Chemistry

Qais Hijazin 10"G"

## Redox Reactions

* in terms of oxygen:-

Redox

| Reduction | Oxidation |
|---|---|
| lose $O_2$ | gain $O_2$ |

reduction: Fe in $Fe_2O_3$

* $Al + Fe_2O_3 \rightarrow Al_2O_3 + Fe$

oxidation: Al

reduction: Cu in CuO

* $H_2 + CuO \rightarrow Cu + H_2O$

oxidation: $H_2$

reduction Zn in ZnO

* $CO + ZnO \rightarrow Zn + CO_2$

oxidation: $O_2$

## In terms of hydrogen

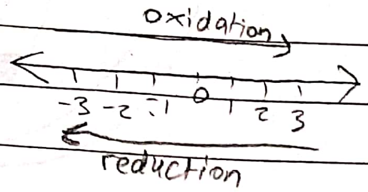
| reduction | oxidation |
|---|---|
| gain $H_2$ | lose $H_2$ |

reduction: $Cl_2$

$H_2S + Cl_2 \longrightarrow HCl + S$

oxidation: S in $H_2S$

* in terms of oxidation state



(for charges)

Rules of ox. state

1- ox. state of any free element is ZERO
Mono di ~~[illegible]~~ poly atomic (Na, K, Ca / $H_2$, $O_2$ / $P_4$, $S_8$)

2- ox. number of any atom in a compound form
group 1 → +1 Li, Na, K, Rb group 3 → +3 only Al
group 2 → +2 Mg, Ca, Sr, Ba group 7 → -1 only F

3- ox. number of hydrogen (+1)
except with metals in metal hydroxides (-1)

non metals :- metals :-
$CH_4^{+1}$ , $NH_3^{+1}$ $\overset{+1}{Na}H^{-1}$ , $\overset{+1}{Ca}\overset{-1}{H_2}$

4- ox. state for oxygen is (-2)
except in peroxide (-1) except in $OF_2$ (+2)

* sodium oxide: $Na^{+1} + O^{-2} \rightarrow Na_2O^{-2}$
* sodium peroxide: $Na^{+1} + O_2^{-2} \rightarrow Na_2O_2^{-1}$
water: $H_2O^{-2}$
hydrogen peroxide: $H_2O_2^{-1}$
calcium oxide: $Ca^{+2} + O^{-2} \rightarrow CaO$
calcium peroxide: $Ca^{+2} + O_2^{-2} \rightarrow CaO_2$

5- the sum of all ox. state in a compound = $O_2$ in ion = charge of ion.

- compounds :-

$\overset{+1}{Na}Cl$ $Cl = -1$

$\overset{\uparrow}{+1 + Cl = 0}$

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

$Cl = +1$

$\overset{+1}{H}ClO_2^{-2}$ $Cl + 1 + 2(-2) = 0$

$Cl = +3$

$N\overset{+1}{H_3}$ $N + \overset{3(+1)}{[illegible]} = 0$

$N = -3$

$N_2O_5^{-2}$ $2N + 5(-2) = 0$

$N = +5$

$\overset{+1}{H_2}S$ $2(+1) + S = 0$

$S = -2$

$\overset{+1}{H_2}S\overset{-2}{O_4}$ $S + 2(+1) + 4(-2) = 0$

$S = +6$

- ions :-

$NO_3^{-\overset{1}{[illegible]}}$ $N + 3(-\overset{2}{[illegible]}) = [illegible] -1$

$N = +5$

$MnO_4^{-1}$ $Mn - 8 = -1$

$Mn = +7$

$SO_3^{-2}$ $S - 6 = -2$

$S = +4$

$Cr_2O_7^{-2}$ $2Cr - 14 = -2$

$Cr = [illegible] +6$

Ex;

$Fe_2O_3^{-2}$ $2Fe + 3(-2) = 0$

$Fe = +3$

$OF_2^{-1}$

$O + 2(-1) = 0$

$O - 2 = 0$

$O = +2$

$SO_4^{-2}$ $S + 4(-2) = -2$

$S = +6$

$V_2O_5^{-2}$ $2V+5(-2)=0$

$V=+5$

$PO_4^{-2\ -3}$

$P+4(-2)=-3$

$P=+5$

$CrO_4^{-2}$

$Cr-8=-2$

$Cr=+6$

$CO^{-2}$

$C-2=0$

$C=+2$

$CO_2^{-2}$

$C+2(-2)=0$

$C-4=0$

$C=+4$

$CO_3^{-2}$

$C+3(-2)=0$

$C-6=0$

$C=+6$

0 3+ 2- 3+ 2- 0
$Al + Fe_2O_3 \rightarrow Al_2O_3 + Fe$
oxidation: $Al \rightarrow Al^{3+}$
reduction: $Fe^{3+} \rightarrow Fe$

writing balanced half ionic equation:
1) Atoms
2) the charge by adding $\bar{e}$ to the side with greater charge by the difference.

0 2+ 1- 2+ 1- 0
$Ca + ZnCl_2 \rightarrow CaCl_2 + Zn$
H.O.O: $Ca \rightarrow Ca^{2+} + 2\bar{e}$
H.O.R: $Zn^{2+} + 2\bar{e} \rightarrow Zn$

0 1+ 1- 1+ 1- 0
$Na + HCl \rightarrow NaCl + H_2$
H.O.O → $Na \rightarrow Na^{+1} + 1\bar{e}$
H.O.R → $2^{+}H + 2\bar{e} \rightarrow H_2$

0 3+ 1- 2+ 1- 0
$Ca + AlCl_3 \rightarrow CaCl_2 + Al$
H.O.O: $Ca \rightarrow Ca^{2+} + 2\bar{e}$
H.O.R: $Al^{3+} + 3\bar{e} \rightarrow Al$

2- 0 -1 0
$H_2S + Cl_2 \rightarrow HCl + S$
H.O.O: $S^{2-} \rightarrow S + 2\bar{e}$
H.O.R: $Cl_2 + 2\bar{e} \rightarrow 2Cl^{-}$

0 1+ 1- 1+ 1- 0
$Na + HCl \rightarrow NaCl + H_2$
H.O.O: $(2Na \rightarrow 2Na^{+1} + \cancel{2\bar{e}}) \times 2$
H.O.R: $2H^{+} + \cancel{2\bar{e}}\ \cancel{4} \rightarrow H_2$

overall: $2Na + 2H^{+} \rightarrow 2Na^{1+} + H_2$

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

$H.O.\,(2Al \rightarrow 2Al^{3+} + \underset{3}{6e}) \times 2$

$H.O.R(\overset{6}{\cancel{2}}H^{+}_{6,} \underset{+6e}{} \rightarrow 3H_2) \times 3$

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

oxidising agent "oxidant"

Its the substance that itself reduced and causes the other tobe oxidised.

reducing agent "reductant"

the substance that itself oxidise to make other reduced

$\overset{0}{Al} + \overset{+3}{Fe_2}\overset{-2}{O_3} \rightarrow \overset{+3}{Al_2}\overset{-2}{O_3} + \overset{0}{Fe}$ ox. agent = $Fe_2O_3$ red. agent = Al

$\overset{+2}{C}\overset{-2}{O} + \overset{+2}{Zn}\overset{-2}{O} \rightarrow \overset{0}{Zn} + \overset{+4}{C}\overset{-2}{O_2}$ ox. agent = ZnO red. agent = CO

$\overset{+1}{H_2}\overset{-2}{S} + \overset{0}{Cl_2} \rightarrow \overset{+1}{H}\overset{-1}{Cl} + \overset{0}{S}$ oxidant : $Cl_2$ reductant : $H_2S$

$\overset{+7}{Mn}\overset{-1}{O_4} + \overset{+2}{Fe} + \overset{+1}{H} \rightarrow \overset{+2}{Mn} + \overset{+3}{Fe} + \overset{+1}{H_2}\overset{-2}{O}$ oxi: $MnO_4^{-1}$ red: $Fe^{2+}$

if substance is ion, In a compound, then the compound is the agent most common oxidising agent

1) oxygen

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

2) Acidify pottasium manganate $KMnO_4/H^+$

$\underset{+7}{MnO_4^{-1}} \longrightarrow \underset{+2}{Mn^{2+}}$

purple colorless

3) Acidify pottassium dichromate $K_2Cr_2O_7/H^+$

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

+6 +3

orange → green

4) Halogens

$2\bar{e} + \overset{\text{yellow}}{F_2^0} \rightarrow \overset{-2}{2F^-}$

$2\bar{e} + \overset{\text{greenyellow}}{Cl_2} \rightarrow 2Cl^-$ colorless

$2\bar{e} + \overset{\text{red brown}}{Br_2} \rightarrow 2Br^-$ solutions

$2\bar{e} + I_2 \rightarrow 2I^-$

↓ purple gas

black solid

red brown solution (aq)

$Na + Cl_2 \rightarrow 2NaCl$

most common reducing agent

1) Hydrogen, $\overset{0}{H_2} + \overset{0}{CuO} \rightarrow \overset{+1\ 2-}{H_2O} + \overset{0}{Cu}$

2) Carbon and carbon monoxide. $\overset{0}{C} + \overset{3+}{Fe_2}\overset{2-}{O_3} \rightarrow \overset{0}{Fe} + \overset{2+\ 2-}{CO}$

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

3) Iodide $\underset{\text{colorless}}{2I^-_{(aq)}} \rightarrow \underset{\text{red-brown}}{I_{2(aq)}} + 2\bar{e}$

## 4) Metals

strongest reductant ↖ K ↗ weakest oxidant

Na

Li

Ca

Mg

Al

ClCO

Zn

Fe

Pb

H

Ca

Ag → strongest oxidant ← $Ag^{+}$

↙ weakest reductant

→ metals more reactive

→ more likely to lose $e^-$

→ more likely to oxidise

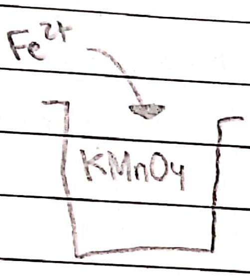
→ more likely to be a reducting agent

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

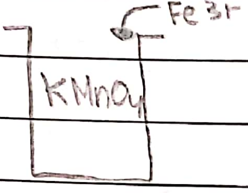
$Cl_2$ $Cl^-$
$F_2$ $F^{-1}$

Q1 $Fe^{2+}$ is a reducing agent
$Fe^{3+}$ is an oxdising agent
record an observation in each of the following reactions

1)

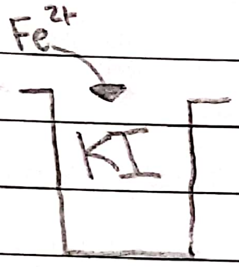


change colour
from purple to
colorless

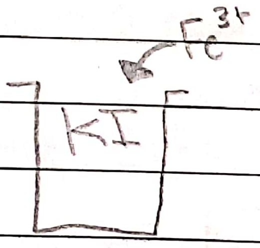


stays purple.

2)



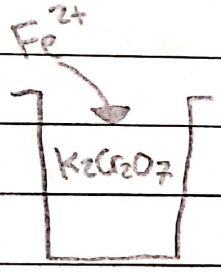
stays colorless



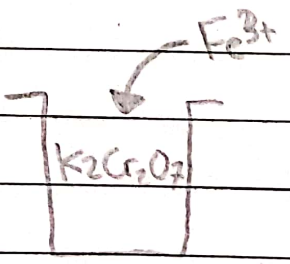
$$2I^- \rightarrow \underbrace{I_2}_{(aq)} + 2e^-$$

colorless → redbrown

3)



orange → green



no change (stays orange).

Discharging

# Electrolysis

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

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

Why the ionic compounds conduct electrity when dissolve in water or being molten?
the ions are free to move.

* Electrolyte : chemical compound that conduct electricity when molten or aqueous.

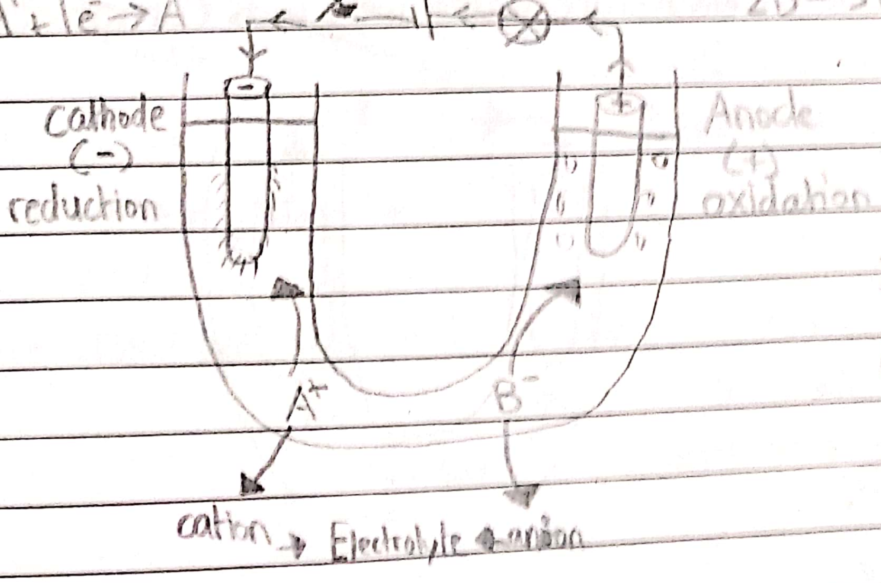
$NaCl_{(s)} \xrightarrow{heat} Na^+_{(L)} + Cl^-_{(L)}$

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

## Electrolysis cell

$A^+ + 1e^- \rightarrow A$

$2B^- \rightarrow B_2 + 2e^-$



Electrodes
- Inert
  - graphite
  - platinum
- reactive
  - copper
  - silver

Corrosion

Electrolysis = discharging

Ion → Element

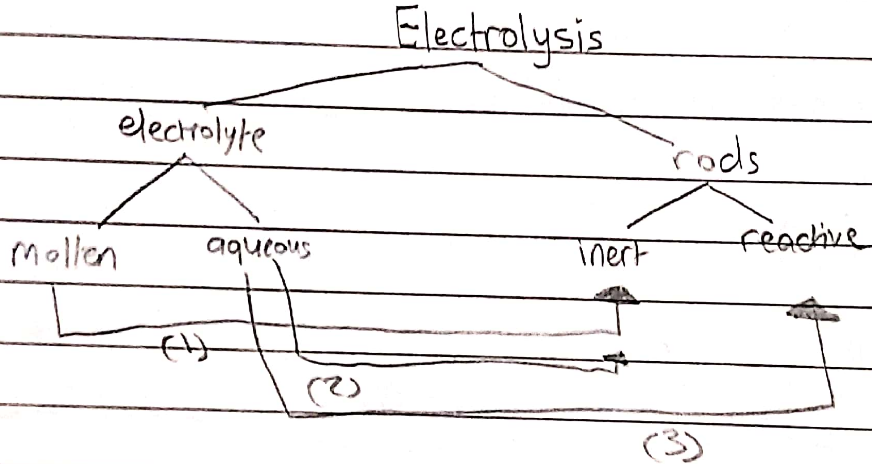
| cations | anions |
|---|---|
| $1\bar{e} + Na^+ \to Na$ | $2F^{-1} \to F_2 + 2\bar{e}$ |
| $2\bar{e} + Mg^{2+} \to Mg$ | $2Cl^{-1} \to Cl_2 + 2\bar{e}$ |
| $2\bar{e} + Ca^{2+} \to Ca$ | $2Br^{-1} \to Br_2 + 2\bar{e}$ |
| $3\bar{e} + Al^{3+} \to Al$ | $2I^{-1} \to I_2 + 2\bar{e}$ |
| $2\bar{e} + 2H^+ \to H$ | $2O^{2-} \to O_2 + 4\bar{e}$ |

$F_2$ yellow gas

$Cl_2$ green yellow gas

$Br_2$ red brown gas and liquid

$I_2$ black solid
purple gas
red brown sol.



