Redox no reg: Cl_2 / H_2 / Br_2 / I_2 / O_2 / N_2 / H_2

2) CaO_2 3) H_2 → H^+ no redox

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4) Iron III 5) (dilute acidified / aqueous / concentrated / molten)

~~K_2CO_3 / Na_2CO_3 / Li_2CO_3~~

~~$CaCO_3$ / $MgCO_3$ / $Al_2(CO_3)_3$ / $ZnCO_3$~~

~~($FeCO_3$ / $Fe_2(CO_3)_3$)~~ $PbCO_3$ / Cu_2CO_3 / $CuCO_3$

~~Ag_2CO_3~~

Redox → oxydation

Redox → Reduction

in terms	Reduction	oxydation
① oxygen	Lose O	gain O

reduction : Fe in Fe_2O_3

$Al + Fe_2O_3 \rightarrow Al_2O_3 + Fe$

oxidation : Al

reduction : (Zn) in ZnO

$CO + ZnO \rightarrow Zn + CO_2$

oxidation : C in CO

reduction : (Cu) in CuO

$H_2 + CuO \rightarrow Cu + H_2O$

oxydation : H_2

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in terms of	Reduction	oxidation
2) Hydrogen	gain H	lose H

Reduction: Cl_2

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

oxidation: S in H_2S

Ex $Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$

$MnO_4^{-1} + Fe^{+2} + H^{+} \rightarrow Mn^{+2} + Fe^{3+} + H_2O$

	Reduction	oxidation
3) oxidation state	decrease	increase

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

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

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

Rules for oxidation state.

1) the oxidation state for any free elem
= zero

monoatomic: Na/K/Ne/

Diatomic: H_2/O_2/ N_2/ F/

Po... P... S...

Read the Q

Subject $Fe_2(O_2)_3$ → (Fe III peroxide) Day Date

2) The oxidation number of any atom in a compound form
group 1 = +1 Li/Na/K/Rb/Cs/Fr
group 2 = +2 Mg/Ca/Sr/Ba exept Be
group 3 = +3 always +3 only for Al
group VII = -1 always -1 only for (F)

3) The oxidation number of hydrogen (+1) exept with metal in metal hydride
$\overset{+1}{C}H_4$ / $N\overset{+}{H}_3$ / Na^+H^- / $\overset{+2}{Ca}\overset{(-1)}{H_2}$

4) The oxidation state of ox (-2) exept in peroxide (-1)
in OF_2 (+2)

O^{2-} Oxide O_2^{-2} peroxide

sodium oxide $\overset{+1}{Na} + O^{-2}$ → Na_2O
sodium peroxide $\overset{+1}{Na} + O_2^{-2}$ → Na_2O_2
H_2O^{-2} $\overset{+1}{H_2}\overset{-1}{O_2}$
water hydrogen peroxide

Calcium oxide — pero.
$\overset{+2}{Ca}\ \overset{-2}{O}$ $Ca^{+2}\ O_2^{-2}$

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5) The sum of all oxidation state in a compound = 0

In an ion = charge of this ion

$Na^{+}Cl^{-}$ $+1 + x = 0$ $x = -1$

$H^{+1}ClO^{2-}$ $1 + x - 2 = 0$

$x = +1$

$H^{+1}ClO_2^{-2}$ $1 + x + 2(-2) = 0$

not peroxide

$x = 3$

$x = +3$

NH_3^{+1} $N + 3 = 0$

$N = -3$

NO $N + (-2) = 0$

$N = 2$

N_2O_5 $2N + 5(-2) = 0$

$2N = 10$

$N = +5$

H_2S H_2SO_4 SO_3

Note: $NaBH_4$

Na^{+1} B^{+3} H_4^{-1} +1

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NO_3^{-1} $N + -6 = -1$

$N = 5$

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

$Mn = +7$

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

$S = 4$

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

$Cr = +6$

Q. Find the oxidation state of each underlined species.

Fe_2O_3	OF_2	SO_4^{-2}
Fe: +3	+2	+6
V_2O_5	PO_4^{-3}	CrO_4^{-2}
+5	+5	+6
CO	CO_2	CO_3^{-2}
+2	+4	+4

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* $2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$

0   +3 −2   +3 −2   0

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

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

* $CO + ZnO \rightarrow Zn + CO_2$

+2 −2   +2 −2   0   +4 −2

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

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

* $H_2S + Cl_2 \rightarrow HCl + S$

+1 −2   0   +1 −1   0

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

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

* $MnO_4^{-1} + Fe^{+2} + H^{+} \rightarrow Mn^{+2} + Fe^{+3} + H_2O$

+7 −2   +2   +1   +2   +3   +1 −2

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

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

Read the Q

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$Cr_2O_7^{-2} + Sn^{+2} + H^{+} \rightarrow Cr^{+3} + Sn^{+4}$

+6 −2 +2 +1 +3 +4

$+ H_2O$

H −2

oxidation = $Sn^{+2} \rightarrow Sn^{+4}$

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

+1 +5 −2 +1 −1 +1 −1 +1 +5 −2

$AgNO_3^{-} + NaCl \rightarrow AgCl + NaNO_3$

Not redox

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

Oxidation: $Na \rightarrow Na^{+}$ — violent and dangerous reaction

red: $H^{+} \rightarrow H_2$

+1 −1 +1 −2

$H_2O_2 \rightarrow H_2O + O_2^{0}$

$Fe + O_2^{-} \rightarrow 2O^{-2}$

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

$O_2^{-} \rightarrow O_2^{0} + 2e^{-}$

0 +3 −2 +3 −2

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

Half of oxidation: $Al \rightarrow Al^{+3}$,

half of reduction: $Fe^{+3} + 3e^{-} \rightarrow Fe$

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

Read the Q

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Writing balanced half ionic equation.

1) Atoms

2) the charge by adding é's to the side with greater charge by the difference.

$Ca^{0} + Zn^{+2}Cl_2 \rightarrow Ca^{+2}Cl_2^{-1} + Zn^{0}$

H.O.O $Ca \rightarrow Ca^{+2} + 2é$

H.O.R $Zn^{+2} + 2é \rightarrow Zn$

overall reaction $Zn^{+2} + Ca \rightarrow Ca^{+2} + Zn$

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

HOO $Na \rightarrow Na^{+} + é) \times 2$

H.O.R $2H^{+} + 2é \rightarrow H_2$

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

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$Ca^{0} + Al^{+3}Cl_3 \rightarrow Ca^{+2}Cl_2 + Al$

H.O.O $(Ca \rightarrow Ca^{+2} + 2e)3$

H.O.R $(Al^{+3} + 3e \rightarrow Al)2$

$3Ca + 2Al \rightarrow 3Ca + Al$

$H_2S^{-2} + Cl_2^{0} \rightarrow HCl + S^{0}$

H.O.O $S^{-2} \rightarrow S + 2e$

H.O.R $Cl_2 + 2e \rightarrow 2Cl$

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

Reactants → Products

Oxidation → e (loose e)

reduction e → (gain e)

OIL RIG →

Oxidation is loose e

Reduction is gain e

no need to know now

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

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

H.O.R $(6H^+ + 6e^- \rightarrow 3H_2)$ 3

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

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

H.O.O $(5Fe^{+2} \rightarrow 5Fe^{+3} + 5e^-)$ 5

H.O.R $5e^- + Mn^{+7} \rightarrow Mn^{+2}$

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

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

H.O.O $(3Sn^{+2} \rightarrow 3Sn^{+4} + 6e^-)$ 3

H.O.R $(2Cr^{+6} + 6e^- \rightarrow 2Cr^{+3})$ 2

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$3Sn^{+2} + 2Cr^{+6} \rightarrow 3Sn^{+4} + 2Cr^{+3}$

$H_2S^{2-} + Cl_2^{0} \rightarrow HCl^{-} + S^{0}$

HOO : $S^{-2} \rightarrow S^{0} + 2e^{-}$

HOR : $Cl_2^{0} + 2e^{-} \rightarrow 2Cl^{-}$

overall reaction: $S^{-2} + Cl_2^{0} \rightarrow 2Cl^{-} + S^{0}$

oxydising agent and reducing agent

oxydising agent "oxydant"

	reducing agent oxid	oxidising agent reduction
O	gain O	lose O
H	lose H	gain H
ox state	↑	↓
e transfer	lose e	gain e

oxydising agent or oxydant"

The substance that itself reduces

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and causes the other substance to be oxidise.

* Reducing agent "reductant"

The substance that itself oxidised and causes the other substance to be reduced.

If the substance is an ion or a compound the agent is the compound itself.

$Al^{0} + Fe_2^{3+}O_3^{2-} \rightarrow Al_2O_3 + Fe^{0}$

oxidation: Al — reducing agent: Al

Reduction: Fe^{3+} — oxid~ agent: Fe_2O_3

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

oxidation: C^{+2} — reducing agent: ZnO

reduction: Zn^{+2} — oxid~ : CO

$H_2^{+1}S^{-2} + Cl_2^{0} \rightarrow HCl^{-} + S^{0}$

oxidant: Cl_2 — reductant: H_2S

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$\overset{+7}{MnO_4^-} + \overset{+2}{Fe} + \overset{+}{H} \rightarrow \overset{+2}{Mn} + \overset{+3}{Fe} + H_2O$

oxidising agent MnO_4^- reductant: Fe^{+2}
oxidation ; Fe^{+2} reduction: Mn^{+7}

most common oxidising agent

1) oxygen $\overset{0}{Fe} + \overset{0}{O_2} \rightarrow \overset{+3}{Fe_2}\overset{-2}{O_3}$
$\overset{0}{S} + \overset{0}{O_2} \rightarrow \overset{+4}{S}\overset{-2}{O_2}$

2) Acidify potassium manganate ($KMnO_4$/H^+) VII

$MnO_4^- \rightarrow Mn^{2+}$
+7 → +2
purple → colorless

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

$Cr_2O_7^{2-} \rightarrow Cr^{3+}$
(+6) → (+3)
Orange → green

4) Halogens $2e^- + F_2 \rightarrow 2F^-$ (yellow → colorless)
$2e^- + Cl_2 \rightarrow 2Cl^-$ (greenyellow)
$2e^- + Br_2 \rightarrow 2Br^-$ (red brown)
$2e^- + I_2 \rightarrow 2I^-$ (purple gas, black solid, Red brown solution (aq))

(Q) H_2O_2

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Most common reducing agent

① Hydrogen: $H_2 + CuO \rightarrow H_2O + Cu$

② carbon and carbon monoxide

$\overset{0}{C} + \overset{+3}{Fe_2}\overset{-2}{O_3} \longrightarrow \overset{0}{Fe} + \overset{+2}{CO}$

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

③ Iodide

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

colorless → red brown

4) metals: K — K^+ weaker oxidant

stronger reductant

Na

Li

Ca

Mg

Al

C/CO

Zn

Fe

Pb

H

Cu

Ag — Ag^+ stronger oxidant

weakest reductant

• metal more reactive, more likely to lose e^- / more likely to oxidize / more likely to be a reducing agent

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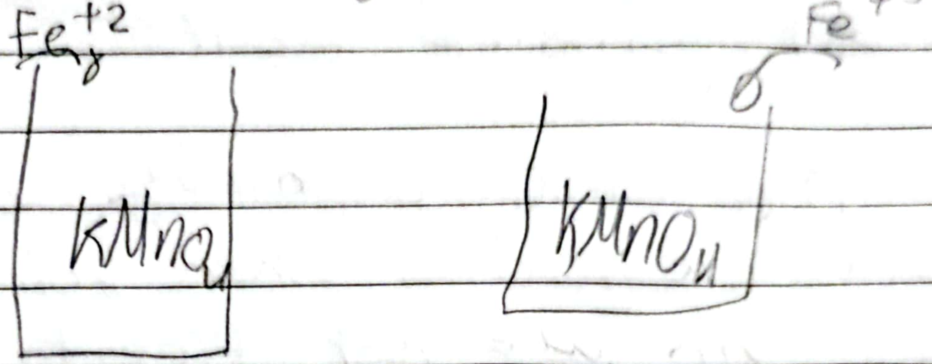
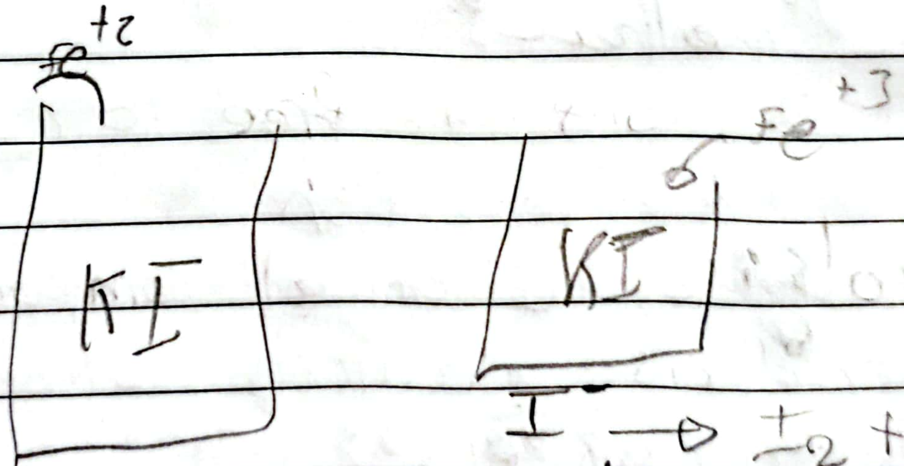
Q: Fe^{2+} is a reducing agent
Fe^{3+} is an oxising agent
Record the observation in each of the following reactions:

① 

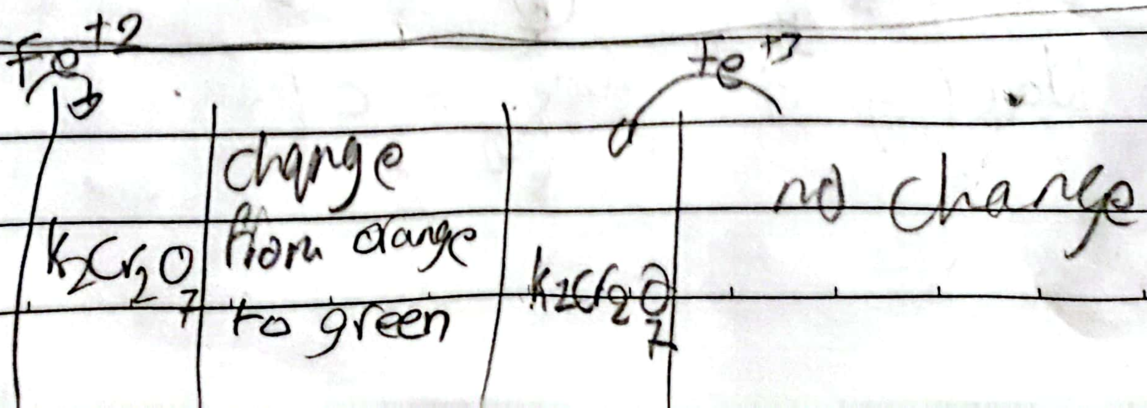
change color from purple to colorless — stays purple

② 

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

stays colorless — red brown

$Fe^{+3} + I^- \rightarrow Fe^{+2} + I_2$

③ 

Br molten → red brown gas
9) electrons move from anode → cathode
9) check charges
III) cathode (positive) attach to cathode

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Electrolysis

electron

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

Why the ionic compounds don't conduct electricity when solid?
Their 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 in aqueous or molten

Electrolyte : chemical compound that conducts electricity when molten or aqueous.

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

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

12) Read the question carefully (anode / cathode) (active / inert)

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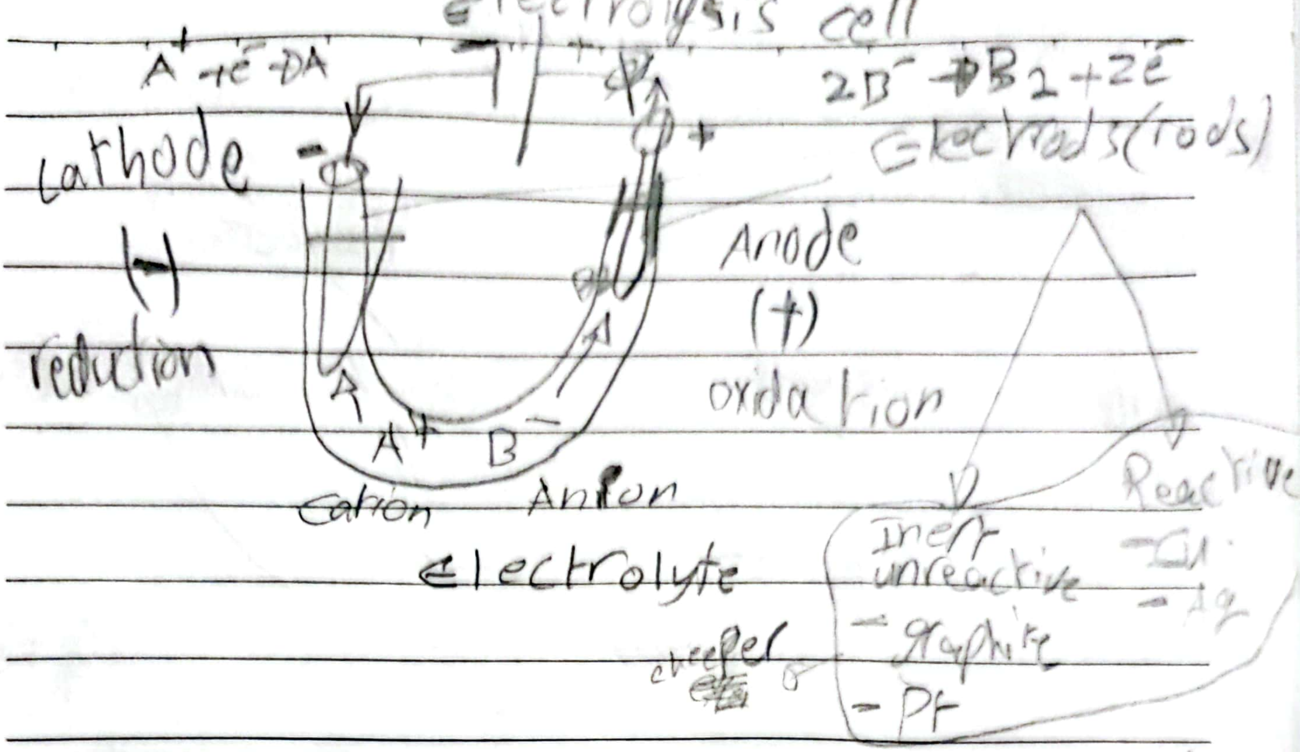

* Cathode: The -ve rod that attracts the +ve ions (cations) where the reduction occurs.

* Anode: The +ve rod that attracts the -ve ions (anions) where the oxidation occurs.

