redox

exampels.!

on reduction

oxidation

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

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

*oxidation $Mg \longrightarrow Mg^{2+}$

reduction Cl_2

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

*oxidation → $S^{2-} \to S$

reduction H^+

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

*oxidation Na

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

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

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

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

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

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

monoatomic
Cu, Zn, Al, Ca

dioAtomic
H_2/O_2/N_2/Br/Zn

poly atomic
P_4

rules of oxidation number:-

1) The oxidation number of any free element is zero

2) The oxidation number of any atom in a compound form

group I = +1 Li, Na, k, Rb, Cs, Fr
group 2 II = +2 mg, ca, Ba, Sr
group 8 III = +3 only for (Al)
group 7 VII = -1 always for (F)

3) The oxidation state of (H) is (+1) exept with metals (-1)

$\overset{+1}{CH_4}$ $Al\overset{-1}{H_3}$
$\overset{+1}{H_2}O$ $N\overset{+1}{H_3}$ $\overset{+1}{Na}\overset{-1}{H}$ $Ca\overset{+1}{H_2}$

4) The oxidation state of O is (2-) exept peroxide
except in OF_2 (+2)

$- \overset{0}{Al} + \overset{3+\,1-}{FeCl_3} \longrightarrow \overset{3+\,1-}{AlCl_3} + \overset{0}{Fe}$

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

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

over all reaction $Al + Fe^{3+} \rightarrow Al^{3+} + Fe$

$Al \longrightarrow Al^{+3}_{3} \cancel{+3}$

$Fe^{3+} \cancel{+3} \longrightarrow Fe$

* writing half ionic equation «Balanced»

1- Balance the atoms

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

2Na

$(2Na \rightarrow Na^{\cancel{+2}\,+1})\times 2$

$2H^{+1} \rightarrow H_2$

$- \overset{0}{Na} + \overset{+1\,-1}{HCl} \rightarrow \overset{+1\,1-}{NaCl} + H_2$

oxidation:- $(2Na \rightarrow Na^{+1} + 1e^{-}) \times 2$ $\cancel{2e^{-}}$

reduction :- $2H^{+} + \cancel{2}e^{-} \longrightarrow H_2$

over all $2Na + 2H^{+} \rightarrow 2Na + H_2$

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

Oxidation :- $(2Al \rightarrow 2Al^{3+}\ 4\cancel{3e}) \times 2$

reduction:- $(\overset{6}{2}H^{+1} \underset{6}{\cancel{+2e}} \rightarrow 3H_2) \times 3$

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

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

half of oxidation :- $(5Fe^{2+} \longrightarrow 5Fe^{3+} \overset{\cancel{5e}}{\cancel{+1e}}) \times 5$

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

over all $5Fe^{2} + Mn^{7+} + 5Fe^{-3} + Mn^{2+}$

half of oxidation → $+\bar{e}$

// // reduction →

OIL RIG

oxidation is losing electron

reduction is Gaining electrons

$\overset{2+\,2+}{CO} + \overset{3+}{Fe_2}\overset{2-}{O_3} \longrightarrow \overset{4+2-}{CO_2} + \overset{0}{Fe}$

half of oxidation :- $(3C^{2+} \longrightarrow {}_3C^{4+} + \overset{3}{\cancel{2}}e) \times 3$

half of reduction :- $(2Fe^{3+} + \overset{6}{\cancel{3e}} \longrightarrow {}_2Fe) \times 2$

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

✱ Identify which species oxidse or reduce.

oxidation state
- oxidation
- reduction

✱ to define oxidation and reduction.

OIL / RIG

↑ oxidant

✱ oxidising and reducing agents

✱ Oxidising agent:- The substance that it self reduced ~~cttus~~ cuses the other substance to be oxidise.

↑ reductant

✱ reducing agent:- the substance that it self oxidised and causes the other substance to be reduced.

- $\overset{0}{Al} + Fe_2O_3 \longrightarrow \overset{3+}{Al_2}O_3 + Fe$

• oxidation Al

- reduction Fe^{3+}

• reductant : Al

oxiant Fe_2O_3

* most common oxidising agent

① oxgyen

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

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

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

② Acidify potassum manganate $KMnO_4$

$\underset{\text{purple}}{MnO_4^{-1}} \longrightarrow \underset{\text{colorless}}{Mn^{2+}}$

③ Acidify potassium dichromate $K_2Cr_2O_7$

$\underset{\text{orange}}{\overset{+6}{Cr_2O_7^{2-}}} \longrightarrow \underset{\text{Green}}{\overset{+3}{Cr^{3+}}}$

~~MnO_4~~

[illegible]

Oxidant	reductant
O_2	H_2
$KMnO_4/H^+$ purple -> to colorless	C, CO
$K_2Cr_2O_7/H^+$ orange -> green	Metals
Halogens	Iodide

④ Halogens yellow-green ~~[illegible]~~ g

$2e + Cl_2 \longrightarrow 2Cl^-$ → colorless

$2e + \underset{\text{Brown}}{Br_2} \longrightarrow 2Br^-$ → colorless

$I_2 \longrightarrow \underset{\text{colorless}}{I^-}$

Brown
Solution
black solid
purple gas
gas

* 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)

* most common reducing agent

① hydrogen $H_2 \longrightarrow H^+ + 2e$ - more reactive

② carbon & carbon monoxide - more able to lose electrons

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

reducing agent ~~sugars~~

- more able to oxidise
- more able to be reducing agent

③ metals

$C + Fe_2O_3 \rightarrow Fe + CO$

reducing agent

④ potassium iodide

$2\underset{\text{colorless}}{I^-_{(aq)}} \longrightarrow \underset{\text{red brown}}{I_2} + 2e$

strongest reducing agent

K
Na
Li
Ca
Mg
Al
C, CO
Zn
Fe
Pb
H
Cu
Ag
Au

Ag → strongest oxidising agent

Ag → weakest reducing agent

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

reducing ~~sugars~~ agent

past paper Q

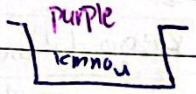
- Fe^{2+} is reducing agent.

Fe^{3+} is an oxidising agent

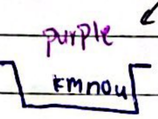
- write the observation in each of the followi

* when we have a reductant we use an oxidant to chang the color and when we have an oxidant we need to put a reductant to change the color

Fe^{2+}



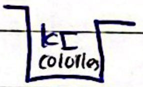
- from purple to colorless



- stays purple

$\underset{+7}{Mn}O_4^{-1} \rightarrow Mn^{2+}$

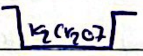
Fe^{2+}



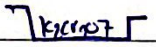
stays the same

Fe^{3+}

red-brown



stays ~~the~~ orange



from orange to green

Electrolysis

Electricity

Aalyisis
"Breaking down"

Electrolysis :- Breaking down Ionic compounds "Molten or aqueous" by passing electrisicity.

electrolyte :- the chemical compound that conduct electristy when molten or aques

Q: why the solid ionic compound don't conduct electricty

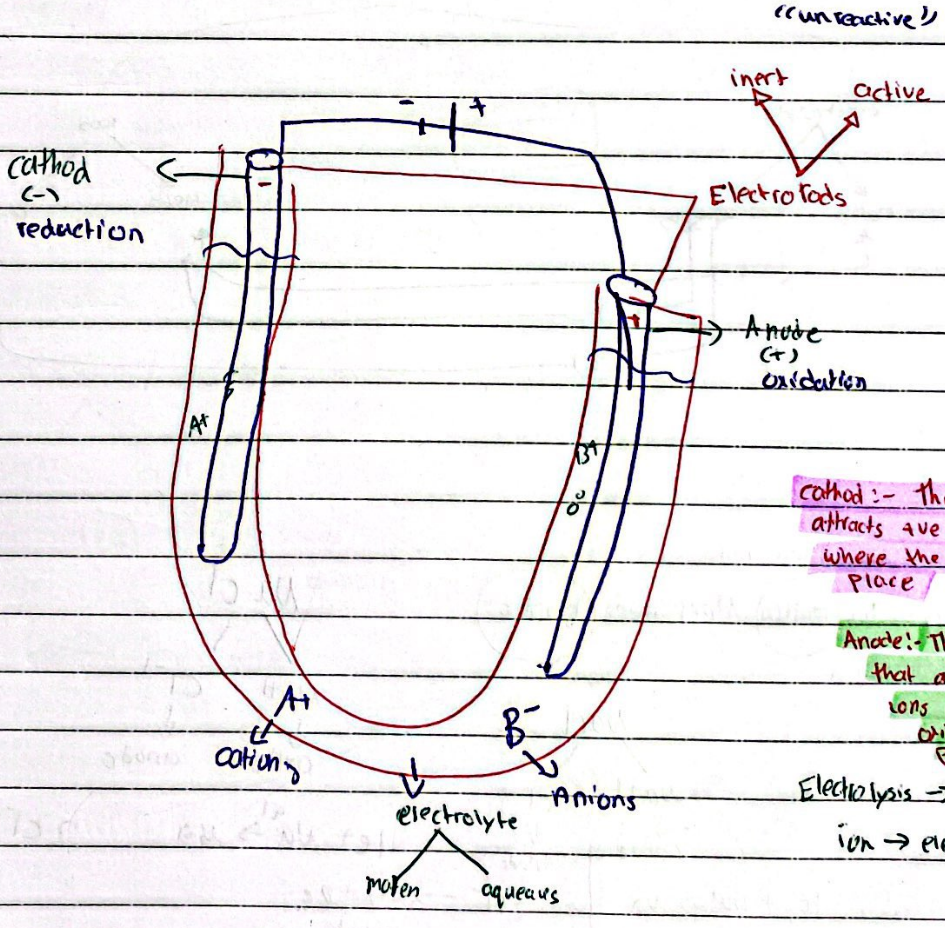
The ions are not free tomove

Q :- why the compound conduct electricity when molten or dissolve in water?

Ions are able to move

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

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



cathod :- the -ve rod that attracts +ve ions (cation) where the reduction takes place

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

Electrolysis → Discharge

ion → element

cations

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

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

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

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

deposite of metal

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

bubbles of colorless gas

Anions

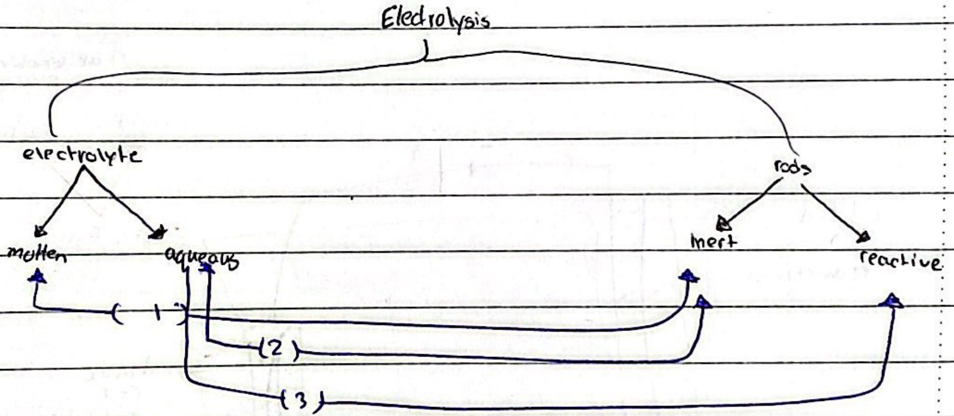
$2Cl^{-1} \rightarrow Cl_2 + 2e$ green yellow gas (~~bubbles of yellow gas~~)

