Red/ox

Reduction

oxygen lose oxygen

hydrogen gain Hydrogen

oxidation

gain oxygen

lose hydrogen

Fe in Fe_2O_3 reduced

$$Al + Fe_2O_3 \longrightarrow Fe + Al_2O_3$$

Al Oxidation : gain O

Zn in ZnO reduced

$$CO + ZnO \longrightarrow CO_2 + Zn$$

C in CO oxidise

Cu in CuO reduced

$$H_2 + CuO \rightarrow Cu + H_2O$$

H_2 oxidised

oxidation S in H_2S

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

reduction Cl_2

oxidation →

-4 -3 -2 -1 0 1 2 3

← reduction

reduction Cu^{+2}

$Mg + Cu^{+2} \longrightarrow Mg^{2+} + Cu$

~~mg^{2+} oxidation~~

oxidation S^{-2}

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

reduction ~~e Cl2~~

reduction H^+

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

oxidation Na

---

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

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

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

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

~~oxidation~~

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

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

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

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

Rules of oxidation no :-

1) The oxidation no of any free element is zero

mono atomic: Cu, Zn, Al, Ca ....

diatomic: H_2, O_2, N_2, F_2, Br_2, Cl_2, I_2

polyatomic: P_4, S_8

2) the oxidation number of any atom is a compound

from group 1 = +1 Na, Li, K, Rb, Cs, Fr

group 2 = +2 Mg, Ca, Ba, Sr

group 3 = +3 Al only

group 7 = -1 always for (F)

3) the oxide state of (H) is +1

~~exec~~ except metals -1

$\overset{+1}{H_2}O$, $N\overset{+1}{H_3}$, $\overset{+1}{Na}O\overset{+1}{H}$, $\overset{2+}{Ca}\overset{1-}{H_2}$

$C\overset{+1}{H_4}$, $Al\overset{-1}{H_3}$

$O = -2$ except peroxide $= -1$ in $OF_2 = +2$	$H = +1$ except with metal (-1)	free element $= 0$ group 1 $= +1$ 2 $= +2$ Al 3 $= +3$ F 7 $= -1$

4) the oxide state of O is $(2-)$

except in peroxide $(1-)$

except in OF_2 $(2+)$

5) the sum of all oxide state of all atoms
in the compound = zero
in the Ion = charge of this Ion

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

CO_2^{-2} $\quad C + 2(-2) = 0$
$C - 4 = 0$
$C = +4$

CO^{2-} $\quad C + (-2) = 0$
$C = 2$

$\overset{+1}{H_2}CO_3^{2-}$ $\quad 2(1) + C + 3(-2) = 0$
$2 + C - 6 = 0$
$C = 4$

$KMnO_4$
$1 + Mn + 4(-2) = 0$
$1 + Mn - 8 = 0$
$Mn = 7$

NO
$N - 2 = 0$
$N = 2$

NO_2 NO_3^{1-}

$N + (2+)(-2) = 0$

$N = 4$ $N \mp 4 = 0$

NH_3 $+4$ $+40$ NO_2^{-1}

$N + \cancel{3}1(3) = 0$

$N-$

N_2O_5 $Cr_2O_7^{-2}$

CrO_4^{-2}

$\underline{V}_2O_5 =$

$2V + 5(-2) = 0$

$2V - 10 = 0$

$\frac{2V}{2} = \frac{10}{2}$

$V = 5$

$\underline{V}O^{+2} =$

$V + 2 = 0$

$-2 \quad -2$

$V = -2$

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

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

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

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

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

reduction: $Mn^{+7} \rightarrow Mn^{+2}$

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

oxidation: $S^{-2} \rightarrow S^{0}$

reduction: $Cl_2 \rightarrow Cl^{-1}$

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

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

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

$Ag + 3(-2) = 0$

$A - 6 = 0$

$+6 \quad +6$

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

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

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

$\overset{6+}{Ag}NO_3^{-2} + \overset{+1}{Na}\overset{-1}{Cl} \rightarrow AgCl + \overset{+1}{Na}NO_3^{-2}$

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

oxidation: $O_2^{-1} \rightarrow O^{0}$

reduction: $O^{-1} \rightarrow O^{-2}$

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

oxd - $Al^0 \rightarrow Al^{3+}$

redu = $Fe^{3+} \rightarrow Fe^0$

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

oxd $Al \rightarrow Al^3 + 3e^-$

reduc $\cancel{2H^+} \rightarrow \overset{0}{H_2}$

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

half of oxid $(5Fe^{2+} \rightarrow 5Fe^{3+} + 5e^-$

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

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

OIL RIG

oxd is lose

Reduction is gain

Oxidising and reducing agents

Oxidising agent / oxidant : the substance that itself reduced and causes the other substance ~~to~~ to ~~reduce~~ oxidise

Reducing agent: reductant : the substance that itself oxidised and causes the other substances ~~to~~ to be ~~red~~ reduced

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

oxidation : Al — reduction : Fe^{3+}

$\overset{3+}{Al_2}\overset{-2}{O_3}$

~~oxidation~~

oxidant : Fe^{3} — reductant : ~~Fe_2O_3~~

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

oxidation C^{2+} — reduction Zn^{2+}

reducing agent CO — oxidising agent : ZnO

Most common oxidising agent

① oxygen

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

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

$\overset{0}{S} + \overset{0}{O_2} \rightarrow \overset{4+}{S}\overset{-2}{O_2}$

② acidify potassium manganate $KMnO_4$

$MnO_4 \Rightarrow Mn^{2+}$

purple colorless

③ Acidyl Potassium dichromate $K_2Cr_2O_7$

$\overset{+6}{Cr_2O_7^{-2}} \rightarrow \overset{+3}{Cr^{3+}}$

orange green

④ Halogens

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

yellowgreen colorless

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

brown Colorless

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

brown solution colorless

purple gas black solid

TOA
CAH
SOH

Most common reducing agent $\overset{+1}{H_2}\overset{-2}{O}$

① Hydrogen

$\overset{0}{H_2} \rightarrow 2\overset{+1}{H^+} + 2e^-$

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

reducing agent

② carbon and carbon monoxide

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

reducing agent

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

reducing agent

strongest reducing agent

more reactive metal

more able to lose e^-

- more able to oxidise
- more able to be reducing agent

weakest reducing agent

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

strongest reducing agent

The less reactive ion is more likely to reduce "to be an oxidising agent"

the more ~~The~~ reactive metal is more likely to oxidise to ~~be~~ a reducing agent."

Five Apple

9) Potassium Iodide

$2I^-(aq) \rightarrow I_2 + 2e^-$

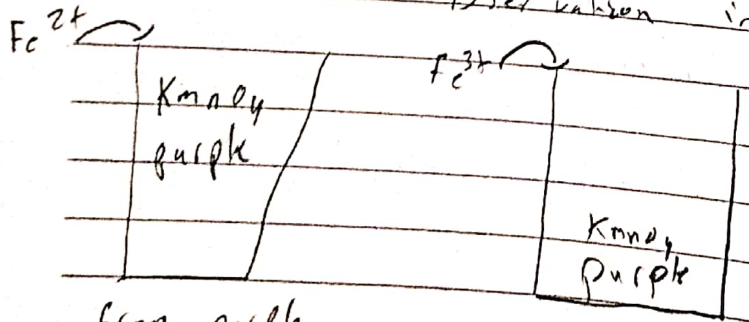
colorless — red brown

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

Fe^{2+} is a reducing agent

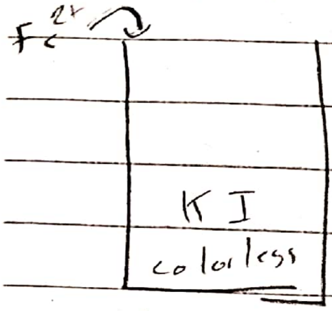
Fe^{3+} is a oxidation agent

write an observation in each of the following

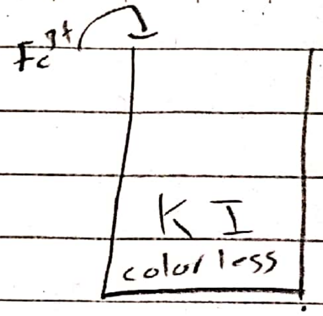


from purple to colorless

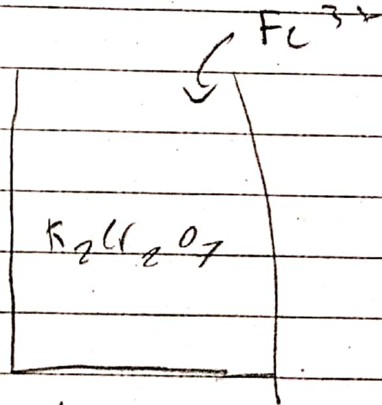
stays purple



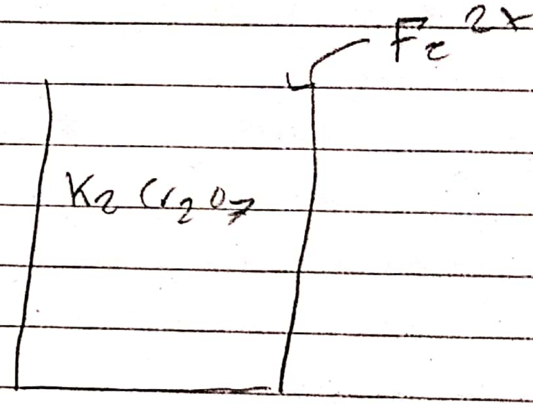
stays
the same



becomes
red-brown



stays orange



from Orange
to green

Electrolysis

Electrolysis : Breaking down Ionic compounds "molten/ ageous" by passing electricity.

Eletrolyte : the chemical compound that conduct electricity when molten or ageous.

Q why the solid Ionic compounds don't conduct electricity

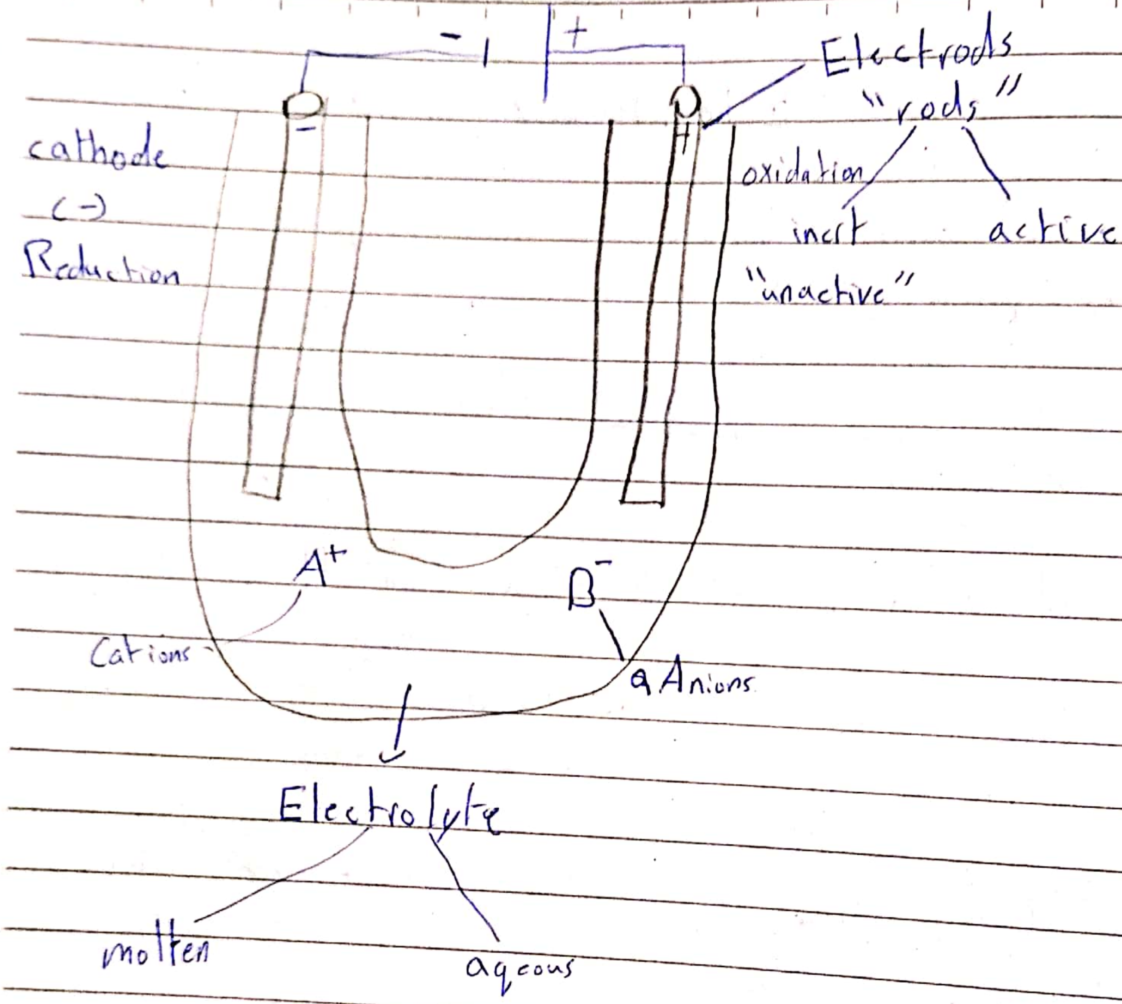
the Ions are not free to move

Q Why the Ionic compounds conduct electricity when molten, ageuos?

free moving Ions.

