Redox

reduction oxidation

in terms of

① oxygen Reduction of Fe in Fe_2O_3

$$Al + Fe_2O_3 \rightarrow Al_2O_3 + \overset{0}{Fe}$$

oxidation Al

reduction Zn in ZnO

$$\underset{2}{C}O + ZnO \rightarrow Zn + CO_2$$

oxidation C in CO

in terms of

② hydrogen reduction : Cl_2

Gain hydrogen = reduction
lose hydrogen = oxidation

$$H_2S + Cl_2 \rightarrow HCl + S$$

oxidation S in H_2S

③ oxidation state Cu^{2+} reduced

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

Oxidation Zn

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

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

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

Cl^{-1} is a spectator ion

$MnO_4^- + Fe^{2+} + h^+ \rightarrow Mn^{2+} + Fe^{2+} + H_2O$

Rules for oxidation state : the oxidation state for any free elemente = 0

① Oxidation State for any atom in a compound
Group 1 = +1
" 2 = +2
" 3 = +3 only for aluminium
" 7 = -1 only for F

③ Oxidation state for hydrogen is (+1) and (-1) only with metals

④ the oxidation state of oxygen is (-2) except in peroxide (-1)
and in OF_2 (+2)

hydrogen peroxide
H_2O_2

Sodium peroxide
Na_2O_2

Calcium peroxide
CaO_2

5) The sumof all oxidation state of all atoms in the compound = zero
in the ion = charge

$\overset{+1}{Na}\overset{-1}{Cl}$ So the charge is Zero

$\overset{+2}{N}O^{-2}$ wecan find chage of other using one

$\overset{+4}{N}O_2^{-2}$ = $N + 2(-2) = 0$
$n = +4$

---

ion: SO_4^{2-} = +6

CrO_4^{2-} = +6

MnO_4^{-1} = $Mn + 4(-2) = -1$
$Mn + -8 = -1$
$m = 7$

$MnO_4^{-2} = 6$

$CrO_3 = +4$

$Cr_2O_7 = +6$

$H_2S = -2$
$SO_2 = +4$
$SO_3 = +6$

$SO_4^{-2} = +6$

$S_2O_3^{-2} = +2$

★

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

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

To balance it

① atoms

② the charge by adding electrons to the side with greater charge

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

Oxidation $(Na \Rightarrow Na^{+1} + 1\bar{e})2$

reductions $H_2^{+2} \xrightarrow[+2\bar{e}]{} H_2$

Electron lost = ~~Elegret~~ Electron gain

$2Na + 2H^{+} \Rightarrow 2Na^{+} + H_2$

Oxiding agents and reducing agents

oxidalsing agent "oxidant"
the substance that itself reduced and causes the other substance to be oxidise

reducing agent ("reductent")
The substance itself is oxidised and causes the other substance to be reduced

if the substance is an ion in the compound you must write the agent with its compound

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

Oxidised Al reducing agent Al
reduced Fe^{3+} oxidaising agent Fe_2O_3

$H2S + Cl_2 \rightarrow HCl + S$

oxidising agent	reducing agent
Cl_2	H_2S

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

oxidant	reductant
H^+	~~#~~ Ca

Oxidizing agents and reducing agents

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Oxidised Al reducing agent Al
reduced Fe^{3+} oxidaising agent Fe_2O_3

$$H2S + Cl_2 \rightarrow HCl + S$$

oxidising agent
Cl_2

reducing agent
H_2S

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

oxidant
H^+

reductant
Ca

Most common oxidising agent

① oxygen

$\overset{0}{Fe} + O_2 \Rightarrow \overset{+2}{Fe_2O_3}$

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

② acidify potassium manganate $KMnO_4 / H^+$ ★

$MnO_4 \Rightarrow Mn$

(+7)   (+2)

purple   colorless

③ Acidify with pottassium dichromate K_2CrO_7/H^+

$Cr_2O_7 \Rightarrow Cr^{3+}$

(+6)   (3+)

orange   green

④ Halogens

$2e + F_2 \longrightarrow 2F^-$

yellow

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

yellowgreen

$2e + Br_2 \longrightarrow 2Br^-$

red brown

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

red brown (aq)

black solid

purple gas

Most common reducing agent

① Hydrogen

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

$H_2 + CuO \rightarrow Cu + H_2O$

H_2 reducing agent

② Carbon and Carbon monoxide

$C + ZnO \rightarrow CO + Zn$

C is reducing agent

$CO + Fe_2O_3 + CO_2 + Fe$

CO is reducing agent

Potassium Iodide KI

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

colorless red-brown

④ Metals

more reactive

more likely to lose $\bar{e}$

" " " oxidise

" " " be oxidising agent

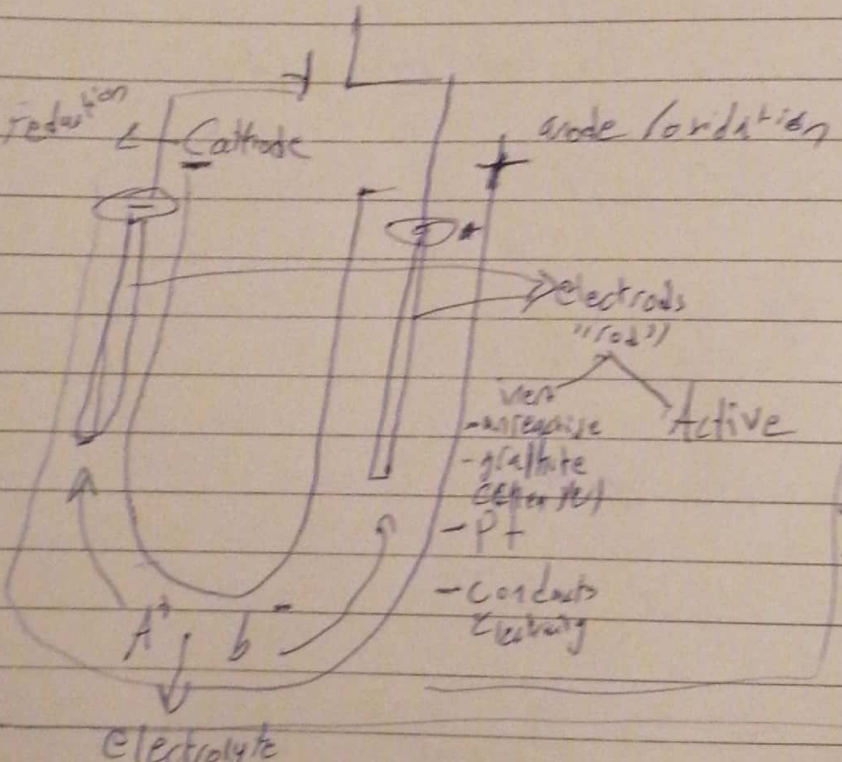
Ag weakest reducing agent

~~Electros~~ Electro|lysis

electricity analysis (breaking down)

The compound that can conduct electricity is ionic compound only when molten/aqueous, because of free ions.

Electrolysis: breaking down chemical Ionic compound "molten or aqueous" by passing electricity



$Ab \xrightarrow{heat} A^+_{(l)} + b^-_{(l)}$
molten

$Ab \xrightarrow{H_2O} A^+_{(aq)} + b^-_{(aq)}$
aqueous

↑
Free moving ions

cathode: The −ve electrode that attracts the +ve Ions Cations where the reduction occurs.

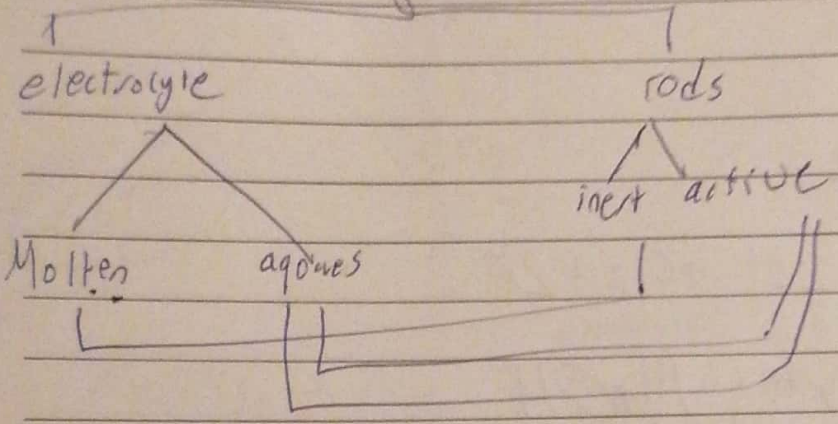
anode: " +ve " " " " −ve Ions (anions) " " oxidation ".

Electrolysis $\Rightarrow$ Discharging

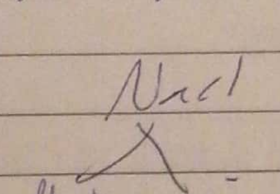
$+1e\ Na^+ \rightarrow Na$ | $2Cl^- \rightarrow Cl_2 + 2e^-$

~~Electrolysis for molten electrolyte~~

Electrolysis

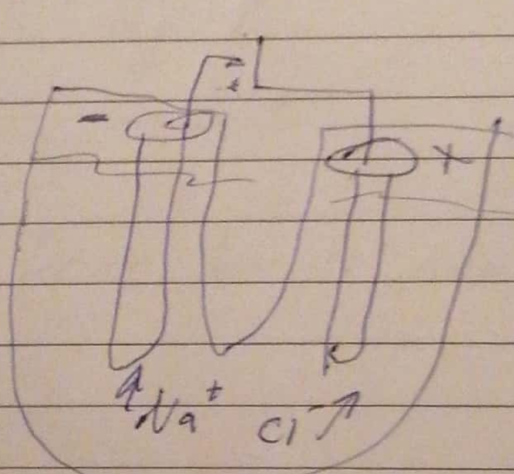


electrolysis for molten electrolyte using inert rods. Electrolysis for mollen NaCl using raphite



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

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



electrolytes : ws ad ap

Only the concentrated halide are morelikely to oxidise the OH^{2}

if others with OH^- they OH will oxidise

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

the less reactive ion is morelikely to reduce and the more reactive ion stays in the electrolyte

K
Na
Li
Ca
Mg
Al
Zn
Fe
Pb
H
Cu
ag
Au

$NaCl_{(aq)}$ /concentrated

Na^+ Cl^-
H^+ OH^-
cathode anode

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

electrolyte: NaOH

8 brine = concentared NaCl

dilute $NaCl_{(aq)}$ / graphite

electrolyte: NaCl
but more concentrated

Na^+ Cl^-

H^+ OH

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

$4OH \rightarrow 2H_2O + O_2 + 4e^-$ = bubbles of colourless gas

$CuSO_4$ (aq) / graphite

SO_4^{2-}

Cu^{+2}

H^+

OH^-

$Cu^{2+} + 2e \rightarrow Cu$ = deposite of Red brown solid

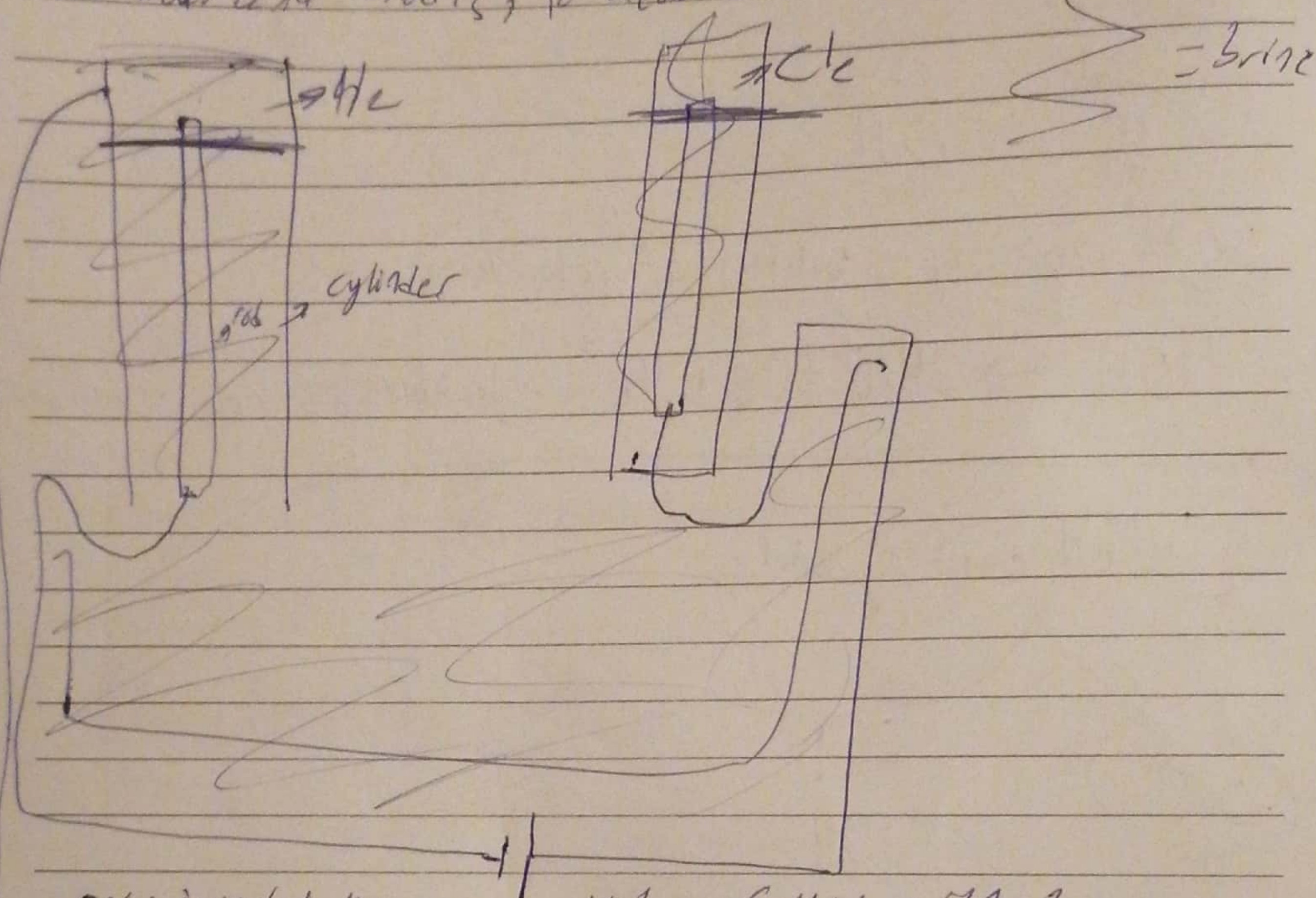
$4OH \rightarrow 2H_2O + O_2 + 4e^-$ = bubbles of colourless gas

electrolyte: H_2SO_4

observations:

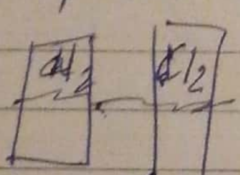
3: liquid fades from blue to colorless due to copper leaving.

