

Redox

in terms of:	Reduction	Oxidation
1. oxygen	lose O	gain O
2. hydrogen	gain H	lose H
3. oxidation state	decrease	increase
4. electron transfer	gains e^- (-ve)	lose e^- (+ve)

* Rules for oxidation state.

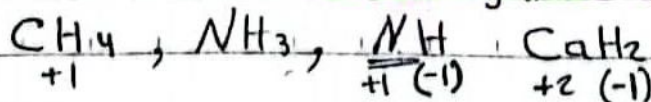
1. The oxidation state for any free element = zero

Monatomic	diatomic	polyatomic
• Na, K, Li...	• $H_2, O_2, F_2,$ N_2, Cl_2, Br_2, I_2	P_4 S_8

2. The oxidation number of any atom in a compound from

group 1 = +1	Li, Na, K, Rb, Cs, Fr	all
group 2 = +2	Mg, Ca, Sr, Ba	(no Be)
group 3 = +3	always +3 only for Al	Al
group 7 = -1	always -1 only for F	F

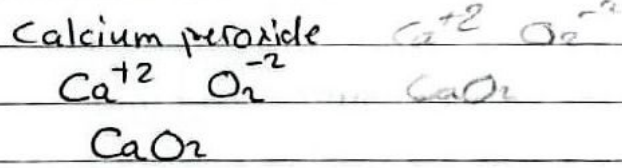
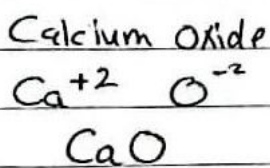
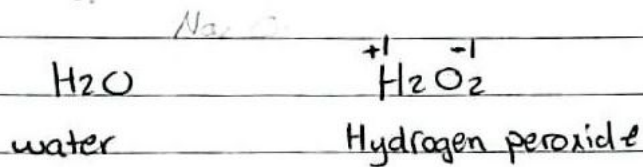
3. The oxidation number of hydrogen (+1)
except with metal in metal hydride (-1)



4. The oxidation state of oxygen (-2) grab
 except in peroxide O_2^{-2} (-1)
 except in OF_2 (+2)

Peroxide O_2^{-2}

- sodium oxide $Na^{+1} O^{-2} \rightarrow Na_2O$
- sodium peroxide $Na^{+1} O_2^{-2} \rightarrow Na_2O_2$

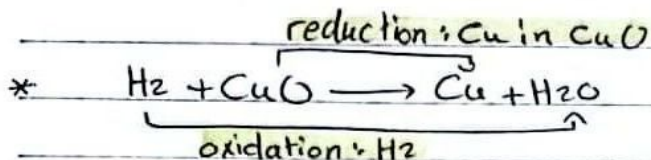
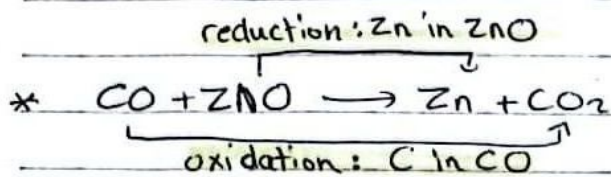
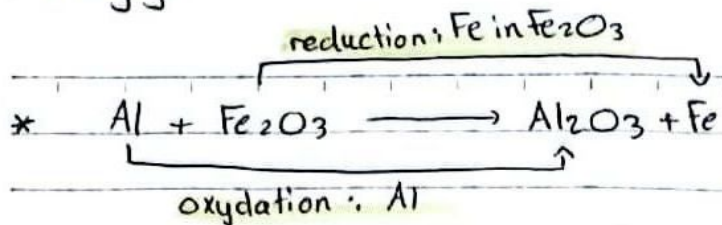


5! The sum of all oxidation state in a compound = 0

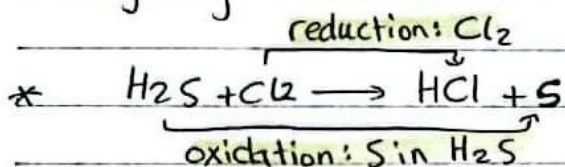
compound	in an ion = charge of this ion
$NaCl$ $+1 + x = 0 \rightarrow x = -1$	NH_3 $N + 3 = 0 \rightarrow N = -3$
$HClO_2$ $1 - 2 + x = 0 \rightarrow x = +1$	NO $N - 2 = 0 \rightarrow N = +2$
$HClO_3$ $1 - 4 + x = 0 \rightarrow x = +3$	N_2O_5 $\frac{2N + 10 = 0}{2} \rightarrow N = +5$

NO_3^{-1} $N + 3(-2) = -1 \rightarrow N = +5$
MnO_4^{-1} $Mn + 8 = -1 \rightarrow Mn = +7$
SO_3^{-2} $S - 6 = -2 \rightarrow S = +4$
$Cr_2O_7^{-2}$ $\frac{2Cr + 14 = -2}{2} \rightarrow Cr = +6$

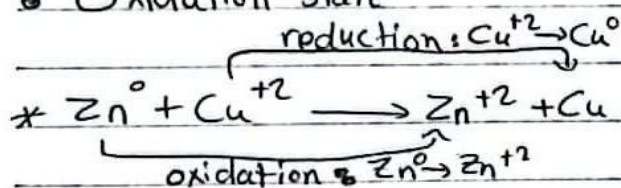
• oxygen



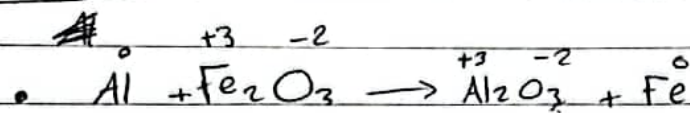
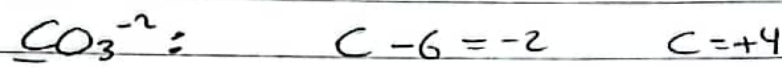
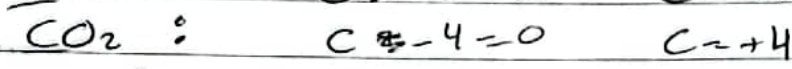
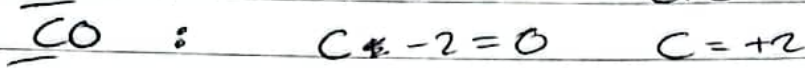
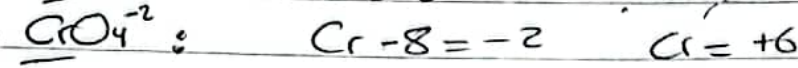
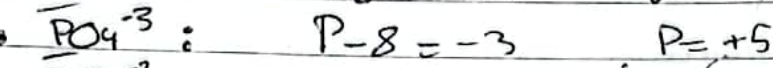
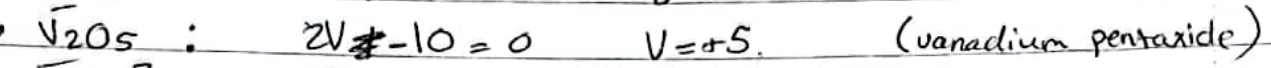
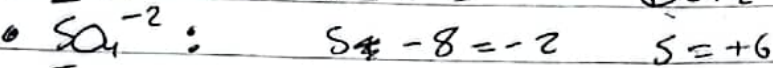
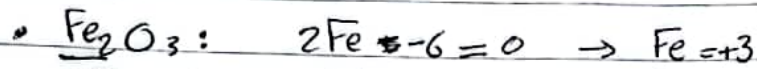
• Hydrogen



• Oxidation state

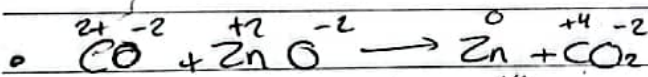


Q. Find the oxidation state of each ~~is~~ under lined species.



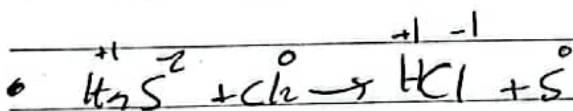
oxidation : $\text{Al} \rightarrow \text{Al}^{+3}$

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



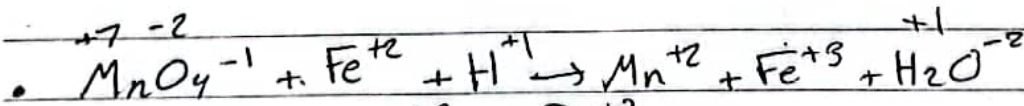
oxidation : $\text{C}^{+2} \rightarrow \text{C}^{+4}$

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



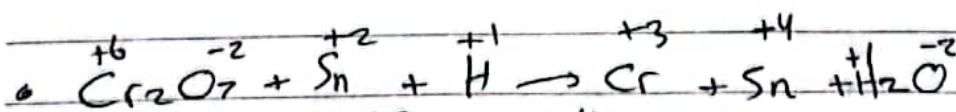
oxidation : $\text{S}^{2-} \rightarrow \text{S}$

reduction : $\text{Cl}_2 \rightarrow \text{Cl}^{-1}$



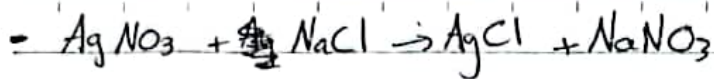
oxidation : $\text{Fe}^{+2} \rightarrow \text{Fe}^{+3}$

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



oxidation : $\text{Sn}^{+2} \rightarrow \text{Sn}^{+4}$

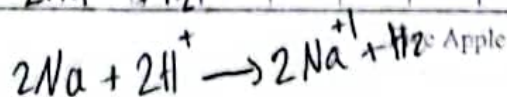
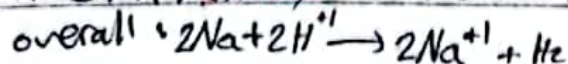
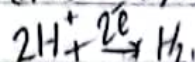
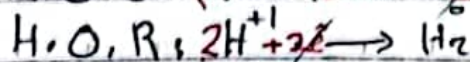
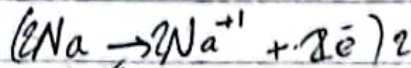
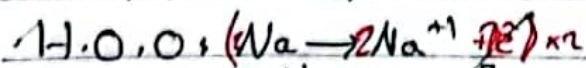
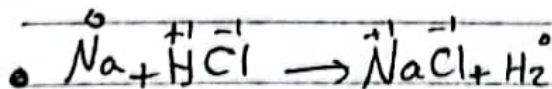
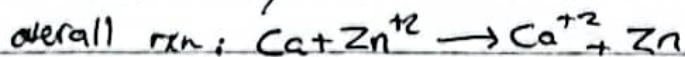
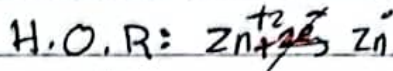
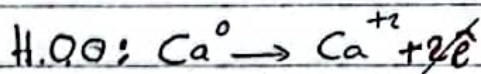
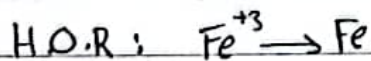
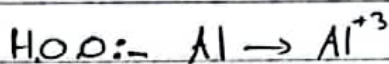
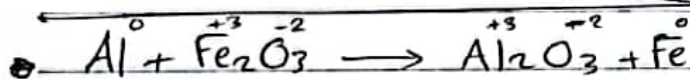
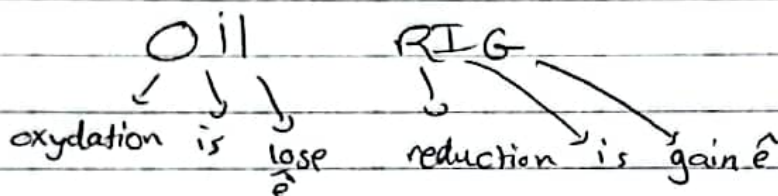
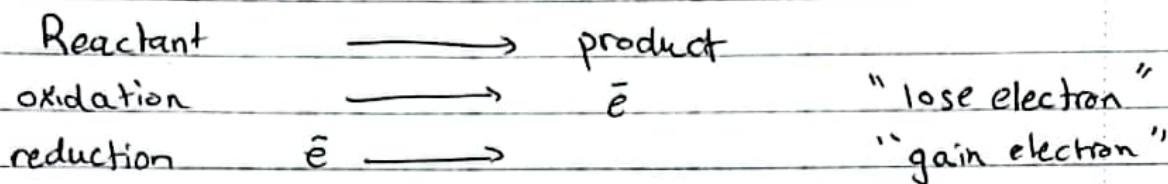
reduction : $\text{Cr}^{+6} \rightarrow \text{Cr}^{+3}$



writing balanced half ionic equations

1) atoms

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



Oxidising agent and Reducing agent

* Oxidising agent: "oxidant"

the substance that is itself reduced
and causes the other substance to
be oxidised

	oxidation	reduction
	reducing agent	oxidising agent
O	gain O	lose O
H	lose H	gain H
OS	↑	↓
\hat{e} electron transfer	lose \hat{e}	gain \hat{e}

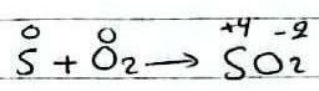
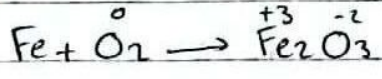
* Reducing agent: "reductant"

the substance that itself is oxidised
and causes the other substance to
be reduced

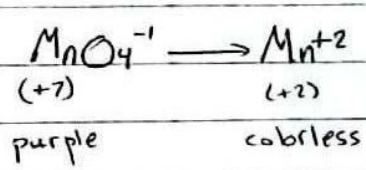
if the substance is an ion,
in a compound the agent
is the compound itself.

most common oxidising agents

① oxygen (oxygen can never be oxidised)

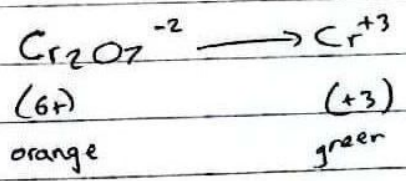


② Acidified potassium manganate KMnO_4/H^+



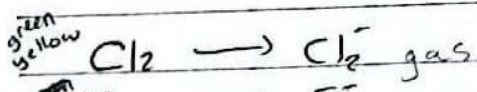
Purple \rightarrow colorless

③ Acidified potassium dichromate $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$

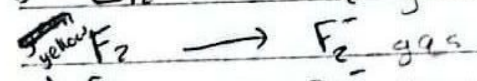


orange \rightarrow green

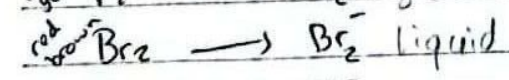
④ Halogens



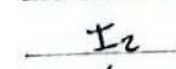
green yellow \rightarrow colorless



yellow \rightarrow colorless



red brown \rightarrow colorless

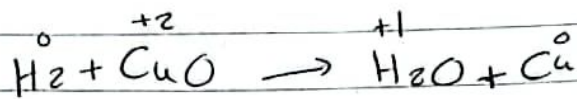


red brown \rightarrow colorless

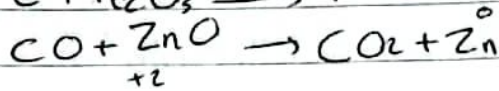
purple gas
black solid
red brown solution

most common reducing agent

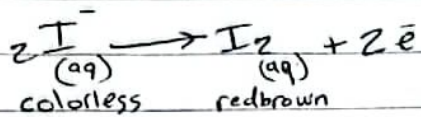
① Hydrogen



② Carbon and carbon monoxide



③ Iodide



colorless → red brown

④ Metals

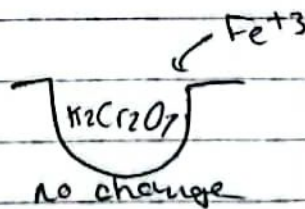
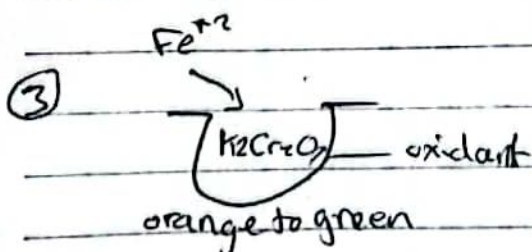
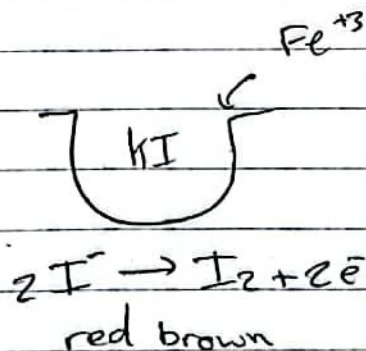
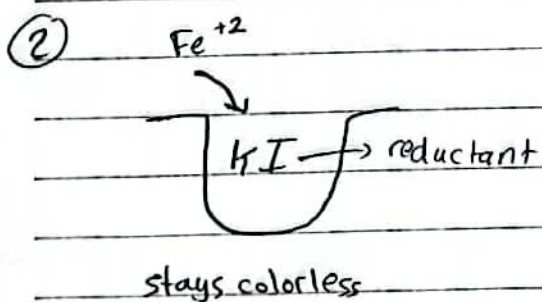
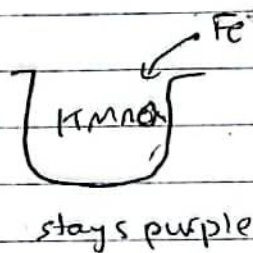
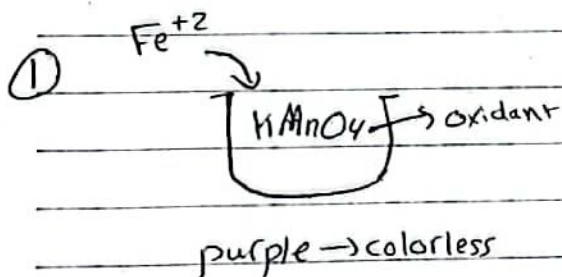
k

	oxidant	reductant	
	O_2	H_2	
purple	$K_2Cr_2O_7/H^+$	C, CO	
orange	$KMnO_4/H^+$	Metals	
	Halogen	Iodide	colorless sol.

