Reactivity series: (Metals)

Most reactive

	Mtal oxide (O^{2-})	Hydroxide (OH^-)
K^{1+}	K_2O	KOH
Na^{1+}	Na_2O	$NaOH$
Li^{1+}	Li_2O	$LiOH$
Ca^{2+}	CaO	$Ca(OH)_2$
Mg^{2+}	MgO	$Mg(OH)_2$
Al^{3+}	Al_2O_3	$Al(OH)_3$
$\boxed{C, CO}$		
Zn^{2+}	ZnO	$Zn(OH)_2$
$Fe^{2+/3+}$	FeO / Fe_2O_3	$Fe(OH)_2 / Fe(OH)_3$
Pb^{2+}	PbO	$Pb(OH)_2$
$\boxed{H}$		
$Cu^{1+/2+}$	Cu_2O / CuO	$CuOH / Cu(OH)_2$
Ag^{1+}	Ag_2O	$AgOH$
Au		
Pt		

Carbonate (CO_3^{2-})

K_2CO_3

Na_2CO_3

Li_2CO_3

$CaCO_3$

$MgCO_3$

$Al_2(CO_3)_3$

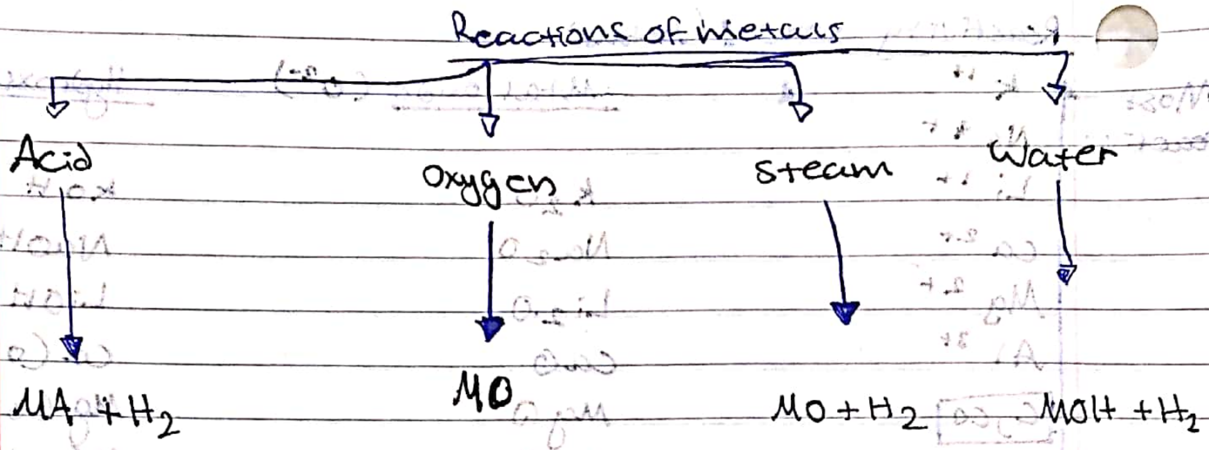
$ZnCO_3$

$FeCO_3 / Fe_2(CO_3)_3$

$PbCO_3$

$Cu_2CO_3 / CuCO_3$

Ag_2CO_3


Reactions of metals
Acid
Oxygen
Steam
Water
MA + H2
MO
MO + H2
MOH + H2

Metals	reaction with oxygen
K^{1+} Na^{1+} Li^{1+}	→ react vigrosly
Ca^{2+} Mg^{2+}	→ reacts less vig.
Al^{3+} C, CO Zn^{2+} $Fe^{2+/+3}$ Pb^{2+} H $Cu^{1+/2+}$	→ Needs energy "heat" to react
Ag^{+1}	→ No reaction

Reaction with H_2O

K Ca	React vig with water
Mg Pb	React with steam
Cu Ag	No reaction

Reaction with Acid

K Pb	react vig. with dilute acid
Cu Ag	No reaction.

Redox

In terms of oxygen

Reduction
lose O

Oxidation
gain O

Examples:

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

In terms of Hydrogen

Redox

Reduction
gain H

oxydation
lose H

Example:

oxidation: S in H_2S

$H_2S + Cl_2 \longrightarrow HCl + S$

reduction Cl_2

Oxidation State

Redox

Reduction
Decrease in charge

Oxidation
Increase in charge.

Example:

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

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

Oxidation $Mg^{0} \rightarrow Mg^{2+}$

Question:-

Identify the charges and find wich one was reduced and oxidised?

Reduction $C^{2+} \rightarrow Cu^{-}$

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

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

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

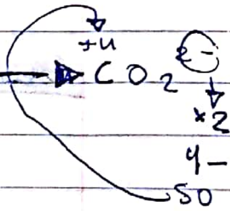
$$\overset{0}{Al} + \overset{3+}{Fe_2}\overset{2-}{O_3} \longrightarrow \overset{3+}{Al_2}\overset{2-}{O_3} + \overset{0}{Fe}$$

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

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

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

Oxidation $C^{2+} \rightarrow C^{4+}$



Rules for oxidation nos

1) The oxidation no. of any free element is **zero**

↙ ↓ ↘

mono atomic — diatomic al — polyatomic

2) The oxidation no. of any atom in a compound from group 1 is **+1** Li, Na, ka, Rb, Cs, Fr

group 2 : **+2** Mg, Ca, Ba, Sr

group 3 : **+3** always only for Al

group VII (7) : **-1** Always for (F)

3) The oxidation state of (H) is **+1** Exept with **Metals** **-1**

Example: $\overset{+1}{H}_2O$ $\quad N\overset{+1}{H}_3$ $\quad \overset{+1}{Na}\overset{-1}{H_2}$ $\quad \overset{2+}{Ca}\overset{1-}{H_2}$ $\quad C\overset{+1}{H}_4$ $\quad Al\overset{-1}{H_3}$

4) The oxidation state of O is **2-** exept in Peroxide **-1**
exept in OF_2 **+2**

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

$\overset{+1}{Na}Cl$ $\quad 1+x=0$
$x=-1$
↓
cl

CO_2^{-2} $\quad C+2(-2)=0$
$C-4=0$
$C=+4$

CO^{2-} $\quad C+(-2)=0$
$C=+2$

$\overset{+1}{H_2}CO_3^{2-}$ $\quad 2(1)+C+3(-2)=0$
$2+C-6=0$
$C-4=0$
$C=+4$

$KMnO_4$ $\quad 1 + Mn + 4(-2) = 0$

$1 + Mn - 8 = 0$

$Mn = +7$

NO $\quad N - 2 = 0$

$N = +2$

NO_2 $\quad N + 2(-2) = 0$

$N - 4 = 0$

$N = +4$

NH_3^{+1} $\quad 3 + N = 0$

$N = +3$

$N_2O_5^{-2}$ $\quad 2N + 5(-2) = 0$

$2N - 10 = 0$

$2N = 10$

$N = +5$

Now if ion:

NO_3^{1-} $\quad N + 3(-2) = -1$

$N - 6 = -1$

$N = +5$

NO_2^{1-} $\quad N + 2(-2) = -1$

$N - 4 = -1$

$N = +3$

$Cr_2O_7^{2-}$ $\quad 2Cr + 7(-2) = -2$

$2Cr - 14 = -2$

$\frac{2Cr}{2} = \frac{12}{2}$

$Cr = +6$

CrO_4^{2-} $Cr + 4(-2) = -2$

$Cr = +6$

○ Find the oxid. state of all underlined atoms :-

$\underline{V}_2O_5$ - $2V + -2(5) = 0$ $\frac{2V}{2} = \frac{10}{2}$

$2V + -10 = 0$
$+10$

$V = 5$

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

* $\underline{V}O^{2+}$ ——> for all the compound
$+4$ but we still say O^{-2} -> so $V - 2 = +2$
$+2$ $+2$
$V = 4$

$H_2\underline{S}$ -2

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

$\underline{S}O_2$ $+4$

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

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

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

* MnO_4^- $+7$ -> MnO_4^- -> $Mn + (-8) = -1$
$Mn - 8 = -1$
$+8$ $+8$
$Mn = +7$

MnO_4^{2-} $+6$

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

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

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

○ $MnO_4^{-1} + Fe^{2+} + H^+ \rightarrow Mn^{2+} + Fe^{3+} + H_2O$

Oxidation: $Fe^{2+} \rightarrow Fe^{3+}$

Reduction: $Mn^{7+} \rightarrow Mn^{+2}$

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

oxidation $S^{2-} \rightarrow S$

reduction $Cl_2 \rightarrow Cl^{-1}$

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

oxidation $C^{2+} \rightarrow C^{4+}$

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

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

Oxidation $Sn^{2+} \rightarrow Sn^{4+}$

reduction $Cr^{+6} \rightarrow Cr^{3+}$

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

↓

Not a redox

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

oxidation $O^{-1} \rightarrow O_2$

reduction $O^{-1} \rightarrow O^{-2}$

Writing half Ionic equation "Balanced":-

- Balance the atoms

- Balance the charge by adding $\bar{e}$'s to the ~~side~~ side that has greater charge by the difference

Examples:

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

Oxidation:- $Al \longrightarrow Al^{3+} + \cancel{3}\bar{e}$

Reduction:- $Fe^{3+} + \cancel{3}\bar{e} \longrightarrow Fe$

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

- $\overset{0}{Na} + \overset{+1}{H}\overset{-1}{Cl} \longrightarrow \overset{+1}{Na}\overset{-1}{Cl} + \overset{0}{H_2}$

oxidatation: $(Na \longrightarrow Na^{+1} + 1\bar{e}) \times 2$

Reduction:- $H^+ + 2\bar{e} \longrightarrow H_2$

$2Na \longrightarrow 2Na^{+1} + 2\bar{e}$

overall reaction:- $2Na + 2H^+ \longrightarrow 2Na^{+1} + H_2$

★ - $\overset{0}{Al} + \overset{+1}{H}\overset{-1}{Cl} \longrightarrow \overset{+3}{Al}\overset{-1}{Cl_3} + \overset{0}{H_2}$

oxidation :- $(Al \longrightarrow Al^{3+} + 3e^-) \times 2$

Reduction :- $(\underset{\downarrow}{②}H^{+1} + 2e^- \longrightarrow H_2) \times 3$

Since the other H is H_2

Overall :- $2Al \longrightarrow 2Al^{3+} + 6e^-$

$6H^{+1} + 6e^- \longrightarrow 3H_2$ → why not 6?

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

★ - $H^+ + MnO_4 + Fe^{2+} \longrightarrow Mn^{2+} + Fe^{3+} + H_2O$

half or oxid. :- $(5Fe^{2+} \longrightarrow 5Fe^{3+} + \cancel{5e^-}) \times 5$

half of reduction :- $Mn^{7+} + \cancel{5e^-} \longrightarrow Mn^{2+}$

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 :- $(3C^{2+} \longrightarrow 3C^{4+} + \overset{6}{\cancel{2}}e^-) \times 3$

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

overall :- $3C^{2+} + 2Fe^{3+} \longrightarrow 3C^{4+} + \cancel{2}Fe$

Half of oxidation $\longrightarrow + \bar{e}$ OiL BiG

" " Reduction $+ \bar{e} \longrightarrow$ oxidation is lose | is Reduction Gain

To identify wich species oxidise or reduce? -

oxidation state

↑ oxidation

↓ reduction

To identify the oxidation ad reduction : -

OiL RiG

Oxidising and reducing agents :-

Oxidising agent / oxidant :- The substance that is self reduced and causes the other substance to be oxidised.

Reducing agent / reductant :- The substant that it self oxidised and causes the other substance to be reduced.

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

oxidation :- Al reduction :- Fe 3+

reductant : - Al oxidant :- Fe_2O_3 compound itself

$\downarrow 0$

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

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

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

reducing agent: CO oxidising agent ZnO

Most common oxidising agent :- (never reducing agents)
(never gets oxidised)

① **Oxygen** :-

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

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

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

② Acidify Potassium manganate (KMnO4)

$\overset{+7}{Mn}O_4^{-1} \longrightarrow \overset{+2}{Mn}^{2+}$

Purple   colorless

③ Acidify Potassium dichromate ($K_2Cr_2O_7$)

$K_2\overset{+6}{Cr_2}O_7^{2-} \longrightarrow \overset{+3}{Cr}^{3+}$

Orange   green

④ **Halogens** :-

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

yellow green   colorless

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

Brown   colorless

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

brown solution   colorless

black solid

Purple gas

- Most common reducing agent :- (Never get reduced)

① **Hydrogen :**

$$H_2 \longrightarrow 2H^+ + \boxed{2e^-}$$

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

Reducing agent

② Carbon and carbon monoxide :-

$$\overset{2+}{CO} + ZnO \longrightarrow Zn \; \overset{4+}{CO_2}$$

Reducing agent

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

Reducing agent

③ **Metals :**

- More reactive metal

↓

More able to lose $\bar{e}$

↓

More able to oxidise

↓

More able to be reducing agent

K
Na
Li
Ca
Mg
Al
$\boxed{C, CO}$
Zn
Fe
Pb
$\boxed{H}$
Cu
Ag
Au → weakest reducing agen → Thus it's ion is the strong

So :-

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:-

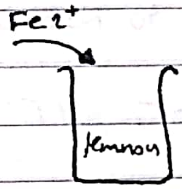
[Ex] $2I^-_{(aq)} \longrightarrow I_{2(aq)} + 2e^-$

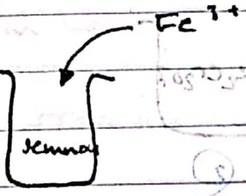
Color less   Red brown

Past Paper question:-

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

Write the observation in each of the following:-

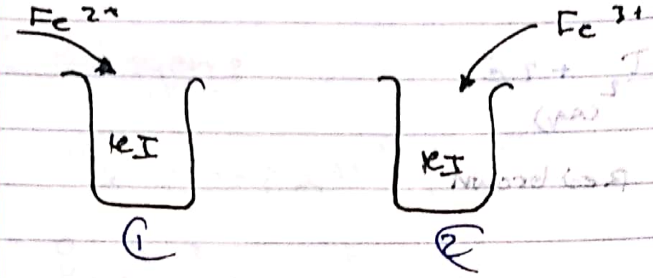




observation:

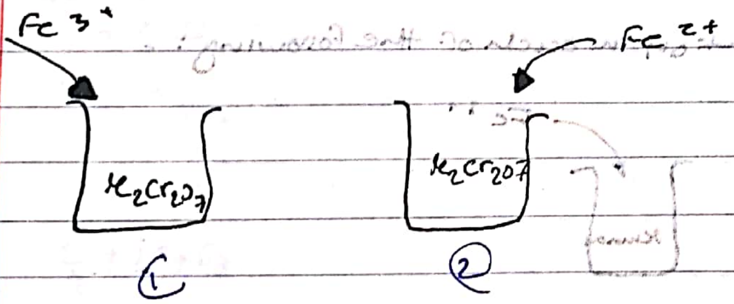
- when Fe^{2+} was added to kmnoy it changed from Purple to colorless
- when Fe^{3+} was added to kmnoy it stays Purple

same as befor question then :



- In beaker 1 it is colorless and stays the same when Fe^{2+} is added

- In beaker 2 it is colorless and changes to red brown when Fe^{3+} is added.



1 → stays orange

2 → From orange to green.

Electaysis.

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

Electrolyghts: The chemical compound that conduct electricity when molten or ageous.

Q:

- Why the solid Ionic compounds don't conduct electricity.

