Metals	Reaction with $O_{2(g)}$	Reaction with $H_2O_{(l)}$	Reaction with acid
K^+ Na^+ Li^+	react vigrosly	K Ca react vig with water	K Pb react vig with diluteacid
Ca^{2+} Mg^{2+}	react less vig.	Mg Pb react with steam	Cu Ag no reaction
Al^{3+} C, CO Zn^{2+} $Fe^{2+/3+}$ Pb^{2+} H $Cu^{1+/2+}$	Need energy (heat) to react	Cu Ag no reaction	
Ag^{1+}	no reaction		

in terms of oxidation state decrease increase

reduction oxidation

Day : .... Date : ....

RedOx :

Reduction oxidation

interms of H_2 gain H_2 lose H_2

in terms of O_2 lose O_2 gain O_2

$Al + Fe_2O_3 \rightarrow Fe + Al_2O_3$

Fe reduced in Fe_2O_3

Al oxidation

$H_2 + CuO \rightarrow Cu + H_2O$

Cu in CuO reduced

H_2 oxidation

$Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$

H^+ Reduction

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

Na oxidation

Cu^{2+} Reduction

$\overset{0}{Zn} + \overset{2+}{Cu}Cl_2 \rightarrow \overset{2+}{Zn}Cl_2 + \overset{0}{Cu}$

Zn oxidation

Fe^{3+} to Fe Reduction

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

Al to Al^{3+} oxidation

Day : .... **Date :** ....

the sum of all oxide state of all atoms in the compound = zero
in the ion = charge of this ion

Free element = 0
group I = +1
group II = +2
groups Al III = +3
F VII = -1
H = +1 except with metal (-1)
O = -2 except peroxide (-1) / OF_2 (2+)

$\overset{+1}{Na}Cl$ $\quad 1+X=0$

$X=-1$

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

$C=+2$

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

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

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

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

$N=+5$

H.O.O →

H.O.R+$\bar{e}$ →

Day : .... Date : ....

+1 +5 -2

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

OiL RiG

O i L — Oxidation is losing $\bar{e}$

R i G — Reduction is Gaining $\bar{e}$

+1 -2

$\overset{+7}{Mn}O_4 + \overset{2+}{Fe} \rightarrow \overset{2+}{Mn} + \overset{3+}{Fe} + H_2O$

Oxid. $(Fe^{2+} \rightarrow Fe^{3+} + 1\bar{e}) \times 5$ $5Fe^{2+} \rightarrow 5Fe^{3+} + 5\bar{e}$

reduc. $Mn^{7+} + 5\bar{e} \rightarrow Mn^{2+}$

Overall reaction - $5Fe^{2+} + Mn^{7+} \rightarrow 5Fe^{3+} + Mn^{2+}$ *

$\boxed{\text{OiL RiG}}$

Listen man!
My ~~[illegible]~~ expload

Day : .... **Date :** ....

oxidant

Oxidising and Reducing Agents

Oxidisingagent is the substance reduced and cau the other substance to be oxidised.

Reductant

Reducingagent is the substance oxidised and cause other substance to be redused.

$$\overset{0}{Al} + \overset{3+}{Fe}_2\overset{2-}{O}_3 \rightarrow \overset{3+}{Al}_2O_3 + \overset{0}{Fe}$$

oxidation Al reduction Fe^{3+}

reductant Al oxidant Fe_2O_3

* Most common oxidising agents

① Oxygen :- $4\bar{e} + O_2 \rightarrow 2O^{2-}$ | $\overset{0}{Fe} + \overset{0}{O}_2 \rightarrow \overset{+3}{Fe}_2\overset{-2}{O}_3$

$\overset{0}{S} + \overset{0}{O}_2 \rightarrow \overset{+4}{S}\overset{-2}{O}_2$

② Acidified potassium manganate $KMnO_4$

$\overset{+7}{Mn}\overset{-1}{O}_4 \rightarrow Mn^{2+}$

Purple colorless

③ Acidifiedpotassium dichromate $K_2Cr_2O_7$

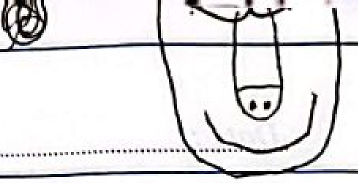
$\overset{6+}{Cr}_2O_7^{2-} \rightarrow Cr^{3+}$

orange green

④ Halogens :- $Cl_2/Br_2/I_2$

$2\bar{e} + Cl_2 \rightarrow 2Cl^-$ $2\bar{e} + Br_2 \rightarrow 2Br^-$ $2\bar{e} + I_2 \rightarrow$

yellow/green gas colorless brown colorless black solid Purple gas



bro I Love this pen!

Too bad it's not mine :(

Fe 2+

Day : .... Date : ....

* Most common reducing agents :-

① Hydrogen $H_2 \rightarrow 2H^+ + 2\bar{e}$

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

Reducing agent

② Carbon and carbon monoxide C, CO

$$\underbrace{\overset{2+}{C}O + \overset{2+}{Zn}\overset{2+}{O} \rightarrow \overset{0}{Zn} + \overset{4+\,2-}{CO_2}}$$

reducing agent

* The most reactive metal is more able to lose $\bar{e}$'s more able to oxidise, more able to be an oxidising agent.

* The least reactive ion is more likely to reduce "oxidising agent"

③ potassium Iodide

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

colorless red-brown

[illegible]

oxidant	reductant
oxygen	Hydrogen
$KMnO_4/H^+$	C, CO
$K_2Cr_2O_4$	Metals
Halogens	Iodide ion

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

* = Will come in external Exam

Day :

Date :

Electrolysis

It needs electricity in order → analysis "breaking down"

* Electrolysis :- Breaking down ionic compounds (aq) (molten) by passing electricity

Q: Why the solid ionic compounds ~~don't conduct~~ electricity

A: the ions are not free to move

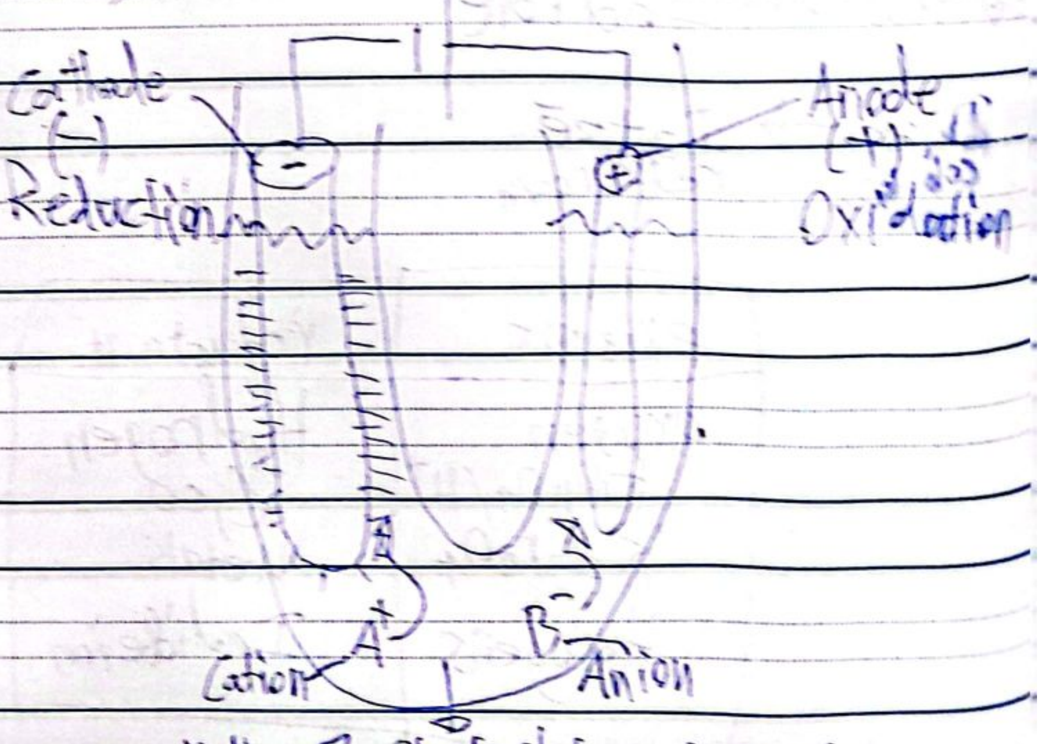
Why ionic compounds conduct electricity when molten

the ions are free to move

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

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

* Electrolyte :- Chemical compound that conducts electricity when molten or aqeous.



Molten & electrolyte → aqueous

Day :

Date :

* cathode :- Negative electrode that attracts positive ions where the reduction takesplace.

* Anode :- The positive electrode that attracts negative ions where the ~~[illegible]~~ oxidation takesplace.

$\boxed{\text{Electolysis = Discharging}}$

Cations

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

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

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

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

deposite of Metal

$2\bar{e} + 2H^{+} \rightarrow H_2$ (bubbles colorless)

$A^{+} + \bar{e} \rightarrow A$

Anions

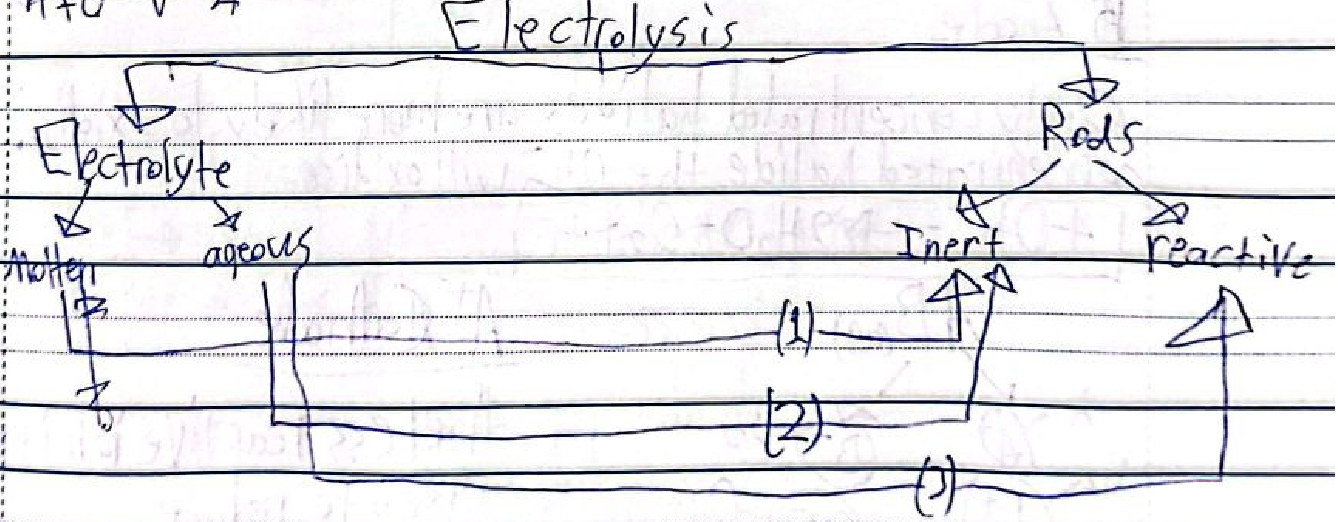
$2F^{-} \rightarrow F_2 + 2\bar{e}$ yellow gas

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

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

$2I^{-} \rightarrow I_2 + 2\bar{e}$ black solid, purple gas

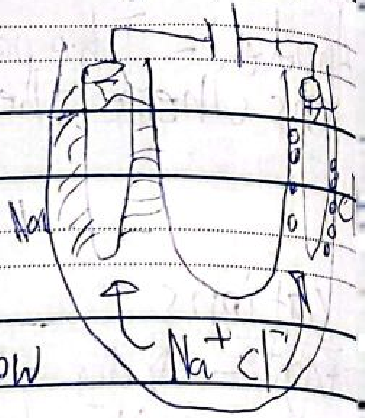
$2O^{-} \rightarrow O_2 + 4\bar{e}$ (Colorless gas)



Molten with inert rods

* Electrolysis for molten NaCl Using graphite

$NaCl_{(l)}$



total ions Na^+	Cl^-
Cathode	Anode
$\bar{e} + Na^+ \rightarrow Na$	$2Cl^- \rightarrow Cl_2 + 2\bar{e}$
deposit of Metal	bubbles of green-yellow gas produced

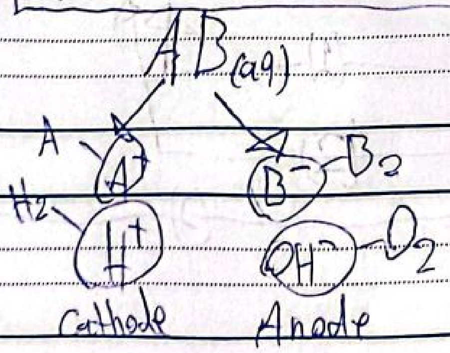
Electrolyte: Used up

Electrolysis for ageous electrolyte using grap

B^- Anode

Only concentrated halides are more likely to oxidise, concentrated halide the OH^- will oxidise

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



A^+ Cathode

the less reactive ion i
likely to reduce

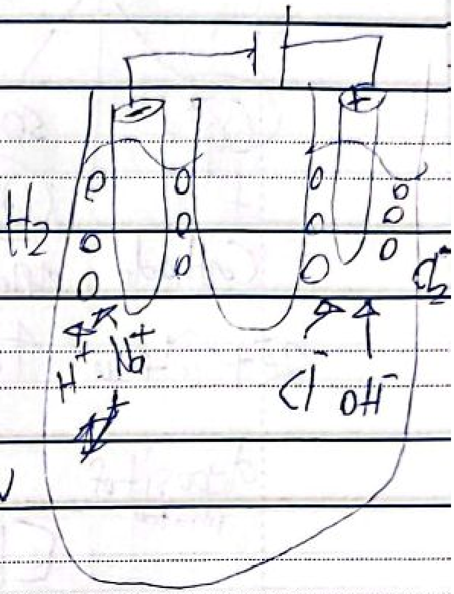
Day : .... Date : ....

Electrolysis for concentrated aqeous Sodium chloride

"Brine"

$NaCl_{(aq)}$

	Na^+	Cl^- Cl_2
H_2	H^+	OH^-
	Cathode	Anode
	$2\bar{e}+2H^+ \rightarrow H_2$	$2Cl^- \rightarrow Cl_2+2\bar{e}$
	bubbles of colorless gas	bubbles of green-yellow gas



Electrolyte: NaOH

Dilute $NaCl_{(aq)}$

$NaCl_{(aq.)}$

Na^+	Cl^-
H^+	OH^-
Cathode	anode
$2\bar{e}+2H^+ \rightarrow H_2$	$4OH^- \rightarrow 2H_2O+O_2+4\bar{e}$
Colorless gas	Colorless gas

Electrolyte: NaCl
more concentrated

$CuSO_{4(aq)}$ graphite

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

H^+ | OH^-

Cathode | anode

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

deposit of metal | colorless gas

Electrolyte: H_2SO_4

$KNO_{3(aq)}$

K^+ | NO_3^-

H^+ | OH^-

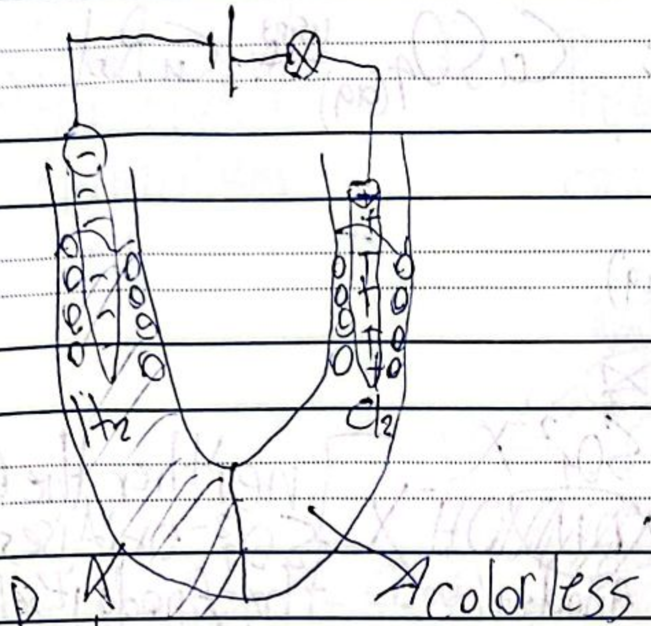
Cathode | anode

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

colorless gas | colorless gas

Electrolyte: KNO_3 more concentrated

Electrolysis for ~~aqeous~~ Brine solution ~~electrolyte using~~ With universal indicator



Cl_2 is a bleaching agent

NaOH is alkali

the Cl_2 delays in it's appearance

Some Cl_2 reacts with NaOH.