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

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



6 Cathode : the ve- rod that attracts +ve ions (cations)
Where reduction takes place.

Anode : the +ve rod that attracts -ve Ions (Anions)
where oxidation takes place

Electrolysis = Discharging

cations	Anions	Ion → element
$1\bar{e} + Na^{+} \rightarrow Na$		
	$2Cl^{-1} \rightarrow$	$Cl_2 + 2\bar{e}$ green-yellow gas
$2\bar{e} + Mg^{+2} \rightarrow Mg$		
	$2Br^{-1} \rightarrow$	$Br_2 + 2\bar{e}$ red-brown
$3\bar{e} + Al^{+3} \rightarrow Al$		
	$2F^{-1} \rightarrow$	$F_2 + 2\bar{e}$ bubbles of yellow gas
$2\bar{e} + Cu^{+2} \rightarrow Cu$		
	$2I^{-1} \rightarrow$	$I_2 + 2\bar{e}$ black solid purple gas
$2\bar{e} + H^{+} \rightarrow H_2$ bubbles of colorless gas		
	$2O^{-2} \rightarrow$	$O_2 + 4\bar{e}$ colorless gas

$A^{+} + 1\bar{e} \rightarrow A$

cations

$2B^{-} \rightarrow B_2 + 2\bar{e}$

Anions

Electrolysis

- Electrolyte
  - molten
  - aqueous
- Rode
  - inert
  - reactive

Molten using inert rods

* Electrolytesis for molten: NaCl using graphite (unactive)

$NaCl$

Na^+	Cl^-
cathode	Anode
$1\bar{e} + Na^+ \rightarrow Na$	$2Cl^- \rightarrow Cl_2 + 2\bar{e}$
deposite of metal	bubbles of green yellow gas

used up

Molten KI / graphite rod

K^{+1}	I^{-1}
cathode	Anode
$1\bar{e} + K^+ \rightarrow K$	$2I^- \rightarrow I_2 - 2\bar{e}$
deposite of metals	purple gas

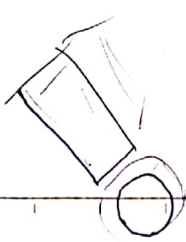
used up

Electrolyte : used up

Molten Al_2O_3 / graphite rod

Al^{3+}	O^{-2}
cath	Ano
$Al^{+3} + 3\bar{e} \rightarrow Al$	$2O^{-2} \rightarrow O_2 + 4\bar{e}$
deposite of metals	bubbles of colorless gas

Electrolyte : used up



Electrolysis for aqeaus electrolyte using graphite

AB

A → A^+ B^- → B_2

H_2 H^+ OH^- O_2

cathode   Anode

At cathode

~~Base~~ the less reactive Ion is more likely to reduce

K^{+1}
Na^{+1}
Li^{+1}
Ca^{+2}
Mg^{+2}
Al^{+3}
Zn^{+2}
Fe^{+3}
Pb^{+2}
H
Cu^{+2}
Ag^{+1}
Au^{+3}
Pt^{+2}

A^+ Anode

only concentrated halides are more likely to oxidise

if not concentrated halide

the OH^- will oxidise

important

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

Elecrolysis for concentrated aqueous sodium chloride "Brine"

$NaCl_{(aq)}$

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

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

bubbles of gas $\quad$ bubbles of green yellow gas

Electrolyte : NaOH

dilute NaCl / graphite

Na^+ $\quad$ Cl^-

H^+ $\quad$ OH^-

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

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

Electrolyte : NaCl

$CuSO_{4(aq)}$ / graphite

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

H^+ OH^-

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

deposite of metals colorless gas

Elec H_2SO_4.

$KNO_{3(aq)}$ / graphite

K^{+1} NO_3^{-1}

H OH

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

colorless colorless

Electro: KNO_3 more conc

conc

$CuCl_{2\,(aq)}$ / graph

Cu^{+2} Cl_2^-

H OH^-

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

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

Electro : H_2O

conc ~~Fe~~ Na Br_2 / graphite

~~Fe^{3+}~~ Na^+ Br^-

H^+ OH^-

$2\bar{e} + H_2 \rightarrow H_2$ $2Br \rightarrow Br_2 + 2\bar{e}$

red brown

Electrolyte : NaOH

$PbBr_2$

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

H^+ OH^-

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

~~H_2SO_4~~ cor HCl

H^{+1} Cl^-

$NaCl_{aq}$

4a

Na^{+1} Cl^- electro: $NaCl$

Q3 all

Q7 all

H^+ OH^-

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

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

Cu^{2+} SO H_2 OH_2 O^-

SCU

Five Apple

Electrolysis for brine solution $NaCl_{(aq)}$ concentrated.

$NaCl_{(aq)}$

Na^+ Cl^-

H^+ OH^-

cathode anode

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

Electrolysis for aqeous electrolyte using Active rod

the active rod made from the same metal ion in the ~~electrolytte~~ electrolyte.

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

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

$CuSO_{4}$ (aq)

Cu^{+2} SO_4^{-2}] neither the OH

H^+ OH^-] nor the SO_4^{-2} oxidise

cathode

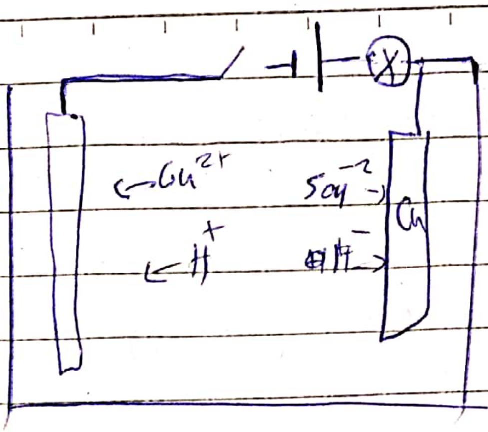
$Cu^{+2} + 2\bar{e} \rightarrow Cu$

deposite of red brown solid mass ↑ increases

the Anode itself will oxidise.

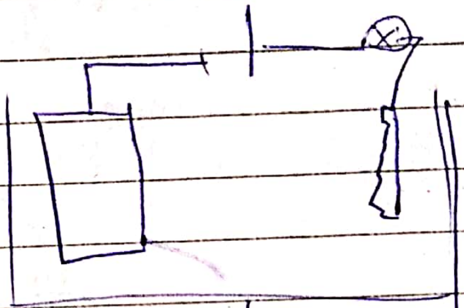
$Cu \rightarrow Cu^{+2} + 2\bar{e}$

Five Apple



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

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



cathode	Anode
its mass will increase Cu^{+2} reduced as Cu deposite	mass decrease Cu oxidise and lose $\bar{e}$,s

Applications on electrolysis

Molten/inert

⇓

Extractio of Al

aqeous/inert

⇓

prepare solution

conc $NaCl_{(aq)}$

Na^+ $Cl^- \rightarrow Cl_2$

H^+ OH^-

H_2 $NaOH$

aqeous/active

① Electro plating

② Refining/purification metals

Electroplating

coating a metal with another metal using electricty.

why? ① preventing from rusting

② more attractive.

How to electroplate a metal spoon with Ag

1- Clean the metal spoon from any impurities or oxide layer to ensure a well sticking.

2- make the metal spon the cathode.

3- the anode must be Ag

4- the electrolyte Must has Ag^+ e.g $AgNO_3$

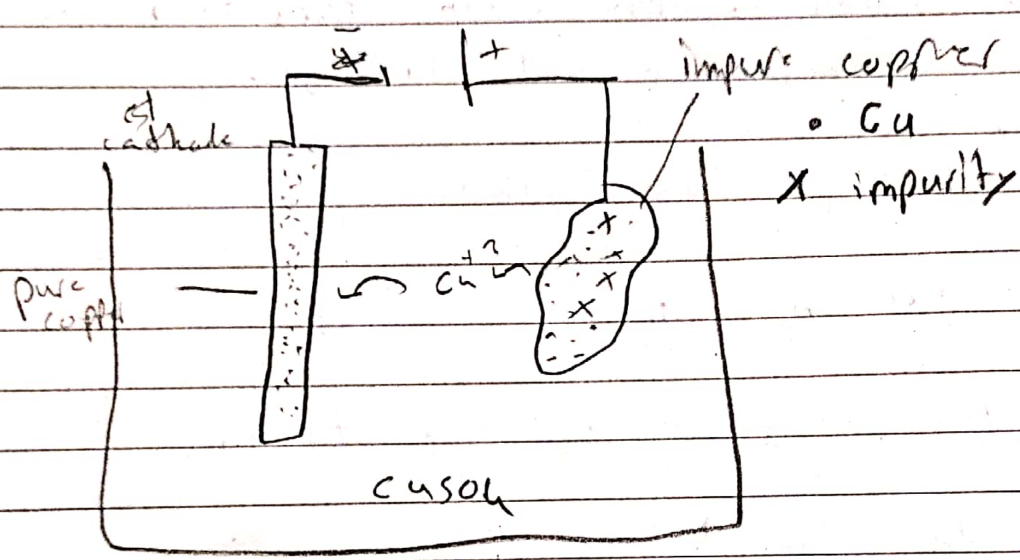
5- switch on the circuit.

6- rotate the metal spoon to ensure an equal distribution

7- rinsed with distel water

8- Dry in oven.

Refining copper / purifying



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

YO BRO WHO

Extraction of metals

* the method of extraction the metal ~~form~~ from its ore depends on the position of this metal in the reactivity series

K
Na
Li
Ca
Mg
Al → Al_2O_3 Bauxite
C, CO
Zn → ZnS zinc blende
Fe → Fe_2O_3 Hematite
Pb
H
Cu → ~~Cu~~ CuS copper sulfide.
Ag
Au

Extraction of Al

ore : Bauxite Al_2O_3 Al m.p is 2000°C

method : Electrolysis

so we dissolve Al_3O_2 in molten Cryolyte Na_3AlF_6, why?

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

2- the increase the electrical conductivity.

