Rules for oxidation:

1) The oxidation number of any free element is zero

mono atomic ← → diatomic → polyatomic: P_4
Cu, Zn H_2/O_2 S_8

2) The oxidation number of any atom in a compound from group 1 = (+1)
(Li, Ih, Na, Rb, Cs, Fr)

i) group 2 = (2+) ((Mg, Ca, Ba, Sr)) | ii) group 3 = (+3) Always for Al

iii) group 7 = (-1) Always for 1

3) The oxidation state of (H) is +1 except with metals (-1)
$\overset{+1}{H}_2O$, $N\overset{+1}{H}_3$, $\overset{+1}{Na}\overset{-1}{H}$, $\overset{2+}{Ca}\overset{1-}{H}_2$, $C\overset{+1}{H}$, $Al\overset{-1}{H}_3$

4) The oxidation state of O is (2-) except in peroxide (1-)
exept in OF_2 (+2)

Redox.

Redox Reaction

~~Reduction~~ ~~Lose O~~

oxidation	Reduction	
gains O	lose O	
Lose H	gains H	
increase	decrease	(oxidation state)

Fe in Fe_2O_3 Reduced

- $Al + Fe_2O_3 \rightarrow Fe + Al_2O_3$

Al is oxidized

Zn in ZnO got reduced

- $CO + ZnO \rightarrow CO_2 + Zn$

C in CO oxidized

Cu in CuO reduced

- $H_2 + CuO \rightarrow Cu + H_2O$

H_2 got oxidized

CO got oxidized

- $CO + Fe_2O_3 \rightarrow Fe + CO_2$

Fe in Fe_2O_3 got reduced

Cl_2 got reduced

- $H_2S + Cl_2 \rightarrow HCl + S$

S in H_2S got oxidised

Reduction Cu^{2+}

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

oxidation Mg

Reduction Cl_2

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

oxidation S^{2-}

Reduction $2H^+$

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

Oxidation Na

reduction $Cu^{2+} \rightarrow Cu^0$

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

Zn got oxidised Zn^{2+}

Reduction $Fe^{3+} \rightarrow Fe^0$

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

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

reduction $ZnO \rightarrow Zn$

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

oxidation $CO \rightarrow CO_2$

The sum of all oxide state of all atoms in The compound = zero

in The ions = charge of the ion

compounds:-

$Nacl \rightarrow \underset{-1}{x} + 1 = \underset{-1}{0} \quad x = -1$

$\overset{-2}{CO} \rightarrow C = +2$

$\overset{-2}{CO_2} \rightarrow C = +4$

$\overset{1+}{H_2}\underline{C}\overset{2-}{O_3} \rightarrow +4$

$\overset{+1}{K}Mn\overset{2-}{O_4} \rightarrow +7$

$N\overset{-2}{O} \rightarrow +2$

$N\overset{-2}{O_2} \rightarrow +4$

$N\overset{+1}{H_3} \rightarrow -3$

$N_2\overset{-2}{O_5} \rightarrow 2N - 10 = 0$

$\quad\quad +10 \quad +10$

$\frac{2N}{2} = \frac{+10}{2}$

$N = +5$

Ions:-

$> NO_3^{-1} \rightarrow \underset{+6}{x - 6} = \underset{+6}{-1} \rightarrow x = +5$

$> NO_2^{-1} \rightarrow \underset{+4}{x - 4} = \underset{+4}{-1} \rightarrow x = +3$

$> Cr_2O_7^{2-} \rightarrow \underset{+14}{2x - 14} = \underset{+14}{-2}$

$\frac{2x}{2} = \frac{12}{2} \rightarrow x = 6$

$> CrO_4^{2-} \rightarrow Cr = +6$

Find The oxidation state of all The underlined atoms.

$\underline{V_2}\overset{2-}{O_5}$ $\boxed{+5}$

$\underline{V}O_2^{+}$ $\boxed{+5}$

$H_2\underline{S}$ $\boxed{-2}$

$\underline{V}O^{2+}$ $\boxed{+4}$

$\underline{S}O_3^{-2}$ $\boxed{+4}$

$\underline{S}O_3$ $\boxed{+6}$

$\underline{S_2}O_3^{-2}$ $\boxed{+2}$

$\underline{Mn}O_4^{-1}$ $\boxed{+7}$

$\underline{Mn}O_4^{-2}$ $\boxed{+6}$

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

Reduction → $Fe^{3+} \rightarrow F$

oxidation → $Al \rightarrow Al^{3+}$

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

Reduction → $Mn^{+7} \rightarrow Mn^{+2}$

Oxidation → $Fe^{+2} \rightarrow Fe^{+3}$

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

oxidation → $S^{-2} \rightarrow S$

Reduction → $Cl \rightarrow Cl^{-1}$

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

Reduction → $Zn^{+2} \rightarrow Zn$

Oxidation → $C^{+2} \rightarrow C^{+4}$

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

Reduction → $Cr^{+6} \rightarrow Cr^{+3}$

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

~~$\overset{0}{Al} + \overset{+3}{Fe}\overset{-1}{Cl_3} \rightarrow \overset{+3}{Al}\overset{-1}{Cl_3} + \overset{0}{Fe}$~~

~~Lose 3$\acute{e}$~~

~~OXi → $Al \rightarrow Al^{3+} + 3\acute{e}$~~

~~Red → $Fe^{3+} + 3\acute{e} \rightarrow Fe$~~

~~gain $\acute{e}$~~

~~- writing half ionic equation "balanced"~~

~~1- balance The atoms~~

~~2- balance the charge by adding $\acute{e}$'s to the side that has greater charge. by The difference~~

$- \overset{0}{Al} + \overset{3+}{Fe}\overset{1-}{Cl_3} \rightarrow \overset{3+}{Al}\overset{1-}{Cl_3} + \overset{0}{Fe}$

$Oxi \rightarrow Al \rightarrow Al^{3+} + \cancel{3\acute{e}}$
lose $3\acute{e}$

$Red \rightarrow Fe^{3+} + \cancel{3\acute{e}} \rightarrow Fe$
gain $3\acute{e}$

1- balance The atoms.
2- balance The charg by adding é's to The greater side.

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

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

$oxi \rightarrow (2Na \rightarrow 2Na^{1+} + \cancel{2\acute{e}}) * 2$
lose $1\acute{e}$

$Red \rightarrow 2H + \cancel{2\acute{e}} \rightarrow H_2$
gain $2\acute{e}$

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

$- Al + HCl \rightarrow AlCl_3 + H_2$

$Oxi \rightarrow 2Al + 2Al^{3+} + 6\acute{e}) * 2$

$Red \rightarrow 6H^{+1} + 6\acute{e} \rightarrow 3H\acute{c}) * 3$

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

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

$Oxi \rightarrow 5Fe^{2+} \rightarrow 5Fe^{3+} + \cancel{5\acute{e}}) * 5$

$Red \rightarrow Mn^{7+} + \cancel{5\acute{e}} \rightarrow Mn^{2+}$

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

$- CO + Fe_2O_3 \rightarrow CO_2 + Fe$

$Oxi \rightarrow 3C^{2+} \rightarrow 3C^{4+} + 6\acute{e}) * 3$

$Red \rightarrow 2Fe^{3+} + \overset{6}{\cancel{3}}\acute{e} \rightarrow Fe) * 2$

$3C^{2+} + 2Fe^{3+} \rightarrow 3C^{4+} + 2Fe$

Oxidising and reducing agents:-

- oxidising agent : The substance that it self reduced and causes The other substance to be oxidisie

- Reducing agent : The substance that itSelf Oxidised and causes the other substance to be reduceded.

$\overset{0}{Al} + Fe_2O_3 \rightarrow \overset{3+}{Al_2}O_3 + Fe$

Oxidation Al	Reduction Fe^{3+}
Reductant Al	Oxidant Fe_2O_3

* most common oxidising agent:-

① oxygen $4\acute{e} + O_2 \longrightarrow 2O^{2-}$

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

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

② Acidify potassium manganate $KMnO_4$

$\overset{+1}{Mn}O_4^{-1} \longrightarrow Mn^{2+}$

③ Acidify potassium dichromate K_2CrO_7

$\overset{+6}{Cr_2}O_7^{2-} \rightarrow Cr^{3+}$

④ Halogens.

$2\acute{e} + \underset{\text{yellow/ green}}{Cl_2} \rightarrow 2Cl^-$

$2\acute{e} + \underset{\text{brown}}{Br_2} \rightarrow \underset{\text{colorless}}{2Br^-}$

$2\acute{e} + I_2 \longrightarrow 2I^-$

brown solution
blaelh solid
purple gass

Subject Date No.

\# Most common Reducing agent

① Hydrogen

$H_2 \rightarrow 2H^+ + 2é$

$H_2 + CuO \rightarrow Cu\ H_2O$

② carbon & carbon monoxide

$\underbrace{\overset{2+}{C}O + ZnO \rightarrow Zn + \overset{+4}{C}O_2}_{\text{it got oxidised, so it's an reductand}}$

$\underbrace{C + Fe_2O_3 \rightarrow Fe + CO}_{\text{Reducing agent}}$

\#The Less reactive ion is more likely To reduce "to be an oxidising agent"

\#the more reactive metal is more likely to oxidise "to be an reducing agent"

strongest reducing agent

- more reactive metal
- more able to loose é's
- more able to oxidise
- more able to be reduced agent

K
Na
Li
Ca
Mg
Al
C, CO
Zn
Fe
Pb
H
Cu
Ag ⟶ Ag^{+1}

weakest reducing agent

strong oxidising agent

③ Metals

④ potassium iodide

$2I^- \rightarrow I_2 + 2é$

colorless red-brown

Oxidant	Reductant
O_2	H_2
$KMnO_4/H^+$	C, CO
purple → colorless	Metals
$K_2Cr_2O_7/H^+$	iodide
orange → green	
Halogens	

Electrolysis For brine solution Nacl (aq) Concentrated,

Nacl

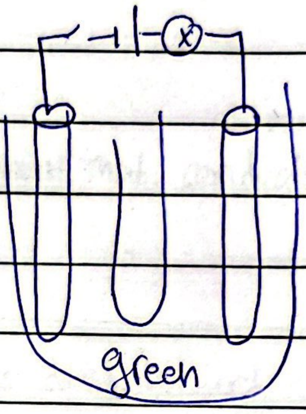
Na^+ Cl^-

H^+ OH^-

Cathode	Anode
$2H^+ + 2e^- \to H_2$	$2Cl^- \to Cl_2 + 2e^-$
bubbles of colorless gas	bubbles of green- yellow gas

Ⓑ

brine + universal indicator



Electrolyte: NaOH

Electrolysis

Electricity ← → Analysis

"Breakdown"

*Electrolysis:- Breaking down ionic compounds "molten" or "aqueous" by passing electricity.

*Electrolyte:- The chemical ~~one~~ compound that conducts electricity when Molten or aqueous.

Q:- why The solid ionic compounds dont ~~c~~conduct electricity ?

-The ions are not free to move

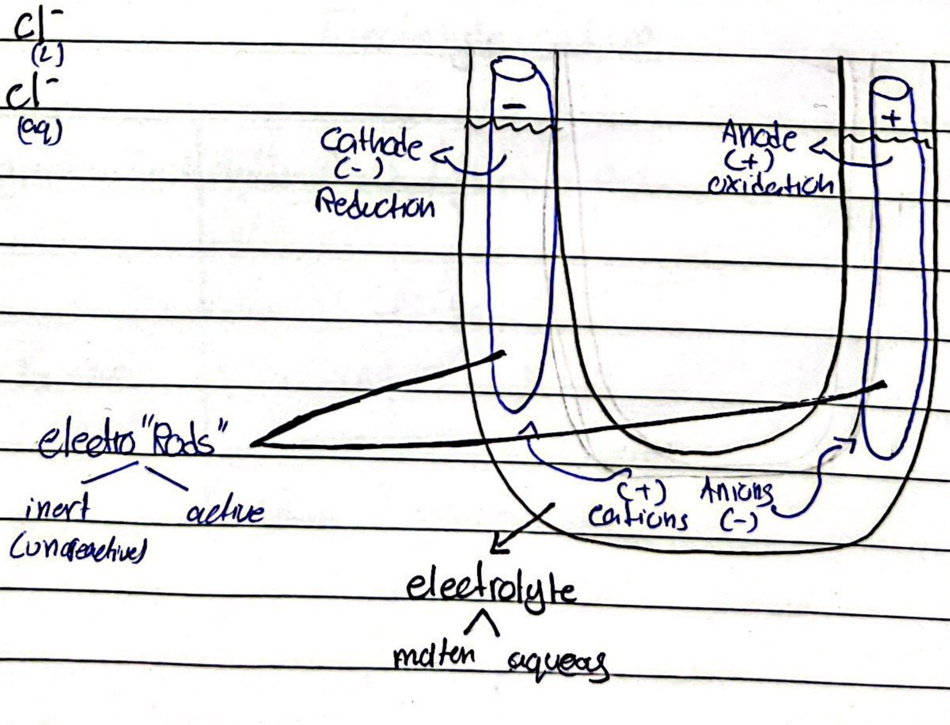
Q:- why The ionic compounds conduct electricity when molten or aq.?