Q1 - Fe^{+2} is a reducing agent

Fe^{+3} is an oxidising agent

record the observation in each of the following reaction.



Electrolysis

Electricity

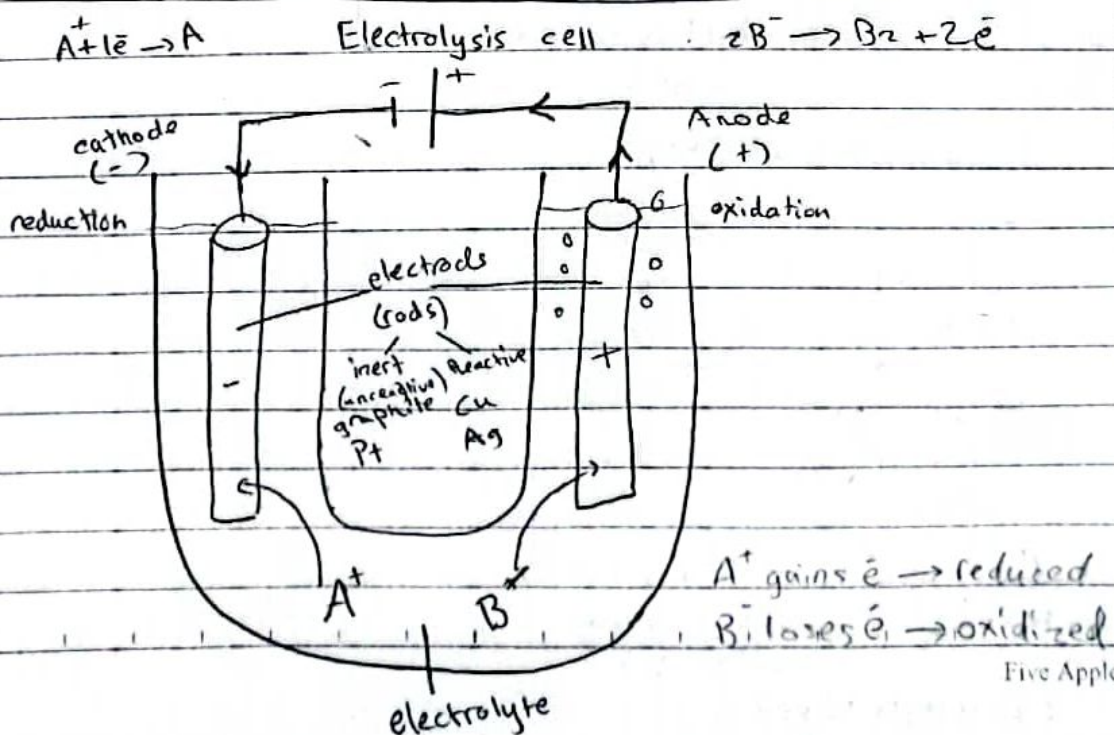
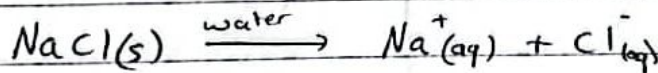
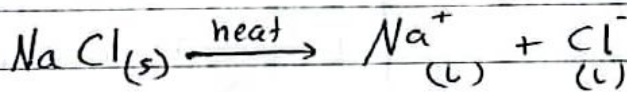
Analysis

• **Electrolysis**: Breaking down chemical compounds (Ionic) when molten or aqueous by passing electricity. only if they are conductors.

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

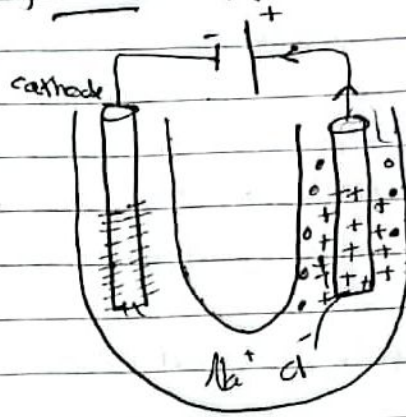
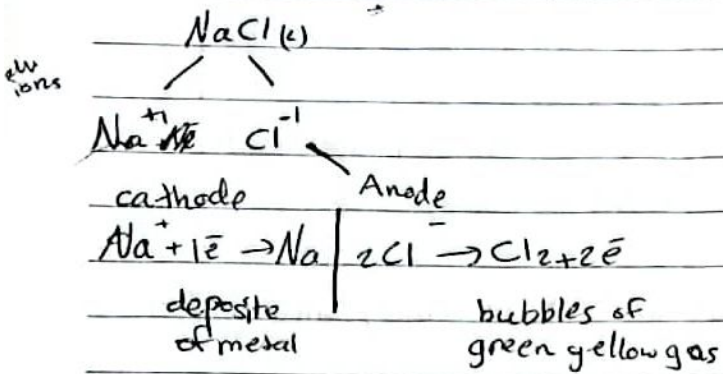
why the ionic compounds don't conduct electricity when solid?
the ions are not free to move

why the ionic compounds conduct electricity when dissolve in water or being molten
the ions ~~are~~ are free to move



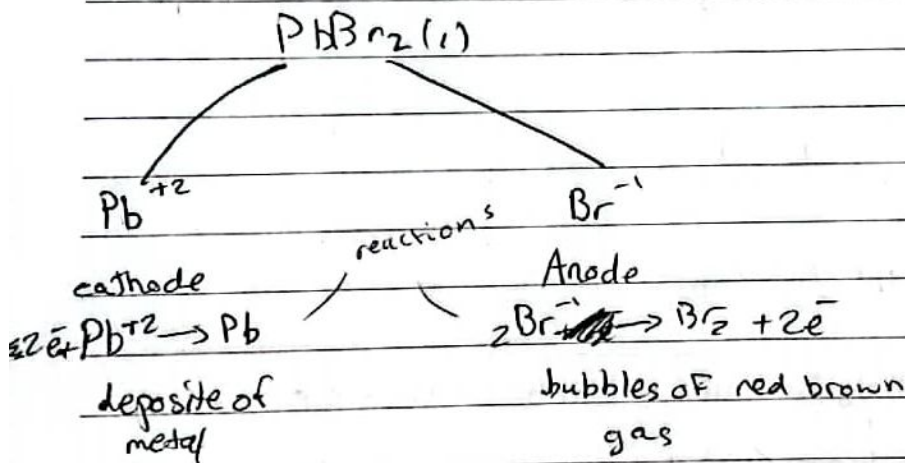
all halides (Az^-) as ions are colorless as solutions
 Electrolyte ~~is~~ is used up only in molten (always)

Electrolysis for molten electrolytes using inert rods (graphite)



Electrolyte: used up $NaCl(l)$ electricity $Na + Cl_2$

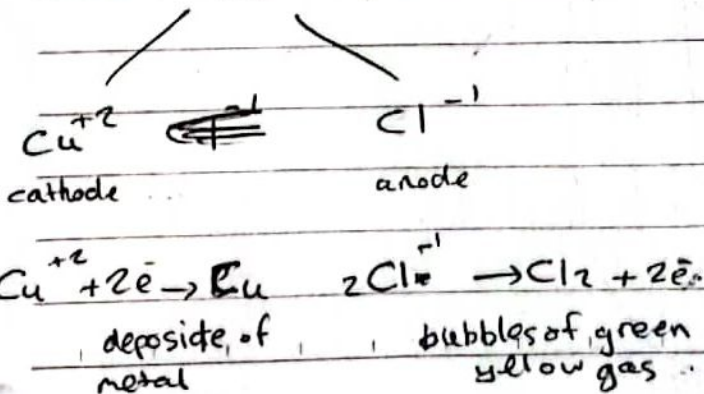
Molten lead (II) Bromide



- | | |
|--------|------------------|
| F_2 | yellow gas |
| Cl_2 | green yellow gas |
| Br_2 | red brown gas |
| | red brown liquid |
| I_2 | black solid |
| | purple gas |
| | red brown sol. |

Electrolyte: used up

$CuCl_2(l)$



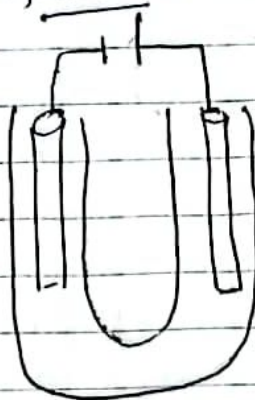
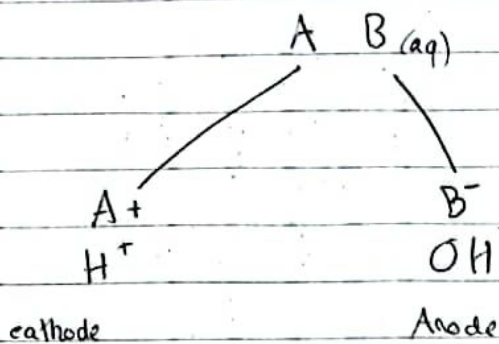
Electrolyte: used up
 consumed

Electrolyte not used up in aqueous

cathode
look at reactivity

anode
look at conc. halides

Electrolysis of aqueous Electrolyte using inert



K ⁺
Na ⁺
Li ⁺
Ca ⁺²
Mg ⁺²
Al ⁺³
Zn ⁺²
Fe ^{+2/+3}
Pb ⁺²
2e ⁻ + H ⁺¹ → H ₂
Cu ^{+1/+2}
Ag ⁺¹
Al ⁺³

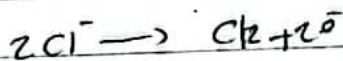
* At the cathode

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

* At the Anode

always OH⁻ except with concentrated halides Cl⁻, Br⁻, I⁻

when the halide oxidise



when OH⁻ oxidise



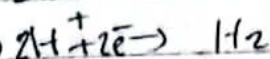
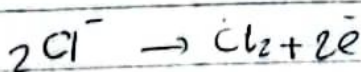
bubbles of colorless gas

Concentrated NaCl(aq) / graphite



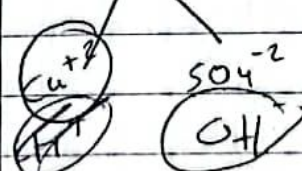
cathode

anode



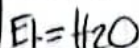
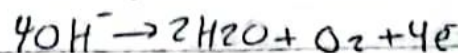
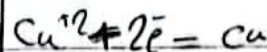
Electrolyte: NaOH

CuSO₄(aq) / graphite



cathode

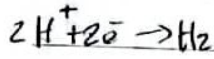
anode



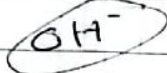
dilute NaCl (aq) / graphite



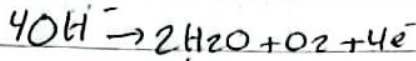
cathode



bubbles of colorless gas



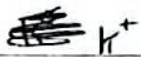
Anode



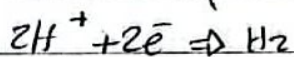
bubbles of colorless gas

Electrolyte: NaCl concentrated (because you took the water from it)

Conc. KI (aq) / graphite



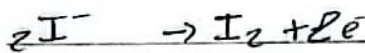
cathode



bubbles of colorless gas



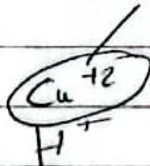
anode



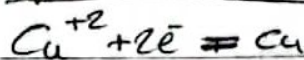
red brown solution

Electrolyte: KOH

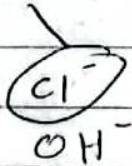
Conc. CuCl₂ (aq) / graphite



cathode



deposit of red brown solid



anode

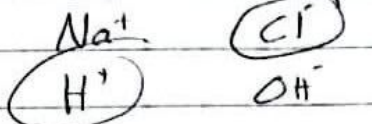


bubbles of green yellow gas

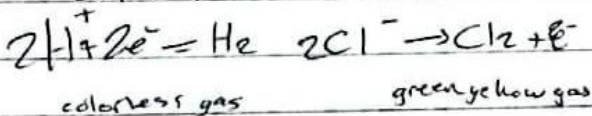
Electrolyte: less conc. Cu

Five Apple

Conc. NaCl called brine solution

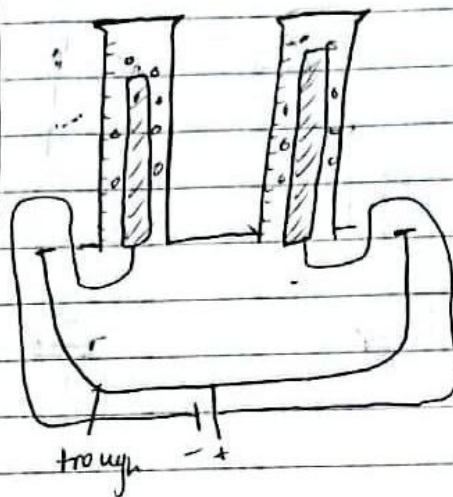


cathode anode

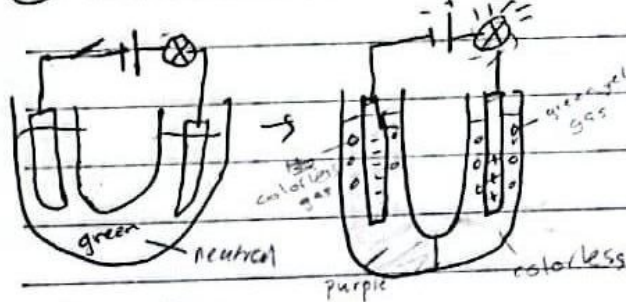


Electrolyte: NaOH

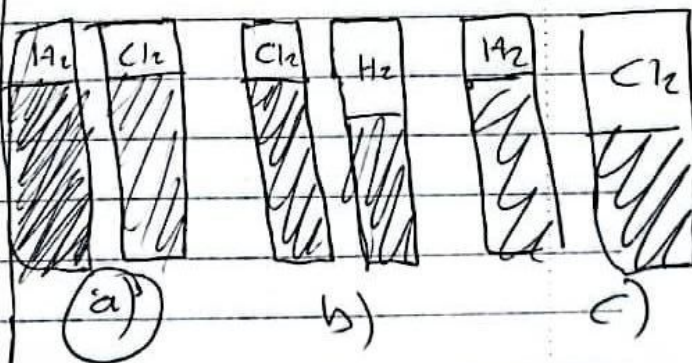
1 plan an exp. to collect and measure the volume of H₂ and Cl₂ produced



3 Brine with universal indicator

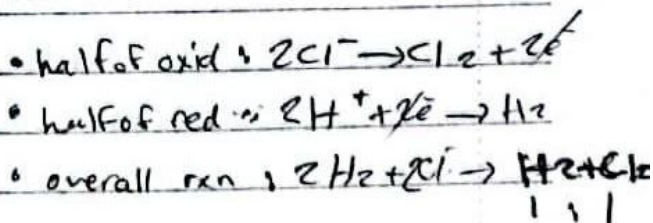


2 the final appearance of the two measuring cylinders are



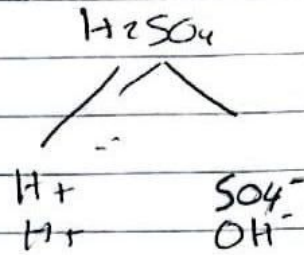
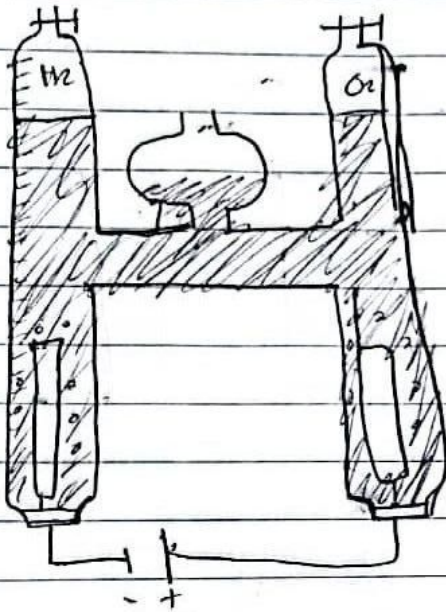
observations

