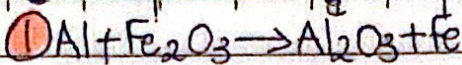




Fe in  $Fe_2O_3$  lose O/ reduce.

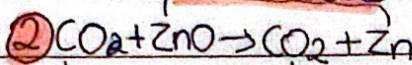
( )

Red/ox  
reduction → oxidation



gain O/oxidise

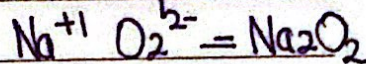
lose O/reduce



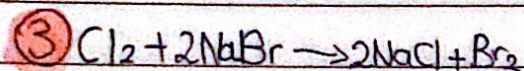
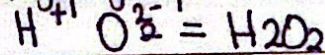
gain O/oxidise

sodium oxide  
 $\text{Na}^+ \text{O}^{2-} = \text{Na}_2\text{O}$

sodium peroxide

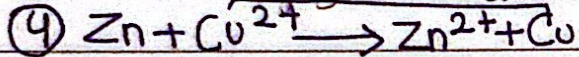


Hydrogen peroxide



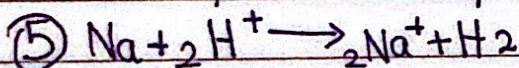
- the oxidation state of chlorine goes from 0 to -1, chlorine has been reduced so chlorine is the oxidising agent.

- the oxidation state of bromine goes from -1 to 0, bromine has been oxidised so the ion is the reducing agent.

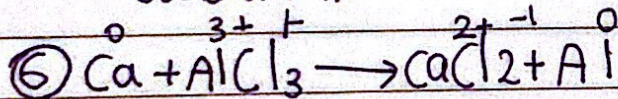


oxidation

reduction  $\text{H}^+$



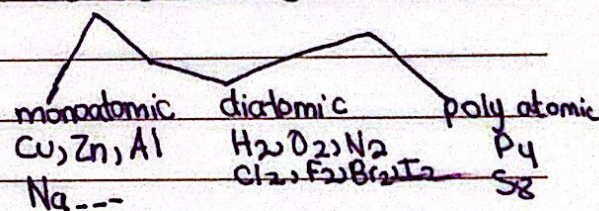
oxidation Na



⑤ the sum of oxid state of all atoms in the compound = zero

### Rules for oxidation state

① the oxidation state for any free element = 0



② the oxidation state for atoms in a compound

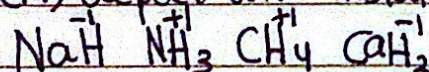
\* From group 1 = +1 Li, Na, K, Rb, Cs

\* from group 2 = +2 Mg, Ca, Sr, Ba

\* from group 3 = +3 only always for Al

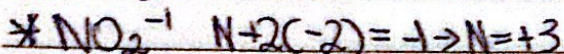
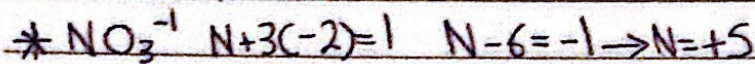
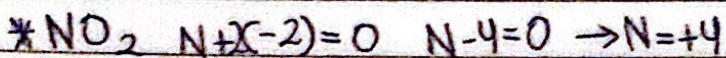
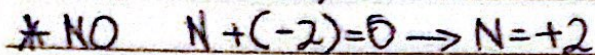
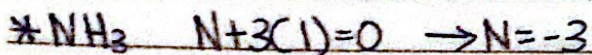
\* group 7 = -1 always for F

③ the oxid state of (H) is (+1) expect with metal (-1)