$2Br \rightarrow Br_2 + 2e$ (~~[illegible]~~ red brown liquid

$F^{-1} \rightarrow F_2 + 2e$ bubbels of yellow gas

$2I \rightarrow I_2 + 2e$ Black solid purple gas

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



* Molten using inert rods

* Electrolysis for molten NaCl using graphite

steps for solving:-

NaCl

Na^{+1} → Cathod

Cl^{-} → Anode

$1e + Na^{+} \rightarrow Na$ deposite of metal

$2Cl^{-} \rightarrow Cl_2 + 2e$ bubbles of green yellow gas

Na Cl

Na^{+1} → cathod

Cl^{-1} → anode

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

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

Electrolyte → used up

* Mollen KI / graphite rods

K^+ — cathode

I^- — Anode

$K^+ + 1e \rightarrow K$

deposite of metals

$2I^- \rightarrow I_2 + 2e$

purple gas

electrolyte → used up

* Mollen Al_2O_3 / graphite rods

Al^{3+} — Cathod

O^{2-} — Anode

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

deposite of metal

$2O \rightarrow O_2 + 4e$

bubbles of colorless gas / relight the glowing splint

electrolyte → used up

* Mollen $CuCl_2$ / graphite

Cu^{2+} — cathod

Cl^{-1} — Anode

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

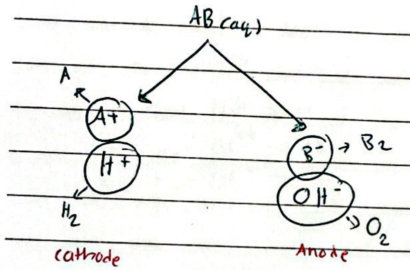
deposit of metal

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

bubbles of green yellow gas / bleach dum p. litmus paper

electrolyte = used up

electrolysis for aqeous electrolyte using graphite



At cathode

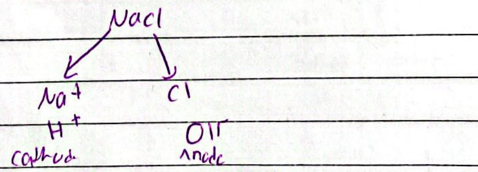
The less reactive ion is more likely to reduce

K^{+1}
Na^{+1}
Li^{+1}
Ca^{2+}
Mg^{2+}
Al^{3+}
Zn^{2+}
Fe^{3+}
Pb^{+2}
H
Cu^{2}
Ag^{+1}
Au^{+3}
Pt^{+2}

At Anode
only concentrated halids are more likly to oxidise
if not concentrated halide the OH^- will oxidise

[illegible] ($4OH^- \rightarrow 2H_2O + O_2 + 4e$)
memorite

Electrolysis for concentrated aqueous sodium chloride ("Brine")



$2H^+ + 2e^- \rightarrow H_2$
bubbles of colorless gas

$2Cl^- \rightarrow Cl_2 + 2e$
bubbles of green yellow gas

Electroly. → NaOH

concentrated

NaCl / graphite

Na^+ Cl^-

H^+ OH^-

cathod anode

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

bubbles of colorless bubbles of green yellow gas

Electrolyte:- NaOH

dilute

NaCl (aq)

Na^+ Cl^-

H^+ OH^-

cathode Anode

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

bubbles of colorless gas

Electrolyte: NaCl more concentrate

$CuSO_{4(aq)}$ graphite

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

H^+ OH^-

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

deposite of metal bubbels of colorless gas

Electrolyte :- H_2SO_4

$KNO_{3(aq)}$ graphite

K^+ NO_3^-

H^+ OH^-

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

bubbels of color less gas bubbels of colorless gas

Electrolyte:- KN

concentrated $CuCl_2$

Cu^{2+} Cl^-

H^+ OH^-

cathode anode

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

deposite of metal red brown bubbels of green yellow gas

Electrolyte → less concentrate

concentrated $FeBr_{(aq)}$ graphite

Fe^{3+} Br_3

H^+ OH^-

cathod anode red brown

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

Eletrolyte:- NaOH

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

$NaCl_{(aq)}$

~~Na^+~~ H^+ cathod

Cl^- OH^- anion

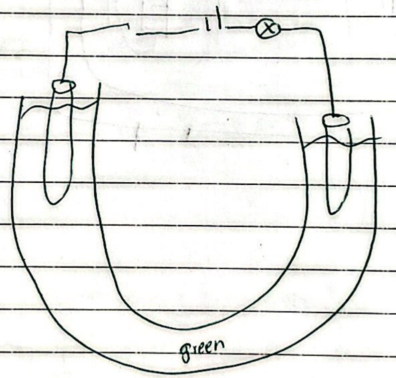
$2H^{+}2e \rightarrow H_2$ colorless bubbles gas

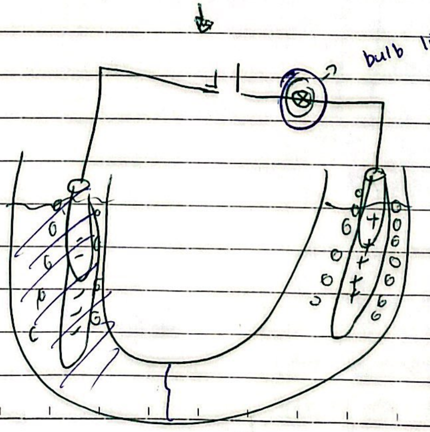
$2Cl^- \rightarrow Cl_2 + 2e^-$ green yellow bubbler gas

Electrolyte I NaOH

Brine + universal indicator

①





purple cuz NaOH is an alkali

→ colorless

the Cl_2 delay in it's apperance

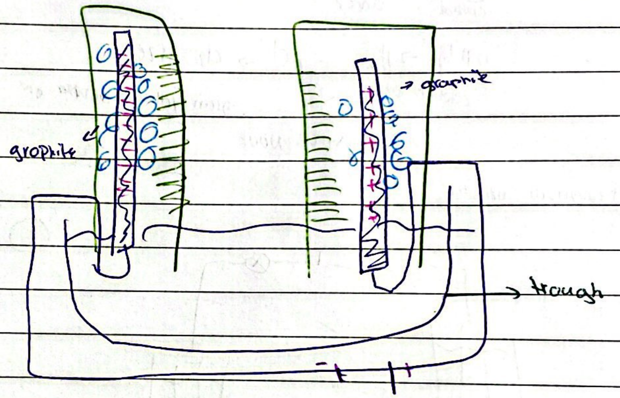
- some Cl_2 reacts with NaOH

Cl_2 is a bleaching agent

② and mesure theire volume

- How to collect the two gasses H_2O Cl_2 on the cattode anode

by using inverted measuring



Electrolysis for aqeous eletroyte using active rod

* the active rod made from the same metal ion in the electroyte

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

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

$CuSO_{4(aq)}$

Cu^{2+}

H^+

cathode

deposite of red brown solid Mass

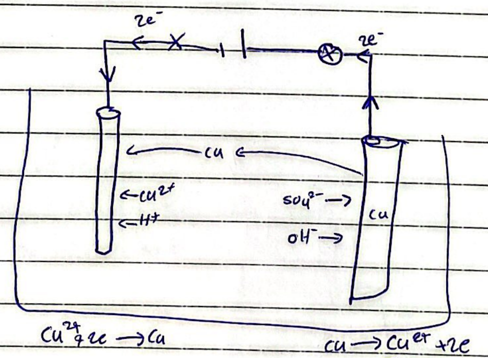
SO_4^{2-} ✗

OH ✗

anode

Neither the OH^- for SO_4^{2-} oxidise the anode itself will oxidise

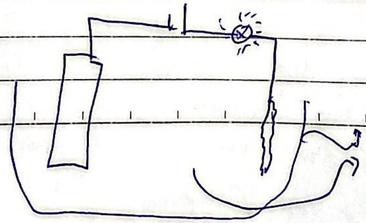
$Cu \rightarrow Cu^{2+} + 2e^-$



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

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

to ~~exchange~~ ~~to catode~~ electrolyte to cathode through the wires



cathode its mass increase Cu^{2+} reduced as Cu deposite

Anode its mass decrease Cu oxidise and lose e's

stays the same because the anode oxidise and deplace the Cu^{2+} in the electrolyte with same rate.

Electroplating:- coating a metal with another metal using electricity

why? ① to prevent rusting
② more attractive

- how to electroplate a metal a metal spoon with Ag ?

1- clean the metal spoon from any impurites or oxide ~~larger~~ 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:- $AgNo_3$

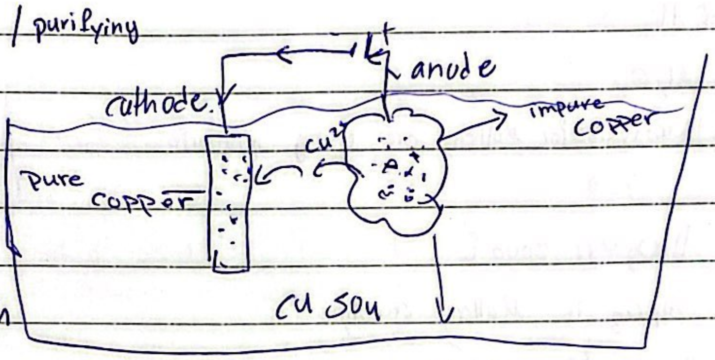
5- switch on the circuit

6- rotate the metal spoon to ensure an equal disturbation

7- rinse with disto water

8- dry in oven

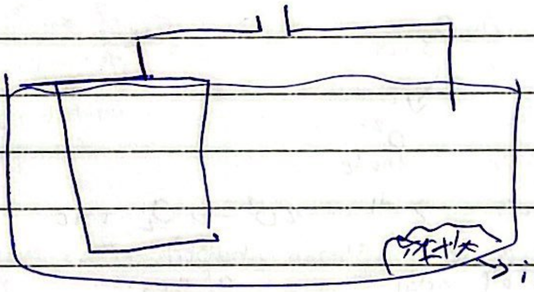
Refining copper / purifying



☒ impurities Ag, Au, Zn (cu)

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

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



Ag, Au : settle down → they are less reactive than cu

Zn :- displace from $CuSO_4$

☒ Extraction of metal

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

K
Na
Li
Ca
Mg
Bauxite Al_2O_3 ← Al } electrolysis / Molten / graphite
C, CO
Zinc chloride ZnS ← Zn
Hematite Fe_2O_3 ← Fe
Pb
H
copper sulfite CuS ← Cu] → reduction by He
Ag

Extraction of Al

Ore :- Boxite Al_2O_3

Method :- Electrolysis for Molten ore using graphite

* the mp of Al_2O_3 is 2000 °c
So we dissolve Al_2O_3 is Molten cryolyte
Na_3AlF_6, why?