Electrolysis for aqeous electrolyte using a ro

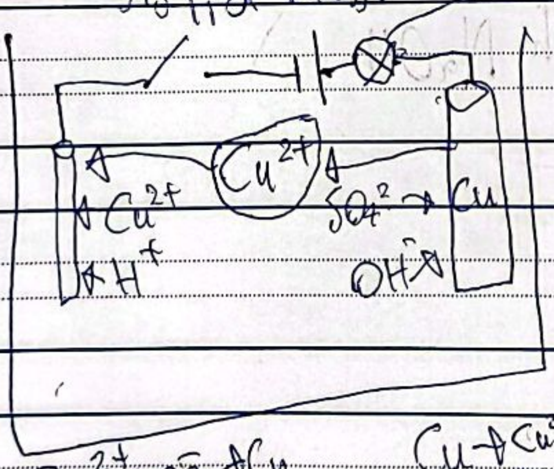
* the active rod made from the same ~~melted~~ metal in the electrolyte $CuSO_{4(aq)}$ $\xrightarrow{using}$ Cu Rod

$CuSO_{4(aq)}$

Cu^{2+}
H^+
Cathode
$Cu^{2+} + 2\bar{e} \rightarrow Cu$
deposite of red brown
Solid mass

SO_4^{2-} X
~~[illegible]~~ OH^- X
Anode
$Cu \rightarrow Cu^{2+} + 2\bar{e}$

neither the OH^- n SO_4^{2-} oxidises the Anode it's self wil oxidise



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

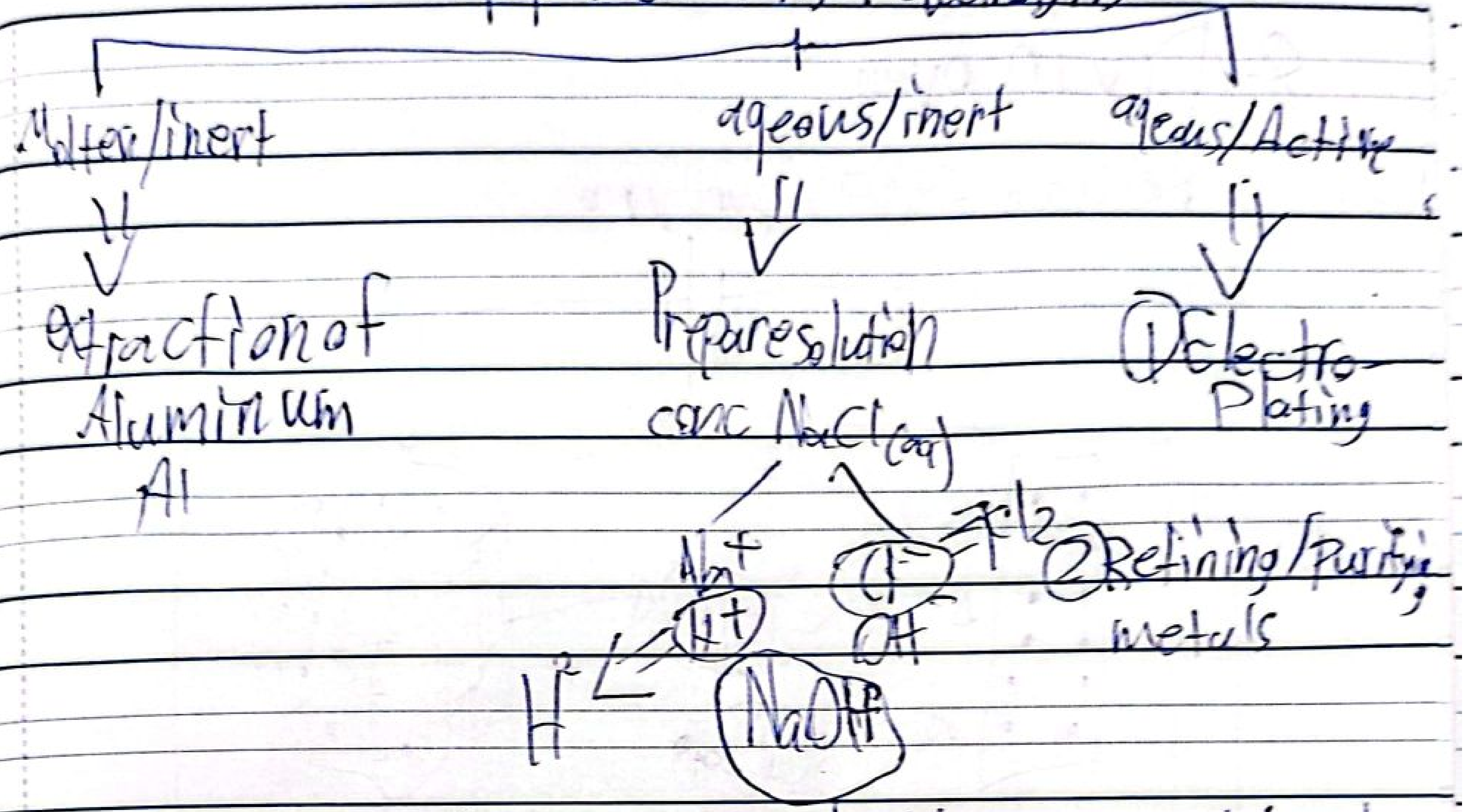
$Cu \rightarrow Cu^{2+} + 2\bar{e}$
to electrolyte
to Cathode through the wire

Cathode
Mass increases
Cu^{2+} reduced
Cu deposite

Anode
it's mas decrease
oxidise
loses el

electrolyte:-
Stays the the same because the anode oxidises and replaces the Cu^{2+} in the electrolyte at the same rate.

Applications of electrolysis



* Electroplating :- Coating a Metal with another metal using electolysis.

why? : ① to prevent rusting
② more attractive

How to electroplate a metal spoon with Ag ? :-

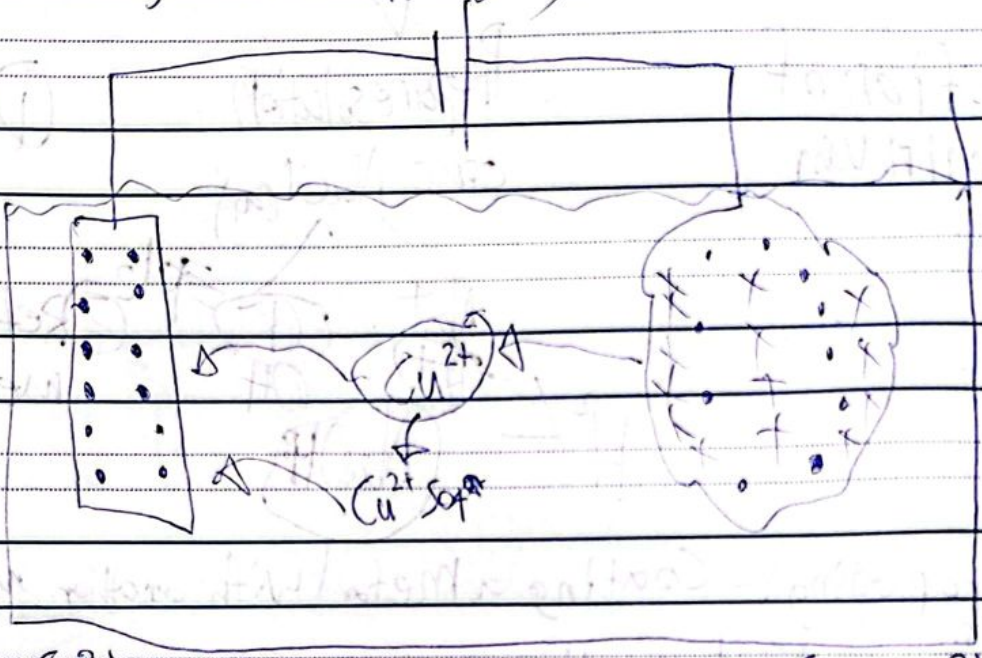
1- Clean the metal spoon from any impurities or oxide layers to ensure good sticking.
2- make the metal spoon the cathode.
3- make the Anode Ag.
4- the electrolyte must have Ag^+ e.g $AgNO_3$.
5- switch on the circuit.
6- Rotate the metal spoon to ensure an even distribution.
7- rinse with distilled water.

·Cu

x impurities: Ag, Au, Zn

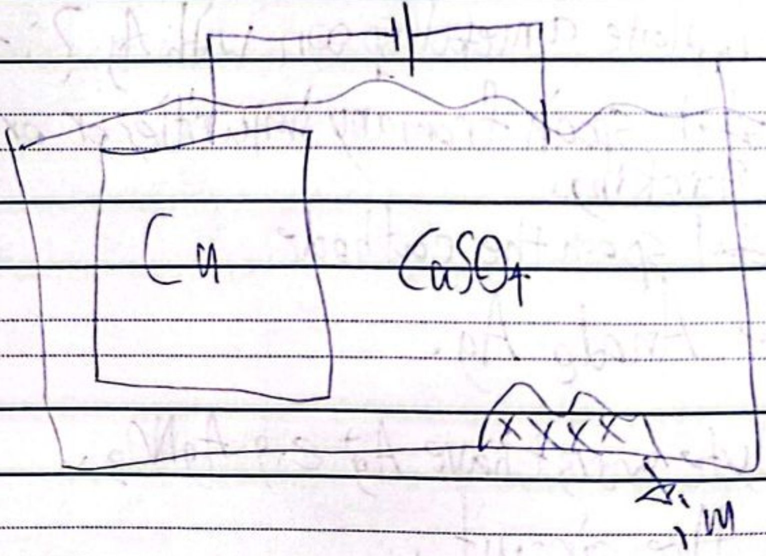
8- Dry in oven

Refining copper/purifying



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

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



Ag, Au: settled they are less reactive than Cu

Zn: displaces Cu from $CuSO_4$

Extraction of metals :-

* The method of extraction of the metal from it's ore depends on the position of this metal in the reactivity serier.

Common names:	ore:		
		K	Electrolysis/Molten/graphite
		Na	
		Li	
		Ca	
		Mg	
Bauxite ←	Al_2O_3 ←	Al	
		C, CO	
Zincblende ←	~~#~~ ZnS ←	Zn	reduction by C, CO
Hematite ←	Fe_2O_3 ←	Fe	
		Pb	
		H	
Copper sulfide ←	CuS ←	Cu	reduction by H_2
		Ag	
		Au	

Extraction of Al

ore: Bauxite Al_2O_3

Method: Electrolysis for molten ore using ~~eg~~ graphite

* ~~[illegible]~~ the m.p. of bauxite is 2000°C

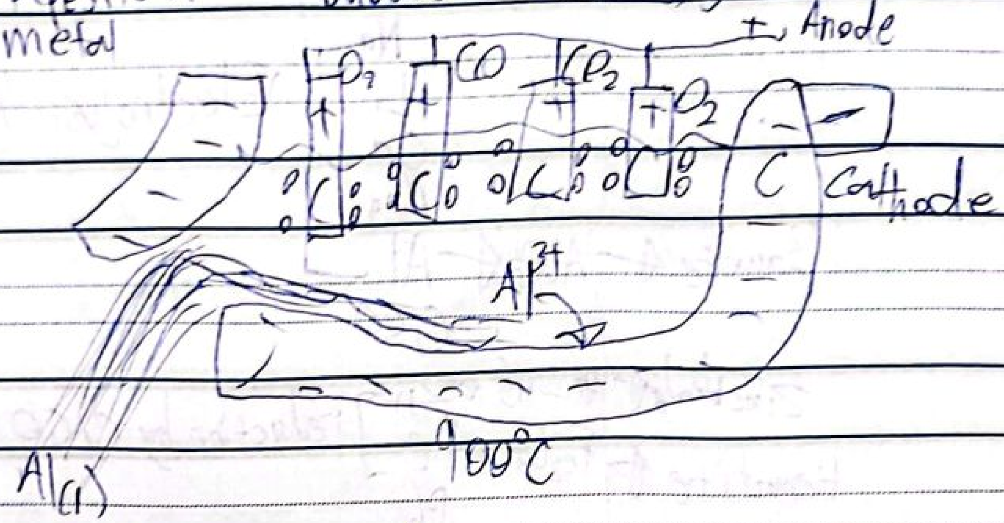
So we dissolve Bauxite in molten cryolite Na_3AlF_6, why?

1- To lower the m.p. to 900°C 2- to increase electrical conductivity.

$Al_2O_{3(l)}$

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

Cathode	Anode
$Al^{3+} + 3\bar{e} \rightarrow Al$	$2O^{2-} \rightarrow O_2 + 4\bar{e}$
Deposite of metal	bubbles of color less gas



gasses produced at anode

1- O_2

2- CO_2

3- CO

reaction of Anodes with O_2, so we must replace Anodes periodically.

Property of Al	Use of Al
malleable	window frame, cooking u
low density	Aircraft bodies
forms a non-toxic oxide layer	food cans
conduct electricity ductile	electrical wire

Day : .... Date : ....

Rusting:-

the reaction of ion with both H_2O and O_2

$\overset{0}{Fe} + \overset{0}{O_2} \xrightarrow{H_2O} \overset{+3}{Fe_2}\overset{-2}{O_3} \cdot n\ H_2O$

oxidation

two rust prevention solutions A and B

Plan an exp to show which is better:-

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

Rust Prevention

① Paint
② oiling
③ greasing
④ cover with plastic

(prevent H_2O & O_2 from reacting with Fe)

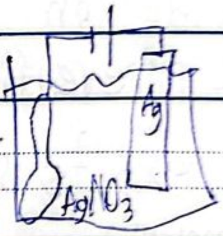
Day : .... Date : ....

⑤ galvanizing

(coating)

⑥ sacrificial protection

⑦ Electro plating



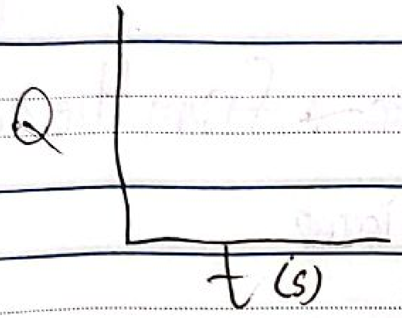
⑧ Cathodic protection

Zn & Mg are more reactive than Fe

Zn & Mg are more likely to oxidise

Rate of reaction:-

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



$\frac{\Delta pH}{\Delta t} = \frac{1}{s}$

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

$\frac{\Delta \text{Volume of gas}}{\Delta t} = cm^3/s$

$\frac{\Delta mass}{\Delta time} = g/s$

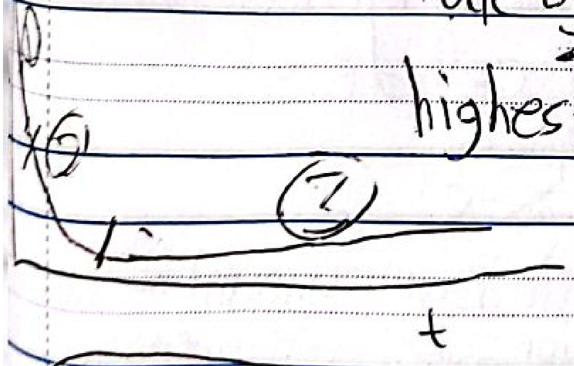
$\frac{\Delta temp}{\Delta t} = °C/s$

$\frac{\Delta \text{electric conductivity}}{\Delta t} = \frac{1}{s}$

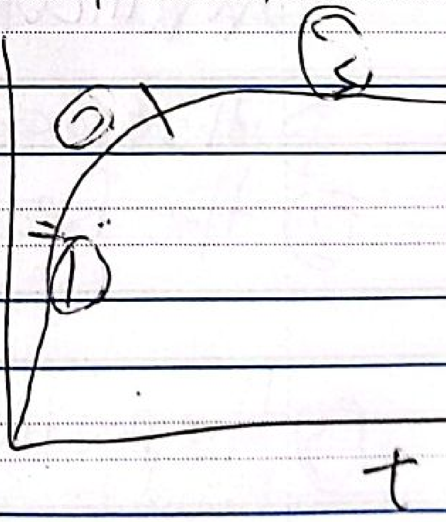
to measure rate of reaction

measure how fast the reactants consumed per unit time

Measure how fast the product produced per unit time



Rate of reaction① = highest



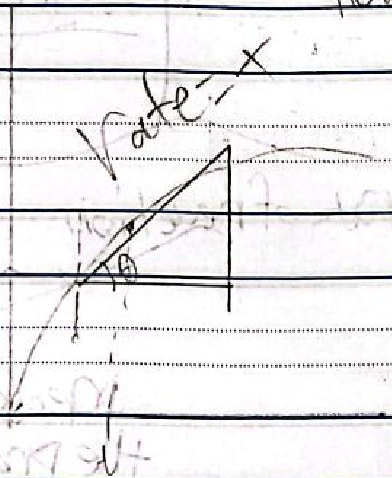
→ more reactants
=
more particles
more collisions per unit time

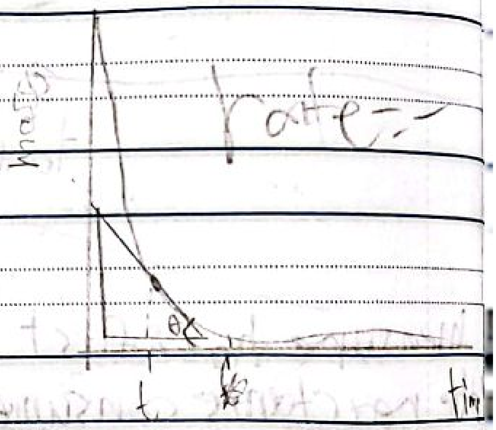
Day : .... Date : ....