(Q1) plan an exp to collect gases produced at cathods and anodes, to measure its volume

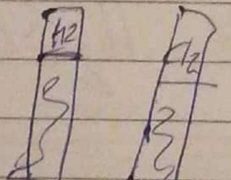


ans: inverted measuring cylinder filled with brine
→ this the volume

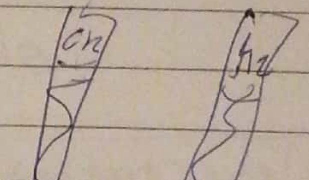
(Q2) the final appearance of two measuring cynnder



a)



B)



c)

~~to answer)~~

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

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

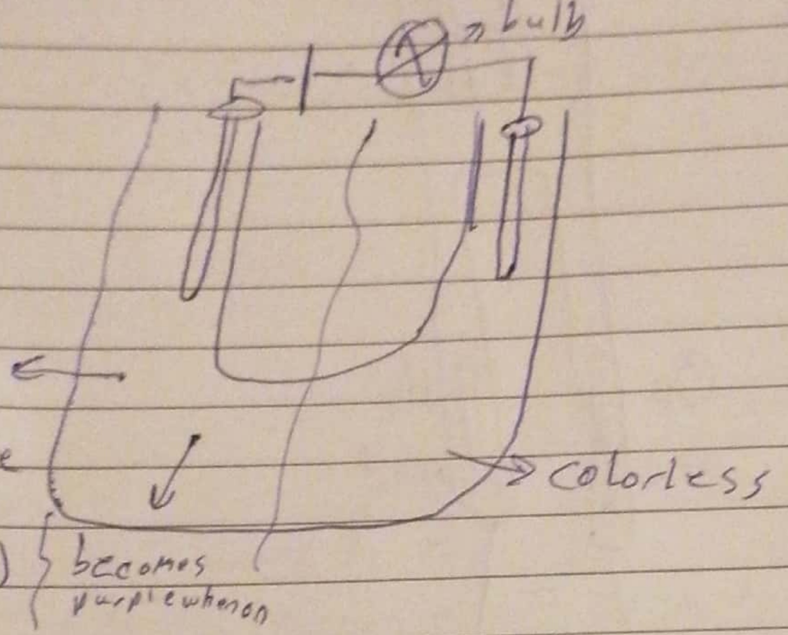
~~Cl~~

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

Ratio 1:1 so its a

Why the Cl_2 gas not immedietly appear as H_2 appear?
Some Cl_2 gas dissolve in the electrolyte

Electrolysis of brine solution with universal indicator



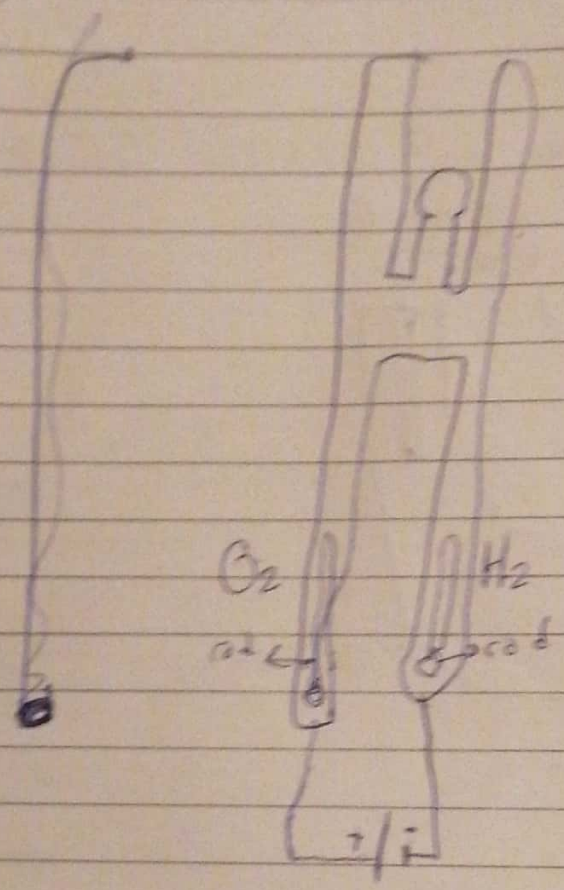
When on:
1: bulb lights up
2: bubbles of colourless gas at cathode
3: " " green yellow gas at anode
4: around the cathode solution is purple
5: " " anode solution is colorless

← because NaOH is alkali

→ because chlorine is a bleaching agent

electrolysis of H_2SO_4 / graphite rods

Hoff-man



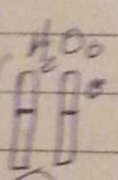
H_2SO_4

H^+ SO_4^{-2}

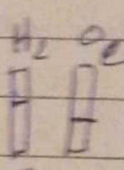
H^+ OH^-

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

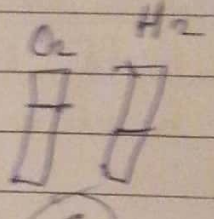
$4OH \rightarrow 2H_2O + O_2 + 4e^-$



ⓐ



Ⓑ



Ⓒ

$(2H^+ + \cancel{2}e \rightarrow 2H_2)\ 2$

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

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

H : O
2 : 1

so answer is C

Electolysis of aqueous electolyte using active rods

* Rod must be made from the same metal

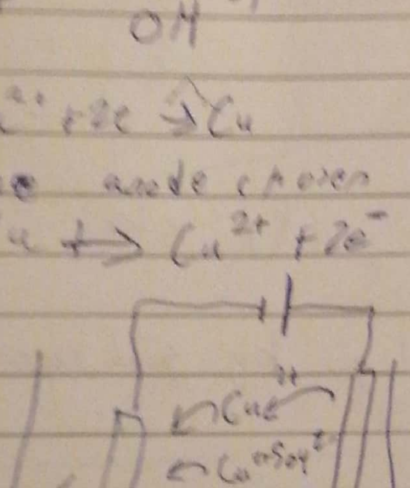
$CuSO_4$ using copper rod

Electrolysis for $CuSO_4 (aq)$ using copper rods

$CuSO_4$

Cu^{2+} SO_4^{2-}
H^+ OH^{-1}

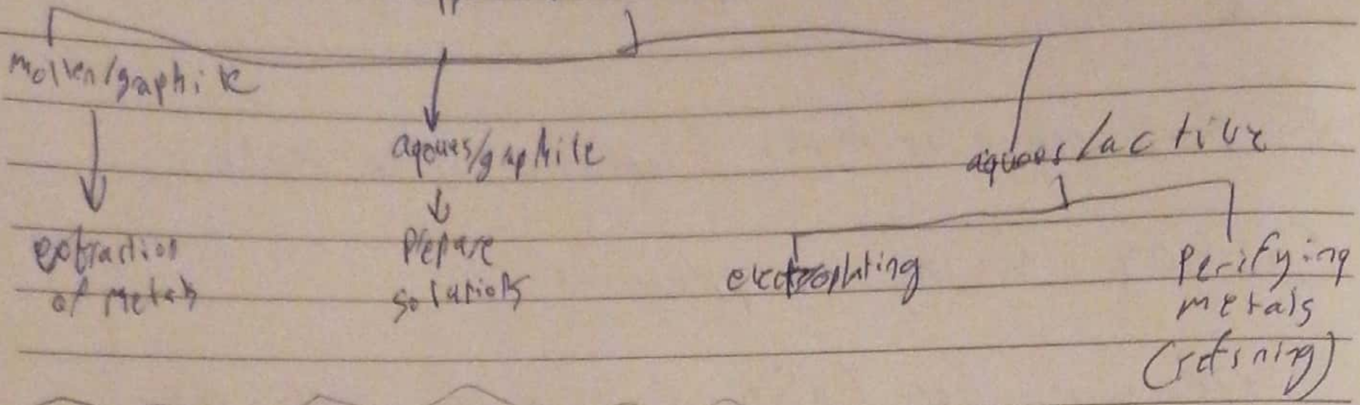
$Cu^{2+} + 2e \rightarrow Cu$
the anode chosen would be the rod
$Cu \rightarrow Cu^{2+} + 2e^-$ inverse of cathode



Cathode increase in mass
Cu^{2+} gain e^-'s and deposit of Cu on it

anode decrease in mass
lose electrons
electrolyte stays the same in the electrolyte ~~with the~~
s[illegible] and replace Cu^{2+} in the electrolyte at the same rate.

application on electrolysis



* Elecroplating is covering a metal with another metal by using electricity

why?

1) to prevent rusting
2) Decoration

How to electroplate metal spoon with silver

1) Clean metal spoon to remove oxide layer by sand paper

2) make the spoon the cathode (-ve)

3) Anode must be made from Ag

4) electrolyte must have Ag as a cation

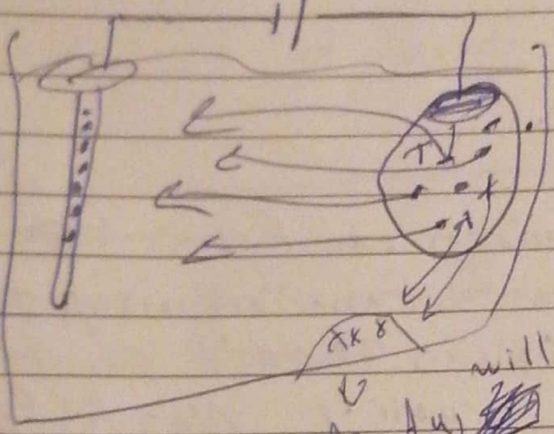
5) turn on the circuit

6) rotate the metal spoon to ensure an equal disturbtion

7) rinse with distilled water

8 dry in oven

purifying



• Cu
x impure

will settle down since less [illegible] reactive than Cu

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

electrolyte: [illegible]O_4

Extraction of metals:

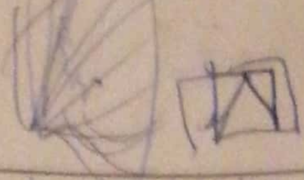
The method of extraction depends on the position of the metal in the reactivity series.

Al_2O_3 is Al ores (bauxite)

Zinc blende $ZnS \leftarrow Zn$

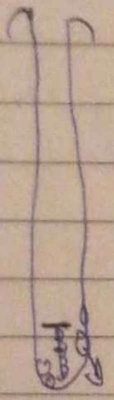
Hematite $Fe_2O_3 \leftarrow Fe$

copper sulfide $CuS \leftarrow Cu$

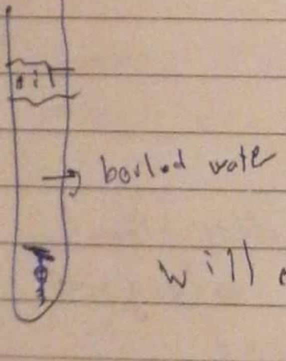


Rusting :-
The reaction of iron with both H_2O and O_2

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



Anydrous $CaCl_2$ "Drying agent" will not rust due to no H_2O present



will not rust since no O_2 present

A and B are two solutions used to prevent rusting. plan an exp to show which solution is better

1. Take a known mass of iron nail
2. Apply known quantity of solution A
3. Put the nail in a known volume of water
4. leave for one week, measure mass.

