Reactivity Series

K^{+1}
Na^{+1}
Li^{+1}
Ca^{+2}
Mg^{+2}
Al^{+3}
C
Zn^{+2}
$Fe^{+2/+3}$
pb^{+2}
H
$Cu^{+1/+2}$
Ag^{+1}

Metal Carbonate CO_3^{-2}

$K^{+1}\ CO_3^{-2} \rightarrow K_2CO_3$

$Na^{+1}\ CO_3^{-2} \rightarrow Na_2CO_3$

$Li^{+1}\ CO_3^{-2} \rightarrow Li_2CO_3$

$Ca^{+2}\ CO_3^{-2} \rightarrow CaCO_3$

$Mg^{+2}\ CO_3^{-2} \rightarrow MgCO_3$

$Al^{+3}\ CO_3^{-2} \rightarrow Al_2(CO_3)_3$

$Zn^{+2}\ CO_3^{-2} \rightarrow ZnCO_3$

$Fe^{+2}\ CO_3^{-2} \rightarrow FeCO_3$ / $Fe^{+3}\ CO_3^{-2} \rightarrow Fe_2(CO_3)_3$

$pb^{+2}\ CO_3^{-2} \rightarrow PbCO_3$

$Cu^{+1}\ CO_3^{-2} \rightarrow Cu_2CO_3$

$Ag^{+1}\ CO_3^{-2} \rightarrow Ag_2CO_3$

Redox → oxidation

↓

Reduction

in terms of ~~oxygen~~	Reduction	Oxidation
1) Oxygen	lose O	gain O

reduction: Fe in Fe_2O_3

$Al + Fe_2O_3 \rightarrow Al_2O_3 + Fe$

oxidation: Al

reduction: Zn in ZnO

$CO + ZnO \rightarrow Zn + CO_2$

oxidation: C in CO

reduction: Cu in CuO

$H_2 + CuO \rightarrow Cu + H_2O$

oxidation: H_2

2) Hydrogen	reduction	oxidation
	gain H	lose H

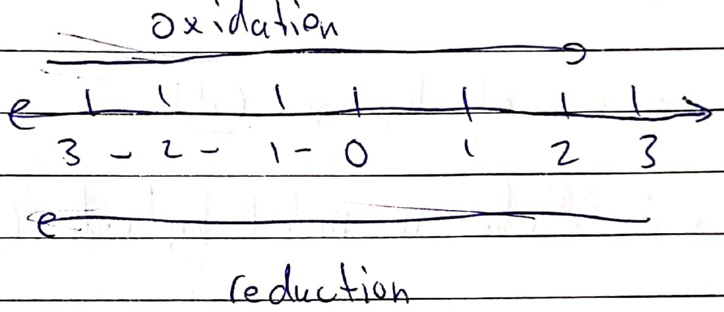
reduction: Cl_2

$H_2S + Cl_2 \rightarrow HCl + S$

oxidation: H_2 in H_2S

③ Oxidation state

	reduction	Oxidation
	decrease	increase



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

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

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

Roles of oxidation state

1) the oxidation state for any free element is Zero

monoatomic   Diatomic   polyatomic

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

all group 1
group I ; +1 Li, Na, K, Rb, Cs, Fr

except Be, Ra
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 no. of hydrogen (+1)

except with Metal in metal hydride (-1)

$C\overset{+1}{H}_4$, $N\overset{+1}{H}_3$, $\overset{+1}{Na}\overset{-1}{H}$, $\overset{+2}{Ca}\overset{-1}{H}$

④ the oxidation state of oxygen (-2)

except in peroxide (-1)

except in OF_2 (+2)

$\overset{~~+2~~ -2}{O}$ oxide $\overset{-2}{O}_2$ peroxide

Soduim Oxide $\overset{+1}{Na}\ \overset{-2}{O} \rightarrow Na_2O$

sodium peroxide $\overset{+1}{Na}\ \overset{-1}{O_2} \rightarrow \underline{\underline{Na_2\overset{-1}{O_2}}}$

$H_2\underline{\overset{-2}{O}}$ $\qquad\qquad$ $H_2\underline{\overset{-1}{O_2}}$

water $\qquad\qquad$ Hydrogen peroxide

calcium oxide $\qquad\qquad$ calcium peroxide

$\overset{+2}{Ca}\ \ \overset{-2}{O}$ $\qquad\qquad$ $\overset{+2}{Ca}\ \ \overset{-2}{O_2}$

CaO $\qquad\qquad$ $CaO_2!$ $\underset{-2}{}$

3 ⑤ The sum of all oxidation state in a compound $= 0$

in a ion = charge of this ion.

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

$\qquad\qquad\qquad\quad -1 \qquad -1$

$$x = -1$$

$\overset{+1}{H}\underline{Cl}\overset{-2}{O}$ $\qquad$ $+1 + x - 2 = 0$

$\qquad\qquad\qquad\qquad\quad +2 \ \ +2$

$$+1 + x = 2$$

$\qquad\qquad\qquad -1 \qquad\quad -1$

$$x = 1$$

$\overset{+1}{H}\underline{Cl}\overset{-2}{O_2}$ $\qquad$ $+1 + x + 2(-2) = 0$

$+1 + x - 4 = 0$

$+4 \ \ +4 \longrightarrow x + 1 = 4 \longrightarrow x = 3$

$\qquad\qquad\qquad\qquad\quad -1 \quad +1$

$\underline{N}H_3$

$N + 3(+1) = 0$

$N + 3 = 0$

$-3 \quad -3$

$N = -3$

$\underline{N}O$

$N + -2 = 0$

$+2 \quad +2$

$N = +2$

N_2O_5

$2N - 10 = 0$

$+10 \quad +10$

$\frac{2N}{2} = \frac{10}{2} \rightarrow N = 5$

H_2S

$2 + S = 0$

$-2 \quad -2$

$S = -2$

H_2SO_4

$2 + S + -8 = 0$

$+8 \quad +8$

$2 + S = 8$

$-2 \quad -2$

$S = 6$

$\underline{S}O_3$

$S + -6 = 0$

$+6 \quad +6$

$S = +6$

$\underline{N}O_3^{-1}$

~~$N + -6 = 0$~~
~~$+6 \quad +6$~~
~~$N = 6$~~

$N \cancel{+} -6 = -1$
$+6 \quad +6$
$N = 5$

MnO_4^{-1}

$Mn - 8 = -1$
$+8 \quad +8$
$Mn = 7$

SO_3^{-2}

$S - 6 = -2$
$+6 \quad +6$
$S = +4$

$Cr_2O_7^{-2}$

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

$$\frac{2Cr}{2} = \frac{+12}{2} \longrightarrow Cr = 6$$

Q:- find the oxidation state of each underlined species

$\underline{Fe}_2O_3$

$2Fe - 6 = 0$
$+6 \quad +6$
$\frac{2Fe}{2} = \frac{6}{2}$
$Fe = 3$

$\underline{O}Fe$

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

$\underline{S}O_4^{-2}$

$S - 8 = -2$
$+8 \quad +8$
$S = +6$

$\underline{V}_2O_5$

$2V - 10 = 0$
$+10 \quad +10$
$\frac{2V}{2} = \frac{10}{2}$
$V = +5$

$\underline{P}O_4^{-3}$

$P - 8 = -3$
$+8 \quad +8$
$P = +5$

$\underline{Cr}O_4^{-2}$

$Cr - 8 = -2$
$+8 \quad +8$
$Cr = +6$

O

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

$\underline{C}O_2$

$C - 4 = 0$
$+4 \quad +4$
$C = +4$

$\underline{C}O_3^{-2}$

$C - 6 = -2$
$+6 \quad +6$
$C = +4$

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

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

reduction: $Fe^{+3} \rightarrow Fe^{0}$

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

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

reduction: $Zn^{+\cancel{4}2} \rightarrow Zn$

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

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

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

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

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

reduction ; $\overset{+7}{Mn} \rightarrow Mn^{+2}$

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

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

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

* $AgNO_2 + NaCl \rightarrow AgCl + NaNO_3$

there is no oxidation

NOT REDOX

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

oxidation: $Na \rightarrow Na^{+1}$

reduction: $H^{+1} \rightarrow H_2^{0}$

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

oxidation:

reduction:

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

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

Half of reduction: $Fe^{+3} + 3e^- \rightarrow$ ~~Fe Fe~~ Fe

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

Writting balanced Half ionic equation

1) ~~Ate~~ Atoms

2) the charge by adding $\bar{e}$s to the side with greater charge
the
by 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 $Ca \rightarrow Ca^{+2} + 2e^-$

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

over all reaction ;; $Ca + Zn^{+2} \rightarrow Ca^{+2} + Zn$

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

over all reaction ; $2Na + 2H^+ \rightarrow 2Na^{+1} + H_2$

H.O.O $Na \rightarrow Na^{+1} + 1e^-$

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

~~over all reaction~~ ;

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

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

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

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

H.O.O $(S^{-2} \rightarrow S + 2e^-$

H.O.R $(Cl_2 + 2e^- \rightarrow 2Cl)$

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

Reactants → products

oxidation → e^- "lose e^-"

reduction ~~lose~~ e^- → "gain electrons"

OIL RIG

O → oxidation
I → is
L → lose e^-
R → reduction
I → is
G → gain e^-

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

H.O.O $(\cancel{3}2\overset{0}{Al} \rightarrow 2Al^{+3} + \overset{6}{\cancel{3}}e^-)\ 2$

H.O.R $(\overset{6}{\cancel{2}}H + \overset{6}{\cancel{2}}e \rightarrow 3H_2)\ 3$

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

$\overset{+7\ -2}{MnO_4^{-1}} + Fe^{+2} + H^{+1} \rightarrow Mn^{+2} + Fe^{+3} + \overset{+1\ -2}{H_2O}$

H.O.O $(5Fe^{+2} \rightarrow 5Fe^{+3} + \cancel{1}e^-) \times 5$

H.O.R $Mn^{+7} + \cancel{5}e^- \rightarrow Mn^{+2})$

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

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

H.O.O $(3Sn^{+2} \longrightarrow 3Sn^{+4} + \cancel{2e^-}) \times 3$

H.O.R $~~6~~2Cr^{+6} + \cancel{3e} \longrightarrow 2Cr^{+3}$ ~~[illegible]~~

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

Oxidising agent and reducing agent

<u>oxidising agent</u> "oxidant"

The substance that it self <u>reduced</u> and causes the other substance to be <u>oxidised</u>

<u>reducing agent</u> "reductant"

The substance that it self ~~oxide~~ <u>oxidised</u> and causes the other substance to be <u>reduced</u>.

If the substance is an <u>ion</u> in a <u>compound</u> the agent is the <u>compound itself</u>

reducting agent

oxidation

oxidising ~~oxidation~~ agent

reduction

Five Apple

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

oxidation Al reducing ~~ing~~ agent Al

reduction ~~Fe_2O_3~~ $\overset{+3}{Fe}$ oxidation agent Fe_2O_3

$$\overset{+2\;-2}{CO} + \overset{+2\;-2}{ZnO} \longrightarrow \overset{0}{Zn} + \overset{+4\;-2}{CO_2}$$

oxidation : C^{+2} oxidising agent : ZnO

reduction : Zn^{+2} reducing agent : CO

$$\overset{+1\;-2}{H_2S} + \overset{0}{Cl_2} \longrightarrow \overset{+1\;-1}{HCl} + \overset{0}{S}$$

oxidation S^{-2} oxidising agent Cl_2

reduction Cl_2 reducing agent H_2S

$$\overset{+7}{Mn}O_4^{-1} + Fe^{+2} + H^{+} \longrightarrow Mn^{+2} + Fe^{+3} + H_2O$$

oxidising agent : MnO_4^{-1} ~~reductant~~ reductant : Fe^{+}

oxidation : Fe^{+2} reduction : Mn^{+7}

Most common oxidising agent

① oxygen

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

~~② Acidify pottasium maga manganate magna magn~~

② Acidify potassium manganate $KMnO_4/H^+$.

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

(+7) (+2)

purple clear

③

③ Acidify potassium dichromate $K_2Cr_2O_7/H^+$

$Cr_2O_7^{-2} \longrightarrow Cr^{+3}$

(+6) (+3)

orange green

④ Halogens

$F_2 \longrightarrow F^-$

yellow

$Cl_2 \longrightarrow Cl^-$

greenyellow

$Br_2 \longrightarrow Br^-$

red brown

$I_2 \longrightarrow I^-$

purple gas

black solid

red brown solution

→ colorless solution

Most common reducing agents

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

② carbon and carbon monoxide

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

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

③ ~~Metals~~ Iodide $I^-_{(aq)} \rightarrow I_{2\,(aq)}$

colourless red-brown solution

K^+ → weakest oxidant → reduce

④ Metals

K → Strongest reductant

↓

oxidise

Na

Li

Ca

Mg

Al

C, CO

Zn

Fe

Pb

H

Cu

Ag → weakest reductant

↓

oxidise

strongest oxidant → reduce

Metal more ~~[illegible]~~ reactive more likely to lose e^- so more likely to oxidise ~~[illegible]~~ more likely to be a reducing agent

Oxides

~~Oxidant and reductant [illegible] reaction [illegible] together + reductant + reductant oxidant + reductant ✓ + oxidant + oxidant X~~

~~oxidant~~	~~reductant~~
~~O_2~~	~~H_2~~
~~$KMnO_4/H^+$~~	~~Metals~~
~~$K_2Cr_2O_7/H^+$~~	~~C/CO~~
~~halo~~	

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

Q :- Fe^{+2} is a $\overset{\text{oxidise}}{\text{reducing agent}}$

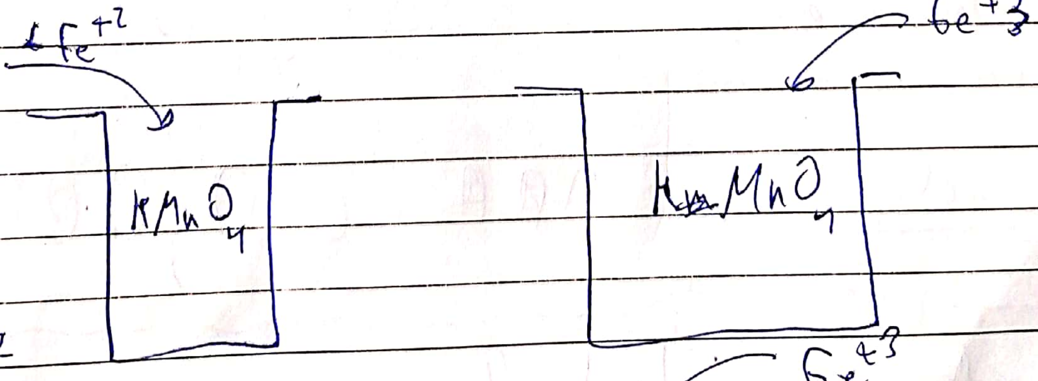
Fe^{+3} is an $\overset{\text{reduce}}{\text{oxidising agent}}$

need to know impo

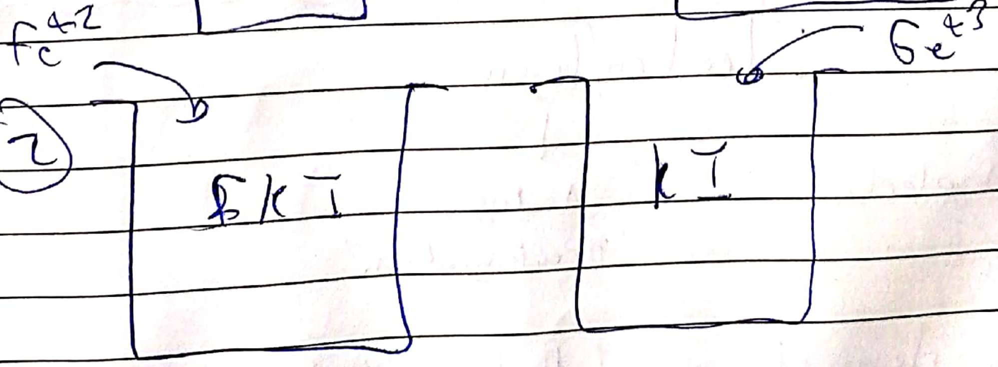
oxidant + reductant ✓
oxidant + oxidant X
reductant + reductant X

record the observation in each of the following reaction

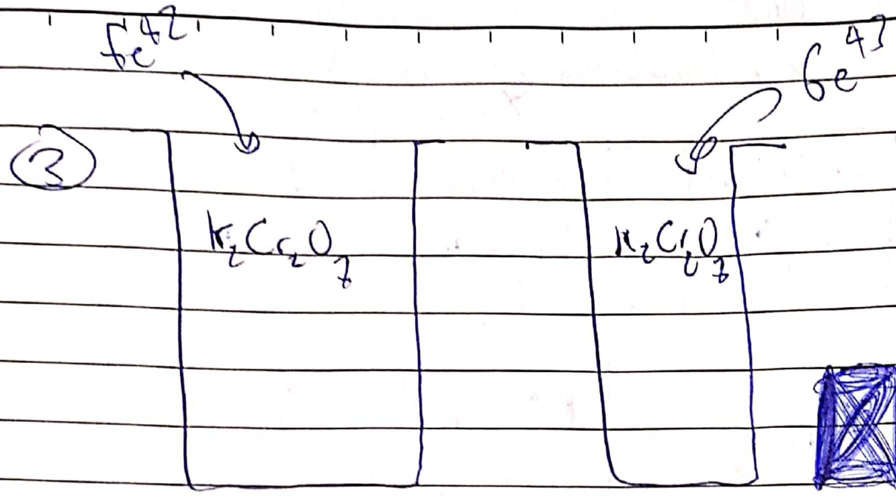
①



②



③



① Fe^{+2}: the color will change from purple to colorless

Fe^{+3}: stays ~~colorless~~ purple

② Fe^{+2}: stays colorless ~~$2I^- \to I_2 + 2e^-$~~

Fe^{+3}: red-brown solution

$$Fe^{+3} + I^- \to Fe^{+2} + I_2$$

③ Fe^{+2}: change from orange to green

Fe^{+3}: no change

Electrolysis

electro

Analysis "Breaking down"

* Electrolyte: chemical compound that conduct electricity when molten or ~~aqus~~ aqeous

Electrolysis: Breaking down chemical compounds (Ionic) when molten or aqeous by passing electricity

Why those ionic compound's don't conduct electricity when solid ? ~~The ions~~

The ions are not free to move

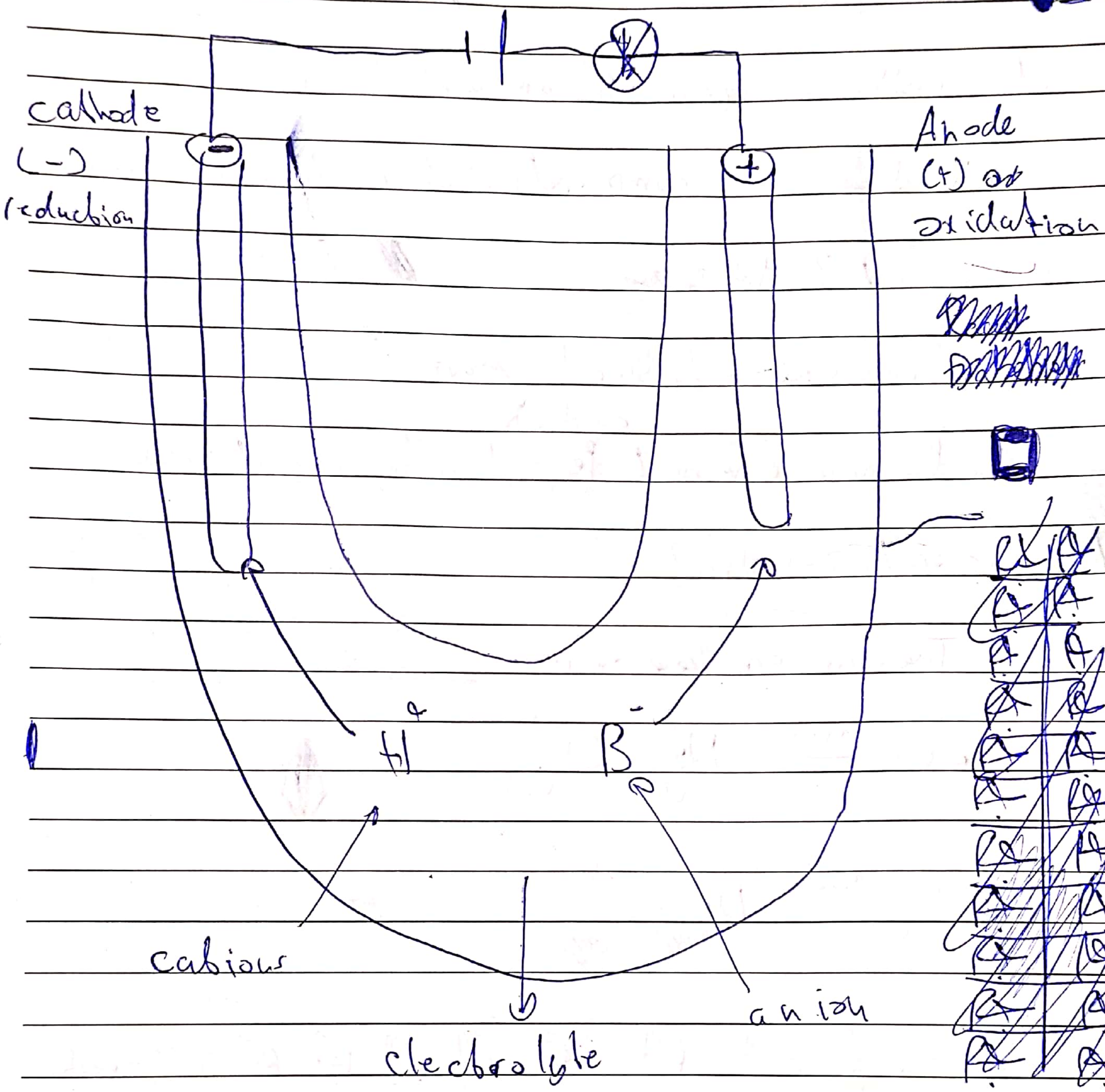
Why the ionic compound conduct electricity when dissolve in water or being molten?

The ions are free to move

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

$$NaCl_{(s)} \xrightarrow[\cancel{heat}]{H_2O} Na^{+1}_{(aq)} + Cl^{-1}_{(aq)}$$

~~Eeles~~ Electrolysis cells



Electrods

Inert
- unreactive
- graphite
- platinum

less expensive

Reactive
- Cu
- Ag

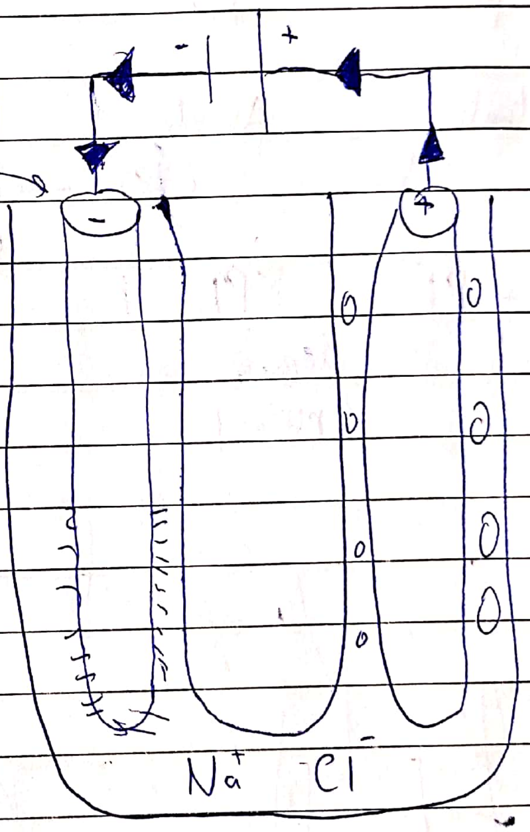
why use graphite / platinium rods in electrolysis? (2pts)

→ conducts electricity
→ unreactive / inert
→ high meltting point

* cathode: the -ve rod that attracts the +ve Ions (cations) where the reduction occurs.

* Anode: the +ve rode that attracts the -ve ions (anions) where the oxidation occurs

electrolysis for molten electrolyte using inert rode (graphite)



$NaCl_{(l)}$

Na^+ | Cl^-
Cathode | Anode

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

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

deposite of metal

bubbles of green yellow gas

Electrolyte: Used up

$NaCl \xrightarrow{electricity} Na + Cl_2$

$NaCl \xrightarrow{electricity} Na + Cl_2$

molten lead(II) bromide

$PbBr_{2\,(L)}$

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

cathode Anode

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

bubbles of red brown gas

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

deposite of metal

electrolyte is used up

Bulb lights up

$CuCl_{2(l)}$ / graphite

$CuCl_2 \rightarrow Cu^{+2}$, Cl^-

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

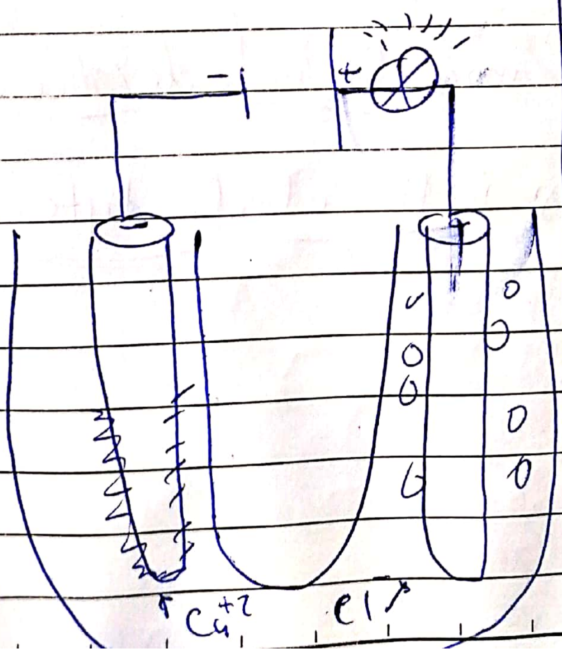
deposite of metals

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

green yellow bubbles of gas formed

electrolyte : ~~used up~~ consumed

bulb will light up



$Al_2O_{3(l)}$ / graphite

$Al_2O_3 \rightarrow Al^{+3}$, O^{-2}

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

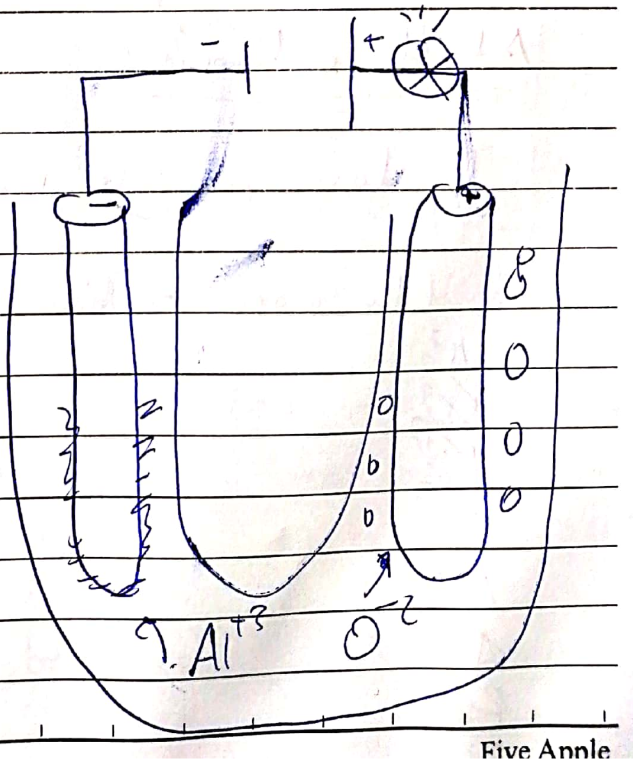
deposite of metals

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

~~[illegible]~~ bubbles of colorless gas

electrolyte is used up

bulb will light up



* ~~Ext~~ Electrolysis ~~of~~ of ~~a~~ aqeous electrolyte using inert ~~[illegible] graphite)~~

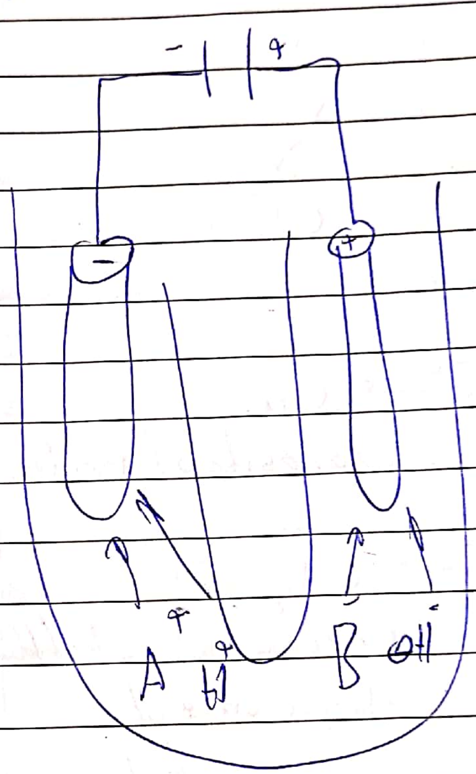
AB

↙ ↘

A^+ B^-

H^+ OH^-

cathode Anode



~~cathode~~

~~[illegible]~~

At the cathode

The less reactive ion is more likely to ~~oke~~ reduce and the more reactive stays in the electrolyte.