-ions are free to move

(dissolved in water)

$Nacl \xrightarrow{heat} Na^{+}_{(l)} + cl^{-}_{(l)}$

$Nacl \xrightarrow{H_2O} Na^{+}_{(aq)} + cl^{-}_{(aq)}$



Cathode:- The -ve rod that attracts +ve ions (cations) where the reduction takes place

Anode: The +ve rod that attracts -ve ions (Anions) where oxidation takes place

|Electrolysis:- Discharging| Ion → Element

Cations

$1e^- + Na^+ \rightarrow Na$] Deposite of metal

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

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

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

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

↳ Form bubbles

Anions

green

$2Cl^{-1} \rightarrow Cl_2 + 2e^-$ -> bubbles of yellow gas

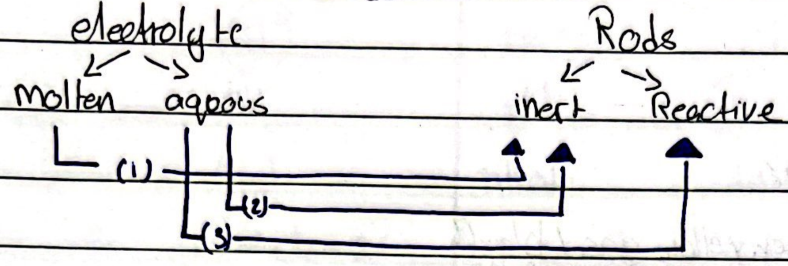
$2Br^{-1} \rightarrow Br_2 + 2e^-$ -> bubbles of green/yellow gas

$2F^{-1} \rightarrow Fe_2 + 2e^-$ -> Red-brown liquid

$2I^{-1} \rightarrow I_2 + 2e^-$ -> Black solid / purple gas

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

Electrolysis



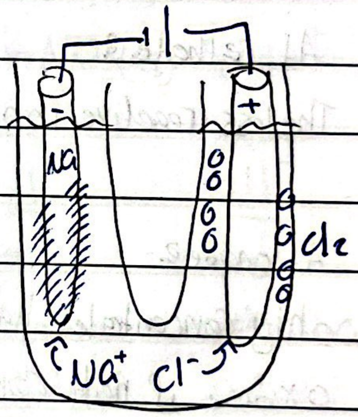
Molten using Inert Rods

* Electrolysis for molten NaCl using graphite.

NaCl

Na^{+1} Cl^{-1}

Cathode	Anode
$1é + Na^+ \rightarrow Na$	$2Cl^- \rightarrow Cl_2 + 2é$
deposite of metal	bubbles of green yellow gas



Electrolyte used up

* Molten lhI /graphite Rod

lh^{+1} I^{-1}

Cathode	Anode
$\overset{+}{lh} + 1é \rightarrow lh$	$2\overset{-1}{I^-} \rightarrow \overset{0}{I_2} + 2é$
deposite of Metal	

Molten Al_2O_3 /graphite Rods

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

Cathode	Anode
$Al^{3+} + 3é \rightarrow Al$	$2O^{2-} \rightarrow O_2 + 4é$
deposite of Metals	bubbles of colorless gas / Relight The glowing split

Subject   Date   No.

Molten $CuCl_2$ / graphite rods

Cu^{2+} Cl^-

cathode	Aonde
$Cu^{2+} + 2\acute{e} \rightarrow Cu$	$2Cl^- \rightarrow Cl_2 + 2\acute{e}$
deposite of Metal	bubbles of green yellow gas / bleach damp limtmus paper electrolyte used up

electrolysis for ageous electrolyte using graphalie

$AB_{(aq)}$

$A \leftarrow A^+$ $B^- \rightarrow B_2$

~~H~~H^+ $OH^- \rightarrow O_2$

Cathode Anode

At cathode :-

The less reactive ion is more lihely to reduce

At anode :-

only concentrated halides are more lihely to oxidise if not concentrated halides The OH^- will oxidise

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

Concentrated NaCl /graphite

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

dilute NaCl (aq) /graphite

Na^+	Cl^-
H^+	OH^-
cathode	Anode
$2H^+ + 2\acute{e} \rightarrow H_2$	$4OH^- \rightarrow 2H_2O + O_2 + 4\acute{e}$
bubbles of	bubbles of colorless gas
Colorless gas	
	electrolyte: NaCl (more conc)

$CuSO_{4(aq)}$ /graphite

Cu^{+2}	SO_4^{2-}
H^+	OH^-
cathode	Anode
$2\acute{e} + Cu^{+2} \rightarrow Cu$	$4OH^- \rightarrow 2H_2O + O_2 + 4\acute{e}$
Deposite of →	bubbles...
Red-Brow	
metal	Electrolyte H_2SO_4

$KNO_{3(aq)}$ /graphite

K^+	NO_3^-
H^+	OH^-
cathode	Anode
$\overset{+2\acute{e}}{2H^+} \rightarrow H_2$	$4OH^- \rightarrow 2H_2O + O_2 + 4\acute{e}$
Bubbles of —	Bubbles of colorless
colorless gas	gas
	Electrolyte → KNO_3 more conc

$CuCl_2$ (conc.) /graphite.

Cu^+	Cl_2^-
H^+	OH^-
cathode	Anode
$Cu^{2+} + 2\acute{e} \rightarrow Cu$	$2Cl^- \rightarrow Cl_2 + 2\acute{e}$
deposite of	bubbles of
Red-brown metal	green yellow
Electrolyte: H_2O	gas

Less conc

Concentrated $NaBr_{(aq)}$ /graphite

Na^+	Br^-
H^+	OH^-
cathode	Anode
$2H^+ + 2\acute{e}$	$2Br^- \rightarrow Br_2 + 2\acute{e}$
$\rightarrow H_2$	red-brown
	solution
	electrolyte NaOH

Electrolysis for aqous electrolyte using Active rod.

* active rod made from the same metal ion in the electrolyte.

[$CuSO_4 \xrightarrow{\text{using}}$ Cu rod]
[$AgNO_3 \xrightarrow{\text{usings}}$ Ag rod]

$CuSO_{4(aq)}$

Cu^{2+} SO_4^{2-} x] neither the OH^-
H^+ OH^- x] nor The SO_4^{2-}

Anode oxidise
The anode itself will oxidise

Cathode	Anode
$Cu^{+2} + 2\acute{e} \rightarrow Cu$	$Cu \rightarrow Cu^{2+} + 2\acute{e}$
deposite of metal (Red-brown)	

Subject Date No.

Applications on electrolysis.

Molten / inert	ageous / inert	ageous / Active
① extraction of Al	⇓ prepare solution conc NaCl Na^+ Cl^- → Cl_2 H_2 ← H^+ OH^- (NaOH)	① electroplating ② refining / purifying metals

---

Electroplating :-

- coating a metal with another metal. using electricity.

why? ① to prevent rusting

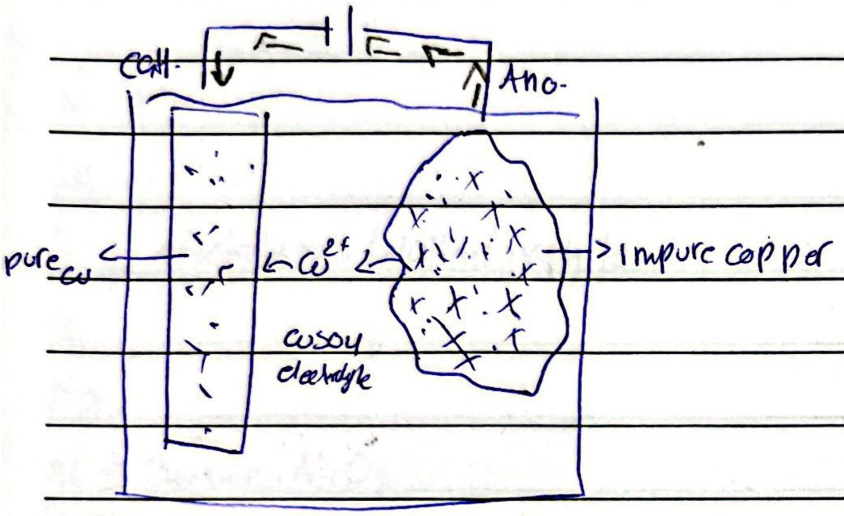
② more attractive

How to electroplate a metal spoon with Ag $\boxed{8}$

- clean the metal spoon from any impurities or oxide layer to ensure a well sticking.
- make the metal spoon the cathode
- the anode must be Ag.
- the electrolyte must has Ag^+ e.g $AgNO_3$
- switch on the circuit
- rotate the metal spoon to ensure an equal distirbution
- rinsed with distilled water
- dry in oven.

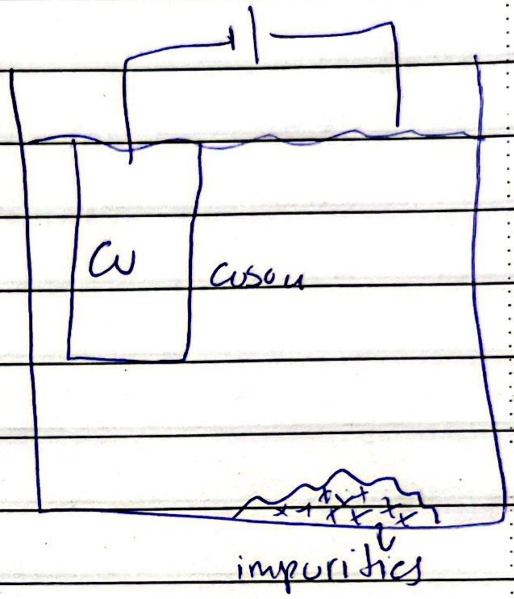
Refining copper / purifying

#$\overset{Cu}{\text{impurities}}$ Ag, Au, Zn



$Cu^{2+} + 2e^- = Cu$

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



#because Cu ~~2+~~ will oxidize and replace Cu^{2+} in the electrolyte

Ag, Au = settle down (less reactive than Cu)

Zn^{0} displace Cu from $CuSO_4$

Extraction of Metals:-

Method of extraction the Metal from it's ore depends on the position of this Metal in the reactivity series:-

K
Na
Li] electrolysis / Mollen / graphite
Ca
Mg

Al -> Bauxide, Al_2O_3

$\boxed{C, CO}$

Zn -> zinc blende, ZnS] Reduction by C, CO
Fe -> Hematite, FeO_3
Pb

$\boxed{H}$

Cu -> copper sulfide, CuS] Reduction by H_2
Ag
Au

Excraction of Al, $\overset{\boxed{ore}}{\text{Bauxite } Al_2O_3}$, $\overset{\boxed{Methode}}{\text{Electrolysis}}$ for Mollen ore using graphite

AU M.p of Al_2O_3 is 2000C°

So we dissolve Al_2O_3 in Molten Crytlyte. Na_3AlF_6, why?

