Redox

↙ ↘

Reduction oxidation.

① Oxygen lose O gain O

reduction: Fe in Fe_2O_3.

$Al + Fe_2O_3 \longrightarrow Al_2O_3 + Fe$

Oxidition: AL.

reduction: Zn in ZnO

$CO + ZnO \longrightarrow Zn + CO_2$

oxidation; C in CO.

reduction: Cu in CuO.

$H_2 + CuO \rightarrow Cu + H_2O$

Oxidation H_2

② Hydrogen lose H gain H.

reduction: Cl_2

$H_2S + Cl_2 \longrightarrow HCl + S$

oxidition S in H_2S

③ oxidation State   reduction decrease   oxidation Increase

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

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

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

Rules for oxidation state.

1) the oxidation state for any free element = Zero

monoatomic	diatomic	Polyatomic
Na, K, Li	H_2, O_2, N_2	P_4
Ne, Ca, Cu	F_2, Cl_2, Br_2, I_2	S_8

② The oxidation number of any atom in a compound from

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

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

group 3 = 3+ always +3 only for Al.

group 7 = -1 always -1 only for F.

Constant.

③ the oxidation number of Hydrogen (+1)
Except with metal in metal hydride (-1).

$C\overset{+1}{H}_4$, $N\overset{+1}{H}_3$, $\overset{+1}{Na}\overset{-1}{H}$, $\overset{2+}{Ca}\overset{1-}{H}_2$

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

O^{2-} oxide

O_2^{2-} peroxide.

Sodium oxide Na^{+1} O^{-2} -> Na_2O^{2-}

Sodium peroxide Na^{+1} O_2^{-2} -> $Na_2\overset{-1}{O}_2$

$H_2\overset{2-}{O}$ $H_2\overset{1-}{O}_2$
water

Calicium oxide	Calicium proxide
Ca^{2+} O^{2-}	Ca^{2+} O_2^{2-} ↓
CaO	CaO_2

5) the of all oxidation state
in a compound = 0
in an Ion = charge of this ion

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

$+1+x=0$
$x=-1$

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

$+1+x-2=0$
$+1+1-2=0$

$\overset{+1}{H}Cl\overset{-2}{O_2}$

$+1+x+2(-2)=0$
$1+x-4=0$
$x=+3$

$N\overset{+1}{H_3}$

$N+3(+1)=0$
$N+3=0$
$N=-3$

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

$N-2=0$
$N=+2$

$N_2\overset{-2}{O_5}$

$N_2-10=0$
$N=+5$

$\overset{+1}{H_2}S$
$S=-2$

$\overset{+1}{H_2}SO\overset{-2}{_4}$
$\overset{2}{S}=+6^{-8}$

$S\overset{-2}{O_3}$
$S=+\overset{-6}{6}$

NO_3^{-1}

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

$N+3(-2)=-1$
$N+-6=-1$
$N=+5$

$Mn+-8=-1$
$Mn=+7.$

SO_2^{2-}

$S-6=-2$
$S=+4$

$Cr_2\overset{-2}{O_7}^{2-}$

$Cr_2-14=-2$
$Cr=+6$

Q: Find the oxidation state of each underlined species.

$Fe_2\overset{-2}{O}_3$
$Fe_2 - 6 = 0$
$F = +3$

$\underline{O}\overset{+3}{Fe}$
$Fe = 2+$

$\underline{S}\overset{-2}{O}_4^{2-}$
$S - 8 = -2$
$S = +6$

$\underline{V}_2\overset{-2}{O}_5$
$V_2 - 10 = 0$
$V = +5$

$\underline{P}\overset{-2}{O}_4^{3-}$
$P - 8 = -3$
$P = +5$

$\underline{Cr}\overset{-2}{O}_4^{2-}$
$Cr - 8 = -2$
$Cr = +6$

$\underline{C}\overset{-2}{O}$
$C = +2$

$\underline{C}\overset{-2}{O}_2$
$C - 4 = 6$
$C = +4$

$\underline{C}\overset{-2}{O}_3^{2-}$
$C - 6 = -2$
$C = +4$

* $\overset{0}{Al} + \overset{3+}{Fe}_2\overset{2-}{O}_3 \longrightarrow \overset{3+}{Al}_2\overset{2-}{O}_3 + \overset{0}{Fe}$

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

* $\overset{2+}{C}\overset{2-}{O} + \overset{2+}{Zn}\overset{2-}{O} \longrightarrow \overset{0}{Zn} + \overset{+4}{C}\overset{-2}{O}_2$

Oxidation: $C^{2+} \rightarrow C^{4+}$
reduction: $Zn^{2+} \rightarrow Zn$

* $\overset{+1}{H}_2\overset{2-}{S} + \overset{0}{Cl}_2 \longrightarrow \overset{1+}{H}\overset{1-}{Cl} + \overset{0}{S}$

Oxidation: $S^{2-} \rightarrow S$
reduction: $Cl_2 \rightarrow Cl^{-1}$

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

Oxidation : $Fe^{2+} \rightarrow Fe^{3+}$
reduction : $Mn^{7+} \rightarrow Mn^{2+}$

over all reaction :
$5Fe^{2+} + Mn^{7+} \rightarrow 5Fe^{3+} + Mn^{2+}$

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

Oxidation : $Sn^{2+} \rightarrow Sn^{4+}$
reduction : $Cr^{6+} \rightarrow Cr^{3+}$
over all reaction : $3Sn^{2+} + 2Cr^{+6} \rightarrow 3Sn^{+7} + 2Cr^{3+}$

$*AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$

Not redox

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

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

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

Oxidation :
reduction :

Sewc
Siw:

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writting balanced half Ionic equation.

1) Atoms

2) the change by adding electrons to the side with greater charge by the difference.

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

half of oxidation: $Al \longrightarrow Al^{3+} + 3\bar{e}$
Half of reduction : $Fe^{3+} + 3^{-} \longrightarrow Fe$.
over all reaction : $Al + Fe^{3+} \longrightarrow Al^{3+} + Fe$

$\overset{0}{Ca} + \overset{2+}{Zn}\overset{1-}{Cl_2} \longrightarrow \overset{2+}{Ca}\overset{1-}{Cl_2} + \overset{0}{Zn}$.

Half of oxidation: $Ca \longrightarrow Ca^{2+} + 2\bar{e}$
Half of reduction: $Zn^{2+} + 2\bar{e} \longrightarrow Zn$.
over all reaction : $Ca + Zn^{2+} \longrightarrow Ca^{2+} + Zn$.

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

Half of oxidation: $(\overset{2}{Na} \longrightarrow \overset{2}{Na^{+1}} + \overset{2}{1\bar{e}}) \times 2$ equal elec
Half of reduction: $2H + 2\bar{e} \longrightarrow H_2$.
over all reaction : $2Na + 2H^{+} \longrightarrow 2Na^{+1} + H_2$.

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

H.O.O : $(\overset{3}{Ca} \longrightarrow \overset{3}{Ca^{2+}} + \overset{6}{2\bar{e}})3$
H.O.R : $(2Al^{3+} + \overset{6}{3\bar{e}} \longrightarrow 2Al)2$
over all ~~reaction~~ reaction : $3Ca + 2Al^{3+} \longrightarrow 3Ca^{2+} + 2Al$.

Reactants → Products.

oxidation → $\bar{e}$ "lose $\bar{e}$".

reduction$^{\bar{e}}$ → "gain $\bar{e}$"

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

H.O.O : $S^{2-} \rightarrow S + 2\bar{e}$
H.O.R : $Cl_2 + 2\bar{e} \rightarrow 2Cl^{-1}$
over all reaction: $S^{2-} + Cl_2 \rightarrow S + 2Cl^{-1}$

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

H.O.O : $(Al \rightarrow Al^{3+} + 3\bar{e}) \times 2$ $\quad 2Al \rightarrow 2Al^{3+} + 6\bar{e}$
H.O.R : $(2H^+ + 2\bar{e} \rightarrow H_2) \times 3$ $\quad 6H^+ + 6\bar{e} \rightarrow 3H_2$.
over all reaction : $2Al + 6H^+ \rightarrow 2Al^{3+} + 3H_2$.

Oxidising agent & reducing agent

oxidising agent "oxidant"

	reducing agent	oxidising agent
O:	oxidation	reduction
	gain O	lose O
H:	lose H	gain H
oxid state:	↑	↓
$\bar{e}$ transfer	lose $\bar{e}$	gain $\bar{e}$

oxidising state "oxidant"

the Substance that its self reduced and causes the other Substance to be oxidise.

reducing agent "reduction"

the substance that it self oxidised and causes the other Substance to be reduced.

If the substance is an Ion in a compound the agent is the compound it self

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

Oxidation : Al ~~reduction~~ reducing agent : Al.

reduction: Fe^{3+} oxidising agent : Fe_2O_3.

$$\overset{2+}{C}\overset{2-}{O} + \overset{2+}{Zn}\overset{2-}{O} \longrightarrow \overset{0}{Zn} + \overset{+4}{C}\overset{2-}{O}_2$$

Oxidation : C^{2+} Oxidising agent : ZnO

reduction : Zn^{2+} reducing agent : CO

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

Oxidant: Cl_2 reductant: H_2S.

$\overset{+7}{Mn}O_4^{-1} + Fe^{2+} + H^{+} \longrightarrow Mn^{2+} + Fe^{3+} + H_2O$.

Oxidinsing agent : MnO_4^{-1} reductent : Fe^{2+}

oxidation : Fe^{2+} reduction : Mn^{7+}

Most common oxidising agent.

① Oxygen

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

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

② Acidify pottassium manganate $KMnO_4/H^+$

$MnO_4^{-1} \rightarrow Mn^{2+}$

(+7) (+2).

Purple Colorless

③ Acidify pottassium dichromate $K_2Cr_2O_7/H^+$

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

(+6) (+3)

orange green.

④ Halogens

$2e^- + Cl_2 \rightarrow 2Cl^-$
$2e^- + Br_2 \rightarrow 2Br^-$
$2e^- + I_2 \rightarrow 2I^-$
$2e^- + F_2 \rightarrow 2F^-$

} ~~white~~ Colorless Solution.

F_2 : yellow
~~Br_2~~ Cl_2 : green yellow
Br_2 : red brown
I_2 : Purple gas
black Solid
red brown
solution (aq).

most common reducing agent.

① Hydrogen. $H_2 + \overset{2+}{Cu}O \rightarrow H_2O + \overset{0}{Cu}$

② Carbon and carbon monoxide:

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

$CO + \overset{2+}{Zn}O \rightarrow CO_2 + \overset{0}{Zn}$

③ Iodide : $\underset{\text{Colorless}}{\overset{(aq)}{2I^-}} \longrightarrow \underset{\text{red brown}}{\overset{(aq)}{I_2}} + 2e^-$

→ is the strongest reductant.

weakest oxidant

④ Metals.

K

Na

Li

Ca

Mg

Al

CuCo

Zn

Fe

Pb

H

Cu

Ag

metal more reactive
more likely to lose e^-
So more likly to oxidise
so more likly to be a reducing agent.

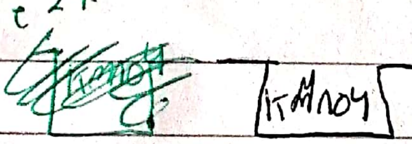
weakest reductant.

Ag^{+2} strongest oxidant.

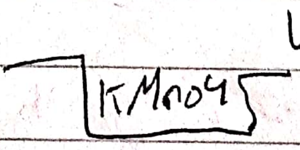
Q:- Fe^{2+} is a reducing agent
Fe^{3+} is an oxidising agent.
record the observation in each of the following reaction.

① Fe^{2+}

Fe^{3+}.



change color from purple to colorless



stays purple

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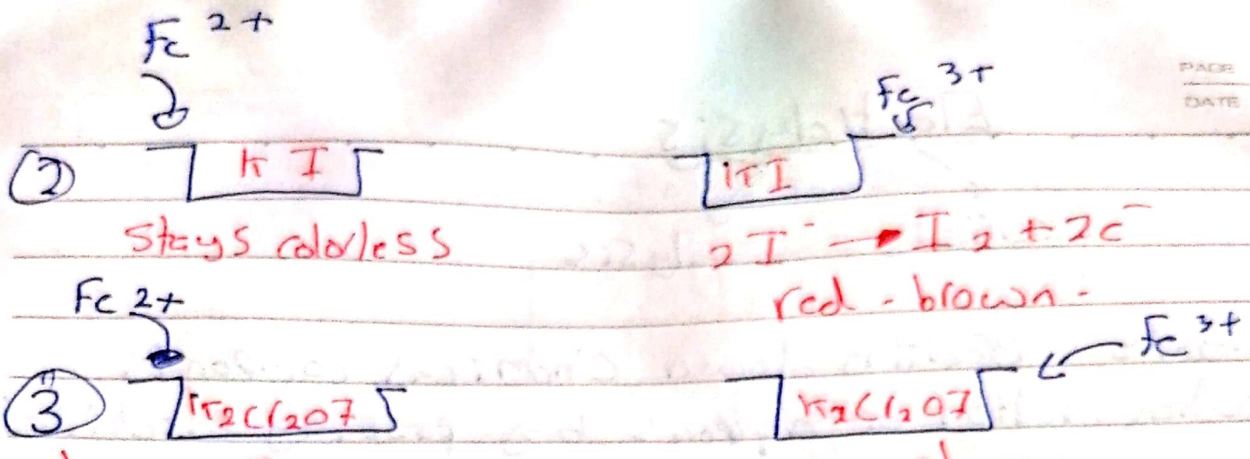


② stays colorless

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

red - brown.

③ Change from orange to green

no change

Electrolysis

Electricity analysis.

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

why the ionic compounds don't conduct electricity when Solid?

The Ions are not free to move.

why the ionic compounds conduct electricity when dissolve in water or being molten?