Region 2 the rate is slower → less reactants = particl = less collisions / unit time

region 3 the reaction is over → from the curve = hori line = grad
= no more limiting reactant = no more collisions

from the graph below
How to measure the rate

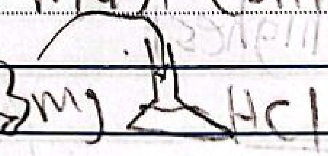




3 main conditions for any chemical reactions:-

① the reactants must be suitable Cu + HCl → no rxn.

② the Reactants must collide



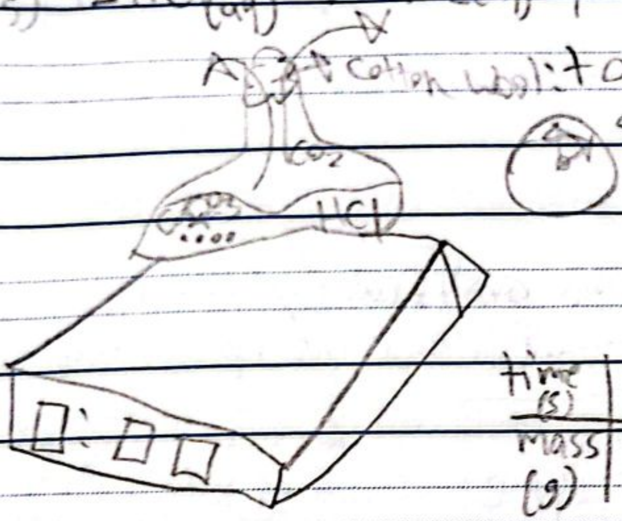
③ The particles have a minimum amount of energy needed to start the reaction = Activation energy.

Bruh!

Day :
Date :

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

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

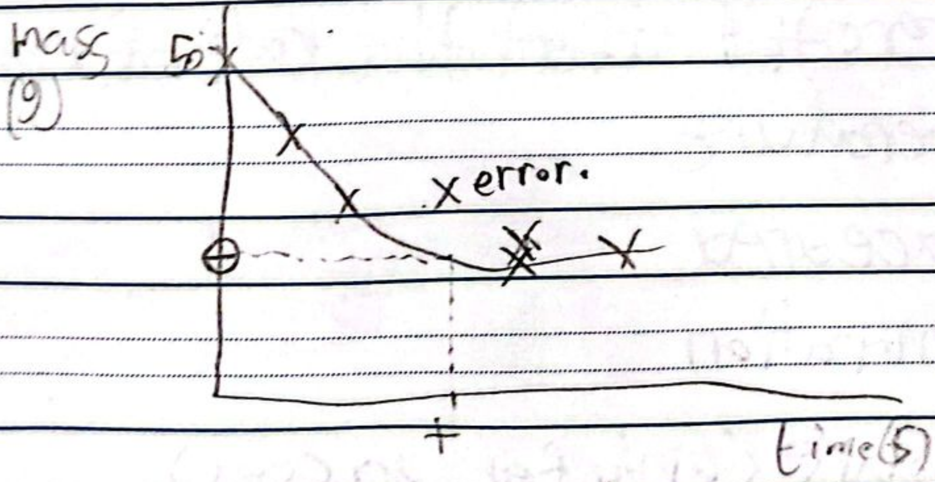


: to allow CO_2 to escape and prevent splashing

?why the mass ↓?
CO_2 escapes

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

−5 −3 −1 −0.5

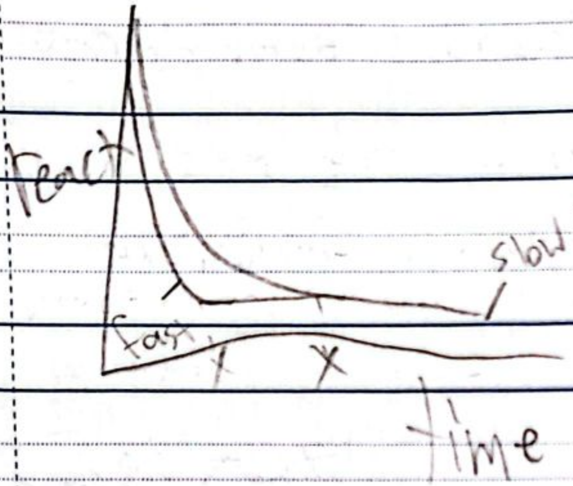


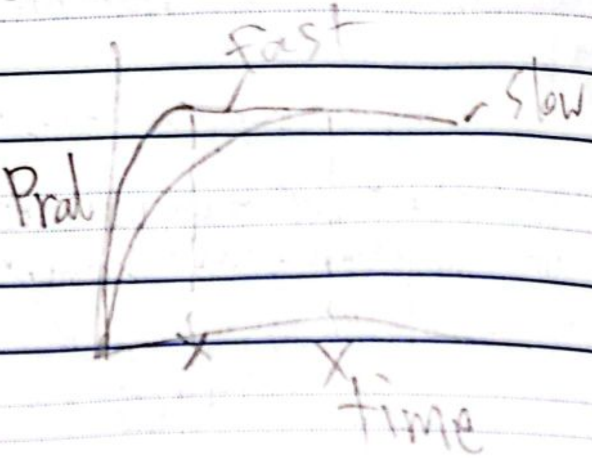
Day : .... Date : ....

Increasing the rate of reaction

Same product with less time / more product in the same time.

faster rate = steeper curve





Factors that affect the rate of rxn:-

① Temperature
② surface area
③ concentration
④ Pressure (only for gasses)
⑤ light
⑥ catalyst

ation energy

Day : Minami ina shimawa Attokaii
Paina purupuru Attamapokapaa Date :

LOL

AHOBaka!!

① Temperature :-

- State how the temp affects the rate of rxn:

faster rate of reaction as the temperature increase.

- explain how the temp affects the rate of rxn:

As the temperature increases the particles gain k.E, so move faster. so particles will have energy ≥ E_a, more effective collisions and faster rate of reaction.

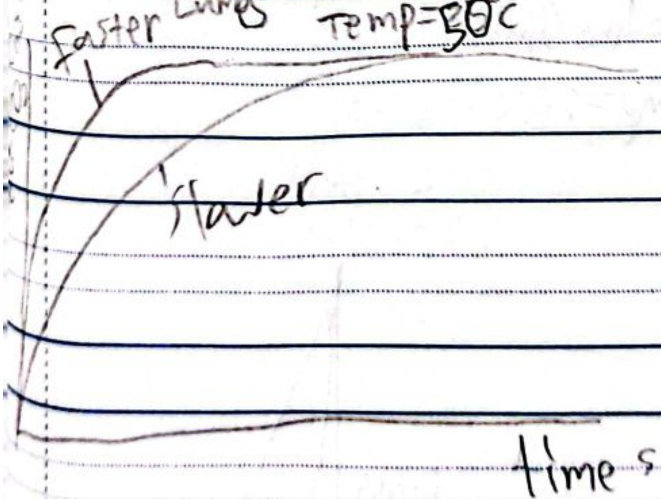
- Plan an exp to show how the temp affects the rate of rxn:

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

Exp1: $m_{CaCO_3} = 2g$ Lumps
$V = 0.1 dm^3$
$M = 0.1 mol/dm^3$
Temp = 25°C

Volume of CO_2 produced per unit time

Exp2: $m_{CaCO_3} = 2g$ Lumps
$V = 0.1 dm^3$
$M = 0.1 mol/dm^3$
Temp = 30°C



Day :

Date :

② Surface area:-

- State how the surface area affects the rate of reaction

As the surface area increases, the rate of reaction increases by reducing the particle size by crushing using mortar and pestile.

- explain how surface area affects the rate of reaction:

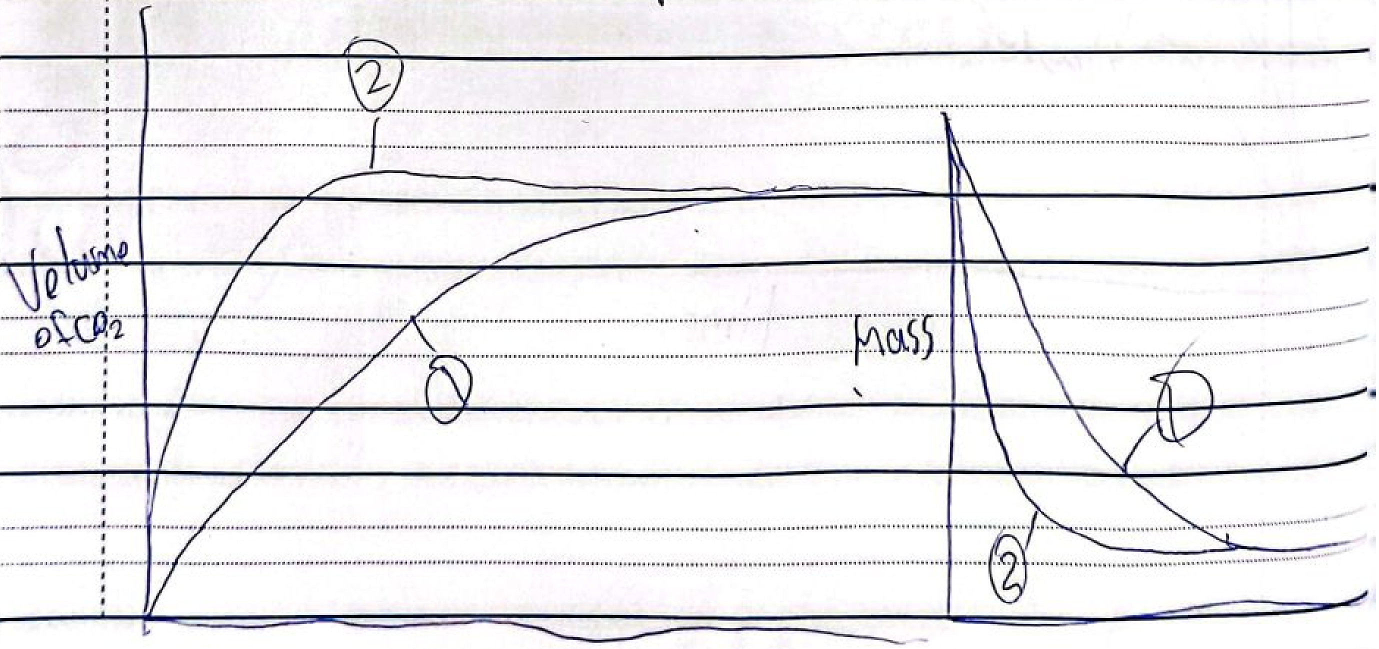
As the surface area increases, more particles exposed to the reaction, so more effictive collisions per unit time, so faster rate of

- Plan an exp to show how the surface area affects the rate of rxn:

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

exp 1
mass = 2g
lumps
$V_{HCl} = 0.1 dm^3$
$M_{HCl} = 1 mol/dm^3$
Temp = 25°C

exp 2
mass = 2g
Powder
$V_{HCl} = 0.1 dm^3$
$M_{HCl} = 1 mol/dm^3$
Temp = 25°C



③ concentration:-

- State how the concentration affects the rate of rxn:

As the conc. increases, the rate of reaction increases.

- explain how the conc. affects the rate of rxn:

As the conc. of reactant increases, more particles, so more effective collisions per unit time, so faster rate of reaction.

- plan an exp to show how the conc. affects the rate of rxn:

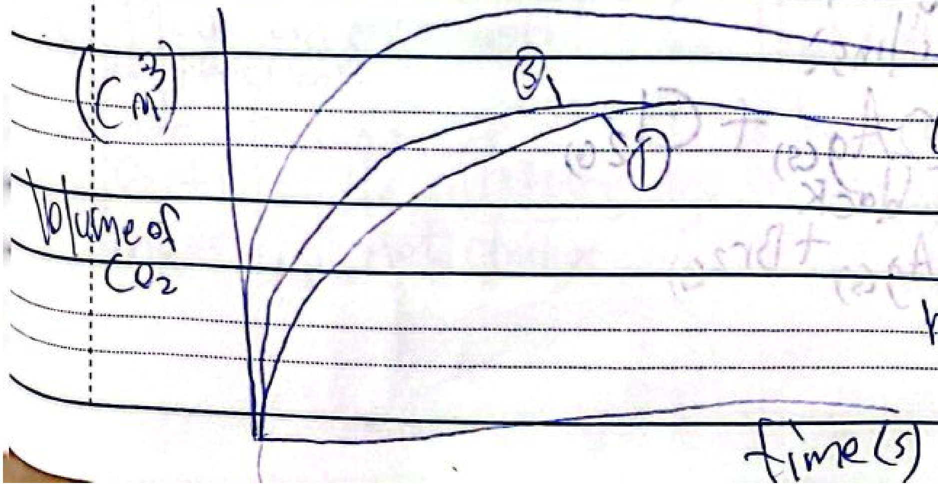
$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

$\downarrow$ needed

exp1 mass 2g lumps
VHCl = 0.1dm³
MHCl = 0.1mol/dm³
Temp = 25°C

exp2 mass 2g lumps
VHCl = 0.1dm³
MHCl = 0.2mol/dm³
Temp = 25°C

exp3 mass 4g lumps
VHCl = 0.1dm³
MHCl = 0.1mol/dm³
Temp = 25°C



② More limiting = faster rate and more product.

more excess = faster rate.

Day : .... Date : ....

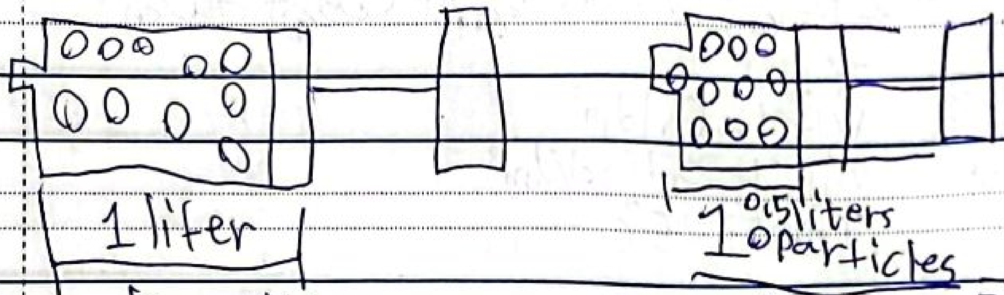
④ Pressure:- "only for gasses"

- State how pressure affects the rate of rxn:

As pressure increases, the rate of reaction increases.

- explain how pressure affects the rate of rxn:

as the pressure increases, by lowering the volume, more particles per unit volume. So more effective collisions per unit time. So faster rate of reaction.



$\frac{10 \text{ particles}}{1 \text{ Liter}} = 6$

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

⑤ Light:- "Photochemical reactions"

- Photosynthesis:

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

(not included)

- Photographic films:

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

black

$2AgBr_{(s)} \xrightarrow{\text{light}} 2Ag_{(s)} + Br_{2(g)}$

Day : .... Date : ....

6) Catalyst: chemical substance that speeds up the rate of rxn without being used up.

Enzyme: Biological catalyst.

How? it provides an alternative pathway with lower Ea, so more particles will have energy equal to or greater than Ea, So more effective collisions per unit time, so faster rate of rxn.

Ea: the ~~main~~ min amount of energy needed to start the rxn

↑Ea slower rate

↓Ea faster rate

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

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

* Known volume of known conc of H_2O_2

* Add a known mass of CuO

* measure amount of oxygen produced per unit time

* repeat the exp without CuO

* the exp with CuO produce more O_2 per the same unit time.

Q2:- plan an exp to show which catalyst is better CuO or MnO_2

* Known volume of known conc of H_2O_2

* Add known mass of CuO

* measure volume of oxygen per unit time

* repeat the exp with same mass of MnO_2

~~per~~ * the exp that produces more O_2 per unit time is the better catalyst.

Q3: Plan an experiment to show that the CuO isn't used up during the reaction!-

* Add a known mass of CuO to H_2O_2 until no more bubbles of O_2, filter the mixture, dry in oven, remeasure the mass, the mass will not change.

