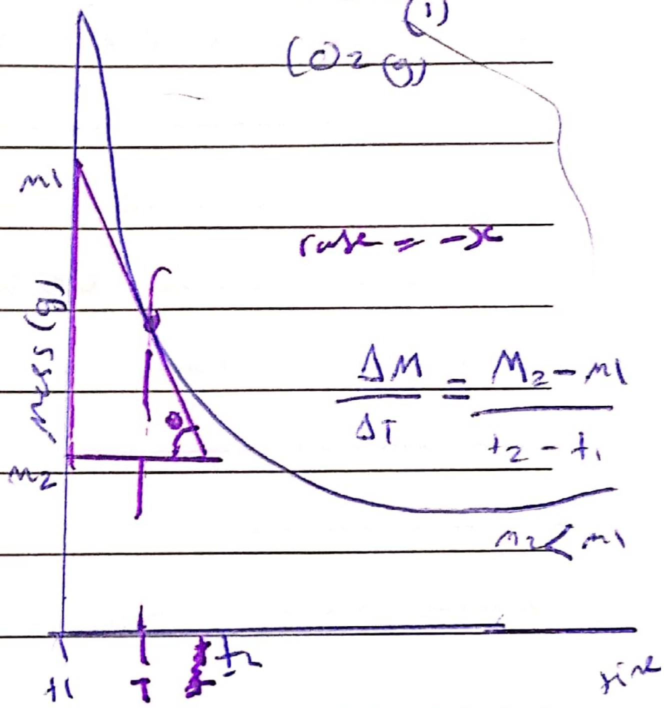




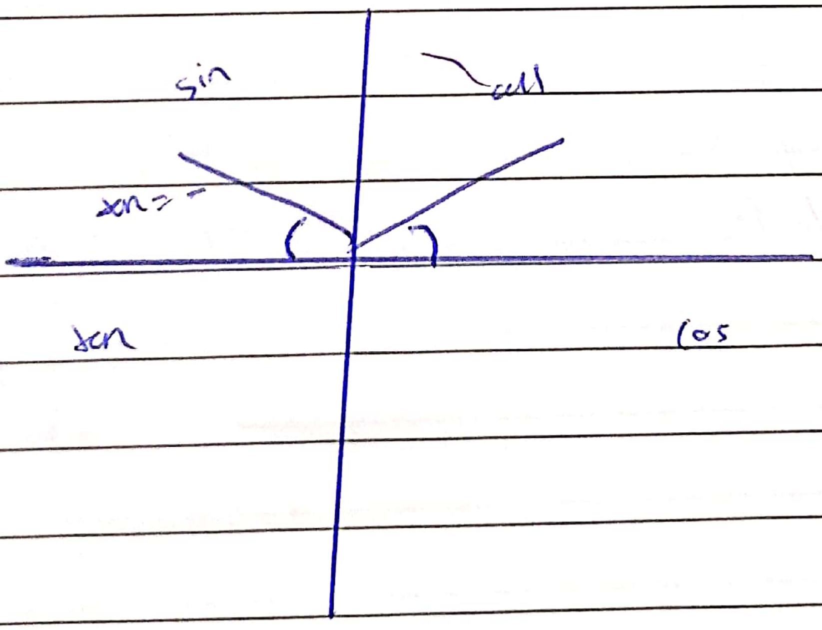
From the graph how to measure the rate:

$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$





$$\frac{\Delta M}{\Delta T} = \frac{M_2 - m_1}{t_2 - t_1}$$

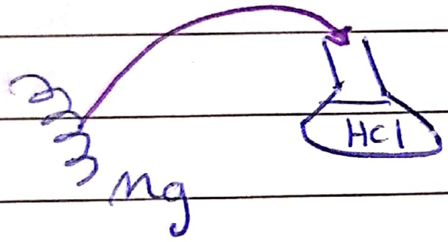


3 main conditions for any chemical reaction;

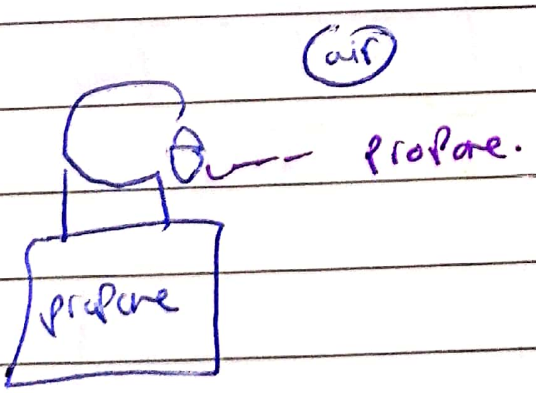
① The reactants must be suitable

$Cu + HCl \rightarrow$ NO reaction

② The reactants must collide



③ The collisions must be effective / The particles have min amount of energy needed to start the reaction.

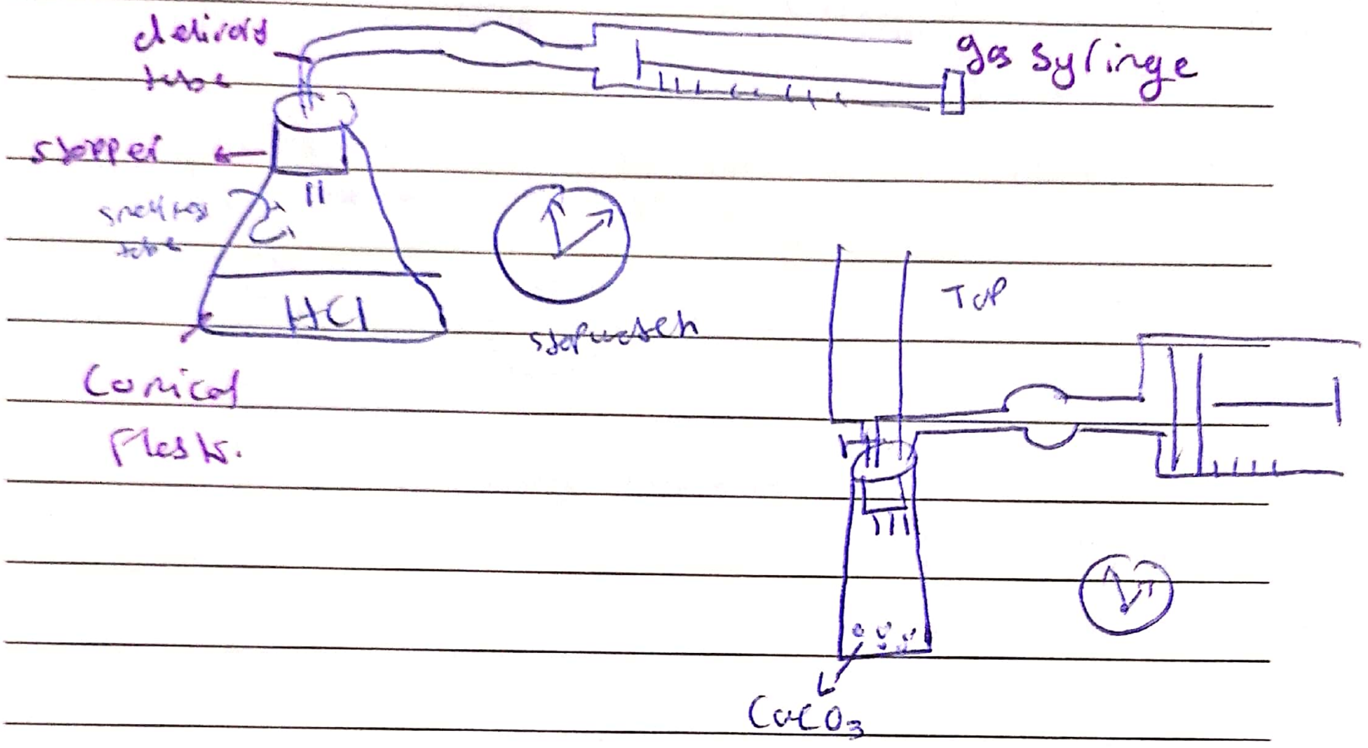


Activation energy

E_a

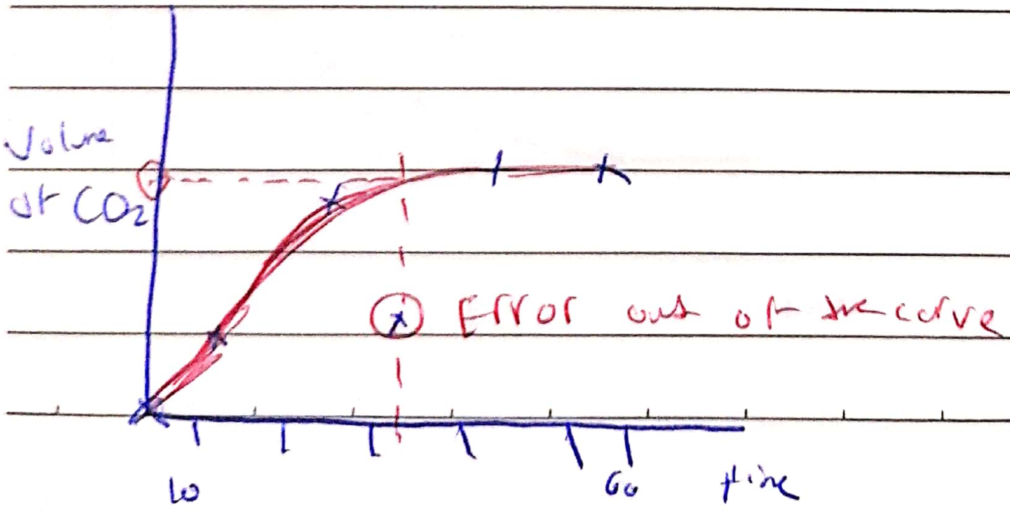
① Measuring the rate by monitoring the volume of gas

$$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$



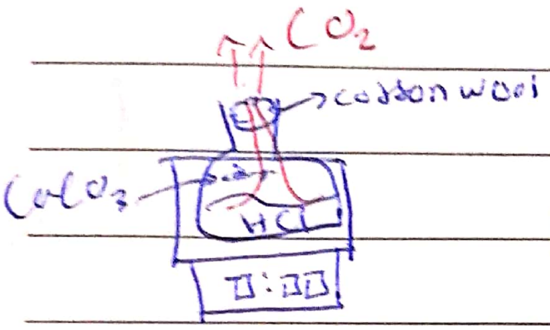
time (s)	10	20	30	40	50	60
volume (cm³)	0	8	13	15	16	16

+8 +5 +2

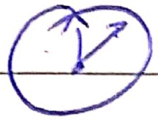


② measuring the rate by monitoring the change in mass of conical flask ~~to~~ contents: per unit time

$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$



To allow CO_2 to escape and prevent splashing

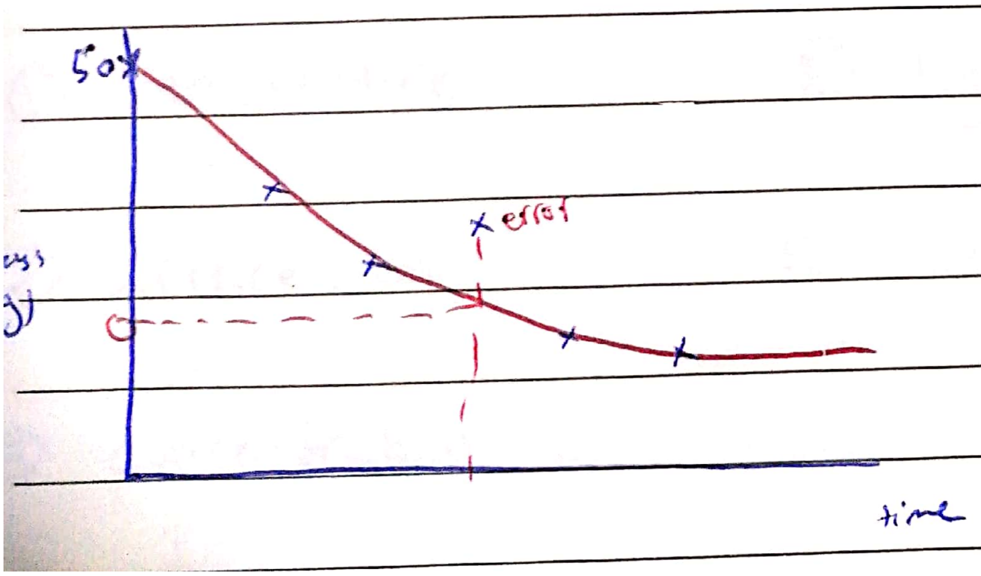


why the mass ↓ ?