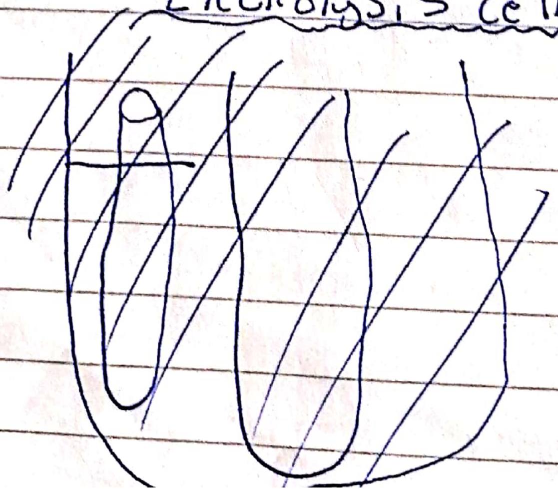
The Ions are free to move.

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

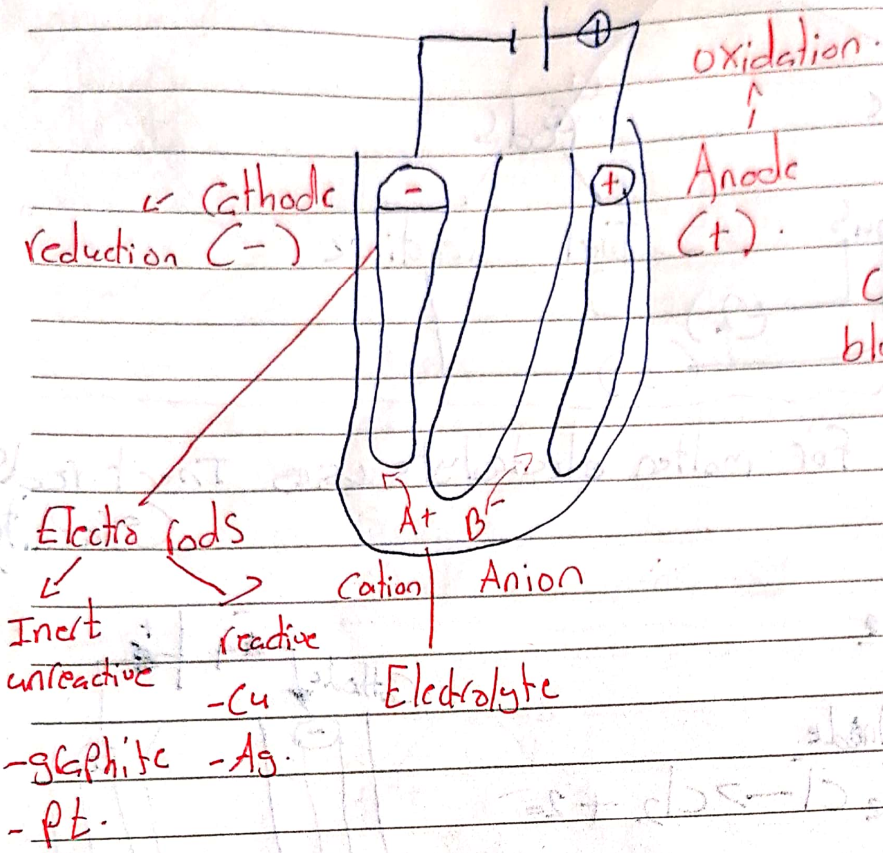
$$NaCl_{(s)} \xrightarrow{heat} Na^{+}_{(l)} + Cl^{-}_{(l)}$$

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

Electrolysis cell



Electrolysis cell



$CuClO_3$.

~~Electro rods~~

Cu^{2+} blue → ClO_3^{2-} yellow

(green)

* cathode: the negative rod that attracts the positi ions (cations) wher the reduction occurs.

* Anode: the positive rod that attracts the negative ions (anions) where the oxidation occurs.

Electrolysis = Dis charging

cations

$1e + Na^+ \rightarrow Na$

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

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

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

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

Anions

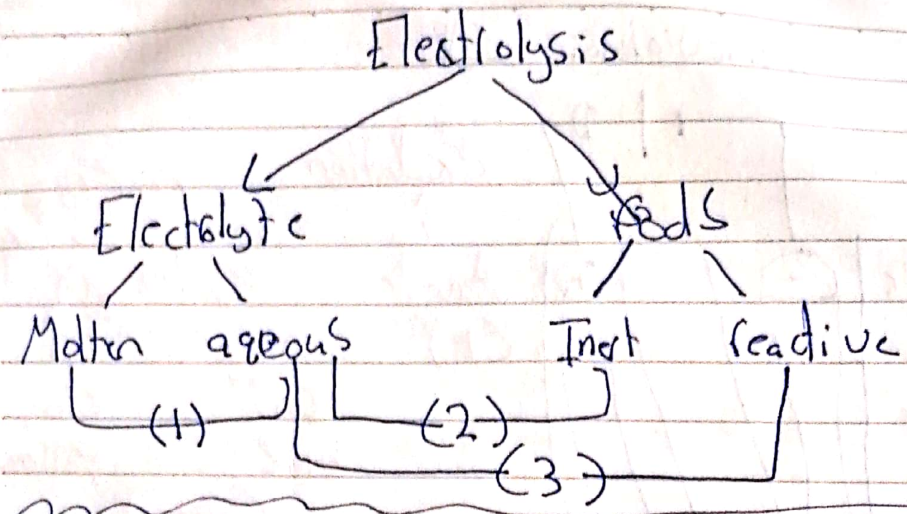
$2F^{-1} \rightarrow F_2 + 2e^-$

$2Cl^{-1} \rightarrow Cl_2 + 2e^-$

$2Br^{-1} \rightarrow Br_2 + 2e^-$

$2I^{-1} \rightarrow O_2 + 4e^-$

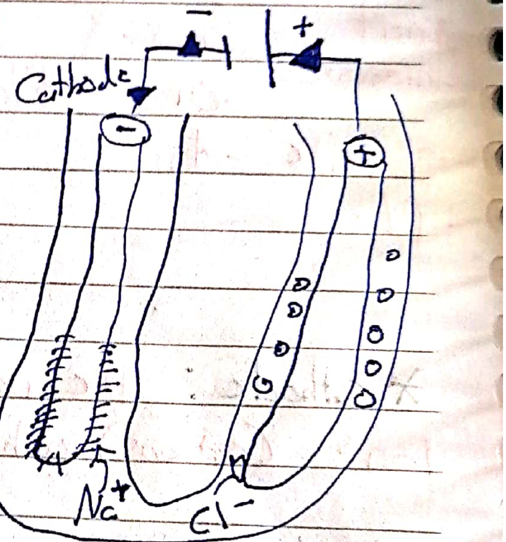
$2O^{2-} \rightarrow O_2 + 4e^-$



Electrolysis for molten electrolyte using Inert rods (graphite)

NaCl

tal ons	Na^+	Cl^-
	Cathode	Anode
	$Na^+ + 1e^- \to Na$	$2Cl^- \to Cl_2 + 2e^-$
	deposite of metal	bubble of green yellow gas.



Electrolyte: used up.

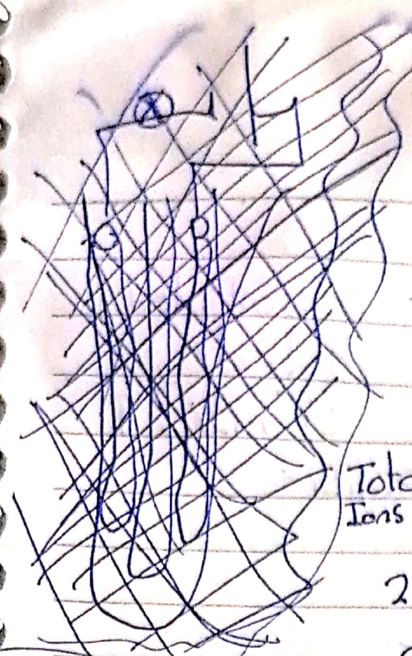
Molten Lead (l) Bromide

Electrolyte: use up.

$PbBr_{2\,(l)}$

Total Ions: Pb^{2+} Br^{-1}

cathode	Anode.
$2e^- \; Pb^{2+} \to Pb$	$2Br^{-1} \to Br_2 + 2e^-$
deposit of metal	Bubbles of red brown gas



$CuCl_2$ (l) graphite

$CuCl_2$

Total: Cu^{2+} Cl^{-1}
Ions

cathode Anode:

$2\bar{e} + Cu^{2+} \rightarrow Cu$ $2Cl^{-1} \rightarrow Cl_2 + 2\bar{e}$

deposite of metal red brown Solid.

bubbles of green yellow gas.

Electrolyte : consumed.

F_2: yellow gas

Cl_2: green yellow gas

Br_2: red brow
gas and liquid

I 2: Black soli
~~Pd~~ Purple gas
red. and brown
Solid

Al_2O_3

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

cathode Anode

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

deposite of metal

Bubbles of colorless gas

Electrolyte : used up.

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* Electrolysis of aqeous Electrolyte using Inert.

A B (aq)

A ← A^+ B⁻

H_2 ← H^+ OH^-

cathode anode

At the cathode:

the less reactive ion is more likel
to reduce and the more reactive
stays in the electolyte.

K^{+}
Na^{+}
Li^{+}
Ca^{+2}
X Mg^{+2}
Al^{+3}
Zn^{+2}
$Fe^{+2,+3}$
Pb^{+2}
$2e^- + H^{+1} \longrightarrow H_2$
$Cu^{+1/+2}$
Ag^{+1}
Au^{+3}

At the Anode:

Always OH^- except concentraded halide
Cl^-, Br^-, I^-

when the halide oxidise:
$2Cl^- \longrightarrow Cl_2 + 2e^-$

when OH^- oxidise
$4OH^- \longrightarrow 2H_2O + O_2 + 4e^-$
bubbles of cololess gas

Concentraded $NaCl_{(aq)}$ / graphite.

Na^+ Cl^-
H^+ OH^-

Cathode | Anode
$2H^+ + 2e^- \longrightarrow H_2$ | $2Cl^- \longrightarrow Cl_2 + 2e^-$
bubbles of cololess gas | bubbles of green yellow gas.

Electrolyte: NaOH

$CuSO_4$ (aq) /graphite

Cu^{2+} SO_4^{-2}
H^+ OH^-
Cathode Anode.

$2e^- + Cu^{2+} \rightarrow Cu$ $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$
deposit of metal bubbles of colorless gas.

electrolyte : H_2SO_4

gas:	test	Result
H_2	lighted splint	PoP
O_2	glowing splint	relight
Cl_2, Br_2	damp litmus paper	turns red then bleach.

dilute NaCl (aq) /graphite.

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

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

bubbles of colorless gas bubbles of colorless gas.

Electrolyte : NaCl.

concentraded KI (aq) /graphite.

K^+ I^-
H^+ OH^-
Cathode Anode
$2H^+ + 2e^- \rightarrow H_2$ $2I^- \rightarrow I_2 + 2e^-$
bubbles of colorless gas red brown.

Electrolyte : KOH.

Concentraded $CuCl_2$ (aq) /graphite

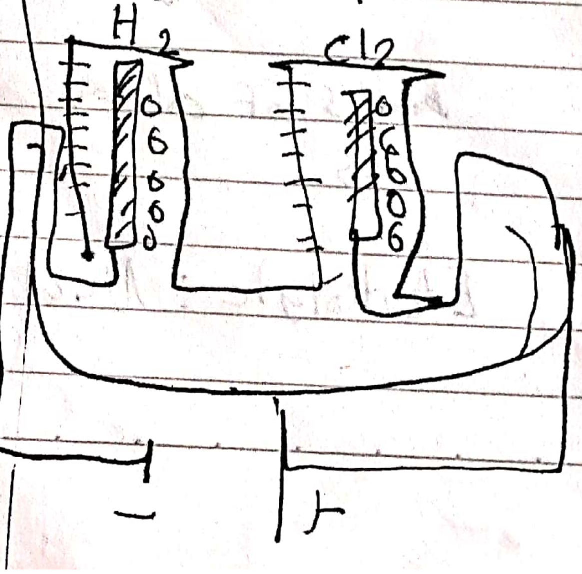
Cu^{2+} Cl^-
H^+ OH^-
Cathode Anode
$Cu^{2+} + 2e^- \rightarrow Cu$ $2Cl^- \rightarrow Cl_2 + 2e^-$
deposite of red brown Solid bubbles of green Jellow gas.

Concentraded Sodium chloride called Brine solution.

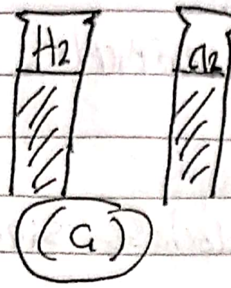
NaCl
Na^+ Cl^-
H^+ OH^-
cathode Anode
$3H^+ + 2e^- \rightarrow H_2$ $2Cl^- \rightarrow Cl_2\ 2e^-$.

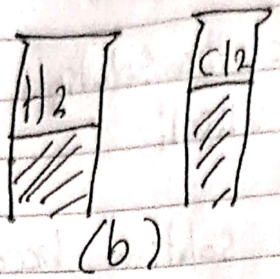
Electrolyte: NaOH.

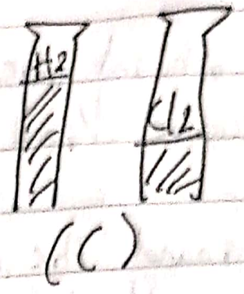
Q1) Plan an exp to collect and measure the volume of H_2 and Cl_2 produced.?