Electrolysis = Discharging

Ion ⟶ element

Cations	Anions
$e^- + Na^+ \rightarrow Na$	$2F^- \rightarrow F_2 + 2e^-$
$2e^- + Mg^{+2} \rightarrow Mg$	$2Cl^- \rightarrow Cl_2 + 2e^-$
$2e^- + Ca^{+2} \rightarrow Ca$	$2Br^- \rightarrow Br_2 + 2e^-$
$3e^- + Al^{3+} \rightarrow Al$	$2I^- \rightarrow I_2 + 2e^-$
$2e^- + 2H^+ \rightarrow H_2$	$2O^{-2} \rightarrow O_2 + 4e^-$

1/ graphite ... conduct electricity

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Electrolysis

Electrolyte
- molten
- aqueous

Rods
- inert
- Active

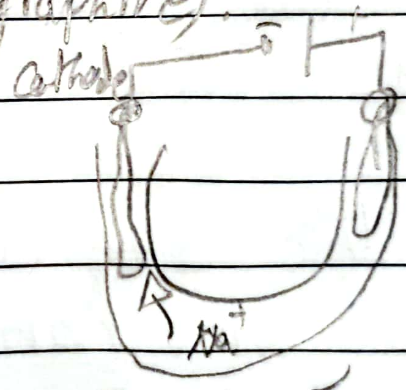
1 (molten – inert), 2 (aqueous – inert), 3 (molten – Active)

Electrolysis for molten electrolyte using inert rods (graphite).

$NaCl_{(l)}$

Total ions: Na^+, Cl^-

cathode, anode



$Na^+ + e^- = Na$ — deposite of metal

$2Cl^- = Cl_2 + 2e^-$ — bubbles of green yellow gas

Electrolyte: used up

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

F_2 Yellow gas Br_2 ... and liquid
Cl_2 green yellow gas
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I_2 black solid
purple gas
red brown solu.

* molten lead II Bromide

$PbBr_2$ (l)

Totalions Pb^{+2} Br^-

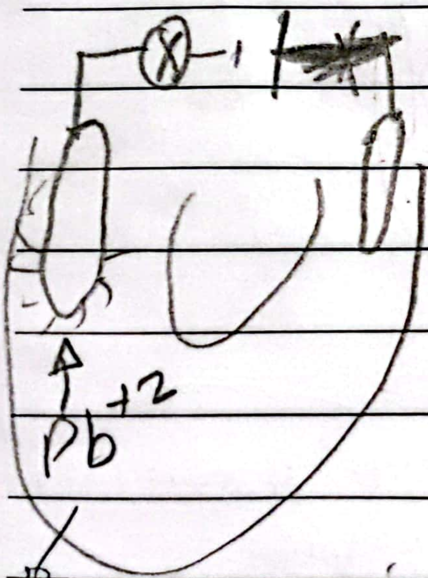
cathode anode

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

$2e^- + Pb^{+2} \rightarrow Pb$ bubbles red brown gas

deposite of metal

Electrolyte used up



conduct electricity because of metals.

$CuCl_2$ (l) / graphite

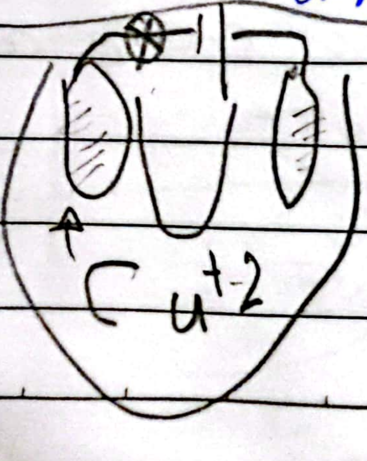
$CuCl_2$

total ions Cu^{+2} Cl^-

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

cathode red brown Anode

→ deposite of metal bubbles of green yellow



Electrolyte used up

why we can't extract
because H^+ will be more likely to reduce not the Al

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$Al_2O_{3(l)}$ / graphite

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

cathode | Anode

Electrolyte used up

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

deposite of metal | bubbles of colorless gas

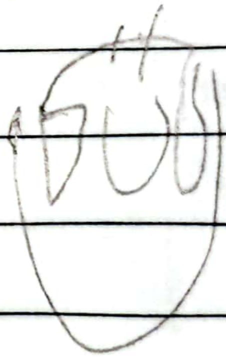
* Electrolysis of aqeous electrolyte using inert.

AB

A^+ B^-

H^+ OH^-

Cathode Anode



At the cathode

The less reactive Ion is more likely to reduce and the more reactive stays in the electrolyte

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K^+	At the anode
Na^+	always OH^- exept concentrated
Li^{+1}	halide, Cl^- / Br^- / I^-
Ca^{+2}	when the halide oxidise
Mg^{+2}	$2Cl^- \rightarrow Cl_2 + 2e^-$
Al^{+3}	
Zn^{+2}	when OH^- oxidise.
$Fe^{+2/+3}$	
Pb^{+2}	$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$
$2H^+ \rightarrow H_2$	bubbles of colorless gas.
$Cu^{+1/+2}$	
Ag^+	concentrated $NaCl_{(aq)}$ / graphite
Au^{+3}	

Na^+ $\qquad$ Cl^-

H^+ $\qquad$ OH^-

Cathode $\qquad$ Anode

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

bubbles of colorless gas $\qquad$ bubbles of green yellow gas

Electrolyte = NaOH

$CuSO_{4(aq)}$ / graphite

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

H^+ $\qquad$ OH^-

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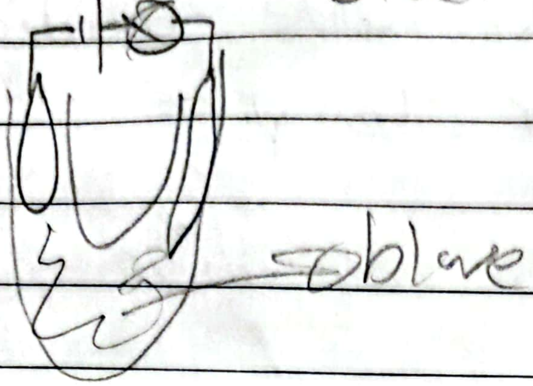
cathode

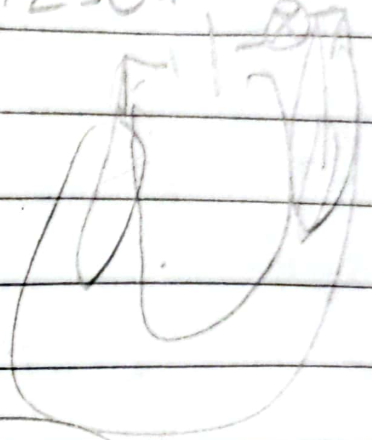
anode

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

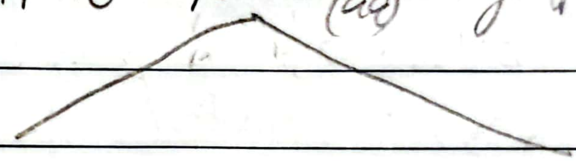
$4OH^- \rightarrow 2H_2O + O_2 + 4e$

electrolyte : H_2SO_4





dilute $NaCl_{(aq)}$ / graphite



Na^+

H^+

cathode

Cl^-

OH

anode

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

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

bubbles of colorless

bubbles of colorless gas

electrolyte : NaCl (become more concentrated)

gas	test	result
H_2	lighted splint	Pop
O_2	glowing splint	relights
[illegible]	[illegible]	[illegible] then bleach

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Conc. $KI_{(aq)}$ / 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

con. $CuCl_{2(aq)}$ / graphite

Cu^{+2} Cl^-

H^+ OH^-

cathode Anode

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

deposite of red brown sollid. bubbles of green yellow gas.

Electrolyte: less cons. $CuCl_2$

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concentrated sodium chloride called brine solution

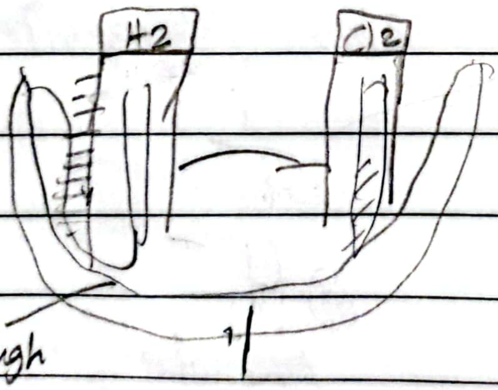
$NaCl_{(aq)}$

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

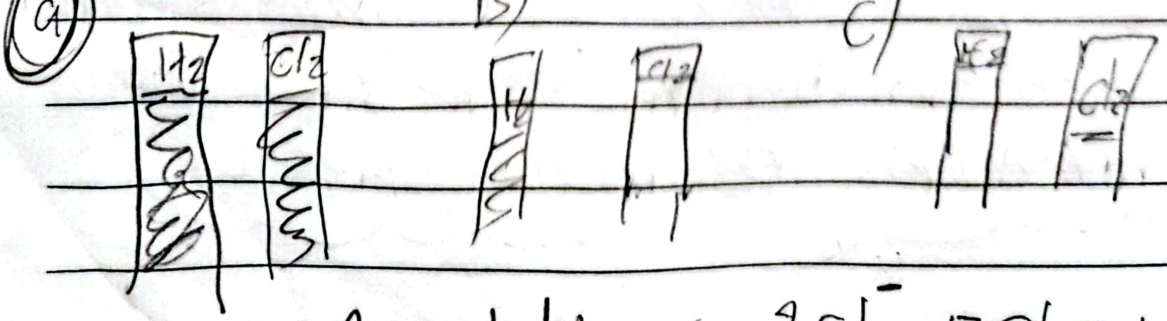
$2H^+ + 2e^- \rightarrow H_2$ $\quad$ $2Cl^- \rightarrow Cl_2 + 2e^-$

electrolyte = NaOH

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



Q2) The final appearance



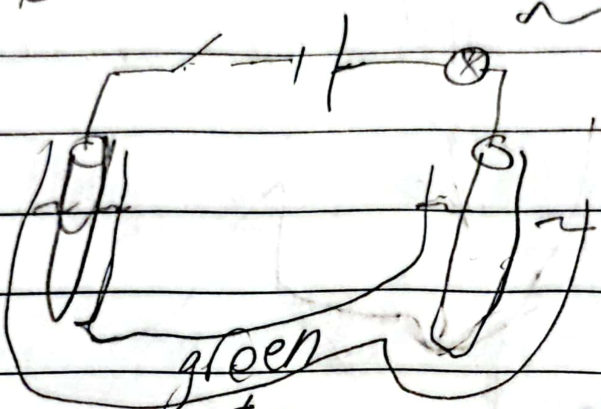
Half eq oxidation: $2Cl^- \rightarrow Cl_2 + 2e^-$

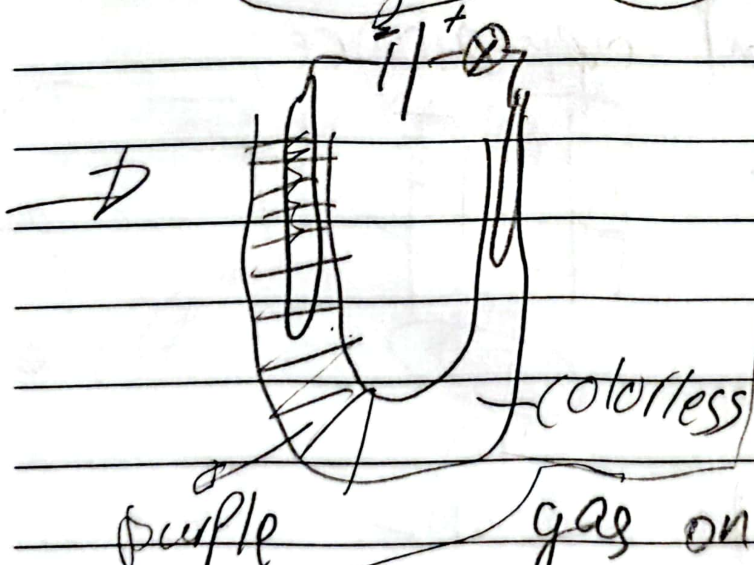
Half of reduction : $2H^+ + 2e^- \rightarrow H_2$

overall reaction: $2H^+ + 2Cl^- \rightarrow H_2 + Cl_2$

1 : 1

Q3) Brine with universal indicator





observation :
1- 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 becomes purple because NaOH is an alkal

5) around the anode the solution becomes colorless since Cl_2 bleach the color.

... Cl_2 not immediately appear as H_2 produce? some Cl_2 dissolve in solution.

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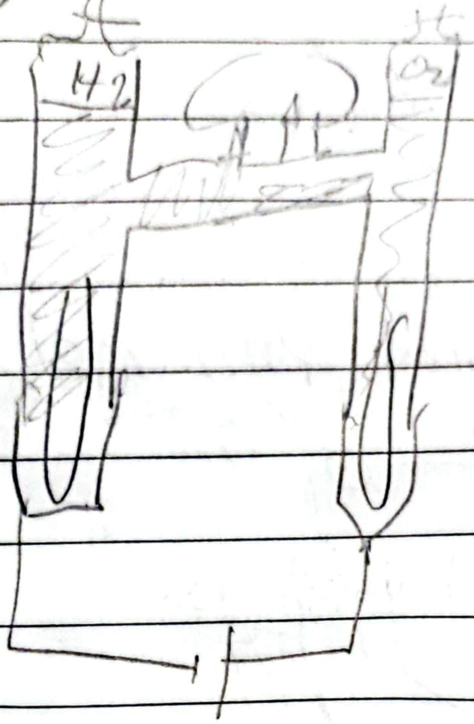
Electrolysis for H_2SO_4 (aq)



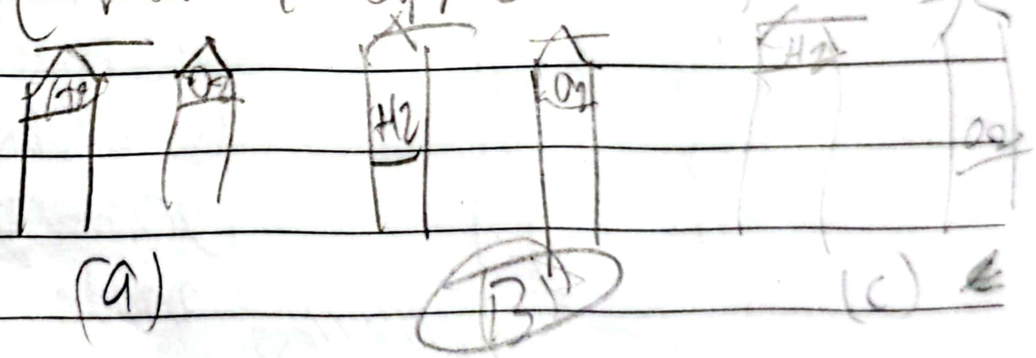
H_2SO_4 → H^+, SO_4^{-2}

H^+ OH^-

H_2 (cathode) / anode

O_2

The final appearance:



$4H^+ + 4e^- \rightarrow 2H_2$

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

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

~~The Cl2 not immediately~~

appear

$Cu^{+2} + 2e^- \rightarrow Cu$ cathode gain mass.
electrons move from anode to cathode

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Electrolosis

Electrolysis : for aquous electrolyte using active rod.

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

$CuSO_4(aq)$ —using→ Cu rod

$AgNO_3(aq)$ —using→ Ag rod

Electrolyte : for aquous $CuSO_4$ using Cu(s)

$CuSO_4(aq)$

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

the anode itself oxidize

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

Electrolyte only allows the ions to pass through

UY

Cu rods?

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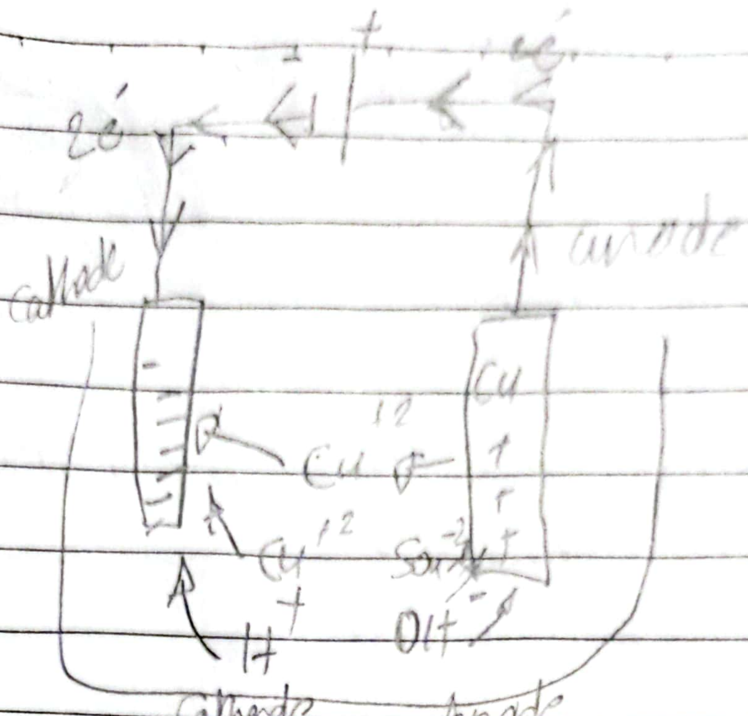
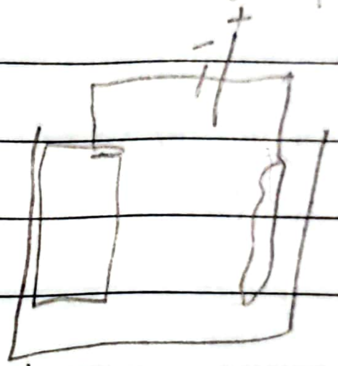


cathode $Cu^{+2} + 2e^- \rightarrow Cu$ Anode $Cu \rightarrow Cu^{+2} + 2e^-$



↑ cathode mass
Cu deposite

Anode
↓ mass
oxidised by lose e^-

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

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Applications on Electrolysis

- molten/inert
  - Extraction of metals.
- aqueous/inert
  - prepare solution
- electroplating / purifying metals

$NaCl_{aq}$

Na^+ $Cl^- \rightarrow Cl_2$

H^+ OH^-

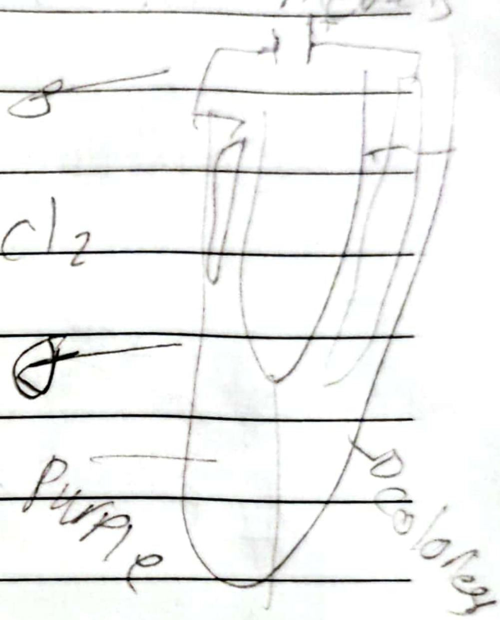
$NaOH$

$CuSO_4(aq)$

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

H^+ $OH^- \rightarrow O_2$

H_2SO_4



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Conc. KI (aq)

K^+ I

H^+ OH

H_2 cathode anode

$Pb(NO_3)_2(aq)$

Pb^{+2} NO_3^-

H^+ OH^-

cathode anode

H_2 O_2

H_2SO_4

H^+ SO_4^{-2}

H^+ OH

cathode anode

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

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~~$4H^+ + NO_3^-$~~ ~~$\rightarrow 2H_2O + O_2 + 2H_2$~~

not included; but read in case

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

Electroplating:
Coating a metal with another metal using electrolysis.

why? 1) to prevent rusting and corrosion
2) more attractive

How to electroplate a metal spoon with silver?
1) clean the spoon from any impurities as 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 contain Ag^+ eg $AgNO_3$
5) turn on the circuit "be sure that the spoon is fully immersed in the electrolyte".