## Electrolysis for molten electrolyte using inert rods (graphite)

$NaCl_{(l)}$

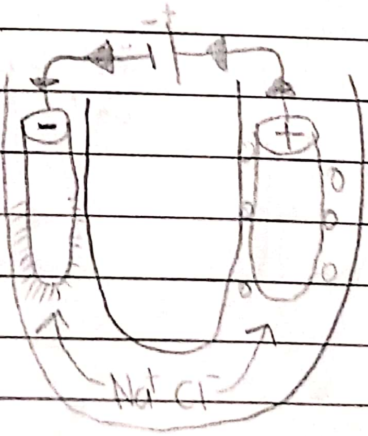
otal ions $Na^+$ $Cl^-$

cathode Anode

$Na^+ + 1\bar{e} \to Na$ $2Cl^- \to Cl_2 + 2\bar{e}$

deposite of metal

bubbles of green-yellow gas



Electrolyte used up

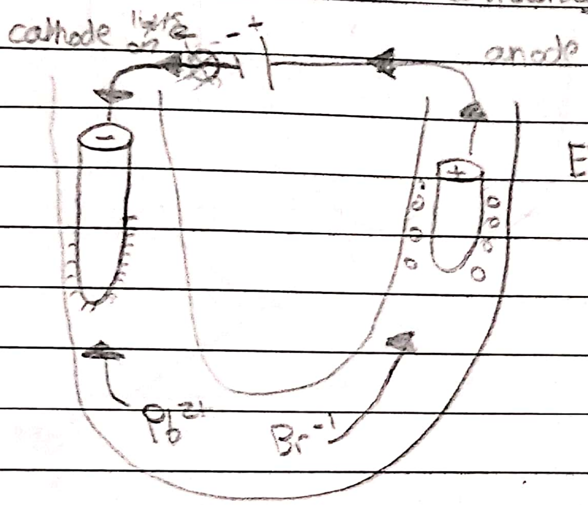
$NaCl_{(l)} \xrightarrow{electricity} Na + Cl_2$

## Molten Lead (II) Bromide

$PbBr_2$ (l)

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

cathode | anode
$2e^- + Pb^{2+} \rightarrow Pb$ | $2Br^{-1} \rightarrow Br_2 + 2e^-$
deposite of metal | bubbles of red-brown gas



Electrolyte : used up

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## $CuCl_2$ (l)/graphite

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

Cathode | Anode
$Cu^{2+} + 2e^- \rightarrow Cu$ | $2Cl^- \rightarrow Cl_2 + 2e^-$
deposite of metal | bubbles of green-yellow gas.

Electrolyte: used up/consumed

## $Al_2O_3$ (l)/ graphite

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

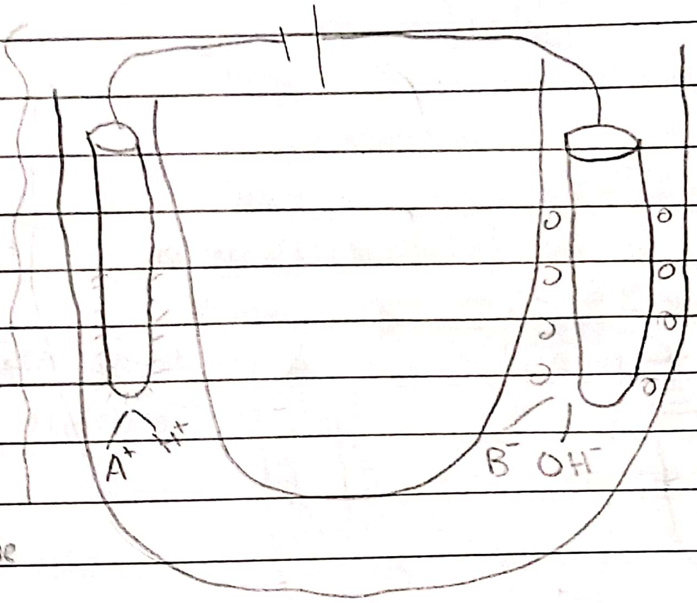
cathode | Anode
$Al^{3+} + 3e^- \rightarrow Al$ | $2O^{2-} \rightarrow O_2 + 4e^-$
deposite of metal | bubbles of colorless gas

Electrolyte : used up

## * Electrolysis of aqueous electrolytes using Inert

AB (aq)

| | |
|---|---|
| A ← $A^+$ | $B^-$ |
| H ← $H^+$ | $OH^-$ |
| cathode | anode |



At the cathode:-
The less reactive Ion is more likely to reduce and the more reactive stays in the electrolyte.

✗
- $K^+$
- $Na^+$
- $Li^+$
- $Ca^{+2}$
- $Mg^{+2}$
- $Al^{+3}$
- $Zn^{+2}$
- $Fe^{+2,+3}$
- $Pb^{+2}$

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

✓
- $Cu^{+1,+2}$
- $Ag^{+1}$
- $Au^{+2}$

At the anode.
always $OH^-$ except concentrated Halide: $Cl^-$, $Br^-$, $I^-$
-when the halide oxidise
$2Cl^- \rightarrow Cl_2 + 2e^-$
-when $OH^-$ oxidise
$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$
bubbles of colorless gas

concentrated NaCl (aq) / graphite

| | |
|---|---|
| $Na^+$ | $Cl^-$ |
| $H^+$ | $OH^-$ |
| cathode | anode |
| $2H^+ + 2e^- \rightarrow H_2$ | $2Cl^- \rightarrow Cl_2 + 2e^-$ |
| bubbles of colorless gas | bubbles of green yellow gas |

electrolyte: NaOH

ALWAYS $OH^-$ EXCept with conc. Halide

ALWAYS $H^+$ Except with less reactive

$CuSO_4$ (aq) / graphite

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

$H^+$ $OH^-$

cathode anode

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

↓ electrolyte: $H_2SO_4$ ↓

deposite of red brown solid colorless gas

dilute NaCl (aq) / graphite

$Na^+$ $Cl^-$

$H^+$ $OH^-$

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

bubbles of colorless gas } bubbles of colorless gas Electrolyte: NaCl

| gas | test | result |
|---|---|---|
| $H_2$ | lighted splint | pop |
| $O_2$ | glowing splint | relight |
| $Cl_2/Br_2$ | damp litmus paper | turns red then bleach |

conc. KI (aq) / graphite

$K^+$ $I^-$

$H^+$ $OH^-$

cathode anode

$2H^+ + 2e^- \rightarrow H_2$ ~~$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$~~ $2I^- \rightarrow I_2 + 2e^-$

bubbles of colorless gas red brown solution

electrolyte: KOH

conc. $CuCl_2$ / graphite

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

$H^+$ $OH^-$

cathode anode

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

deposite of red brown solid } bubbles of green-yellow gas

electrolyte: less conc. $CuCl_2$

---

conc. sodium chloride called brine solution.

NaCl (aq)

$Na^+$ $Cl^-$

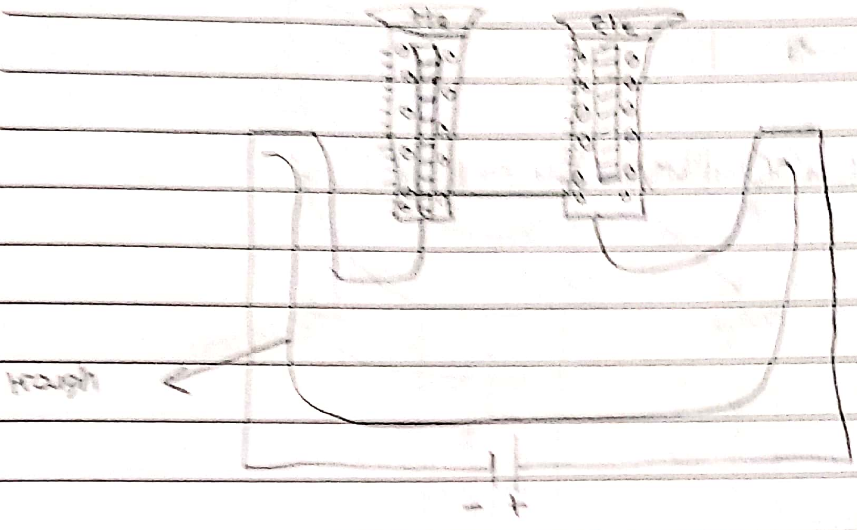
$H^+$ $OH^-$

cathode anode

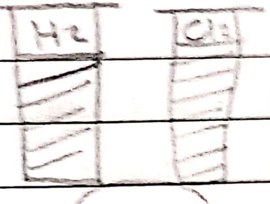
$2H^+ + 2e^- \rightarrow H_2$ } $2Cl^- \rightarrow Cl_2 + 2e^-$

electrolyte: NaOH

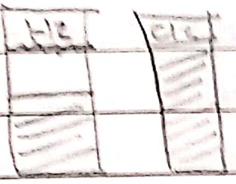
Q1: Plan an experiment to collect and measure the volume of $H_2$ and $Cl_2$ produced?



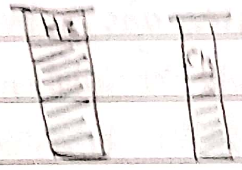
Q2 - the final appearance of the two measuring cylinders are:



(a)



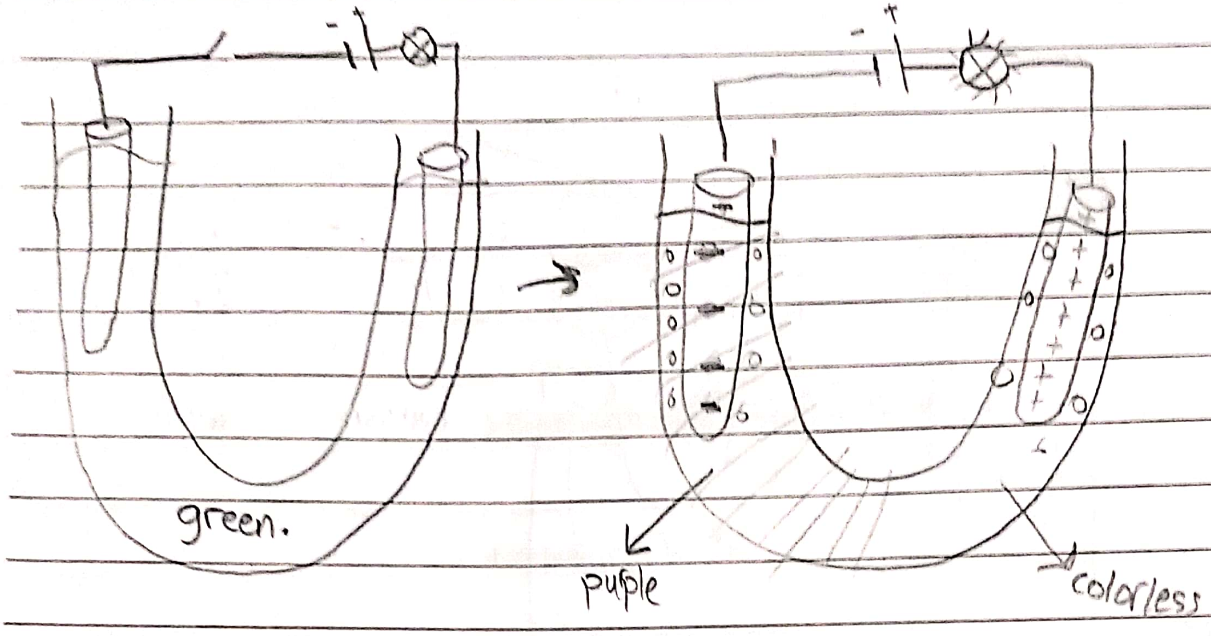
(b)



(c)

H.O.O: $2Cl^- \rightarrow Cl_2 + 2e^-$
H.O.R: $2H^+ + 2e^- \rightarrow H_2$
overall rxn: $2H^+ + 2Cl^- \rightarrow Cl_2 + H_2$
1:1

Q3: Brine with universal indicator



observation.

1- the bulb lights up

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

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

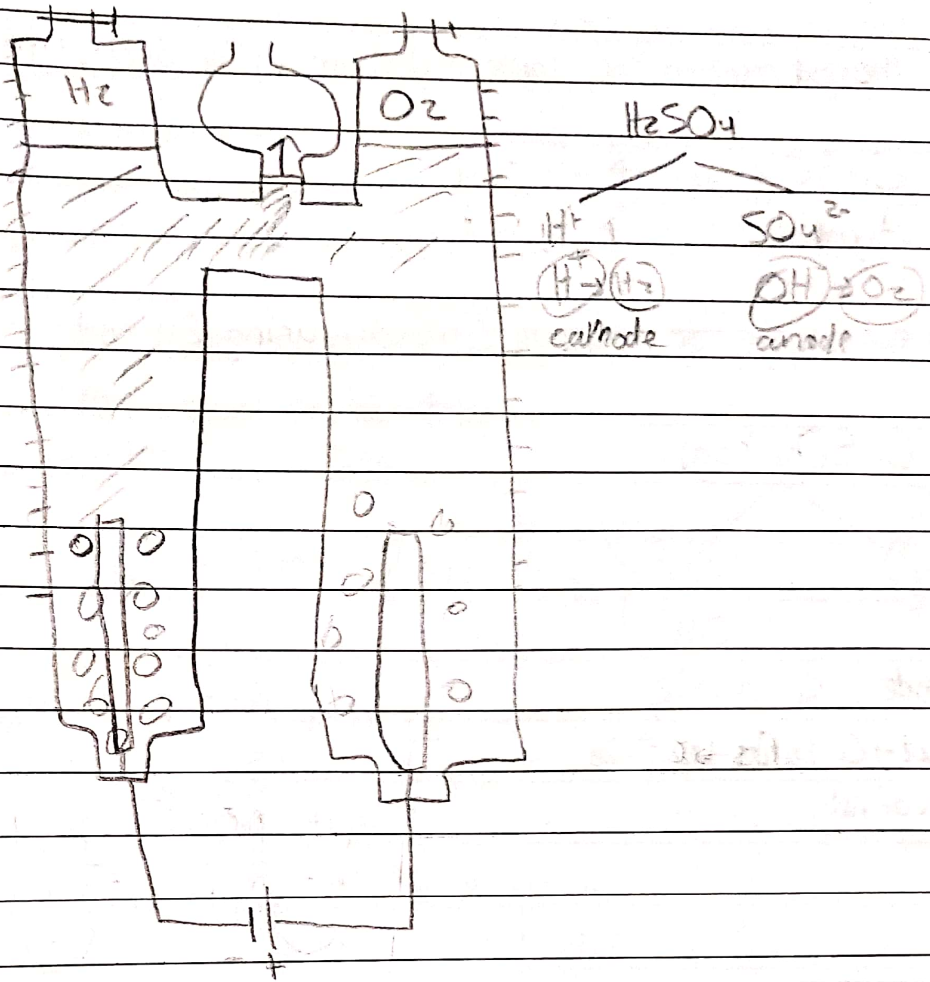
4- around the cathode the solution becomes purple because NaOH is an alkali

5- around the anode the solution becomes colorless since $Cl_2$ bleaches the color.

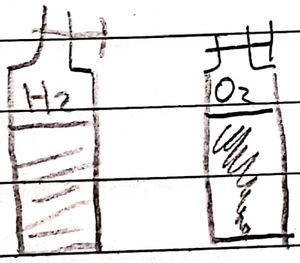
the $Cl_2$ not immedially appear as $H_2$ produce ? answer some $Cl_2$ dissolve in solution.