CO_2 escape.

time (s)	0	10	20	30	40	50
mass (g)	50	45	42	41	40.5	40.5

-5 -3 -1 -0.5



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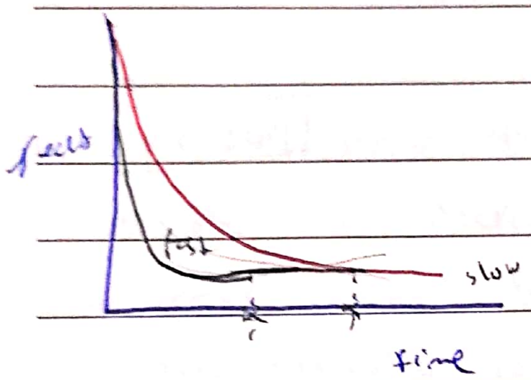
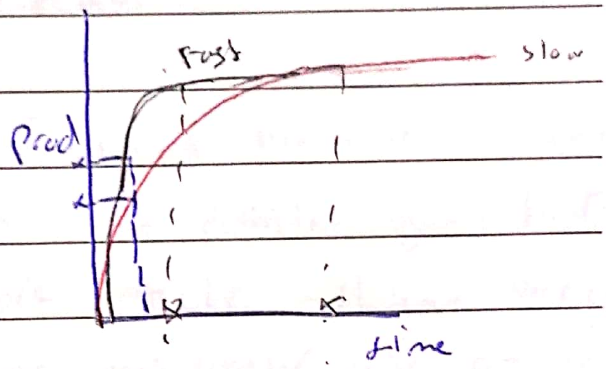
Increase the rate of Reaction

Same Product with less time

or

more Product per the same time.





faster rate = steeper curve.

Factors affect the rate of reaction:

① temperature

② surface area

③ concentration

④ Pressure

⑤ light

⑥ catalyst.

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Temperature:

- State how the temp affect the rate of reaction.

as the temprature increases the rate of reaction increases.

- explain how the temp affects the rate of reaction [5

As the temp increases: the particles gain K.E so move faster. So more particle will have energy ≥ Ea so more effective collisions and faster rate of reaction

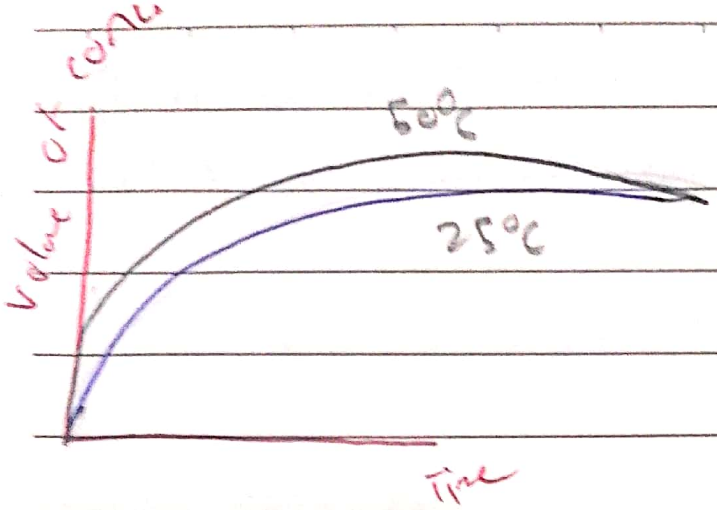
- plan an experiment to show how the temp affect the rate of reaction:

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

Exp1: mass $CaCO_3$ = 2g V = 0.1 dm^3 temp = 25°C
Lumps M = 0.1 mol/dm^3

Volume of CO_2 per unit time:

exp 2: $MCaCO_3$ = 2g V = 0.1 dm^3
Lumps M = 0.1 mol/dm^3
Temp = 50°C



② Surface area;

- state how the surface effect the rate of reaction.

As the surface area increase. by redueing the particle size / crushing using morter and pestile. The rate of reaction increase.

- explain how the surface affect the rate of reaction.

As the surface area increase more particles exposed to the reaction so more effective collision. Per unit time. so faster rate of reaction.

- Plan an exp to show how the surface area affect the rate of reaction:

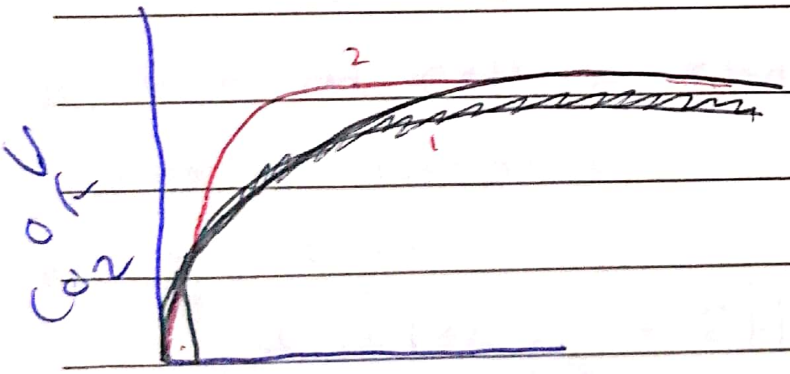
$CaCO_{3(aq)} + 2HCl_{(aq)} \rightarrow CaCl_{(aq)} + H_2O + CO_{2(g)}$

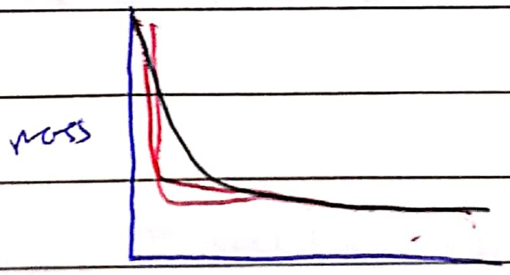
Ex. 1 mass 2g
Lumps.

V HCl : 0.1dm³
m HCl : 1mol/dm³
Temp : 25°C

Ex. 2 mass = 2g
Powder

V HCl : 0.1dm³
M HCl : 1mol/dm³
Temp : 25°C





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③ Concentration : • amount •

* state how the conc. affect the rate of reaction.

As the concentration increases the rate of reaction increase.

* explain how the concentration affect the rate of reaction

As the concentration of Reactants increase more particles.

So more effective collisions per unit time

So faster rate of reaction.

* Plan an exp to show ~~ho~~ ew the conc. affect the rate of reaction ?

need 0.005 0.04 N = 0.005

add 0.02 0.01

$CaCO_{3(aq)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O + CO_{2(g)}$

excess V = 0.12

Exp. mass V HCl = 0.1 dm³

2.0 g M HCl = 0.1 mol / dm³

Lumps Temp 25°C

Ex 2 mass V HCl = 0.1 dm³

2.0 g M HCl = 0.2 mol / dm³

Lumps

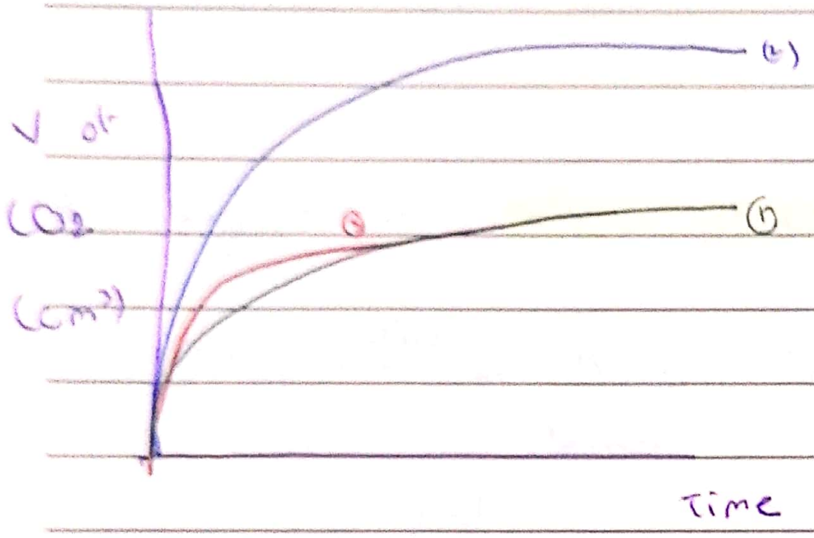
Temp = 25°C

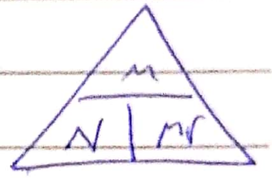
Exp3 mass 4.0g lumps

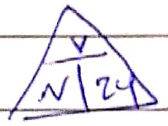
V HCl = 0.1dm³

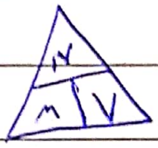
M HCl = 0.1 mol / dm³

Temp = 25 °C









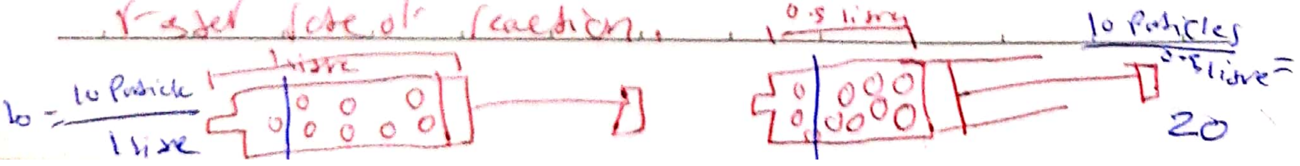
4) Pressure "only for gases"

Explain how the pressure affect the rate of reaction:

As the pressure increase (by lowering the volume) more particles per unit volume.

So more effective collisions per unit time

faster rate of reaction.



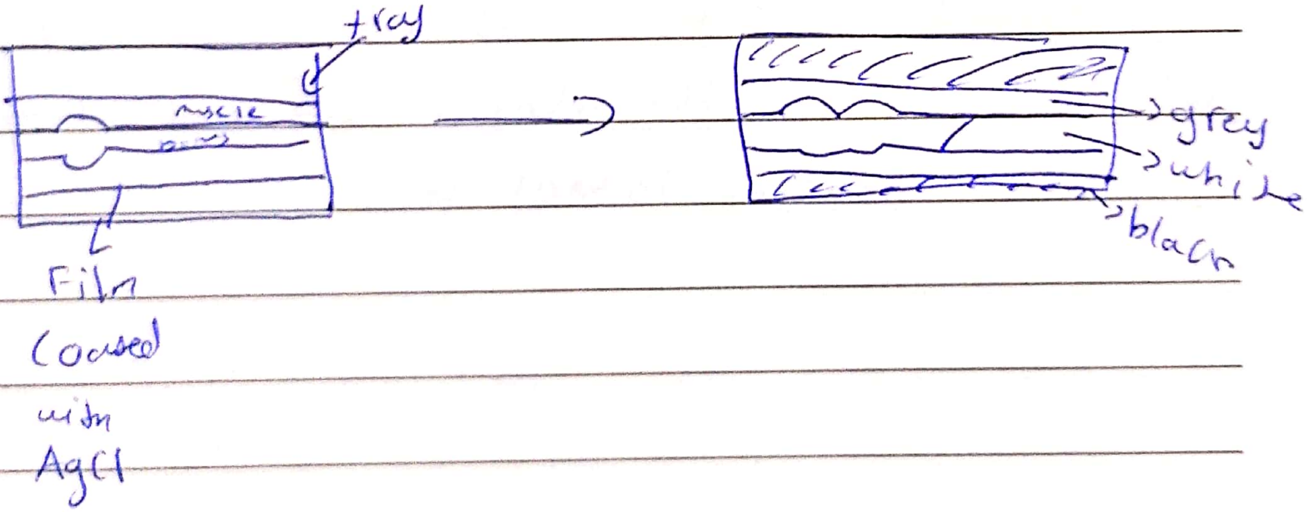
5) light "for photo chemical reaction)

photosynthesis:

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyl}]{\text{light}} C_6H_{12}O_2 + 6O_2$$

* Photographic films "out of syllabus"

$$AgCl_{(s)} \xrightarrow{\text{light}} \underset{\text{black}}{Ag_{(s)}} + Cl_{2(g)}$$



6) Catalyst: Chemical substance that speeds up the rate of reaction without being used up.

Enzyme: biological catalyst

How?

It Provides an alternative Pathway with lower EA so more Particles will have energy equal to or greater than Ea. So more effective collisions per unit time. So faster rate of reaction.

EA: min amount of energy needed to start the Rxn

↑ Ea slower rate

↓ Ea faster rate.

$$H_2O_2 \xrightarrow[MnO_2]{CuO\ or} 2H_2O + O_2$$

Q, Plan an exp to show that CuO is a catalyst for this Rxn:

* known volume of known conc. of H_2O_2
* add a known mass of CuO
* measure the volume of O_2 per unit time
* repeat the exp without CuO
* conc. the exp with CuO produce more O_2 per the same unit time.

Q2: Plan one exp to show which Catalyst is better CuO or MnO$_2$.