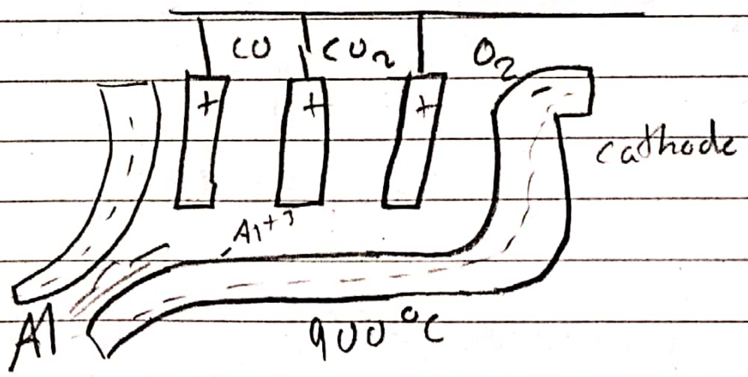
Al_2O_3

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

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

deposite of metals

bubbles of colorless gas



gases produced at anode

1- O_2

2- CO_2

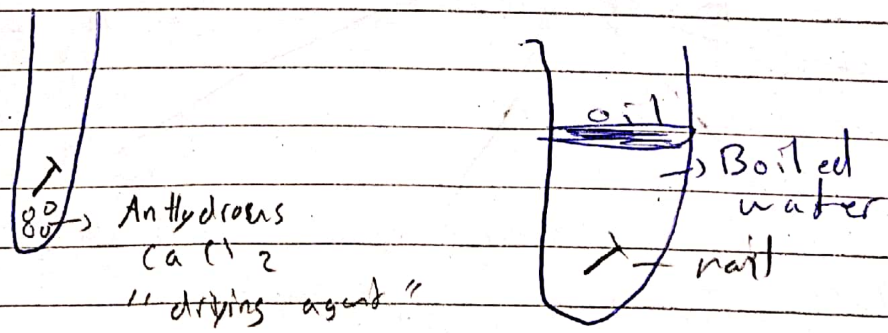
3- CO

reaction of Anods with O_2 ~~[illegible]~~ so we must replace the anode periodically.

property of Al	use of Al

Rusting: the reaction of Irom with both H_2O and O_2

$$\overset{0}{Fe} + O_2 \xrightarrow{H_2O} \overset{+3}{Fe_2O_3} + H_2O$$



no H_2O

No O_2

* two rust presension solutions A & ~~&~~ and B plan ~~and~~ an exp to show which brand is better.

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

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Rust prevention

painting

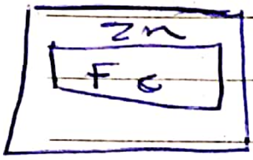
oiling

greasing

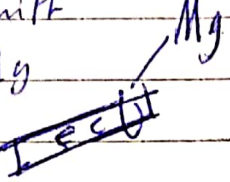
cover with plastic

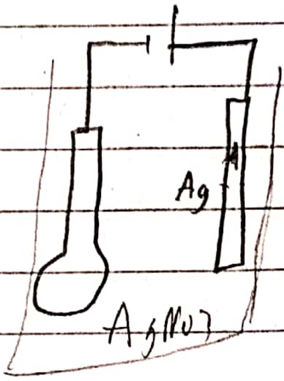
(prevent H_2O, O_2 from reaching)

Galvanizing | sacrificial protection | Electro plating | cathodic protection



H_2O connecting with Mg





Zn Mg are more reactive than Fe

" likely to oxidise

So Fe is less likely to rust

② surface area.

- state how the s surface area affect the rate of Reaction?

As the surface area increases by reducing the partical size. The rate of reaction Increases.

- explain how the surface area affect the rate of reaction?

As the surface area ~~increas~~ increase more particals exposed to the reaction so more effective collisions per unit time so faster ~~Fater~~ rate of reaction.

- Plan an experiment to show how the surface area affect the ~~r~~ rate of reaction.

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

exp1 : Mass = 2g
Lumps

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

$M_{HCl} = 1\ mol/dm^3$

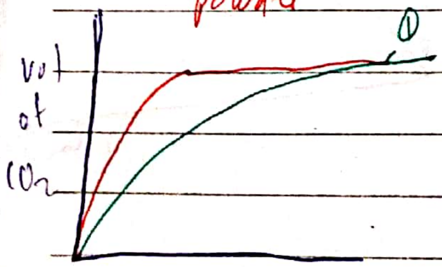
Temp 25 °C

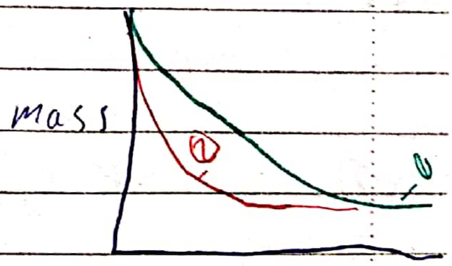
exp2 Mass = 2g
powder

HCl = 0.1

M HCl = 1 mol

Temp 25 °C





③ Concentration

☆ State how the conc affect the rate of Reaction

As the concentration increase the rate of Reaction increase

☆ explain how the concentration affect the rate of reaction.

As the conc ~~increases~~ of Reactants increases more particals, so more effective collisions per U.T, so faster rate.

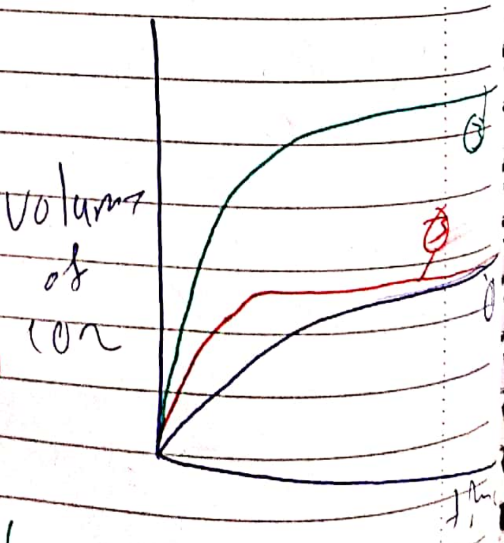
Plan an exp to show how the conc

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

ex1 mass 2.0g Lumps — $V_{HCl} = 0.1dm^3$, $m_{HCl} = 0.1 /mol$, Temp = 25°C

exp2 mass ~~2.0~~ 2.0g Lumps — $V_{HCl} = 0.1dm^3$, $m_{HCl} = 0.2 /mol$, Temp = 25°C

exp3 mass = ~~4~~ 4.0g Lumps — $V_{HCl} = 0.1$, M: 0.1 mol, Temp 25



Catalyst 6)

: chemical substance that speeds up the rate of reaction without being used up.

Enzyme: Biological catalyst

Ea: the min amount energy needed to start the rxn

↑EA slower rate

↓EA Higher rate.

How? it provides an alternative pathway with lower EA.

so more particals will have energy equal to or greater than EA

so more effective collisions per ~~time unit~~ unit time so faster rate of reaction.

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

1) plan an exp to show that CuO is a catalyst for this ~~ex~~ RXN

- take know volume of known conc of H_2O_2
- Add a known mass of CuO
- Measure the volume of O_2 per unit time
- repeat the experment without CuO
- Conclusion: the exp with CuO ~~with~~ will produce more oxygen.

Q2) plan an exp to show which catalyst is better CuO and MnO_2

- Known volume of H_2O_2 know conc
- Add Known mass CuO
- repeat with MnO_2 (same mass)
- Conclusion: the rxn that produce more O_2 is a better catalyst.

Q3) plan an exp to show that the CuO not used up during a reaction.

- add a Known mass of CuO to H_2O_2 until no more bubbles of O_2
- filter the mixture
- dry in oven
- remeasure the mass
- Conc: the mass will be the same.

Reversible reactions

chemical Reactions

one way

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

$Mg + HCl \rightarrow MgCl_2 + H_2$

~~$CaCO_3 + HNO_3 \rightarrow Ca(NO_3)_2 + H_2$~~

$CaCO_3 + HNO_3 \rightarrow$ ~~$CaNO_3$~~ $Ca(NO_3)_2 + H_2O + O_2$

both ways

React $\underset{\text{backward}}{\overset{\text{forward}}{\rightleftarrows}}$ Products

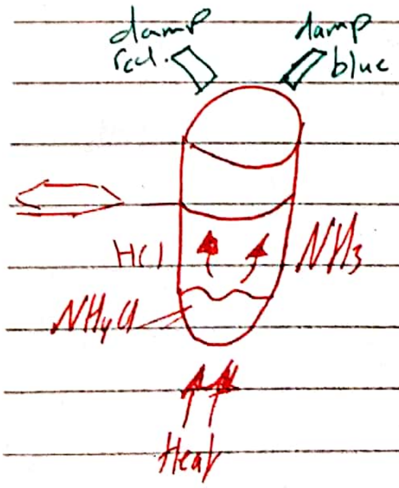
$3H_2 + N_2 \rightleftarrows 2NH_3$

$2SO_2 + O_2 \rightleftarrows 2SO_3$

$NH_4Cl \rightleftarrows NH_3 + HCl$.

$NH_4Cl \xrightarrow{\text{Heat}} NH_{3\,(g)} + HCl_{(g)}$

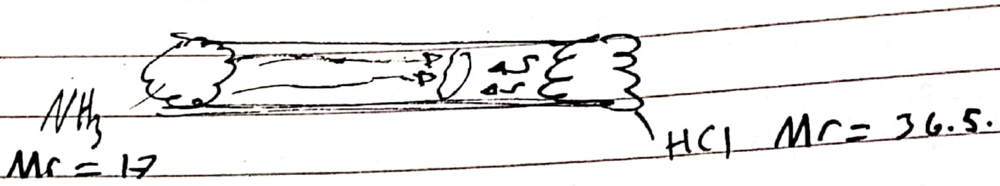
ammonium chloride → ammonia + Hydrogen chloride.



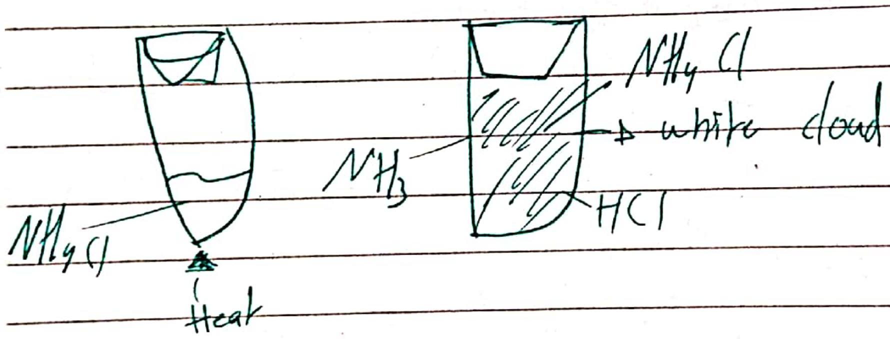
Which damp litmus paper will change its color first explain your answer?

The damp red litmus paper changes it color to blue first since NH_3 is a base and lighter than $HCl_{(g)}$ which is acidic.