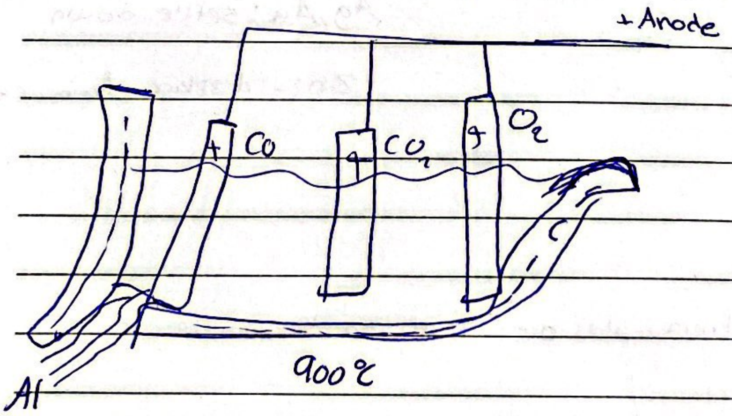
1- to lower the mp. to 900 °c so less cost
2- to increase the electrical conductivity

$$\begin{tikzcd} & Al_2O_{3(l)} \arrow[dl] \arrow[dr] & \\ Al^{3+} & & O^{2-} \end{tikzcd}$$

cathode — anode

$Al^{3+} + 3 \longrightarrow Al$ — $2O^{2-} \longrightarrow O_2 + 4e$

deposite of metal — bubbels of gus.



gases produced at anode

1- O_2
2- CO_2] reactions of tools
3- CO

Propities of Al	use of Al
Malleable	window fram, cooking
low density	Air craf bodies
from non-toxic	food cans
conduct electricity	electrical wire

slow reaction

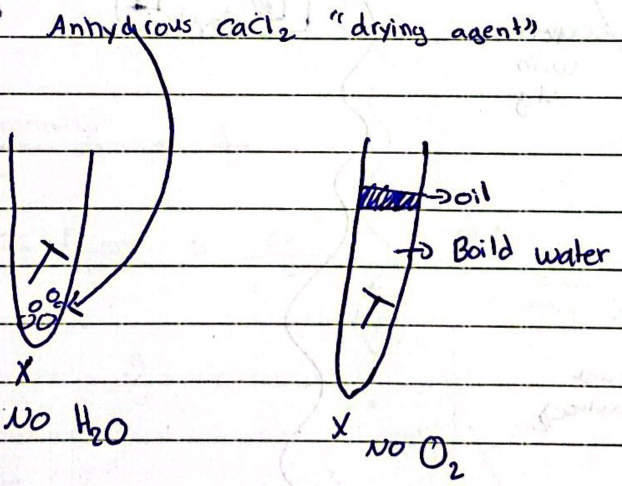
- Rusting :-

The reaction of iron with both H_2O $ O_2

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

oxidation

- ~~Anydrates~~ Anhydrous $CaCl_2$ "drying agent"



- two rust prevension solution A,B

- Plan an exp to show which Brand is the better
- Take a known mass of iron nail
- apply a known voume of solution A
- add them to a known voume of water for 1 week
- dry the iron nail
- mesure the mass
- repeat the exp using solution B

- The exp which cause less increase in mass is the better solution

Rust prevention

① Paint
② oiling
③ greasing
④ cover with plastic

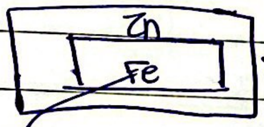
(prevent H_2O & O_2 from reacting with Fe)

⑤ Galvanizing

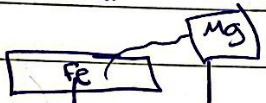
⑥ sacrificial protection

⑦ catholing Plating

⑧ Electro plating

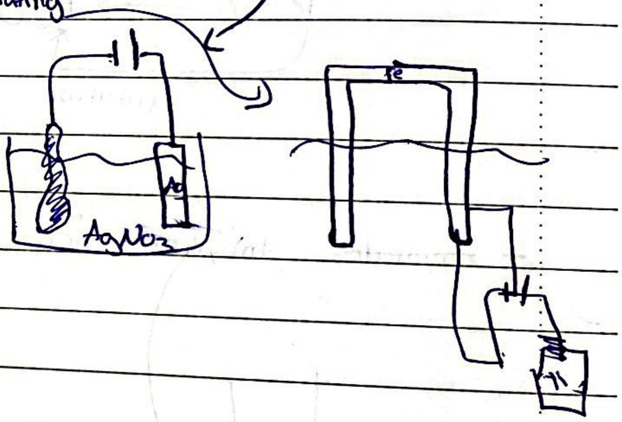


Coating with Zn



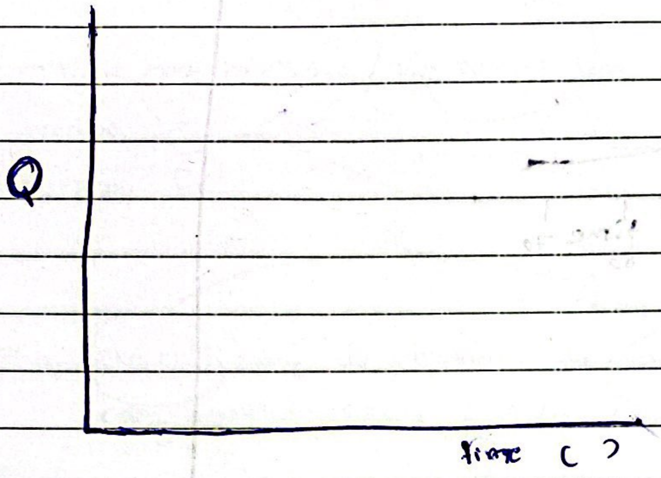
Connecting with Mg

Zn & Mg are more reactive than Fe,
More likely to oxidise
so Fe is less likely to rust (oxidise)



Rate of reaction

$$\text{Rate} = \frac{\text{change in Quantity}}{\text{Changein time}} = \frac{\Delta Q}{\Delta T}$$



$$\frac{\Delta \text{PH}}{\Delta \text{time}} = \frac{1}{s}$$

$$\frac{\Delta \text{light intensity}}{\Delta \text{time}} = \frac{1}{s}$$

$$\frac{\Delta \text{volume of gas}}{\Delta \text{Time}} = \frac{cm^3}{s}$$

$$\frac{\Delta \text{Mass}}{\Delta \text{Time}} = \frac{g}{s}$$

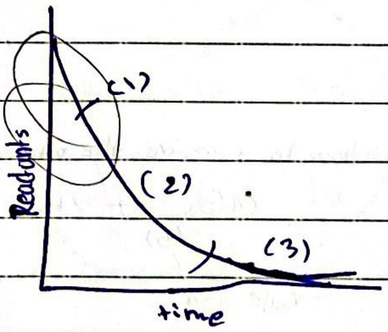
$$\frac{\Delta \text{temp}}{\Delta \text{Time}} = \frac{C^o}{s}$$

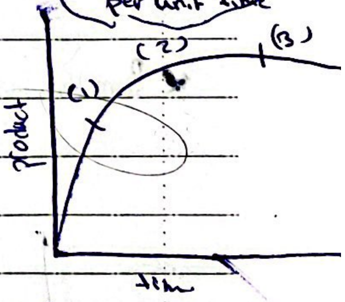
$$\frac{\Delta \text{electrical}}{\Delta \text{Time}} = \frac{1}{s}$$

to measure the rate of reaction

measure how fast the reactants consumed per unit time

measure how fast the product produced per unit time

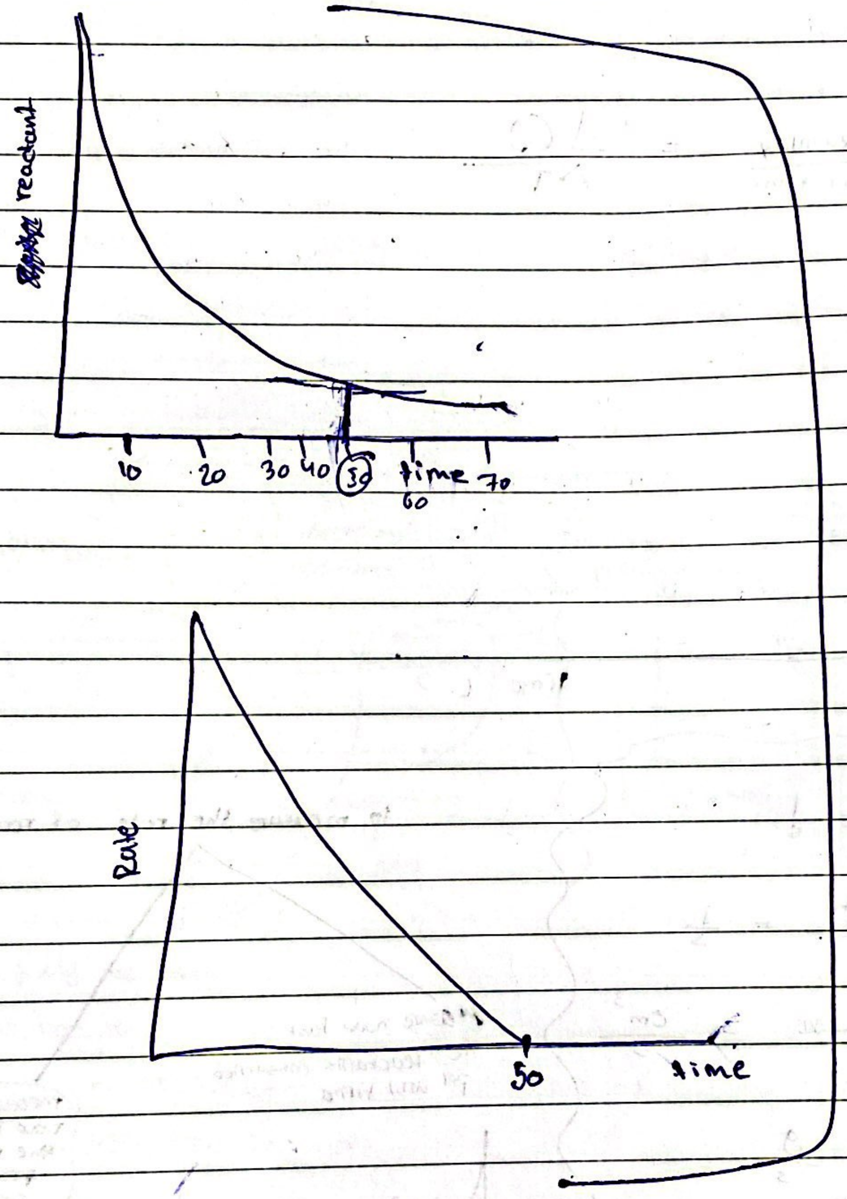




region (1) :- The rate is the highst ⇒ from the curve: steepest high gradiant & More reactant so more particles so more effective collisions per unit time

region (2) :- The rate is slower ⇒ from the curve: less steep → lower gradiant / less reactent / less particles less effective collisions

region (3) : The reaction is done from the curve: horizontal line gradient :- 0 Not More limiting agent & No more effective collisions

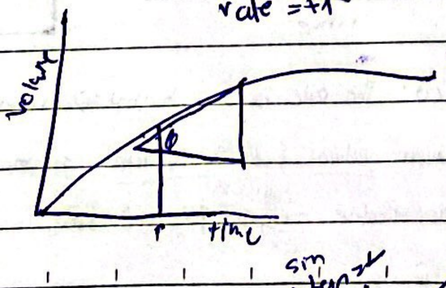


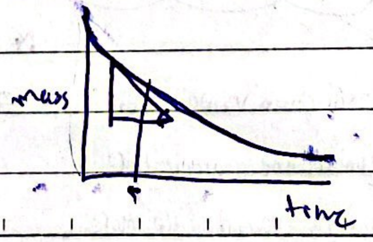
- from the graph how to measure the rate

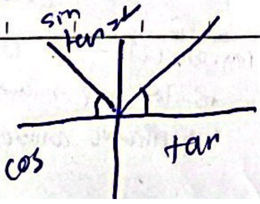
$CaCO_{3(s)} + 2HCl \rightarrow CaCl_{2(aq)} + H_2O + CO_{2(g)}$

rate = +X

rate = -







3 main conditions for any chemical reaction:-

① the reactant must be suitable
$Cu + HCl \rightarrow$ No rxn

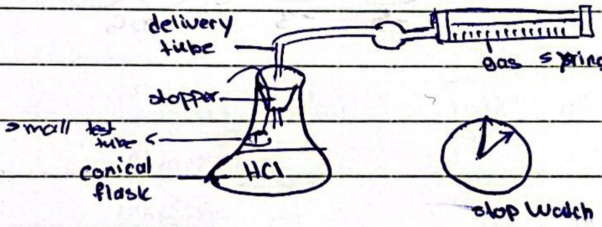
② the reactant must collide

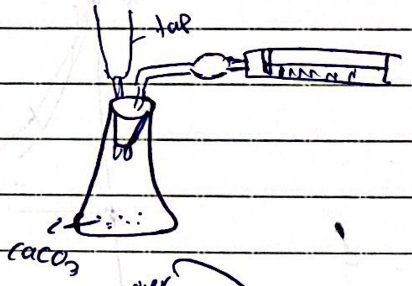
③ the collisons must be effective / the particles have min amount of energy to start the reaction

Activation enegy Er

① Measuring the rate using by monitoring the volume of gas

$CaCO_3 + 2HCl \rightarrow CaCl_{2(aq)} + CO_2 + H_2O$



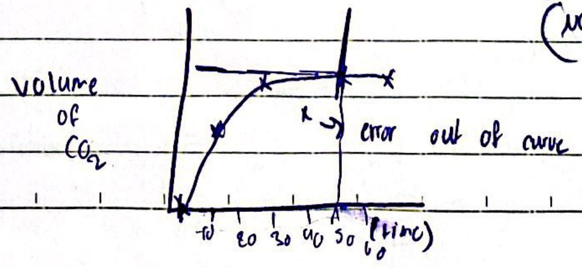


Time	0	10	20	30	40	50
volume (cm3)	0	8	13	13	16	16

+8 +5 +2

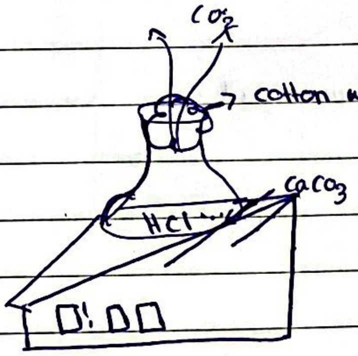
over

(no more limiting factor)



② measaring the rate by monitoring the change ~~of~~ in mass of conical flask per unit time

$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O + CO_2(g)$



to allow CO_2 to escape and prevent splashing

? why the mass ↓ ?