- 1- the bulb lights up
- 2- bubbles of green yellow gas on the anode
(oxidation of Cl⁻)
- 3- bubbles of colorless on the cathode
(reduction of H⁺)
- 4- around the cathode the solution becomes purple, because NaOH is an alkali
- 5- around the anode the solution becomes colorless because Cl⁻ bleaches the color

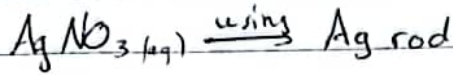


4 Cl₂ not immediately appear as H₂ produce?
 some Cl₂ dissolve in solution

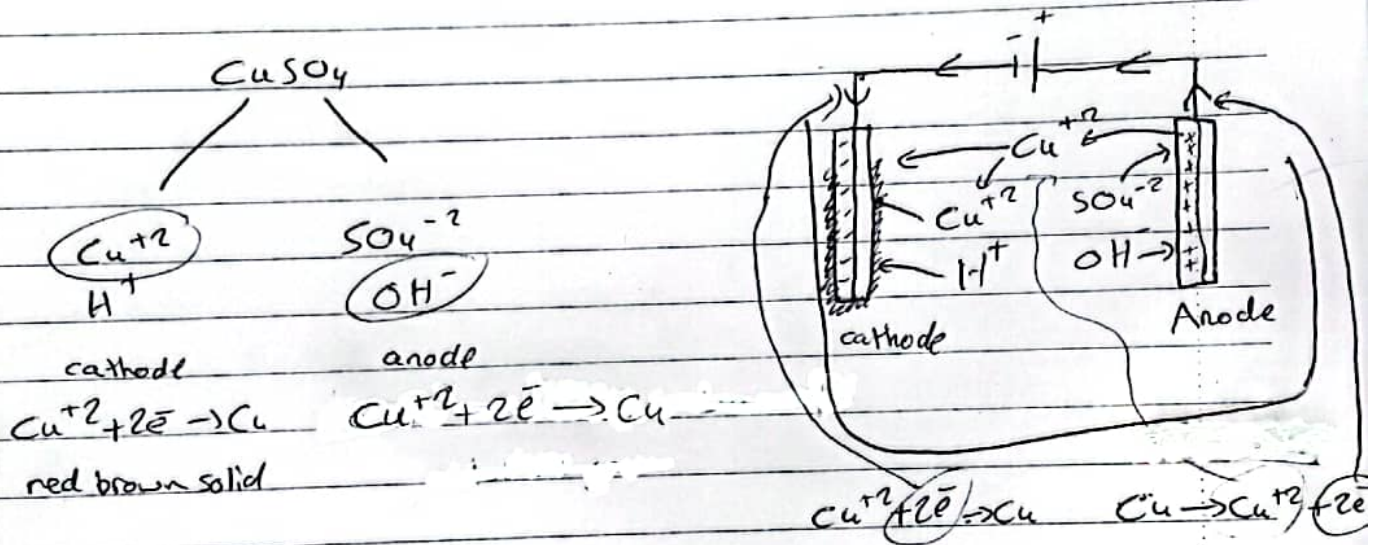
Electrolysis for $H_2SO_4(aq)$
Woff-man



Electrolysis for aqueous electrolyte using Active rod
 * the rod must be the same metal ion in the electrolyte.



Electrolysis for aqueous CuSO_4 using Cu rod



cathode increase in mass
 Cu deposition

Anode decrease in mass
 oxidised by lose e^- 's

Electrolyte

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

Application of Electrolysis

molten/inert

↓
extraction of
metals

aqueous/inert

↓
prepare solution

aqueous/active

Electroplating

purifying
metals

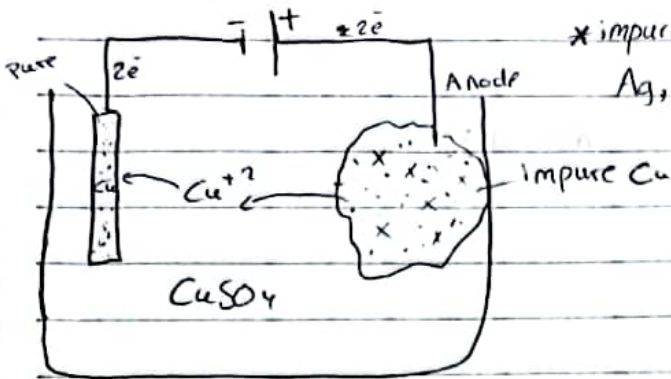
How to electroplate a spoon with silver.

1. clean the spoon from any impurities or oxide layer using sand paper
2. make 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 is fully immersed in the electrolyte"
6. rotate the spoon to ensure an equal distribution
7. rinse with distilled water
8. dry in oven

2

Purifying metals

Refining copper



• Cu
 * impurities
 Ag, Au, Zn



impurities
 Au, Ag settle down
 $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$

Anode must be the impure element
 Cathode must be the pure element

Electrolyte must have a solution containing element

Extraction of metals from their ores.

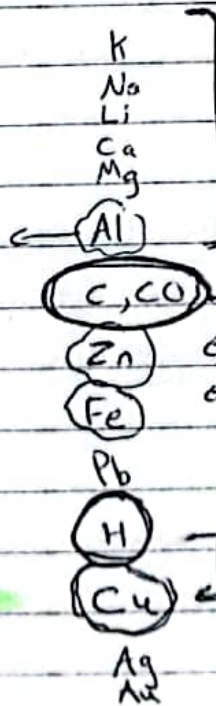
* The method of extraction depends on the position of metal in reactivity.

Bauxite : Al_2O_3

Zincblende : ZnS

Hematite : Fe_2O_3

Copper(II) sulfide : CuS



Electrolysis / molten / inert

reduction by C, CO

reduction by H_2

lowers the m.p

the more impure the substance the lower the m.p
↓
cryolite only for Al

Extraction of aluminum

ore: Al_2O_3 Bauxite

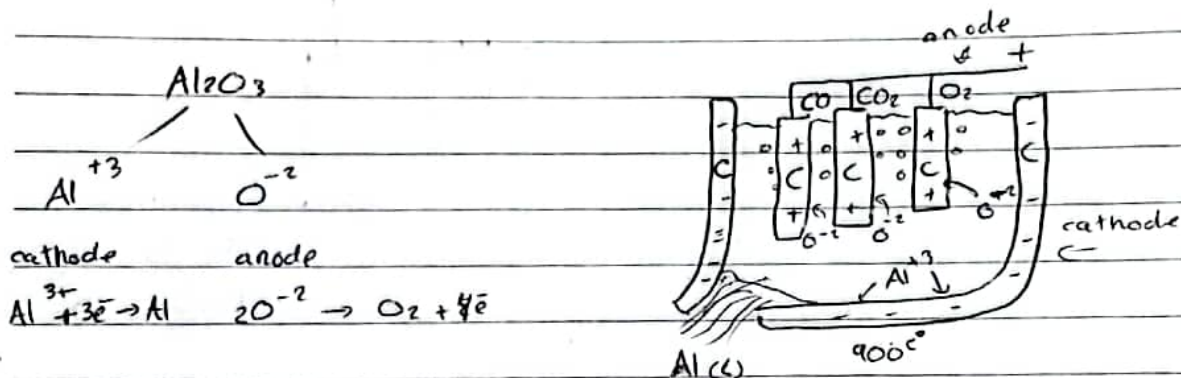
Method: Electrolysis for molten Al_2O_3 / graphite

* m.p of Al_2O_3 is about $2000^\circ C$

so we dissolve the Al_2O_3 in a molten cryolite Na_3AlF_6

- To lower the m.p to $900^\circ C$ so less cost

- to increase the electrical conductivity



gases produced at Anode

1- O_2

2- CO_2

3- CO

} reaction of rods with O_2

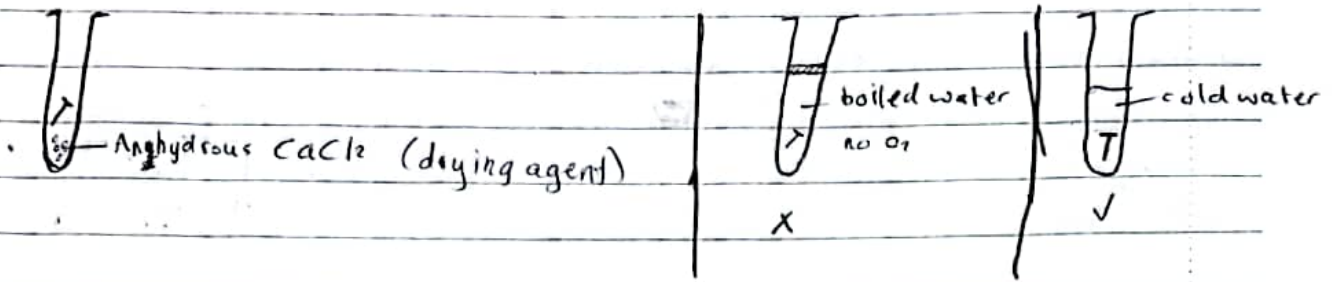
So we must replace them periodically

Aluminum	Property	use
	- low density	- Aircraft bodies
	- ductile	- electrical wires
	- malleable	- cooking utensils - window framing
	- conduct electricity	- wires
	- form an oxide layer (un toxic)	Food cans

If I want to electroplate something I put it as the cathode

If I want to refine something I put it as the anode

Rust is reaction of (iron) with both O_2 and H_2O
 Rust is hydrated iron (III) (it is a slow reaction)



* Plan an experiment to show which rust prevention solution is better. $Fe + O_2 \xrightarrow{H_2O} Fe_2O_3 \cdot nH_2O$

1. take a known mass of iron nail
2. apply a known volume of first solution
3. put them in a known volume of water
4. For 1 week
5. dry them and measure the mass again (dry in oven/hair dryer)
6. repeat the exp. with the second solution

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

* How to prevent rusting

1. grease/oil (to prevent O_2 and H_2O from reaching the iron)
2. painting
3. cover with plastic

* How to prevent rusting (long term)

1. galvanizing (coating iron with zinc)
2. sacrificial protection (connecting iron with magnesium)



Zn and Mg are more reactive

Zn and Mg are more reactive than Fe

more likely to oxidise

more likely to lose e^-

Fe is less likely to rust

3. electroplating

4. cathodic protection

Prevent

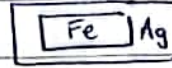
Galvanizing



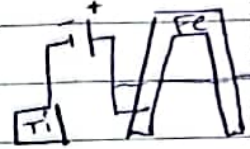
sacrificial protection



Electroplating



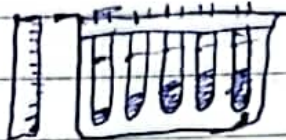
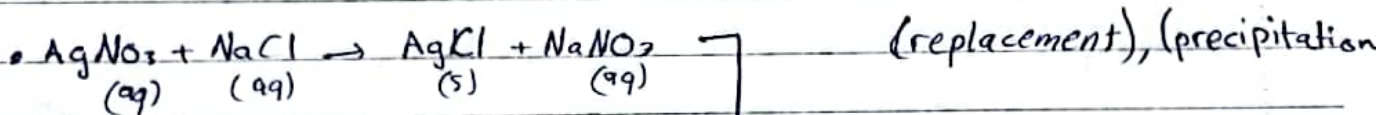
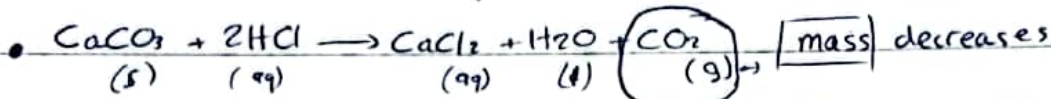
cathodic



Rate of reaction

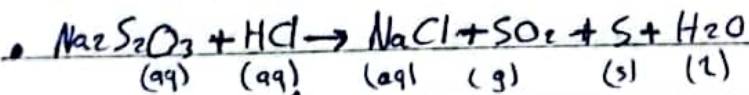
rate of reaction: change in quantity over change in time

$$\text{Rate} = \frac{\Delta Q}{\Delta t} \longrightarrow \begin{matrix} \Delta \text{mass} & \Delta \text{volume} & \Delta \text{PH} & \Delta \text{conc.} & \Delta \text{Temp} \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ \frac{\text{g}}{\text{s}} & \frac{\text{cm}^3}{\text{s}} & \frac{1}{\text{s}} & \frac{\text{mol}}{\text{dm}^3 \cdot \text{s}} & \frac{\text{C}^\circ}{\text{s}} \end{matrix}$$



time (s)	0	10	20	
length (cm)	-	-	-	1

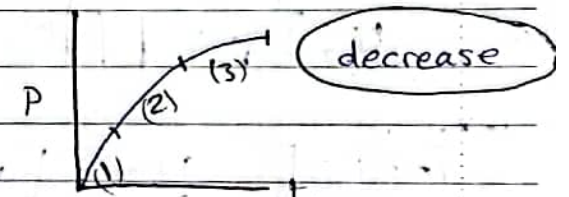
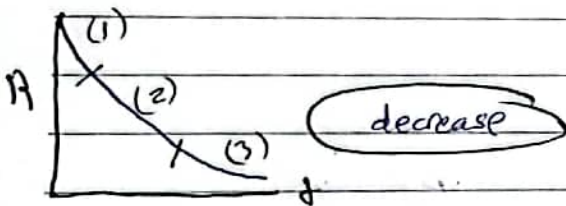
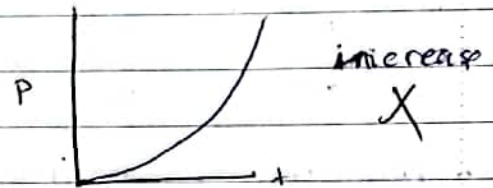
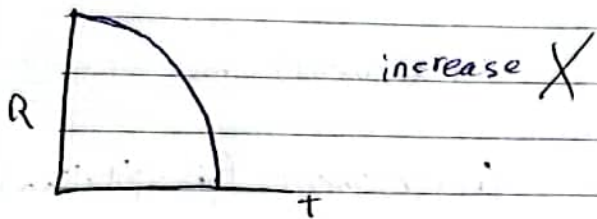
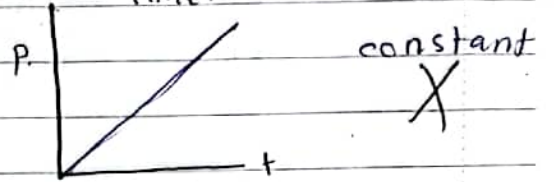
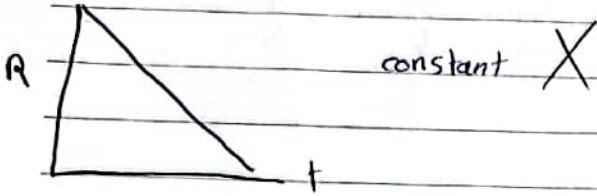
$$\frac{\Delta \text{distance}}{\text{time}}$$



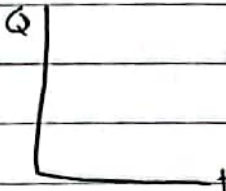
time needed for the cross to disappear
 the higher the conc. the faster the reaction

how fast the reactant is consumed per unit time

how fast the product is produced per unit time.



rate = gradient



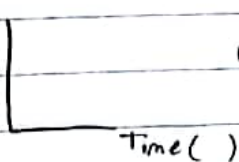
$$\text{rate} = \frac{Q}{t}$$

Rate of reaction

$$\text{Rate} = \frac{\Delta \text{quantity}}{\Delta \text{time}}$$

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

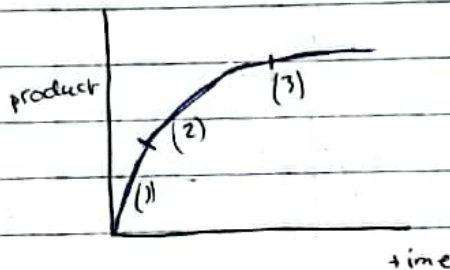
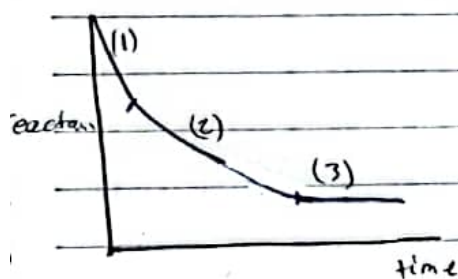
rate = gradient



measure the rate of reaction

How fast the reactant
is consumed per unit time

How fast the product
is produced per unit time



* region (1):