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

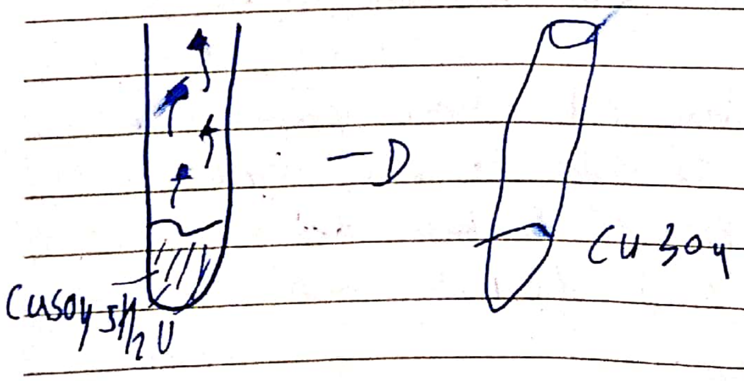


$NH_4Cl \rightleftharpoons NH_{3(g)} + HCl_{(g)}$



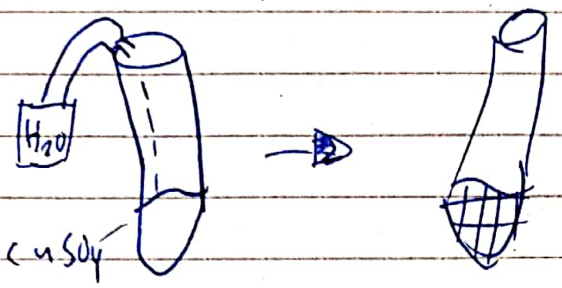
$CuSO_4 \cdot 5H_2O \xrightarrow{Heat} CuSO_4 + 5H_2O$

blue white

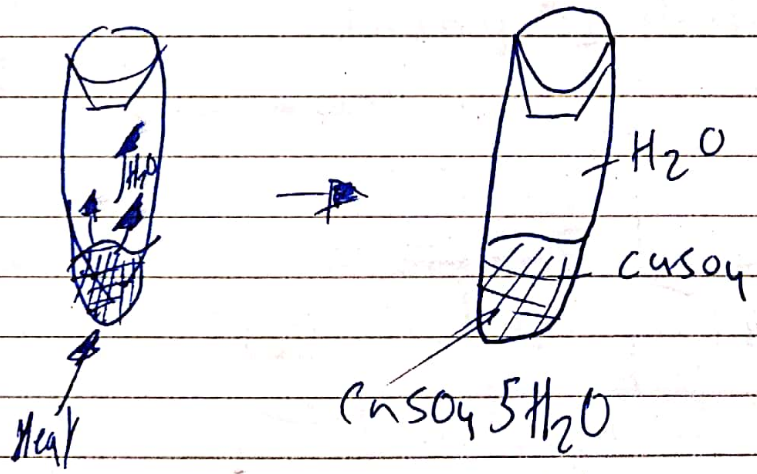


$CuSO_{4(s)} + 5H_2O \rightarrow CuSO_4 \cdot 5H_2O$

white



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

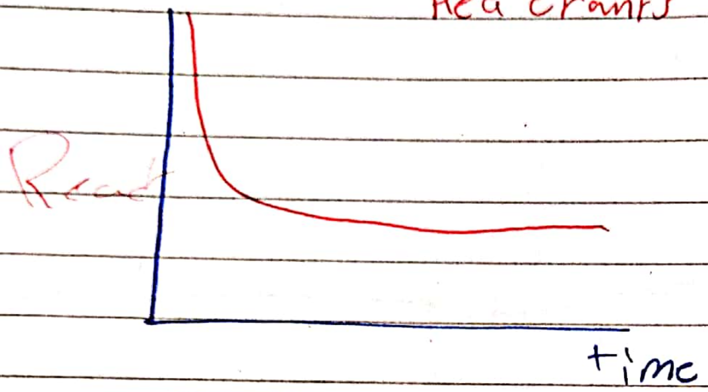


Equilibrium
mixture

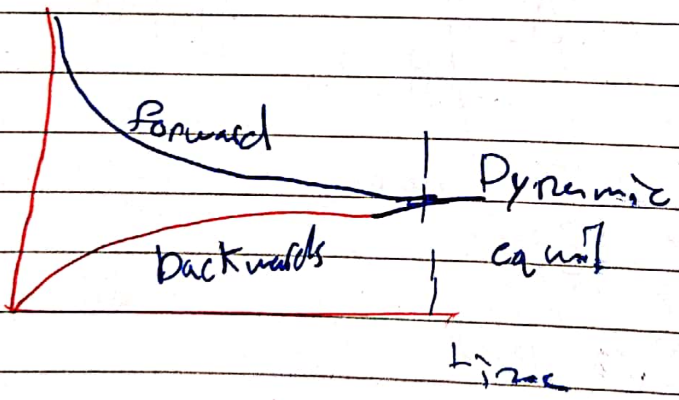
Dynamic equilibrium.

One way

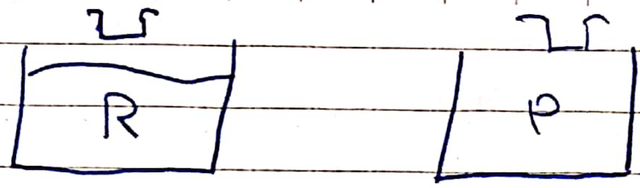
Reactants → products.



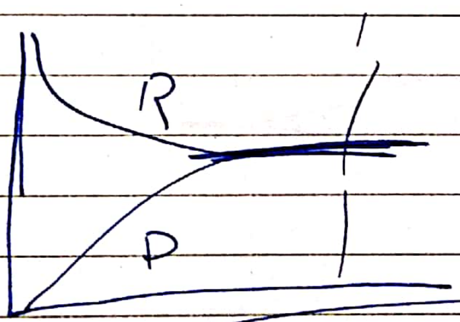
Reactants ⇌ product

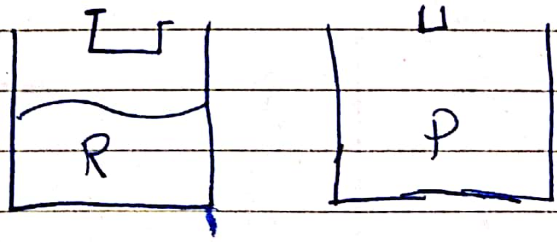


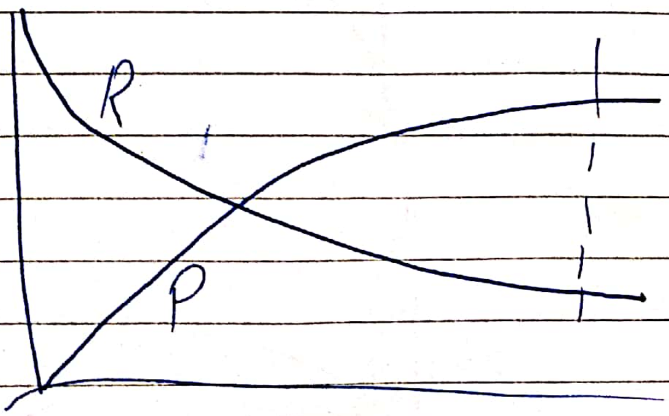
Dynamic equil: when the rate of forward equal the rate of backwards.

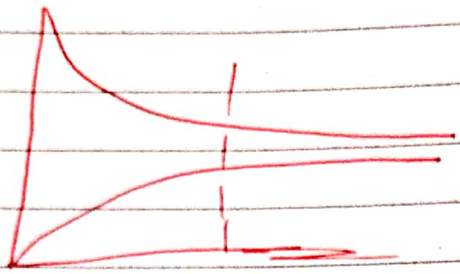


200	0
180	20
150	50
120	80
100	100



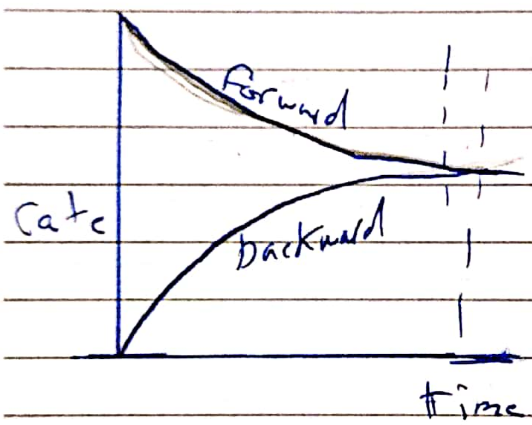


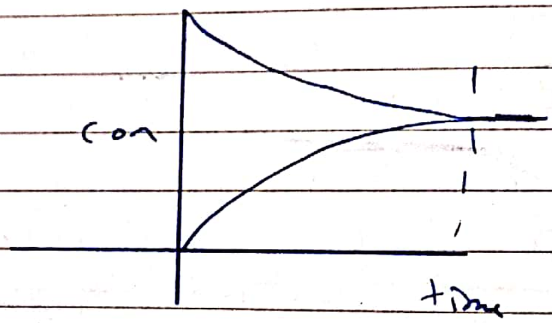




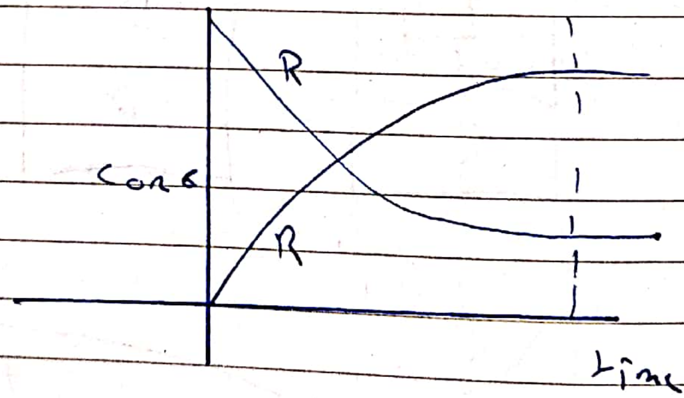
in terms of concentration

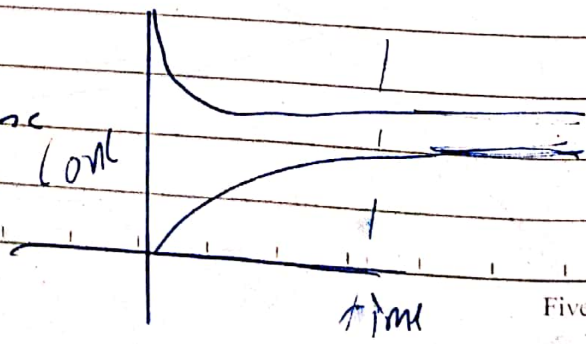
equil. when the Concentration of Reactants and products are constant





In terms of Rate when the rate of forward rxn Equal the rate of backwards.





In terms of conc when the conc of the Reactants and product are constant

EASY

Le chatelier principle

If the system at equilibrium $\rightleftharpoons$
and any external factor disturb the equil
shift itself either ~~to faw~~ to the forward $\rightleftharpoons$
or to the backwards $\rightleftharpoons$
to return back to the equilibrium.

Temp   presure   conc

Endothermic:
Absorbing $\Delta H = ve^{+}$

Exothermic:
release $\Delta H = -ve$

$\Uparrow$ Temp shift to endo

$\Downarrow$ Temp shift to exo

As the temp increases the equil shift to the side that absorb heat
endothermic side.

" "" decrease """" Release heat
which is exothermic side.

the sign ~~of~~ of ΔH is always represent the forward Reaction.

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

$\uparrow$ temp shift forward to the endo side
$\uparrow\uparrow$ rate of endo
$\uparrow$ rate of exo

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

↑ temp shift backwards endo

↑ Rate of endo ↑↑

Rate of exo ↑

↑W ↑X   Y↓ Z↓

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

↑ shifts forward to endo.

rate endo forward ↑↑

rate exo backward ↑

C↑ D↑ A↓ B↓

↓ Temp shift forward to the exo

Rate ~~of~~ endo ↓↓

Rate of exo ↓

W↓ X↓   Y↑ Z↑

↓ Temp shift backwards to the exo

Rate of forward ↑↑

Rate of backward ↓↓

A↑↑ B↑↑ C↓↓ D↓↓

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

↑ Temp

1) Rate of ~~fo~~ backwards ⇑ ⇑

2) Rate of forward ⇑

3) The yeild of NH_3 (decreases)

increases Temp to shift the equil to the ~~backward~~ to the endo

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

The yeild of $_2SO_3$ increase by cooling, explain why?

The forward reaction is exothermic forward by cooling

$\uparrow$ pressure rate of less gas mole $\uparrow\uparrow$

② pressure

rate of more gas mole $\uparrow$

$\downarrow$ pressure $\downarrow\downarrow$ rate of less gas mole

$\downarrow$ rate of more gas mole.

$\uparrow$ pressure => shift to the side with less prosure

Which has less gas moles

$\downarrow$ pressure => shift to the side with more pressure

$$\underbrace{3H_{2(g)} + N_{2(g)}}_{4\ mols} \rightleftharpoons \underbrace{2NH_3}_{2\ mols}$$

$\uparrow$ pressure shift forward to the side less p.

