CO_3^{2-}

All metal carbonates

P K_2CO_3

Na Na_2CO_3

Ca $CaCO_3$

Mg $MgCO_3$

Al $Al_2(CO_3)_3$

Zn $ZnCO_3$

Fe $FeCO_3$ $Fe_2(CO_3)_3$

Pb $PbCO_3$

Cu $CuCO_3$

Redox

in terms of	reduction	oxidation

① oxygen — lose O — gain O

$$\underbrace{Al + \overbrace{Fe_2O_3 \rightarrow Al_2O_3}^{\text{reduction: Fe in } Fe_2O_3} + Fe}_{\text{oxidation: Al}}$$

$$CO + ZnO \rightarrow Zn + CO_2$$

reduction: Zn in ZnO

oxidation: C in CO

$$H_2 + CuO \rightarrow Cu + H_2O$$

reduction Cu in CuO

oxidation H_2

$$H_2S + Cl_2 \longrightarrow HCl + S$$

reduction: Cl_2

oxidation: S in H_2S

② Hydrogen — gain H — lose H

$Zn + CuCl_2 \longrightarrow ZnCl_2 + Cu$

In terms of

(3) oxidation state — decrease: reduction; increase: oxidation

$\xrightarrow{\text{oxidation}}$

-3 -2 -1 0 1 2 3

$\xleftarrow{\text{reduction}}$

$\overset{0}{Zn} + \overset{2+}{Cu} \rightarrow Zn^{2+} + Cu$

oxidation $Zn^0 \rightarrow Zn^{2+}$

Rules of oxidation state

1) the oxidation state for any free element = Zero

monoatomic

Na, K, Li

Ne, Ca, Cu

polyatomic

P_4

S_8

di atomic

F_2, Cl_2, Br_2

I_2

2) the oxid. no. of any atom in a compound from

group IA = +1 Li, Na, K, Rb, Cs, Fr

group II = 2+ Mg, Ca, Sr, Ba

group III = 3+ always +3 only for Al

group VII = −1 always −1 only for F

constant

③ the oxidation number of Hydrogen (+1) in
semi-rted considered non-metal 99% of compound
except with metal in metal hydride (−1)

$\overset{+1}{CH_4}$, $\overset{+1}{NH_3}$, $\overset{+1}{Na}\overset{-1}{H}$, $\overset{2+}{Ca}\overset{1-}{H_2}$

④ oxidation state of Oxygen (−2)

except in peroxide (−1)

except in OF_2 (2+)

O^{2-} oxide O_2^{-2} peroxide

sodium oxide Na^{+1} O^{-2} ⟶ Na_2O^{2-}

sodium peroxide Na^{+1} O_2^{-2} ⟶ $Na_2O_2^{-2}$

Five Apple

H_2O^{2-} $H_2O_2^{1-}$

water Hydrogen peroxide

calcium oxide calcium peroxide

$Ca^{2+} O^{2-}$ $Ca^{2+} O_2^{-2}$

CaO CaO_2

calcium oxide

Ca^{2+} O^{2-}

CaO

calcium peroxide

Ca^{2+} O_2^{2-}

CaO_2

5) the sum of all oxidation states in a compound $= 0$

in an ion = charge to this ion

$+1 + -1 = 0$

$NaCl$

Find charge of (Xs) in the following:

$\overset{+1}{H}\overset{x}{Cl}O^{2-}$

$1 + x - 2 = 0$

$x - 1 = 0$
$+1 \quad +1$

$x = +1$

$Cl = +1$

$\overset{+1}{H}\overset{x}{Cl}(O_3)^{-2}$

$1 + x + 2(-2) = 0$

$1 + x - 4 = 0$

$x - 3 = 0$
$+3 \quad +3$

$x = 3$
$Cl = 3$

$\overset{x}{N}\overset{+1}{H_3}$

$x + 3(+1) = 0$

$x + 3 = 0$
$-3 \quad -3$

$x = -3$
$N = -3$

$\overset{x}{N}\overset{+2}{O}$

$x + 2 = 0$
$-2 \quad -2$

$x = -2$

$\overset{x}{N_2}\overset{-2}{O_5}$

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

$2x + -10 = 0$
$+10 \quad +10$

$\frac{2x}{2} = \frac{10}{2}$

$x = +5$
$N = +5$

Five Apple

important:

$\overset{x}{N}\overset{-2}{O_3}$ (1-) → ionic charge for the whole compound

→ Ionic charge for the whole compound

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

$N - 6 = -1$
$+6 \quad +6$

$N = +5$

$\overset{x}{Mn}O_4^{-1}$ $\quad Mn + 4(-2) = -1$

$Mn - 8 = -1$
$+8 \quad +8$

$Mn = +7$

$\overset{x}{S}O_3^{2-}$ $\quad S + 3(-2) = 2-$

$S - 6 = -2$
$+6 \quad +6$

$S = +4$

$Cr_2O_7^{2-}$

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

$2x - 14 = -2$
$+14 \quad +14$

$x = +6 \quad Cr = +6 \quad \frac{2x}{2} = \frac{12}{2}$

Q :- Find the oxidation state of each underlined species:

$\overset{+3}{Fe_2}\overset{-2}{O_3}$ $\qquad$ $\overset{+2}{O}\overset{-1}{F_2}$ $\qquad$ $\overset{+6}{S}\overset{-2}{O_4}{}^{2-}$

$\overset{+5}{V_2}\overset{-2}{O_5}$ $\qquad$ $\overset{+5}{P}\overset{-2}{O_4}{}^{3-}$ $\qquad$ $\overset{+6}{Cr}\overset{-2}{O_4}{}^{2-}$

$\overset{+2}{C}\overset{-2}{O}$ $\qquad$ $\overset{+4}{C}\overset{-2}{O_2}$ $\qquad$ $\overset{+4}{C}\overset{-2}{O_3}{}^{2-}$

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

oxidation $\overset{0}{Al} \rightarrow Al^{+3}$

reduction $= \overset{+3}{Fe} \rightarrow \overset{0}{Fe}$

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

oxidation $= \overset{+2}{C} \rightarrow \overset{+4}{C}$

reduction $= \overset{+2}{Zn} \rightarrow \overset{0}{Zn}$

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

oxidation $= \overset{-2}{S} \rightarrow \overset{0}{S}$

reduction $= \overset{0}{Cl_2} \rightarrow \overset{-1}{Cl}$

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

oxidation = $Fe^{+2} \rightarrow Fe^{+3}$

reduction = $Mn^{+7} \rightarrow Mn^{+2}$

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

oxidation = $Sn^{+2} \rightarrow Sn^{+4}$

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

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

Not a Redox

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

oxid = $\overset{0}{Na} \rightarrow Na^{+1}$

redu = $H^{+1} \rightarrow \overset{0}{H_2}$

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

overall rxn $Al + Fe^{3+} \rightarrow Al^{3+} + Fe$

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

half oxidation: $Al \rightarrow Al^{3+} + \cancel{2}\bar{e}$

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

writing balanced half Ionic equation.

1) Atoms

2) the charge: by adding $\bar{e}$ to the side with greater charge by the difference.

$\overset{0}{Ca} + \overset{2+}{Zn}\overset{1-}{Cl_2} \rightarrow \overset{2+}{Ca}\overset{1-}{Cl_2} + \overset{0}{Zn}$

H.O.O $Ca \rightarrow Ca^{2+} + \cancel{2\bar{e}}$

H.O.R $Zn^{2+} + \cancel{2\bar{e}} \rightarrow Zn$

overall rxn $Ca + Zn^{2+} \rightarrow Ca^{2+} + Zn$

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

H.O.O $(Na \rightarrow Na^{+1} + 1\bar{e}) \times 2 \rightarrow (2Na \rightarrow 2Na^{+1} + \cancel{2}\bar{e}$

balance atoms first

H.O.R $2H^{+1} + 2\bar{e} \rightarrow H_2$

overall rxn $2Na + 2H^{+} \longrightarrow 2Na^{+1} + H_2$

$\overset{0}{Ca} + \overset{3+}{Al}\overset{-1}{Cl_3} \longrightarrow \overset{+2}{Ca}\overset{-1}{Cl_2} + \overset{0}{Al}$

H.O.O $(Ca \rightarrow Ca^{2+} + 2\bar{e})\ 3$

H.O.R $(Al^{3+} + 3\bar{e} \longrightarrow Al)\ 2$

overall rxn $3Ca + 2Al^{3+} \longrightarrow 3Ca^{2+} + 2Al$

reactants $\longrightarrow$ products

oxidation $\longrightarrow$ $\bar{e}$ "lose $\bar{e}$"

reduction $\bar{e}$ $\longrightarrow$ "gain $\bar{e}$"

Oil Rig

is lose is gain

$$\overset{2-}{H_2S} + \overset{0}{Cl_2} \longrightarrow H\overset{-1}{Cl} + \overset{0}{S}$$

H.O.O

$$Al + HCl \longrightarrow AlCl_3 + H_2$$

H.O.O $(Al \longrightarrow Al^{3+} + 3\bar{e}) \times 2$

H.O.R $(2H^{+} + 2\bar{e} \longrightarrow H_2) \times 3$

↓

$$2Al \longrightarrow 2Al^{3+} + \cancel{6\bar{e}}$$

$$6H^{+} + \cancel{6\bar{e}} \longrightarrow 3H_2$$

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

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

H.O.O $(Fe^{2+} \longrightarrow Fe^{3+} + 1\bar{e}) \times 5$

H.O.R $Mn^{+7} \longrightarrow Mn^{2+}$
$+ 5\bar{e}$

$5\,Fe^{2+} \longrightarrow 5\,Fe^{3+} + 5\,\bar{e}$

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

$\overset{+6}{Cr_2}\overset{-2}{O_7}{}^{2-} + Sn^{2+} + H^+ \rightarrow Cr^{3+} + Sn^{4+} + H_2O$

H.O.O $(3Sn^{+2} \rightarrow 3Sn^{+4} + 6\bar{e})3$

H.O.R $(2Cr^{+6} + 6\bar{e} \rightarrow 2Cr^{+3})2$

$3Sn^{2+} + 2Cr^{+6} \rightarrow 3Sn^{+4} + 2Cr^{3+}$

oxidising agent and reducing agent

oxidising agent "Oxidant"

the substance that itself reduced and causes the other substance to be oxidize.

reducing agent "reductant"

the substance that itself oxidised and causes the other substance to be reduced.

Imp

if the substance is an Ion in a compound the agent is the compound itself

	reducing agent	oxidizing
O	gain O	lose O
H	lose H	gain H
oxid state.	↑	↓
$\bar{e}$ transfer	lose $\bar{e}$	gain $\bar{e}$

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

oxidation Al reducing agent : Al

reduction Fe^{3+} oxidizing agent : Fe_2O_3

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

oxidation C^{2+} oxidizing agent : ZnO

reducing Zn^{2+} reducing agent CO

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

oxidant Cl_2

reductant H_2S

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

oxidizing agent MnO_4^{-1}

reductant : Fe^{2+}

most common oxidizing agent

① oxygen

$Fe + O_2 \rightarrow Fe_2O_3$

$S + O_2 \rightarrow SO_2$

② Acidify pothassium manganate $KMnO_4 / H^+$

$\underset{(+7)}{MnO_4^{-1}} \rightarrow \underset{(+2)}{Mn^{2+}}$

purple → colorless

③ Acidify potassium dicromate $K_2Cr_2O_7 / H^+$

$\underset{(+6)}{Cr_2O_7^{2-}} \rightarrow \underset{(+3)}{Cr^{3+}}$

orange green

(4) Halogens

$\bar{e} + F_2 \longrightarrow 2F^-$
yellow

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

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

$\bar{e} + I_2 \longrightarrow 2I^-$
purple gas
black solid
red brown solution
(aq)

colorless solution

most common reducing agent

(1) Hydrogen:

(2) carbon and carbon monoxide

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

$CO + \overset{2+}{Zn}O \longrightarrow CO_2 + \overset{0}{Zn}$

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

colorless → red-brown

(4) Metals

strongest reductant K → K^+ ← weakest oxidant

Na

Li

Ca

Mg

Al

~~Zn~~ C, CO

Zn

Fe

Pb

H

Cu

Ag

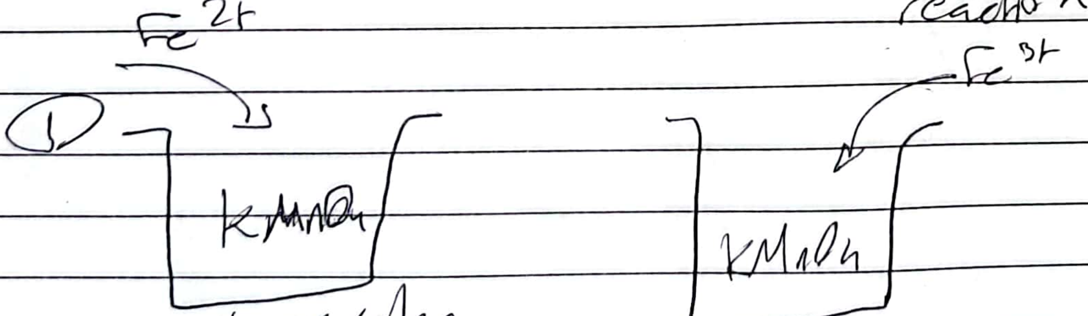
oxidant	reductant
O_2	H_2
$KMnO_4$	C, CO
$K_2Cr_2O_7$ / H^+	Metals
Halogen	Iodide

Q:- Fe^{2+} is a reducing agent

Fe^{3+} is an oxidising agent

record the observation in each of the following reaction

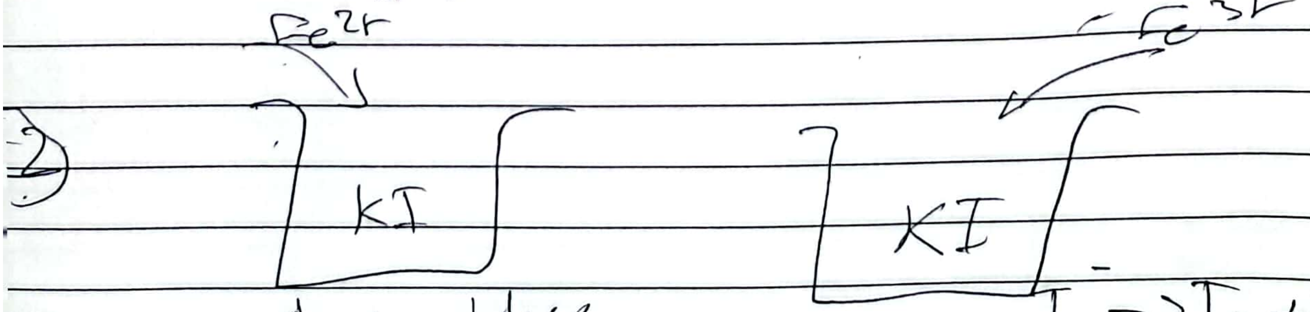
1)



change color from purple to colorless

stays purple

2)

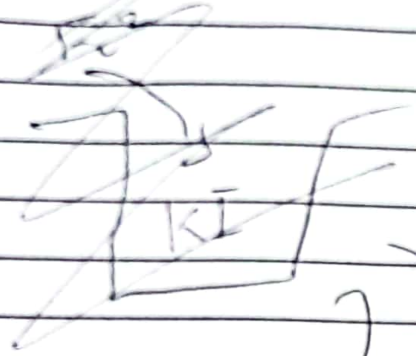


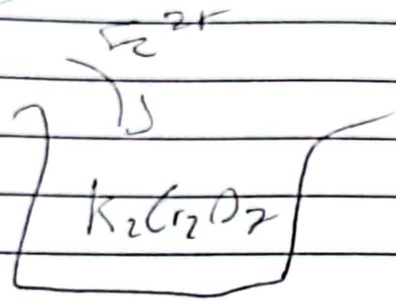
stays colorless

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

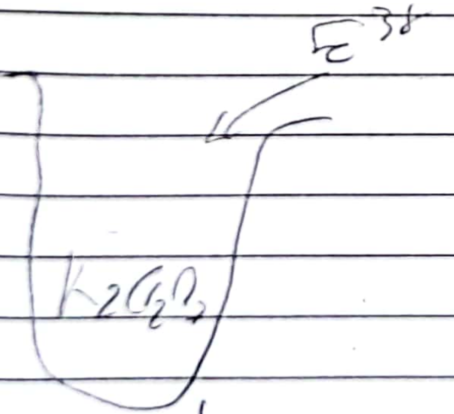
red brown

3)





change from
orange to green



no change

Electrolysis

electricity

Analysis
"breaking down"

electrolysis: breaking down chemical compounds (Ionic)
when molten or aqueous by passing electricity.

~~&~~ electrolyte: chemical compound that conduct electricity
when molten or aqeous

why the ionic compounds don't conduct electricity
when solid?
the ions are
not free to move

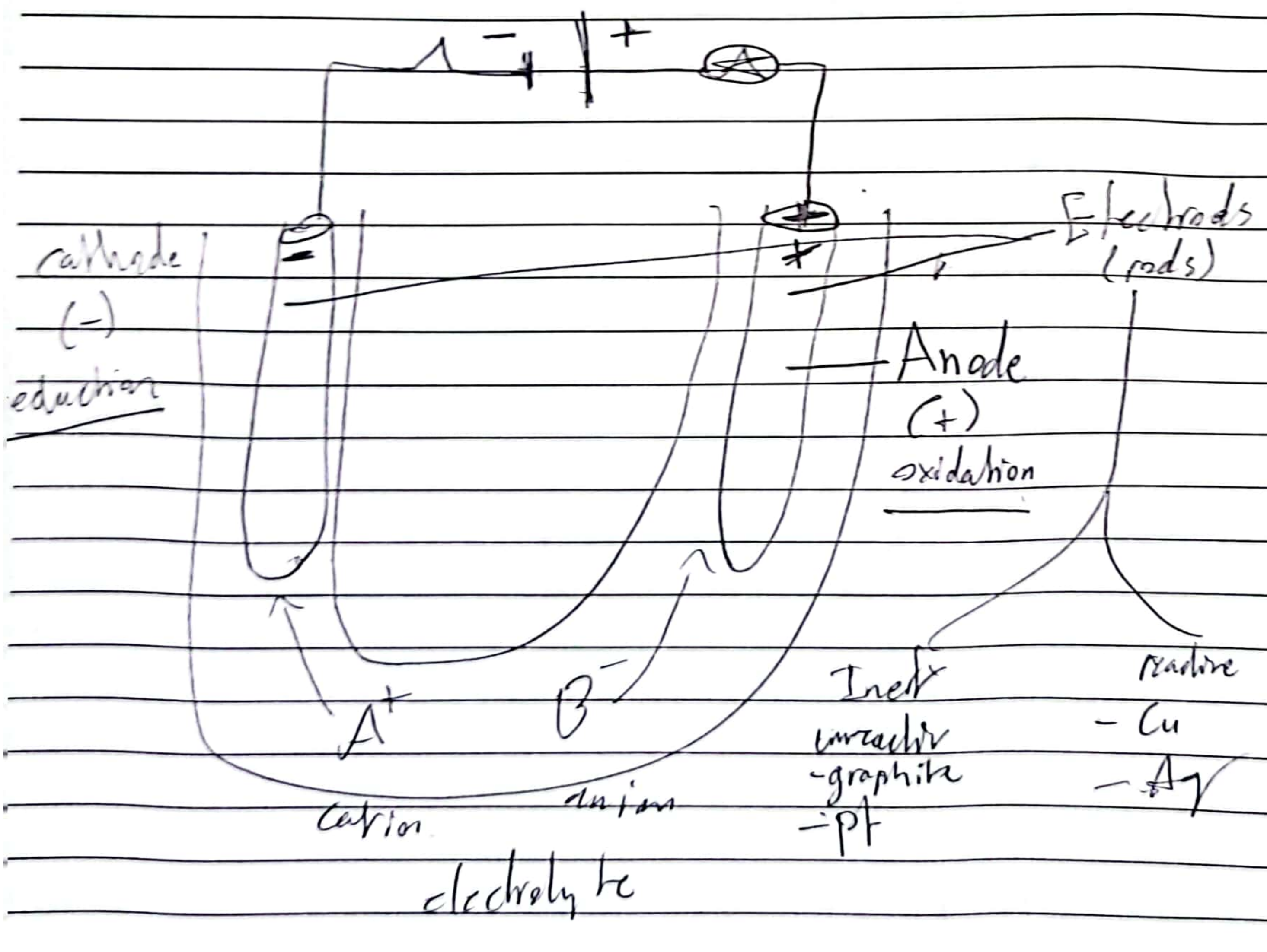
why the ionic compound conduct electricity when
dissolve in water or molten

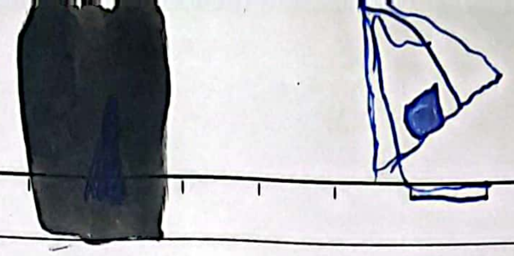
ions are free to move

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

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

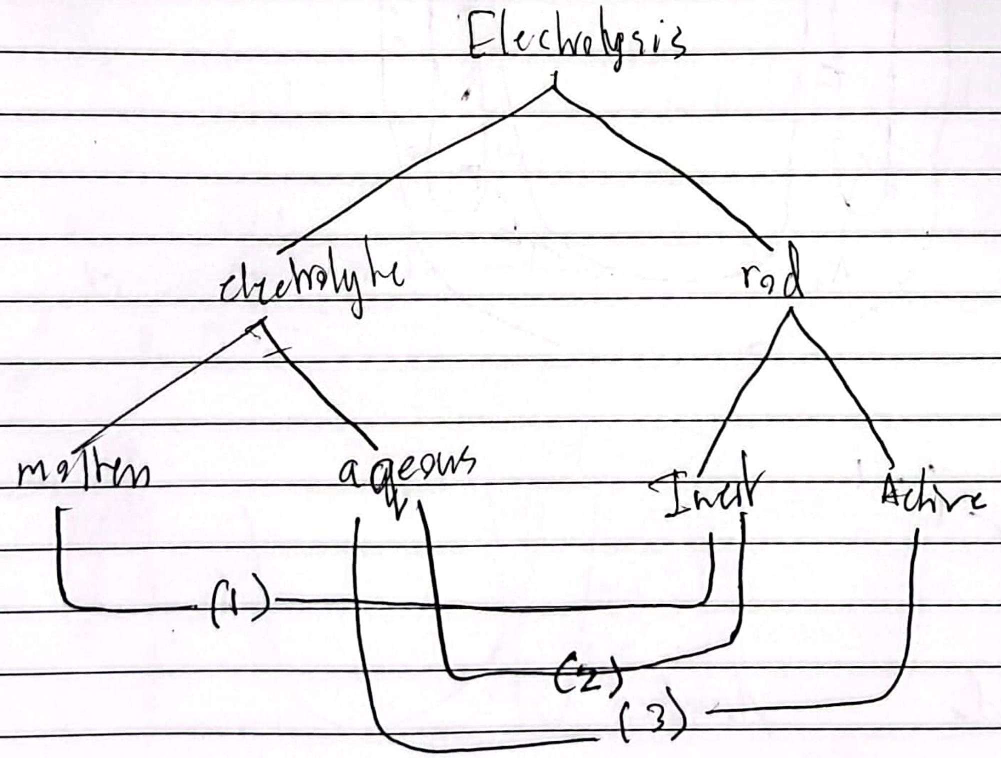
Electrolysis cell



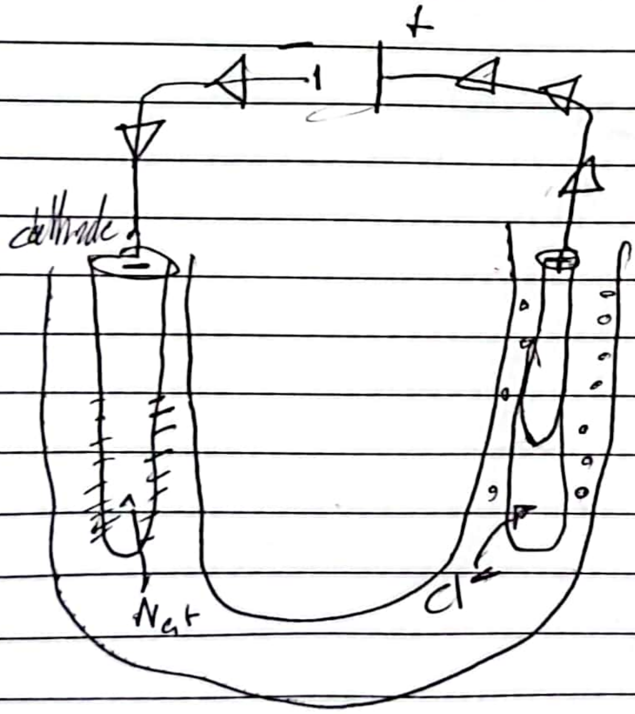


Cathode: the -ve rod that attracts the +ve ions (cations) where the reduction occurs.