Electrolysis for $H_2SO_4$ (aq)

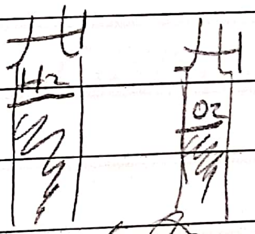
Hoffman device



Q2: the final appearance:



a



b

c

## Electrolysis for aqueous electrolyte using active rod

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

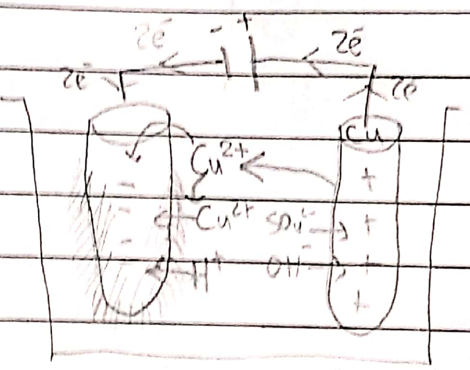
$CuSO_4 (aq) \xrightarrow{using} Cu$ rod
$AgNO_3 (aq) \xrightarrow{using} Ag$ rod

## Electrolysis for aqueous $CuSO_4$ using Cu rod

$CuSO_4 (aq)$

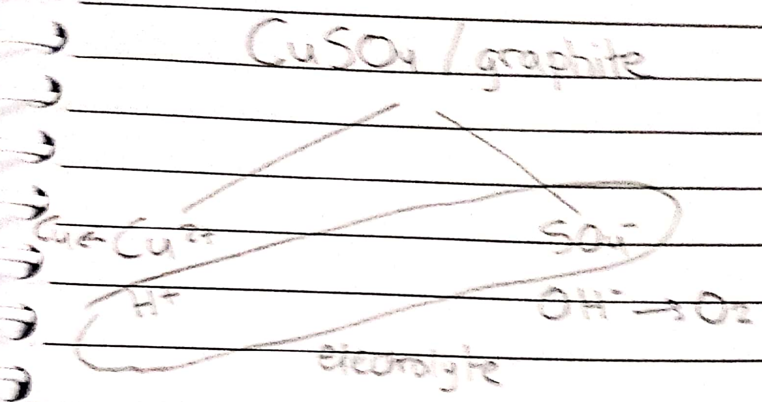
$Cu^{2+}$     $SO_4^{2-}$ } × the anode itself oxidise
$H^+$     $OH^-$

| cathode | anode |
|---|---|
| $Cu^{2+} + 2\bar{e} \rightarrow Cu$ | $Cu \rightarrow Cu^{2+} + 2\bar{e}$ |
| deposite of red-brown s | |

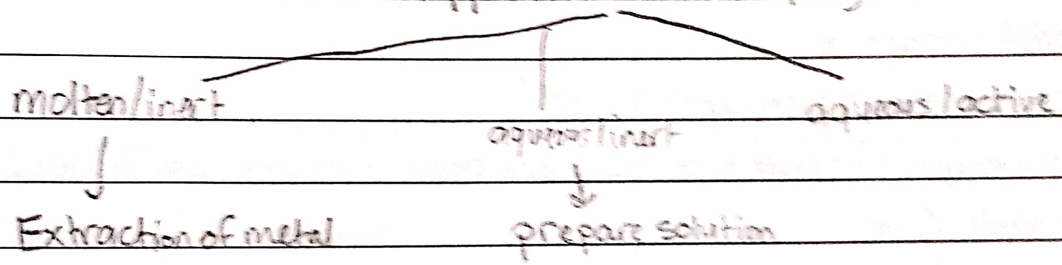


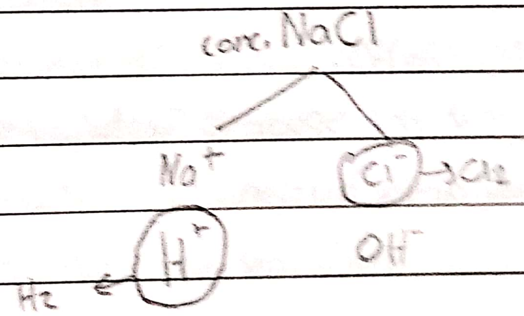
| cathode | anode |
|---|---|
| ↑ mass | ↓ mass |
| Cu deposite | oxidised by lose $\bar{e}$'s |

electrolyte: stays the same concentration.
anode oxidised and replace $Cu^{2+}$ in the electrolyte with the same rate



## Applications of Electrolysis

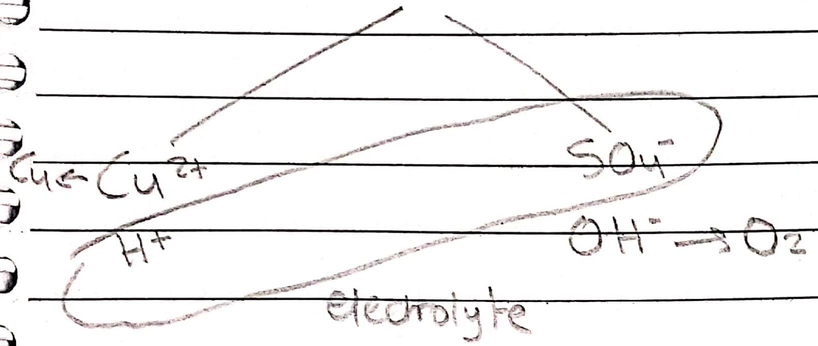




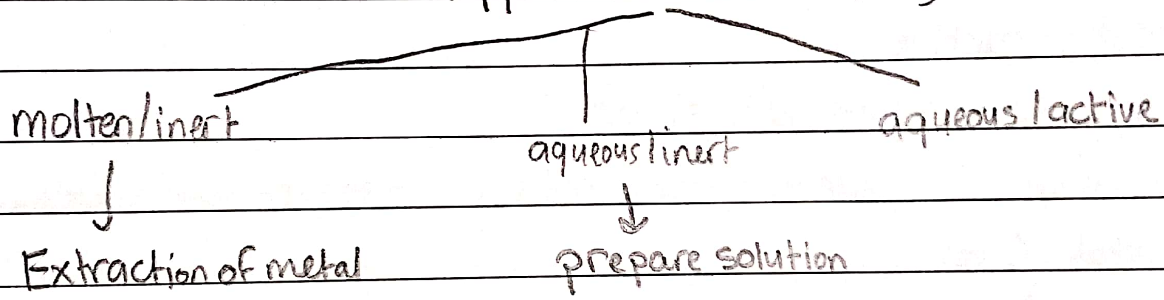
electrolyte: NaOH

$CuSO_4$

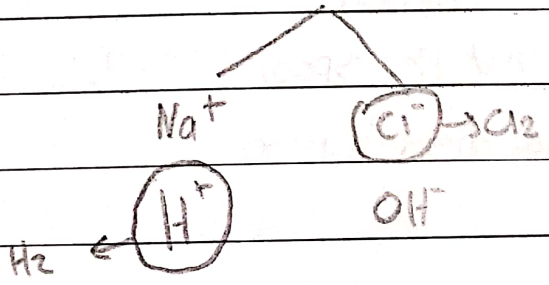
$CuSO_4$ / graphite



Applications of Electrolysis

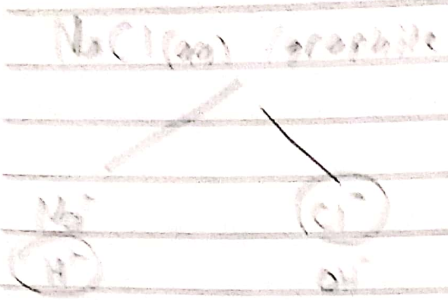


conc. NaCl



electrolyte: NaOH

$CuSO_4$



Electroplating: coating a metal with another metal using electrolysis

why? 1) to prevent rusting

2) more attractive

How to electroplate a metal spoon with silver ?

1- clean spoon from any impurities or oxide layer using sand paper to ensure good sticking.

2- make spoon the cathode (-ve)

3- the anode must be Ag

4- electrolyte must contain $Ag^+$ or: $AgNO_3$

5- Turn on the circuit "be sure that the spoon is fully immersed in the electrolyte"

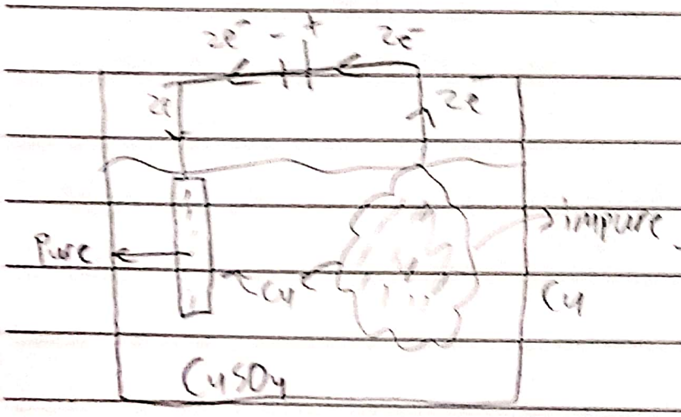
6- rotate the spoon to ensure an equal distribution

7- rinse with distilled water

8- dry in oven

---

Purifying Metals / Refining Copper

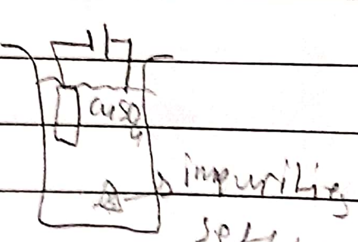


Cu

* impurities

→ Ag, Au, Zn

Cu



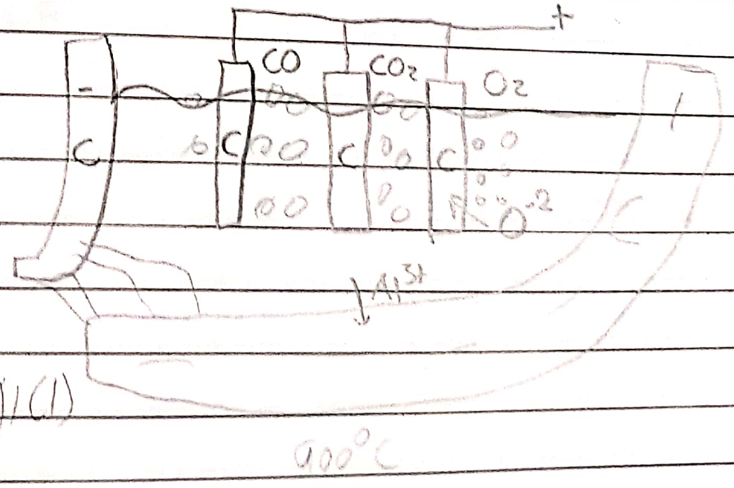
$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

Extraction of Metals from their ions
the method depends on position of metals in reactivity series.

electrolysis / molten graphite
K
Na
Li
Ca
Mg
Al
C/CO
Zn - red. by C/CO
" " . Fe
Pb
H
Cu ] red by $H_2$
Ag
Au

Extraction of Aluminium
ore:- $Al_2O_3$ bauxite
Method :- Electrolysis of molten $Al_2O_3$ / graphite
*. m.p of $Al_2O_3$ is about 2000°
so we dissolve $Al_2O_3$ in a molten cryolite $Na_3AlF_6$
- to lower the m.p to 900°c so less cost
- to increase electrical conductivity

$Al_2O_3(l)$
$Al^{3+}$ cathode
$O^{2-}$ anode
$Al^{3+} + 3e^- \rightarrow Al$ $2O^{2-} \rightarrow O_2 + 4e^-$



gases produced at anode
1- $O_2$
2- $CO_2$ ] reactions of rod
3- CO ] with $O_2$
so we must replace them periodically

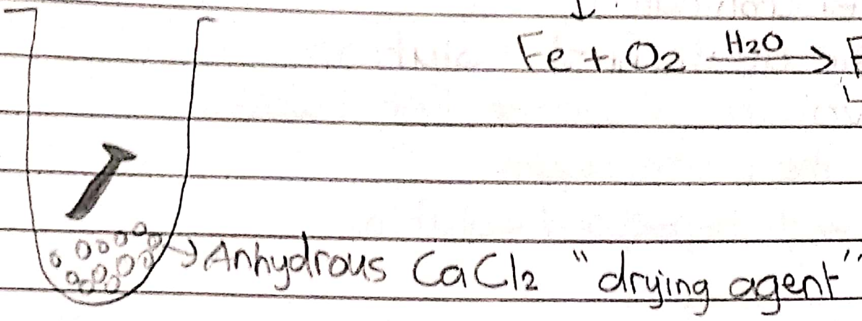
| property | use |
|---|---|
| - low density | - Aircraft bodies |
| - ductile | - electrical bodies |
| - malleable | - window frame / cooking utensills |
| - conduct electricity | - wires |
| - form oxide layer which is non-toxic | - food cans |

Rust: Reaction of Iron with both $O_2$ and $H_2O$

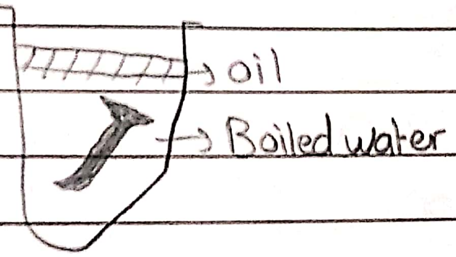
Slow reaction: 6 to 7 days

↓

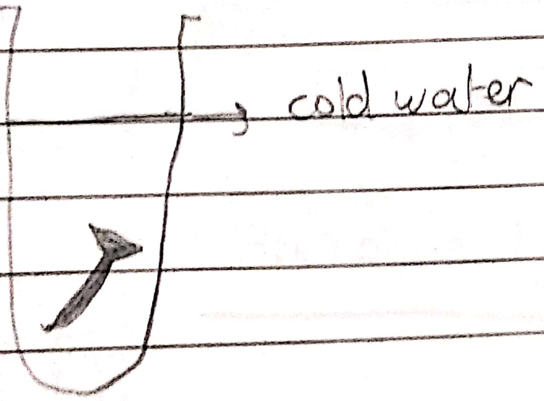
$Fe + O_2 \xrightarrow{H_2O} \underbrace{Fe_2O_3 \cdot nH_2O}_{\text{brown}}$



X



X no $O_2$



✓

Plan an exp. to show which rust prevention solution is better.

- take a known mass of Iron nail
- apply a known volume of the first solution
- put them in a known volume of water for 1 week.
- dry them and measure the mass again.
- repeat the experiment with the second solution.

conclusion: the exp. which cause more increase in mass, is the worse solution.

## How to prevent rusting

1- painting
2- oiling
3- greasing
4- cover with plastic

} to prevent $O_2$ and $H_2O$ from reaching the iron.

also

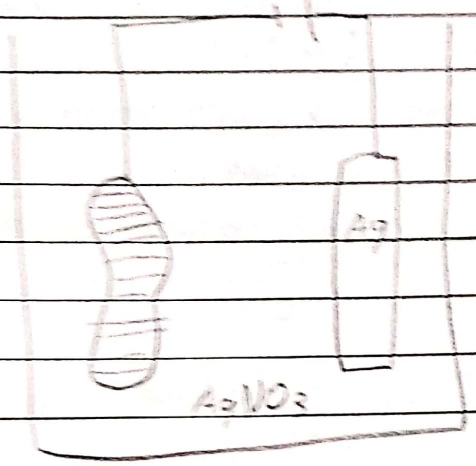
1- galvanising → coating iron with zinc

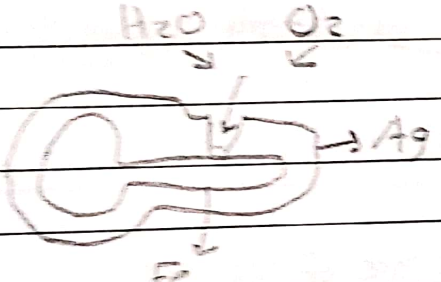
2- sacrificial protection → connecting with Mg

Zn and Mg are more reactive than Fe, more likely to oxidise more likely to lose $e^-$'s so Fe is less likely to rust.