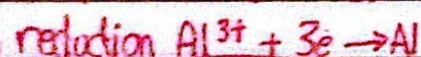
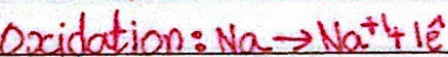
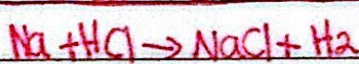
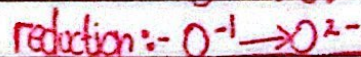
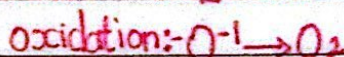
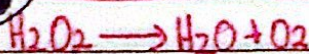
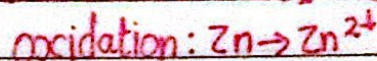
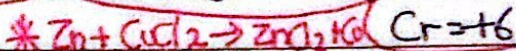
④ the oxid state of O is -2 expect in peroxide (-1) & expect in  $\text{O}_2$  (+2).

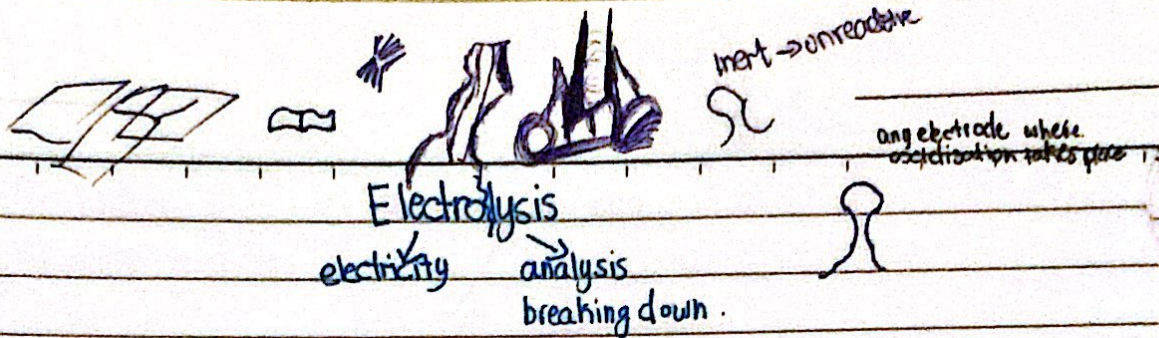
Find the oxidation state of all underlined atoms.



half of oxidation  $\rightarrow$  e losing

half of reduction  $\rightarrow$  e gaining





\*electrolyte:- the chemical compound that conduct electricity.

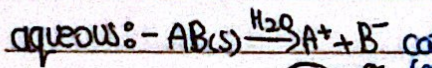
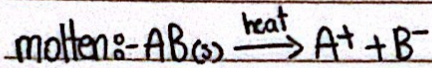
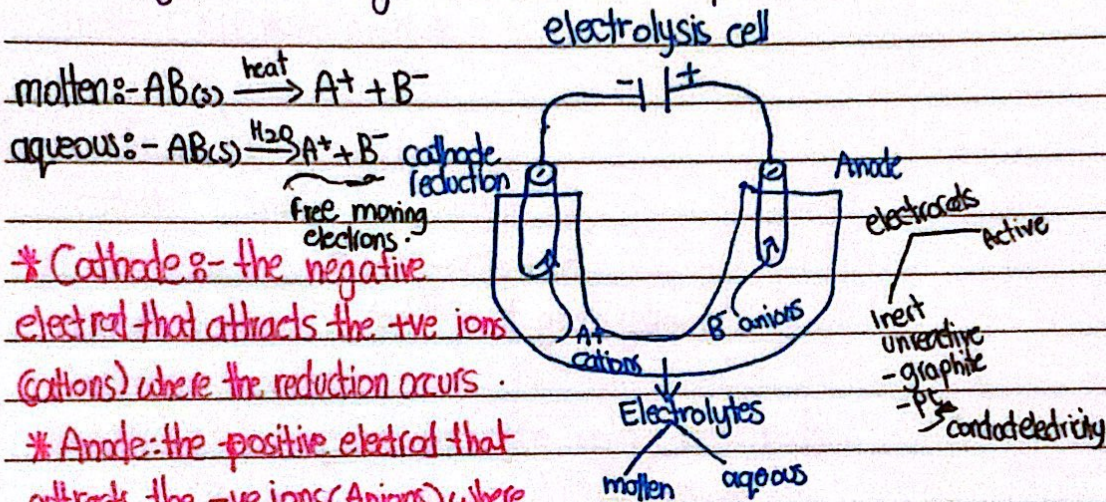
Q- why ionic compounds don't conduct electricity when solid.