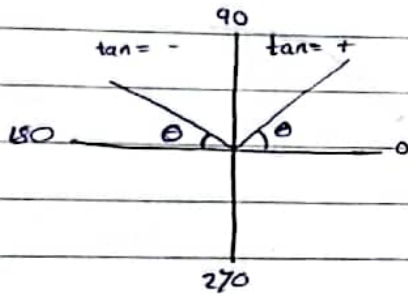
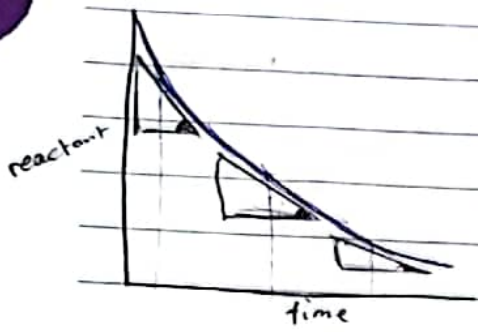
1. more amount of reactants
2. more particles
3. more effective collisions per unit time

* region (2):

1. slower rate \Rightarrow less steep
2. less number of particles
3. less no. of effective collisions per unit time

* region (3):

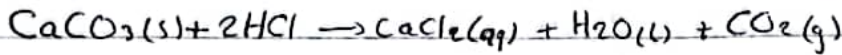
1. reaction is over \Rightarrow gradient = 0
2. no more limiting factor (horizontal)
3. no more effective collisions



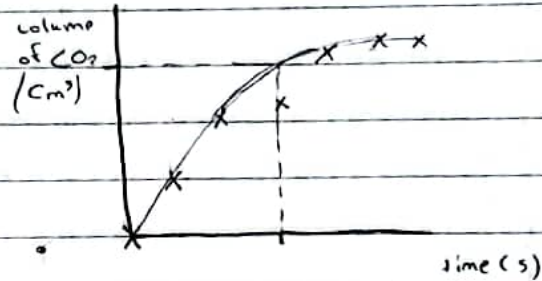
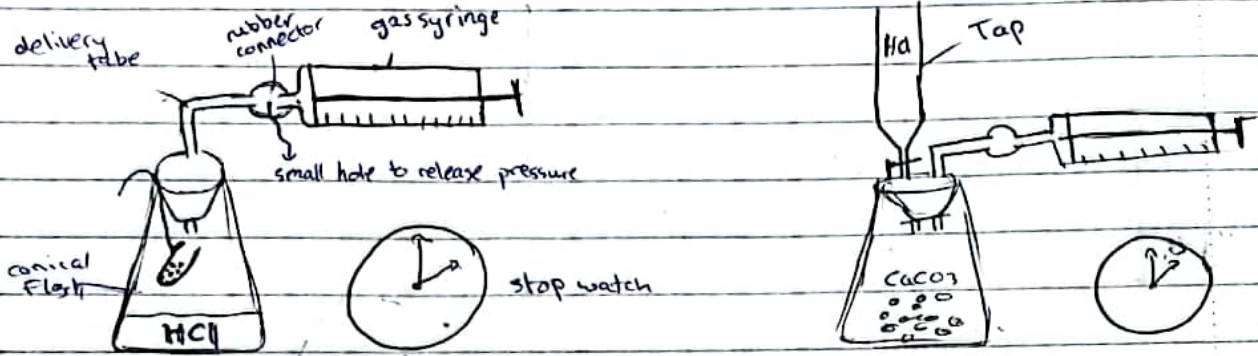
* For any chemical reaction there are three main conditions

- ① the reactants must be suitable $\text{Cu} + \text{HCl} \rightarrow \text{no rxn}$
- ② the reactants must collide
- ③ the collisions must be effective (minimum amount of energy to start rxn)
Activation energy $\rightarrow E_a$

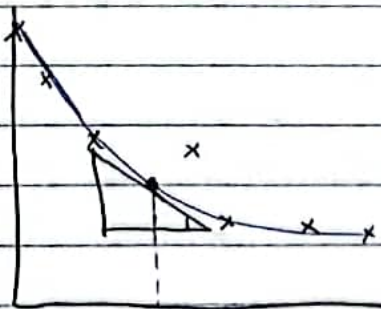
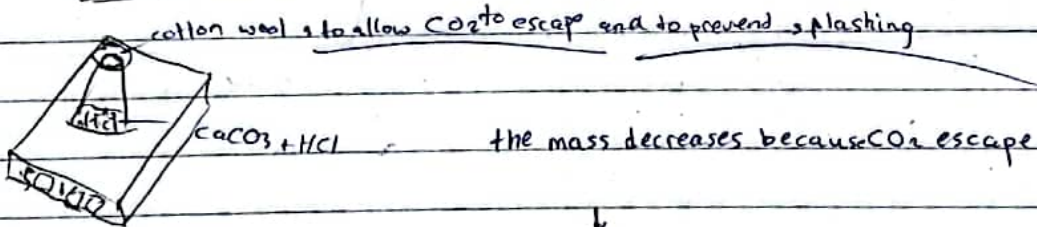
Measuring rate of reaction:



1) measuring the volume of gas per unit time

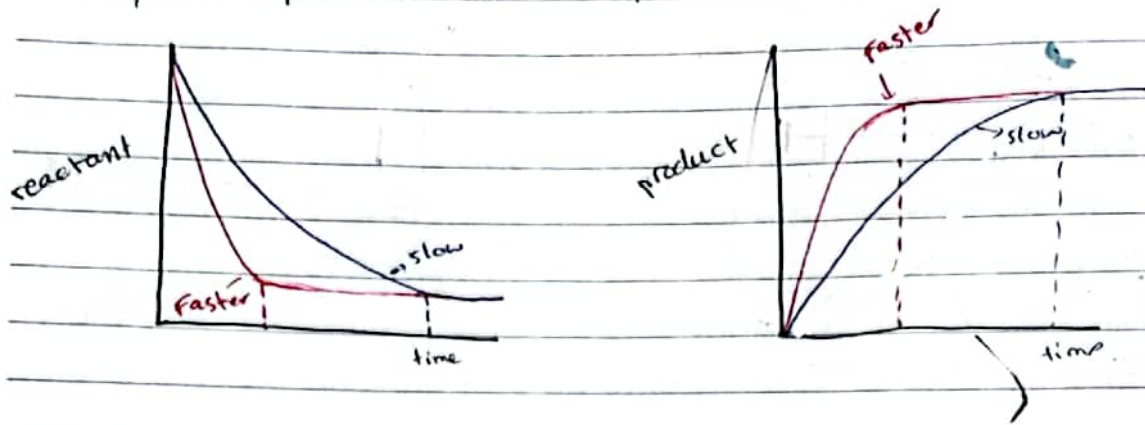


2) measure the mass of the conical flask + content per unit time

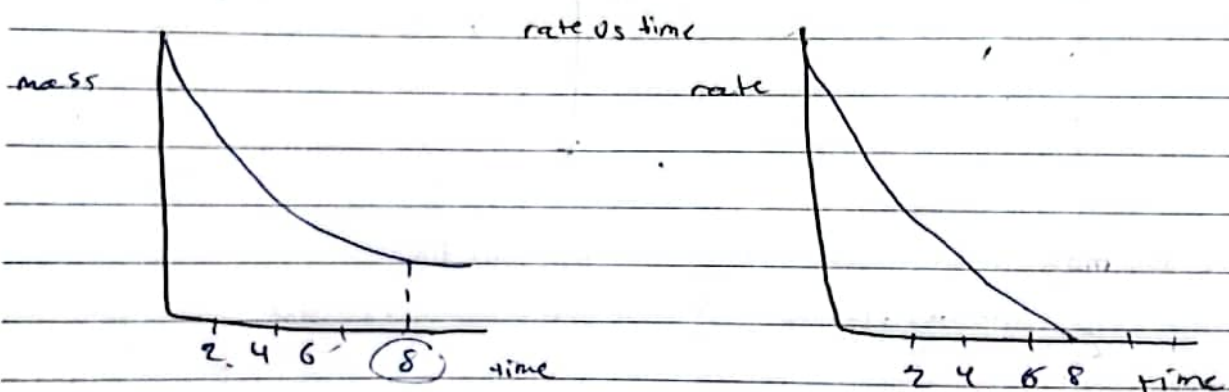


Increasing the rate of reaction

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



Q1- the graph below shows how the amount of reactants changes with time



* Factors that affect the rate of reaction

- ① temperature *
- ② concentration/amount *
- ③ surface area *
- 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. affects the rate of reaction. (5 pts)

As the temperature increases

→ the particles gain more k.E so move faster

→ the particles will have energy equal or greater than the E_a

→ so more effective collisions per unit time

→ so faster rate of reaction

* (Plan an experiment to show) how the temp. affects the rate of reaction.



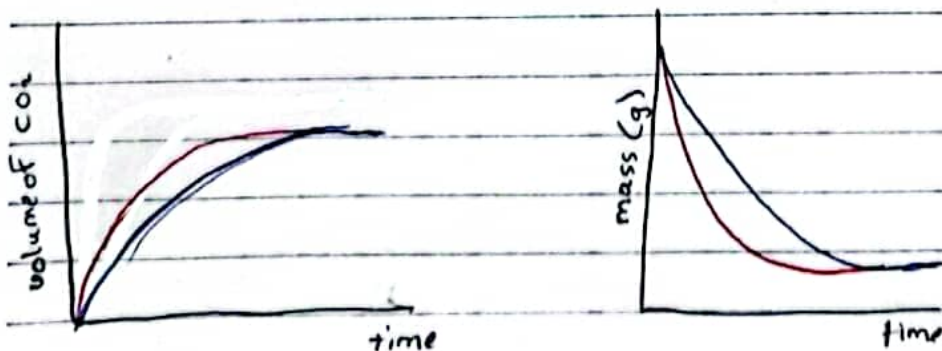
Exp 1. mass = 2.0 g lumps
 $V_{\text{HCl}} = 0.1 \text{ dm}^3$
 $M_{\text{HCl}} = 1 \text{ mol/dm}^3$
temp = 25°C

take a known mass of lumps CaCO_3
add them to a known volume of known conc. of HCl
at 25°C. using a gas syringe

• measure the volume of CO_2 produced per time

Exp 2. mass = 2.0 g lumps
 $V_{\text{HCl}} = 0.1 \text{ dm}^3$
 $M_{\text{HCl}} = 1 \text{ mol/dm}^3$
temp = 50°C

• repeat the experiment at 50°C
• conc. the exp at 50°C produce CO_2 in less time.
(or draw a graph)



② surface area

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

As the surface area increases, the rate of reaction increases

* **Explain** how the surface area affects the rate of reaction

As the surface area increases.

• (decrease the particle size by crushing using mortar and pestle)

• more particles exposed to the reaction

• more effective collisions per unit time

• so faster rate

* Plan an experiment to show how the surface area affect the rate of reaction.



③ concentration "Amount"

* (state) how the concentration affect the rate of reaction.

As the conc. increases, the rate of reaction increase,

* Explain how the conc. affect the rate of reaction

As the conc. increase,

more particles

so more effective collisions per unit time

so faster rate of reaction

* Plan an experiment

Exp. 1 mass $\text{CaCO}_3 = 2\text{g}$ $V = 0.1 \text{ dm}^3$
lumps HCl

$M_{\text{HCl}} = 0.1 \text{ mol/dm}^3$

Temp = 25°C

Exp. 2 mass $\text{CaCO}_3 = 2\text{g}$
lumps

$V = 0.1 \text{ dm}^3$

$M_{\text{HCl}} = 0.2 \text{ mol/dm}^3$

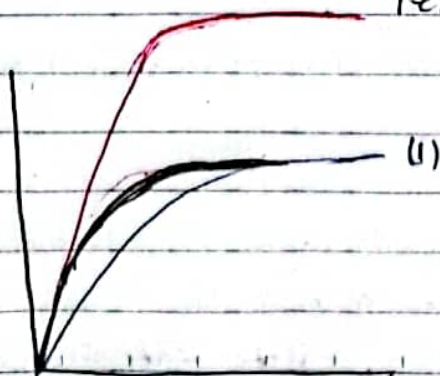
Temp = 25°C

Exp. 3 mass $\text{CaCO}_3 = 4\text{g}$
lumps

$V = 0.1 \text{ dm}^3$

$M_{\text{HCl}} = 0.1 \text{ mol/dm}^3$

Temp = 25°C

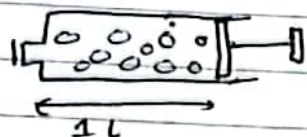


④ Pressure "only affect gas"

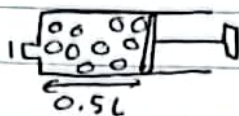
* Explain how the pressure

As the pressure increases (by reducing the volume)

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



10 particles = 10
1 litre

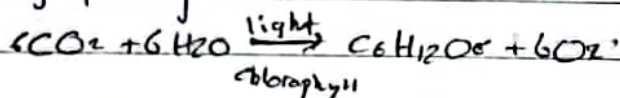


20 particles = 20
0.5 litres

⑤ Light "only for photochemical reactions"

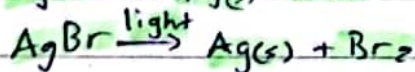
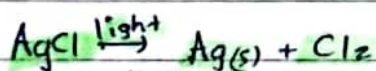
↓
reaction that needs light to occur

eg. photosynthesis



Photographic films

Films coated with silver chloride or silver bromide



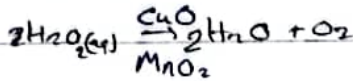
⑥ Catalyst

chemical substance that speeds up chemical reaction without being used up

How? it provides an alternative way with lower E_a so more particles will have energy equal to or more than E_a .

So more effective collisions per unit time, so faster rate of rxn

the reaction



- ① CuO
- ② MnO₂ — black solids

Q1. plan an experiment to show that CuO is a catalyst for this rxn. (6pt.)

take a known volume with a known concentration of H₂O₂ at known temp.

measure the volume of O₂ produced per unit time

repeat the exp using CuO

* the experiment using CuO will produce more O₂ per same unit time

Q2. plan an experiment to show which of the two catalysts is better
CuO or MnO₂

take a known volume of H₂O₂ with a known conc. ~~and~~ at known temp.

take a known mass of each catalyst

Q the exp which produce more O₂ per same unit time
used better catalyst

Q3. plan an experiment to show that CuO is not used during the rxn.

measure the mass of CuO

add to H₂O₂ ~~and~~ until no more fizzes

filter the mixture

dry the solid, dry in oven

remeasure the mass

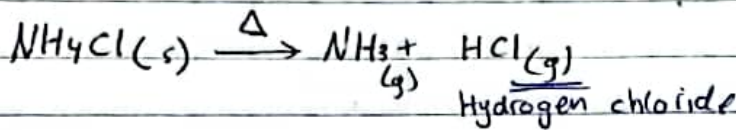
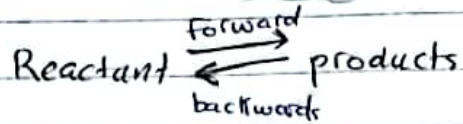
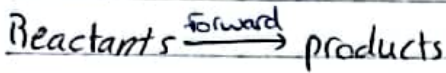
* same initial and final mass

Reversible reaction

Types of chemical rxn

one way

both ways

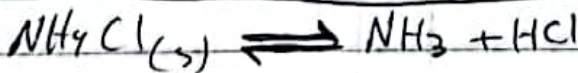
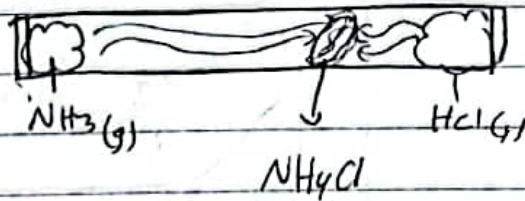
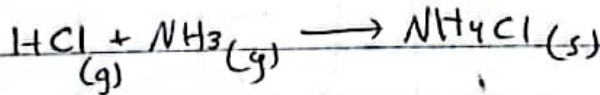


Ammonium chloride

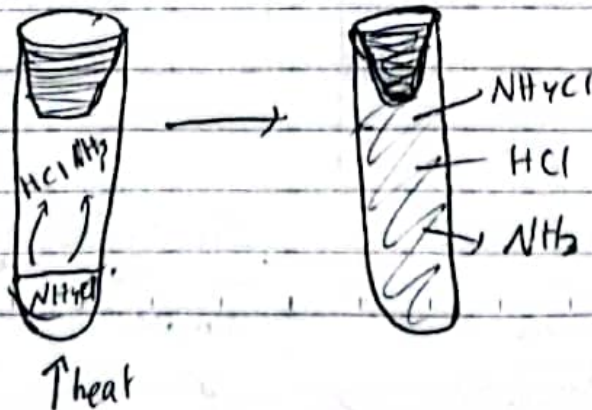
Ammonia

Which damp litmus paper will change first, why?
 the red litmus paper changes to blue. First because
 NH₃ is an alkali and lighter than HCl which is
 acidic Faster