Reversible Reaction

Chemical Reactions

One way

Reactants $\xrightarrow{forward}$ Products

$Mg + HCl \rightarrow MgCl_2 + H_2$

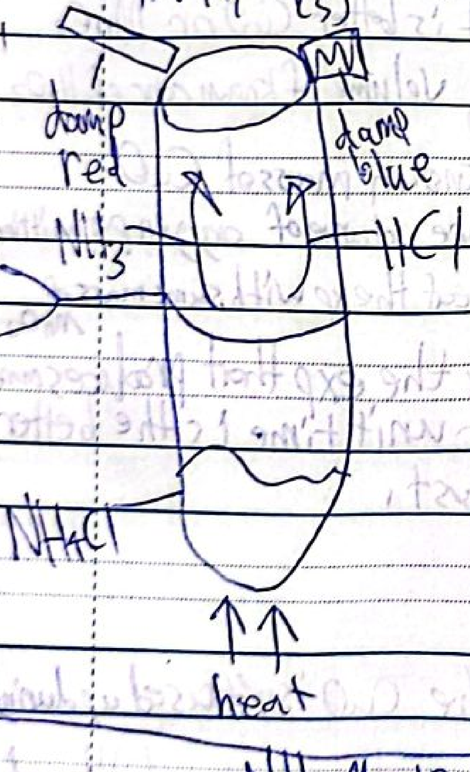
$NH_4Cl_{(s)} \xrightarrow{heat} NH_{3(g)} + HCl_{(g)}$

Both ways

$Reactant \underset{backward}{\overset{forward}{\rightleftarrows}} Products$

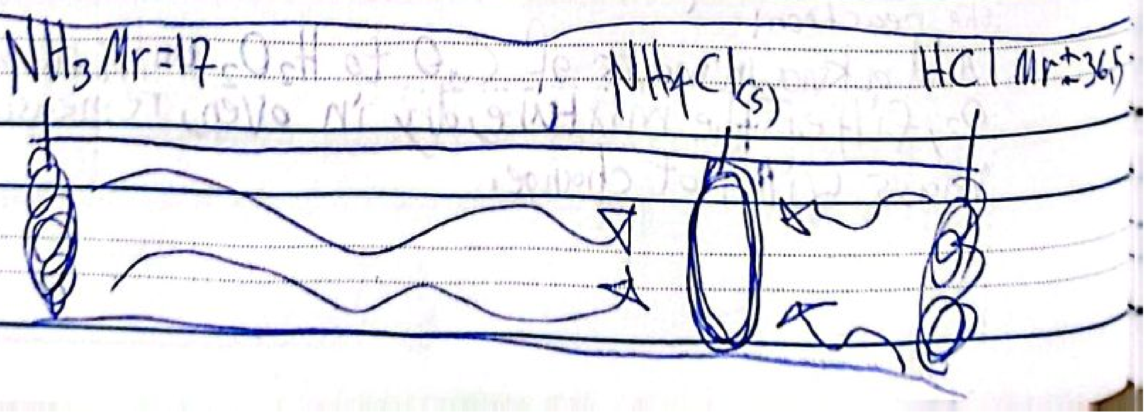
$3H_2 + N_2 \rightleftarrows 2NH_3$

$NH_4Cl \rightleftarrows NH_3 + HCl$

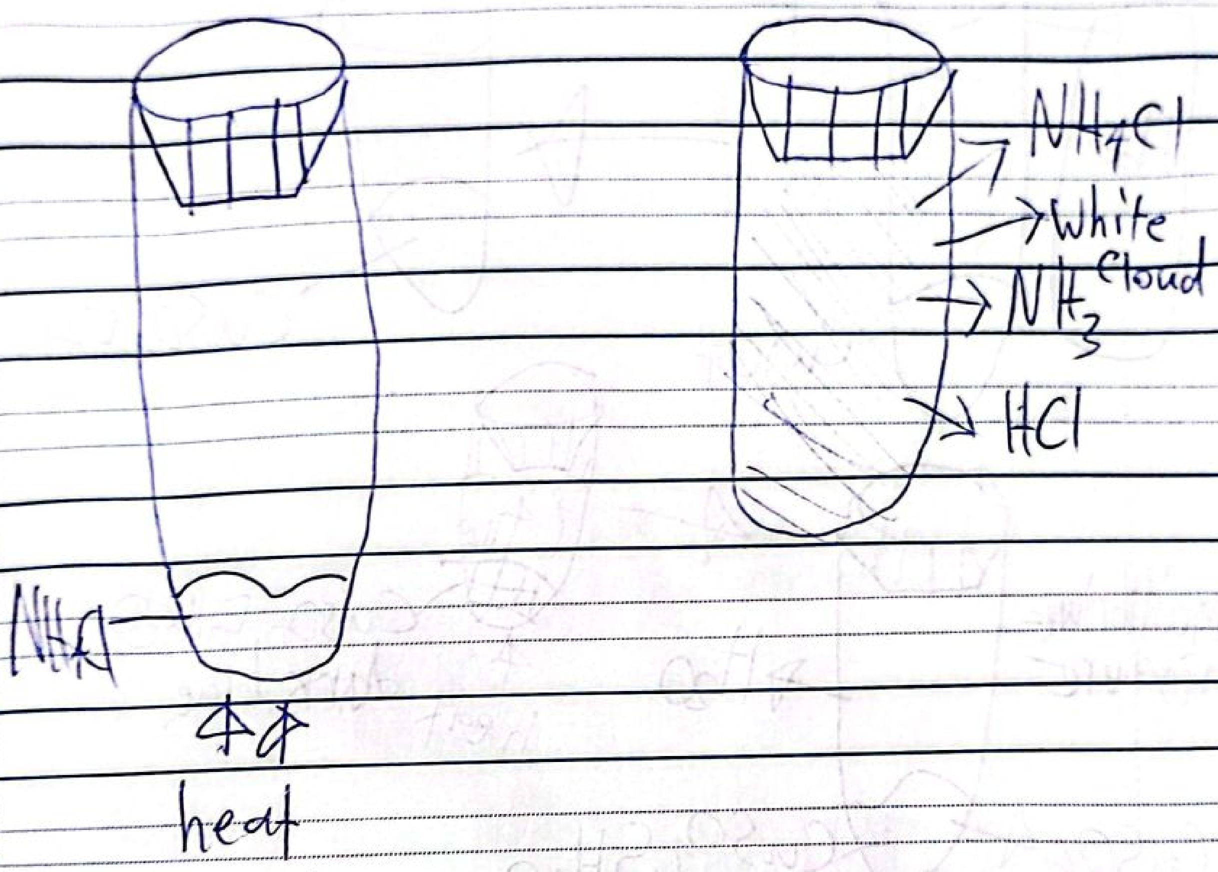


Q:- Which damp litmus paper will change it's color first, explain your answer

The damp red litmus paper changes to blue first since NH_3 is Alkali and lighter than HCl which is acidic.

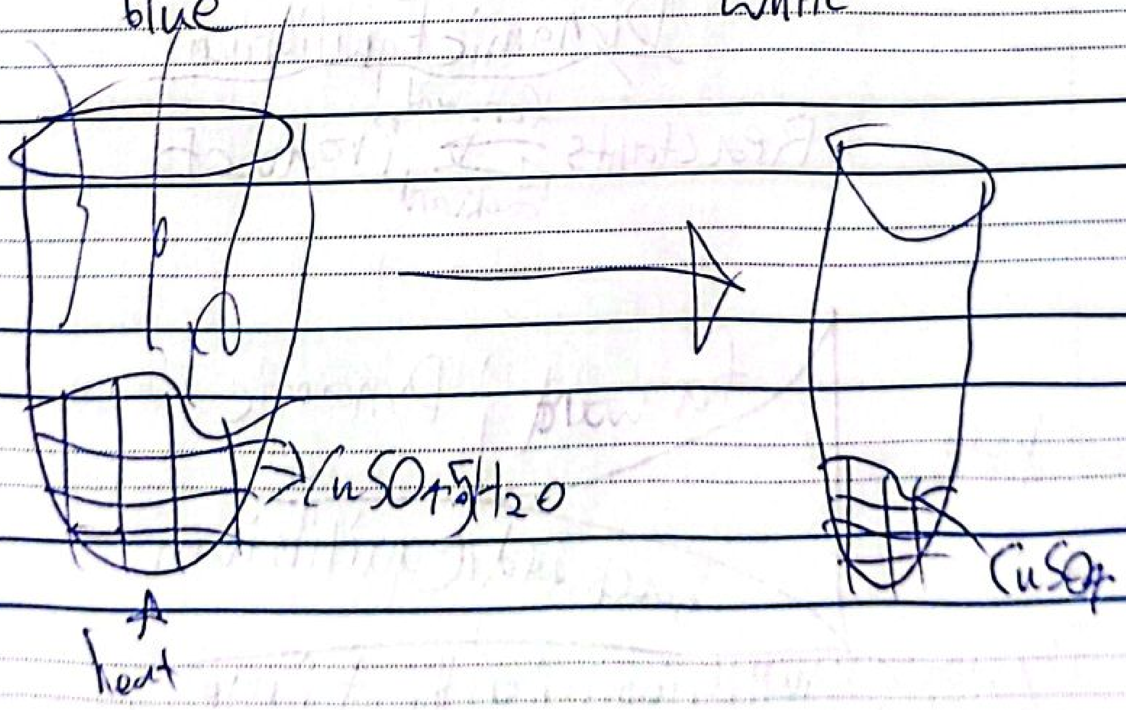


$NH_4Cl_{(s)} \rightleftharpoons NH_{3(g)} + HCl_{(g)}$

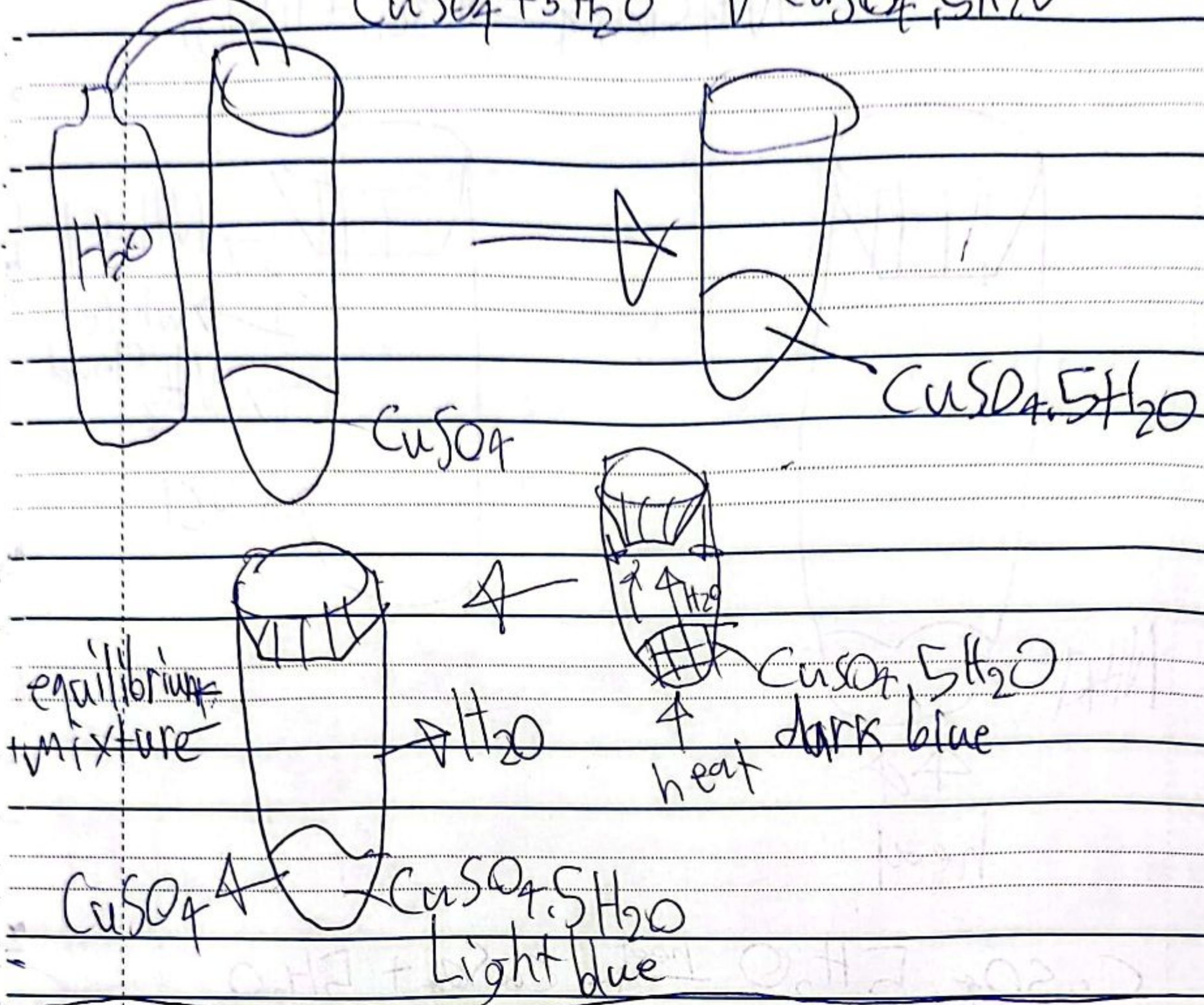


$CuSO_4 . 5H_2O \xrightarrow{heat} CuSO_4 + 5H_2O$

blue   white

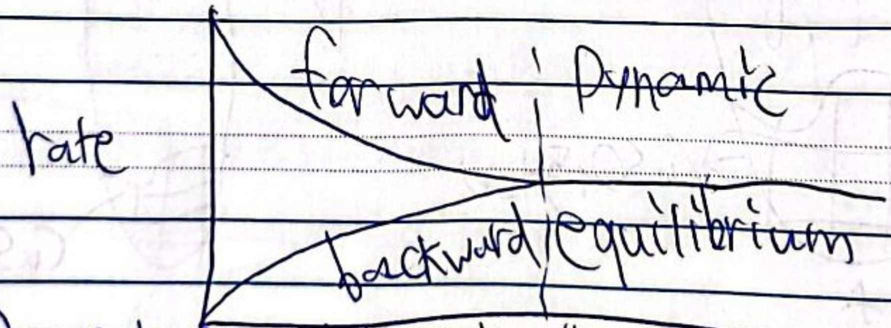


$CuSO_4 + 5H_2O \rightarrow CuSO_4.5H_2O$



Dynamic Equilibrium

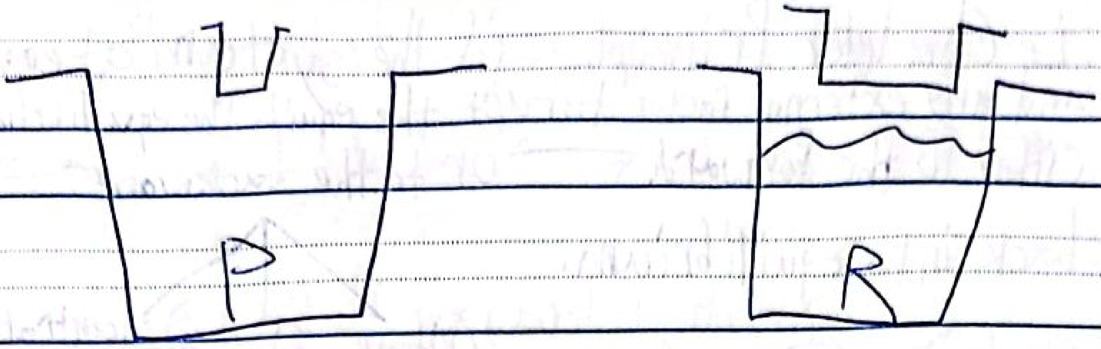
$$\text{Reactants} \underset{\text{backward}}{\overset{\text{forward}}{\rightleftharpoons}} \text{Product}$$

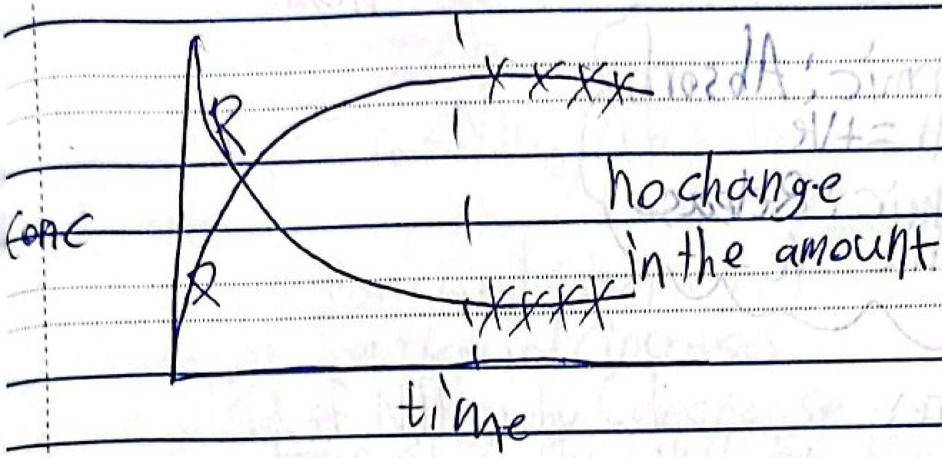


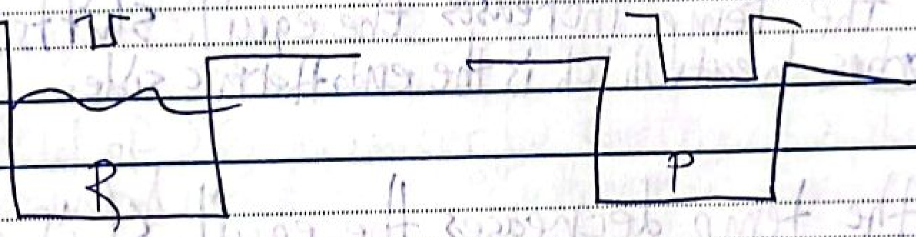
Dynamic equilibrium when the time
rate of forward equals the rate of backwards.

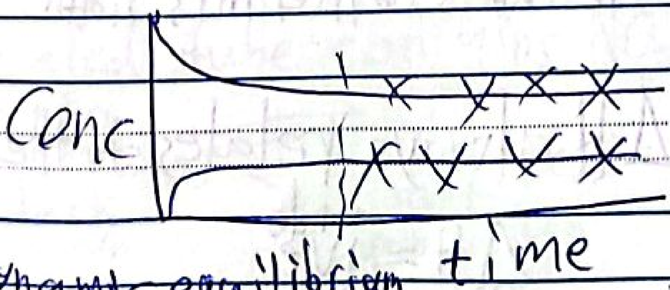
EZP2

Day : .... Date : ....