Anode: the +ve rod



electrolysis for Molten electrolyte using Inert rods (graphite)



$NaCl_{(l)}$

Cl^{-1}

Na^+

cathode Anode

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

deposite of metal $\quad$ bubbles of green yellow gas

electrolyte used up

$NaCl_{(l)} \xrightarrow{electricity} Na + Cl_2$

Molten lead(II) bromide

$PbBr_2(l)$

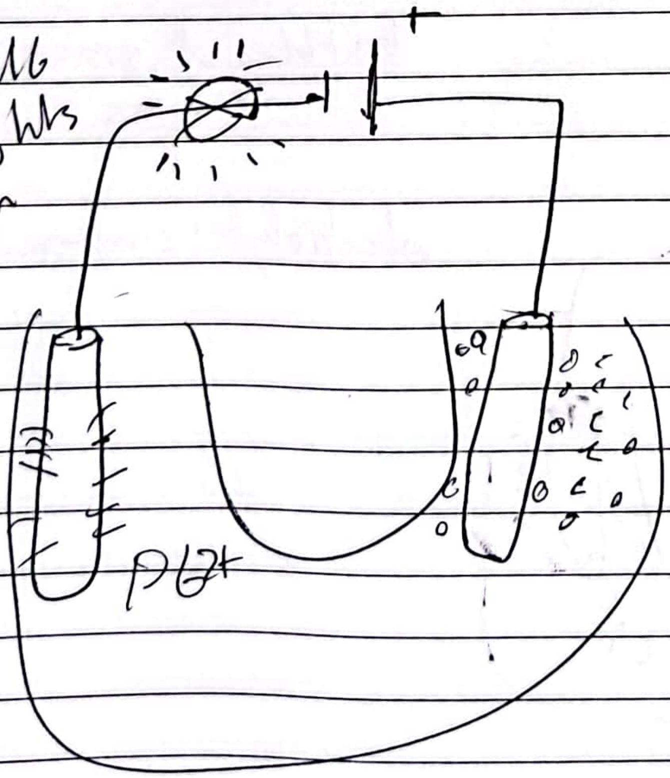
behal ions Pb^{2+} — Br^{-1}

Cathode — Anode

$2\bar{e} + Pb^{2+} \rightarrow Pb$ — $2Br^{-1} \rightarrow Br_2 + 2\bar{e}$

deposite of metal — bubbles of red brown gas

bulb lights on



$CuCl_{2(l)}$ / graphite

$CuCl_2$

total ions

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

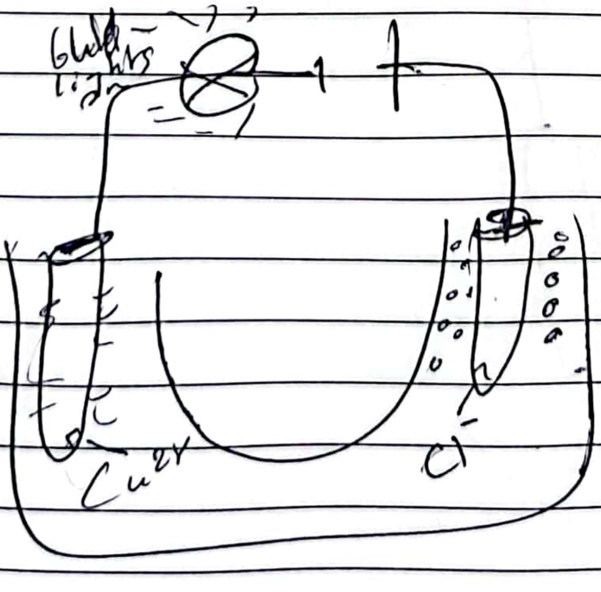
cathode Anode

$2\bar{e} + Cu^{2+} \longrightarrow Cu$ $2Cl^{-1} \longrightarrow Cl_2 + 2\bar{e}$

deposite of metal

bubbles of green gas

electrolyte: consumed



Al_2O_3 (l)/graphite

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

Cathode Anode

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

deposite of metal bubbles of colorless gas

electrolytes used up

* Electrolysis of aqueous electrolyte using inert

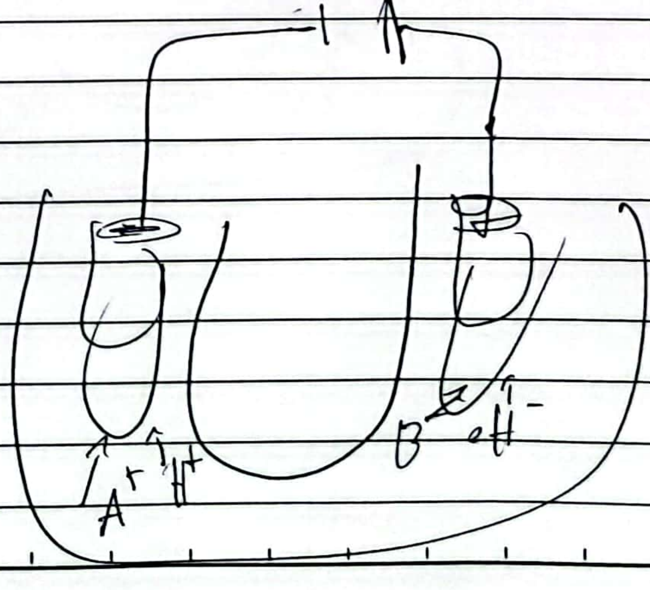
$$AB_{(aq)} \rightarrow A^+ + B^-$$

H^+ OH^-

Cathode Anode

At the cathode

the less reactive Ion is more likely to reduce and th more reactive stays in the electrolyte (reactivity series)



At ~~the~~ the anode

always OH^- except concentrated halide
Cl^-, Br^-, I^-

when the halide oxidise

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

when OH^- oxidise

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

bubbles of colorless gas

concentrated NaCl / graphite

Na^+ — Cl^-

H^+ — OH^-

cathode — Anode

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

bubbles of colorless gas — bubbles of green-yellow gas

electrolyte: NaOH

$CuSO_4$ (aq) (graphite)

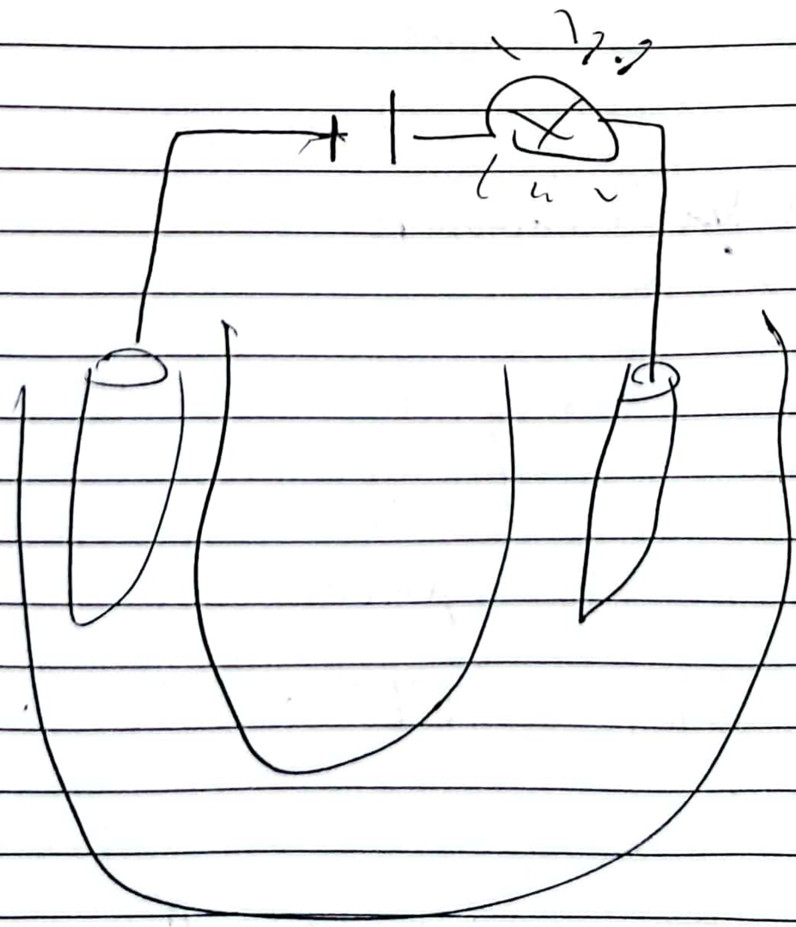
Cu^{+2} SO_4^{2-}

H^+ OH^-

cathode anode

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

electrolyte: H_2SO_4



dilute NaCl(aq)/graphite

Na^+ Cl^-

H^+ OH^-

cathode Anode

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

bubbles of colorless gas bubbles of colorless gas

electrolyte : NaCl

conc. KI (aq) / graphite

K^+ I^-

H^+ OH^-

cathode Anode

$2H^+ + 2e^- \rightarrow H_2$ $2I^- \rightarrow I_2 + 2e^-$

bubbles of colorless gas red brown

electrolyte : KOH

conc. $CuCl_2$ (aq) / graphite

Cu^{2+} Cl^-

H^+ OH^-

cathode Anode

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

deposit of red brown solid

bubbles of green yellow gas

electrolyte : less conc $CuCl_2$

gas	test	result
H_2	lighted splint	pop
O_2	glowing splint	relight
Cl_2, Br_2	damp litmus paper	turns red then bleach

concentrated sodium chloride called brine solution

$NaCl_{(aq)}$

Na^+ Cl^-

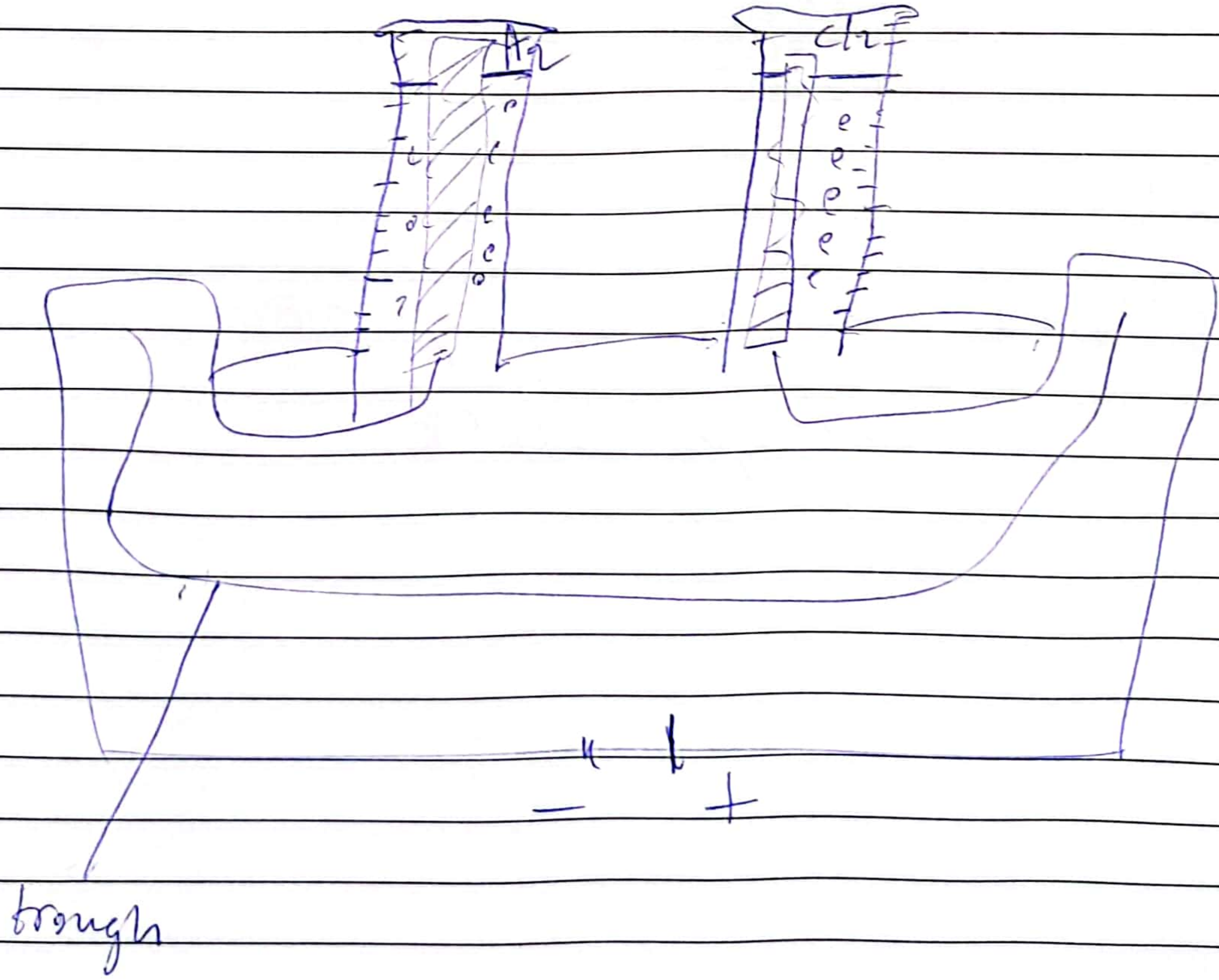
H^+ OH^-

cathode Anode

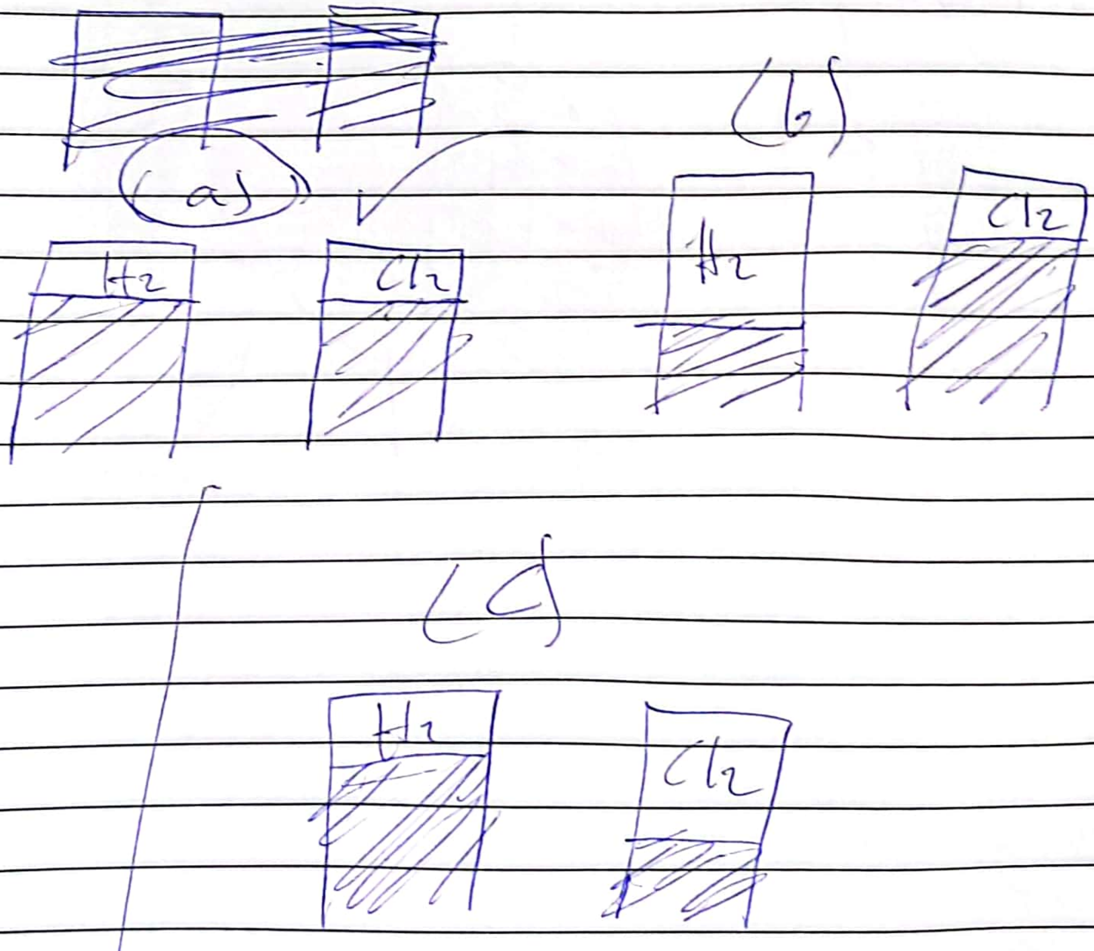
$2H^+ + 2\bar{e} \rightarrow H_2$ $2Cl^- \rightarrow Cl_2 + 2\bar{e}$

electrolyte : NaOH

Q: plan an exp to collect and measur the volume of H_2 and Cl_2 produced



Q2 The final appearance of the two measuring cylinders ar



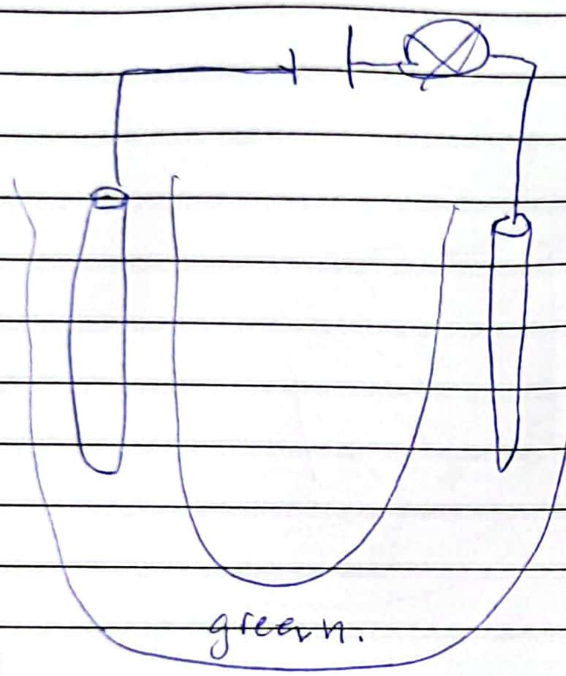
Half of oxid : $2Cl^- \rightarrow Cl_2 + 2\bar{e}$

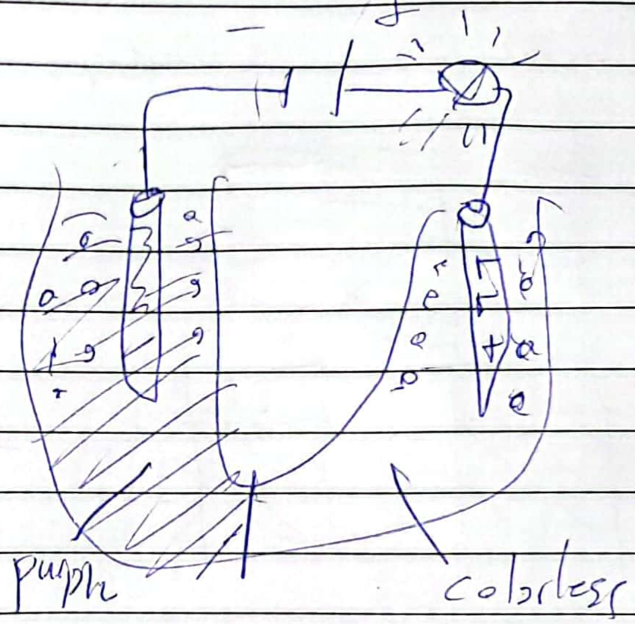
Half of red. : $2H^+ + 2\bar{e} \rightarrow H_2$

overall rxn. $2H^+ + 2Cl^- \rightarrow H_2 + Cl_2$

$1 : 1$

93c brine with univeral indicator





Observation.

1- the bulb light up

2- bubbles of green yellow gas on the anode
(oxidation of Cl^-)

3- bubbles of colorless gas on the cathode (reduction of H^+)

4- around the cathode the solution becomes purple because NaOH is an alkalai

5- around the anode the solution becomes colorless colorless since Cl_2 bleach the color

The Cl_2 not immediatly appear as-

H_2 produce? some Cl_2 dissolve in solution electrolysis for aqueous electrolyte using active rod

* the rod must be the same metal Ion in the electrolyte

$CuSO_4$ (aq) $\xrightarrow{\text{using}}$ Cu rod

$AgNO_3$ (aq) $\xrightarrow{\text{using}}$ Ag rod

electrolysis for aqeous $CuSO_4$ using Cu rod

$CuSO_4$ (aq)

Cu^{2+} SO_4^{2-} ✗

H^+ OH^- ✗

the anode itself oxidize

cathode

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

Anode

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

$CuSO_4$

cathode anode

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

H^+ OH^-

$Pb(NO_3)_2$ (aq)

Pb^{2+} NO_3^{-1}

H^+ OH^-

cathode Anode

H_2 O_2

Five A

H_2SO_4

H^+
H^+

SO_4^{-2}
OH^-

cathode

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

Anode

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

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

1 : 2

electroplating :

coating a metal with another metal using electrolysis

why? 1) to prevent rusting

2) more attractive

How to electroplate a metal spoon, with silver?

1- clean the spoon from any impurities or ~~oxid~~

oxide layer using sand paper. to ensure a good sticking

2- make the spoon the cathode (-ve)

3- the anode must be , Ag.