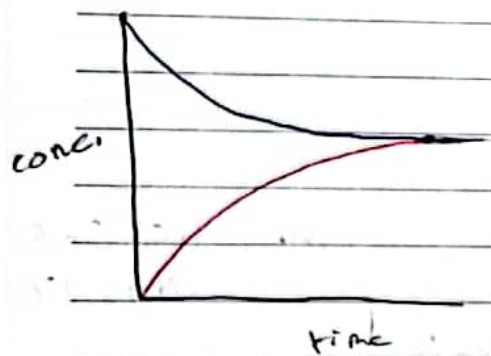
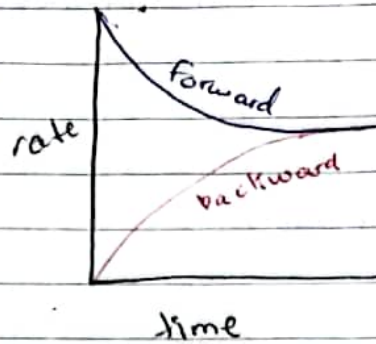
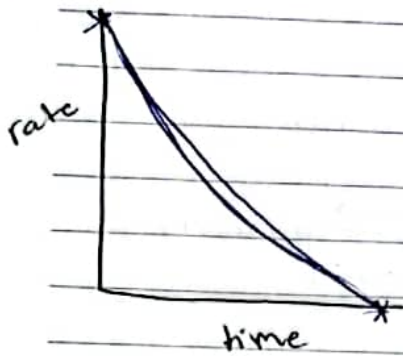
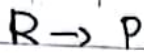
Mr HCl 36.5
 NH₃ 17



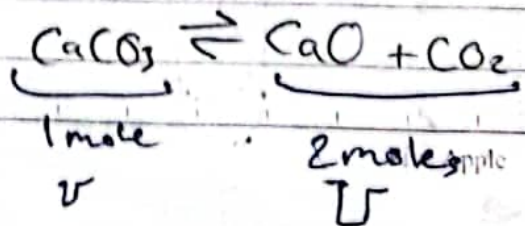
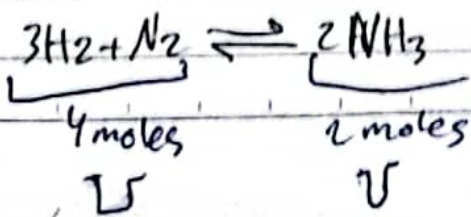
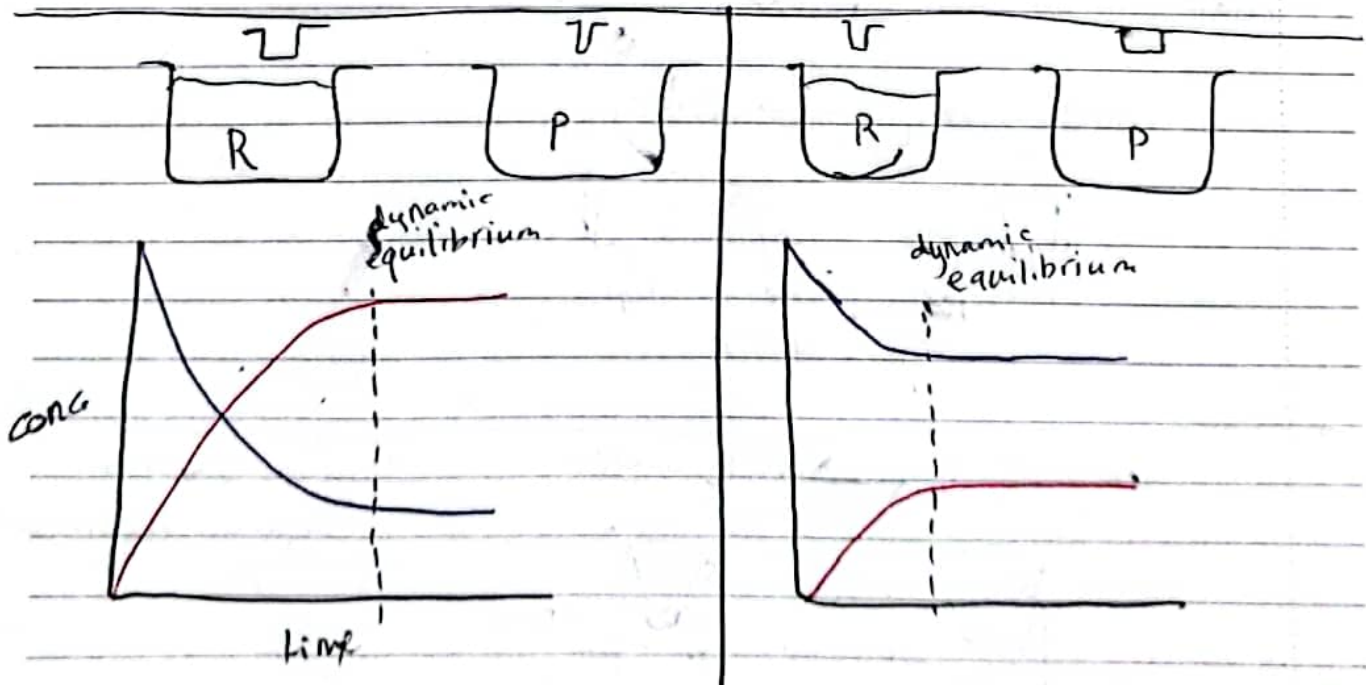
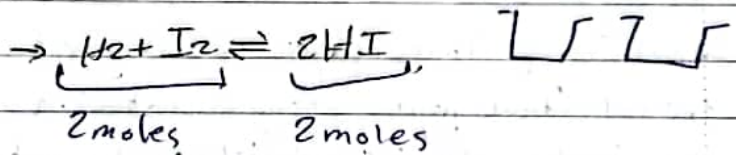
Reversible \rightarrow by closing
 dynamic equilibrium
 \rightarrow d



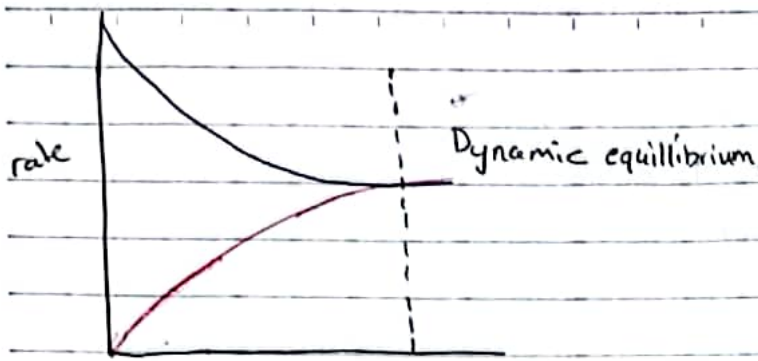
Five Apple



at in terms of rate
when the rate of ~~reaction~~ ^{forward} reaction
is equal to the rate of backward
reaction

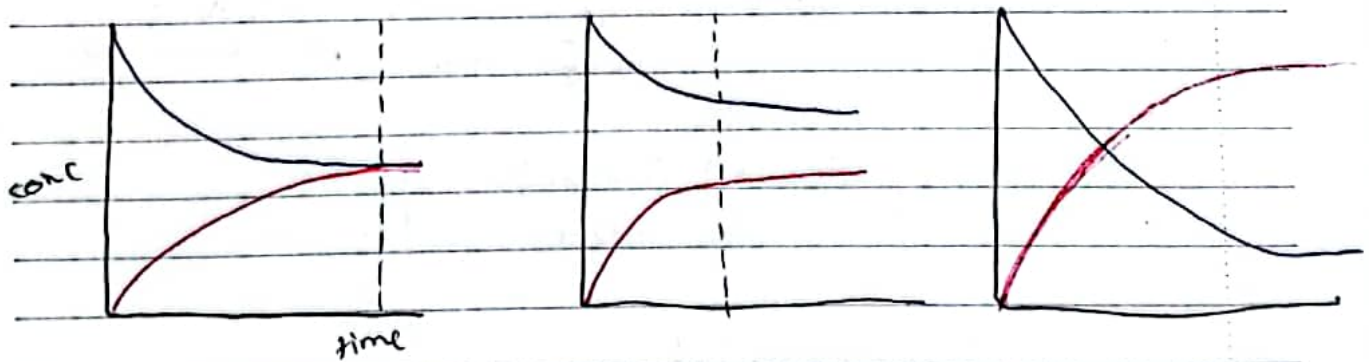


in terms of rates



the rate of forward ↓
less reactants so less particles
less effective collisions
the rate of backward ↑
more product
more particle
more effective collisions

in terms of conc.



Le Chatelier principles

- if the system at equil \rightleftharpoons and any external factor disrupt the equil.
- the equil can shift itself either to the forward \rightleftharpoons or to the backward \leftleftharpoons to ~~the~~ return back to the equil

factors that affect the position of the equilibrium

① Temp

- Endo and Exo
- \uparrow temp: shift to endo
- \downarrow temp: shift to exo

② pressure

- As pressure ^{high \rightarrow low} increases shift to side with less particles
- As pressure ^{low \rightarrow high} decreases shift to side with more particles
more gas particles

\uparrow pressure : \uparrow rate of less gas
 \uparrow rate of more gas

\downarrow pressure : \downarrow rate of less gas
 \downarrow rate of more gas

③ concentration

- $\uparrow R$ } shift forward
- $\downarrow P$ }
- $\downarrow R$ } shift backward
- $\uparrow P$ }

D Temperature

↑ temp

↑↑ rate of endothermic

↑ rate of exothermic

shift to endo

↓ temp

↓↓ rate of endothermic

↓ rate of exothermic

shift to exo

$\Delta H =$

Enthalpy change

+ve

-ve

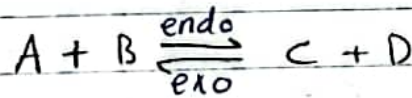
gain E

lose E

endo

exo

the sign of ΔH always represents the forward rxn



$\Delta H = +ve$ (endo)

amount of:

↓ A ↓ B ↑ C ↑ D
shift to endo

↑ Temp

↑↑ rate of forward

↑ rate of backward

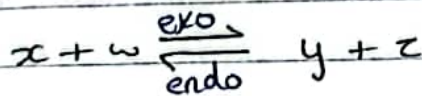
↓ Temp

↓↓ rate of backward

↓ rate of forward

amount of:

↑ A ↑ B ↓ C ↓ D
shift to exo



$\Delta H = -ve$ (exo)

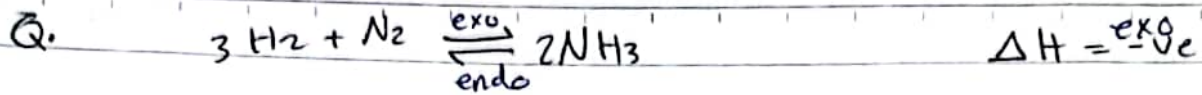
↑ Temp

↑ rate of forward

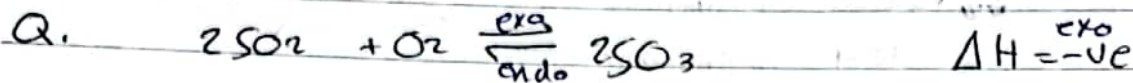
↑↑ rate of backward

↑ x ↑ w ↓ y ↓ z

shift to endo

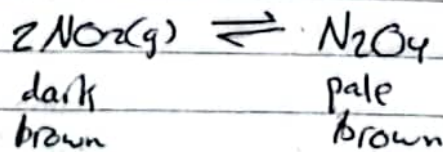


to produce more yield of NH_3
 we must use low temp (↓ temp, ↓ exo, faster)
 to favor the forward reaction which is the exothermic.



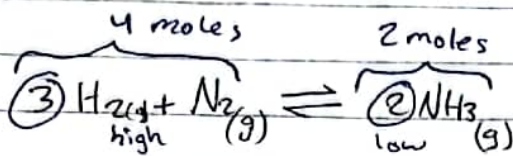
	rate of forward	rate of backward	% SO_3
↑ Temp	increase	increase	decrease
↓ Temp	decrease	decrease	increase

Mixture of NO_2 and N_2O_4 at equilibrium in a sealed tube



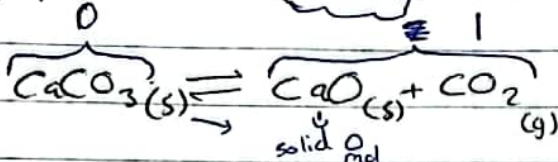
if we put this sealed tube in a cold water bath the mixture becomes paler. why?
 because the forward reaction is exothermic enhanced by cooling.

Pressure



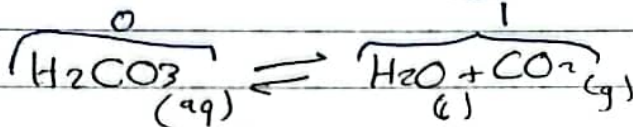
high pressure • shift **Forward** to the side with less gas moles

↑ % NH₃

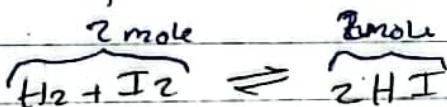


low pressure • shift **Forward** to side with more gas moles

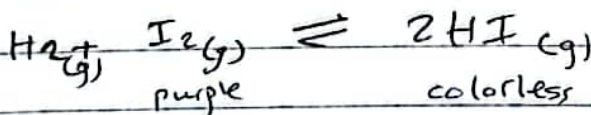
↑ % CO₂



low pressure • shift forward to the side with more gas moles

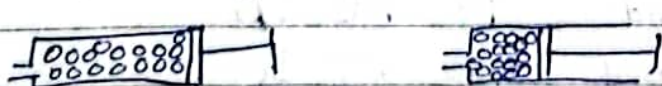


changing the pressure has no effect on the position of the equil.
since both sides has the same no. of gas moles



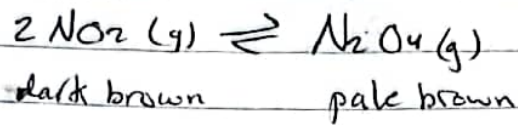
the equil. doesn't effect by increasing the pressure.

why by increasing the pressure the mixture becomes more purple?



I₂ molecules become closer to each other, so the color seems to be darker

sealed tube contains mixture of NO_2 and $\text{N}_2\text{O}_4(\text{g})$ at equilibrium



by increasing pressure the color of the mixture

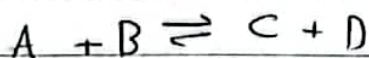
- a) becomes paler then goes darker
- b) " darker " " paler
- c) " paler and stays paler
- d) " darker " " darker

③ concentration



\uparrow Reactant } shift to ~~to~~ forward
 \downarrow Product }

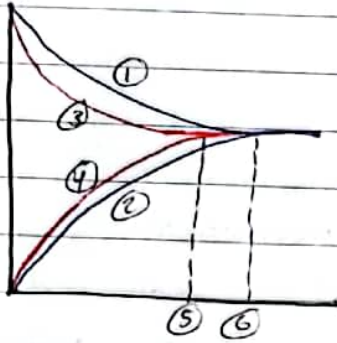
\downarrow Reactant } shift backward
 \uparrow Product }



$\uparrow [A]$	shift to forward	$\downarrow B$	$\uparrow C$	$\uparrow D$
$\downarrow [B]$	shift to backward	$\uparrow A$	$\downarrow C$	$\downarrow D$
$\uparrow [C]$	shift to backward	$\uparrow A$	$\uparrow B$	$\downarrow D$
$\uparrow [D]$	shift to backward	$\uparrow A$	$\uparrow B$	$\downarrow C$

* Catalyst

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



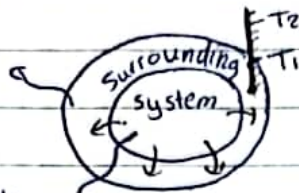
- 1) Rate of forward reaction without catalyst
- 2) // // backward // // //
- 3) // // forward // with //
- 4) // // backward // // //
- 5) time taken to reach equilibrium with catalyst
- 6) // // // // // without //

Energetics

Exothermic

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

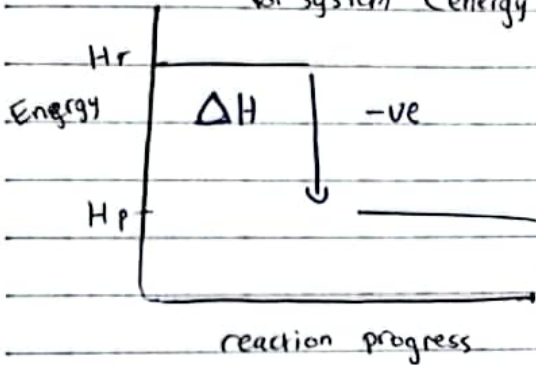
$$Q = mc \Delta T$$



$$T_2 > T_1$$

$$\Delta H = -ve$$

For system (energy diagram)



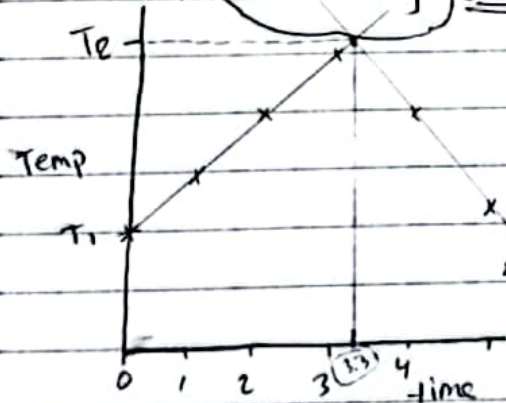
Enthalpy = Heat contents
"stored energy"