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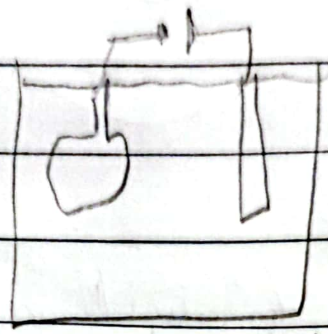
6) Rotate the spoon to ensure an equal distribution.

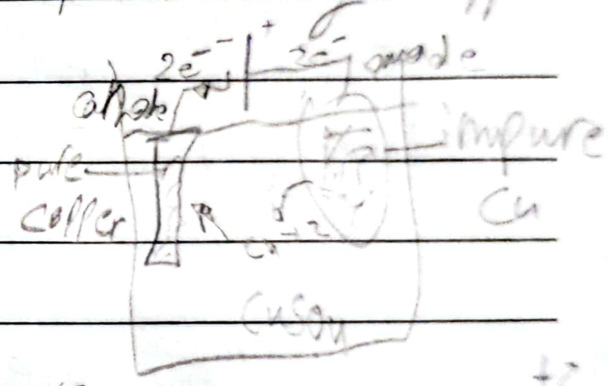
7) rinse with distilled water.

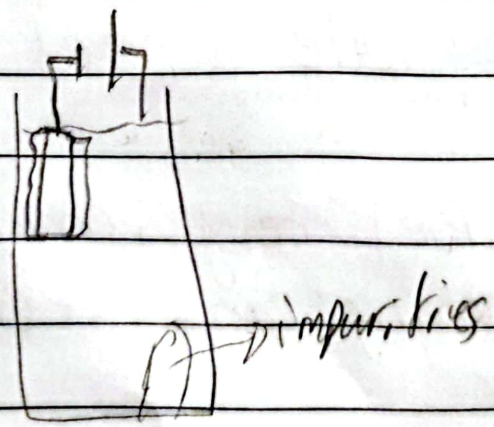
8) dry in oven



2/ purifying metals / Refining copper.

Acidified copper II sulphate.





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

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

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

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K
Na
Li
Ca
Mg } electrolysis / molten / graphite
Bauxite → Al
Al_2O_3
C, CO
zinc (II) blende ZnS → Zn } reduction by C, CO
Hematite Fe_2O_3 → Fe
Pb
H } reduction by H_2
copper (II) sulphide CuS → Cu
Ag
Au

Extraction of Aluminum

Ore : Al_2O_3 Bauxite

method: Electrolysis for molten Al_2O_3 using graphite rods.

* m.p of Al_2O_3 is about 2000°c.
so we disolve Al_2O_3 in a molten cryolite Na_3AlF_6

* to lower the m.p to 900°c so less cost
* to increase the electrical conductivity

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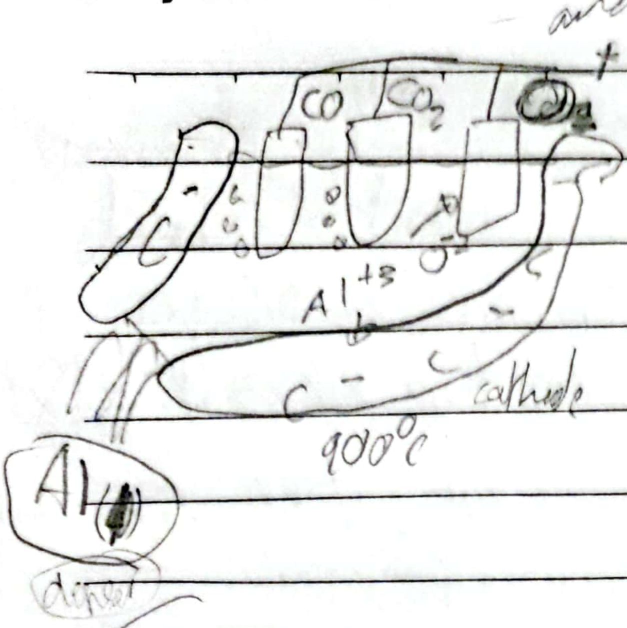

Electrolyte: molten mixture of pure Al_2O_3 dissolved in molten cryolite.

gases produced at anode 1) O_2 2) CO 3) CO_2

reaction of rods with O_2 so we must replace them periodically

$Al_2O_{3(l)}$ → Al^{+3} (cathode), O^{-2} (anode)

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

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

property	use
- low density	- Aircraft bodies
- ductile	- electrical wires.
- malleable	- window frame, cooking utensils
- conduct	- wires
- Form an oxide layer which is nontoxic	- food cans

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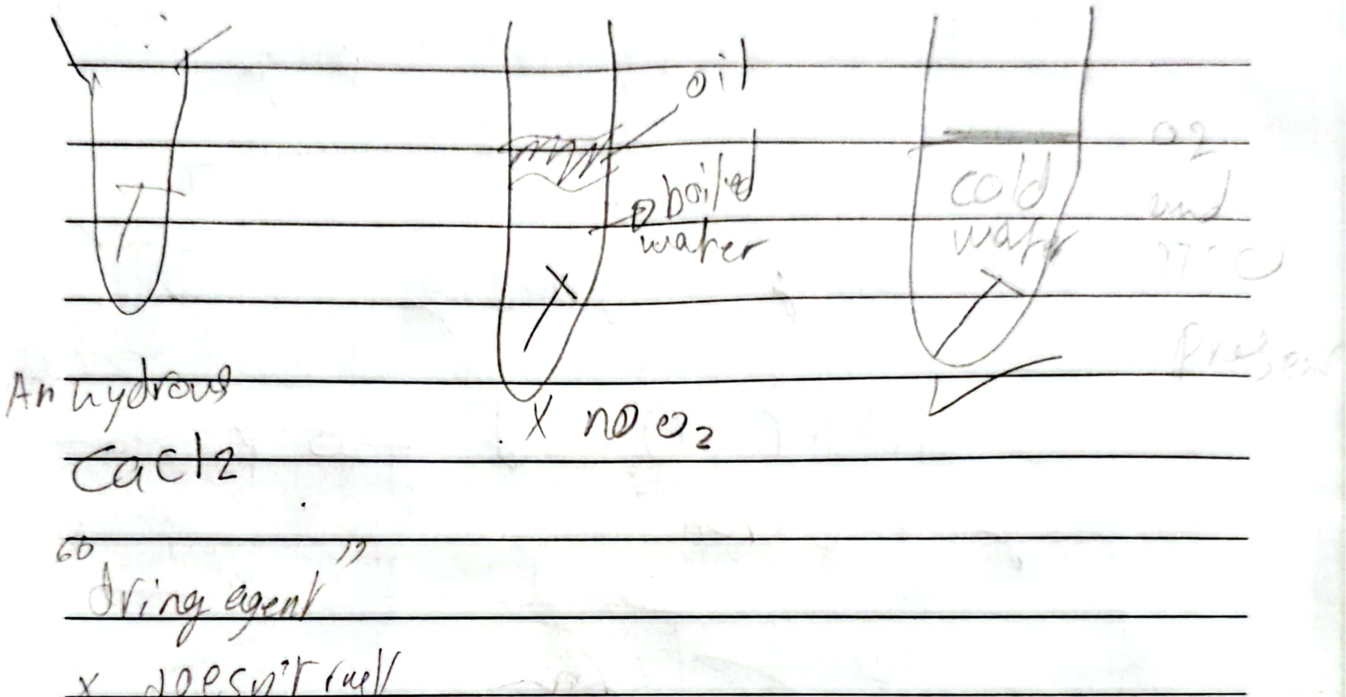
Rusting

Rust: reaction of (Iron) with both O_2 and H_2O

slow reaction → 6-7 days.



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

brown / red brown

Q. plan an experiment to show which rust prevention solution is better.

1) Take a known mass of Iron nail
2) apply a known volume of the first solution
3) put them in a known volume of water
4) for 1 week
5) dry them and measure the mass again

with (drying oven) to prevent the lost of mass on tissues rusting only on iron.

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6) Repeat the exp with ...

7) conclusion: The exp. ... increase in mass ...

How to prevent rusting

painting oiling greasing

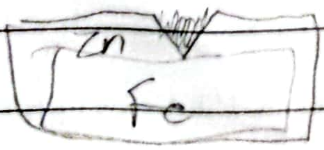
"To prevent O_2 and H_2O from reaching the iron"

long term

Galvanizing coating

sacrificial protection

connecting



Zn and Mg are more reactive

more likely to oxidise

more likely to lose e^-

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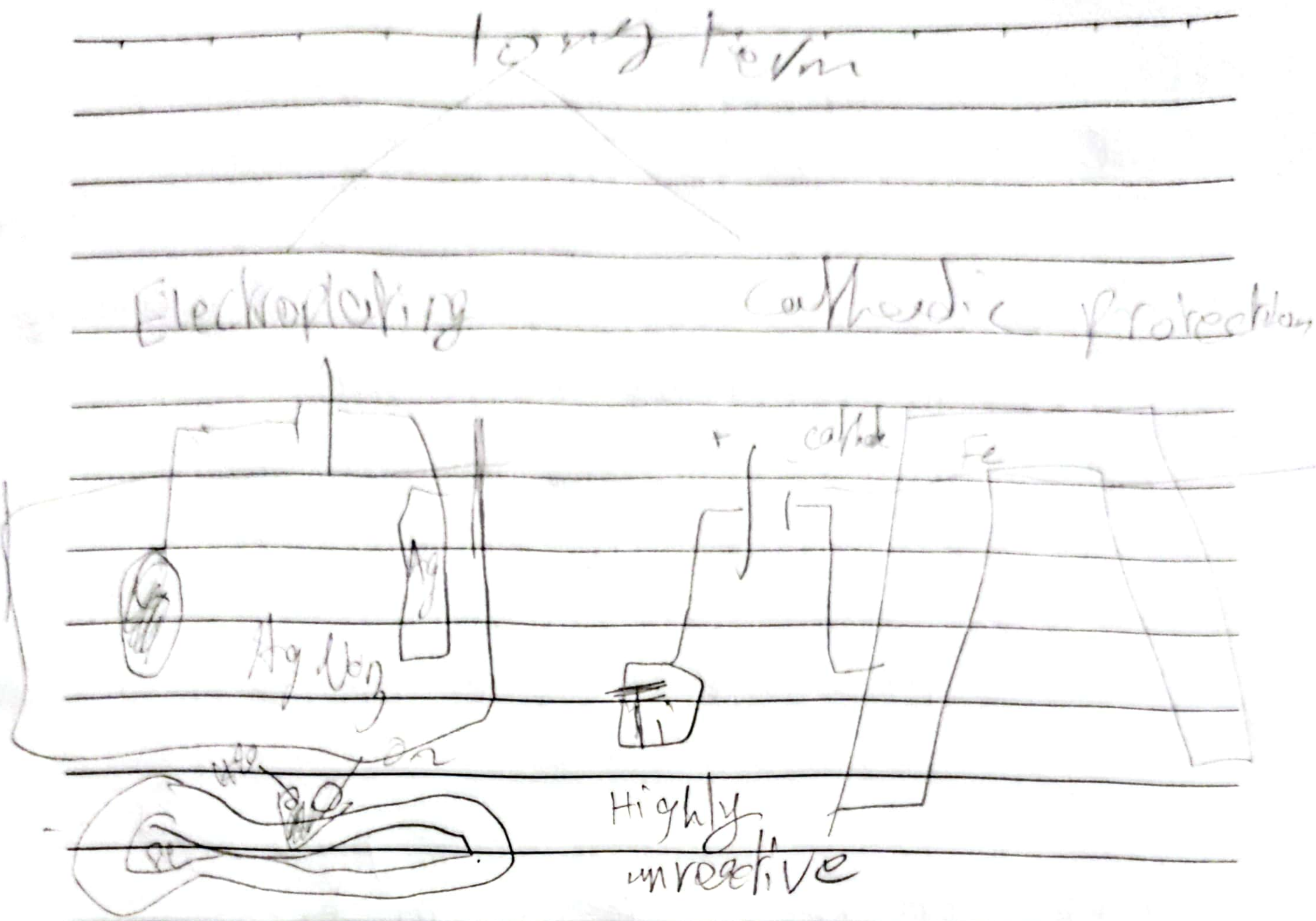
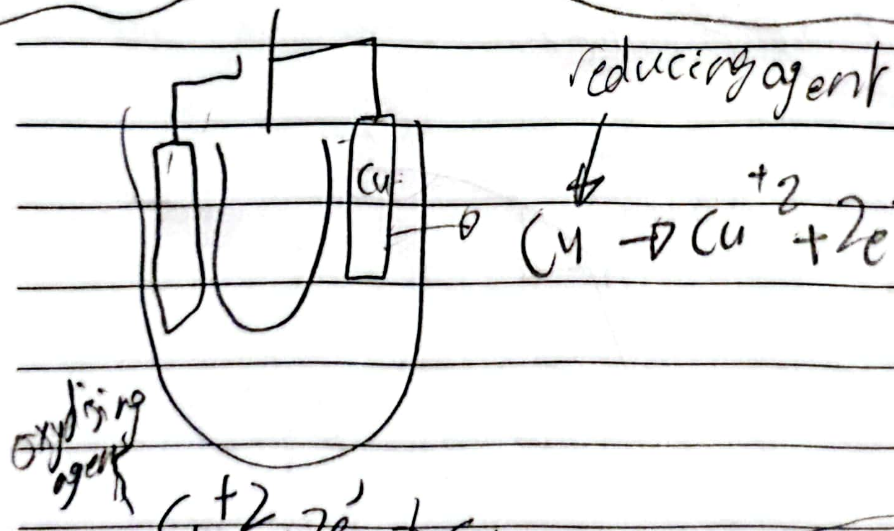




$Cu \rightarrow Cu^{+2} + 2e^-$

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

Notes for rale: 1) Read the question carefully and plot the graph slowly and carefully.
2) don't extend the lines.

worksheet

Subject ______ Day ______ Date ______

Rate of reaction

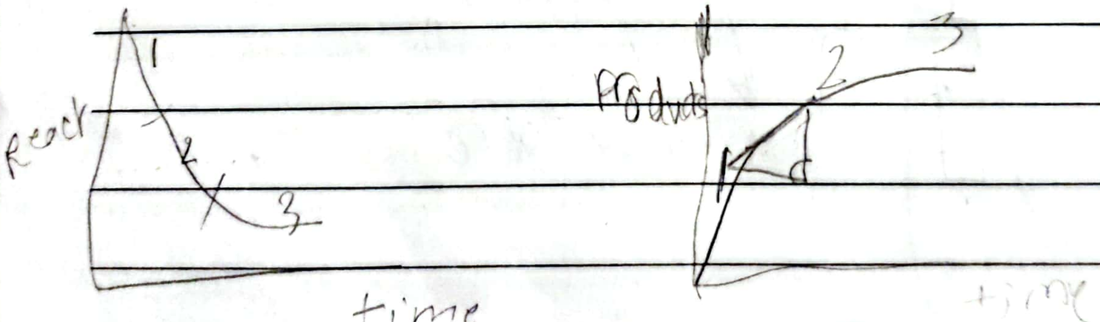
Rate = $\frac{\text{change in a quantity}}{\text{change in time}}$

$\frac{\Delta mass}{\Delta time}$ / $\frac{\Delta conc}{\Delta time}$ / $\frac{\Delta pH}{\Delta time}$ / $\frac{\Delta volume}{\Delta time}$ / $\frac{\Delta temp}{\Delta time}$ / $\frac{\Delta \text{height of precipitate}}{\Delta time}$

measure the rate of reaction

How fast the reactants consumed per unit time

How fast do products form per unit time



region 1

Fastest rate → from the graph steepest

- more ammount of reactants
- more particles
- more effective collisions per unit time

Read the question carefully

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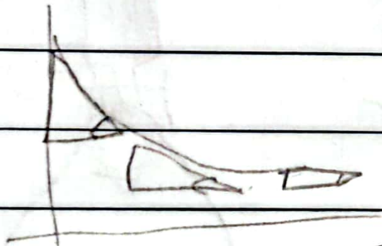
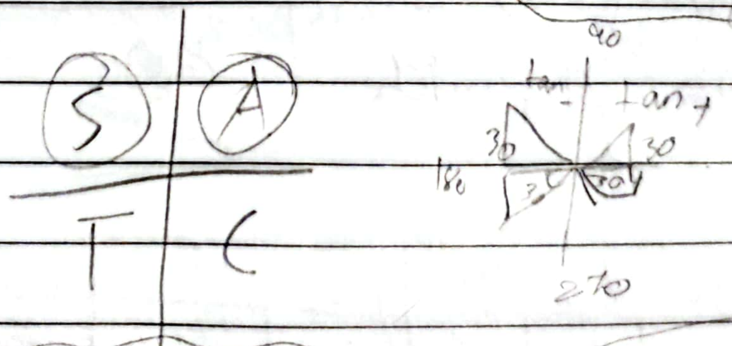
Region (2):
→ slower → from the graph, less steep
→ less of particles
→ so less number of effective collisions per unit time.

Region (3): reaction is over → gradient
→ 0 (horizontal)
• no more limitting factor
• no more effective collisions per unit time.