  The Ions are not free to move

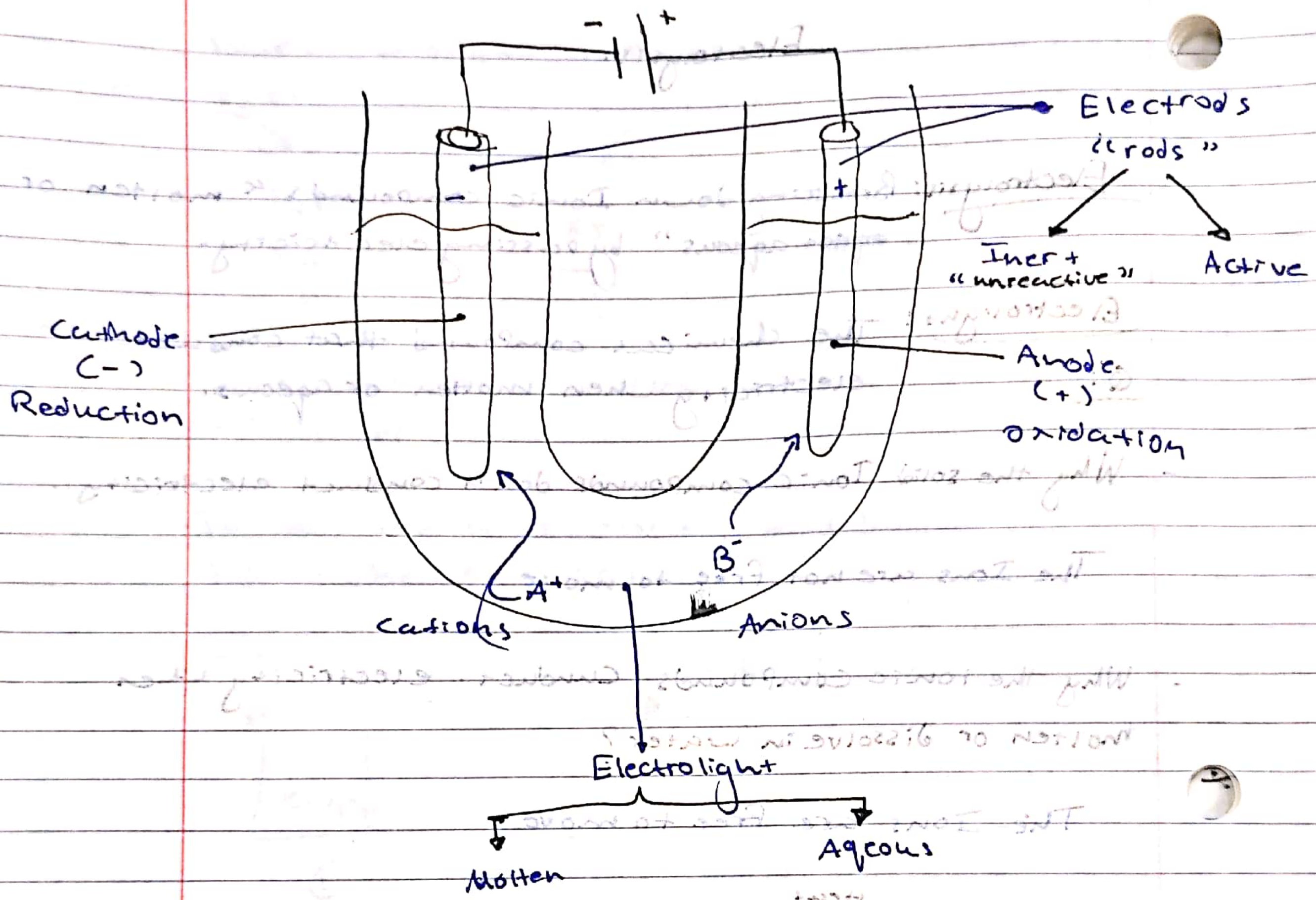
- Why the ionic compounds conduct electricity when molten or dissolve in water?

  The Ions are free to move.

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

* $NaCl_{(s)} \xrightarrow{H_2O} Na^{+}_{(aq)} + Cl^{-1}_{(aq)}$

* We change the the Ions to Element



Cathode:- The -ve rod that attracts +ve Ions (cations) where the reduction takes Place

Anode:- The +ve rod that attracts -ve Ions (Anions) wher the oxidation takes Place.

Cations :

$2\bar{e} + Mg^{2+} \longrightarrow Mg$

$1\bar{e} + Na^{+} \longrightarrow Na$

$2\bar{e} + Cu^{2+} \longrightarrow Cu$

$3\bar{e} + Al^{3+} \longrightarrow Al$

Deposite of metal

$1\bar{e} + H^{+} \longrightarrow H_2$ bubbles of colorless gas

$\boxed{1\bar{e} + A^{+} \longrightarrow A}$

Anions :

$2F^{-1} \longrightarrow F_2 + 2\bar{e}$ bubbles of yellow gas

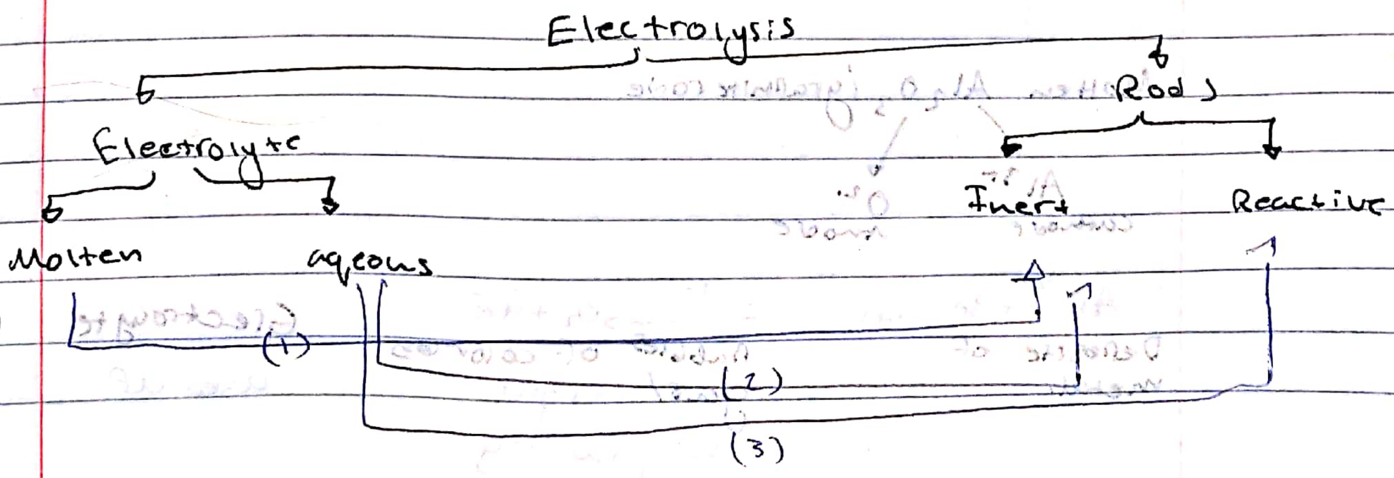
$2Cl^{-1} \longrightarrow Cl_2 + 2\bar{e}$ Green yellow gas

$2Br^{-1} \longrightarrow Br_2 + 2\bar{e}$ Red brown liquid

$2I^{-1} \longrightarrow I_2 + 2\bar{e}$ Black solid, Purple gas

$2O^{2-} \longrightarrow O_2 + 4\bar{e}$ Colorless gas

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



- Moten using Inert rod (example)
* Electrolysis for molten NaCl using graphite rod

$NaCl_{(l)}$

Na^{+1}	Cl^{-1}
Cathode	Anode
$1\bar{e} + Na^{+1} \to Na$	$2Cl^{-1} \to Cl_2 + 2\bar{e}$
Deposite of metal	bubbles of green in yellow gas.

Electrolyte: Used up

Molten KI / graphite rods

K^{+1}	I^{-1}
Cathode	Anode
$1\bar{e} + K^{+1} \to K$	$2I^{-} \to I_2 + 2\bar{e}$
Deposite of metal	Purple gas

Electrolyte : Used up.

Molten Al_2O_3 / graphite rode

Al^{3+}	O^{2-}	
cathode	Anode	
$Al^{3+} + 3\bar{e} \to Al$	$2O^{2-} \to O_2 + 4\bar{e}$	Electrolyte
Deposite of metal	Bubbles of colorless gas/ relight the glowing spring	used up

- Moten using Inert rod (example)

* Electrolysis for molten NaCl using graphite rod

$NaCl_{(l)}$

Na^{+1}	Cl^{-1}
Cathode	Anode
$1\bar{e} + Na^{+1} \rightarrow Na$	$2Cl^{-1} \rightarrow Cl_2 + 2\bar{e}$
deposite of metal	bubbles of green in yellow gas.

Electrolyte: Used up

Molten KI / graphite rods

K^{+1}	I^{-1}
Cathode	Anode
$1\bar{e} + K^{+1} \rightarrow K$	$2I^{-} \rightarrow I_2 + 2\bar{e}$
Deposite of metal	Purple gas

Electrolyte : Used up.

Molten Al_2O_3 / graphite rode

Al^{3+}	O^{2-}	
Cathode	Anode	
$Al^{3+} + 3\bar{e} \rightarrow Al$	$2O^{2-} \rightarrow O_2 + 4\bar{e}$	Electrolyte
Deposite of metal	Bubbles of colorless gas/ relight the glowing splint	used up

Molten $CuCl_2$ /graphite rods

Cu^{2+} Cathode

Cl^{-1} Anode

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

deposite of metal

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

bubbles of greenyellow gas / bleach damp litmus paper.

Electrolyte:

used up

Electrolysis for aqeous electrolyte using graphite :

$AB_{(aq)}$

$\leftarrow A^+$ $\qquad$ $B^- \rightarrow B_2$

$2 \leftarrow H^+$ $\qquad$ $OH^- \rightarrow O_2$

Cathode $\qquad$ Anode

Ruels:

At Cathode

The less reactive Ion is more likely to reduce

K^{+1}

Na^{+1}

Li^{+1}

Ca^{2+}

Mg^{2+}

Al^{3+}

Zn^{2+}

Fe^{3+}

Pb^{+2}

$\boxed{H}$

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

memoris :

$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$ (bubbles)

Electrolysis for concentrated aqeous sodium chlorid "Brine"

$NaCl_{(aq)}$

Na^+ Cl^-

H^+ OH^-

Cathode Anode

Electrolyte: NaOH

$2H^+ + 2e^- \rightarrow H_2$ $2Cl^- \rightarrow Cl_2 + 2e^-$

bubbles of colorless gas

bubble of green yellow gas

Dilute

$NaCl_{(aq)}$

Na^+ Cl^-

H^+ OH^-

Cathode Anode

wins: $2H^+ + 2e^- \rightarrow H_2$ $4OH^- \rightarrow H_2O + O_2 + 4e^-$

bubbles of colorless gas

bubbles of colorless gas

∇

Electrolyte: NaCl

(more concentr water is less)

$CuSO_4$ (aq)

Cu^{+2} +2 $\qquad SO_4^{2-}$

$H^+ \qquad OH^-$

Cathode $\qquad$ Anode

$2\bar{e} + Cu^{+2} \rightarrow Cu \qquad 4OH \rightarrow 2H_2O + O_2 + 4\bar{e}$

deposite of red brown metal $\qquad$ bubbles of colorless gas

Electrolyte : H_2SO_4

KNO_3 -

$K^+ \qquad NO_3^-$

$H^+ \qquad OH^-$

$2e^- + 2H^+ \rightarrow H_2 \qquad$ OH wins $\rightarrow 4OH \rightarrow 2H_2O + O_2 + 4e$

Bubbles of colorless gas $\qquad$ Bubbles of colorless gas

Electrolyte : - KNO_3 more concentrated

concentrated

$CuCl_2$

$Cu^{2+} \qquad Cl_2^-$

$H^+ \qquad OH^-$

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

Deposite of metal $\qquad$ bubbles of green - yellow gas

Electrolyte : less concentrated

can't say H_2O

concentrate. $NaBr$

$$\begin{tikzcd}[column sep=small] & NaBr \arrow[dl] \arrow[dr] & \\ Na^+ & & Br^- \end{tikzcd}$$

H^+ OH^-

cathode Anode

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

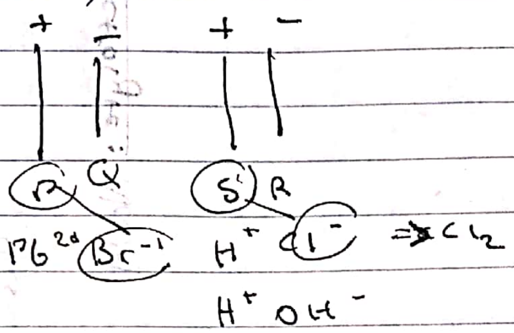
red brown solution

Electrolyte: $NaOH$

Δ Answer of Paper on group, redox ----

1) a   2) B   3) B -->

4)   5) A



H.w in:

Q6) multiple choice + Q3 All + Q4(a) + Q5 + Q7

* Electrolysis for brine solution NaCl (aq) concentrated : -

NaCl (aq)

Na^+ Cl^-

H^+ OH^-

Cathode Anode

$2H^+ + 2e^- \rightarrow H_2$ $2Cl^- \rightarrow Cl_2 + 2e^-$

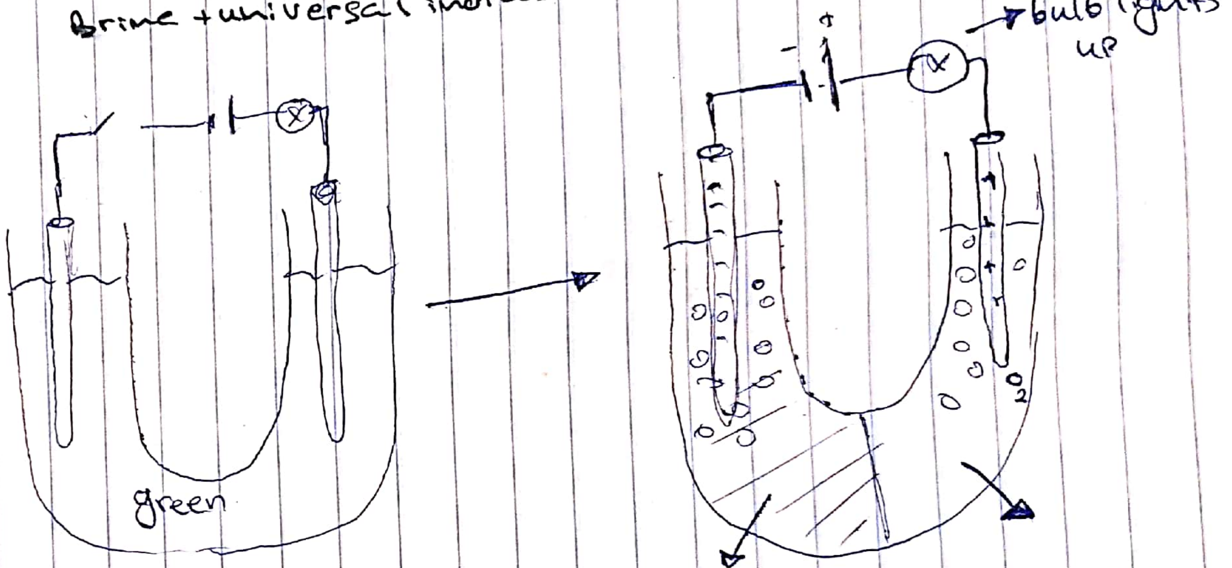
bubbles of colorless gas

bubbles of green yellow gas

Electrolyte : NaOH

observations :

Brine + universal indicator



The Cl_2 delay in its appearance.
- some Cl_2 react with NaOH (Bleaching)

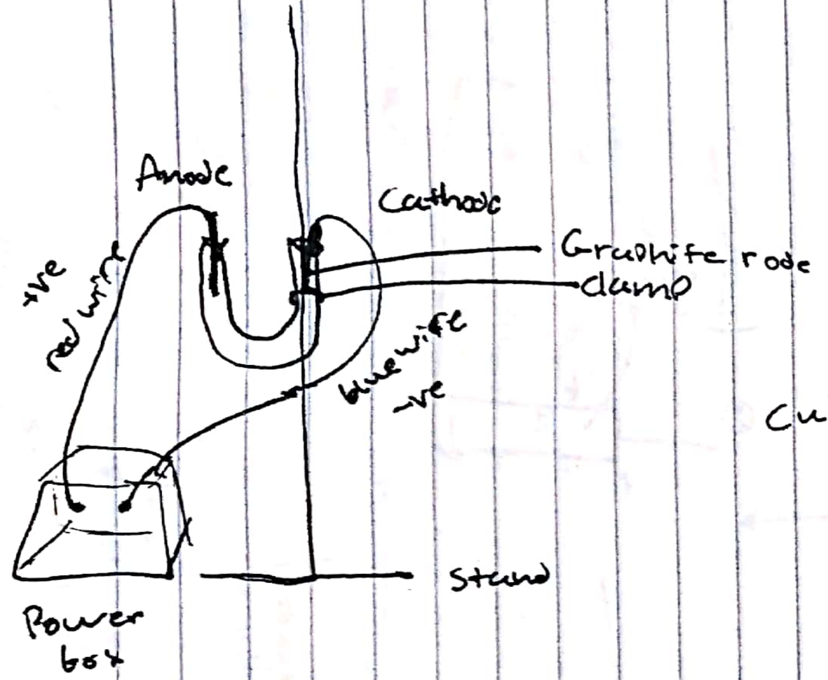
Purple NaOH is an alkali

Colorless Cl_2 is a bleaching agent

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

~ by using inverted measuring cylinder.