Hr = Enthalpy of reaction
Hp = Enthalpy of product

For surrounding (temp diagram)

$$Q = mc \Delta T$$

\downarrow \downarrow \downarrow \downarrow
 J g $J/g \cdot ^\circ C$ $^\circ C$



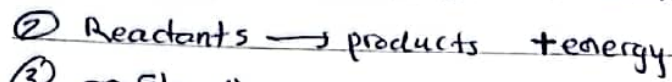
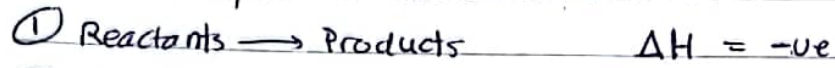
reaction is over
so return back to room temp.
to find when the reaction finished.
two intersecting points

↑ Q : more exothermic
↑ ΔT ✓

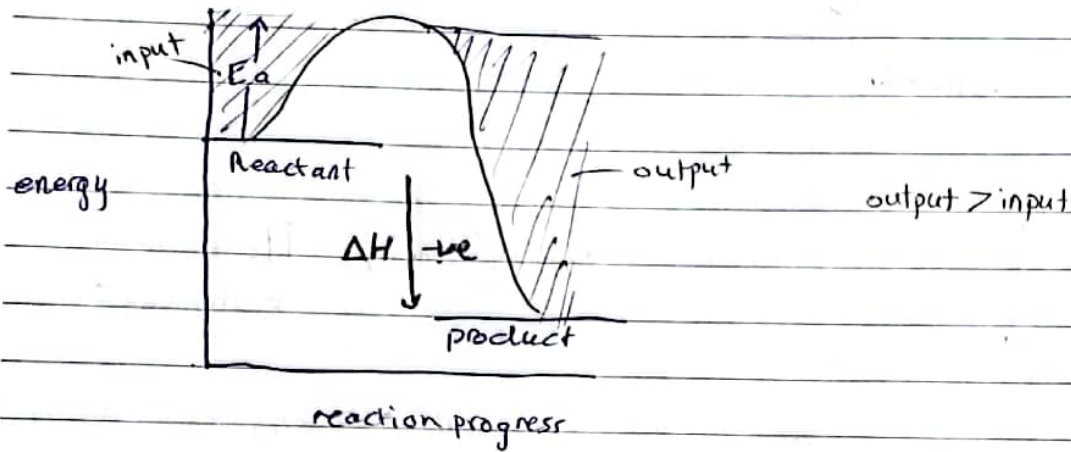
examples on exothermic:

- 1- Freezing, condensation
- 2- respiration
- 3- Combustion
- 4- neutralization
- 5- displacement
- 6- voltaic cells
- 7- building up bonds

How to express an exothermic reaction.



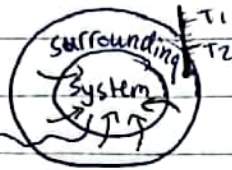
③ profile diagram



Endothermic

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

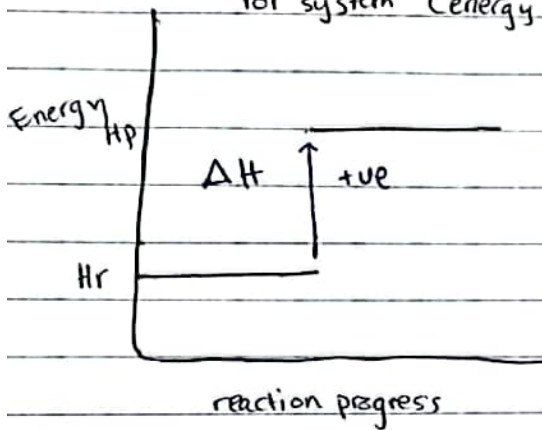
$$Q = mc\Delta T$$



$$T_1 > T_2$$

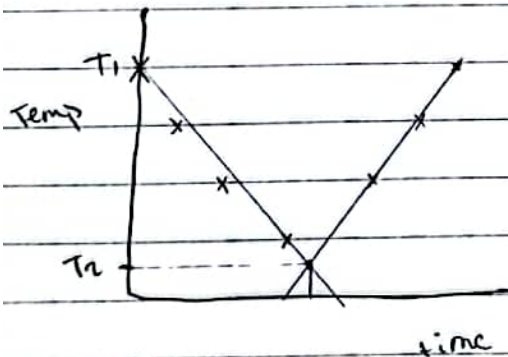
$$\Delta H = +ve$$

for system (energy level diagram)



Enthalpy = Heat contents
"stored energy"

For surrounding (Temp diagram) $\rightarrow Q = mc\Delta T$



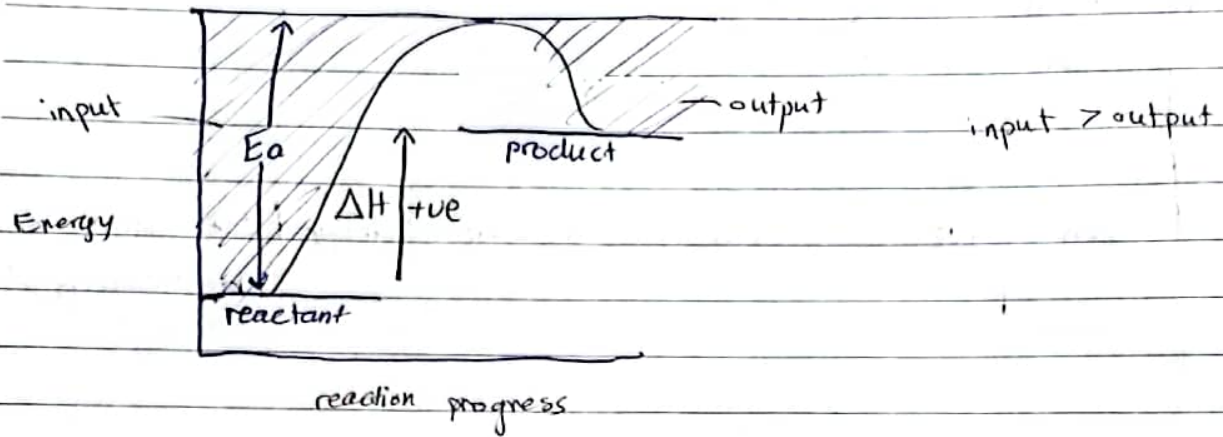
$Q \uparrow$ more endothermic

examples on Endothermic:

- 1- Boiling, melting
- 2- Photosynthesis
- 3- Thermal decomposition
- 4- Electrolysis
- 5- photographic films
- 6- dissolved ammonium salts
- 7- breaking down bonds

How to express an endothermic reaction

- ① Reactant \rightarrow products $\Delta H = +ve$
- ② Reactants + energy \rightarrow product
- ③ profile diagram



measuring ΔH reactions

theoretical
using bond energy

experimental
combustion displacement neutralization

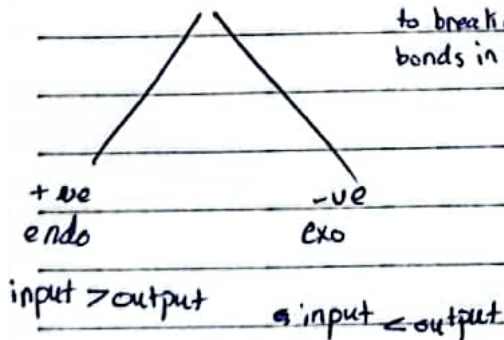
ΔH using bond energy:

- Bond energy is the amount of energy needed to break 1 mole of a bond in a gaseous state released to build

bond	bond energy kJ/mol
H-H	436

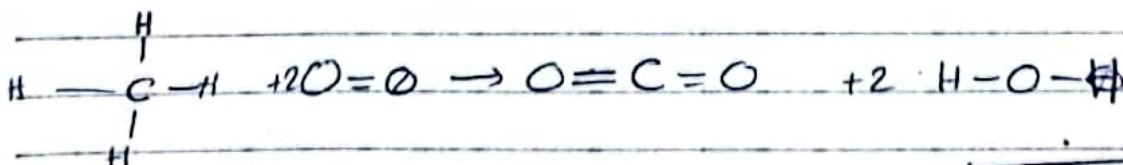
$$\Delta H_{\text{reaction}} = \sum \text{input} - \sum \text{output}$$

to breakdown bonds in reactants to build up bonds in product



to use this equation

- balanced equation
- covalent structure
- bond energy



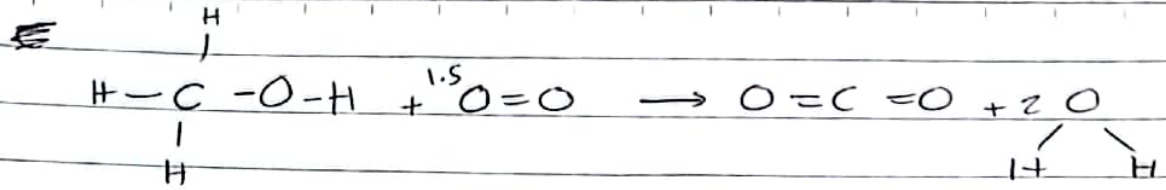
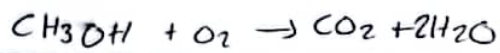
$$\begin{array}{l} 4 \times \text{C}-\text{H} \rightarrow 4 \times 413 \\ 2 \times \text{O}=\text{O} \rightarrow 2 \times 495 \end{array} \quad \begin{array}{l} \text{C}=\text{O} \quad 2 \times 799 \\ \text{O}-\text{H} \quad 4 \times 463 \end{array}$$

input input output

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

input < output

$$\Delta H = \frac{-808}{\text{etc}} \text{ kJ/mol}$$



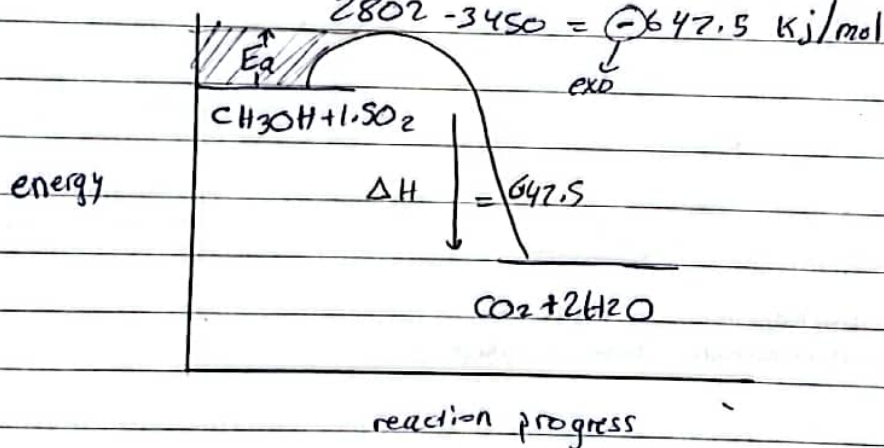
bond broken

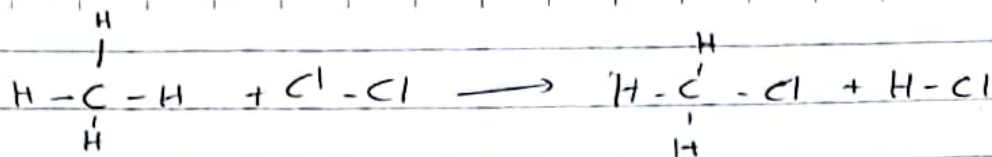
bond built

3x C-H	3x 413	2x C=O	2x 799
1x C-O	358	4x O-H	4x 463
1x O-H	463		<u>3450</u> kJ
1.5x O=O	1.5x 495		
	<u>2802</u> kJ		

$$\Delta H = \sum \text{input} - \sum \text{output}$$

$$2802 - 3450 = -647.5 \text{ kJ/mol}$$

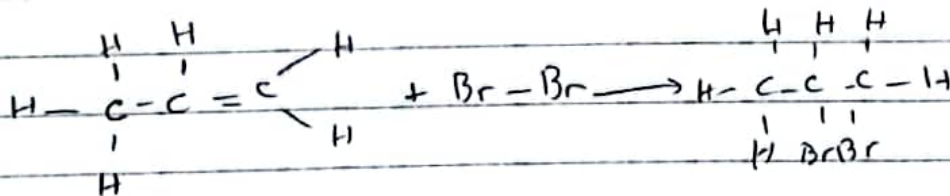
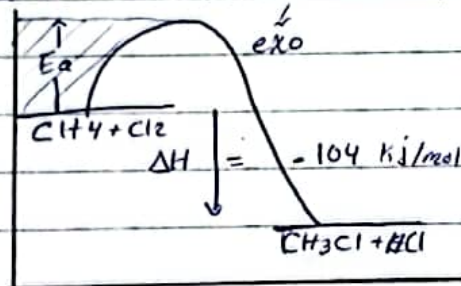




bond broken		bond built	
1 x C-H =	413	1 x C-Cl	328
1 x Cl-Cl =	242	1 x H-Cl	431
	<u>655</u>		<u>759</u>

bond	energy
C-H	413
Cl-Cl	242
H-Cl	431
C-Cl	328

$$\Delta H = 655 - 759 = -104 \text{ kJ/mol}$$



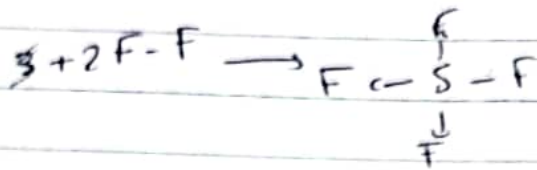
Br-Br =	193	2 x C-Br	2 x 276
C=C	614	C-C	348
	<u>807</u> kJ		<u>900</u> kJ

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

$$\Delta H = 807 - 900 = -93 \text{ kJ/mol}$$

exo

when sulfur react with Fluorine the reaction give ^{exo} 780 kJ/mol



if the bond energy of F-F is 160 kJ/mol
find the bond energy of S-F

bond broken

$$2 F-F = 160 \times 2$$

$$= 320$$

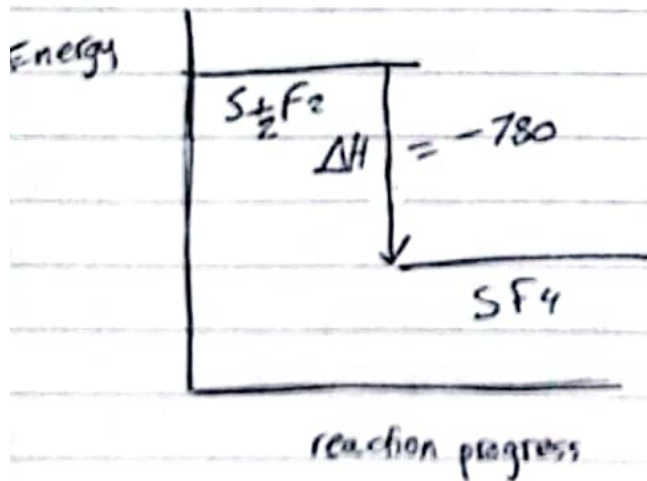
bond built

$$4 \times S-F = ?$$

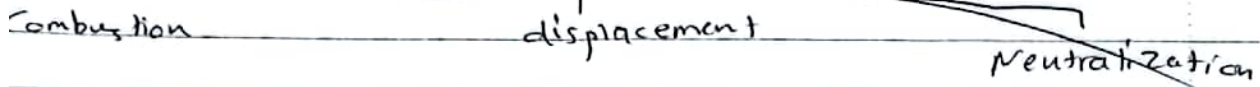
$$320 - 4SF = -780$$

$$+780 \qquad \qquad +780$$

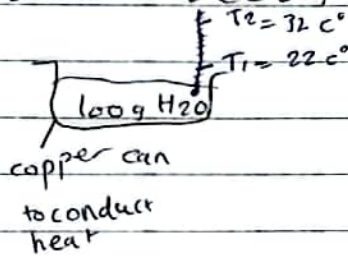
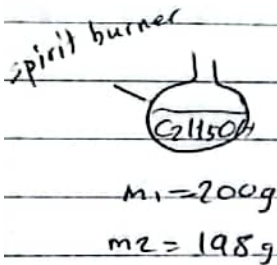
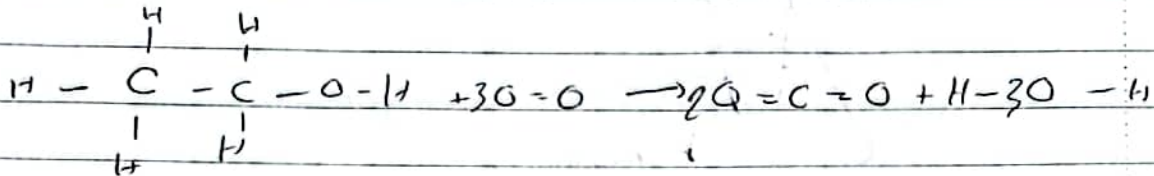
$$\frac{4 S-F}{4} = \frac{1100}{4} \rightarrow S-F = 275 \text{ kJ/mol}$$



Finding ΔH (energy change) practically:



Finding ΔH combustion



$$Q = mc\Delta T$$

Energy transfer = 100×4.2
 $\Delta T = 32 - 22 = 10$
 $Q = 4200 \text{ J} \approx 4.2 \text{ kJ}$

4.2 kJ Produced from 2g of $\text{C}_2\text{H}_5\text{OH}$

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

$$96.6 \text{ kJ/mol} \leftarrow = \frac{4.2 \text{ kJ}}{46 \text{ g}} \times 1 \text{ mole}$$

two Fuels A and B

Plan an expts show which one gives more energy

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

Ignite the fuel and record the final mass and final temperature of water.