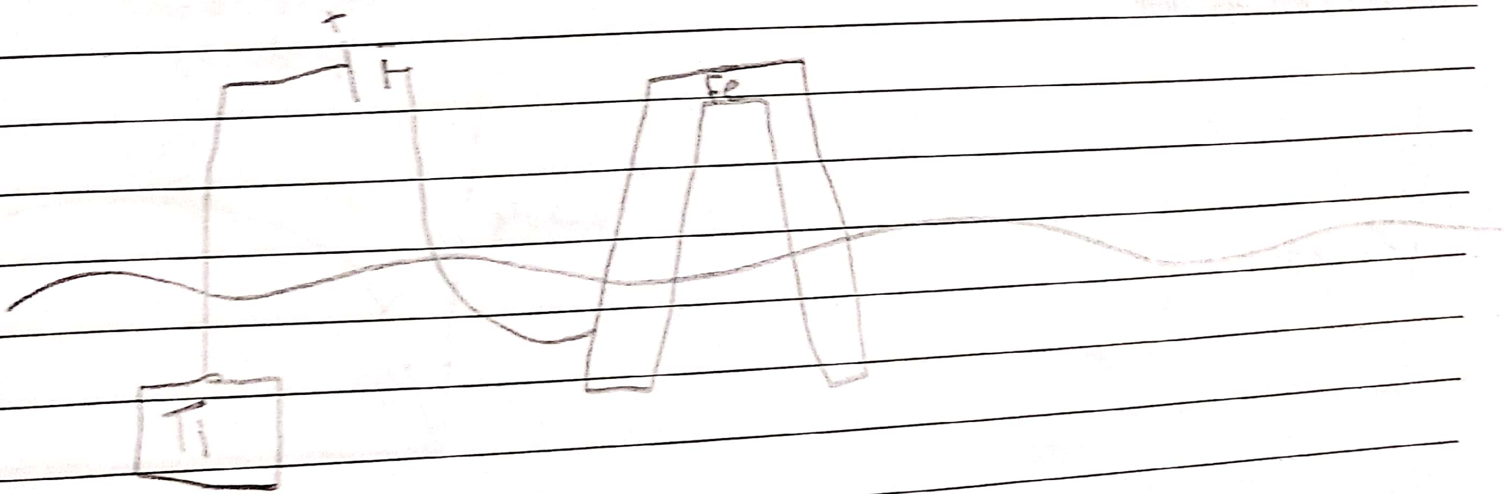
3- Electroplating
4- cathodic protection

## electroplating





## cathodic protection

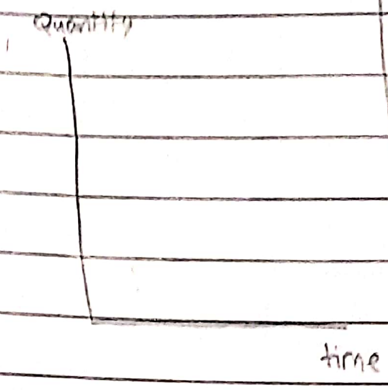


Ti is highly unreative

# Rate of Reaction

$$\text{Rate} = \frac{\text{change in quantity}}{\text{change in time}}$$

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



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

$$\frac{\Delta\text{conc}}{\Delta\text{time}} \qquad \frac{\Delta\text{light intensity}}{\Delta\text{time}}$$

$$\frac{\Delta\text{pH}}{\Delta\text{time}}$$

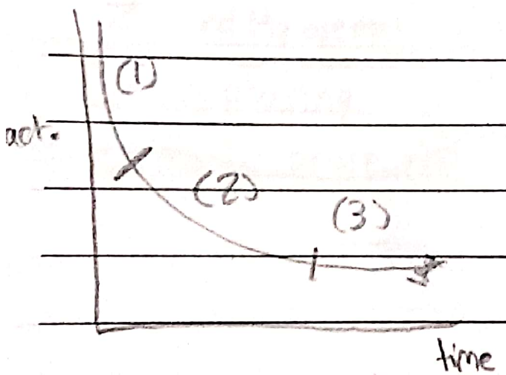
$$\frac{\Delta\text{volume}}{\text{time}}$$

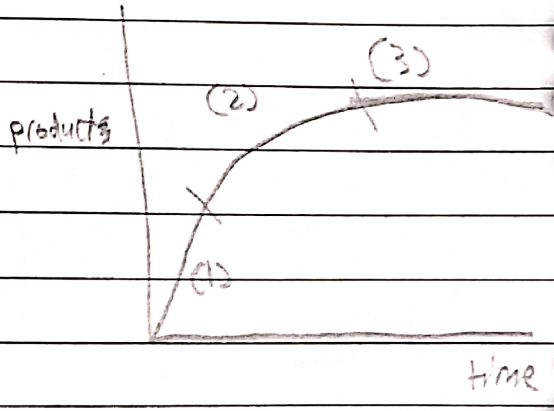
$$\frac{\Delta\text{temp}}{\Delta\text{time}}$$

Measure the rate of reaction

how fast reactant is consumed per unit time

How fast product is produced





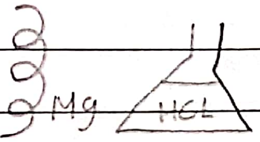
region (1) Fastest rate → From the graph, steepest.
in the beginning more amount of reactants / more particles / more effective collisions per unit time (3)

region (2) slower rate → from the graph · less steep
less number of particles / less effective collisions per unit time / less amount of reactants.

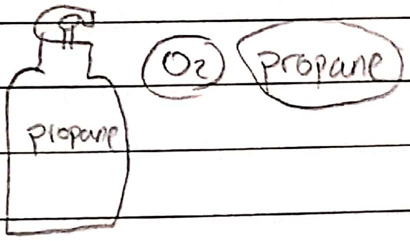
region (3) reaction is over → gradient = 0 / horizontal
no more limiting factor
no more effective collisions

for any chemical reaction, there are 3 main conditions

1) Cu + HCL → no reaction

2)


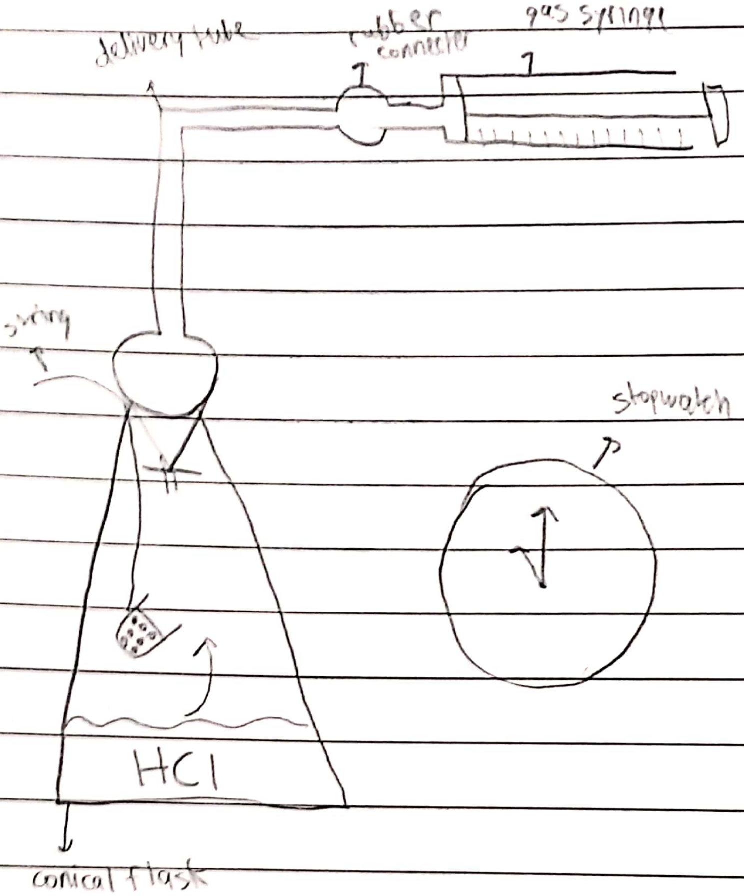
no rxn  the reactant MUST collide.

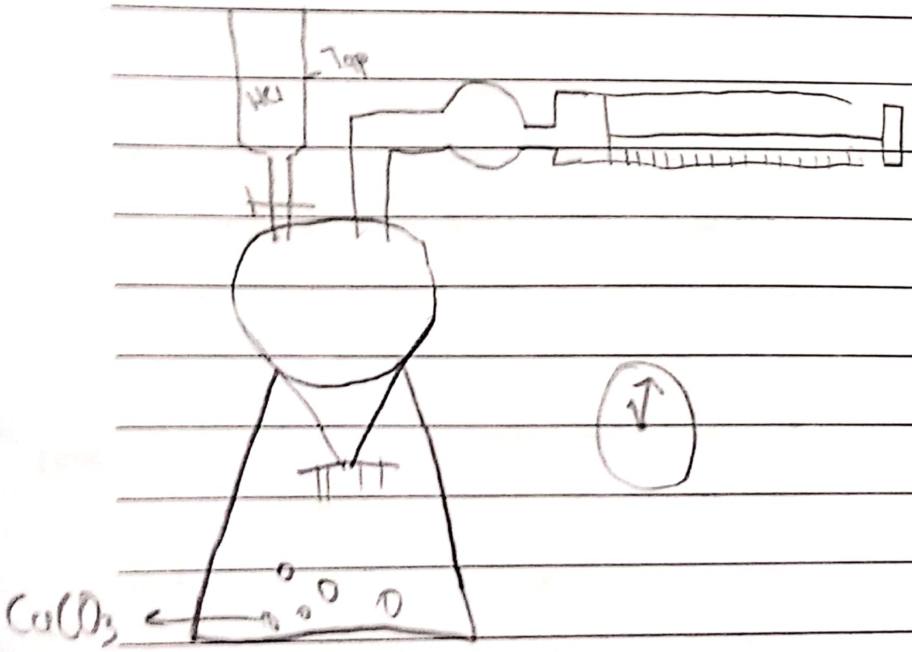
3)


the collisions must be effective (minimum amount of energy to start reaction).
activation energy, Ea

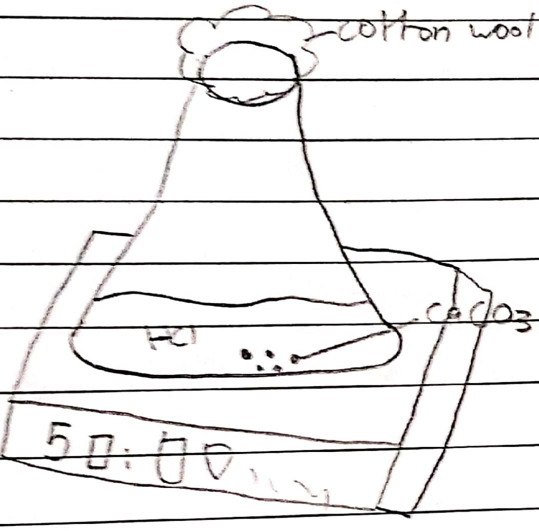
# Measuring Rate of Reaction

1) measuring the volume of gas per unit time





2) measure the mass of the conical Flask + contents per unit time



cotton wool to prevent splashing and $CO_2$ to escape

* the mass decrease because $CO_2$ escape.

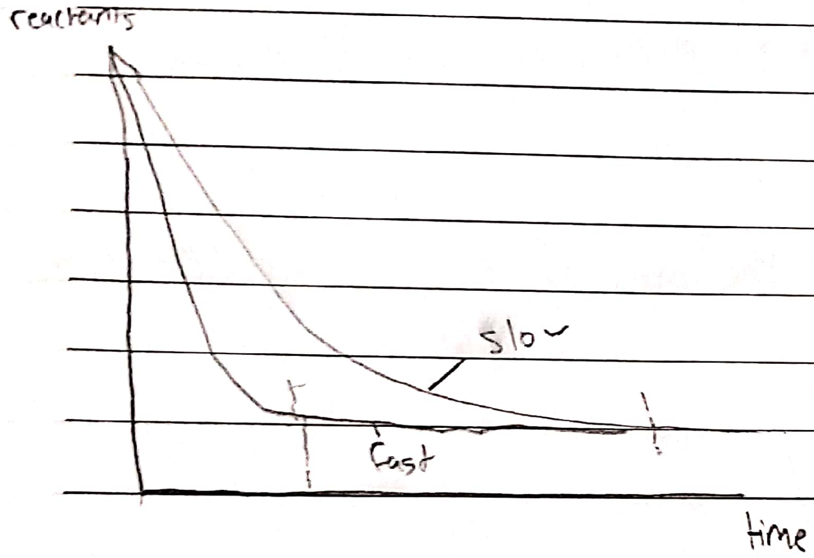
Reaction is over

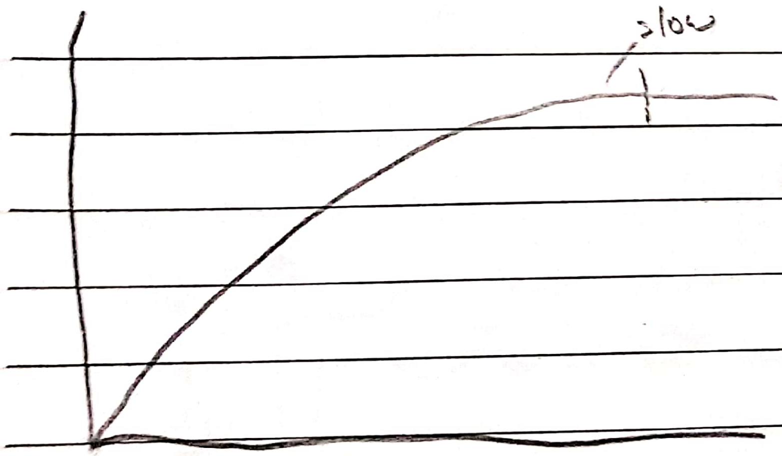
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| time | 0 | 30 | 60 | 90 | 120 | 150 | 180 |
| mass | 50 | 40 | 35 | 33 | 32.5 | 32.5 | 32.5 |

−10 −5 −2 −0.5 . . . .

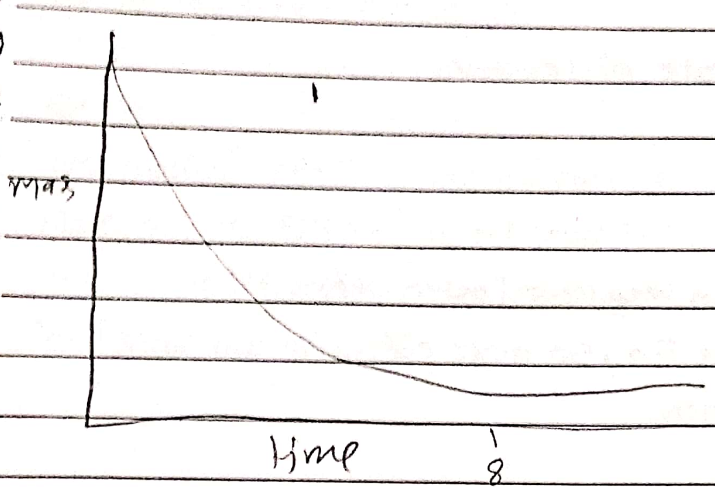
## Increasing the Rate of Reaction

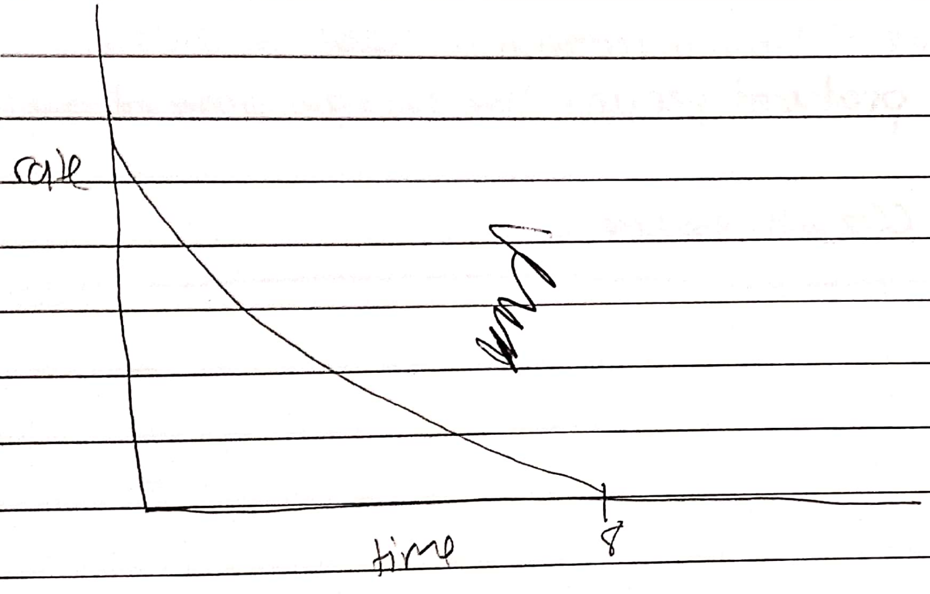
- more product per same period of time }
or same products per less time } steeper curve





Q: The graph below shows how the amount of reactants changes with time





Factors affecting rate of reaction

1) temp

2) surface area

3) pressure

4) concentration

5) light intensity

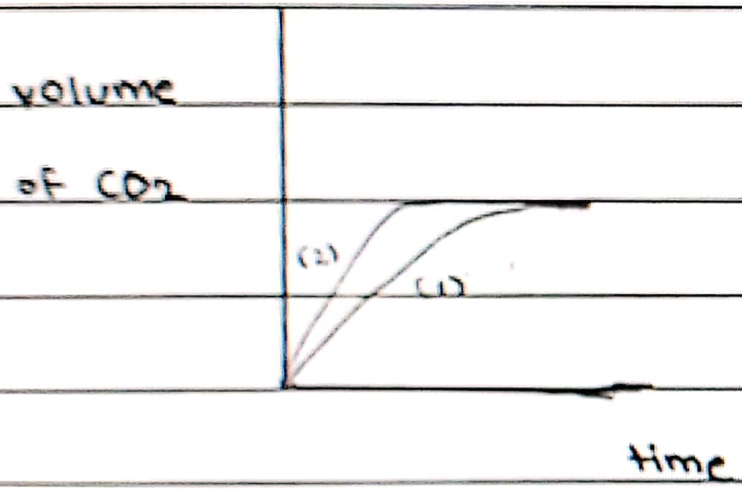
6) catalyst

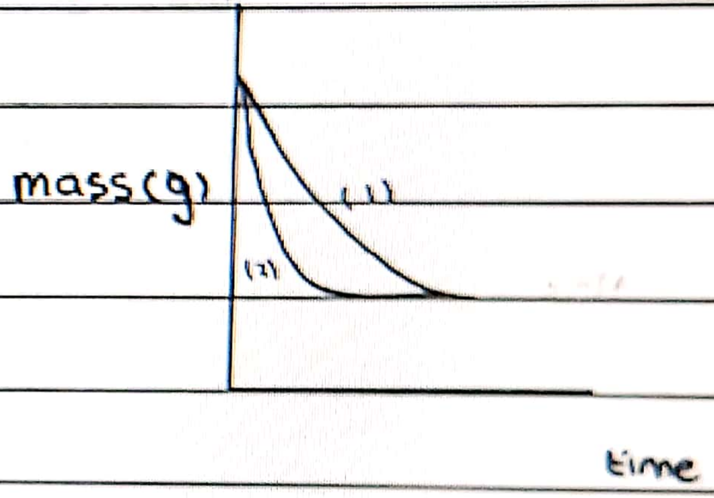
1) Temp.