Experiments in lab :



①

$CuSO_4$ (aq)] blue

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

H^+ OH^-

Cathode Anode

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

Electrolyte : H_2SO_4 → colorless

Conc.

② KI (aq)

K^+ I^-

H^+ OH^-

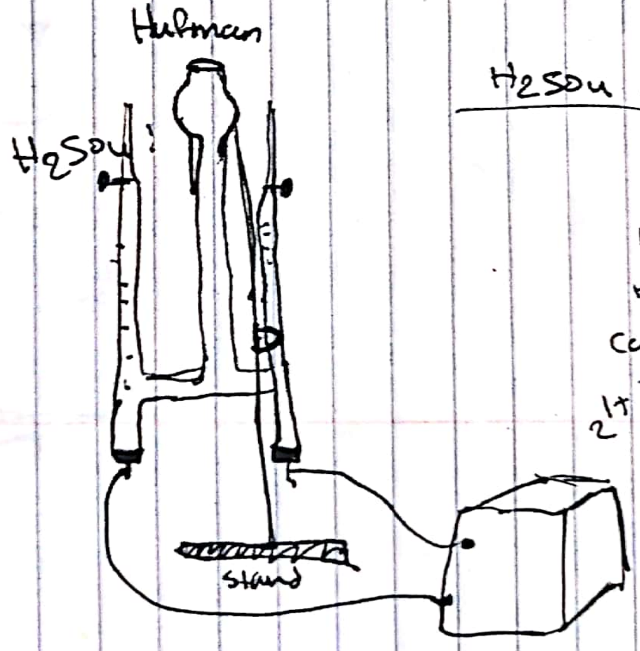
↓ ↓

H_2 I_2

↓ ↓

H_2 gas Produced

red brown color (solution) (Iodine)



H_2SO_4 :

H_2SO_4

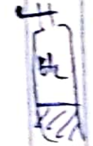
H^+ SO_4^{-2}

H^+ OH^-

Cathode Anode

$2H^+ + 2e^- \rightarrow H_2$ $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$

→ becomes:



more H_2 gas formed than O_2

because

↓

Ratio 2:1

overall:

$4H^+ \rightarrow 4e^- \rightarrow 2 - 1$

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

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

* Electrolysis for aqeous electrolyte using Active rod.

* the active rod made from the same metal ion in the electrolight.

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

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

Example:

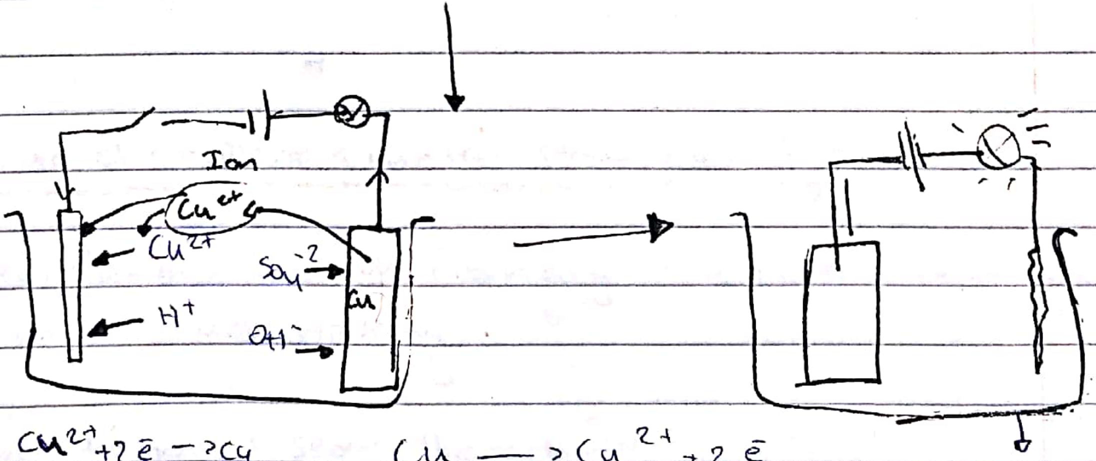
$CuSO_{4(aq)}$

Cu^{2+} H^+ → Cathode

SO_4^{2-} x, OH^- x → Anode] → Neither OH^- nor SO_4^{2-} oxidise the Anode itself will oxidise

$Cu^{+2} + 2\bar{e} \rightarrow Cu$ — $Cu^0 \rightarrow Cu^{2+} + 2\bar{e}$

Deposite of red brown solid mass ↑



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

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

Cu^{2+}: to cathode through electrolyte

$2\bar{e}$: To cathode through the wires

Cathode:- It's mass ↑ Cu^{2+} reduced as Cu deposite

Anode: It's mass decreased Cu oxidise and lose $\bar{e}$'s

Always
* over all:- The electrolyte stays the same because the anode oxidise and replaced the Cu^{2+} in the electrolyte with the same rate

Applications on electrolysis

Molten / Inert
⇓
Extraction of Aluminum

Aqeous / Inert
⇓
Preperation of Solution

conc NaCl (aq)

Na^+ — $Cl^- \Rightarrow Cl_2$

$H_2 \Leftarrow H^+$ — OH^-

$\boxed{NaOH}$

Purifying water

Aqeous / Active

① Electro ~~lysis~~ Plating

② Refining / Purifying metals

Electroplating:-

It is coating a metal with another metal using electricity.

why do we do it?

① To Prevent rusting

② More attractive

How to electroplate a metal spoon with Ag?

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

2- Make the metal spoon the cathode.

3- The Anode must be Ag

4- The electrolyte must have Ag^+ eg $AgNO_3$

5- Switch on the circuit

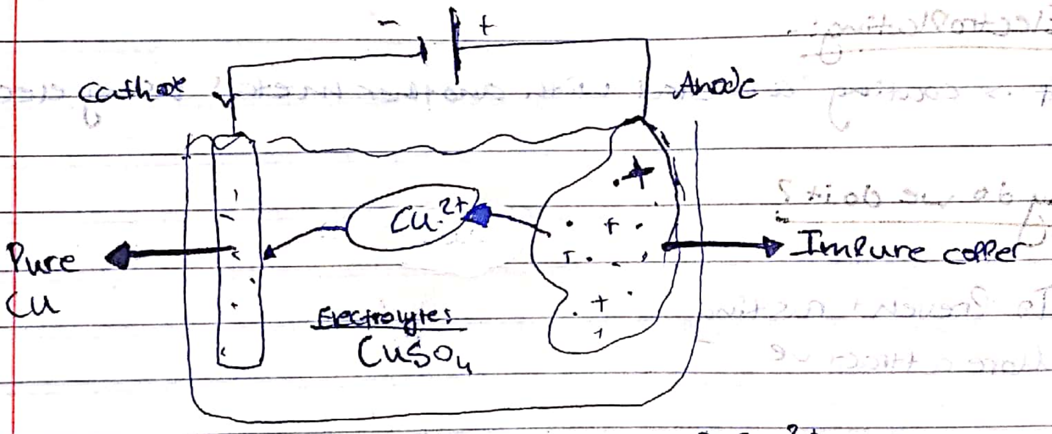
6- rotate the metal spoon to ensure an equal distribution.

7- rinse the spoon with distaled water

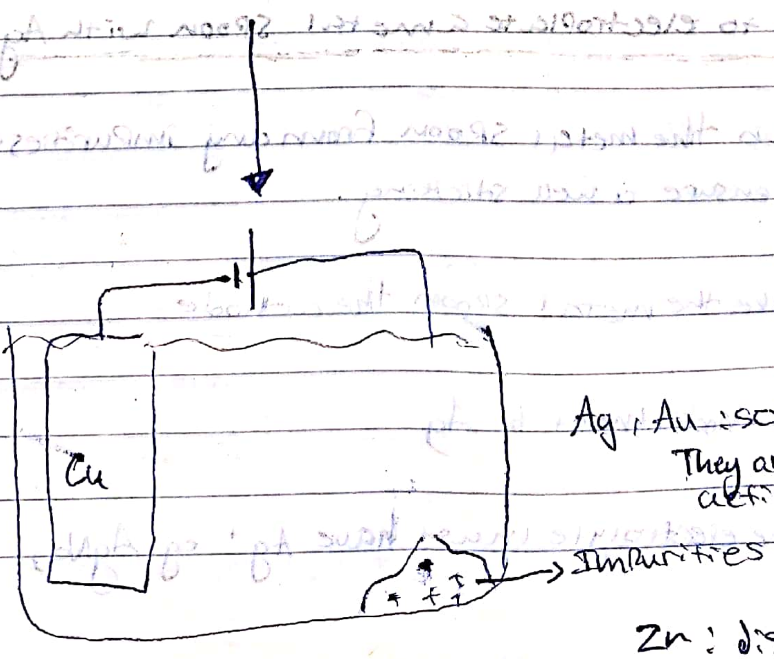
8- Dry in oven

Example: Question:

How can you collect copper from Impure copper



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



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

Zn: displace Cu from $CuSO_4$

Extraction of metals :

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

ore.		K	Electrolysis /Molten/ graphite ↳ Because if (aq) H_2 will win
NaCl Brine		← Na	
		Li	
		Ca	
		Mg	
Bauxite	Al_2O_3	← Al	
		C, CO	
zinc blende	ZnS	← Zn	Reduction by C, CO
Hematite	Fe_2O_3	← Fe	
		Pb	
		H	
copper sulfide	CuS	← Cu	Reduction by H_2
		Ag	
		Au	

Example!

Extraction of Al :-

Ore : Bauxite Al_2O_3

Methode : Electrolysis for molten ore using graphite.

- But there is a problem... *the m.p of Al_2O_3 is 2000°C so :-

We use dissolve Al_2O_3 in molten cryolyte Na_3AlF_6, why? no need to memoise

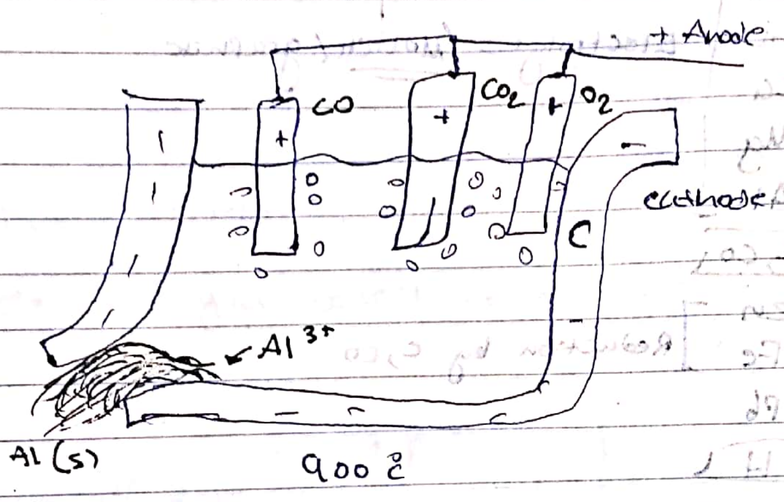
1- To Lower the m.P to 900°C so less cost.

2- To increase the electrical conductivity

$$Al_2O_3 (l)$$

$$\swarrow \quad \searrow$$

Al^{3+}	O^{2-}
Cathode	Anode
$Al^{3+} + 3e^- \rightarrow Al$	$2O^{2-} \rightarrow O_2 + 4e^-$
Deposit of metal	bubbles of gas.



- Produced
- Found

Gases Produced at anode

1 - O_2

2 - CO_2] Reaction of Anode with O_2

3 - CO

so we must replace the Anode Periodically

because graphit rode reacted because high temp.

Property of Al	Use of Al
Malleable →	Window frame, Cooking utensils
low dencity →	Air bodies
form non-toxic oxide layer →	food cans
conduct electricity. ductile. →	Electrical wire

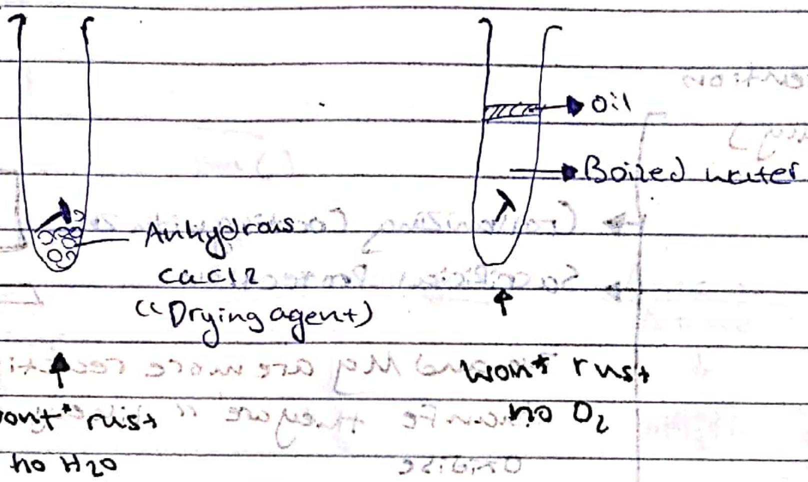
Slow reaction
So in experiment
leave minimum
a week

Rusting

- It is the reaction of Iron with both H_2O and O_2

$$\underbrace{\overset{0}{Fe} + O_2 \xrightarrow{H_2O} \overset{+3}{Fe_2}O_3 \cdot n\ H_2O}_{\text{Oxidation reaction}}$$

Ex 1



Question! rust

Two outs Prevension solutions A and B.

Plan an experement to show which brand is the best (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 1 week
- Dry the iron nail
- Measure the mass
- repeat the experiment using solution B
- The experiment which causes less increase in mass is the better solution.