~~K^+~~
~~Na^+~~
~~Li^+~~
~~Ca~~
~~Mg~~

K^+
Na^+
Li^+
Ca^{+2}
Mg^{+2}
Al^{+3}
Zn^{+2}
$fe^{+2/+3}$
pb^{+2}
H^+
$Cu^{+1/+2}$
Ag^+
Au^{+3}

At the Anode

always ~~the~~ OH^- except (concentrated) halide,

$Cl^- / Br^- / I^-$

when the halide oxide

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

~~when~~ when ~~the~~ OH^- oxidise

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

bubbles of colorless gas

Concentrated $NaCl_{(aq)}$ / graphite

Na^+ $\quad$ Cl^-

H^+ $\quad$ OH^-

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

~~bot~~ bubbles of colorless gas

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

~~bot~~ bubbles of green yellow gas

electrolyte : NaOH not used up

$CuSO_4$ (aq) / graphite

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

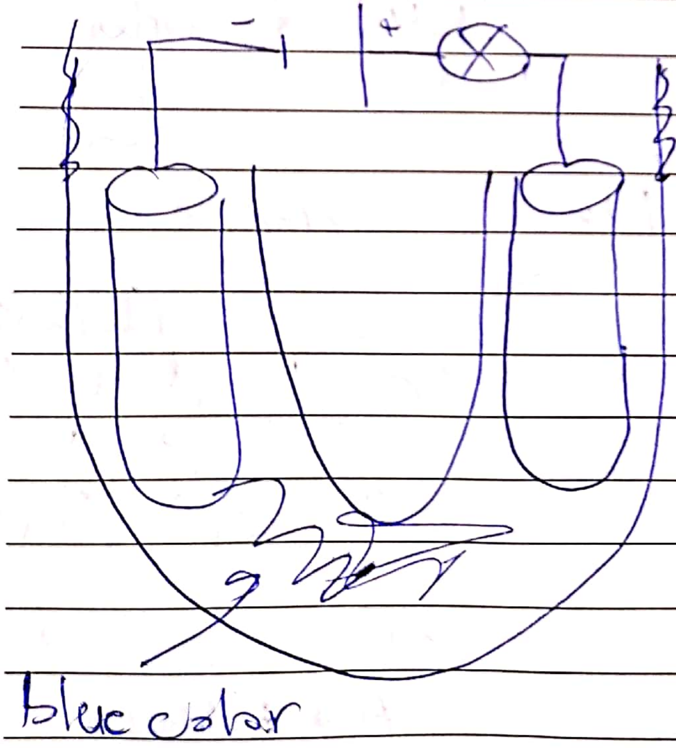
H^+ $\boxed{OH^-}$

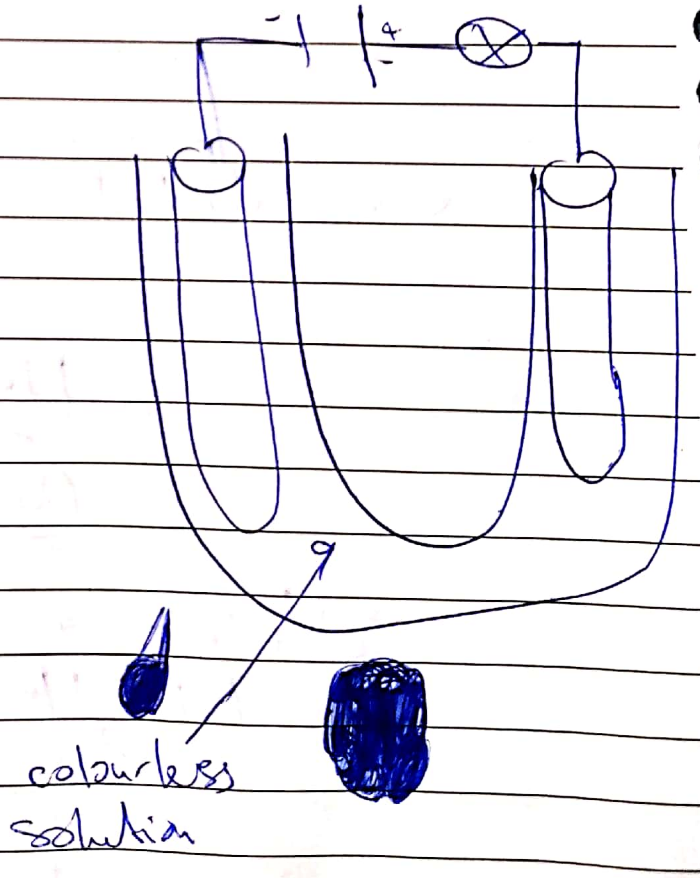
cathode

anode

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

electrolyte is not used up , H_2SO_4





dilute $NaCl_{(aq)}$ / graphite

Na^+ Cl^-

H^+ OH^-

cathode Anode

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

bubbles of colorless gas

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

bubbles of colorless gas

electrolyte: NaCl

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

conc. $KI_{(aq)}$ / graphite

KI

K^+ $\quad$ I^-

H^+ $\quad$ OH^-

cathode $\quad$ anode

$2e^- + 2H^+ \longrightarrow H_2$ $\quad$ $2I^- \longrightarrow I_2 + 2e^-$

bubbles
with colorless
gas

red brown solution

electrolyte: KOH

conc. $CuCl_{2(aq)}$ /graphite

$CuCl_2$

Cu^{+2} $\quad$ Cl^-

H^+ $\quad$ OH^-

$2e + Cu^{+2} \rightarrow Cu$ deposits of metal

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

~~electrolyte~~

Concentrated sodium chloride/brine solution

$NaCl_{(aq)}$

Na^+ $\boxed{Cl^-}$

$\boxed{H^+}$ OH^-

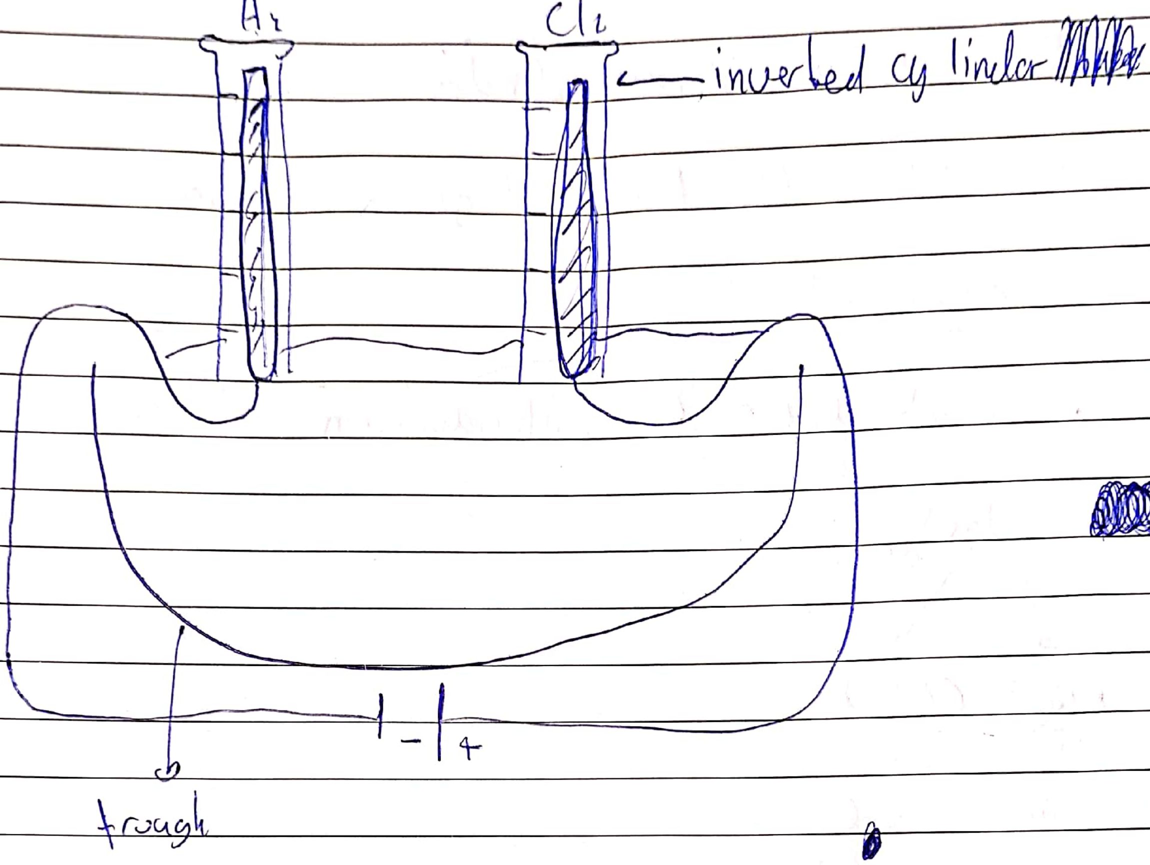
cathode anode

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

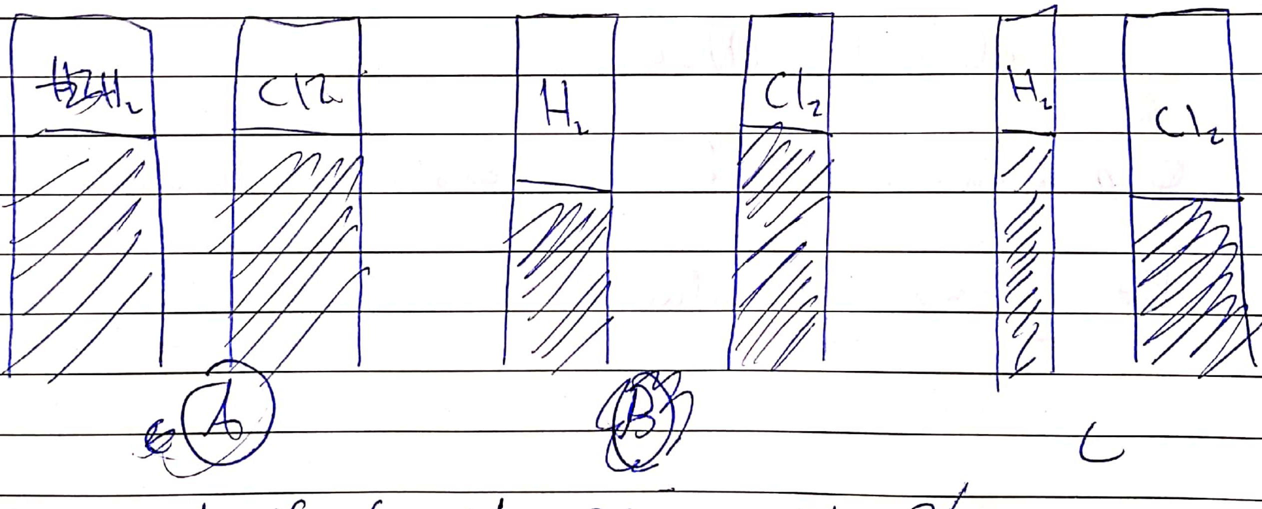
$2Cl^- \rightarrow Cl_2 + 2e$

electrolyte: NaOH

Q plan an experiment to collect and measure the volume of ~~the~~ $\underline{H_2}$ and $\underline{Cl_2}$ produced?



Q2: the final apearance of two measuring ~~cyl~~ cylinders are



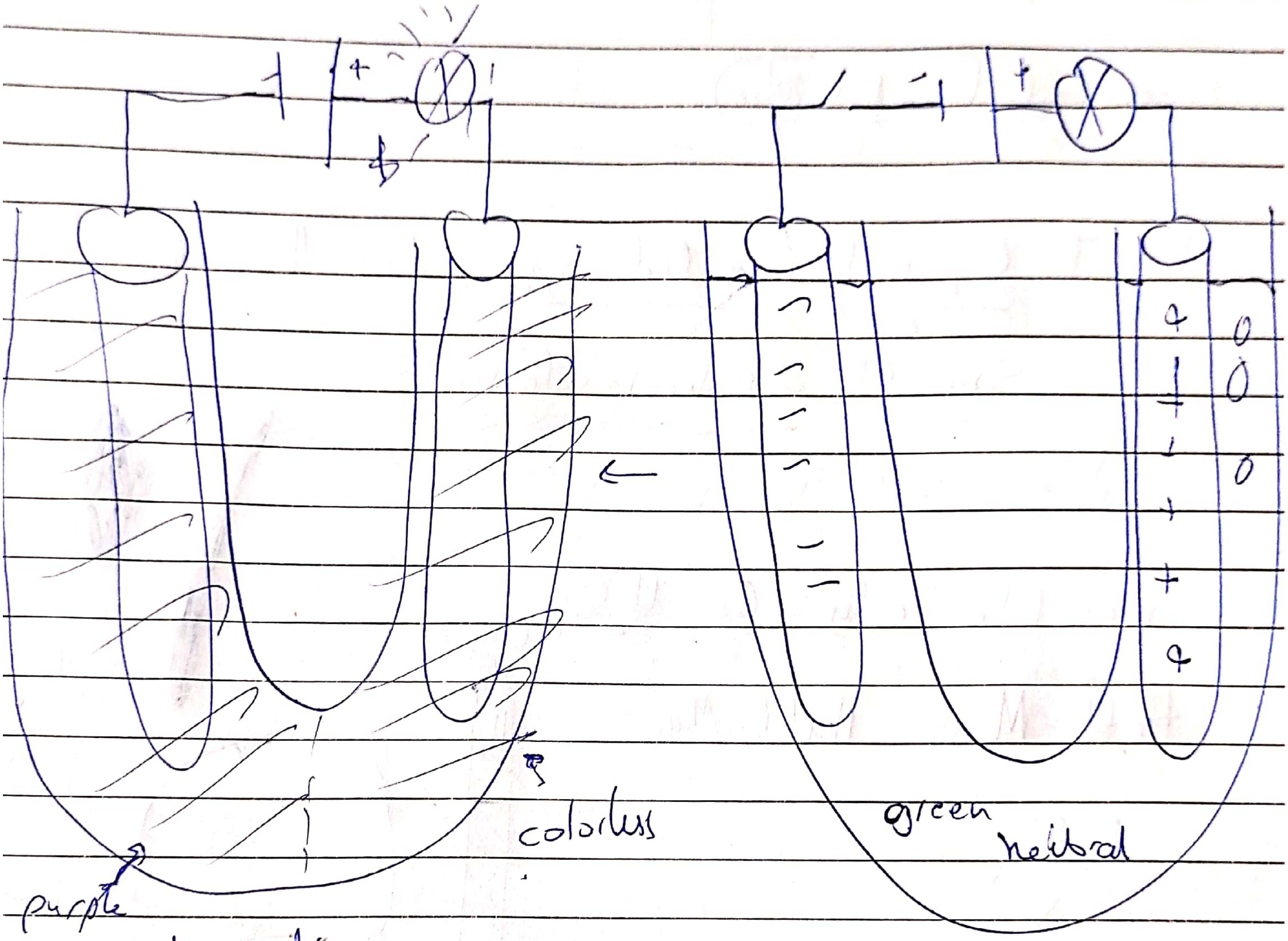
half of oxid: $2Cl \rightarrow Cl_2 + \cancel{2e}$

half of reduction: $2H^+ + \cancel{2e} \rightarrow H_2$

$2Cl + 2H \rightarrow Cl_2 + H_2$

1 : 1

Q3 :- brine with universal indicator



observation:

1- bulb ~~lights~~ lights up 

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

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

4 - around the cathode the solution become purple because NaOH is an alkali

8- 5- around the anode the solution become colorless

since Cl_2 bleach the color

The Cl_2 not immediately appear as H_2 produced?

Some Cl_2 dissolve in solution /electrolyte

Exta Electrolysis for H_2SO_4 (aq)

~~Half-Man~~. Huff-Man

H_2SO_4

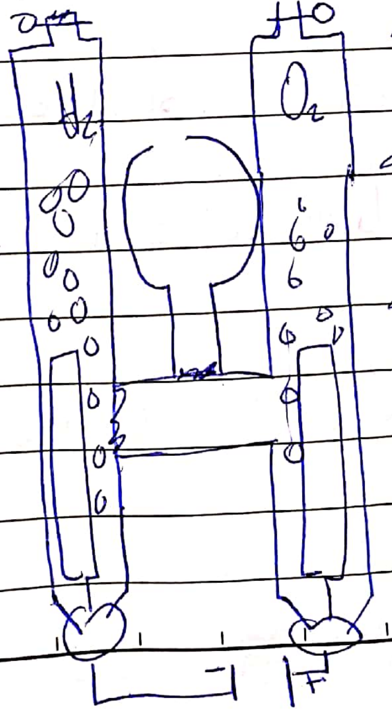
H^+ SO_4^{-2}

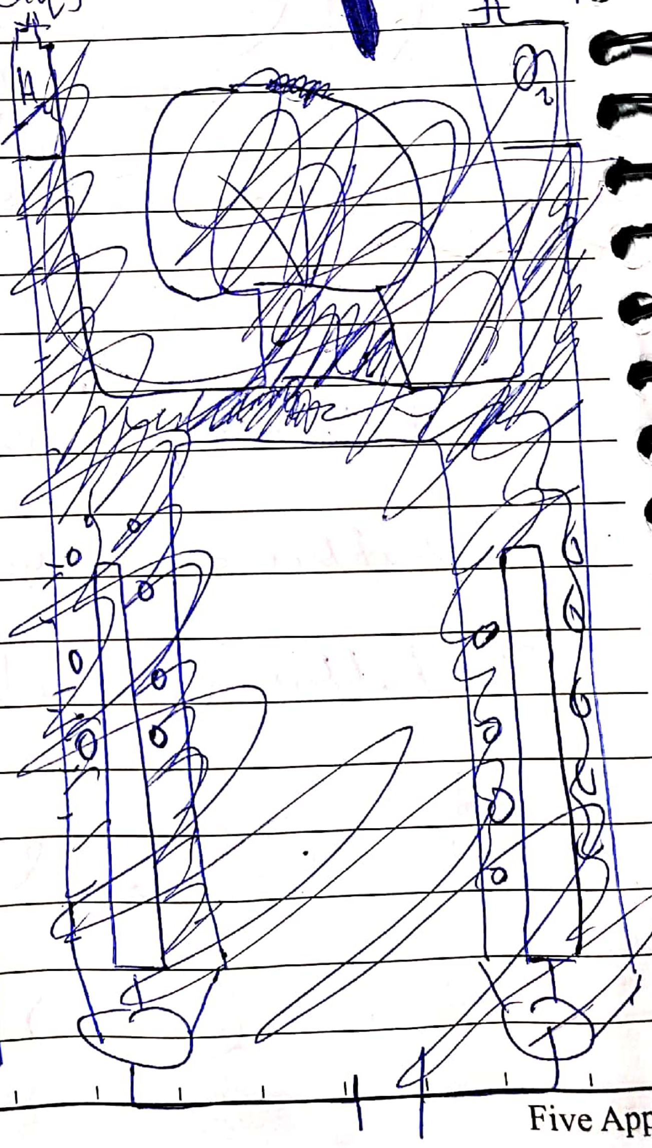
H^+ OH^-

H_2

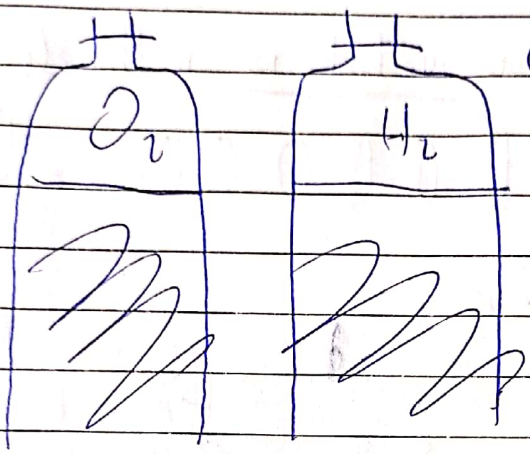
cathode   anode

H_2 O_2





Q2: the final appearance of two measuring cylinder are



A

$(\cancel{2e} + 4H^+ \longrightarrow 2H_2) \times 2$

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

$\cancel{4}$

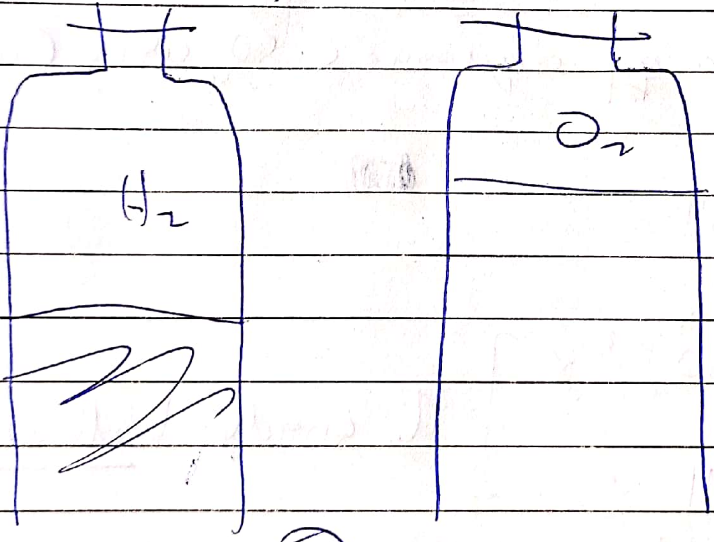
$4H^+ + 4OH^- \longrightarrow 2H_2O + 2H^+ + O_2$

2 : 1

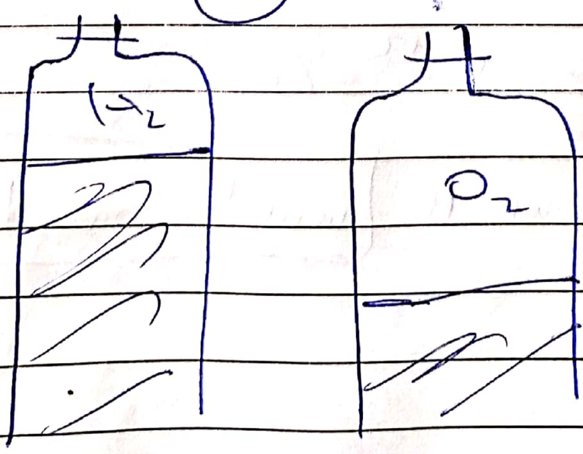
~~$2e^- + 2H^+ \longrightarrow H_2$~~

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

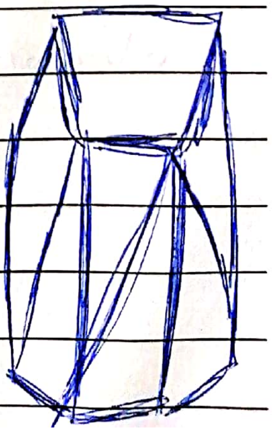
~~$2H^+ + 4OH^- \longrightarrow H_2 +$ [illegible]~~



ⓑ



C



cathode gain mass.

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

~~cathode~~ ~~anode~~

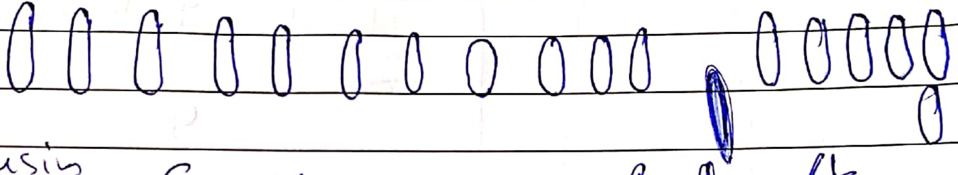
electrons move from [illegible] to [illegible]

anode cathode

~~Eat~~ Electrolysis for aqeous electrolyte using active rod

* The rod must be the same metal ion in the electrolyte

electrolyte



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

Pt Pt Pt

Pt Pt Pt Pt Pt Pt Pt

Pt Pt Pt Pt Pt Pt Pt

Pt Pt Pt Pt Pt Pt

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

electrolyte for ~~aq~~ aquosus $CuSO_4$ using Cu rod

$CuSO_4$

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

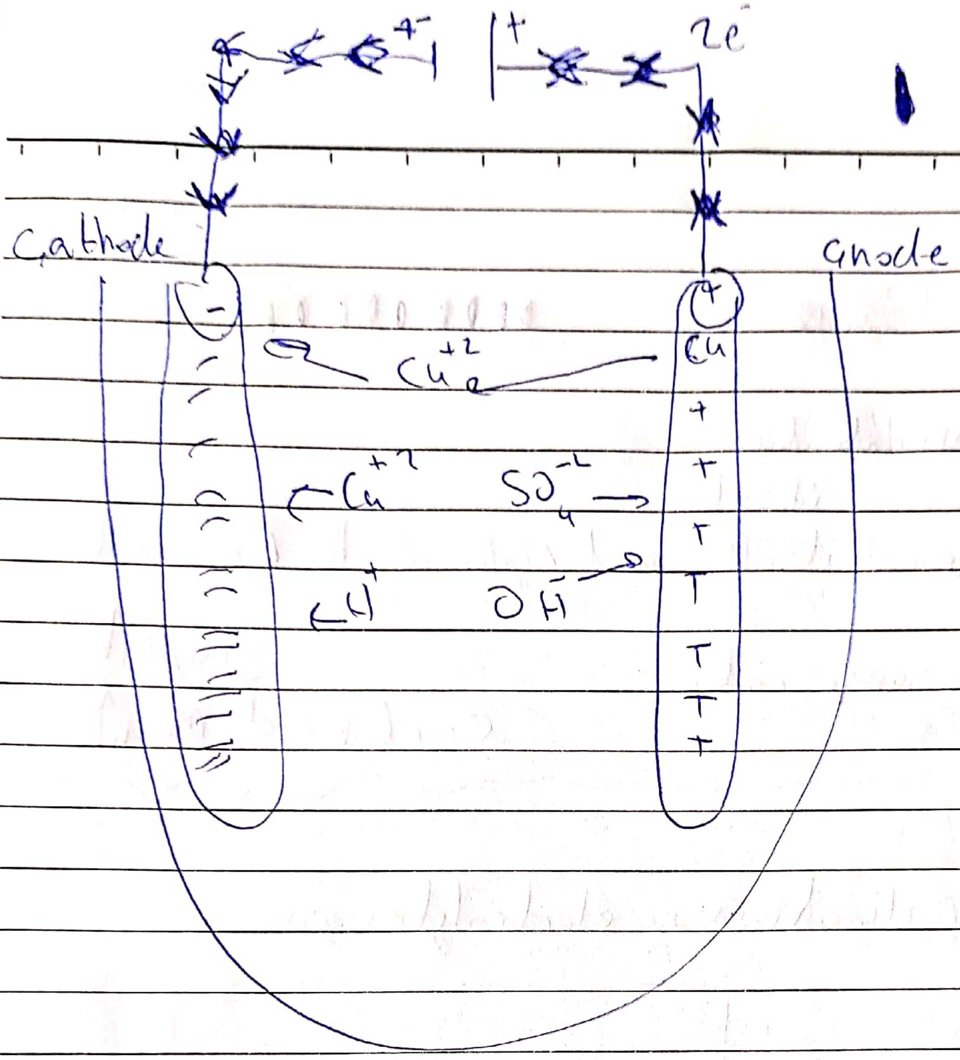
H^+ OH^- x

the anode itself oxidise

cathode Anode

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

electrolyte only allows the ions to pass through



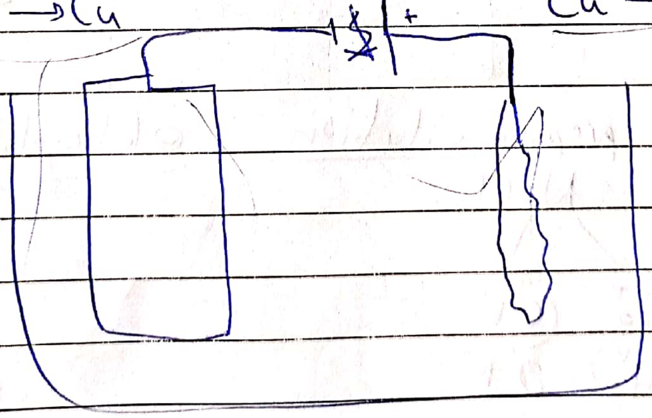
Cathode

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

Anode

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

→



↑ cathode
mass
Cu deposite

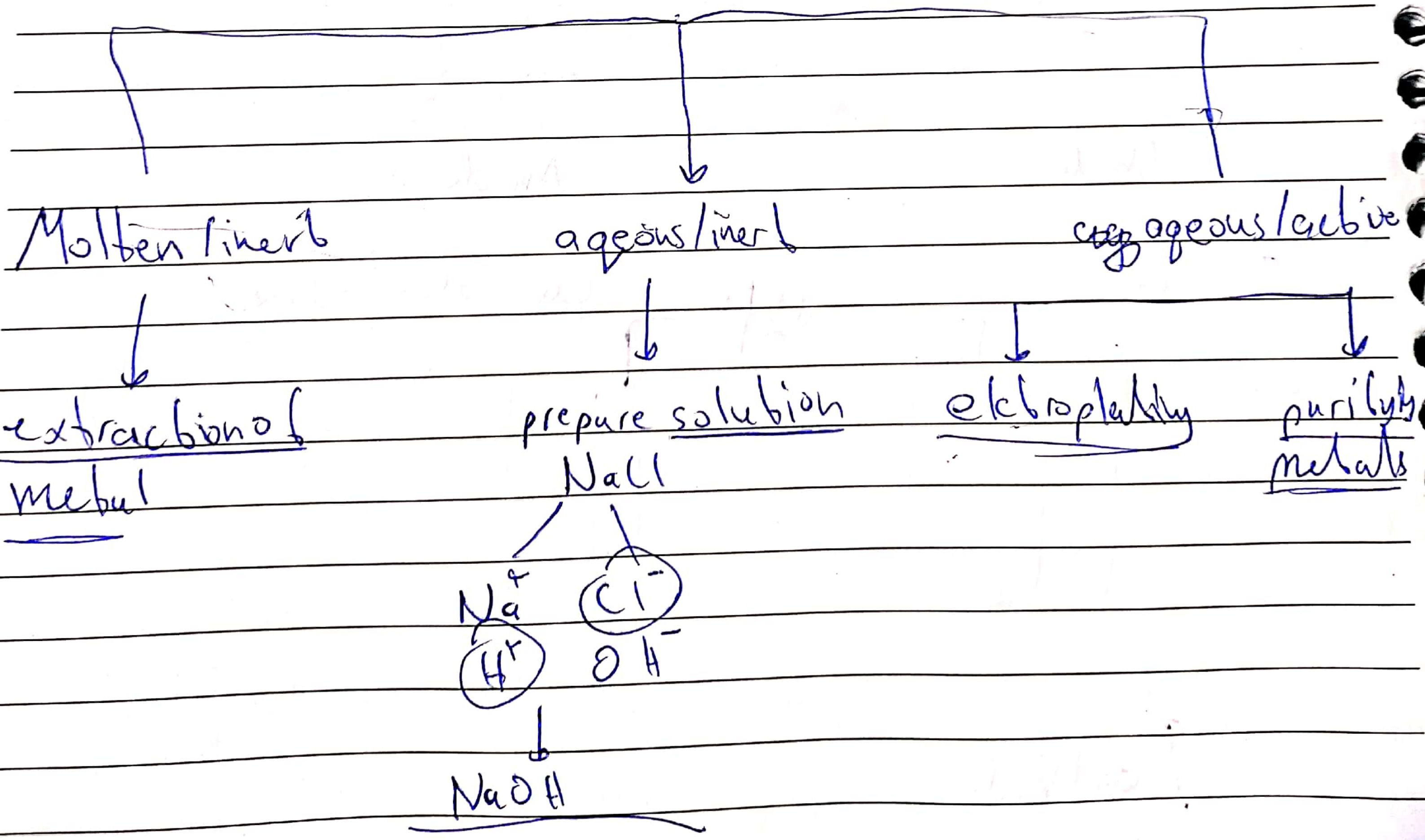
Anode
↓ mass
oxidised by lose
e^-

Electrolyte ~~stays the same~~

- stays the same concentration
- the anode oxidised itself ~~itself~~ and replaced the Cu^{+2} in the electrolyte with the same rate

graphite
carbon rods meant

Applications on electrol~~ytes~~ysis



conc. $KI_{(aq)}$ / graphite

KI

K^+ I^-

H^+ OH^-

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

Bubbles of colourless gas

~~purple gas Bubbles~~ red-brown solution

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

H_2SO_4

H^+ SO_4^{-2}

H^+ OH^-

~~cathode~~
cathode

Anode

$(\cancel{4H^+}\ 2H^+ + 2e \rightarrow H_2) 2$ $\quad 4OH^- \rightarrow 2H_2O + O_2 + 4e$

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

$O_2 : 2H_2$
1 : 2

Electroplating:

coating a metal with another metal using electrolysis

why? 1) to prevent rusting

2) more attractive

8 marks
6

How to electroplate a metal spoon with silver?