* known volume of known conc. of H_2O_2

* add known mass of CuO

* add known mass of O_2 per unit time

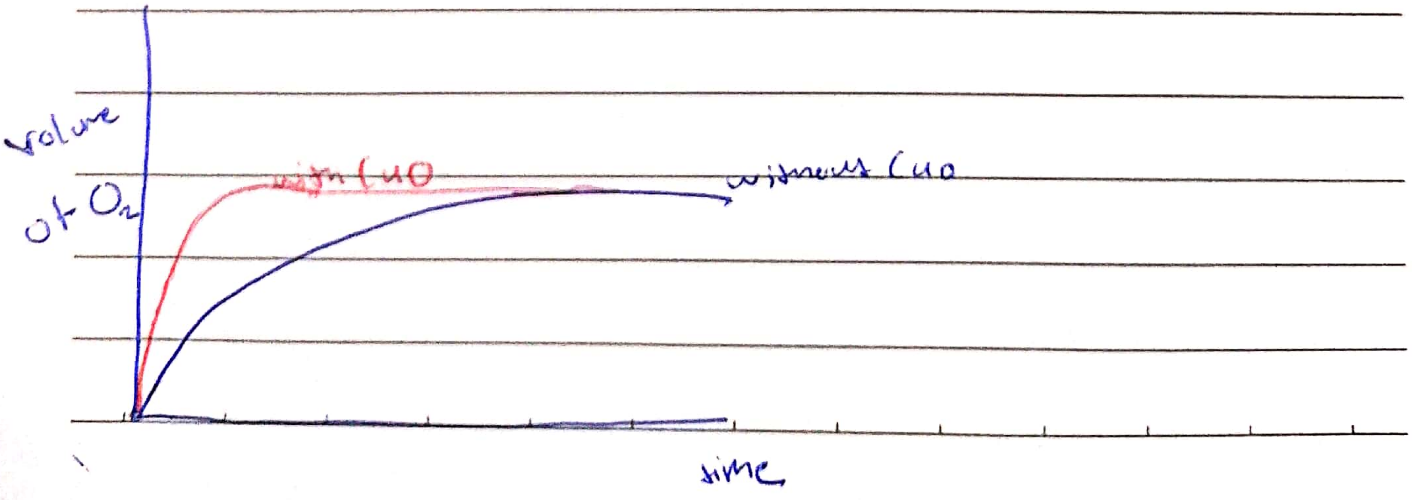
* Repeat with MnO$_2$ (same mass)

conc. the exp that produce more O_2 per the same unit time is the better catalyst.

Q3: Plan an exp to show that the CuO not used up during the reaction.

- add a known mass of CuO to H_2O_2 until no more bubbles of O_2
- Filter the mixture
- dry in oven
- re measure the mass

conc. the mass will not change.



Reversible Reactions

Chemical reactions:

one way

forward

reactors → Products

both ways

forward →

← backward

$Mg + HCl \rightarrow MgCl + H^2$

$CaCO_3 + HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$

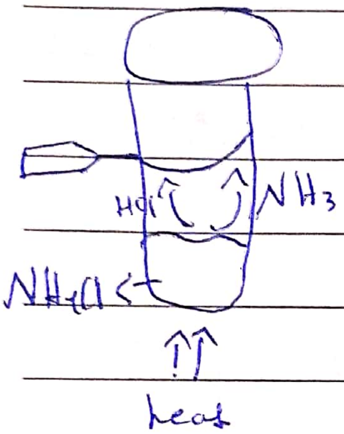
$3H_2 + N_2 \rightleftharpoons 2NH_3$

$2SO_2 + O_2 \rightleftharpoons 2SO_3$

$NH_4Cl \rightleftharpoons NH_3 + HCl$

$NH_4Cl_{(s)} \xrightarrow{heat} NH_{3(g)} + HCl_{(g)}$

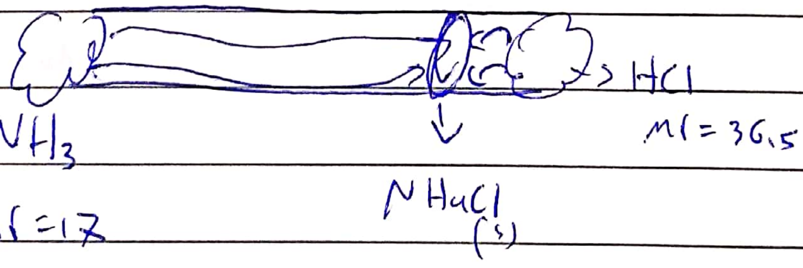
Ammonium Chloride → Ammonia + Hydrogen Chloride



Q:- which damp litmus paper will change its color first explain your answer?

The damp red litmus paper change its color to blue first becose $NH_{3(g)}$ is Alkali and lighter than ~~NH3~~ $HCl_{(g)}$ which is acidic.

$NH_{3(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(s)}$



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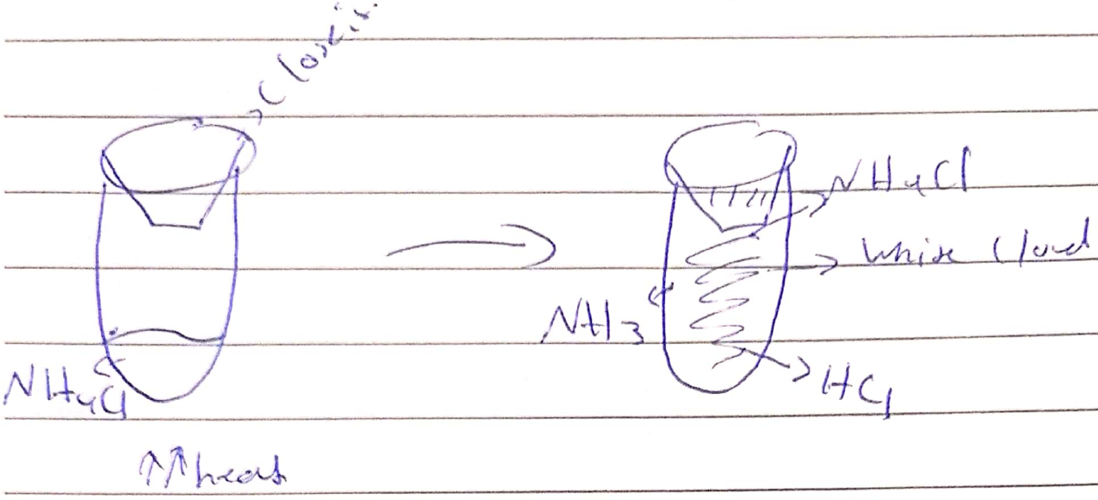
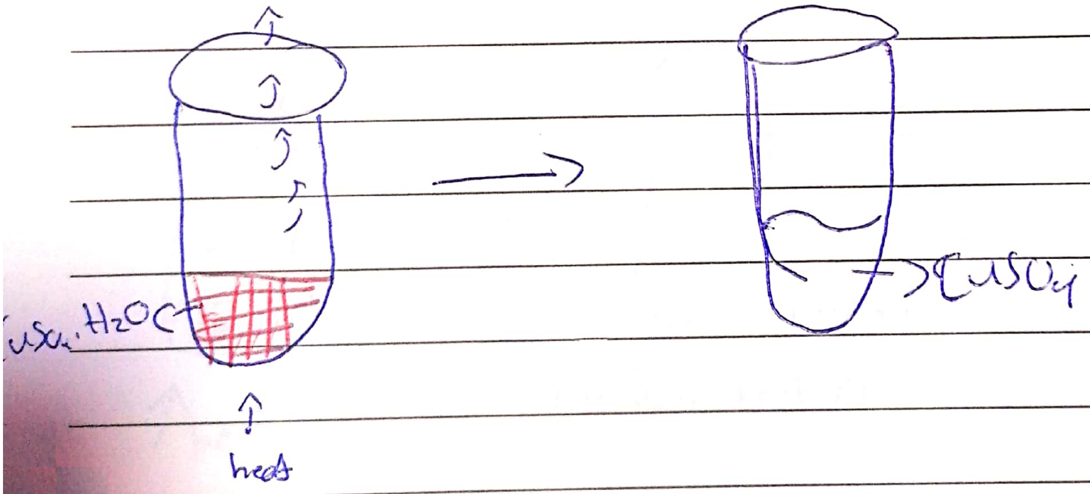
$NH_4Cl_{(s)} \rightleftharpoons NH_{3(g)} + HCL_{(g)}$



$CuSO_4 \cdot 5H_2O \xrightarrow{heat} CuSO_4 + 5H_2O$

blue   white



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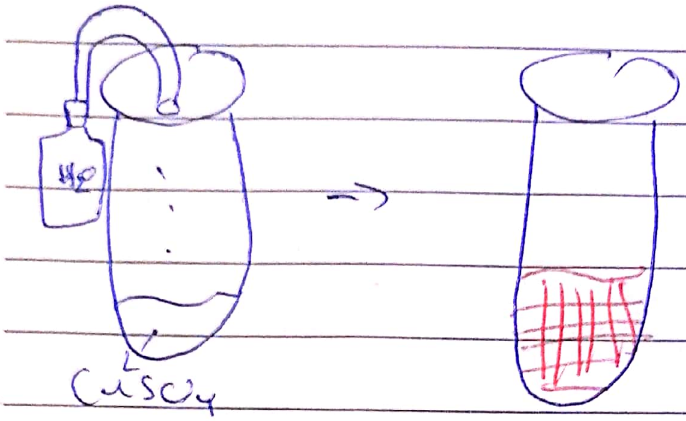
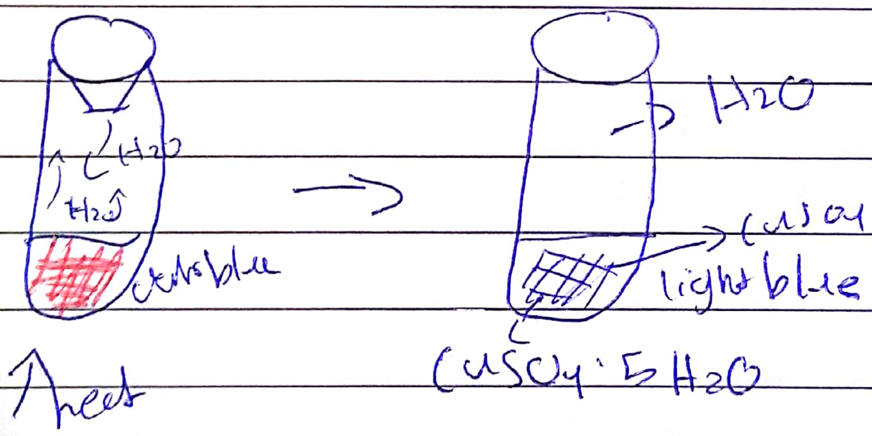
$CuSO_{4(aq)} + 5H_2O \rightarrow CuSO_4 \cdot 5H_2O$

white



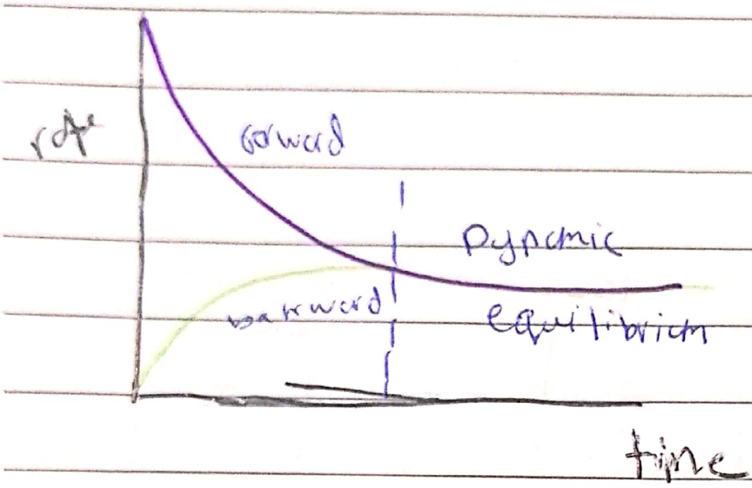
$CuSO_4 \cdot 5H_2O \rightleftharpoons CuSO_4 + 5H_2O$



equilibrium
Mixture.