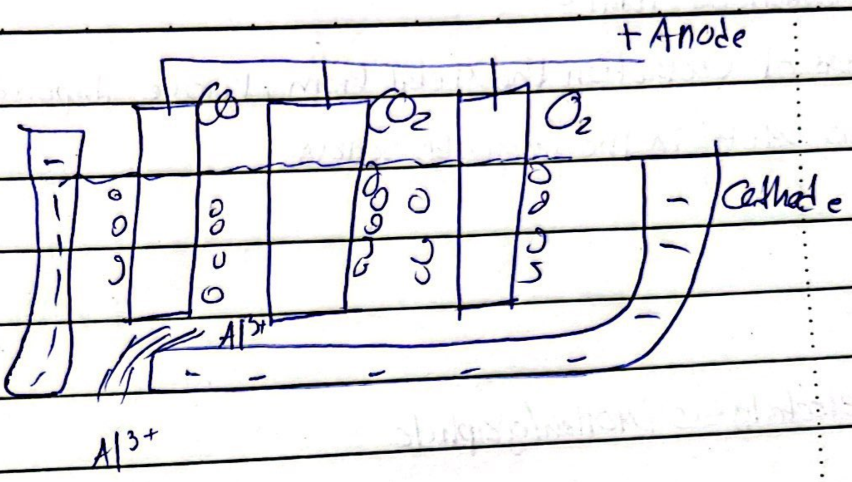
1- to lower the m.p to 900c° so less cost

2- to increase the electrical conductivity.

Al_2O_3

$Al^{3+} \leftarrow \quad \rightarrow O^{2-}$

Cathode	Anode
$Al^{3+} + 3\acute{e} \rightarrow Al$	$2O^{2-} \rightarrow + 4\acute{e}$
deposit of metal	bubble of gas



property of Al

- Malleable
- low denisty

Form non-toxic oxide layer

Conduct electricity ductile

Use of Al

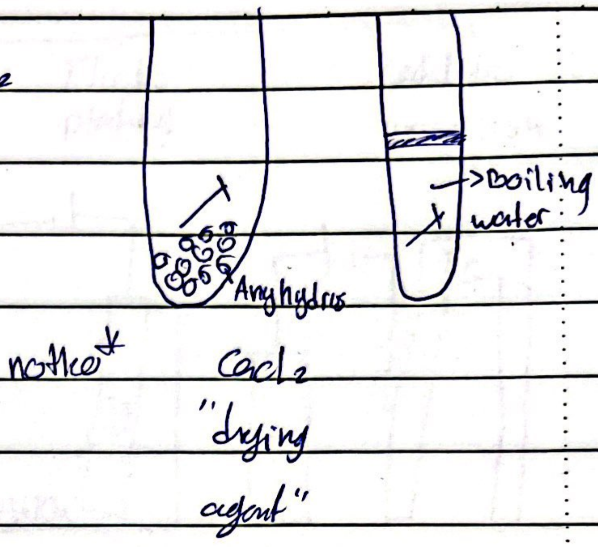
- window frame, cooking utensils
- Air craft bodies
- food cans

electrical wire

Rusting:

The reaction of iron with Both H_2O & O_2

$$Fe + O_2 \xrightarrow{H_2O} \overset{+3}{Fe_2}O_3 \cdot nH_2O$$



slow reaction

plan an experiment to show which brand is the best. A or B

- Take a known mass of iron nail.
- Apply a known volume of solution A
- Add them to a known volume of water for 1 week
- dry the iron nail
- measure the mass
- Repeat the exp using solution B
- The exp which cause less increase in mass is the best.

Rust prevention

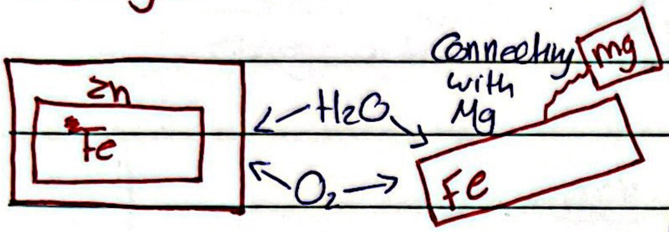
Paint oiling greasing cover with plastic

(prevents H_2O & O_2 from reacting)

Galvanizing

Coating Zn

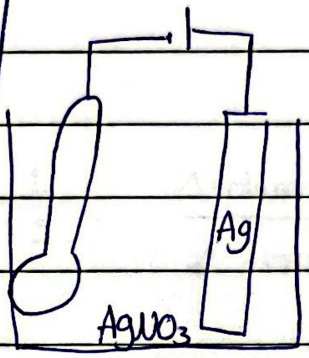
sacrificial protection



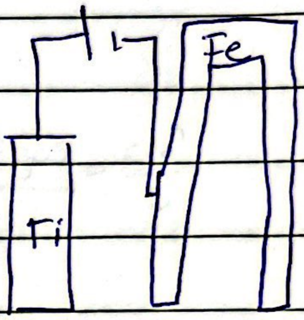
Zn& Mg are more likely to react
Than Fe it's more likely to oxidise

∴Fe is less likely to react (Rust)
(oxidize)

Electro plating

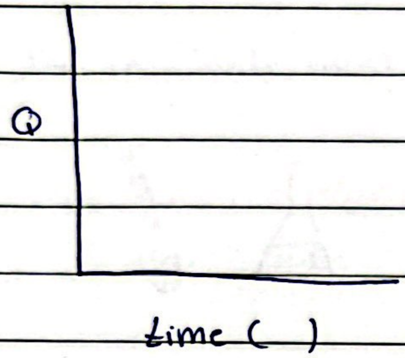


Catalitic protection



Rate of reaction :-

$$\text{Rate} = \frac{\text{change in Quantity}}{\text{change in time}} = \frac{\Delta Q}{\Delta t}$$



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

$$\frac{\Delta \text{volume of gas}}{\Delta \text{ time}} = \frac{cm^3}{s}$$

$$\frac{\Delta \text{light intesity}}{\Delta \text{ time}} = \frac{1}{s}$$

$$\frac{\Delta \text{Mass}}{\Delta \text{time}} = \frac{g}{s}$$

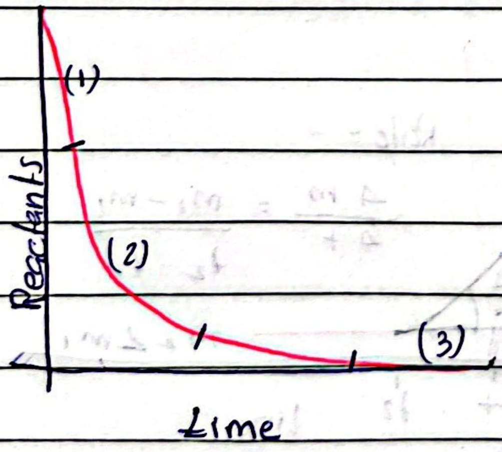
$$\frac{\Delta \text{temp}}{\Delta \text{time}} = \frac{C^\circ}{s}$$

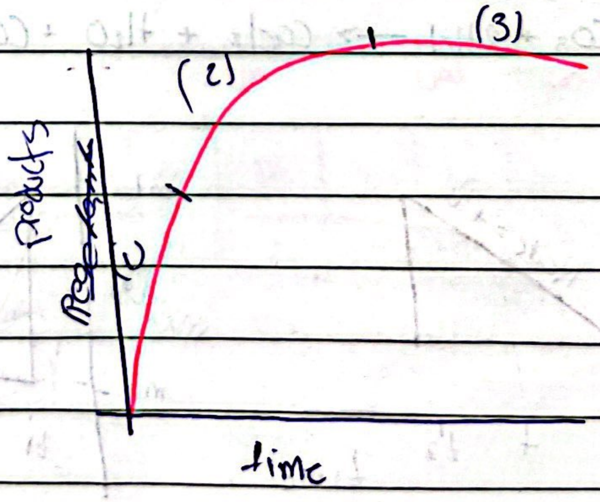
$$\frac{\Delta \text{electrical conductivity}}{\Delta \text{ time}} = \frac{1}{s}$$

to measure the rate of reactions

measure how fast the reactants consume per unit time

measure how fast the products produce per unit time.





- Reigon (1) the rate is the highest -> from the curve
  steepest high gradient

  more reactants
  so more particles
  so more effective collisions per unit time

- Reigon (2) the rate is slower -> from the curve:
  less steep lower gradient

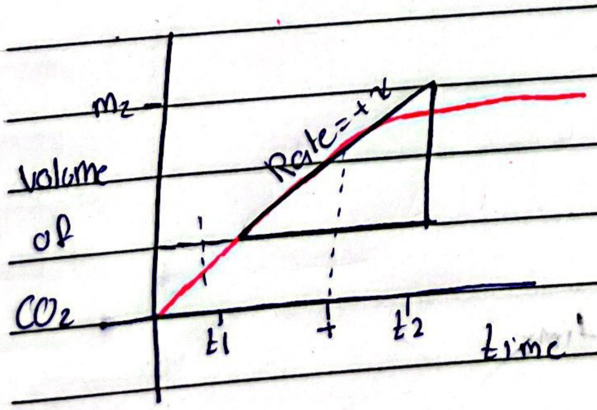
  less reactants
  less particles
  so less effective collisions per unit time.

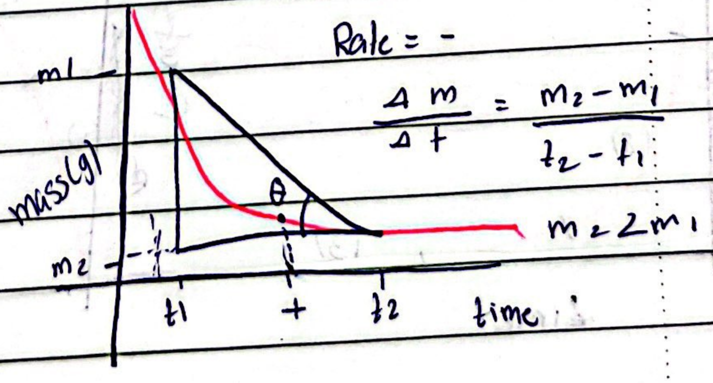
- Reigon (3) The reaction is over -> from the curve
  Horizental line gradient = 0

  no more limiting reagent
  no more effective collisions

From the graph how to measure the rate.

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





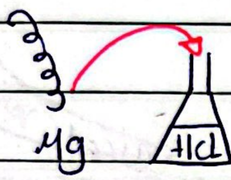
$$\text{Rate} = -\frac{\Delta m}{\Delta t} = \frac{m_2 - m_1}{t_2 - t_1}$$

3main conditions for any chemical reactions:

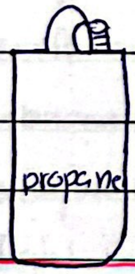
① the reactants must be suitable :