$\downarrow$ pres shift backwards to the side with more p.

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

$\uparrow$ pressure shift backwards to the side less gas mole

$\downarrow$ pressure shift forward to the side more gas mole

$H_2 + I_2 = 2HI$

pressure will not affect the position of equil

same gas moles.

~~↑~~ pressure rate of l.g.m ↓ ↓ } shift to less gas mole

pressure rate of m.g.m ↓ } shift more gas moles

$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_3$

$\Delta H = -ve$

effect	Rate of forward	Rate of backwards	yield NH_3
↑ Temp	↑	↑	↓
↑ pressure	↑	↑	↑
↓ pressure	↓	↓	↓

Q: the reaction $H_{2(g)} + I_{(g)} \rightleftharpoons 2HI$ at equilibrium

purple colorless

Why by increasing the pressure the position of equil doesn't change?

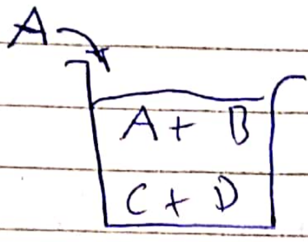
because the both sides of the reaction have the same no of gas moles

why increasing the pressure the mixture becomes more purple? the gas particals of Is become closer together and the color looks more deep

Five Apple

Concentration:

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



↑[A] shift forward

↓B ↑C ↑D

↓[C] shift backwards

A↑ B↑ D↓

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

Temp 40 – 450°c

pressure

Concentration add excess H_2 of N_2
remove NH_3 imidiatly (Condensation

Indicator

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

Add HCl
acid
proton donor $\Big\}$ $\uparrow H^+$ shift backwards
more HIn more color (1)
less In^- less color (2)

Add NaOH
proton acceptor $\Big\}$ $\downarrow H^+$ more In^- more color (2)
$OH^- + H^+$
less HIn less color (1)

Energetics

(Energy in chemical reactions)

Energy: the ability to work.

in chemical rxr

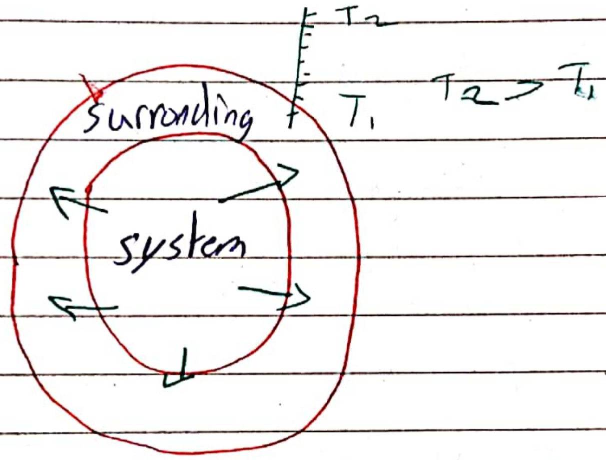
to breakdown bonds	the build up the bonds in the products.
Reactants	
Input	output
Absorb	Release
take in	give out
Endothermic.	Exotheirmic

input > output
Endothermic.
output > input
exotheirmic.

Enthalpy: Heat contents stored energy in bonds.

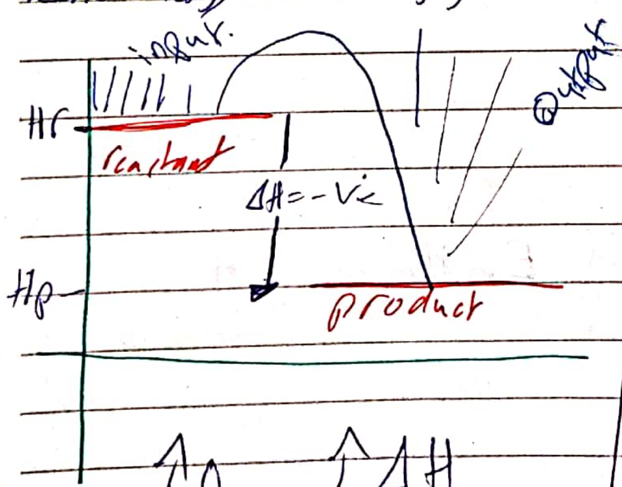
Exothermic Reaction:

Reaction that Release (give out) energy to the surrounding when they take place.



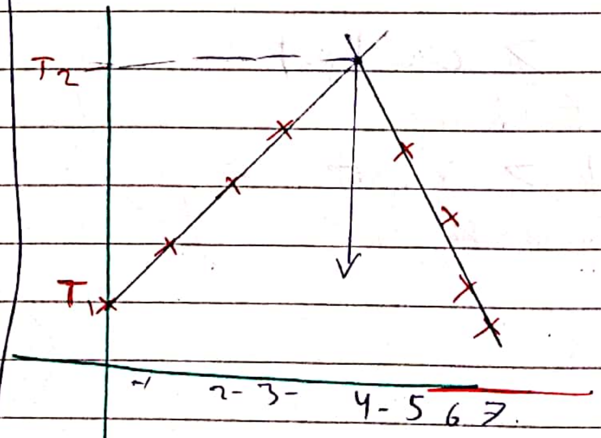
for system:

~~Ene~~ Energy level diagram:



$\uparrow q \quad \uparrow \Delta H$

for surrounding
Temp diagram

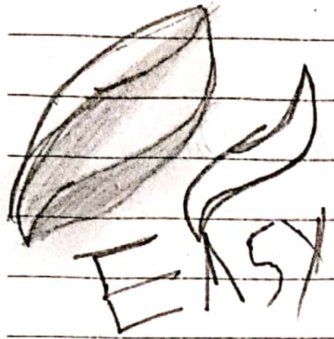


$$q = mc\Delta T$$

q: energy (J)
m: mass (g)
c: specific Heat capacity
ΔT: change the temp.

$C_{water} = 4.2 J/g^{\circ}C$

Five Apple



C—H	413
O—H	463
O=O	496
C=O	799

$CH_4 + 2\,O{=}O \rightarrow O{=}C{=}O + 2\,H_2O$

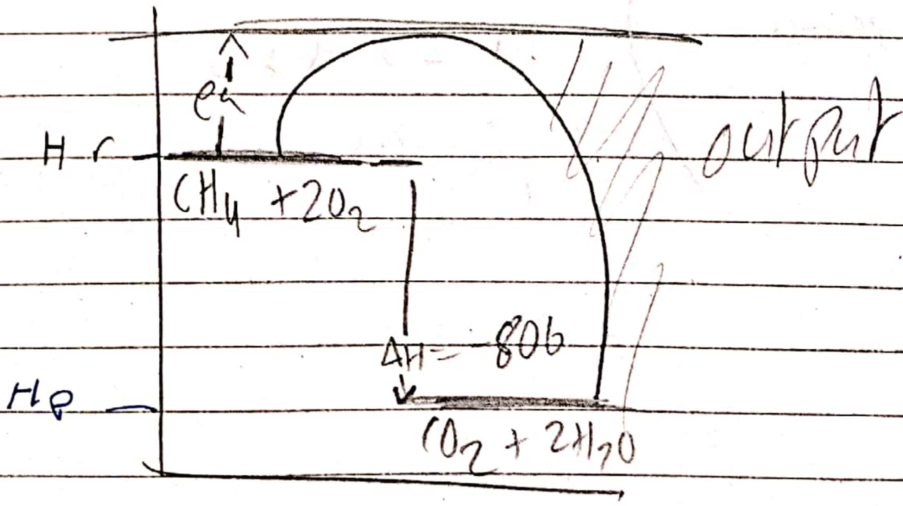
bond broken

413×4
496×2
2644

799×2
$+\ 463 \times 4$
3450

$2644 - 3450 = -806$

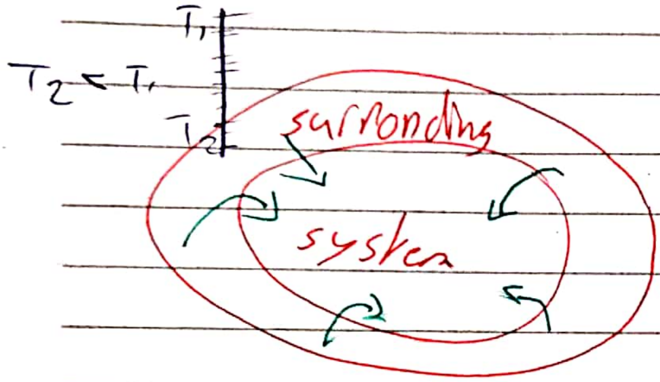
exothermic



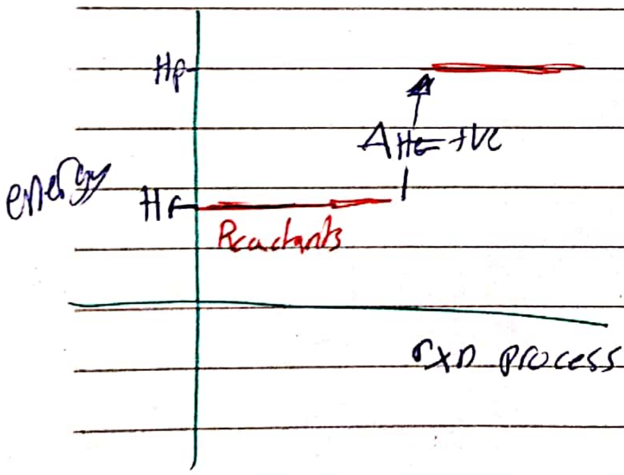
Endothermic Reactions:

~~Endo thermic~~

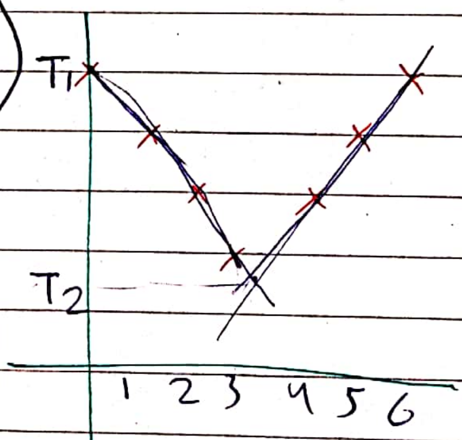
Reactions that absorb (take in) energy from the surrounding when they take place.



For system:
energy level diagram:



For surrounding
Temp diagram:



$Q = mc\Delta T$

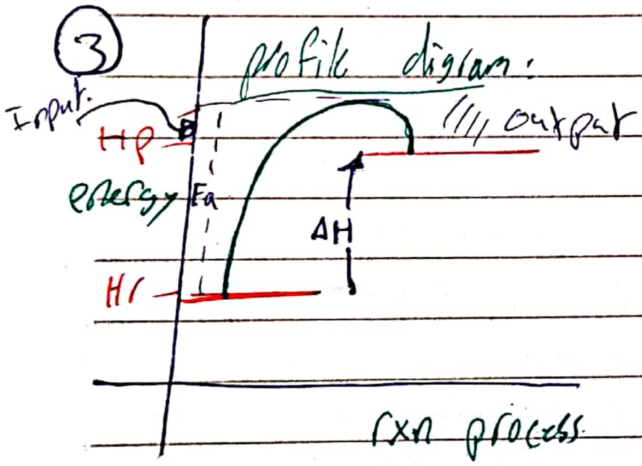
Endothermic:

How to express Endothermic Rxns:-

① Reactant + Energy ⟶ products

② Reactants ⟶ products $\Delta H = +ve$

③ profile diagram:



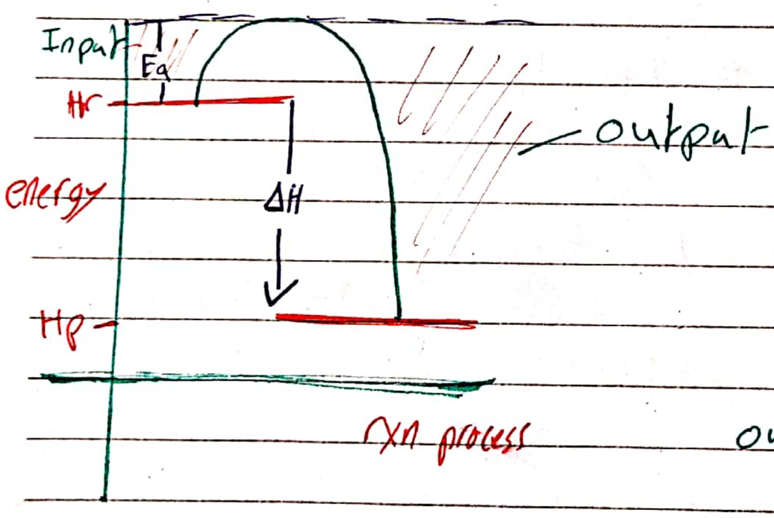
Exothermic:

How to express exothermic rxn:

① Reactants ⟶ ~~ex~~ products + energy

② Reactants ⟶ products . $\Delta H = -ve$

③ profile diagram:



output > input.