1) clean the spoon from any impurities ~~or~~ oxide layer
why was
using sand paper. (to ensure a good sticking)

2) make the spoon the cathode (-ve)

3) Anode must be Ag

4) the electrolyte must contain Ag^+ e.g $AgNO_3$

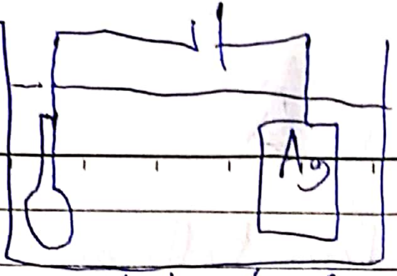
5) turn on the circuit "be sure that the spoon is fully immersed in the electrolyte"

6) rotate the spoon to ensure an equal distribution

7) rinse with distileed water

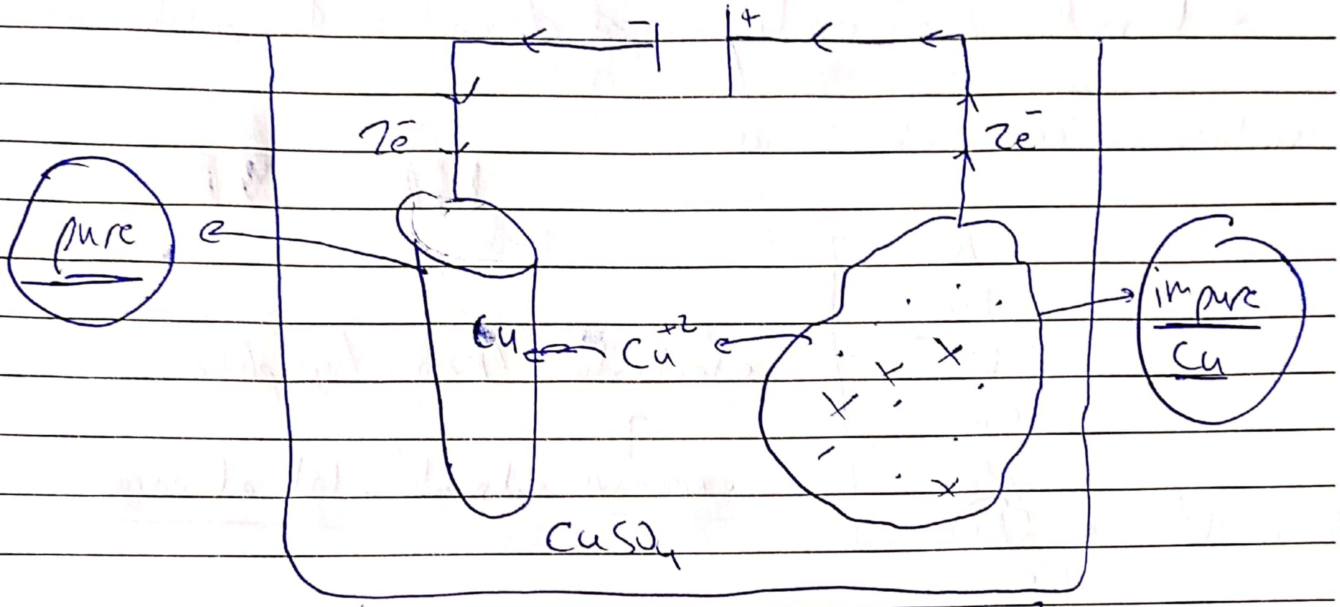
8) dry in oven

Ag Ag Ag Ag Ag Ag Ag Ag Ag Ag Ag Ag



cathode is pure
anode is impure

② purifying metals / refining copper

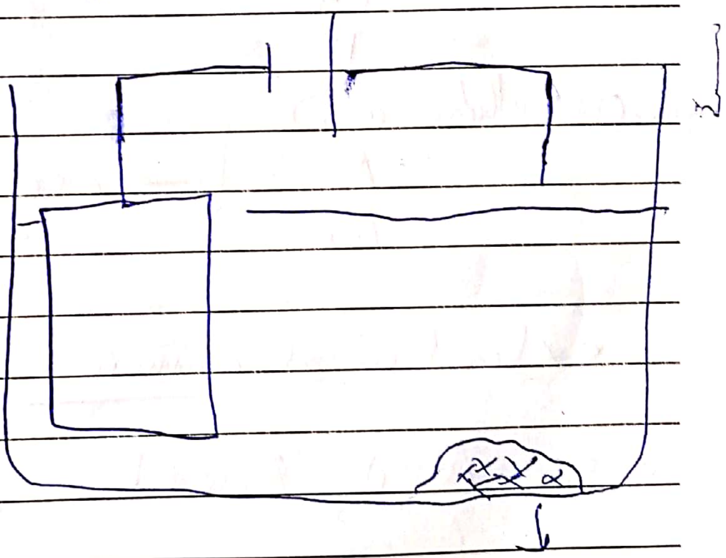


$Cu^{+2} + 2e^- \rightarrow Cu$

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

Cu
+ impurities

Ag, Au
Zn



impurities
Au, Ag
settle down (
less reactive)

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

Five Apple

Zn dissolves in solution

Extraction of metals from their ores

* method of extraction ~~of~~ depends on the position of metals in reactivity series

K
Na
Li
Ca
Mg
Bauxite Al_2O_3 ← Al
→ electrolysis / molten / graphite
↑
expensive and needs a lots of energy

C, CO

Zinc blende ZnS ← Zn
hematite Fe_2O_3 ← Fe
Pb
H
→ reduction by C, CO

silver
copper / Ag_2S can be reduced by carbon but carbon is more expensive that hydrogen

copper(II) sulfate ← Cu
Ag
Au
→ reduction by H_2

extraction of aluminium

ore :- Al_2O_3 Bauxite

method: electrolysis for molten Al_2O_3 / graphite carbon rods

* m.p of Al_2O_3 is about 2000°C

so we dissolve Al_2O_3 in a molten cryolite only for Al

add Na_3AlF_6

→ To lower the m.p to $\boxed{900°C}$ ~~cost~~ so less cost

→ to increase the electrical conductivity

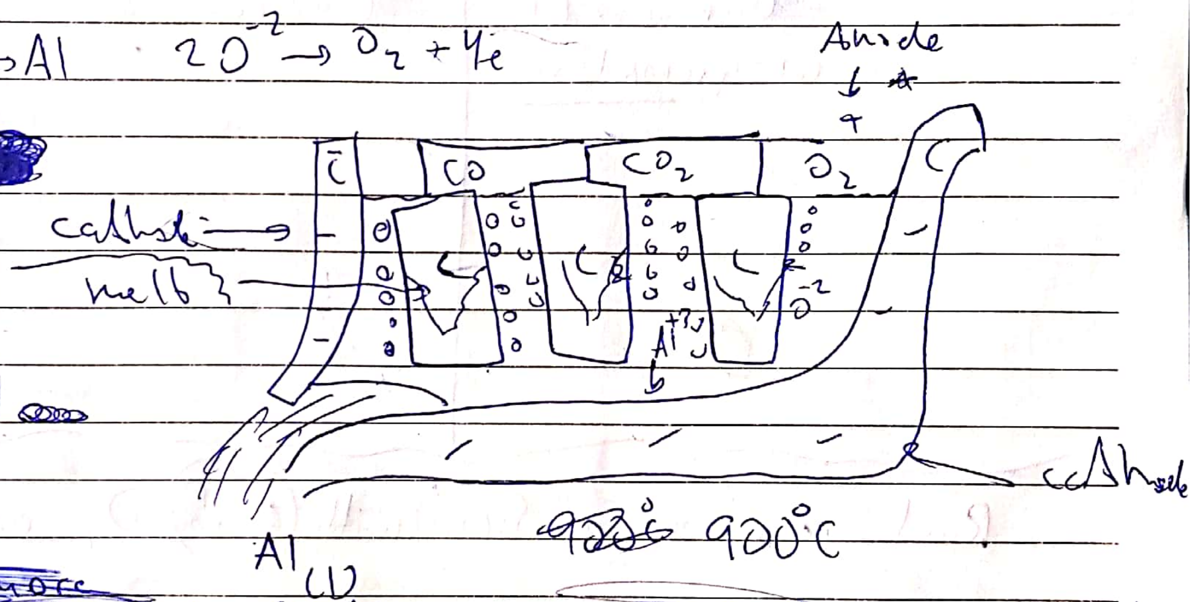
→ reduce cost

$$Al_2O_{3(l)}$$

Al^{+3} Cathode

O^{-2} Anode

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



~~Al is more dense than the solution so it falls first to be collected~~

~~gases produced at cathode~~

Al is more dense then the solution so its more likely to falls first to be collected

gases produced at anode

1- O_2

2- CO_2

3- CO

] → reaction with carbon rods with O_2

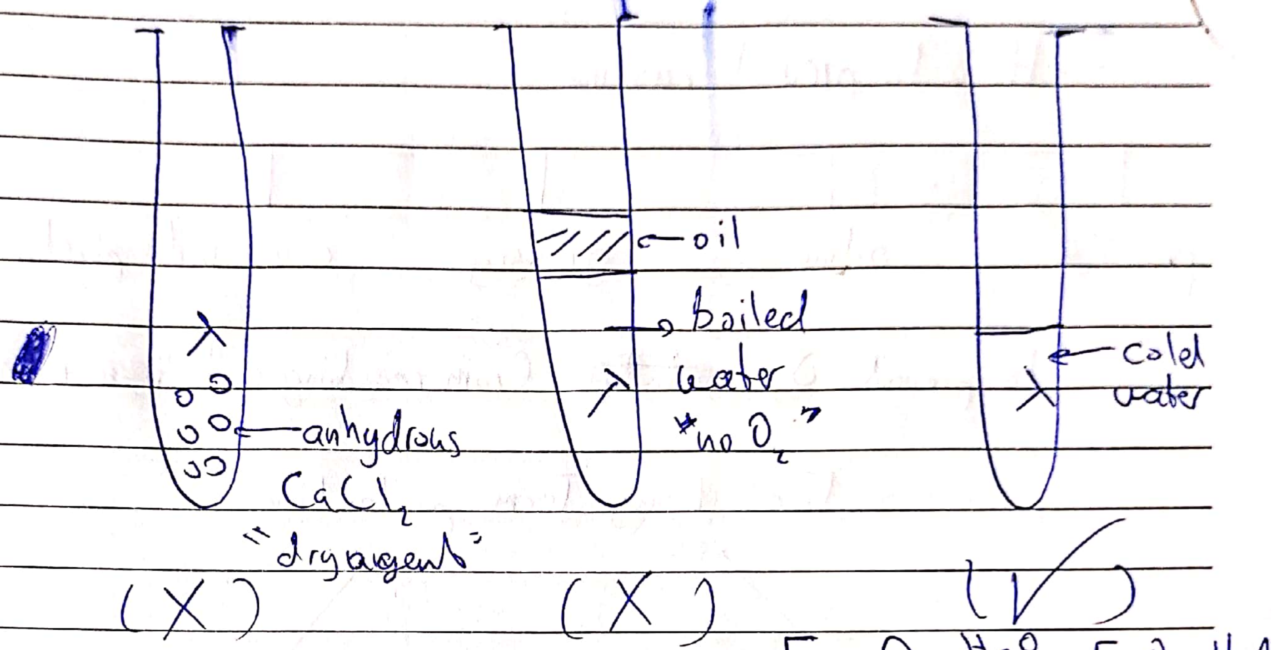
so we must replace them periodically

Aluminum properties

property	use
- low density	- Aircraft bodies
- ductile	- electrical wires
- malleable	- window frames, cooking utensils
- conducts electricity	- wires
- form an oxide layer which is not toxic	- food cans

Rust: reaction of iron with both O_2 and H_2O

Slow reaction → 6 - 7 days



$Fe + O_2 \xrightarrow{H_2O} F_2O_3 \cdot nH_2O$

plan an experiment to show ~~with~~ which rust prevention solution is better

→ Take an known mass of Iron nail; apply a known volume of the first solution

→ put them in a known volume of water for one week

→ dry them and measure them again

→ $\boxed{\text{repeat}}$ the experiment with the 2nd solution

conclusion: the experiment which cause more increase in mass worse solution

How to prevent rusting

painting

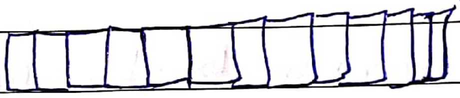
oiling

greasing

cover with plastic

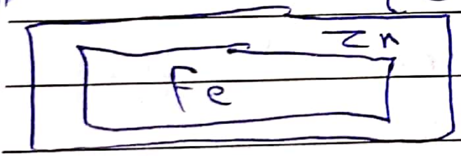
"to prevent O_2 ~~[illegible]~~ from reacting with ~~[illegible]~~ iron"

For Long Term protection



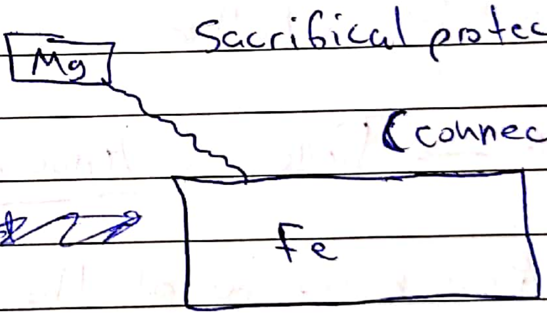
used in ships ↓

Galvanizing (coating)



Sacrificial protection (connecting)

~~used~~



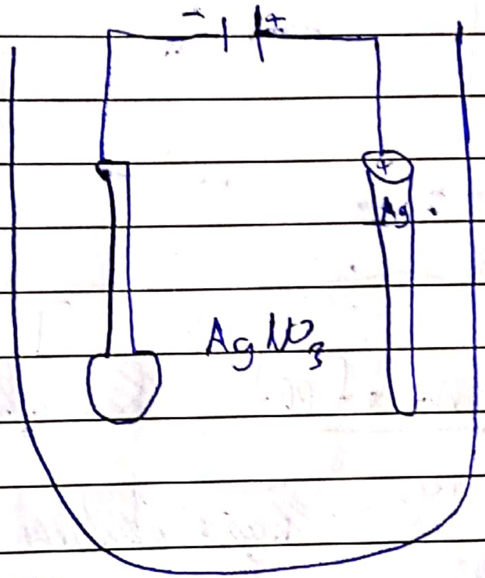
Zn and Mg are more reactive than Fe ~~more~~ so more likely to lose e^-'s so Fe is less likely to ~~rust~~ oxidis

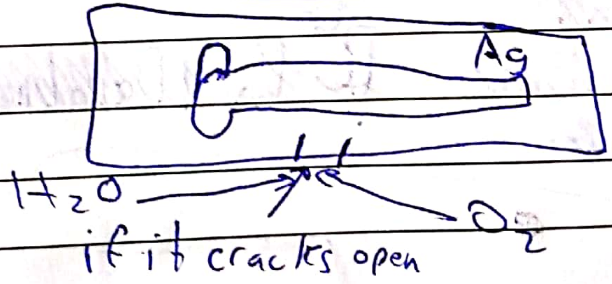
so less likely to rust

For long term protection

why use these 2 methods?
Ti - highly unreactive
- conducts electricity

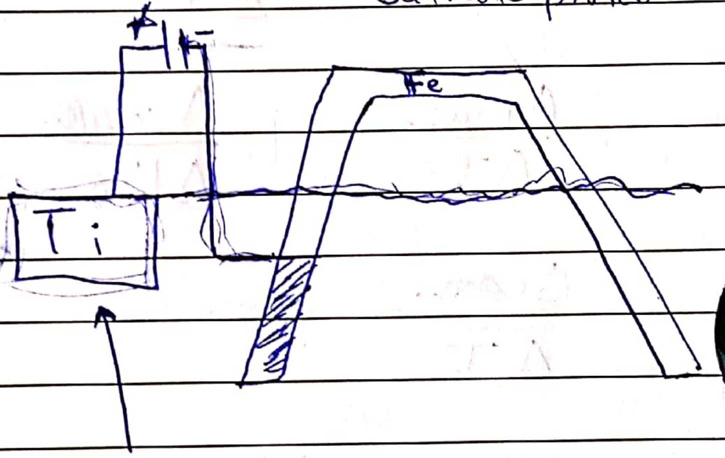
electroplating





if it cracks open

cathode
cathodic protection



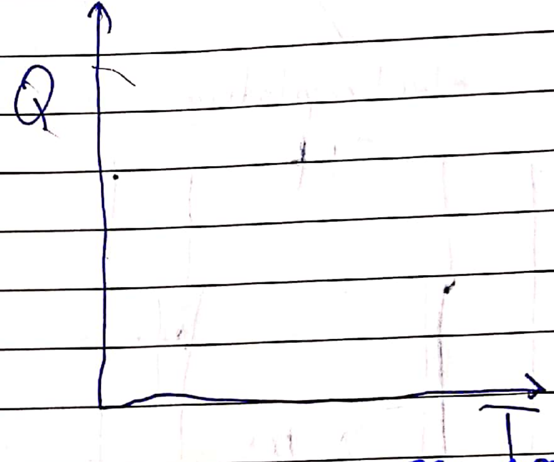
highly unreactive

high

Rate of reaction

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

$$Rate = \frac{\Delta Q}{\Delta T}$$



$$\frac{\Delta Mass}{\Delta T} \qquad \frac{\Delta volume}{\Delta time}$$

$$\frac{\Delta conc.}{\Delta T}$$

$$\frac{\Delta \text{height of ppt}}{\Delta time}$$

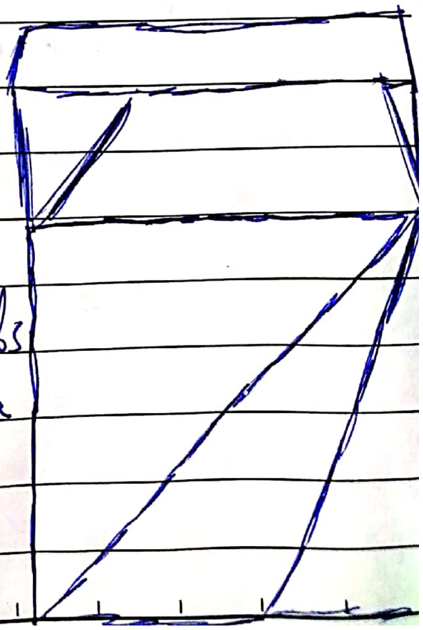
$$\frac{\Delta pH}{\Delta T} \qquad \frac{\Delta temp.}{\Delta time}$$

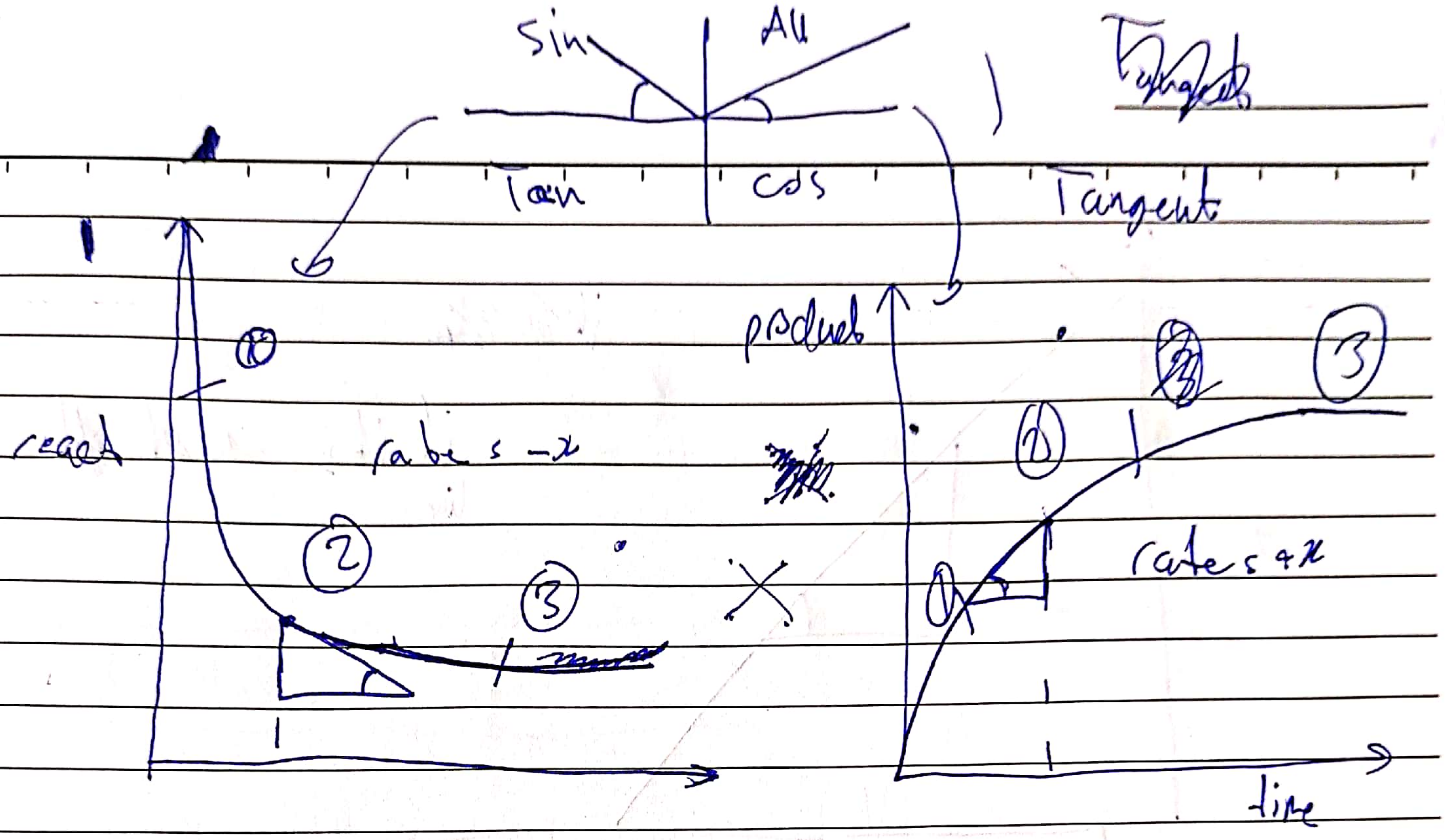
$$\frac{\Delta \text{Light intensity}}{\Delta time}$$

Measuring 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

At ~~the~~ More amount of reactants a more particles

so more effective collisions per unit time

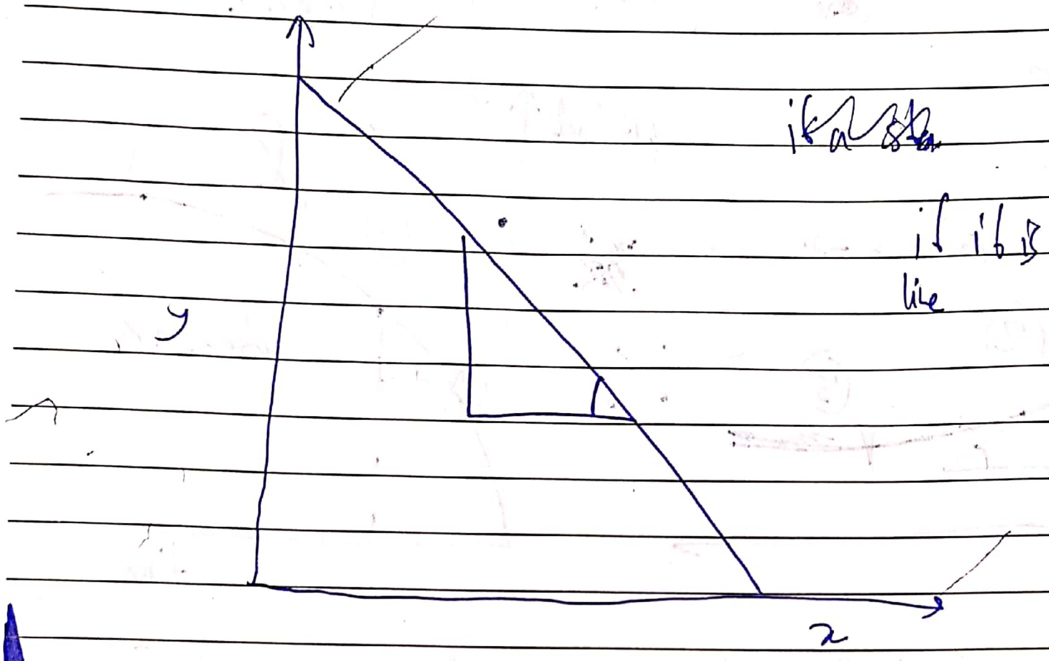
region 2: Slower rate → from the graph: less steep

less number of particles so less number of effective

collisions per unit time

Region 3: reaction is over → gradient = zero (horizontal line)