Repeat the experiment using fuel B

of the fuel which cause more temperature rise per gram fuel produce more energy

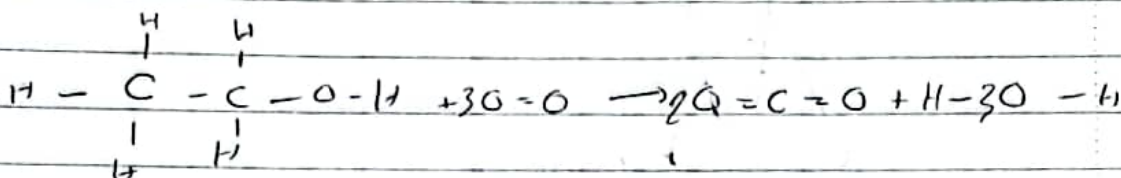
Finding ΔH (energy change) practically:

Combustion

displacement

neutralization

Finding ΔH combustion

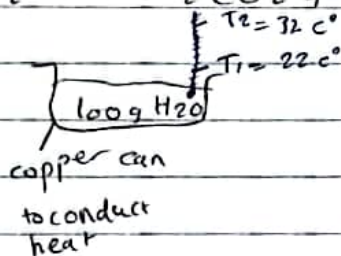


spirit burner



$m_1 = 200\text{g}$

$m_2 = 195\text{g}$



$$Q = mc\Delta T$$

$$\text{Energy transfer} = 100 \times 4.2$$

$$\Delta T = 32 - 22 = 10$$

$$Q = 4200 \text{ J} \approx 4.2 \text{ kJ}$$

$$4.2 \text{ kJ} \xrightarrow{\text{Produced from}} 2\text{g of C}_2\text{H}_5\text{OH}$$

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

$$96.6 \text{ kJ/mol} \leftarrow = \frac{4.2 \text{ kJ}}{2\text{g}} \times 46\text{g}$$

Q two Fuels A and B

Plan an expts show which one gives more energy

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

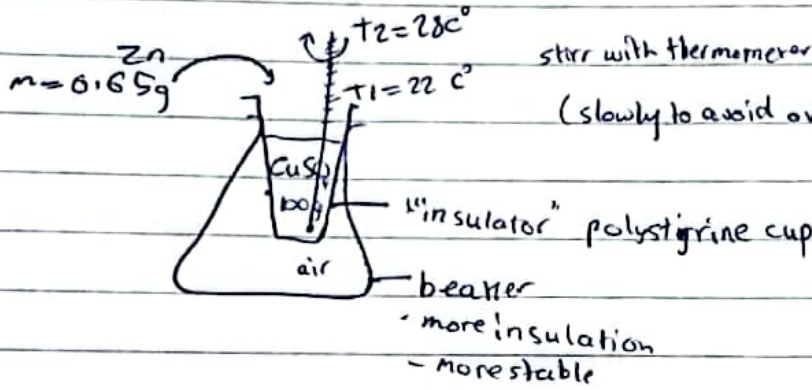
take a known mass of fuel A

Ignite the fuel and record the final mass and final temperature of water.

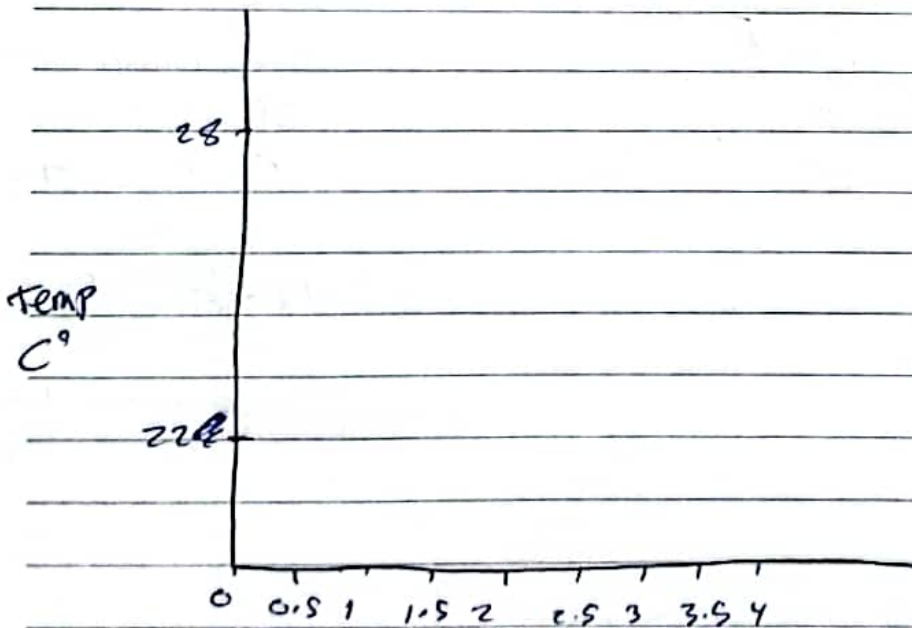
Repeat the experiment using fuel B

or the fuel which cause more temperature rise per gram fuel produce more energy

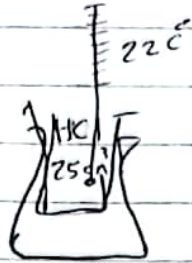
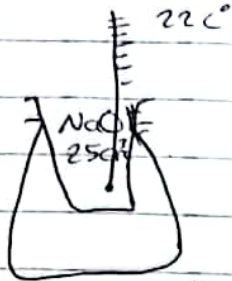
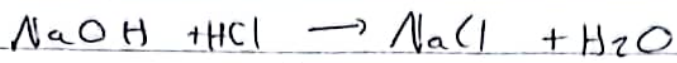
Measuring ΔH displacement



$$Q = mc\Delta T$$
$$= 100 \times 4.2 \times 6$$
$$= 2520 \text{ J} = 2.52 \text{ KJ}$$

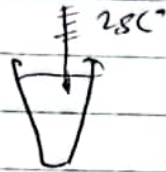


Measuring ΔH - neutralization



$$c = 4.2 \text{ kJ}$$

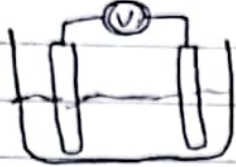
$$1 \text{ g/cm}^3$$



$$Q = 50 \times 4.2 \times 6$$
$$= 1260 \text{ J}$$

Alternative resources of energy

voltic cell



Hydrogen fuel cell

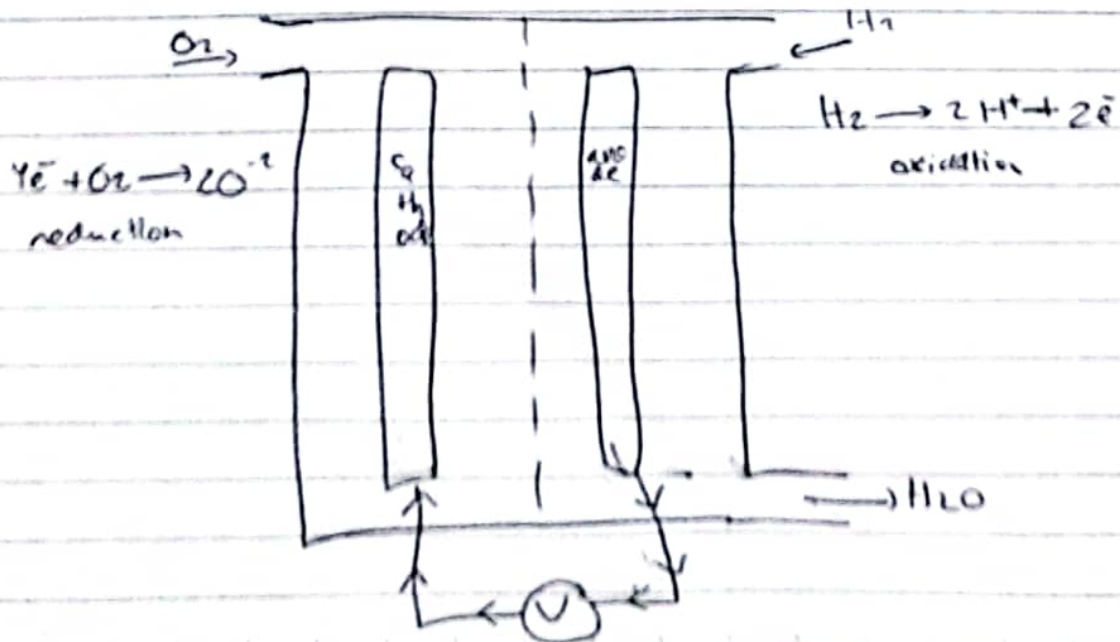
Uranium ${}^{235}_{92}\text{U}$

Hydrogen fuel cell

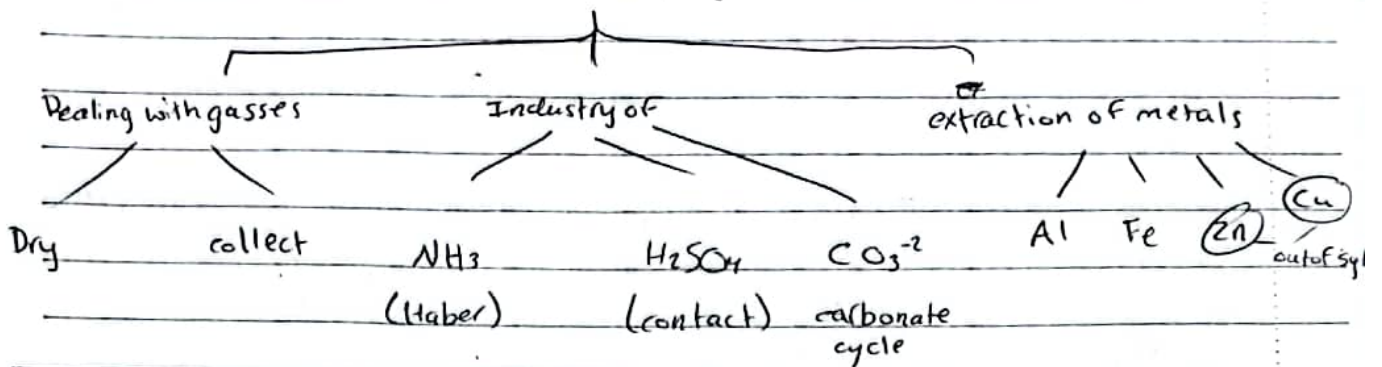


- advantages:
- only one waste product (H_2O)
 - no CO_2
 - produce high amount of energy
 - generate electricity

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



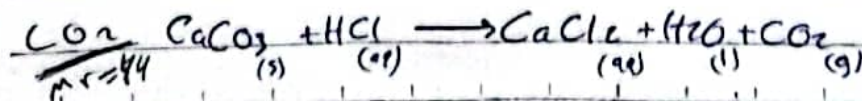
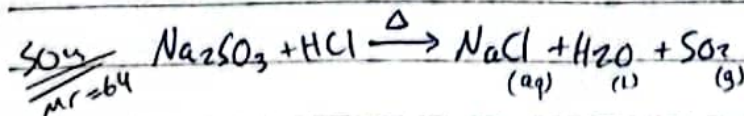
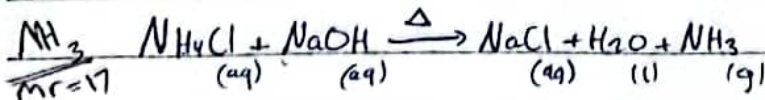
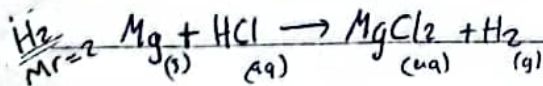
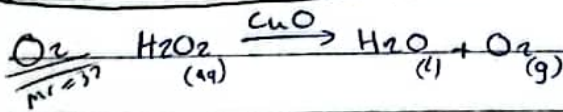
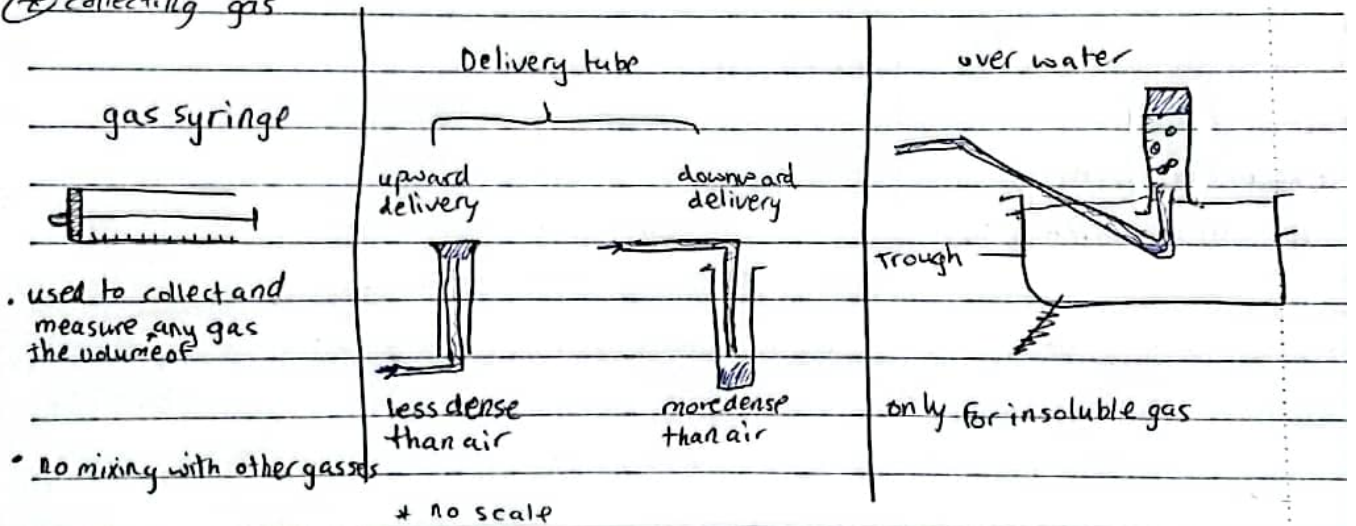
Industrial chemistry



① Dealing with gasses

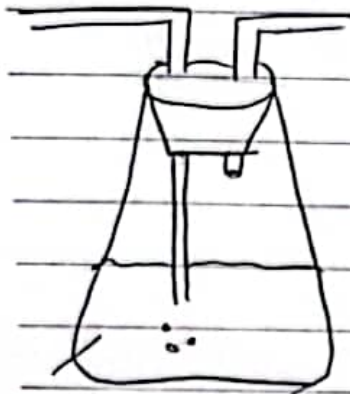
Rxn → wet gas → dry → collect

* collecting gas



Drying gases

① Concentrated H_2SO_4



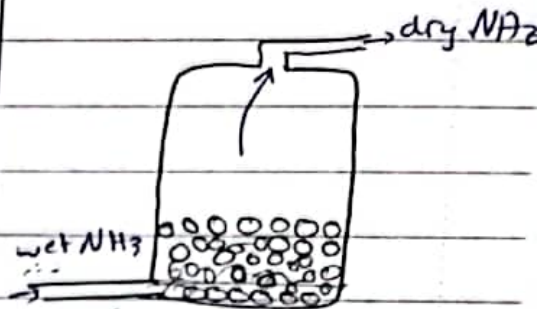
conc. H_2SO_4 (becomes dilute)
used to dry any gas
except NH_3
it neutralises the H_2SO_4
 $NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

② Anhydrous $CaCl_2$

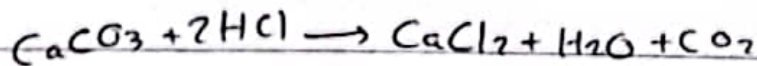


Anhydrous $CaCl_2$
used to dry any gas
except NH_3

③ Calcium Oxide CaO

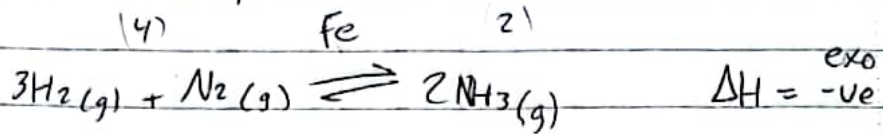


Draw a suitable apparatus used to collect and measure volume of dry CO_2 gas (insoluble)
From:



Fertilizer Industrial

Industry of Ammonia "Haber process"

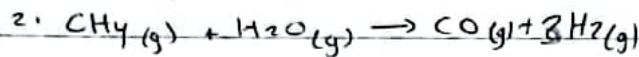


How to obtain

① Nitrogen: Fractional distillation of liquid

↓ different b.p ↓ cooling under high pressure

② Hydrogen: 1. cracking of alkane (organic)



Essential condition (Haber) 1

1) Temp: 400 - 450 °C

Temp

400

450

less than 400

adv. shift forward
(more yield)

more than 450

dis. less yield
(shift backward)

dis. slower rate of reaction adv. faster rate

2) pressure: 200 atm

- 1. more yield of NH_3
- 2. faster rate

- 1. risk of explosion
- 2. expensive

3) Iron as a catalyst

add excess H_2 and N_2
back to converter

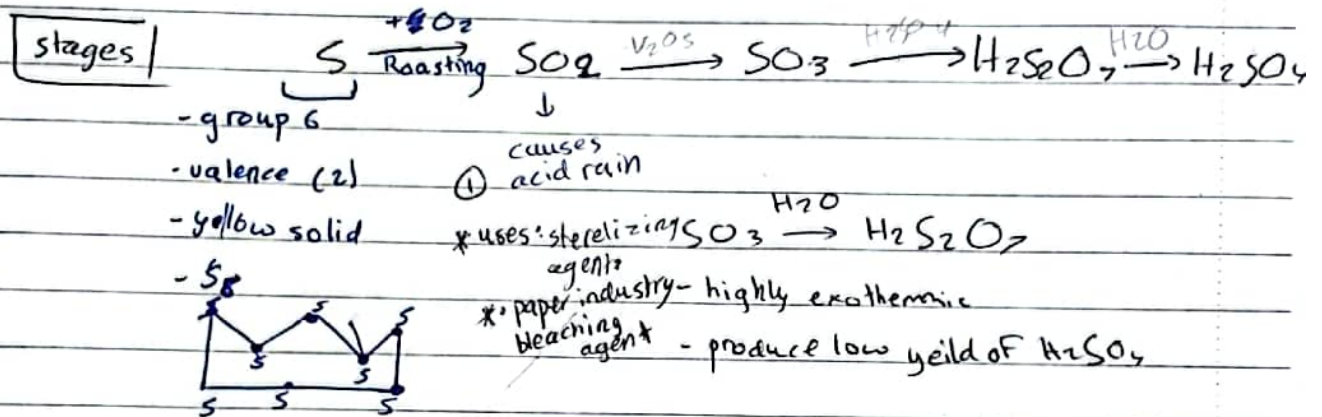
Remove NH_3 immediately
by cooling

Five Apple

Uses of ammonia

- 1- Fertilizer
- 2- cleaning detergents
- 3- smelling salts

Industry of H_2SO_4 (contact process)

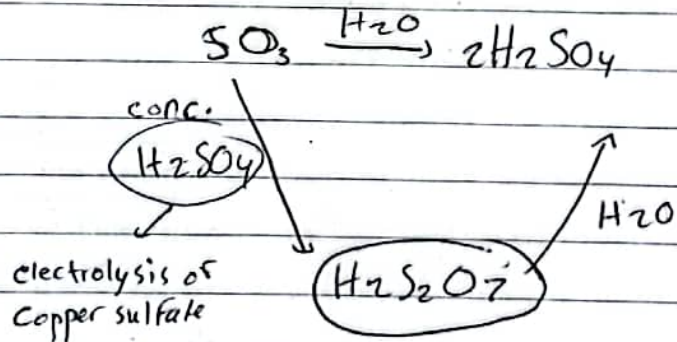


uses: medicine
match

making rubber

ore: zinc blende ZnS

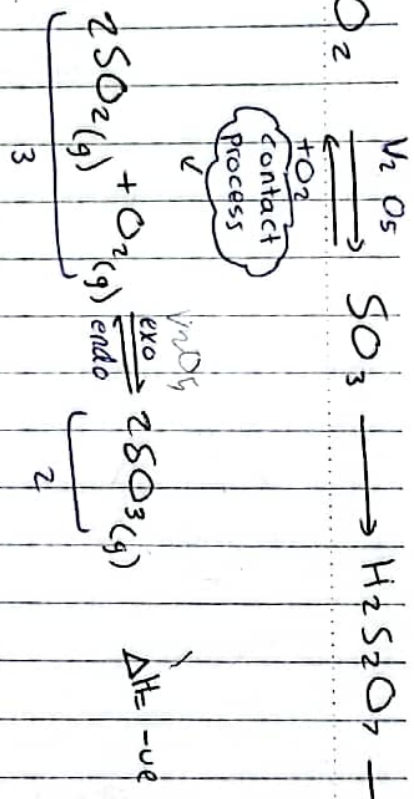
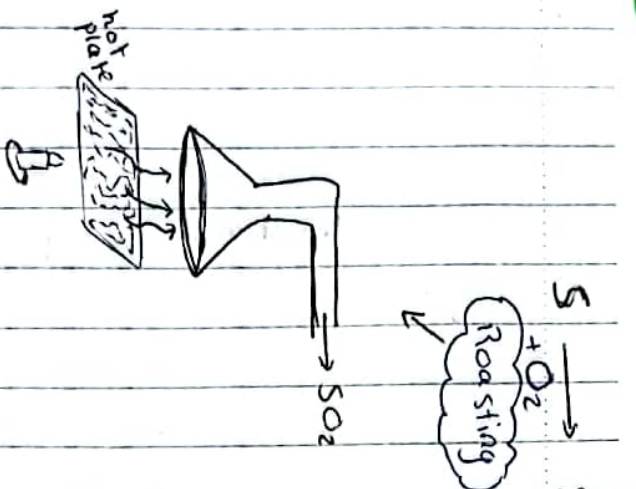
from fossil fuels



uses of H_2SO_4

fertilizer

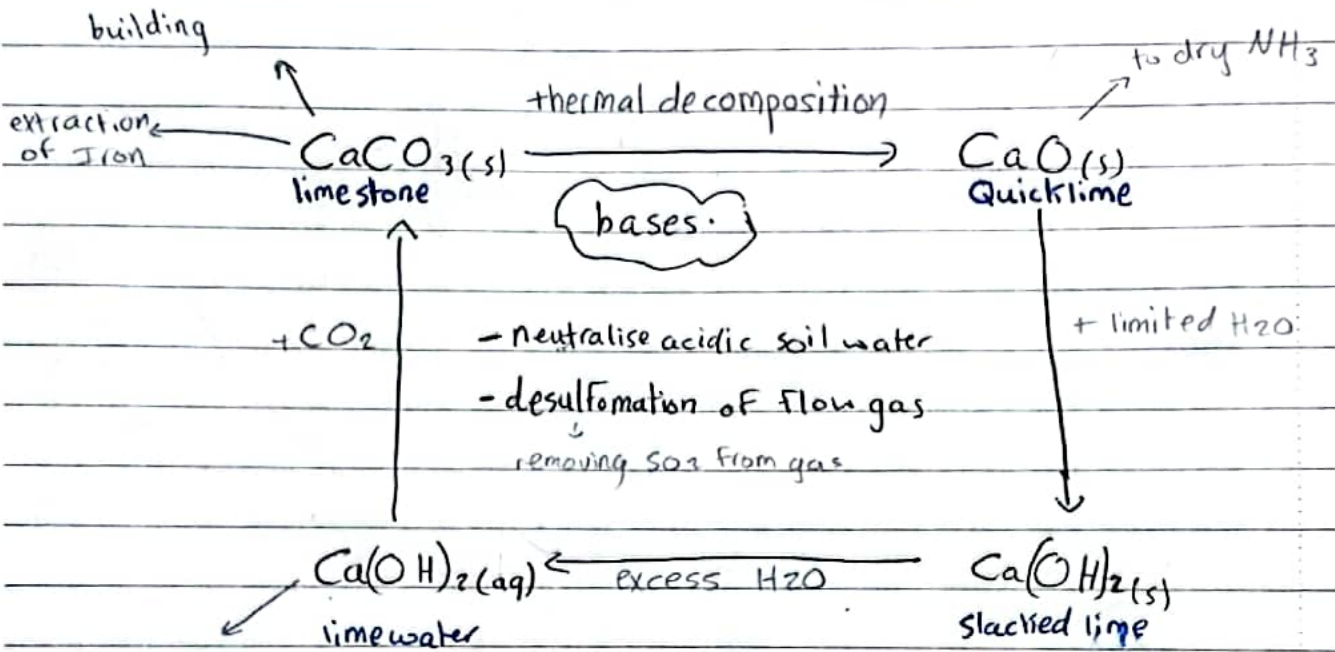
drying agent



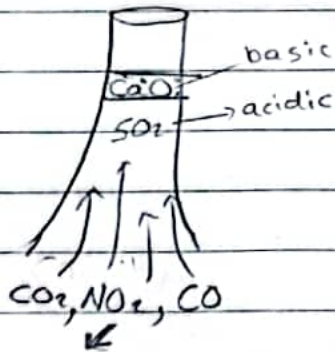
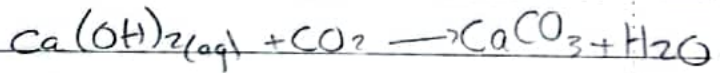
essential conditions

- 1) Temp: $400 - 450^\circ C$ (high pressure favours the forward rxn. (fewer gas mole))
- 2) Pressure: 2 atm (2 atm gives max yield of SO_3)
- 3) catalyst: V_2O_5 Vanadium (V) oxide

Carbonate cycle



test carbon dioxide



Sulfomation

Extraction of Iron,

Ore: Fe_2O_3 "Hematite"

Method: reduction by C, CO

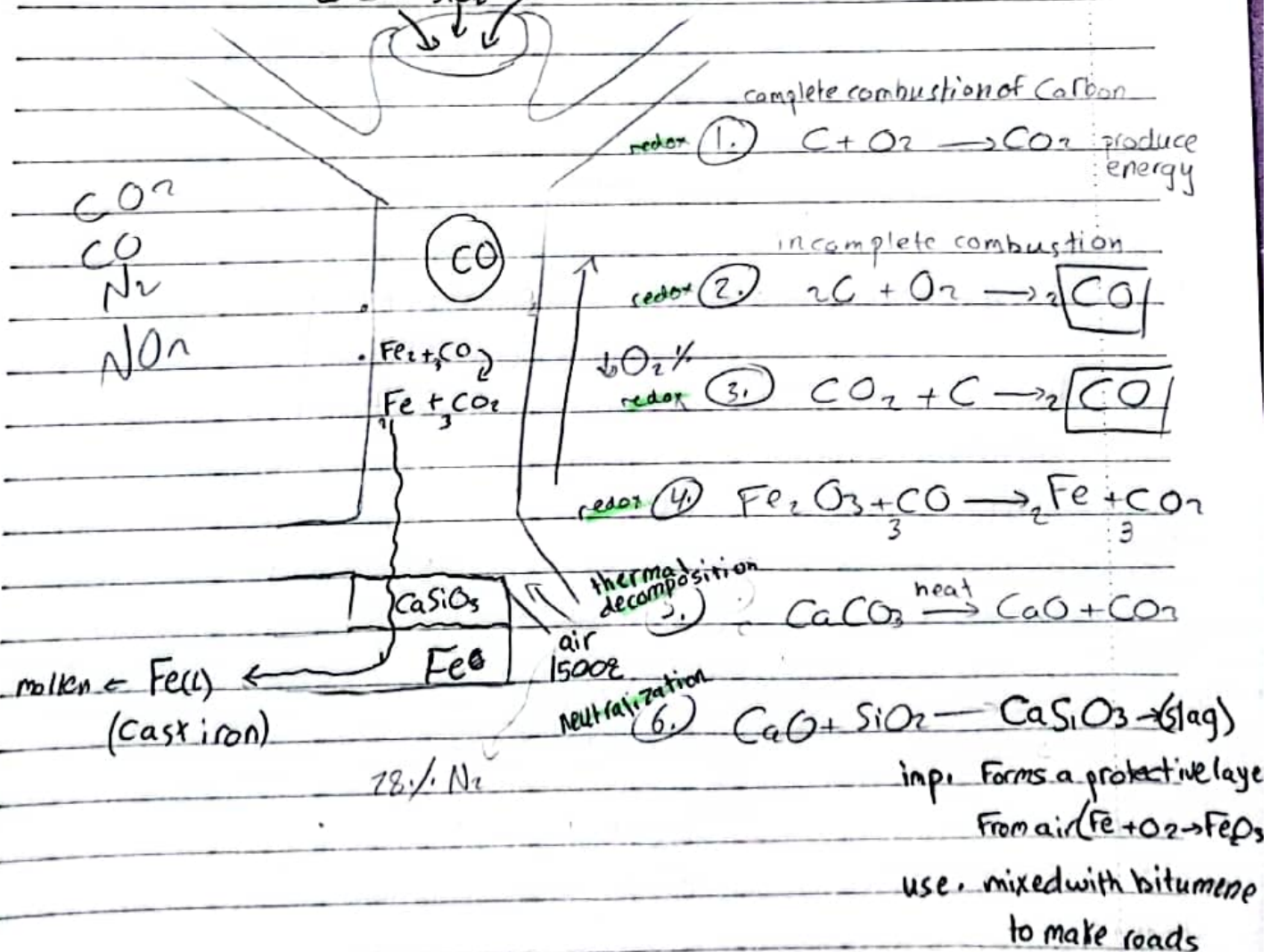
Place: blast Furnace

Raw materials: Fe_2O_3 mixed with SiO_2

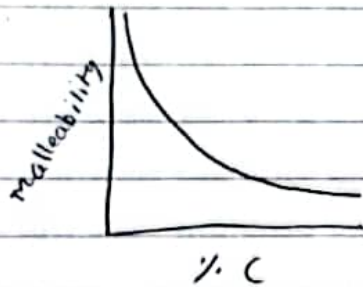
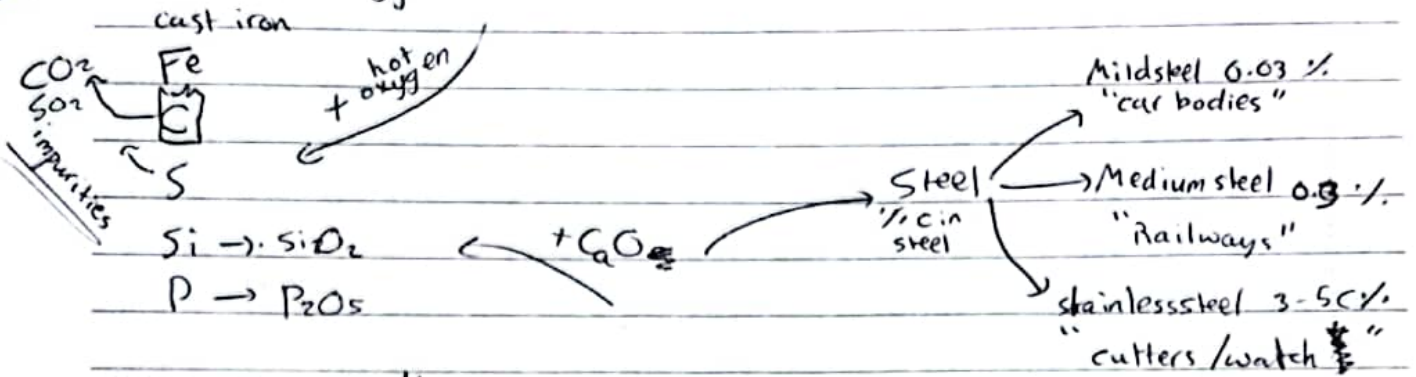
$CaCO_3$ "lime stone"

coke "Carbon" (Pure)

air $1500^\circ C$
 $CaCO_3$, Fe_2O_3 , SiO_2 , C



steel making "oxygen base process"



* mild steel least malleable
car bodies don't shatter

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.

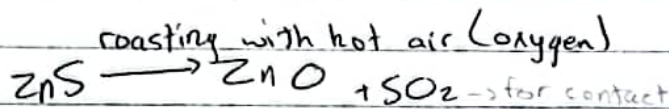
ore: zinc blende ZnS

method: reduction by carbon and carbon monoxide

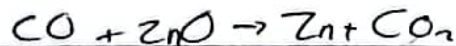
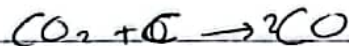
place: blast furnace

C, CO, H_2 can only reduce
the less reactive metal only
from its oxide

step 1.



step 2.



Temp. $1500^\circ C$

boiling point of zinc is $907^\circ C$ (gets out as gas, 100% pure)

produced as pure gas must condense.

and the other impurities, since they have high B.p., stay in the furnace