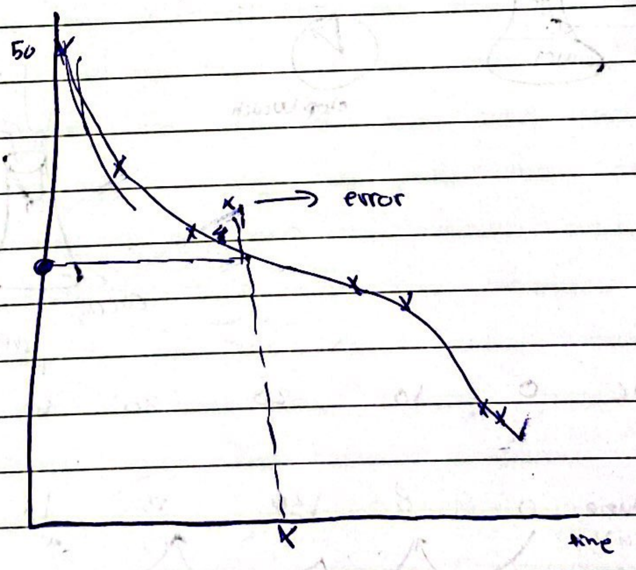
CO_2 escape

no more limiting factor

over ↑

time (s)	0	10	20	30	40	50
mass (g)	50	45	42	41	40.5	40.9

-5 -3 -0.5

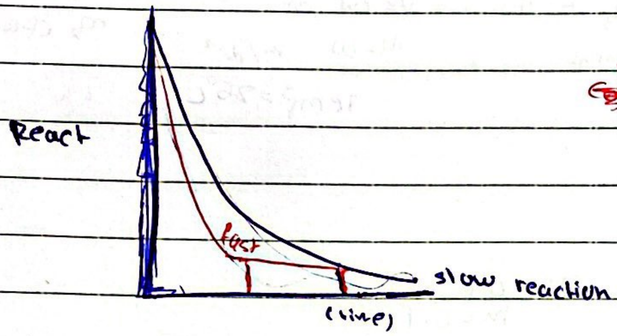


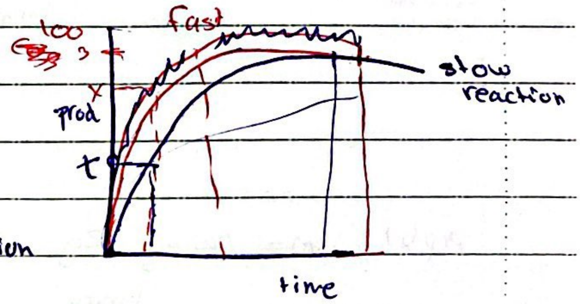
it should be a straight line

increasing the rate of reaction.

faster rate = steeper curve

Same product with less time or more product per the same time





Factors affect the rate of reaction
① tempreture
② surface area
③ ~~cab~~ concentration
④ pressure (only for gas)
⑤ light
⑥ catalyst

Tempreture

state how the tempreture affect the rate of rxn

As the temp increases the rate of reaction increases

- expect how the temp affect the rate of rxn (5).

As the temp increase the particles gain ① kinatic energy so move faster ② so more particles will have energy ≥ Ea so more effective collisons and faster rate of reaction.

plan an exp to show how the temp affect the rate of rxn?

$caCO_{3(s)} + 2HCl_{(aq)} \rightarrow caCl_{2(aq)} + H_2O + CO_2$

exp 1 mass $caCO_3$ = 2g lumps

$V = 0.1\ dm^3$

$M = 0.1\ m/dm^3$

temp = 25°C

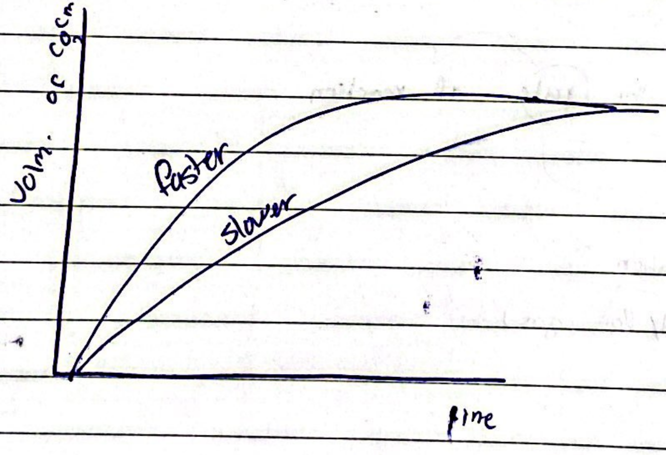
Volume of CO_2 (produced per unit time)

exp(2) m = $caCO_3$ = 2g lumps

V = 0.1

m = 0.1

temp = 50°C



② surface area

- state how the surface area affect the rate of reaction

As the surface area increases, the rate of reaction increases
(by reducing the particle size / crushing using motar / pestle)

- explain how the surface area affect the rate of reaction

As the surface area increases more particles exposed to the reaction so more effective collisions per unit time, faster rate of reaction

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

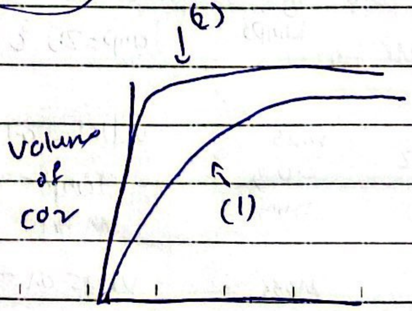
$$CaCO_{3(s)} + 2HCl_{(Ag)} \rightarrow CaCl_{2(Aq)} + H_2O_{(l)} + CO_{2(g)}$$

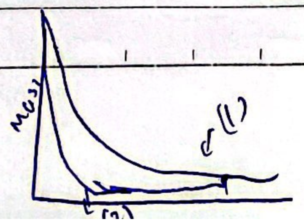
exp 1
$CaCO_3$ = 2g
lumps

V = 0.1 dm^3
M = 0.1 m / dm^3
Temp = 25 C°

exp 2
$CaCO_3$ = 2
~~lumps~~
powder

V = 0.1
M = 0.1
Temp = 25 °C





② concentration "amount

state how the concentration affect the rate of reaction

As the concentration increase rate of reaction increases

explain how the concentration affect the rate of reaction

As the concentration of reaction increases more particles so more effective collisions per unit time so faster rate of reaction

plan an exp to show how the conc

add 0.02 / needed 0.05

$CaCO_3{(s)} + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

exp 1 Mass 2.0 g lumps $Mr = 100$

$V\ HCl = 0.1\ dm^3$

$M\ HCl = 0.1$

temp = 25 °C

exp 2 mas 2.0 g lump

$V\ HCl = 0.1\ dm^3$

temp = 25 °C

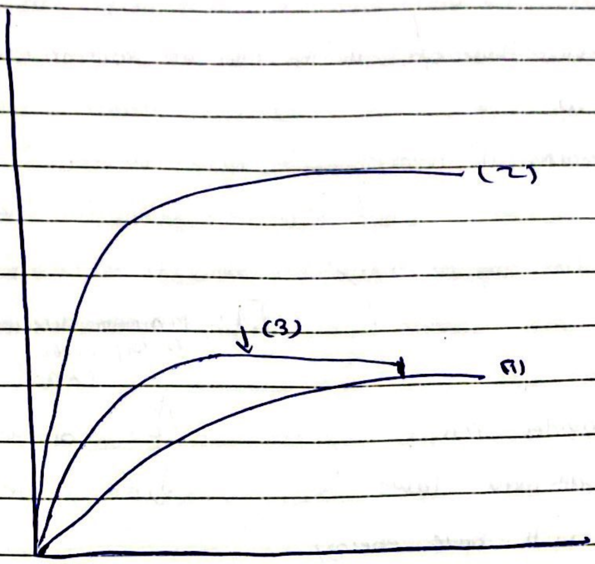
M HCl

exp 3 mass 4.0 g lumps

$V\ HCl = 0.1\ dm^3$

$M = 0.1$

Temp 25 °C



4) pressure "only for gas"

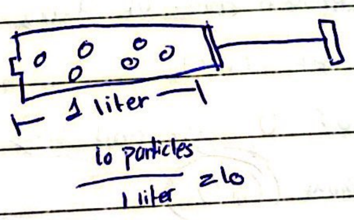
explain how the pressure affect the rate of reaction?