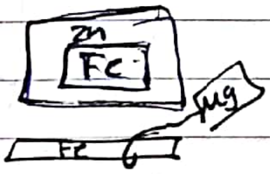
Rust Prevention

- Paint
- oiling
- Greasing
- Cover with Plastic

* Prevent H_2O and O_2 from reacting Fe

Rust Prevention (chemically)

- Galvanizing Coating with Zn



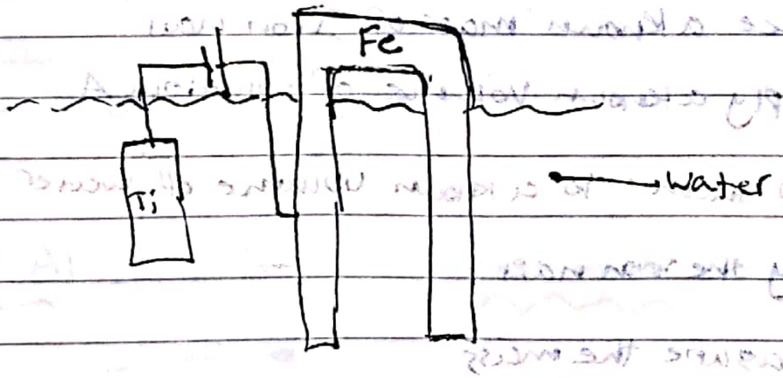
- Sacrificial Protection

Zn and Mg are more reactive than Fe they are " likely to oxidise

so

Fe is less likely to rust (oxidise)

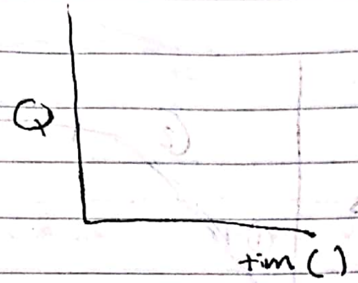
- Electroplating
- Cathodic Protection



Rate of reaction :-

Rate = $\frac{\text{Change in quantity}}{\text{Change in time}} = \frac{\Delta Q}{\Delta t}$

on graph :



Examples :

$\frac{\Delta PH}{\Delta time}$ ↓ unit: $\frac{1}{s}$

$\frac{\Delta \text{volume of gas}}{\Delta time}$ ↓ $\frac{cm^3}{s}$

$\frac{\Delta mass}{\Delta Time}$ ↓ $\frac{g}{s}$

$\frac{\Delta Temp}{\Delta time}$ ↓ $\frac{^\circ C}{s}$

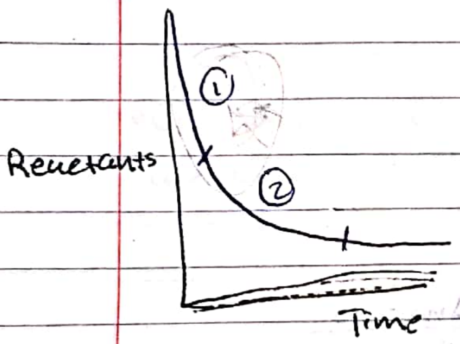
$\frac{\Delta \text{elect. cond}}{\Delta time}$ ↓ $\frac{1}{s}$

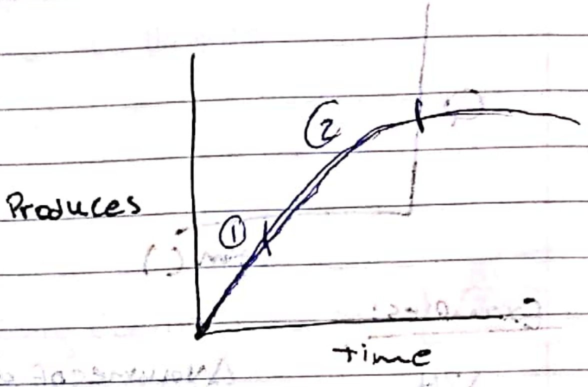
$\frac{\Delta \text{lights intencity}}{\Delta time}$ ↓ $\frac{1}{s}$

To measure the rate
of reaction

Measure how fast
the reactants consumed
Per ~~[illegible]~~ time
unit

Measure how fast the
Product Produced Per unit
time





Region (1) :- The rate is the highest => from curve:
Steepest
(high gradient)

- more reactants
- so more Particle
- so more effective collisions

Region (2) : The rate is slower => from the curve:
less steep
lower gradiend

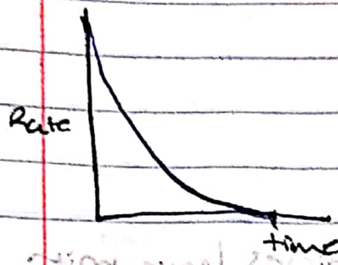
- less Reactants
- less particles
- so less effective collisions.

Region (3) : The reaction is over => from curve:
Horizontal line gradient
≈0

- No more limmiting reagent
- No more effective collisions

question!

How does the rate change with time?

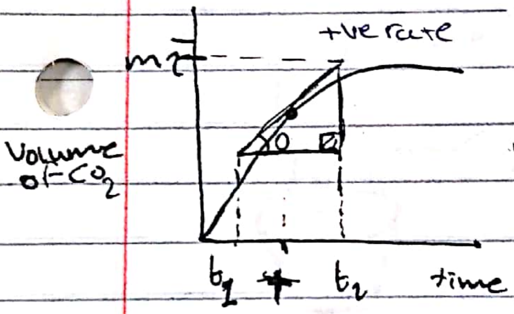


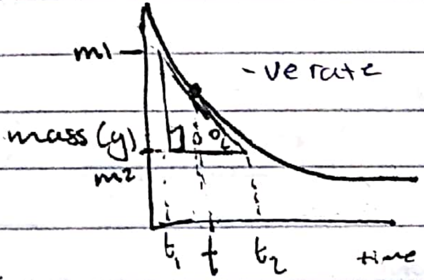
As time passes
rate decreases

Example cambridge might bring:

From the graph how to measure the rate:

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





$$\frac{\Delta m}{\Delta T} = \frac{m_2 - m_1}{t_2 - t_1}$$

$m_2 < m_1$

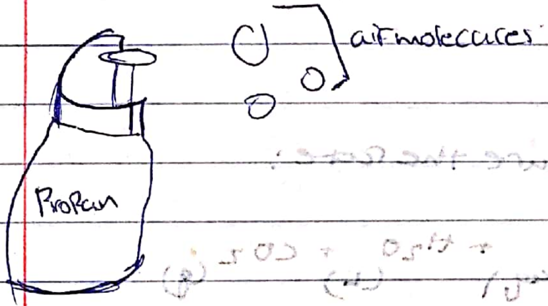
① Since it's curved and hard to calculate gradient draw a line that intersect with most Points, lower a triangle from it and see where the base of the triangle measures.

▲ 3 main conditions for any chemical reaction:-

① The reactants must be suitable:-

② The reactants must collide

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



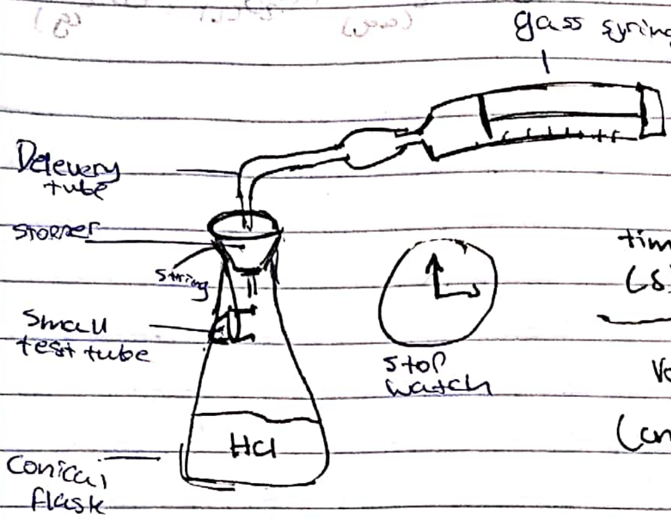
This is called:-

Activation energy.

How can you know therate?,

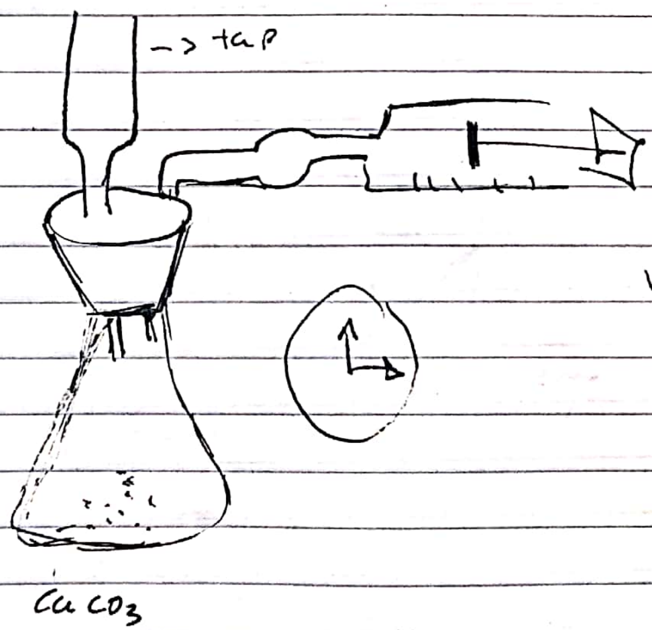
① Measure the rate by monitoring the volume of gas!-

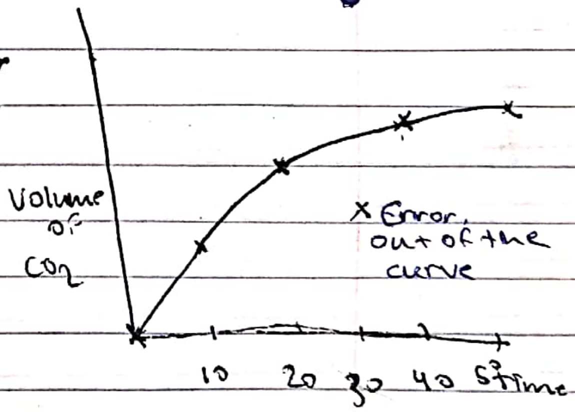
$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$



over: no more - limiting factors

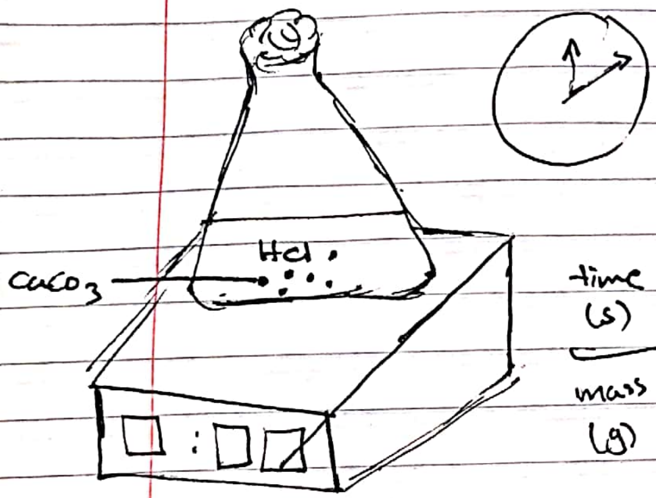
time (s)	0	10	20	30	40	50
Volume (cm3)	0	8	13	15	16	18
		+2	+5	+2	+1	





② Measuring the rate by monitoring the change in mass of conical flask + contents per unit time.

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



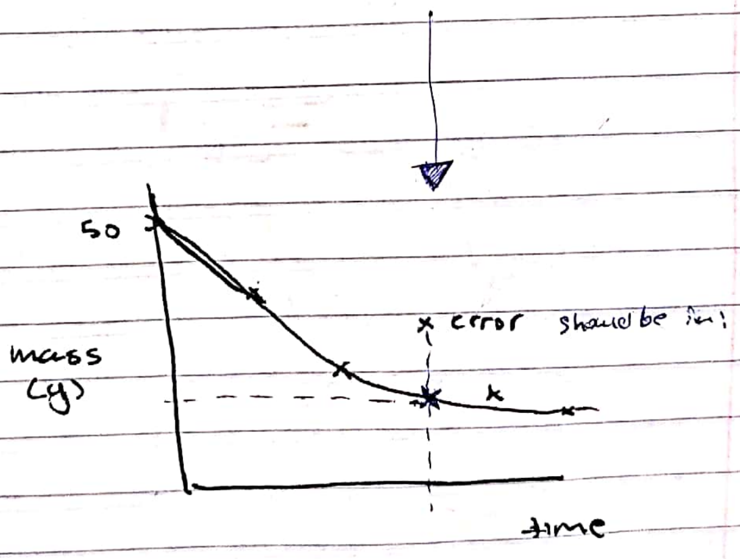
? Why is mass decreasing ?

CO_2 escape

over

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

-5 -3 -1 -0.5

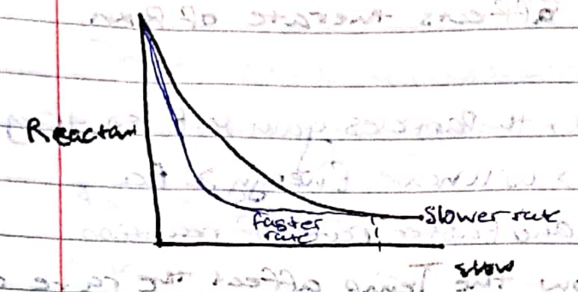


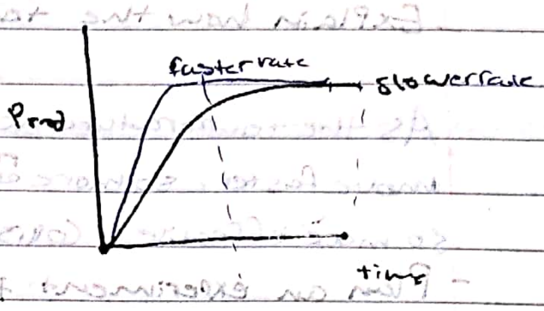
★ What is meant by increasing the rate of reaction :-

- Same Product with less time

OR

More Product Per the same time





★ Factors affect the rate of reaction :-

① Temperature

② surface area

③ concentration

④ Pressure (only for gases)

⑤ Light

⑥ catalyst.

↑temp to endo
↓temp to exo

Press: goes to less moles

① Temperature:

- state how the temp effects the rate of Rxn :-

As temperature increases the rate of reaction increases

- Explain how the temp affects the rate of Rxn

As the temperature increases, the Particles gain K.E so they move faster. so more Particles will have Energy ≥ Ea so more effective. Collisions and faster rate of reaction

-- Plan an experment to show how the temp affect the rate of Rxn?

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

exp1: $m_{CaCO_3} = 2g$ lumps

$V = 0.1 dm^3$

$M = 0.1 mol/dm^3$

Temp = 25°C

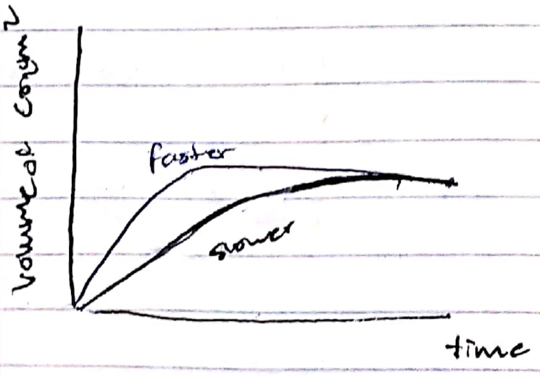
Volume of CO_2 Produced Per unit time

exp2: $m_{CaCO_3} = 2g$ Lumps

$V = 0.1 dm^3$

$M = 0.1 mol/dm^3$

Temp = 50°C



② Surface Area: * by reducing the Particle size
↓
by crashing → using mortar and Pestile.

- State how the surface area affect the rate of reaction :-

As the surface area increases

The Rate of reaction increases

- Explain how the surface area affects the rate of reaction :-

As the surface area increases,
more Particles exposed to the reaction.
so more effective collisions Per unit time
so faster rate of reaction.

- Plan an experiment to show how the surface area affect the rate of reaction?

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

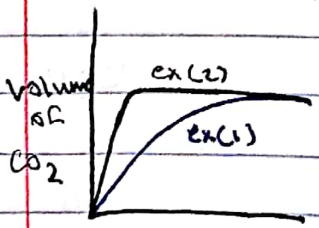
Answer:

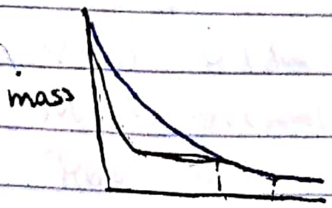
Ex 1: mass = 2g
Lumps

V HCl = 0.1 dm^3
M HCl = 1 mol/dm^3
Temp = 25°c

Ex 2: mass = 2g
Powder

V HCl = 0.1 dm^3
M HCl = 1 mol/dm^3
Temp = 25°c





③ Concentration "Amount"

- State how the concentration affect the rate of reaction :-

As the concentration increases

the rate of reaction increases

- Explain how the concentration affect the rate of reaction:-

As the rate of reaction increases:

more Particles.

so more effective collisions Per unit time.