Measuring ΔH reaction using bonding energies

bond	bond energy Kj/mol
H—H	436

(endo)

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

(exo)

bond building $H + H \rightarrow H - H + 436 Kj$

Bonding energy

The ~~amount~~ amount of the energy needed to break 1 mol of Bonding in a gaseous state.

or The amount of energy released to Build 1 mole of Bond in a gaseous state.

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

ΔH = total input − total output

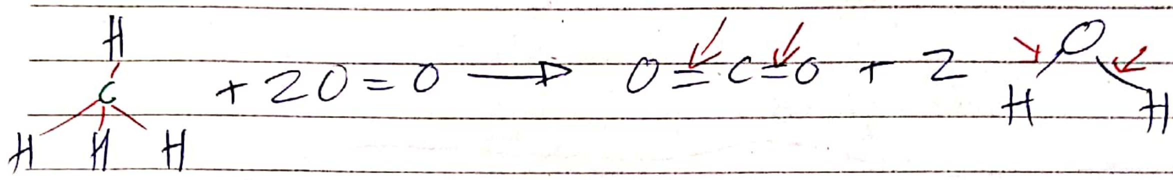
endo exo

in-out

bond	bond energy Kj/mol
C–H	413
O–H	463
O=O	496
C=O	799

easy

الرضي



bond broken

4x C–H   4x 413

\+

2 x O=O   ~~4~~2x 2x 496

2644 Kj

bond formed

2x C=O   2x799

4x O–H   4x 463

~~3580~~ 3450 Kj

~~2644 − 3450 = −8~~

ΔH = input − output

~~exo~~

= 2644 − 3450 = − 806 Kj

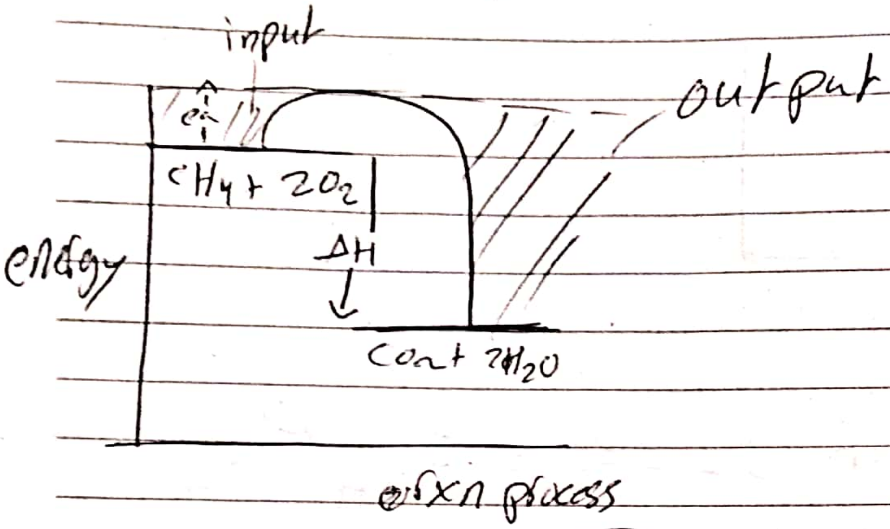
exothermic

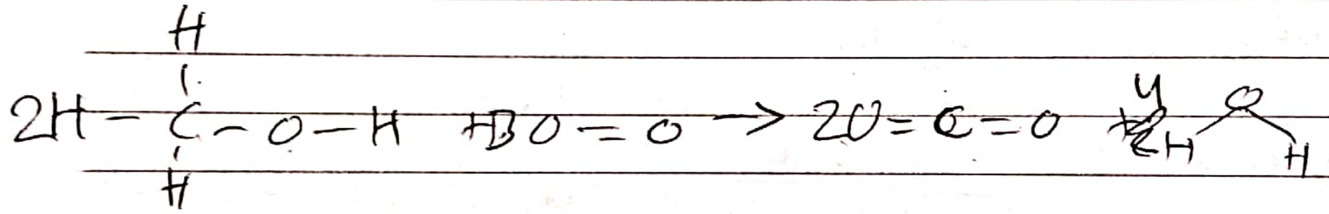
① $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ + 806 Kj/mol

② $CH_4 + 2O_2 \rightarrow 1CO_2 + 2H_2O$ $\Delta H = -806$

Five Apple

3 profile diagram





bond Broken

413 x 6
358 x 2
463 x 2
3 x 496 +

3548

~~7046~~

70

~~2 x 799~~
4 x 799
8 6 x 463
+ 5974

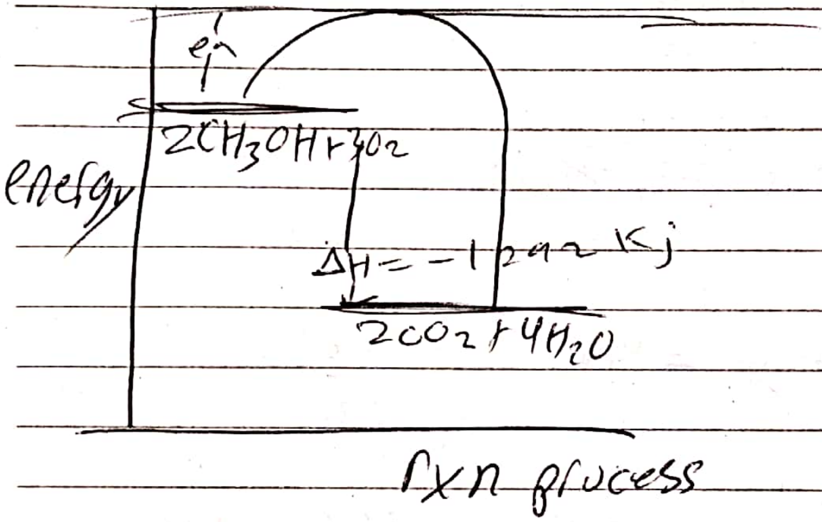
4364 − 5974 = −1605 exo

5608 − 5974 = −366 exo

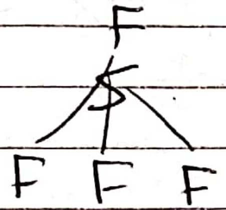
KCl $CuSO_4$

K^{+1} Cl^-

H OH^-



$S + 2F-F \longrightarrow$



F-F	160
S-F	x

2×160

320

780

$320 + y \rightarrow 4x$ $\quad \dfrac{320 + y}{4} \longrightarrow \dfrac{x\,x\,4}{4}$

$320 + y \rightarrow$

$320 + y = 4x = \quad \dfrac{320 + y}{4} \longrightarrow x$

~~320+y~~

$$320 - 4x = 788$$
$$+4x \qquad +4x$$

$$320 \cancel{+y} - 4x = 788$$
$$-320 \qquad\qquad -320$$

$$-y - 4x = 468$$

e

$$320 - y - 4x = 788$$

1

$$\cancel{-} 320 + y - 4x = 788$$
$$-320 \qquad\qquad -320$$

2

$$y - 4x = 468 + 4x$$
$$+4x$$

$$320 - 4x = 788$$
$$-320 \qquad -320$$

$$y = 468 + 4x$$

$$\frac{-4x}{-4} = \frac{468}{-4}$$

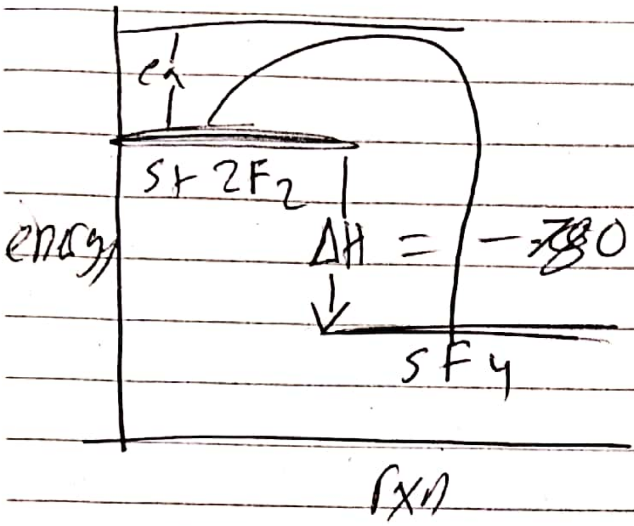
$$320 - 4x = -788$$
$$-320 \qquad -320$$

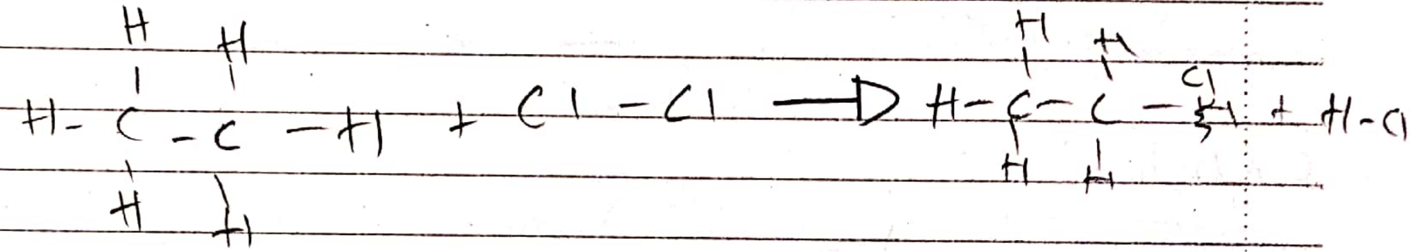
S-F= $x = -117$

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

S-F = -117

$$x = 275 \text{ Kj / mol}$$





3x413	3x413
328	2x413
+ 3x413	328
242	+ x
3048	2393+x

Cl–Cl	242
~~H–Cl~~	~~413~~
C–H	413
H–Cl	2
C–Cl	328

$$3048 - 2393 + x = -104$$
$$+2393 \qquad +2393$$

$$3048 + x = 2289$$
$$-3048 \qquad -3048$$

$$x = -759$$

$$x = -759$$

specific Heat capacity

$Q = m\,c\,\Delta T$

mass (g)

change in temperature

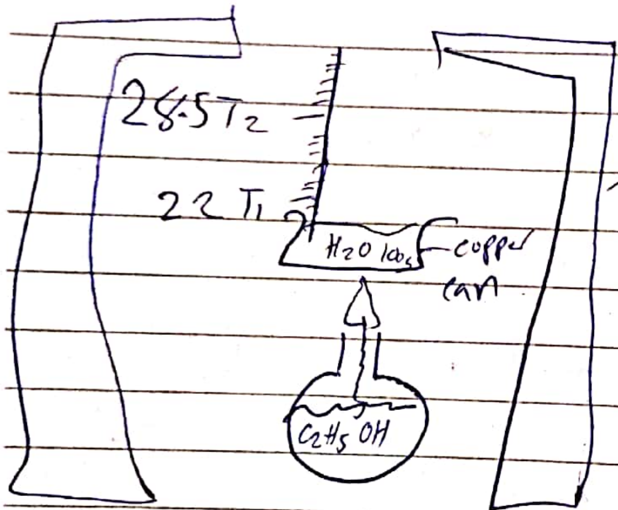
neutralization

combustion displacement

1

Combustion

2



shield to reduce heat loss

$m1 = 200g$

$C_{water} = 4.2\ J/g.C^{\circ}$

$Q = 100 \times 4.2 \times (28.5 - 22) = 2730\ J$

2730 —— 2g C_2H_5OH

62790 J/mol —— 46g

$Mr = C_2H_5OH = 46$

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

Five Apple

two fuels A, B

plan an exp show which fuel produce more energy

take a known mass of fuel A in a spirit burner
place a known mass of water in a copper can
measure the initial temp of water (T_1)

ignite the fuel A ~~for 5 mins, measure the final mass~~
measure the final temp of the water (T_2)

repeat for the exp using fuel (B)

The fuel which cause more temp ~~change~~ change is the one that produce more energy.