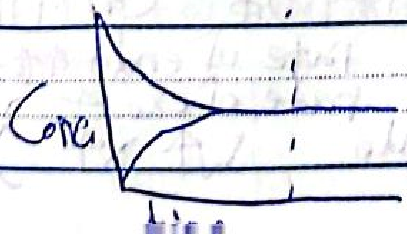






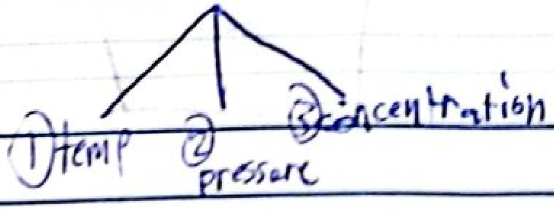
Dynamic equilibrium

in terms of concentration: when the concentration of reactants and products are constant.



Day : .... Date : ....

Le Chateler Principle:- if the system is at equilibrium ⇌ and any external factor disrupt the equil, The equilibrium shifts it's either to the forward ⇌ → or to the backward ⇌ → to turn back into equilibrium.



Endothermic: Absorb
ΔH = +ve
Exothermic: Release
ΔH = -ve

① Temperature:-

As the temp increases the equil. shifts to the side that Absorbes heat which is the endothermic side.

As the temp decreases the equil. shifts to the side that Releases heat which is the exothermic side.

* The sign of ΔH always relates to the forward reaction.

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

↑ shifts forward to the endo side

rate of endo ↑↑
rate of exo ↑

A↓ B↓ C↑ D↑

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

rate of endo ↑↑
rate of exo ↑

↑ temp shift backward to the endo

W↑ X↑ Y↓ Z↓

Date :

↓temp, shift forward to the exo

rate of endo ↓ W↓ X↓ Y↑ Z↑

rate of exo ↓

↓temp, Shifts backward to the exo

rate of ~~endo~~ forward ↓ A↑ B↑ C↓ D↓

rate of ~~exo~~ backward ↓

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

↑ Temp

1) Rate of forward (increase)

2) Rate of backward (increase)

3) the yield of NH_3, why (decrease

increase temp, shifts the equil. to the backward to the endo.

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

the yield of SO_3 increases by cooling, explain why?

The forward reaction is exothermic, favoured by cooling.

Sealed tube contains NO_2 and N_2O_4 at equil.

$\underset{\text{dark brown}}{2NO_{2(g)}} \rightleftharpoons \underset{\text{light brown}}{N_2O_{4(g)}}$

if we put this tube in a cold water bath the color becomes ~~to~~ paler, explain why?

since the forward reaction is exothermic, favoured by cooling.

② Pressure:- ↑pressure ⇒ shift to the side with less press
less gas moles

↓pressure ⇒ shift to the side with more pressure.

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

↑ shift forward to the side with less gas mole.

↓ shift backward to the side with more gas moles

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

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

↓ shift forward to the side with more gas moles

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

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

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

↓pressure rate of less gas mole ↓↓ } shift to more gas
rate of more gas mole ↓ } mole

Q complete the table :-

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

effect	Rate of forward	Rate of backward	yield of NH
↑temp	↑	↑↑	↓
↑pressure	↑↑	↑	↑
↓pressure	↓	↓↓	↓

1- Thereaction $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ at equilibrium
Purple Colorless

1) why by increasing the pressure the position of equilibrium does not change: Because both sides of the reaction both have the same number of gas moles.

why by increasing the pressure the mixture becomes more purple
The gas particles of I_2 became closer together and the color appears more condensed.

Mixture of NO_2 and N_2O_4 at equil in a tube

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

by increasing the pressure mixture

1) becomes darker and stays darker.

) " " " darker " " goes darker.

) " " " Paler " " stays Paler.

) " " " Paler " " goes darker.

③ Concentration:-

$A+B \rightleftharpoons C+D$

$\uparrow[A]$ shift forward | $\uparrow[C]$ Shift backwards

$B\downarrow$ $C\uparrow D\uparrow$ $A\uparrow B\uparrow D\downarrow$

$$\overbrace{3H_{2(g)}+N_{2(g)}}^{4\text{ mols}} \underset{\text{endo}}{\overset{\text{exo}}{\rightleftharpoons}} \overbrace{2NH_{3(g)}}^{2\text{ mols}} \qquad \Delta H \overset{\text{exo}}{=} -ve$$

Temp 400-450°C

Pressure 200 atm

Concentration add excess H_2 & N_2
Remove NH_3 immediately (condensation)

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

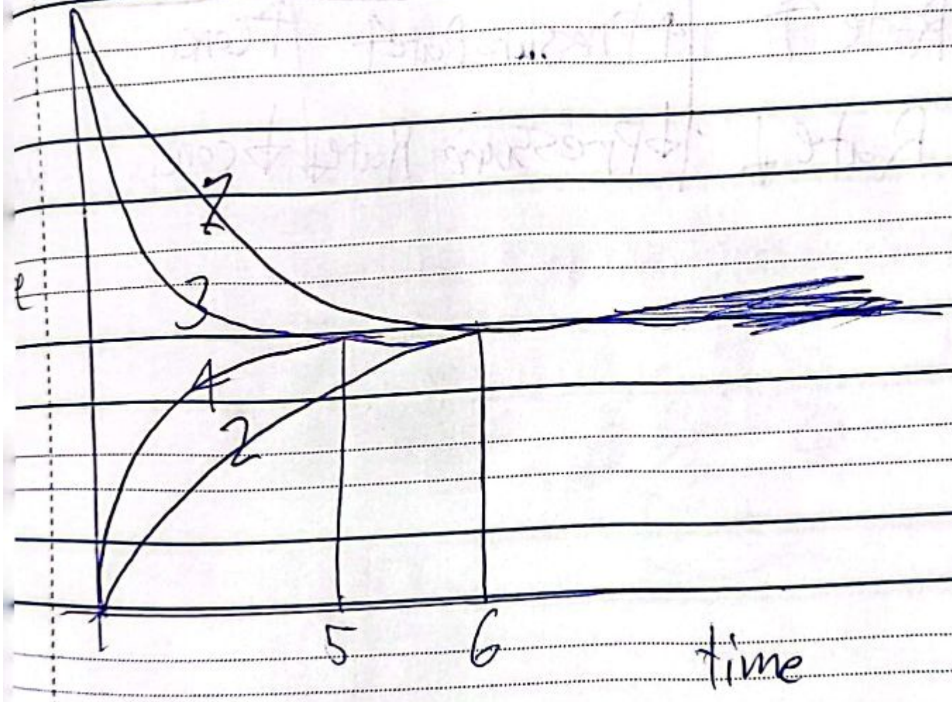
add HCl, acid, Proton donor } $\uparrow H^+$ shift backward
More HIn more color 1
less In^- less color 2

add NaOH, proton acceptor, $OH^- + H^+$ } $\downarrow H^+$ more In^- More color 2
less HIn less color 1
Shift forward

* Catalyst.

has no effect on the equilibrium because it speeds up the rate of forward and backward.

so it causes the equil. to occur with less time.



1) rate of forward without catalyst 2) rate of backward without catalyst
3) Rate of forward with catalyst 4) Rate of backward with catalyst
5) time taken to reach equil. with catalyst.
6) time taken to reach equil. without catalyst.

Position of equil.

Temperature	Pressure	Concentration
↑ temp shift to endo ↓ temp shift to exo	↑ Pressure shift to less gas moles ↓ Pressure shift to more gas mole	↑R ↓P } shift forward ↓R ↑P } shift backward
↑ Temp Rate ↑	↑ Pressure Rate ↑	↑ conc Rate ↑
↓ Temp Rate ↓	↓ Pressure Rate ↓	↓ conc Rate ↓

Energetics (Energy in chemical reaction)

Energy: Ability to do work

input > output
Endothermic
output > input
Exothermic

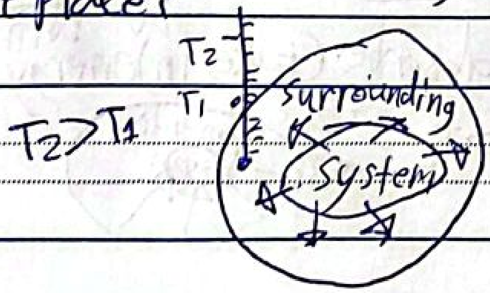
in chemical Rxn,

- to breakdown bonds in Reactants
  - Input
  - Absorb
  - take in
  - endothermic
- to buildup the bonds in the Products
  - output
  - Release
  - give out
  - Exothermic

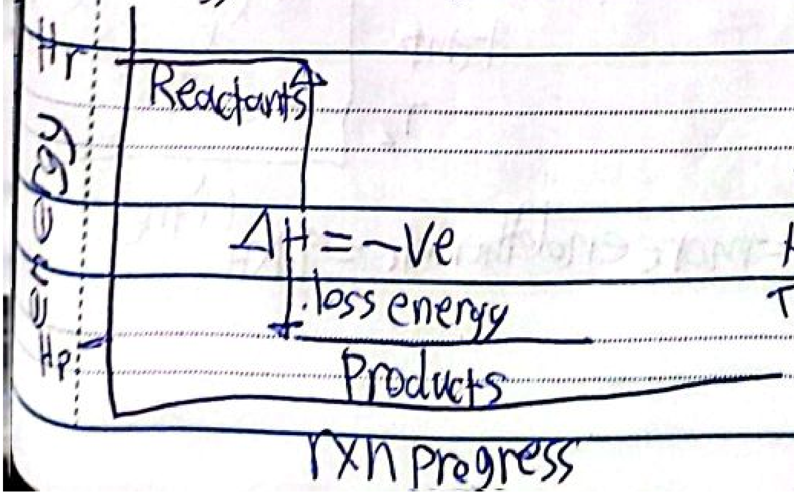
Enthalpy: Heat contents stored in bonds.

Exothermic Reactions:-

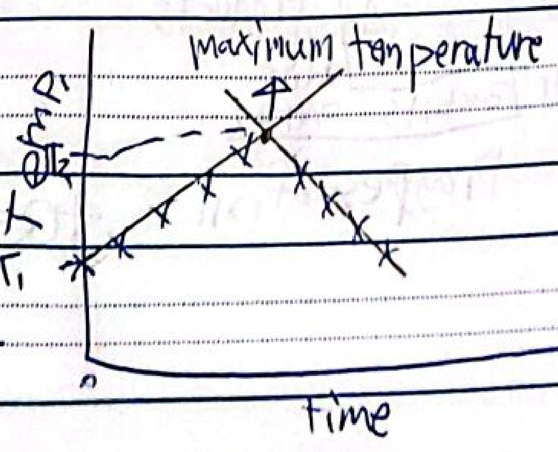
Reaction that releases (gives out) energy to the surrounding when they take place.



for system
Energy level diagram:-



for surrounding
temperature diagram:-



$Q = mC\Delta T$ $\uparrow Q$ = More exothermic = $\uparrow \Delta H$

Q → energy (J)
m → Mass (g)
C → Specific heat capacity
ΔT → change in temperature

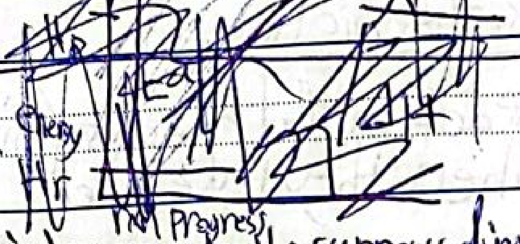
C_{water} = 4,2 J/g°C

Examples:-
1 - combustion
2 - displacement
3 - neutralization
4 - respiration
5 - freezing, condensation
6 - voltaic cell
7 - building up bonds

Exothermic Reactions:-

How to express exothermic reactions

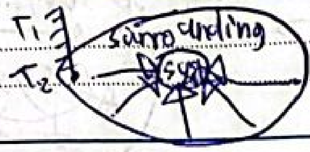
① Reactants → Products + energy
② Reactants → Products ΔH = -ve
③ Profile diagram:-



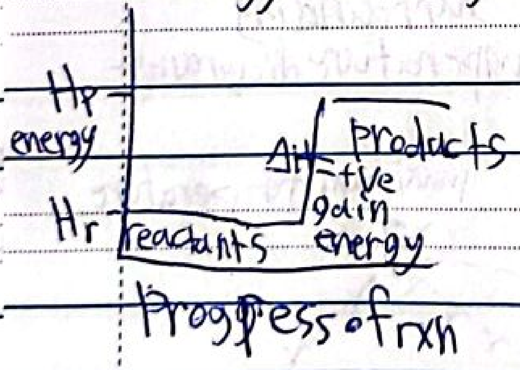
endothermic reactions:-

Reaction that absorbes (takes in) energy to the surrounding when they take place.

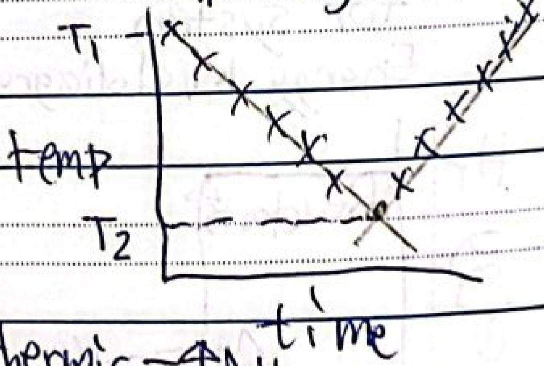
$T_1 > T_2$



for system
Energy level diagram



for surrounding
Temp diagram



$\uparrow Q$ = more endothermic = $\uparrow \Delta H$

Day : Date :

Examples:-

1- Photosynthesis
2- Photographic films
3- thermal decomposition
4- electrolysis
5- boiling, melting
6- breaking down bonds

Endothermic Reactions:-

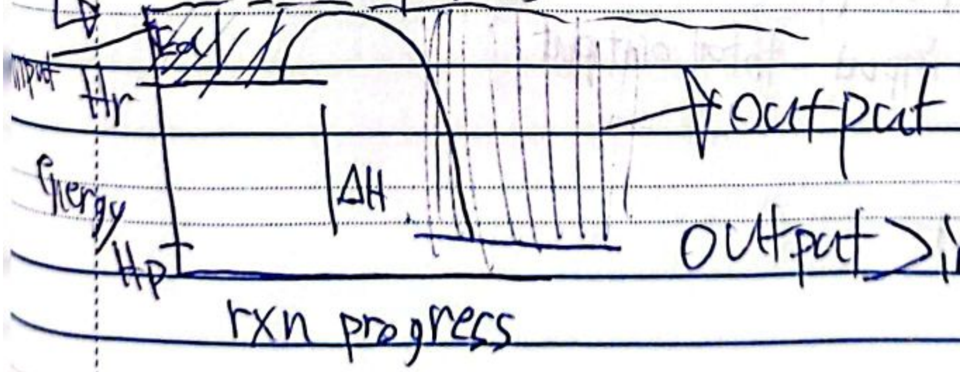
* How to express Endothermic Reactions:-

① ~~Reactant gives out product Reactants + energy → Products~~

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

③ Profile diagram:-

input > output



output > input

Day : .... Date : ....

measuring ΔH_{rxn} using bond energy:-

Bond	bond energy kJ/mol
H-H	436

(endo)

bond breaking $H\text{-}H_{(g)} + 436kJ \rightarrow H_{(g)} + H_{(g)}$

(exo)

bond building $H_{(g)} + H_{(g)} \rightarrow H\text{-}H_{(g)} + 436kJ$

Bonding energy:-

The amount of energy needed to break 1 mol of bond in gaseous state. ~~or the amount that energy needed to~~ or The amount of energy ~~released~~ released when building 1 mol of bond in gaseous state.