So faster rate of reaction

Plan experiment1

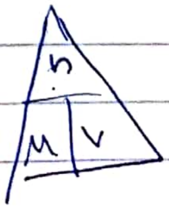
needed 0.005 0.04

add 0.02 0.01

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

excess

uses moles



Exp1 mass: 2.0g Lumps Mr=100

V_{HCl} = 0.1dm³

M_{HCl} = 0.1mol/dm³

Temp = 25°C

Exp2 mass: 2.0g Lumps

VHCl: 0.1 dm³

MHCl: 0.2mol/dm³

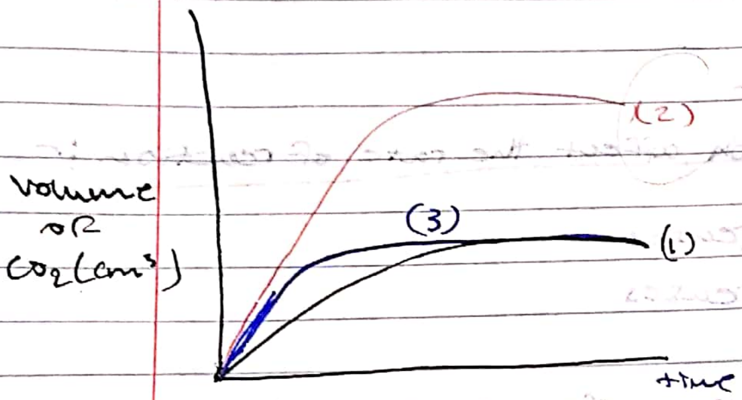
Temp : 25 °C

EXP3 Mass : 4.0g Lumps

VHCl: 0.1dm³

MHCl: 0.1mol/dm³

Temp 25°C



more limitting —> faster rate
more Product

more excess —> faster rate

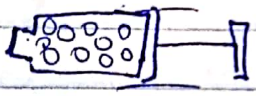
(4) Pressure:-

(only gaseous reactants)
(only for gases)

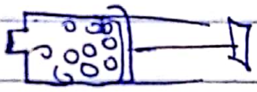
- Explain how Pressure affect the rate of reaction?

Answer: As the pressure increase (by lowering the volume)
more Particles per unit volume
so more effective collisions per unit time.
So faster rate of reaction

"more Particles per unit volume"



$\frac{10 \text{ Particles}}{1L} = 10$



$\frac{10 \text{ Particles}}{0.5L} = 20$

-10 in one Liter is equilivant to 20particles in 0.5L meaning
greater Pressure.

(5) Light "for Photochemical reaction: -

- **Photosynthesis**

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6O_2$$

★ photographic films OUT OF SYL (not in)

(6) Catalyst:

It is:
A chemical substance that speeds up the rate of reaction without being used up.

- Enzyme:
Biological catalyst

- E.A: (Activation energy):

The minimum amount of energy needed to start the reaction

↑ EA slower rate
↓ EA Faster rate

- How does the catalyst speed up the reaction?

It provides an alternative pathway with lowe Ea
so more particles will have energy equal to or greater than Ea
so more effective collisions per unit time
so faster ~~ao~~ rate of reaction.

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

Q1) Plan an experiment to show that CuO is a catalyst for this Reaction :-

→ Take known volume of known concentration of H_2O_2.

→ Add a known mass of CuO

→ Measure the volume of O_2 Produced Per unit time.

→ Repeat the experiment without CuO

→ **Conclusion**: The experiment with CuO produce more O_2 Per the same unit time.

Q2) Plan an experiment to show which Catalyst is better CuO or MnO_2 :-

→ known Volume of know concentration of H_2O_2

→ Add known mass of CuO

→ Measure the volume of O_2 Per unit time.

→ Repeat ~~w~~ with MnO_2 (same mass)

→ **Conclusion**: The experiment that Produce more O_2 Per the same unit time is the better catalyst

Q3) Plan an experiment to show that the CuO not used up during the reaction?

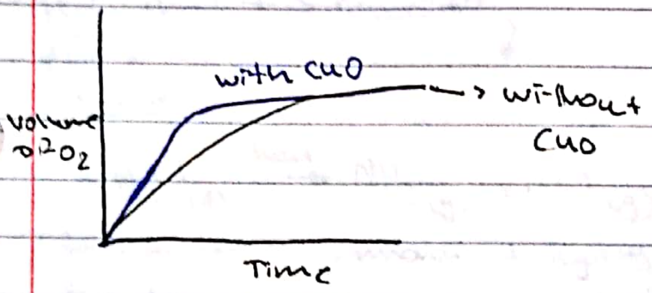
→ Add a known mass of CuO to H_2O_2 until no more bubbles of O_2

→ Filter the mixture

→ Dry in oven

→ Remeasure the mass

→ Conclusion: The mass will not change.



* HCl when gas isn't acidic so you can't say Hydrochloric acid

Reversible Reaction

Chemical reactions

One way
*(irriversable)

Both ways
*(reversable)

Reactants $\xrightarrow{\text{Forward}}$ Products

Reactant $\underset{\text{backward}}{\overset{\text{Forward}}{\rightleftharpoons}}$ Products

$Mg + HCl \rightarrow MgCl_2 + H_2$

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

$3H_2 + N_2 \rightleftharpoons 2NH_3$

$2SO_2 + O_2 \rightleftharpoons 2SO_3$

~~N~~ $NH_4Cl \rightleftharpoons NH_3 + HCl$

Profe that it is reversable

*[Ex]

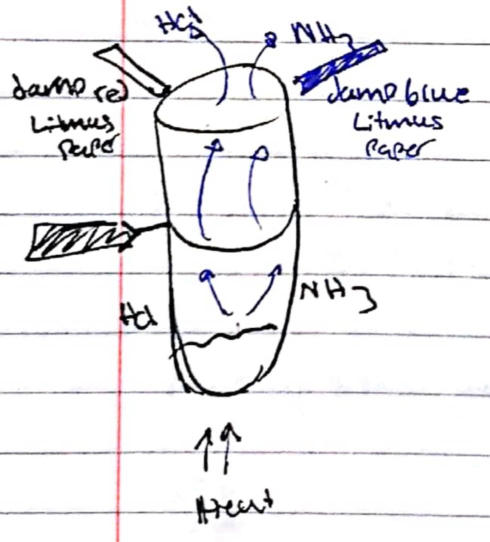
Foward

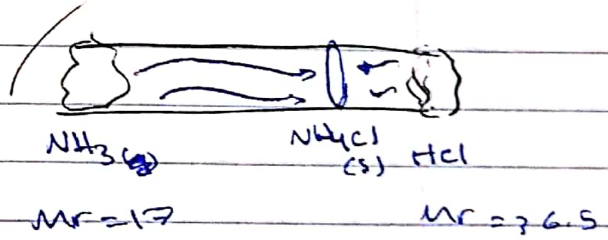
$NH_4Cl_{(s)} \xrightarrow{\text{heat}} NH_{3(g)} + HCl_{(g)}$

Ammonium chloride   Ammonia + hydrogen chloride

Backward

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

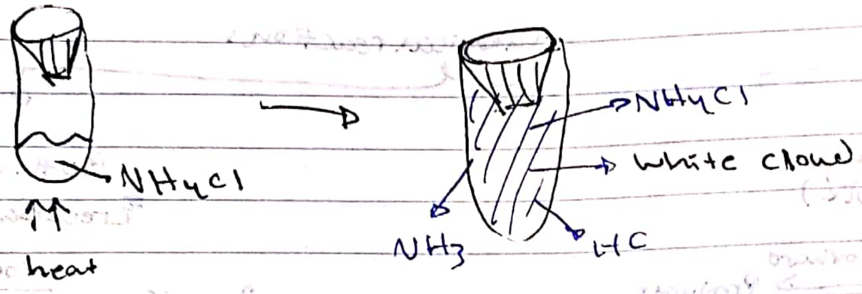




Q) which damp litmus paper will change it's color first explain your answer?

The damp red litmus paper changes it's color to blue first.
since $NH_{3(g)}$ is Alkali and lighter than $HCl_{(g)}$ which is acidic

How can we obtain all of them together?



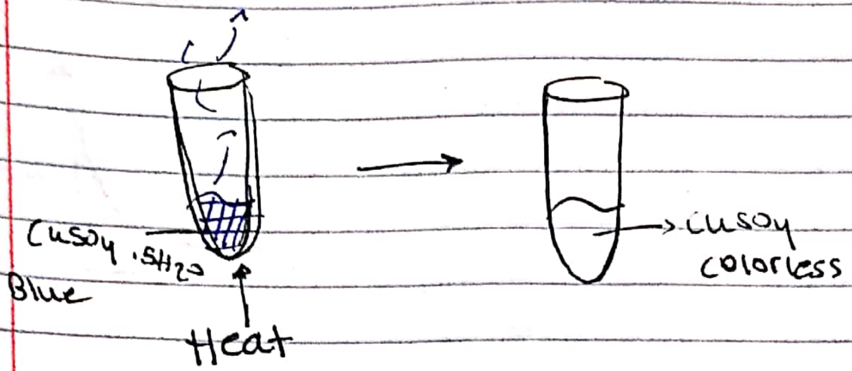
① They turn into gas

② since there is bung it won't escape

③ They react (the gases)

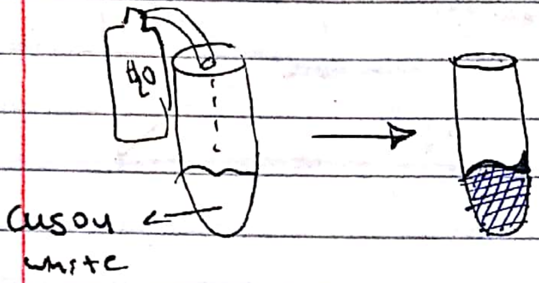
* $CuSO_4 \cdot 5H_2O_{(s)} \xrightarrow{Heat} CuSO_{4(s)} + 5H_2O$

Blue white



$CuSO_{4(s)}$ ~~$+5H_2O$~~ $\longrightarrow CuSO_4 \cdot 5H_2O$

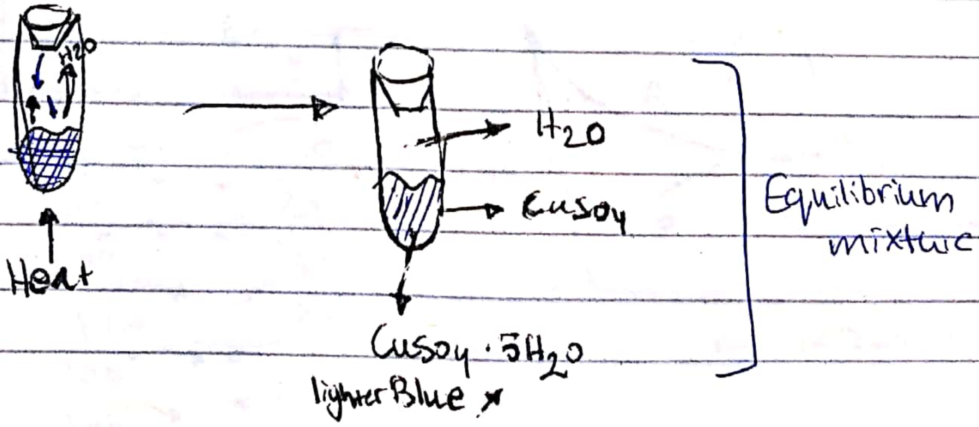
white



To make it a reversible reaction:

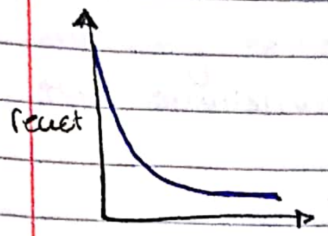
used a closed system.

$CuSO_4 \cdot 5H_2O \overset{\Delta}{\rightleftharpoons} CuSO_4 + 5H_2O$



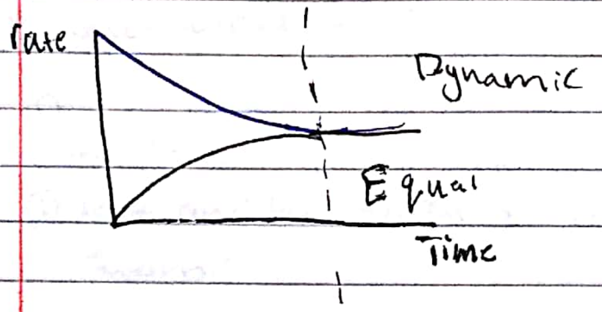
oneway :

Reactants → products



Dynamic Euilibrium :

Reactants $\rightleftharpoons$ Product

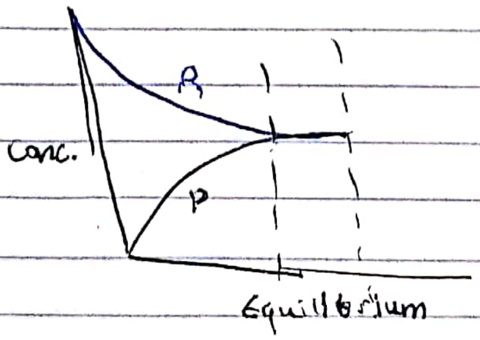


Dynamic equal :- When the rate of Forward equal to the rate of backward

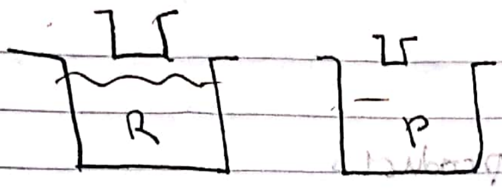
- when answering question write the when about the concentration in the next page

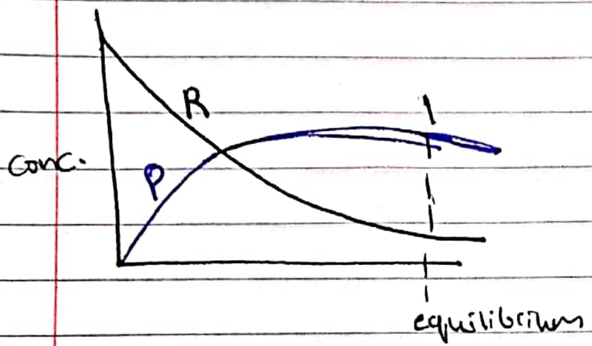
Exp we do in class with waters :-

200 →	← 0
180 →	← 20
150 →	← 50
120 →	← 30
100 →	← 100
100 →	← 100

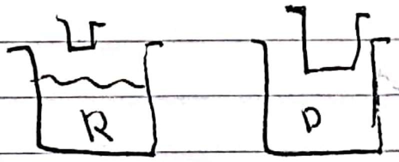


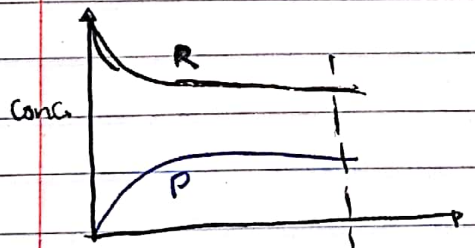
①





②





Dinamic equilibrium

In terms of concentration : When the Concentration of Reactants and Products are constant

↓

TiO ?

Remmember concentration then write constant

↓T exo ↑T endo

Le chateler Principle

Deff. :-

It is If the system is at equilibrium $\rightleftharpoons$
and any external factor distrubts the equilibrium
the equilibrium shifts it self either to the forward $\underset{\leftarrow}{\longrightarrow}$
or to the backward $\overset{\rightarrow}{\longleftarrow}$
To return back to the equilibrium

Factors that effect equilibrium :-

- → Temperature
- → Pressure
- → Concentration

(1) Temp :-

① look and find which is the endo thermic and wich is the exo thermic.

	Rate ;
② ↑Temp Shifts to endo (ΔH = +ve)	↑↑ endo ↑ exo
↓Temp Shifts to exo (ΔH = -ve)	↓↓ endo ↓ exo

(2) Pressure !