4- the electrolyte must contain Ag^+ eg. $AgNO_3$

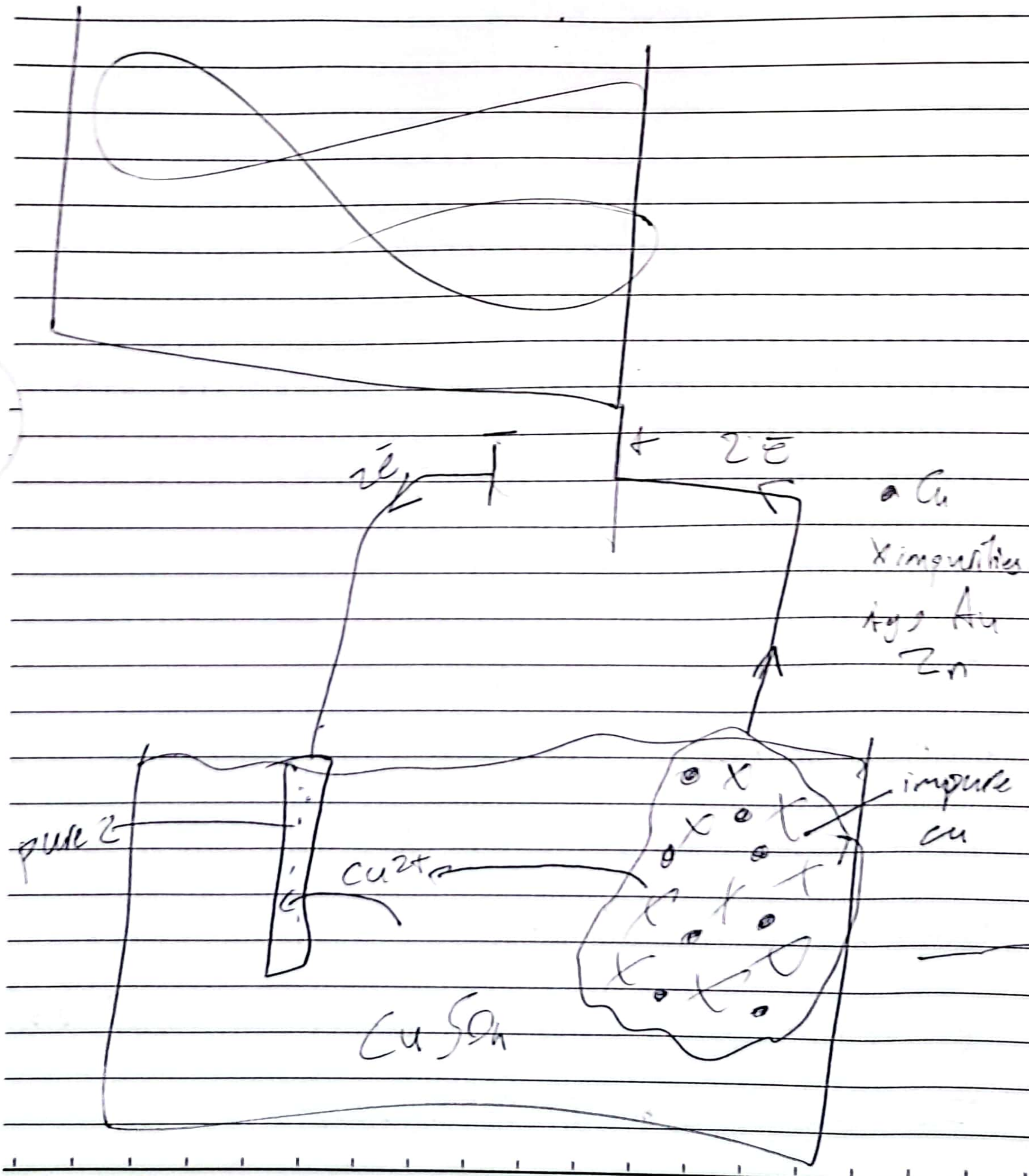
5- turn on the circuit "be sure that the spoon is fully submerged in the electrolyte

6- rotate the spoon to ensure an equal distribution

7- rinse with distilled water

8- dry in oven

② purifying Metals / refining Copper



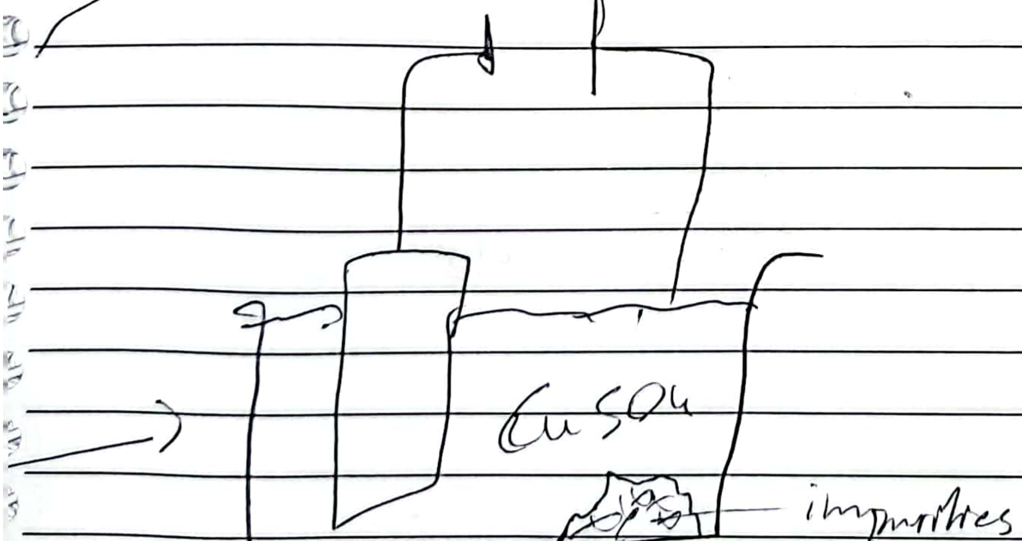
$Cu^{+2} + 2e^- \rightarrow Cu$ $\qquad$ $Cu \rightarrow Cu^{+2} + 2e^-$

extraction of metals from their ores

- the method of extraction depends on the position of metal in reactivity series

K
Na → electrolysis / molten / graphite
Li
Ca
Al_2O_3 Mg
bauxite ← Al
C, CO
Zinc blend ZnS ← Zn
Fe
Pb →
Fe_2O_3 hematite

H
copper sulfide CuS ← Cu → reduction by H_2
Ag
Au



Au, Ag settle down (less reactive)

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

Extraction of Aluminium

ores :- Al_2O_3 bauxite

method :- electrolysis for molten Al_2O_3 / graphite

m.p of A_2O_3 is about 2000°C

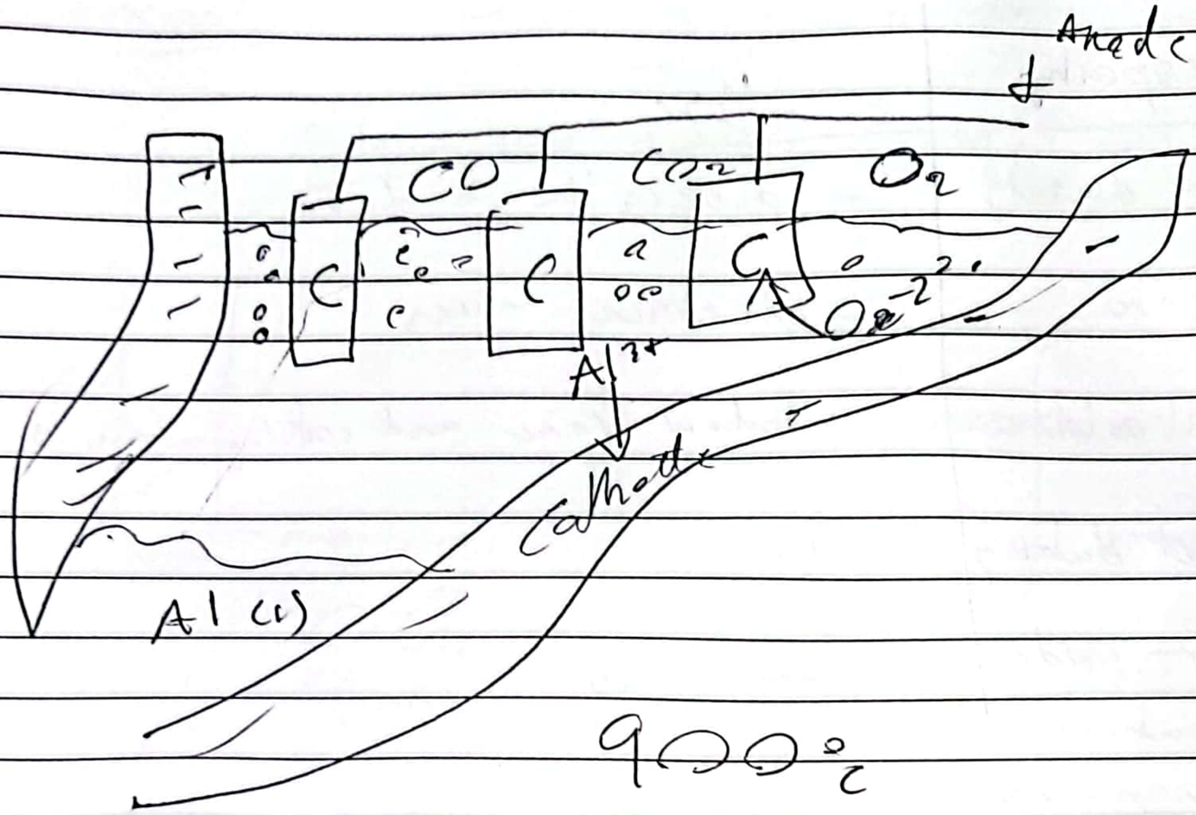
So we dissolve Al_2O_3 in a molten cryolite Na_3AlF_6

- to lower m.p to 900°C so less cost
- to increase the electrical conductivity

Al_2O_3 (l)

Al^{3+} cathode — O^{2-} Anode

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



gases produced at anode

1- O_2

2- CO_2] reaction of rods with O_2

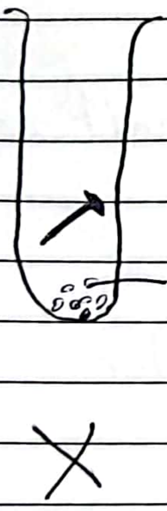
3- CO

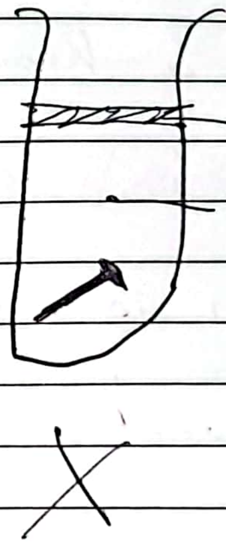
So we must replace them periodically

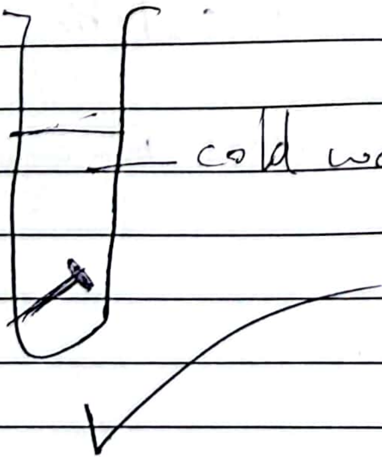
property	use
- low density	- aircraft bodies
- ductile	- electrical wires
- malleable	- window frame and cooking utensils
- conduct electricity	- wires
- form an oxide layer which is non-toxic	- food cans

Rust: reaction of Iron with both O_2 and H_2O

Slow reaction => 6-7 days







$Fe + O_2 \xrightarrow{H_2O} \underbrace{Fe_2O_3 \cdot nH_2O}_{brown}$

Plan an exp to show - which rust prevension solution is better.

take a known mass of Iron nail apply a known volume of the first solution.

put them in a known volume of water for 1 week

dry them and measure the mass again

$\boxed{repeat}$ the exp with the 2nd solution

conclusion:- the exp which causes more increase in mass, worse solution.

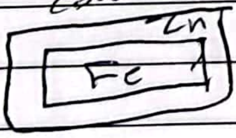
How to prevent rusting

painting | oiling | greasing | cover with plastic

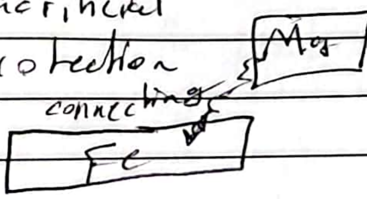
"to prevent O_2 and H_2O from reaching the iron."

Zn and Mg are more reactive than Fe
more likely to oxidise
more likely lose e^-s
so Fe less likely to rust

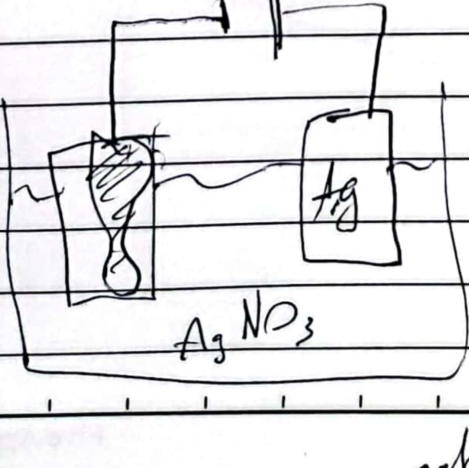
Galvanizing
coating



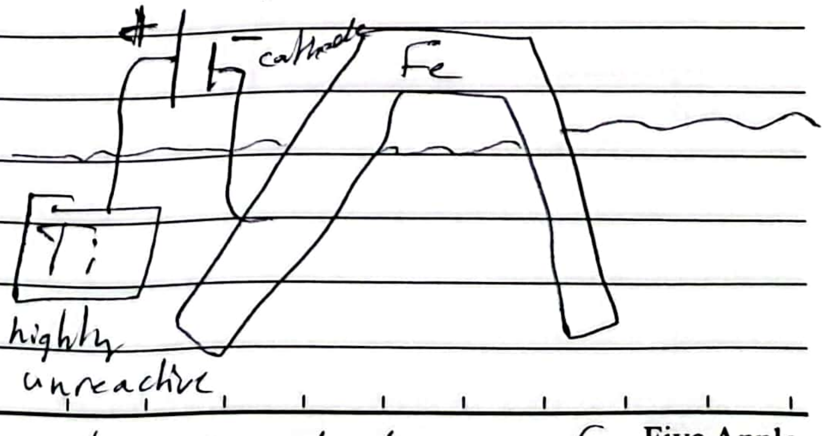
sacrificial protection



electroplating



Cathodic protection.



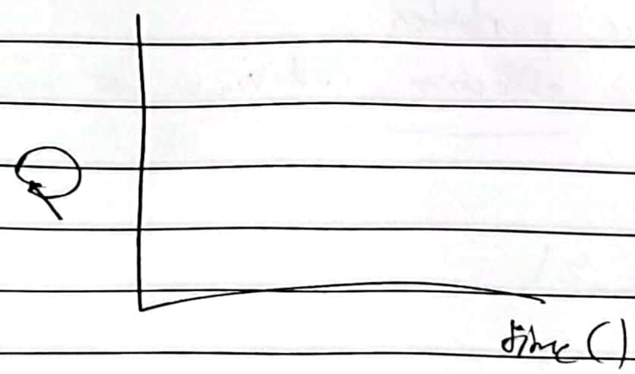
highly unreactive

cathode always reduction so Fe can't rust and oxidise

Rate of reaction:

$$\text{Rate} = \frac{\text{change in a Quantity}}{\text{change in time}}$$

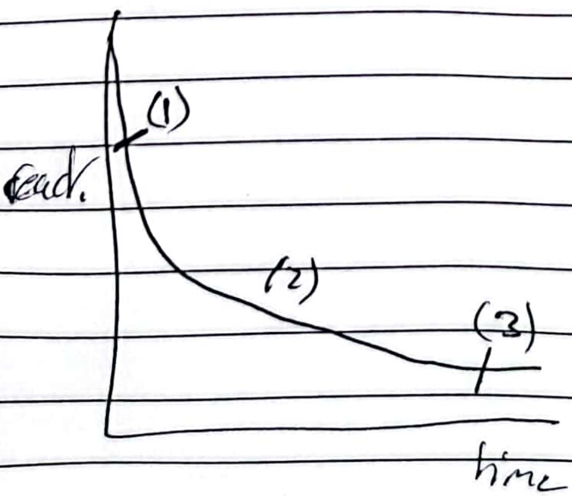
$$\text{rate} = \frac{\Delta R}{\Delta t}$$

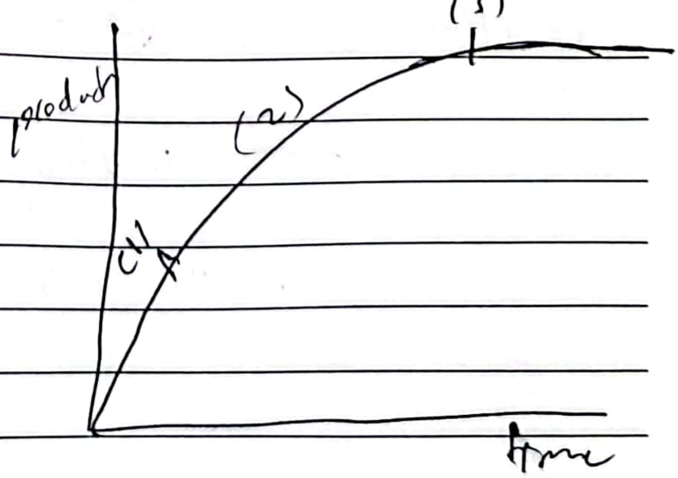


measure the rate of reaction

How fast the reactants consumed per unit time.

how fast the products produced per unit time





region(1)

fastest rate => from the graph, steepest

more amount of reactants
more particles
more effective collisions per unit time

region (2)

slower rate => from the graph, less steep

less no. of particles

so less no. of effective collisions per unit time

region (3)

reaction is over => gradient = 0 (horizontal)

no more ~~effective~~ limiting factor

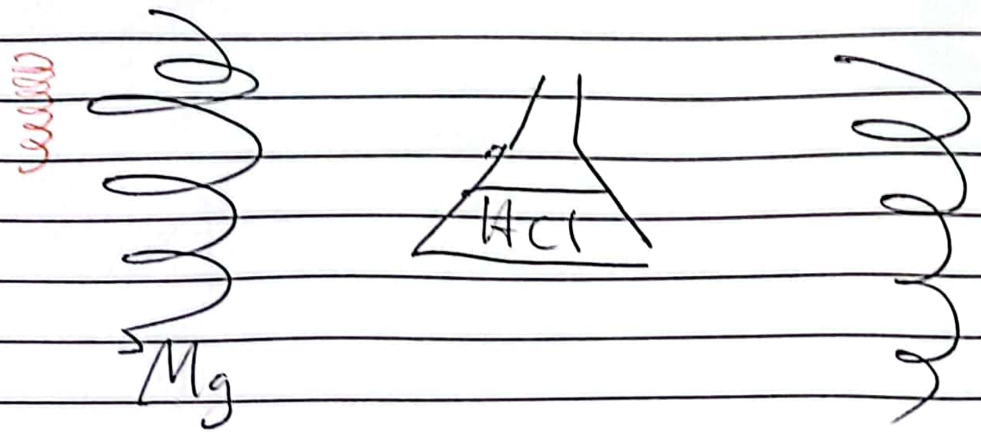
no more effective collisions

For any chemical reaction there are three main conditions.

1. the reactants must be suitable

$Cu + HCl \rightarrow$ no rxn

2. the reactants must collide



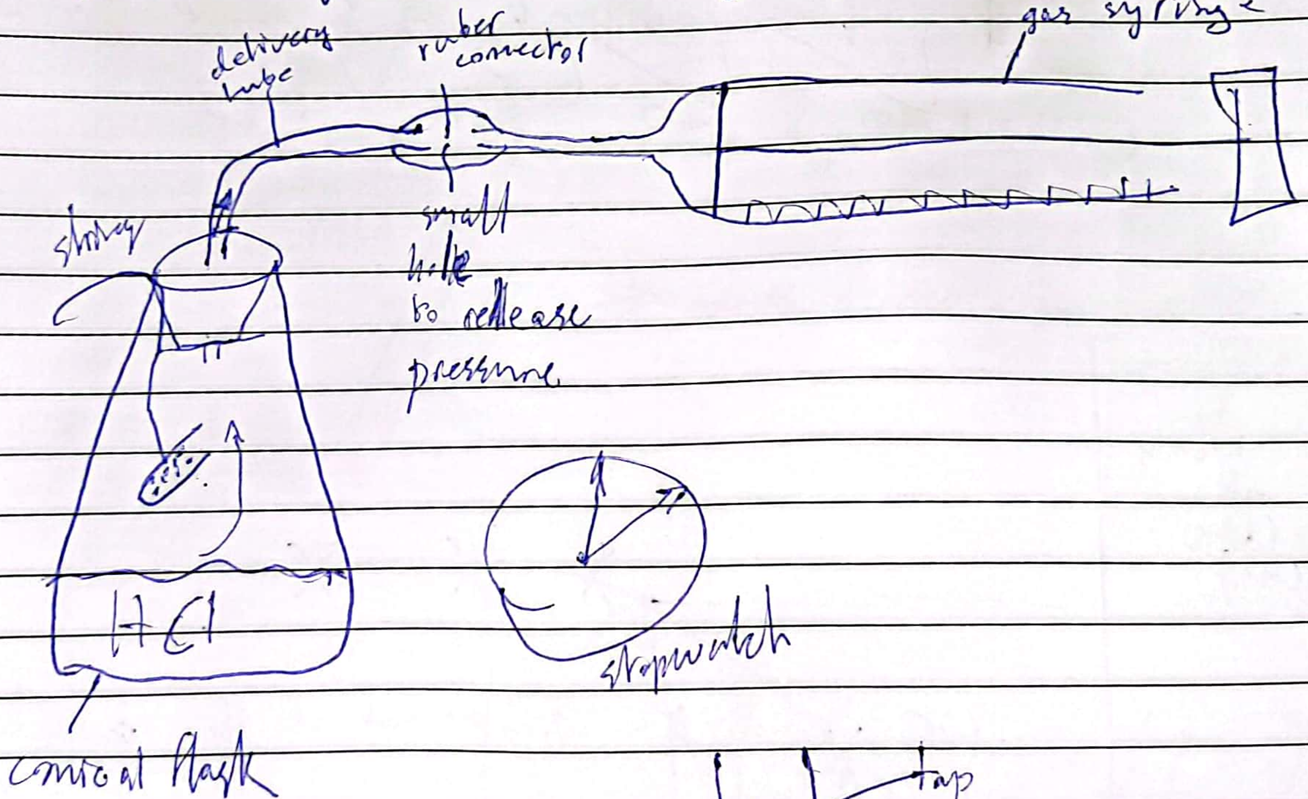
3. the collisions

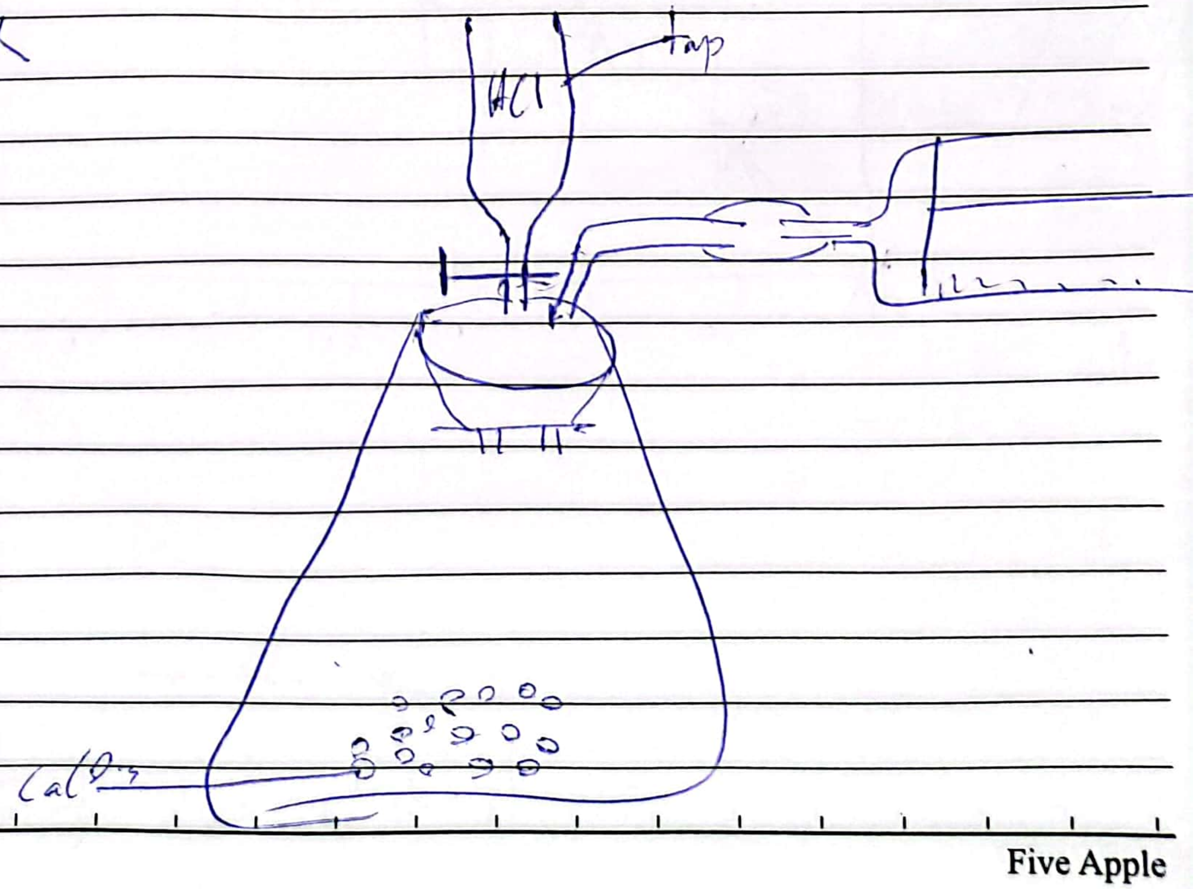
Z

measuring rate of reaction:-

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

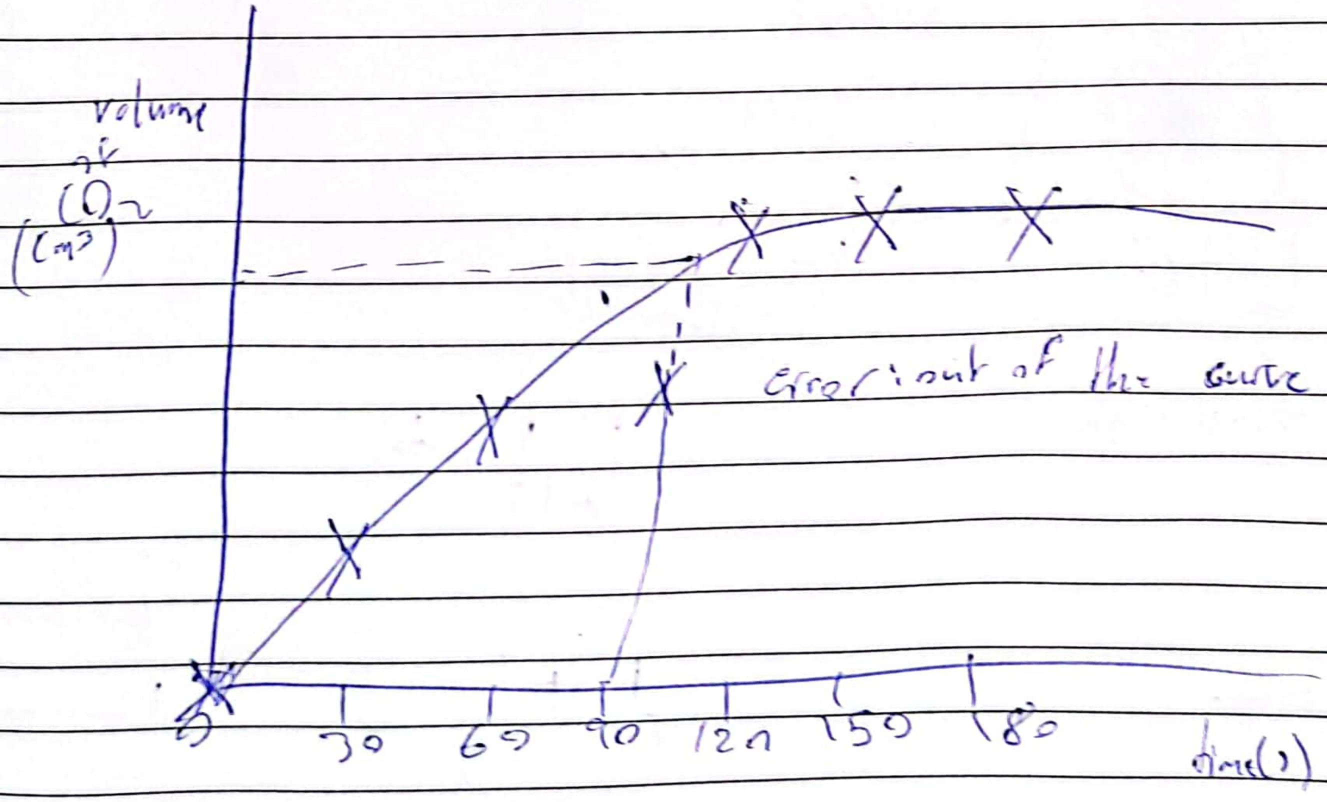
1) measuring the volume of gas per unit time.