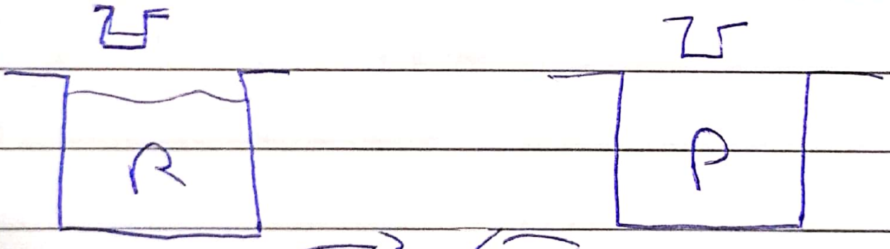
Dynamic equilibrium!

$$\text{Reactents} \underset{\text{backwards}}{\overset{\text{forward}}{\rightleftharpoons}} \text{Product}$$

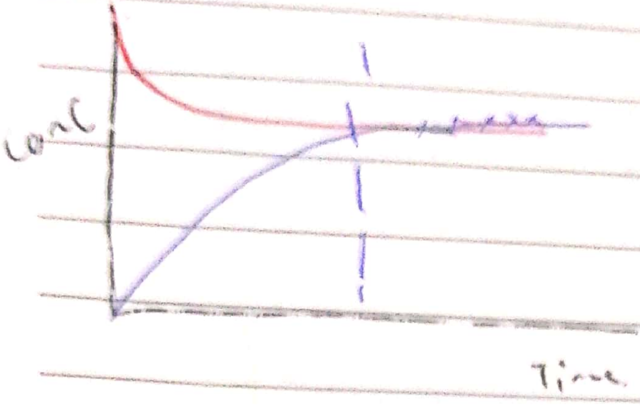


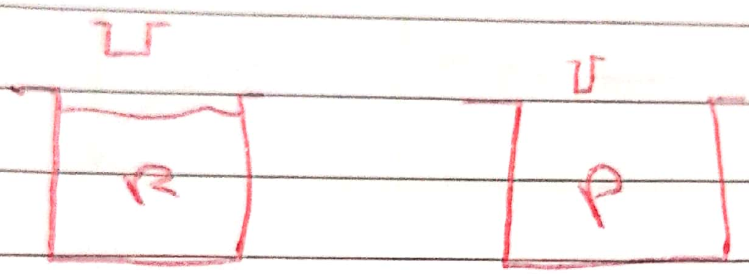
In terms of rate:

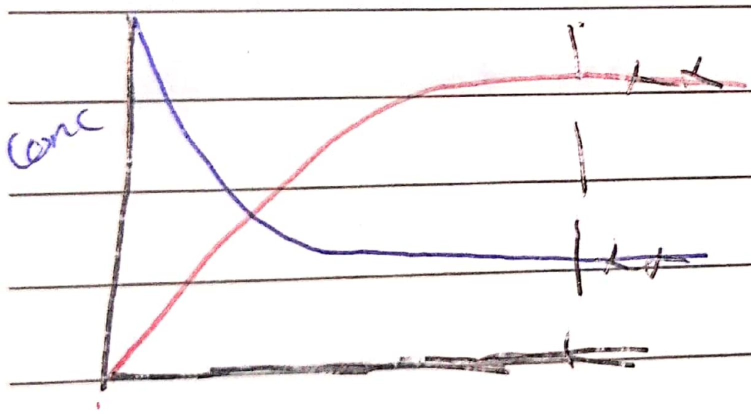
Dynamic equilibrium: when the rate of forward equal the rate of backward

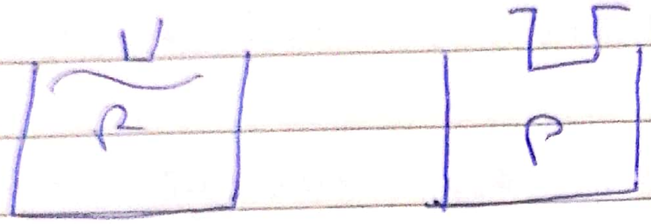


200	0
180	20
150	50
120	80
100	100
100	100


Conc
Time


R
P


Conc



In terms of concentration,
when the concentration of Reactants
and product are constant.

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Le chateler Principle:

If the system at equilibrium $\rightleftharpoons$ and any external factor distrub the equil.

The equi. shift it self either to the forward $\underset{\leftarrow}{\longrightarrow}$ or ~~to~~ the backward $\overset{\rightarrow}{\longleftarrow}$

to return back to the equil.

Endothermic : Absorb $\Delta H = +ve$

exothermic : release $\Delta H = -ve$

Pressure

Temp

Conc.

↑ Temp ↑↑ rate of endo

↑ rate of exo

↓ temp ↓↓ rate of endo

↓ rate of exo

Temp : endo and exo

↑ Temp shift to endo

↓ Temp shift to exo

① temperature:

As the temp increases the equil shift to the side that absorb heat. which is the endothermic side.

As The Temp decreases the equil shift to the side that release heat which is exothermic side.

The sign at ΔH is always Represent the forward reaction;

$$A + B \underset{exo}{\overset{endo}{\rightleftharpoons}} C + D \quad \Delta H = \overset{endo}{+ve}$$

↑ temp shift forward to the endoside

↑↑ rate of endo
↑ rate of exo

$$A + B \underset{exo}{\overset{endo}{\rightleftharpoons}} C + D \quad \Delta H = \overset{endo}{+ve}$$

↑ temp shift forward to the endo
rate of forward ↑↑
rate of backward ↑
↓A ↓B ↑C ↑D

↓ Temp shift backward to the exo
rate of forward ↓↓
rate of backward ↓

↑A ↑B ↓C ↓D

$$w + x \underset{\text{endo}}{\overset{\text{exo}}{\rightleftharpoons}} y + z \quad \Delta H \underset{\text{exo}}{-\text{ve}}$$

↑ temp shift backward to the endo

rate of endo ↑↑

rate of exo ↑

↑w ↑x ↓y ↓z

↓ Temp shift forward to the exo

rate of endo ↓↓

rate of exo ↓

↓w ↓x ↑y ↑z

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$3H_{2(g)} + N_{2(g)} \underset{}{\overset{exo}{\rightleftharpoons}} 2NH_{3(g)}$ $\Delta H = \overset{exo}{-ve}$

↑ temp

1) rate of forward: increase

2) rate of backward: increase

3) yeild of NH_3, why: decrease

Increase temp shift the equil. to the backward to the endo.

$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

The yeid of SO_3 increase by cooling explain why!

The forward reaction is exothermic favoured by cooling.

Subject ____ Day ____ Date ____

② Pressure :

↑ Pressure => shift to the side with less pressure.

has less gas moles

↓ Pressure => shift to the side with less Pressure.

more

$$\underbrace{3H_{2(g)} + N_{2(g)}}_{4mol} \rightleftharpoons \underbrace{2NH_3}_{2mol}$$

↑ Pressure shift forward to the side with less gas moles.

↓ Pressure shift backward to the side with more gas moles.

$$\overbrace{CaCO_{3(s)}}^{0} \rightleftharpoons \overbrace{CaO_{(s)} + CO_{2(g)}}^{1}$$

↑ Pressure shift backward

To the side with less gas mole

↓ pressure shift inward

to the side with more gas mole.

$$\overbrace{H_{2(g)} + I_{2(g)}}^{2\,mol} \rightleftharpoons \overbrace{2HI_{(g)}}^{2\,mol}$$

↑ Pressure has no effect on the position at equilibrium

They have the same Number of gas moles.

complete the table

$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_3$ $\Delta H =$ −

Subject ______ Day ______ Date ______

effect	rate of forward	rate of backward	yeild of NH_3
↑ temp	↑	↑	↓
↑ pressure	↑	↑	↑
↓ pressure	↓	↓	↓

Subject ____________ Day ____________ Date ____________

Q1- Reaction $H_{2(g)} + \overset{\text{Purple}}{I_{2(g)}} \rightleftharpoons \overset{\text{colorless}}{2HI_{(g)}}$

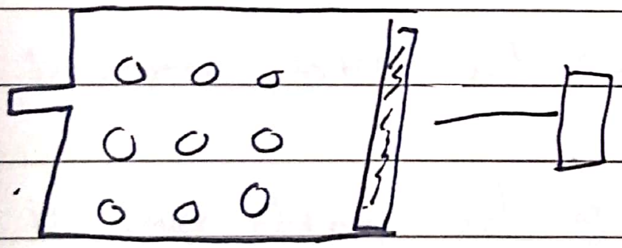
at equilibrium;

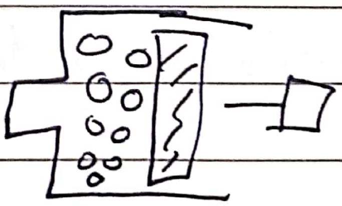
I) why by increasing the pressure equili: doesn't change;

because both side of the reaction have the same number of gas moles.

II) why by increasing the pressure the mixture becomes more purple;

The gas particles of I_2 become closer together and the color appears more condense.





↑ Pressure rate of less gas mole ↑↑ } shift to less gas mole
rate of more gas mole ↑

↓ Pressure rate of less gas mole ↓↓ } shift to more gas mole.
rate of ~~less~~ more gas mole ↓

Q: Mixture of NO_2 and N_2O_4 at equl. in a sealed tube;

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$$

dark brown — Pale brown.

by increasing the Pressure the mixture:

a) becomes darker and stays darker

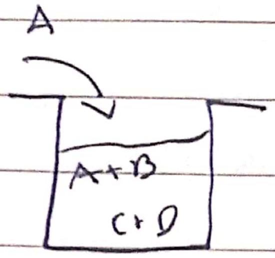
[✓ b)] becomes darker and goes Paler

c) becomes paler and stays Paler

d) becomes paler and goes darker.

Concentration :

$A + B \rightleftharpoons C + D$



forw
↑ [A] shift ~~back~~ward

↓B ↑C ↑D

↑ [C] shift backward

↑A ↑B ↓D

$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $\Delta H = -ve$

conc. add excess H_2 and N_2 remove NH_3 imidiatly (condensation)

temp. 400 - 450°C

pressure ~~add excess H_2 and N_2 remove NH_3~~

~~Practical~~ 200 atm

Indicator:

$$HIn_{(aq)} \rightleftharpoons H^+_{(aq)} + In^-_{(aq)}$$

color(1) color(2)

add HCl
acid
proton donor

$\uparrow H^+$, shift backward
more HIn more color (1)
less In^- less color (2)

add NaOH
proton acceptor
$OH^- + H^+$

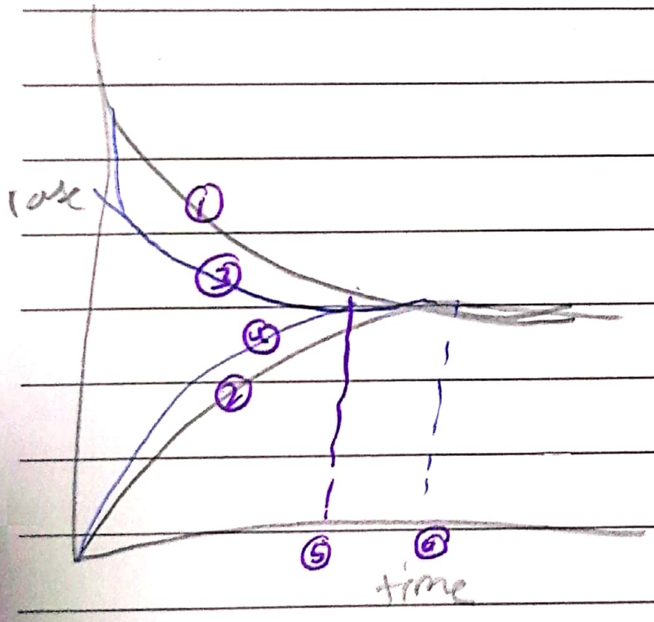
$\downarrow H^+$
more In^- more color
less HIn less color

* catalyst:

has no effect on the position of equil.

because it speeds up rate of forward and backward.

So it cause the equil to occur with less time.



1) rate of forward without catalyst

2) rate of forward without catalyst

3) rate of forward with catalyst

4) rate of backward with catalyst.

5) time taken to reach equil with catalyst

6) time taken to reach equil'l without catalyst

Energetics:

(Energy in chemical Reactions)

Energy; The ability to do work

in Chemical Rxn

To break down bonds in Reactands	to build bonds in Products
In Put	out Put
Absorb	release
take in	give out
Endothermic	exotherm

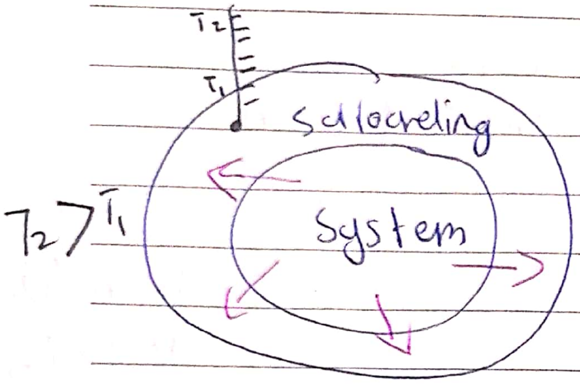
input > output
Endothermic

Output > input
exothermic

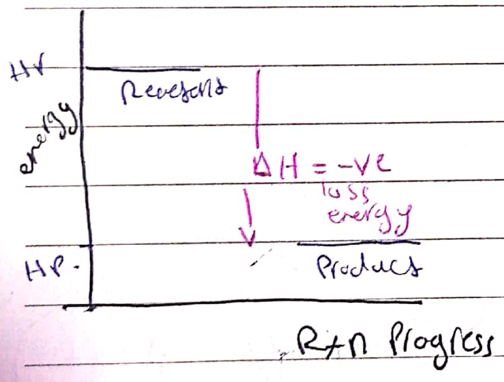
Enthalpy: Heat contents
Stored energy in bonds

Exothermic Reactions:

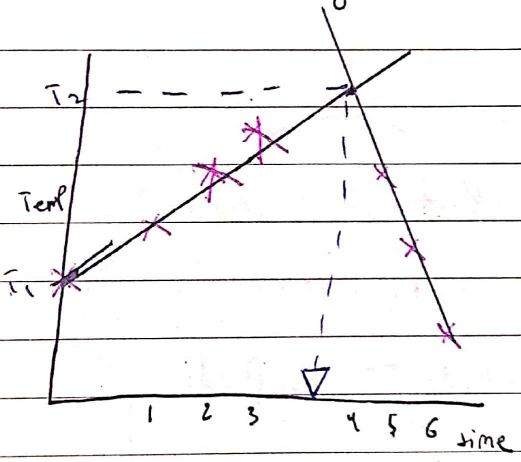
Reactions that release (give out) energy to the surrounding when they take place.