* State how the the temp. affect the rate of reaction.
as temp. ↑ rate of rxn ↑

* explain " " " " " " " "
as the temp. ↑, the particles gain k.e so they move faster, they will have energy equal to or greater than the Ea, so more effective collisions per unit time so faster rate of reaction.

* plan an exp to show how the temp affect rate of reaction.
take a known mass of lumps of $CaCO_3$
add them to a known volume of known concentration of $HCl$ at 25°C,
measure the volume of $CO_2$ produced per unit time using gas syringe and stopwa
repeat the exp. at 50°c
the exp. at 50°c produce $CO_2$ with less time





- take a known mass of lumps $CaCO_3$, add them to a known volume of known conc. of 25°C, measure the volume of $CO_2$ produced. Repeat the exp. at 50°C. The exp. at 50°C produces $CO_2$ with less time.

state how surface area affect the rate of reaction.

as surface area ↑ rate of rxn ↑

explain " " " " " " " "

as surface area ↑ (decrease particle size by using mortar or ~~[illegible]~~ pestile)

More particles exposed to the reaction

more effective collisions per unit time

so faster rate

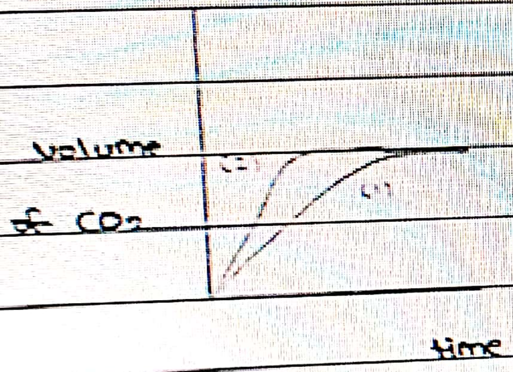
- Explain how the surface area affects the rate of reaction.

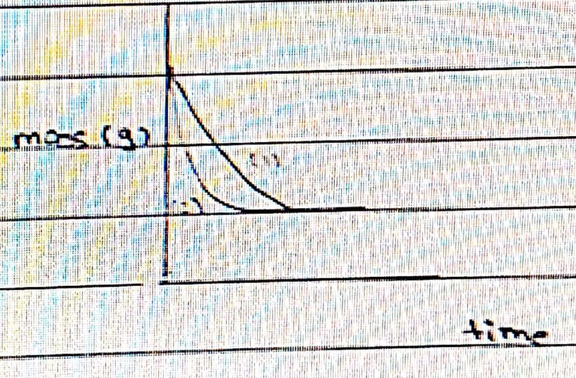
as the surface area increases, (decrease the particle size by crushing usi
mortar & pestile) more particles exposed to the reaction, more effective collisions per unit time so faster rate.

- Plan an exp. to show how the surface area affects the rate of reaction.

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

| - conical flask 1 :- | - conical flask 2 :- |
|---|---|
| mass = 2g (lumps) | mass = 2g (Powder) |
| $V_{HCl} = 0.1\ dm^3$ | $V_{HCl} = 0.1\ dm^3$ |
| $M_{HCl} = 1\ mol/dm^3$ | $M_{HCl} = 1\ mol/dm^3$ |
| Temp = 25°C | Temp = 25°C |





3) concentration, "Amount"

* state how concentration affect the rate of reaction

as conc. ↑ the rate of rxn ↑

* explain " " " " " " "

as conc. increases, more particles, so more effective collisions per unit time, so faster rate of rxn.

* plan an exp.

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

exp1 mass $V_{HCl} = 0.1\ dm^3$

$CaCO_3 = 2g$

lumps $M_{HCl} = 0.1\ moll/dm^3$

$M_r = 100$ Temp = 25°C

exp2 mass $V = 0.1$

$CaCO_3 = 2g$

lump

- Plan an exp. to show how the conc. affects the rate of rea

[redacted]

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

- conical flask 1 :-

mass = 2g (lumps)

$V_{HCl}$ = 0.1 dm³

$M_{HCl}$ = 0.1 mol/dm³

Temp = 25°C

- conical flask 2 :-

mass = 2g (lumps)

$V_{HCl}$ = 0.1 dm³

$M_{HCl}$ = 0.2 mol/dm³

Temp = 25°C

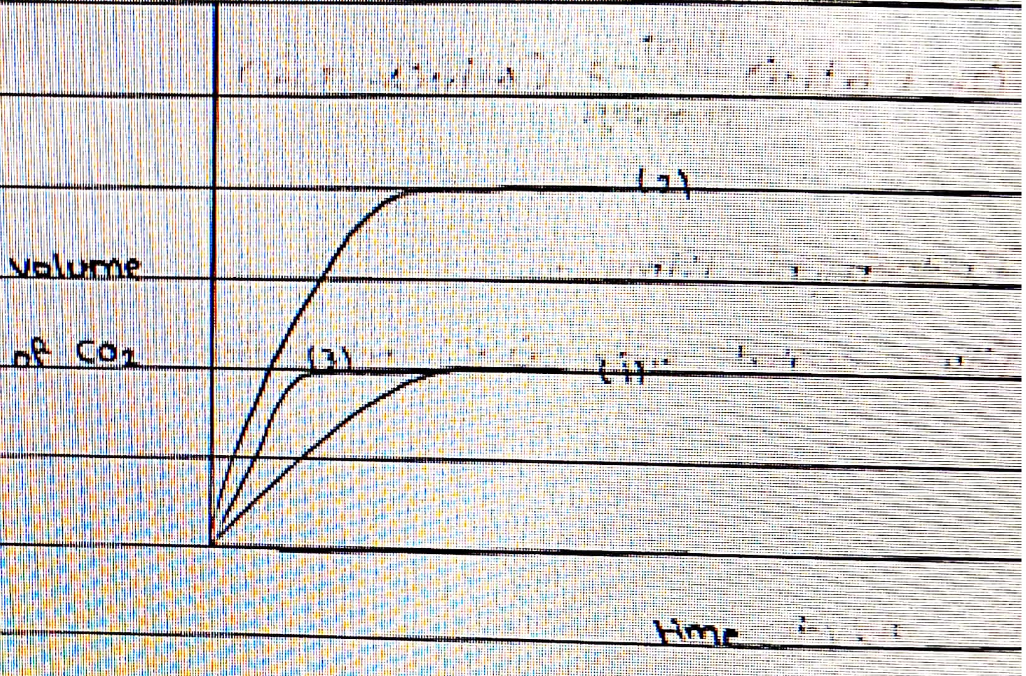
- conical flask 3 :-

mass = 4g (lumps)

$V_{HCl}$ = 0.1 dm³

$M_{HCl}$ = 0.1 mol/dm³

Temp = 25°C

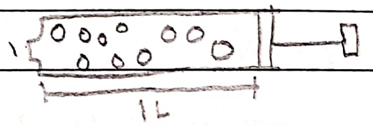


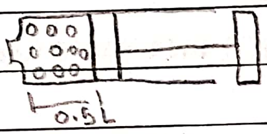
4) pressure "Only affect the gas"

explain how the pressure affect rate of reaction.

As the pressure increase (by reducing the volume)

so more particles per unit volume. so more effective per unit time so faster rate of reaction.





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

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

need light to take place

5) Light "Only for photochemical reactions eg:- photosynthesis

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

photographic films: Films coated with AgCl or AgBr

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

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

6) catalyst

chemical substance that speeds up a reaction without being changed or used up

How? it provide an alternative way with lower Ea

so more particles will have energy equal to or more than Ea

so more effective collisions per unit time

so faster rate of reaction

Next page

The reaction

$$2H_2O_2{}_{(aq)} \xrightarrow[2)\,MnO_2]{1)\,CuO} 2H_2O_{(l)} + O_{2(g)}$$

1) plan an exp to show that CuO is a catalyst for this reaction.

take a known volume with a known conc. of $H_2O_2$ at known temp.

measure the volume of $O_2$ produced per unit time

repeat the exp using CuO

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

2) plan an exp to show which is better catalyst CuO or $MnO_2$

Same as Q1 + same mass of catalyst

Conc. exp which produce more $O_2$ per unit time used better catalys

3) plan an exp to show ~~which~~ that CuO not used up during rxn.

measure the mass of CuO

add to $H_2O_2$ until no more fizzes

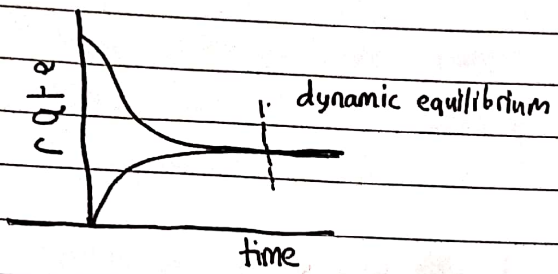
Filter the mixture

dry the solid in oven

remeasure the mass

* some initial and final mass

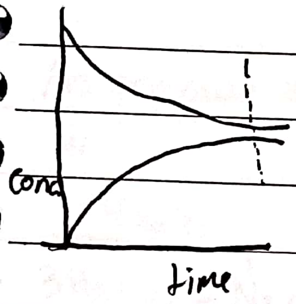
in terms of rate

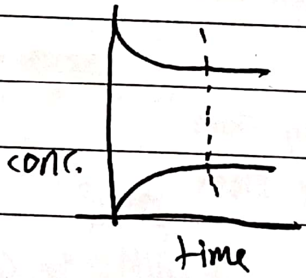


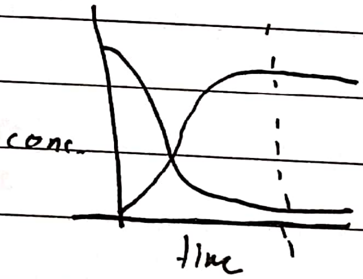
rate of forward ↓
less reactants
so less particles
so less effective collisions per unit time

rate of backward ↑
more product
so more particles
so more effective collisions per unit time.

in terms of conc.







Le chatelier princple.
if the system at equil. ⇌
and any external factor disrubt the equil.
the equil can shift itself either
to the forward ⇌
or backward ⇌
then return to equil.

# Types of chemical reactions

one way

reactants $\xrightarrow{\text{forward reaction}}$ products

both ways

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

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

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

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

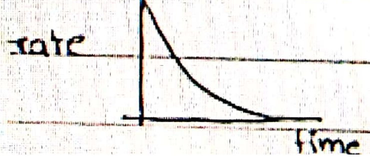
Ammonium Chloride    Ammonia    Hydrogen Chloride

* Which damp litmus paper will change its colour first, why?

the damp red litmus paper changes to blue, ~~First~~ because $NH_3$ is an alkali and lighter than HCl which is acidic.

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

* R → P



1) Temp

↑Temp shift to endo rate↑

↓ Temp shift to exo rate↓

| Temp | pressure |
|---|---|
| " | ↑ shift to less gas moles |
| " | ↓ shift to more gas moles. |

| | | | |
|---|---|---|---|
| temp↑ | rate↑ | ↑pressure | ↑↑ rate of less g.m<br>~~↑ rate of more g.m~~ |
| temp↓ | rate↓ | ↓pressure | ↓ rate of more g.m<br>↓↓ rate of less g.m |

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

$2NO_2(g) \rightleftharpoons N_2O_4(g)$

dark brown — pale brown

if we put this sealed tube in a cold water bath the mixture becomes paler. wh

because the forward reaction is exothermic enhanced by cooling.

2) pressure

As pressure increase

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

As pressure decrease

" " " " " " " more pressure
more gas mole

$\underbrace{3H_2(g) + N_2(g)}_{\text{4 moles}} \rightleftharpoons \underbrace{2NH_3(g)}_{\text{2 moles}}$

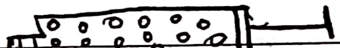
↑pressure shift $\overset{\text{forward}}{\text{to}}$ the side with less gas moles, so ↑ $NH_3$%

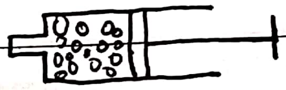
↓ pressure shift backward to the side with more gas moles

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

— purple　　　　colorless

the equil. dosen't affect by increasing the pressure.
why by increasing the pressure the mixture becomes more purple?
the $I_2$ molecules become closer to each other so the color seems to darker





sealed tube contains mixture of $NO_2(g)$ and $N_2O_4(g)$ at equil.

$2NO_2(g) \rightleftharpoons N_2O_4(g)$

dark-brown　　　　pale brown

(As) question

by increasing pressure color will

a) paler then darker
b) darker then paler

I am qais

Factors that affect position of equilibrium

1) Temp ↑ shift to endo
↓ shift to exo

2) pressure ↑ to less gas moles
↓ to more gas moles

3) concentration ↑R ↓P } shift Forward
↓R ↑P shift backward

$A + B \rightleftharpoons C + D$

↑ [A] shift forward ↓B ↑C ↑D
↓ [B] shift backward ↑A ↓C ↓D
↑ [C] shift backward ↑A ↑B ↓D

Indicator.

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

| | |
|---|---|
| color1 | color2 |
| red | yellow |

add HCl : proton donor ↑$H^+$ shift backward
More HIn color 1
less In color 2

add NaOH proton acceptor ↓$H^+$ shift forward more In color 2
less HIn color 1

Q: The reversible reaction below at equilibrium

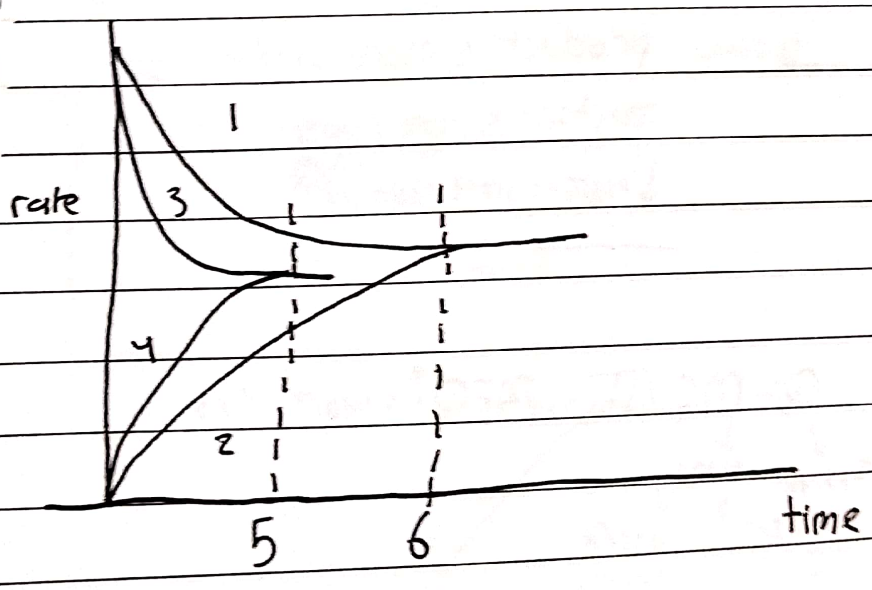
$$\underset{\text{orange}}{Cr_2O_7^{-2}} + Fe^{2+} + H^{+} \rightleftharpoons \underset{\text{green}}{Cr^{3+}} + Fe^{3+} + H_2O$$

Explain why by adding HCl to the rxn mixture, the color of the mixture becomes green?