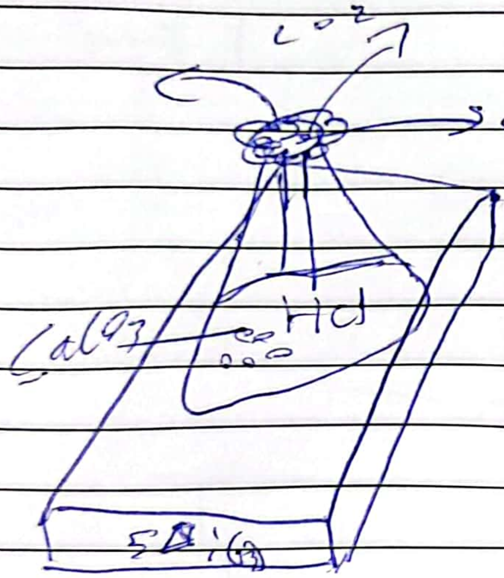


time	0	30	60	90	120	150	180
Volume of CO_2 cm^3	0	10	15	17	17.5	17.5	17.5

+10 +5 +2 +0.5



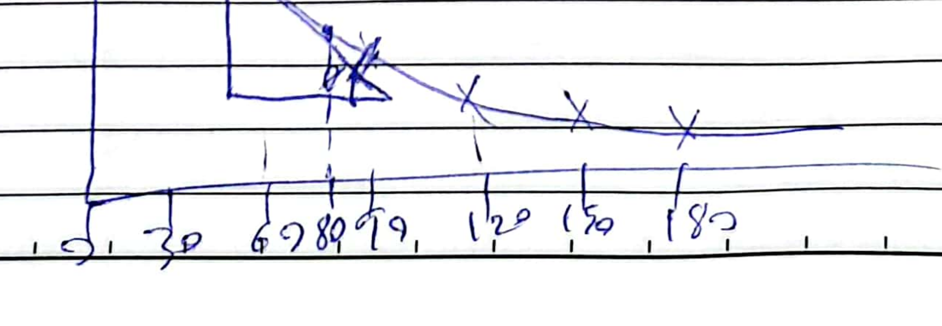
② measure the mass of the conical flask & contents per Unit time



F, allow CO_2 to escape and prevent splashing

mass decrease because CO_2 escape

time (s)	0	30	60	90	120	150	18[illegible]
mass (g)	50	40	35	33	32.5	32.5	32.5

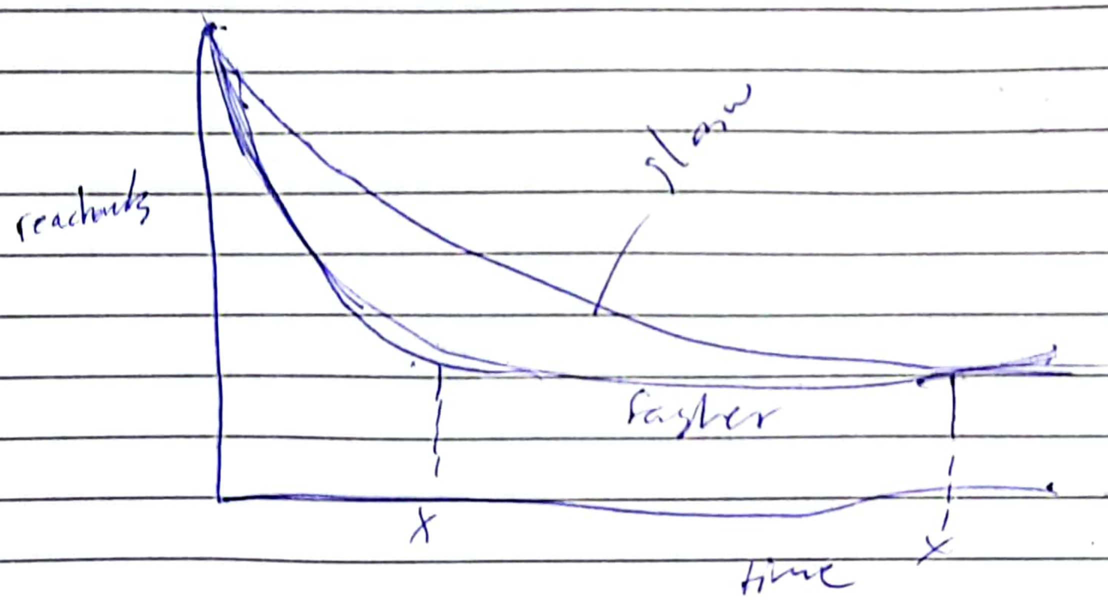


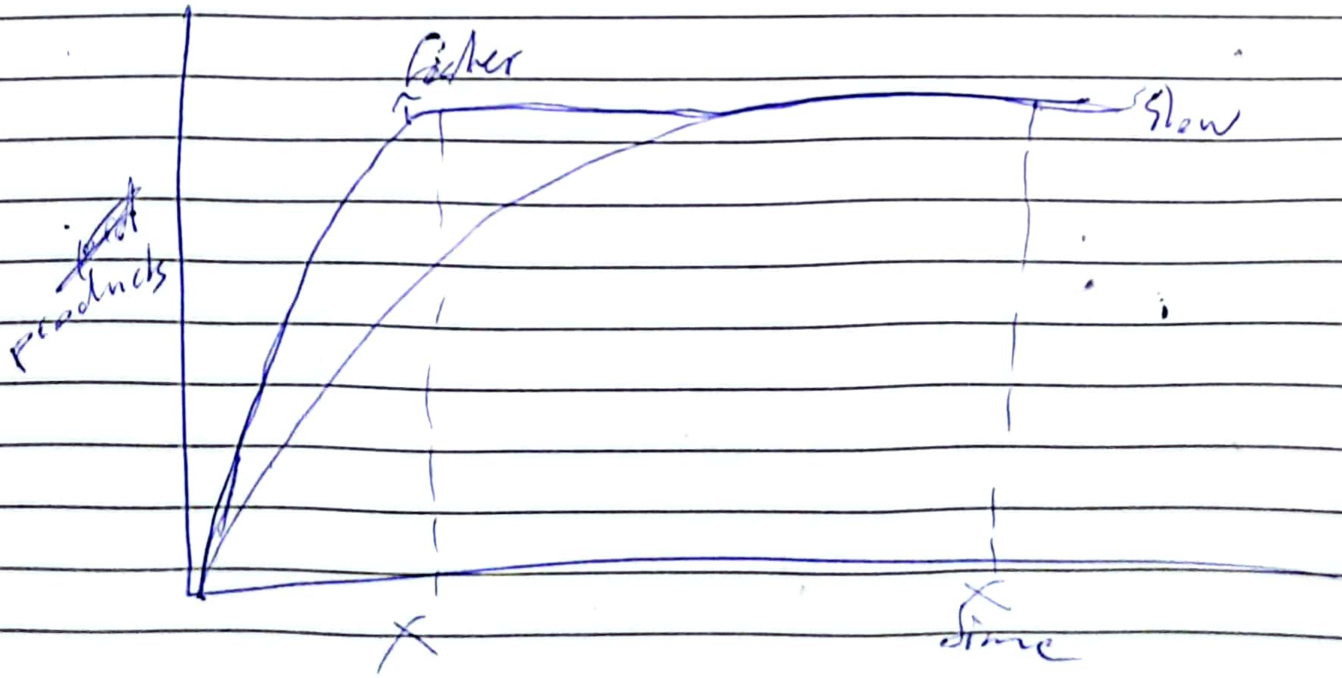
to find the rate at specific time at = 80s draw tangent

Increasing the rate of reaction

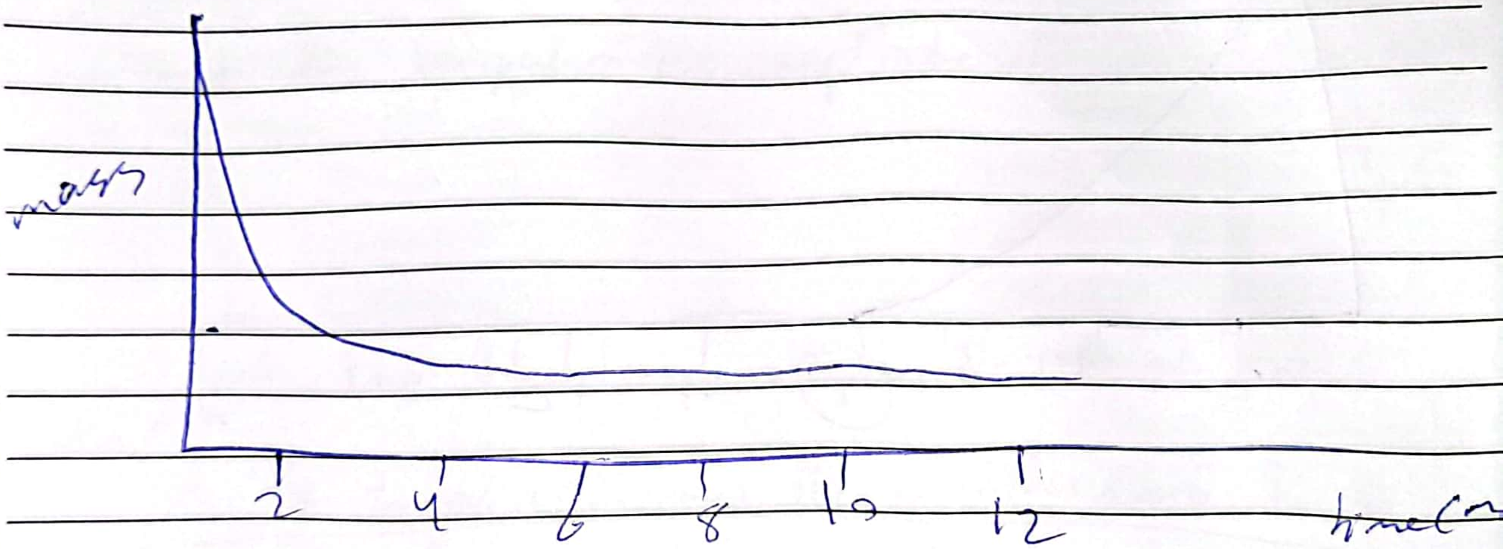
more product per same period of time } steeper curve

or same products per less time

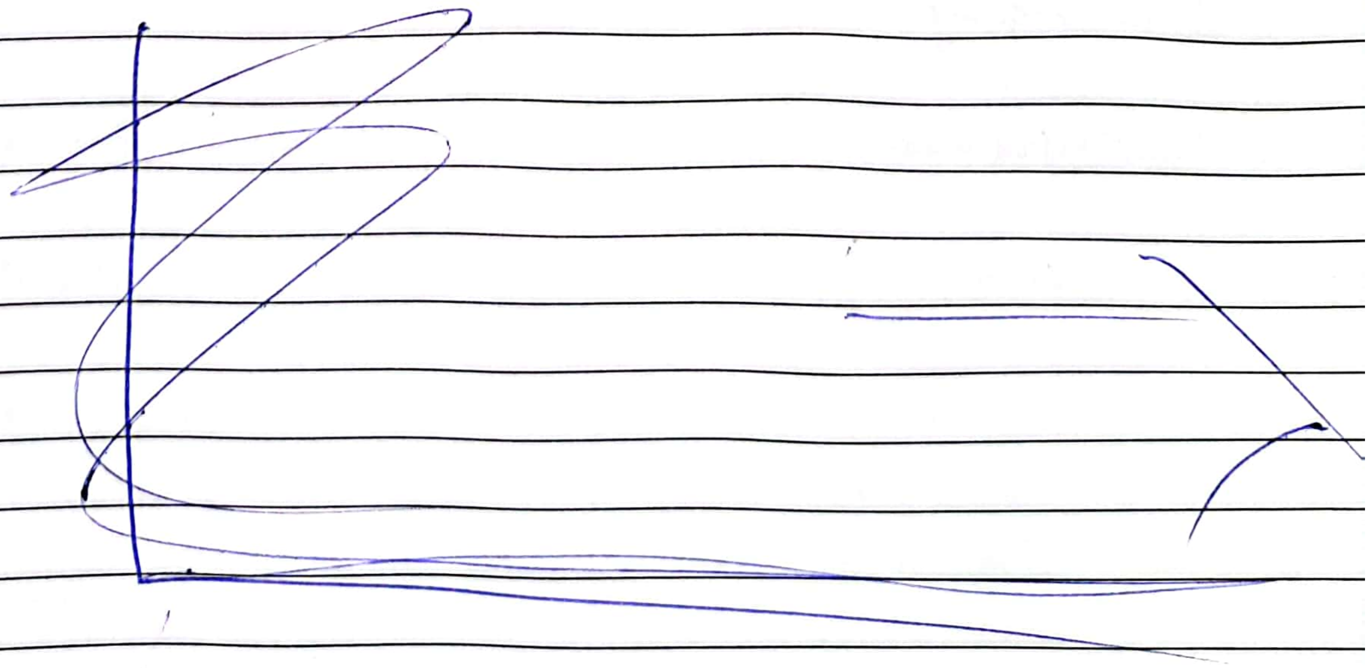


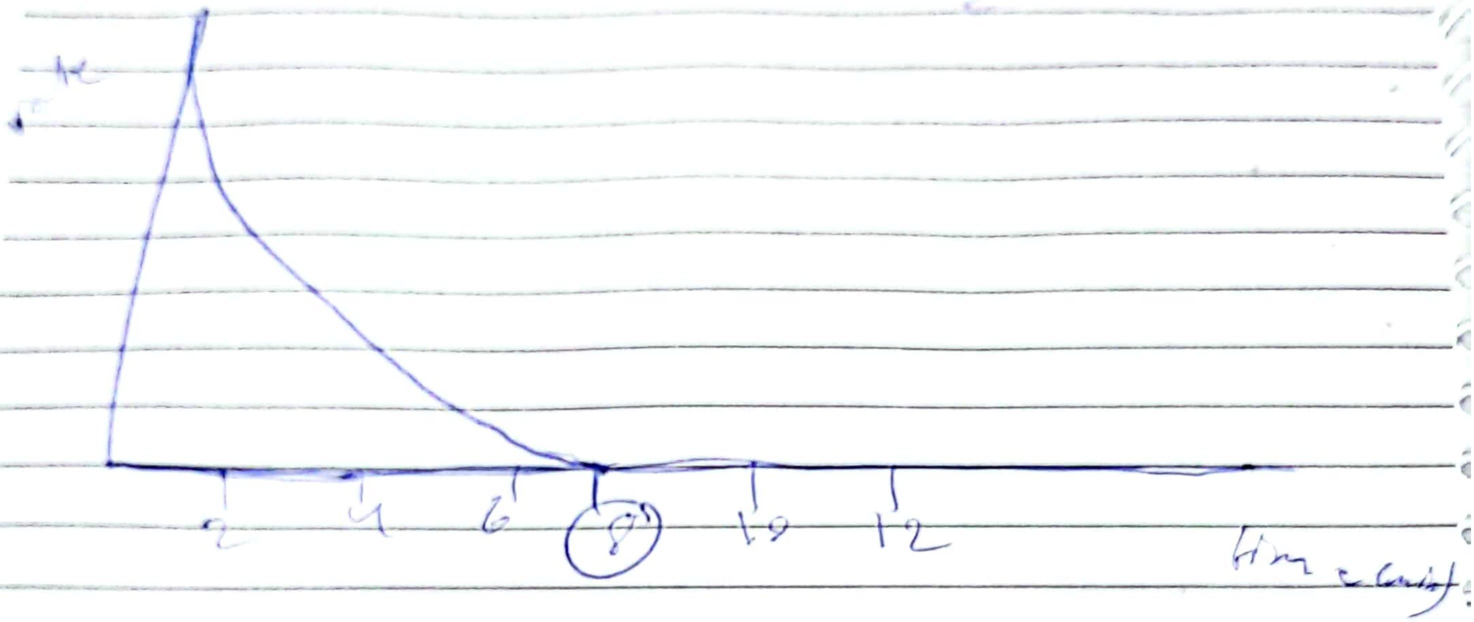


Q :- the graph below shows how the amounts of reactants changes with time



Draw rate vs time graph for this reaction





Factors affect the rate of reaction.

1. temp
2. surface area
3. con

D) Tempcahve

* state how the temp affect the rate of reaction

as the temperature increases, the rate of rxn increases.

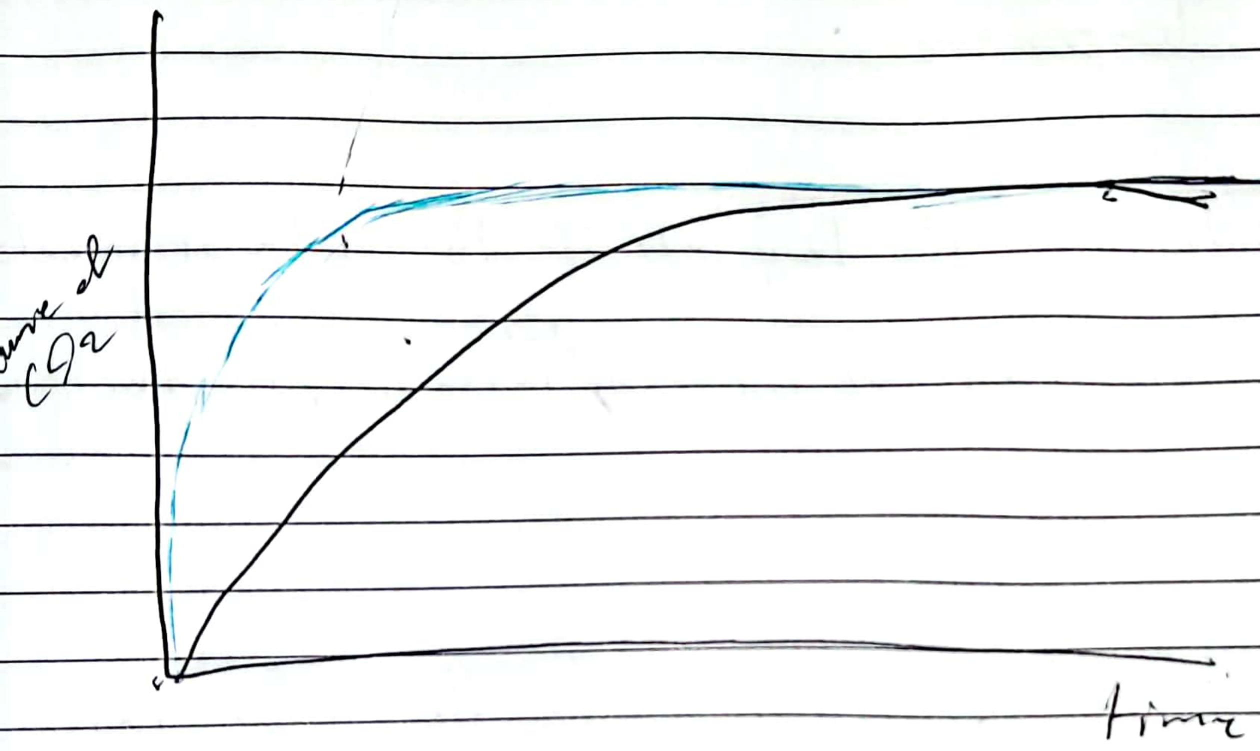
* explain how the temp affect the rate of rxn. [5]

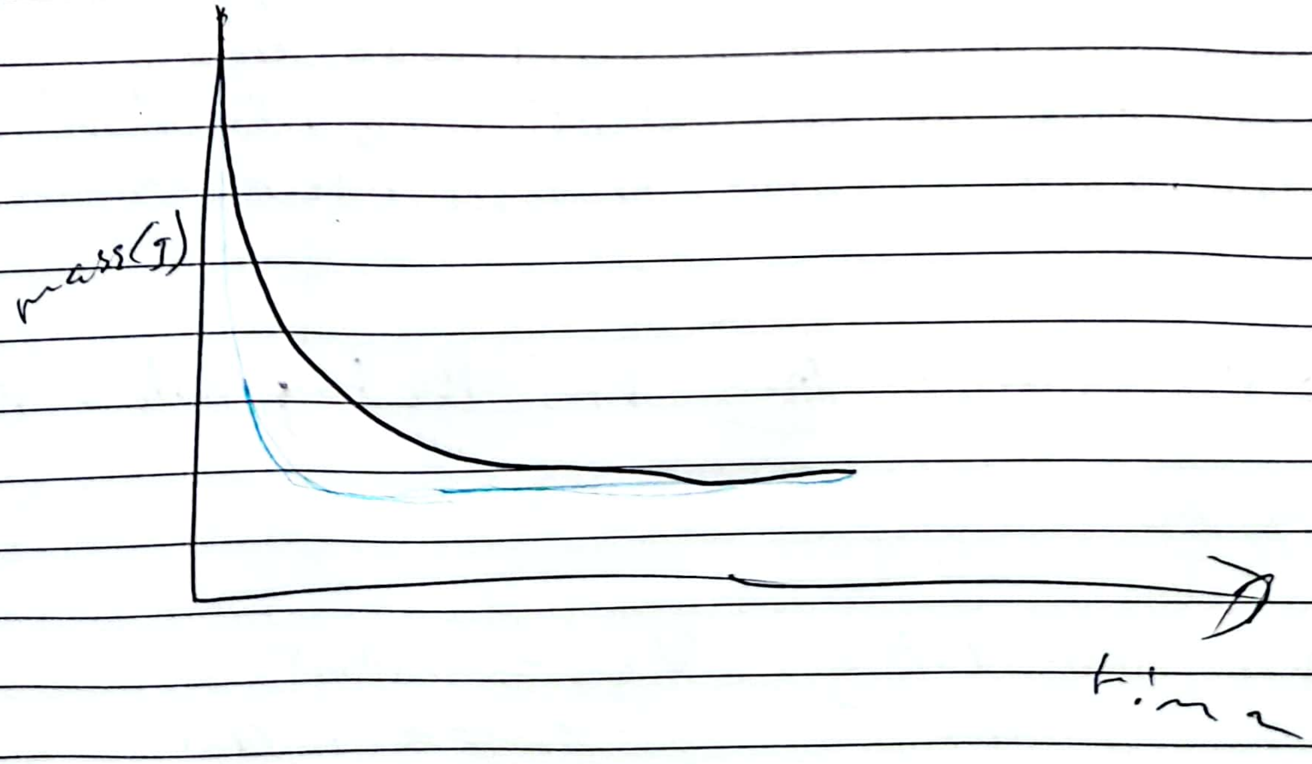
As the temperature increases, the particles gain K.E, so they move faster, particles will have energy equal to or greater than the activation Ea energy, so more effective collisions per unit time, so faster rate of reaction.

* plan an exp. to show how the temp affect the rate of reaction.

exp 1 mass = 2.0 g V_{HCl} = 0.1 dm³
lumps M_{HCl} ~~= 2~~ 1 mol/dm³
temp = 25°C

exp 2 mass = 2.0 g V_{HCl} = 0.1 dm³
lumps M_{HCl} = 1 mol/dm³
temp = 50°C


ume of
CO_2
time


mass(g)
time

take a known mass of lumps $CaCO_3$ add them to a known volume of known conc of HCl at 25°C

measure the volume of CO_2 produced using gas syringe per unit time

repeat the exp at 50°C

the exp at 50°C produce CO_2 with less time.