↑ Pressure to less gas moles
↓ Pressure to more gas moles

Rate

↑↑ rate of less gass mole
↑ rate of more gass mol
↓↓ rate of less gas mole
↓ rate of more gass mol

(1) In temperature:

rule:

- As the temperature Increases the equilibrium shifts to the side that Absorbs heat which is the Endothermic side

- As the temperature Decreases the equilibrium shifts to the side that Releases heat which is the Exothermic side

Examples: -

Q) $w + x \rightleftharpoons y + z$ $\Delta H = -ve$ with ↑ Temp

Answer: -

$w + x \underset{endo}{\overset{Exo}{\rightleftharpoons}} y + z$ $\Delta H = -ve$] exo

↑ Temp Shifts backwards to the endo

Rate of endo ↑↑

Rate of exo ↑

↑w ↑x ↓y ↓z

Q): with lower temperature: -

↓ temp shifts ~~towar~~ forward to the exo

Rate of endo ↓↓

Rate of exo ↓

↓w ↓x ↑x ↑z

Q) $A + B \rightleftharpoons C + D$ $\Delta H = +ve$

Answer :-

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

AT ↑ Temp :-

↑ temp shifts forward to the endo

Rate of forward ↑↑

Rate of backward ↑↑

A↓ ↓B ↑C ↑D

At ↓ temp :-

↓ Temp shifts backward to the exo

Rate of forward ↓↓

Rate of backward ↓

↑A ↑B ↓C ↓C

(2) **Pressure**
(Only in gas)

↑ Pressure => Shifts to the side with **less** Pressure which has **less** gas moles.

↓ Pressure => Shifts to the side with **more** Pressure which has **more** gas moles.

↑ Pressure: Rate of less gas mol ↑↑, rate of more gas mol ↑ } Shifts to the less gas moles

↓ Pressure: rate of less gas mole ↓↓, rate of more gas mole ↓ } Shift: to ~~[illegible]~~ more gas moles

Example:

$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_{3(g)}$

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

Q) $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$

mol = 0   mol = 1

↑ Pressure shift backward : To the side with less gas mole

↓ Pressure Shift forward ; To the side with more gas mole

Q) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

mol = 2   mol = 2

↑ Pressure has no effect on the position of equilibrium they have the same number of moles.

Effect	Rate of forward	Rate of backward	yeild of NH_3
↑ Temp	↑	↑	↓
↑ Pressure	↑	↑	↑
↓ Pressure	↓	↓	↓

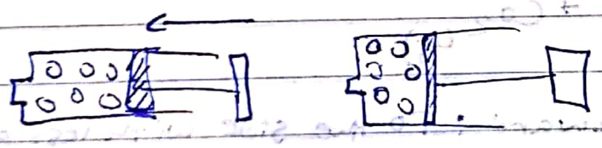
Q:- The reaction $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ at equilibrium :-
Purple colorless

* Why by increasing the Pressure, the position of equilibrium doesn't change?

Because both sides of the reaction have the same number of gas moles.

* Why by increasing the pressure the mixture becomes more Purple?

The gas ~~molecules~~ Particles of I_2 become closer together and the color appears more condense



Q:- Mixture of NO_2 and N_2O_4 at equal 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 stays Paler
(D) Becomes Paler goes darker

Answer
B

3) Concentration:- when there is a higher concentration at one side it starts to give forward or backward to return to the equilibrium

Example for understanding:-

$A + B \rightleftharpoons C + D$

what happens to:-

↑[A] Shift forward ↓B ↑C ↑D

what happens to:-

↑[C] shifts backwards ↑A ↑B ↓D

question including all factors:-

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

what should you Do in these factors to increase the Production of Amonia

- Temp:- Increase

$3H_{2(g)} + N_{2(g)} \underset{endo}{\overset{exo}{\rightleftharpoons}} 2NH_{3(g)}$ between 400 - 450 °C

- Pressure: Increase 200 atm

- Concentration:

Add excess H_2 and N_2

remove NH_3 imidiantly (by concentration) using concentration in Indicator:

Just understand

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

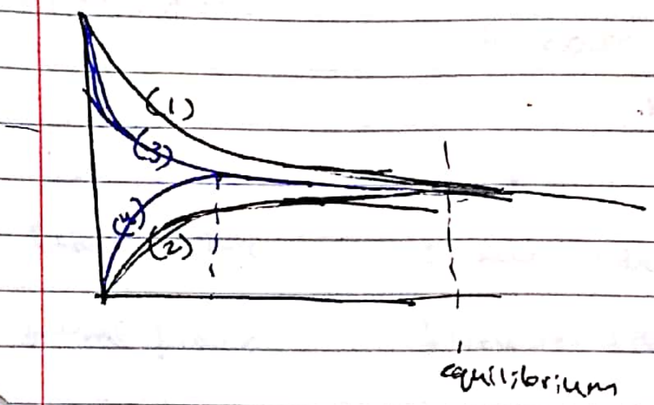
color (1) color (2)

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 (2)
less HIn less color (1)

*How Do catalysts effect the equilibrium?

- Has **no** effect on the **position of equilibrium** because it speeds up the rate of forward and backward so It causes the equilibrium to occure with **less time**



1) :- Rate of forward without catalyst

2 : Rate of backward without catalyste

3 : Rate of forward with catalyst

4 : Rate of backward with catalyst

5 : Time taken to reach equilibrium with Catalyst

6 : Time taken to reach equilibrium without catalyst

Revision key

Position of equilibrium

Temp

↑ temp shifts to endo

↓ temp shifts

Pressure

↑ pressure shifts to less gas mole

↓ Pressure shifts to more gas mole.

Concentration

↑R
↓P } shifts forward

↓R
↑P } shifts backward

Rate:

↑ temp ↑ rate

↓ temp ↓ rate

Rate:

↑ Pressure ↑ Rate

↓ Pressure ↓ Rate

Rate:

↑ conc. ↑ Rate

↓ conc. ↓ Rate

Energetics

(Energy in a chemical reaction)

Energy :- It is the ability to do work.

In a chemical reaction

- To break down in Reactants
  - Absorb energy
  - ↓ Endothermic
- To build up the bond in the Products
  - release energy
  - ↓ Exothermic

Notes :

* Input > Output → Endothermic

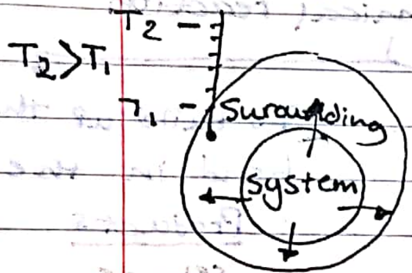
• Output > input → Exothermic

* Enthalpy : Heat contents

Defined as :- Stored energy in bonds.

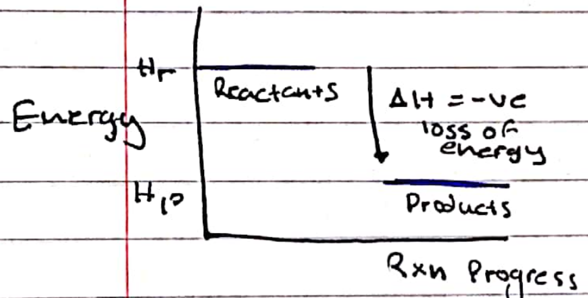
Exothermic Reaction:-

It is a reaction that releases (Gives out) energy to th Surrounding when they take Place!



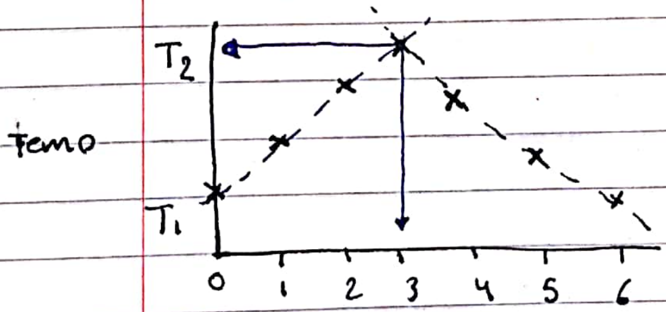
* Thermometer should always be in the surrounding

For system energy level diagram:- (asked to be drawn when Profile (next Page))



↑ Q (energy) more exothermic

For surrounding Temperature diagram:-



$$\underset{\text{Energy (J)}}{Q} = \underset{\text{Mass (g)}}{m}\,\underset{\text{specific heat capacity}}{c}\,\underset{\text{Change in Temp}}{\Delta T}$$

$C_{water} = 4.2\,J/g\cdot c^{\circ}$

↓ memorize.

Exothermic Reactions Examples:

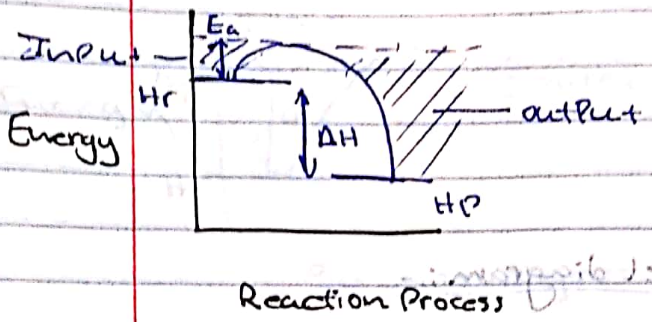
- Combustion
- Displacement
- Neutralization
- Respiration
- Freezing / condensation
- Voltaic cell
- Building up bonds

+ How to express exothermic reaction:-

① Reactants $\rightarrow$ Products + energy

② Reactants $\rightarrow$ Products $\Delta H = -ve$

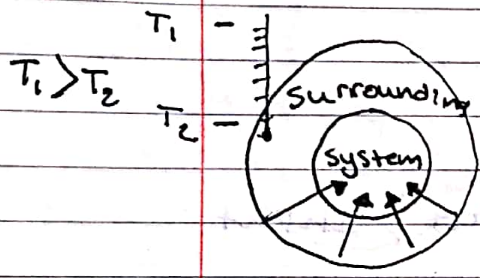
③ Profile diagram:-



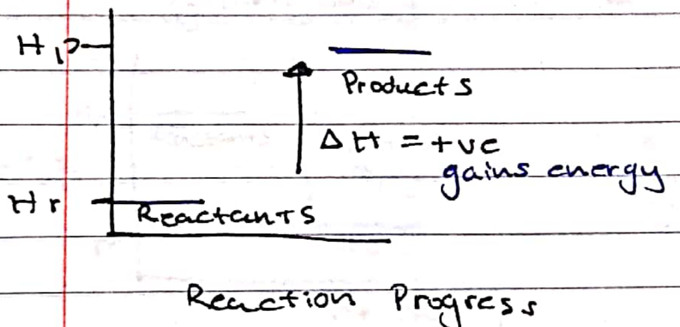
Output > Input

Endothermic Reactions:

It is a reaction that absorbs (takes in) energy from the surrounding when they take place.

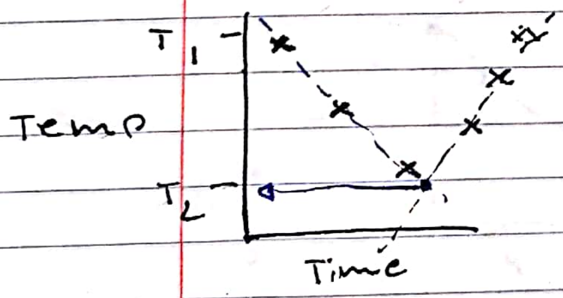


- For system Energy level diagram:-



↑Q more endothermic (energy)

- For surrounding Temperature diagram:-



$Q = mc\Delta T$

Examples of endothermic reactions:

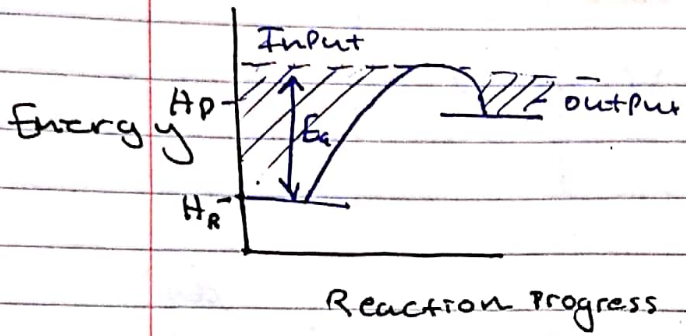
- Photosenthesis
- Photographic films
- Thermal decomposition
- Electrolysis
- Boiling, melting
- Breaking down bonds.

*How to express Endothermic reactions:-

① Reactants + Energy → Products

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

③ Profile diagram:-



E_a = Activation energy

Input > output

Measuring ΔH reaction using Bond energies:-

Don't memorize it's an Example :-

↓

Bond	Bond energy kj/mol
H−H	436

(endo)

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

(exo)

Bond building $H_{(g)} + H_{(g)} \longrightarrow H-H_{(g)} + 436\,kj$

Bonding Energy:

It is the amount of energy Needed to Break 1mol of bond in a gaseous state

OR

The amount of energy Released to Build 1 mole of bond in a gaseous state.

* Always make sure it is balanced!

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

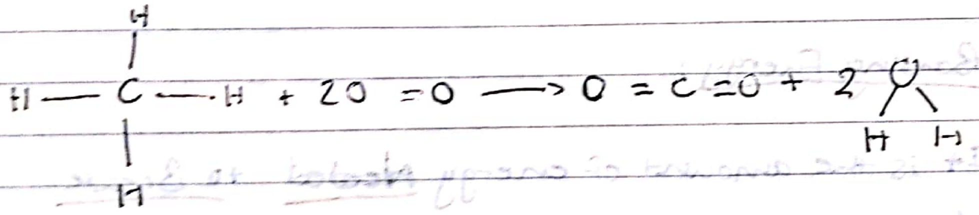
$$\begin{tikzcd} & \Delta H \arrow[dl] \arrow[dr] & \\ \text{Endo } (+) & & \text{Exo } (-) \end{tikzcd}$$

= Total input − Total output

Input>output   Input<output

Example:

Bond	Bond energy kj/mol
C−H	413
O−H	463
O=O	496
C=O	799



$$CH_4 + 2\,O{=}O \longrightarrow O{=}C{=}O + 2\,H_2O$$

Bond broken:

4 × C−H → 4×413

2 × O=O   2×496 +

Total input: 2644 kj

Bond build:

2×C=O → 2×799

4×O−H → 4×463 +

3450 kj

$$\Delta H = \text{Input} - \text{output}$$

$$= 2644 - 3450 = \ominus 806 \text{ kj/mol}$$

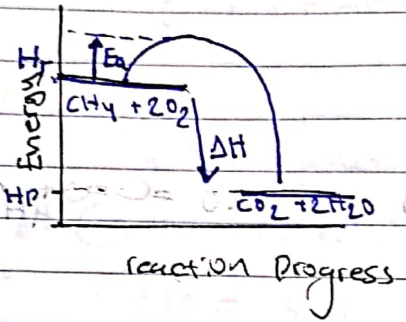
So exo

How to express the exothermic :- (can ask one of the three)

① $CH_4 + 2O_2 \longrightarrow Co_2 + 2H_2O$ + 806 kj/mol

② $CH_4 + 2O_2 \longrightarrow Co_2 + 2H_2O$ $\Delta H = -806$ kj/mol

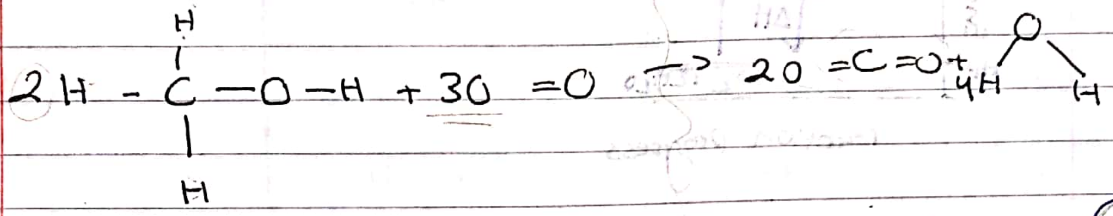
③ Profile diagram:-



Queston:

↙ given

Bond	Bond energy kj/mol
C – H	413
O = O	496
C = O	799
O – H	463
C – O	358



Bond Broken

① 6×C–H => ② 6×413
2×C–O => 2×358
2×O–H => 2×463
3×O=O => 3×496

Add

③ 5608 kj

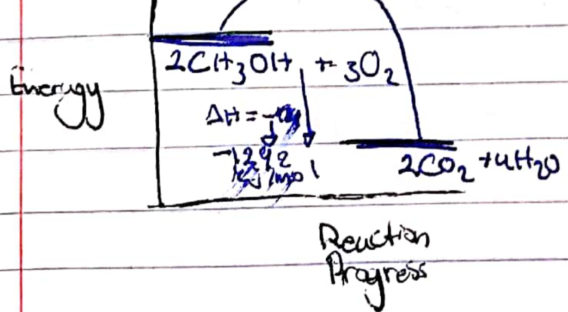
Bond built

① 4×C=O => ② 4×799
+
8×O–H => 8×463

③ 6900

ΔH = 5608 – 6900
= –1292 kj/mol

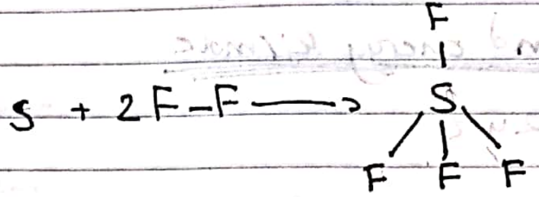
Profile Diagram:



Q.