$Cu + HCl \rightarrow$ no reaction

② the reactants must collide



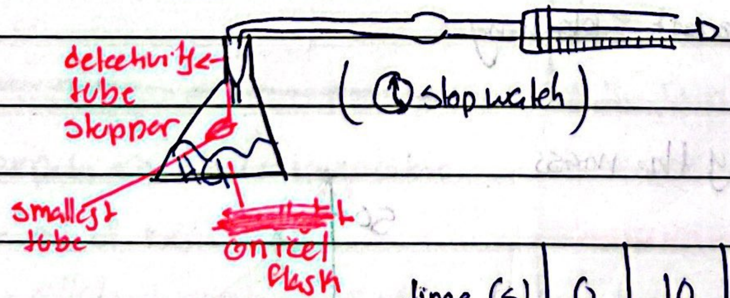
③ the collisions must be effective / the particles have min ammount of energy needed to start the reaction → Activation energy Ea



measuring the rate by monitoring the volume of gas

reactants measure

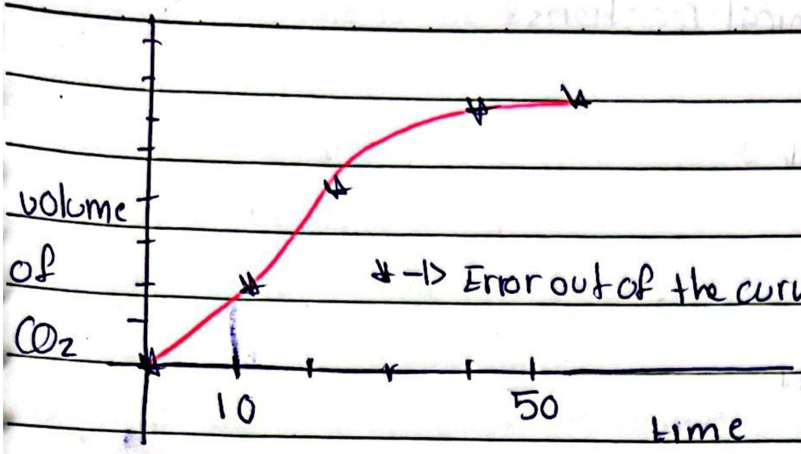
$\underline{CaCO_3 + 2HCl} \rightarrow CaCl_2 + \underline{CO_2} + H_2O$



over: no limmiting factor

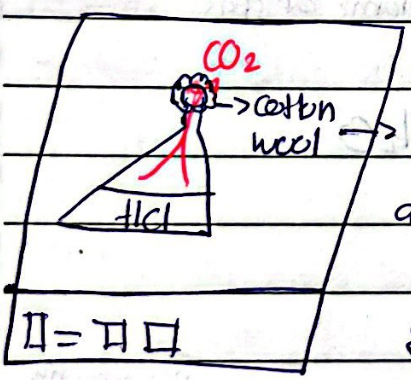
time (s)	0	10	20	30	40	50
volume (cm³)	0	8	13	15	16	16

+8 +5 +2 +1



② measuring the rate by monitoring the change in mass of conical flask + contents + per unit time

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

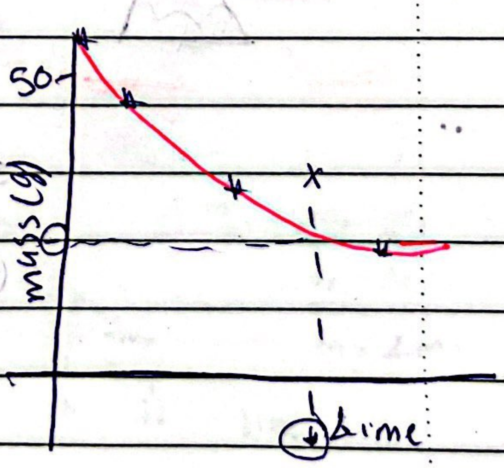


to allow CO_2 to escape and prevent splashing

? why the mass

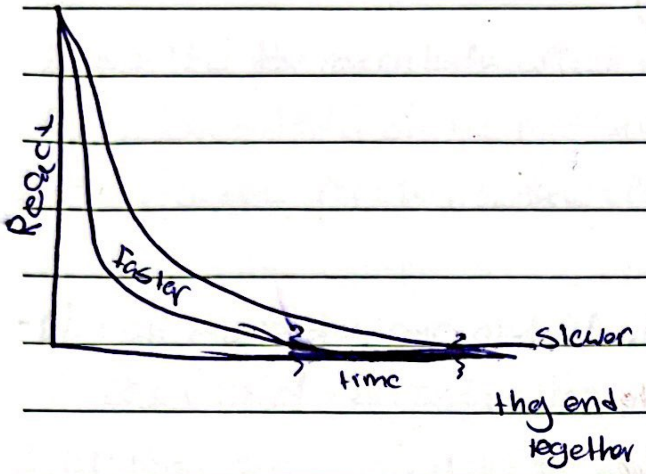
CO_2 escaped

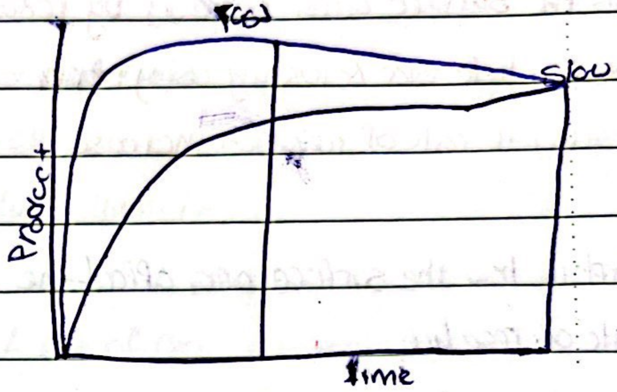
time(s)	0	10	20	30	40	50
mass(g)	50	45	42	41	40.5	40.5



increasing the rate of reaction

Same products with less time or more products per the same time





Factors that effect the rate of reactions

① temprature
② surface area
③ concentration
④ pressure (only gases)
⑤ light
⑥ catalysts

plan an exp to show how temprature affects the rate of rxn

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

Exp. 1:- $CaCO_3$ = m = 2g v = 0.1 dm^3 M = 0.1 mol/dm^3 temp = 25°C

Exp. 2:- $CaCO_3$ = m = 2g v = 0.1 dm^3 M = 0.1 mol/dm^3 temp = 50°C

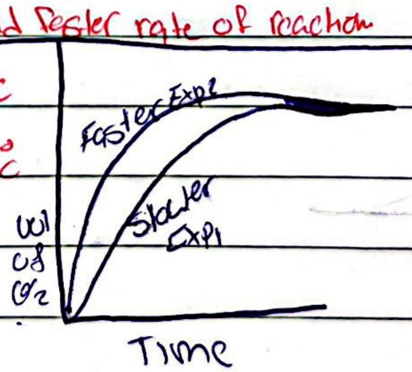
temprature:-

- state how the temprature affects the rate of Rxn?

As the temp increases the rate of Rxn increase.

- explain how the temp affect the rate of Rxn?

as the temp increase the particles gain K.E so move faster so more particles will have energy ≥ EA so more effective collisions and faster rate of reaction



② Surface area

- State how the surface area affects the Rate of reaction.

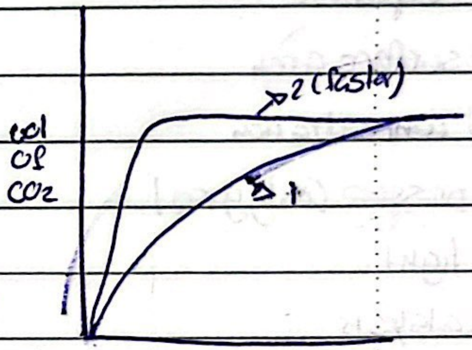
- As the surface area increases by reducing the particle size / crushing using mortar or pestle, the rate of reaction increase.

- Explain how the surface area affect the Rate of reaction.

- As the surface area increases, more particles are exposed to the reaction so more effective collisions per unit time, faster rate.

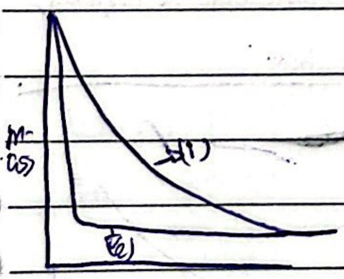
- plan an exp to show how the surface area affects the rate of reaction.

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



Exp.1 : mass = 2g (lumps) vHCl = 0.1 dm³ MHCl = 1 mol/dm³ temp = $25^{\circ}C$

Exp.2 : m = 2g (powder)



③ concentration gradient "amount"

- state How the concentration affects the rate of reaction.
- As the concentration increase the rate of Rxn increase.

- Explain How ~~the~~ the concentration affects the rate of reaction.
- As th concentration of the reactants increase more particles so more reacting so more effective collisions/t

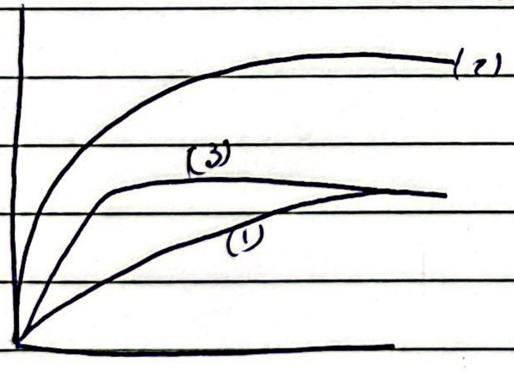
- plan an Exp to show conc. gradient affect rate of rxn

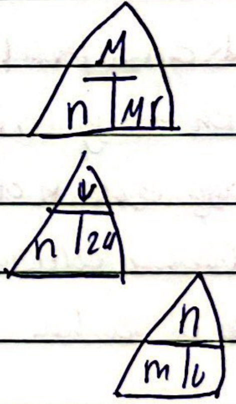
$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ ~~temp=25°C~~

Exp1: mass=1.0g lump V of HCl =0.1/dm³ 0.1/mol/dm³ temp=25°C

Exp2: mass=2.0g lump V=0.1dm³ M=0.2mol/dm³ temp=25°C

Exp3: mass 4.0g lump V= 1dm³ 0.1 mol/dm³ temp=25°C





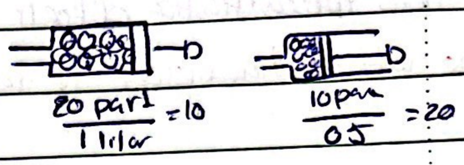
more limiting factor rate more product

mol exp(3) → faster RoR

pressure "only for gases"

- explain how pressure affects the rate of rxn?

- As the pressure increase "volume decrease" more particles per unit volume so more effective collisions rate of rxn is faster



- light for photochemical rxn
  - → photosynthesis

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

photographic films "AgCl, AgBr"

$2AgCl \rightarrow 2Ag + Cl_2$

$2AgB \rightarrow Ag + Br_2$

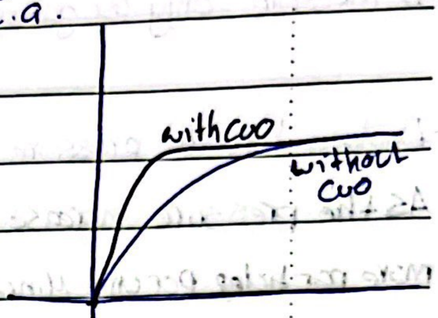
⑥ catalyst

- Catalyst is substance that speeds up the rate of reaction without being used up.

How?

- it provides an alternative pathway with lower activation energy so more particles will have energy equal to or greater than Ea so more effective collisions per unit time so faster rate of reaction

How? it provide an alternative pathway with a low E.a; so more particles will have energy equal to or greater than E.a.
so more effective collisions per unit time.
so faster rate of reaction



$H_2O_2 \xrightarrow[MnO_2]{CuO\ or} 2H_2O\ O_2$

Q1) plan an experiment to show that CuO is a catalyst for this Rxn.
- known volume of known conc of H_2O_2.
- Add a known mass of CuO
- measure the volume of O_2 per unite time.
- Repeat the exp without CuO
- Concl: the exp with CuO produce more O_2 per the same unit time.

Q2) plan an expt to show which catalyst is better CuO or MnO_2
- known volume of known conc of H_2O_2
- Add known $\underline{\overset{\boxed{\text{solid}}}{\text{mass}}}$ of CuO
- measure volume of O_2 per unit time
- Repeat with MnO_2 (same mass).
- Concl: the exp that produce more O_2 per unit time is better catalyst.

Q3) plan an expt to show that CuO is not used up in the rxn.
- Add a known mass of CuO to H_2O until no more bubbles of O_2,
filter the mixture, dry in oven, remeasure the mass, Concl: the mass will not change.