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



For any chemical reaction there are three main conditions,
1) Cu + HCl → no reaction
The reactants must be suitable
2). The reactants must collide.
Mg & HCl

cemical reaction not in a beaker

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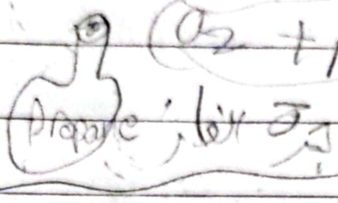
~~3) The collisions must be effective w/ min amount of energy to start the reaction (activation energy) Ea~~

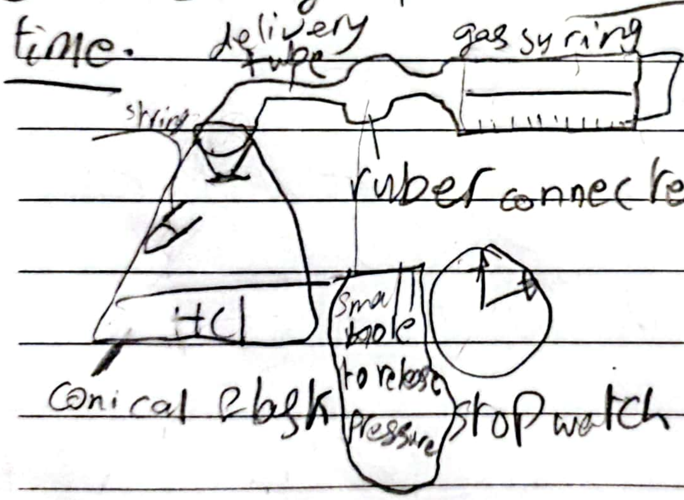


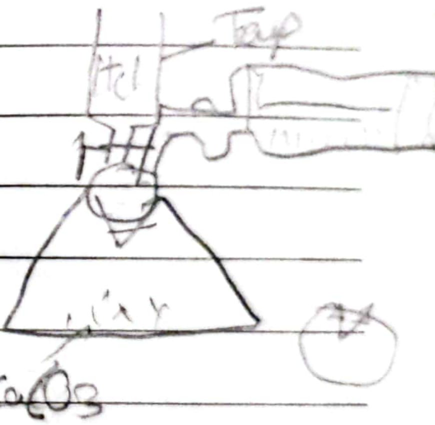
O_2 + propone

Measuring Rate of Reaction

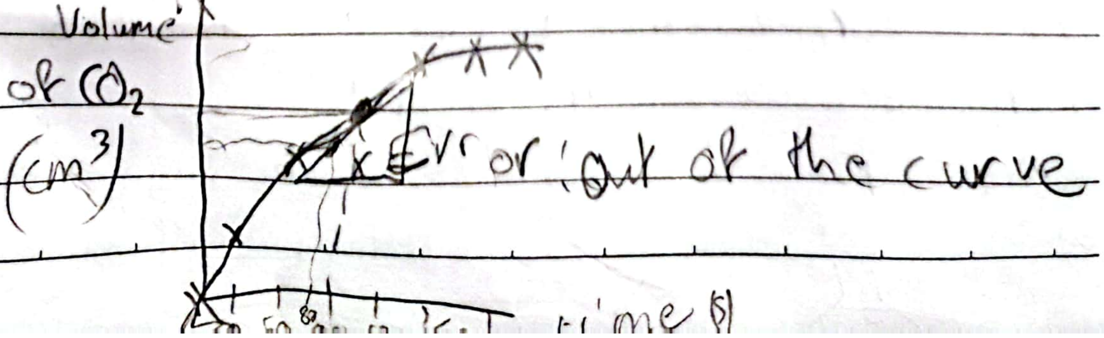
$CaCO_{3(s)} + 2HCl \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

① Measuring the Volume of gas per unit time.





time(s)	0	30	60	90	120	150	180
volume of CO_2	0	10	15	17	17.5	17.5	17.5



In equations : 1) balancing 2) correct answer. 3) (aq) us heat and arrows.

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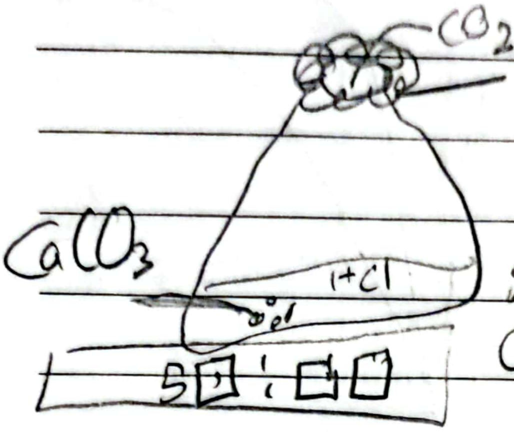
2) Measure the mass of the conical flask + contents per unit time.

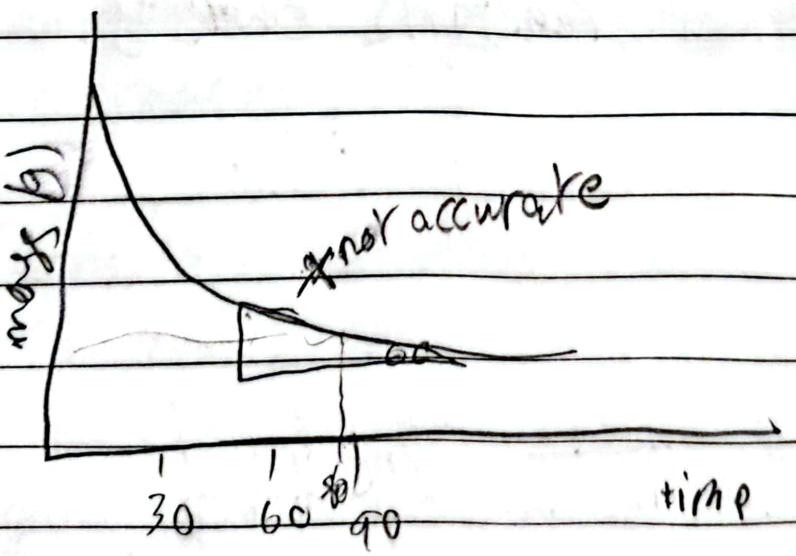


cotton wool to allow CO_2 to escape and prevents splashing

the mass decrease because CO_2 escapes

time(s)	0	30	60	90	120	150	180
mass (g)	50	40	35	33	32.5	32.5	32.5

-10 -5 -2 -0.5



To find the rate at specific time. at t=80s draw tangent

Increasing the rate of reaction

more product per same period of time

same product per less time

steeper curve

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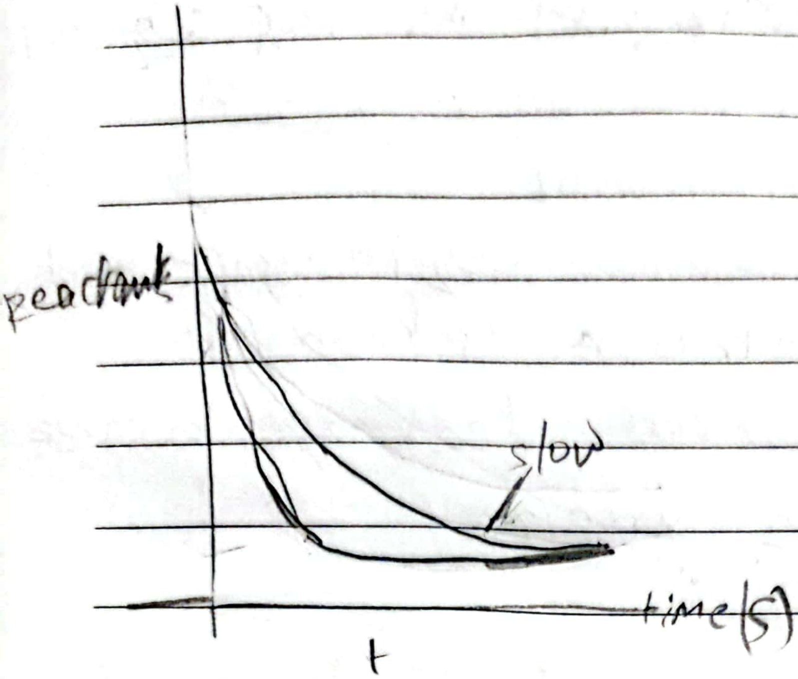
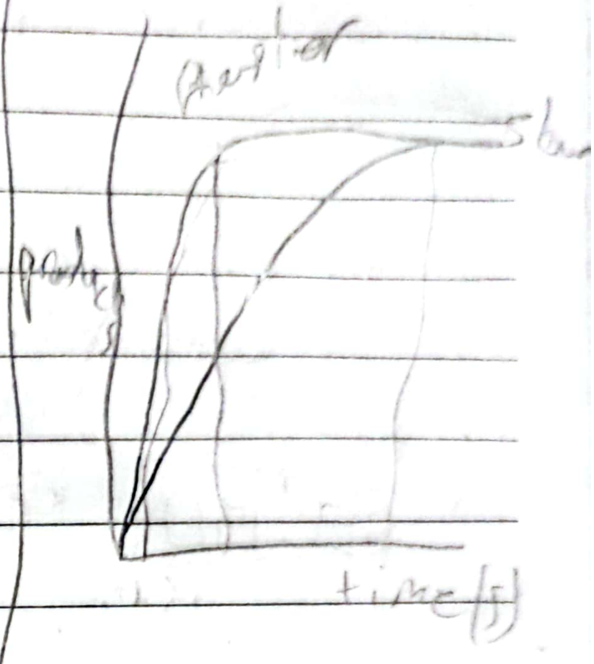
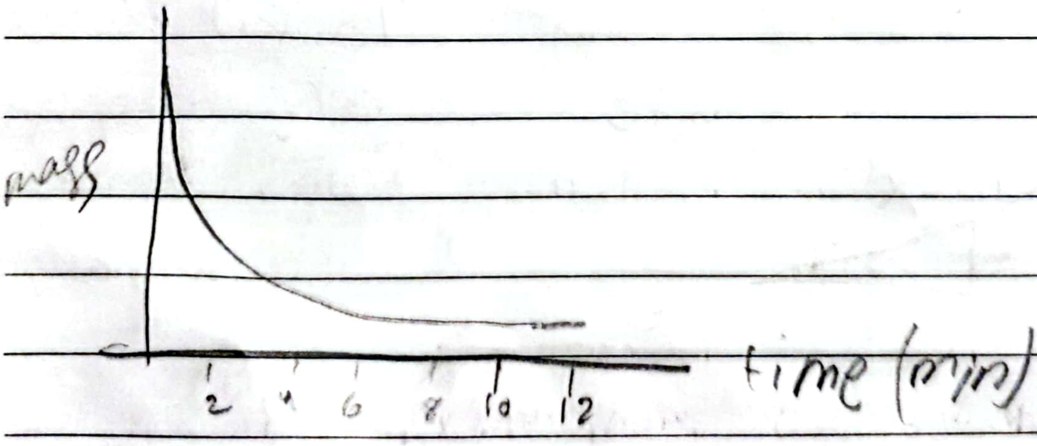
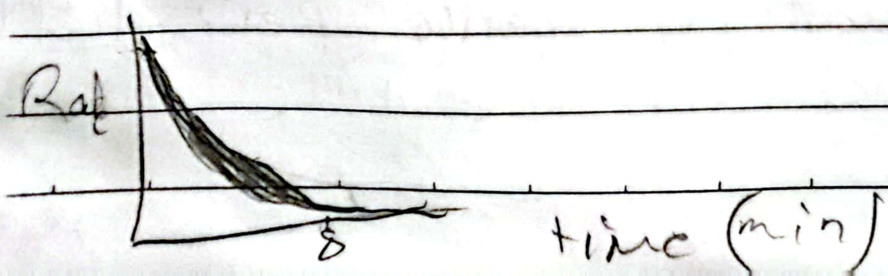




Q) The graph below shows how the amount of reactants changes with time



Draw Rate V.S time graph for this reaction.



when do we use the rap?

Scale: burette
no scale: rap.

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Factors affect the rate of Reaction

1. Temperature
2) Surface area
3) concentration/ammount
4) Pressure
5) light intensity
6) catalyst.

1. Temperature

* State how the temp affect the rate of reaction: As the temperature 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 move 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.

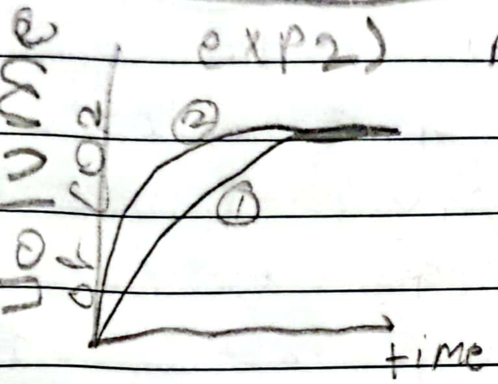
Subject ____ Day ____ Date ____

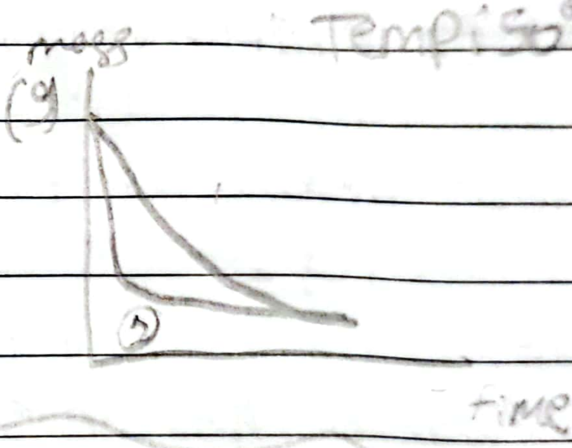
Plan an experiment to show how the temperature affect the rate of reaction?

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

exp. mass = 2.0g
lumps
V HCl = 0.1 dm^3
M HCl = 1 mol/dm^3
Temp: 25°c

exp 2) mass = 2g
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 known conc of HCl at 25°c. Measure the volume of CO_2 produced using gas syringe per unit time. Repeat the exp at 50°c. The exp at 50°c produce CO_2 with less time

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2) surface area

* state how the surface area affect the rate of reaction.

As the surface area increases the rate of reaction increases

* explain

As the surface area increases (decrease the particles size by crushing using mortar & pestel). More particles exposed to the reaction. More effective collisions per unit time, so faster rate

plan an ex

$CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O + CO_{2(g)}$

mass = 2g V HCl = 0.1 dm^3

lumps M HCl → 1 mol/dm^3

temp = 25°C

exp 2) mass = 2g V HCl = 0.1 dm^3

powder M HCl = 1 mol/dm^3

temp 25°C

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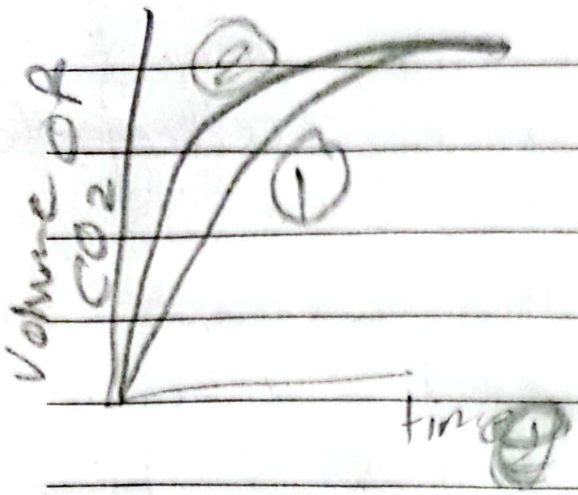

3) concentration "Ammount"

* state how the concentration affect the rate of reaction.

As the conc increases, the rate of reaction ↑.

* explain how the conc. affect the rate of reaction.

As the concentration increases more particles so more effective collision per unit time so faster rate of reaction

Plan an ex

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

add: 0.02   0.01   limiting

need: 0.005   0.01

n = 0.005

V = 0.12

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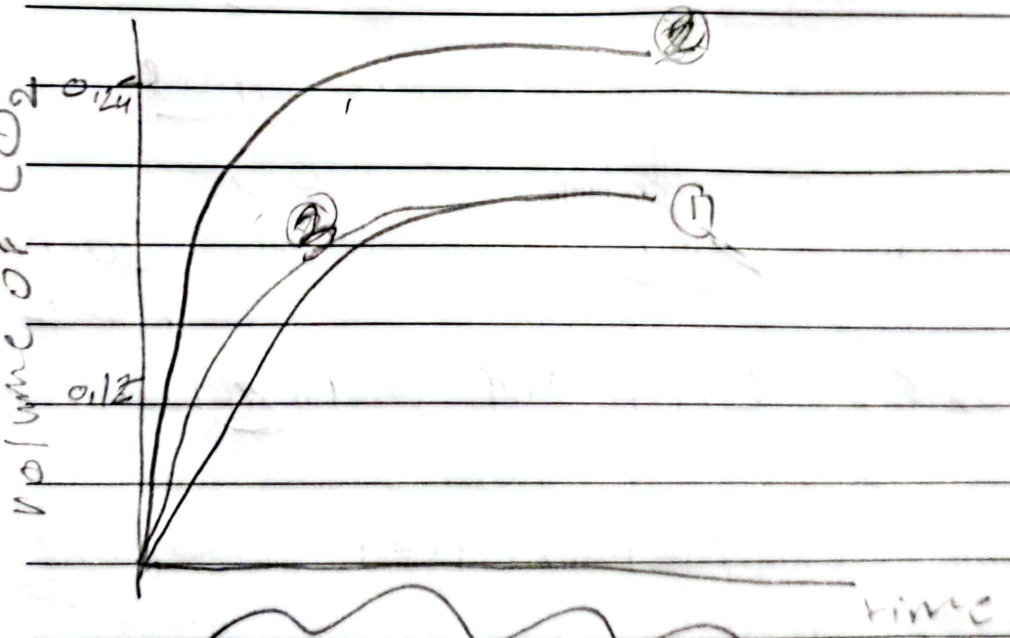
Exp 1 mass $CaCO_3$ = 2g lumps
Mr = 100 M_{HCl} = 0.1 mol/dm³
V_{HCl} = 0.1 dm³ Temp = 25°C
Mr = 100

Exp 2) mass $CaCO_3$ = 2g V = 0.1 dm³
lumps M = 0.2 mol/dm³ Temp = 25°C
n = 0.01 V = 0.24

Exp 3) mass $CaCO_3$ = 4g V = 0.1 dm³
M = 0.1 mol/dm³ Temp = 25°C
lumps



more limiting → faster rate, more product

more excess → faster rate

~~more particles~~ more particles per unit volume

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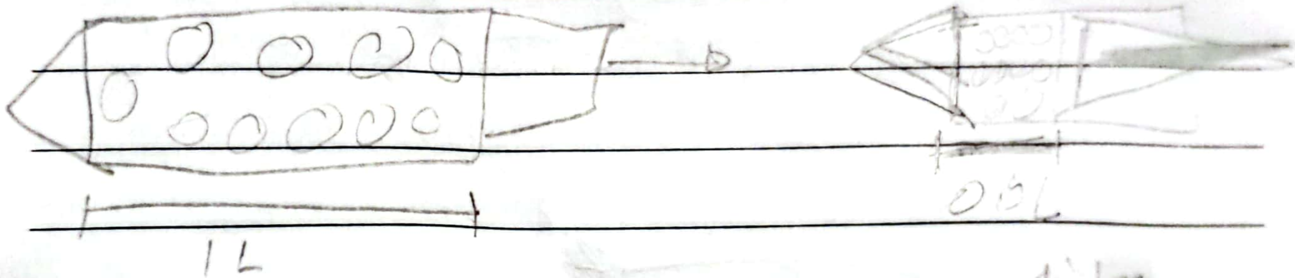
4) Pressure: "only affect the gas"

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



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

10 particles / 0.5

20 particles / 1L

5) Light: "Only for photochemical reaction"

Reactions that need light to occur

e.g. photosynthesis:

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

Photographic films: Films coated with AgCl or AgBr

Subject ~~Ea~~ Day ______ Date ______

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

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

b) Catalyst: chemical substance that speeds up the reaction without being used up.

HOW: 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 (rxn).

The reaction: $2H_2O_{2(aq)} \xrightarrow[MnO_2]{CuO} 2H_2O_{(l)} + O_{2(g)}$

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

Take a known volume with a known conc. of H2O2 at known temp. Measure the volume of O_2 produced per unit time. Repeat the exp using CuO. — The experiment using CuO will produce more O_2 per same unit time.