No more limiting factor so no more effective collisions

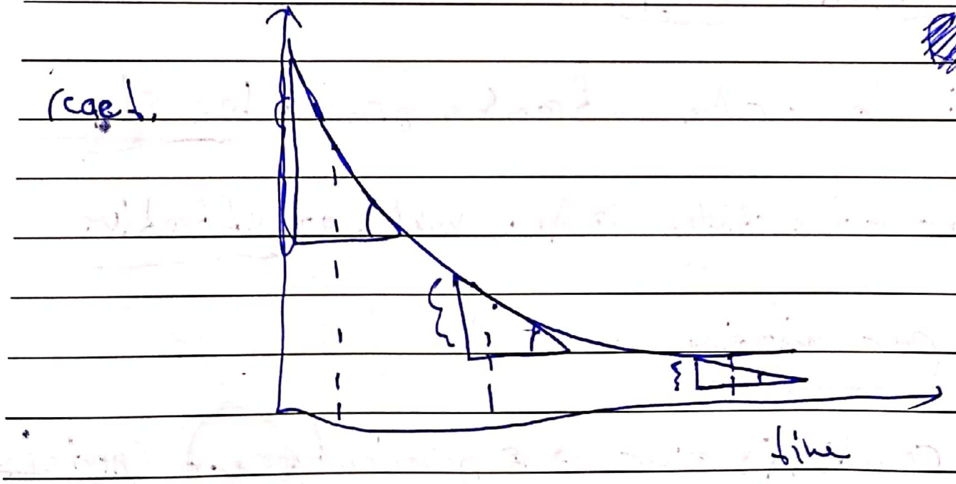


if a str

if it is a straight line

gradient = $\frac{\Delta y}{\Delta x}$

Tan θ

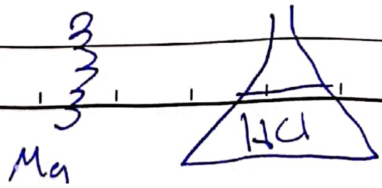


For any chemical reaction there 3 main conditions

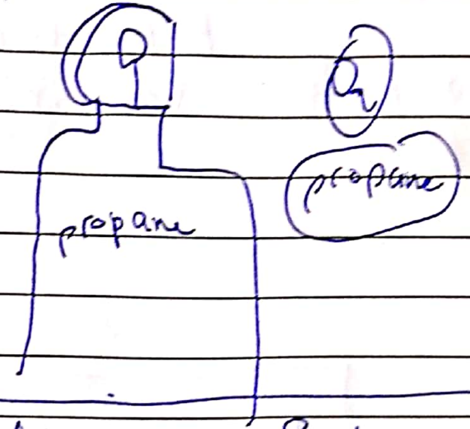
① The reactants must be suitable

Cu + HCl → no reaction

② the reactants must collide



②



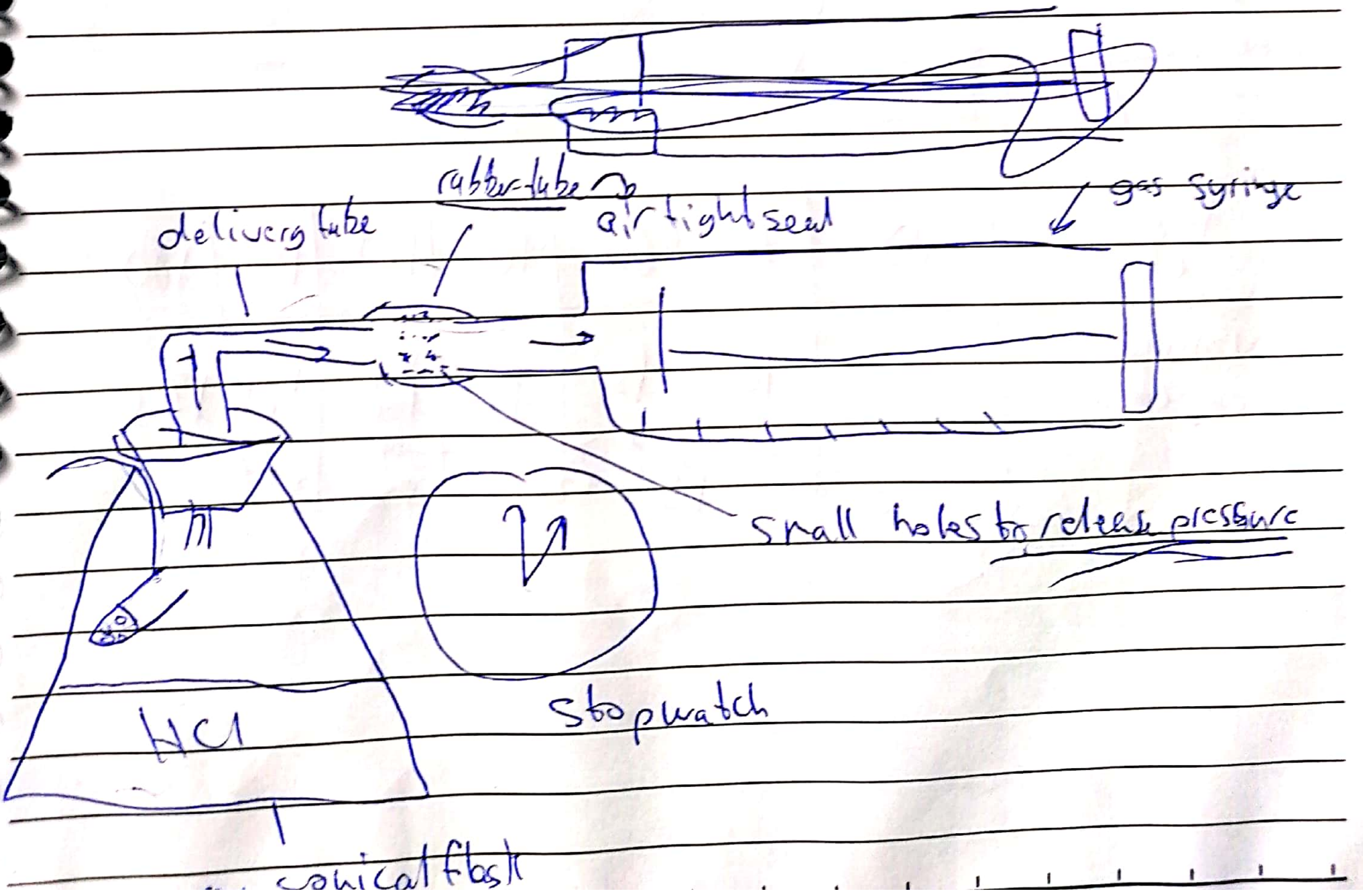
the collisions must be effective / minimum amount of energy to start should Ea

Measuring Rate of reaction

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

① measuring of gas per unit time

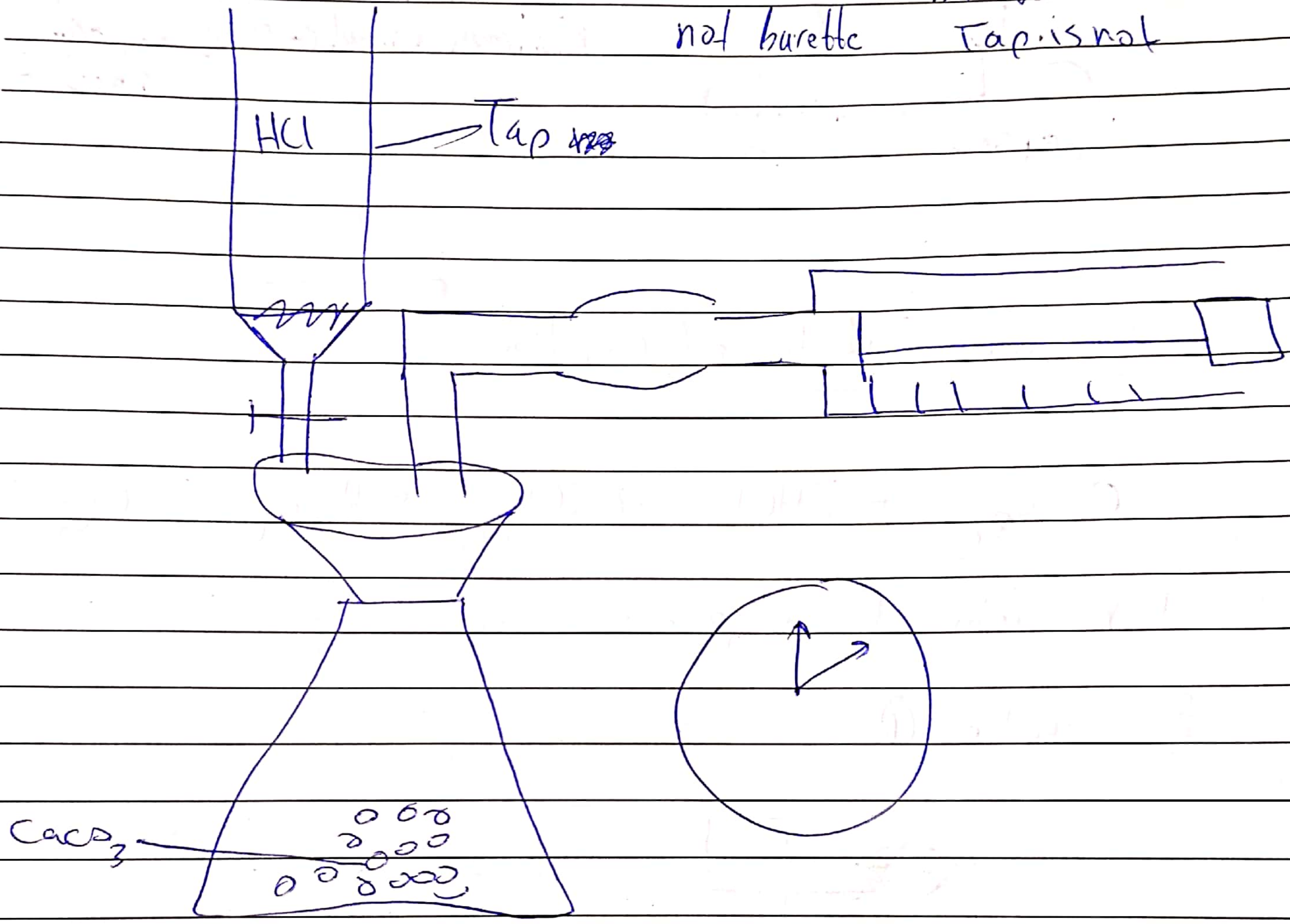
② method ①



method 2

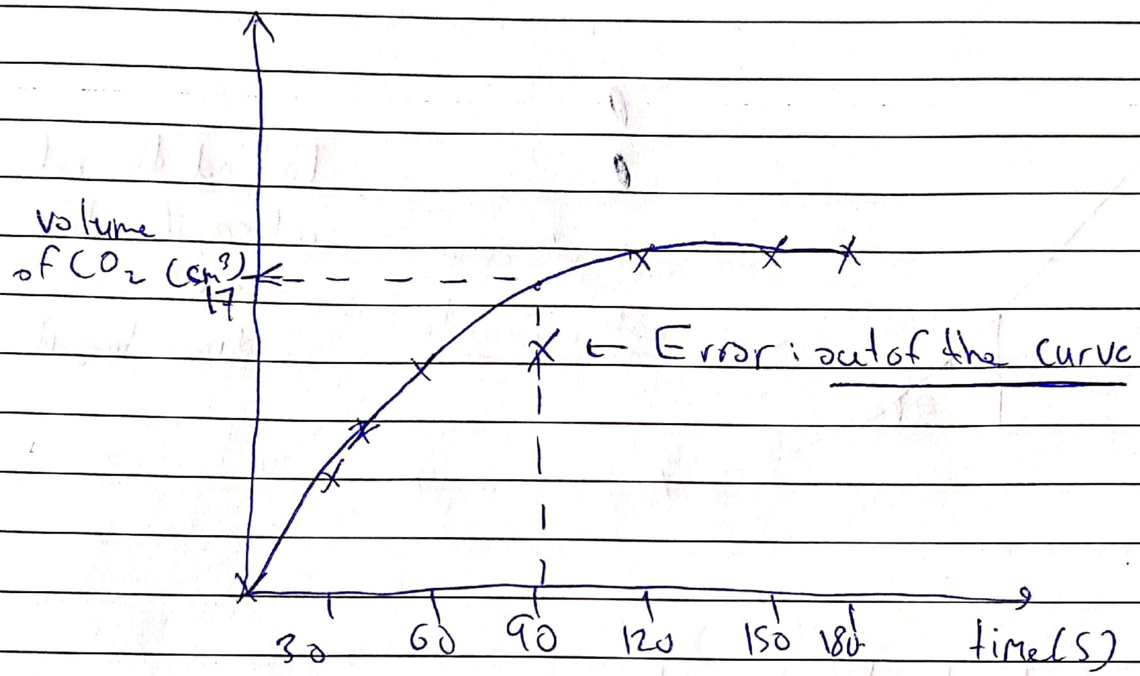
burrete is cascaled

not burette   Tap is not

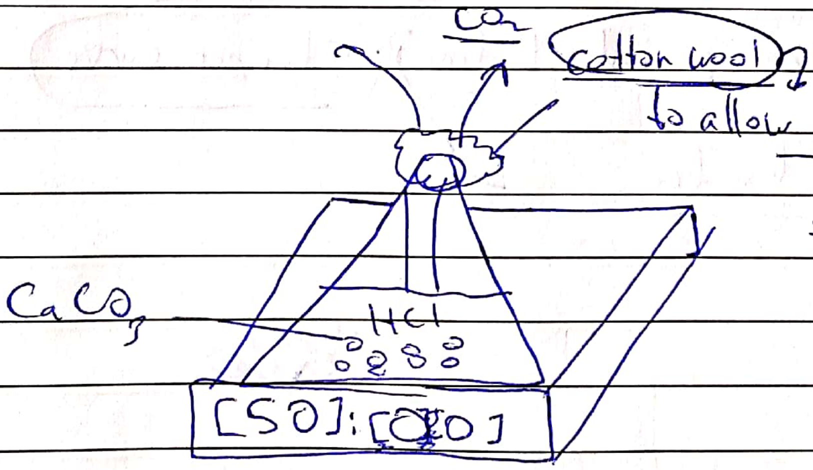


time (s)	0	30	60	90	120	150	180
volume of CO_2 cm^3	0	10	15	17	17.5	17.5	17.5

104   k5+   42   0.5



② Measure the mass of conical flask + Content per unit time



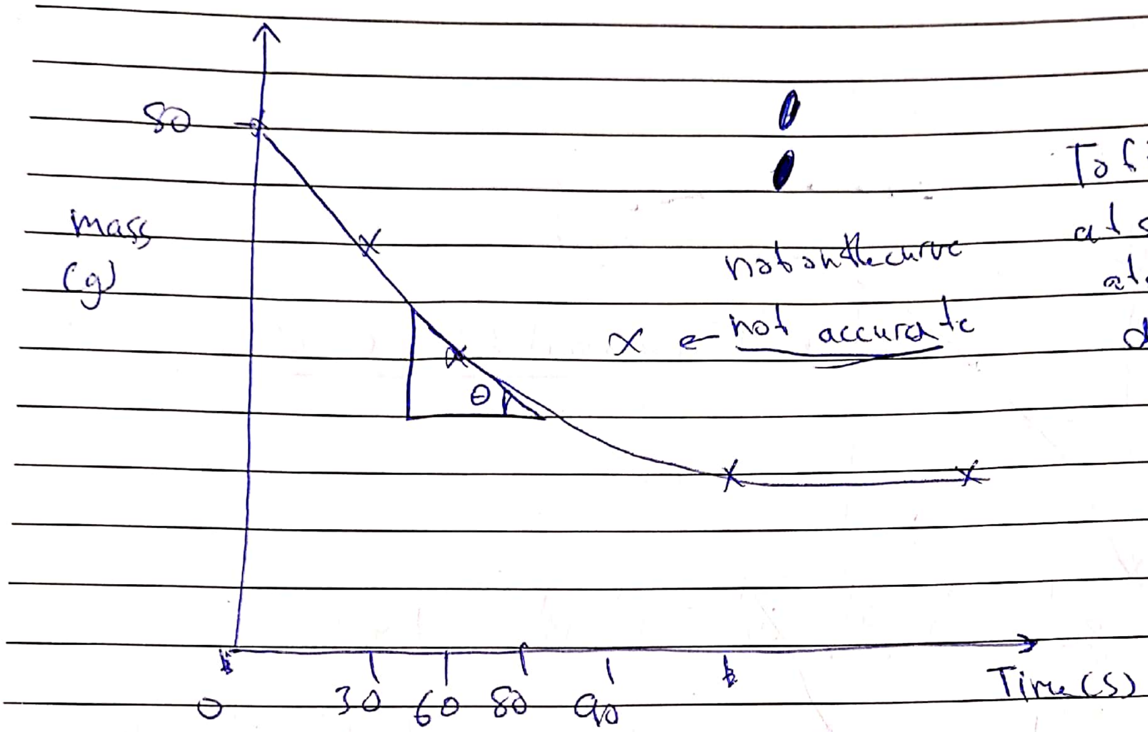
to allow CO_2 to escape and prevent splashing

* the mass decrease because CO_2 escape

over ↓

time (s)	0	30	60	90	120	150	180
mass(g)	~~55.5~~ 50	40	35	33	32.5	32.5	32.5

-10 -5 -2 -0.5

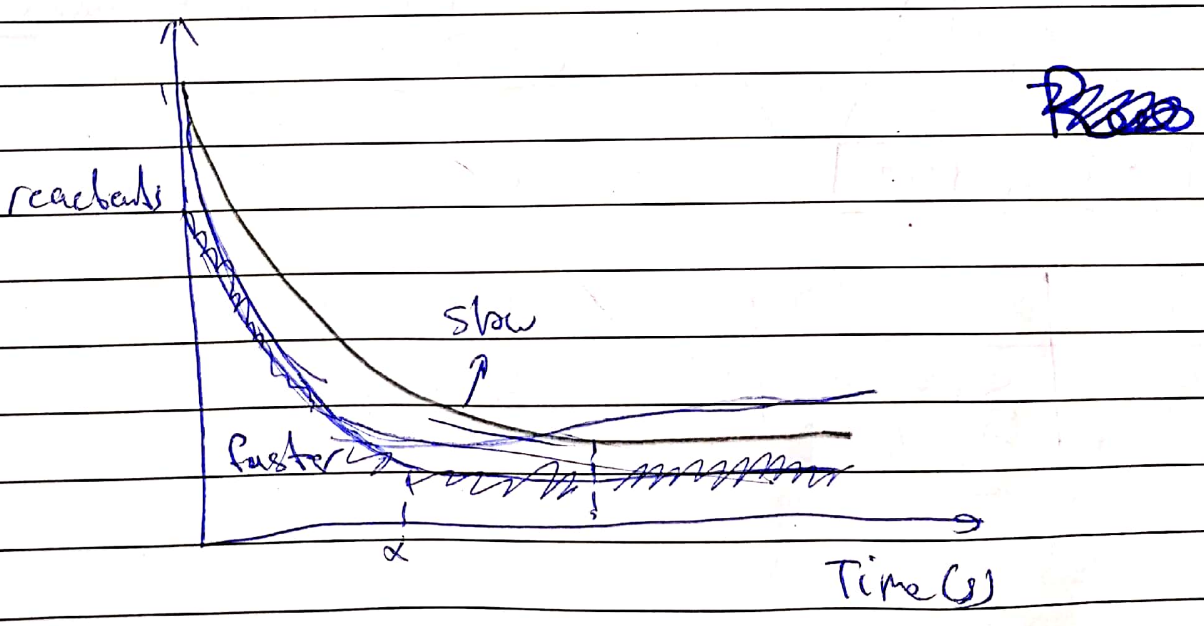


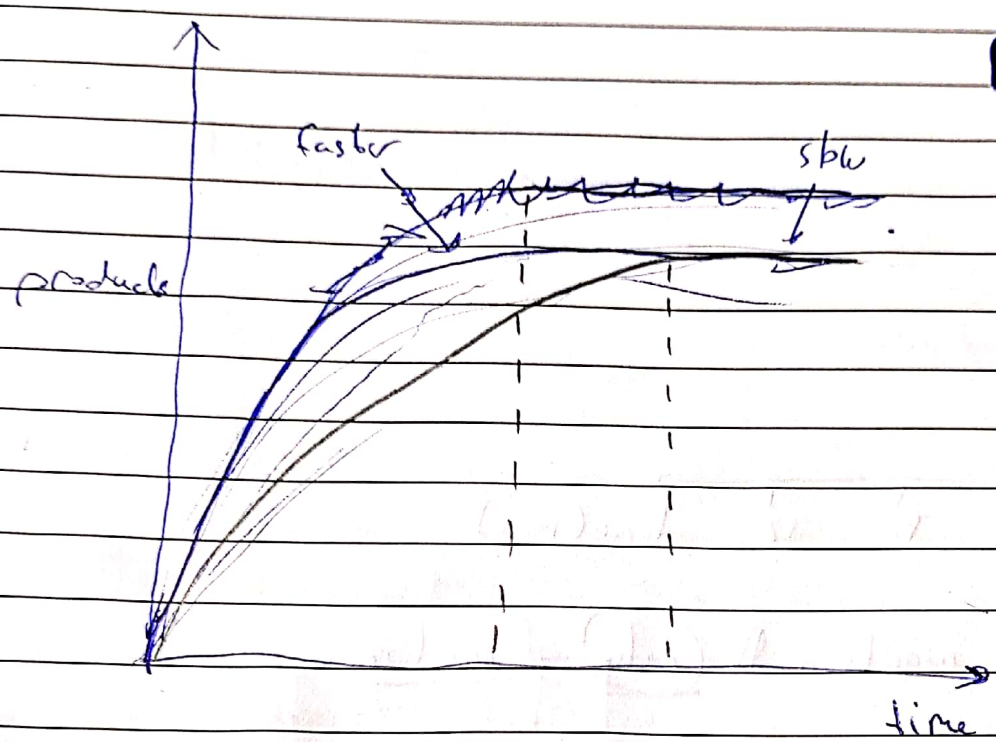
To find the rate at specific time at 60 s draw tangent

Increasing the rate of reaction

More product per ~~same~~ same period of time } steeper curve

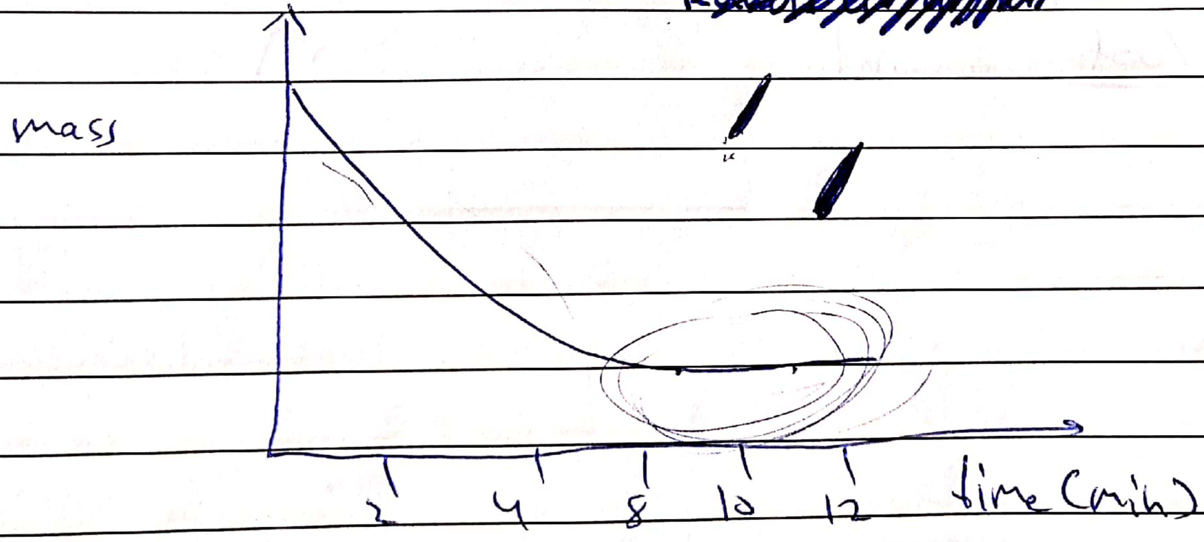
or Same product per less time



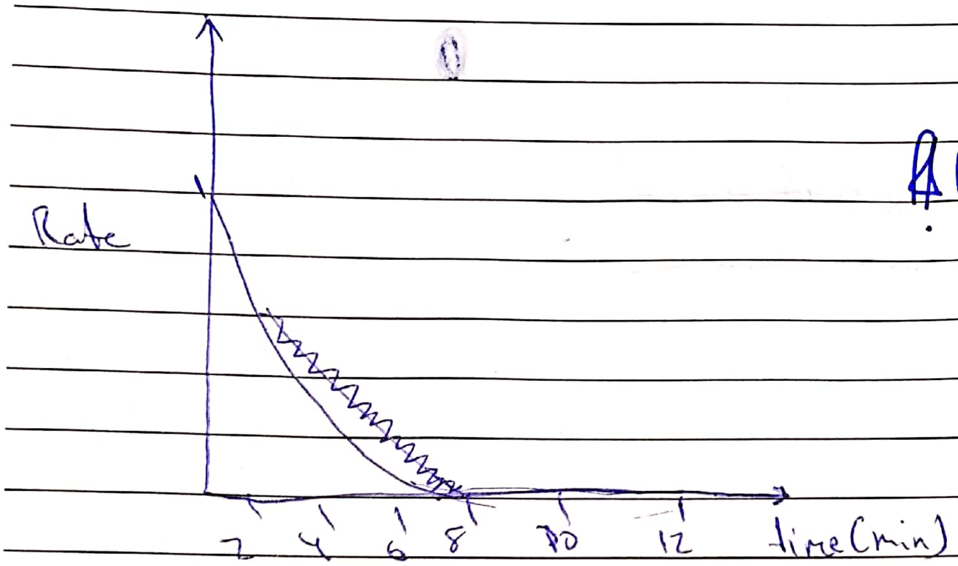


Q. the graph below shows how the the amounts of reactants changes with time

[redacted]



Draw rate vs time graph for this reaction



Factors affect of ~~reaction~~ the rate of reaction

① Temp

② Surface area

③ concentration/~~[illegible]~~ amount

④ pressure

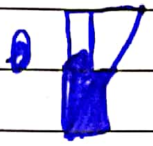
⑤ light intensity

⑥ catalyst

① Temprerature

* state how the temps affect the rate of reaction (1pt)

As the temprature increases the rate of reaction of reaction increase



* ~~explain~~ how the temp affect the rate of reaction (5pts)

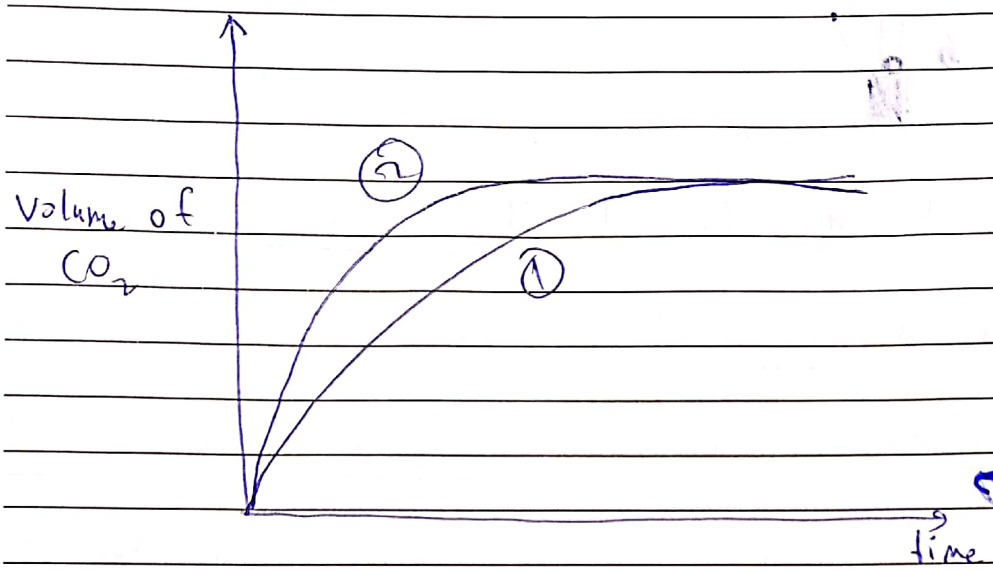
→ As the temprature increases → the particles gain Kinetic energy so move faster. → the particles will have energy equel · to or greater ~~tan~~ than the Ea . → So more effective collisions per unit time. → so faster rate of reaction

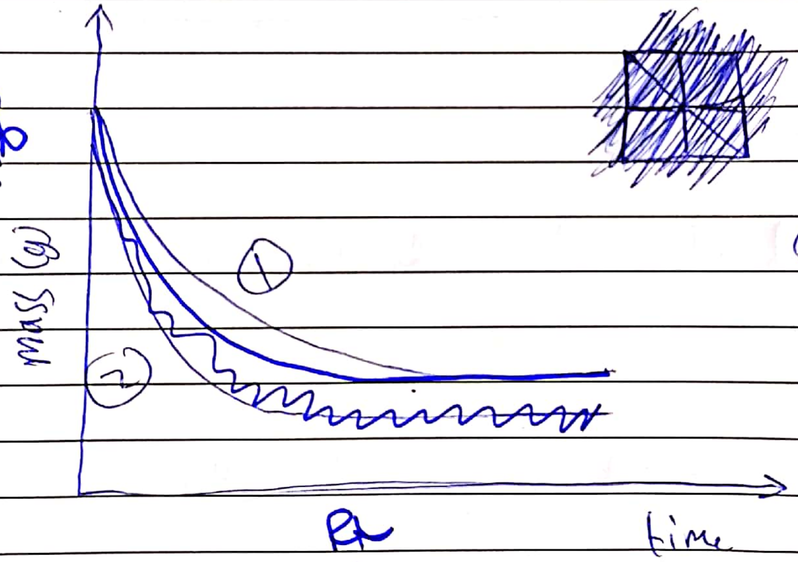
* Plan an exp. to show how the temp affect the rate of reaction (6pts)

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

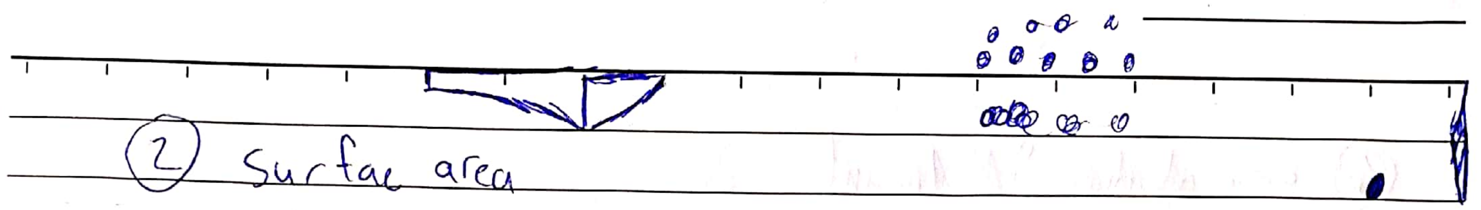
exp 1 mass = 2.0g V HCl = 0.1 dm³
M HCl = 1 mol/dm³
lumps Temp = 25°C

exp 2 mass = 2g V HCl = 0.1 dm³
M HCl = 1 mol/dm³
lumps Temp = 50°C





take a known mass of lumps $CaCO_3$ add them to known volume ~~of~~ and known concentration of HCl at 25°C. Measure the volume of ~~co~~ CO_2 produced per unit time using gas syringe. Repeat the experiment the exp at 50°C. The exp. at 50°C produce CO_2 with less time.