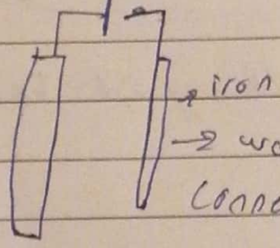
5. repeat exp using solution B
in conclusion: The exp which causes less increase in mass is the better solution

How to prevent rusting

1) painting
2) oiling
3) Greasing
4) cover with plastic
} forms a layer that prevents O_2 and H_2O from reaching Fe

5) Galvanising: Coat with Zn, more reactive than Fe so more likely to oxidise so more likely to lose electron, so Fe is more likely to rust
6) secrifical protection: ~~coat~~ Same as zinc

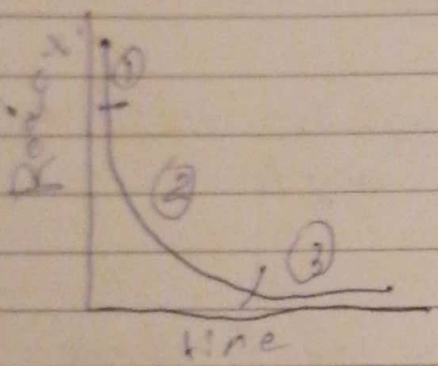
7) Electroplating: Refer to other pages + Zn and Mg if scratched can make another layer
8) cathodeic protection:

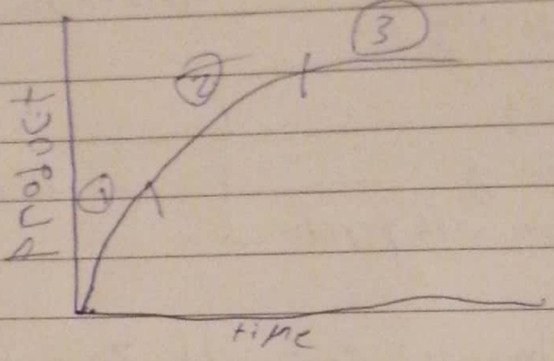


→ won't rust since its connected to the cathode to measure the rate of reaction

how fast the reactant consumed per unit time

How fast the products produced per unit time



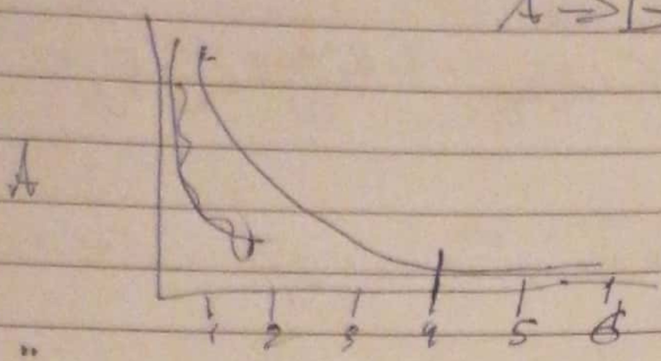


① for both; fastest from the curve because its so steep + gradient
more reactants
so more particles
so more effective collisions per unit time
so faster rate of reaction

② for both: slower rate from the graph because less steepness and less gradient
less reactants
so less particles
so less effective collisions per unit time so slower rate of reaction

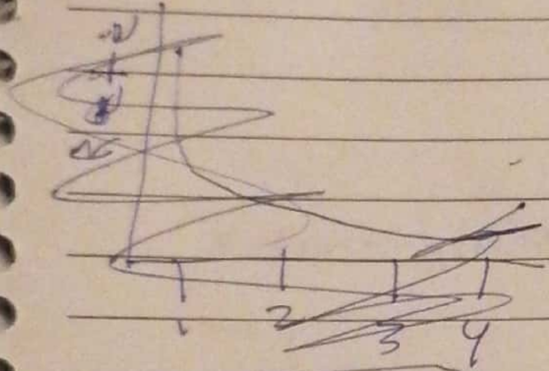
③ for both: reaction is over ⇒ from the graph the gradient is 0 and horizontal line
no more limiting reagent
~~[illegible]~~ so no more effective collisions
so the reaction is stop.

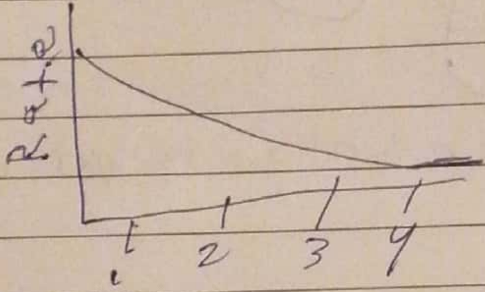
A→B



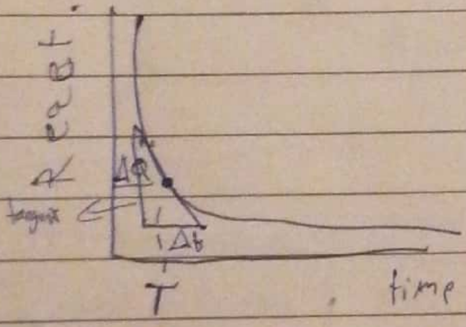
Draw a graph for rate vs time

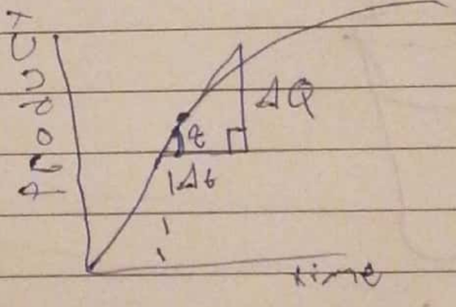
(at 4 it stopped reacting)





to measure the rate → find the gradient





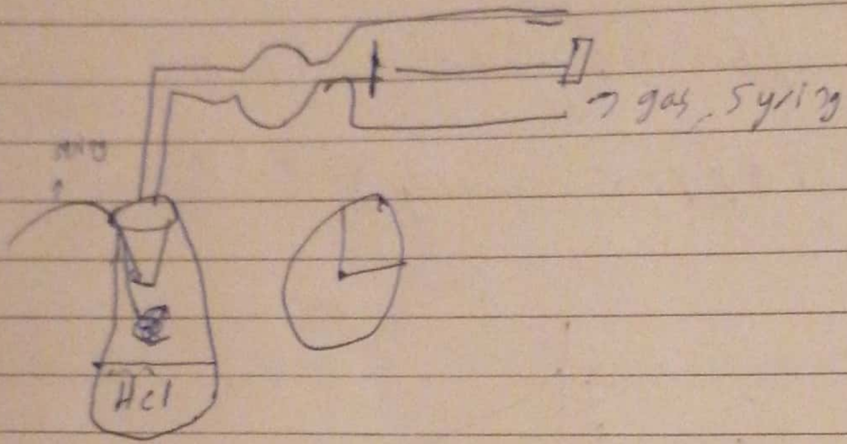
$$Rate = \frac{\Delta Q}{\Delta t}$$

A

to measure rate

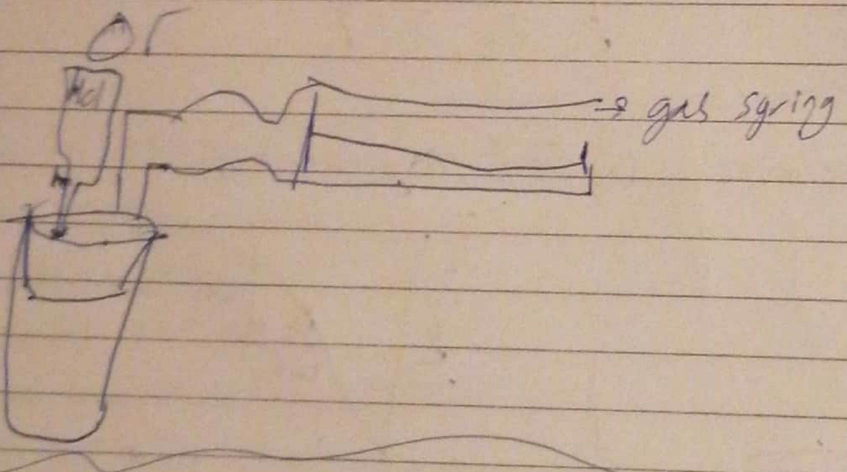
$CaCO_3 + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

Measure the volume of CO_2 produced per unit time



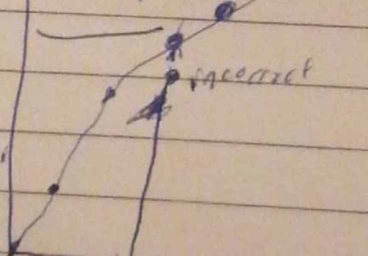
use string so minimum gas escapes out of expirment

Or

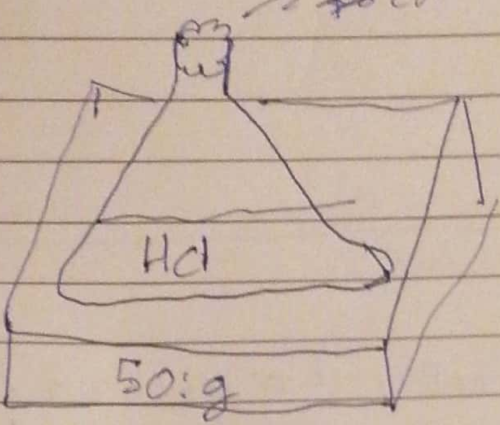


time	0	30	60	90	120	150
Volume	0	20	30	33	34	34

The incorrect becomes on the line and becomes expected volume



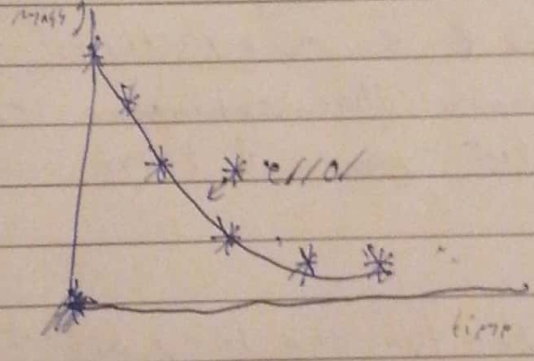
② Measure the mass of the conical flask with its contents per unit time



→ cotton wool, to allow CO_2 to escape and prevents splashing

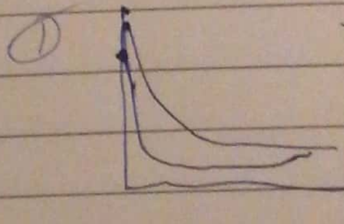
* why the mass decrease CO_2 escaped

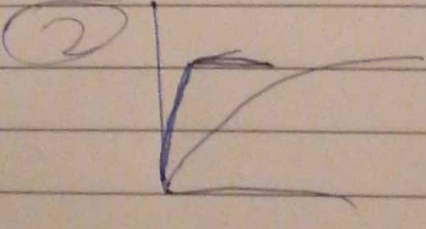
time	0	30	60	90	120	150
mass	50	45	41	40	39.5	39.5



* error

Faster rate of reaction
① more product per same unit time] steeper
② same product less time





Factors affect the rate of reaction:-

① Temprature
② surface area
③ concentration
④ pressure
⑤ light intensity
⑥ Catalyst

① Temprature

Q1) State how the temp affect rate of reaction?

as temp increase rate of reaction increases. (less time)

Q2) Explain " " " " " " " " " " " " ?

: As the temp increase the particles gain kinetic energy so the move faster ~~so~~ * so more particles will have energy equal to or greater than ~~activation~~ activation energy. * more effective collisons per unit time so faster rate of reaction.

Q3) Plan an exp to show how the temp affect rate of reaction

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

Exp 1

Mass 2g
of $CaCO_3$
in lumps

Volume
HCl = 0.1 dm^3
Concentration = 1 mol/dm^3
temp = 25°C

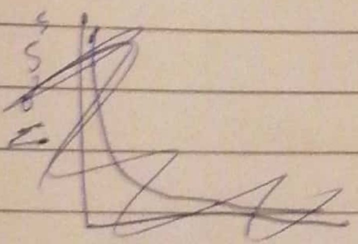
Exp 2

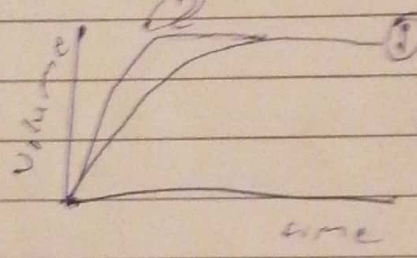
Mass 2g
of $CaCO_3$
in lumps

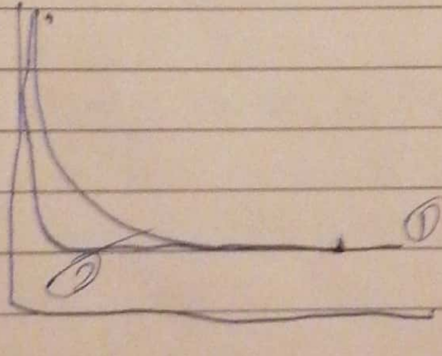
Volume
HCl = 0.1 dm^3
~~Cn~~ cn = 1 mol/dm^3
temp = 50°c

---

①







② Surface Area

State how the surface area affect the rate of reaction?

As the surface area increases (by crushing using mortar and pestile) making particle size smaller so rate of reaction increases.

explain '' '' '' '' '' '' '' ?

As surface Area increases, more particles are exposed to the reactions. So more effective collisions per unit time. So faster rate of reaction.

Plan an exp to show '' '' '' '' '' ''

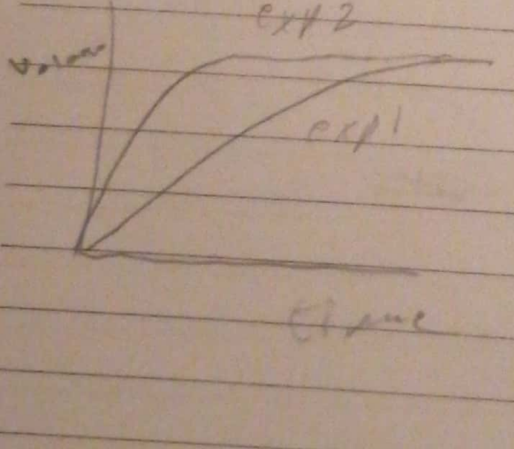
$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

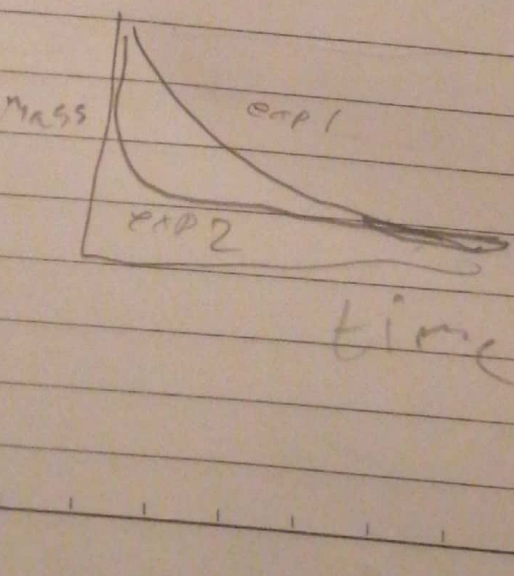
Exp1: $CaCO_3$ 2g
lumps

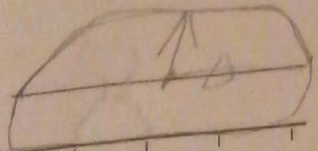
V: HCl 0.1dm³
M HCl = 1mol/dm³
temp = 25°C

Exp2: m: $CaCO_3$ 2g
powder

V: HCl 0.1dm³
M HCl = 1mol/dm³
temp = 25°







jmf

③ concentration: amount

Q1) State how the conc affect rate of reaction
As the concentration increase the rate of reaction increase

Q2) explain " " " " " " " " " " " " ?
As the con of reactant increases more particles so more effective collisone per unit time. So faster rate of reaction.