Subject Day Date

2) plan an exp to show which of the two catalyst is better [illegible]

- same as Q1 same [illegible]

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

3) plan an exp to show that [illegible] not used up during the reaction

- measure the mass of [illegible]
- add the H_2O_2 until no more [illegible]
- filter the mixture
- dry the solid in oven
- remeasure the mass

∴ same initial and final mass

Damp / not if not then no change in color in litmus paper

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Reversible Reaction

Types of chemical rxn

one way

Reactants --forward--> Products

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

$Mg + HCl \rightarrow MgCl_2 + H_2$

both ways

Reactants ⇌ products (forward / backward)

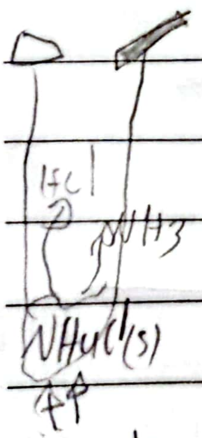
$NH_4Cl \rightleftharpoons NH_3 + HCl_{(g)}$

$CaCO_3 \rightleftharpoons CaO + CO_{2(g)}$

$3H_{2(g)} + N_2 \rightleftharpoons 2NH_{3(g)}$

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

Ammonium chloride → Ammonia + Hydrogen chloride



Q: which damp litmus paper will change its color first, why? (9)

The damp litmus paper changes to blue first because $NH_{3(aq)}$ is an alkali and lighter than $HCl_{(aq)}$ which is acidic

~~exact~~ constant in conc.

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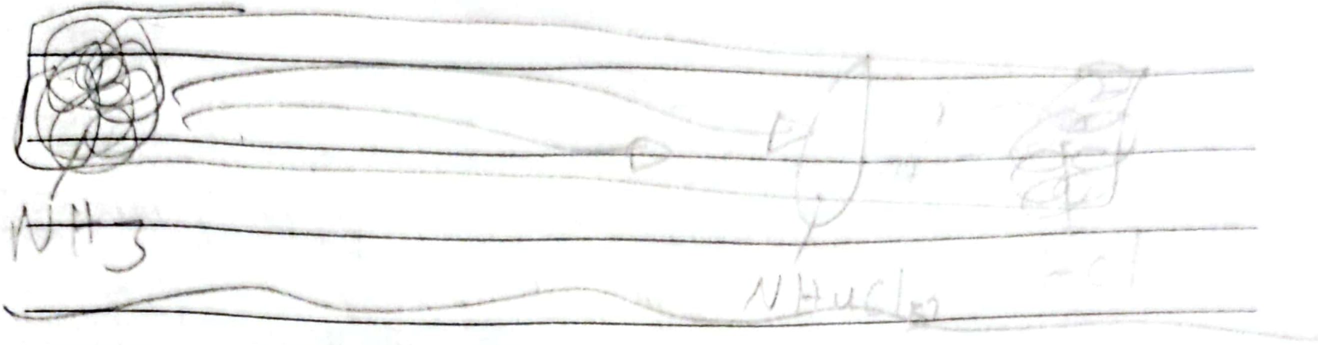
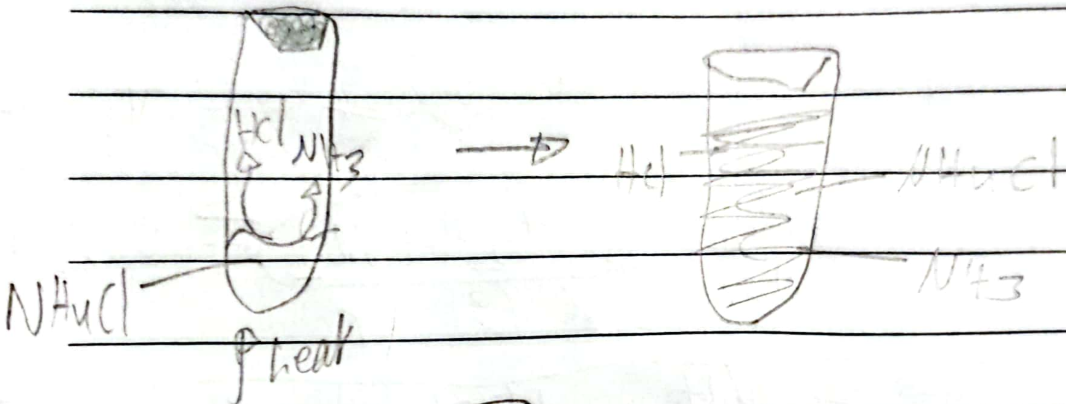
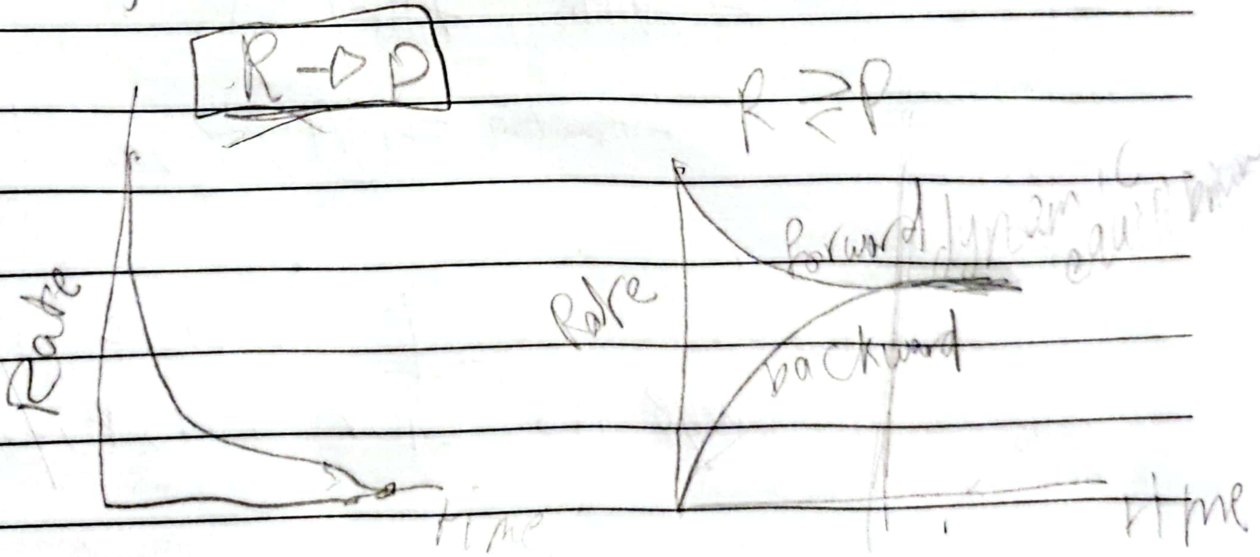
$HCl_{(g)} + NH_{3(g)} \rightarrow NH_4Cl_{(s)}$



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





In terms of rate: when the rate of forward reaction is equal to the rate of backward reaction.

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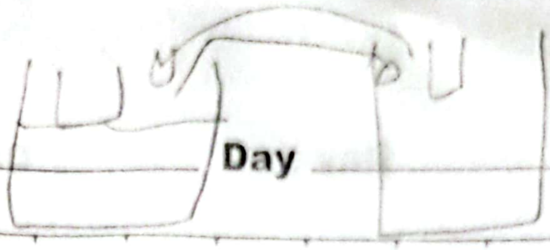
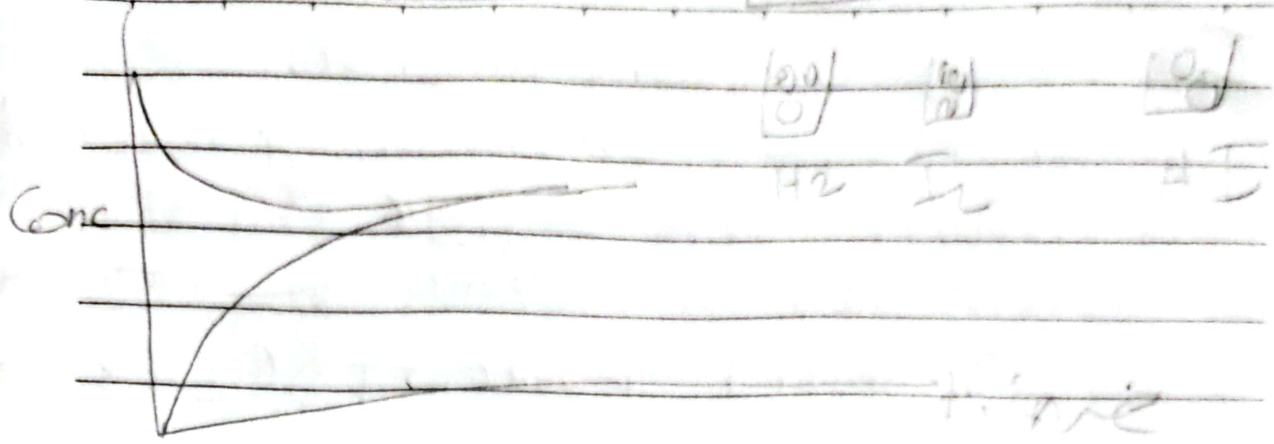
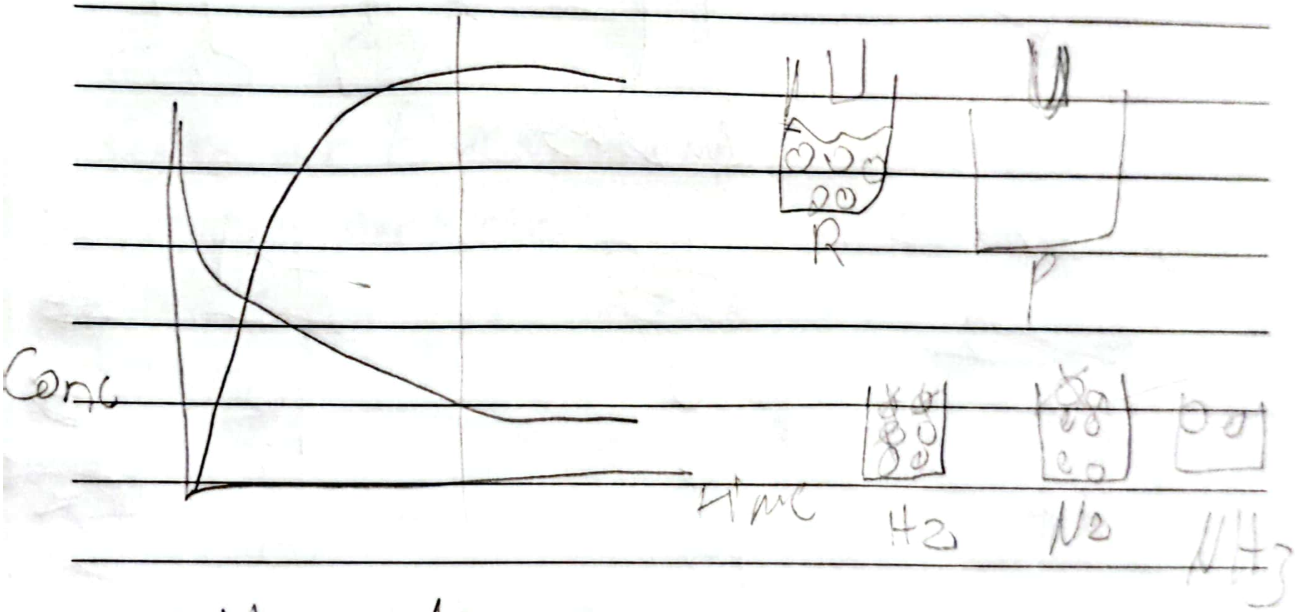




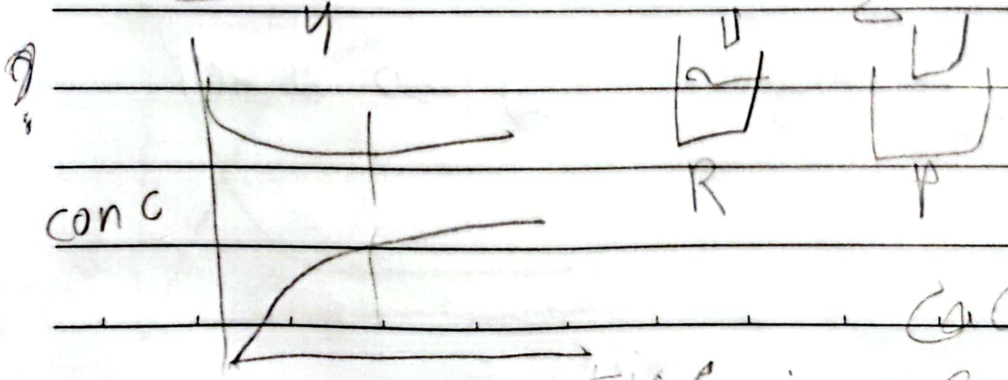
$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

2 moles — 2 moles



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

4 — 2



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

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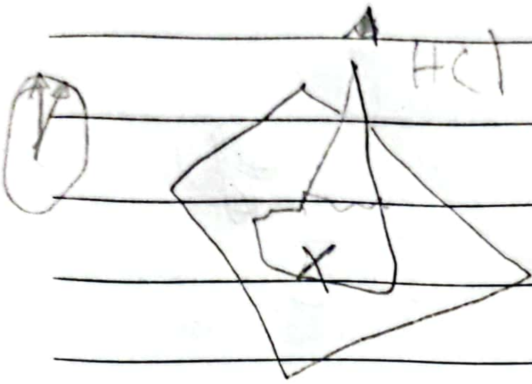
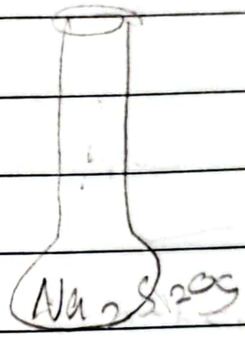
In terms of concentration.
When the concentration of reactants and products are constant

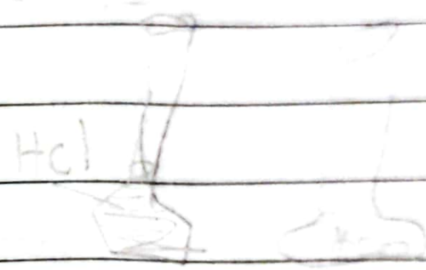
$Na_2S_2O_3 + HCl \to NaCl + SO_2$

HCl

Volume of $Na_2S_2O_3$







Volume of $Na_2S_2O_3$	H_2O	HCl	
			[illegible]
50	0	10	38
40	10	10	[illegible]
35	15	10	3
30	20	10	48
10	40	10	2.5

1) $Na_2S_2O_3$ 2) H_2O 3) HCl

We should write both definitions.

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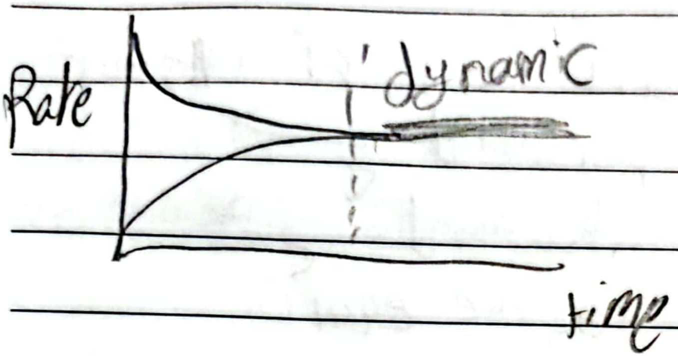
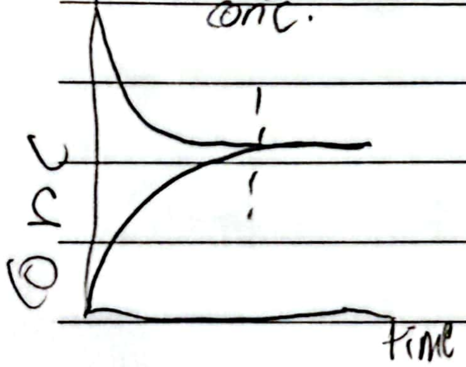
why rate of forward ↓

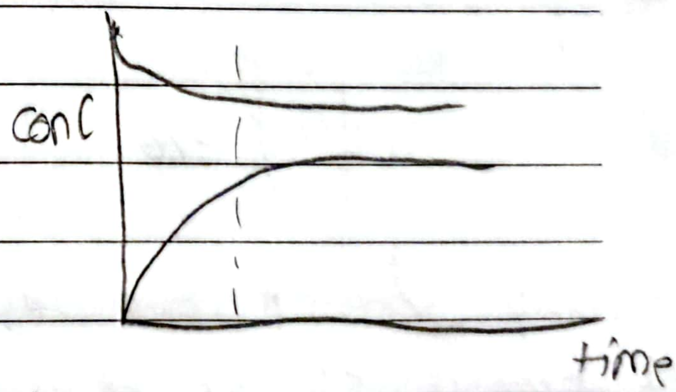
The rate of forward ↓ less reactants so less particles so less effective collisions per unit time.

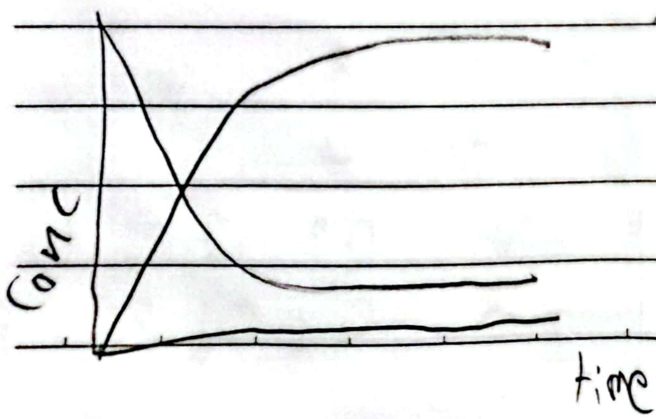


Rate of Backward ↑ more products so more particles so more effective collisions per unit time.

In terms of conc.







⇌ ⇋

Subject be careful Day Date

Le Chatelier principle.

If the system at equil ⇌

and any external factor disturb the equillibrium.

The equil can shift itself either to the forward ⇀ or to the backward ↽ to return back to the equil

Factors affect the position of equil.

① Temp

~ endo & exo

↑ temp shift to endo

↓ temp shift to exo

② Pressure

③ conc

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① Temperature

↑ Temp ↑↑ rate of endothermic. ↑ rate of exothermic — Shift to Endo

↓ Temp ↓↓ rate of endothermic ↓ rate of exothermic — shift to EXO

ΔH =
Enthalpy change

The sign of ΔH is always represent the forward reaction

+ve	-ve
gain	lose
Endo	EXO

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

↑ Temp ↑↑ rate of forward
↑ rate of backward

↓ Temp ↓ rate of forward
↓ rate of backward

↓A ↓B ↑C ↑D shift forward to the endo
↑A ↑B ↓C ↓D ~ backward ~ exo

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

↑ temp ↑ rate of forward } shift
↑↑ rate of backward } to endo

↑x ↑w ↓y ↓z if endo

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

to produce more yield of NH_3, we must use low temp to favour the forward reaction which is the exothermic

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

	Rate of forward	rate of backward	% SO_3
↑ Temp	increase	increase	decrease
↓ Temp	decrease	decrease	increase

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mixture of NO_2 and N_2O_2 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 paller? 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 mole)

As the pressure decrease ~ more pressure. (more gas mo less)

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

4 moles — 2 moles

↑ pressure. shift forward to the side with less gas moles. ↑ % NH_3.