The ions are not free to move.

But they conduct electricity when molten or dissolved in water

The ions are free to move.

\*Electrolysis:- breaking down chemical compound "molten or aqueous" by passing electricity

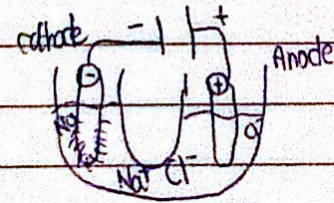
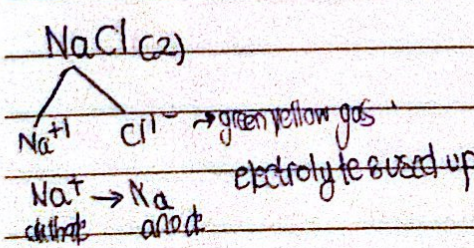


\*Cathode:- the negative electrode that attracts the +ve ions (cations) where the reduction occurs.

\*Anode:- the positive electrode that attracts the -ve ions (Anions) where the oxidation occurs.

Ion  $\rightarrow$  element

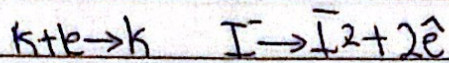
Cations	Anions
$1e^- + Na^+ \rightarrow Na$	$2Cl^- \rightarrow Cl_2 + 2e^-$ (green yellow gas)
$2e^- + Ca^{2+} \rightarrow Ca$	$2Br^- \rightarrow Br_2 + 2e^-$ (red brown)
$2e^- + 2H^+ \rightarrow H_2$	$2O^{2-} \rightarrow O_2 + 4e^-$ (colorless gas)
	$2F^- \rightarrow F_2 + 2e^-$ (yellow gas)
	$I^- \rightarrow I_2 + 2e^-$ (purple gas)





electrolysis for molten

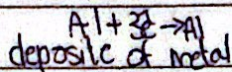
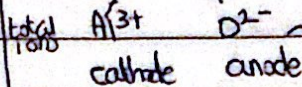
KI using graphite



deposit of metal      purple gas

electrolytes - used up

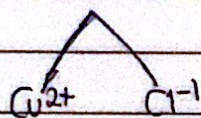
molten  $Al_2O_3$  using graphite



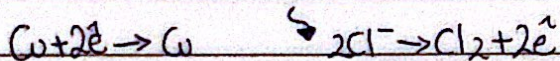
bubbles of colorless gas

electrolytes used up

molten  $CuCl_2$  using graphite



cathode      anode



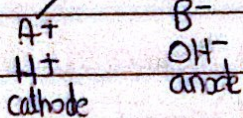
deposit of metal      bubbles of green yellow gas

electrolyte  $\rightarrow$  used up

\*electrolysis for aqueous electrolyte using inert rods

$AB(aq)$

At cathode

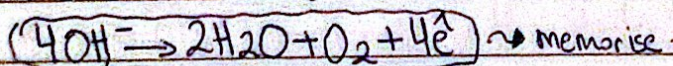


\*the less reactive ion is more likely to reduce & the more reactive ion stays in the electrolyte

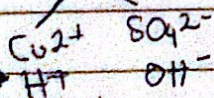
NOTES  
 $Cu^{2+}$   
 $Ag^+$   
 $Al^{3+}$

at anode

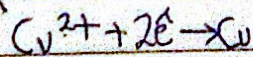
\*only the concentrated halide ( $Cl^-$ ,  $Br^-$ ,  $I^-$ ) are more likely to oxidise than  $OH^-$  if others with  $OH^-$ , the  $OH^-$  will oxidise.