② Surfac area

* State how the surface area affect the rate of reaction (1pt)

~~As~~ As the surface area increases as the rate of reaction increases

* explain how surface ~~are~~ Area affect the rate of reaction (3/4 pts)

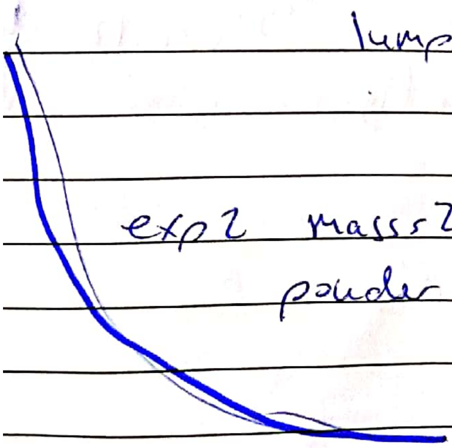
As the surface area increases. (decrease the particle size by crushing using mortar and pestile)
more particles exposed to the reaction
more effective collisions per unit time so faster rate of reaction

~~Read Read Read~~

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

exp1 Mass = 2g lumps
V HCl = 0.1 dm^3
M HCl = 1 mol/dm^3
Temp = 25

exp2 mass = 2g powder
VHCl = 0.1 dm^3
M HCl = 1 mol/dm^3
Temp = 25 °C



Same graph

③ concentration "Amount"

* state how the concentration affect the rate of reaction

As the conc. ↑ the rate of reaction ↑

* explain how the conc. affect the rate of reaction (3 pts)

As the concentration increases

→ more particles

→ so more effective collisions per unit time

→ so faster rate of reaction

plan an exp.

n = ~~0.05~~ 0.005

$CaCO_3{}_{(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{(aq)} + H_2O_{(l)} + CO_2{}_{(g)}$

V = 0.12

need 0.005 0.04 limiting

add 0.02 $\boxed{0.01}$

exp. 1 mass

$CaCO_3 = 2g$

$V = 0.1\ dm^3$

$M^{HCl}_{HCl} = 0.1\ mol/dm^3$

lumps

Temp = 25°C

Mr = 100g

exp 2 mass

$V = 0.1\ dm^3$

$CaCO_3 = 2g$

$M = 0.2\ mol/dm^3$

lumps

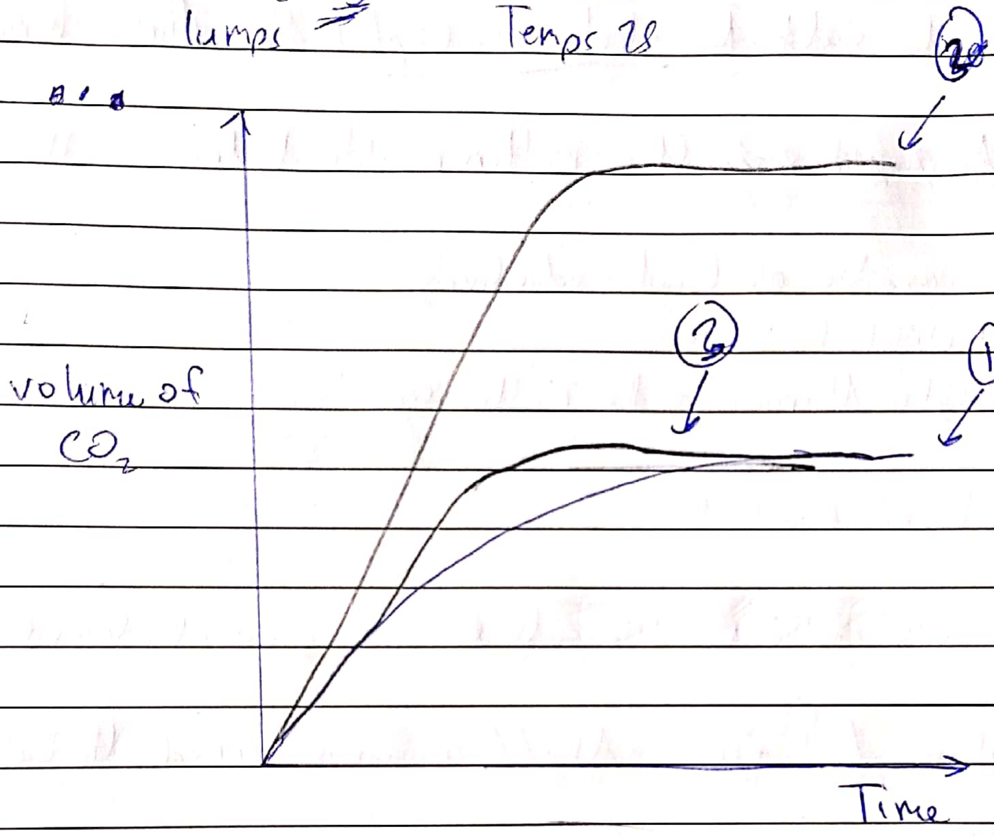
Temp = 25°C

exp 3 mass $CaCO_3 = 4g$ lumps

$V = 0.1\ dm^3$

$M = 0.1\ mol/dm^3$

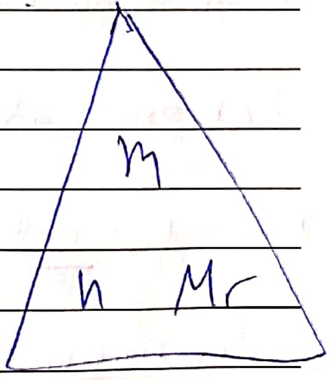
Temp = 28

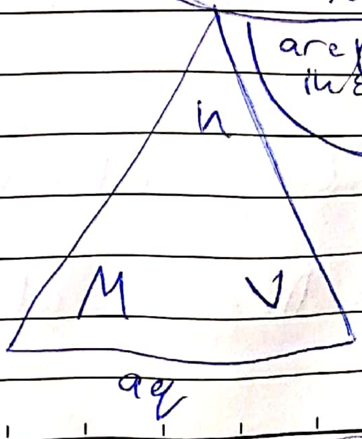


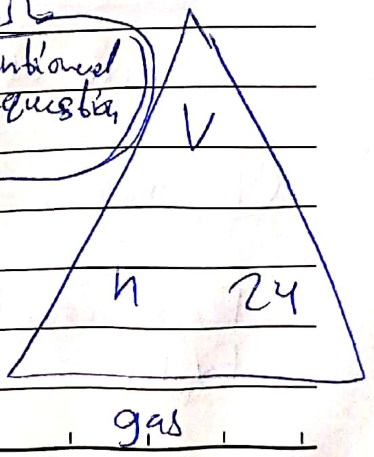
more limiting → faster rate
more product

more excess → ~~fa~~ faster rate

In ~~faster~~ rate of reaction the limiting and excess are mentioned in the question







* extraction of metals:

from it is ore / alumina
Describe the extraction of aluminium? Include the electrolyte, the electrodes and the reactions at ~~the~~ the electrodes. (6pts): ~~M~~ Markscheme:

1) ~~Aluminium oxide~~ Use molten cryolite to decrease the melting point ~~by 900°C~~ of the electrolyte to 900°C and to increase the electrical conductivity

2) dissolve the electrolyte Alumina in the molten cryolite.

3) Use ~~cost~~ graphite carbon rods

4) the aluminium ions are reduced at the cathode so it gains electrons to form aluminium atoms, $Al^{+3} + 3e^- \rightarrow Al$ / Aluminium is formed at the cathode

5) the ~~oxygen ions~~ oxide ~~are~~ is oxidised ~~at~~ at the anodes ~~to~~ so it loses electrons to form oxygen atoms, $2O^{-2} \rightarrow O_2 + 4e^-$ / oxygen is formed at the anode

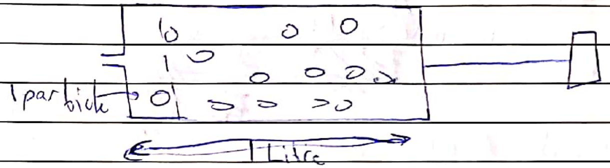
6) anodes melt so carbon reacts with oxygen to ~~form~~ produce carbon dioxide and carbon monoxide. / $C + O_2 \rightarrow CO_2$

Rate of reaction:

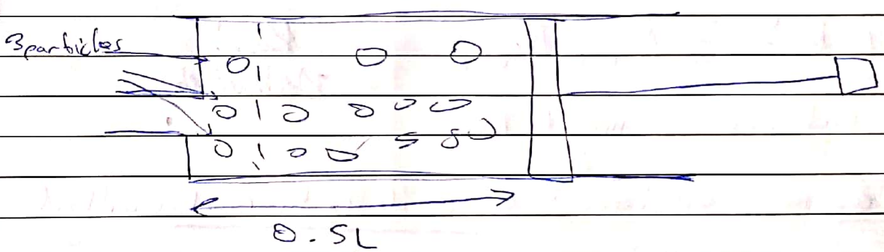
④ pressure :- "Only affect gas" ↑ pressure ↑ rate of reaction

~~Explain~~ how the pressure affect the rate of reaction?
Explain

As the pressure increases (by reducing the ~~volume~~ volume) so more particles per unit volume. So more effective collisions per unit time. So faster rate of reaction



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



~~$\frac{10 \text{ particles}}{0.5 \text{ litres}} = 20$~~

$$\frac{10 \text{ particles}}{0.5 \text{ litres}} = 20$$

⑤ Light. "only for photochemical" Reaction
↓
Reactions that need light to occur
e.g :- photosynthesis

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

~~photographic films~~ [redacted]

~~films coated with AgCl or AgBr~~

Photographic films? not in the sylabyss [redacted]

Films coated with AgCl or AgBr

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

$AgBr \xrightarrow{\text{light}} Ag_{(s)} + Br_{2(l)}$

Raad
Dahabneh

- 6) Catalyst need to know

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 to or more than Ea "Activation energy"

So ~~more~~ more effective collisions per Unit time

So faster rate of reaction

The Reaction

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

B

① Plan an exp. to show that CuO is a catalyst for this reaction. (6pts)

Take a known volume with a known conc. of H_2O_2 at known ~~volume~~ temp.

measure the volume of O_2 produced per unit time. Repeat the exp. using CuO

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

② Plan an exp. to show which of the two catalyst is better CuO or MnO_2. (6pts)

Same as Q1 + Same mass of catalyst

The exp which produce more O_2 per ~~unit time~~ the same unit time used better catalyst

③ Plan an exp. to show that CuO not used up during the reaction. (5pts)

Measure the mass of CuO

add to H_2O_2 until no more fizzes

filter the mixture

dry the solid in an oven

remeasure the mass

+ ~~same~~ Same initial and final mass

Reversible Reaction

Types of chemical rxn

one way

$\text{Reactants} \xrightarrow{\text{forward}} \text{products}$

$CaCO_3 + HCl \rightarrow CaCl_2 + H_2O + CO_2$

$Mg + HCl \rightarrow MgCl_2 + H_2$

Both ways

$\text{Reactants} \underset{\text{backward}}{\overset{\text{forward}}{\rightleftharpoons}} \text{produc}$

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

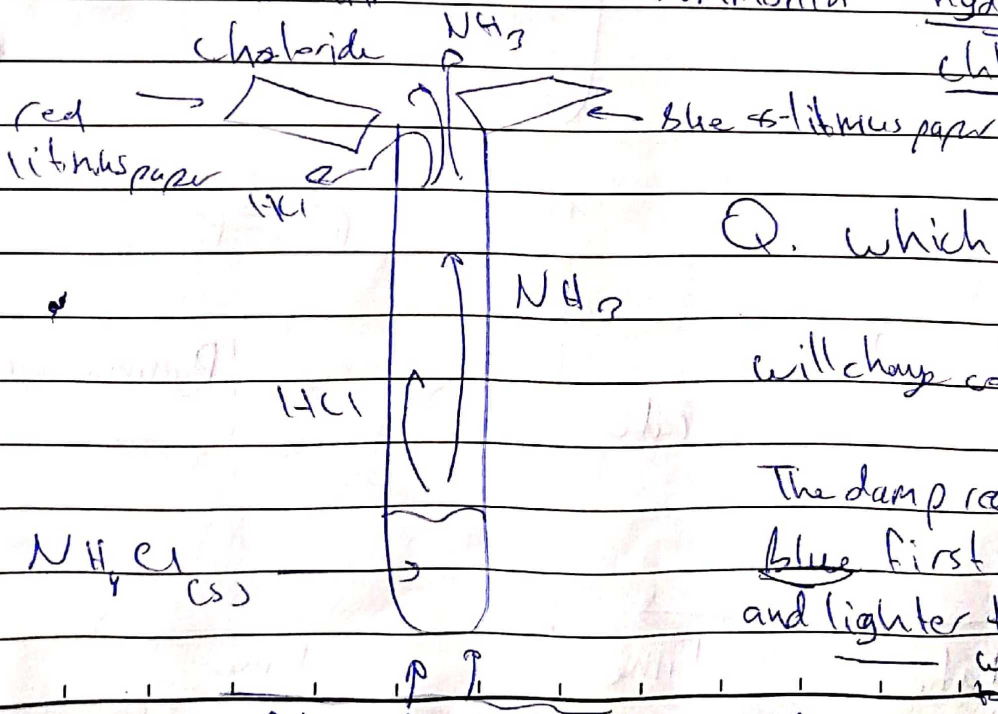
$CaCO_3 \rightleftharpoons CaO_{(g)} + CO_{2(g)}$

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

~~[illegible]~~

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

Ammonium chloride — Ammonia — hydrogen chloride

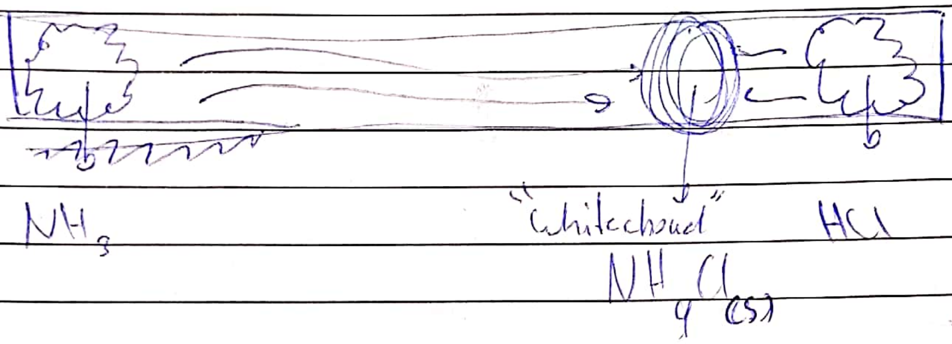


Q. which damp litmus paper will change color ~~fis~~ first, why? (3pts)

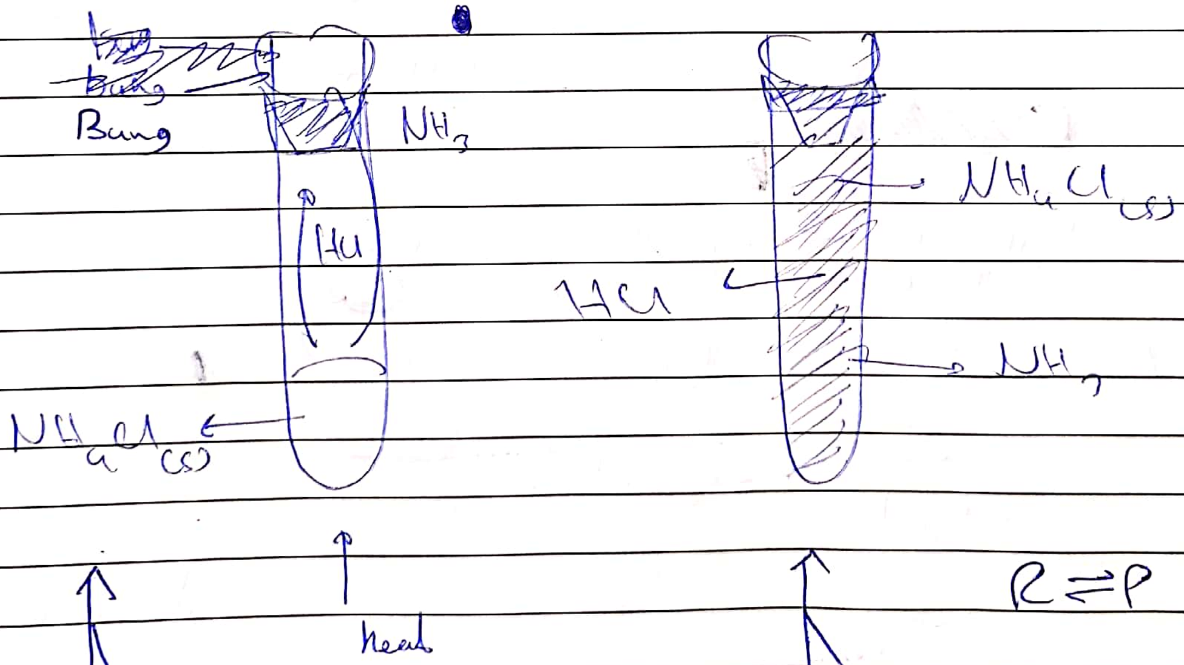
The damp red litmus paper changes to blue first because $NH_{3(aq)}$ is an alkali and lighter than $HCl_{(aq)}$ which is acidic when it ~~touches damp litmus paper~~

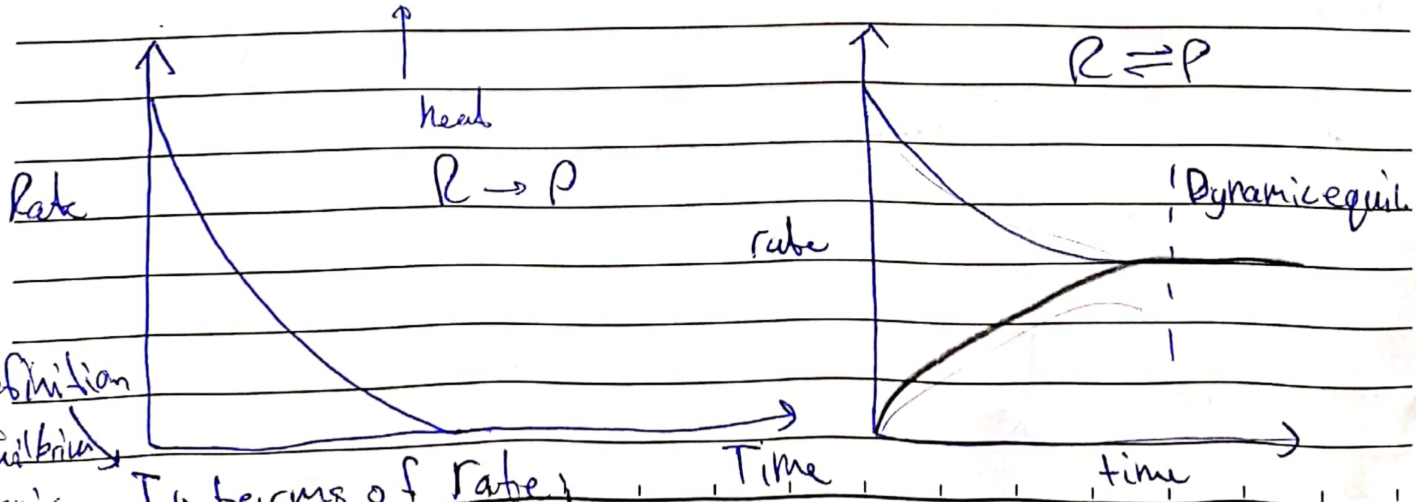
if the litmus ~~papers~~ is not damp ~~no~~ there will be no ~~c~~ color change

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



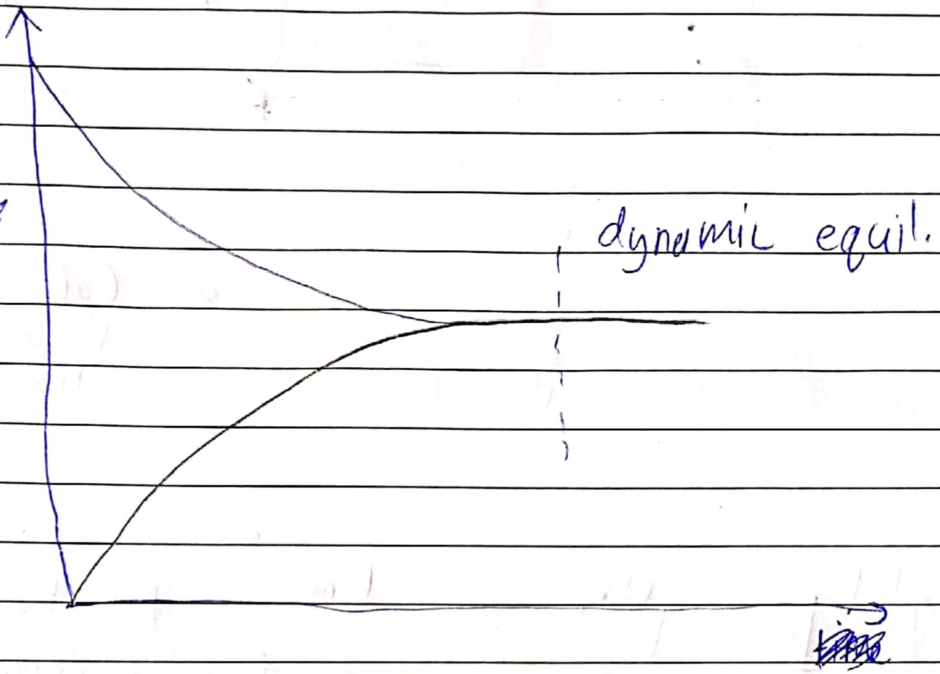
$NH_4Cl_{(s)} \rightleftharpoons NH_{3(g)} + HCl_{(g)}$





definition of equilibrium
dynamic

In terms of rates, when the rate of forward ~~a~~ rxn. ~~at~~ is equal to the rate of backward R rxn.



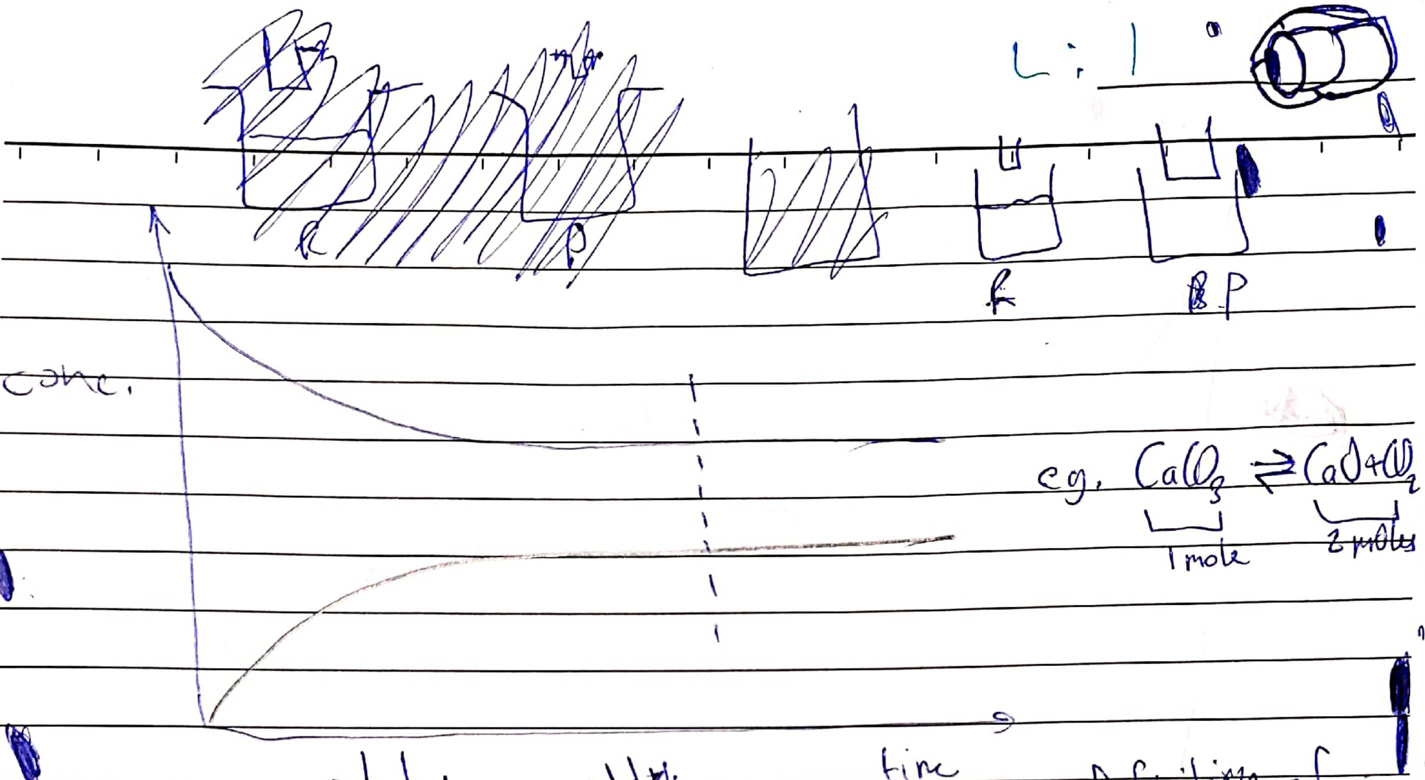
The rate of forward ↓

less reactants so less particles

so less effective collision per unit time

The rate of backward increases
more products
so more particles
so more effective collisions per unit time

$$\underbrace{H_2 + I_2}_{2\ moles} \rightleftharpoons \underbrace{2HI}_{2\ moles}$$



eg. $CaCO_3 \rightleftarrows CaO + CO_2$

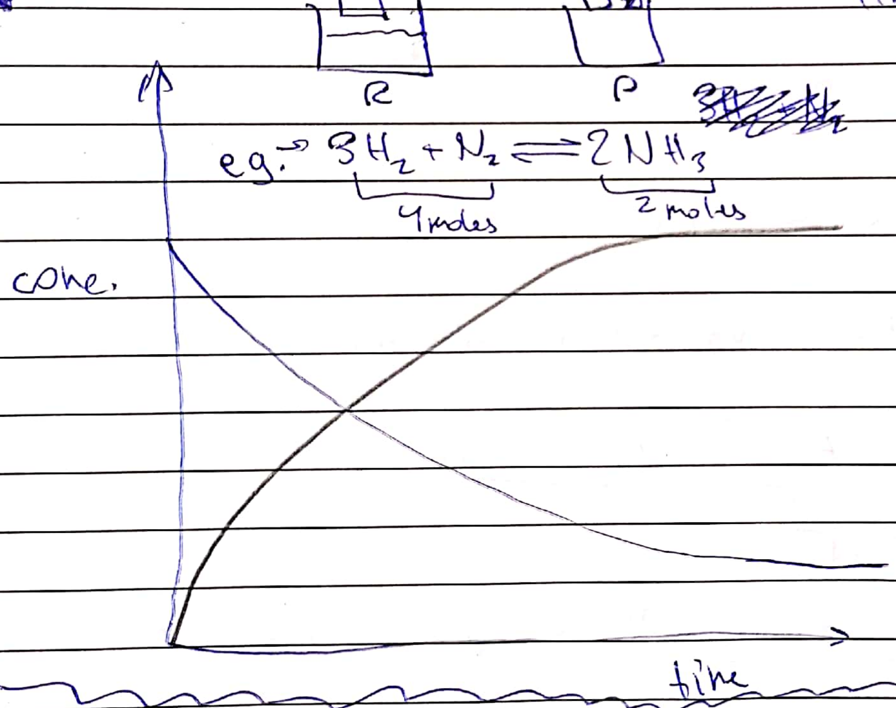
$\underbrace{CaCO_3}_{1\ mole}$ $\underbrace{CaO + CO_2}_{2\ moles}$

Definition of dynamic equilibrium ↓

In terms of conc.:

When the conc. of ~~the~~ ~~Re~~ Reactants and products are constant

~~Rea~~



eg.⇝ $\underbrace{3H_2 + N_2}_{4moles} \rightleftharpoons \underbrace{2NH_3}_{2\ moles}$

When defining dynamic equilibrium always mention both in terms of rate and conc. to get the full mark

Le chatelier principle — equal length of arrows ↓

if the system at equil. $\rightleftharpoons$

and any external factor distrub the equil.