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

↓ less pressure shift forward to the side with more gas mole

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

changing the pressure has no effect on the position of equilibrium since both sides has the same number of gas moles

$H_2CO_{3(aq)} \rightleftharpoons H_2O_{(l)} + CO_{2(g)}$

↓ less pressure, shift forward to the side with more gas mole.

temp ← → conc

↓

pressure

↑ pressure shift to less gas mole

↓ pressure sh—— more

↑ pressure ↑↑ rate of | less gas mole

↑ —— | more

↓ pressure ↓↓ —— | less

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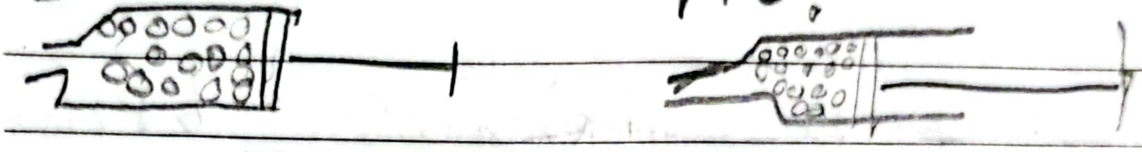
$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

purple   Colorless

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



The I_2 molecules become closer to each other so the color seems to be darker

Q) Sealed tube contains mixture of $NO_{2(g)}$ & $N_2O_{4(g)}$

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

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 ~~darker~~ paler

d) ~ darker ~ darker

Subject ______ Day ______ Date ______

Factors that affect position of equilibrium

1) Temp ↑ shift to endo
↓ shift to exo

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

3) concentration ↑R) shift ↓P) forward
↓P) shift ↑P) backward

$A + B \rightleftharpoons C + D$

↑[A] shift forward ↓B ↑C ↑D

↓[B] shift backward ↑A ↓C ↓D

↑[C] shift backward ↑A ↑B ↓D

Indicator:

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

color₁ red — color₂ yellow

Add HCl i proton donor ↑H^+ shift backward

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more HIn more color 1

Less In less color 2

add NaOH : proton acceptor ↓H^+ shift forward more In color 2

less HIn color 1 less

Q1) The reversible reaction below at equilibrium

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

orange green

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

→ HCl is an acid : (proton donor)

→ more H^+

→ shift forward

→ more Cr^{+3} more green

→ less $Cr_2O_7^{-2}$ less orange

* Catalyst

has no effect on the position of equilibrium since it speeds.

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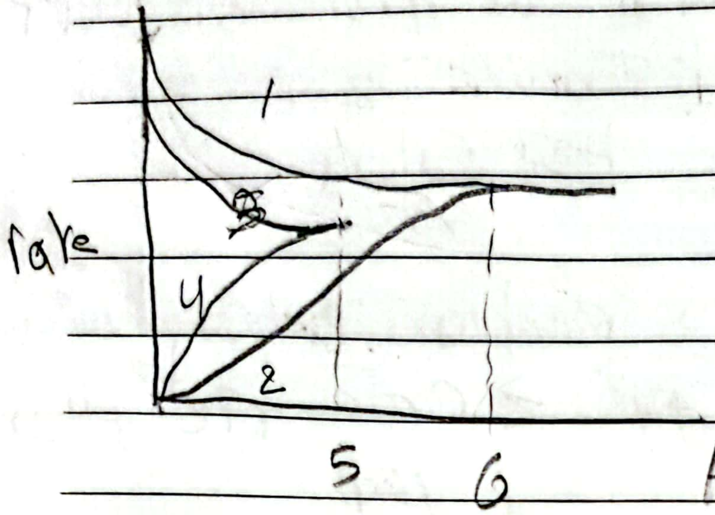
of the rate forward and backwar



1) Rate of forward without catalyst
2) rate of backward without catalyst
3) ~~~~ forward wi~~ ~~
4) rate of backward ~~~~
5) Time taken to reach equili with cataly
6) ~~~~ without ~

Q we have to draw two intersecting points.

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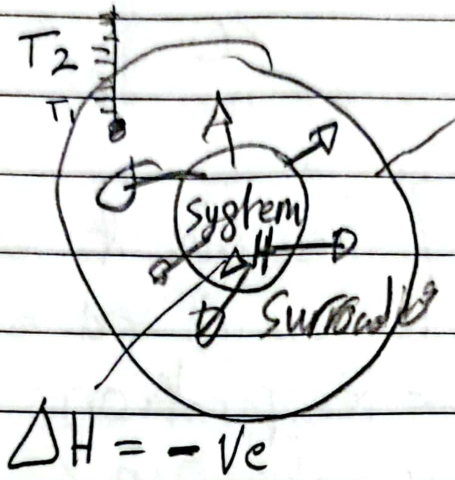
Energetics

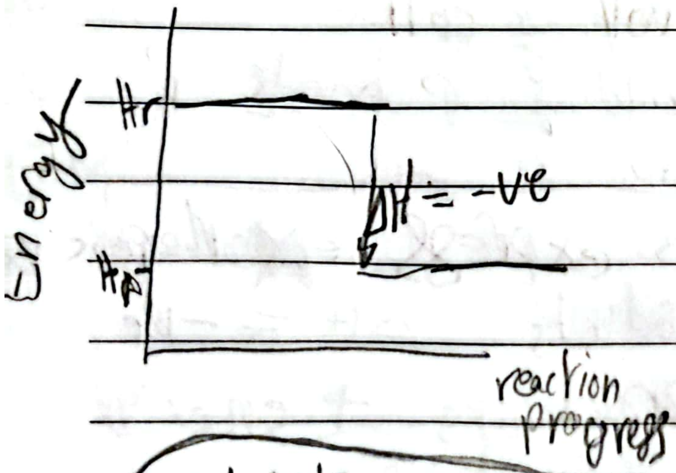
Exothermic:

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



$T_2 > T_1$

For system (Energy level diagram)



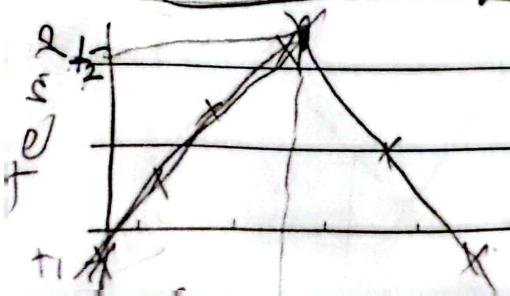
Enthalpy: Heat contents "stored energy"

Hr enthalpy of reactants

HP enthalpy of products

product is more stable

for surrounding (Temp diagram)



reaction is over so return back to room temp.

time

Q depends on ΔT not temperature
change in temp.

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

- Q → Energy transfer = Joules
- m → mass g
- c → specific heat capacity 4.2 J/g.C
- ΔT → Change in temperature °C

↑Q ↑ΔT more exothermic

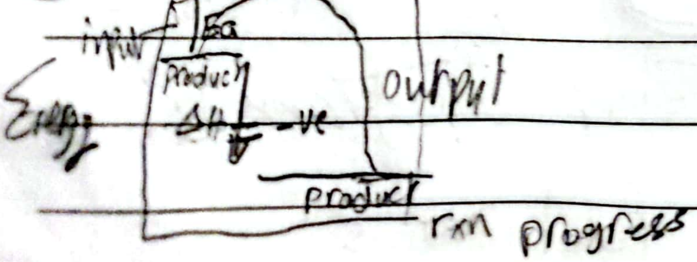
(a) water 100g
$T_1 = 30°c$
$T_2 = 40°c$
$\Delta T = 10°c$

(b) water 100g
$T_1 = 80°c$
$T_2 = 82°c$
$\Delta T = 2°c$

a) needs more energy

examples of exothermic
1- freezing and condensing
2- Respiration
3- combustion
4- Neutralization
5- displacement Zn + $CuSO_4$ (aq)
6- Volting cell
7. building up bonds

Exothermic: How to express exothermic rx
① Reactants → products $\Delta H = -ve$
② Reactants → Products + energy
③ profile diagram



Output > input

cata (b)reack
ana build
photosynthesis

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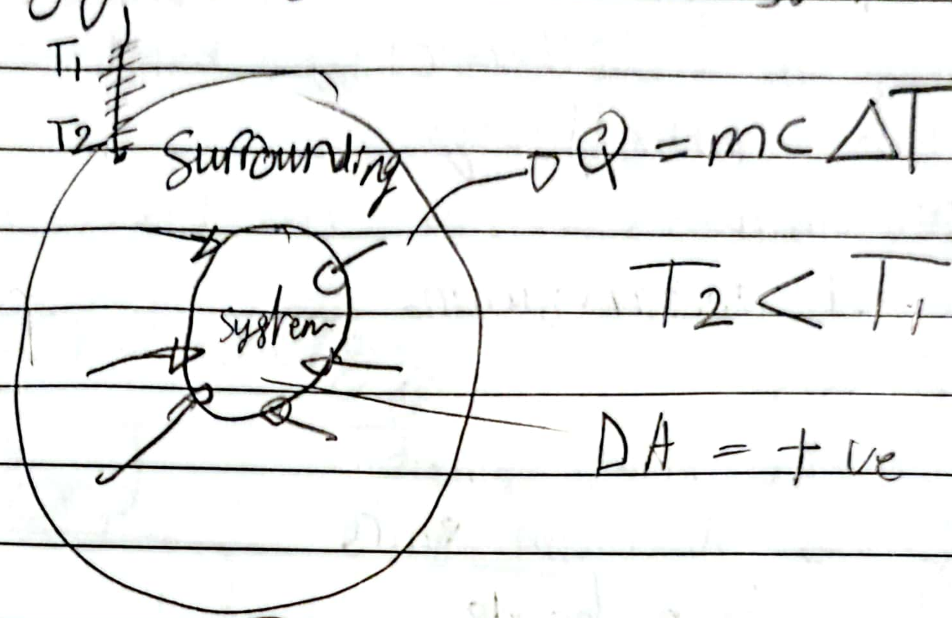
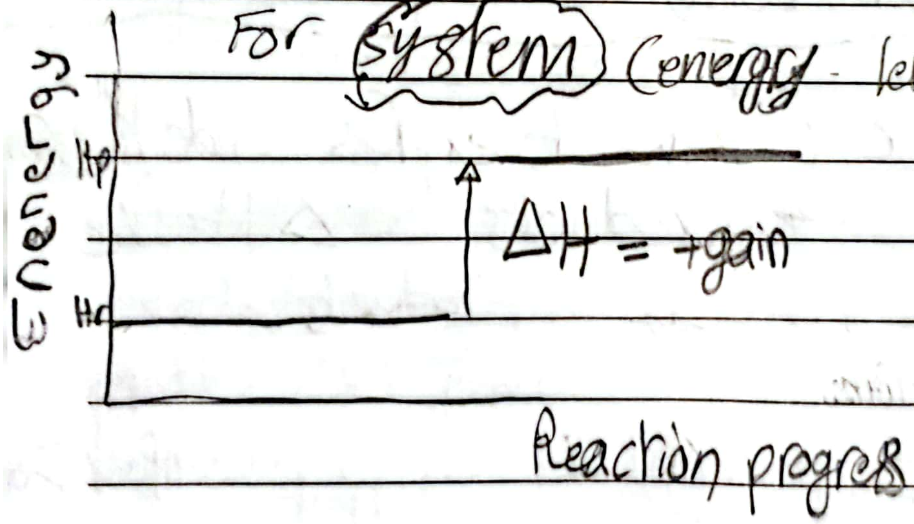
Endothermic:

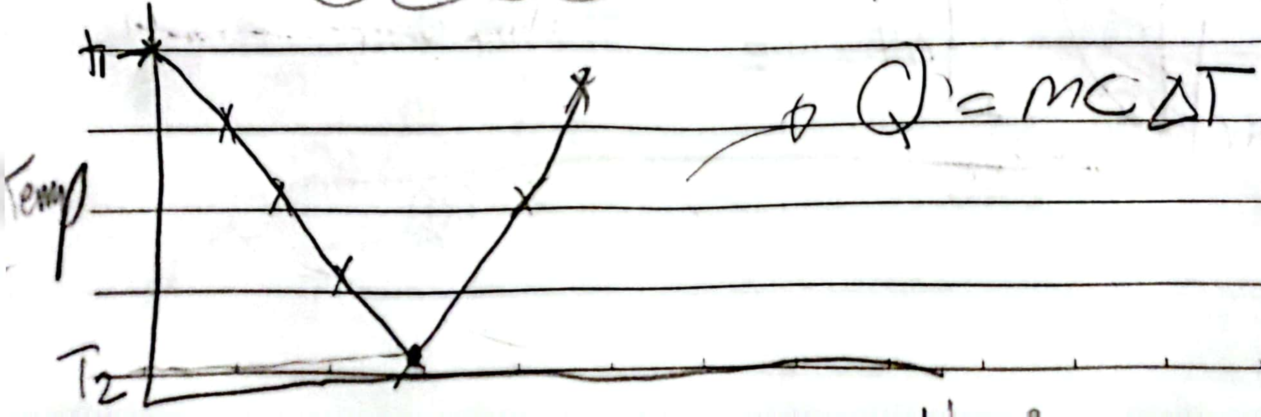
Reactions that absorb (take in) energy from the surrounding.



For system (energy level diagram).



For surrounding (Temp. diagram)



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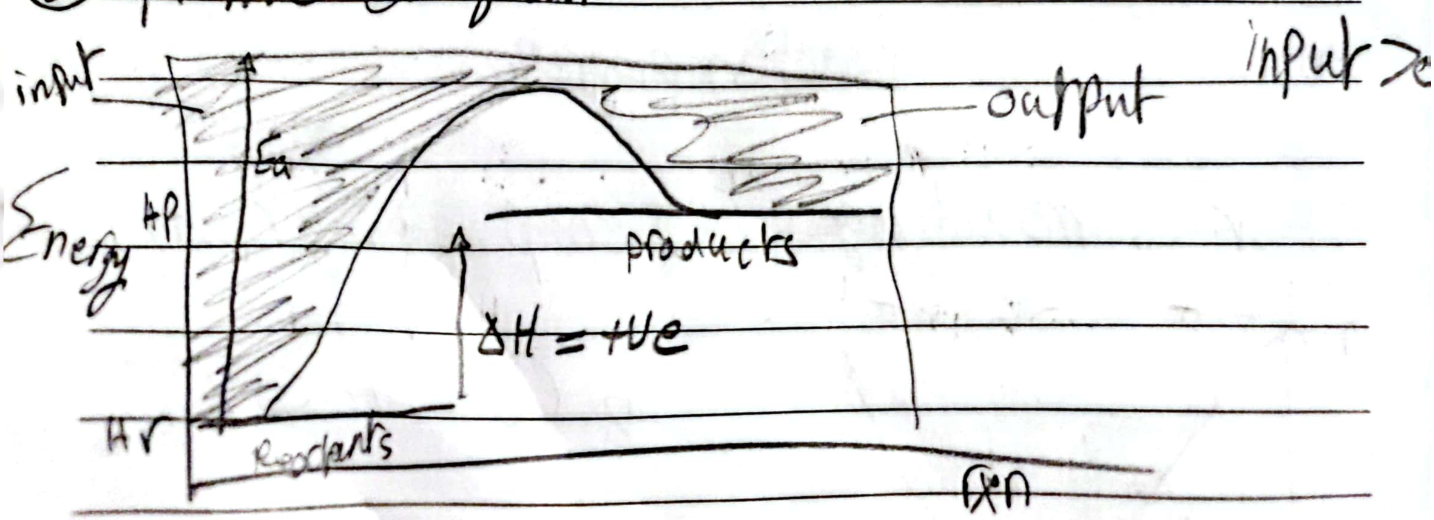
↑Q ↑ΔT
more endothermic

Examples on endothermic:
1- Boiling, melting
2- photosynthesis
3- Thermal decomposition.
4- Electrolysis
5- photographic films.
6- Dissolves Amonium salts
7- Breaking down bonds.

Endothermic: How to express endotherm
① Reactants → products ΔH = +ve
② Reactants + energy → products
③ profile diagram



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Measuring ΔH reaction

Theoretical — using bond energy

experimental — Combustion, displacement, Neutralization

ΔH reaction using bond energy

Bond energy

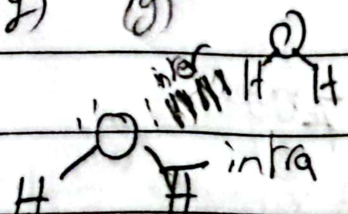
Bond	Bond energy Kj/mol
H — H	436

don't memorize

Bond energy: The ammount of energy needed to break 1 mol of a bond in gaseous state. OR) ~~Then~~ ~~~~~~ released to build ~~~~~~

$H-H_{(g)} + 436 \text{ Kj/mol} \rightarrow H_{(g)} + H_{(g)}$

$H_{(g)} + H_{(g)} \rightarrow H-H_{g} + 436 \text{ Kj/mol}$



Subject ______ Day ______ Date ______

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

- $\sum input$: to break down bonds in React
- $\sum output$: to build up bonds in prod

endo (+): input > output

exo (−): input < output

To use this equation.