For system:
Energy level diagram:



For surrounding
Temp diagram:



(energy transfer)

↑Q ↑ΔH

more exothermic

$$Q = m\ c\ \Delta T$$

Q → Energy (J)

m → mass (g)

c → specific heat capacity

ΔT → change in temp

($c_{water} = 4.2\ J/g\ °C$)

example process:

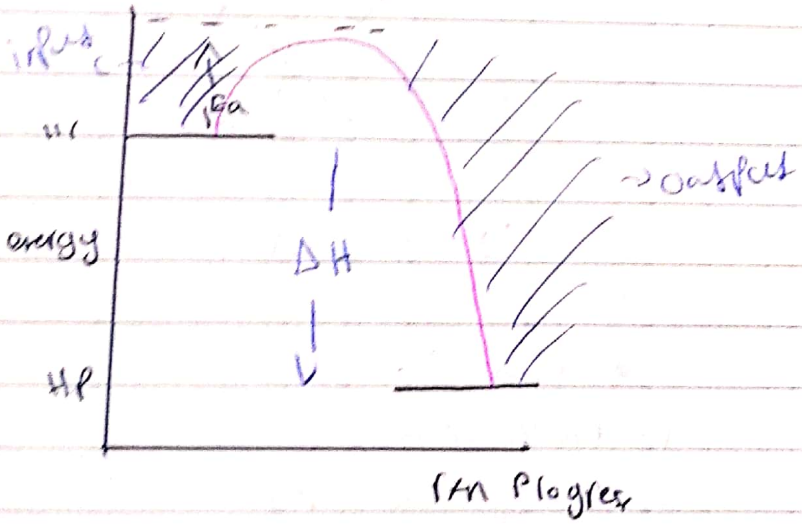
1) combustion
2) displacement
3) neutralization
4) respiration
5) freezing condensation
6) voltaic cell
7) building bonds.

* how to express exothermic reactions:

① Reactant $\longrightarrow$ product + energy

② Reactant $\longrightarrow$ product $\Delta H = -ve$

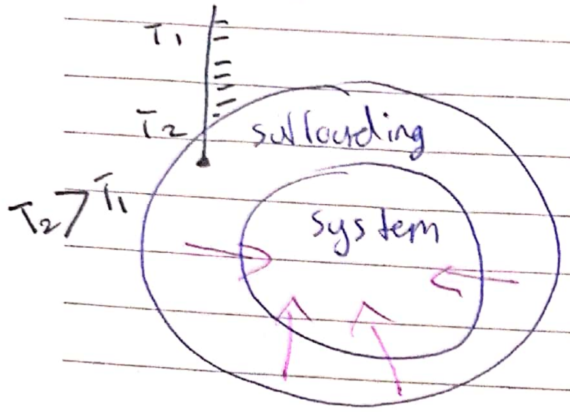
③ Profile diagram



output > input

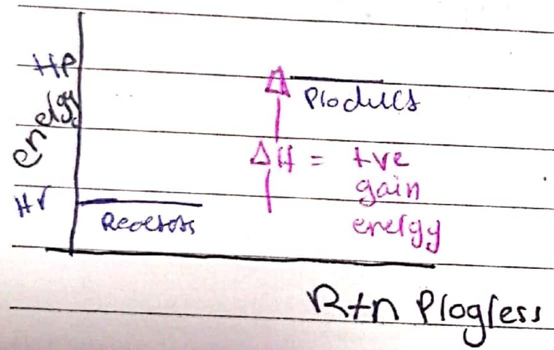
Endothermic Reactions:

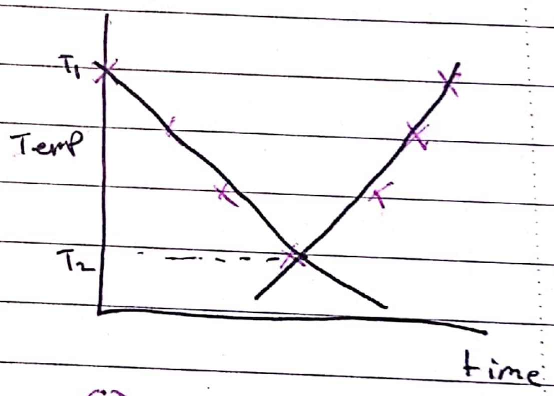
Reactions that absorb (take in) energy from the surrounding when they take place.



For system:
Energy level diagram

For surrounding:
Temp diagram





↑Q more endothermic

$Q = m c \Delta T$

Examples processes:
1) combustion exothermic
2) displacement
3) neutralization
4) respiration
5) Freezing / condensation
6) voltaic cells
7) building

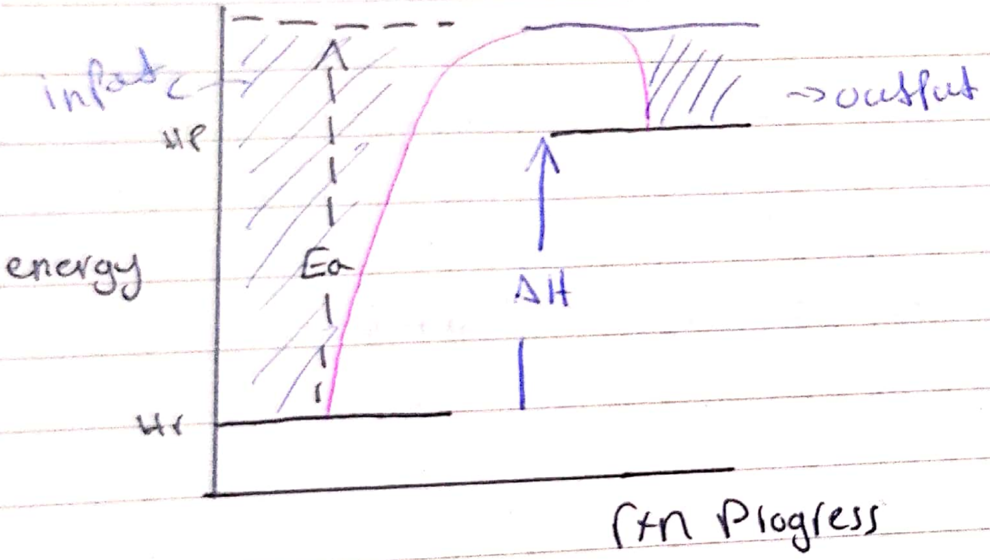
examples:
1) Photosynthesis
2) Photographic films
3) Thermal decomposition
4) electrolysis
5) boiling melting
6) breaking down bonds.

* How to express endothermic reactions:-

① Reactant + energy ⟶ product

② Reactants ⟶ Products $\Delta H = +ve$

③ Profile diagram



input > output

Measuring ΔH rxn using bond energies:

Bond	Bond energy kJ/mol
H − H	436

(endo) breaking bond $H-H_{(g)} + 436\,kJ \longrightarrow H_{(g)} + H_{(g)}$

bond building $H_{(g)} + H_{(g)} \longrightarrow H-H_{(g)} + 436\,kJ$ (exo)

Bond Energy:

The amount of energy needed to break 1 mol of bond in a gaseous state.

or

The amount of energy released to build 1 mol of bond in a gaseous state.

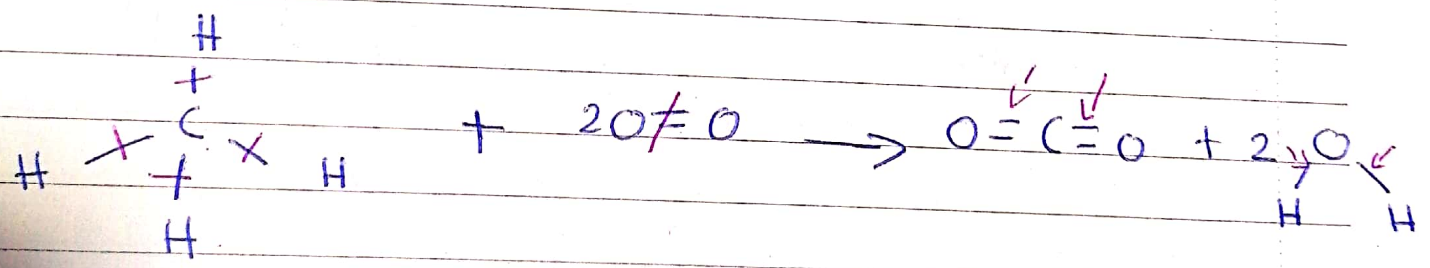
$\Delta H_{rxn} = \underset{\text{sum total}}{\sum} \text{input} - \underset{\text{sum total}}{\sum} \text{output}$

ΔH = total input − total output

+ endo in > out

− exo out > in

bond	bond energy kJ/mol
C−H	413
O−H	463
O=O	496
C=O	799



bond broken

4× C−H 4 × 413
+
2× O=O 2 × 496

total input 2644 kJ

ΔH = input minus ← $\ominus$ output

2644 − 3450

= $\ominus$806 kJ/mol

exo

bond build

2× C=O 2 × 799

4 + O−H 4 × 463

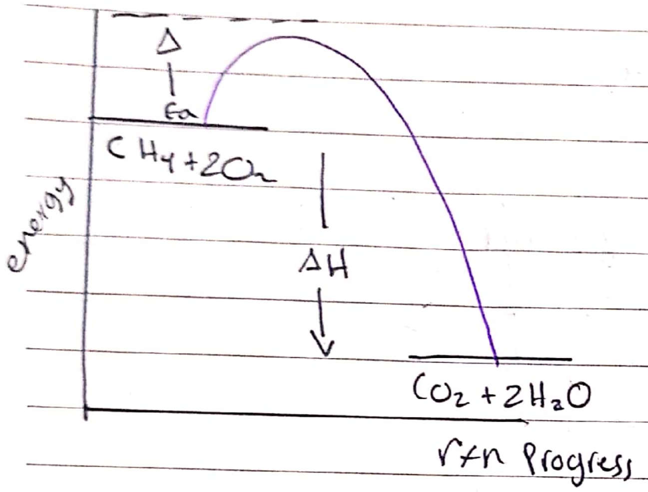
3450 kJ

How to express the reaction!