Q2) the final appearance of the two measuring Cylinders are



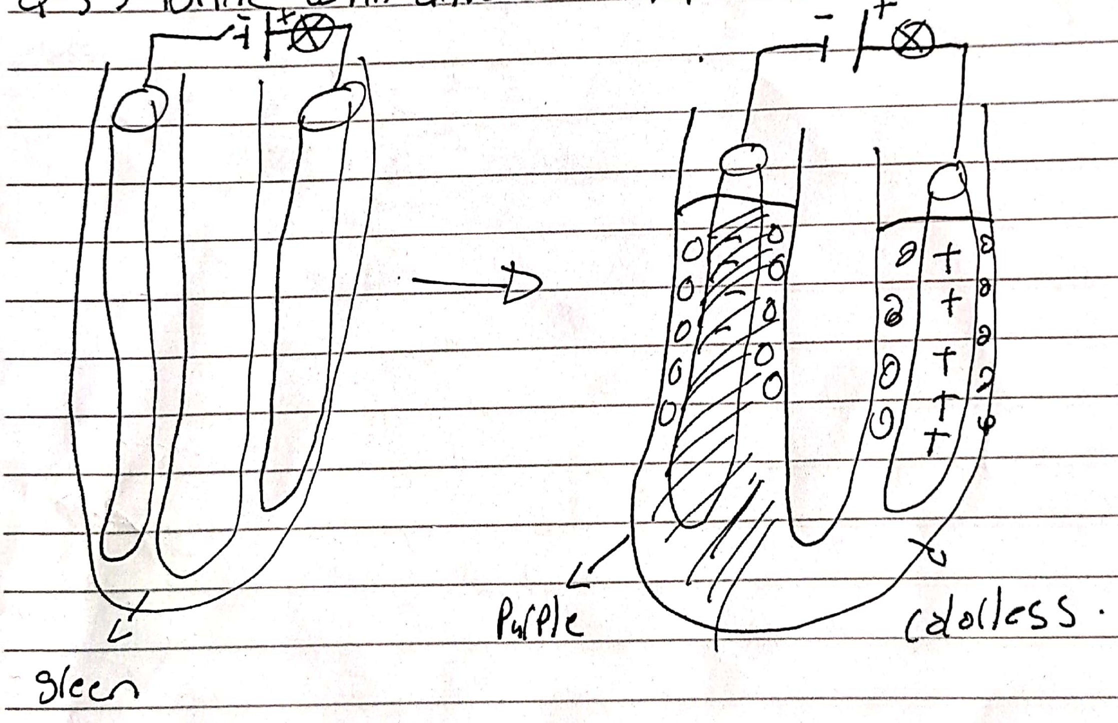




Half of oxid : $2Cl^- \rightarrow Cl_2 + \cancel{2e}$
Half of reduction : $2H^+ + \cancel{2e} \rightarrow H_2$.

over all reaction : $2H^+ + 2Cl^- \rightarrow H_2 + Cl_2$
1 : 1.

Q3) Brine with universal indicator. :



observation:
1- the bulb light up

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

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

4- around the cathode the solution ~~because~~ becomes purple
because NaoH is an allkali.

5- around the Anode the solution becomes colorless since
Cl_2 bleach the color.

graphite = carbon.

Applications on Electrolysis

molten / Inert
⇓
Extraction of metals.

aqueous / Inert
⇓
prepare solution.

aqueous / Active
- Electroplating
- Purifying metals.

conc. $NaCl_{(aq)}$

Na^+ $\quad Cl^- \Rightarrow Cl_2$

$H_2 . C = H^+$ $\quad OH^-$

⇓

$NaOH$.

e C ——

$CuSO_{4 (aq)}$.

rless.

$Cu C = Cu^{2+}$ $\quad SO_4^{2-}$

H^+ $\quad OH^- \Rightarrow O_2$

⇓

H_2SO_4.

How to electroplate a spoon with silver.

1. Clean the spoon from any impurities or oxide layer using sand paper.
2. Make the spoon the cathode (-ve).
3. the anode must be Silver.
4. the electrolyte must contain silver eg. $AgNo_3$.
5. turn the circuit "be sure that the spoon ~~it~~ is fully immersed in the electrolyte.
6. rotate the spoon to ensure an equal distribution
7. rinse with distilled water.
8. dry in oven.

Concentrated $KI_{(aq)}$ / graphite:

K^+ $\boxed{I^-} \rightarrow I_2$

$H_2 \leftarrow \boxed{H^+}$ OH^-

Cathode Anode

$CuSO_4$

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

H^+ $\boxed{OH^-}$

Cathode Anode

Cu O_2

H_2SO_4

$Pb(NO_3)_{2(aq)}$

Pb^{2+} NO_3^{-1}

$\boxed{H^+}$ $\boxed{OH^-}$

Cathode Anode.

H_2 O_2.

H_2SO_4.

H^+ SO_4^{2-}

$\boxed{H^+}$ $\boxed{OH^-}$

Cathode Anode.

$2H^+ + 2e^- = H_2$ $4OH \rightarrow 2H_2 + O_2 + 4e^-$.

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

$1 : 2$.

Concentrated $KI_{(aq)}$ / graphite.

K^+ $\quad$ I^- $\rightarrow I_2$

$H_2 \leftarrow H^+$ $\quad$ OH^-

Cathode $\quad$ Anode

$CuSO_4$

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

H^+ $\quad$ OH^-

Cathode $\quad$ Anode

Cu $\quad$ O_2

H_2SO_4

$Pb(NO_3)_2(aq)$

Pb^{2+} $\quad$ NO_3^{-1}

H^+ $\quad$ OH^-

Cathode $\quad$ Anode.

H_2 $\quad$ O_2.

H_2SO_4.

H^+ $\quad$ SO_4^{2-}

H^+ $\quad$ OH^-

Cathode $\quad$ Anode.

$2H^+ + 2e^- = H_2$ $\quad$ $4OH \rightarrow 2H_2 + O_2 + 4e^-$.

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

1 : 2.

Electroplating :

Coating a metal with another metal using Electrolysis.

why? 1) to prevent rusting.
2) more ~~att~~ attractive.

How to electroplate a metal spoon with silver

1) clean the spoon from any Impurities or oxide layer using sand paper to ensure a good sticking

2) Make the spoon the cathode (-ve).

3) the Anode must be (Ag)

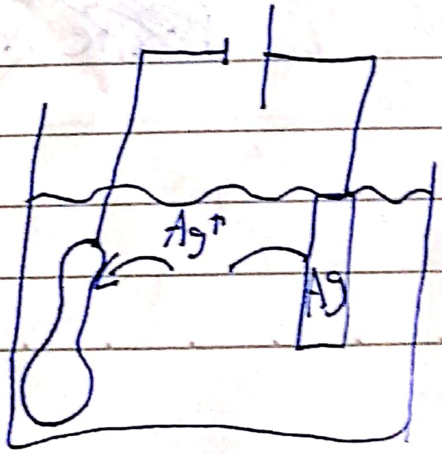
4-) the electrolyte must contains Ag^+ $AgNo_3$.

5) turn on the circuit "be sure that the spoon is fully immersed in the electrolyte.

6) rotate the spoon to ensure an equal distribution

7) rinse with distiled water.

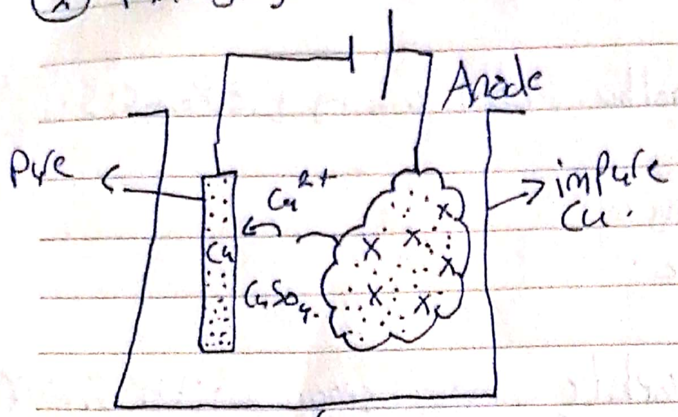
8) dry in oven.



$Ag^+ + e^- \rightarrow Ag$.

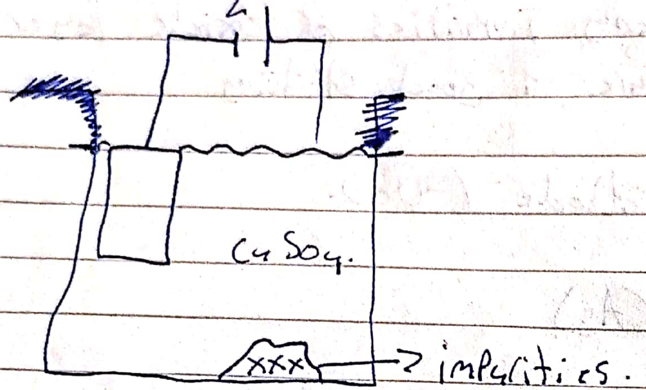
$Ag \rightarrow Ag^+ + e^-$

② Purifying Metals / Refining copper.



Cu impurities.
Ag, Au, Zn.

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



Au, Ag ⇒ settle down. (less reactive)
$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$.

Extraction of metals from their ores.

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

~~K~~
~~Na~~
~~Li~~
~~Ca~~
Baxite → ~~Mg~~
~~Al~~
~~C~~
~~Zn~~
~~Fe~~
~~Pb~~
~~H~~ ~~Ag~~
~~Cu~~ ~~Au~~

K
Na
Li] => Electrolysis /molten /graphite.
Ca
Mg
Al] > Bauxite. Al_2O_3.
C,CO
Zn → zinc blende ZnS.] reduction by C,CO.
Fe → Hematite Fe_2O_3.
Pb
H
Cu → copper(II) sulphite CuS.] reduction by H_2.
Ag
Au.

Extraction of aluminium.

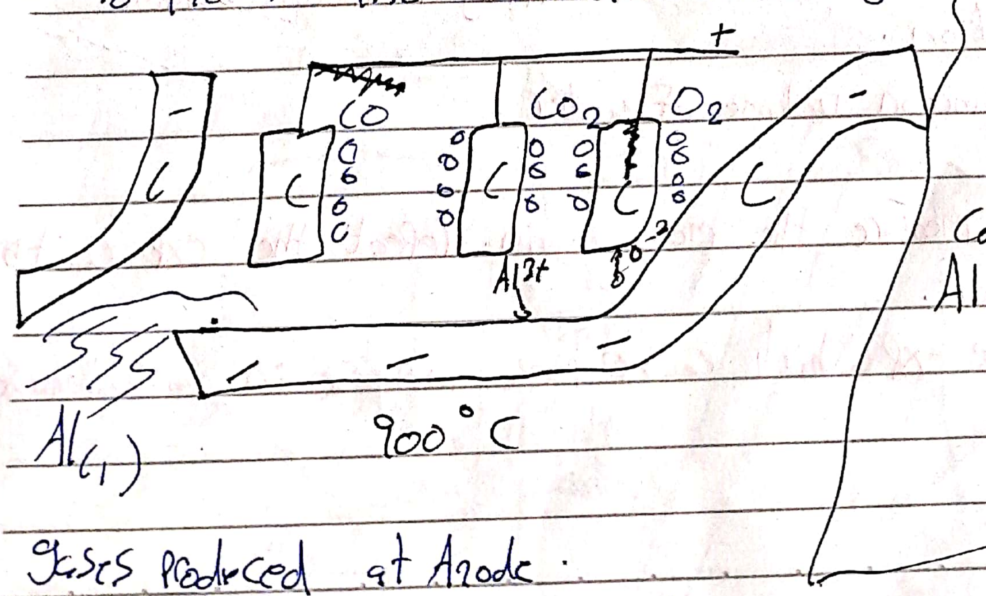
ore :- Al_2O_3 Bauxite.

Method :- Electrolysis for molten Al_2O_3 /graphite.

* m.p of Al_2O_3 is about 2000°C

So we dissolve Al_2O_3 in a molten cryolite Na_3Al

- to lower the m.p to 900°C so less cost.
- to increase the electrical conductivity.



$Al_2O_3(l)$ → Al^{3+} , O^{2}

Cathode Anode.

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

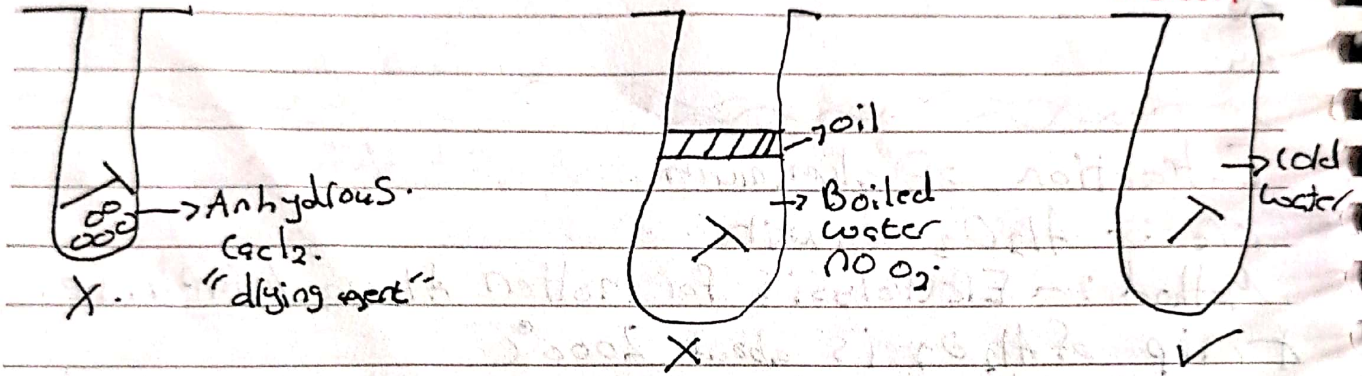
gases produced at Anode.

1- O_2 3- CO / reaction of rods with O_2 so we must replace them periodically

Aluminium.

Property	Use
- low density	- Aircraft bodies.
- ductile	- electrical wires
- malleable.	- window frame / cooking utensils.
- conduct electricity	- wires.
- Form an oxide layer which is non toxic.	- food cans.

Rust: Reaction of Iron with both O_2 and H_2O.
Slow reaction => 6 to 7 days. ($Fe + O_2 \xrightarrow{H_2O} \underbrace{Fe_2O_3 \cdot nH_2O}_{brown}$)



*Plan an exp to show which rust prevention ~~Sol~~ Solution is better.

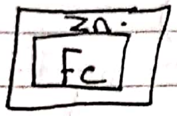
Take a known mass of Iron nail apply a known volume of the first Solution.
Put them in a known volume of water.
For 1 week.
dry them and measure the mass again. repeat the exp with the ~~s~~ 2nd solution.
Conclusion:- the exp which cause more increase in mass, worse Solution.

How to prevent rusting.

- Painting
- Oiling
- greasing
- cover with plastic.