1. balanced equation. ✓
2. covalent structure.
3. bond energy

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

H-C(H)(H)-H + 2 O=O → O=C=O + 2 H-O-H

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

<u>bond broken</u>

4 x C−H → 4 x 413

2 x O=O → 2 x 495 +

2642(kj)

bond formed:

2xC=O → 2 x 799

4 x O−H → 4 x 463 +

3450(kj)

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

$= 2642 - 3450 = -808\ kj/mol$

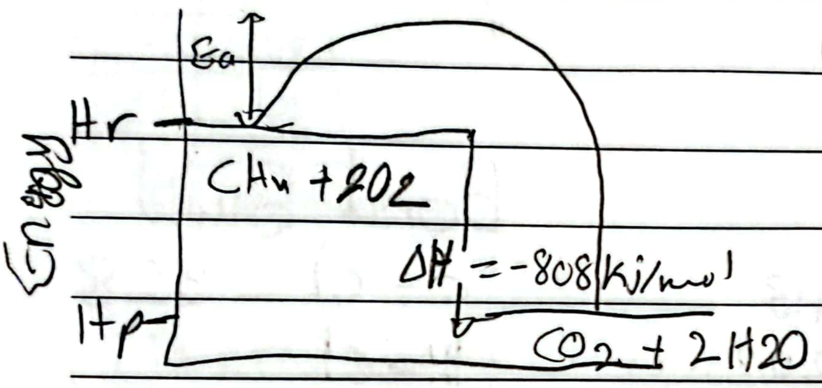
input < output exo

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

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

1) label / EA / ΔH

Hr / Hp



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

bond broken		bond build	
3×C−H	(4×413)	2×C=O	2×799
1.5×O=O	(1.5×495) +	4×O−H	4×463 +
1×O−H	(1×463)		3450 kj
1×C−O	(1×358)		
	2802.5 kj		

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

$= -647.5\ kj/mol$

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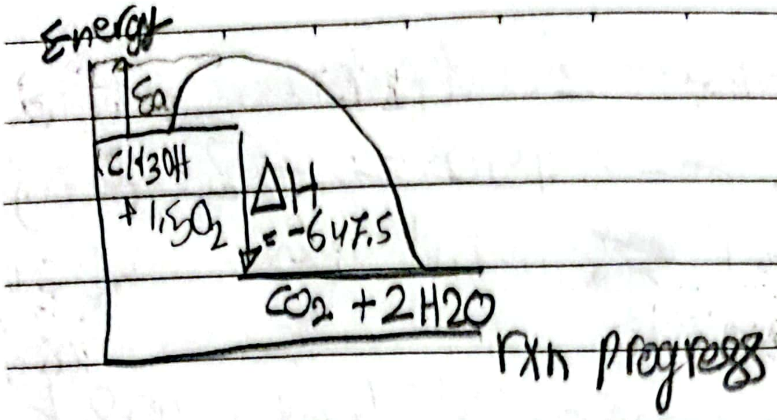
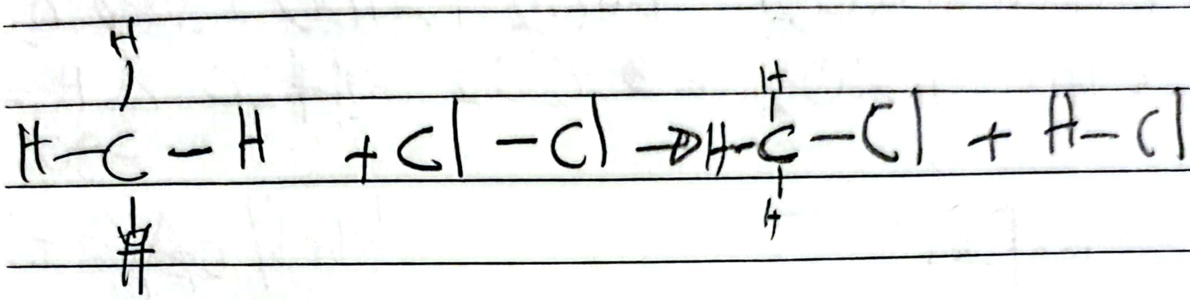
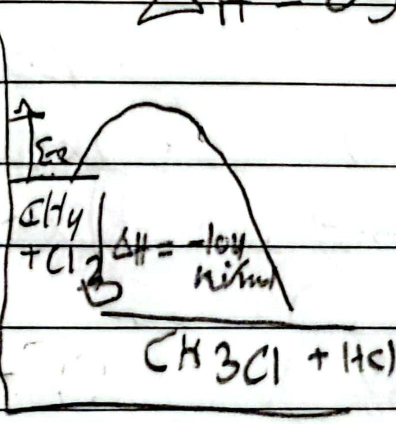


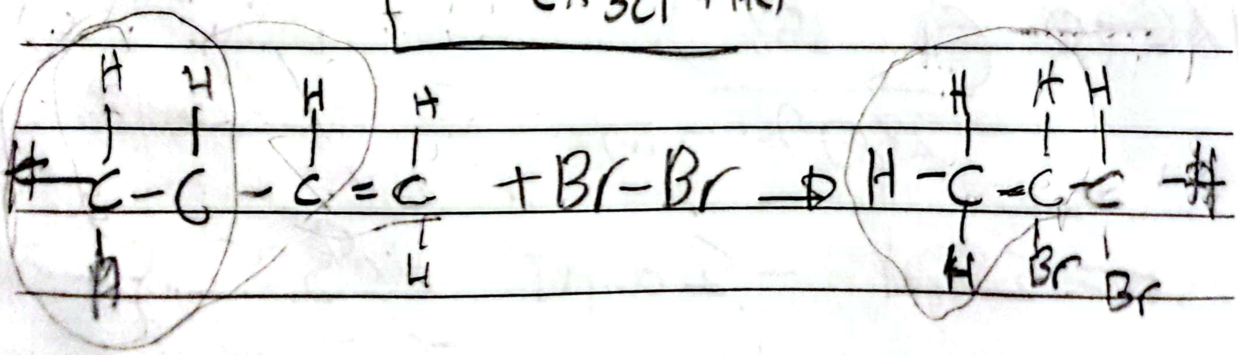


Bond Broken		Bond Build	
1x C–H	413	C–Cl	328
1x Cl–Cl	+ 242	H–Cl	431
	655 Kj		759 Kj

bond	bond energy Kj/mole
C-H	413
Cl-Cl	242
H-Cl	431
C-Cl	328

$\Delta H = 655 - 759 = -104$ Kj (exo)





Σ -780

Subject $160 \times 2 - 4xx = -780$ Day ______ Date ______

320

Bond broken		bond build	
Br - Br	193	2 x C - Br	2 x 276
C = C	614	C - C	348 +
	807 kj		900 kj

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

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

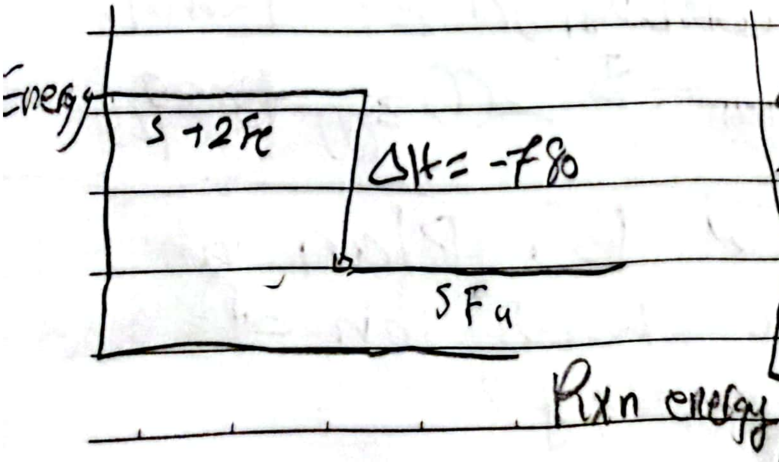
When sulfer react with florine the reaction give 780 kj/mol.

S + 2F-F → F-S(F)(F)-F

If the bond energy of F-F is 160 kj/mol

1) Draw an energy level diagram.

2) Find the bond energy of S-F?



ΔH = input - output

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

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

S-F = 275 kj/mol

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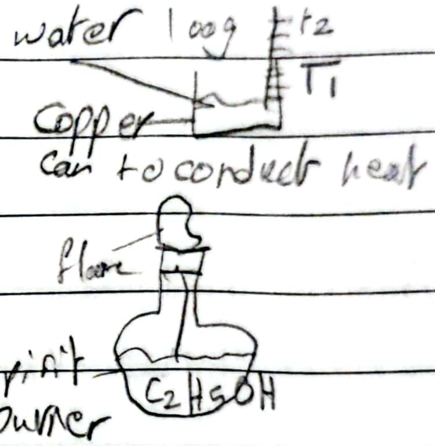
Finding ΔH (energy change) practical

combustion | displacement | Neutralization

Finding ΔH combustion.

H–C(H)(H)–C(H)(H)–O–H + 3O=O → 2O=C=O + 3 ...



for surrounding

energy transfer: $Q = mc\Delta T$

$= 100 \times 4.2 \times 10$

$= 4.200\,kJ$ burn → 2g ethanol

ΔH ?? — 46g ethanol (1 mol)

= 96.6 kJ/mol

$m_1 = 200g$

$m_2 = 198\,g$

$M_r = C_2H_5OH = 46g$

Measuring ΔH combustion for ethanol.

$C_2H_5OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 3H_2O_{(l)}$

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

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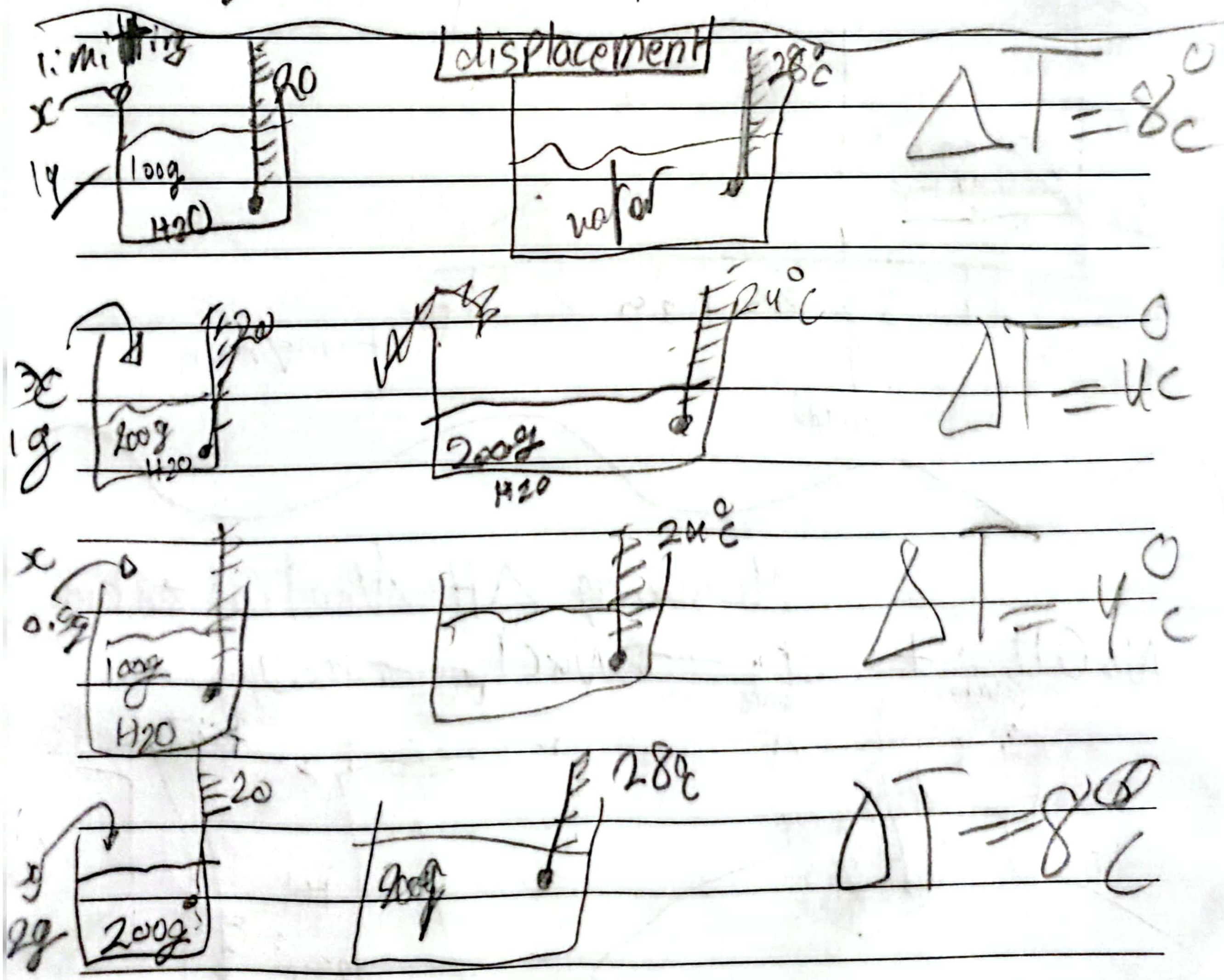
1- Take a known mass of water with known initial Temp. in a copper can.

2- Take a known mass of fuel mass of fuel A.

3) Ignite the fuel and record the final mass and final temp of water.

4- Repeat the exp using fuel B.

5- The fuel which cause temp rise per gram of fuel. produce more energy.



notes, ~~glass~~ disadvantage   Stirring → increase heat

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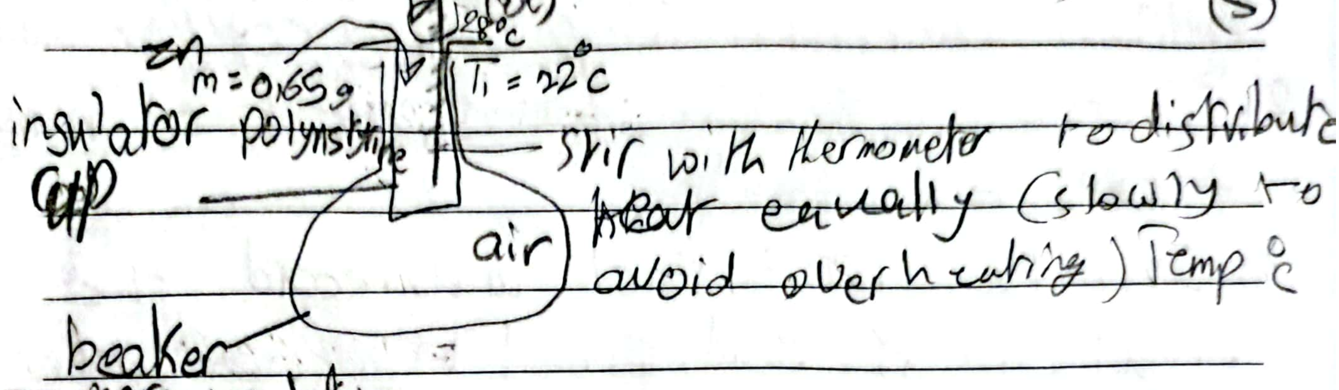
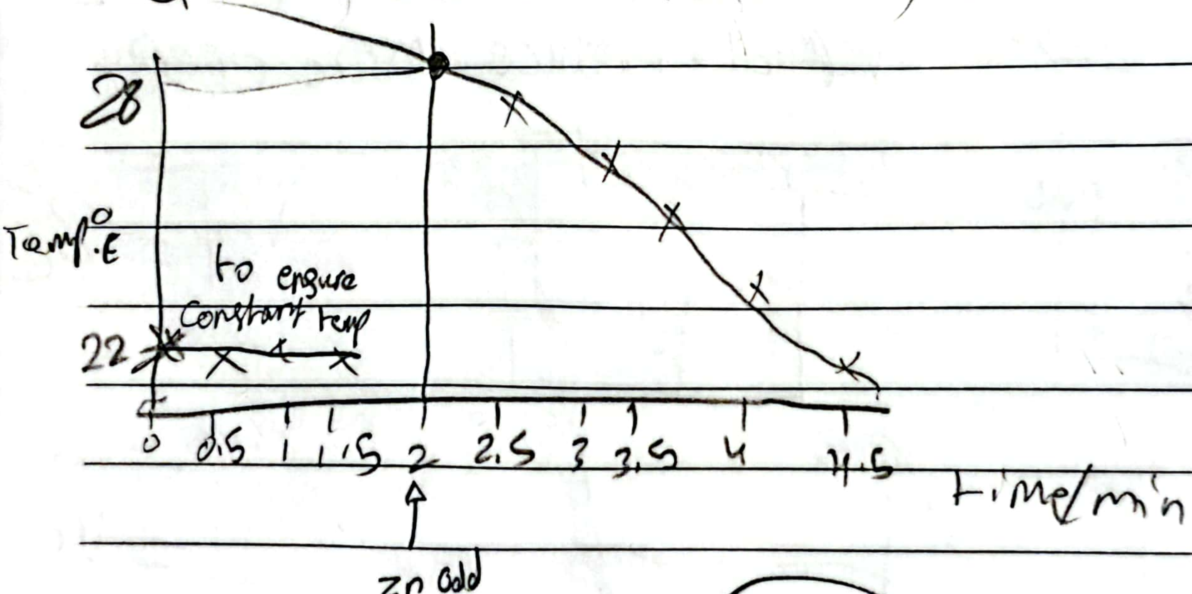
Measuring ΔH displacement

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



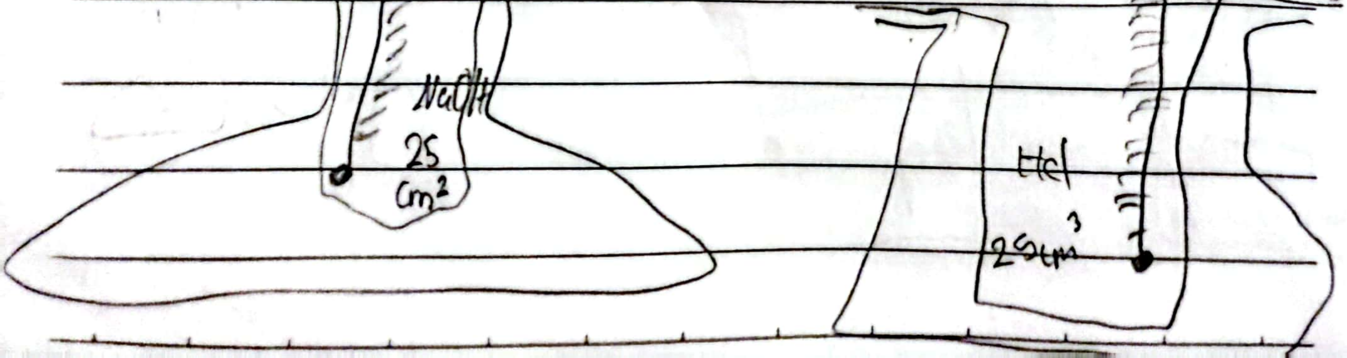
beaker
- more insulation
- more stable

$Q = mc\Delta T = 100 \times 4.2 \times 6 = 2520 J = 2.52$



Measuring ΔH Neutralization

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



$^{235}_{92}U$ → out of syllabus

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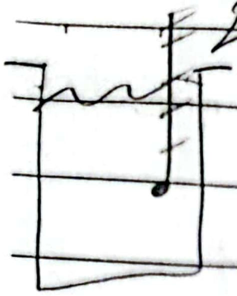


specific heat capacity
= 4.2 J/g.°C
d = 1 g/cm³

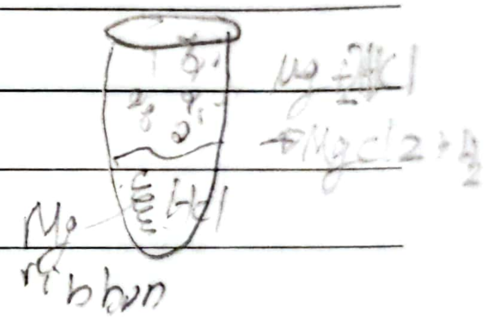
$Q = mc\Delta T = 0 = 50 \times 4.2 \times 6$
$= 1260 J$

Alternative Resources of energy

- Voltaic cell ✗
- Hydrogen fuel cell
- Uranium old split

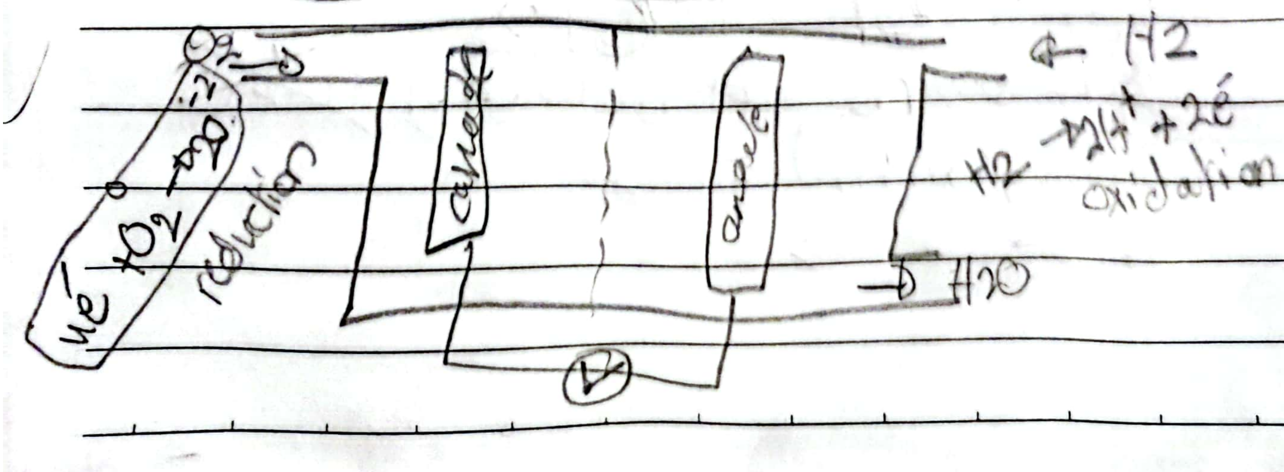
Hydrogen fuel cell.