$CuSO_4$



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



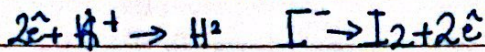
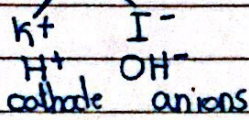
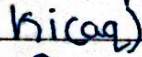
electrolyte :-  $H_2SO_4$

water  
magnesium  
Breeze



10/10/2022

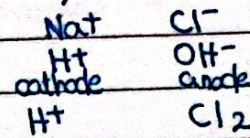
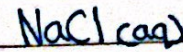
~~Concentrated~~  
\* Concentrated potassium iodide



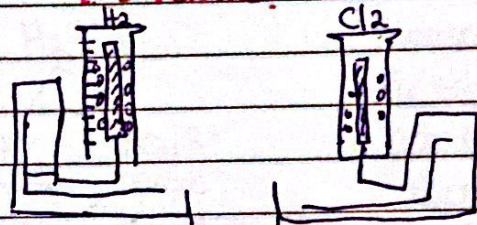
bubbles of colorless gas  
electrolyte: KOH

red brown solution

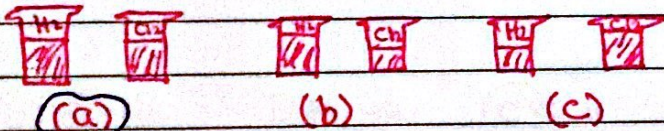
\* concentrated sodium chloride solution "Brine"



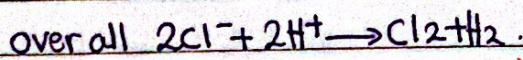
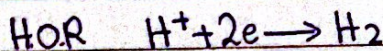
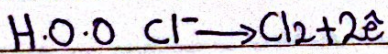
Q1:- plan an exp to collect the gas produced at cathode & anode & measure its volume?



the final appearance of the two measuring cylinder?  $I^+$



\* write the overall reaction

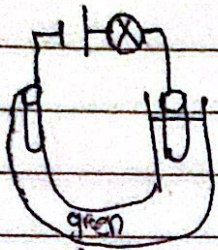


Q:- why the  $Cl_2$  gas not immediately appear as  $H_2$  appear?

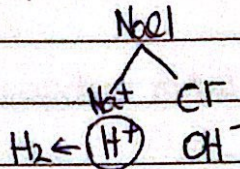
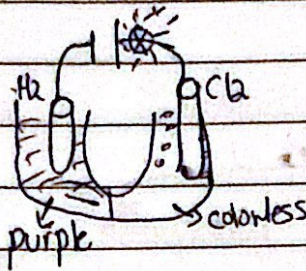
Some  $Cl_2$  gas dissolve in the electrolyte.

Q:- Brine solution with universal indicator

electrolysis for brine solution with universal indicator.

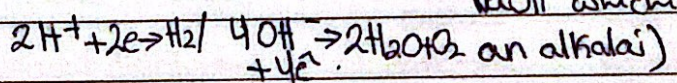
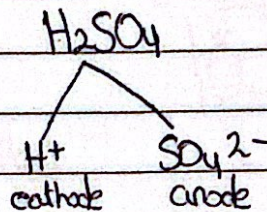
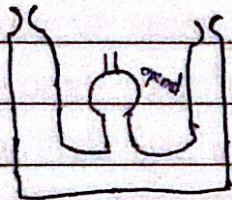


NCl  
neutral  
univ indicator

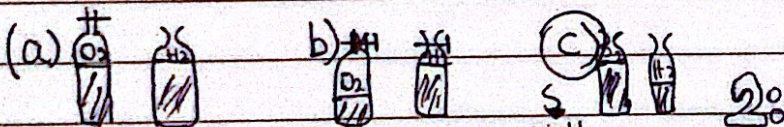


- 1- light turn on
- 2- bubbles of colorless gas at cathode
- 3- bubbles of green yellow gas