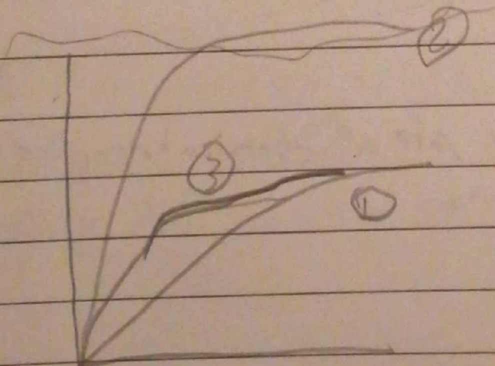
Q3) plan an exp to show " " " " " " " " " " " " ?

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

Exp 1: m 2g
lumps
V
0.1 dm^3
m 1mol/dm^3

Exp: 2 2g
lumps
V
0.1 dm^3
m = 2mol/dm^3

Exp3: ~~[illegible]~~ 4g
lump
0.1 dm^3
1mol/dm^3



added
~~CaCO3 + [illegible] 2HCl~~

next page

mole 0.005 mole 0.04

mol 0.01 0.01

$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

4) pressure "only affect the gas"

state how pressure " " " " "

? more pressure $\overset{faster}{}$ rate of reaction

Explain " " " " " " " " ?

by increasing the pressure (by deducing the volume) more particles per unit volume, so more effective collisions per unit time, so faster rate of reaction

5) light "only for photochemical reaction" (reactions that need light to occur)

1) Ex: photo synthesis. $6CO_2 + 6H_2O \xrightarrow{light} C_6H_{12}O_6 + 6O_2$

2) photographic films (not in our new syllabus)

$AgCl \xrightarrow{light} Ag + Cl_2$

$AgBr \xrightarrow{light} \overset{black}{Ag} + Br_2$

Q6) catalyst :

chemical substance that speeds up rate of chemical reaction without being used up

How? provide an alternative pathway with lower activation energy (Ea).
(Ea): Minimum amount of energy needed to start the reaction.

State // // / / / // / / / ?
increases rate of reaction

Explain // // / / / / / / / ?
More particles will have energy equal to or greater than Ea. so more effective collisions per unit time, so faster rate of reaction.

(Q) Decomposition of hydrogen peroxide

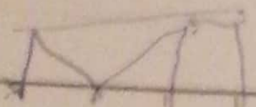
~~$2H_2O_2$~~ $2H_2O_2(aq) \xrightarrow[MnO_2]{CuO} 2H_2O + O_2$

① Plan an exp to show CuO is a catalyst for this reaction.
① take know volum temp + con c of H_2O_2
② measure volume of O_2 produced per unit time
③ repeat with CuO
④ Conclusion:- the exp with CuO produce more O_2 per unit time

② Plan an exp to show which catalyst CuO or MnO_4 is better
① same as Q1
Only diff is need same mass of CuO and MnO_4

③ " " " " " " " to show that CuO was not used up during reaction

- take known mass CuO
- do exp until no more bubbles of O_2
- filter mixture
- dry in oven
- measure the mass
- conc: the mass ~~without~~ won't change



Reversible reaction

Types of reaction

One way

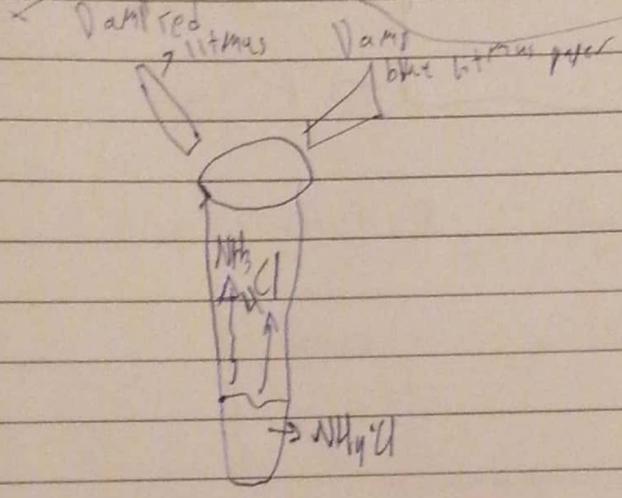
forward

Reactants → products

$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

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

$NH_4Cl_2 \rightleftharpoons NH_3 + HCl$



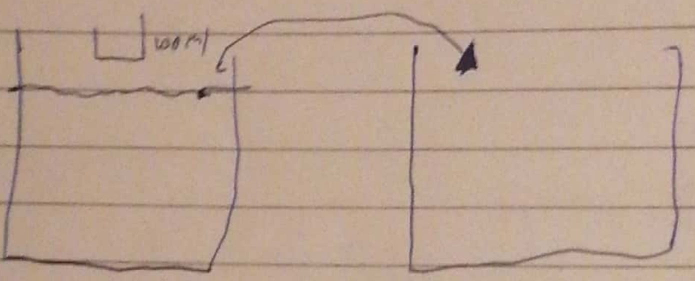
Which damp litmus paper change its color first, why?

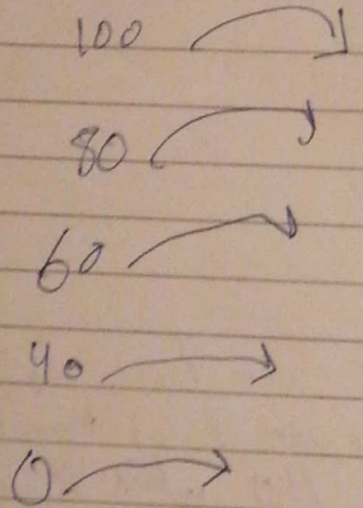
The red damp l.p will change its color first because NH_3 is a basic gas and lighter than HCl which is an acidic gas.

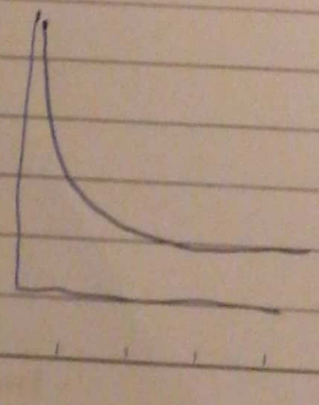
$Na_2S_2O_3 + HCl \rightarrow NaCl + H_2O + S + SO_2$

$Na_2S_2O_3$	~~HCl~~ H_2O	~~H_2O~~ HCl	time taken for x to disappear
50	0	10	30s
40	10	10	
35	15	10	
30	20	10	
10	40	10	

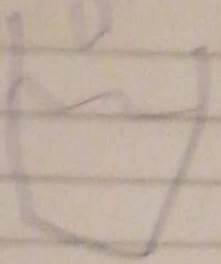
Dynamic equilibrium

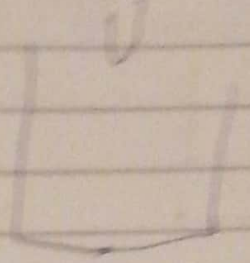






rate decrease with time as reactants consumed so less particles so less effective collisions.





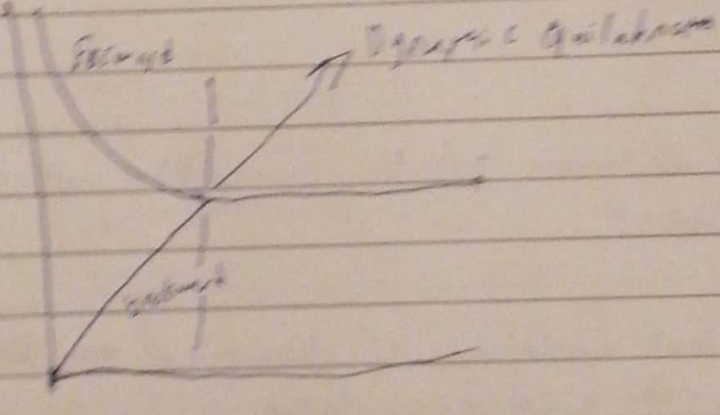
$$\begin{tikzcd}100 \arrow[r, bend left] & 0 \arrow[l, bend left]\end{tikzcd}$$

$$\begin{tikzcd}80 \arrow[r, bend left] & 20 \arrow[l, bend left]\end{tikzcd}$$

$$\begin{tikzcd}60 \arrow[r, bend left] & 40 \arrow[l, bend left]\end{tikzcd}$$

$$\begin{tikzcd}50 \arrow[r, bend left] & 50 \arrow[l, bend left]\end{tikzcd}$$

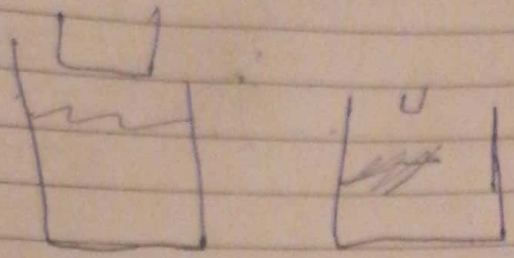
enclosed reaction = Dynamic Equilibrium

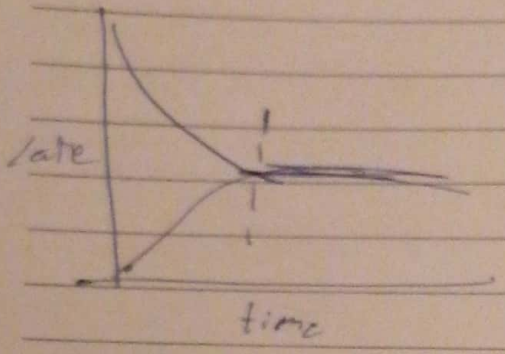


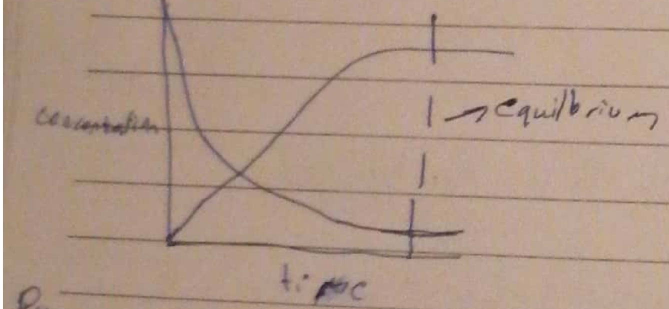
rate of forward decrease with time because less reactants so less particles so less effective collision per unit time.

dynamic equilibrium

In terms of rate: when rate of forward = backward reaction







Dynamic equilibrium

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

when asked about definition of dynamic equilibrium write in terms of rate and concentration

Factors affect position of equil $\rightleftharpoons$

① temp
② pressure
③ concentration

① As temp increase it will shift to endoside (endothermic)
② Rate of endo side increases
Rate of exoside increases but less than endo

② As temp decreases it will shift to exothermic side
Rate of endo side decreases the most
rate of exoside decreases but less than endo

The sign of ΔH (energy change) always represents forward side

ΔH
+ endo gain energy
− exo lose energy

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

if raise temp it will shift forward to endoside
so A and B supply more product making C and D more

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

↓ temp shift forward to the exoside ↓W ↓X ↑Y ↑Z

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

↓ temp swift backward to the opposide ↑A ↑B
↓C ↓D

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

to obtain high yield of NH_3 in terms of ~~temp~~ temp we us (high [✓ low]) temp

Why: to favour the exothermic side, which is the ~~[illegible]~~ forward reaction.

$2SO_{2(g)} + O_2 \underset{endo}{\overset{exo}{\rightleftharpoons}} 2SO_3$ $\Delta H = -ve$

	rate of Forward	rate of backward	yield of SO_3
↑ temp	↑	↑	↓
↓ temp	↓	↓	↑

Q:- Sealed tube contains mixture of equi
$2NO_{2(g)} \rightleftharpoons N_2O_4$
dark brown Pale brown
if this tube is added to a cold water bath, the mixture becames paler. explain why?
The forward reaction is exothermic. favoured by low temp

② Pressure "only for gases"

↑ Pressure shift to the side with less pressure
with less gas moles

↓ Pressure shift to the side with greater pressure
with more gas moles

~~Why increasing~~

$H_2 + I_2 \rightleftharpoons 2HI$

① Why increasing the pressure has no effect on the position of equil?
Because both side has the same number of gas moles.

② Why by increasing the pressure the mixture becomes more purple
I2 molecules become closer together and the colour becomes more dense.

Sealed tube contains NO_2 and N_2O_4 at equilibrium.

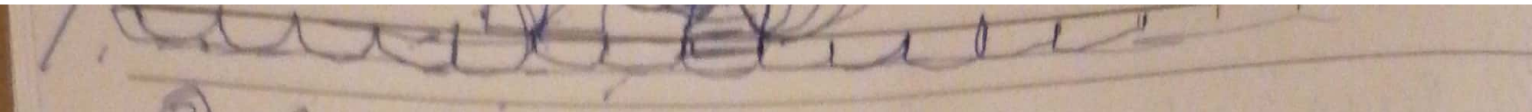
$2NO_{2(g)} \rightleftharpoons N_2O_4$

dark brown colorless

When the pressure of the system increase the color of the mixture:

a) becomes paler then goes darker
B) " darker " " paler
c) " paler and stays paler
D) " darker " stays darker

answer is (B)



③ Concentration.

Reactant $\rightleftharpoons$ Product

↑ reactant } shift equil to forward
↓ products }

↓ reactant } shift equil to backward
↑ product }

$A + B \rightleftharpoons C + D$

↑ A shift forward ↓B ↑C ~~↑~~D
↑ B shift backward ↑ A ↓C ↓D
↑ C " " ~~↑~~ A ↑ B ↓ D
↓ ~~↑~~ D " forward ↓A ↓B ↑C

Indicator

emethyl orange $HIn \rightleftharpoons H^+ + In^-$
red yellow

Add HCl (~~H~~$^+$ donor)
Shift backward
more HIn more red color
less In^- less colour ~~z~~ 2

Add NaOH (~~H~~ proton accepter) Shift forward
more In^- more yellow
less HIn less red.