The equil. can shift itself either

~~the to and any external factor~~
To the forward. →

or ~~the~~ to the backward. ←

To ~~the~~ return back to the equil.

~~EX~~ ~~In terms of rate~~ R

factors affect the position of equilibrium

① Temp.
② pressure.
③ concentration.

Temp.	pressure.	concentration.
← - - - endo and exo	↑ pressure. Shift to less gas moles	↑ R ↓ P shift forward
↑ temp shift to endo	↓ pressure. shift to more gas moles	
↓ temp shift to exo	↑ pressure. [illegible] ↑ rate of less gas mole	↓ R ↑ P shift backwards
↑ temp. ↑ rate	↑ rate of more gas moles	
↓ temp. ↓ rate	↓ pressure ↓ rate of less gas moles ↓ rate of more	

① ~~Pemperature~~ Temperature

↑ temp. ↑↑ rate of endothermic (shift to Endo)

more than exo

↑ rate of exothermic

↓ temp. ↓↓ rate of endothermic (shift to exo)

↓ rate of exothermic

ΔH ← Enthalpy change

+ve	-ve
gains energy	lose energy
Endo	Exo

The Sign of ΔH is always represent the forward reaction

amount:

$A + B \underset{exo}{\overset{endo}{\rightleftharpoons}} C + D$ { shift forward to endo — ↓ A&B ↑C↑D — ΔHs +ve

↑ temp, ↑↑ rate of ~~for~~ forward { ~~↓ temp~~ ~~A B~~

↑ rate of backward { ↓ ~~↑~~ A ↓B

$\rightleftharpoons$ ~~⇌~~ $\leftrightharpoons$ → they might use this instead of this

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

↑ temp. ~~↑ the rat~~ ↑ rate of forward

↑↑ rate of backward

shift to endo

↑x ↑w ↓y ↓z

Q. $3H_{2(g)}$ + ~~N_2~~ $N_{2(g)} \underset{endo}{\overset{exo}{\rightleftharpoons}} 2NH_{3(g)}$ $\Delta H = -ve$

* To produce more yield of NH_3 we must use low temp.

→ to favour the forward reaction which is exothermic

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

	Rate of forward	Rate of backward	% SO_3
↑ temp.	increase	increases	decrease
↓ temp.	decrease	decrease	increases

↓ temp.

↓ rate of forward

↓ rate of backward

amount:

↑A ↑B ↓C ↓D

shift ~~backward~~ to exo

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

$$2NO_{2(g)} \underset{endo}{\overset{exo}{\rightleftharpoons}} N_2O_{4(g)}$$

Dark brown pale brown

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

Because the forward reaction is exothermic enchanced by cooling

② ~~Press~~ Pressure

As the pressure increases

the equil. shift to the side with low pressure

with less gas mole

As the ~~P~~ pressure decreases

" " " " " " " more pressure

with more gas moles

$$\overbrace{3H_{2(g)} + N_{2(g)}}^{4\text{ moles}} \rightleftharpoons \overbrace{2NH_{3(g)}}^{2\text{ Moles}}$$

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

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

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

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

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

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

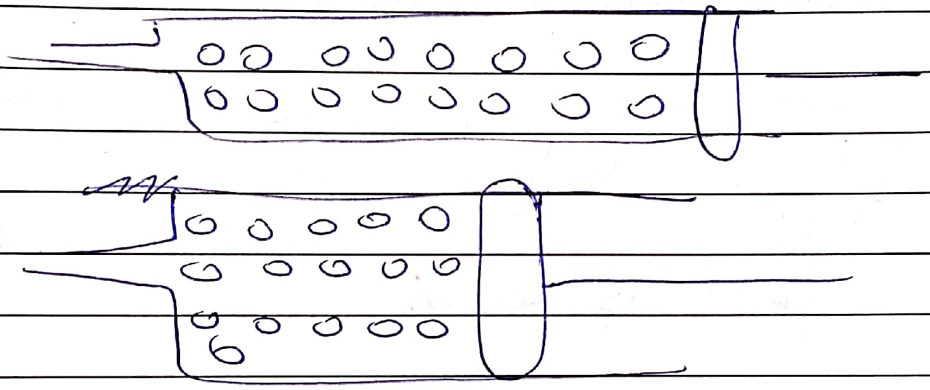
changing the pressure has no affect on the position of the equilibrium since both sides has the same no. of gas moles

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

purple colorless

The equil. doesn't affecting by increasing the pressure

Why be increasing the pressure the mixture becomes more purple?



The I_2 molecules becomes so closer to each other so ~~the~~ the color seems to ~~t~~ be darker

Sealed tube contains mixture of $NO_{2(g)}$ and $N_2O_{4(g)}$ at equilibrium

As level P.P question

$$\overbrace{2NO_{2(g)}}^{2\text{ moles}} \rightleftharpoons \overbrace{N_2O_{4(g)}}^{1\text{ mole}}$$

dark brown Pale brown

By increasing the pressure the color of the mixture becomes

A) Becomes paler then goes darker

[✓ b) " darkers " " paler]

c) " paler and stays paler

d) " darker " " darker

③ concentration

$$\text{React.} \rightleftharpoons \text{Products}$$

↑ Reactant
↓ product } shift forward

↓ Reactant
↑ products } shift backwards

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

↑ [A] shift forward ↓B ↑C ↑D

↓ [B] shift backwards ↑A ↓C ↓D

↑ [C] shift backward ↑A ↑B ↓D

Indicator

Methyl orange

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

color (1) color (2)

red yellow

Add HCl : proton donor ↑ H^+ shift backwards

more HIn more color (1)

less In^- less color (2)

add NaOH : proton accepter ↓ H shift forward

more In^- more collor (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 can mixture.

The color of the mixture becomes green?

HCl is an acid. (proton donor)

more H^+

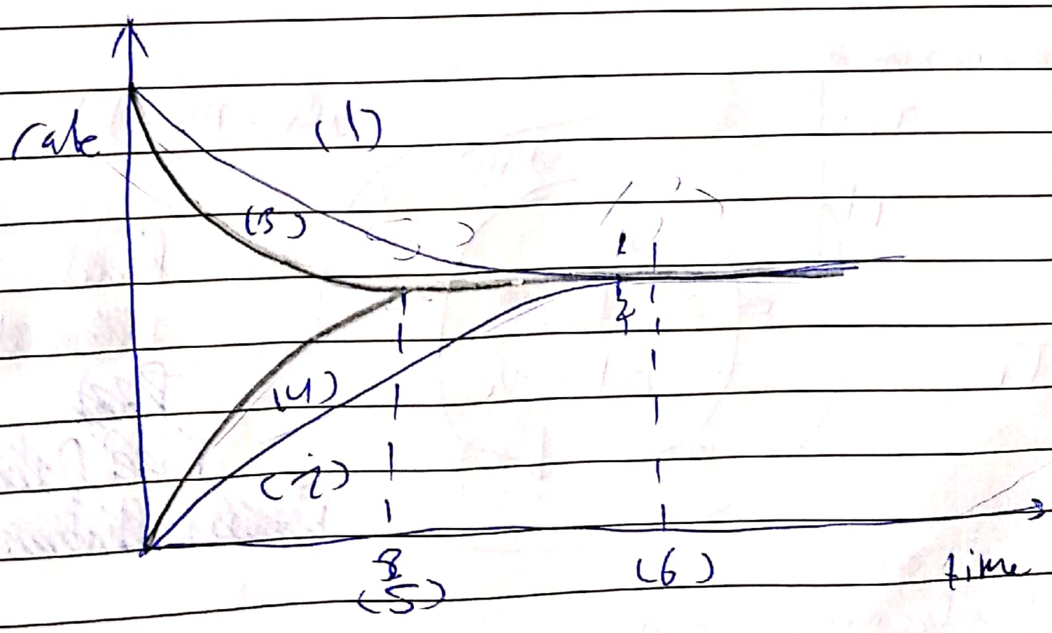
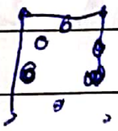
shift forward

more Cr^{+3} more green

less $Cr_2O_7^{-2}$ less orange

* catalyst

has no effect on the position of equilibrium 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 equil. with catalyst

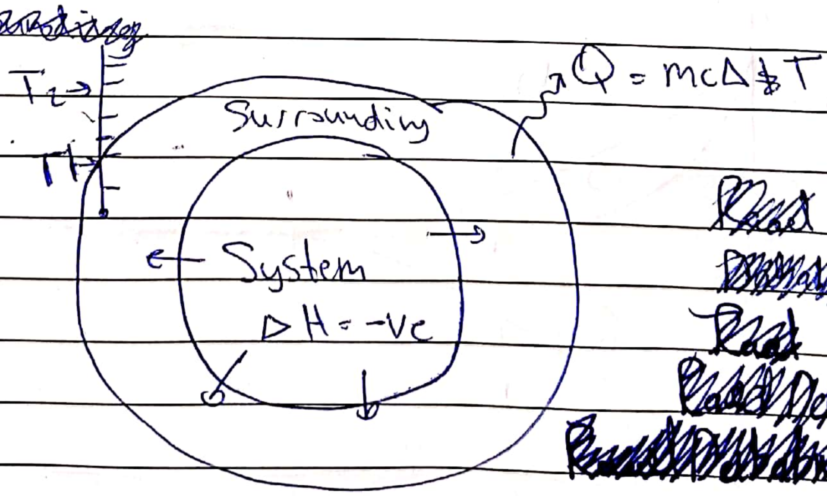
6) " " " " " without "

~~Energitics~~ Energitics

Exothermic

Reactions that give out (release) energy to the surrounding

~~To the surrounding~~



$T_2 > T_1$

Q.

energy transfer, J ← $Q = m\,c\,\Delta T$ → change in temp °C

m ↓ mass g

c ↓ Specific heat capacity

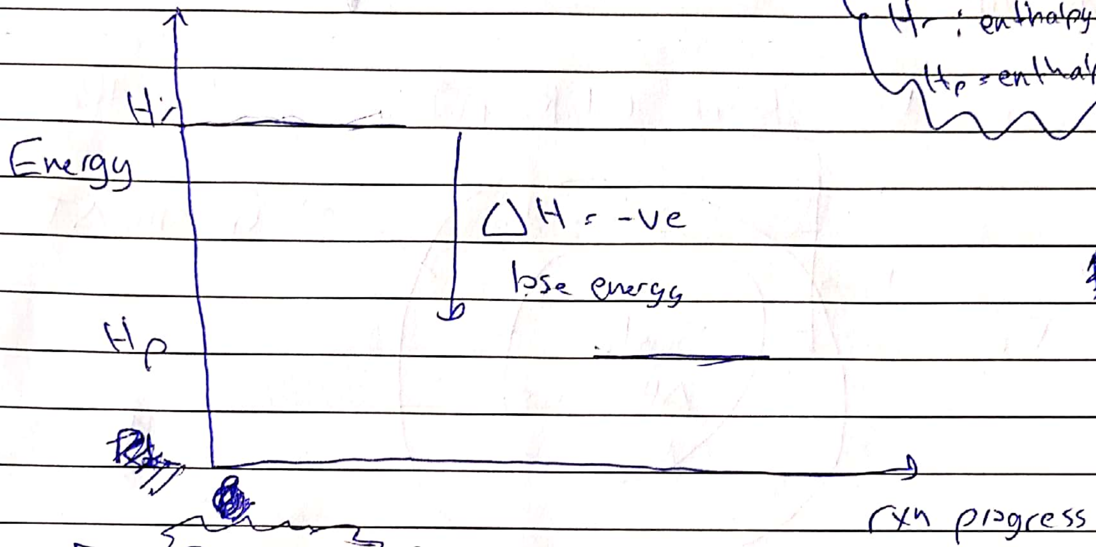
for water → $\boxed{4.2\ J/g°C}$

product is more stable

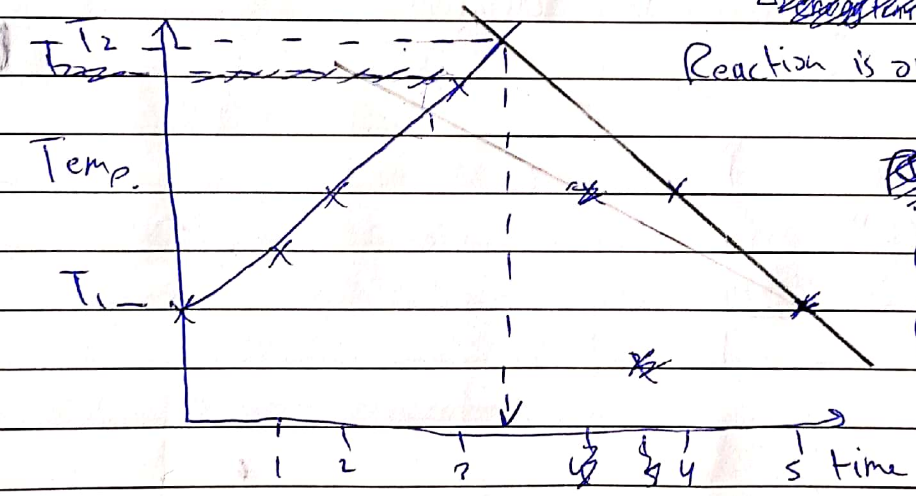
more energy less stable

Enthalpy: Heat contents
H_r : enthalpy of reactants
H_p = enthalpy of product

for {system} (Energy diagram)



For {Surrounding} (temp diagram) → $Q = mC\Delta T$



Reaction is over, Some turn back to room temp.

Q ↑
more exothermic
↑ΔT

Examples on Exo:

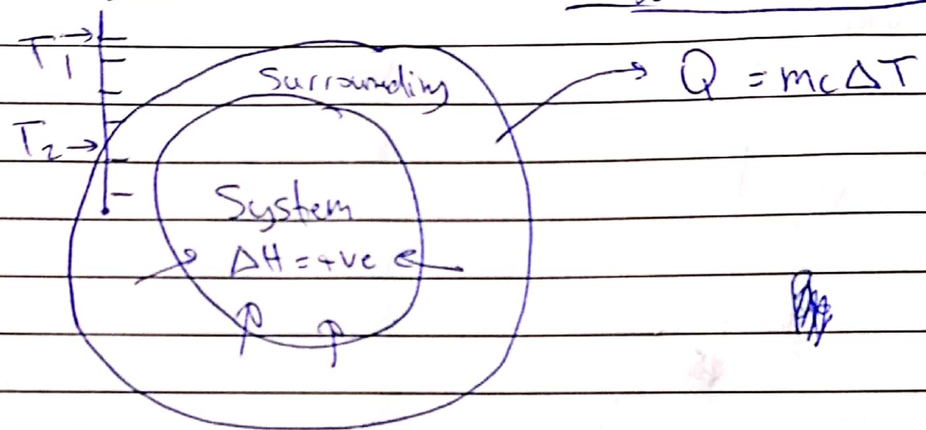
1- Freezing and condensation
2- Respiration
3- Combustion
4- neutralization
5- displacement $Zn + CuSO_{4(aq)}$
6- voltaic cell
7- Building up bonds

Continue of exo is after 2 pages

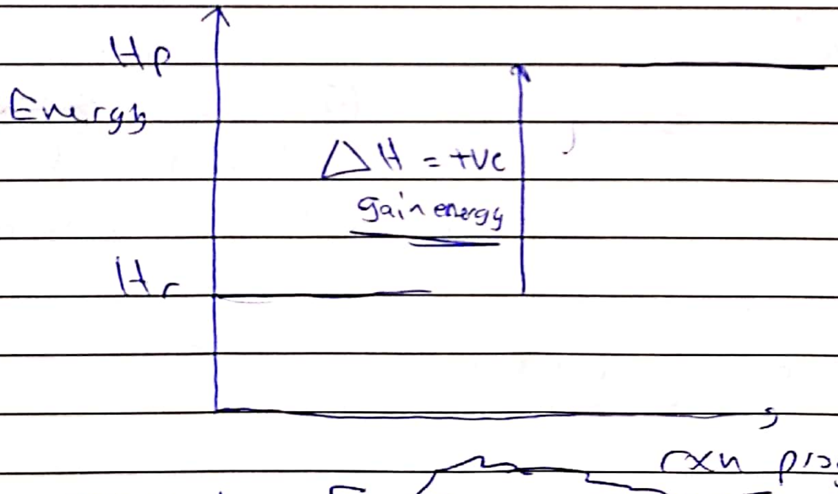
Endothermic

Reactions that absorb (take in) energy from the surrounding

$T_1 > T_2$



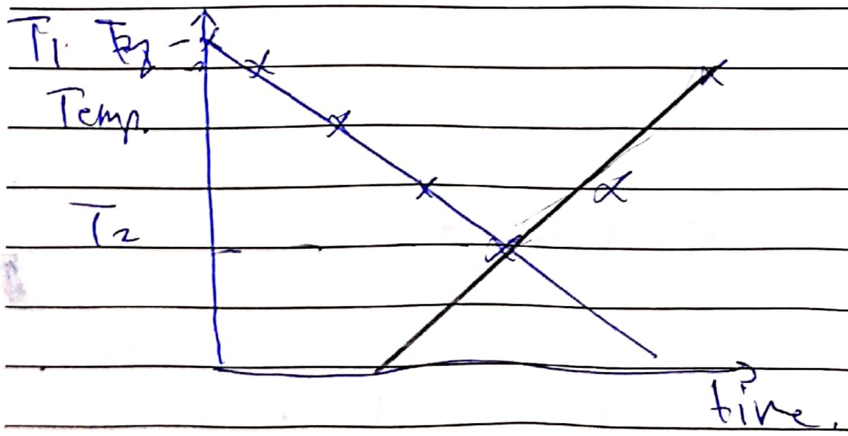
For System (energy level diagram)



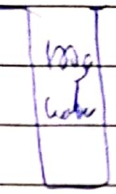
~~Temperature~~ For Surrounding (Temp. diagram)

$Q = mc\Delta T$

Q↑ ↑ΔT & more endothermic



(a)



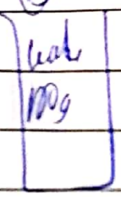
T_1 = 80

T_2 90

ΔT = 10°C

Needs more energy

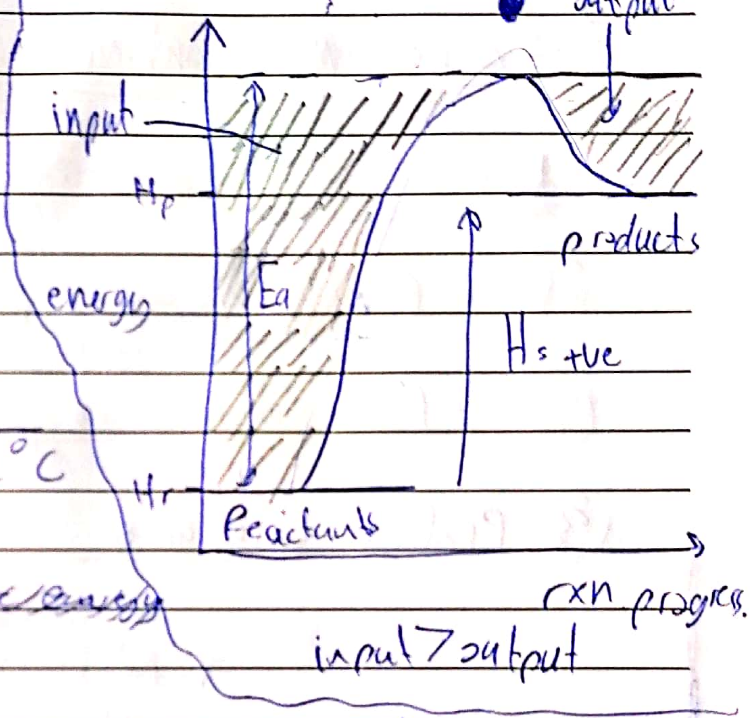
(B)



T_1 = 80
T_2 = 82

ΔT = 2°C

~~needs more energy~~



Examples on Endo

1- Boiling, melting
2- photosynthesis
3- Thermal decomposition
4- Electrolysis - (because of battery)
5- photographic films
6- dissolve Ammonium salt
7- Breaking down bonds

How to express endothermic

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

② Reactants + energy → product eg. photosynthesis

③ profile diagram

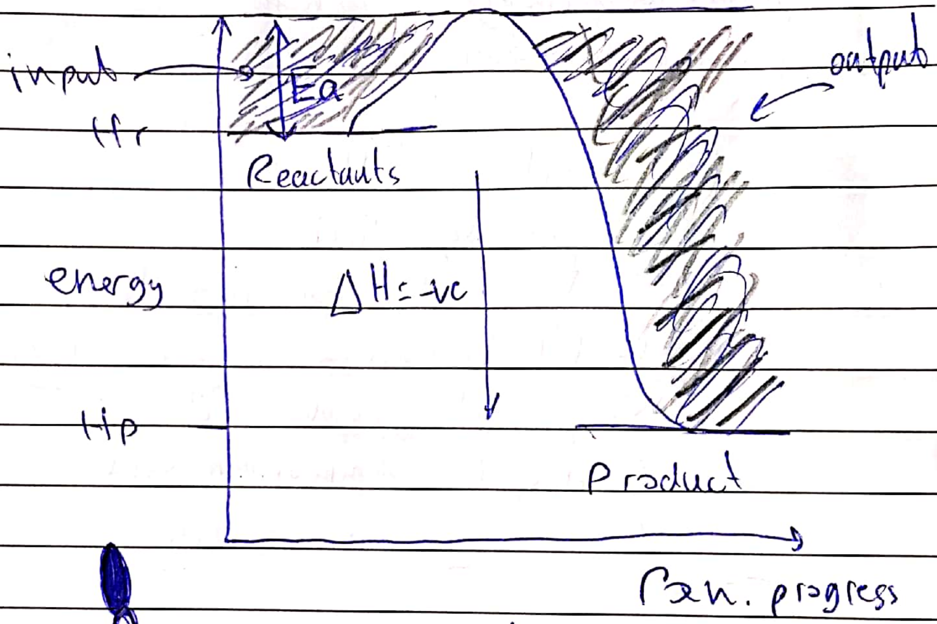
Exothermic continue:

How to express exothermic rxn.

① Reactant → products ΔH = -ve

② Reactants → products + Energy eg. respiration

③ Profile diagrams



output > input

Measuring ΔH reaction

theoritical
- Using Bond energy

experimental
- combustion
- displacement
- neutralizatio

Δ ~~reaction~~ H reaction using bond energy :-

Bond energy : the amount of energy needed to ~~break~~ break ~~two~~ 1 mol of a bond in gaseous state → ve because we need to overcome the intermolecular bonds first

Or " " " " released to build " " "

" " " "

Bond	Bond energy Kj/mol
H – H	436

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

$H_{(g)} + H_{(g)} \longrightarrow H-H_{(g)}$ ~~+43~~ 436 kj/mol

$\Delta H\ reaction = \sum input - \sum output$

To break down bonds in React

to buildup bonds in products

+ endo
input > output

- exo
input < output

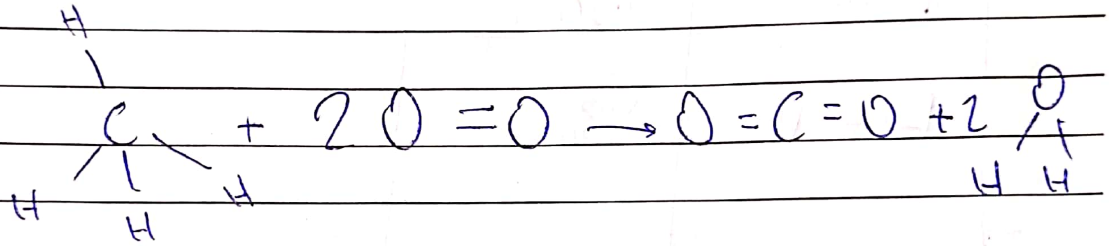
To use this equation

① Balanced equation

② covalent ~~Bonds~~ structure

③ Bond energy

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



Bonds	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

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

4 ~~2~~x O − H ⇒ 463 × 4

3450 kJ

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

$2642 - 3450 = -808\ kj/mol$

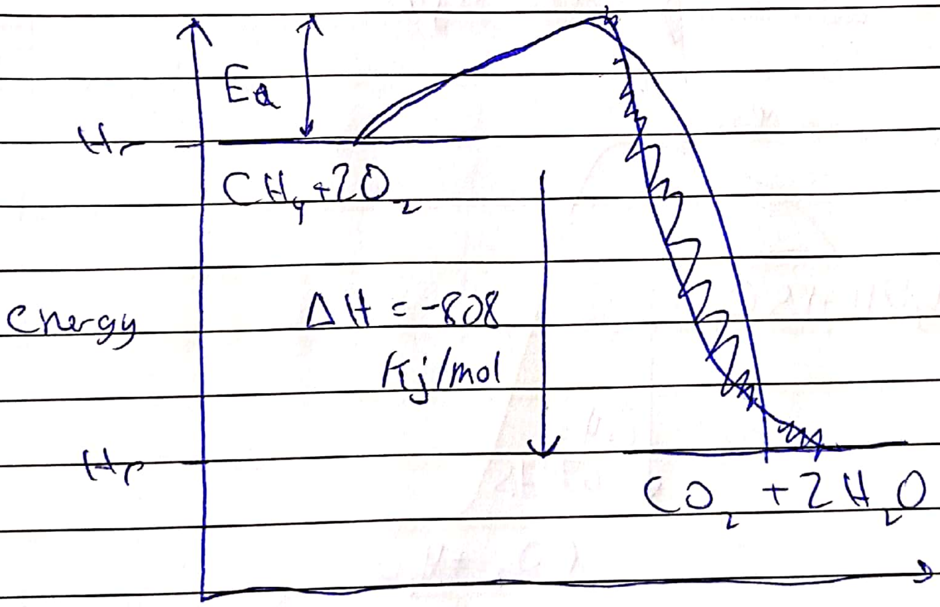
↓

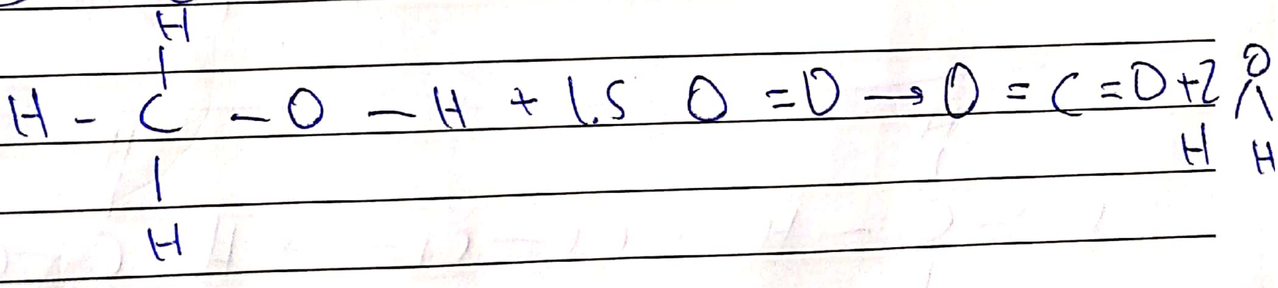
exo

input < output

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + 808 kj/mol$

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





$$H-\overset{H}{\underset{H}{C}}-O-H + 1.5\ O=O \rightarrow O=C=O + 2\ H-O-H$$

Bond broken

$3 \times C-H = 3 \times 417$
$1 \times C-O = 1 \times \cancel{57}358$
$1 \times O-H = 1 \times 463$
$1.5 \times O=O = 1.5 \times 495 +$
2802.5 Kj