As the pressure increase (by lowring the volume)

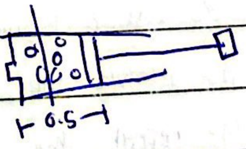
More particles per unit volume

so more effective collisions per unit time

so faster rate of reaction



$\frac{10 \text{ particles}}{1 \text{ liter}} = 10$



$\frac{10 \text{ Partcles}}{0.5 \text{ liter}} = 20$

5) light " for photo chemical

- photosynthesis

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

photographic films

$2AgCl_{(s)} \xrightarrow{\text{light}} 2Ag + Cl_{2(g)}$

6) catalyst

Chemical substance that speeds up the rate of reaction without being used up

enzyme : Biological catalyst

alternative pathway for EA ↓ less

How? ~~slower rate~~ it provides an alternative pathway lowe Ea , particles will have energy to or greater than Ea
so more effective collisions per unit time so faster rate of reaction

EA :- minimum amount of energy needed to start rxn

↑Ea slower rate

↓Ea faster rate

$$H_2O_2 \xrightarrow[MnO_4]{CuO} 2H_2O + O_2$$

Q1:- plan an exp to show that CuO is a catalyst for this rxn

1. known volume of known conc of H_2O_2
2- add a known mass of CuO
3- measure the volume of O_2 per unit time
4- repeat the exp without CuO

conclusion:- the exp with CuO produce more O_2 per unit time

the same

Q2 plan . an exp to show which is better CuO or MnO_2

- known volume of known of known conc of $2H_2O$
- add a known of CuO
- measure the volume of CO_2 per unit time
- repeat with MnO_2 (same mass)

conclusion:- the exp that produce more O_2 per unit time is better catalyst

Q3. plan an exp to show that the CuO not used up during the reactions

- add a known mass of CuO to H_2O_2 (unit) no more bubbles of O_2
- filtrate the mixture
- dry in oven
- re measur the mass

conclusion mass will change

Reversible reaction

Chemical reactions

one way forward

Reactant → products

$Mg + HCl \rightarrow MgCl_2 + H_2$

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

both ways

$React \underset{backward}{\overset{forward}{\rightleftharpoons}} Product$

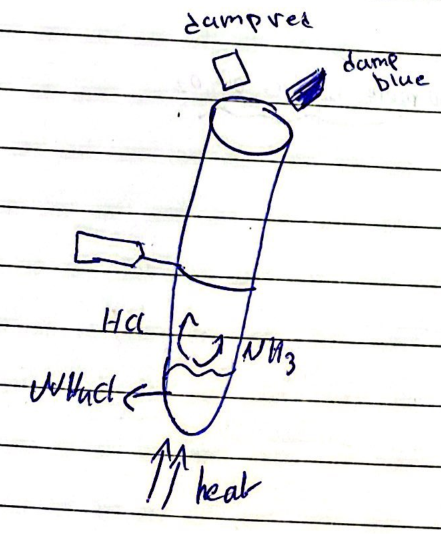
$3H_2 + N_2 \rightleftharpoons 2NH_3$

$2SO_2 + O_2 \rightleftharpoons 2SO_3$

$NH_4Cl \rightleftharpoons NH_3 + HCl$

$\underset{(s)}{NH_4Cl} \xrightarrow{heat} \underset{(g)}{NH_3} + \underset{(g)}{HCl}$

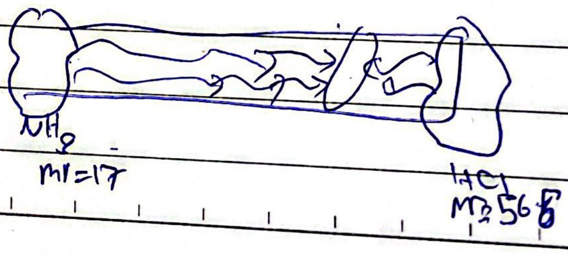
Ammonium chloride - ammonia + Hydrogen chloride



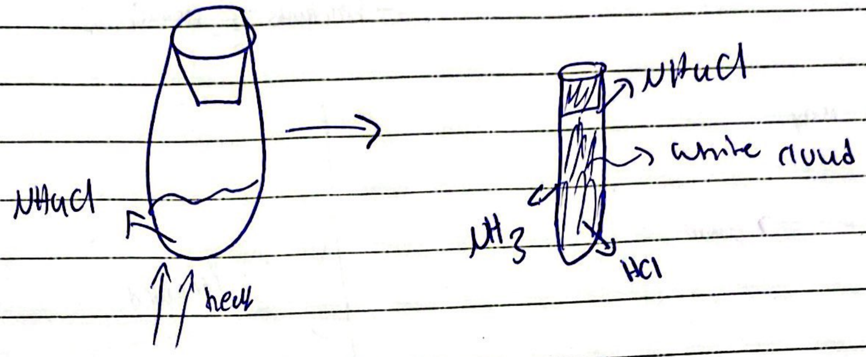
Q- which damp litmus paper will change it's color first explain your answer?

The damp red litmus paper changes it's color to blue first since NH_3 is base or alkaline and lighter than HCl which is acidic

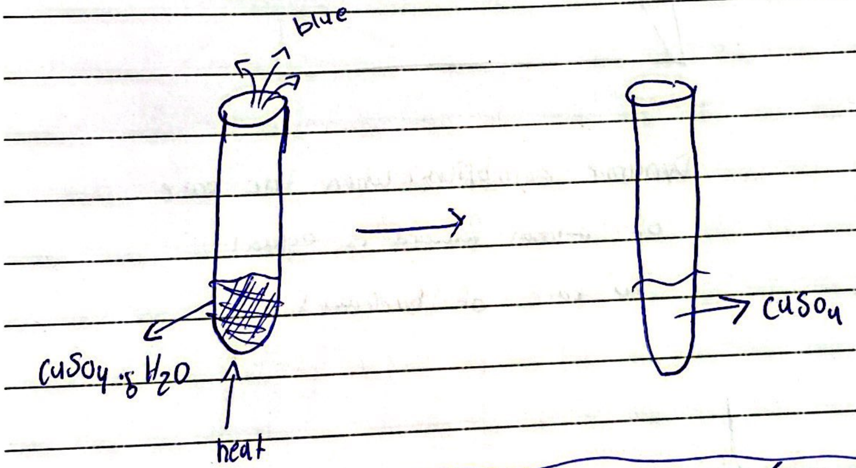
$\underset{(aq)}{NH_3} + \underset{(s)}{HCl} \rightarrow$



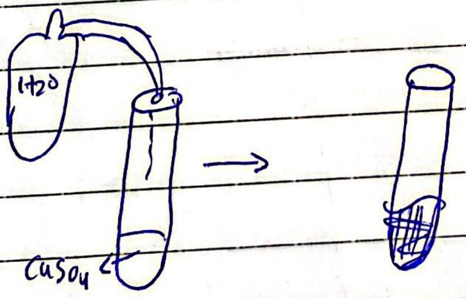
$NH_4Cl_{(s)} \rightleftharpoons NH_{3(g)} + HCl$



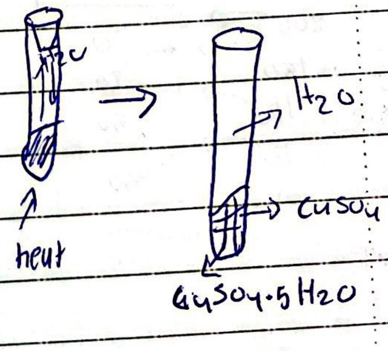
$\underset{blue}{CuSO_4\cdot5H_2O} \xrightarrow{heat} \underset{white}{CuSO_4} + 5H_2O$



$\underset{white}{CuSO_4} + 5H_2O \rightarrow CuSO_4\cdot5H_2O$



$CuSO_4\cdot5H_2O \rightleftharpoons CuSO_4 + 5H$



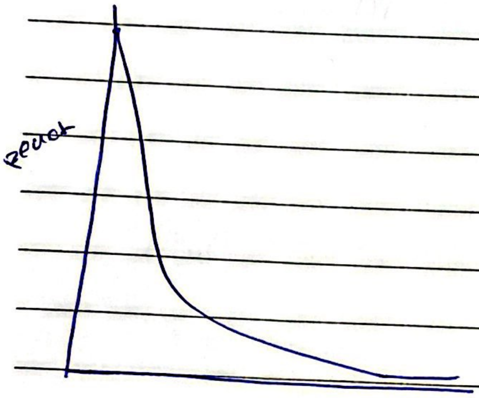
Equillibrium mixture

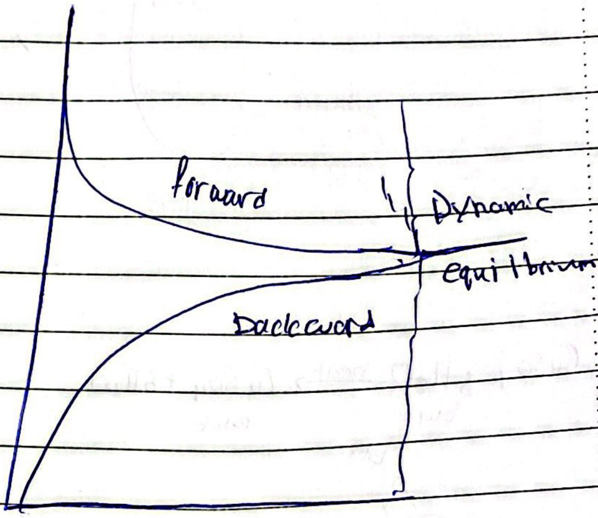
Dynamic equilibrium.

Reactants $\rightleftharpoons$ product

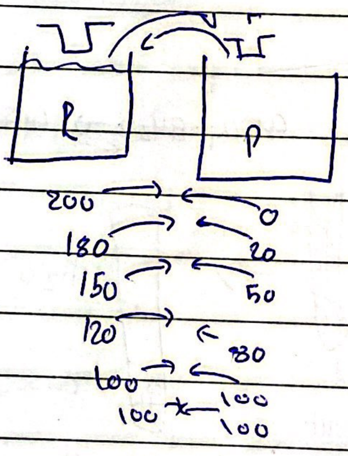
one way

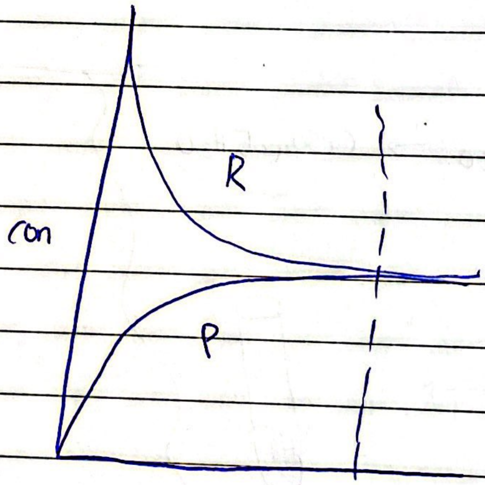
Reactant → products

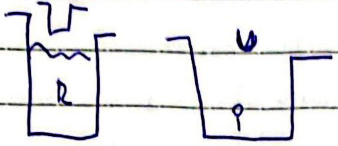


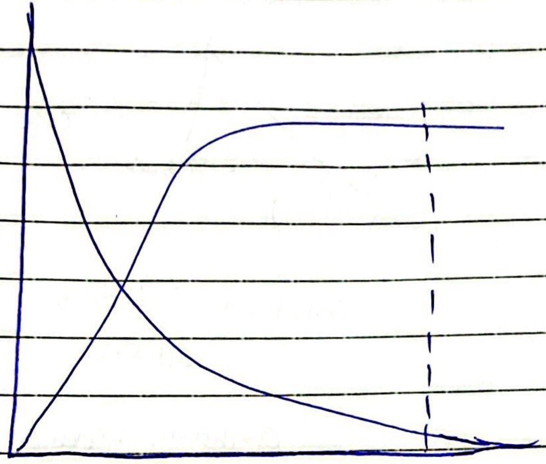


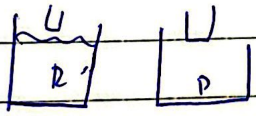
Dynamic equilibrium when the rate of ~~reaction~~ forward is equal to rate of backward.

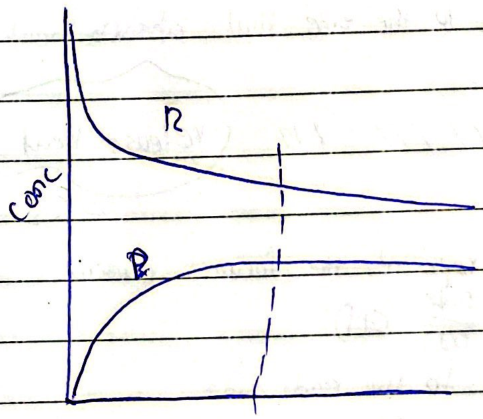












← equil: when the concentration of reactant and product are constant
in terms
of concentration

le chateler principle

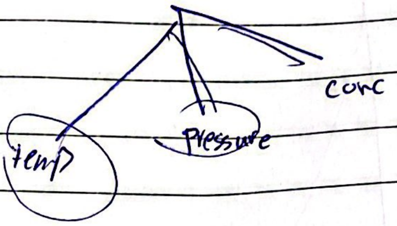
if the system at equilibrium →

and any external factor disrubt the equil

the equil shift it self either to the forward →

or to the backward ←

to return back to the equil



endothrmic : ABsorb

$\Delta H = +ve$

exothermic : release

$\Delta H = -ve$

① Temp

↑ temp shift to endo

↓ temp shift to exo

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

// // // decrease // // // // ///// // in release heat which is the exothermic side.

the sign of ΔH is always represent the forward reaction

$$A+B \underset{exo}{\overset{endo}{\rightleftharpoons}} C+D$$

↑ the temp ~~dH~~ shift forward to the endo side

↑↑ rate of endo

↑ rate of exo

$W+X \xrightleftharpoons[\text{endo}]{\text{exo}} Y+Z$ $\Delta H = -ve^{\text{exo}}$

↑ temp shift backward to the endo

rate of endo ↑

rate of exo ↓

↑W ↑X ↓Y ↓Z

$A+B \xrightleftharpoons[\text{exo}]{\text{endo}} C+D$ $\Delta H = +ve^{\text{endo}}$

① Temp.