HCl is an acid. (proton donor)
more $H^+$
shift forward
more $Cr^{3+}$ more green
less $Cr_2O_7^{2-}$ less orange

* catalyst

has no effect on the position of equilibrium since it speeds up the rate forward and backward

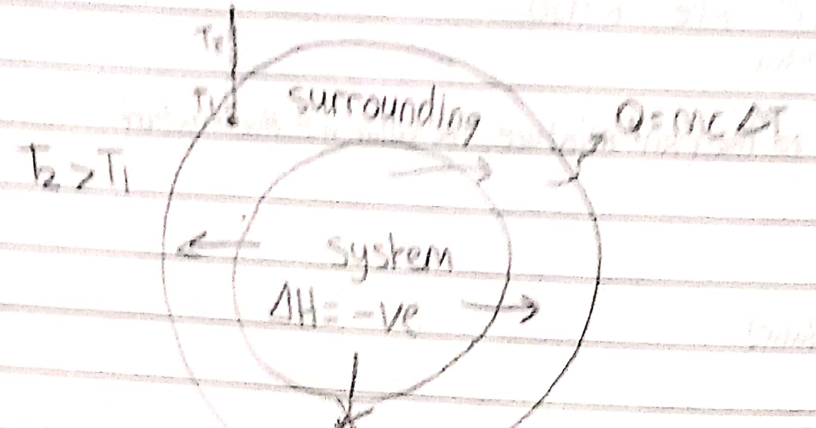


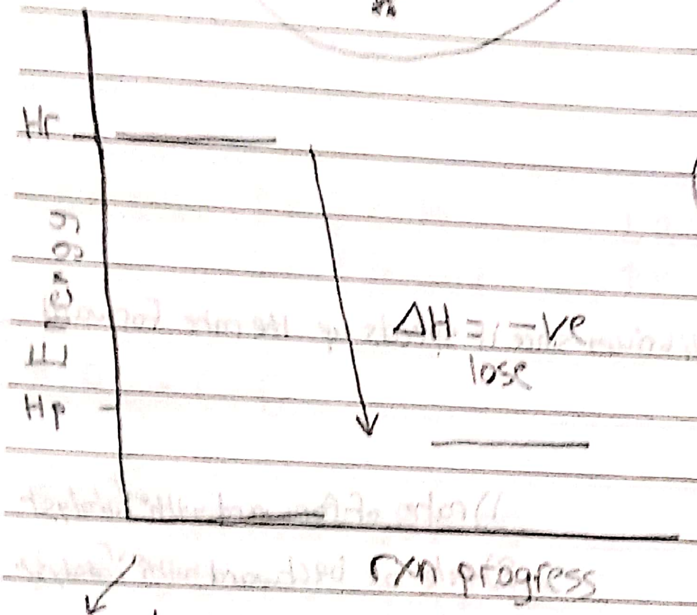
1) rate of forward without catalyst
2) rate of backward without catalyst
3) rate of forward with catalyst
4) rate of backward with catalyst
5) time taken to reach equil. with catalyst
6) " " " " " without catalyst

# Energetics

[illegible]

exothermic reaction : reaction that gives out energy to the surrounding



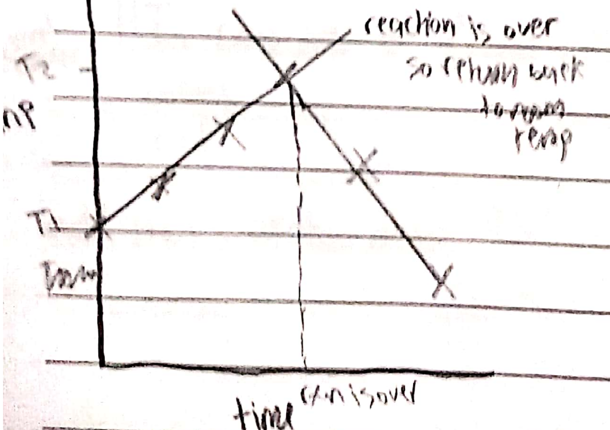


Entalpy: Heat contents
"stored energy"
Hr: Enthalpy of reactant
Hp: Enthalpy of product

product is more stable
reactant is more hyper
↓ energy: more stability

Energy level diagram

For surrounding (temp diagram)



$Q = mc\Delta T$ ↑ΔT ↑Q = more exo

Q → Energy transfer = J

m → mass g

c → specific heat capacity 4.2 J/g.C°

ΔT → change in temp

exo

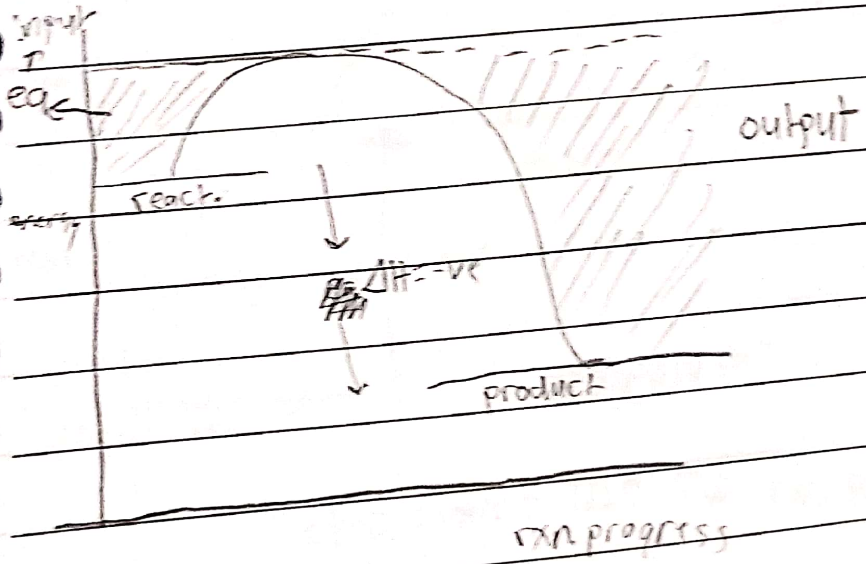
examples on exo [redacted]

1- freezing, condensing
2- respiration
3- combustion
4- neutralization
5- displacement
6- voltic cell
7- building up bonds

[redacted]

How to express exo. rxn.

1) Reactants → product $\Delta H = -ve$
2) Reactants → product + energy
3) Profile diagram

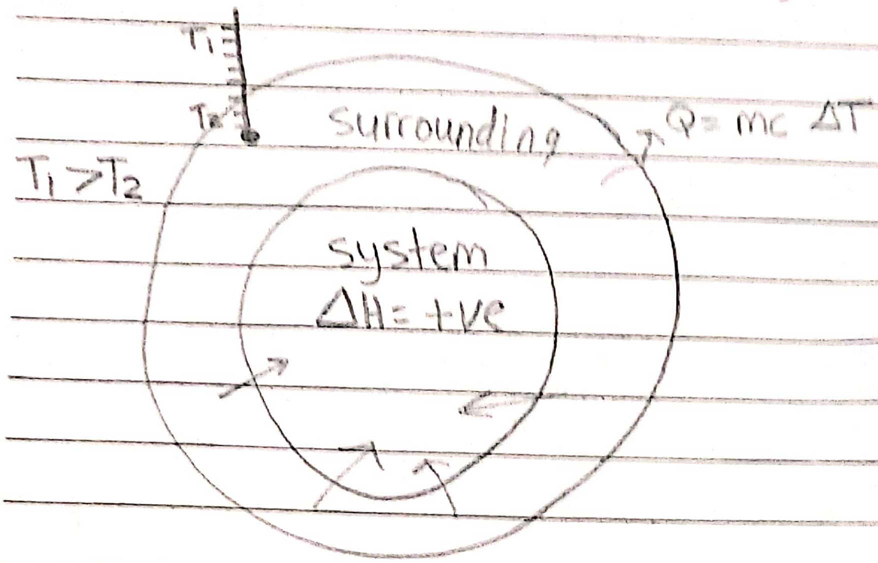


output > input

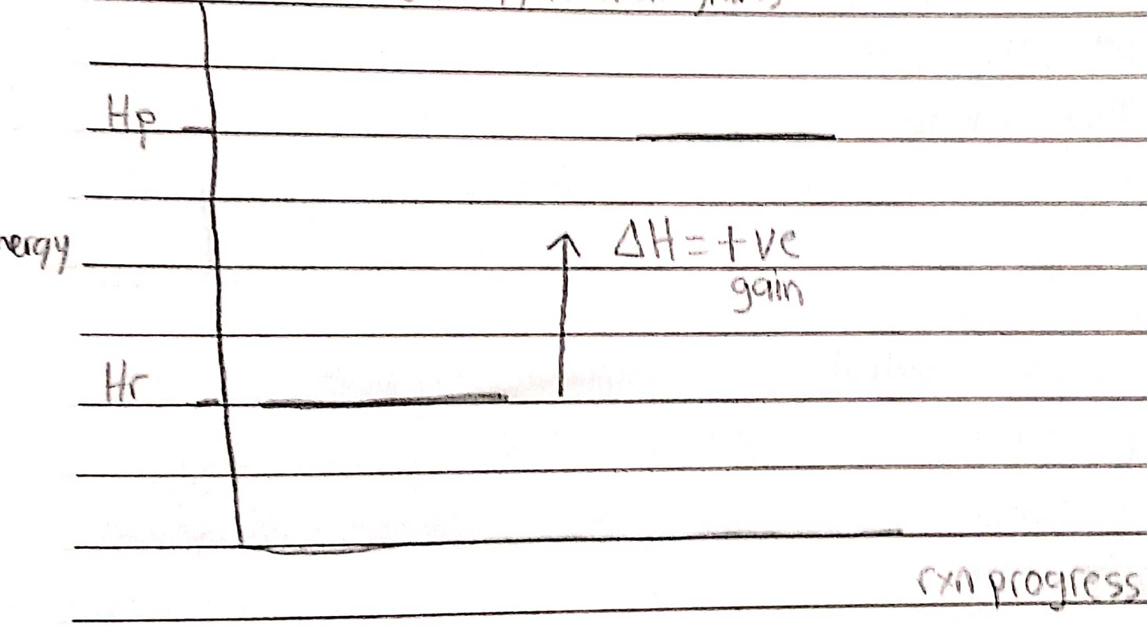
endo

(absorb)

endothermic: reaction that takes in energy from the surroundings.



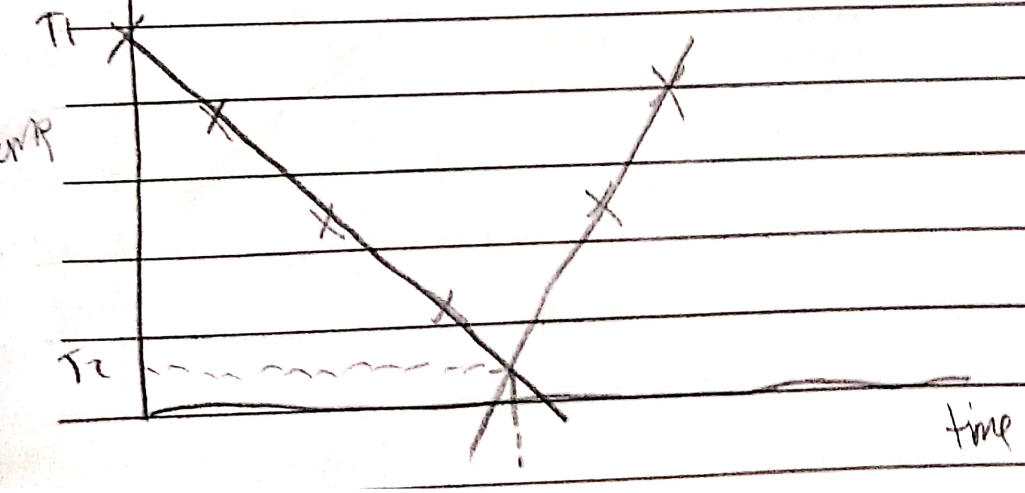
For system (energy level diagram)



For surrounding (temp diagram)

Q↑ ↑ΔT = more endo

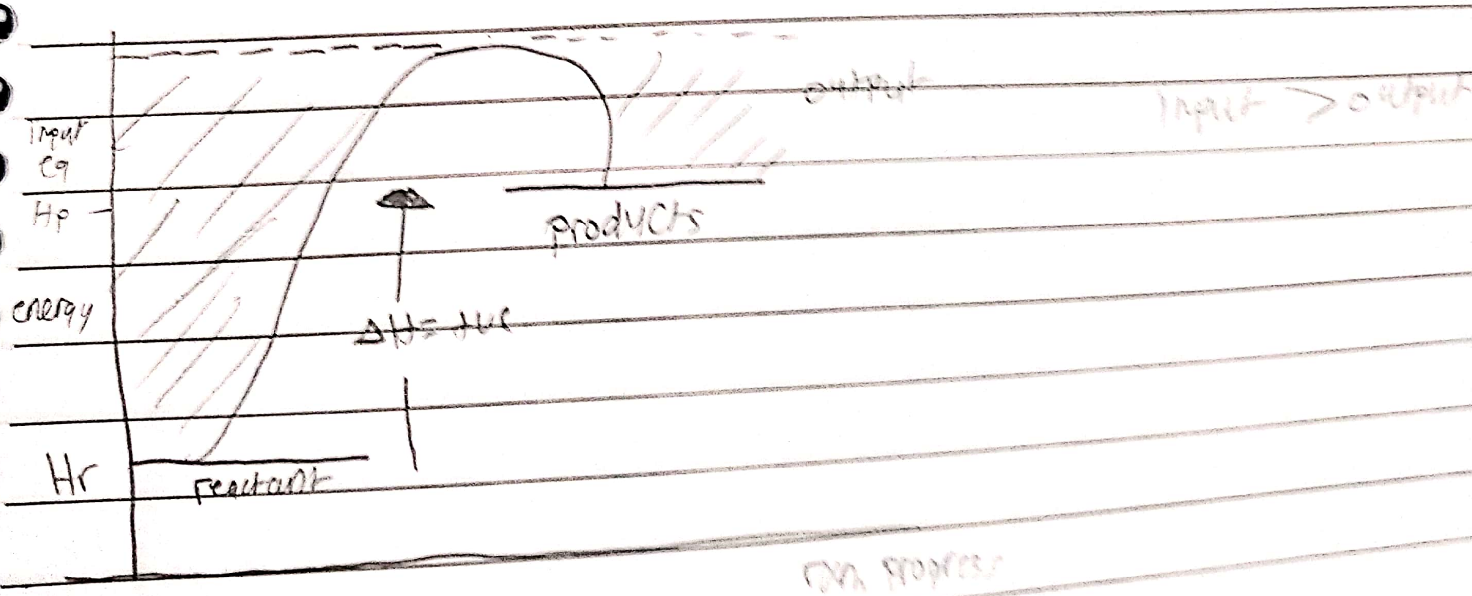
$Q = mc\Delta T$



endo

examples on endo
1- Boiling, evaporation
2- photosynthesis
3- thermal decomposition
4- electrolysis
5- photographic films
6- dissolving ammonium salts
7- breaking down bonds

How to express endo. rxn.
1) Reactants → products $\Delta H$ +ve
2) Reactant + energy → product
3) profile diagram



# Measuring ΔH reactions

theoritical
- using bond energy

experimental
combustion displacement neutralization

## * ΔH reactions using bond energy :- (theoritical)

| bond | bond energy kj/mol |
|---|---|
| H - H | 436 |

Bond energy : the amount of energy (needed to break / released to build) 1 mol of a bond in gaseous state.