(2) surface area

* state how surface area affect rate of rxn

As the surface area increases the rate of reaction increase

explain how the surface area affect the rate of rxn

As the surface area increases (decrease the particle size by crushing using mortar and pestile)

more particles exposed to the reaction.

more effective collisions per unit time,

So faster rate

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

$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O + CO_2$ (g)

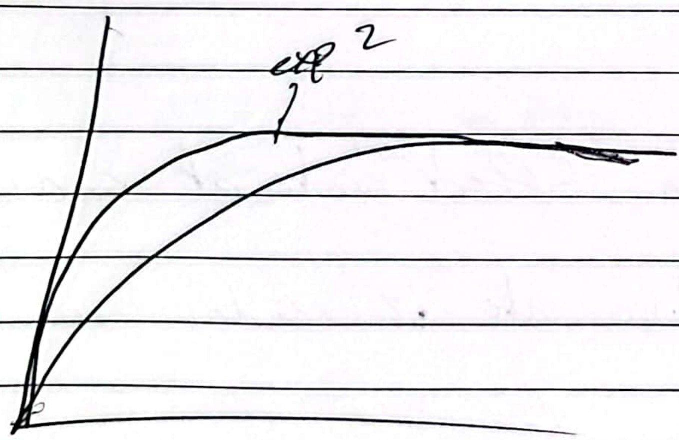
exp 1 mass = 2.g
lumps

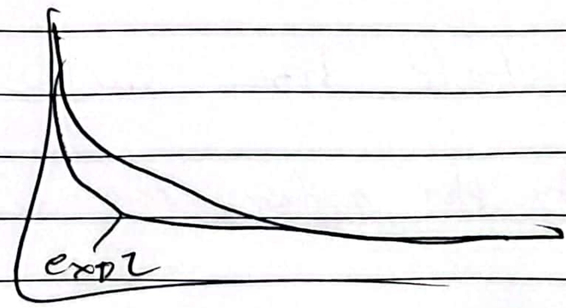
$V_{HCl} = 0.1\ dm^3$
$M_{HCl} = 1\ mol/dm^3$
temp = 25°C

exp 2 mass = 2.2g
powder

$V_{HCl} = 0.1\ dm^3$
$M_{HCl} = 1\ mol/dm^3$

temp = 25°





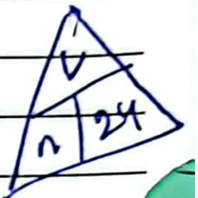
③ concentration "Amount"

* state how the concentration affect the rate of reaction.

as the conc. increases the rate of rxn increases

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

As the conc increase.
more particles
more effective collisions per unit time
so faster rate of rxn.

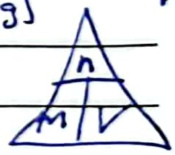


plan an exp ...

need 0.005 0.02 0.04 0.01 limiting   n = 0.005

$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$ V = 0.12

(s) (aq) (aq) (l) (g)

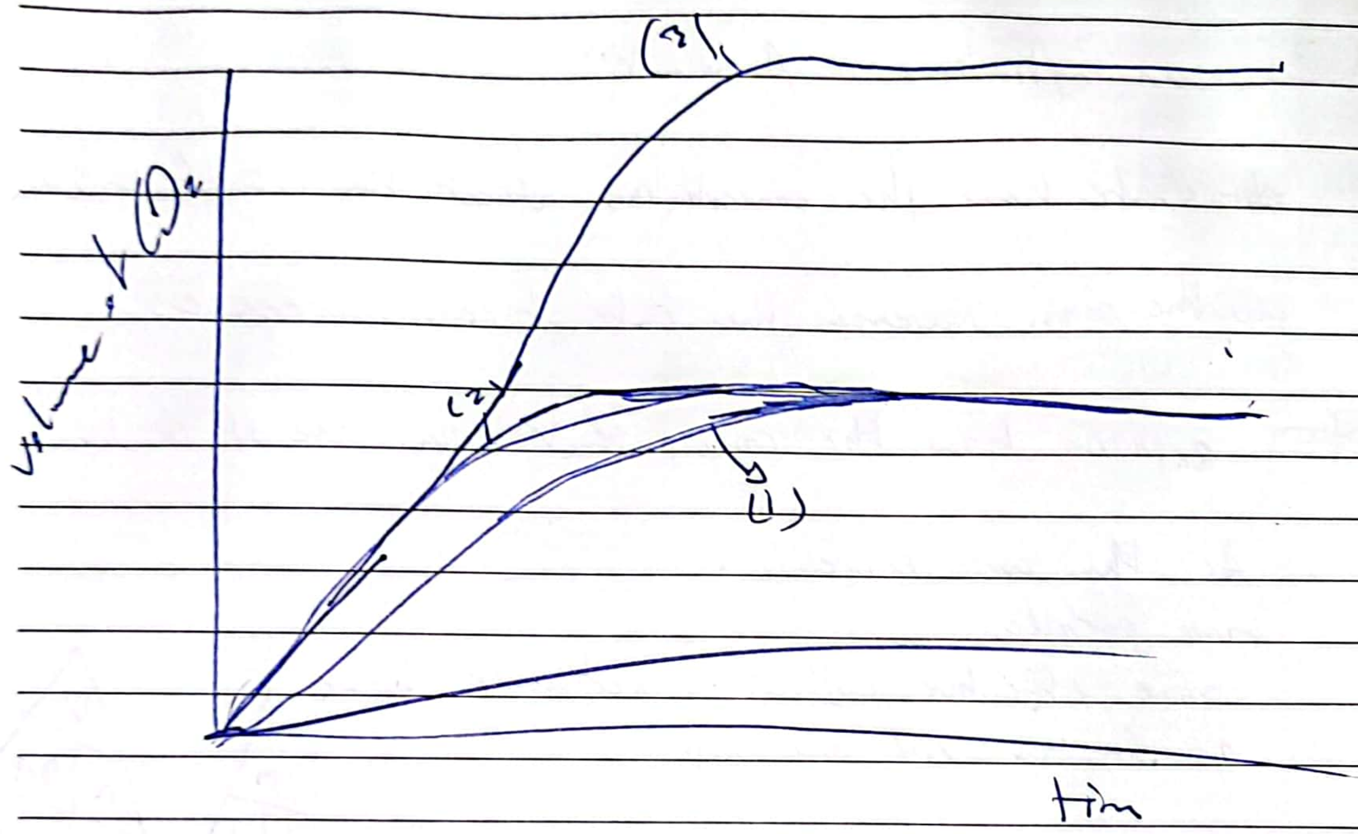


exp 1   mass
$CaCO_3 = 2g$ V = 0.1 dm³
lumps   HCl
Mr = 100 M_{HCl} = 0.1 mol/dm³
temp 25°C

exp2   mass
$CaCO_3 = 2g$ V = 0.1 dm³
lumps   M = 0.2 mol/dm³
temp = 25°C

exp 3   mass
$CaCO_3 = 4g$ V = 0.1 dm³
lumps
M = 0.1 mol/dm³
temp = 25°C

Five Apple



time
more limiting → faster rate
more product

more excess → faster rate

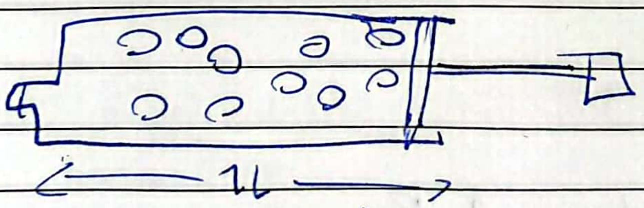
1) pressure :- "only affect the gases"

explain how the pressure affect the rate of reaction?

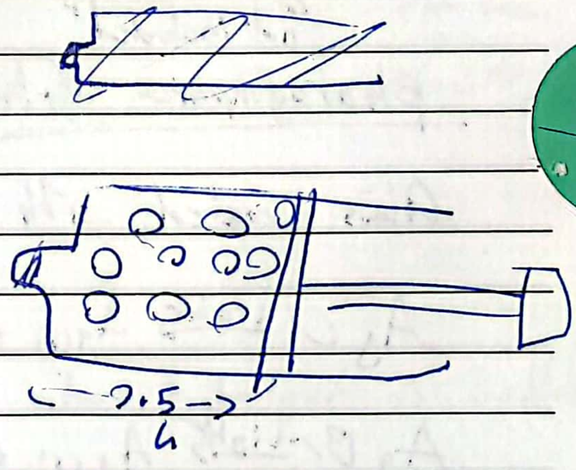
As the pressure increases (by reducing the volume)

so more particles per unit volume. so more effective

collisions per unit time. so faster rate of reaction



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



$\frac{10}{0.5} = 20$

5) light. "only for photochemical reaction"

reaction that need light to occur

eg :- photosynthesis

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

"not included"

photographic films:

films coated with AgCl or AgBr

$$AgCl \xrightarrow{\text{light}} Ag_{(s)} + Cl_2$$

$$AgBr \xrightarrow{\text{light}} Ag_{(s)} + Br_2$$

6) catalyst.

chemical substance that speeds up the reaction without being used up

How? it provides an alternative way with lower Ea so more particles will have energy equal or greater than Ea, so more effective collisions per unit time.

activation energy

So faster rate of rxn.

Five Apple

the reaction

$$H_2O_{2(aq)} \xrightarrow[\text{② } MnO_2]{\text{① } CuO} 2H_2O_{(l)} + O_{2(g)}$$

① plan an experiment to show that CuO is a catalyst for this reaction:

take a known volume with a known conc. and known temp of H_2O_2 measure the volume of O_2 produced per unit time, repeat the exp. using CuO

- the exp using CuO will produce more O_2 per the same ~~time~~ unit time

② plan exp to show which of the two catalyst is better CuO or MnO_2.

Same as Q.1

+ same mass of catalyst

~~one~~ exp ~~with~~ that produced more O_2 per same unit time is better

③ plan an exp to show that CuO not used up during the reaction.

measure the mass of CuO

add to H_2O_2 until no more fizzes

filter the mixture

dry the solid in oven

re measure the mass

same initial ~~mass~~ and final mass

Reversible Reaction

Type of chemical rxn

One way

reactants $\xrightarrow[\text{forward}]{}$ products

both ways

reactants $\underset{\text{backward}}{\overset{\text{forward}}{\rightleftharpoons}}$ products

$CaCO_3 + HCl \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

$Mg + HCl \rightarrow MgCl_2 + H_2$

no need to know

rxns

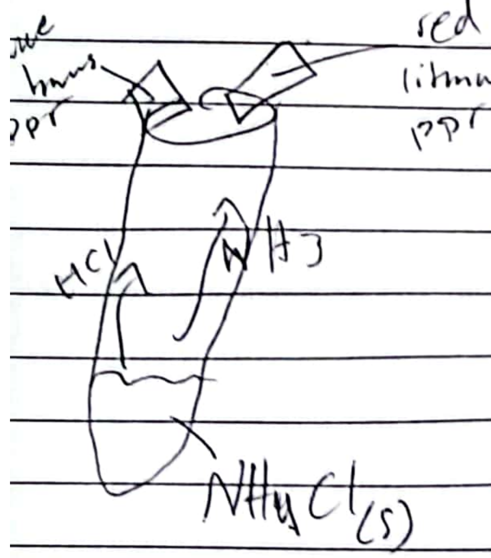
$NH_4Cl \rightleftharpoons NH_{3(g)} + HCl_{(g)}$

$CaCO_3 \rightleftharpoons CaO_{(s)} + CO_{2(g)}$

$3H_2 + N_2 \rightleftharpoons 2NH_3$

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

Amonium chloride — Amononia — Hydrogen chloride

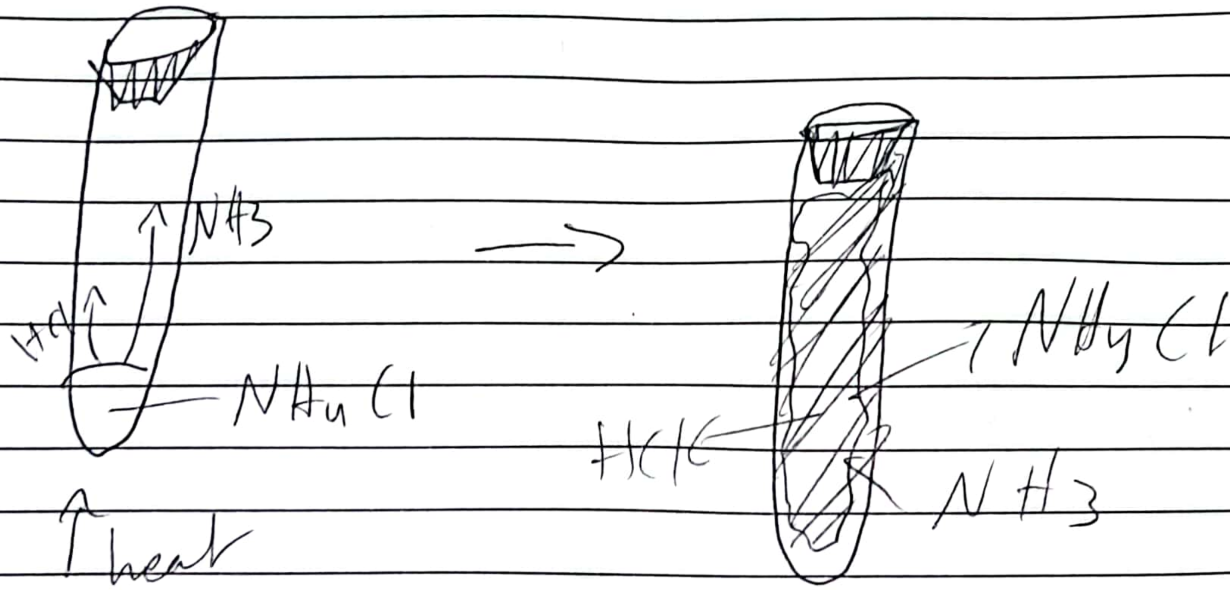


Q. which damp litmus paper. will change its colo first? why?

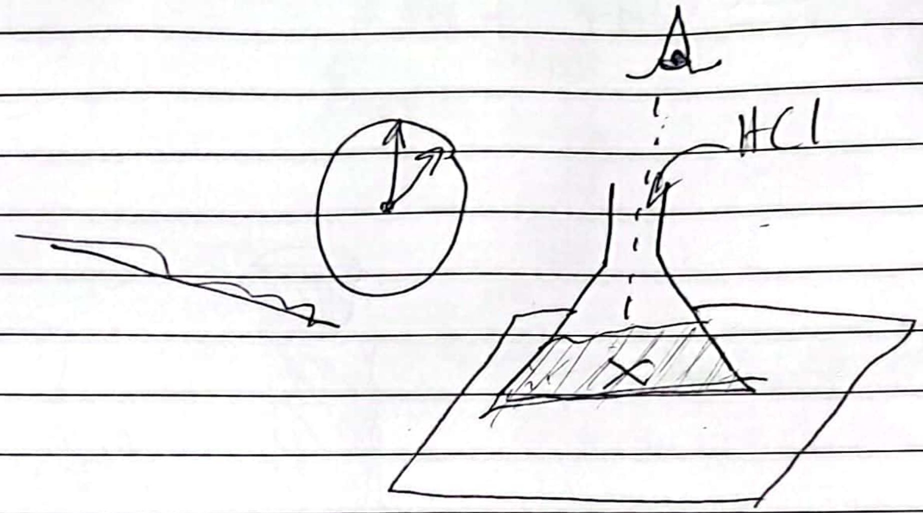
the damp red litmus paper changes to blue first because NH_3 is an alkali and lighter than $HCl_{(aq)}$ which is acidic.

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

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



$Na_2S_2O_3 + HCl \longrightarrow NaCl + SO_2 + S + H_2O$

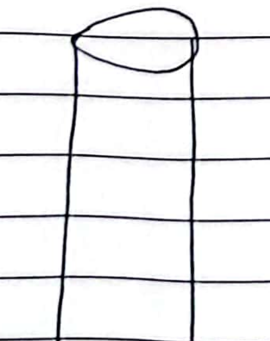


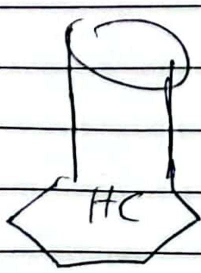
1) $Na_2S_2O_3$

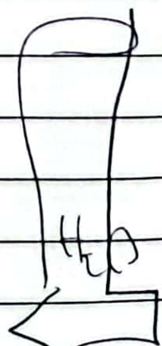
2) H_2O

3) HCl

Volume of $Na_2S_2O_3$	H_2O	HCl
50	0	10
40	10	10
35	15	10
30	20	10
10	40	10

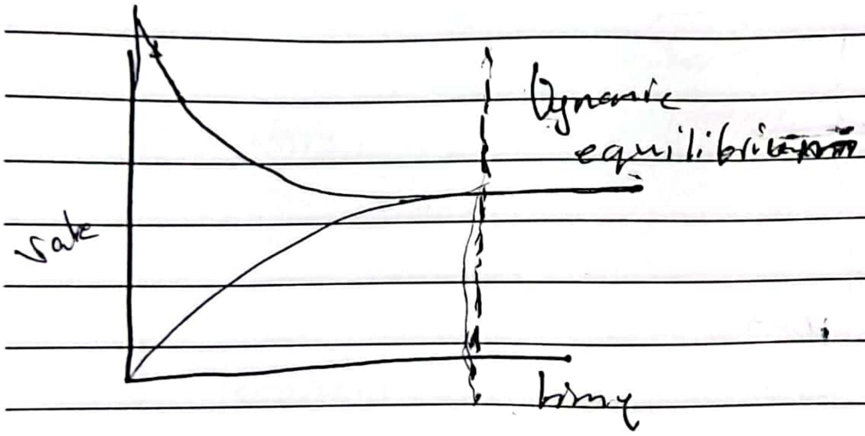






Dynamic equilibrium

In terms of rate



the rate of forward decrease

less reactants

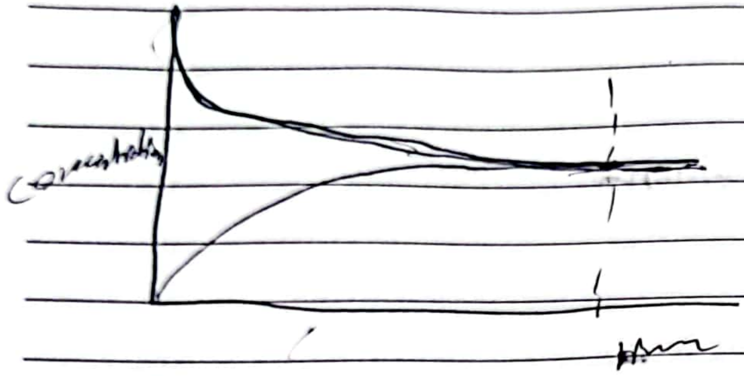
less particles

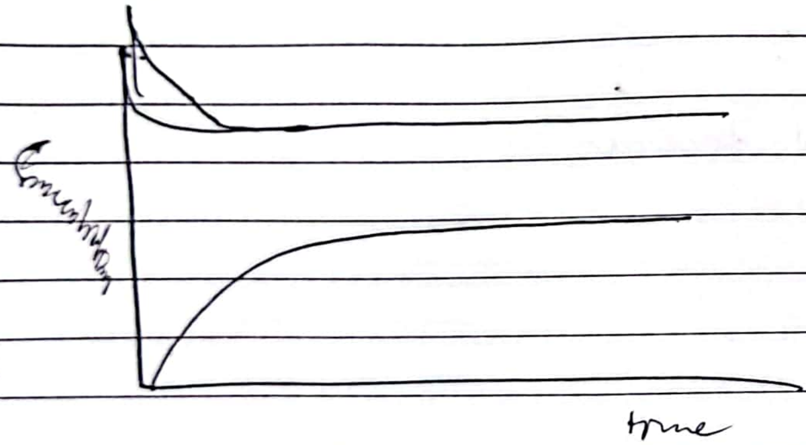
less effective collisions per unit time

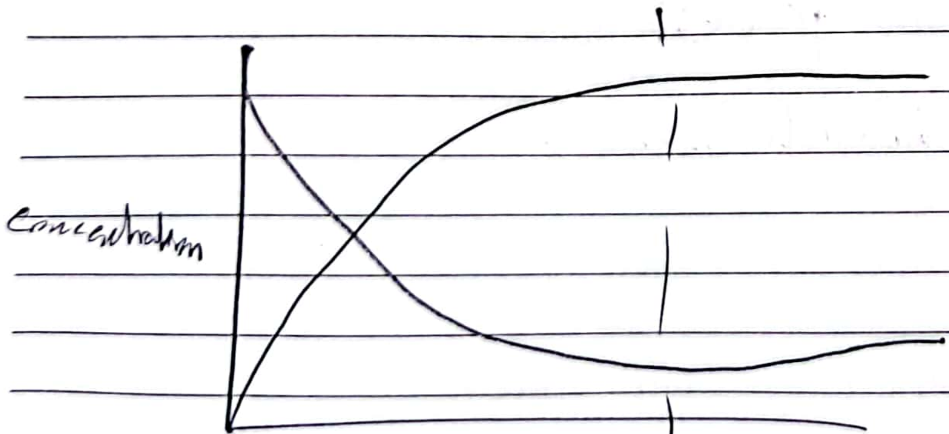
the rate of backwards increases

more product
more particles
more effective collisions per unit time

in terms of concentration







Factors that affect the position of equilibria

1 temprature

2 pressure

3 concentration

1 temprature

Δ endo & exo

↑ temp shift to endo

↓ temp shift to exo

Le Chatelier principle

if the system at equil. $\rightleftharpoons$

and any external factor disrubt the equil.

the equil can shift itself either to the forward $\rightleftharpoons$

or to the backward $\rightleftharpoons$

to return back to the equil.

D temprature.

↑ temp ↑↑ rate of endothermic

↑ rate of exothermic

shift to endo

↓ temp ↓↓ rate of endothermic

↓ rate of exothermic

shift to exo

ΔH

enthalpy change

the sign of ΔH is always represents the forward reaction.

+ve	-ve
gain	lose
Endo	Exo

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

↑ temp ↑↑ rate forward

↑ rate backward

↓A ↓B ↑C ↑D

shift forward to the endo

↓ temp ↓↓ rate of forward

↓ rate of Backward

↑A ↑B ↓C ↓D

shift backward to exo

$X + W \underset{endo}{\overset{exo}{\rightleftharpoons}} Y + Z$ $\quad$ $\Delta H \overset{exo}{=} -ve$

↑ temp ↑ rate of forward

↑↑ rate of backward

shift to endo

↑X ↑W ↓Y ↓Z

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

to produce more yield of NH_3

we must use low temp

to favour the forward reaction which is the exothermic

mixture of NO_2 and N_2O_4 at equil. in a sealed tube.

$$\underset{\text{dark brown}}{2NO_{2(g)}} \rightleftharpoons \underset{\text{pale brown.}}{N_2O_4(g)}$$

if we put this sealed tube in ~~a~~ cold water bath the mixture becomes paler? why?

because the forward reaction is exothermic advanced by cooling.