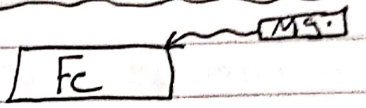
"to prevent O_2 and H_2O from reaching this Iron"

Galvanizing:



Coating

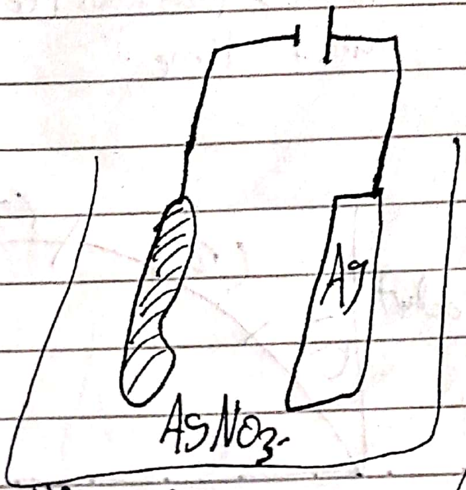
Sacrificial Protection:



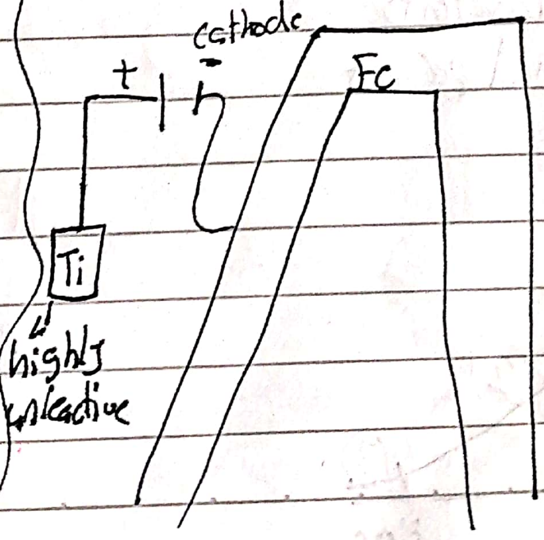
Connecting.

Zn and mg are more reactive than Fe. More likely to oxidise, more likely to lose e^-'s.
So Fe is less likely to rust.

Electroplating:



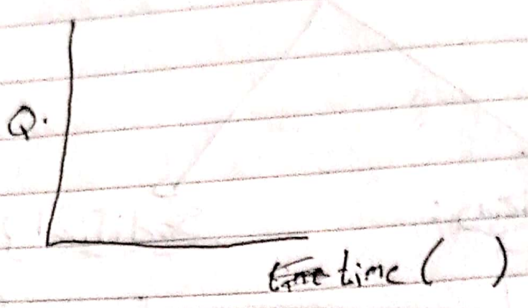
Cathodic Protection:



Rate of reaction:

$$\text{Rate} = \frac{\text{Change in Quantity}}{\text{change in time.}}$$

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

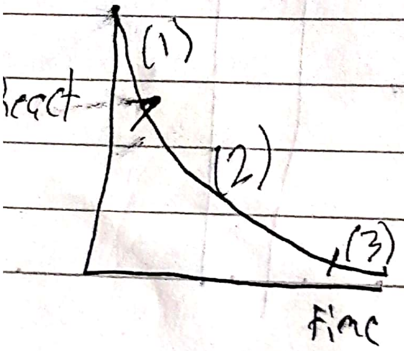


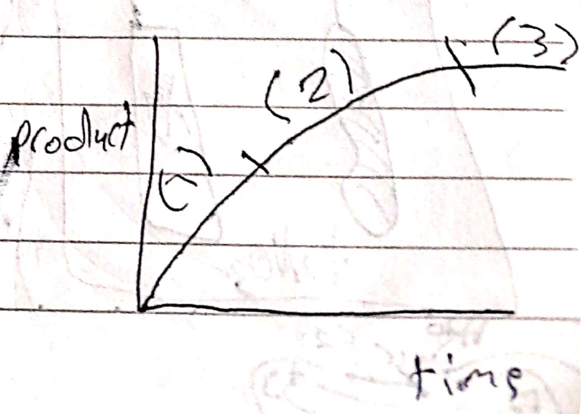
$$\frac{\Delta \text{mass}}{\Delta \text{Time}} \qquad \frac{\Delta \text{concentration}}{\Delta \text{Time}} \qquad \frac{\Delta \text{pH}}{\Delta \text{time}} \qquad \frac{\Delta \text{volume}}{\Delta \text{time}}$$

$$\frac{\Delta \text{Temp}}{\Delta \text{time}} \qquad \frac{\Delta \text{height of ppt}}{\Delta \text{time}} \qquad \frac{\Delta \text{light intensity}}{\Delta \text{time.}}$$

Measure the rate of reaction

- How fast the reactants consumed per unit time.
- How fast the products produced per unit time.





region (1)
Fastest rate => from the graph. steepest.
more amount of reactents more particles.
more effective. collisions per unit time.

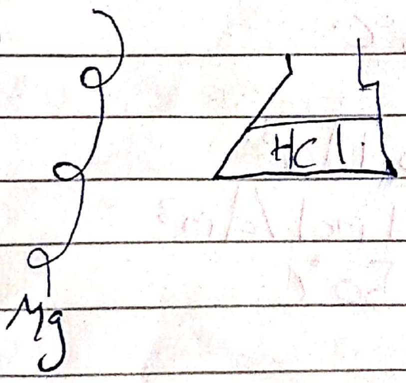
region (2).
Slower rate => from the graph. less steep.
less number of particles.
So less no. of effective collisions. per unit time.

region (3).
reaction is over => gradient = 0 (horizontal).
no more limitting factor.
no more effective collisions.

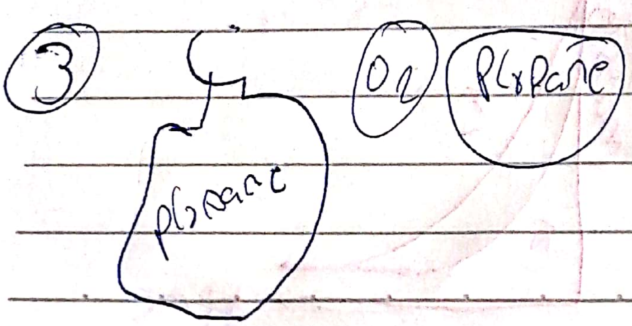
For any chemical reaction there are three main conditions.

① the reactents must be suitible.
Cu + Hcl -> no reaction.

② the reactents must collide.



③ the collisions must be effective / min amount of energy to St
the reaction.



Activation Energy Ea

① Temperature :

* State how the temp affects the Rate of reaction.

As the temp increases the Rate of reaction increases.

* Explain how the temp affect the Rate of Reaction.

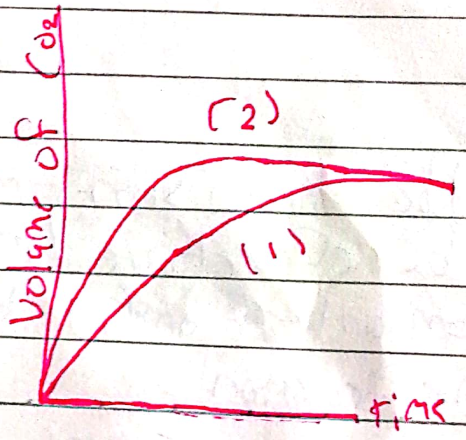
As the temp increases the Particles gain K.E so more faster the particles will have energy equal to or greater than the Ea.
So more effective collisions per unit time
so faster rate of Reaction.

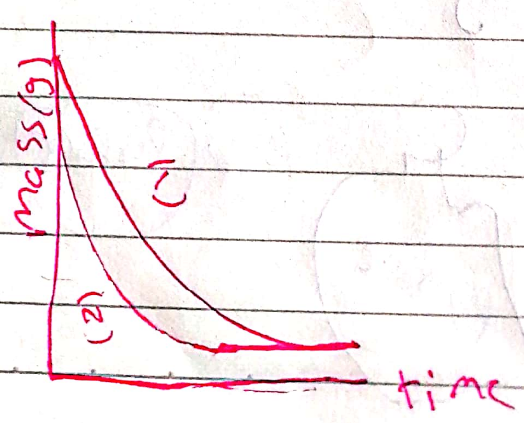
* Plan an exp. to show how the temp effect the Rate of Reaction.

$CaCO_{3(s)} + 2Hcl_{(aq)} \longrightarrow Cacl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$.

exp (1). mass = 2.0g. lumps
$V_{Hcl} = 0.1 dm^3$.
$M_{Hcl} = 1 mol/dm^3$
Temp = 25°C.

exp (2). mass = 2.0g. lumps
$V_{Hcl} = 0.1 dm^3$.
$M_{Hcl} = 1 mol/dm^3$
Temp = 50°C.





take a known mass of lumps $CaCO_3$ add them to a known volume of know conc of Hcl at 25°C.
Measure the volume of CO_2 produced using gassyring per unit time.
Repeat the exp at 50°C.
the exp at 50°C produce CO_2 with less time.

(2) Surface area.

* State how the surface Area affect the Rate of Reaction ~~Area~~.
As the surface area increase the Rate of Reaction inc.

* Explain how the surface area of effect the Rate of reaction.
As the Surface area increases (decrease the particles size by crushing using mortar of pestile.).
more Particles exposed to the reaction more effective collisions per unit time so faster rate.

* Plan an exp to show how the surface area affect the Rate. of reaction?

exp (1) mass = 2.0g lumps
V Hcl = 0.1 dm³.
M Hcl = 1 mol/dm³
Temp = 25°c.

exp (2) mass = 2.0g powder.
V Hcl = 0.1 dm³
M Hcl = 1 mol/dm³
Temp = 25°c.

③ concentration, "Amount":

* State how the concentiction affect the Rate of Reaction.

As the concentration increases the rate of Reaction increases

* explain how the concentration affect the rate of reaction.

As the concentration increase. more particles, so more
affective collisions per unit time
So faster rate of Reaction.

* Plan an exp. to show how the conc the rate of reactio.

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

exp (1). mass
$CaCO_3 = 2g$
lumps

$V_{HCl} = 0.1 dm^3$
$M_{HCl} = 0.1 mol/dm^3$
Temp = 25°C.

xp (2). mass
$CaCO_3 = 2g$
lumps

$V = 0.1 dm^3$
$M = 0.2 mol/dm^3$
Temp = 25°C.

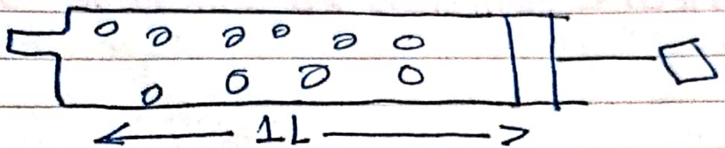
p (3). mass
$CaCO_3 = 4g$
lumps

$V = 0.1 dm^3$
$M = 0.1 mol/dm^3$
Temp = 25°C.

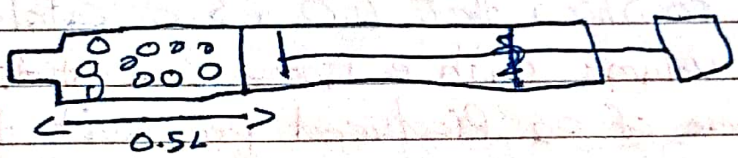
4) Pressure :- "only affect the gas"

explain how the pressure affect the Rate of reaction?

As the pressure increases (by reducing the volume.) So more particles per unit volume so more effective collisions per unit time so faster rate of reaction.



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



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

5) light. "only for Photochemical Reaction":

Reaction that needs light to occur.

e.g :- photosynthesis.

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

Photographic Films.

films coated with AgCl or AgBr

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

$ABr \xrightarrow{\text{light}} Ag_{(s)} + Br_2.$

6) catalyst.

Chemical substance that speeds up the reaction without being used up.

How? ~~it Ea~~ Activation energy.

It provides an alternative way with lower Ea. So more particles will have energy equal to or more than Ea. So more effective collisions per unit time. So faster rate of reaction.

The reaction

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

① Plan an exp to show that CuO is a catalyst for this (Xn (6pts)

take a known volume with a know concentration of H_2O_2 measure the volume of O_2 produced per unit time repeat the experment using CuO.

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

② Plan an exp to show which of the two catalyst is better CuO or MnO_2.

Same as Q 1 + Same mass of catalyst.

- the exp which produce more O_2 per the same unit time used better catalyst

③ Plan an exp to show that CuO not closed up during the reaction.

measure the mass of CuO, add H_2O_2 until no more fizzes, filter the mixture, dry the solid in oven, remeasure the mass.

* same initial and final mass.

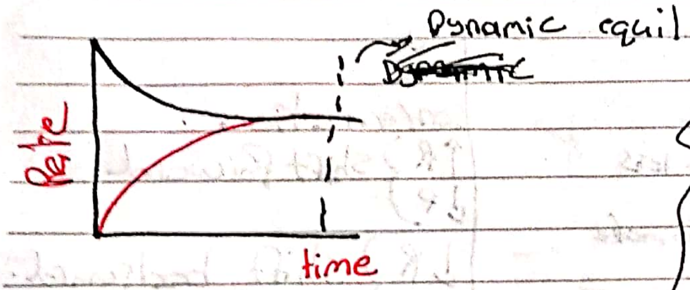
Reversible Reaction.

Types of chemical rxn.

one way.
Reactants $\xrightarrow{\text{forward}}$ products

both ways.
Reactants $\underset{\text{backwards}}{\overset{\text{forward}}{\rightleftharpoons}}$ products.

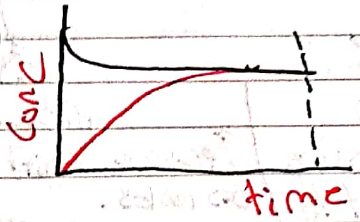
in terms of Rate:

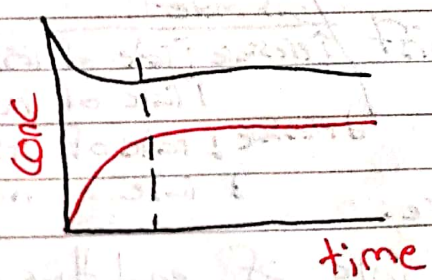


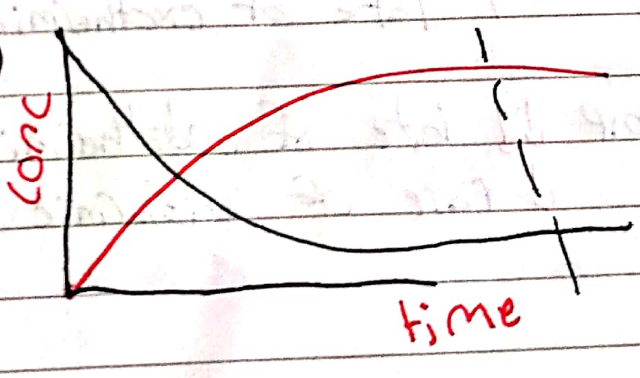
the rate of forward ↓
less Reactants so less
particles so less effective
collisions per unit.

the rate of backwards ↑
more products so more
particles so more effective
collisions per unit time.

in terms of conc:







Le chatelier principle:

if the system at equil $\rightleftharpoons$
and any external factor distubt the equil.
the equil can shift itself either.
to the forward $\rightharpoonup$
or to the backward $\leftharpoondown$
to return back to the equil.