The $Cr_2O_7^{-2}$ and Cr^{3+} ions were in equil

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

orange green

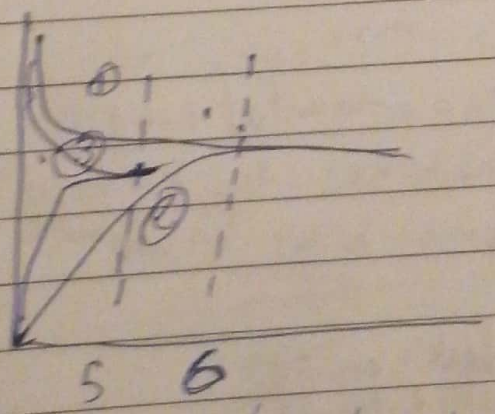
Why by adding HCl to the equil the color of the system becomes green?

Adding HCl increases amount of H^+ so the equil shifts forward

So more Cr^{3+} more green

less $Cr_2O_7^{2-}$ less orange

* Catalyst has no effect on the position of equil. but only speeds up rate of forward and backward reaction. so less time to reach equil.



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

energetics

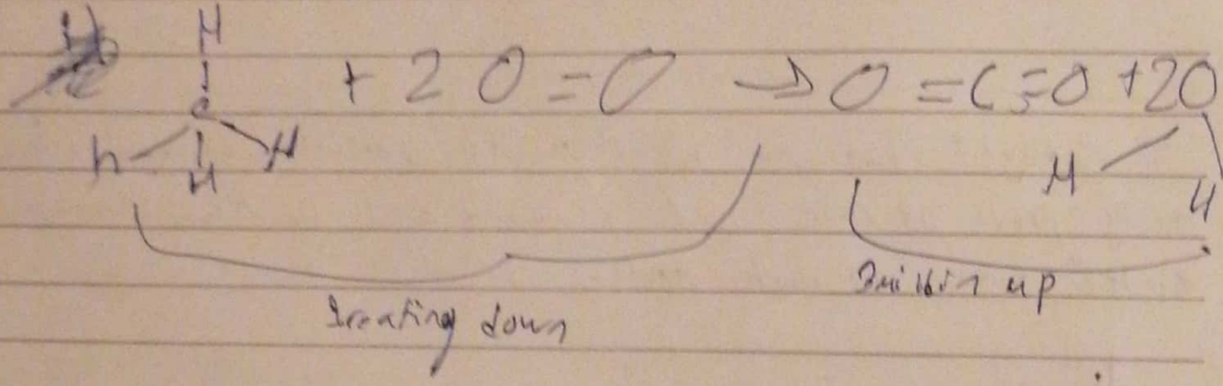
energy : The ability to do work
Joules   Joules

work in chemical rxn

breaking down bonds of reactants
endothermic input

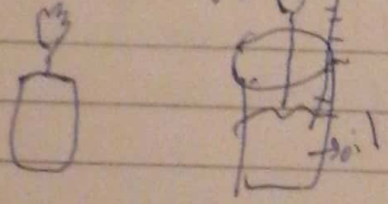
building bonds in products
exothermic output

input > output ⇒ endo
input < output ⇒ exo



the amount of energy realesed by building up bonds in product > The amount of energy absorbed by breaking down bonds in reactants

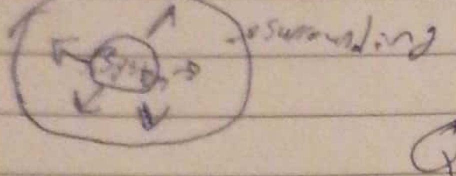
chemical energy : Enthalpy : Heat energy (stored energy)



exo  higher final temp

endo  lower " "

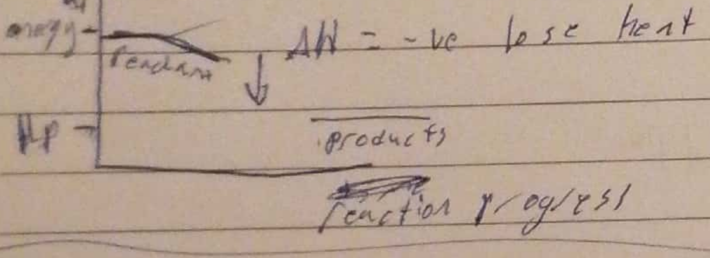
exo thermic: Reactions that give out (release) energy to surrounding



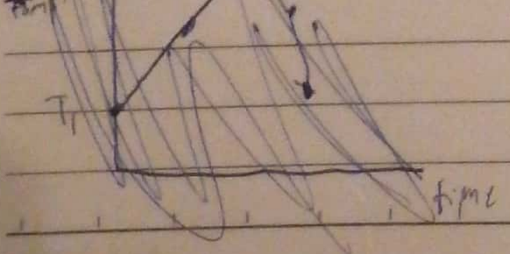
$$Q = MC\Delta t$$

Q = Joules
M = mass
C = Specific heat capacity J/g·C (4.2 J/g·C for water)
Δt : change in tempretuwe (even if negative use positive in formula)

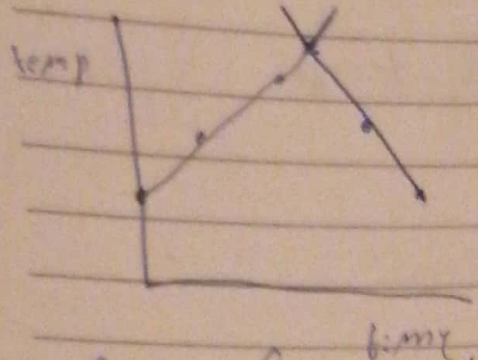
For the system we represent with energy level diagram



for surronding temp diagram



Temp declease because reaction is over, so return back into room temp



point of intersection = highest temp

to make more reliable redo the test with more time intervals instead of every 1 min every 30 seconds

examples on exothermic

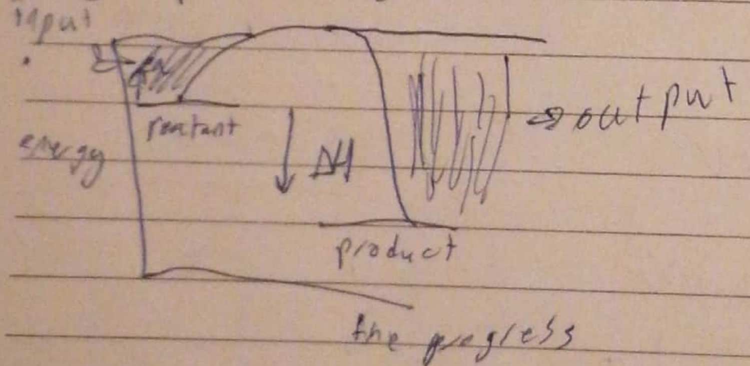
1) combustion
2) nuetrilization
3) displacement
4) voltaic cell
5) freezing, cooling
6) building up bonds
7) respiration.

How to express exothermic

① $\Delta H = -ve$

② reactant → product + energy

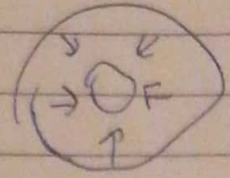
③ profile diagrams



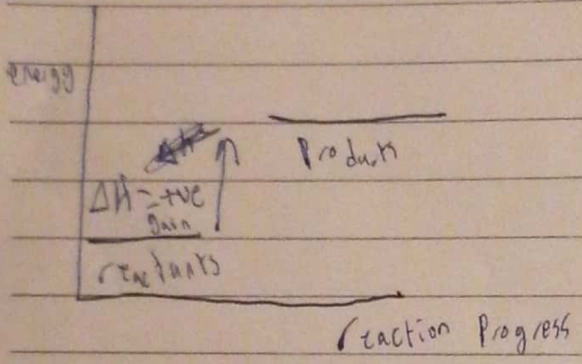
Output > input

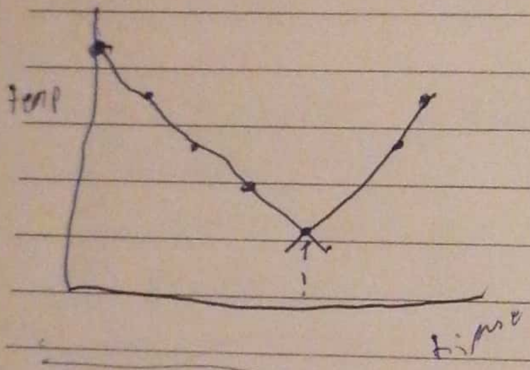
endo thermic

reactions that absorb (take in) energy from surrounding



For system energy level diagram





examples:

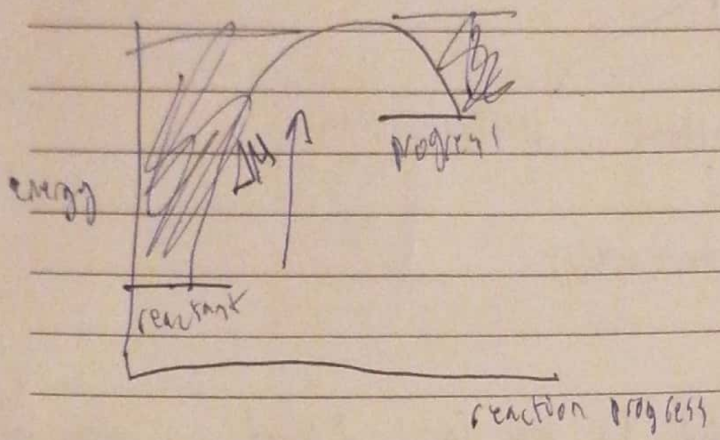
1) photosynthesis
2) photographic films
3) electrolysis
4) boiling, melting
5) breaking down bonds
6) thermal decomposition

how to express endo

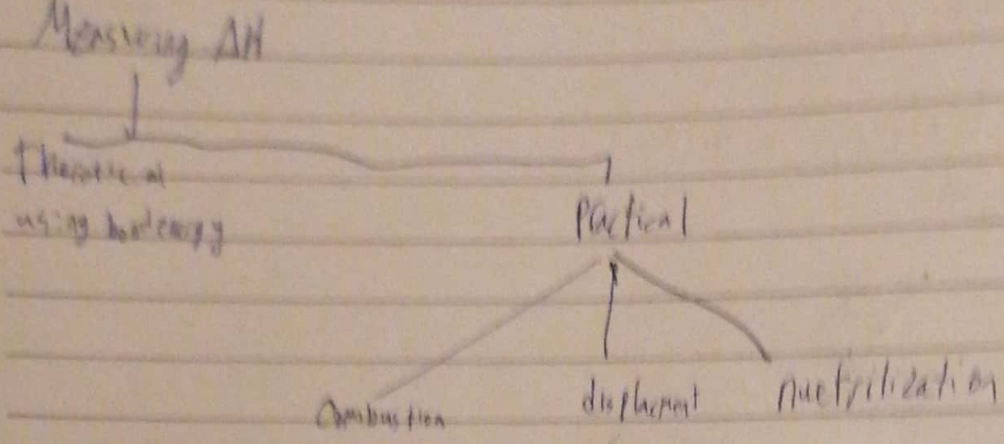
① $\Delta H = +ve$

② reactant + energy → product

③ profile diagram



Input > output



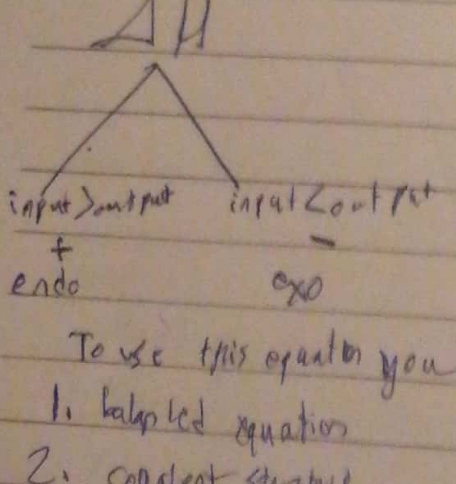
Measuring ΔH reaction using bond energy

bond energy:
The amount ~~[illegible]~~ of energy needed to break 1mol of bond in gaseous state
" " " " released " built " " " " "

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

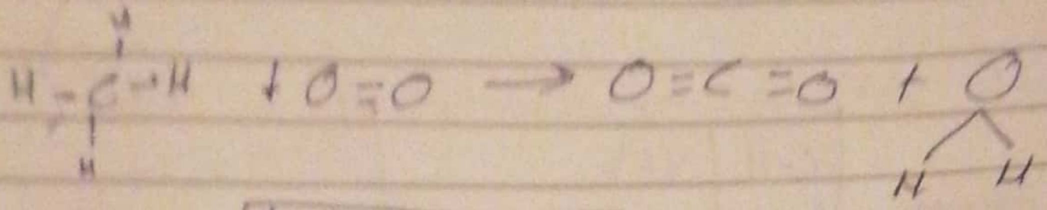
to break down bonds in reactants

to build up bonds in products



To use this equation you need:
1. balanced equation
2. covalent structure
3. bond energy