② pressure

As the pressure increase

the equil shift to the side with less pressure,
with less gas mole

As the pressure decrease

" " " " " " more pressure

more gas moles

$$\underbrace{3H_{2(g)} + N_{2(g)}}_{4\text{ mole}} \rightleftharpoons \underbrace{2NH_{3(g)}}_{2\text{ moles}}$$

↑ pressure. shift forward to the side with less gas moles ↑ % NH_3

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

↓ pressure. shift forward to the side with more gas moles

↑ pressure. shift backward to the side with less gas mole

$$\overbrace{H_2CO_{3(aq)}}^{0} \rightleftharpoons \overbrace{H_2O_{(l)} + CO_{2(g)}}^{1}$$

↓ pressure. shift forward to the side with more gas mole

$$\overbrace{H_{2(g)} + I_{2(g)}}^{2\text{ mole}} \rightleftharpoons \overbrace{2HI_{(g)}}^{2\text{ mole}}$$

changing the pressure has no effect ~~on~~ the position of equilibrium

since both side has the same no of gas moles

increase ~~p~~ pressure

~~Pressure~~

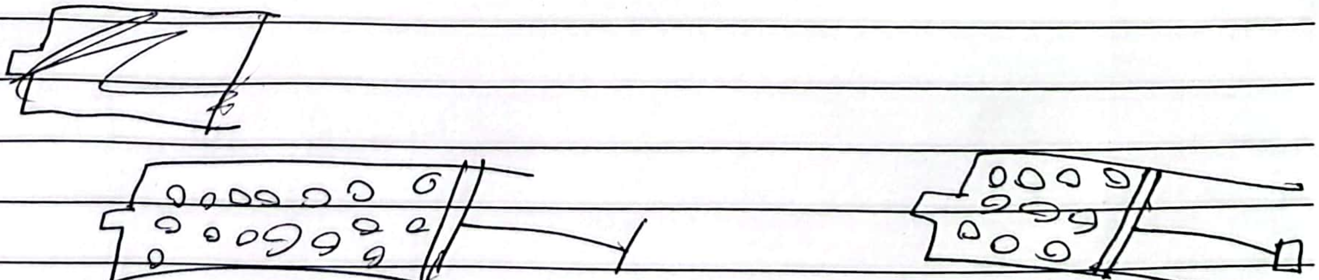
~~Pressure~~

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

purple colorless

the equil doesn't affect by increasing the pressure

why by increasing the pressure the mixture becomes more purple?



the I_2 molecules become closer to each other so the color seems to be darker.

sealed tube contains mixture of $NO_{2(g)}$ and

$N_2O_4(g)$

at equilibrium

③ concentration

$$Reactants \rightleftharpoons products$$

↑ reactant
↓ product } shift forward

↓ reactant
↑ product } shift backward

$$A + B \rightleftharpoons C + D$$

↑ [A] shift forward ↓ B ↑ C ↑ D

↓ [B] ↑ A ↓ C ↓ D

↑ [C] shift backward ↑ A ↑ B ↓ D

Indicators

methyl orange

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

add HCl: proton donor ↑H^+ shift backward

more HIn more color (1)

less In^- less color (2)

add NaOH: proton accepter ↓H^+ shift forward

more In^- more color (2)

less HIn less color (1)

Q:- The reversible reaction below at equilibrium

$$Cr_2O_7^{-2} + Fe^{2+} + H^+ \rightleftharpoons Cr^{3+} + Fe^{3+} + H_2O$$

orange green

explain why by adding HCl to the-rxn mixture.

the color of the mixture becomes green?

HCl is an acid. (proton donor)

more H^+.

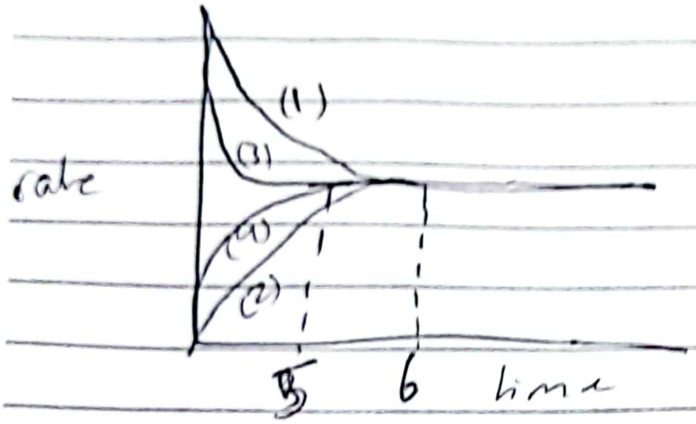
equil. shift forward

more Cr^{3+} so more green

less $Cr_2O_7^{2-}$ - less orange

☆ Catalyst has no effect on the position of equilibri:

since it speeds up the rate of forward and backward



(1) rate of forward reaction without catalyst

(2) " " backward " " "

(3) rate " forward " with "

(4) " " backward " ".

5) time taken to reach equilibrium with catalyst

6) " " " " " without "

Energetics

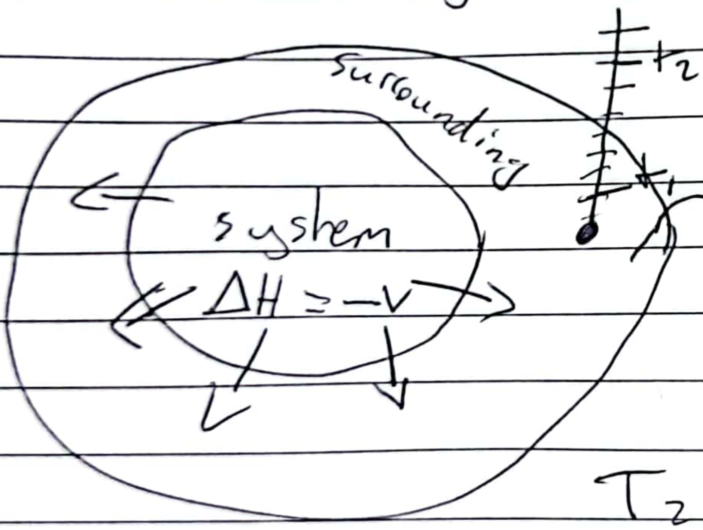
Enthalpy: Heat contents
"stored energy"

Hr
Enthalpy of reactants

Hp
Enthalpy of products

Exothermic

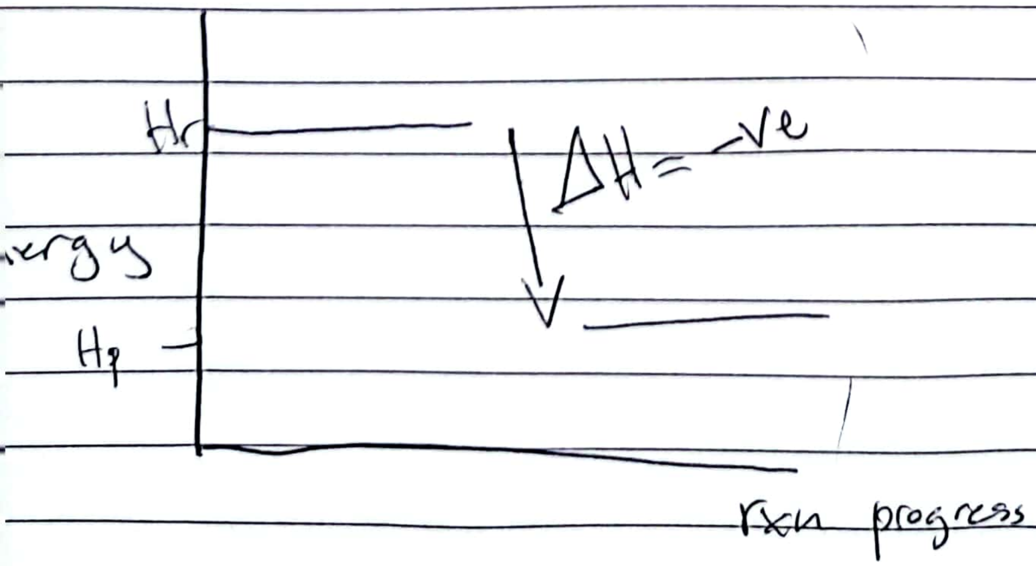
Reactions that give out (release) energy to the surrounding

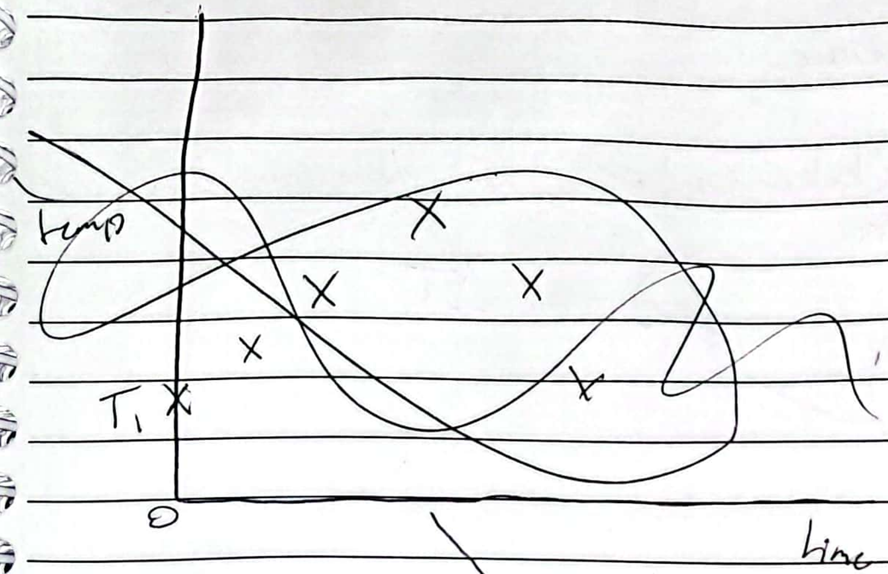


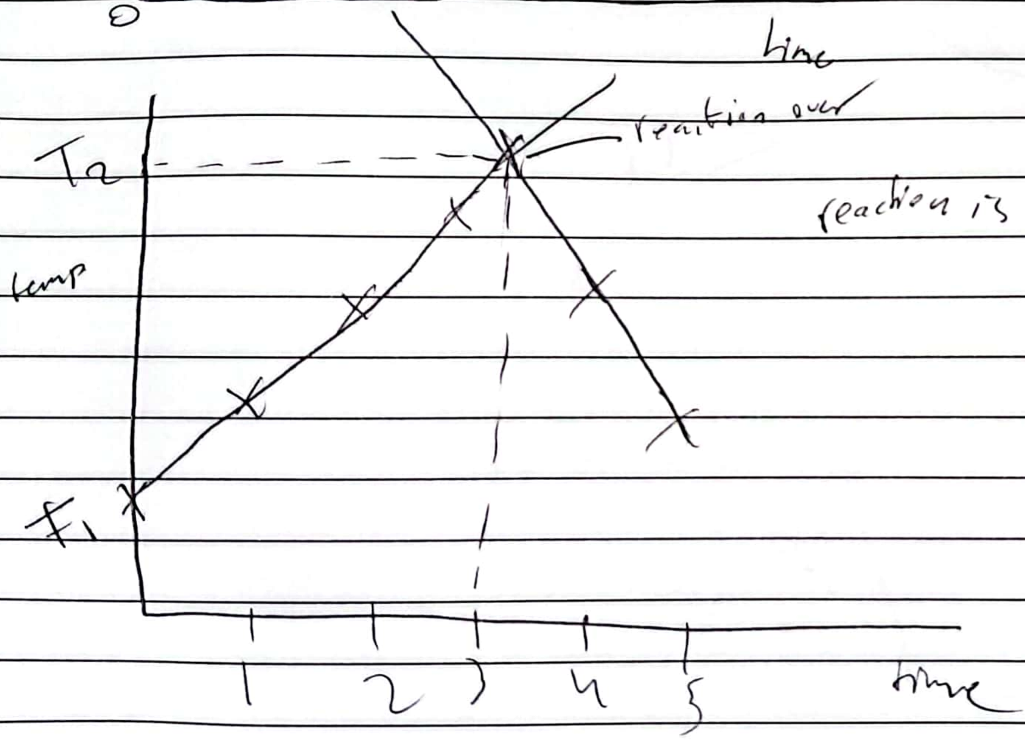
$Q = mc\Delta T$

$T_2 > T_1$

For system (energy level diagram)







reaction is over, so return back to room temp

$$Q = mc\Delta T$$

Q → Energy transfer = J

m → mass g

c → specific heat capacity 4.2 J/g°C

ΔT → change in temp °C

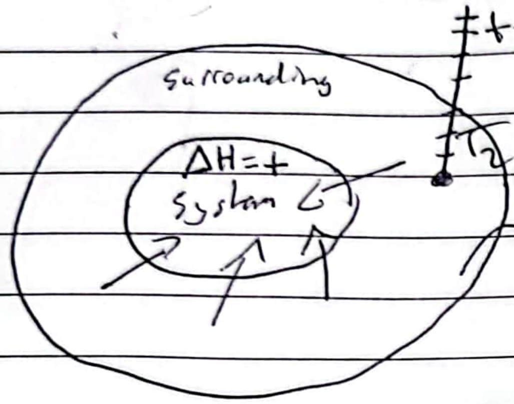
↑Q ↑ΔT

more exothermic

Energetiss

Endo thermic

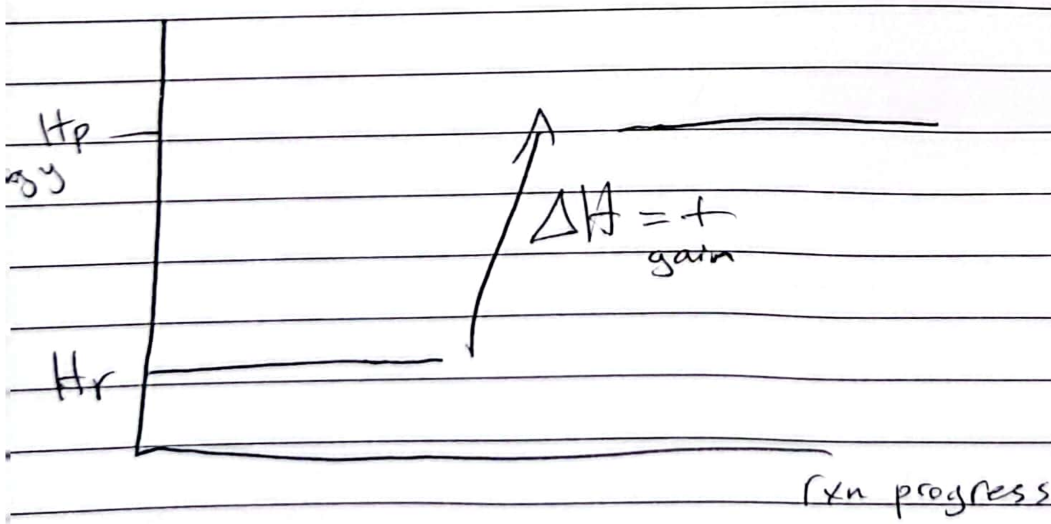
reactions that absorb (take in) energy from the surrounding

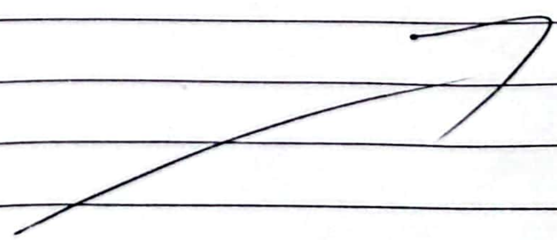


$Q = mc\Delta T$

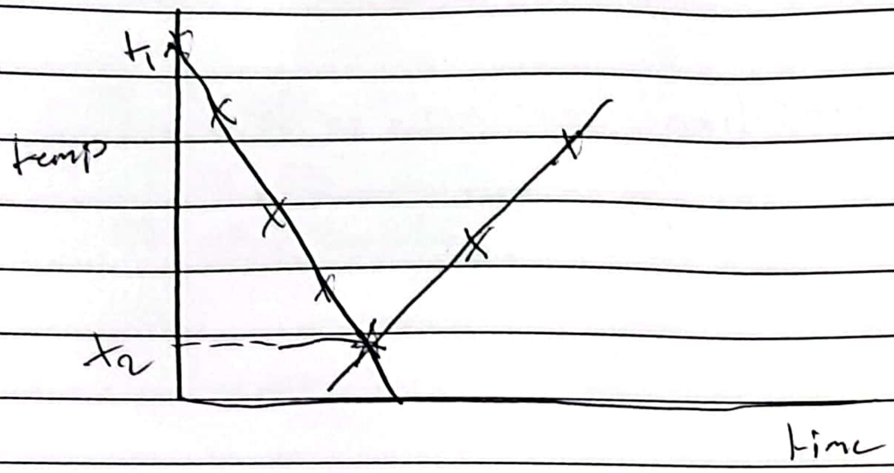
$T_2 < T_1$

for system (energy level diagram)





for surrounding (temp diagram)



$Q = mc\Delta T$

$\uparrow Q \quad \uparrow \Delta T$

more endothermic

Exothermic:

examples on exo:-

1. freezing, condensation

2. respiration

3. combustion

4- neutralization

5- displacement $Zn + CuSO_4$

6- voltaic cell

7- building up bonds

Endothermic

examples on endo:

1- boiling, melting

2- photosynthesis

3- thermal decomposition

4- electrolysis

5- photographic

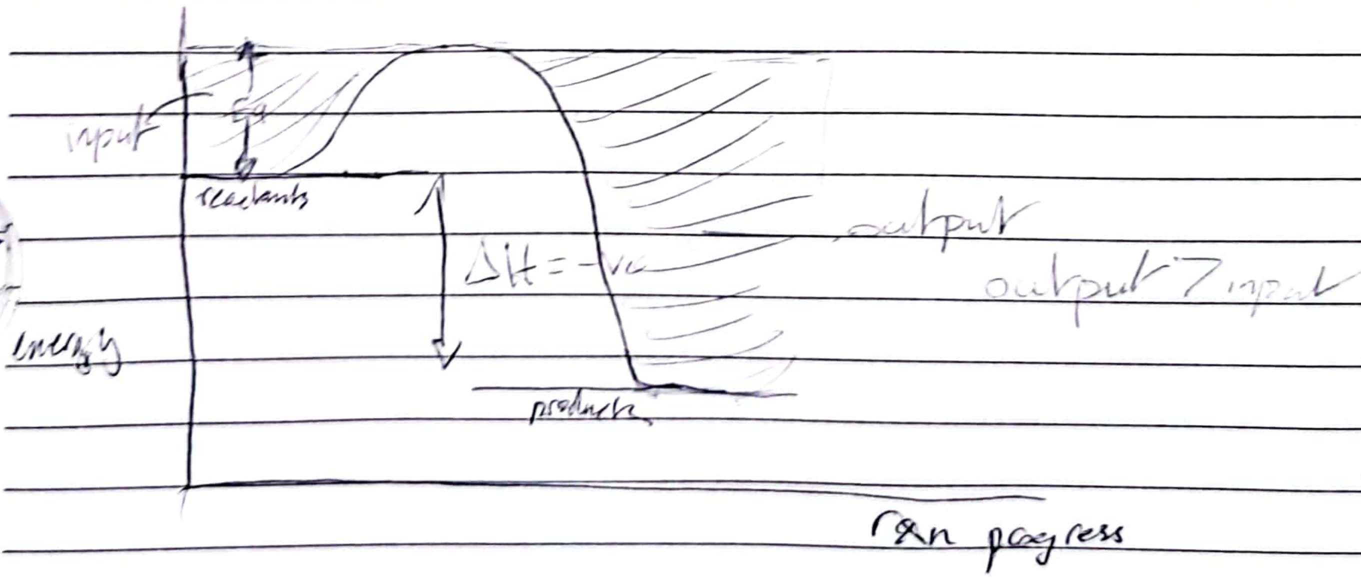
6. dissolve Ammonium salt

7. breaking down bonds

Exothermic

How to express exothermic rxn.

1. Reactants ⟶ products $\Delta H = -ve$
2. Reactants ⟶ products + Energy
3. profile diagram



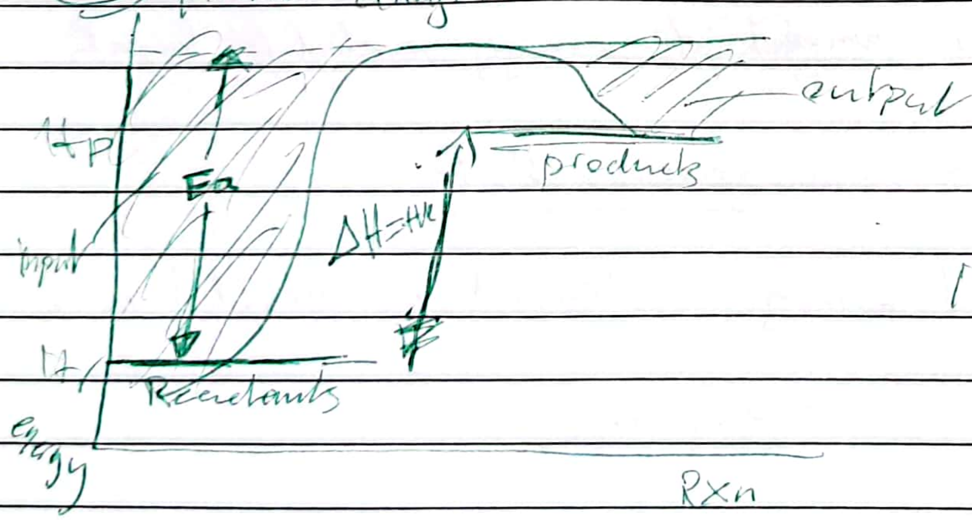
Endothermic

How to express endothermic

① Reactants ⟶ products $\Delta H = +ve$

② Reactants + energy ⟶ products

③ profile diagram



Input > output

Measuring ΔH reaction:

theoretical using bond energy

experimental

combustion

displacement

neutralization

ΔH reaction using bond energy :-

Bond energy: the amount of energy needed to break 1 mol of a bond in a gaseous state.

or

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

bond	bond energy kJ/mol
H − H	436

$H-H_{(g)} + 436\ kJ/mol \rightarrow H_{(g)} + H_{(g)}$

$H_{(g)} + H_{(g)} \longrightarrow H-H_{(g)} + 436\ kJ/mol$

ΔH reaction $= \overset{\text{sum}}{\sum}$ input $-$ $\sum$ output

to break down bonds in react

to build up bonds in products

+ endo

input > output

− exo

input < output

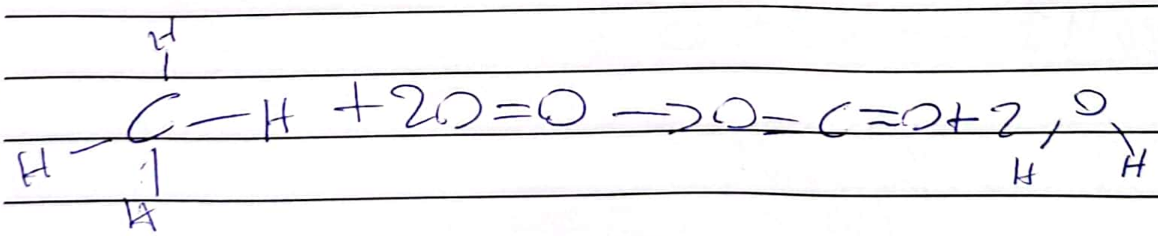
to use this equation:

① balanced equation

② covalent structure

③ bond energy

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$



bond	energy
C—H	413
O=O	495
C=O	799
O—H	463
C—O	358

bond broken

$4 \times C-H \Rightarrow 4 \times 413$

$2 \times O=O \Rightarrow 2 \times 495$ +

2642 Kj

bonds formed

$2 \times C=O \Rightarrow 2 \times 799$

$4 \times O-H \Rightarrow 4 \times 463$

3450 Kj

$\Delta H = \Sigma input - \Sigma output$

$= 2642 - 3450$

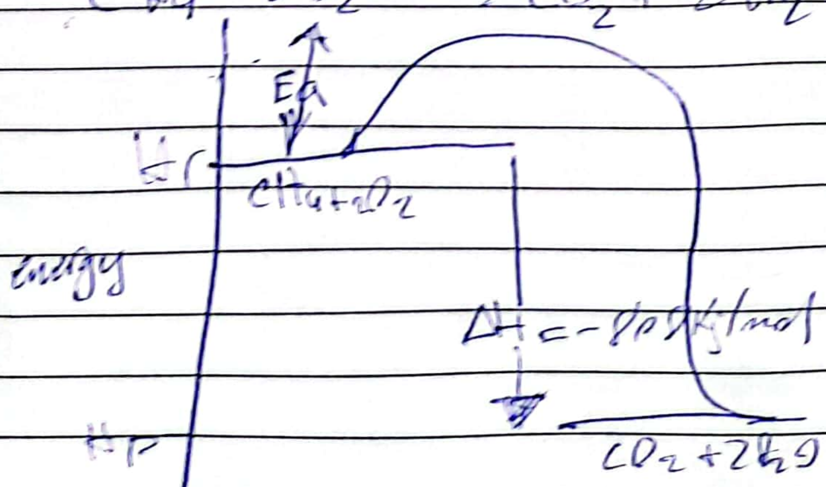
$= \ominus 808$ Kj/mol

exo

input < output

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + 808$ Kj/mol

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O \quad \Delta H = -808$ Kj/mol



H — C — O — H + 1.5 O=O ⟶ 2 O=C=O + 2 H–O–H

bond broken:

$3 \times C-H : 3 \times 413$
$1 \times C-O : 1 \times 358$
$1 \times H-O : 1 \times 463$
$1.5 \times O=O : 1.5 \times 495$ +
2802.5