- $H-H + 436\,kj/mol \rightarrow H_{(g)} + H_{(g)}$ (endo.)

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

* why gaseous ?

If it is in the solid state it will need energy to overcome the forces of attraction between particles to become liquid → gas, the bond is then broken using bond energy.

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

$\Delta H$ reaction $= \underbrace{\sum \text{input energy}}_{\text{to break down bonds in reactant}} - \underbrace{\sum \text{output energy}}_{\text{to break down bonds in product}}$

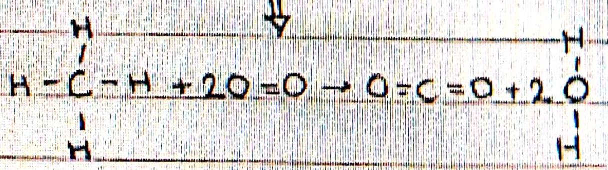
ΔH
- ΔH = +ve endo. input > output
- ΔH = -ve exo. input < output

to use equation :
1) balance equation
2) covalent structure
3) bond energy

## examples :

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

⇓



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

| bond | bond energy |
|---|---|
| C - H | 413 |
| O = O | 495 |
| C = O | 799 |
| O - H | 463 |

| bond broken | | bond build | |
|---|---|---|---|
| 4 * C-H → | 4 * 413 + | 2 * C=O | 2 * 799 + |
| 2 * O=O | 2 * 495 | 4 * O-H | 4 * 463 |
| | 2642 kj | | 3450 kj |

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

$= 2642 - 3450$  ∴ $\Delta H = \boxed{-}808$ kj/mol

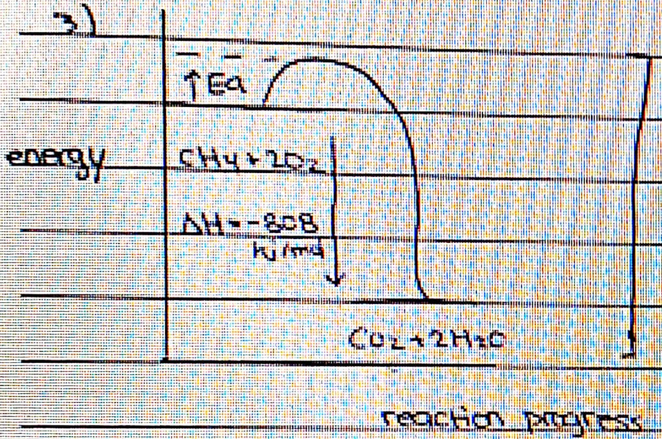
exo.

- because it's exo. it can be writen as:

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

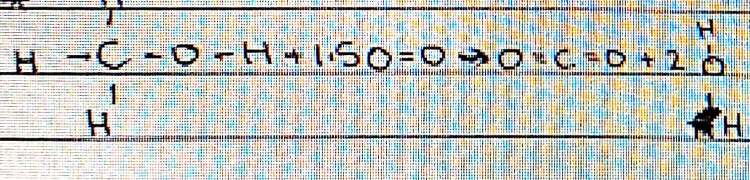
2) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$  $\Delta H = -808$ kj/mol

3)



Profile diagram.

*



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

| bond | bond energy |
|---|---|
| C-H | 413 |
| O=O | 495 |
| C=O | 799 |
| O-H | 463 |

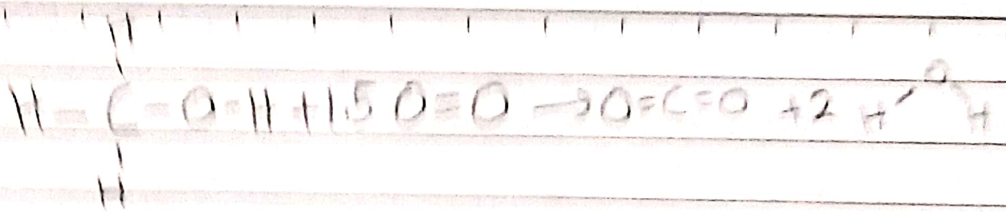
$\boxed{C-O \quad 358}$

| bond | broken |
|---|---|
| 3 * C-H | 3 * 413 |
| 1 * C-O | 1 * 358 + |
| 1 * O-H | 1 * 463 |
| 1.5 * O=O | 1.5 * 495 |
| | 2802.5 kj |

| bond build | |
|---|---|
| 2 * C=O | 2 * 799 + |
| 4 * O-H | 4 * 463 |
| | 3450 kj |

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

$\Delta H = -647.5$ kj/mol (exo.)



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

bond broken

3 x C-H

1 x C-O

1 x O-H

1.5 x O=O

↓

3 x 413

1 x 358 +

1 x 463

1.5 x 495

2802.5 kj

bond build

2 x C=O

4 x O-H

2 x 799

4 x 463

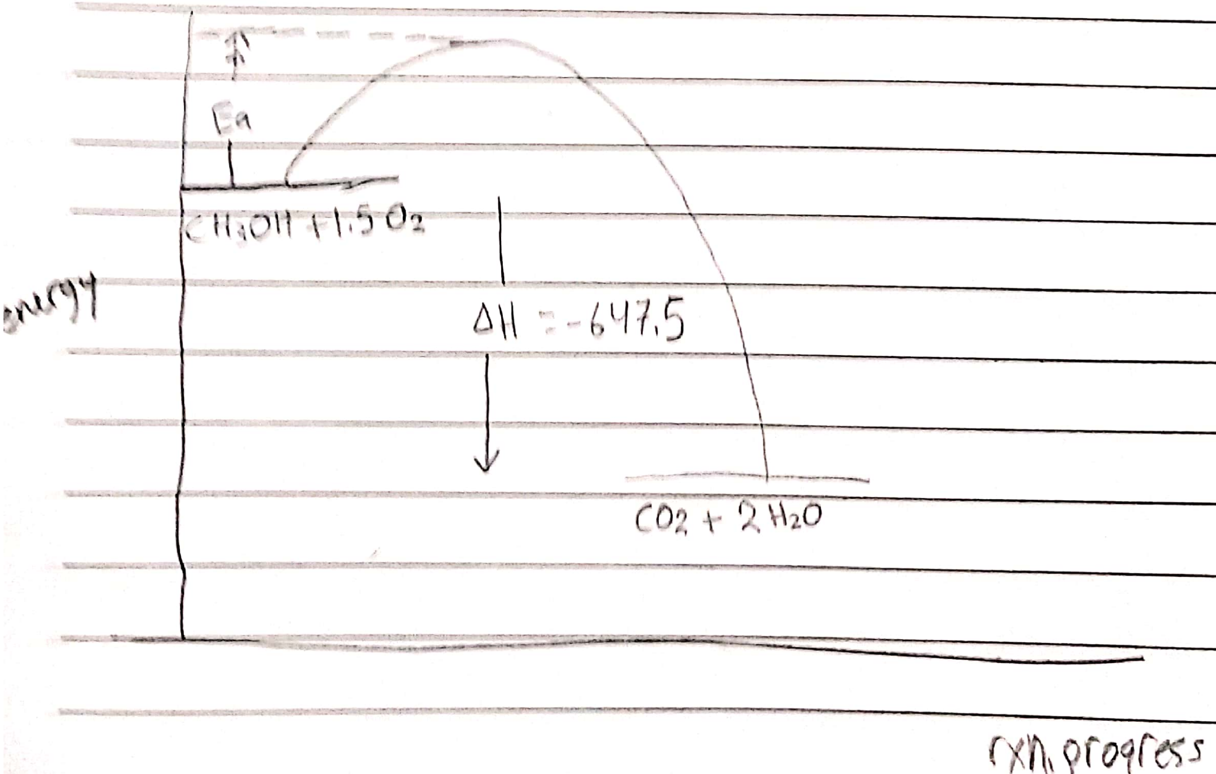
3450 kj

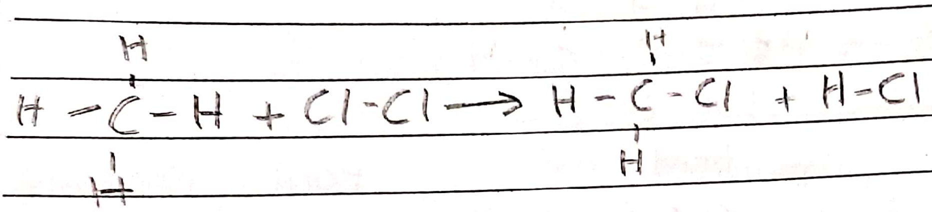
| bond | bond energy |
|---|---|
| C-H | 413 |
| C-O | 358 |
| O=O | 495 |
| C=O | 799 |
| O-H | 463 |

$\Delta H = \Sigma input - \Sigma output = 2802.5 - 3450$

$= -647.5$ kj/mol

exo



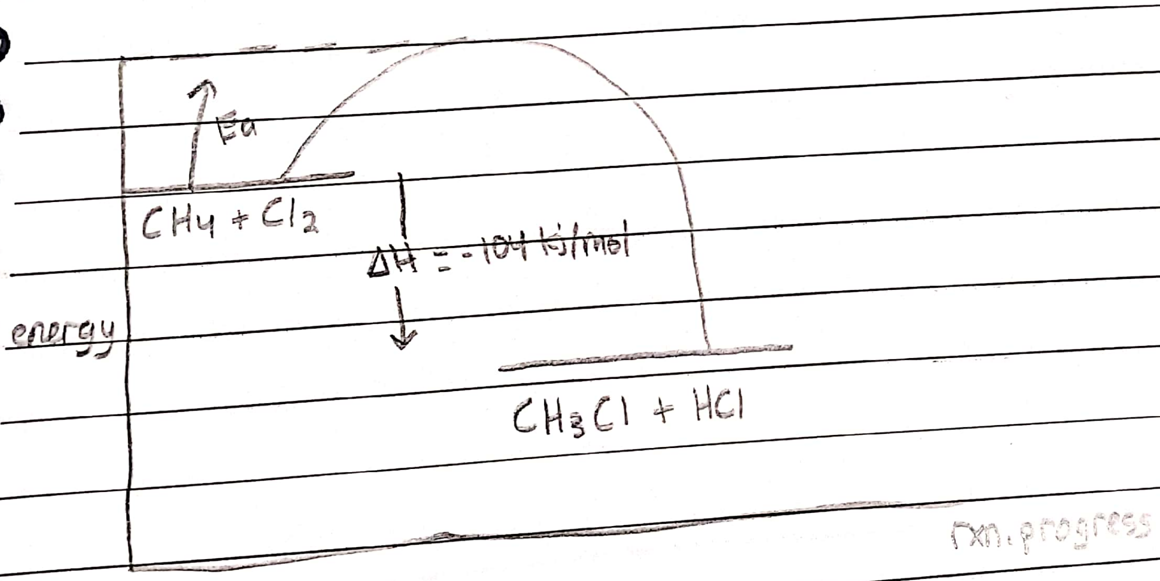


$$H-\overset{H}{\underset{H}{C}}-H + Cl-Cl \longrightarrow H-\overset{H}{\underset{H}{C}}-Cl + H-Cl$$

| bond | bond energy |
|---|---|
| C-H | 413 |
| Cl-Cl | 242 |
| H-Cl | 431 |

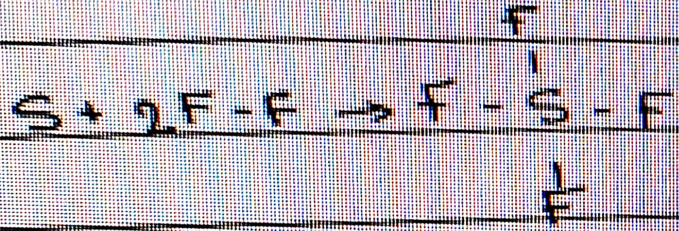
| bond broken | | bond build | |
|---|---|---|---|
| 1 x C-H | 413 | C-Cl | 328 |
| 1 x Cl-Cl | + 242 | H-Cl | 431 |
| | 655 kj | | 759 kj |

$\Delta H = 655 - 759 = \ominus 104$ Kj/mol
exo



* When sulfur react with florine the reaction gives 780 kj/mol

e>0 ΔH



$$S + 2F-F \rightarrow F-\underset{\underset{F}{|}}{\overset{\overset{F}{|}}{S}}-F$$

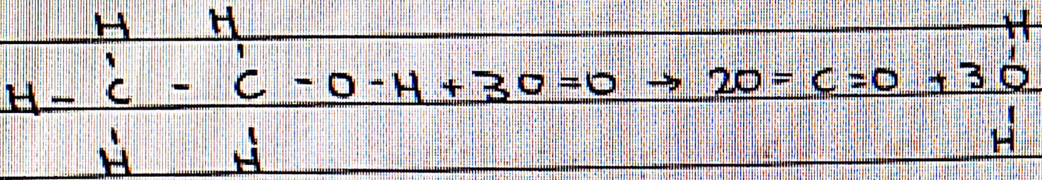
if the bond of F-F is 160 kj/mol,

1) draw an energy level diagram

2) Find bond energy of S-F

* experimental :-

* combustion :



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

for surrounding

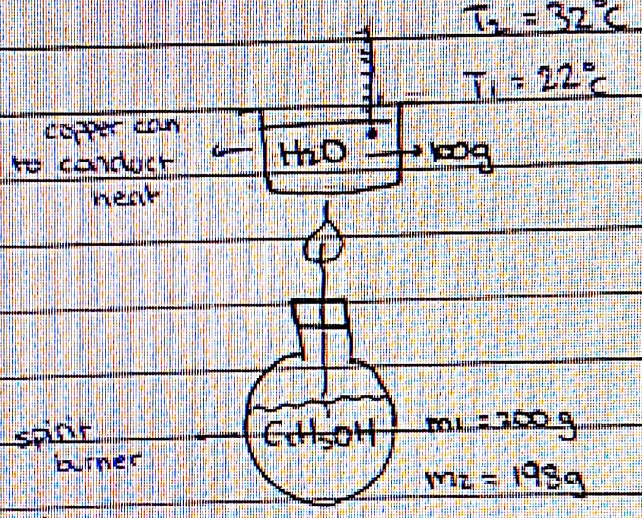
energy transfer ← $Q = mc\Delta T$

$= 100 \times 4.2 \times 10$

$= 4200\,J = 4.2\,kJ$

↓

burn 2g ethanol



$4200\,J \xrightarrow{burn} 2g$ ethanol

$\Delta H\ ?$ → 46 g ethanol (1 mole)

[illegible]

$\frac{4200 \times 46}{2} = \Delta H$

$= 96.6$

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

* 2 fuels A & B, plan an exp. to show which one produce more energy

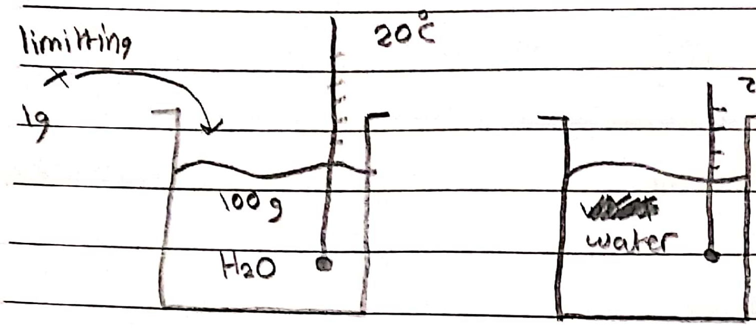
take a known mass of water with known initial temp in a copper can

take a known mass of fuel A, ignite the fuel & record the final mass

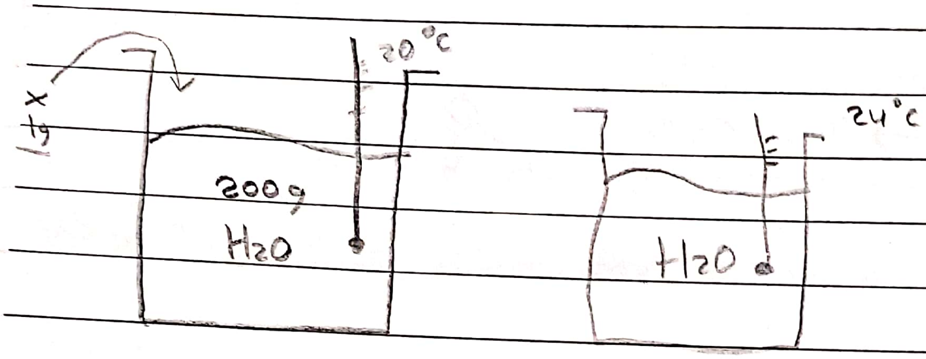
and the final temp of water

repeat the exp using fuel B. The fuel which causes more

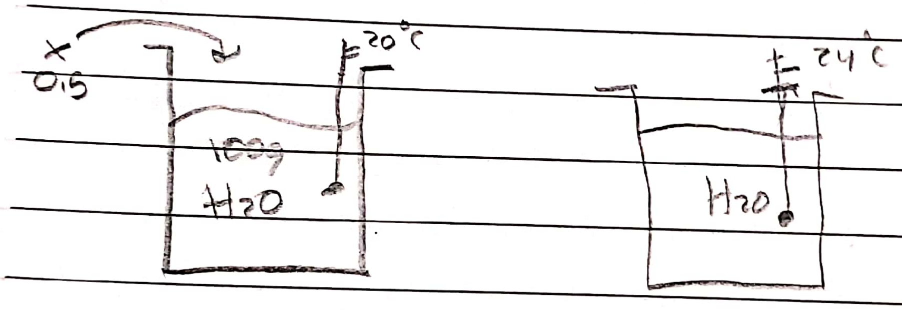
temp rise per gram of fuel produce more energy