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



bond	bond energy
C-H	413
O=O	458
O-H	463
C=O	799

bond broken

$4 \times C{-}H = 4 \times 413$

$2 \times O{=}O = 2 \times 458$ +

2568

bond build

$2 \times C{=}O = 2 \times 799$ +

$4 \times O{-}H = 4 \times 463$

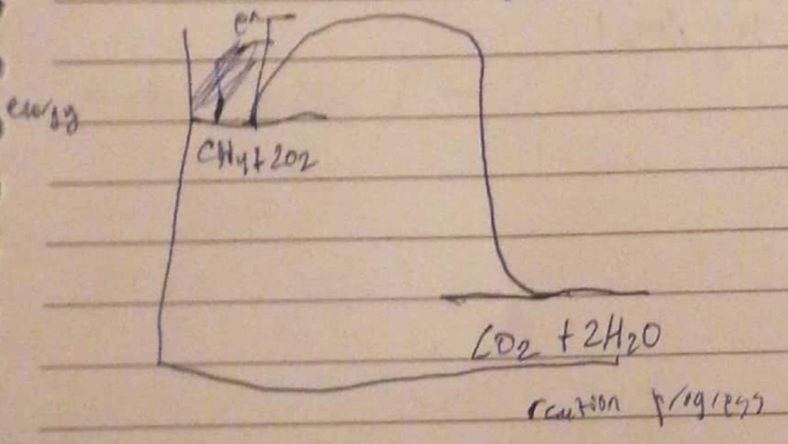
3450

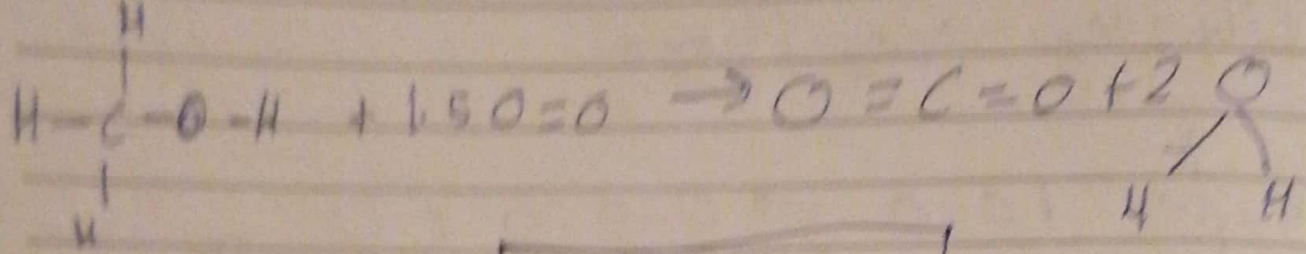
$\Delta H = 2568 - 3450$

$\Delta H = \textcircled{-}882\ kj/mol$

↓
exo

Draw profile diagram





$$H-\overset{H}{\underset{H}{C}}-O-H + 1.5\,O=O \rightarrow O=C=O + 2\,H_2O$$

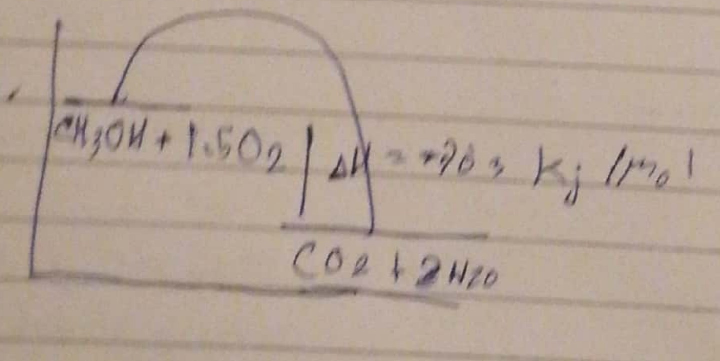
~~3x C-H = 3x~~ c

C-H	413
C-O	358
O-H	463
O=O	498
O=C	799
~~O-H~~	

3 × 413
1 × 358
1 × 463
1.5 × 498
2747 kJ

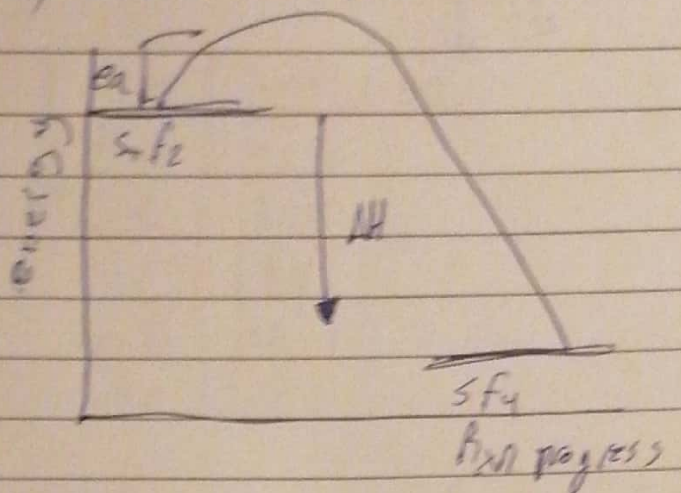
2 × 799
4 × 463
3450

2747 − 3450 = −703 kJ/mol
cko



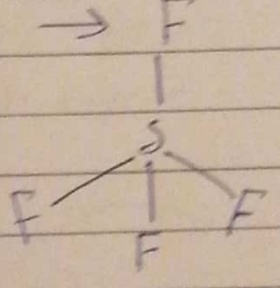
reaction between sulfur and fluorine. gives out 780 kj/mol
if the bond energy F-F is 160 kj/mol

1) Draw a profile diagram for the reaction



2) Find the bond energy for S-F

S + 2F-F →



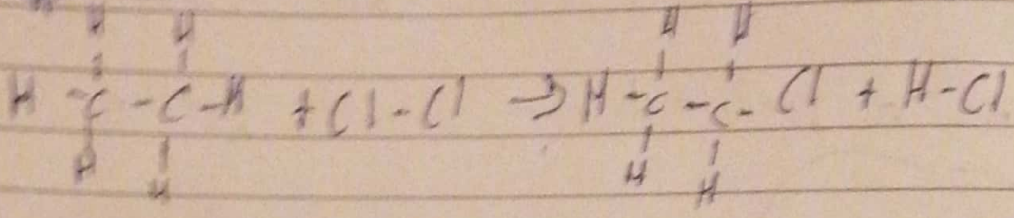
$-780 = (2 \times 160) - (4x)$

$-780 = 320 - 4x$

$\frac{-1100}{-4} = \frac{-4x}{-4}$

$x = 275$ kj/mol

[redacted]



$$H-C-C-H + Cl-Cl \rightarrow H-C-C-Cl + H-Cl$$

bond	bond energy
C-H	413
C-C	348
Cl-Cl	242
C-Cl	328
H-Cl	431

6x413
1x348
1x242
3068

5x413
1x328
1x348
1x431
3172

3068 - 3172 = -104

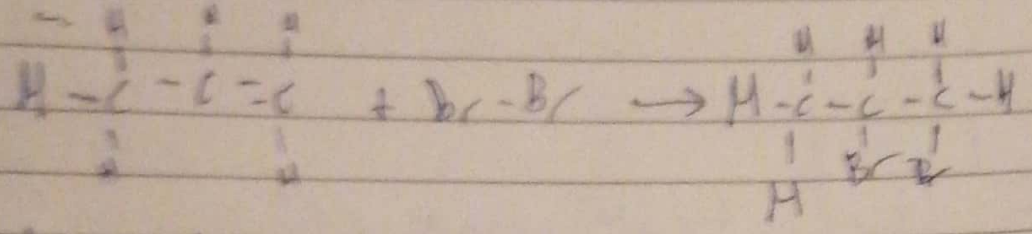
Or only calc broken bond

C-H 413 +
Cl-Cl 242
655

C-Cl 328 +
H-Cl 431
759

655 - 759 = -104

Calculate ΔH reaction and deduce if rxn is exo or endo



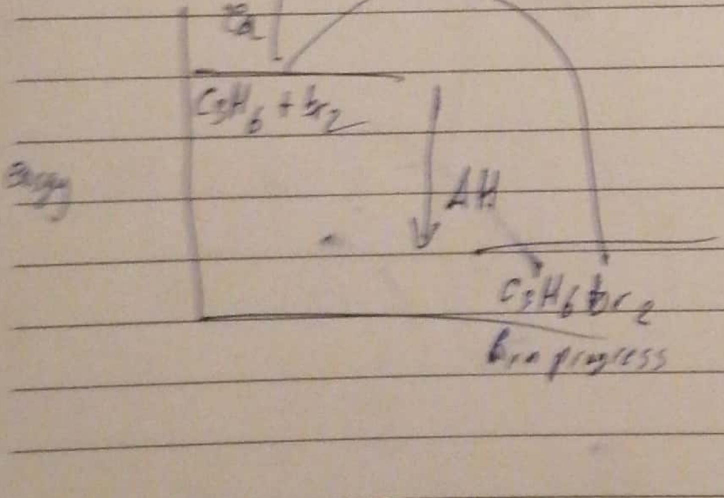
bond	bond energy
C-H	413
C-C	348
C=C	614
Br-Br	193
C-Br	276

C=C 614
Br-Br 193
807

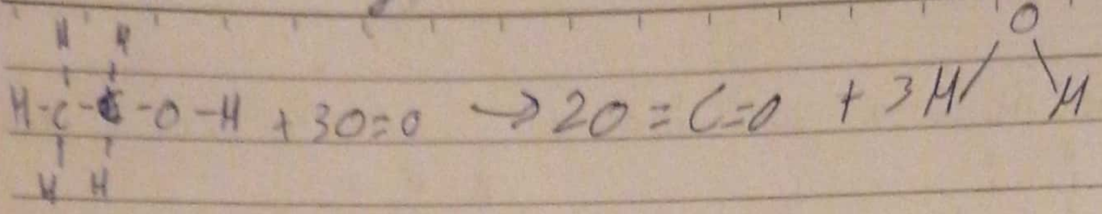
C-C 348
C-Br 2×276
960

807 − 900 = −93 Kj/mol exothermic

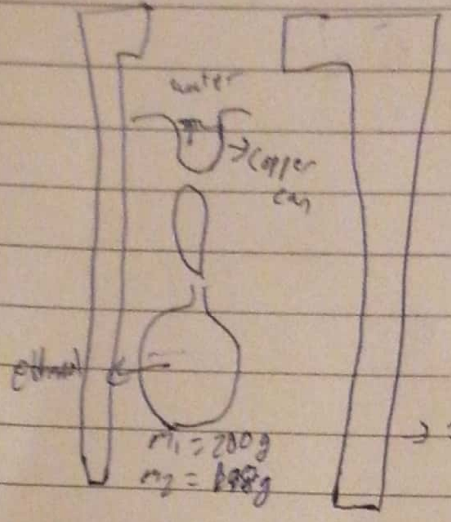
Draw profile diagram



Practically



$$\mathrm{H{-}C{-}C{-}O{-}H + 3O{=}O \rightarrow 2O{=}C{=}O + 3H{-}O{-}H}$$



Was: 22° became 28°

→ to reduce heat loss (polythene)

$Q = 100 \times 4.2 \times 6$
$Q = 2520\ J$
$2.52\ kJ$

$2.52\ kJ \xrightarrow{\text{released}} 2g\ C_2H_5OH$
$M_r = 46g$

$$\Delta H = \frac{46 \times 2.52}{2} = -57.96\ kJ/mol$$

two fuels A and B

Plan an exp to show which fuel produce more energy

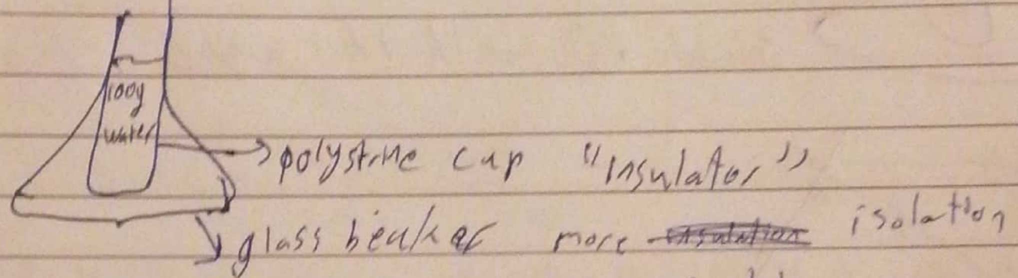
① take known mass of ~~fuel~~ A water with initial temp
② take known mass of fuel B
③ Ignite the fuel and measure final mass
④ and final temp of water
⑤ repeat with B

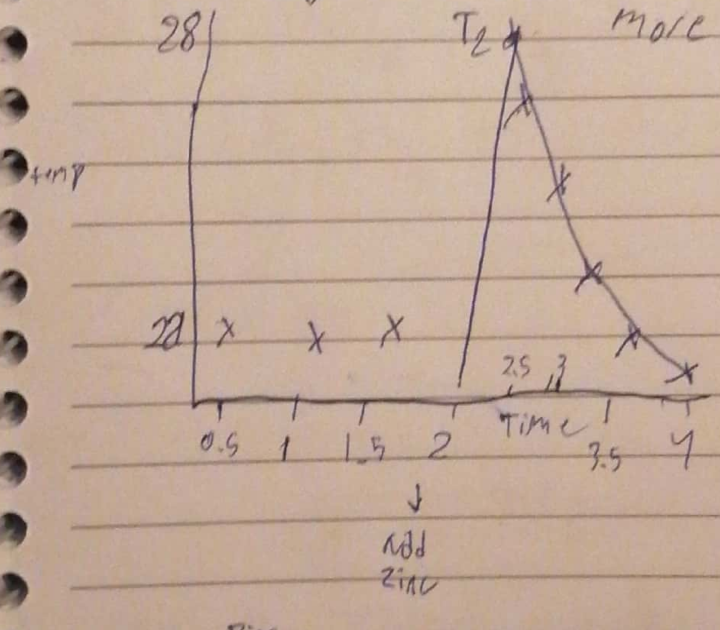
Conclusion: fuel which cause more temp change is are produce more energy