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

ΔH = total input - total output

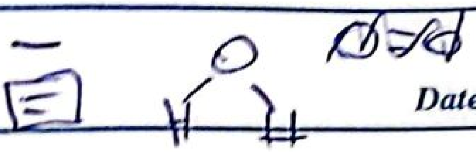
$+$ endo input>output

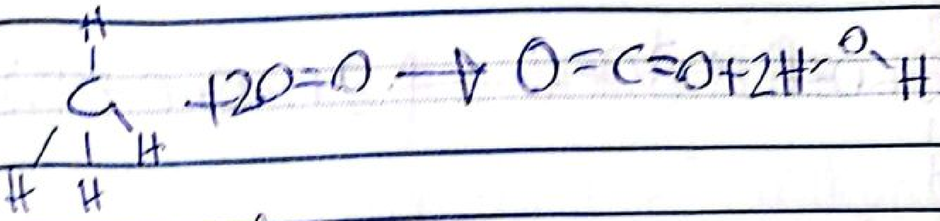
$-$ exo output>input

2644

3450

Date :





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

bond broken:-

$4 \times C{-}H$ } 4×413
$2 \times O{=}O$ } $2 \times 496 +$
2644kj

bond formed:-

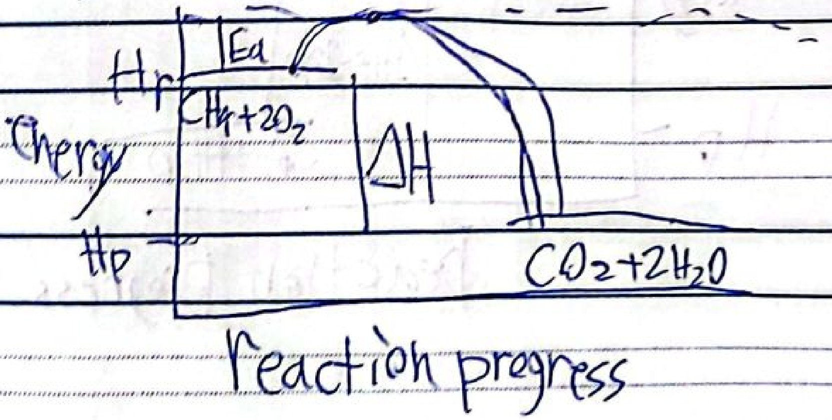
$2 \times C{=}O$ } 2×799
$4 \times O{-}H$ } $4 \times 463 +$
3450kj

ΔH = input − output
= 2644 − 3450
= −806 kj/mol

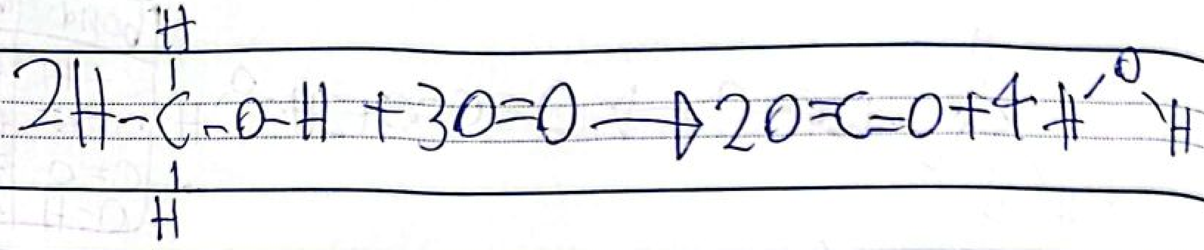
① $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + 806$ kj/mol

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

③ profile diagram



Day : Date :



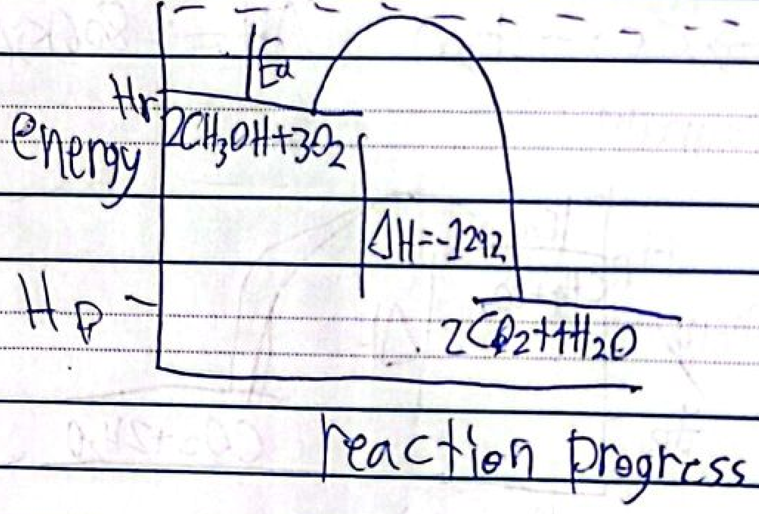
$$2H-\overset{H}{\underset{H}{C}}-O-H + 3O=O \longrightarrow 2O=C=O + 4H-O-H$$

bonds broken:- bonds built:-

$6\times C-H$ } 6×413
$2\times C-O$ } 2×358
$2\times O-H$ } 2×463 +
$3\times O=O$ } 3×496
~~4120kj~~
5608 kj 5608

$4\times C=O$ } 4×799
$8\times O-H$ } 8×463 +
6900kj

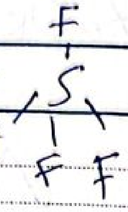
$\Delta H =$ ~~4120~~ 5608 $- 6900$
-1292kj
$\Delta H =$ ~~-2780~~ kj/mol
exothermic reaction



Sulfur reacts with florine to give sulfur tetrafloride and release 780kj/mol

if the bond energy for F-F is 160kj/mol draw a profile diagram for this reaction and find the energy for S-f

$S+2f-F \rightarrow$



$2 \times f-f = 2 \times 160 = 320kj$

$4 \times S-F = 1100$

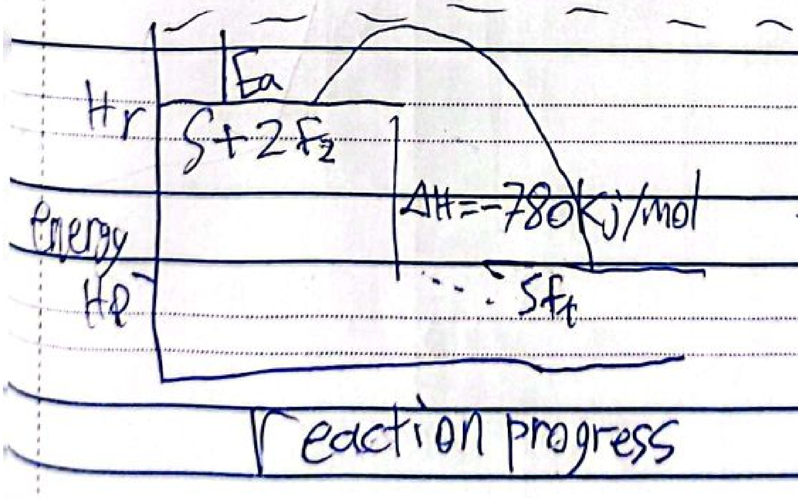
$\frac{1100}{4} = 275$

$\Delta H = -780$

$\Delta H = 320 - x$

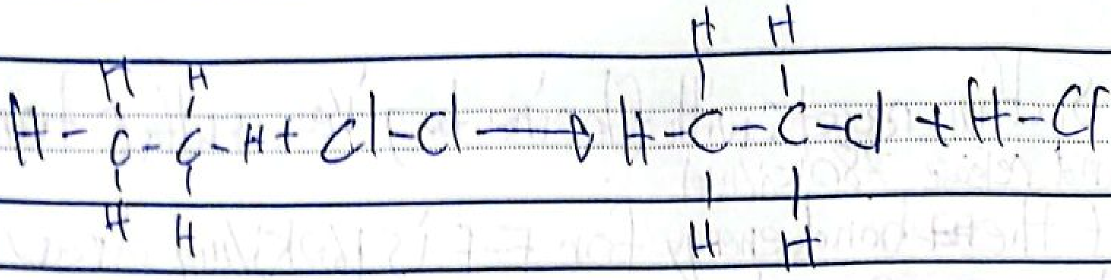
$-780 = 320 - x$

$x = 1100$



S-F = 275

Day : .... Date : ....



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

6xC-H
1xCl-Cl } 2720kj

5xC-H
1xC-Cl
x=1xH-Cl } 2393+xkj

ΔH=-104 kj/mol

$-104=(2720)-(2393+x)$

H-Cl=431kj

Combustion

$C_2H_5OH+3O_2 \rightarrow 2CO_2+3H_2O$

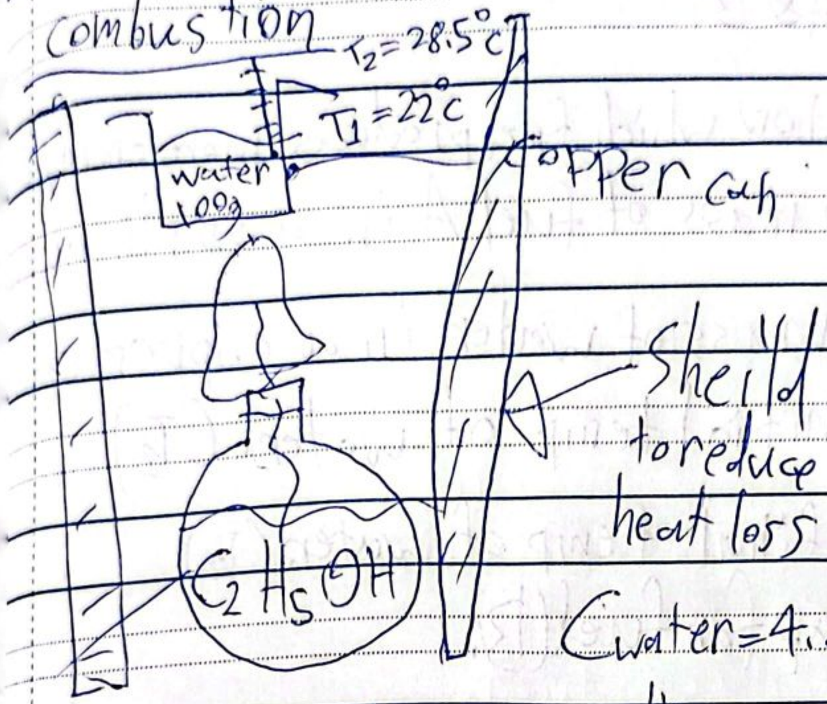
displacement

$Zn+CuSO_4 \rightarrow ZnSO_4 + Cu$

neutralization

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

combustion



$C_{water} = 4.2 J/g.°C$

$m_1 = 200g$

$m_2 = 198g$

surrounding

$Q = mc\Delta T$

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

$= 2,730J$

$\Delta H = kj/mol$

$\frac{46}{2} = 23$ $\quad 2,730J \xrightarrow{burn} 2g\ C_2H_5OH \quad Mr_{C_2H_5OH} = 46g$

$2,730 \times 23 =$

$\boxed{62,790 J/mol} \leftarrow 46g$

$\Delta H = -62.79 kj/mol$

Two fuels A&B

Plan an exp to show which fuel produces more energy?

* Take a known mass of fuel A in a spirit burner.

Place a known mass of water in a copper can.

Measure the initial temp of water. (T_1)

ignite fuel A.

Measure the final temp of water. (T_2)

repeat the exp for fuel (B).

The fuel which causes more temperature change is the one that produces more energy.

Displacement

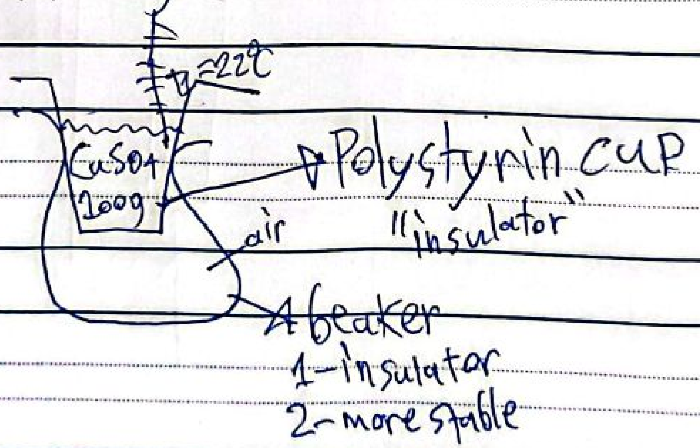
$Zn_{(s)} + CuSO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$