Factor affect the position of equilibrium.

① Temp
... endo/exo
↑ temp shift to endo
↓ Temp shift to exo.

② Pressure
↑ pressure shift to less gas moles.
↓ pressure shift to more gas mole.

↑ pressure ↑ rate of less gas mole
↑ rate of more gas mole.
↓ pressure ↓ rate of less gas mole
↓ rate of more gas mole.

③ Concentration.
↑ R, ↓ P } shift forward
↓ R, ↑ P } shift backward.

① Temprature.

↑ temp ↑↑ rate of endothermic
↑ rate of exothermic

{ Shift to endo }

↓ temp ↓↓ rate of endothermic
↓ rate of exothermic

{ Shif to exo }

$\Delta H =$
Enthalpy change

$\swarrow$	$\searrow$
+ve	-ve
gain	lose
Endo	exo

{The Sign of ΔH is always
represent the forward reaction}.

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

$\uparrow$ Temp $\uparrow$ rate of forword
$\uparrow$ rate of backward

$\downarrow A \downarrow B \uparrow C \uparrow C$
shift back to the ~~exo~~ end

$\downarrow$ Temp $\downarrow$ rate of forward
$\therefore$ $\downarrow$ rate of backwards

$\uparrow A \uparrow B \downarrow C \downarrow D$ shift backward to the exo.

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

$\uparrow$ temp $\uparrow$ rate of forward
$\uparrow$ rate of backward
} shift to endo.

$\uparrow X \uparrow W \downarrow Y \downarrow Z$

Q: $3H_{2(s)} + N_{2(s)} \underset{endo.}{\overset{exo}{\rightleftharpoons}} 2NH_{3(s)} \qquad \Delta H = -ve$ exo

to produce more yield of NH_3.
we must use how temp
to favour the forward reaction which
is the exo thermic.

Q: $2SO_{2(g)} + O_{2(g)} \underset{endo}{\overset{exo}{\rightleftharpoons}} 2SO_{3(g)}$ $\Delta H = -ve$

	rate of forward	rate of backword	% SO_3
↑ temp	increase	increase	decrease
↓ temp	decrease	decrease	increase.

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

$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$.

dark brown — pale brown.

if we put this sealed tube in a cold water bath the mixture becomes paler brown? why?

because the forward reaction is exothermic enhanced by cooling.

② pressure:

As the pressure increase
the equil shift to the side with less pressure.
with less gas moles.

As the pressure decrease.
the equil shift to the side with more pressure
more gas moles.

Dawood ♡ chocolate log

1 mole   2 mole

③$H_{2(g)}$ + 1$N_{2(g)} \rightleftharpoons 2NH_{3(g)}$

↑ pressure shift forward to the side with less gas moles. $[\uparrow NH_3$
↓ pressure shift backwards to the side with more gas moles.

0   1

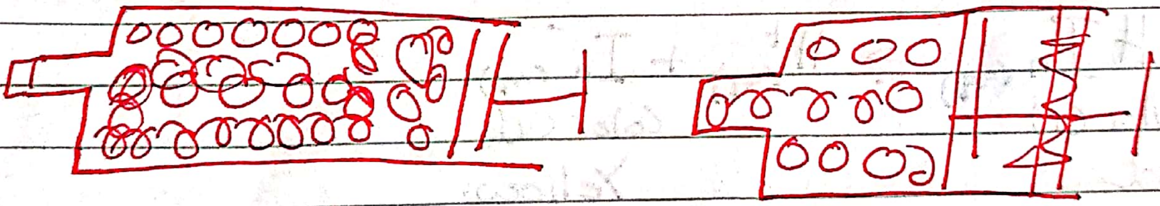
$CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$

↓ pressure shift forward to the side with more gas moles.
↑ pressure shift backwards to the side with less gas moles.

~~H_2O_3~~

$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$
purple   colorless.

The equil doesn't affect by increasing the pressure. why by increasing the pressure the mixture becomes more purple?



the I_2 molecules become.
Closer ~~to~~ to each other so the color seems to be darker.

Seald tube contains mixture of $NO_{2(g)}$ and $N_2O_{4(g)}$.
at equilibrium.

“AS”

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

by increasing the pressure the color of the mixture:
a) becomes paler then goes darker
b) // darker // // paler
c) // paler and stays paler
d) // darker // // darker.

③ Concentration:

Reactant ⇌ Products.

↑Reactant } shift forward
↓Product

↓Reactant } shift backward
↑Product

A+B ⇌ C+D

↑[A] shift forward ↓B ↑D ↑C

↓[B] shift backword ↑A ↓C ↓D

↑[C] Shift backword ↑A ↑B ↓D

Indicator:

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

color (1) — color (2)

red — Yellow.

add Hcl: Protondonor ↑H^+ shift backword.

more HIn more color(1)

less In^- Less color(2).

dd NaoH: Proton accepter ↓H^+ shift forward.

more In^- More color (2)

Less HIn Less color(1).

Q) the reversible reaction below at equilibrium.

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

orange green.

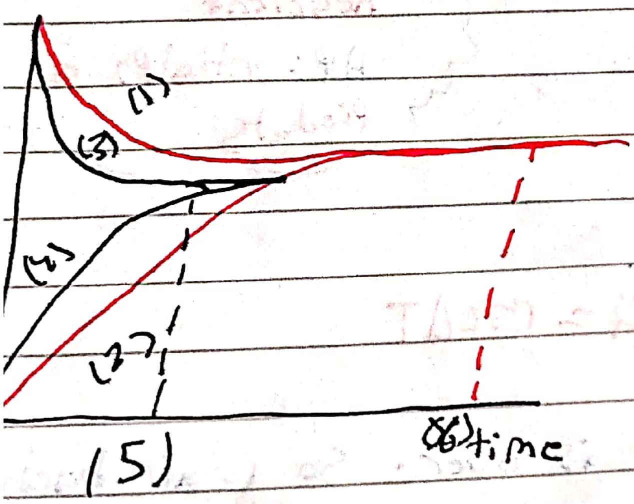
Explane why by adding Hcl to the reaction mixture. the color of the mixture. beomes green?

Hcl is an acid. (proton donor). more H^+. Shift forwa
more Cr^{3+}. more green. Less $Cr_2O_7^{-2}$ Less orange.

---

* catalyst:

has no effect on the position of equilibrium.
Since it speeds up the rate of forward of backward.



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

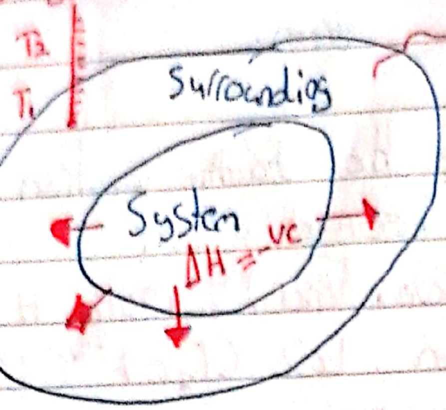
Energetics

4.2J/g°C

Exothermic:

Reactions that give out (Release) energy to the Surrounding.

$T_2 > T_1$



$\rightarrow Q = mc\Delta T$

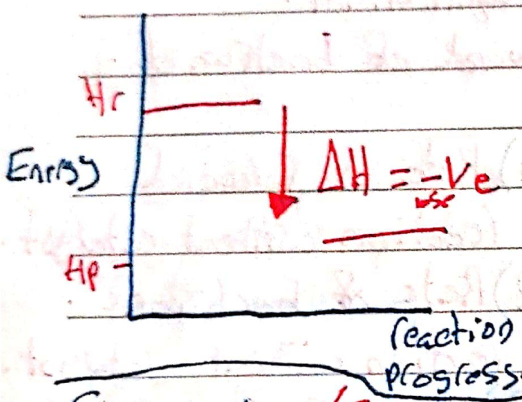
m = mass "g"

c = Specific heat capacity

ΔT = change in Temp °C

Q = Energy transfer "J"

For System (Energy level diagram).

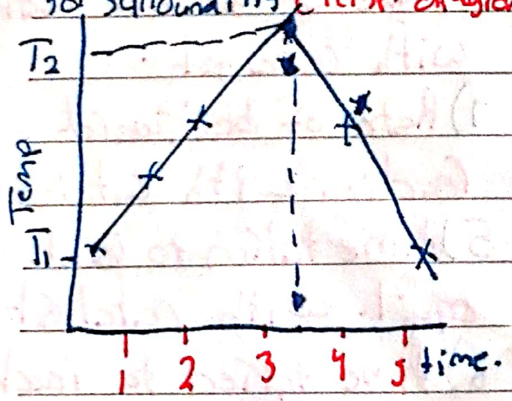


Enthalpy: Heat contents "stored energy"

Hr: enthalpy of Reactant

Hp: enthalpy of Products

For Surrounding (Temp. diagram). $\rightarrow Q = mC\Delta T$



reaction is over. So return back to room Temp.

$\uparrow Q$ $\uparrow \Delta T$

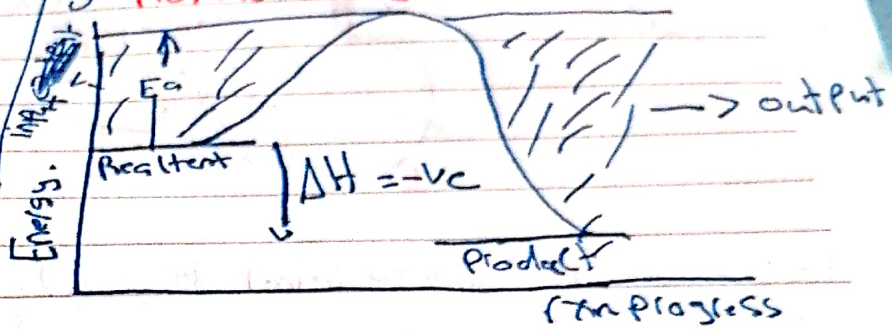
more exothermic

examples of exo :-

1- Freezing and condensation.
2- respiration.
3- combustion.
4- neutralization.
5- displacement.
6- Voltaic cell.
7- building up bonds.

How to exeress exothermic rxn.

1- Reactants ⟶ products $\Delta H = -ve$
2- Reactants ⟶ products + Energy.
3- profile diagram.

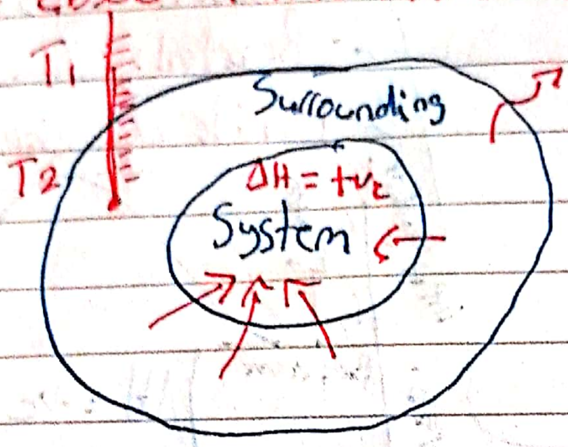


output > input.

Endothermic:

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

$T_2 < T_1$



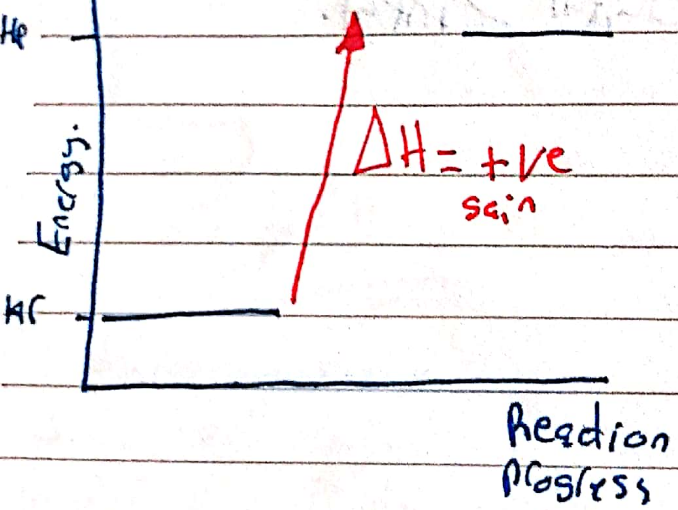
$Q = mc\Delta T$

m = mass

c = specific heat capacity

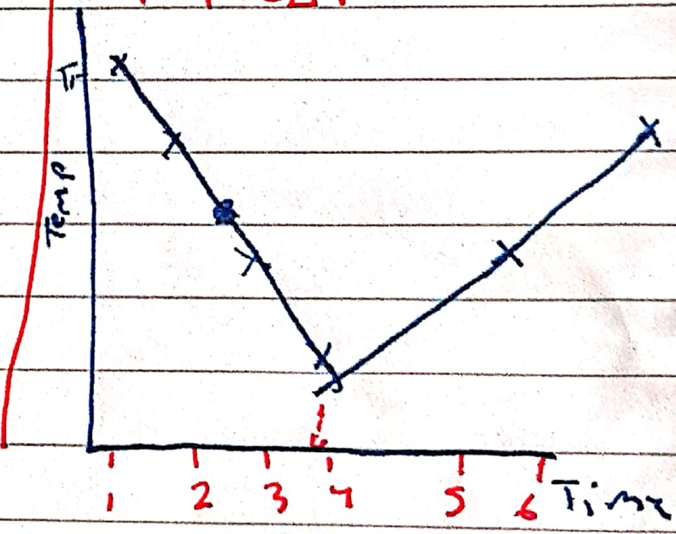
ΔT = change in temp

For system (Energy level diagram).