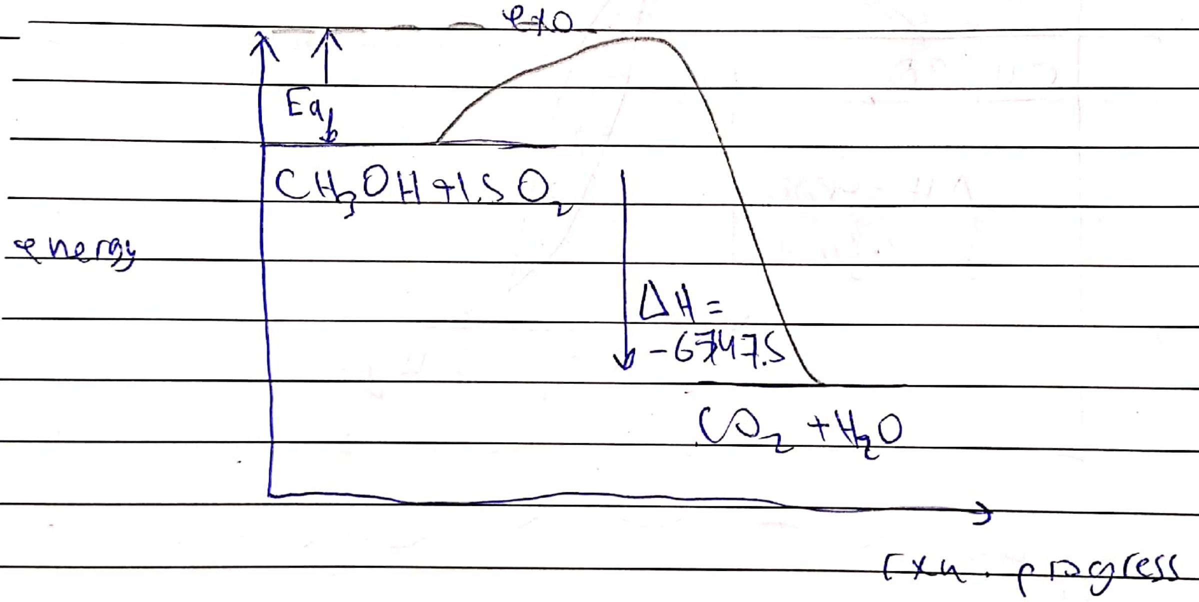
Bond build

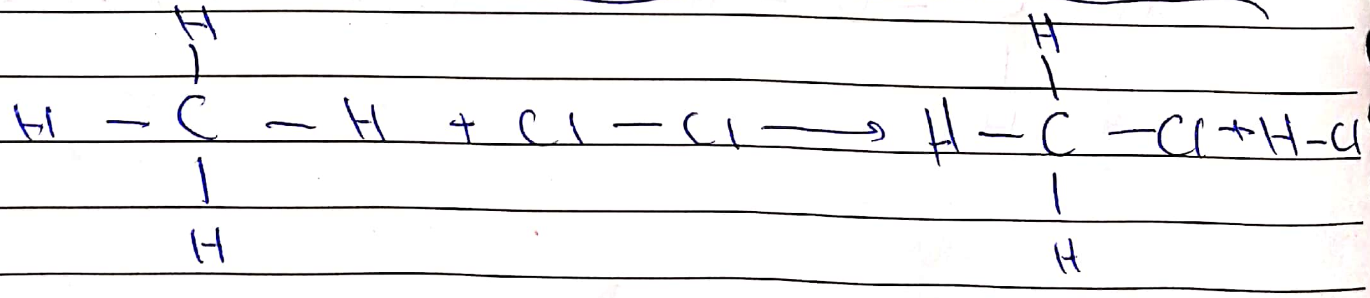
$2 \times C=O = 2 \times 794$
$4 \times O-H \quad 4 \times 463 +$
3450 Kj

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

$2802.5 - 3450 =$

-647.5 Kj/mol





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

Bond Broken

1 x C − H = 413

1 x Cl − Cl 242 +

655

Bond build

C − Cl 328 +

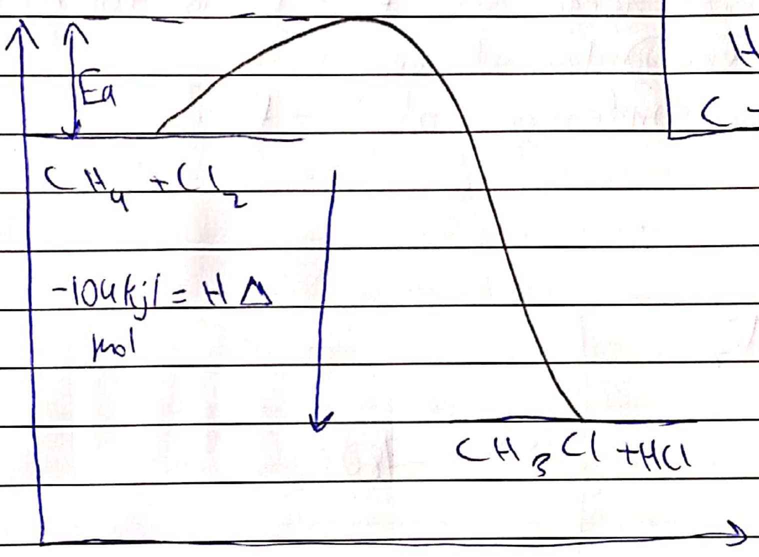
H − Cl 431

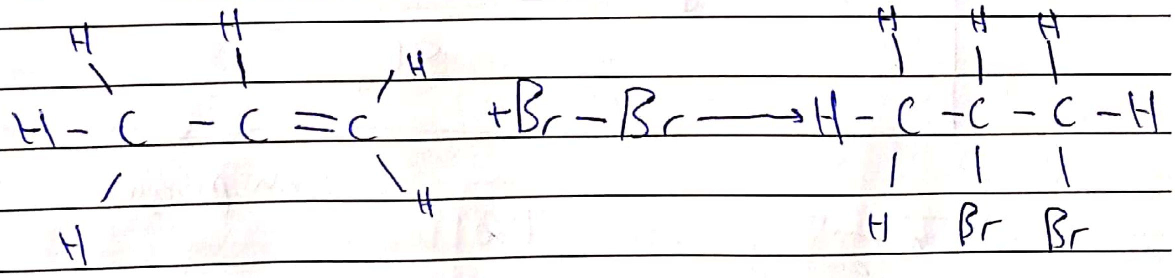
759 kj

Bond	Bond energy kj/mole
C − H	413
Cl − Cl	242
H − Cl	431
C − Cl	328

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

exo





Bond Broken

Br − Br = 193

C = C = 614 +

807 kj

Bond build

2 × C − Br = 2x2

C − C = 348

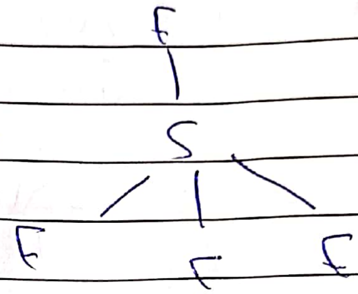
900

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

When Sulfur react with florine the reaction

Means exo ← give 780 kj/mol

S + 2F—F →

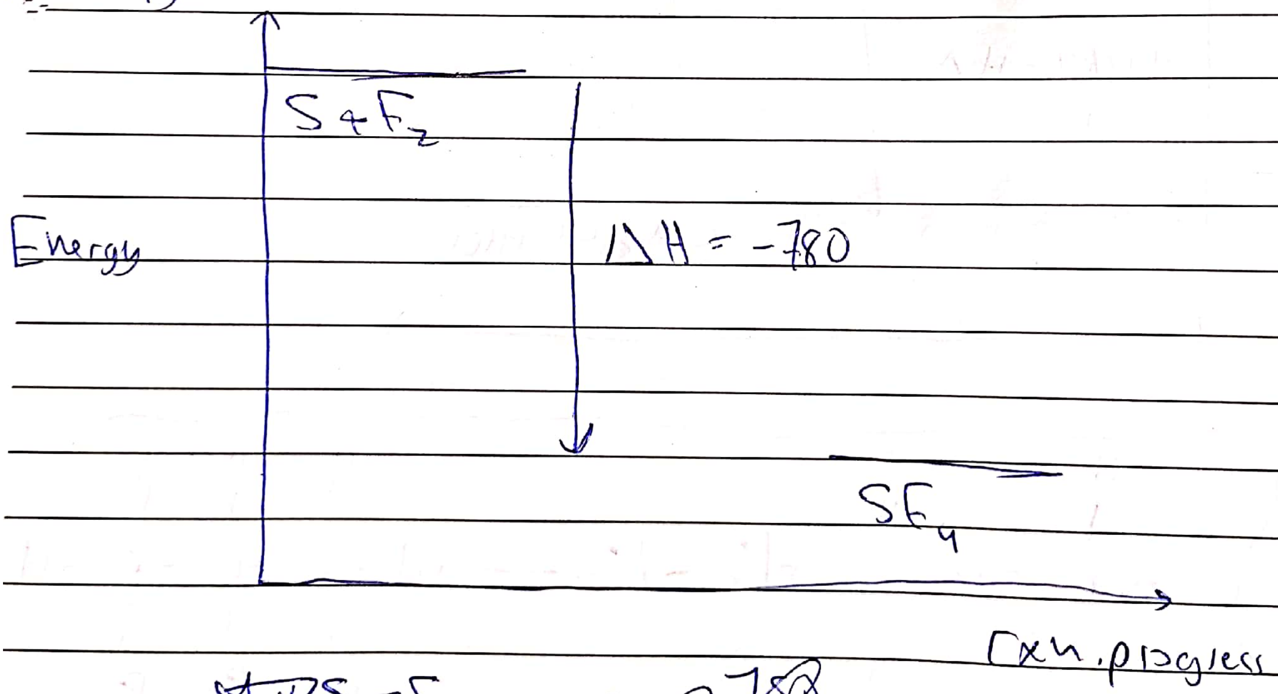


if the bond energy of F – F is 160 kj/mol

1) Draw an energy level diagram

2) Find the bondenergy of S – F ?

1)



[illegible]

[illegible]

[illegible]

2) ΔH = input - output

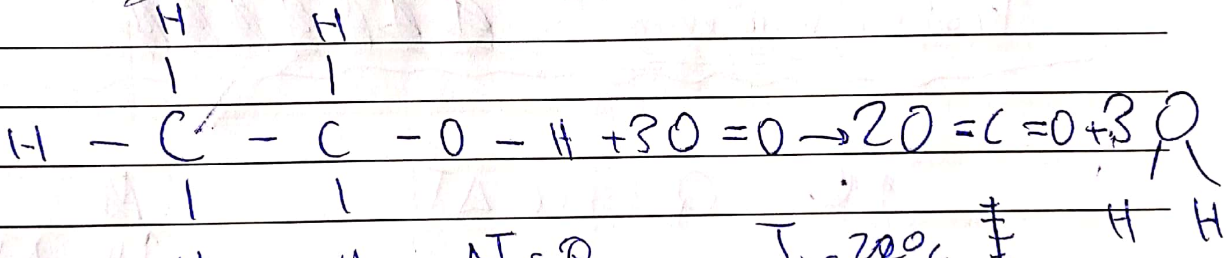
$-780 = (2 \times 160) - 4 \times S\text{-}F$

$\frac{-1100}{-4} = \frac{-4S\text{-}F}{-4} \rightarrow S\text{-}F = 275$ kj/mol

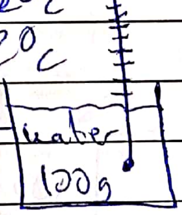
Finding ΔH (energy Change) practically

combustion — displacement — Neutralization

Finding ΔH combustion.



$CH_3CH_2OH + 3O{=}O \rightarrow 2O{=}C{=}O + 3H_2O$



$T_1 = 22^\circ C$

$T_2 = 32^\circ C$

copper can to conduct heat

$Q = mc\Delta T \rightarrow \Delta T = \frac{Q}{mc}$

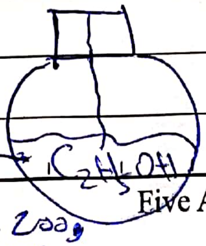
energy transfer = 100 × 4.2 × 10 = 4200 J = 4.2 kj

ΔH 4.2 kj → 2g C_2H_5OH

1 moles

$\boxed{96.6\ kj/mol} \leftarrow 46\ g\ C_2H_5OH$

$\boxed{\Delta H = -96.6\ kj/mol}$



spirit burner

$m_1 = 200g$

$m_2 = 198g$

Two fuels A and B.

Plan an exp. to show which one produces more energy

Take a known mass of water with known initial temp. in a copper can.

take a known mass of fuel A.

ignite the fuel and record the final mass and final temp. of water

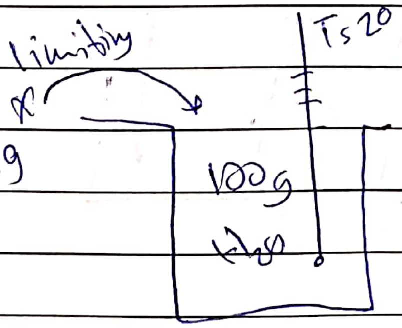
Repeat the exp. using fuel B

The fuel causes more temp. ΔT rises per gram of fuel

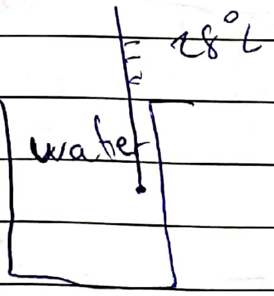
Produce more energy

$Q = mc\Delta T$

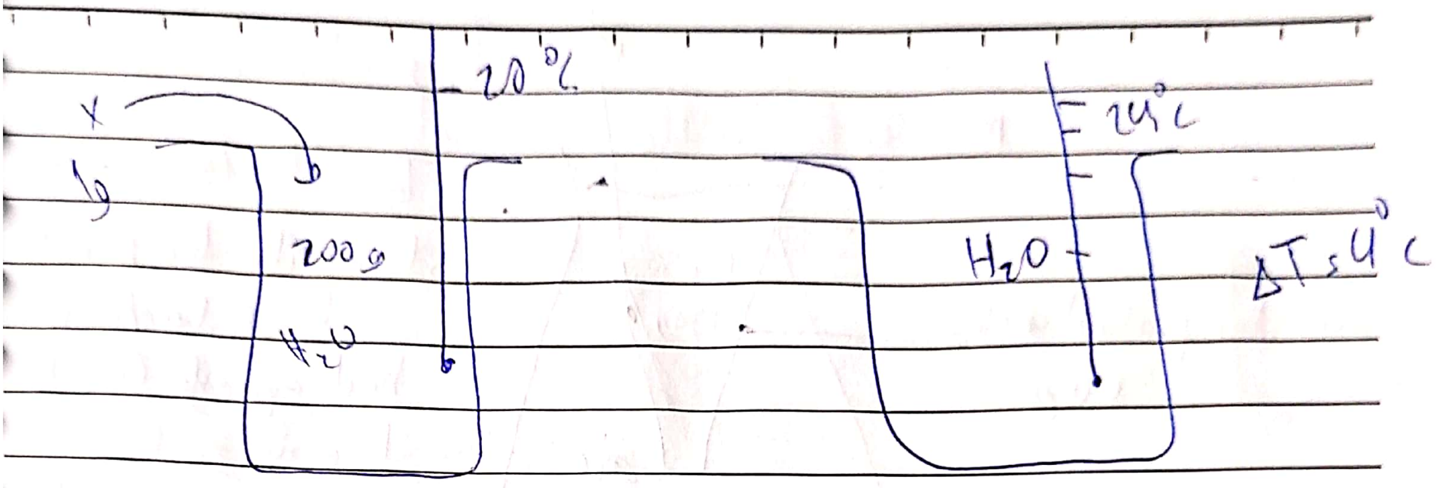
↑m ΔT↓

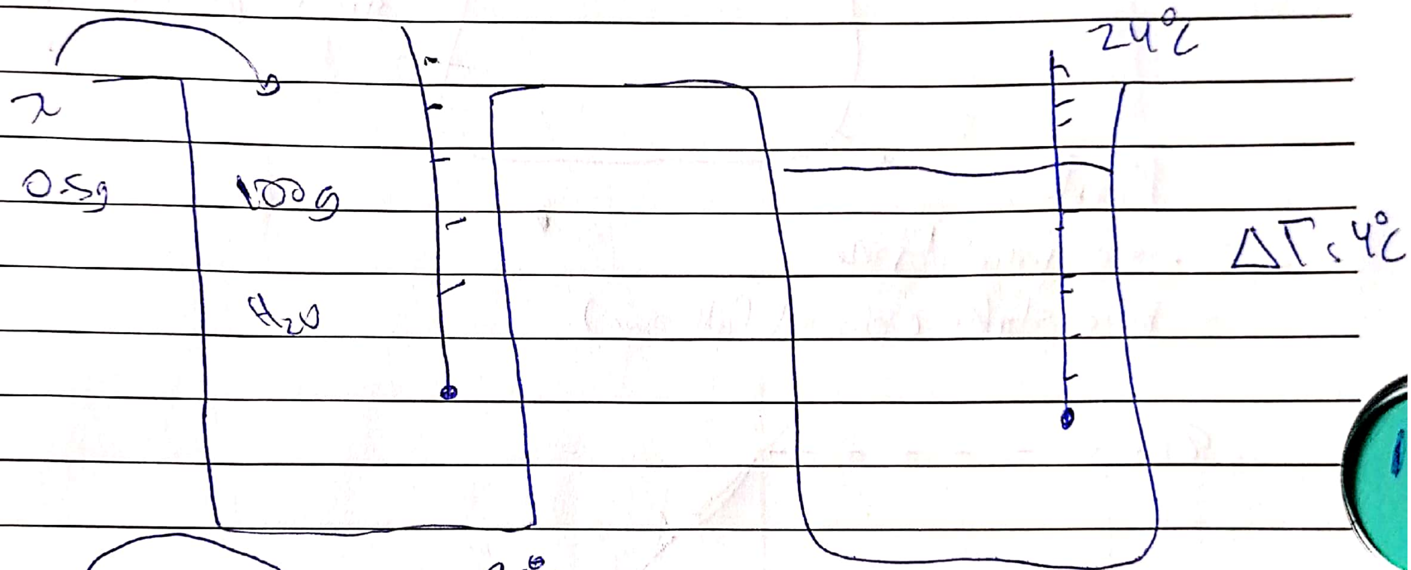


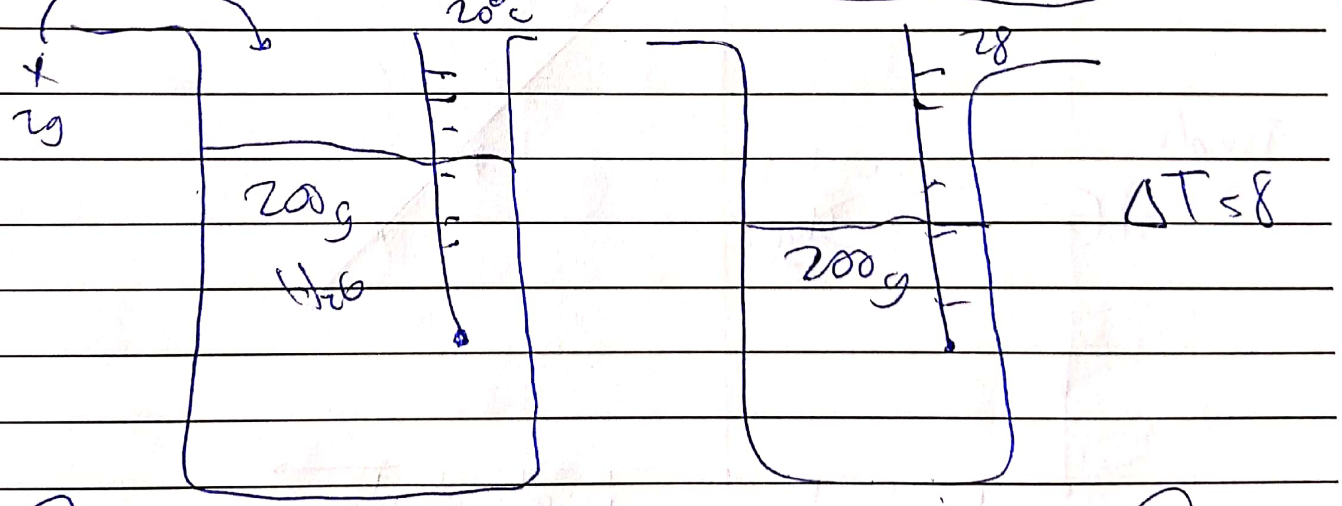
~~↑M ↑ΔT~~



$\Delta T = 8°C$

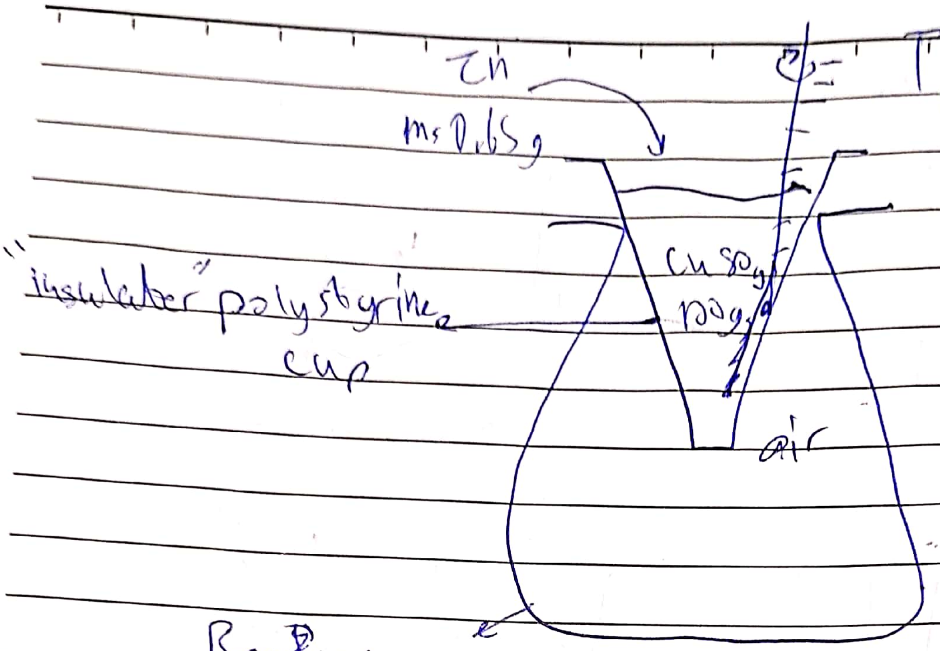






Measuring ΔH displacement

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

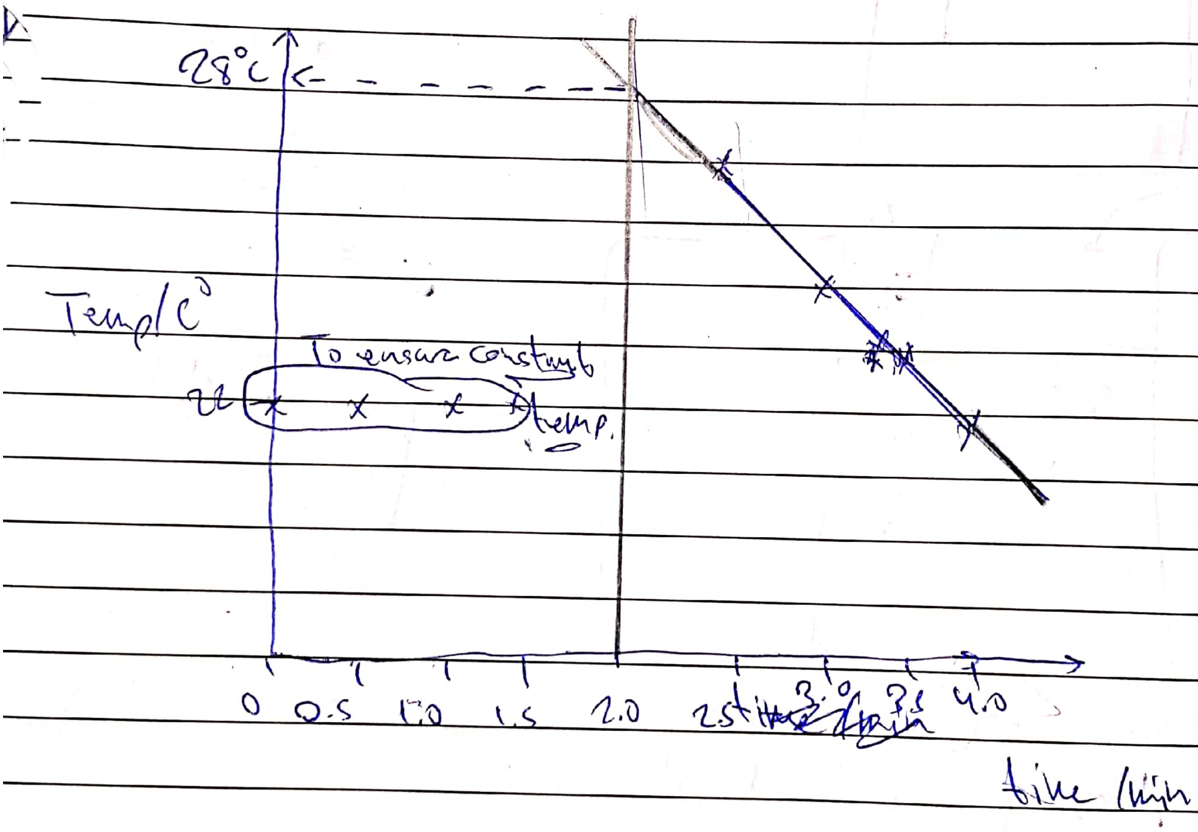


$T_1 = 22°C$

~~T_2~~ $T_2 = 28°C$

Stir with thermometer to distribute heat equally (slowly to avoid over heating)
air is poor conductor

Beaker
- more insulation
- more stable (do not fall over)



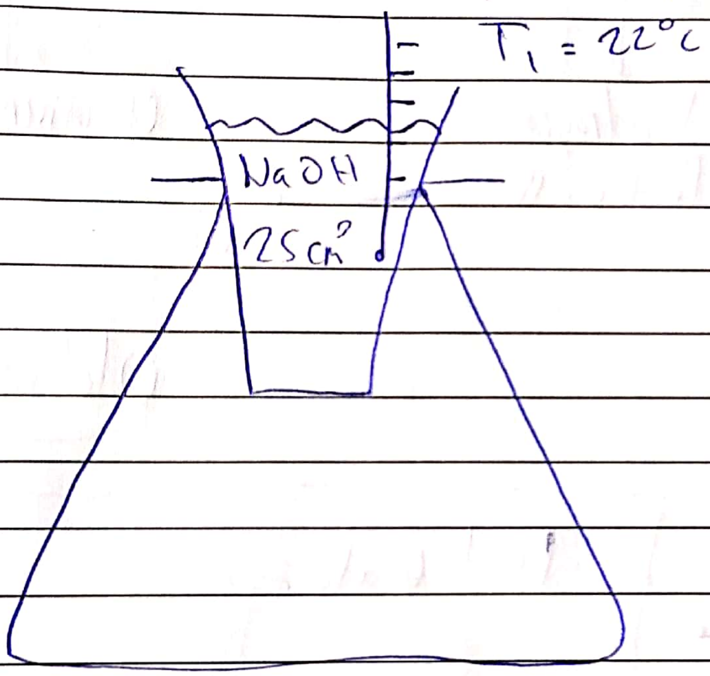
$Q = mc\Delta T \rightarrow$

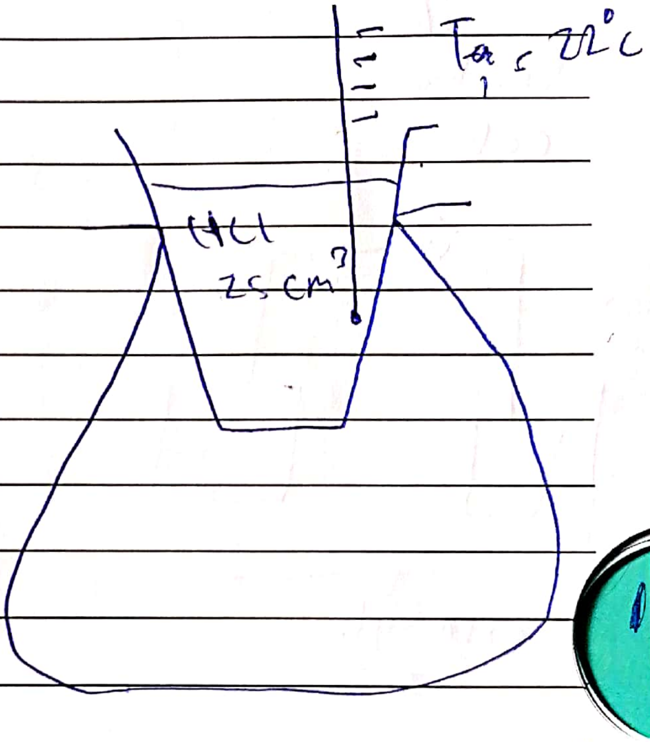
$= 100 \times 4.2 \times 6 =$

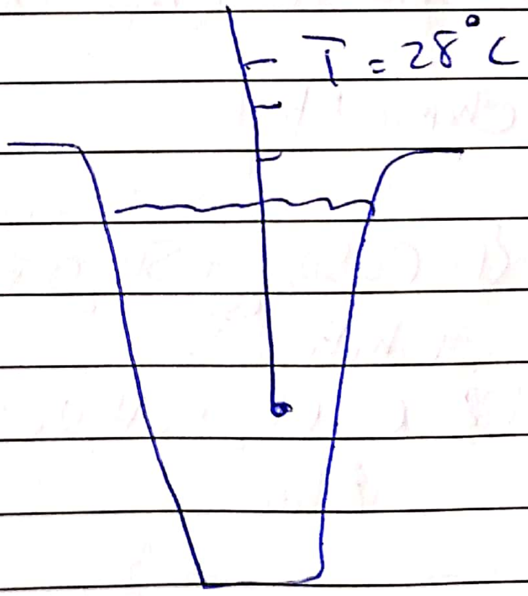
2520 J = 2.52 kJ

Measuring ΔH Neutralization

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







ρ ~~d~~ $= 1 g/cm^3$

$25+25 \times 1 = \underline{50}$

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

1260 J

Alternative Resources of energy

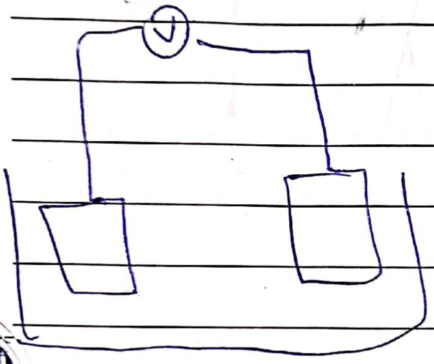
Voltaic cell

Hydrogen fuel cell

Uranium

$^{235}_{92}U$

Old syl.