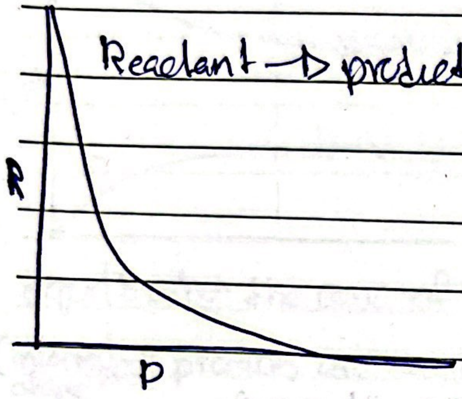
Chemical Reactions

one way

Reactant $\xrightarrow{forward}$ product

$Mg + HCl \rightarrow MgCl$

$CaCO_3 + HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$



Both way

React $\xrightleftharpoons[backward]{forward}$ products

$3H_2 + N_2 \rightleftharpoons 2NH_3$

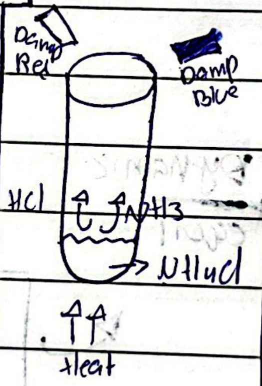
$2SO_2 + O_2 \rightleftharpoons 2SO_3$

$NH_4Cl \rightleftharpoons NH_3 + HCl$

$2NO_2 \rightleftharpoons N_2O_4$

$NH_4Cl \xrightarrow{Heat} NH_3 + HCl$

Ammonium chloride → Ammonia + Hydrogen chloride.



Q which damp litmus paper will change first explan your answer?

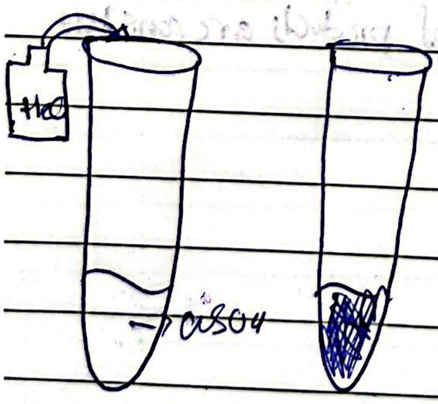
the damp red l.p changes color to blue first since NH_3 is Alkali and lighter than HCl which is acidic

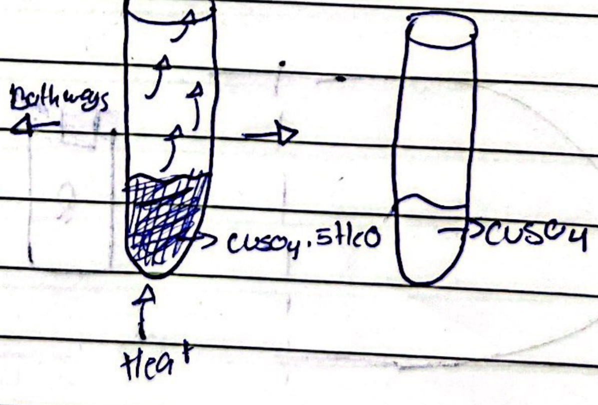
$CuSO_4 + 5H_2O \rightarrow CuSO_4.5H_2O$

$CuSO_4 \rightarrow CuSO_4 + 5H_2O$

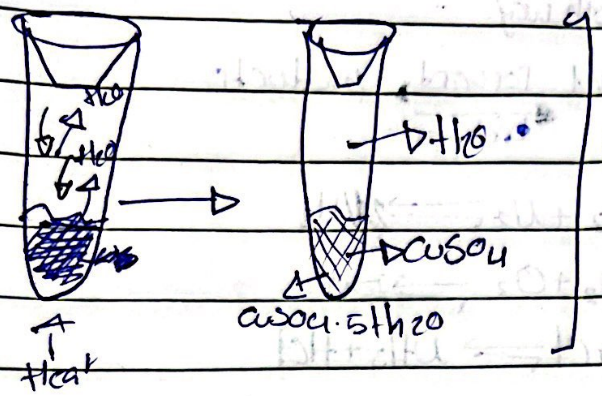
blue

~~colorless~~ white



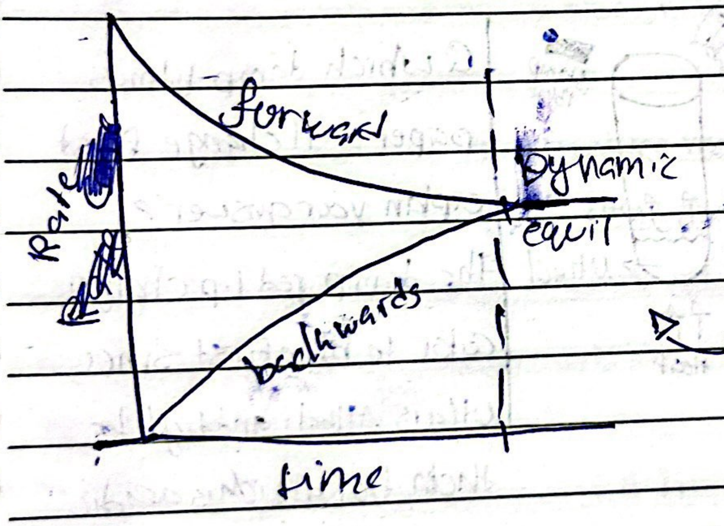


$CuSO_4 \cdot 5H_2O \rightleftharpoons CuSO_4 + 5H_2O$

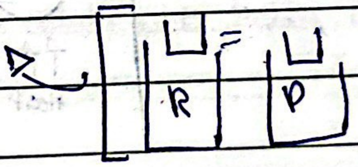


Dynamic equilibrium :-

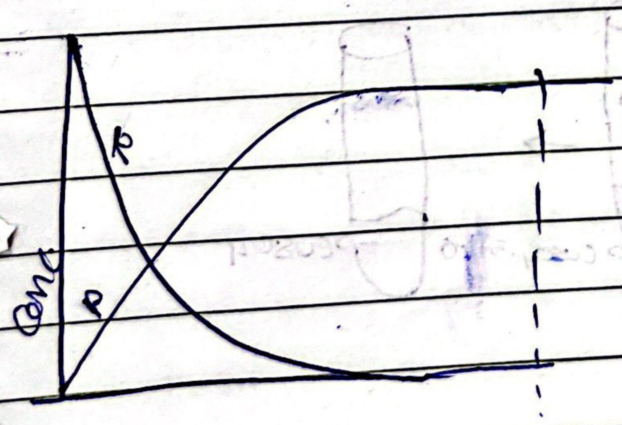
$Reactant \underset{backwards}{\overset{forward}{\rightleftharpoons}} products$

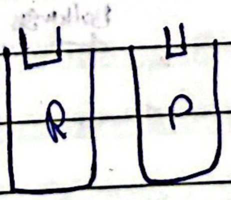


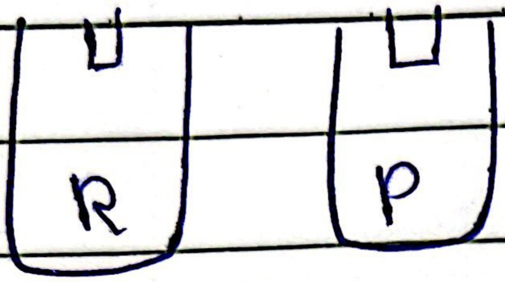
Dynamic equilibrium-
when the rate of forward equal the rate of backward

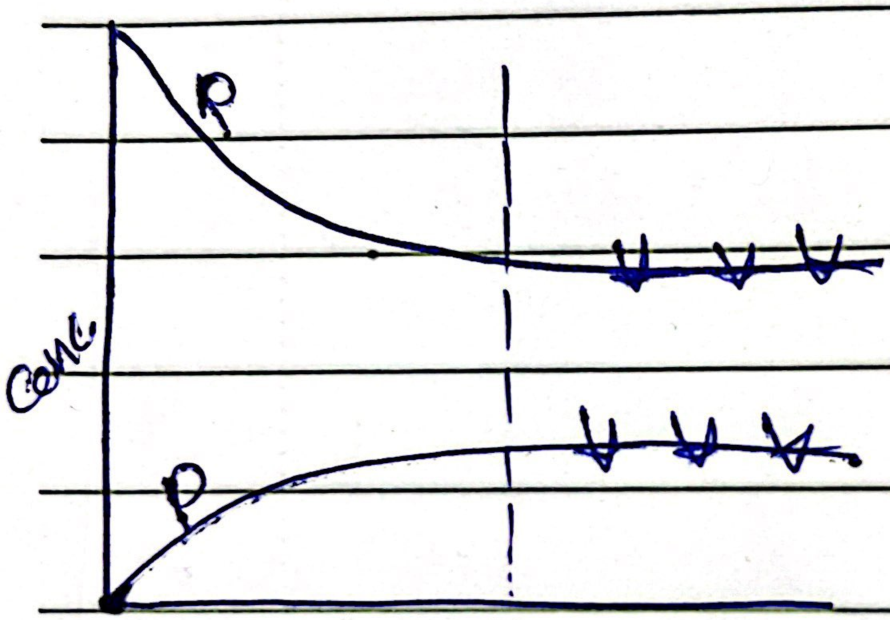


In terms of cnss when the conc of Reactants of products are constant









equil8 when the conc of reactants
(interms of conc) of products are constant

Le chanteler principle

if the system at equilibrium($\rightleftharpoons$) and any external factor distrubt the equilibrium; the equilibrium will shift either forward($\longrightarrow$) or backwards($\longleftarrow$)

to return back to the equilibrium

pressure

concentration

temprature

Endothermic
$\Delta H = +ve$
Exothermic
$\Delta H = -ve$

temprature: endo and exo
↑ temp, shift to endo
↓ temp, shift to exo

- As the temprature increases the equilibrium shifts to the side that absorbs heat which is endo thermic
- " " " decreases " " " " " " " exerts " which is exothermic

- the sign of ΔH is always represented by the forward reaction

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

$\boxed{\uparrow \text{temp}}$ → shifts to the endo side (forward)
↑↑ forward rate ↓A ↓B + ↑C ↑D
↑ backwards rate

Subject

Date

↓ temp → shifts to the exo side (backwards)

↓↓ Rate of forward

↓ Rate of backwards ↑A ↑B → ↓C ↓D

→ $w + x \underset{Endo}{\overset{Exo}{\rightleftharpoons}} y + z \quad \Delta H = \overset{Exo}{-ve}$

- ↓ temp shift to exo, forward
  Rate of endo ↓↓, Rate of exo ↓ ↓w ↓x ↑y ↑z
- ↑ temp shift to endo, backwards
  Rate of exo ↑[illegible], Rate of endo ↑↑ ↑w ↑x ↓y ↓z

$3H_2 + N_2 \underset{endo}{\overset{exo}{\rightleftharpoons}} 2NH_3 \quad \Delta H = \overset{exo}{-ve}$

temp ↑

Rate of Reaction increase Rate of backwards increase they yeild of NH_3, why? it will decrease, increase in temp shifts to equilibrium to the backwards to the endo

$2SO_2 + O_2 \rightleftharpoons 2SO_3 (g)$

the yeid of SO_3 increase by cooling explain why?

the forward reaction is exo favoured by cooling

Sealed tube contains NO_2 and N_2O_4 at equilibrium

$\underset{\text{dark brwn}}{2NO_2} \rightleftharpoons \underset{\text{pale brwn}}{N_2O_4}$

if we put this tube in a cold water bath the color beomes paler
forward Reaction is exothermic favoured by cooling

pressure

↑ pressure → shifts to the side with less pressure which has Less gas molecules

↓ pressure → shifts to the side with more pressure which has more gas moles

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

↑ pressure : shifts forwards, side of less moles
↓ pressure : shifts backwards, side more moles

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

↑ pressure : shifts backwards, less moles
↓ pressure : shifts forwards, more moles

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

↑ pressure : has no effect on the position of equi
↓ pressure : they have the same no. of gas moles

↑ pressure Rate of less gas mole ↑↑
Rate of more gas mole ↑
~~shifts less gas mole~~

↓ pressure Rate of more gas mole ↓↓
Rate of less gas mole ↓
shifts more gas mole

Complete the table

$\underbrace{3H_{2(g)} + N_{2(g)}}_{4mole} \rightleftharpoons \underbrace{2NH_3}_{2mole} \quad \Delta H = -ve$

Effects	Rate of forward	Rate of backward	yeild of NH_3
↑ temp	↑	↑	↓
↑ pressure	↑	↑	↑
↓ press	↓	↓	↓

Q the Reaction $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI$ at equilibrium why by increasing the pressure the position of equi does not change ??