For surrounding (Temp. diagram)

$Q = mc\Delta T$.



↑Q ↑ΔT

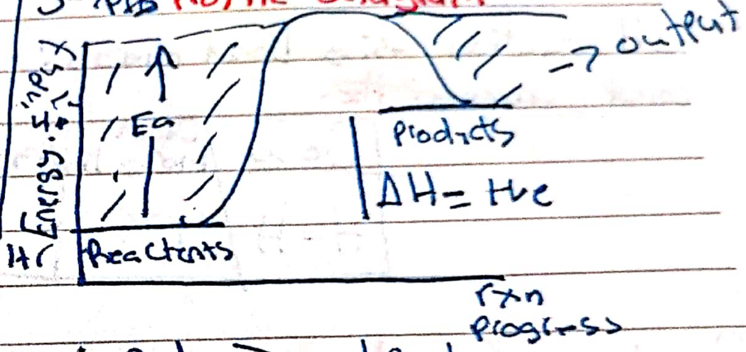
more endothermic

examples on endo :-

1- boiling and melting.
2- Photosynthesis.
3- Thermal decomposition.
4- Electrolysis
5- Photografic films
6- dissolve Ammunium Salt.
7- Breaking down bonds.

How to express endothermic rxn.

1- Reatents → products $\Delta H = +ve$.
2- Reactents + energy → products.
3- ~~Pro~~ Profile diagram:



input > output.

Measuring ΔH reaction.

theoritical
using bond energy

experimental
1- combustion
2- displacement
3- neutrilization.

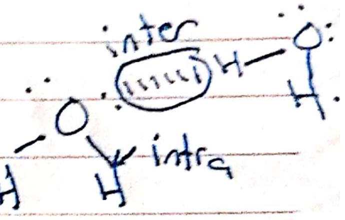
ΔH reaction using Bond energy:

~~Band energy: the~~

Bond	Band energy kj	/mol
H-H	436	

Bond energy: the amount energy needed to break 1mol of a bond in a gaseous state or " " " released to build " " " ".

$H-H_{(g)} \xrightarrow[+436\ kJ/mol]{} H_{(g)} + H_{(g)}$



$H_{(g)} + H_{(g)} \longrightarrow H_{(g)}-H_{(g)}$ +436 kJ/mol

$H_2O_{(s)} \xrightarrow{2000} H_2O_{(l)} \xrightarrow{1500} H_2O_{(g)}$

5000.

$\downarrow$ Ⓔ 1500

$2H_{(g)}$.

$O_{(g)}$

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

to break down bonds in Reactant

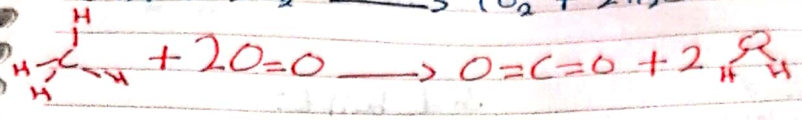
to build up bonds in products.

+ endo
input > output

− exo
output > input

* to use this equation. ① balanced equation
② covalent structure
③ bond energy.

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O.$



Bond	Bond energy
C–H	413
O=O	495.
C=O	799.
O–H	463
C–O	358

→ next page.

Bond broken:

$4 \times C{-}H \Rightarrow 4 \times 413$ +

$2 \times O{=}O \Rightarrow 2 \times 495$

2642 kj

Bond formed:

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

$4 \times O{-}H \Rightarrow 4 \times 463.$

3450 kj.

$\Delta H = \Sigma \text{input} - \Sigma \text{output}.$

$= 2642 - 3450$

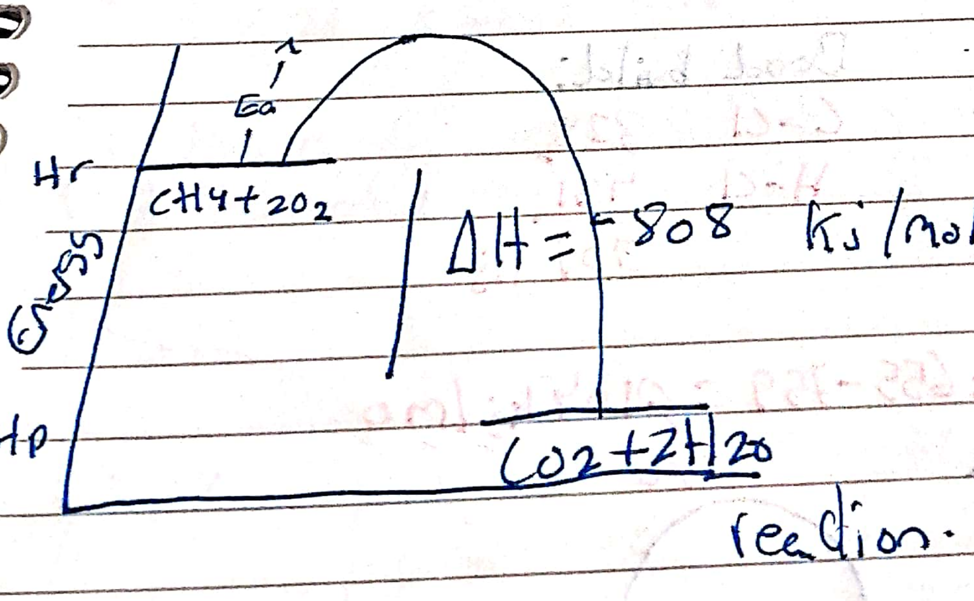
$= -808$ kj/mol

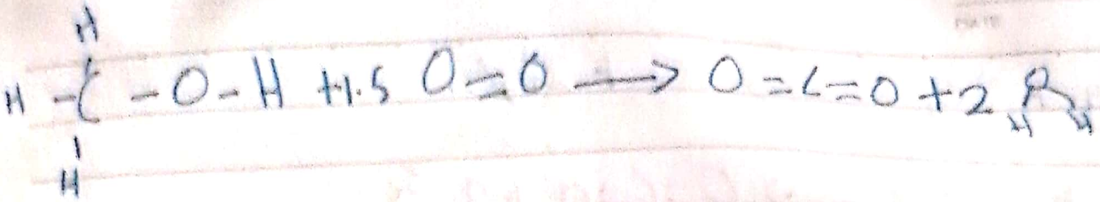
exo

input < output.

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + 808$ kj/mol

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + \Delta H -808$ kj/mol





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

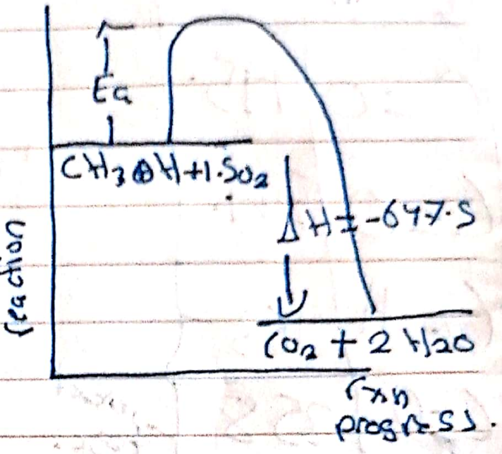
Bond broken:

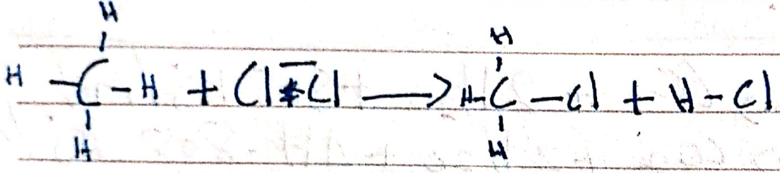
$3 \times C-H$ 3×413 +
$1 \times C-O$ 1×358 +
$1 \times O-H$ 1×463 +
$1.5 \times O=O$ 1.5×495
2800 kj/~~mol~~

Bond build:

$2 \times C=O$ 2×799 +
$4 \times O-H$ 4×463
3050 kj

$\Delta H = \Sigma \text{ input} - \Sigma \text{ output}$
$= 2802.5 - 3450$
$= \ominus 647.5$ kJ/mol
exo.





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

Bond broken:

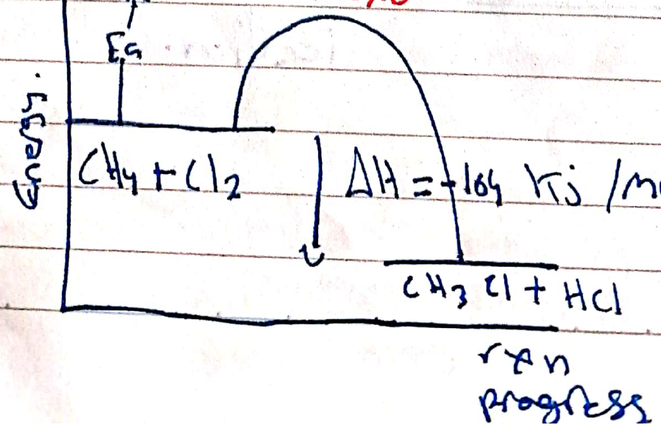
$1 \times C-H$ 413 +
$1 \times Cl-Cl$ 242
655 kj

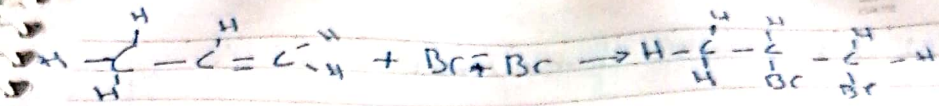
Bond build:

$C-Cl$ 328 +
$H-Cl$ 431
759 kj

$\Delta H = 655 - 759 = \ominus 104$ kj/mo
exo.

Bond	bond energy kJ/mol
C–H	413
Cl–Cl	242
H–Cl	431
C–Cl	328





Bond broken:

Br-Br 193 +
C=C 614
807 kj

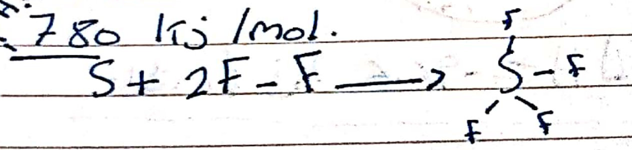
Bond build:

2×C-Br 2×276 +
C-C 347
900 kj

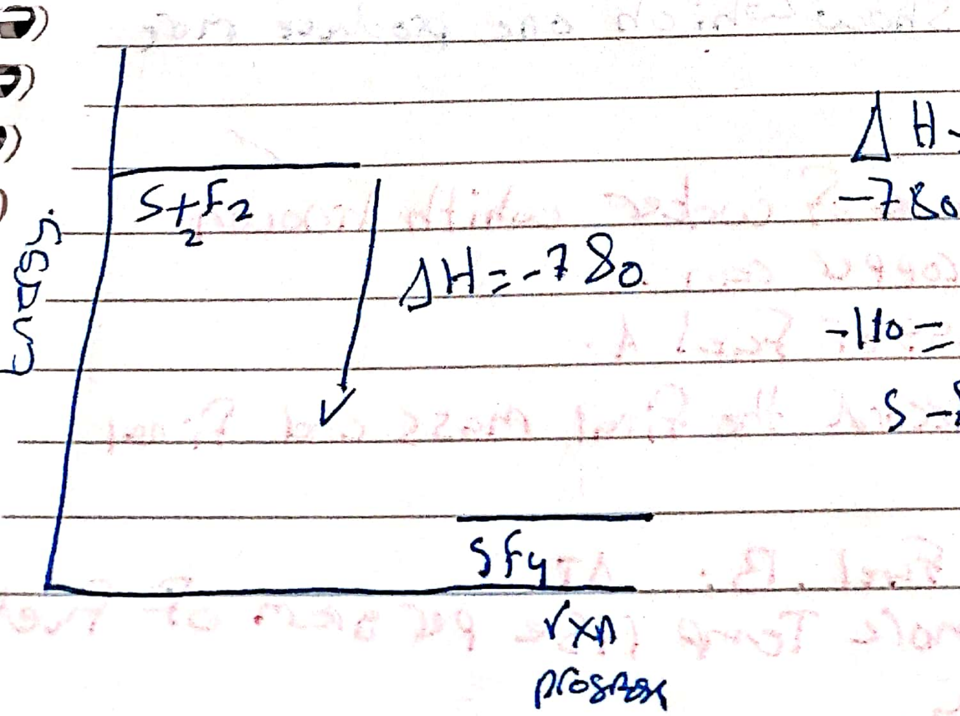
$\Delta H = 807 - 900 = -93$ kj/mol.
exo

Bond	Bond energy kj/mol
C-H	413
C-C	348
C=C	614
Br-Br	193
C-Br	276

when sulfur react with florine the reaction give ΔH: -780 kj/mol.



if the bond energy of F-F is 160 kj/mol.
Find the bond energy of S-F?



ΔH = input - output.
$-780 = (2\times160) = 4\times F-F$

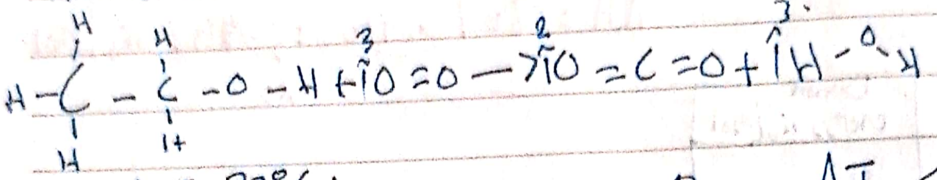
$-110 = 4S-F$
$S-F = 275$ kj/mol

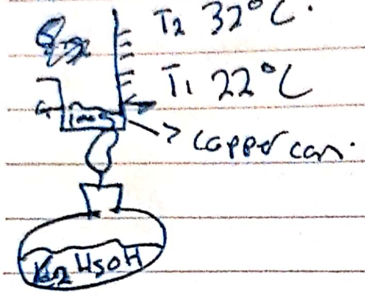
Finding ΔH (energy change) practically:

1] combustion
2] displacement
3] Neutrilization.

Finding ΔH combustion.

$\Delta T = \frac{Q}{mc}$





m1 = 200g
m2 = 198g

$Q = mc\Delta T$.