Old syl.

Test water

physical test: B.p =100°C

chemical test

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

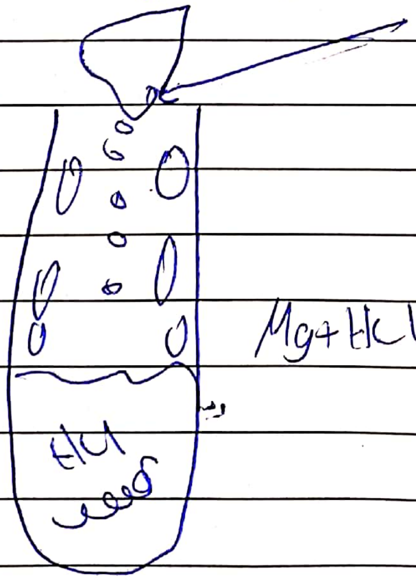
white blue

② $CoCl_2 + 6H_2O \rightleftharpoons CoCl_2 \cdot 6H_2O$

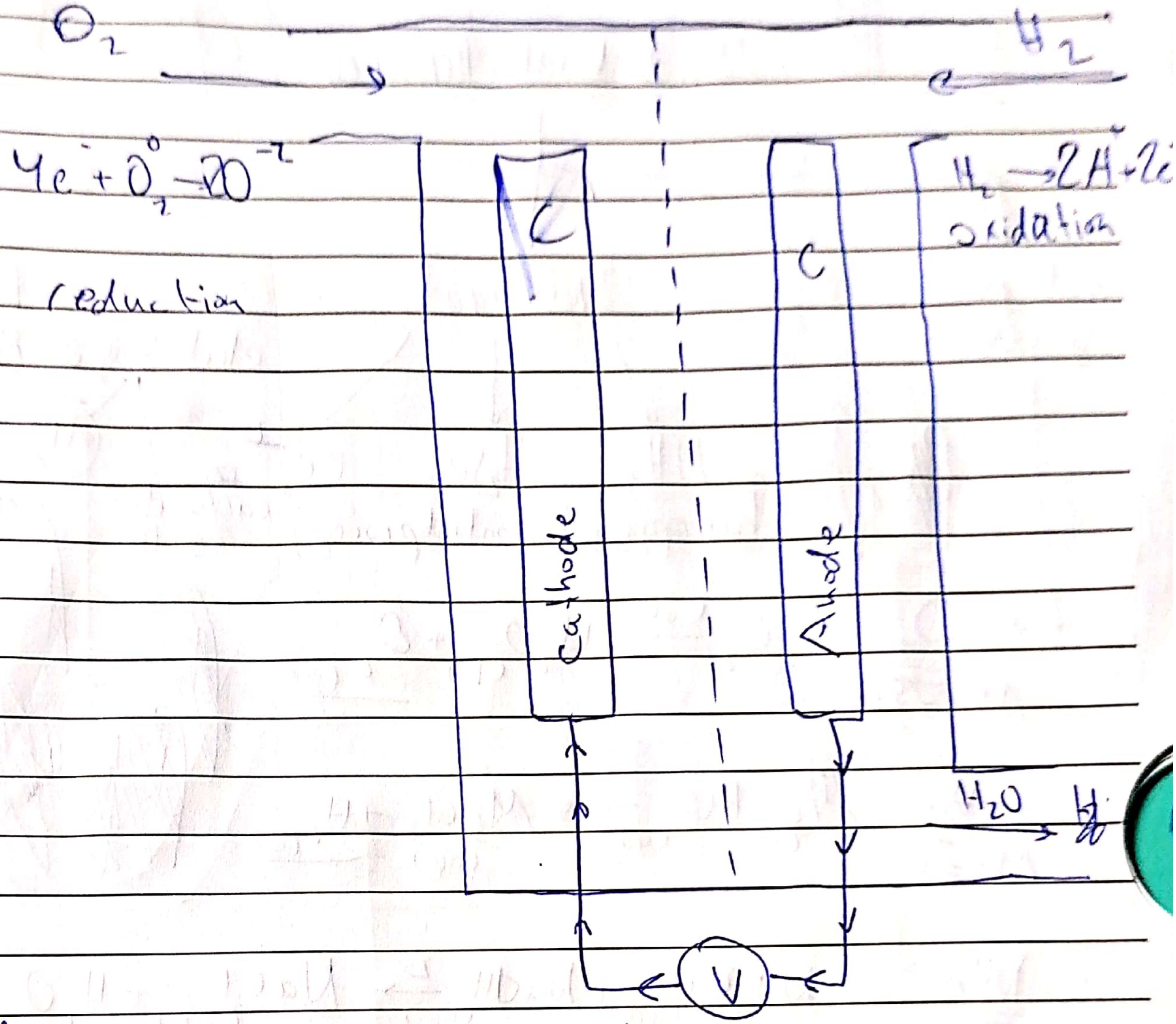
Blue pink

~~H2~~ Hydrogen fuel cell

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



$Mg + HCl \rightarrow MgCl + H_2$



Advantages: Only one wast product. (H_2O)

- NO CO_2
- produce high amount of energy
- genarate electricity

disadvantages:

~~exp expens~~

- expensive
- hard to store and ~~of~~ transport
- ~~Bi~~ Risk of explosion

Industrial chemistry

Dealing with gases

Industry of
- NH_3 haberprocess
- H_2SO_4 contact process
- CO_3^{-2} carbonate ~~cycle~~

Extraction electrolysis of metals
- Al
- Fe
- Zn Cu
- old syll.

O_2 $H_2O_2 \xrightarrow{CuO} H_2O_{(L)} + O_{2(g)}$

Mr = 32

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

Mr = 2

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

Mr = 17

SO_2 $Na_2SO_3 + HCl \xrightarrow{\Delta} NaCl_{(aq)} + H_2O_{(l)} + SO_{3(g)}$

Mr = 64

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

Mr = 44.

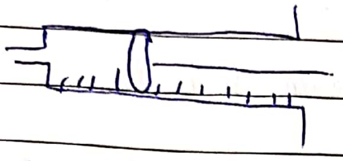
Rxn. → wet gas → dry → collect

density of air = 28.5

× collect gas

only collect, can't measure because it is not scaled

Gas syringe



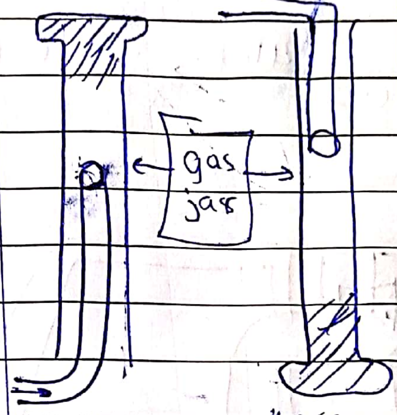
- used to collect and measure the volume of any gas

- no mixing with other gases

Delivery tube

upward delivery

downward delivery

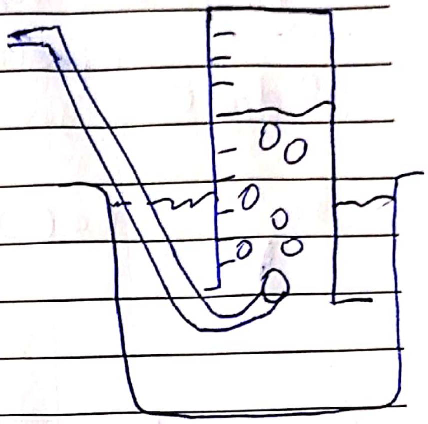


less dense than air

more dense than air

* mix with air
* can escape

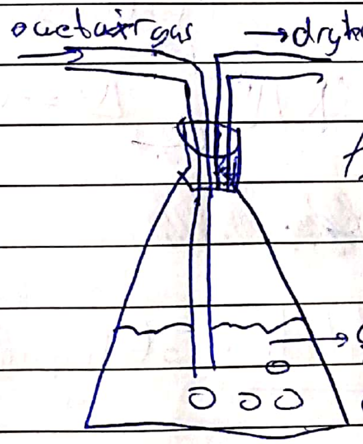
Over water



Only for insoluble ~~gases~~ gas

Drying gases

① concentrated H_2SO_4



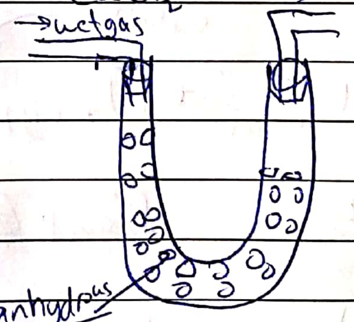
→ conc. H_2SO_4 (becomes ~~dilut~~ ditlute)

used to dry any gas, except NH_3.

it natrelise the H_2SO_4

$NH_3 + H_2SO_4 \to (NH_4)_2SO_4$

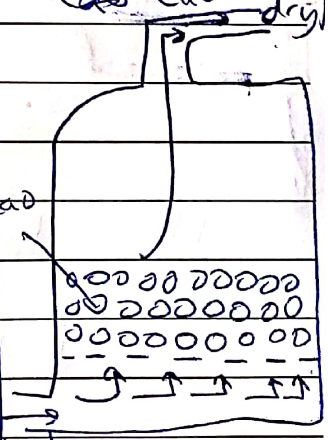
② Anhydrous $CaCl_2$



used to dry any gas except NH_3

③ Calcium oxid

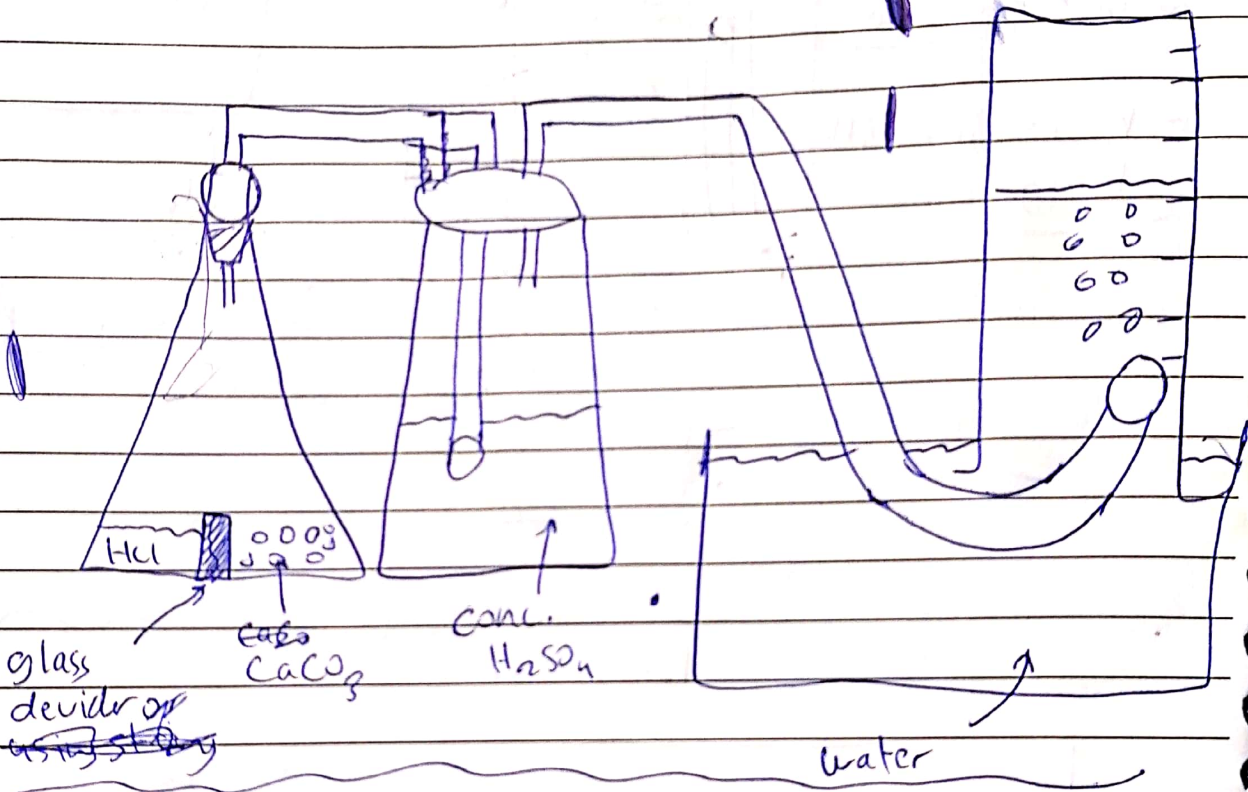
~~CaO~~ = CaO = oxid



the question mentions if it is soluble or insoluble and if it's dense

Draw a Suitable apparatus used to collect and measure volume of dry CO_2 (insoluble) gas form *you can use also a gas syringe

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



Industry of Ammonia "Haber process"

catalyst → Fe

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

2 NH_3 → prepare Fertilizers

How to obtain

① Nitrogen :- fractional distilation of liquid air

distilation → different B.p

liquid air → cooling under high pressure

② hydrogen : ① ~~Ca~~ Cracking of Alkanes. (organic)

② $CH_4 + H_2O \rightarrow CO_{(g)} + 3H_{2(g)}$

essential condition

air
78% N_2
21% O_2
0.9% Ar
0.03% CO_2
0.01% H_2
0.06% others

1) temp. 400 — 450°C

Temp 400°c - 450°C

less than 400°c

adv.

higher yield of NH_3
- shift forward to the exo side

dis.

slower rate
particles lose kinetic energy so less effective collisions per unit time

more than 450°c

adv.

faster rate

dis.

less yeild
- shift backwards to the endo side

2) peressure

200 ~~ATM~~ 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

& 3) Fe catalyst

add excess H_2 and N_2

Return back to converter

remove NH_3 immidiatly

By cooling

Uses of ammonia

1- Fertelizers

2- cleaning detergents

3- smelling salts

ustry of $_2SO_4$) Contact process

Stages

S (1) (2) (3)

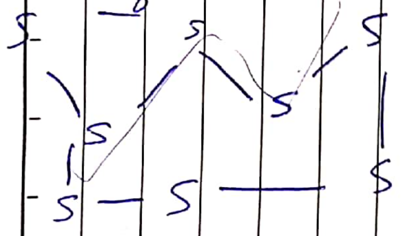
contact process (Industry of (H_2SO_4))

stages

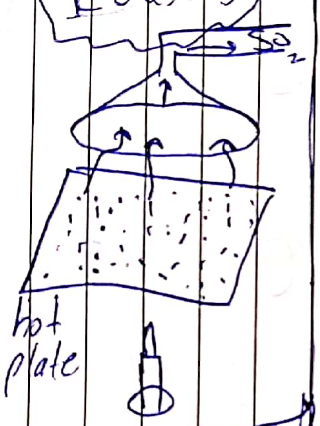
$S \xrightarrow[+O_2]{(1)} SO_2 \xrightarrow[+O_2]{(2)} SO_3 \xrightarrow{(3)} H_2S_2O_7 \xrightarrow{(4)} H_2SO_4$

Roasting — contact process — oleum

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



- uses :
  - ~~mediet~~
  - medicine
  - match
  - rubber
- ore :
  - zinc blende ZnS
  - from fossil fuels



- SO_2 cause acid rain
- uses of SO_2
  - kills bacteria (sterilization)
  - paper industry
  - bleaching agent

$$2SO_{2(g)} + O_{2(g)} \underset{endo}{\overset{V_2O_5}{\underset{exo}{\rightleftharpoons}}} 2SO_{3(g)}$$

3 moles — 2 moles

exo

$\Delta H = -ve$

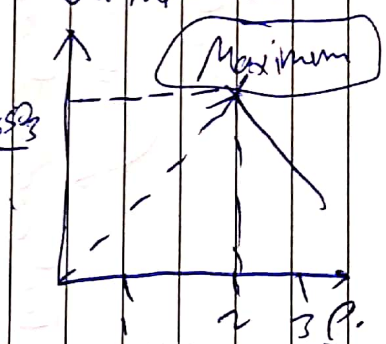
essential conditions

1) temp. 400 - 450°C
2) pressure 2atm
"high pressure favour the forward rxn. (fewer gas mole)"

2atm gives max yeild of SO_3

imp.

3) catalyst V_2O_5
Vanadium (V) oxide

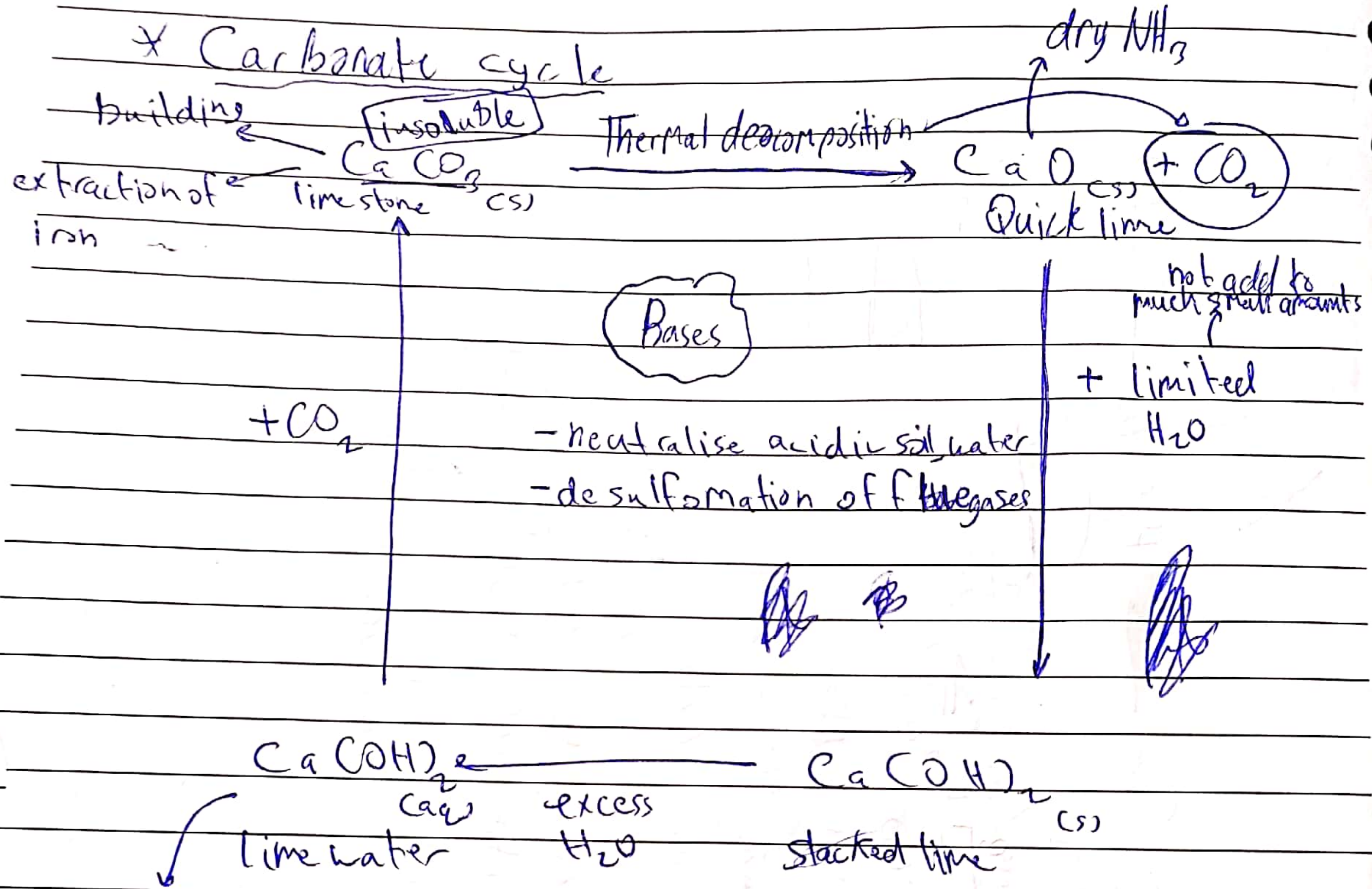


SO_3 → conc. H_2SO_4 → $H_2S_2O_7$ → H_2O → $2H_2SO_4$

$SO_3 \xrightarrow{H_2O} 2H_2SO_4$

- highly exothermic
- produce low yeild of the SO_4

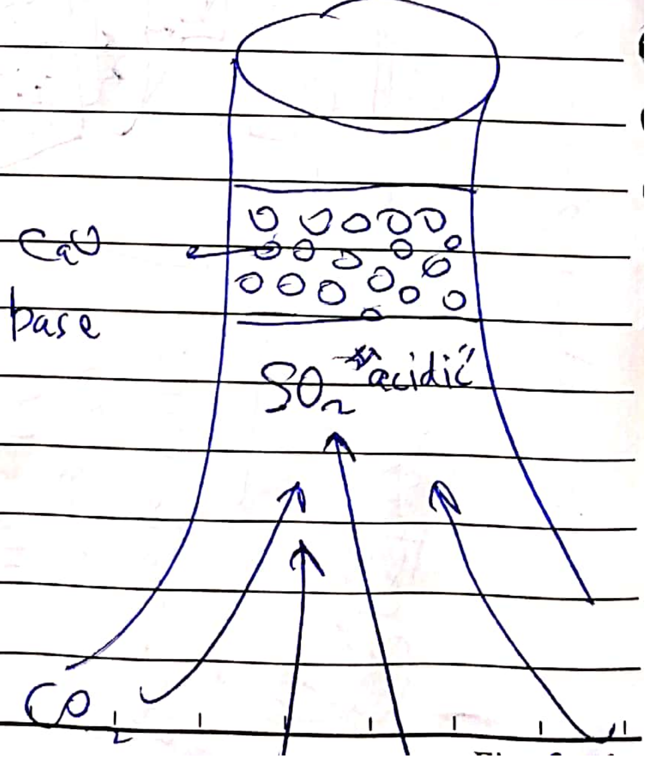
* Carbonate cycle



Test carbon dioxide

CO_2

$$Ca(OH)_{2(aq)} + CO_2 \rightarrow CaCO_{3(s)} + H_2O$$



Extraction of metals

K

Na

Li

Ca

Mg

Al → Al_2O_3 bauxite] Electrolysis / Molten

C, CO

reduction { Zn → ZnS zinc blende] reduction by C & CO

old. syll!

Fe → Fe_2O_3 hematite] "Blast furnace"

pb

H] reduction by H_2

CuS ← Cu

old. syll.

Ag

Au

pt

Extraction of iron

Ore: Fe_2O_3 "Hematite"

Methode: reduction by C & CO

place: blast furnace

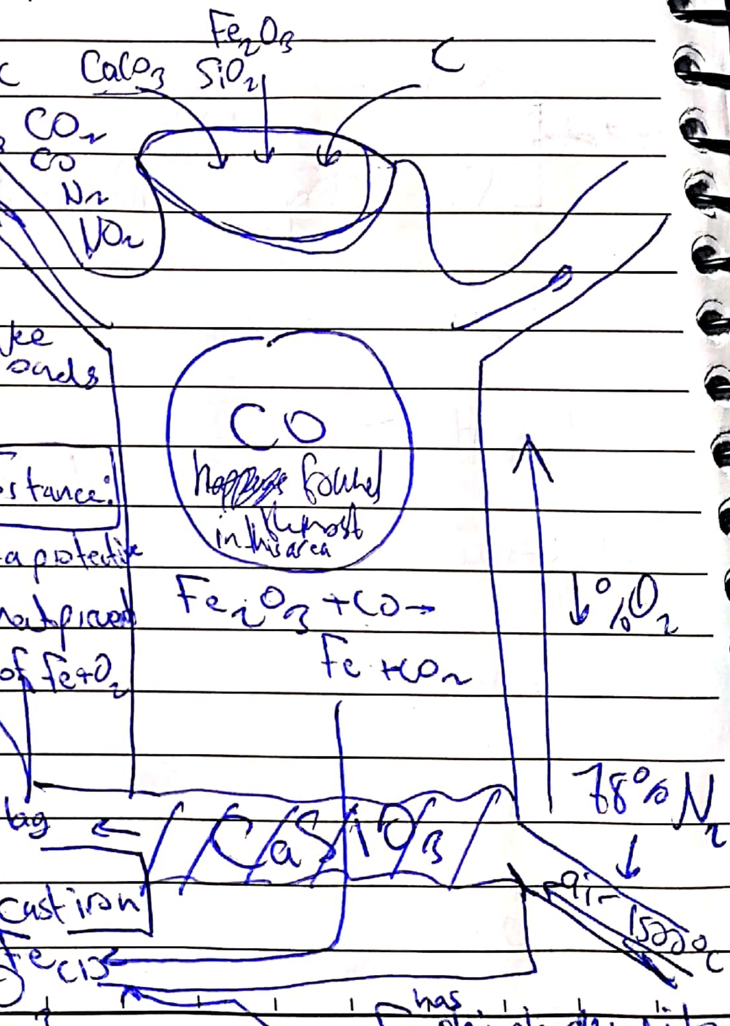
main impurit

Raw materials :- Fe_2O_3 mixed with SiO_2 acidic impurities

$CaCO_3$ "lime stone"

coke "Carbon "pure""

air 1500°c



complete combustion

Redox $C + O_2 \rightarrow CO_2$

use mixed with bitumen to make roads

incomplete combustion this one only

Redox $2C + O_2 \rightarrow 2CO$

Redox $CO_2 + C \rightarrow 2CO$

importance: form a protective layer that prevent ~~the reaction~~ the reaction of Fe + O_2

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

Termal decomposition $CaCO_3 \xrightarrow{heat} CaO + CO_2$

base

(heat) $CaO + SiO_2 \rightarrow CaSiO_3$

base acid calcium silicate slag.

Fe has high density so he goes down the

Steel making "Oxygen Base process"

Cast iron

~~[illegible]~~

~~[illegible]~~

Fe

main impurity → $\boxed{C}$ ~~[illegible]~~ impurities

S

Si

P

Fe

$CO_2\uparrow \leftarrow$ C ← hot O_2

$SO_2\uparrow \leftarrow$ S ← CaO

acidic {

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

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

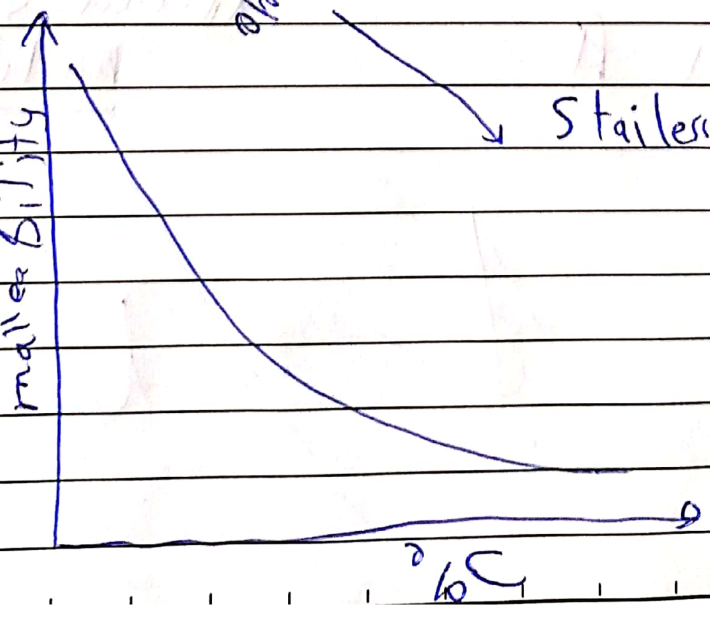
use

Steels (%C in steel)

→ Mild steel 0.03%C "carbodies"

→ Medium Steel 0.3%C _ Railways

→ Stailess steel 3-5%C _ cutte wate



Alloy;

Mixture of metal with another metal or semi metal

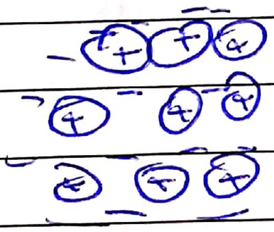
Brass Cu, Zn

Branze Cu, Sn

Steel Fe, C, Ni, Cr

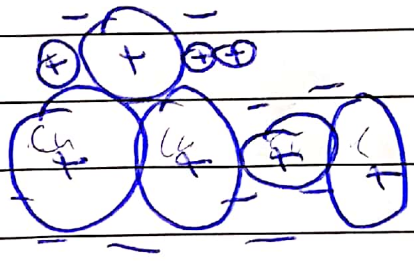
Metal

Cu



Brass

Cu, Zn



harder

different size of metals

Raael A.

* Extraction of Zinc

Ore: Zinc blende ZnS

Method: reduction by C and CO

place: blast furnace

~~B Roasting with hot hot Oxygen~~

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

Step 1: Roasting with hot oxygen

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

Step 2: $C + O_2 \rightarrow CO_2$

$$C + O_2 \rightarrow 2CO$$

$$CO_2 + C \rightarrow 2CO$$

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

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 the have high B.p stay in the furnace