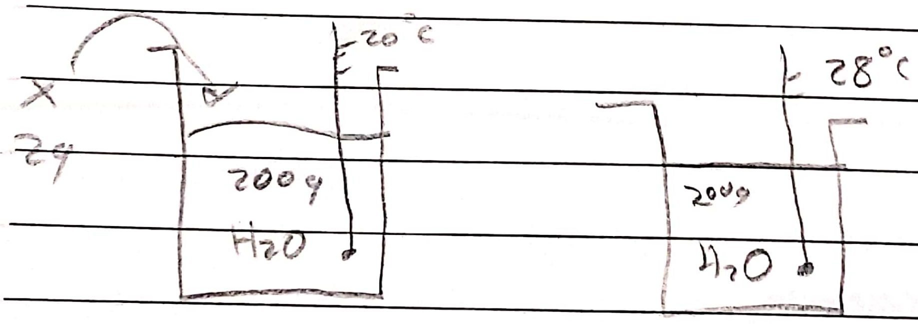
$\Delta T = 8^\circ C$



$\Delta T = 4^\circ C$



$\Delta T = 4^\circ C$



$\Delta T = 8^\circ C$

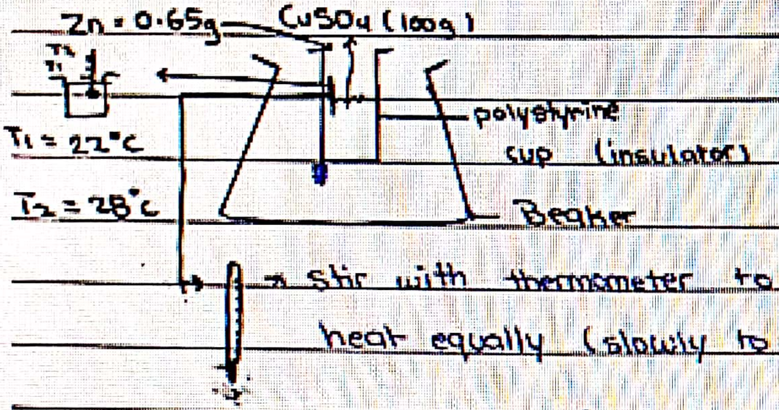
* displacement :

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

* why do we put a beaker below the polystyrine cup?

→ more stable

→ more insulation



* Stir with thermometer to distribute heat equally (slowly to avoid overheating)

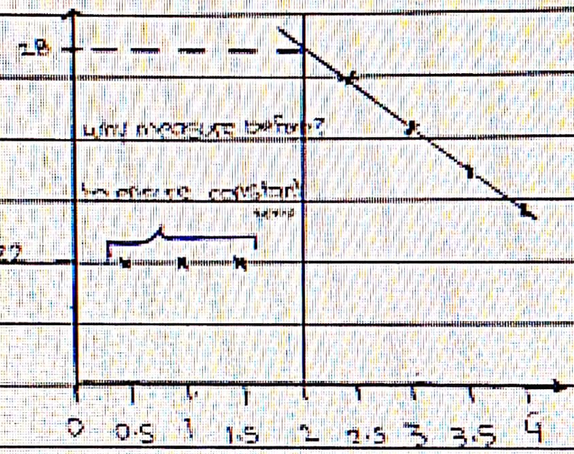
$Q = mc\Delta T$

$Q = 100 * 4.2 * (28-22)$

$Q = 100 \times 4.2 * 6$

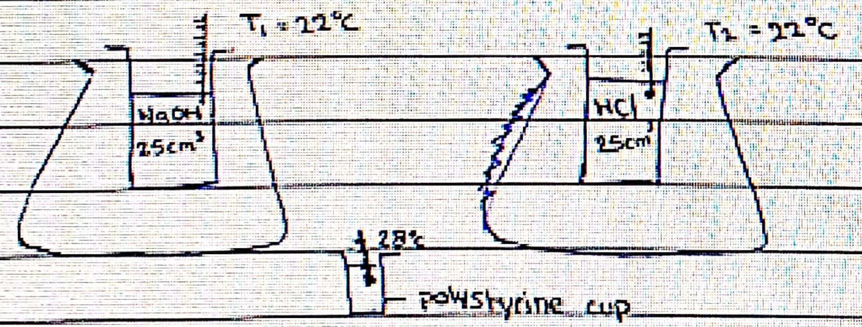
$Q = 2520\ j$

$Q = 2.52\ kj$



* neutralization :

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



specific heat capacity = 4.
j/m

density = $1 g/cm^3$

$Q = mc\Delta T$

$\Delta T = 28 - 22 = 6°C$ $m = ?$ $\rho = m/v$

$C = 4.2$ $1 = m/25$

$50 \times 4.2 \times 6$ $m = 25$

$= 1260 J$ $m_{total} = 25 + 25 = 50$

test for water
physical test : B.P = 100°C
chemical test: 1) $CuSO_4 + 5H_2O \rightleftharpoons CuSO_4 . 5H_2O$ 2) $CoCl_2 + 6H_2O \rightleftharpoons CoCl_2 . 6H_2O$
white / blue / blue / pink

Alternative Resources of Energy

voltaic cell

Hydrogen fuel cell

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

old syl.

## Hydrogen fuel cell

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

advantages: Only one waste product ($H_2O$)
- no $CO_2$
- produce high amount of energy
- generate electricity

disadvantages:
- expensive
- hard to store and transport
- risk of explosion.

Industrial

## Industry of Ammonia. "Haber process"

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

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

How to obtain:-

1) Nitrogen: Fractional Distillation of liquid air

$\Downarrow$ different b.p — $\Downarrow$ cooling under high pressure.

2) Hydrogen: 1) Cracking of alkanes. (organic)

2) $CH_{4(g)} + H_2O_{(g)} \longrightarrow CO_{(g)} + 3H_2$

## Essential conditions

1) Temp. 400°-450°c
2) Pressure. 200 atm
3) Fe catalyst

add excess of $H_2$ and $N_2$

$\boxed{\text{return back to converter.}}$

remove $NH_3$ immediately

$\boxed{\text{by cooling}}$

Uses of Ammonia:

1- Fertilizers
2- Cleaning detergents
3- Smelling salts

Temp 400-450

less ↙ more ↘

| less | more |
|---|---|
| adv. | adv. |
| - higher yield of $NH_3$ | - faster rate |
| - shift forward to exo side | |
| dis. | dis. |
| - slower rate | - less yield |
| particle lose ke | - shift backward to endo side |
| less effective collisions per unit time | |

Pressure: 200 atm

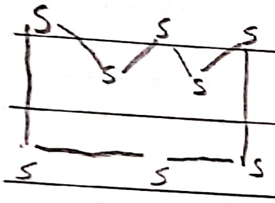
| adv: | dis: |
|---|---|
| 1- more yield of $NH_3$ | 1- risk of explosion |
| shift → to the side with less gas mole | 2- expensive |
| 2- Faster rate | |

(Industry of $H_2SO_4$) Contact process

Stages $S \xrightarrow{+O_2} SO_2 \overset{+O_2}{\rightleftharpoons} SO_3 \rightarrow H_2S_2O_7 \rightarrow H_2SO_4$

roasting contact process oleum

- group (VI)
- valency (2)
- yellow dinal
- $S_8$



uses : medicine
match
rubber

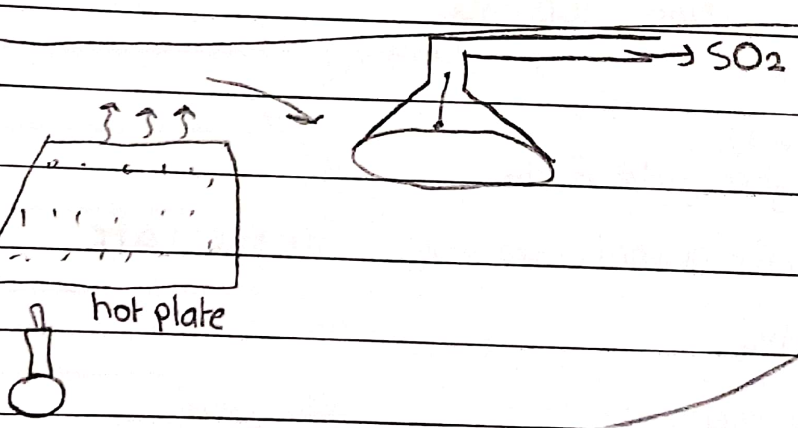
ore: zinc blend $ZnS$

From Fossil Fuel

$SO_2$
cause
acid rain.

$SO_3 \xrightarrow{H_2O} 2H_2SO_4$
- highly exo
- produce low yield of $H_2SO_4$

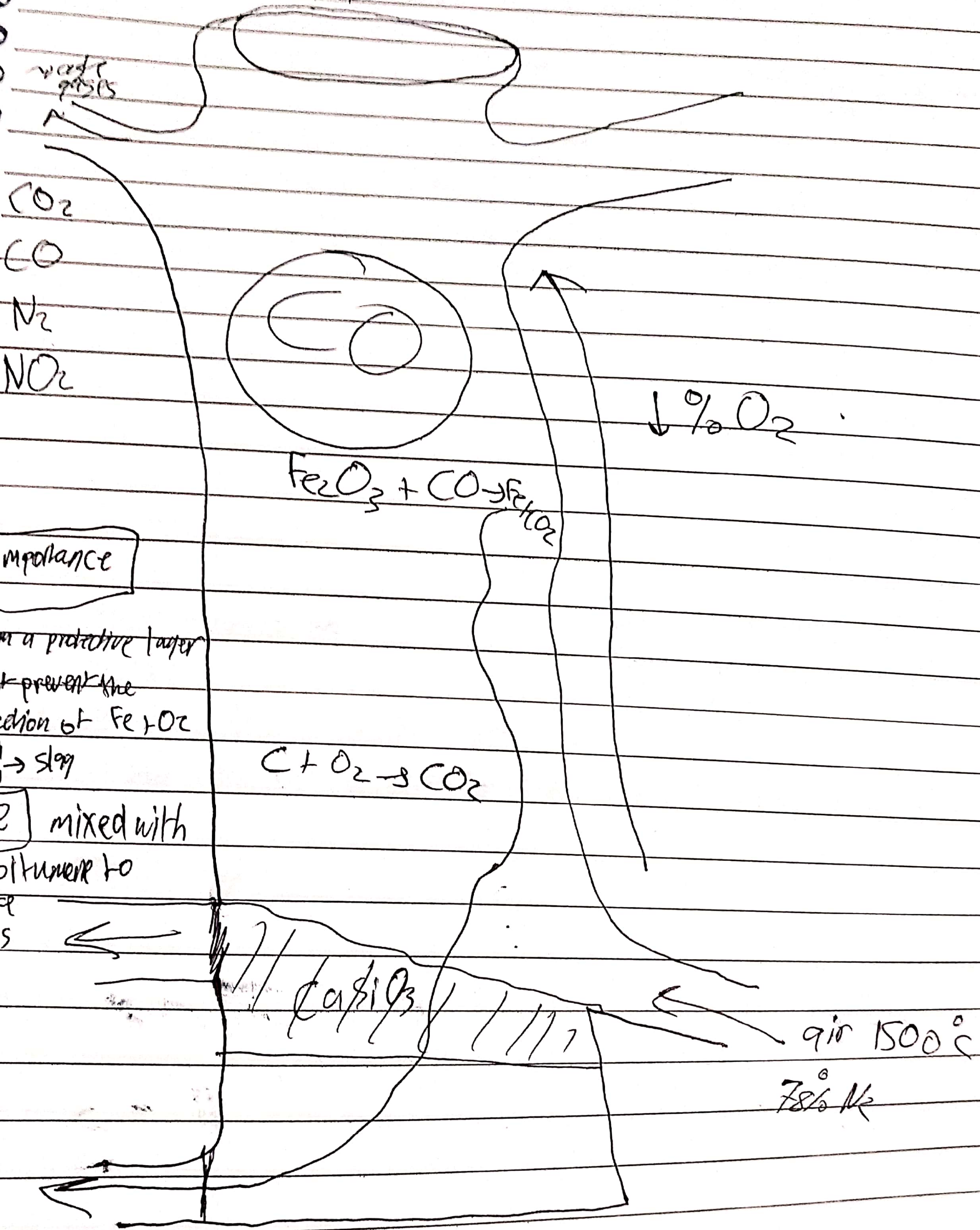
Conc. $H_2SO_4$ → $H_2S_2O_7$ $\xrightarrow{H_2O}$



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

exo
$\Delta H = -ve$

# Extraction of Iron



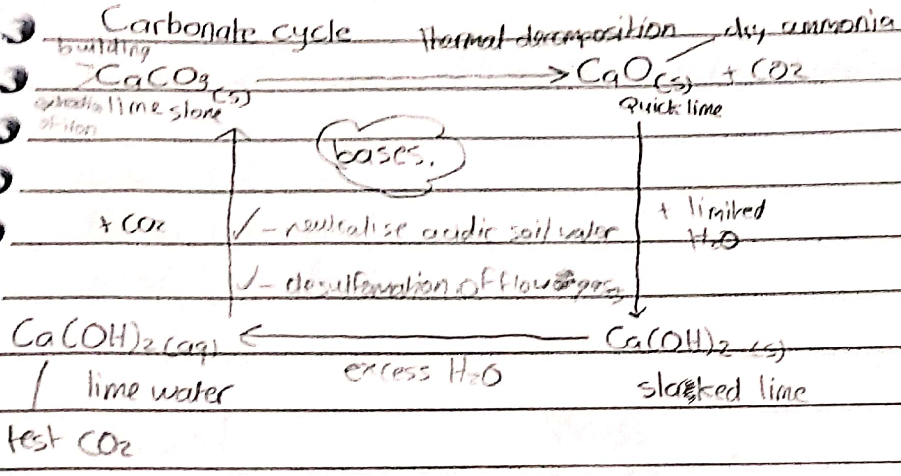
importance

Form a protective layer ~~that prevent the~~ reaction of Fe + $O_2$

→ slag

use mixed with bitumene to make rods

Carbonate cycle



$Ca(OH)_{2(aq)} + CO_2 \rightarrow CaCO_3 + H_2O$

3 a)

i) Quick lime

$CaO_{(s)}$

ii) step 3

iii) thermal decomposition

iv) heating

v) $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

vi) it can react with an acid as a base and with a base as an acid

b)

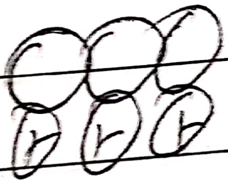
Alloy

Mixture of metal with another metal or semi metal

Brass Cu, Zn
Bronze Cu, Sn
Steel Fe, C, Ni, Cr

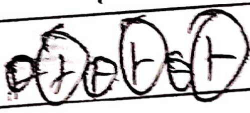
Metal

Cu



Brass

Cu, Zn



## Extraction of Zinc

ore: Zinc blend $ZnS$
method: reduction by C and CO
place: blast furnace

Step 1: Roasting with hot oxygen

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

Step 2:

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

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