Sulfur reacts with Florine to give Sulfor tetrafloride. 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



ΔH = Input – output

they Bond released this exo so -ve

$-780 = (2 \times 160) - 4 \times S-F$

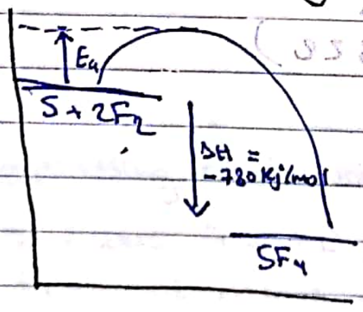
$-780 = 320 - 4S-F$

$-1100 = -4S-F$

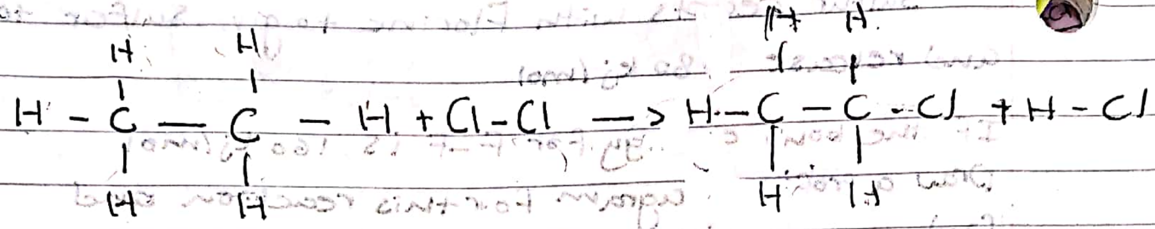
$/-4 \quad /-4$

*$S-F = 275$ kj/mol

Profile Diagram:



Q



$$H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H+Cl-Cl\rightarrow H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-Cl+H-Cl$$

Bond	Bond energy kj/mole
Cl - Cl	242
C - H	413
H - Cl	?
C - Cl	328

Find the bond enery of H-Cl if the amount of energy released is 104 kj/mol :-

ΔH = Broken - Built

$-104 = (413+242) - (x+328)$

$-104 = 655 - x - 328$

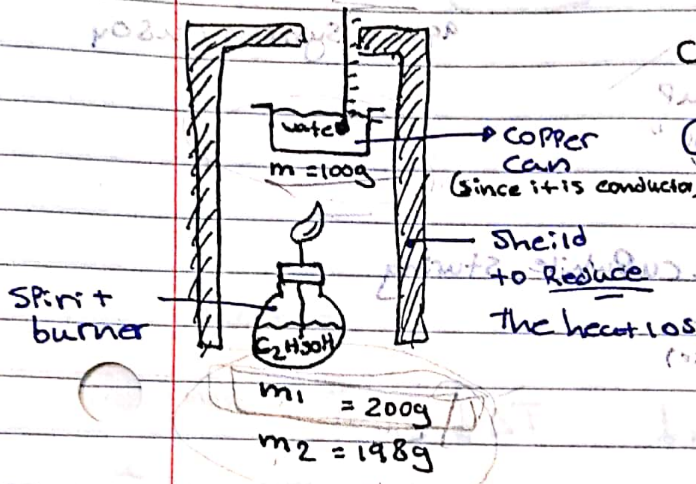
$x = 431$ kj/mol.

* out of syllabus to calculate but they get it sometimes.

Ways to measure the amount of energy transfer:-

- Combustion
- Displacement
- Neutralization

① Combustion:-



$C_{water} = 4.2\ J/g.°c$

$Q = mc\Delta T$

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

$= 2730\ J$ cale: (but this is in joules we need it in moles)

2730 J → burn → 2g C_2H_5OH (change in mass of C_2H_5OH)

x → 46g

x = 62790 J/mol

$\Delta H = -62.79\ kj/mol$ (− since it is exothermic)

*Question using combustion:-

Two fuels A and B, Plan an experiment to show which fule Produces 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 temperature of water (T_1)
Ignite the fuel A (for 5min and measure the final mass) ← no need to write
Measure the final temp of water (T_2)
Repeat the experiment using fuel (B)
The fuel which causes more Temperature change → is the one that Produces more energy

② Displacement Reaction:

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

$m = 0.65g$ $V = 100\,cm^3$

$d = 1g/cm^3$

$m = 100g$

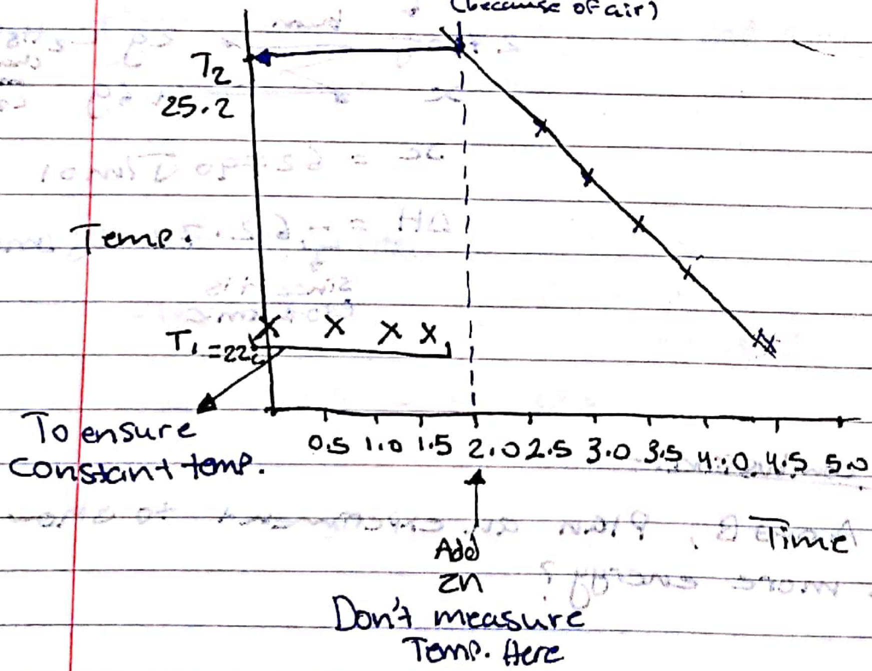
→ Polystyrin cup "Insulator"

→ Beaker:

→ Stables the cup while sturing

→ Insulation (because of air)

* Here the surrounding is the water ~~inside~~ the aques system $CuSO_4$



$Q = mc\Delta T$

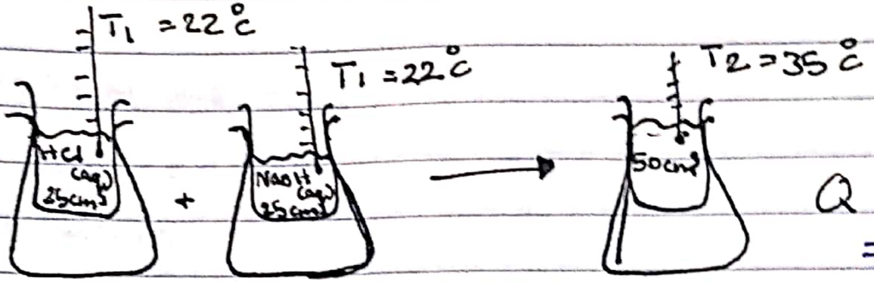
$= 100 \times 4.2 \times 3.2$

$=$ J

1 —> 6
0.5 —> ??

③ Neutralization:

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



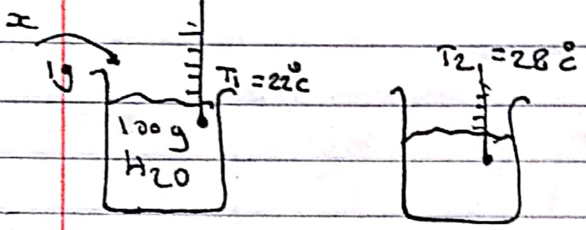
if mass ↑
ΔT ↓

$Q = mc\Delta T$
$= (25+25) \times 4.2 \times 13 =$
~ J

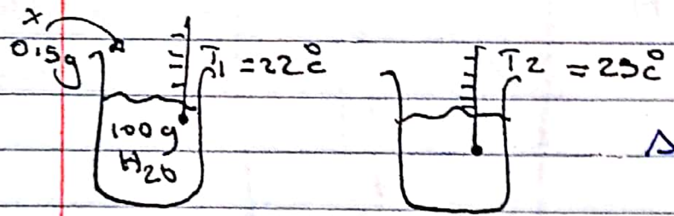
question:

note: ↑mass ↓ΔT   ↓mass ↑ΔT

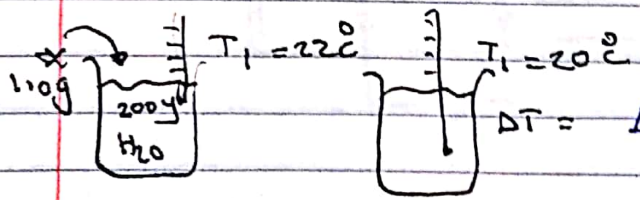
The point here is not to calculate but to show and that if the reactant increases Temp ↑



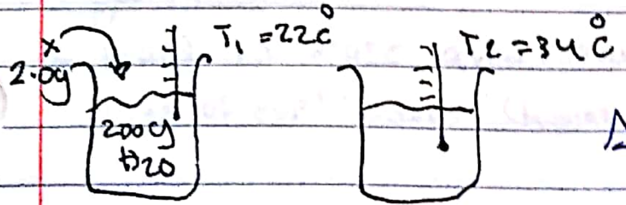
ΔT = 6°C



ΔT = 3°C



ΔT = ΔT = 3°C



ΔT = 12°C

Alternative Resourced of energy

The one insylabus :-

→ Hydrogen fuelcell

Not in sylabus :-

→ Voltic cell

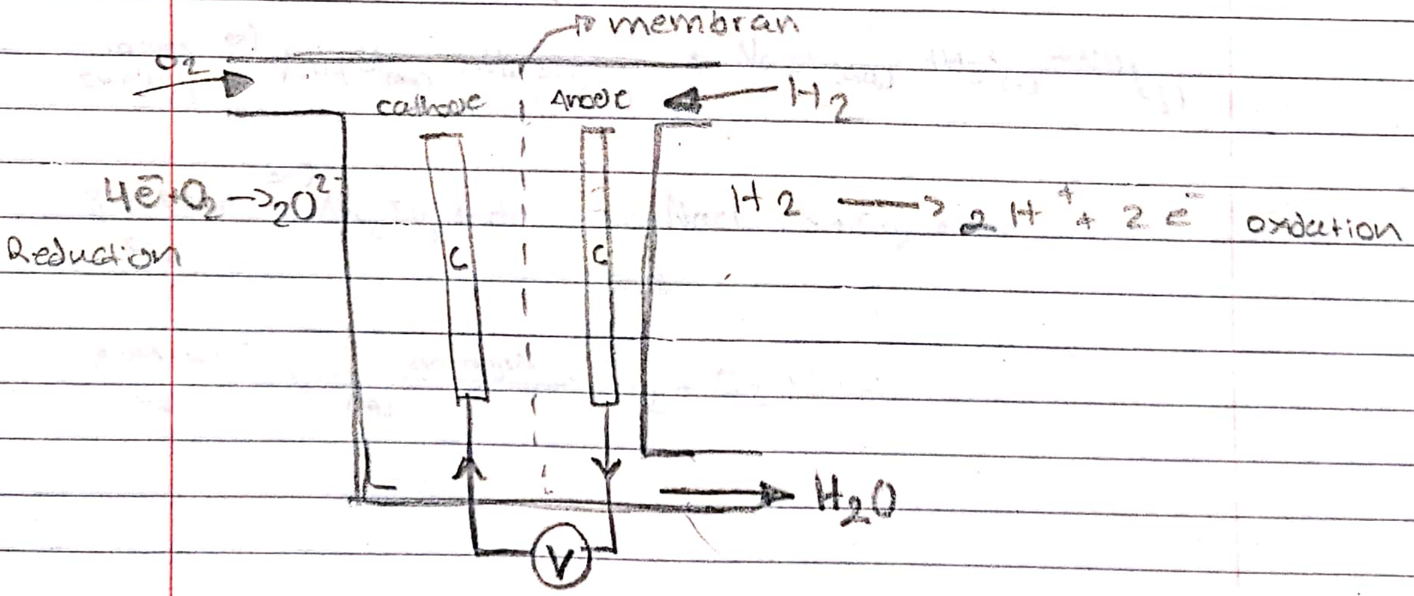
→ Uranium

Hydrogen fuel cell:-

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

Positive:

* Oly Produces H_2O as Waste Product vith ↑ amount of energy and no CO_2 Produced (No Pollution)



Negative:

→ Hard to Store and transport

Risk of explosions (hydrogen is flamable)

Industrial Chemistry

- Dealing with gases
  - Dry
  - Collect
- Industry
  - NH_3 (Haber Process)
  - H_2SO_4 (contact process)
  - (CO_3^{-2}) not in
- Extraction
  - Fe
  - (Zn) not in
  - Cu
  - Al

Dealing with gases:-

(ex) giving out H_2 $Mg_{(s)} + Hcl_{(aq)} \rightarrow Mgcl_{2(aq)} + H_{2(g)}$

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

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

gives out SO_2 ex) $Na_2SO_3 + Hcl \rightarrow Nacl + S + SO_2 + H_2O$

gives out Cl_2 ex) $Nacl_{(aq)} \xrightarrow{\text{electrolysis}} H_2 + Cl_2 + NaOH$

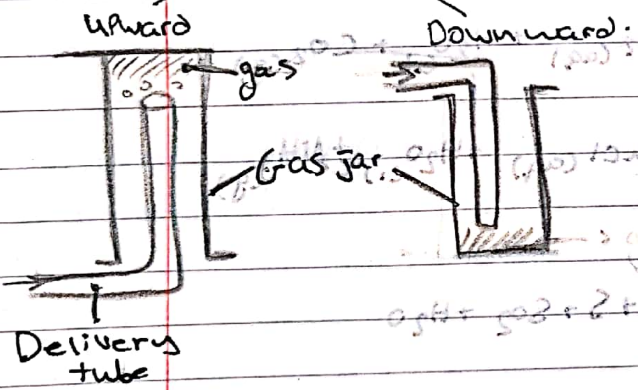
How to collect the gases ?

- Gas syring
- Delivery
- Over water

(1) Gas syring :

* collect and measure the volume of any gas.