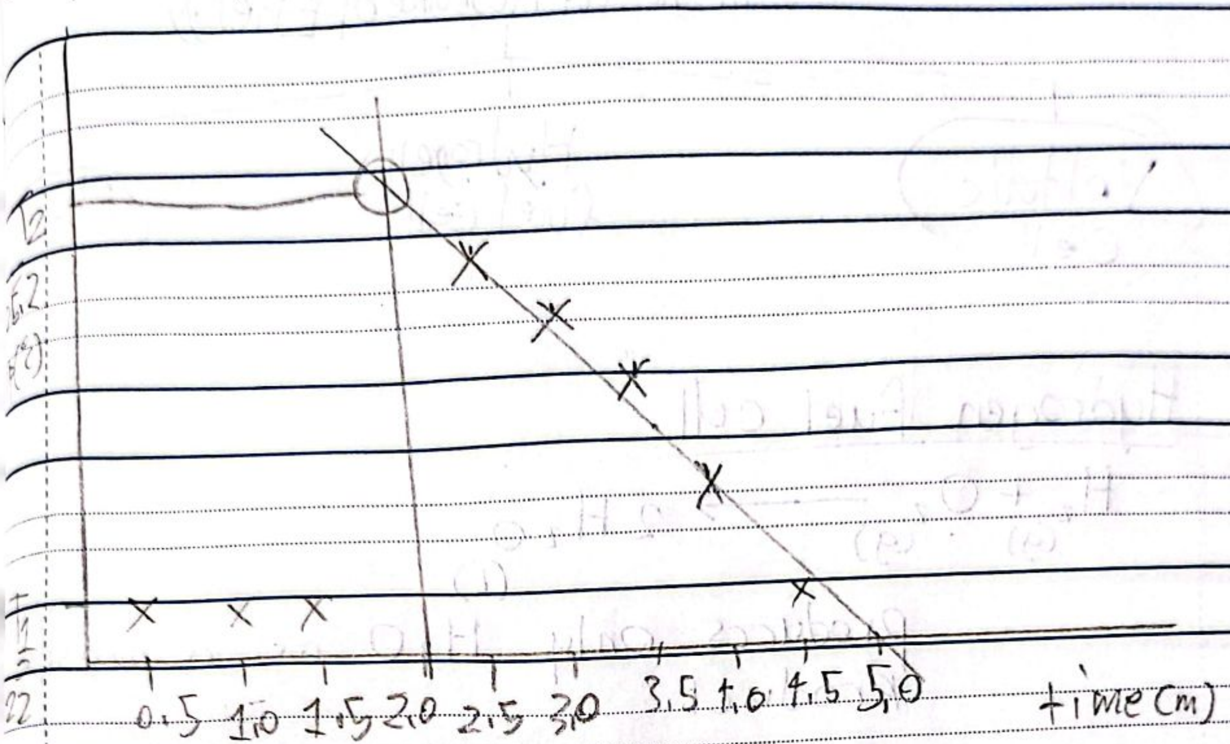
$m = 0.65g$

$V = 100cm^3$

$d = 1g/cm^3$

$m = 100g$



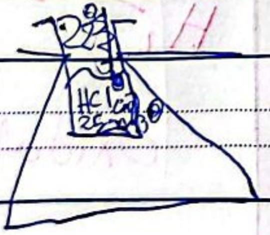


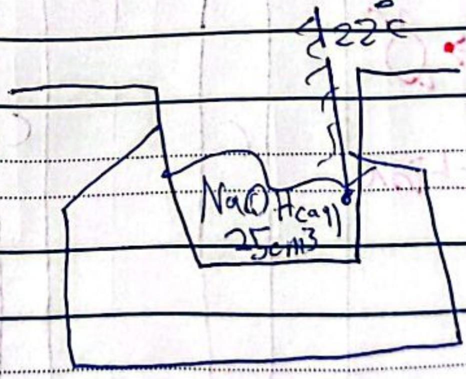
$Q = mc\Delta T$

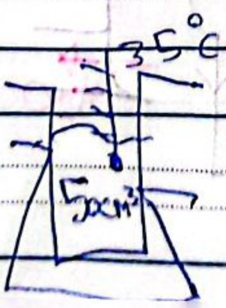
$Q = 100 \times 4.2 \times (25.2 - 22)$

$Q = 1{,}344 J = 1.344 KJ$

Neutralization:-



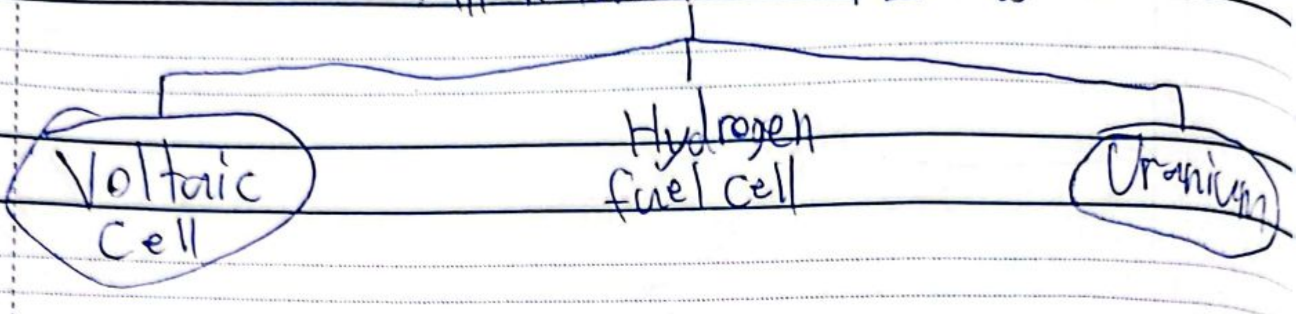




$Q = MC\Delta T$

$Q = (25+25) \times 4.2 \times 13 = 2730J$

Alternative Resource of Energy



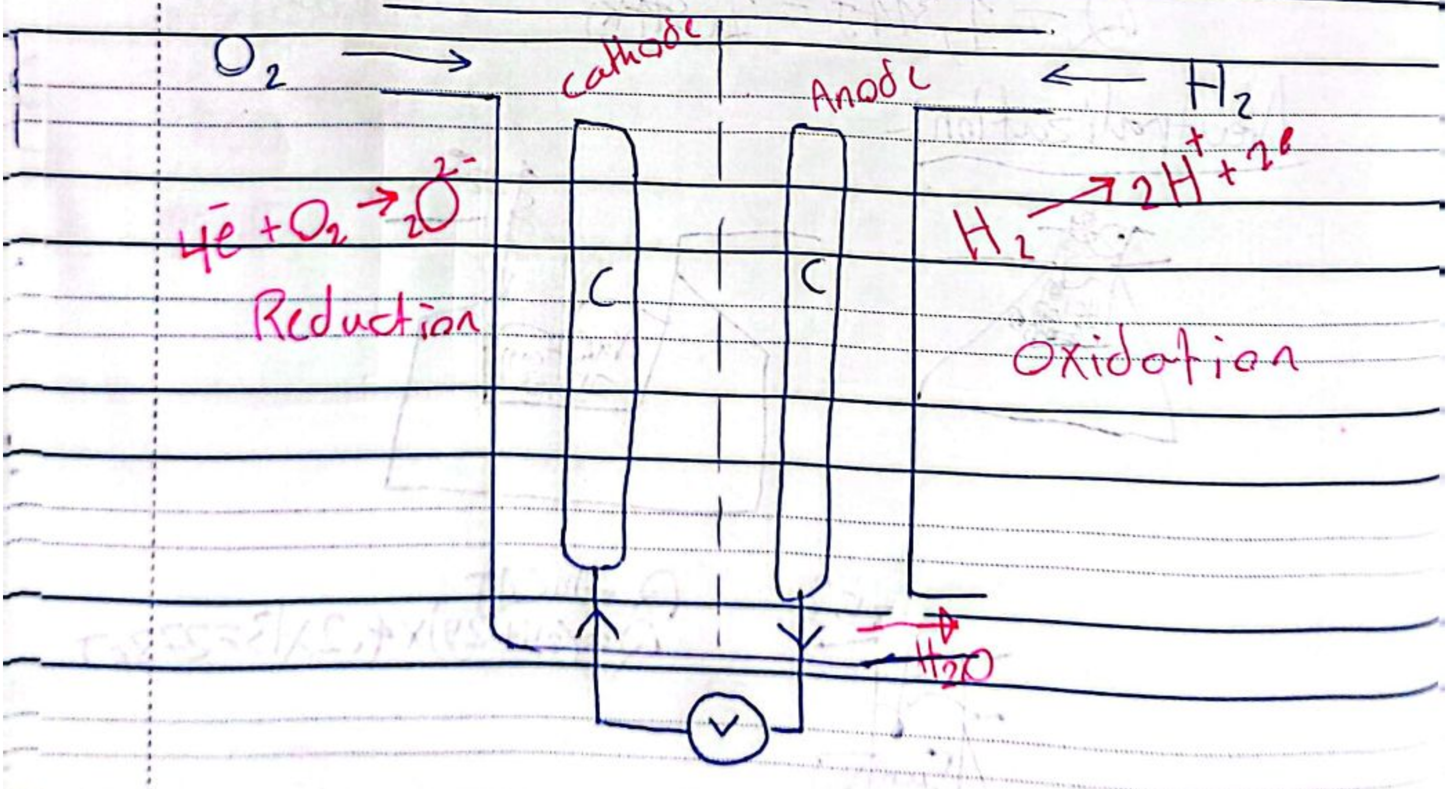
Hydrogen fuel cell.

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

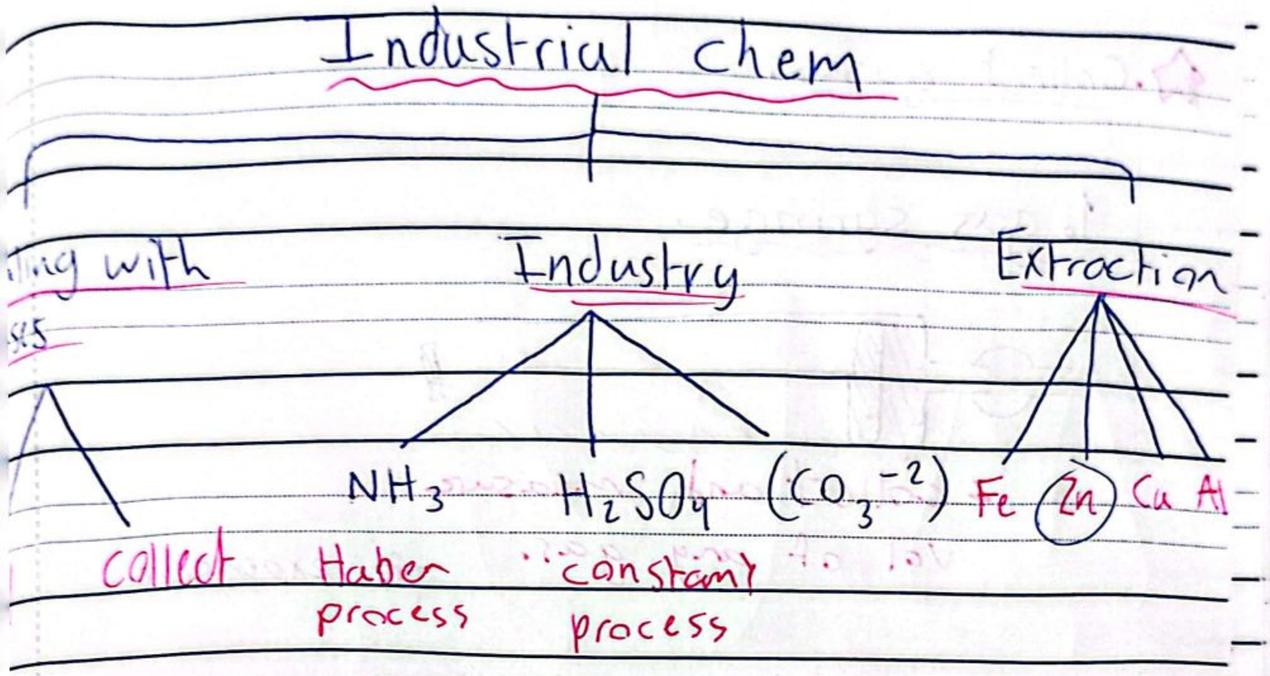
produces only H_2O as a waste product.

produce high amount of energy

NO CO_2 produced (not pollutant)



Industrial chem



• Dealing with gases.

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

CO2
$CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$
r=44

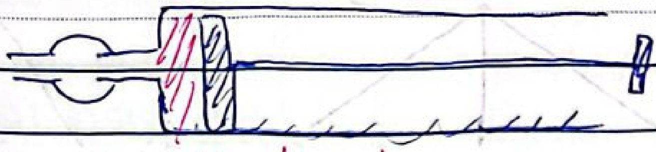
NH3
$NH_4Cl_{(aq)} + NaOH_{(aq)} \xrightarrow{\Delta} NaCl_{(aq)} + H_2O_{(1)} + NH_{3(g)}$
r=17

$Na_2SO_3 + HCl \longrightarrow NaCl + S + SO_2 + H_2O$
14

$NaCl_{(aq)} \xrightarrow{electrolysis} H_2 + Cl_2 + NaOH$
71

★: Collect gases.

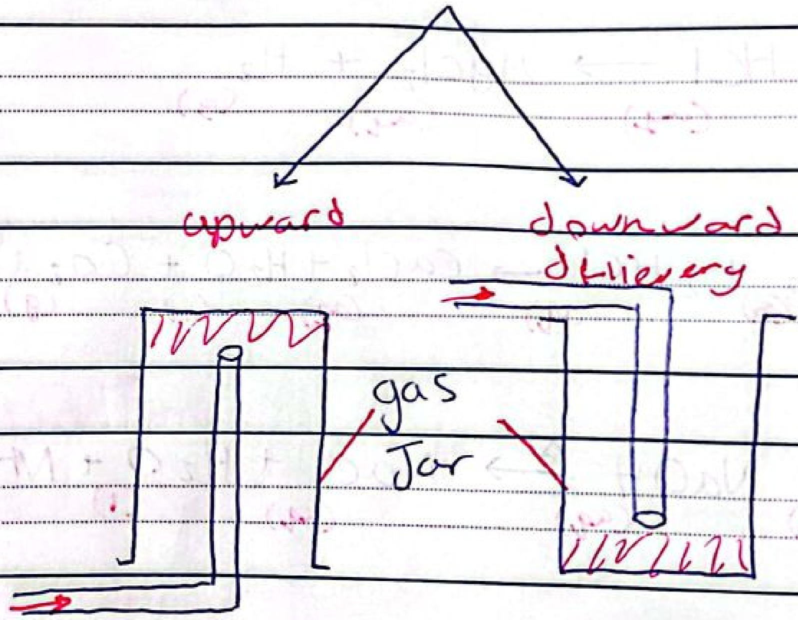
1. gas syringe.



* collect and measure vol of any gas.

★. expensive

2. Delievery.



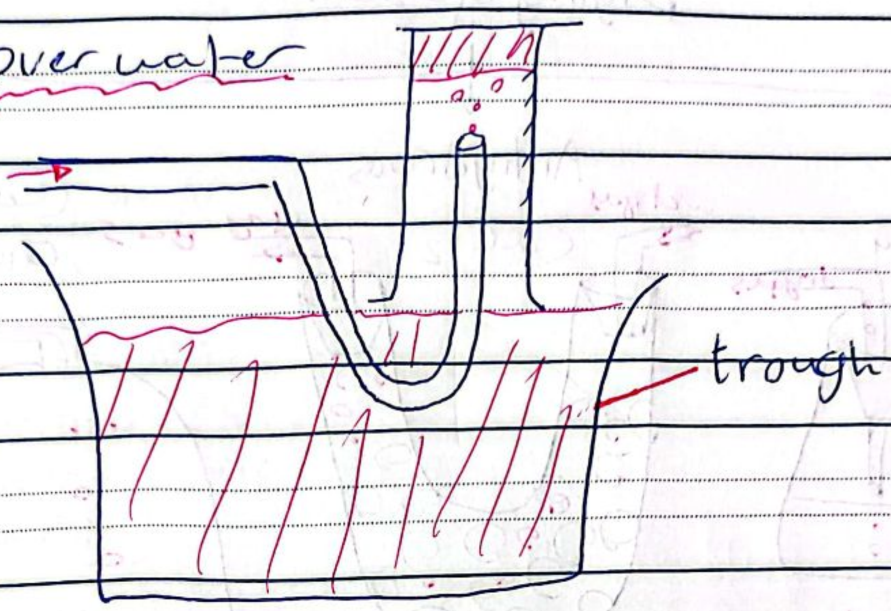
to collect less dense gas in air
- NH_3
- H_2

★. Some gas might escape

★. Mix with other gases

to collect more dense gas than air
- SO_2
- CO_2
- Cl_2

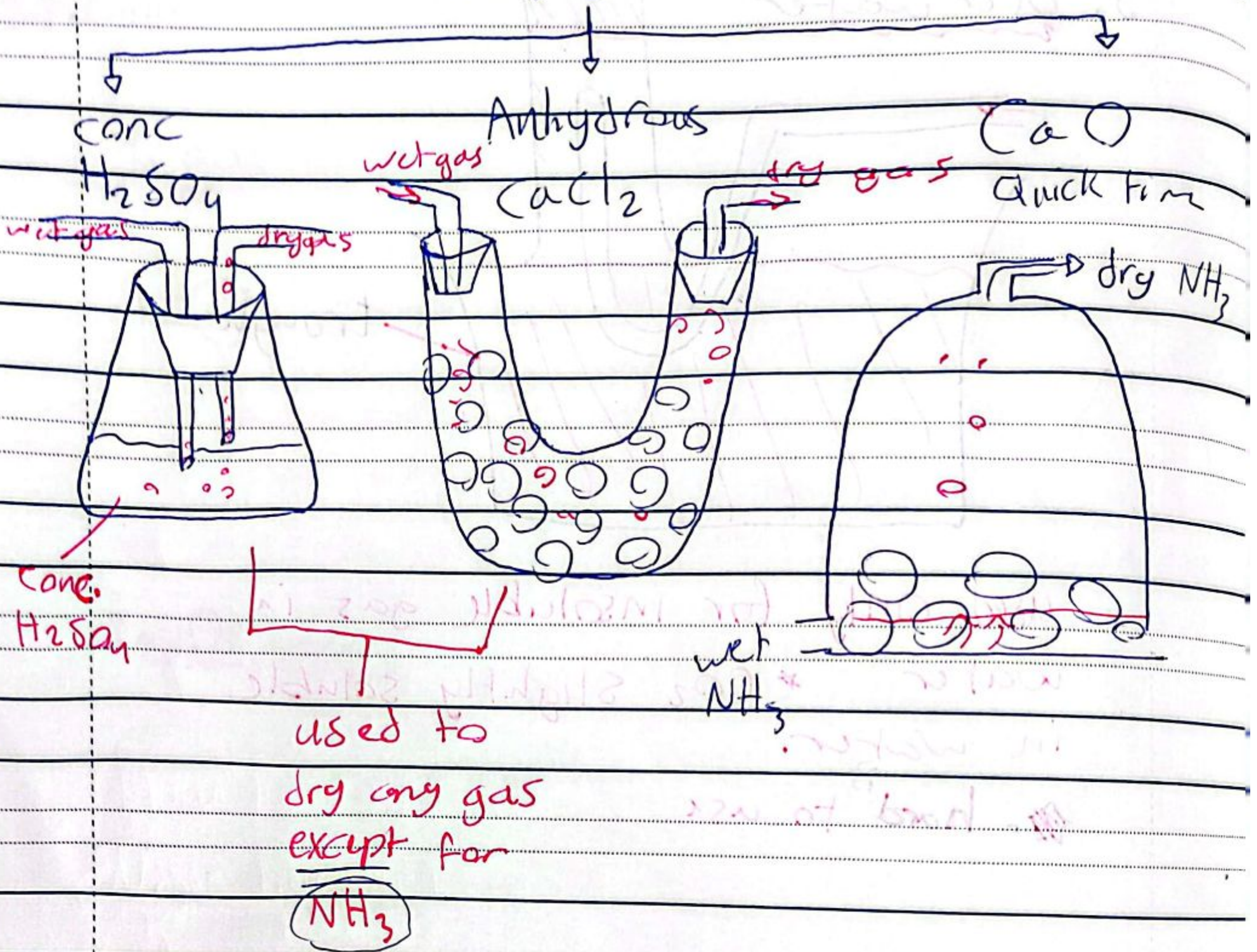
3. over water



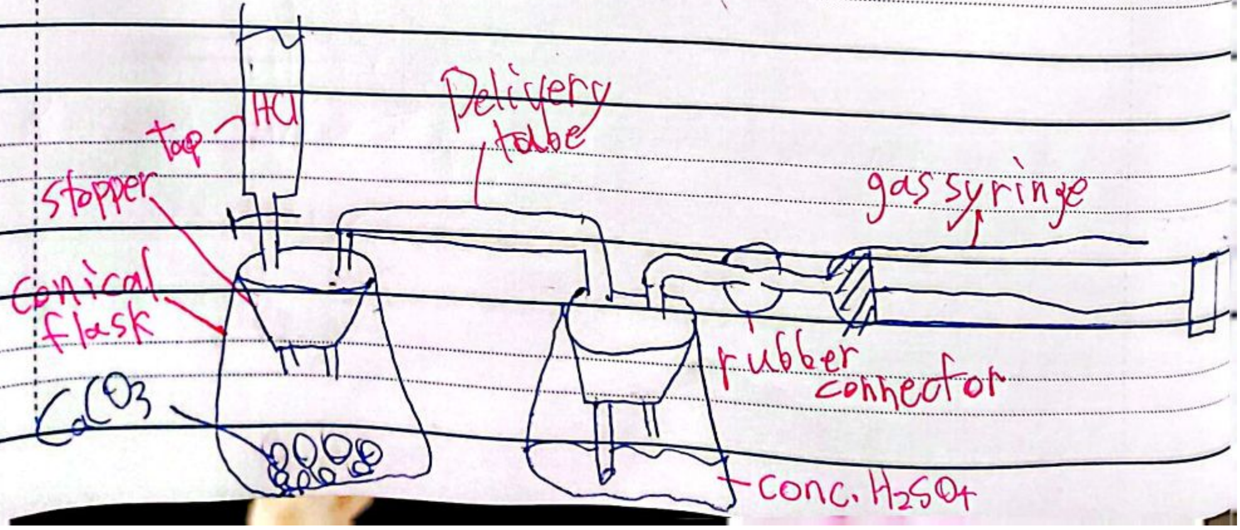
used only for insoluble gas in water * CO_2 slightly soluble in water.

★. hard is to use

Drying gases



Q) draw an apparatus to collect and measure



Day : .... Date : ....