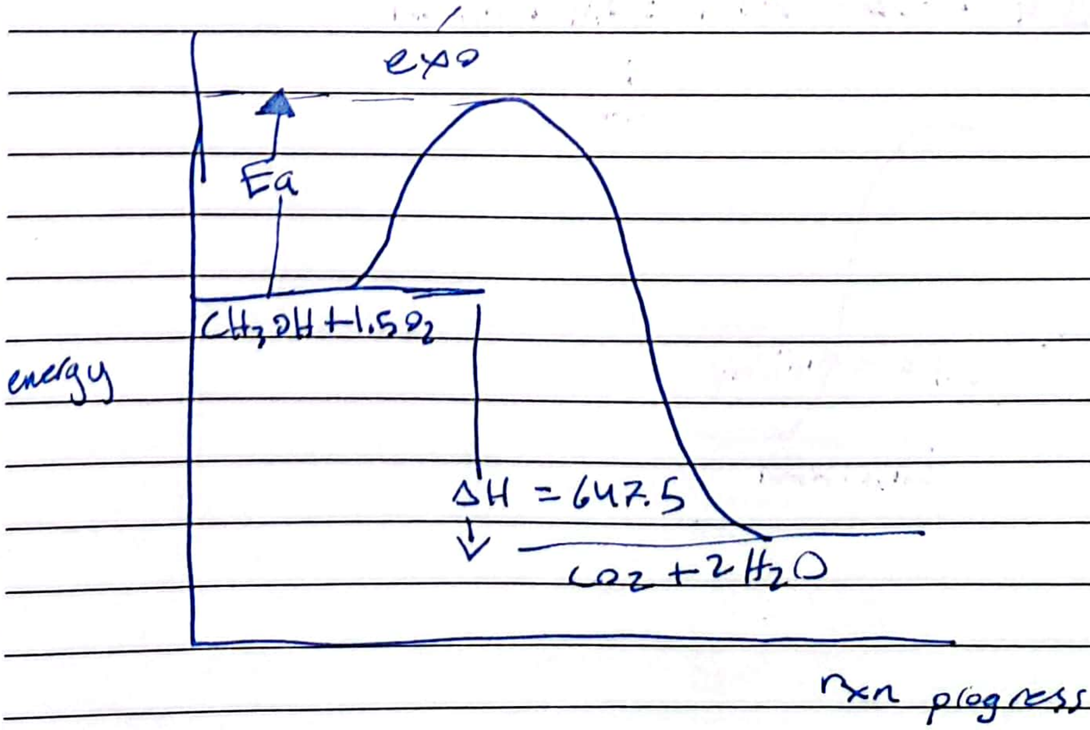
bonds formed:

$2 \times C=O : 2 \times 799$
$4 \times O-H : 4 \times 463$ +
~~2524~~
3450

$\Delta H = \Sigma \text{input} - \Sigma \text{output}$
$= 2802.5 - 3450$

$= -647.5$ kj/mol

exo



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

bond	bond energy Kj/mole
C-H	413
Cl-Cl	242
H-Cl	431
C-Cl	328

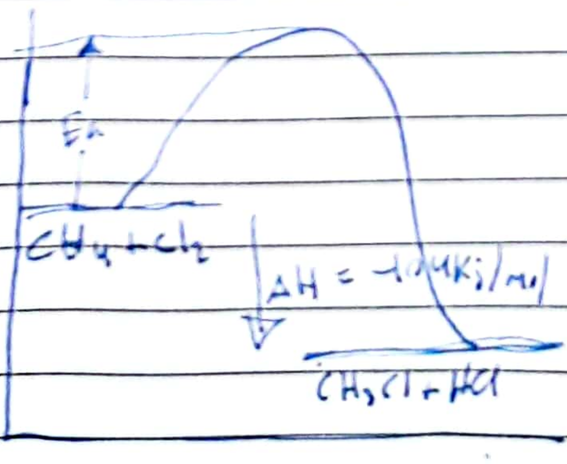
bond broken

1 x C-H 413
1 x Cl-Cl 242
655 kj

Bond build

C-Cl 328
H-Cl 431
759 kj

$\Delta H = 655 - 759 = -104$ kj/mol
↓
exo



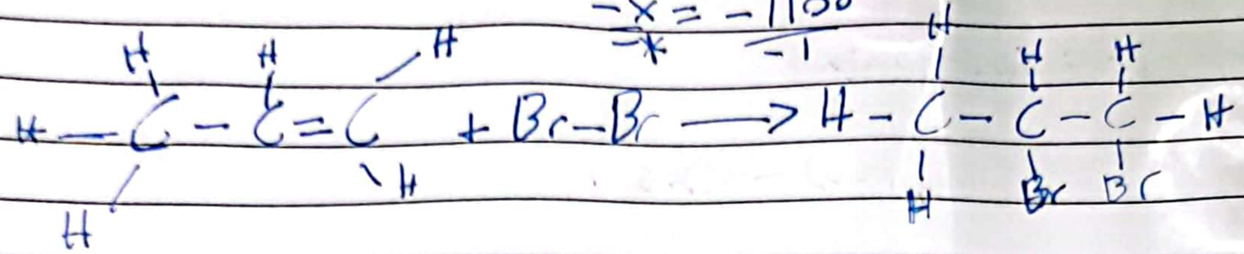
*

$x = 1100$

$320 - x = -780$ $\qquad \frac{1100}{4} = 275$

$-320 \qquad\quad -320$

$\frac{-x}{-1} = \frac{-1100}{-1}$



Bond ~~form~~ broken

Br—Br	193
C=C	614
	807 kj

bond build

2 × C—Br	2 × 276
C—C	348
	900 kj

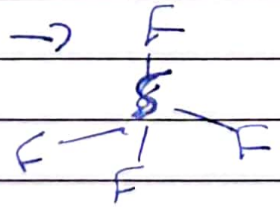
$\Delta H = 807 - 900 = -93$ kj/mol

exo

---

when sulfur react with florine the reaction give 780 kj/mol

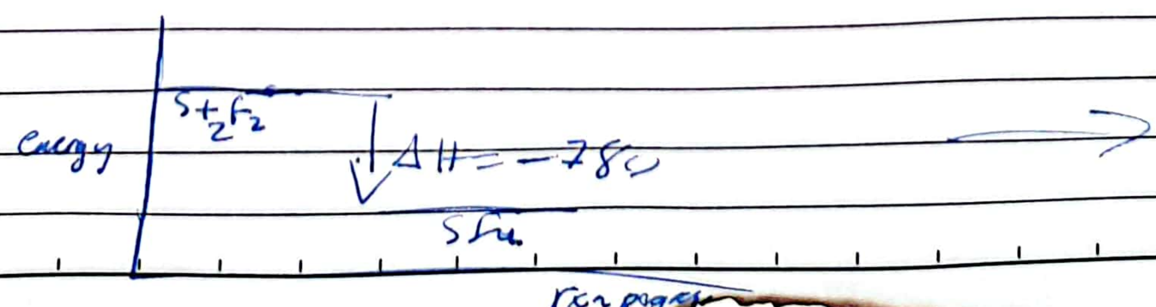
S + 2F—F →



if the bond energy of F—F is 160 kj/mol.

1) Draw an energy level diagram

2) find the bond energy of S—F?



2) ΔH = input − output

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

$-1100 = -4S{-}F$

$S{-}F = 275$ Kj/mol

Finding ΔH (energy changes) practically

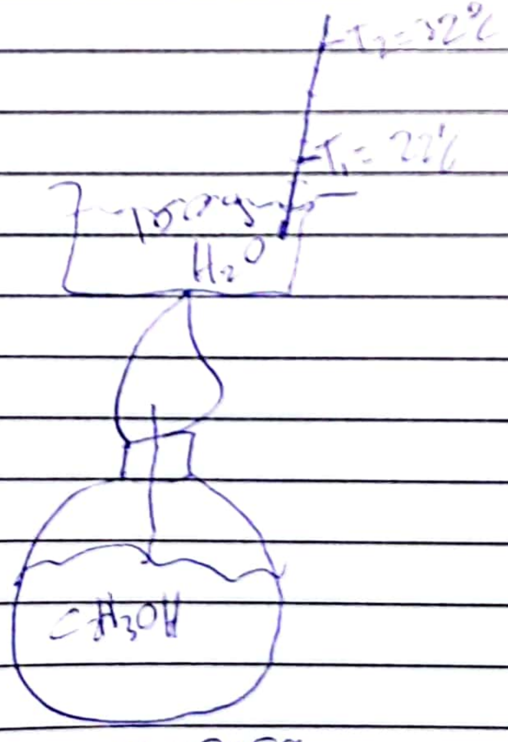
combustion

displacement

neutralization

Finding ΔH combustion for ethanol.

$C_2H_5OH_{(l)} + 3O_{2(g)} \longrightarrow 2CO_2 + 3H_2O_{(l)}$



$m_1 = 200g$

$m_2 = 198$

$Q = mc\Delta T$

energy transfer $= 100 \times 4.2 \times 10$

$= 4200 J$

$= 4.2 kJ$

$4.2 kJ$ produced from $2g$ C_2H_5OH

ΔH 96.6 kJ/mol ← 1 mole = 46 g C_2H_5OH

$\Delta H = -96.6 kJ/mol$

two fuels A & F

plan an exp to show which one produce more energy?

take a known mass of water with initial temp in a copper can, take a known mass of fuel A.

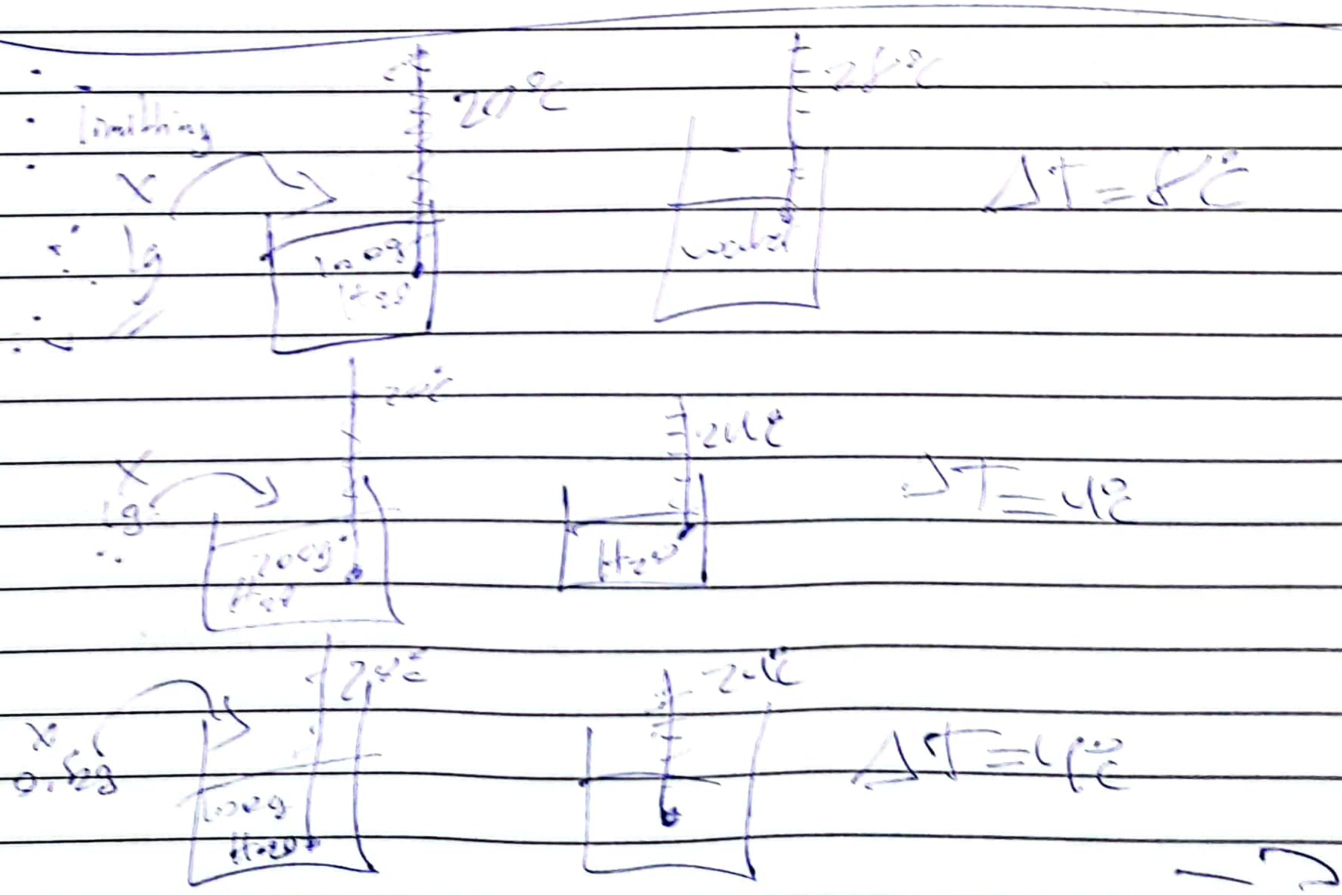
ignite the fuel and record the final mass and final temperature of water

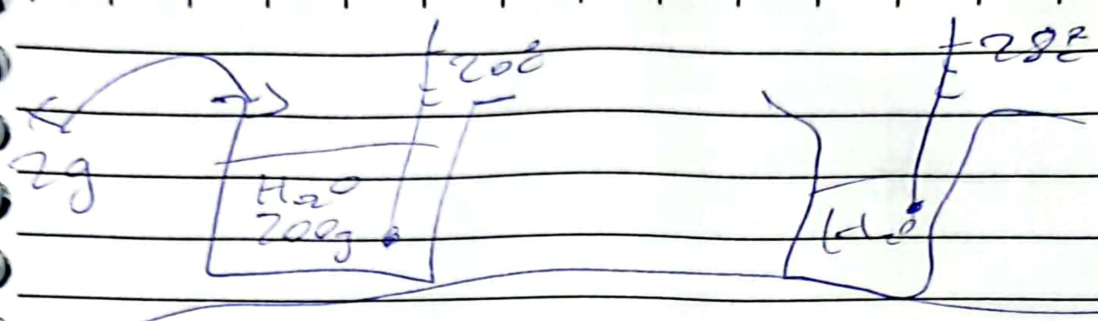
repeat the exp using fuel B.

- the fuel which cause more temp rise (ΔT) per gram of fuel produce more energy

Same condition.

limiting

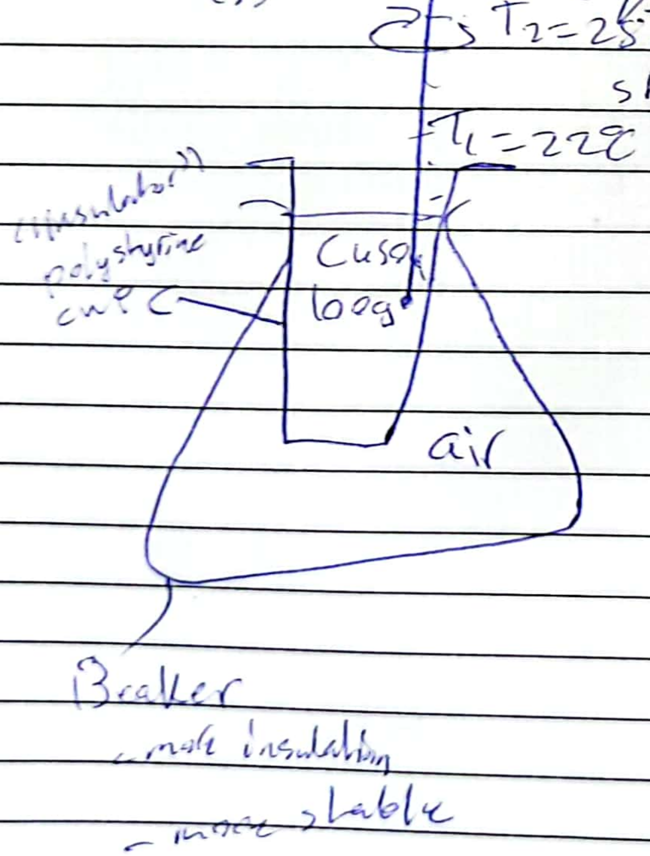




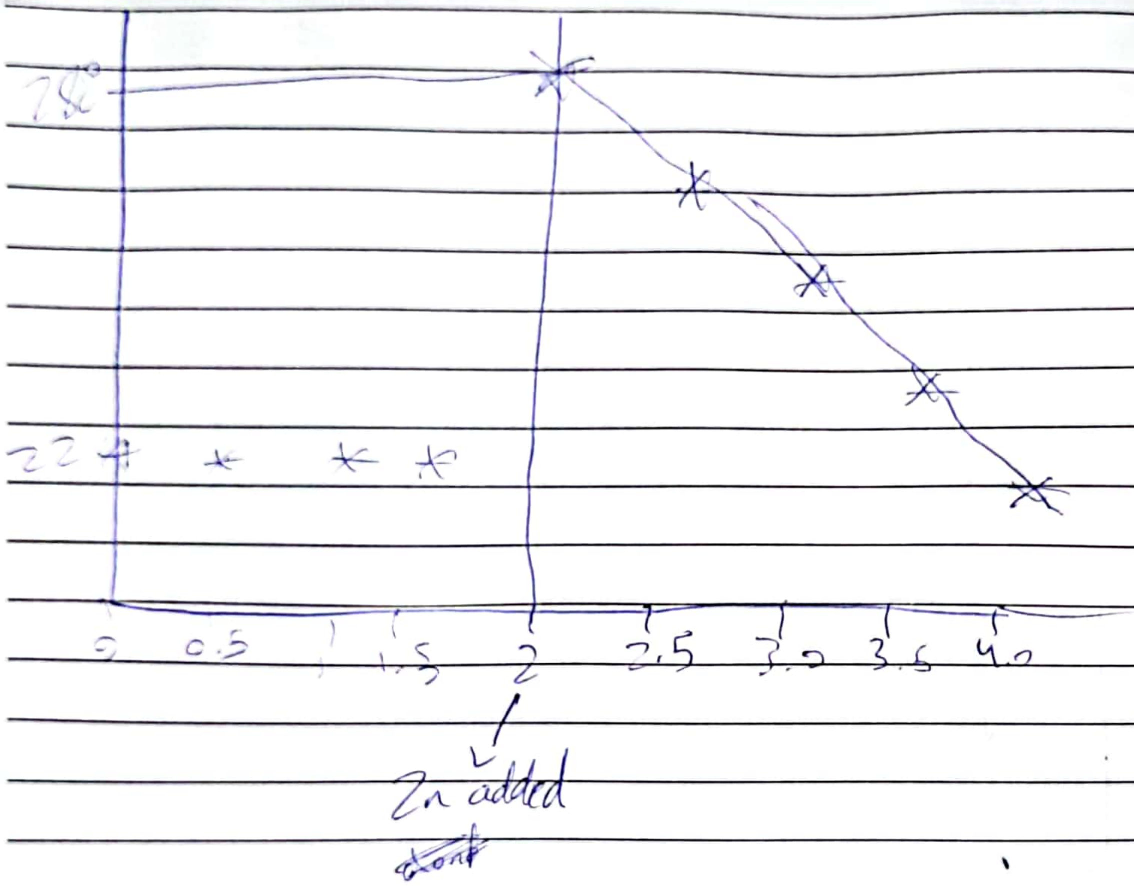
$T\Delta = 8°C$

measuring ΔH displacement

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



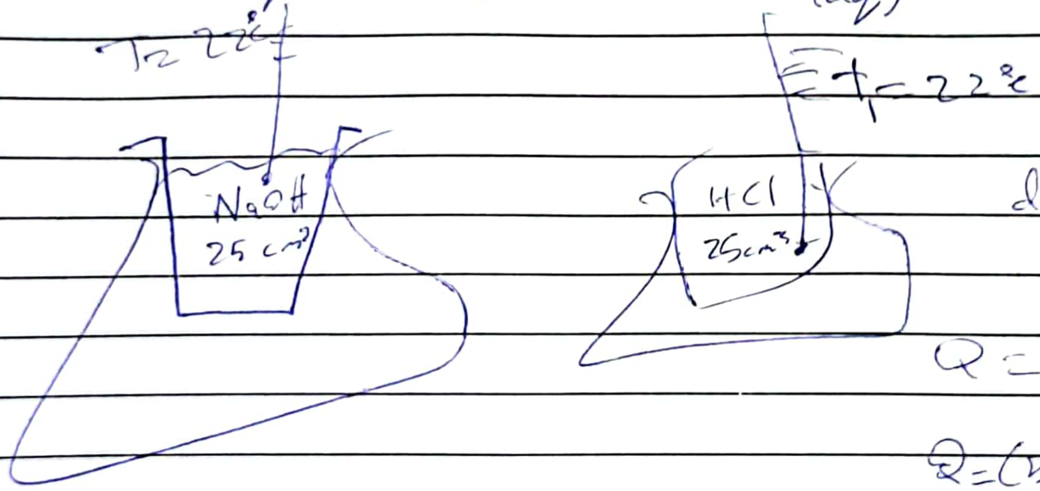
stir with thermometer
to distribute heat equally
(slowly to)
avoid overheating



$$Q = mc\Delta T$$
$$= 100 \times 4.2 \times 6$$
$$= 2520\,J = 2.52\,kJ$$

measuring - ΔH neutralization

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



$d = 1 g/cm^3$

$Q = mc\Delta T$

$Q = (50) \times 4.2 \times 6$

$= 1260 J$

test water

physical test: B.P = 100°

chemical test

① $CuSO_{4(s)} + 5H_2O \rightleftharpoons CuSO_4 \cdot 5H_2O$

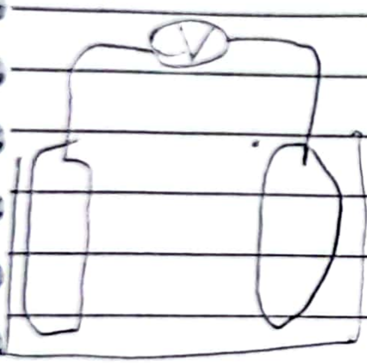
white ⟶ blue

or $CoCl_2 + 6H_2O \rightleftharpoons CoCl_2 \cdot 6H_2O$

blue   pink

Alternative Resources of energy

Voltaic cell.



Hydrogen fuel cell

Uranium $^{235}_{92}U$

Old syl.

Hydrogen fuel cell

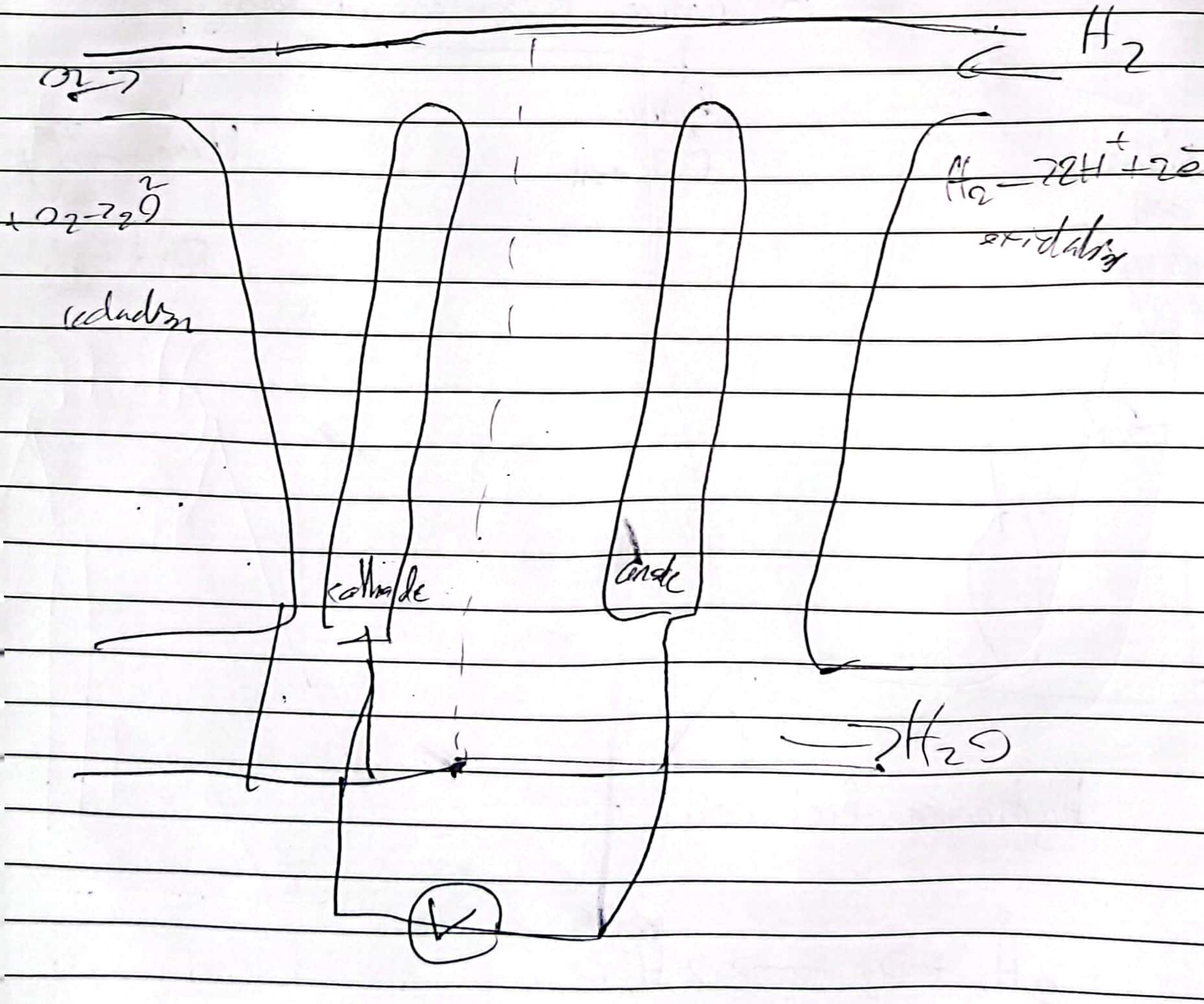
$$2\overset{0}{H_2} + \overset{0}{O_2} \longrightarrow 2\overset{+1}{H_2}\overset{-2}{O}$$

• advantages: - Only one waste product. (H_2O)

- no CO_2
- produce high amount of energy
- generate electricity

disadvantages: - expensive

- hard to store and transport hydrogen
- risk of explosion.