- bcs both sides of the equi/Reaction has the same number of gas moles.

why by ↑ the press the mixture becomes more purple

because the gas particles of I_2 becomes closer together and the color appear more condense.

Q Mixture of NO_2 and N_2O_4 at equil in a sealed tube (multiple choice):

$\underset{\text{dark brown}}{2NO_2} \rightleftharpoons \underset{\text{pale brown}}{N_2O_4}$

by increasing the pressure the mixture

a) becomes darker and stays dark

[✓ b)] becomes dark and become pale

c) becomes paler and stays paler

d) becomes paler and goes darker

Temp

↑temp ↑↑ endo rate

↑ exo rate

↓ temp ↓↓ endo rate

↓ exo rate

pressure

↑pressure ↑↑ rate of less gas moles

↑ rate of more gas moles

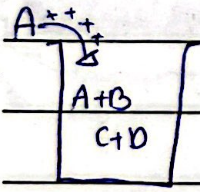
↓ pressure ↓↓ less gas moles rate

↓ rate of more gas moles

∴ shift to the side with more gas moles

Concentration

$A + B \rightleftharpoons C + D$



↑[A] shift forward

↓B ↑C ↑D

↑[C] shift backward

↑A ↑B ↓D

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

Temp: 400°C - 450°C

pressure: 200 atm.

concentration: add excess H_2 & N_2

remove NH_3 imidiatly (condensation)

Indicator:-

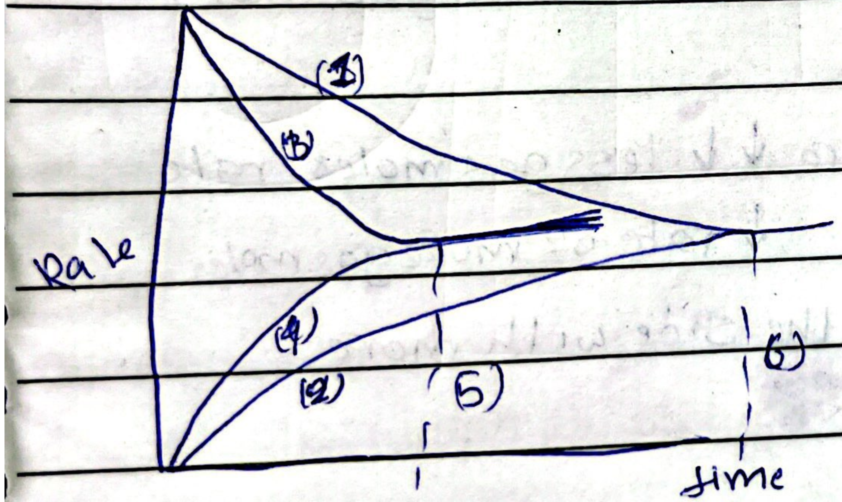
$HIn_{(aq)} \rightleftharpoons H^+_{(aq)} + In^-_{(aq)}$

Add HCl acid proton denor	↑H^+ shift backward more HIn more color(1) less In^- less color(2)
Add NaOH proton acceptor $OH^- + H^+$	↓H^+ more In^- more color (2) less HIn less color (1)

\# catalyst:-

- has no effect on the position of equilibrium bcs it speeds up the rate of forward & backwards, so it causes the equil to occur with less time

(1)



Energetics :- (Energy in chemical reactions)

Energy :- The ability to do work

in chemical reaction

Endothermic :-	Exothermic :-
breaking down	To build up The
bonds in Reactants;	bond in The products
input. absorb	output. Release
Take in.	give out.

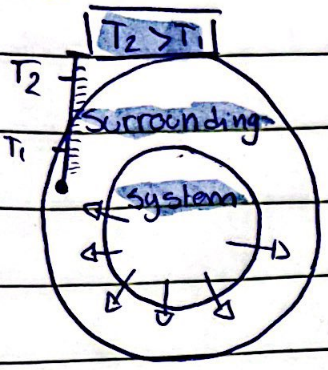
input > output
Endothermic

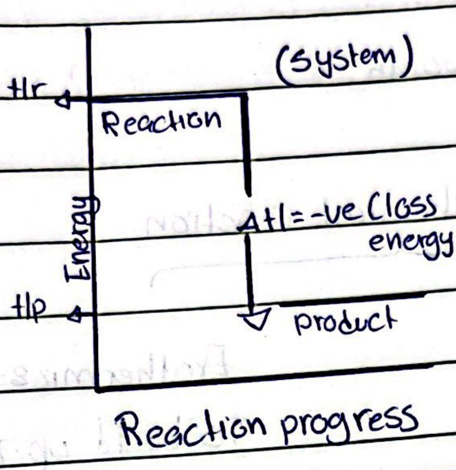
input < output
Exothermic

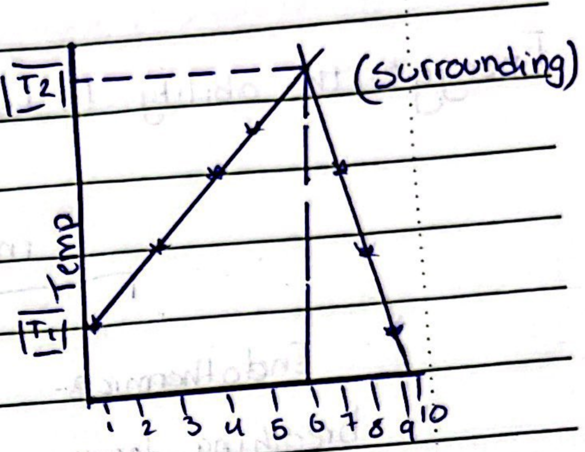
Enthalpy :- Heat contents
Stored energy in bonds

Subject **Exothermic reactions:-** Date No.

Reaction that release (give out) energy to the surrounding when They talhe place.







$Q = mc\Delta T$

energy (J)

mass (g)

Specific heat capacity (water = 4.25 J/g)

change in Temp

$\uparrow Q$ = Exothermic

Examples of exothermic Rxns:-

1- combustion

2- displacement

3- neutralization

4- respiration

5- freezing

6- Condensation

7- voltaic cell

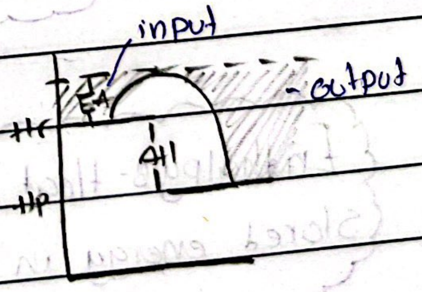
8- building up bonds

How to express exo Rxs:-

① Reactants → product + Energy

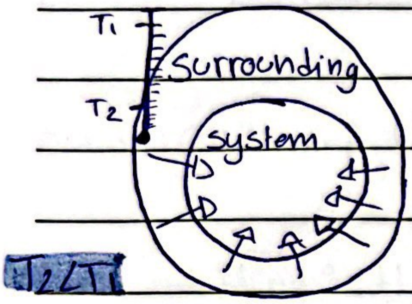
② ΔH = -ve

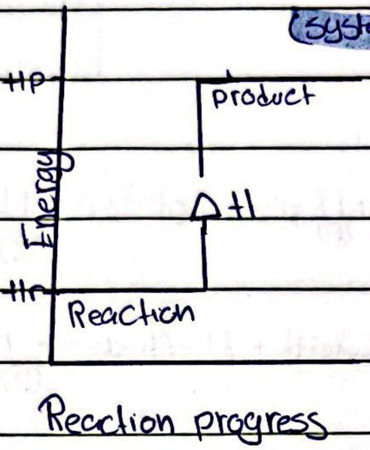
③ profile diagram

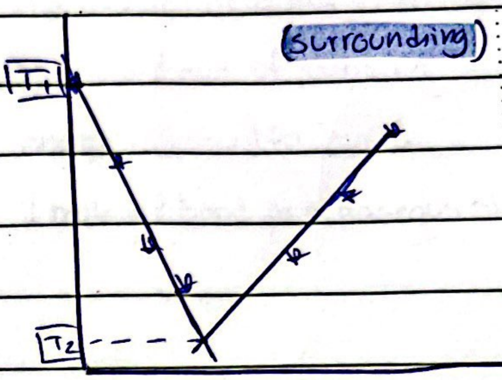


Endothermic Reaction:-

Reactions that absorb(take in) energy from the surrounding when They take place.







$Q = mc\Delta T$ ↑Q more endo

Examples:-

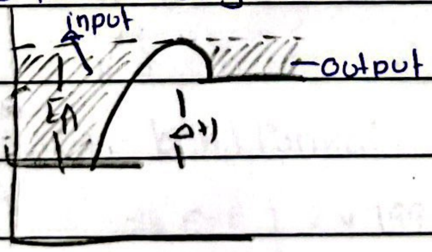
1- photosynthesis
2- photographic films
3- Thermal decomposition
4- electrolysis
5- Boiling, melting
6- breaking down bonds

How to express endo Rxns:-

① Reactants + energy → products

② $\Delta H = +ve$

③ profile diagram:-



Measuring ΔH_{Rxn} using bond energies:-

bond	bond-breaking
H-H	436

Bond breaking:-

The amount of energy needed To break 1 mol of bond in energy released to build 1 mole of bond in a gaseous state

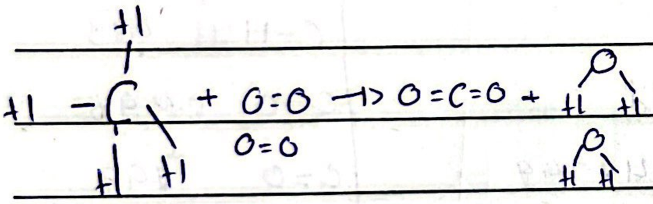
(endo)
bond breaking:- $H-H_{(g)} + 436\ kJ \longrightarrow H_{(g)} + H_{(g)}$

(exo)
bond building:- $H_{(g)} + H_{(g)} \longrightarrow H-H + 436\ kJ$

$\Delta H_{rxn} = \sum input - \sum output.$

ΔH = total iput - total output

- exo + endo



bond	bond energy
C-H	413
O=O	496
C=O	799
O-H	4.63

bond broken

$4 \times C-H$] 4×413
$2 \times O=O$] 2×496 +
2644 kJ

bond formed

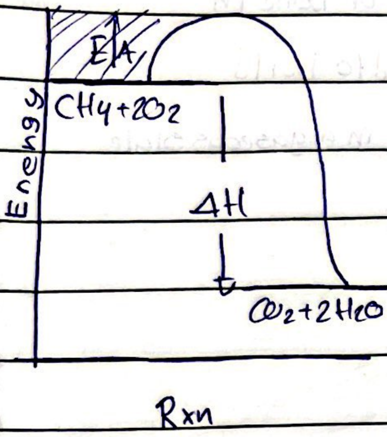
$2 \times C=O$] 2×799
$4 \times O-H$] 4×463 +
3450 kJ

ΔH = iput - output
$= 2644 - 3450$
$= -806$ kJ/mol
exo

① $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + 806$ kJ/mol

② $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ $\Delta H = -806$ kJ/mol

③ profile diagrams-



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

bond	energy
C-H	413
O=O	496
C=O	799
O-H	463
C-O	358

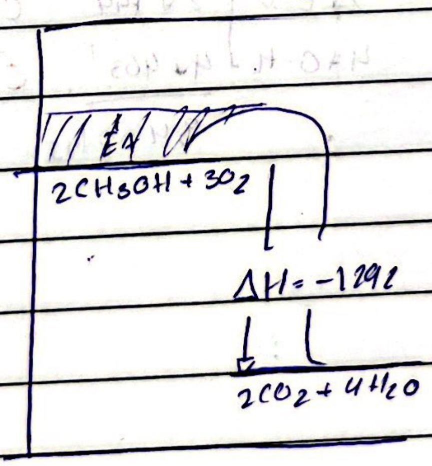
bond broken

6 × C-H	6 × 413
2 × C-O	2 × 358
2 × O-H	2 × 463
3 × O=O	3 × 496
	5608 kJ

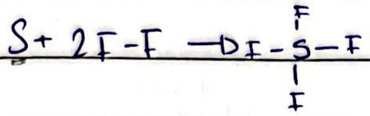
bond build

4 × C=O	4 × 799
8 × O-H	8 × 463
	6900 kJ

$\Delta H = 5608 - 6900$
$= -1292$ kJ/mol.