---

ΔH reaction for displacement

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





28 - 22 = 6°

$Q = mc\Delta t$

$Q = 100 \times 4.2 \times 6$

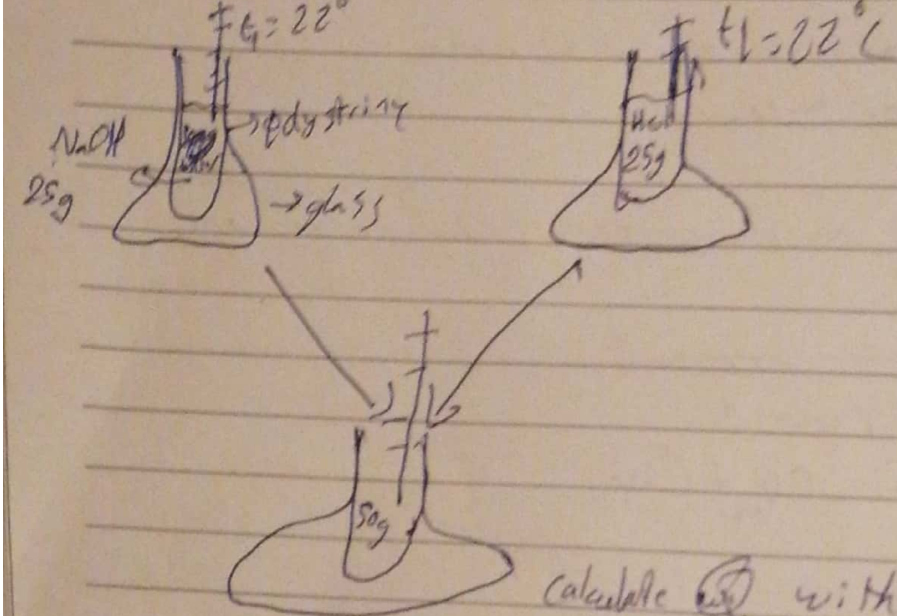
$Q = 2520\ J$

Add Zinc at 2 minutes to ensure no heat transfer and ensure constant temp

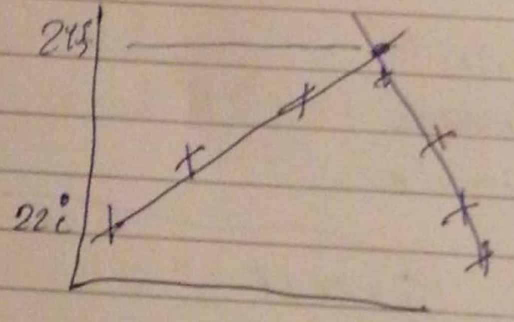
Five Apple

ΔH Neutralization

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

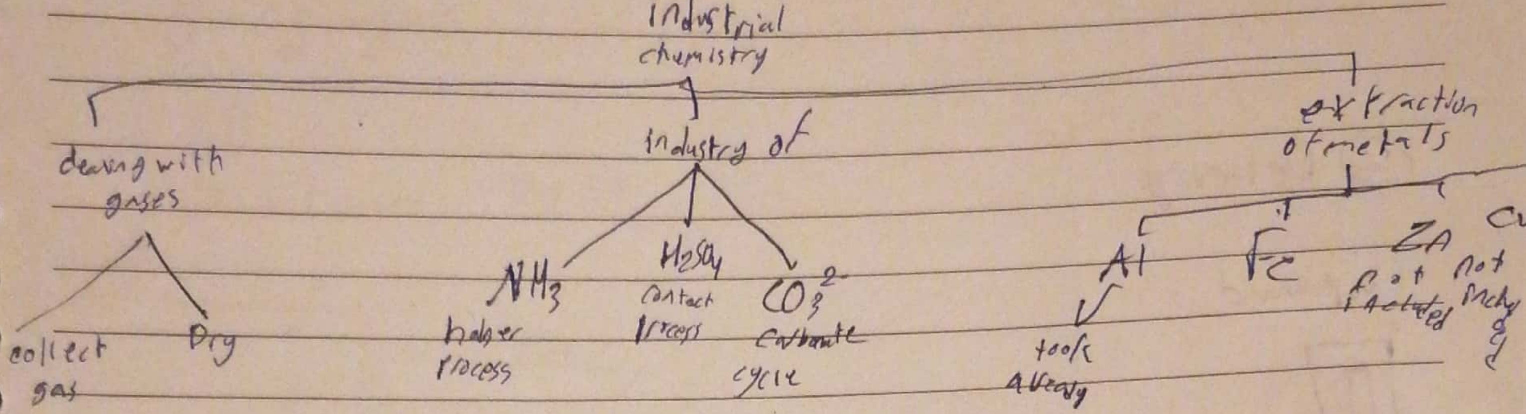


calculate Q with this graph



$Q = 50 \times 4.2 \times 2.5$

$= 525\ J$



Dealing with gas gas comes out wet we dry it

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

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

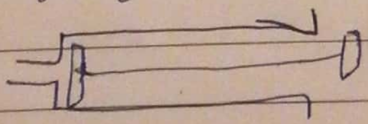
CO_2 ; $CaCO_{3(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O_{(L)} + CO_{2(g)}$

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

SO_2 ; $Na_2SO_{3(aq)} + HCl_{(aq)} \xrightarrow{\Delta} NaCl_{(aq)} + SO_{2(g)} + H_2O_{(L)}$

Collect gas

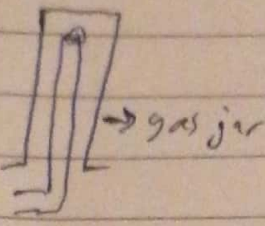
① gas Syringe



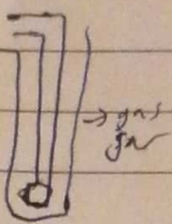
used to measure and collect any gas

② Delievry

upward



collect less dense gas than air



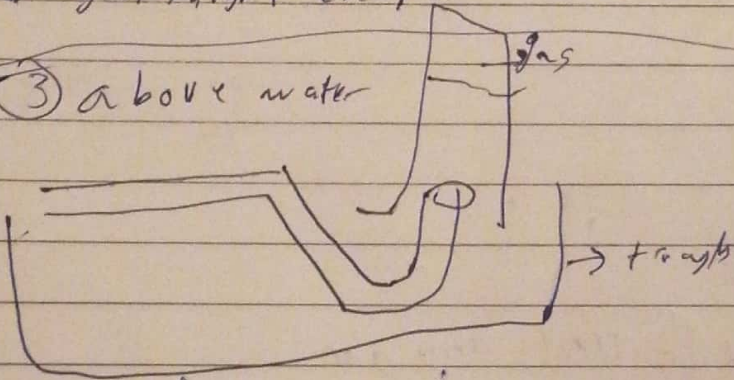
collect more dense gas than air

~~used~~

density air = 28.5

disadvangtes of both
¥ .mixes with other gas
¥ gas might escape

③ above water

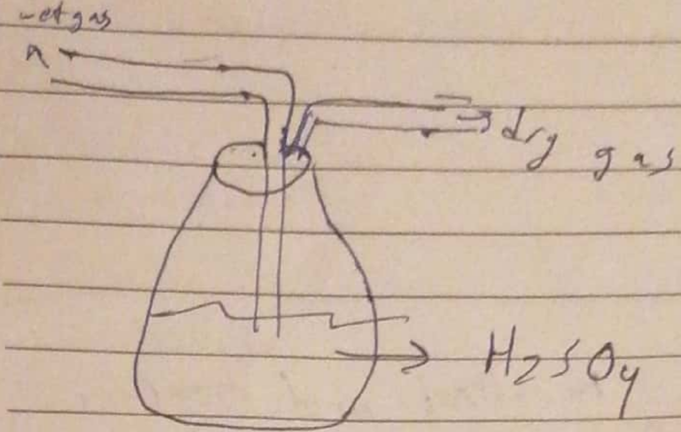


~~only for gases which don't dissolve~~
only for insoluble gas in water

Drying gas

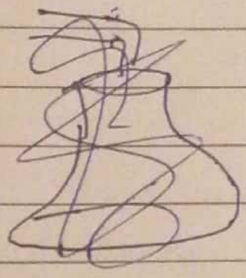
①

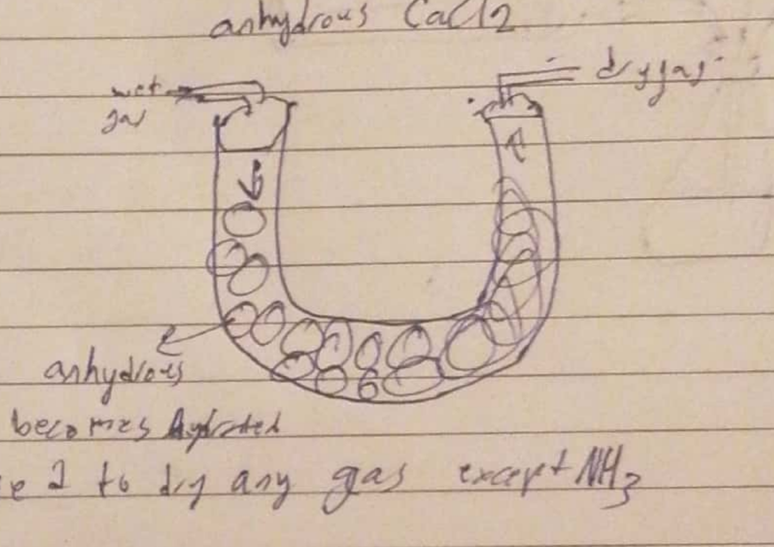
concentrated H_2SO_4



This method works to dry any gas except (NH_3) since it will react with H_2SO_4 (neutralization)
then H_2SO_4 becomes more dilute because it gains water

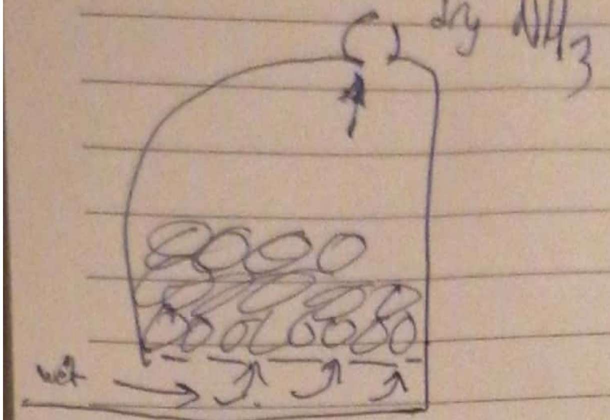
②





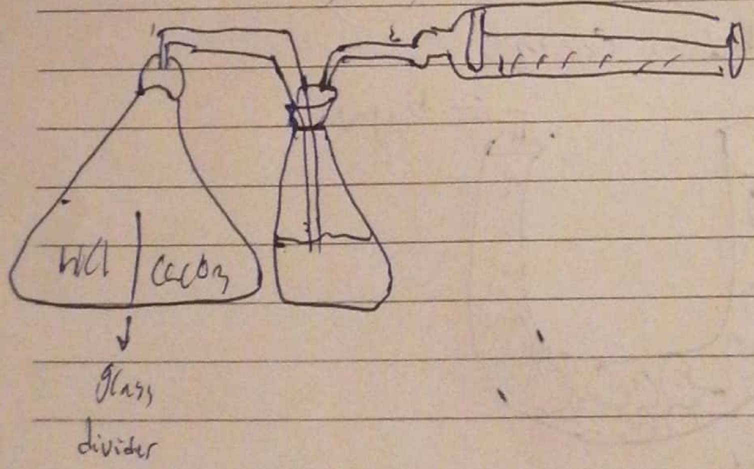
use 2 to dry any gas except NH_3

③ CaO (base



draw a suitable apparates to collect and measure the volume of dry CO_2 from this rxn
(insoluble)

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



Industry of ammonia (NH_3) Haber process

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

uses of amonia: Fertilizer, Cleaning detergent, smelling salt

essential conditions
temp: 400-450°C
Pressure: 200 Atm
catalyst: Fe

how to obtain

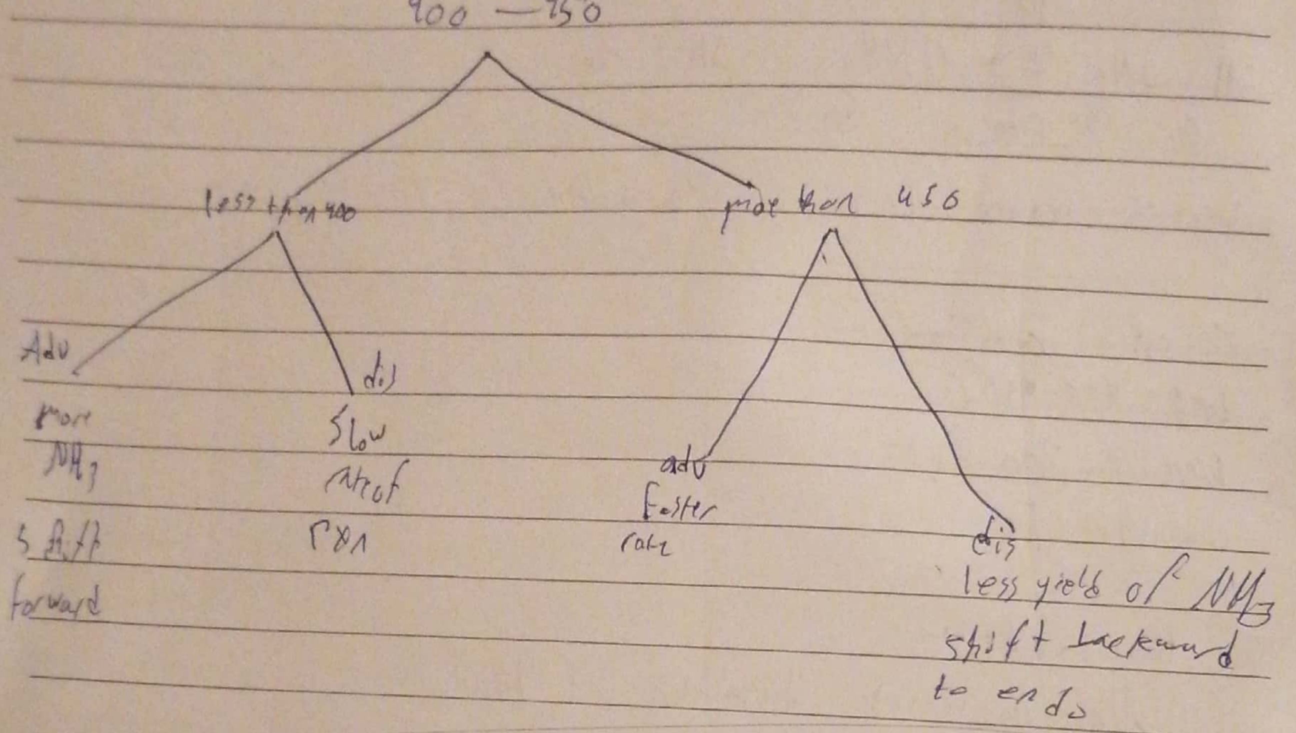
N_2: fractional distillation of liquid air