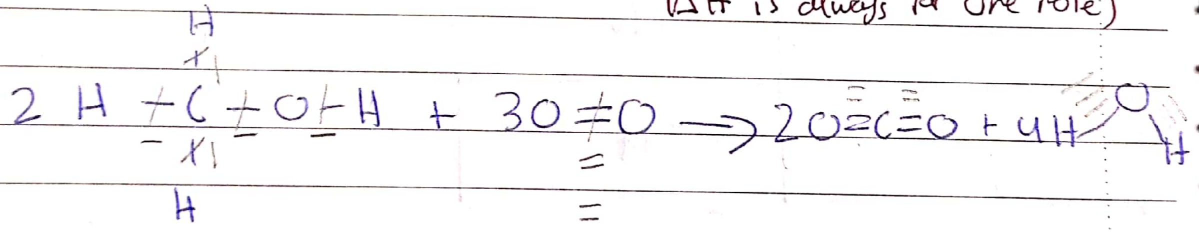
① $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ + 806 kJ/mol

② $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ $\Delta H = -806$ kJ/mol

③ profile diagram



(ΔH is always for one mole)



bond broken

6 × C−H 3 × O=O

2 × C−O +

2 × O−H

bond build

4 × O=C

8 × O−H

6 × 413

\+ 2 × 358

\+ 2 × 463

\+ 3 × 496

5608 kJ

$\Delta H = 5608 - 6900$

$= -1292$ kJ/mol

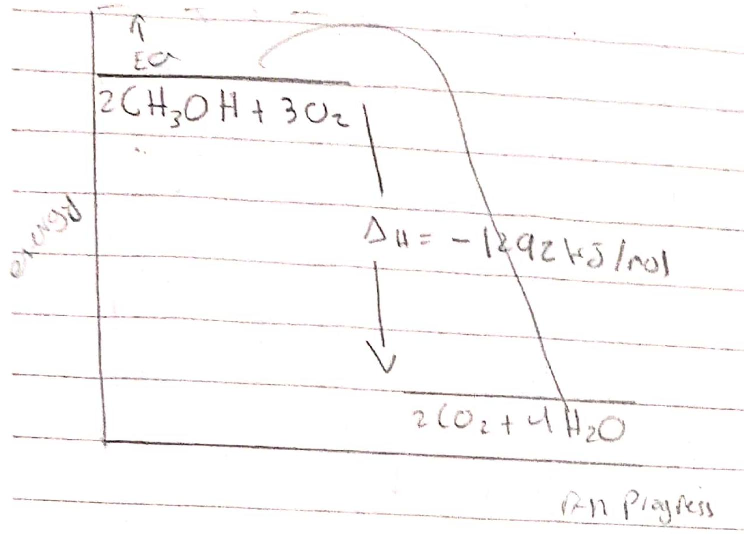
exo

4 × 799

\+ 8 × 463

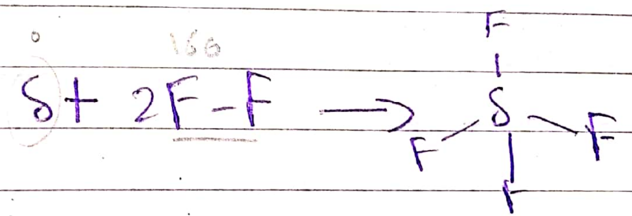
6900 kJ

diagram Profile !



bond	bond energy kJ / mol
C – H	413
O = O	496
C = O	799
O – H	463
C – O	358

Sulfur react with Florine to give sulfur tetra Floride and (Release) 780 kJ/mol.
If the bond energy for F – F is 160 kJ/mol
draw a Profile diagram for this reaction and find the bond energy for S – F



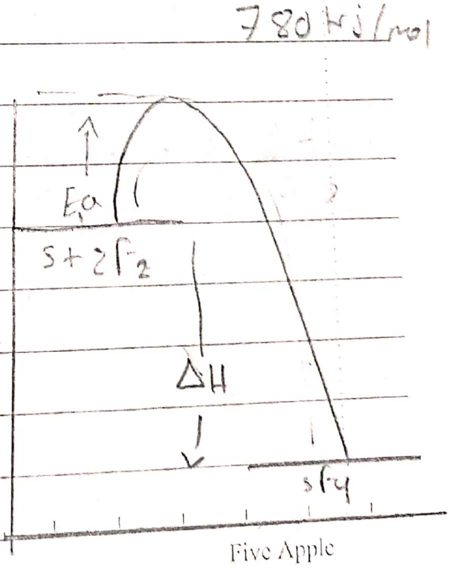
$S + 2F-F \rightarrow$

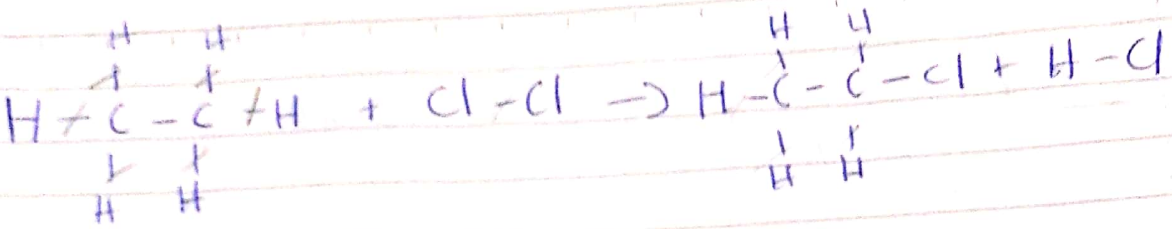
$2 \times 160 = 320$
input

$-780 = 320 - 4 \times S-F$
-320

$\frac{-1100}{-4} = \frac{-4\,S-F}{-4}$

$\boxed{S-F = 275 \text{ kJ/mol}}$





$H-C-C-H + Cl-Cl \rightarrow H-C-C-Cl + H-Cl$

Find the bond energy of H–Cl if the amount of energy $\boxed{\text{released}}$ is 104 kJ/mol;

bond	bond energy kJ/mol
Cl–Cl	242
H–Cl	??
H–C	413
C–Cl	328

$-104 =$

break	build
$6 \times 413 =$	5×413
$1 \times 242 =$	1×328
	$1 \times x$
(2720)	$-\ (2393 + x)$

$-104 = 2720 - 2393 - x$

$-104 = 327 - x$

$-327 \quad -327$

$\frac{-431}{-1} = \frac{-x}{-1} = \quad x = 431$

Measuring the amount of energy transfer!

surrounding

$$Q = m\,c\,\Delta T$$

Q → Energy transfer (Joule) J

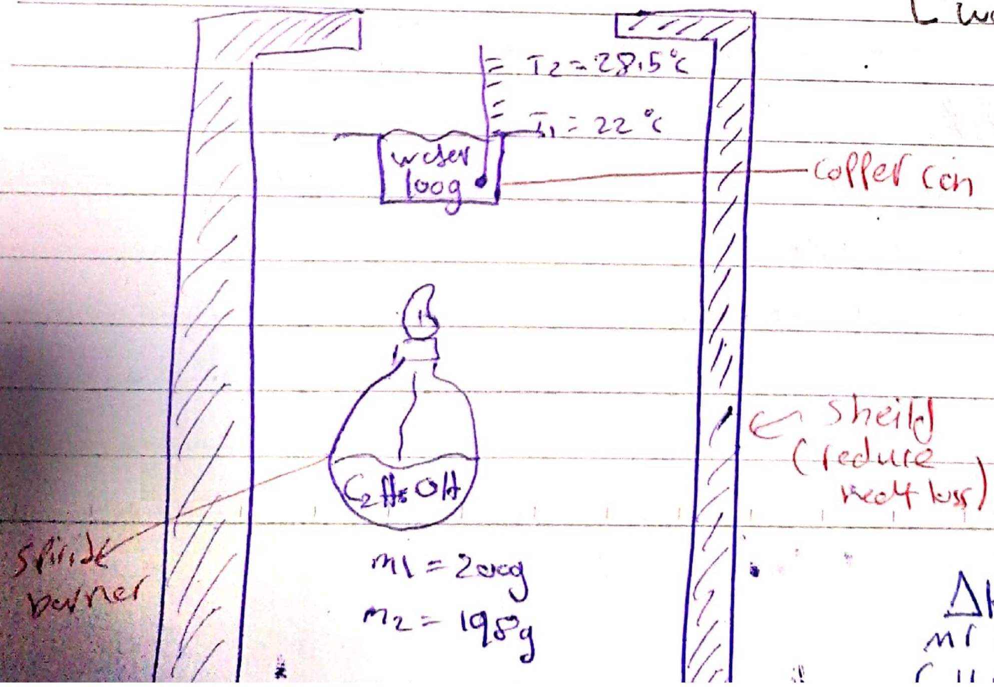
m → mass (g)

c → specific heat capacity for water 4.2 J/g.C°

ΔT → change in temp

Combustion — displacement — neutralization

Combustion!



C water = 4.2 J/g.°C

surrounding

$Q = m\,c\,\Delta T$

$100 \times 4.2 \times (28.5 - 22)$

$= 2730$ J

$2730 \xrightarrow{burn} 2g\ C_2H_5OH$

$\dfrac{62790\ J/mol}{1000} \longleftarrow 46g$

ΔH (kJ)/mol

$\Delta H = -62.79$ kJ/mol

mr = 46g

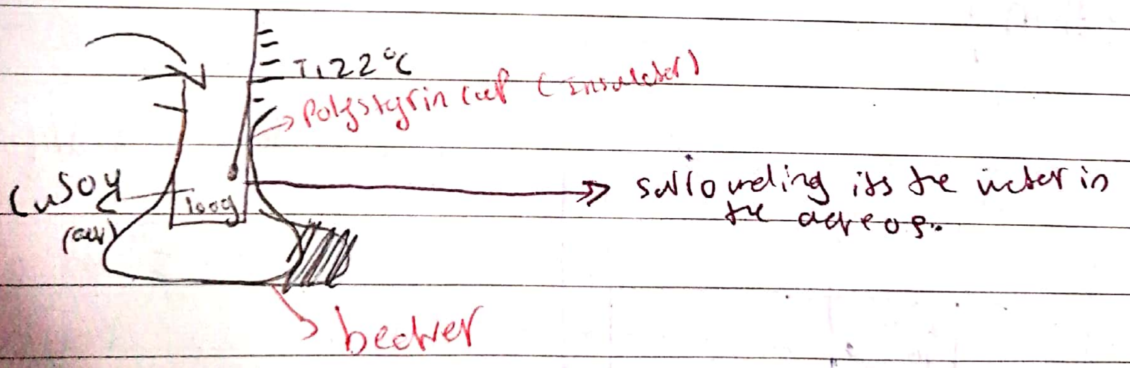
Two fuels A and B
Plan an experinment to show which fuel
Produce more energy!

Take a known mass of fuel A in a spirit burner
place a known mass of water in a copper can
measure the initial tempreture of water. (T₁)
Ignite the fuel A [redacted]
measure the final tempreture of water (T₂)
Repeat the experinment to fuel B
The fuel which case more tempreture change.
is the one that Produce more energy

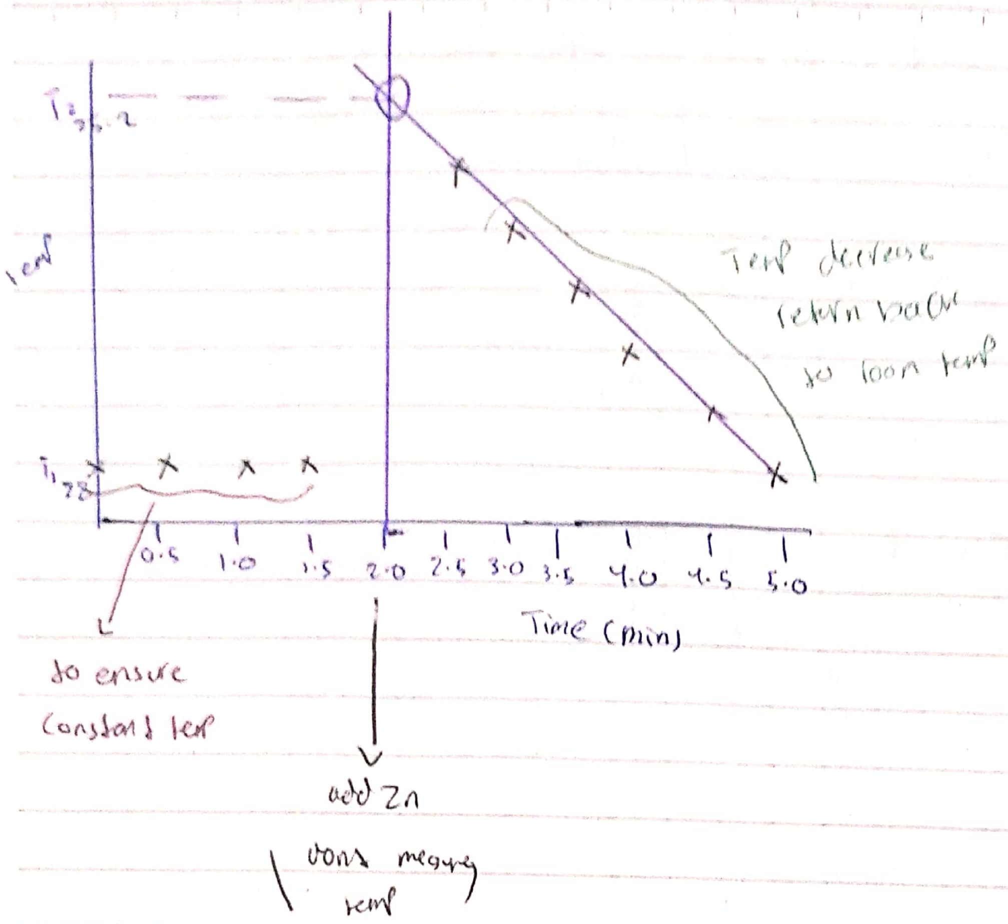
[redacted] displacement !