Sulfer react with Florine to give sulfer tetrafloride. and release -780 kJ/mol if the bond energy for F-F is 160 kJ/mol. draw a profile diagram for this reaction & find the bond energy for S-F



$S + 2F-F \longrightarrow SF_4$

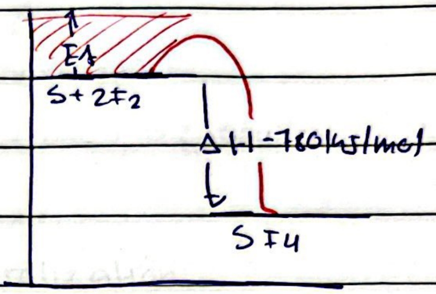
ΔH = input - output

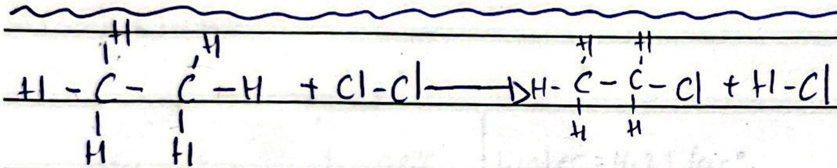
$-780 = (2 \times 160) - 4 \times S-F$

$-780 = 320 - 4\,S-F$

$\frac{-1100}{-4} = \frac{-4\,S-F}{-4}$

S-F = 275 kJ/mol





$CH_3-CH_3 + Cl-Cl \longrightarrow H-CH_2-CH_2-Cl + H-Cl$

$(3 \times C-H) \times 2$ $(3 \times 413) \times 2 = 2478$

$+$ Cl-Cl $+ 242$

$\boxed{2500}$

bond building

$3 \times C-H + 2 \times C-H \rightarrow 5 \times 413 = 2065$

2065 + H-Cl

-104 = 2500 - 2065 + H-Cl

-104 = 435 + H-Cl

-435 -435

H-Cl = -539

Measuring the amount of energy transfer

$Q = mc\Delta T$ → change in temp

Q → energy transfer (Jule)

m → Mass

c → specific heat capacity for H_2O 4.2 J/gc°

combustion

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

↓

displacement

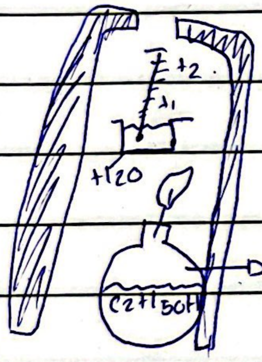
$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

↓

Neutralization

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

✱ combustion :-



$t_1 = 22°C$

$t_2 = 28.5$

$H_2O = 100g$

$m_1 = 200g$

$m_2 = 198g$

water = 4.2 J/gc°

$Q = mc\Delta T$

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

$= 2730\,J$

2730 J → 2g C_2H_5OH

$\boxed{62790\ J/mol}$ ← 46g → Mr

$\Delta H = -62.79\ kJ/mol$

Displacement :-

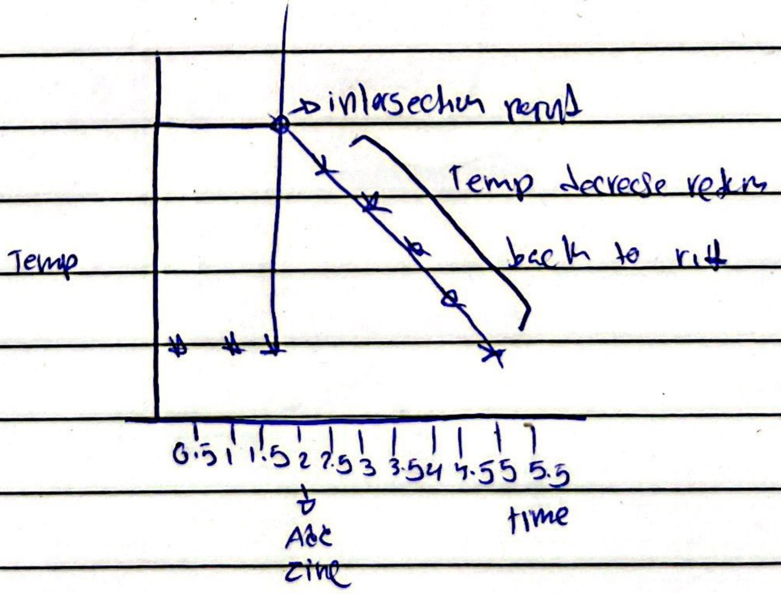
$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

Zn: m = 0.65g

$CuSO_4$: V = 100cm³, d = 1g/cm³, m = 100g

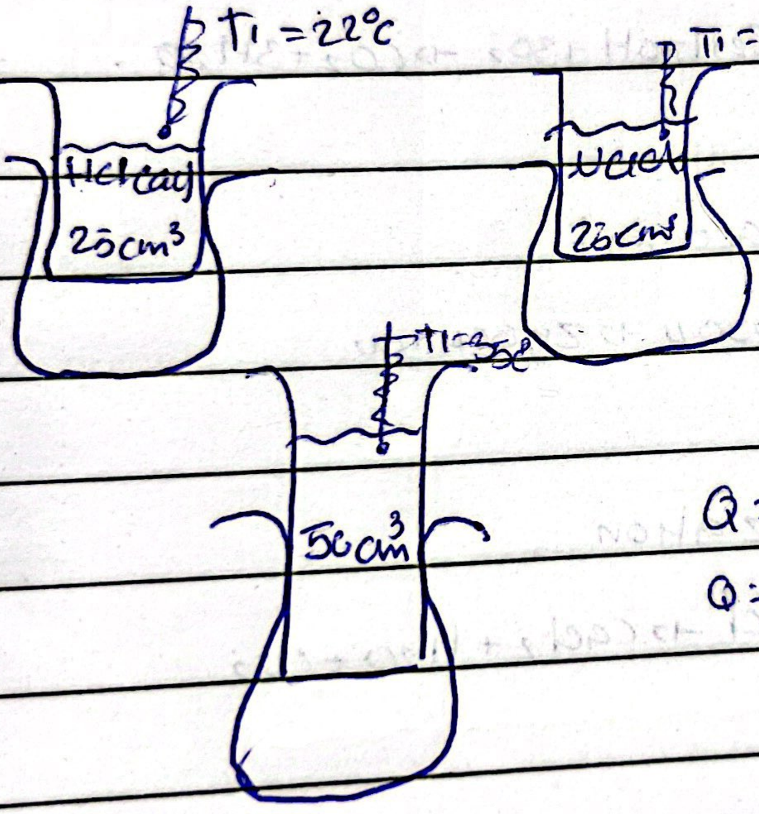
polystyrain cup "insulator"

Beaker :-
- insulator
- more stable



A Neutralization :-

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

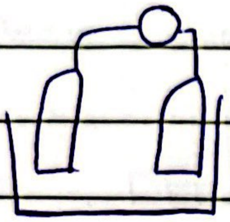


$Q = mC\Delta T$

$Q = (25+25) * 4.2 * 13 = \_\_ J$

Alternative resources of energy

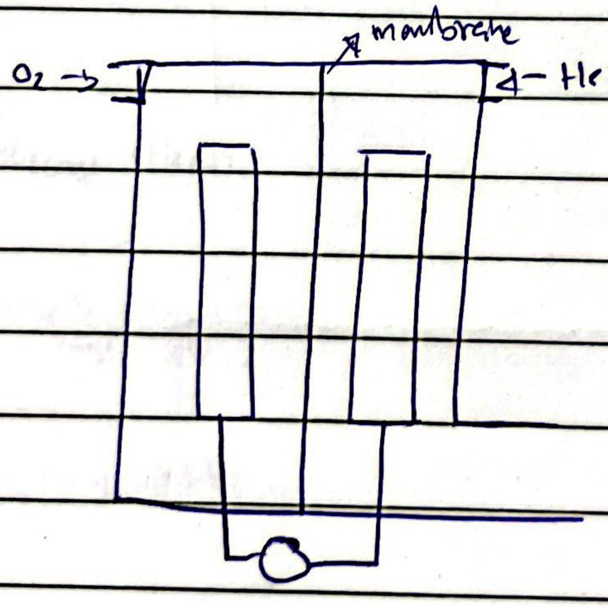
voltaic cell Hydrogen feulcell uraimum



$2H_2 + O_2 \rightarrow 2H_2O$

produce only H_2O as a waste product, high amount of energy

no CO_2 produced



Indsinal chemistry :

- Dealing with gases
  - dry
  - collect
- Industry.
  - NH_3 (Haber process)
  - H_2SO_4 (contract process)
  - (SO_3^{-2})
- Extraction
  - Fe
  - Zn
  - Cu
  - Al

Dealing with gases

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

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

NH_3) $NH_4Cl + NaOH \rightarrow NaCl + H_2O + NH_3$

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

Cl_2) $NaCl \xrightarrow{electrolysis} H_2 + Cl_2 + NaOH$

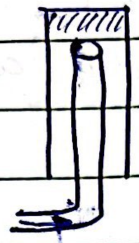
Collect gases:-

① gas syringe

* collect and measure the volume of any gas

② Delivery

upwards

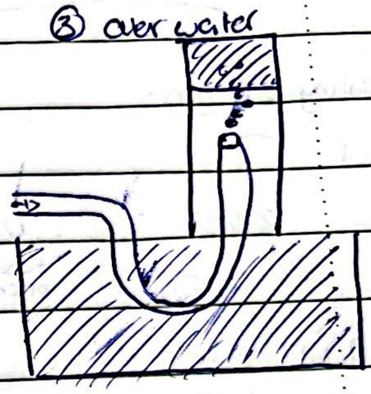


less dense gases

downwards

more dense gases

③ over water



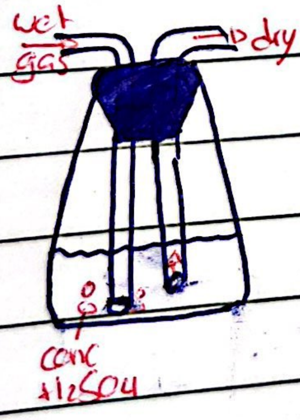
* used only for insoluble gas in water.

* CO_2 is slightly soluble in water

* hard to use

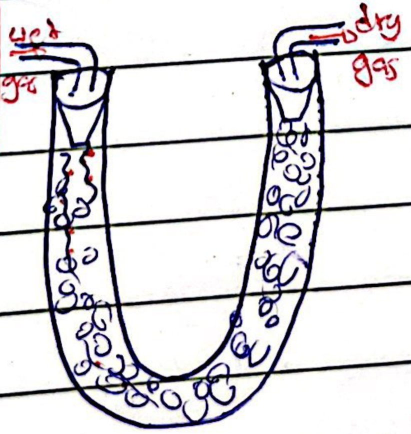
Drying gases:-

conc H_2SO_4



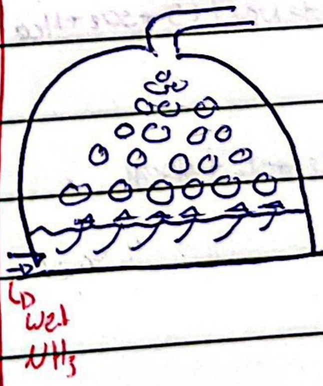
* used to dry any gas except NH_3

Anyhydrous $CaCl_2$



* used to dry anygas except NH_3

CaO Qcick time



Industry of NH3
(Haber process)

memorise:-

$2H_{2(g)} + N_2 \rightleftharpoons 2NH_{3(g)}$ {ΔH = -ve}

Uses of NH3:-

- fertilizers (N, P, K)
- Cleaning detergent
- Smelling salts

Essential conditions:-

1- Temprature: 400°c - 450°c

2- Pressure: 200 atm

3- Catalyst: Fe

#We can also:-

- Add exces H2 and N2, return back to the converter
- Remove NH3 immediatly

#How?