↑temp ⇈ rate of endo ↑ rate of exo] shift to endo

↓temp ⇊ rate of endo ↓ rate of ex] shift to exo

shift to less gas moles

② pressure

↑pressure rate of less gas moles ↑↑ rate of more ↑

↑pressure ⇒ shift to the side with less pressure which has less gas moles

↓pressure ⇒ shift to the side with more pressure which has more gas moles

shift to more gas moles

↓pressure rate of less ⇊ gas moles rate of more gas moles ↓

① ②

$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_3$

↑pressure shift forward → to the side with less gas mole

↓pressure shift backward to the side with more gas mols

0 1

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

↑pressure shift backward less pressure with less gas moles

↓pressure shift ~~backward~~ forward to the side with more gas mole

2mol 2mol

$H_2 + I_2 \rightleftharpoons 2HI_{(g)}$

↑pressure has no effect on the position of equilibrium

they have the same no. of gas moles

$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_3$ ΔH = -ve

4 mol 2 mol

complete the table

effect	rate of forward	rate of backward	Yield ~~Yitrd~~ of NH_3
↑temp	increase	increase	decrease
↑pressure	increase	increase	increase
↓pressure	↓	↓	↓

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

purple colorless

① why by increasing the pressure the position of equili dosn't change?

\ because both side of the reaction have the same number of gas mole

② why by increasing the pressure the mixture more purple

the gas partides of I_2 become closer togther and the color increase more condense

Q:- mixture of NO_2 and N_2O_4 at equi 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) " darker " stay paler

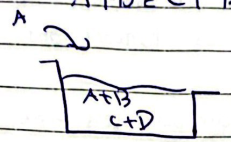
" ~~sta~~paler " stays paler

c) " paler " goes darker

d) " paler " goes darker

③ concentration

$A + B \rightleftharpoons C + D$



↑[A] shift forward
↓B ↑C ↑D

↑ [C] shift backword
↑A ↑B ↓D

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

Temp 40.0 – 450 °C
·pressure 200 Atm
concentration add excess hydrogen H_2 and nitrogen N_2

remove NH_3 imidily condensation

indicator

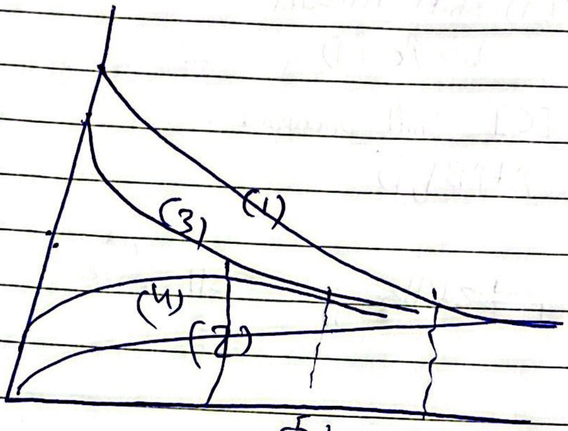
$HIn_{(aq)} \rightleftharpoons H^+_{(aq)} + In^-_{(aq)}$
color 1 color 2

add HCl
acid
proton
donor
{ ↑ H^+ shift backword
more HIn more color (1)
less In^- less color (2)

add NaOH
proton acceptor
$OH^- + H^+$
{ ↓ H^+ more In more color (2)
less HIn less color (1)

catalyst

has no effect on the position of equilibrium
because it speeds up the rate of forward and backward
so it causes the equil to occur with less time



(5) → time taken w catalyst

6 — // // no catalyst

energtics

*energy in chemical reaction

energy:- the ability to do work

in chemical Rxn

to break down
bonds in
Reactants
input absorb
take in endothermic

to build
up
the
bonds
in the
product
output
release
give
out
exotherm

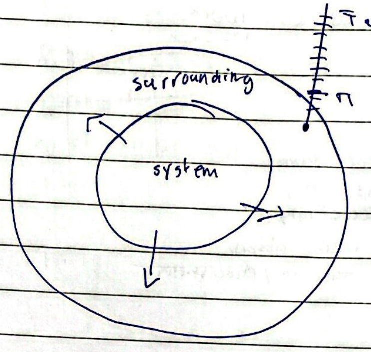
input > output
endothermic

output > input
exothermic

Enthalpy: heat content/
stored energy in
bonds

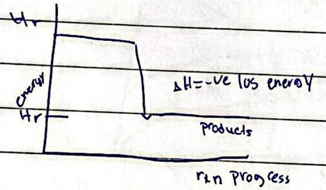
exothermic Reaction.

reaction that release (give out) energy to the surrondiny when they take place

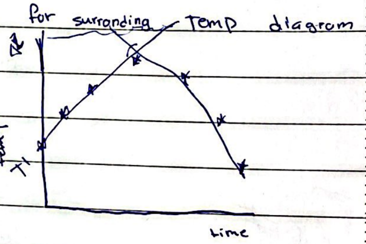


$T_2 > T_1$

for system / energy level diagram



for surronding Temp diagram



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

energy, mass, specific heat capacity, change in temp

$(\uparrow Q)\uparrow\Delta H$

↓

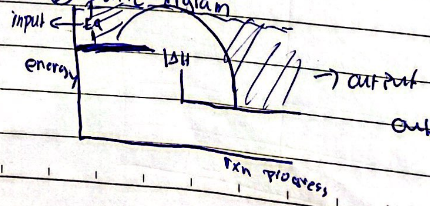
more exothermic

how to express exothermic Rxns

① Reactants ⟶ product + Energy

② Reactants ⟶ products $\Delta H = -ve$

③ profile digram



output > input

examples

1- combustion

2- displacement

3- neutralization

4- respiration

5- freezing, condinsation

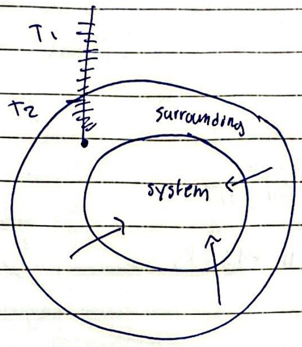
6- voltia cell

7- building up bonds

endothermic reaction

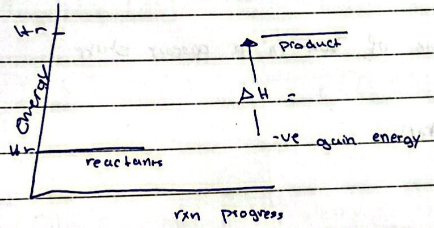
reaction that absorb (take in) energy from the surrounding when they take place

$T_2 < T_1$

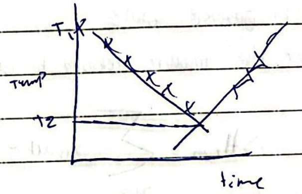


for system

energy level diagram



for surronding temp diagra



$Q = m c \Delta T$

↑Q more endothermic

examples

1- Photosynthesis

2- Photographic films

3- thermal decompostion

4- electrolysis

5- boiling and melting

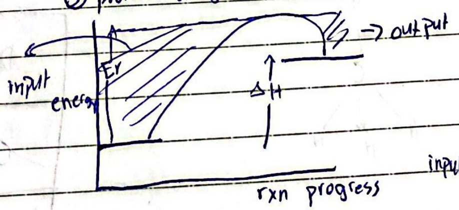
6- breaking bonds down

* how to express endothermic reactions

① Reactant gives off product (reactants + energy ⟶

② reactants ⟶ product ΔH = +ve

③ profile diagram



input > output

Σ

~~Exothermic~~

measuring ΔH rxn using bonds energies

bond	bond energy kJ/mol
H - H	436

(endo)
Bond breaking $H\text{-}H + 436kj \longrightarrow H_{(g)} + H_{(g)}$

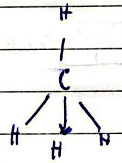
(exo)
Bond building $H_{(g)} + H_{(g)} \longrightarrow H\text{-}H + 436kj$

Bond energy: The amount of energy needed to break 1 mole of bond in gasouse state
or the amount released to build 1 mole of bond in a gaseous state

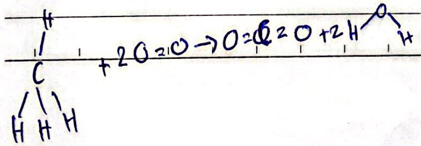
$$\Delta H_{rxn} = \sum_{sum} input - \sum_{sum} output$$

ΔH = total input - total output

+ endo: input > output
- exo: input < output



bond	bond energy
C-H	413
O-H	463
O=O	498
C=O	799



input

bond broken
4×C-H
2×O=O
4×413
2×496 +
2644 kj

output

bond formed
2×C=O
4×O-H
2×790
4×463 +
3450 kj

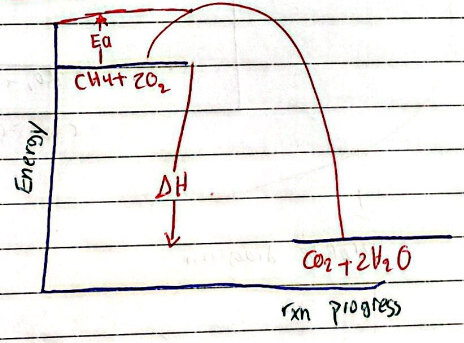
ΔH = input - output
= 2644 - 3450
= ⊖806 kj mol

exothermic

①
$(CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + 806 kj)$ First kind of expression

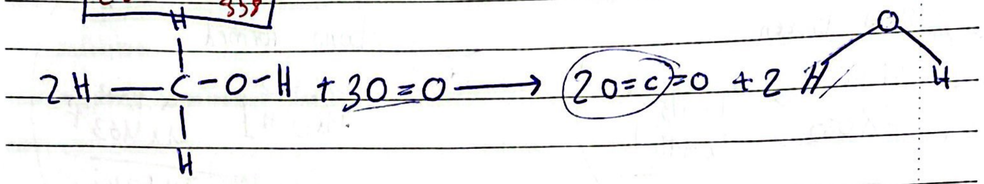
② $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ $\Delta H = -806$ kj mol

③ profile diagram → always for the system



bond	bond energy kj/mol
C-H	413
O=O	496
C=O	799
O-H	463
C-O	358

[redacted]



$2H-\overset{H}{\underset{H}{C}}-O-H + 3O=O \longrightarrow 2O=C=O + 2H-O-H$

bond broken

6XC-H

3XO=O

2XO-H

2XC-O

[redacted]