Industry of NH_3
(haber process)

exo

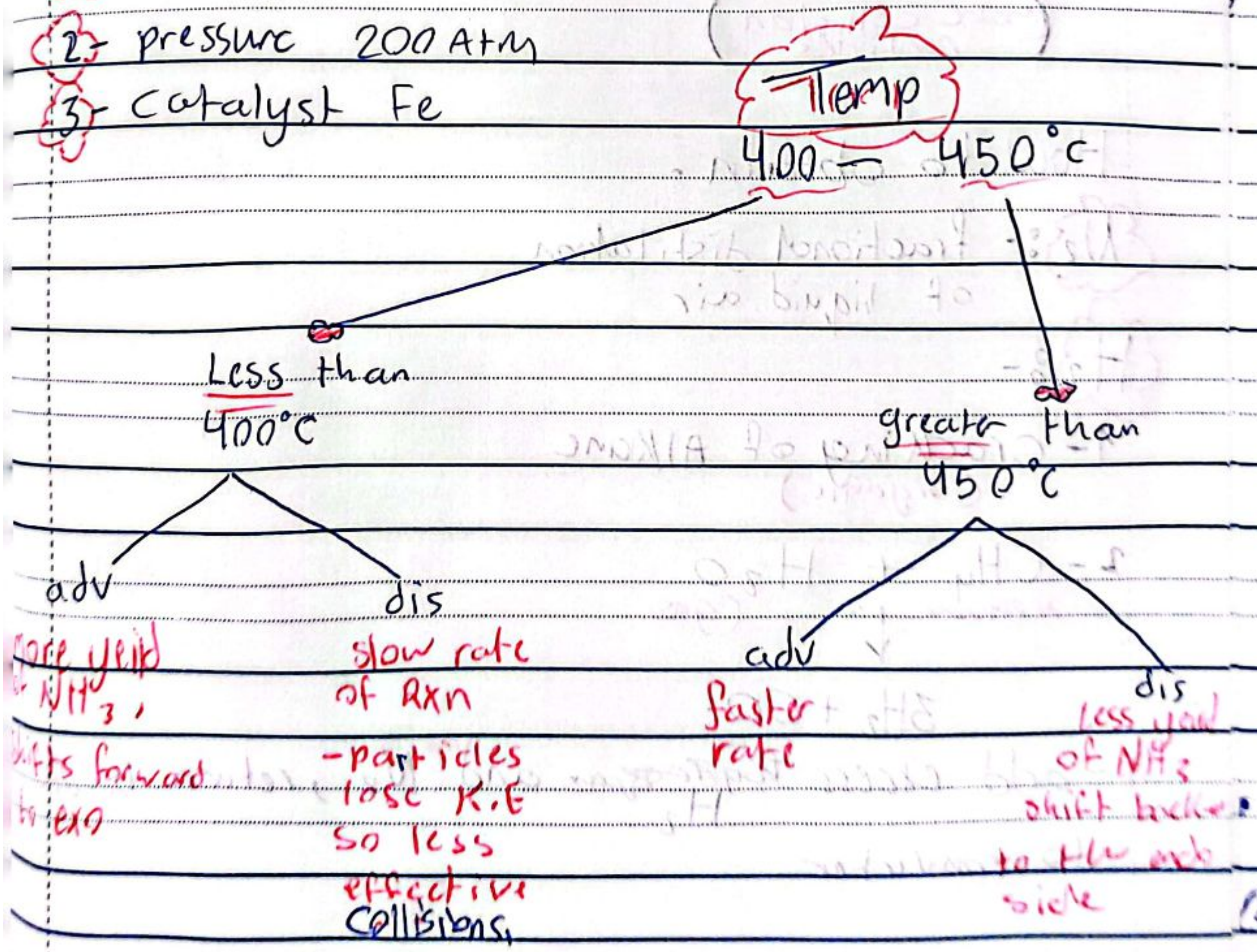
$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $\Delta H = -ve$

Uses of NH_3

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

essential condition

1- Temp 400° – 450°
2- pressure 200 Atm
3- catalyst Fe



pressure 200 Atm

high pressure

adv

1- more yeild of NH_3
(shift forward to the side with less gas)

2- faster rate
(more collision particles)

dis

1. Risk of explosion

2. expensive !

How to obtain.

N_2 :- fractional distilation of liquid air

H_2 :-

1- Cracking of Alkane (organic)

2- CH_4 + H_2O
Methane (gas)

$\downarrow$

$3H_2 + CO$

*- add excess ~~Hydrogen~~ H_2 and N_2 , return back to converter

Day :

Date :

*- remove NH_3 immediatly. How?

- by cooling down NH_3, it condences

Day : Date :

Industry of H_2SO_4

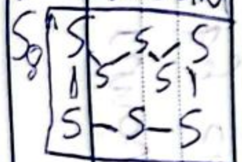
"Contact process"

$S \xrightarrow[(1)]{\text{Roasting}} SO_2 \xrightarrow[(2)]{\text{Contact process}} SO_3 \xrightarrow[(3)]{\text{conc. } H_2SO_4} \underset{\text{Oleum}}{H_2S_2O_7} \xrightarrow[(4)]{H_2O} H_2SO_4$

H_2SO_4 oily liquid
- dilute: typical acid
- conc.: drygas

group VI
yellow Solid

S_8



Ore:- Zinc blend
ZnS

Source:- fossil fuel

Uses:- medicine
fireworks
magnets
rubber

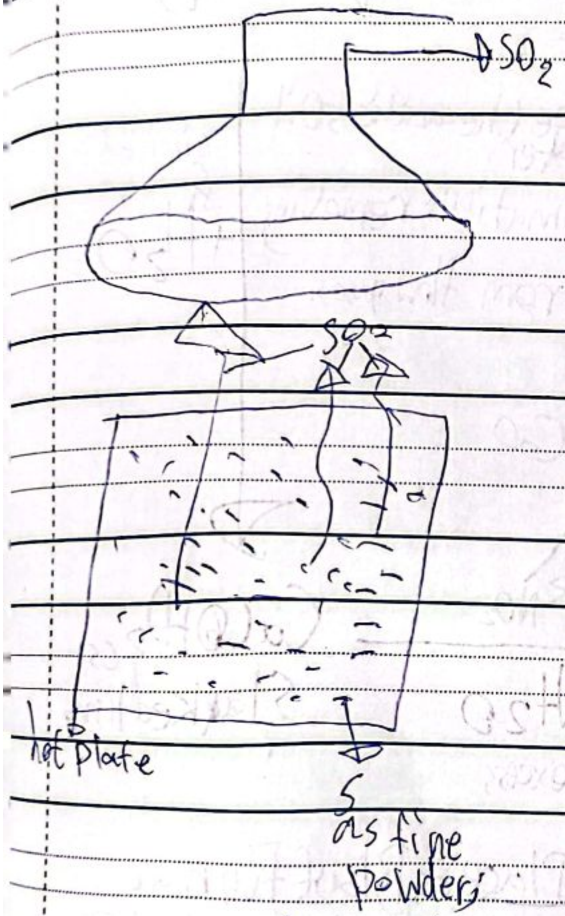
SO_2:
chocking smell
- test SO_2
turns acidified $KMnO_4$ from purple to colorless.

Uses:-
* Paper industry.
- Bleaching agent
* food preservative
- kills bacteria

Day : .... Date : ....

① Roasting :-

$S + O_2 \rightarrow SO_2$



More surface area
So faster rate of rxn,

② Contact process

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

1) temp 400-450°C

2) Pressure 1-2atm. "high pressure"
favour the forward side which has less gas moles

why?
max yield at 2 atm;

3) catalyst V_2O_5 Vanadium (V) oxide
↓
Penta

③-④ $SO_3 \xrightarrow{H_2O} H_2SO_4$ X
high exothermic
Produce low yield of H_2SO_4

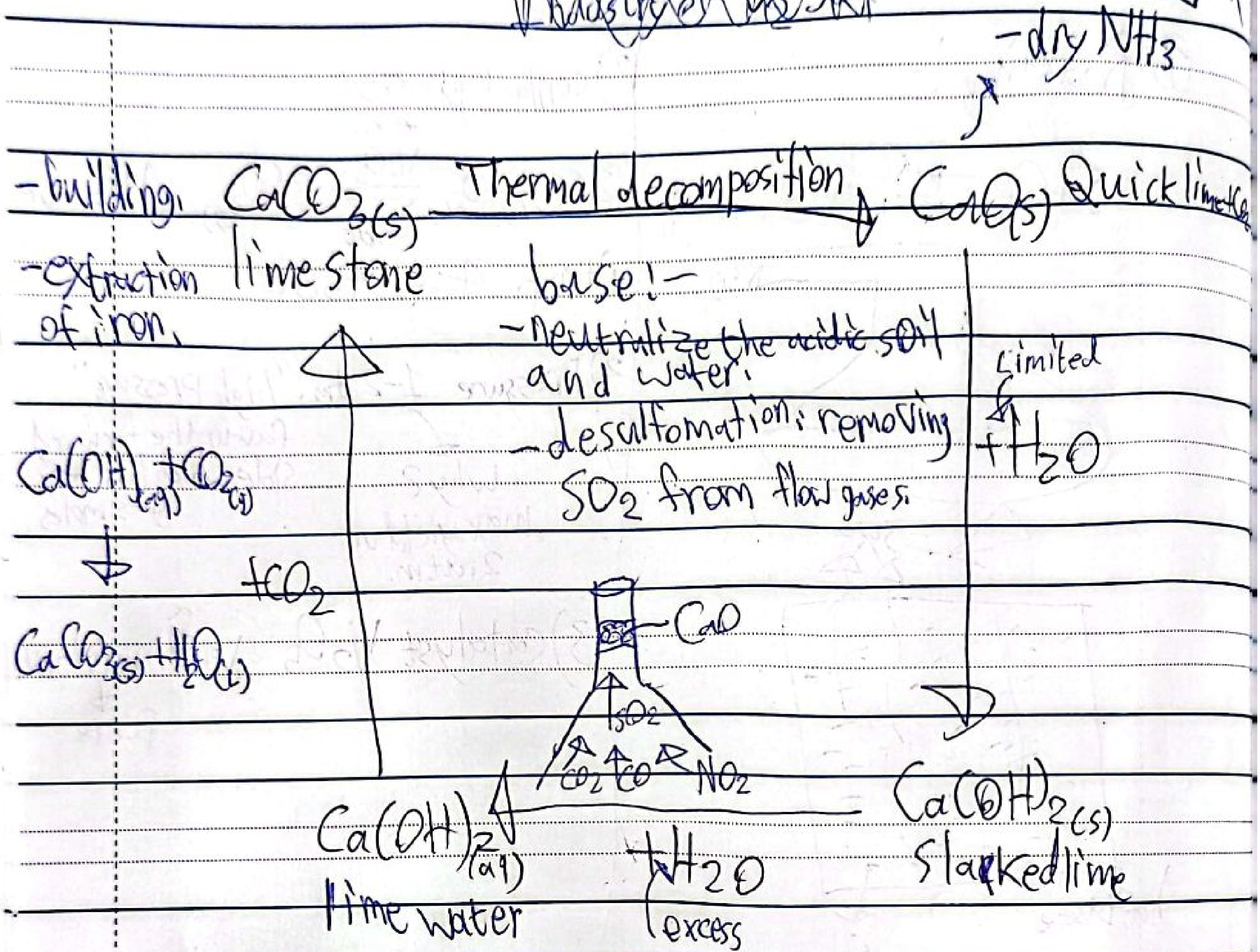
$$\begin{tikzcd} SO_3 & & 2H_2SO_4 \\ \text{Conc. } H_2SO_4 \arrow[dr] & & \\ & H_2S_2O_7 \arrow[uur, "H_2O"'] & \end{tikzcd}$$

Oleum

Monkey

Day : .... Date : ....

Carbonate cycle



- building,
- extraction of iron,

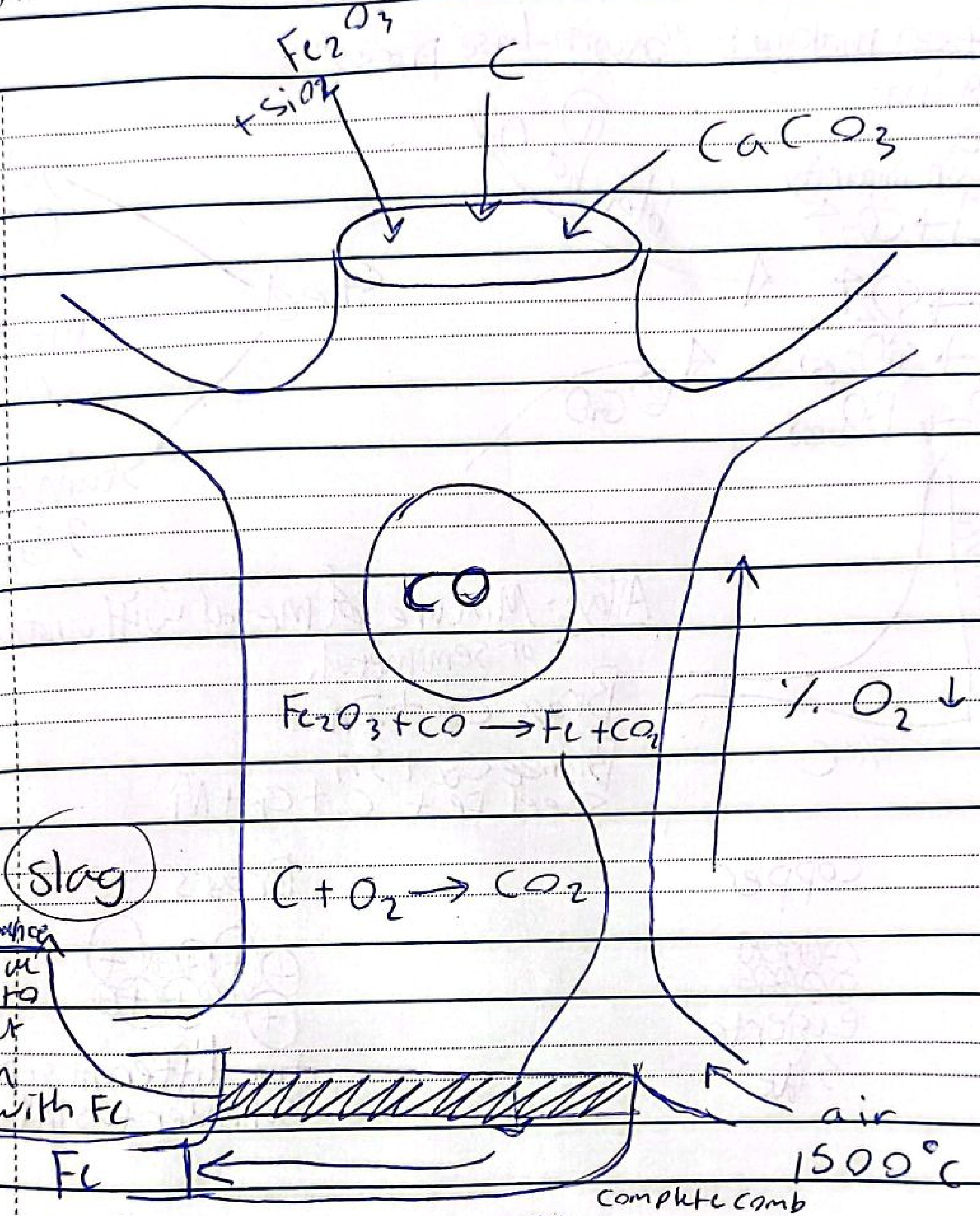
base:-
- neutralize the acidic soil and water;
- desulfomation: removing SO_2 from flow gases.

Extraction of iron:- Place:- Blast Furnace.

ore:- Hematite : Fe_2O_3 Method:- Reduction by C&CO

Raw materials:- ① Fe_2O_3 + acidic impurities ② $CaCO_3$ (lime stone)
③ coke (pure carbon) ④ air ($T=1{,}500°C$)

Day : .... Date : ....



mportance
otective
yer to
revent
rxn
O_2 with Fe

Fe
cast
iron
impure

e
xed
th
umine
make
and.

complete comb

① $C + O_2 \rightarrow CO_2$

incomplete comb

② $2C + O_2 \rightarrow 2CO$

③ $CO_2 + C \rightarrow 2CO$

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

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

Calcium
silicate ←
slag

⑥ $CaO + SiO_2 \rightarrow CaSiO_3$

Steel making :- "oxygen-base process"

cast iron

Fe

main impurity

$\boxed{C} \rightarrow CO_2\uparrow$

$S \rightarrow SO_2\uparrow$

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

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

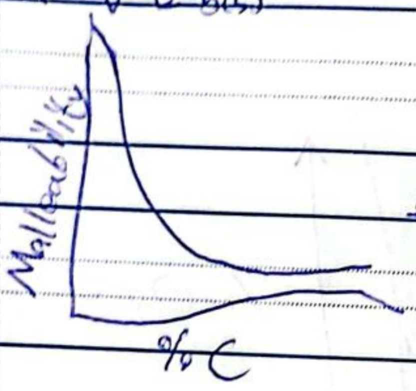
① blow hot O_2

② CaO

Steel — Mild 0.03% C

Steel — medium 0.3% C

Steel — Stainless 3-5% C



Alloy :- Mixture of metal with another me
or semimetal,

Brass Cu + Zn

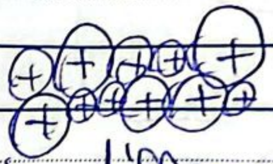
Bronze Cu + Sn

Steel Fe + C + Cr + Ni

copper

easier to slide

Brass



two different sizes
so harder to slide