$Zn_{(s)} + CuSO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$

M = 0.65g
V = 100cm³
d = 1g/cm³
m = 100



1- insulator
2- more stable

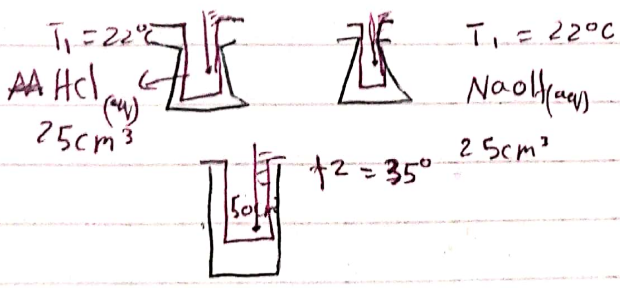


$Q = mc\Delta T$

$100g \times 4.2 \times 3.2 = 1344$

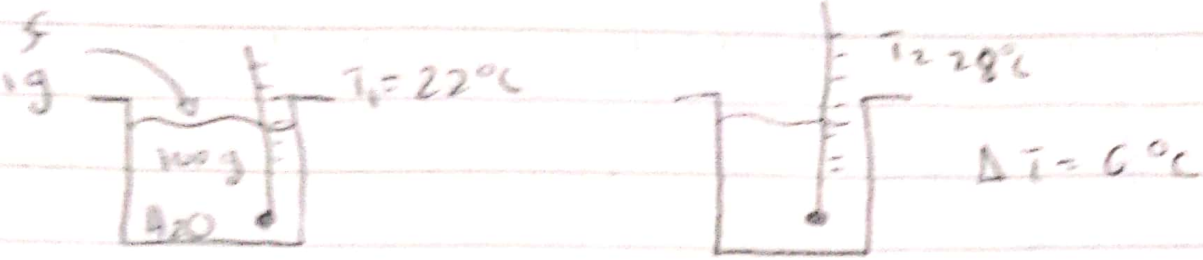
Neutralization:

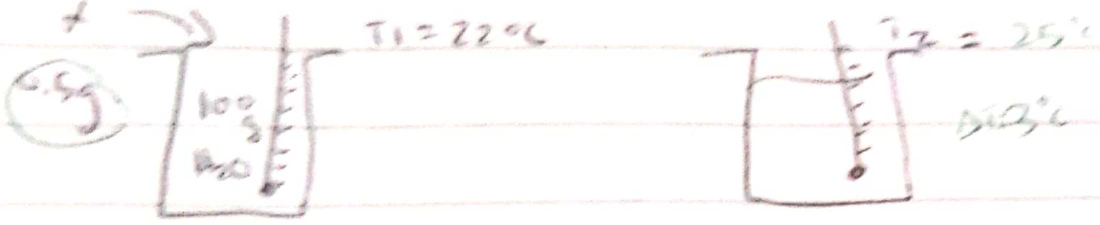
$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

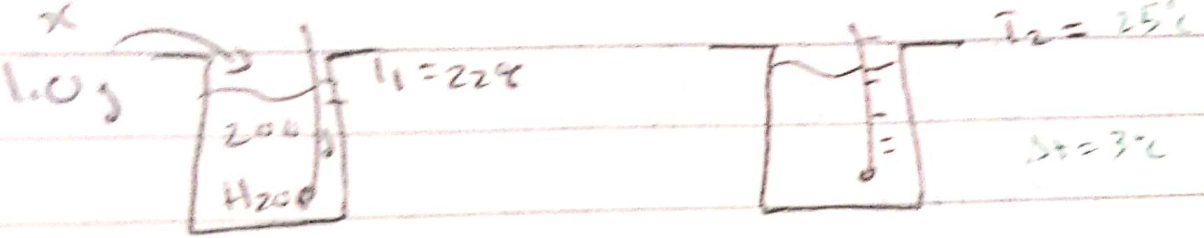


surrounding: $Q = mc\Delta T$

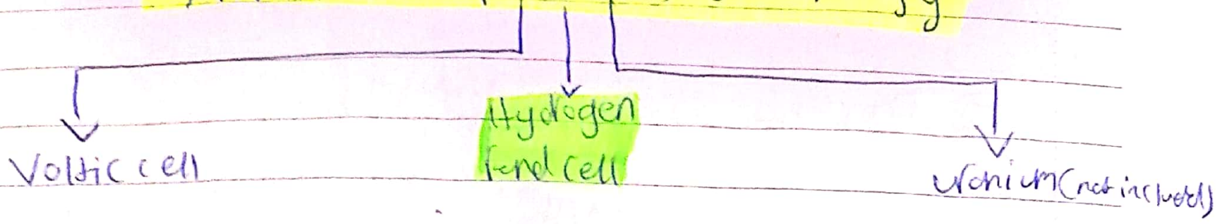
$Q = (25+25) \times 4.2 \times 1$


1g
100 g
H₂O
T₁ = 22°C
T₂ = 28°C
ΔT = 6°C


x
0.5g
100 g
H₂O
T₁ = 22°C
T₂ = 25°C
ΔT = 3°C


x
1.0 g
200 g
H₂O
T₁ = 22°
T₂ = 25°C
Δt = 3°C

Alternative Resources of energy

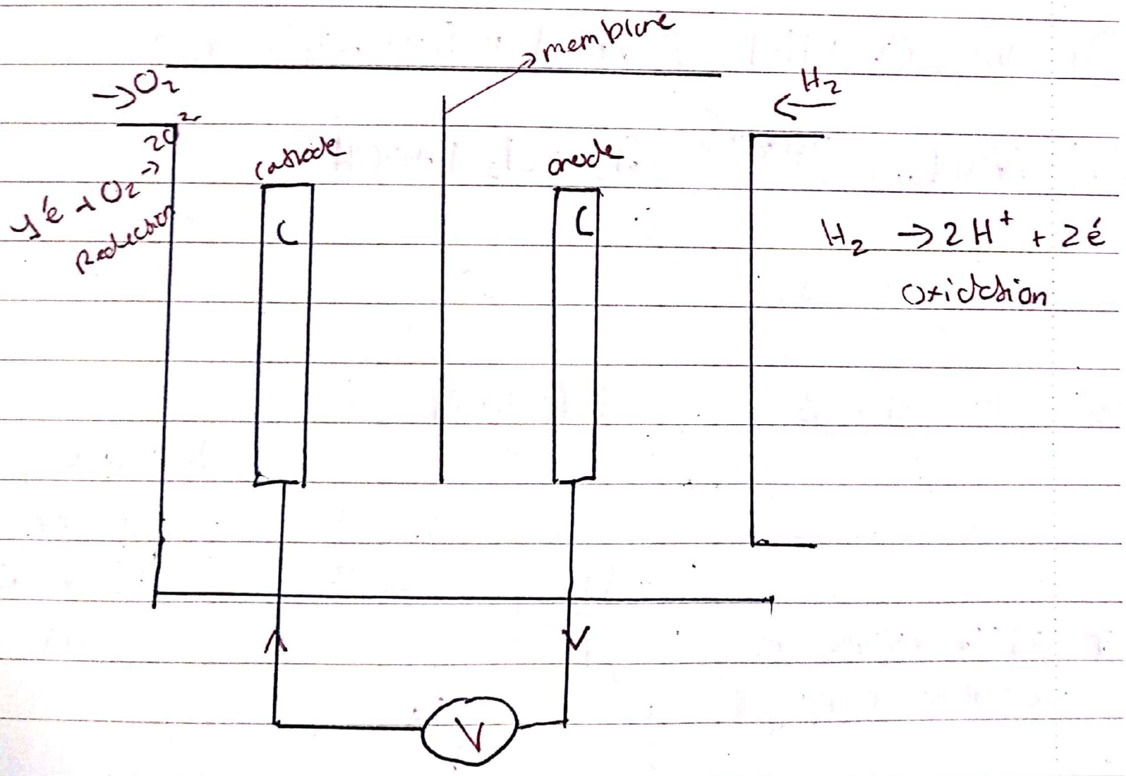


Hydrogen fuel cell:

$$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(l)}$$

Positive

- Produce only H_2O as wast product
- Produce High amount of energy "electrical"
- NO CO_2 produced (Not Pollutent)



-ve

- hard to store and transport
- Risk of explosion

Industrial chemistry

- Dealing with gases
  - dry
  - collect
- Industry
  - NH_3 Haber Process
  - H_2SO_4 Contact Process
  - (CO_3^{-2})
- extraction
  - Fe
  - Cu
  - Al

Dealing with gases:

(H_2) $Mg_{(s)} + HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$

(CO_2) $CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

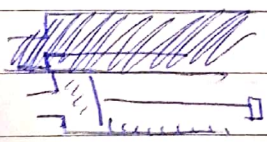
(NH_3) $NH_4Cl_{(aq)} + NaOH_{(aq)} \xrightarrow{\Delta} NaCl_{(aq)} + H_2O_{(l)} + NH_{3(g)}$

(SO_2) $Na_2S_2O_3 + HCl \rightarrow NaCl + S + SO_2 + H_2O$

(Cl_2) $NaCl_{(aq)} \xrightarrow{electrolysis} H_2 + Cl_2 + NaOH$

Collecting gases:

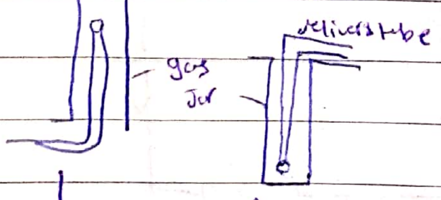
① gas syringe:



* Collect and measure the volume of any gas

② Delivery:

- upward
- downward



dis: some gases might escape
- mix with other gases

Collect less dense gases than air
NH_3
H_2

collect more dense gases than air SO_2
CO_2
Cl_2

③ Over water.

used only for insoluble gas in water

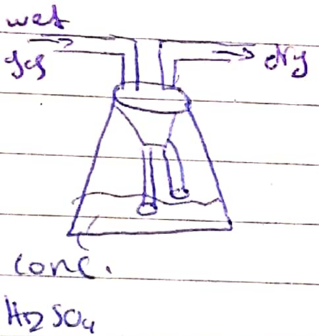
* CO_2 Slighdly soluble in water

* hard to use

Drying gases:

Conc. H_2SO_4

absorbs water

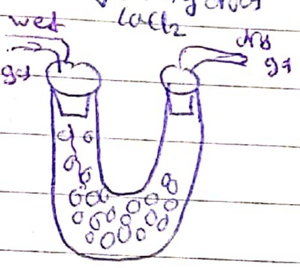


* used to dry any gas except NH_3

↓

Its basic (Alkaline)

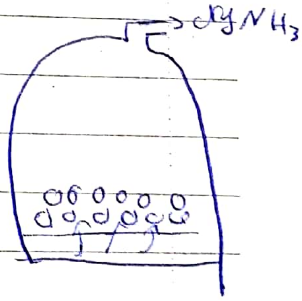
Anhydrous $CaCl_2$



* used to dry any gas except NH_3

CaO

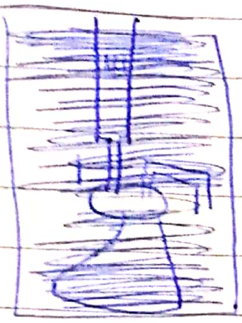
Quick time

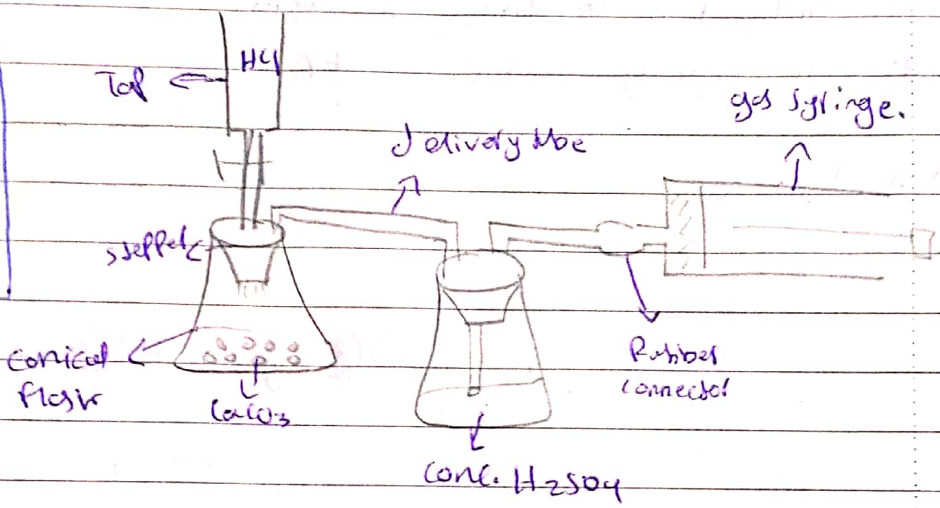


* only ammonia

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

draw an apparatus to collect and measure a dry sample of CO_2





Industry of NH_3

(Haber process)

$$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_{3}\ (g) \qquad \Delta H = -ve$$

Uses of NH_3

1- Fertilizers. (N, P, K)
2- Cleaning detergent.
3- smelling salts.