Energy transfer = 100 × 4.2 × 10
= 4200 J = 4.2 kJ.

4.2 kJ $\xrightarrow{\text{produced}}$ 2g C_2H_5OH
from
1 mole ← = 46g C_2H_5OH

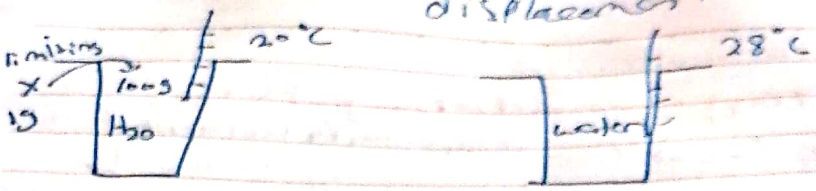
ΔH $\boxed{96.6\ \frac{kJ}{mol}}$

ΔH = -96.6 kJ/mol.

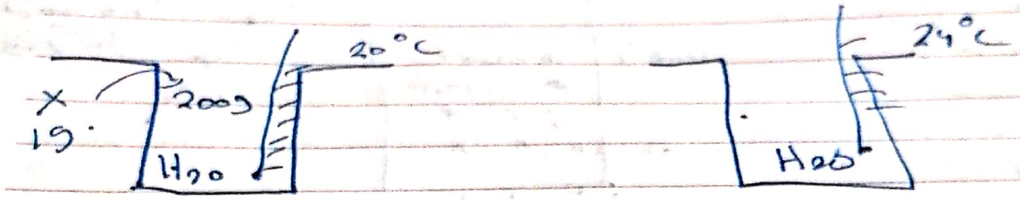
Two fuels A and B.
Plan an exp to show which one produce more energy?

Take a known mass of water whith known initial Temp in a copper can.
Take a known mass of fuel A.
ignite the fuel and record the final mass and final Temp of water.
Repeat the exp using fuel B: ΔT
The fuel which cause more Temp rise per gram of fuel Produce more energy.

displacement.

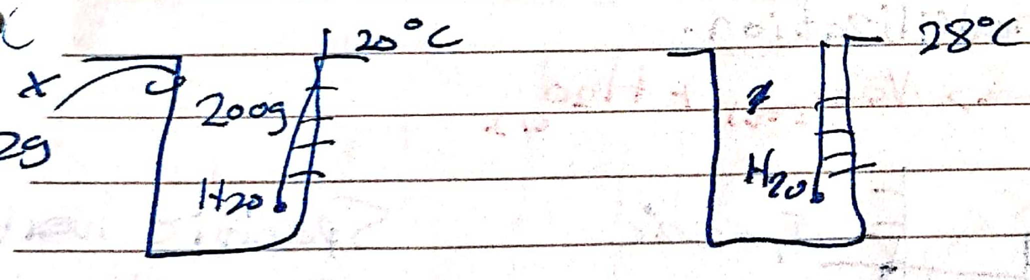


ΔT=8°C



ΔT=4°C

ΔT= 4°C.



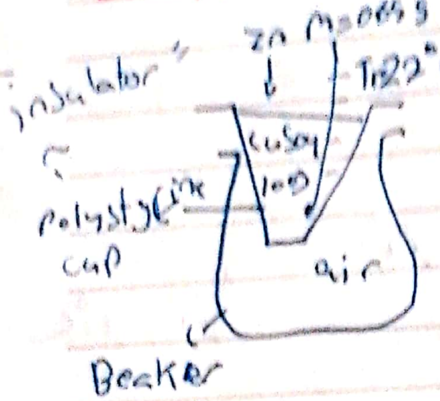
ΔT= 8°C.

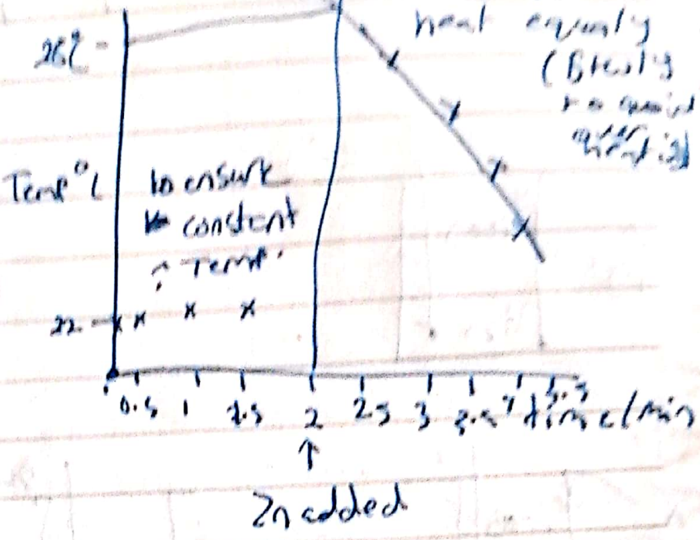
measuring ΔH displacement.

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

Zn m=0.65 g

$T_1 = 22°C$ $T_2 = 28°C$ → stirs with thermometer to distribute heat equally (Evenly to avoid [illegible])





- more insulation
- more stable.

$Q = mc\Delta T$

$= 100 \times 4.2 \times 6$

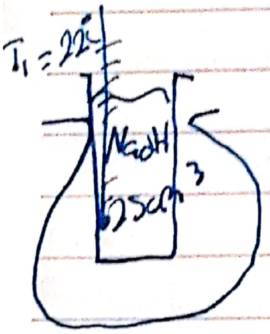
$= 2520\ J$

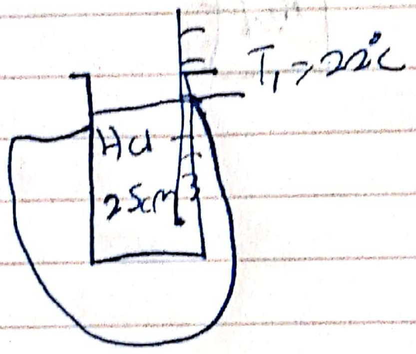
$= 2.52\ kJ$.

---

measuring ΔH neutrilization.

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

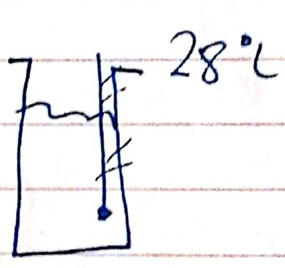




Specific heat capacity

$= 4.2$.

$d = 1g/cm^3$



$Q = mc\Delta T$.

$= 50 \times 4.2 \times 6$

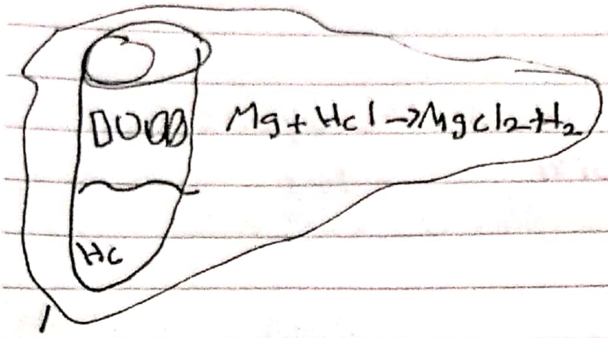
$= 1260.\ J$

$= 1.26\ kJ$.

Altrenative resourcese of energy.

Hydrogen fuell cell.

$2H_2 + O_2 \rightarrow 2H_2O.$



$Mg + HCl \rightarrow MgCl_2 + H_2$

mabcdng .

test water.

- Physical test

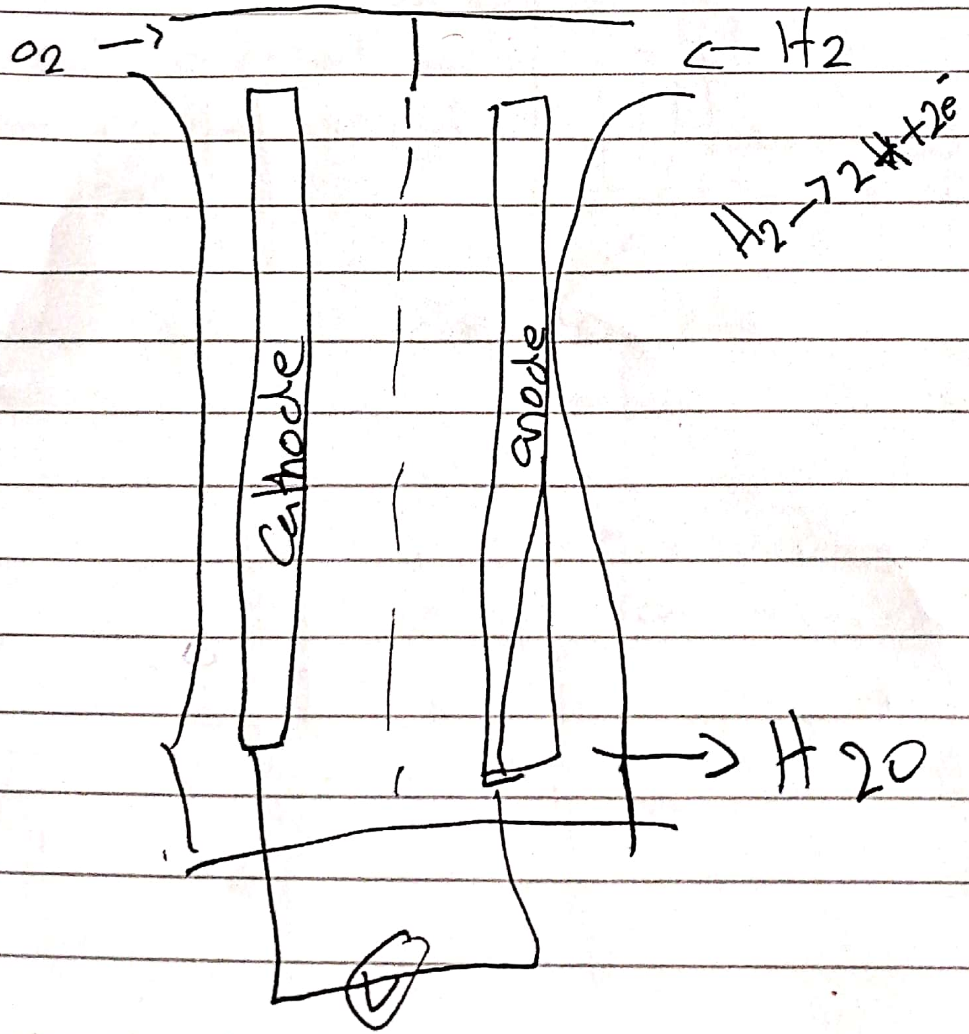
= B.P = 100°C

Chemical test

~~① CuSO4 test white~~

① $CuSO_{4(s)} + 5H_2O \rightleftharpoons CuSO_4 . 5H_2O$
white — blue.

② $CoCl_2 + 6H_2O \rightleftharpoons CoCl_2 . 6H_2O$
blue — pink



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

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

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

Industrial Chemistry.

Dealing with gases.
- Dry
- Collect

Industry of
- NH_3 Haber Process
- H_2SO_4 contact process
- CO_3 carbonate cycle

Extraction of metals
- Al
- Fe
- Zn
- Cu.

Dealing with gas:

Rxn ⟶ $\overset{\text{wet}}{\text{gas}}$ ⟶ dry ⟶ collect

* collect Gas:

Gas syringe:

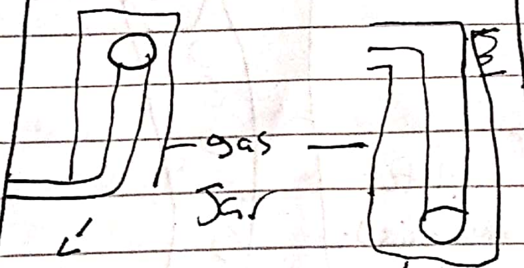
Used to collect and Measure the volume of any gas.

- no mixing with other gases.

Delivery tube:

upward delivery

downward delivery.

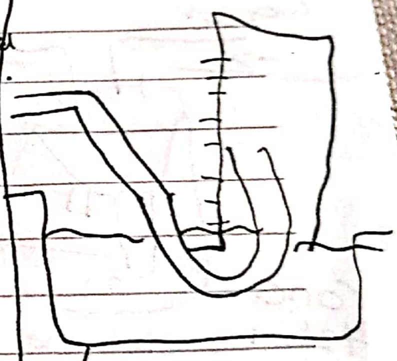


less dense than air

more dense than air

- mix with air.
- can escape

over water:



Trough.

Only for insoluble gas.

O_2: $H_2O_{2(aq)} \xrightarrow{CuO} H_2O_{(l)} + O_{2(g)}$.

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

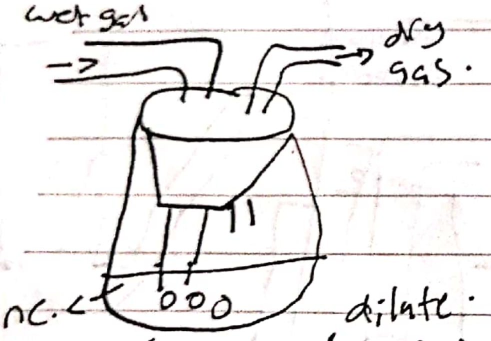
NH_3: $NH_4Cl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O + NH_3$

SO_2: $Na_2SO_3 + HCl \longrightarrow NaCl_{(aq)} + H_2O + SO_2$.

CO_2: $CaCO_3 + HCl \longrightarrow CaCl_2 + H_2O + CO_2$.

Drying gases:

1] concentrated H_2SO_4.



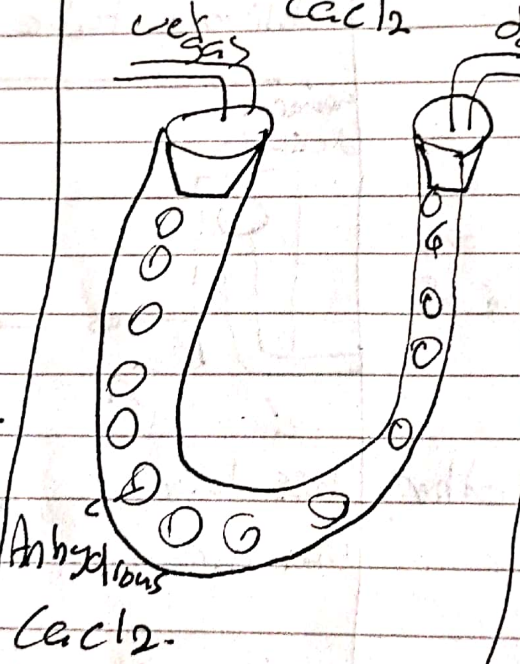
(becomes).

used to dry any gas exept NH_3.

it natiralise the H_2SO_4.