---

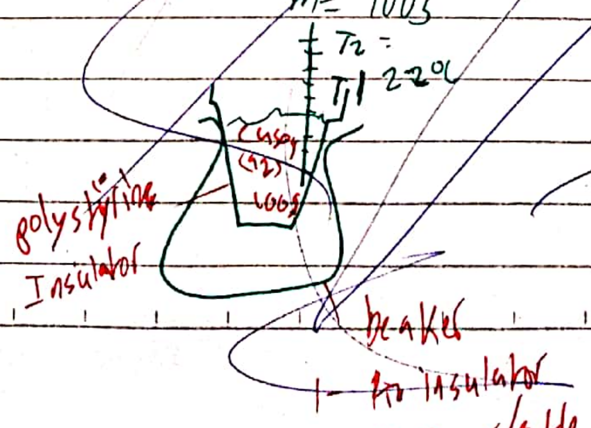
displacement Reaction

$Zn_{(s)} + CuSO_4 \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$

$m = 0.65g$ $V = 100\ cm^3$

$d = 1g/cm^2$

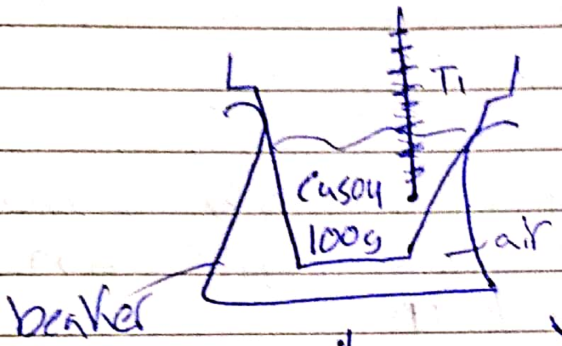
$m = 100g$

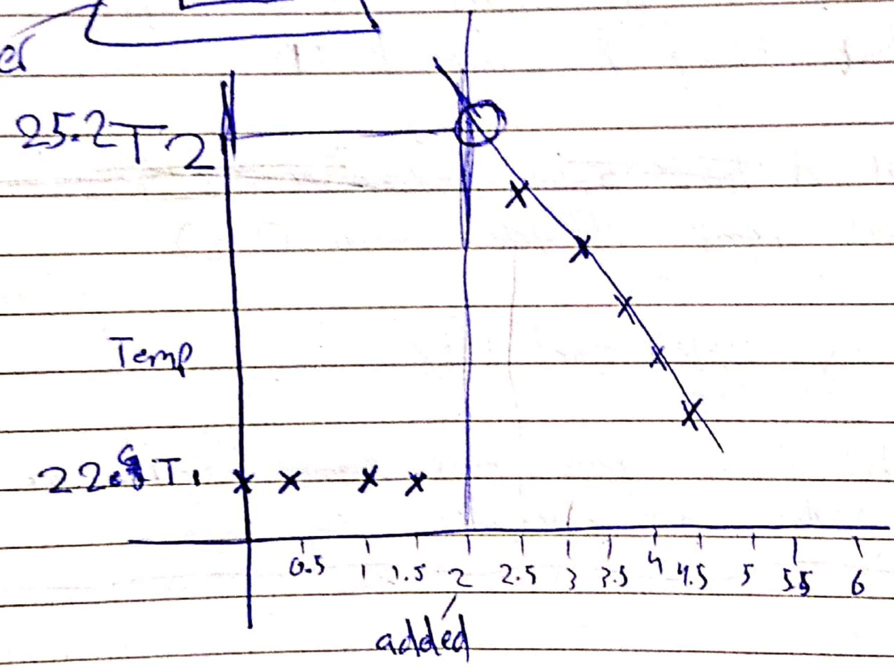


displacment.

$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

4.2 Kj/mol





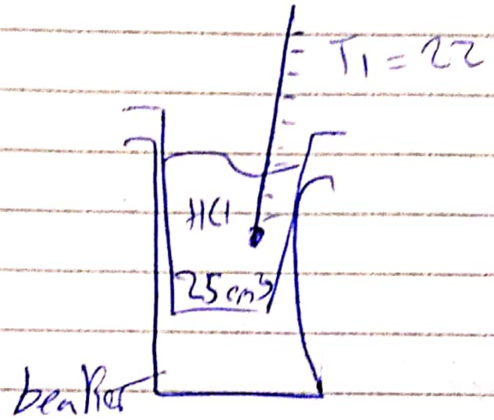
$Q = mc\Delta t$

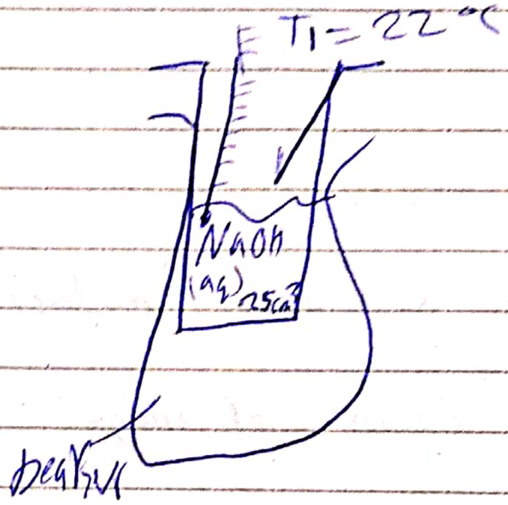
$100 \times 4.2 \times 3.2$

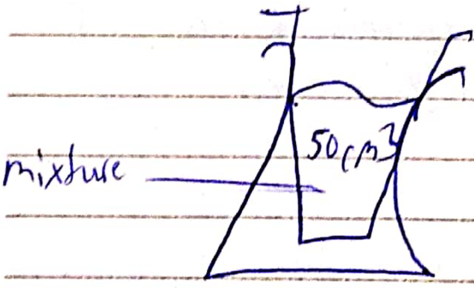
$Q = 9$ʌS

Neutralization

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



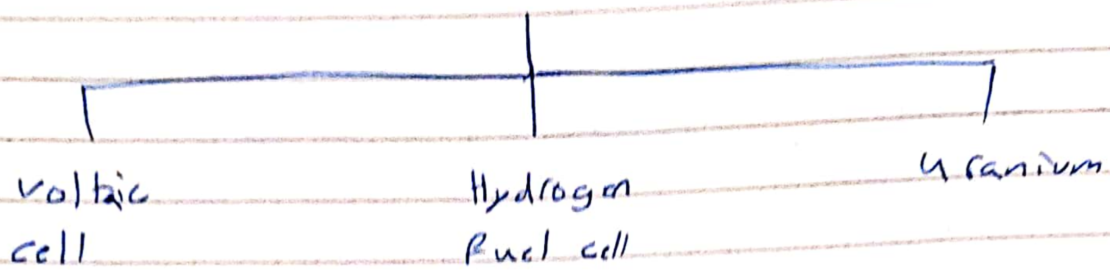




$$Q = mc\Delta T$$

$$Q = 50 \times 4.2\cancel{4} \times 13 = J$$

$$Q = J$$



Hydrogen fuel cell

$2H_2 + O_2 \rightarrow 2H_2O$

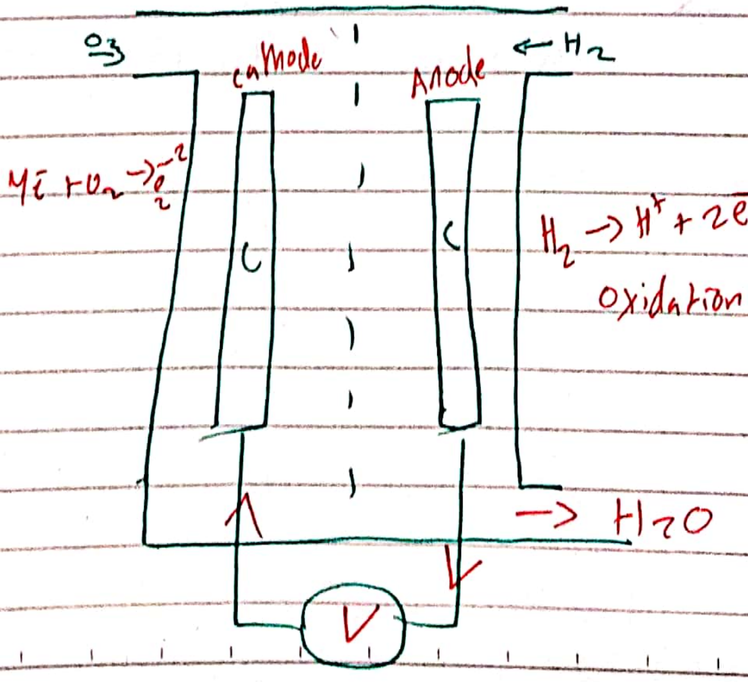
advantages

produce only H_2O as waste product.

produce high amount of energy

no CO_2 produced

disadvantages: hard to store and trasport Risk of explosions.



Industrial chemistry

Dealing with gases
- dry
- collect

Industry (CO_3^{-2})
- NH_3 — Haber process
- H_2SO_4 — contact process

Extraction
- Fe
- Zn
- Cu
- Al

Dealing with gases.

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

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

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

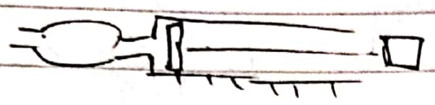
SO_2: $Na_2SO_3 + HCl \rightarrow NaCl + S + SO_2 + H_2O$

Cl_2: $\cancel{NaCl_{2(l)} \xrightarrow{electrolysis} Na + Cl_2 + H}$

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

collecting gases

① gas syringe

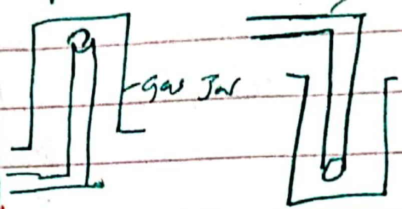


* collect and measure the volume of any gas.

ad.