* remove NH_3 immediatly by cooling down condensing NH_3

Essential conditions:

1- Temp 400°C — 450°C

2- Pressure 200 atm

3 - Catalyst Fe

* add excess H_2 and N_2 return back to converter

Pressure 200 atm

high Pressure

- adv
  - 1- more yeild of NH_3 (shifts forward to the side with less gas)
  - 2- faster rate (more collisions per unit time)
- dis
  - 1- risk of explosion
  - 2- extensive

Temp 400°C — 450°C

- Less then 400
  - adv
    - more yeild of NH_3, shift forword to the exo side
  - dis
    - Slow rate of Rxn
    - particles lose K.E so less effective collision per
- more then 450
  - adv
    - faster rate
  - dis
    - less yeild of NH_3, shift backword to the endo side

How to obtain

N_2 :- Fractional destilation
of liquid air

H_2:-

① Cracking of Alkane
(organic)

② $CH_4 + H_2O_{(g)}$
methane $\downarrow$
$3H_2 + CO$

Industry of H_2SO_4

$$S \xrightarrow[①]{\text{Roasting}} SO_2 \overset{\text{Contact process } ②}{\rightleftharpoons} SO_3 \xrightarrow[③]{\text{conc. } H_2SO_4} H_2S_2O_7 \xrightarrow[④]{H_2O} H_2SO_4$$

oleum

H_2SO_4 oily liquid

dilute: typical acid

conc: dry gas

S

① grap VI

yellow solid

S_8

Ore: zinc blend ZnS

Source: fossile fuel

uses:

- Fire works
- medicine
- matches
- rubber

SO_2

② Chocking smell

- test SO_2

Turns acidify $KMnO_4$ from purple to colorless

uses

* paper Industry (bleaching agent)

* food Preservation (kills bacteria)

③ $SO_3 \xrightarrow{H_2O} H_2SO_4$

high exothermic

produce low yeild of H_2SO_4

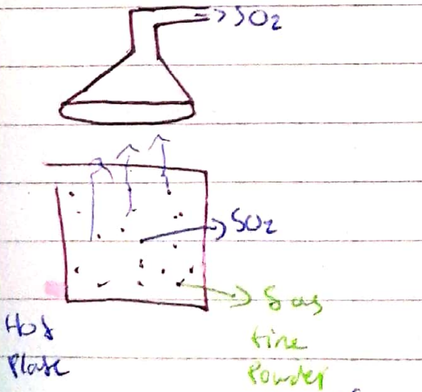
(not used because highly low yeild need lot of water.)

$$\begin{tikzcd} SO_3 \arrow[d] & & 2H_2SO_4 \\ & H_2S_2O_7 \arrow[ur, "+H_2O"'] & \end{tikzcd}$$

oleum

① Roasting:

$S + O_2 \rightarrow SO_2$



more surface area so faster rate of rxn

② Contact process:

$$2SO_{2(g)} + O_2 \underset{\text{endo}}{\overset{\text{exo}\atop V_2O_5}{\rightleftharpoons}} 2SO_3$$

$\Delta H = \overset{\text{exo}}{-ve}$

① Temp 400 - 450°C

② pressure 1-2 atm "high pressure"

favor the forward side which has less gas moles

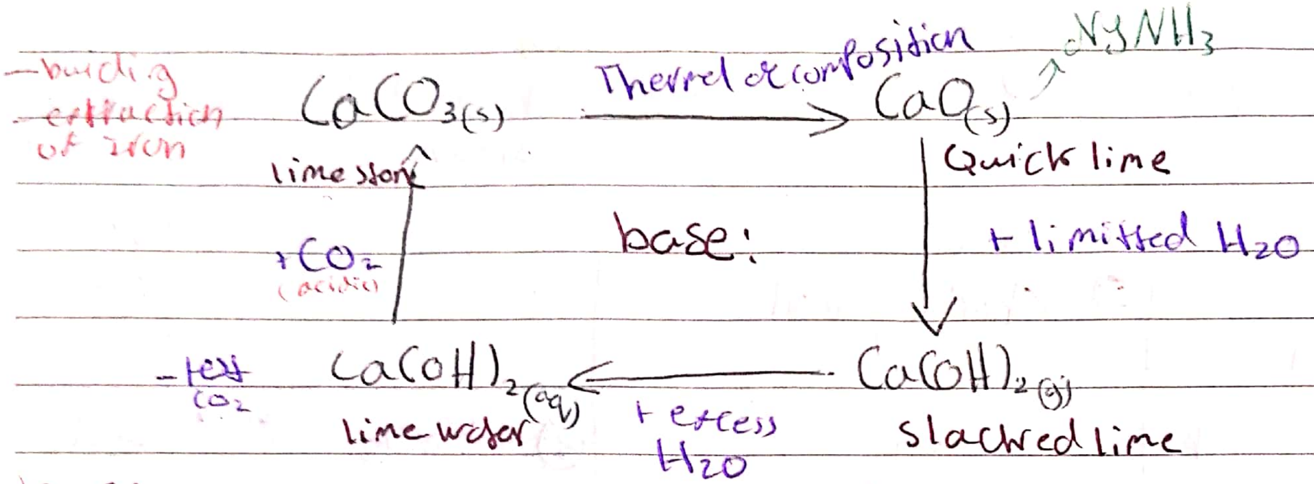
(max yeild at 2 atm)

③ catalyst V_2O_5

Vandium (V) Oxide

Penta

Carbonate cycle:



Uses:

- neutralises the acidic soil and water

- Desulfonation:
  Removing SO_2 from flow gases

test CO_2

$Ca(OH)_2 + CO_{2(g)} \rightarrow CaCO_{3(s)} + H_2O_{(l)}$

Extraction of metals

K
Na
Li] electrolysis molten
Ca
Mg
bauxite Al_2O_3 ← Al
C,CO
Zn → ZnS Zinc blende] reduction
Fe → Hematite Fe_2O_3] by C and CO
Pb
H
CuS ← Cu] reduction by Hydrogen
Ag
Au
Pt

Extraction of Iron;

ore: Hematite : Fe_2O_3
Method: reduction by C and CO
Place: Blast Furnace

Raw materials: ① Fe_2O_3 + acidic impurities SiO_2 (sand)
② $CaCO_3$ (lime stone)
③ coke (pure carbon)
④ air ($T = 1500°C$)

Extraction of Iron:

complete combustion

Redox ① $C + O_2 \rightarrow CO_2$ produce energy

incomplete combustion

redox ② $2C + O_2 \rightarrow 2CO$

redox ③ $CO_2 + C \rightarrow 2CO$

redox ④ $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

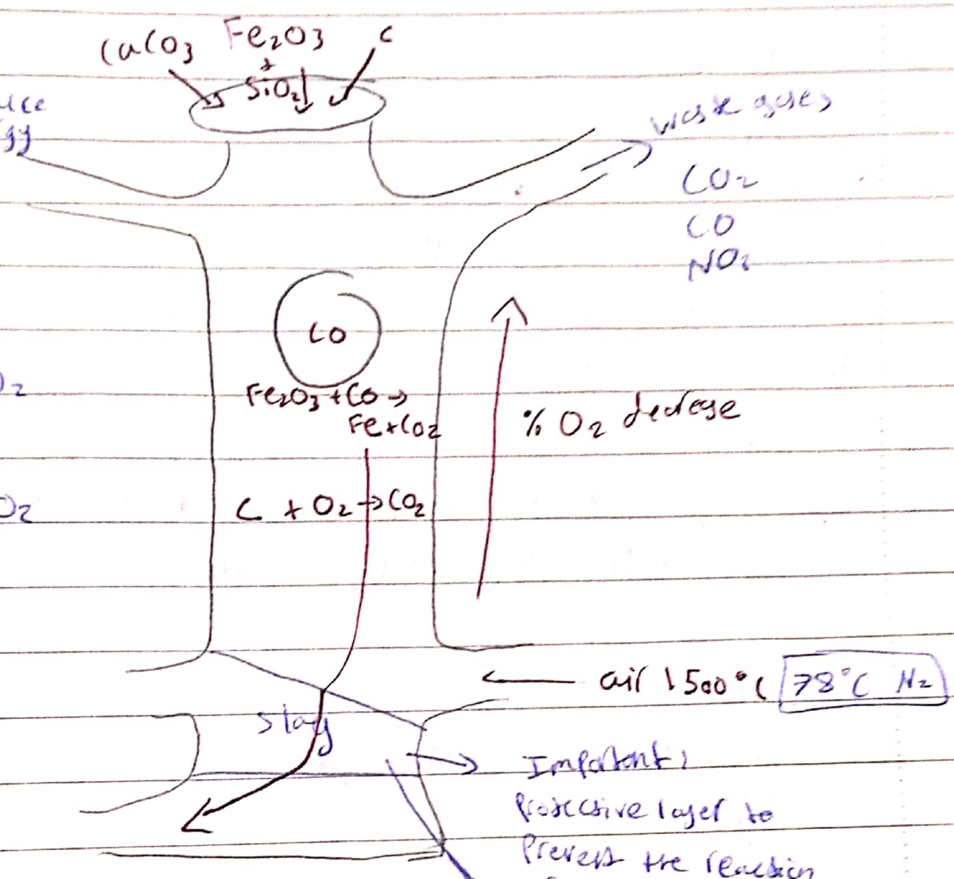
thermal decomposition

⑤ $CaCO_3 \xrightarrow{heat} CaO + CO_2$

⑥ $CaO + SiO_2 \rightarrow CaSiO_3$

Neutrilization.

calcium silicate (slag)



Important: protective layer to prevent the reaction of O_2 with Fe

use: Mixed with bitumen to make roads.

Steel making "oxygen_base Process"

(s) iron

Fe

main impurity

$CO_2 \leftarrow \boxed{C}$

$SO_2 \leftarrow S$

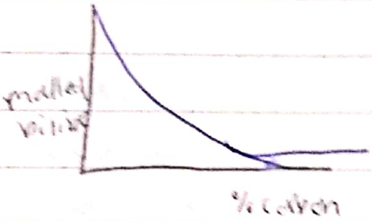
$SiO_{2(s)} \leftarrow Si$

$P_2O_{5(s)} \leftarrow P$

① blow hot O_2

② CaO

Steel
- Mild steel "carbodies" 0.03% C
- medium steel "railways" 0.3% C
- stainles steel 3-5% C "cutlery" "watches"



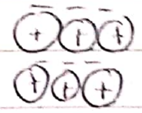
Alloy: Mixture of metal with another metal or semi metal.

Brass : Cu + Zn

Bronze : Cu + Sn

steel : Fe + C + Cr + Ni

copper



easier to slide

Brass

(two different sizes so) harder to slide

Extraction of metals;

* The method of extraction the metal from its ore depends on the position of the metal in the reactivity series;

ore: main rock that the metal comes from.

K
Na
Li
Ca
Mg
Bauxite ← Al
Al_2O_3 C,CO
Zinc blend ZnS ← Zn
Hematite Fe_2O_3 ← Fe
Pb
H
copper sulfide CuS ← Cu
Ag
Au

K – Al] Electrolysis molten

Zn – Pb] reduction by C&CO

Cu] reduction by H

Extraction of Al:

ore: Bauxite Al_2O_3
method: Electrolysis for molten using graphite.

* M.P of Al_2O_3 is 2000°c

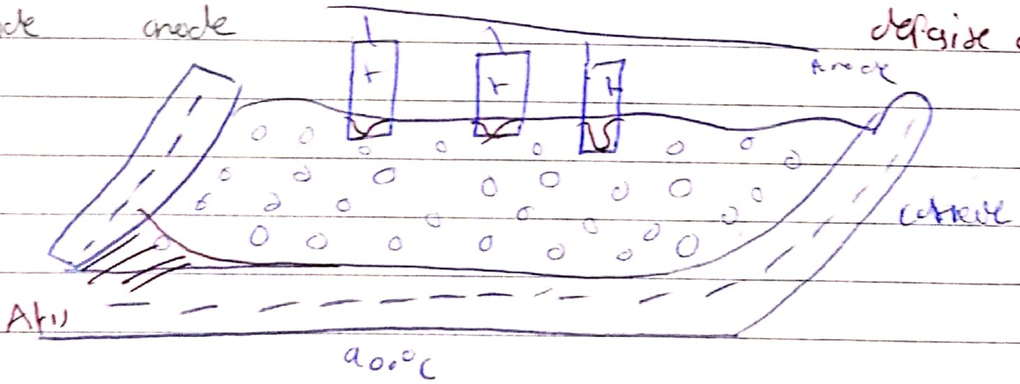
So we dissolve Al_2O_3 in molten cryolyte Na_3AlF_6
why?

1- lower the melting point to 900°c (less cost)
2- increase electrical conductivity.

$Al_2O_{3(l)}$ → Al^{3+} (cathode), O^{2-} (anode)

$2O^{2-} \rightarrow O_2 + 4e^-$
bubbles of gas.

$Al^{3+} + 3e^- \rightarrow Al$
deposite of metal



gas Produced at anode
1- O_2
2- CO_2
3- CO
corrosion of anode with O2 so we must replace the Anod periodically

Property of Al	use of Al
Malleable	window frame
Low density	Air craft bodies
Conduct electricity ductile	electrical wires
form non toxic oxide layer	Food cans.