6x 413

2x 358

2x463

3x496

5608 kj

bond formed

~~3~~ 4XC=O

~~C=O~~

8XO-H

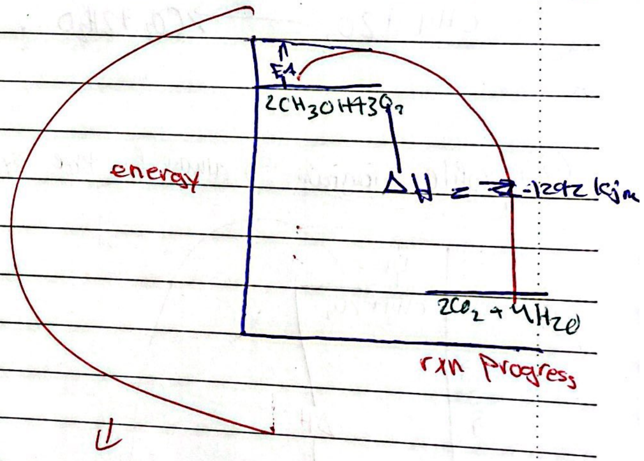
4x799

8x463

6900 kj

$\Delta H = 5608 - 6900$

[redacted] $= -1292$ kj/mol



Profile diagram

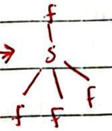
exothermic

sulfer reacts with florine to give sulfertetraflorine and release 780 kj/mol.

if the bond energy for f-f is 160 kj/mol

draw a profile diagram for this reaction find the bond energy for S-F

$S + 2F\text{-}F \longrightarrow$

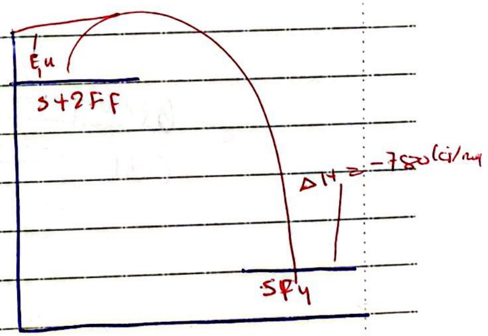


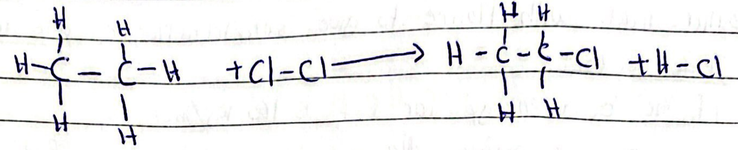
$\Delta H = \text{input} - \text{output}$

$-780 = (2 \times 160) - 4\,S\text{-}F$

$-780 = 320 - 4\,S\text{-}F$

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





$\text{H-C-C-H} + \text{Cl-Cl} \longrightarrow \text{H-C-C-Cl} + \text{H-Cl}$

bond	bond energy
Cl-Cl	242
C-H	413
H-Cl	?
C-Cl	328

Find the bond energy of H-Cl if the amount of energy released is 104 kJ mol exo th

ΔH = input - output

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

$-104 = 655 - x - 328$

$x = 431$ kJ/mol

~~6×C-H~~ ~~6×413~~

Cl-Cl ~~1×242~~

Measuring the amount of energy ~~transfe~~ transfer
surrounding

$Q = mC\Delta T$

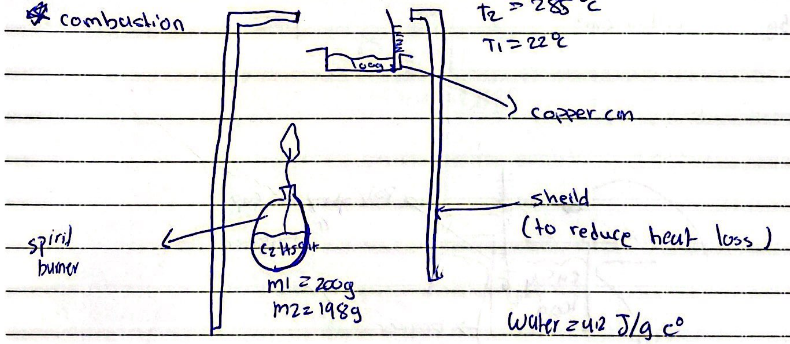
energy transfer (Q)
mass (g) (m)
specifc heat capacity for water 4.2 J/g·C° (C)
change in temp (ΔT)

combustion
$C_2H_5OH + O_3 \rightarrow \underset{3}{CO_2} + H_2O$

displacement
$Zn + CuSO_4 + Cu$

neutdalion
$CuCO_3 + HCl \rightarrow CaCl_2 + H_2O + CO_2$

combustion



$T_2 = 28.5 °C$
$T_1 = 22 °C$

water = 4.2 J/g c°

surrounding = mCΔT
= 100x4.2 (28.5 - 22)
= 2730 J

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

$62790\,J \longrightarrow 46g$

$\Delta H = -62.79\ kJ/mol$

two fuels A & B

Plan an exp to show which fuel produce more energy?

Take a known mass of fuel A in a sprit burner

place a known mass of water in a copper can.

measure the intial temp of water (T_1)

iginte the fuel A

measure the final temp of water (T_2)

repeat the exp using fuel B

the fuel which cause more temp change is the one that produce more energy.

*Displacement reaction

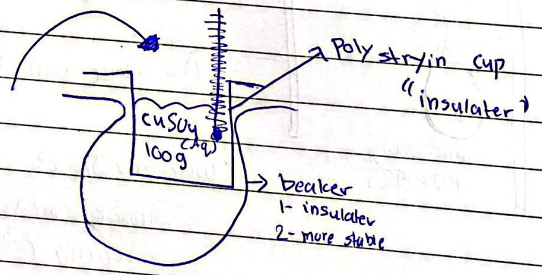
$d = \frac{m}{v}$ $1 = \frac{m}{100}$

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

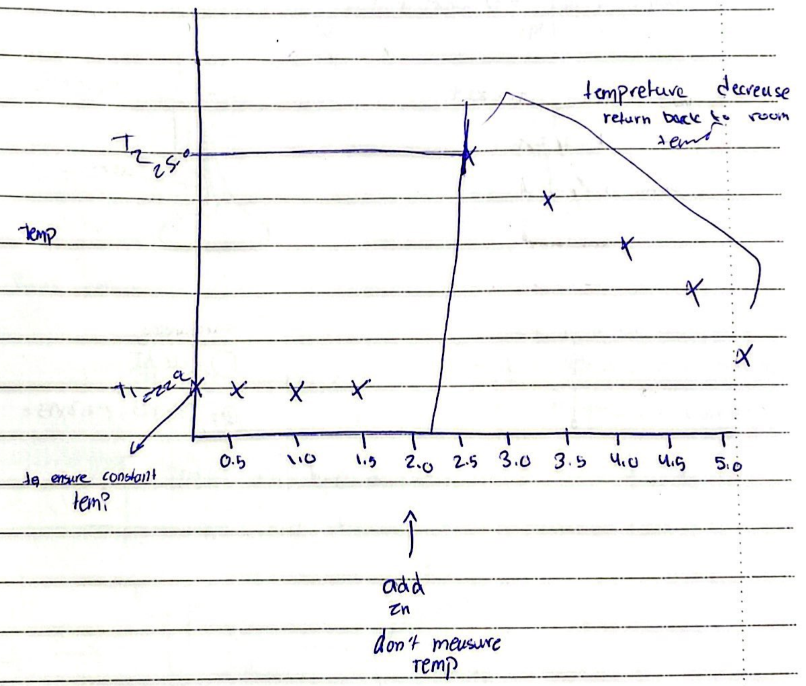
m=0.65g v= 100 cm³

d= 1g /cm³

m= 100 g



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

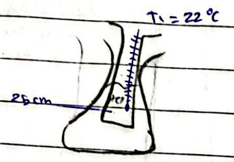


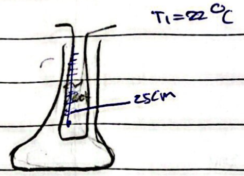
$Q = mc\Delta T$

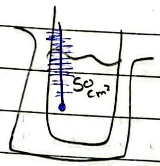
$= 100 \times 4.2 \times 8.2$

Neutralization

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



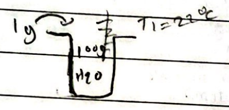


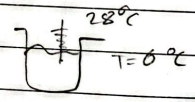


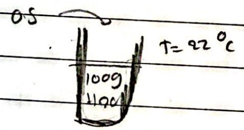
surrounding

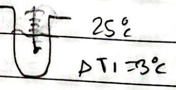
$Q = mc\Delta T$

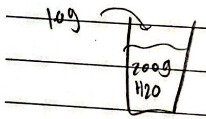
$Q = (25+25) \times 4.2 \times 13 =$ J

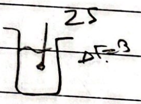












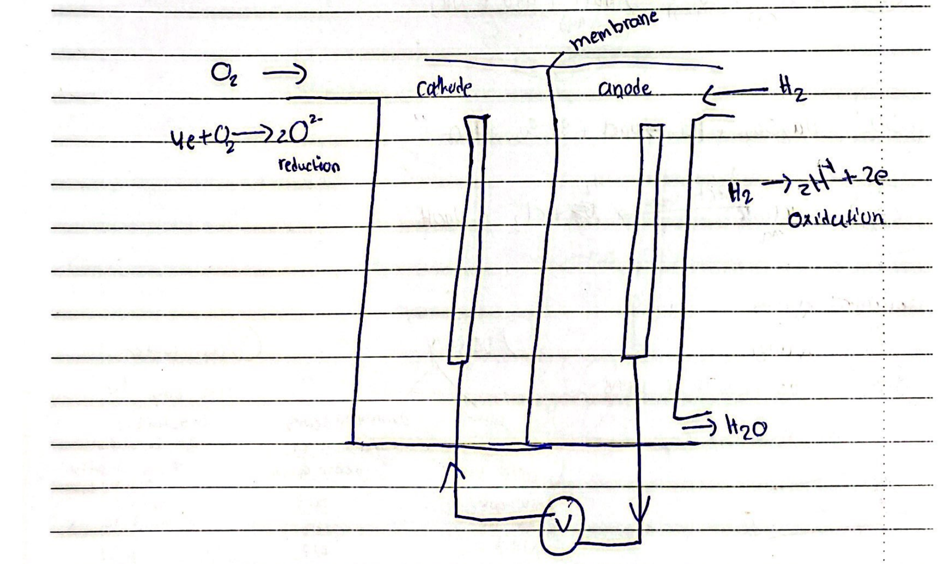
- Alternative recourse of energy
  - voltaic cell
  - hydrogen fuell cell
  - Uranium

hydrogen fuel cell

$2H_2 + O_2 \longrightarrow 2H_2O$
(g) (g) (l)

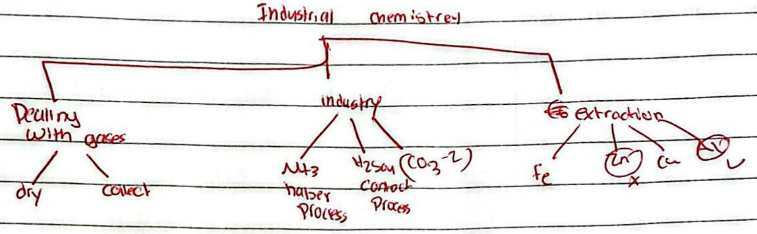
-ve hard to store and transport / risk of explosion
hydrogen is flamable

+ve [produce ony h_2O as waste product and produce high amont of energy "electrical" no CO_2 produced (not pullutent)



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

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



Dealing with gases

(H₂) $Mg_{(s)} + HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$

(CO₂) $CaCO_{3(s)} + HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O + CO_{2(g)}$

(NH₃) $NH_4Cl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O + NH_3$

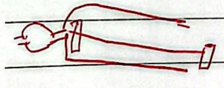
(SO₂) $Na_2SO_3 + HCl \rightarrow NaCl + S + SO_2 + H_2O$