H_2: ① cracking of alkanes (organic)
② $CH_4 + H_2O \rightarrow CO + 3H_2$

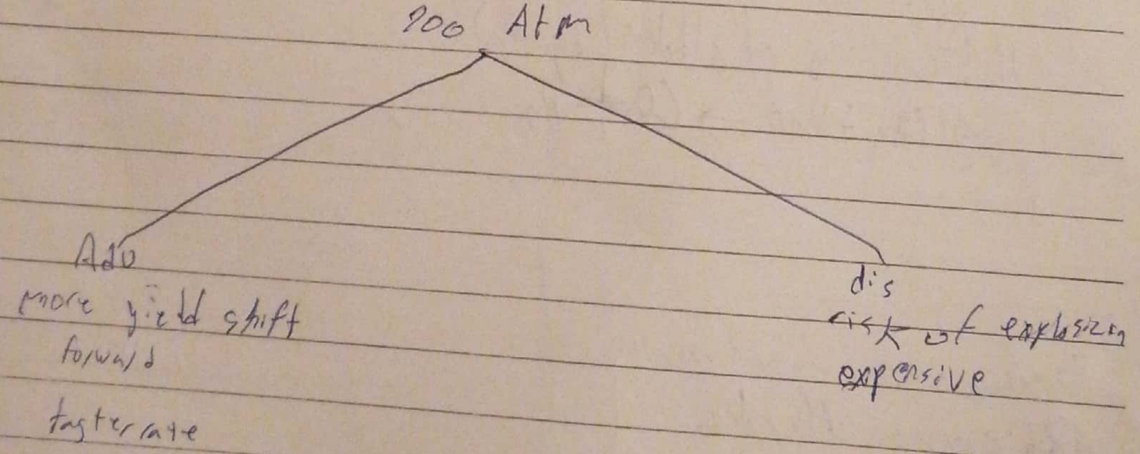
to enhance the forward reaction
Add excess H_2, N_2
return back to converter

remove NH_3 imediatly ? how?
~~cooling NH_3, then~~ cooling them NH_3 condense

temp



Pressure



or Industry of sulfuric acid.

fossil fuels $S \rightarrow SO_2 \rightarrow SO_3 \rightarrow H_2S_2O_7 \rightarrow H_2SO_4$

Zincblende | food preservative

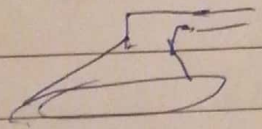
ve: fireworks, matches | paper industry

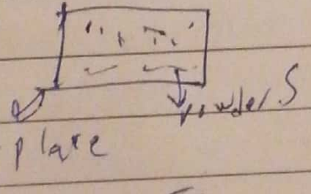
bleaching agent

$SO_3 \xrightarrow[\text{Highly exothermic + low yield ✗}]{H_2O} 2H_2SO_4$

add conc H_2SO_4 → $H_2S_2O_7$ → add H_2O → $2H_2SO_4$

From S to SO_2 (roasting)





$S + O_2 \rightarrow SO_2$

From SO_2 to SO_3 Contact process

$$2SO_2 + O_2 \underset{\text{endo}}{\overset{V_2O_5}{\underset{\longleftarrow}{\overset{\text{exo}}{\longrightarrow}}}} 2SO_3 \quad \Delta = -ve$$

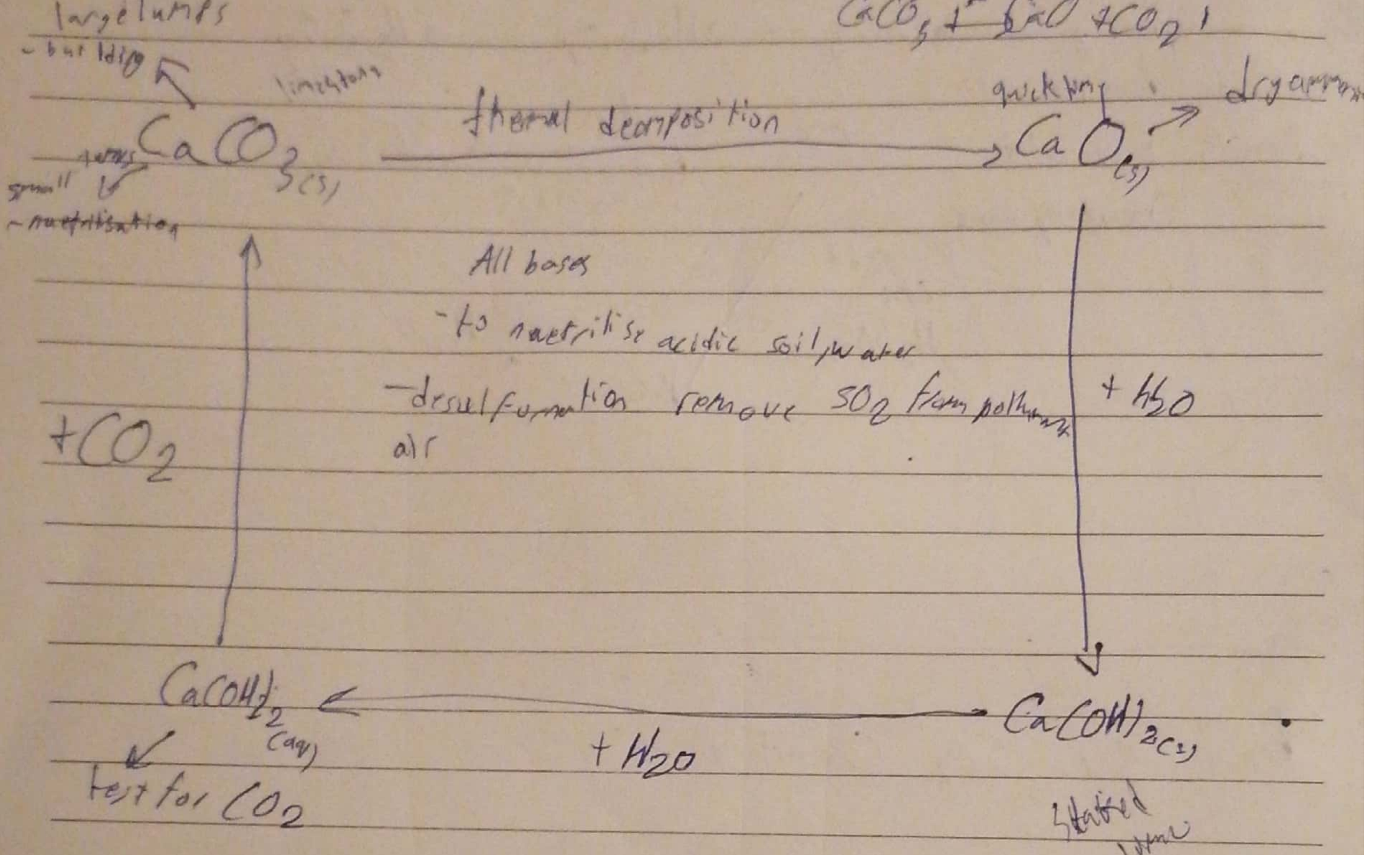
① temp 400 - 450°

② pressure 2 Atm max yield 98% at 2 Atm

③ catalyst : V_2O_5 (vanadium (V) oxide)

Carbonate Cycle

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2 \uparrow$



All bases
- to neutrilise acidic soil, water
- desulfurnation remove SO_2 from pollution air

extraction of metals

K
Na
Li
Ca
Mg
Al

C, CO

Zn (zinc blende)] reduction by C, CO
Fe (hematite)] "blast furnace"
Pb
H
Cu] reduction by H_2
Ag
Au

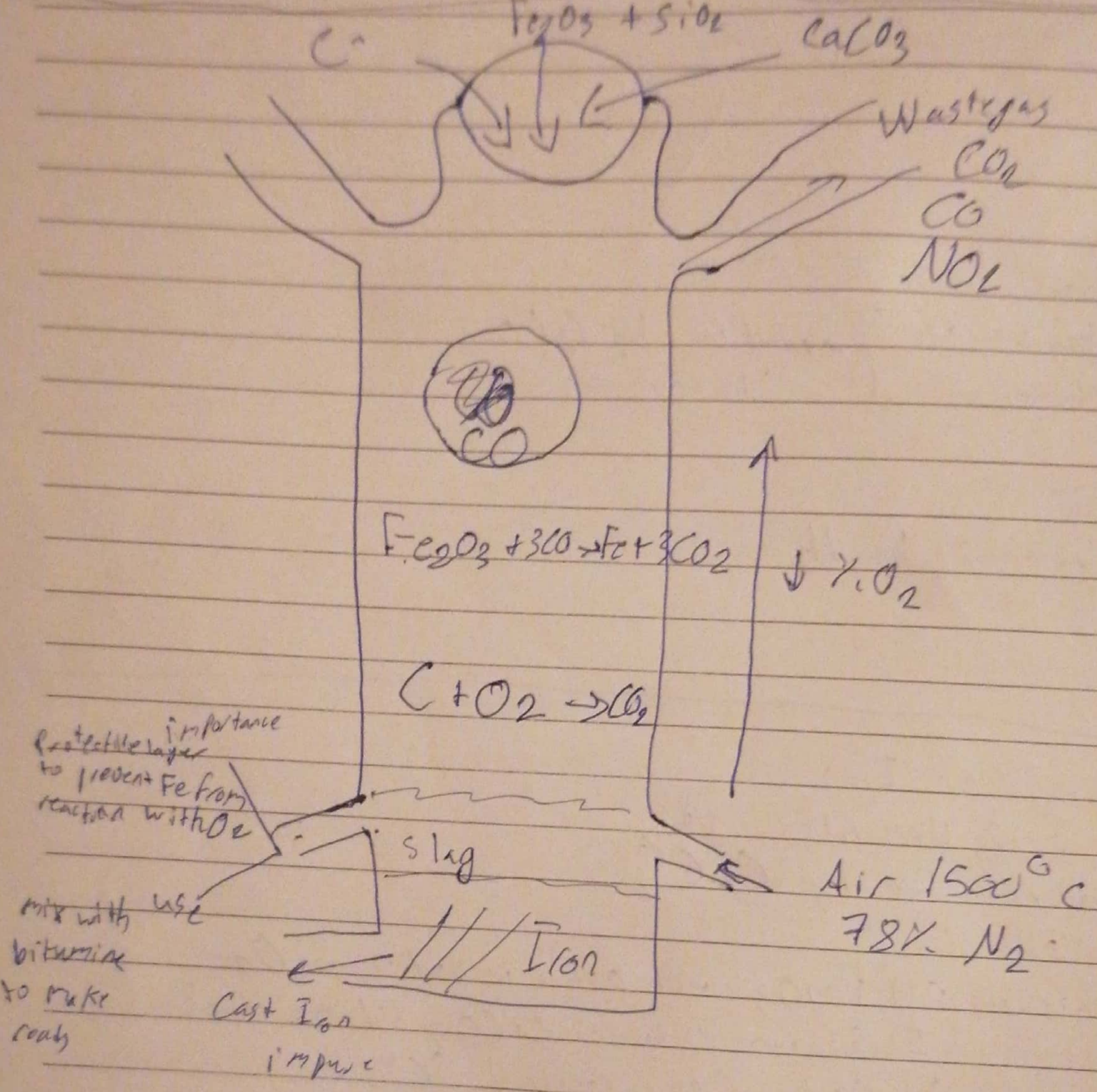
Extraction of Iron
ore: Fe_2O_3 Hematite
method: reduction by C, CO
place: blast furnace
raw materials (1) Fe_2O_3 with acidic impurities SiO_2
2) Calcium carbonate $CaCO_3$ "limestone"
3) Coke (pure carbon) "C"
4) Air 1600°C

---

reactions in furnace
① complete combustion $C + O_2 \longrightarrow CO_2$ produce energy
② incomplete " $C + O_2 \longrightarrow CO$ (redox)
③ $CO_2 + C \longrightarrow 2CO$ (redox)
④ $F_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$ (redox)

5) $CaCO_3 \xrightarrow{heat} CaO + CO_2$ (thermal decomposition)

6) $CaO + SiO_2 \rightarrow CaSiO_3$ (neutralization)



Steel making "Oxygen-base process"

Cast Iron

$\boxed{C}$ — hot air removes them CO_2, SiO_2

S

Si — base CaO — Si_2, P_2O_5 get neutrilized

P

Steel

mild steel car body

0.03% C

medium steel railing

0.3% C

stainless cutlers / watch

3-5% C

Extraction of zinc (not in external but just incase)

Ore: Zinc blende
method: reducing by C, CO
place: blast furnace

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

$ZnS + C \rightarrow$ no rxn

step1: $ZnS + O_2 \rightarrow ZnO + SO_2$ (roasting with O_2)

Step: 2 blast furnace

$C + O_2 \rightarrow CO_2$
$2C + O_2 \rightarrow 2CO$
$CO_2 + C \rightarrow 2CO$
$CO + ZnO \rightarrow \underset{\downarrow}{Zn} + CO_2$

produced Zn is 100% pure because

temp inside furnace is 1500°C and b.p of zinc is 907°c so Zn is produced as gas leaving other impurities behind

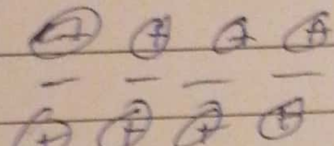
Alloy :- mixture of metal with another metal or semi-metal

Brass: Cu, Zn

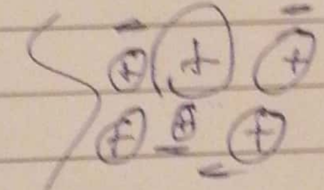
bronze: Cu, Sn

steel: Fe, C, Cr, Ni

Cu



same size so easier to side.



two different size so harder to slide.