② Delivery

upward — downward

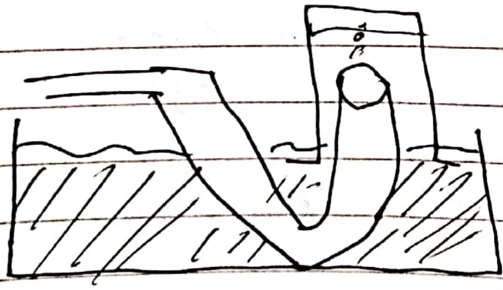


to collect less dense gas than air

more dense than the air

③ Over water

trough

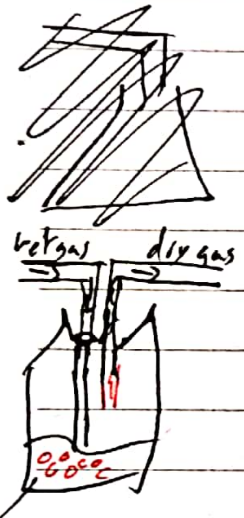


used only for insoluble gas in water ↗ CO_2 slightly soluble in water

* hard to use

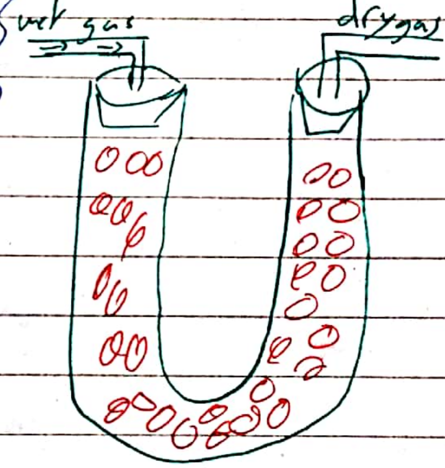
Drying Gases

conc H_2SO_4



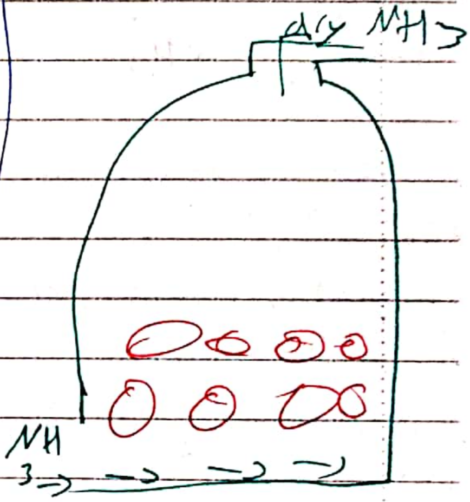
used to dry any gas except NH_3

Anhydrous $CaCl_2$



used to dry gas any gas except NH_3

CaO
quick lime



to dry NH_3

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

draw an apparatus to co'

Industry

(Haber process)

$$3H_2 + N_{2(g)} \underset{endo}{\overset{exo}{\rightleftharpoons}} 2NH_{3(g)} \quad \Delta H = -ve$$

Uses of NH_3

1- fertilization.

2- Cleaning detergent.

3- smelling salts.

essential condition

400°C – 450°C

essential condition

1- 400°C – 450°C

2- pressure 200 ATm

3- catalyst Fe.

• add excess H_2 & N_2.

• remove NH_3 immediately by condensation

Temp 400 – 450

less than 400

adv: more yeild of NH_3

dis: slower rate

greater than

adv: faster rate

dis: less yeild of NH_3

Temp 400 - 450

less than 400

adv
more yeild of NH_3

dis
slower rate of reaction

more than 450

adv
faster rate of reaction

dis
less yeild of NH_3

pressure 200 atm

high pressure

adv

1- more yeild of NH_3

2- faster rate (more collisions per unit time)

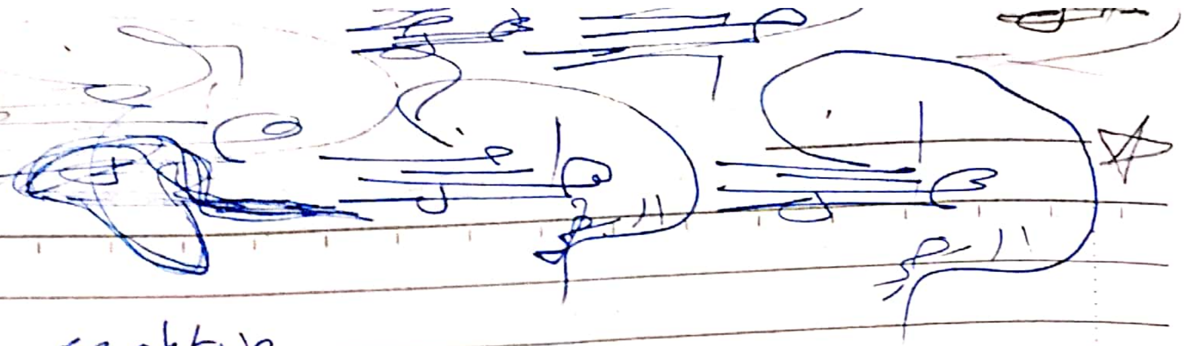
dis

1- risk of explosion.

2- expensive.

$S \rightarrow SO_2 \rightarrow SO_3$

H_2SO_4



How to ~~of~~ obtain

N_2 :- fractional distilation of liquid air.

H_2 :- (1) Cracking of ~~Alk~~ Alkane (organic)

(2) $\underset{\text{methane}}{CH_4} + \underset{(g)}{H_2O}$

$\downarrow$

$3H_2 + CO$

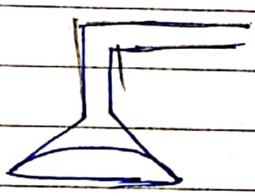
Idustry of H_2SO_4

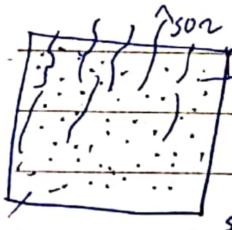
~~S → SO₂ → SO₃ → H₂S₂O₇ → H₂SO₄~~

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

① Roasting

$S + O_2 \rightarrow SO_2$





as fine powder more surface area so faster rate of rxn.

② contact process

$$2SO_2 + O_2 \underset{\text{endo}}{\overset{\text{exo},\ V_2O_5}{\rightleftharpoons}} 2SO_3 \qquad \Delta H = -ve \ (\text{exo})$$

1) Temp 400 – 450

2) pressure 1 – 2 atm "high pressure" ~~favour~~ favour the side that has less gas mole

~~Maxin~~ max yeild at 2 atm.

Catalyst V_2O_5 Vanadium (V) penta oxide

Roasting then contact process ~~an~~ add conc H_2SO_4 to SO_3, $H_2S_2O_7$ is formed then remove the H_2O.

Five Apple

1- ~~Essay~~

essay

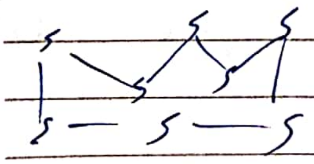
$SO_3 \xrightarrow{H_2O} H_2SO_4$ X

high exothermic
produce low
yeild of H_2SO_4

$SO_3 \xrightarrow{\text{conc } H_2SO_4} H_2S_2O_7$ (Oleum.) $\xrightarrow{H_2O} 2H_2SO_4$

S

group VI
yellow solid



Ole :- Zincblend ZNS
source :- fossile feul

uses :-
- medicine
- matches
- rubber

SO_2 chocking smell

- test SO_2

Turns acidify
$KMnO_4$
from purple
to colorless

uses : paper industry
bleaching agent

Extraction of Iron

ore Hematite Fe_2O_3

method reduction by C & CO

place Blast furnace

raw material 1- Fe_2O_3 with acidic impurities sand SiO_2

2- lime stone $CaCO_3$

3- Coke (pure carbon)

4- air 1500°C

complete combustion

① $C + O_2 \rightarrow CO_2$

~~im~~ incomplete combustion

② $2C + O_2 \rightarrow 2CO$

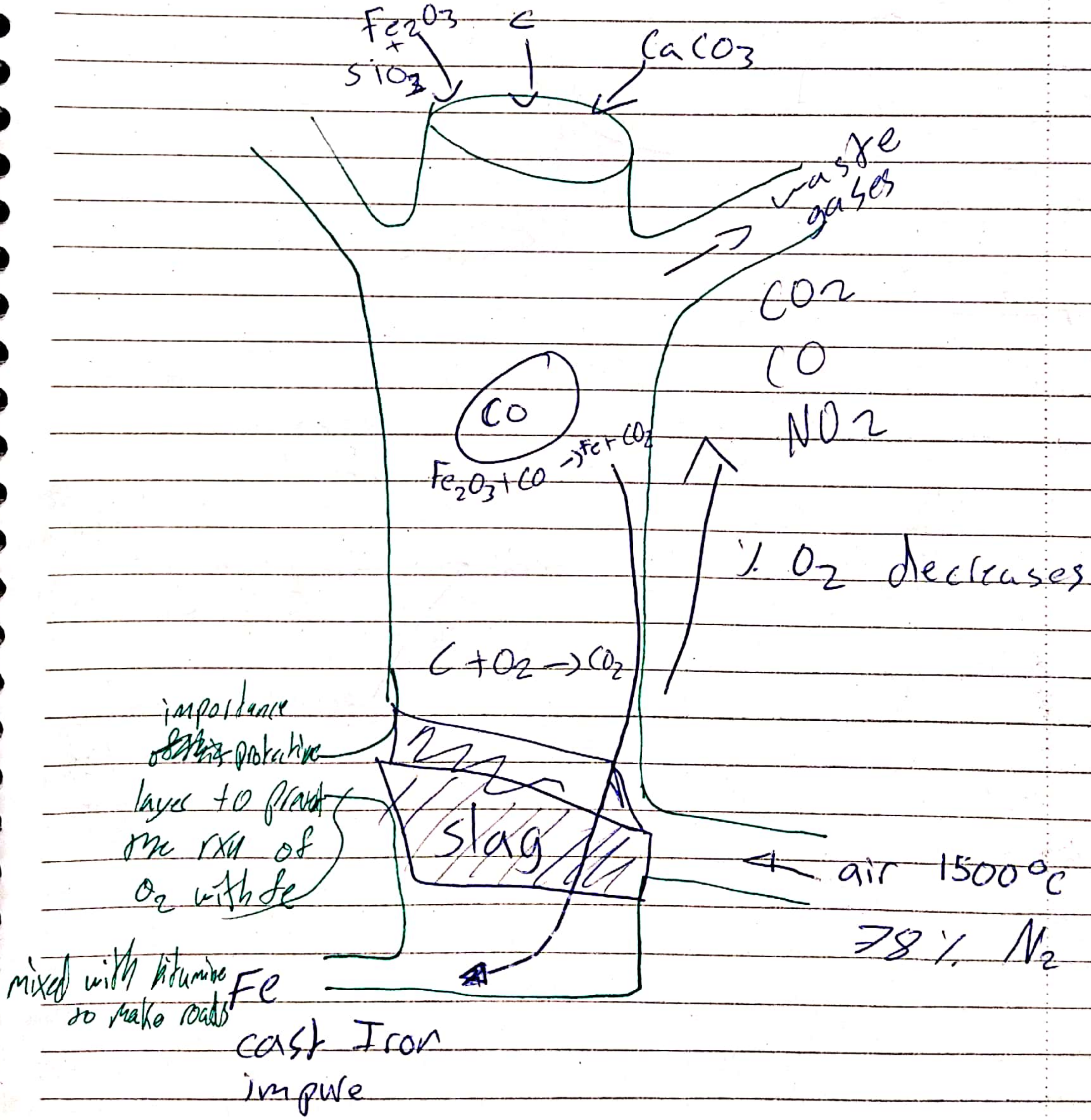
③ $CO_2 + C \rightarrow 2CO$

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

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

6 $CaO + SiO_2 \rightarrow CaSiO_3$

calcuim silicate slag.



~~\$~~ Steel making "oxygen-base process"

~~Cast~~ Cast Iron
Fe

main impurity

CO_2 - $\boxed{C}$

SO_2 $\boxed{S}$

SiO_2 $\boxed{Si}$

P_2O_5 $\boxed{P}$

blow hot air

CaO

~~steel~~

steel
- mild steel 0.03% C (car ~~b~~ bodies)
- medium steel 0.3 C (Rail way)
- stainless steel 3-5 C (cutters)

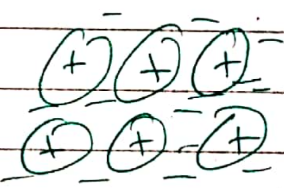
Alloy : mixture of metal with another metal or semi-metal.

Brass $Cu + Zn$

Bronze ~~S~~ $Cu + Sn$

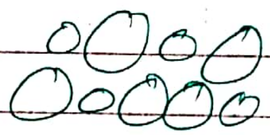
Steel $Fe + C + Cr + Ni$

copper



easier to slide

brass



two diffrent sizes so harder the slide.