(Cl₂) $NaCl_{(aq)} \xrightarrow{electrolysis} H_2 + Cl_2 + NaOH$

collect gases

① gas syringe

collect and measure the volume of any gas



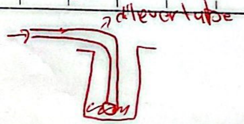
expensive

② Delivery

upward
to collect less dense gases than air
NH_3
H_2

downward delivery
to collect more dense gas than air
SO_2
CO_2
Cl_2

- some gas might escape
- mix with other gases

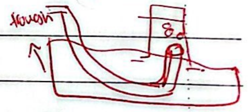


③ over water

used only for insoluble gas in water

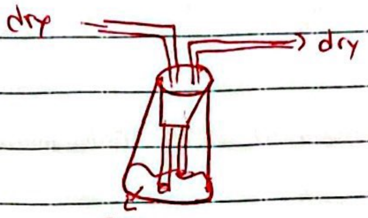
CO_2 slightly soluble in water

hard to use



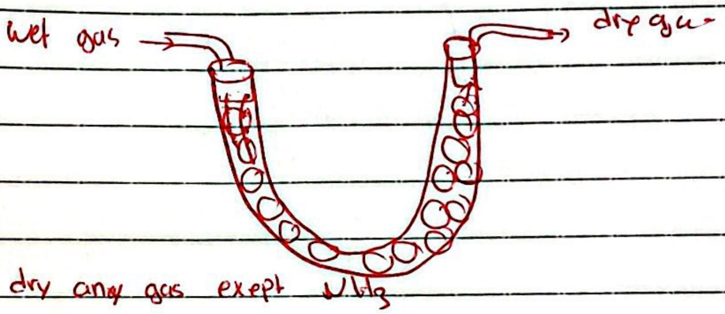
Dry gases

① concentrated H_2SO_4



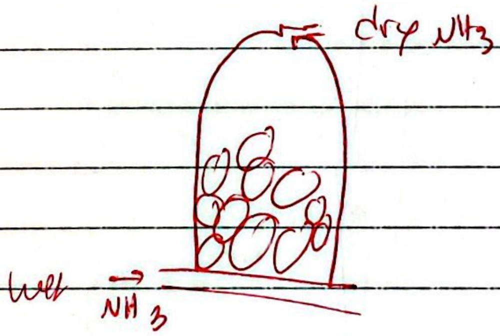
conc H_2SO_4
used to dry any gas exept NH_3

② Anhydrous $CaCl_2$



used to dry any gas exept NH_3

CaO
Quick lime



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

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

Industry of NH_3 (haber process)

$3H_2 + N_2 \underset{endo}{\overset{exo}{\rightleftharpoons}} 2NH_3\ (g)$ $\Delta H = \boxed{-ve}$ exo

uses of $\boxed{NH_3}$
1- Fertelizers (N,P,K)
2- Cleaning detergent
3- smelling salts

temp 400-450°c
- less than 400°c
  - adv: More yield of NH_3, shift forward to the exo side
  - dis: slow rate of rxn ✓
    - particles lose K.E ✓
    - so lose effective collisons per unit time ✓
- greater than 450°c
  - adv: faster rate
  - dis: less yield of NH_3 shift backward to the endo side

essential conditions
1- temp 400°c – 450°c
2- pressure 200 atm
3- catalyst (Fe)

* add excess hydrogen (H_2) and nitrogen (N_2) return back to converter

* remove NH_3 immediatly? How?
by cooling down NH_3 condense

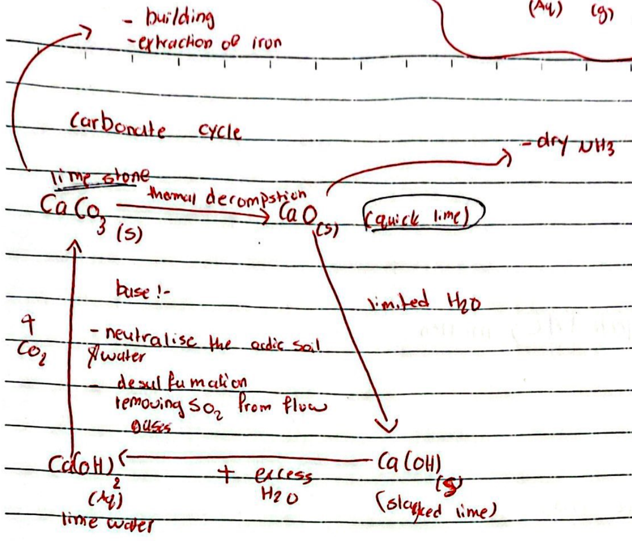
pressure 200 atm
high pressure
- adv
  1- more yield of NH_3 (shift forward to the side with less gas)
  2- faster rate (more collions per unit time)
- dis
  1- risk of explosion
  2- expensive

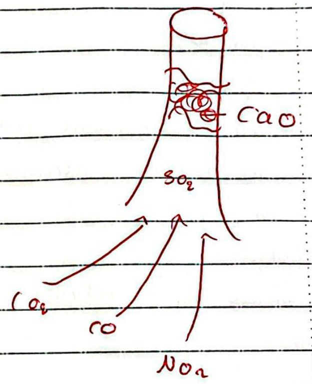
* how to obtain
N_2: fractional distilation of (liquid air)
H_2: ① cracking of alkane (organic)
② $CH_4 + H_2O\ (g)$
methane
↓
$3H_2 + CO$

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

test CO_2

~~$Ca(OH)_2 + CO_2$ (aq) (g)~~





i) cacium carbonate, CaO

ii) step 3

iii) thermal decompstion

iv) heat

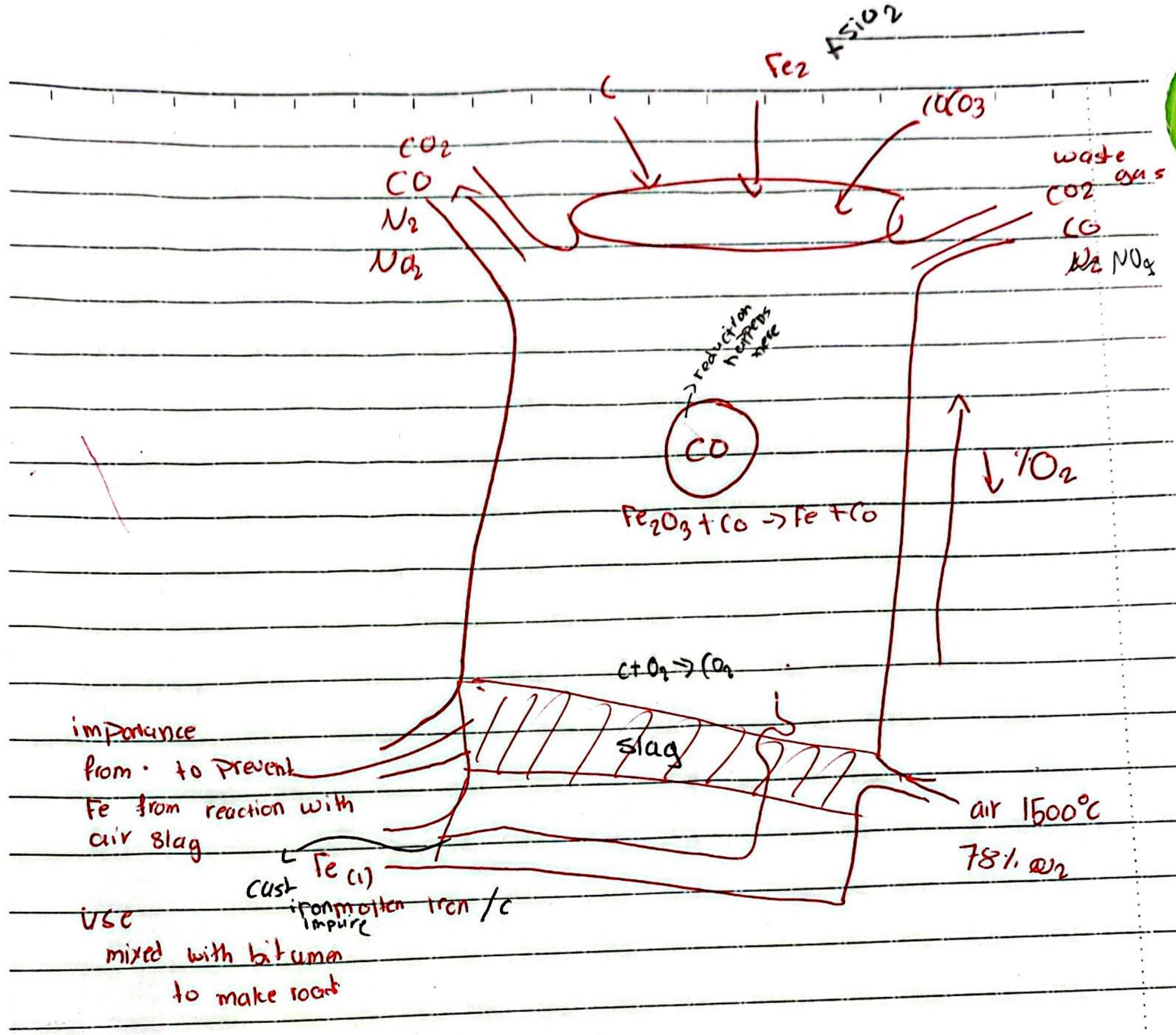
v) $Ca(OH)_2 + CO_{2(g)} \rightarrow CaCO_3 + H_2O$

vi) CO_2 is acidic oxide and $Ca(OH)_2$ is baisc extraction of metal

K
Na
Li
ca — electrolyte, mollen
mg
Al
C, CO
Zn → ZnS zinc blind
Fe → Fe_2O_3 Hematite
pb
H
Cu → CuS reduction by H_2
As
Au
Pt

extraction of iron
Ore :- Hematite Fe_2O_3
method :- reduction by C, CO
place :- Blast furnance

Raw materials : ① Fe_2O_3 + acidic $\overset{\text{impurties}}{\uparrow}$ SiO_2
② $CaCO_3$ (clime stone)
③ coke (pure carbon)
④ air (T = 1500°c)



redox combo

① complete ↑ $C + O_2 \longrightarrow CO_2$ ⟶ produce energy

redox

② incomplete comb $2C + O_2 \longrightarrow 2CO$ ⑥ / $CO_2 + C \rightarrow 2CO$ redox

redox

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

④ $CaCO_{3(s)} \xrightarrow{heat} CaO$ thermal decompotion

⑤ $CaO + SiO_2 \longrightarrow CaSiO_3$ calcium silicate / slag ∫ neutralization

base acid ~~calcuim sulfate~~

steel making "Oxgyen-base process"

cast iron

Fe

CO_2 ← C → main impurity

SO_2 ← S

$SiO_{2(s)}$ ← Si

P_2O_5 ← P

① blow hot O_2

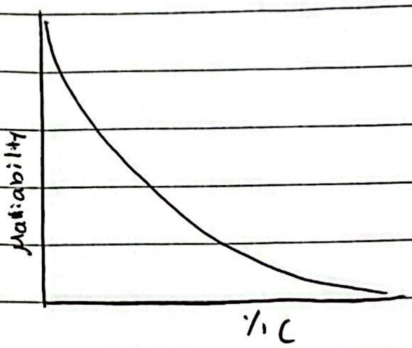
② CaO

steel

mildsteel 0.03% C → ① car bodies

medium steel 0.3% C → ① rail ways

stainless steel 3-5% C → kitchen, watch



as the carbon increase, Malliabillty decrease → hard, britl

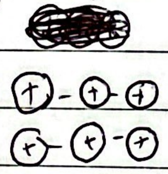
Alloy:- Mixture of metal with another metal or semi-metal

① Brass → Cu + Zn

② Bronze → Cu + Sn

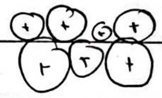
③ steel → Fe + C + Cr + Ni

Copper



easir slide

Brass



two diffrent sizes so harder to slide