$H_2 + O_2 \rightarrow H_2O$



observations:

→ bubbles
→ water formed



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advantages: Only one waste product
- No CO_2
- produce high ammount of energy
- generate electricity

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

notes: 1) Mg + HCl → $MgCl_2$
2) measure → delivery ~~tube~~
3) conc/anhydrous
4) ⇌ ⇆

delivary tube: can't measure Volume

Subject ______ Day ______ Date ______

Industrial Chemistry

- Dealing with gases
  - dry
  - collect
- Industry of
  - NH_3 Haber process
  - H_2SO_4 contact process
  - CO_3^{-2}
- Extraction of metals
  - Al
  - Fe
  - Zn
  - Cu

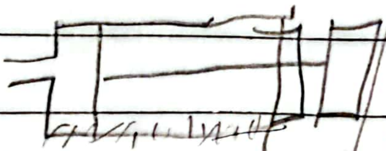
Dealing with gas

Rxn → wet gas → drying → collecting

① Collecting gas

mix with air / can escape

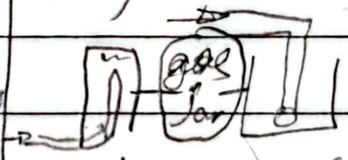
gas syringe



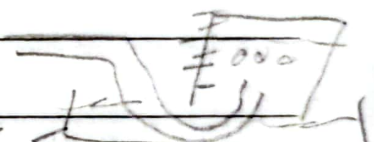
- used to collect & measure the volume of any gas.
- no mixing with other gases.

Delivery

- upward delivery: less dense than air
- downward delivery: more dense than air



over water



Trough

only for insoluble gas

Ex) $H_2O_{2(aq)} \xrightarrow{CuO} H_2O_{(l)} + O_{2(g)}$

mr 32

H_2) $Mg_{(s)} + HCl_{(aq)} \rightarrow MgCl_2 + H_{2(g)}$

mr 2

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

17

SO_2) $Na_2SO_3 + HCl \xrightarrow{\Delta} NaCl_{(aq)} + H_2O_{(l)} + SO_{2(g)}$

64

density of air → 28.5

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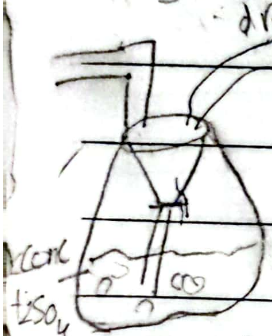
(CO_2) $CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_2$

Drying gases.

① concentrated H_2SO_4

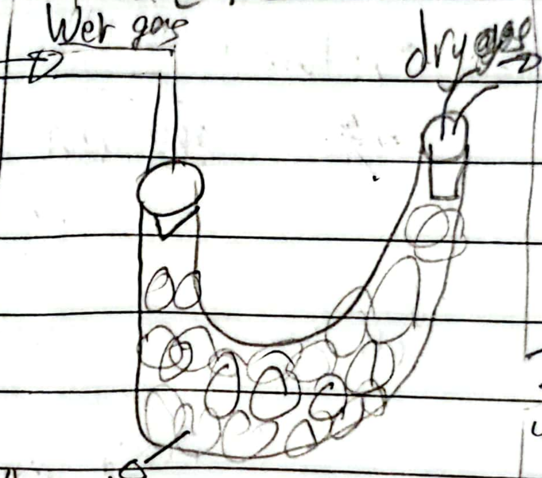


(becomes diluted)

used to dry any gas. Except NH_3 it neutralises the H_2SO_4

$NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

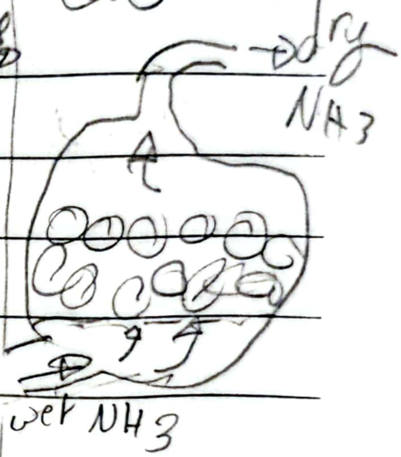
② Anhydrous $CaCl_2$



used to dry gas except NH_3

~~Cl_2~~ gas

③ calcium oxide CaO



and basic gases but only NH_3 is included in syllabus.

Draw a suitable ~~delivery tube~~ apparatus used to collect & measure volume of dry CO_2 gas from

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

reversible not advantage — ? — disadvantage

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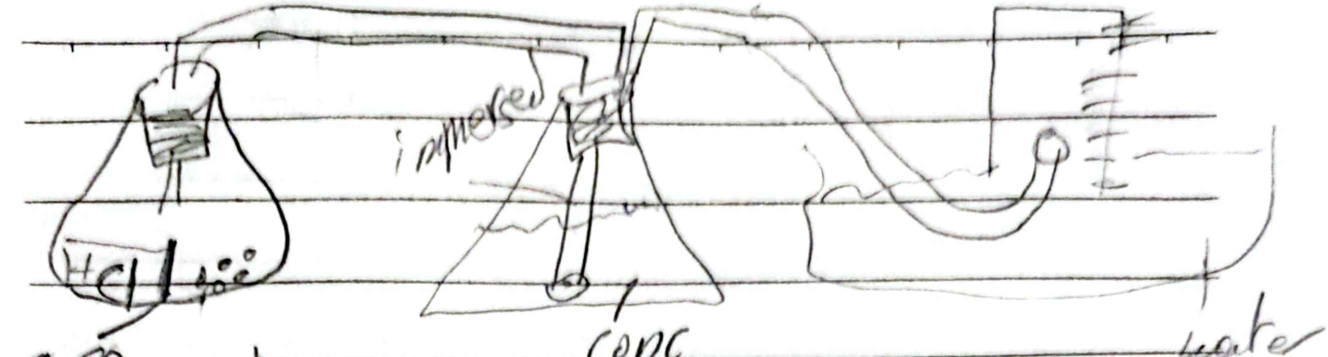

Industrial Industry of Ammonia

"Haber process"

prepare fertilizers

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

exo

pressure ↑ rate ↑ yeild NH_3

pressure : risk of explosion + expensive.

How to obtain

① Nitrogen : fractional distillation of liquid air
different B.P — cooling under high pressure

② Hydrogen : ① cracking of Alckanes (organic)
② $CH_{4(g)} + H_2O_{(g)} \rightarrow CO_{(g)} + 2H_{2(g)}$
methane

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

ratio: we need H 3 : N 1 because ratio 3 : 1

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essential condition...

1) Temp 400 — 450°c

Temp 400°c — 450°c

less than 400°c

advantages; higher yield of NH_3
- shift forward to the exo side
disadvantages; slower rate - particles lose K.E so less effective collisions per unit time.

More than 450°c
adv; faster rate.
dis; less yield - shift backward to the endo side

2) pressure 200 ATM

more pressure 200 ATM
adv; more yield of NH_3 shift forward to the side with fewer gas mole
2- faster rate
dis
1) risk of explosion 2- expensive

for more yield

1) add more iron catalyst 2) ↑ pressure 3) ↑ particles size of iron catalyst

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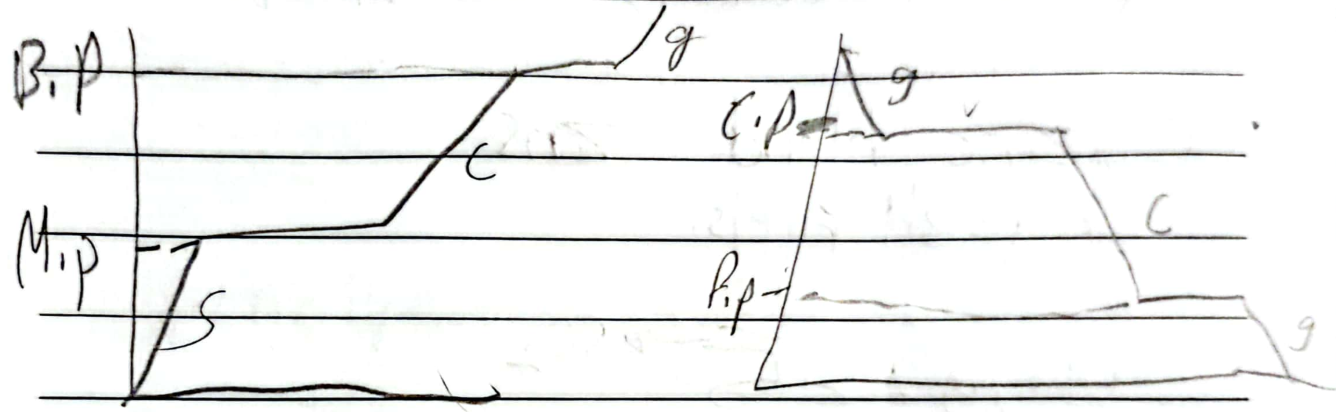
a) 1 only B) 2 only c) 1 and 2 d) 2 and 3

3) Fe catalyst

add excess H_2 & N_2

return back to converter

remove NH_3 immidiatly by cooling



Uses of ammonia:

1) fertilizers 2) cleaning detergents

3) smelling salts

Industry of H_2SO_4) Contact process

stages $S \xrightarrow[+O_2]{(1)} SO_2 \xrightarrow[+O_2]{(2)} SO_3 \xrightarrow{(3)} H_2S_2O_7 \xrightarrow{(4)} H_2SO_4$

(1) Roasting (2) contact process

why the reaction important:

Contract / making sulfuric acid

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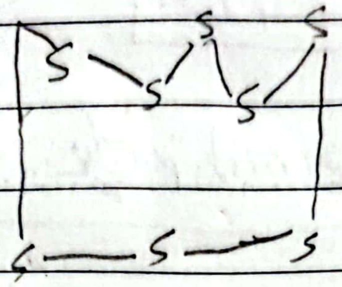
S: group VI - Valency (2)

- yellow solid - S_8

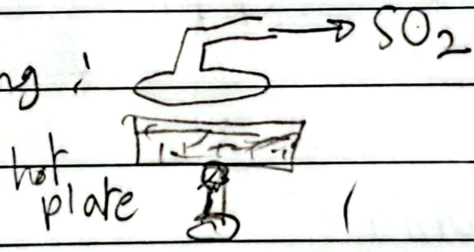


uses: medicine, match, rubber

ore: zinc blend ZnS

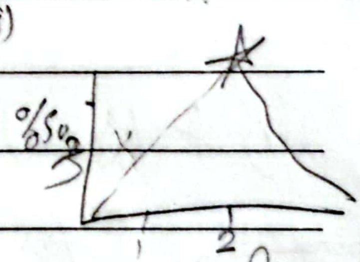
fossil fuels.

Roasting:



Contract process

$$2SO_{2(g)} + O_{2(g)} \underset{endo}{\overset{exo \; V_2O_5}{\rightleftharpoons}} 2SO_{3(g)} \quad \Delta H = -ve \text{ (exo)}$$



essential conditions:

1) temp: 400 - 450°c
2) pressure: 2 ATm "High pressure favour the forward rxn, 2 Atm gives max. yield of SO_3 (fewer gas moles)
3) Catalyst V_2O_5 Vanadium (V) oxide

saturday.

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* SO_2 cause acid rain.

$SO_3 \xrightarrow{H_2O\ X} H_2SO_4$ → drying agent. → nuetralize bases

- highly exothermic
- produce low yield of H_2SO_4

conc H_2SO_4 ↓

$H_2S_2O_7$ oleum —H_2O→ H_2SO_4

electrolysis of $CuSO_3$

question; a i) Temp 400-450°C, pressure 2ATM, catalyst V_2O_5

ii) decrease, because it will shift backward to end side.

iii) prepare olium then add water

uses of SO_2; kills bacteria (sterilization)

* paper industry bleaching agent.

~~Sr~~(OH)$_2$

base ~~≠~~ alkali

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Carbonate cycle

building / extraction of iron

dry NH_3

$CaCO_{3(s)}$ —thermal decomposition→ $CaO_{(s)}$ + CO_2

lime stone — quick lime

(bases)

→ nuetralise acidic soil water

→ desulfonation of flow gases

+CO_2 ↑

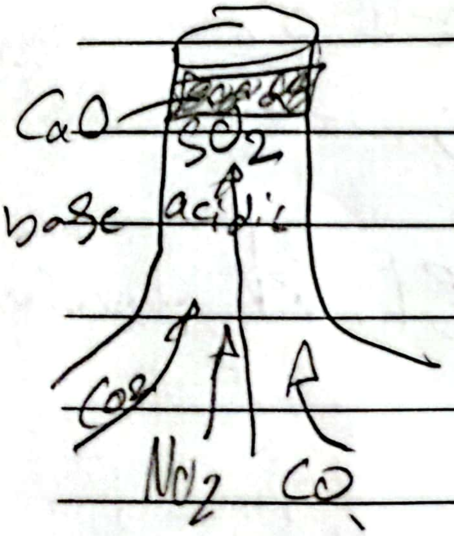
↓ limited H_2O

$Ca(OH)_{2(aq)}$ ← excess H_2O — $Ca(OH)_{2(s)}$

lime water — slacked lime

+ ~~est~~ CO_2

$$Ca(OH)_{2(aq)} + CO_2 \rightarrow CaCO_{3(s)} + H_2O$$



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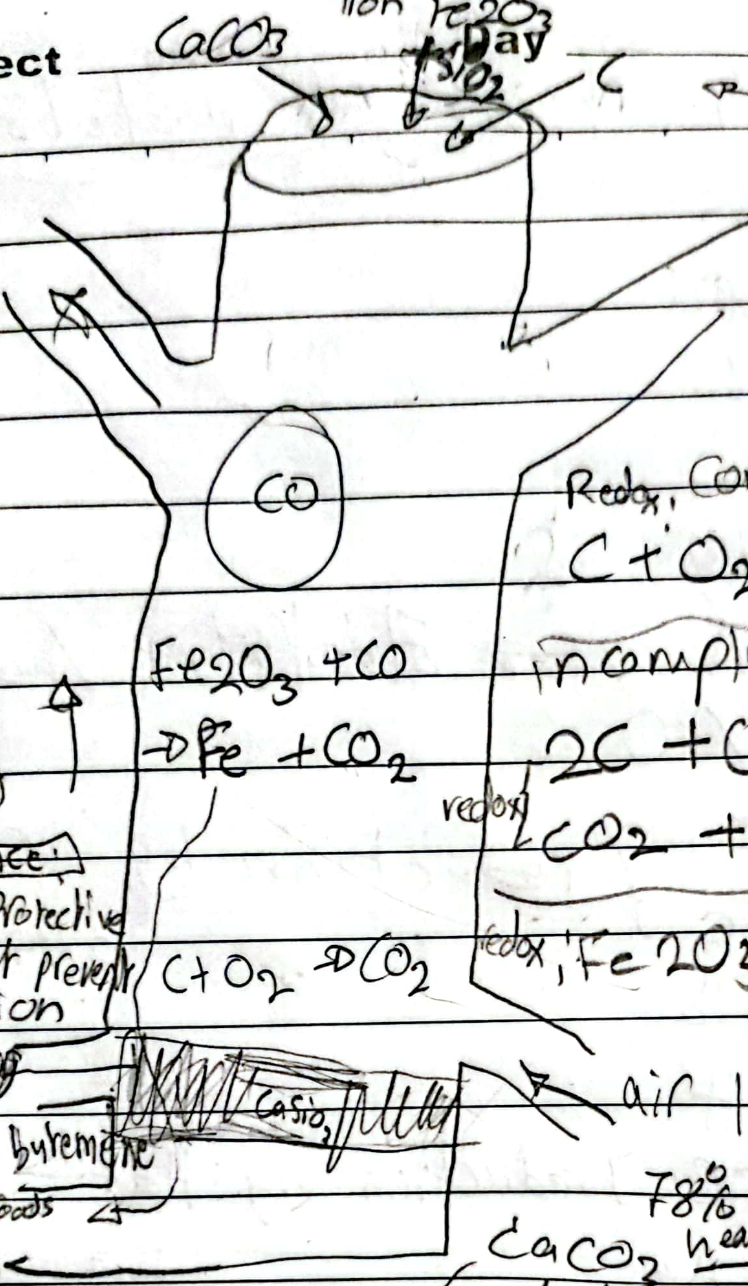
Extraction of metals

K
Na
Li
Ca
Mg
Bauxite Al_2O_3 α [Al] → Electrolysis / molten.
C/CO
zinc blende α ZnS Zn] reduction by C & CO
Hematite Fe_2O_3 α Fe] "blast furnance"
Pb
H
CuS α Cu] reduction by H_2
Ag
Au
Pt

Extraction of Iron

Ore: Fe_2O_3 "Hematite"
methode: reduction by C, CO
Place: Blast furnance.
Raw materials: Fe_2O_3 mixed with SiO_2 acidic impurities.
$CaCO_3$ "lime stone"
coke "Carbon "pure""
air 1500°c

Don't forget to copy from phone.



C ← pure carbon
Coke

waste gases
CO_2
CO
N_2
NO_2
↓ % O_2

Importance: form a protective layer that prevents the reaction of Fe + O_2

Use: mixed with bitumen to make roads

Fe (l)

cast iron

Redox: complete combustion
$C + O_2 \rightarrow CO_2$ produce energy

incomplete comb
$2C + O_2 \rightarrow 2CO$

redox: $CO_2 + C \rightarrow 2CO$

redox: $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

air 1500°C
78% N

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

extraction of iron: reduction by C, C

why we can't reduce Al: Al is more reactive than Carbon.

→ (Neutr) $CaO + SiO_2 \rightarrow CaSiO_3$
base acid Calcium Sillicate
slag

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steel making "oxygen base process"

cast iron

Fe — hot O_2

impurities:

CO_2 ← [C]

SO_2 ← S

SiO_2 ← Si

P_2O_5 ← P

CaO

steel

%C in steel

→ mild steel 0,03%C "car bodies"

→ Medium steel 0.3%C, Railways.

→ stainless steel 3-5%C, cutters, water

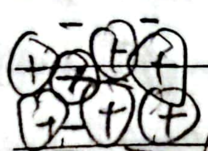
Alloy: mixture of metal with another metal or semi-metal

Brass Cu, Zn

Bronze Cu, Sn

steel Fe, C, Ni, Cr

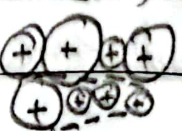
Metal Cu



ductile & brittle (less malleable)

Brass

Cu, Zn



harder

different size of metals.

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Extraction of zinc

ore: zinc Blende ZnS

methode: reduction by C & CO

place: Blast Furnace.

C, CO and H_2 can only reduce. The less reactive metal from its oxide.

$C + ZnS \rightarrow$ no reaction

step 1: $ZnS \rightarrow ZnO + SO_2$ Roasting with hot air $+O_2$

step 2: $C + O_2 \rightarrow CO_2$

$2C + O_2 \rightarrow 2CO$

$CO_2 + C \rightarrow 2CO$

$CO + ZnO \rightarrow Zn + CO_2$

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

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the furnace.