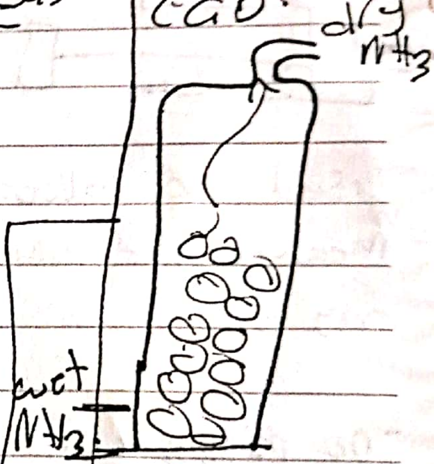
$NH_3 + H_2SO_4 \rightarrow NH_42 + SO_4$.

2] Anhydrous $CaCl_2$



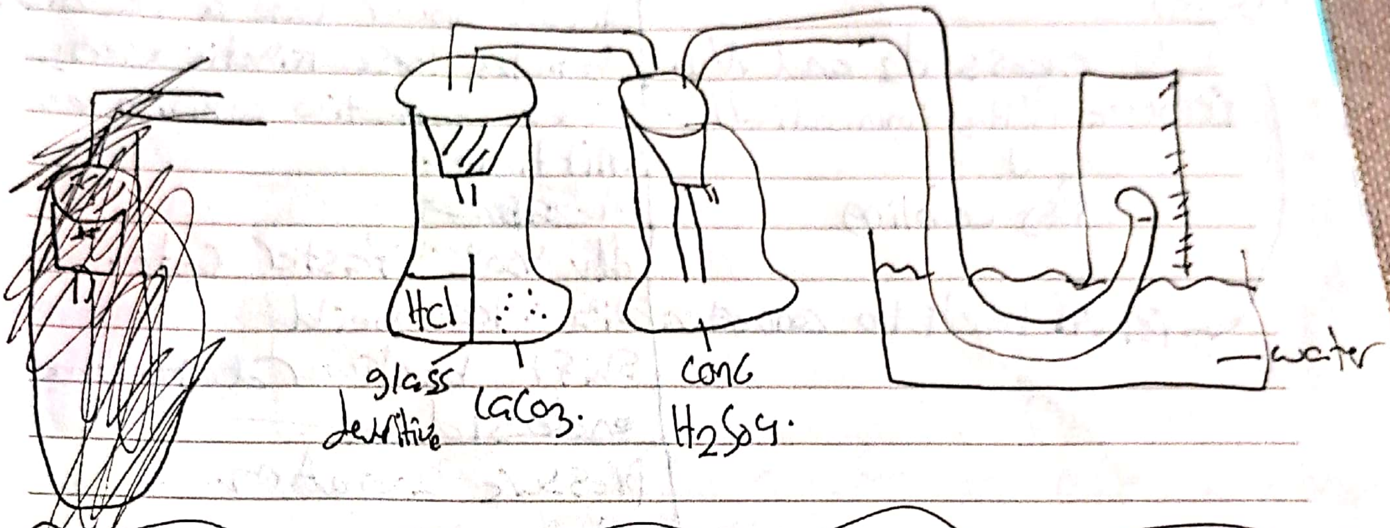
used to dry any gas exept NH_3.

3] Calcium oxide. CaO.



Draw a Suitable apperatus used to collect and measure volume of dry CO_2 (insoluble) gas from.

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



Industrial

prepare fertilizers.

Industry of ammonia. "Haber process".

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

How to obtain :

① nitrogen:- fractional distilation of liquid air.
↓ diffrent B.P
↓ cooling under high ~~ta~~ pressure.

② Hydrogen:- 1) cracking of Alkanes. (organic).
2) $CH_{4(g)} + H_2O_{(g)} \rightarrow CO_{(g)} + 3H_{2(g)}$.

essential condition.

1) temp : 400-450 °C
2) pressure 200 Atm.
3) Iron catalyst

reuse

add excess H_2 and N_2.
remove NH_3 immediatly.
↓
By cooling

→ return back to converter.

Temp 400 °C – 450 °C.
less than 400 °C.

adv: higher yeild NH_3
Shift forward to the exo side.
diss: slower rate of reaction.
Particles loose kinetic energy so less effectiv collision per unit time.

Adv 450 °C: faster rate.
dis : less yeild
Shift backward to the endoside

Pressure 200 atm.
adv:
1- more yield of NH_3 shift forward to the side with fewer gas mole.
2- faster rate.
dis:
1- risk of explosion.
2- expensive.

uses of ammonia.
1- fertelizers.
2- cleaning detergents.
3- Smelling Salts

(Industry of H_2SO_4). Contact process.

Stages: $S \xrightarrow[+O_2]{(1)} SO_2 \underset{+O_2}{\overset{(2)}{\rightleftharpoons}} SO_3 \xrightarrow{(3)} H_2S_2O_7 \xrightarrow{(4)} H_2SO_4$.

Roasting

Contact Process

oleum.

SO2 cause acid rain.

- group (VI).
- valency (2).
- Yellow solid
- ~~SS~~ S_8

uses: * medicine
* match.
* rubber.

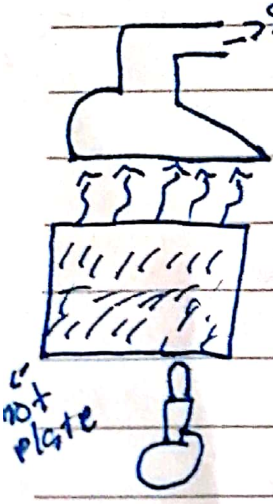
ore: * Zinc blende
ZnS
* from fossile fuel.

* uses of SO2:
kills bacteria.
(Sterilization).
* Paper Industry.
bleaching agent

$$\begin{tikzcd}
SO_3 \arrow[r, "H_2O\ \times"] \arrow[dr, "conc\ H_2SO_4"'] & 2H_2SO_4 \\
& \boxed{H_2S_2O_7} \arrow[u, bend right, "H_2O"']
\end{tikzcd}$$

- highly exo thermic.
- produce low yield of H_2SO_4.

Stage (2).

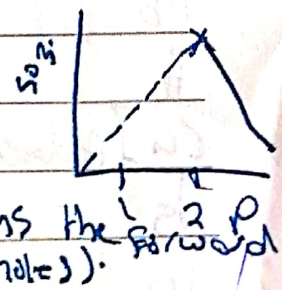


Stage (3).

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

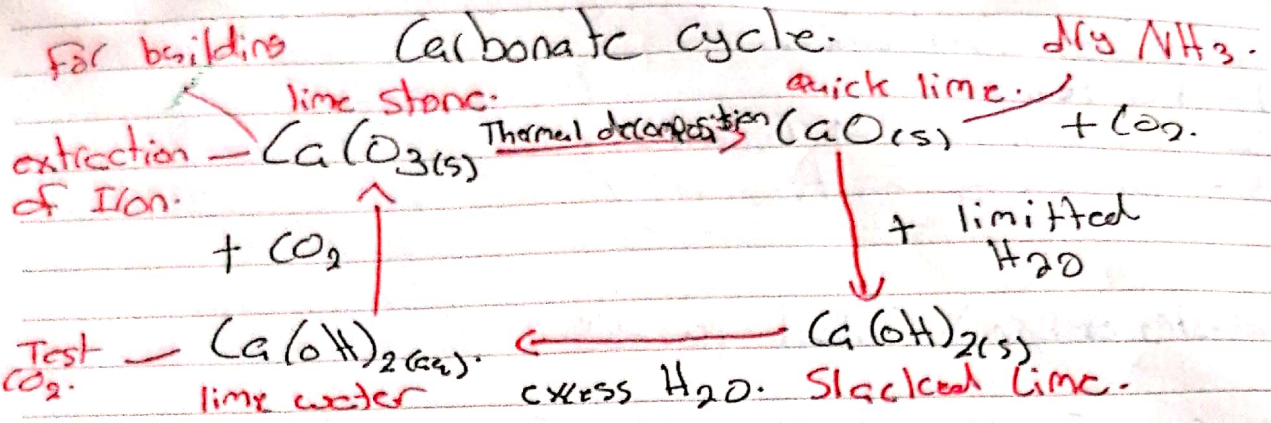
exo.
$\Delta H = -ve$

essential conditions:
1) Temp 400-450 °C.
2) pressure 2 Atm
3) Catalyst V2O5
Vanadium (V) oxide



high pressure favors the forward rxn (fewer gas moles).
2 atm gives max yield of SO3.

Carbonate cycle.



Bases:
- natalise acidic Soilwater.
- desulfomation of flow gases

Extraction of metals.

K
Na
Li
Ca
Mg
Al] Electrolysis/molten
C, CO
Zn] Reduction by C and CO "blast furnace"
Fe
Pb
H
Cu] Reduction by H_2
Ag
Au
Pt

Zn: Zinc blend
Fe: Hematite
Fe_2O_3.
Al: Bauxite
Al_2O_3.
Cu: CuS.

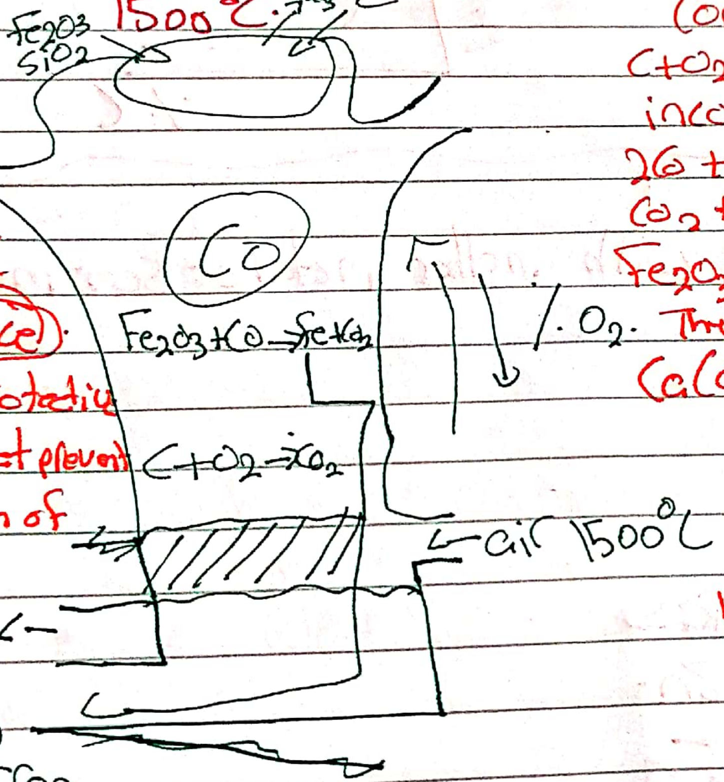
30/11/2022

Extraction of Iron:

Ore: Fe_2O_3 "Hematite"
Methode: reduction by C and CO
Place: blast furnace.

Raw materials:- Fe_2O_3 mixed with SiO_2 acidic Impiurities.

$CaCO_3$ " lime stone "
Coke " Carbon Pure "
air 1500 °C.



waste gases:
CO_2 N_2
CO NO_2

Slag:-
Importance:
form a protective layer that prevent the raction of Fe2O3.

Complete combustion:
$C+O_2 \rightarrow CO_2$ (produce energy)
incomplete combustion:
$2C+O_2 \rightarrow 2CO$
$CO_2+C \rightarrow 2CO$.
$Fe_2O_3+3CO \rightarrow 2Fe+3CO_2$.
Thermal decomposition:
$CaCO_3 \xrightarrow{heat} CaO+CO_2$.

Neutrilization Reaction:
$CaO + SiO_2 \rightarrow CaSiO_3$.
base acid calicium silicate slag.

uses of slage:
Mixed with bitumene to make roads

Steal malting "Oxygen base process.

Cast Iron

Fe

$\boxed{C} \rightarrow CO_2$

$S \rightarrow SO_2$

$Si \rightarrow SiO_2(s)$

$P \rightarrow P_2O_5(s)$.

hot O_2

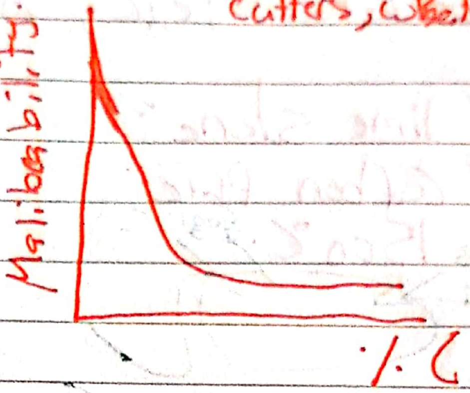
CaO.

lime impurities.

Steel → Mild steal "car bodies.

→ Medium steel. 0.3% C, Railways.

→ Stailessteal 3.5% C cutters, watch



Alloy:

mixture of metal with another metal or semi metal.

Brass Cu, Zn.

bronze Cu, Sn.

Steel Fe, C, Ni, Cr.

Metal

Cu

Brass

Cu, Zn.

harder

different size of metals.

Extraction of Zinc:

Ore:- Zinc blend ZnS.
Method :- reduction by C and CO.
Place:- blast furnace.

C, Co and H_2 can only reduce the less reactive metal only from it's oxide

Step 1:- Roasting with ~~bo~~ hot oxygen.
$ZnS + O_2 \longrightarrow ZnO + SO_2$.

Step 2:-
$C + O_2 \rightarrow CO_2$.
$C + O_2 \rightarrow 2CO$.
$CO_2 + C \rightarrow 2CO$
$CO + ZnO \rightarrow Zn + CO_2$.

the temp inside the furnace 1500°C and B.P at Zi
907°C. So it produced as pure gas must condens
and the other impurities since they have high B.P s
in the furnace.