H2
O2
H2 → 2H+ + 2e
oxidation
+O2 → 2O2
reduction
cathode
anode
H2O
V

Industrial chemistry

- dealing with gases
  - Dry
  - collect
- industry of
  - NH_3 — Haber process
  - H_2SO_4 — contact process
  - CO_3^{-2} — carbonate cycle
- extraction of metals
  - Al
  - Fe
  - Zn
  - Cu

Dealing with gases :

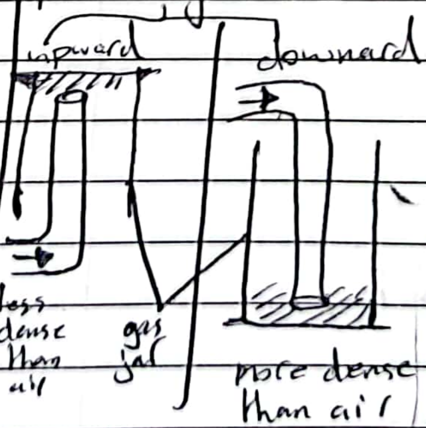
rxn → wet gas → dry → collect

* collect gases

gas syringe

- used to collect and measure the volume of any gas
- no mixing with other gases.

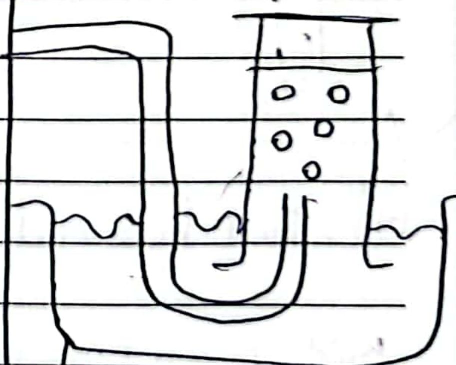
Delivery tube



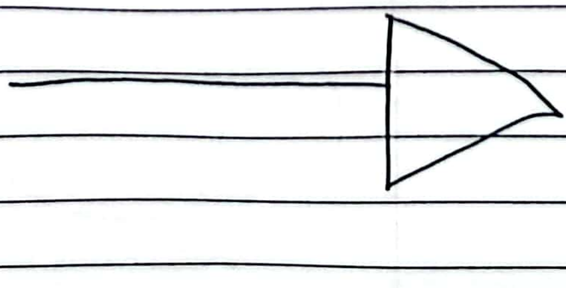
* mix with air

* can escape

over water

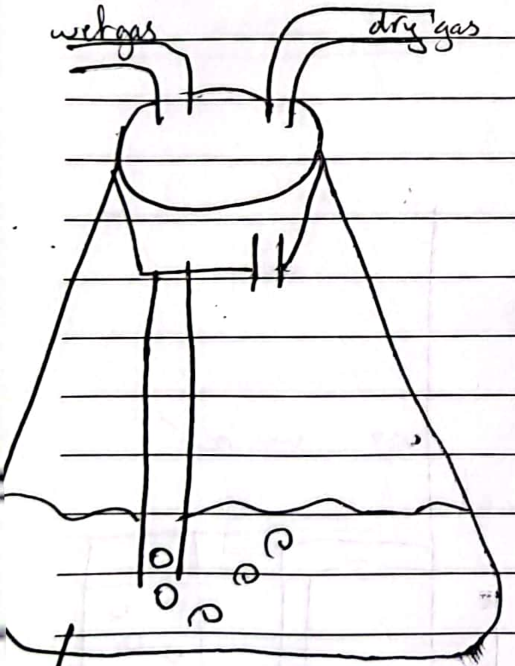


only for insoluble gas



Drying gases

① concentrated H_2SO_4

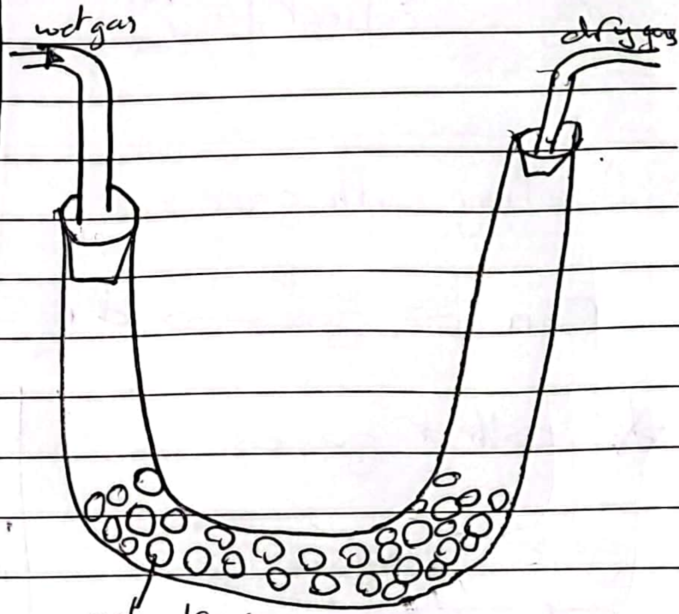


conc. H_2SO_4 (becomes dilute)

used to dry any gas

except NH_3
it neuralise the H_2SO_4
$NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

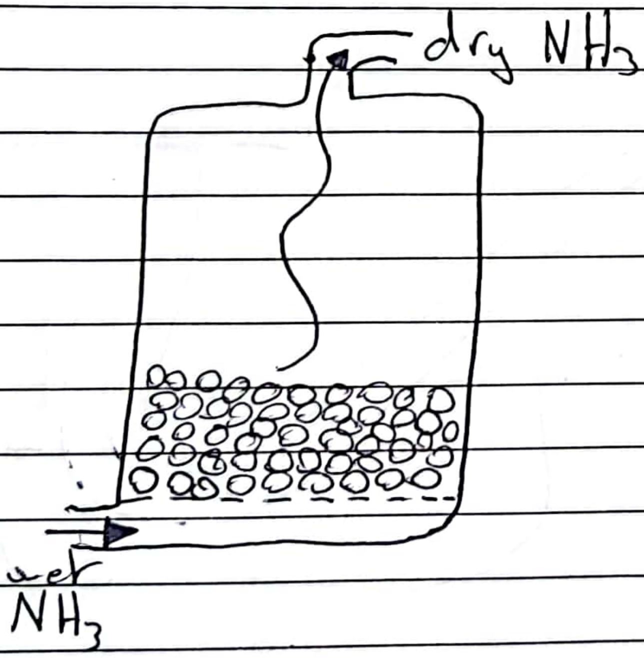
② Anhydrous $CaCl_2$



anhydrous $CaCl_2$
used to dry any gas except NH_3

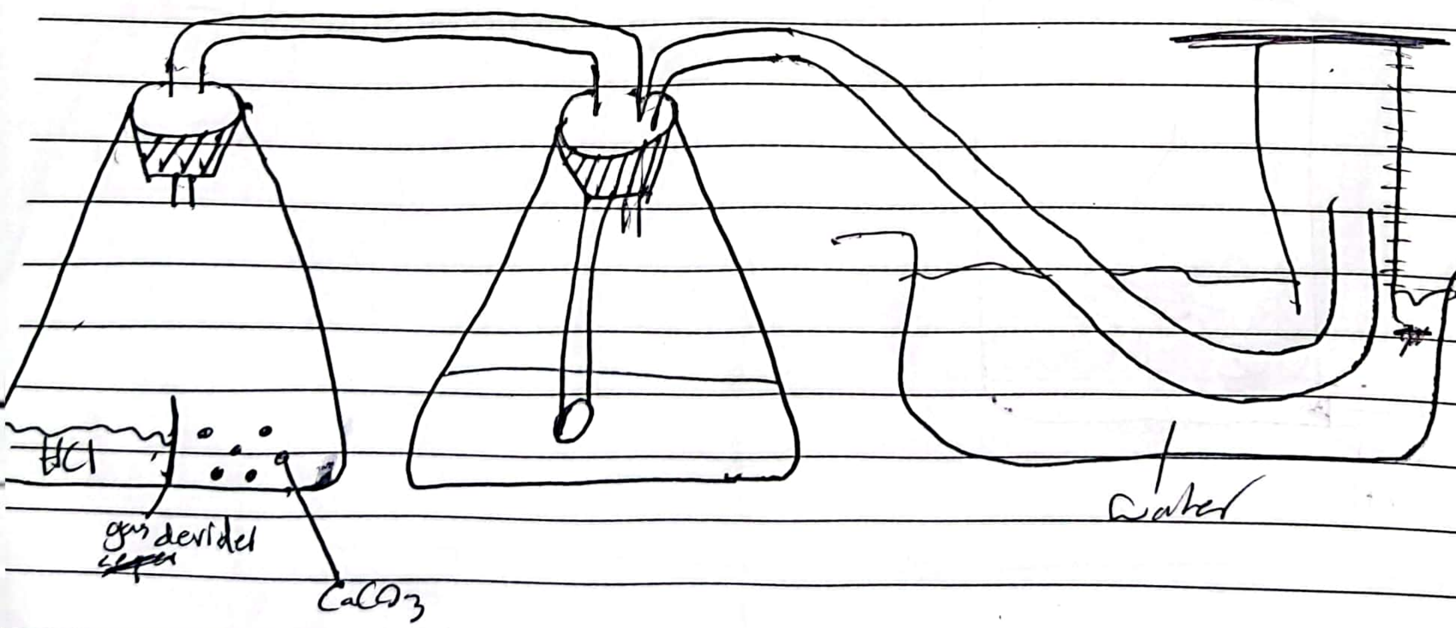
③ Calcium oxide

CaO



Draw a suitable apparatus used to collect and measure volume of dry CO_2 gas from

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



Industrial -

Industry of Ammonia "Haber process"

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

How to obtain.

① Nitrogen :- fractional distillation of liquid air

different B.P — cooling under high pressure

② Hydrogen :- ① cracking of Alkanes. (organic).

② (methane) $CH_{4(g)} + H_2O_{(g)} \rightarrow CO_{(g)} + 3H_{2(g)}$

essential condition

1) temp 400-450°C

2) pressure 200 atm.

3) Fe catalyst

add excess H_2 and N_2

remove NH_3 immediately.

Temp

400°C — 450°C

less than 400°C

adv.	dis.
higher yield of NH_3 - shift forward to exo side	slower rate particles lose K.E so less eff. collisions per unit time.

more than 450°C

adv.	dis.
faster rate	less yield - shift back to the endo side

pressure. 200 atm

adv:

1- more yield of NH_3
shift forward to the side with fewer gas mole

2- faster rate.

dis:

1- risk of explosion

2- expensive

uses of Ammonia

1- fertelizers

2- cleaning detergents

3- smelling salts

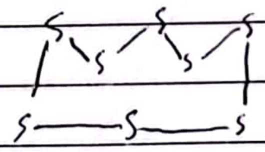
(industry of H_2SO_4) Contact process

$\boxed{\text{stages}}$

$S \xrightarrow{(1)} SO_2 \xrightarrow{(2)} SO_3 \xrightarrow{(3)} H_2S_2O_7 \xrightarrow{(4)} H_2SO_4$

$+O_2$ Roasting. contact process oleum

- group (VI)
- valency (2)
- yellow solid
- S_8

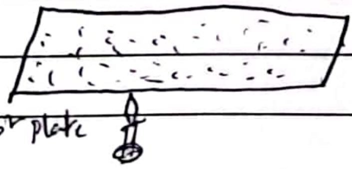


SO_2 causes acid rain

* uses of SO_2
kills bacteria (sterilization).
* paper industry (bleaching agent)

uses: medicine
* match
* rubber

ore: zinc blend ZnS
* from fossil fuel



$SO_3 \xrightarrow{H_2O} H_2SO_4$
- highly exothermic
- produce low yields of H_2SO_4

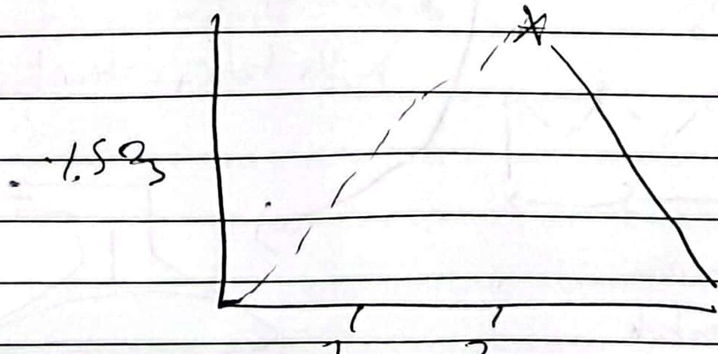
H_2SO_4 H_2O

$H_2S_2O_7$

$$\overbrace{2SO_{2(g)} + O_2}^{3} \xrightleftharpoons[endo]{\overset{V_2O_5}{exo}} \overbrace{2SO_{3(g)}}^{2} \qquad \Delta H = \overset{exo}{-ve}$$

essential conditions.

1) temp 400-450°C
2) pressure 2 atm, * high pressure favour the forward rxn (fewer gas mole)
   2 atm gives ~~max~~ - yield of SO_3



3) catalyst V_2O_5 vanadium (V) oxide

Carbonate Cycle

Dry NH_3

for building

extraction of iron

$CaCO_{3(s)}$ limestone $\xrightarrow{\text{thermal decomposition}}$ $CaO_{(s)}$ Quick lime

bases

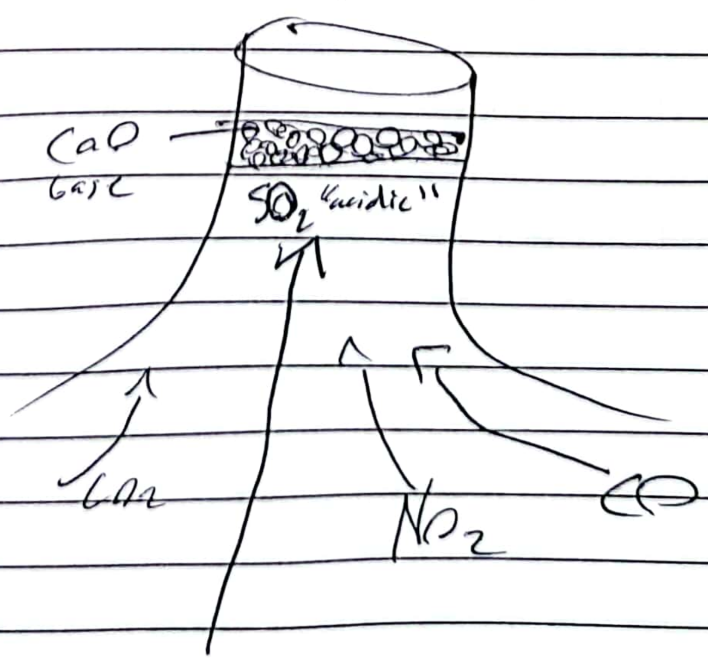
- neutralise acidic soil water
- desulfromation of flow gases

$CaO_{(s)} \xrightarrow{+\text{ limited } H_2O} Ca(OH)_{2(s)}$ slacked lime

$Ca(OH)_{2(s)} \xrightarrow{\text{excess } H_2O} Ca(OH)_{2(aq)}$ lime water

$Ca(OH)_{2(aq)} \xrightarrow{+CO_2} CaCO_{3(s)}$

test CO_2



Extraction of Metals

K

Na

Li

Ca

Mg

Al_2O_3 ~~A~~ ← Al ✓ → electrolysis (molten)
Bauxite

C, CO

ZnS ← Zn
zinc blend

Fe ← Fe_2O_3
Hematite

reduction by C and CO
"blast furnace"

Pb

H

CuS ← Cu] reduction by H_2

Ag

Au

Pt

Five App

extraction of Iron.

ore : Fe_2O_3 "hematite".

method: reduction by C and CO

place : blast furnace

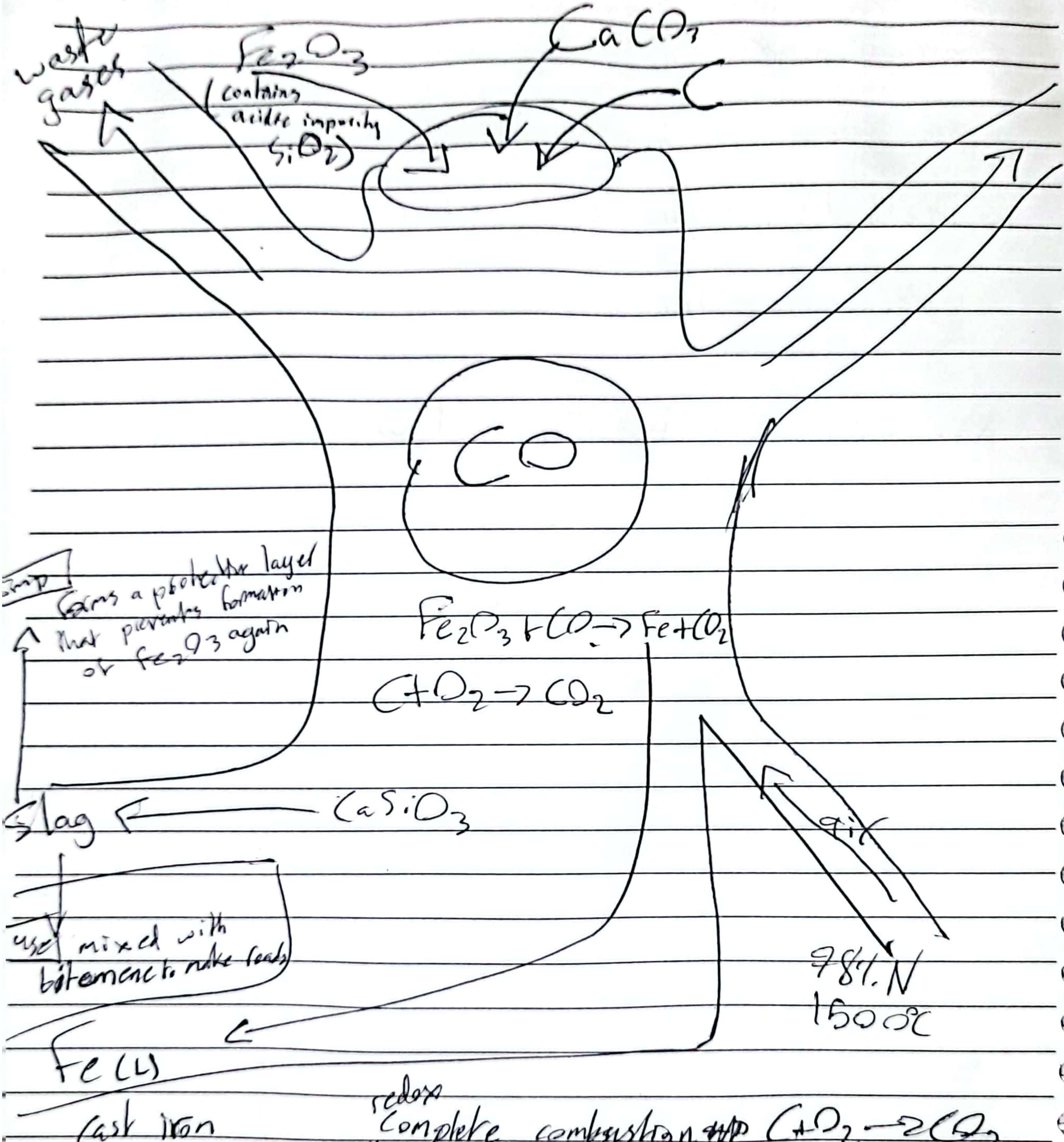
Raw materials :- Fe_2O_3 mixed with SiO_2 acidic impurities

$CaCO_3$ "lime stone"

coke "carbon pure"

air 1500°c

Five Apple



redox
Complete combustion ~~exo~~ $C + O_2 \rightarrow CO_2$

redox
incomplete combustion ~~exo~~ $2C + O_2 \rightarrow 2CO$

redox
$CO_2 + C \rightarrow 2CO$

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

thermal decomp $CaCO_3 \xrightarrow{heat} CaO + CO_2$

neutralization $\underset{basic}{CaO} + \underset{acidic}{SiO_2} \rightarrow CaSiO_3$

calcium silicate "slag"

Steelmaking "oxygen base process".

cast iron is impure it contains

CO_2 SO_2

Fe

hot O_2

$\boxed{C}$

$\boxed{S}$

$Si \rightarrow SiO_2 \leftarrow CaCO_3 \xrightarrow{heat} CaO$ (neutralize

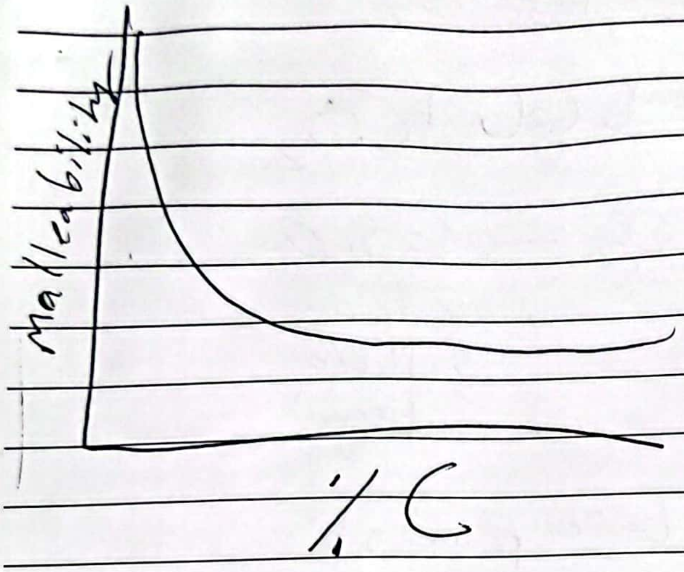
$P \rightarrow P_2O_5$

Steel

→ mild steel 0.03% C "car bodies"

→ medium steel 0.3% C "railways"

→ stainless steel 3-5% C cutlery and watch.



Alloy: mixture of metal with another metal or a semi metal.

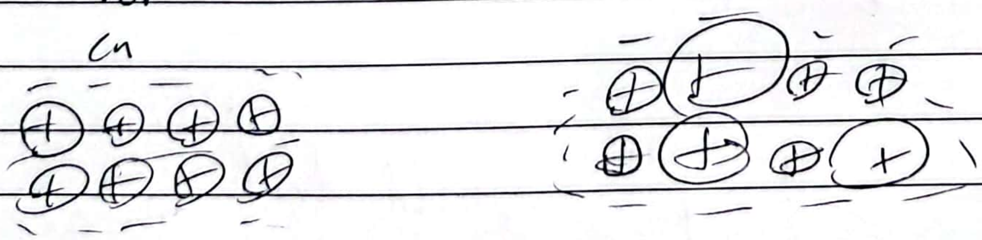
brass - Cu, Zn

bronze Cu, Sn

steel Fe, C, Ni, Cr

Metal

Cu



all alloys are harder than their pure metals.

extraction of Zinc

ore : zinc blende ZnS

method : - reduction by C and CO

place :- Blast furnace.

C, CO and H_2 can only reduce the less reactive metal, only from its oxide

step 1:- Roasting with hot oxygen.

$$ZnS + O_2 \rightarrow ZnO + SO_2$$

step 2:-

$$C + O_2 \rightarrow CO_2$$
$$2C + O_2 \rightarrow 2CO$$
$$CO_2 + C \rightarrow 2CO$$
$$CO + ZnO \rightarrow Zn + CO_2$$

the temp inside the furnace 1500°C, and the B.p of Zinc is 907°C, so it produced as pure gas must condense, and the other impurities since they have high B.p stay in the furnace.