(condensation)

Cooling down NH3 ; (g) → (l)

How to obtain:-

N2:- Fractional distilation of liquid air.

H2:- ① cracking of Alkane (organic)

② $CH_4 + H_2O$
methane ↓
$3H_2 + CU$

Scanned with CamScanner

1- temprature 400°C - 450°C

- less than 400°C
  - Adv.
    - -more yeild of NH3, shift forward to the exo side
  - dis
    - -slow down rate of reaction
    - why?
    - -particles lose K.E; so less effective energy per unit time
- Greater than 450°C
  - Adv.
    - -Faster Rate of Reaction
  - dis
    - -less yeild of NH3, shift backwards to the endo side

2- pressure 200 atm (High pressure)

- Adv.
  - ①- more yeild of NH3 (shift to the side with less gas moles (forward))
  - ② Faster rate (more collions per unit time)
- dis
  - ①- Risk of explosion
  - ②- Expensive

How to obtain:-

N2: fractional distillation of liquid air

H2: ① cracking of Alkane

② $CH_4 + H_2O$ (methane)

↓

$3H_2 + CO$

* Add excess H_2 & N_2, Return Back to converter
* Remove NH_3 immediatly, How? cooling down. NH_3 condenses

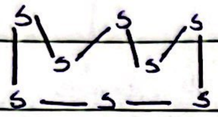
Industry of H_2SO_4

$$S \xrightarrow{\text{Roasting}} SO_2 \underset{}{\overset{\text{contact processe}}{\rightleftharpoons}} SO_3 \xrightarrow{\text{conc. } H_2SO_4} H_2S_2O_7 \xrightarrow{H_2O} H_2SO_4$$

- Group VI

Yellow solid

$[S_8]$



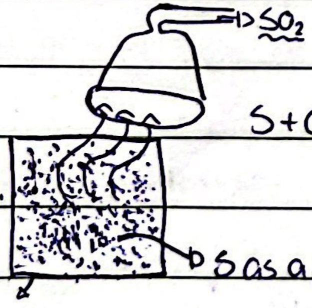
* ores- zinc blend (ZnS)

* Sources- fossil fuel

* uses:- - Medicine

- fire worths
- matches
- rubbers

① Roasting



$S + O_2 \rightarrow SO_2$

S as a powder:- larger surface area for a faster reaction

* Oily liquid

dilute	concentrated
typical	Dry
acid	gas.

* choching smell

- test SO_2 turns acidify $KMnO_4$ from purple to colorless

* uses:

- paper industry bleaching agent
- food preservatives kills bacteria.

② contact process :-

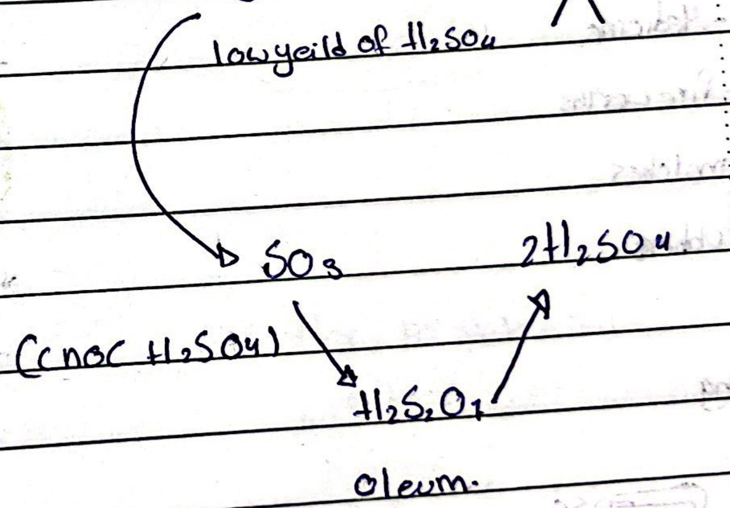
$$2SO_2 + O_2 \underset{Endo}{\overset{V_2O_5}{\underset{Exo}{\rightleftharpoons}}} 2SO_{3(g)} \quad \Delta H = -ve$$

1) temprature 400-450

2) pressure 1-2 atm " high pressure favour the
to Max forward reaction which has
less ~~~~ gas moles "

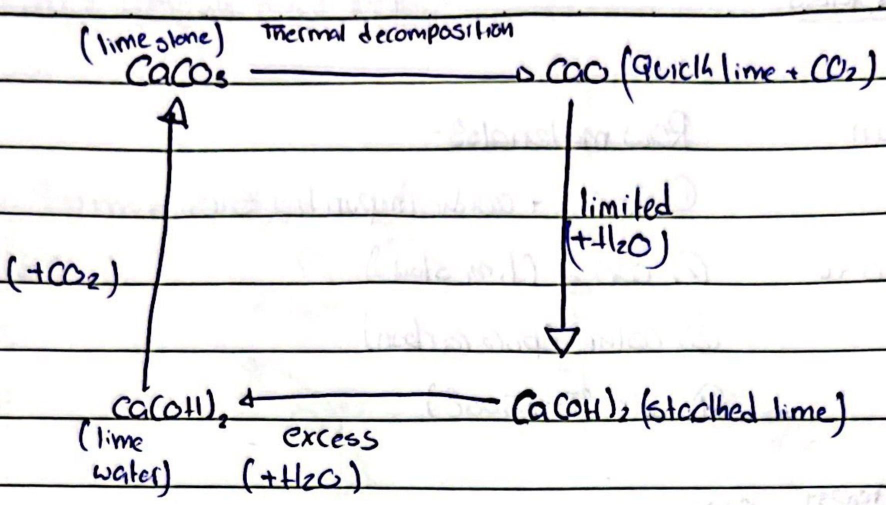
3) catalyst (V_2O_5)
vanadium (v) oxide
penta

#③-④ $SO_3 \xrightarrow{H_2O} H_2SO_4$
high exo produce
low yeild of H_2SO_4



Subject Date No.

Carbon cycle

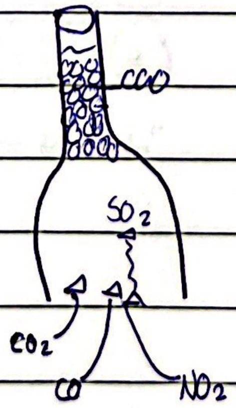


*bases- - neutralise the acidic soil and water
- desulfmation, removing SO_2 from flow gases.

*$CaCO_3$ → - building
- extraction of iron

*CaO → - dry NH_3

*$Ca(OH)_3$ → test CO_2



*test for CO_2:-

$Ca(OH)_3 + CO_2 \rightarrow CaCO_3 + H_2O$

Extraction of metals:

Extraction of Iron

- ores: Hematite Fe_2O_3
- Method: reduction by CO + C
- place: Blast furnace

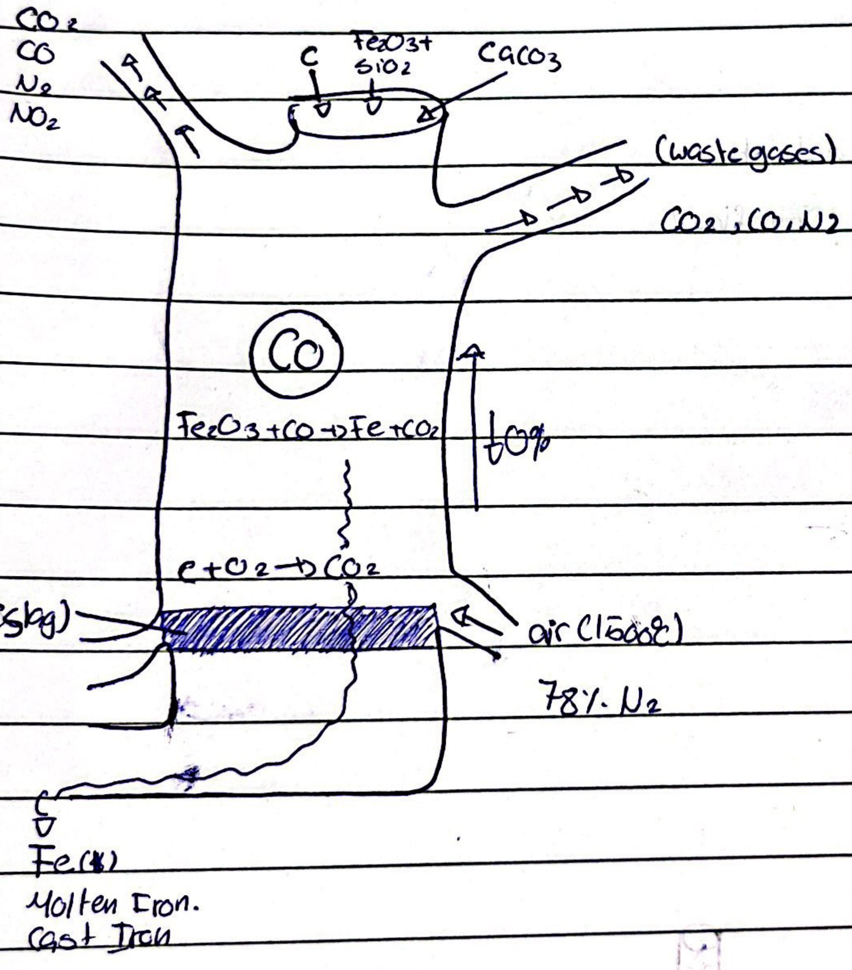
Raw materials:-

① Fe_2O_3 + acidic impurities SiO_2

② $CaCO_3$ (limestone)

③ coke (pure carbon)

④ air ($T = 1500°C$)



complete combustion

① $C + O_2 \rightarrow CO_2$ (produce energy.
Redox

incomplete combustion

② $2C + O_2 \rightarrow 2CO$ Redox

③ $CO_3 + C \rightarrow 2CO$ Redox

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

⑤ $CaCO_3 \xrightarrow{heat} CaO + CO_2$ T.D

⑥ $\underset{base}{CaO} + \underset{acid}{SiO_2} \rightarrow \underset{slag}{CaSiO_3}$ Neut.

Steel making : "oxygen-base process"

cast iron

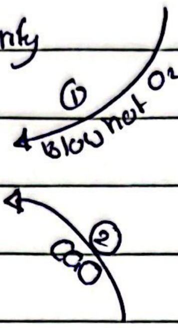
Fe

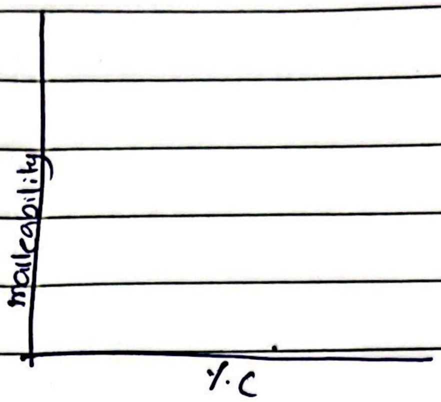
$CO_2\uparrow \leftarrow \boxed{C} \rightarrow$ main impurity

$SO_2\uparrow \leftarrow S$

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

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





Steel
- mild steel "car bodies"
- medium steel "Railways"
- stainless stell "cutlers" "watches" "utensils"

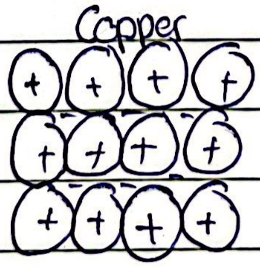
* Alloy : mixture of metal with another metal or semi-metal

Brass :- Cu+Zn

Bronze :- Cu+Sn

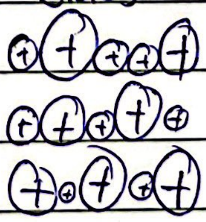
Steel : Fe+C+Cr+Ni

Copper



"easier to slide"

Brass



"two different sizes ; so harder to slide"