(2) Delivery :-



Upward:

To collect less dense gas than air
ex] NH_3
H_2

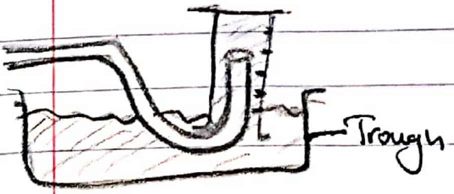
Downward:

To collect more dense gas than air
ex] SO_2 , CO_2 , Cl_2

Disadvantag:

- Some gas might escape
- Might mix with other gases

(3) over water :-



* Used only for insoluble gas in wate
* Co_2 slightly soluble in water

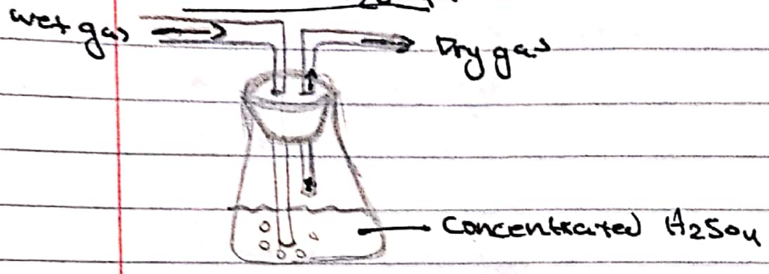
Disadvantage:

Hard to Use

Drying gases:-

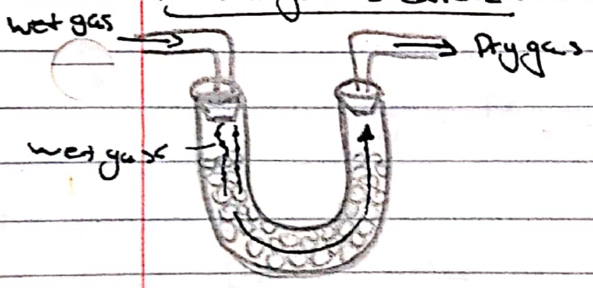
- Concentrated H_2SO_4
- Anhydrous $CaCl_2$
- CaO quick lime

(1) conc. H_2SO_4 :-



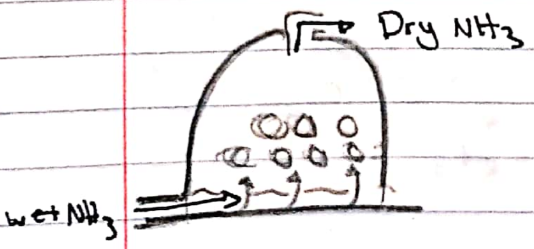
* Used to dry any gas except NH_3

(2) Anhydrous $CaCl_2$:-



* Used to dry any gas except NH_3

(3) CaO quick lime :-



* Used for Drying NH_3

Industry of NH_3
(Haber Process)

memorise:

$$2H_{2(g)} + N_2 \rightleftharpoons 2NH_{3(g)}$$ ΔH = -ve .

uses of NH_3 :-

1 - Fertelizers (N , P , k)
2 - Cleaning detergent
3 - Smelling salts

Essential condition :-

1 - Temp 400°c — 450°c
2 - Pressure 200 atm
3 - Catalyst Fe

*** we can also :-**

- add excess H_2 and N_2 , return back to converter
- Remove NH_3 immediatly

How?

Cooling down NH_3 condense

How to obtain : -

N_2 :- Fractional distilation of liquid air .

H_2 :- ① Cracking of Alkane (organic)

② $CH_4 + H_2O_{(g)}$
methane

$\downarrow$

$3H_2 + CO$

1- Temp 400 - 450 °C

- Less than 400 °C
  - Adv.
    - More yield of NH_3, shift forward to the exo side
  - Dis.
    - Slow rate of Reaction
    - why?
    - Particles lose K.E. So less effective collisions per unit time.
- greater than 450 °C
  - Adv.
    - faster rate
  - Dis.
    - Less yield of NH_3 shift backward to the endo side

2- Pressure 200 atm

- high Pressure
  - Adv.
    - 1- More yield of NH_3 (shift forward to the side with less gas mol)
    - 2 - Faster rate (more collisions per unit time)
  - Dis.
    - 1 - Risk of explosion
    - 2 - Expensive

Industry of H_2So_4

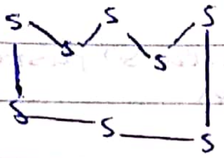
$$S \xrightarrow[(1)]{} So_2 \underset{(2)}{\rightleftharpoons} So_3 \xrightarrow[(3)]{} \underset{(\text{oleum})}{H_2S_2O_7} \xrightarrow[(4)]{} H_2So_4$$

Roasting   Contact Process   +conc. H_2So_4 $+H_2O$

Properties and uses :-

① **S:**

- group VI
- Yellow solid
- S_8



(has a crown shape)

ore :- Zinc blend ZnS

Also found in fossile fuel

Uses:

- Medecine
- fire works
- matches
- rubber

② **So_2:**

- Chocking smell
- tested by:

turns acidify $KmnO_4$ from Purple → Colorless

Uses:

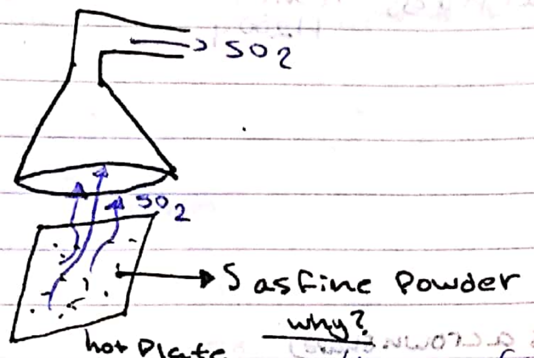
- Paper industr → bleaching agent
- food presrvative → kills bacteria

③ **H_2So_4:**

- oily liquid → **dilute:** Typical acid
  → **concentrated:** Dry gas

(1) Roasting:-

$S + O_2 \rightarrow SO_2$



why?
More surface area so faster rate of reaction

(2) Contact Process:

$2SO_{2(g)} + O_{2(g)} \underset{}{\overset{V_2O_5}{\rightleftharpoons}} 2SO_{3(g)}$ $\Delta H = -ve$

exo

1) Temp:- 400 - 450 °C

2) Pressure:- 1-2 atm "high Pressure"
favour the forward side wich has less gas mole

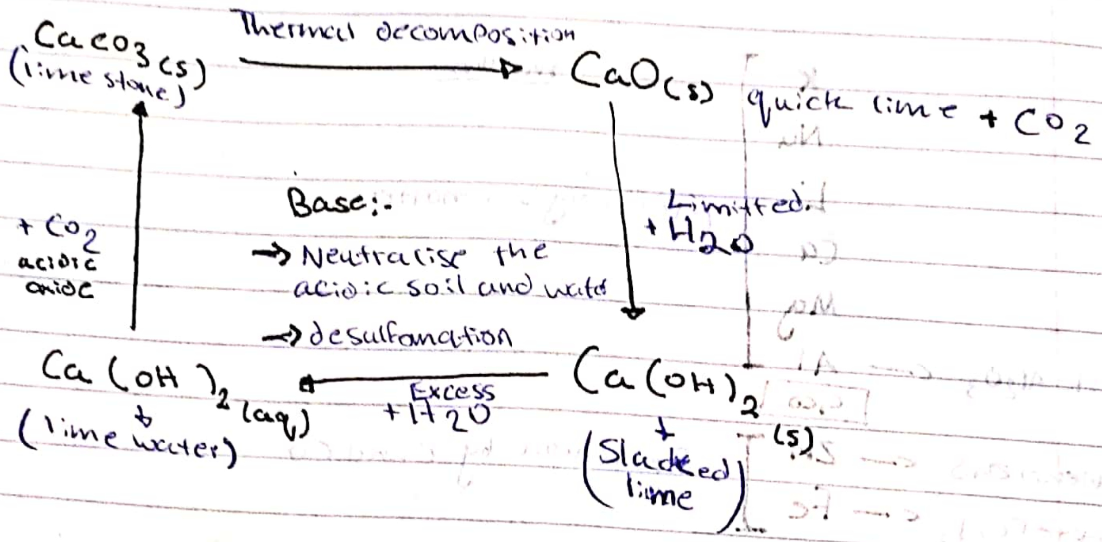
- why 1-2 only?
Max yield at 2 atm

3) Catalyst:- V_2O_5 vanadium (V) oxide
↓
Penta

(3) $SO_3 \xrightarrow{H_2O} H_2SO_4$ } → Not used
because highly exothermic H_2O evaporates and Produces low yield of H_2SO_4
while using large amounts of H_2O is bieng used

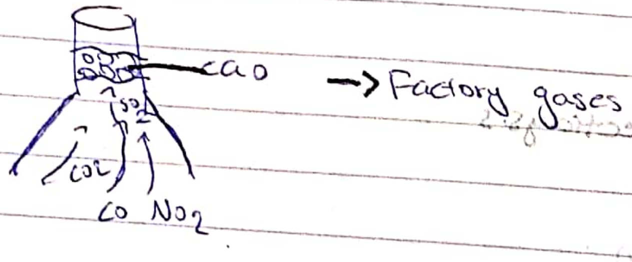
SO_3
+ concentrated H_2SO_4 → $H_2S_2O_7$ Oleum → $+H_2O$ → $2H_2SO_4$

Carbonate cycle



Desulfonation:

It is used to remove SO_2 from flow gases



- Uses:

- $CaCO_3$:- - building
  - extraction of Iron
- CaO :- - Dry NH_3
- $Ca(OH)_{2(aq)}$:- - Test CO_2

Test for CO_2:

$Ca(OH)_{2(aq)} + CO_{2(g)} \longrightarrow CaCO_{3(s)} + H_2O_{(l)}$

Extraction of metals

		method
	K	Electrolysis molten
	Na	
	Li	
	Ca	
	Mg	
Bauxite Al_2O_3 <—	Al	
	C,CO	
Zin blend ZnS <—	Zn	Reduction by C and CO
Hematite Fe_2O_3 <—	Fe	
	Pb	
	H	
CuS <-	Cu	Reduction by H_2
	Ag	
	Au	

Al —> found in electrolysis

Extraction of Iron :-

Ore :- Hematite Fe_2O_3

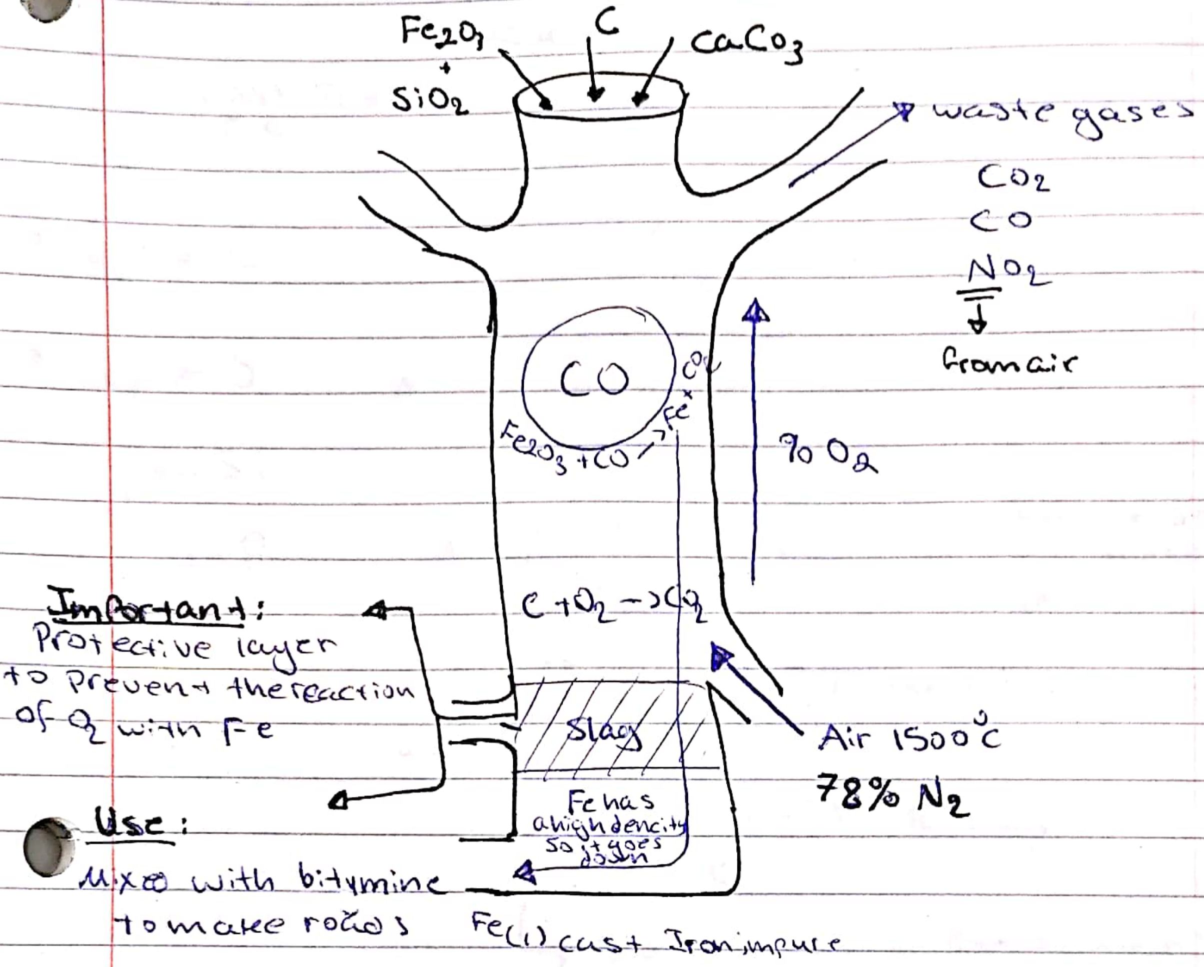
Methode :- Reducing by C and CO_3

Place :- Blast Furnace

not methode

Raw materials :- ① Fe_2O_3 + acidic impurities SiO_2
② $CaCO_3$ (lime stone)
③ Coke (Pure carbon)
④ Air (T = 1500 °C)

Blast furnace



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

Use: Mixed with bitymine to make roads

Reactions that accure:

① $C + O_2 \longrightarrow CO_2$] → Complete combustion to Produce energy
redox

② $2C + O_2 \longrightarrow 2CO$] → Incomplete combustion
redox

③ $CO_2 + C \longrightarrow 2CO$
redox

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

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

⑥ $\overset{Base}{CaO} + \overset{Acid}{SiO_2} \longrightarrow \underbrace{CaSiO_3}_{\text{Calcium Silicate slag}}$
Neutralization

Steel makin "oxygen base process"
cast Iron

Cast Iron
Fe

↑ CO_2 ← C

↑ SO_2 ← S

$SiO_{2(s)}$ ← Si

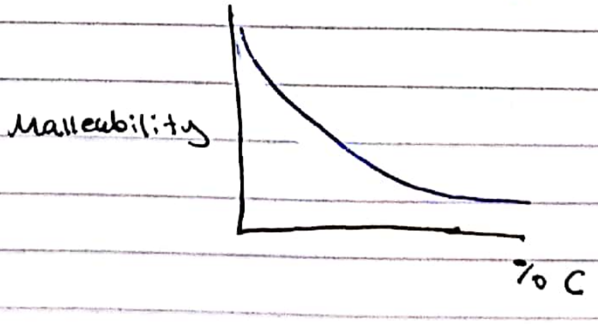
$P_2O_{5(s)}$ ← P

① blow hot O_2
which gives CO_2, SO_2, $SiO_{2(s)}$, $P_2O_{5(s)}$
but we don't want these so

② Add CaO

Steel
- Mild Steel "car bodies"
  0.03% C
- Medium Steel "Railways"
  0.3% C
- Stainless steel "cutters, watch"
  3-5 % C

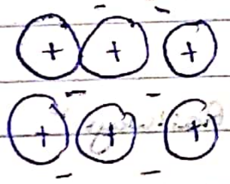
* As the amount of % C ↑ Malleability ↓



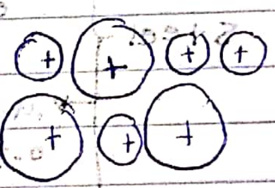
Alloy :- Mixture of metal with another metal
(stronger than pure metal) or semimetal

Brass	Cu+Zn
Bronze	Cu+Sn
Steel	Fe+C+Cr+Ni

copper



Brass



easier to slide

- That's why it's more malleable

Two different sizes so harder to slide