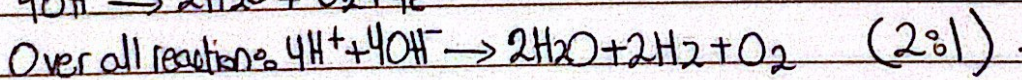
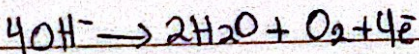
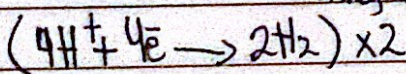
electrolysis for H<sub>2</sub>SO<sub>4</sub>(aq) / graphite rods.



- 4- around the cathode the solution is purple
- 5- around the anode the solution is colorless because Cl<sub>2</sub> is a bleaching agent.



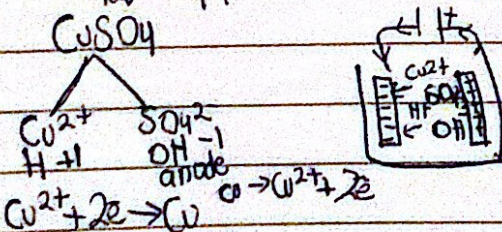
→ they were all two right answer



electrolysis of aqueous electrolyte using active rods

\* the rod must be made from the same metal in the electrolyte.

CuSO<sub>4</sub> using copper rods. / AgNO<sub>3</sub>(aq) using silver rods.



cathode: increase in mass

Cu<sup>2+</sup> gain e<sup>-</sup>s & deposit of Cu on it.

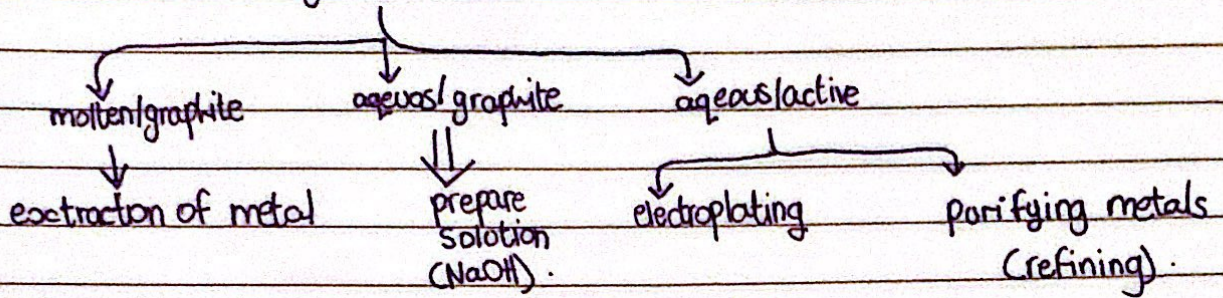
anode: decrease in mass, lose electrons

electrolyte: stays the same, the anode oxidise & replace Cu<sup>2+</sup> in the electrolyte with the same rate.

Five Apple

15/9/2022

## applications on electrolysis.



• electroplating - covering a metal with another metal by using electricity.

why? 1) prevent rusting 2) decoration.

• how to electroplate a metal spoon with Ag?

1) clean the metal spoon to remove the oxide layer by sand paper.

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

3) the anode must be made from Ag

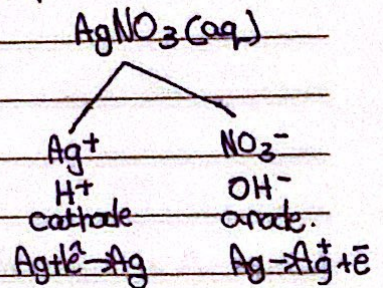
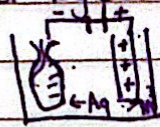
4) the electrolyte must contain Ag (ex:  $\text{AgNO}_3$ )

5) ~~rotate~~ turn on the circuit

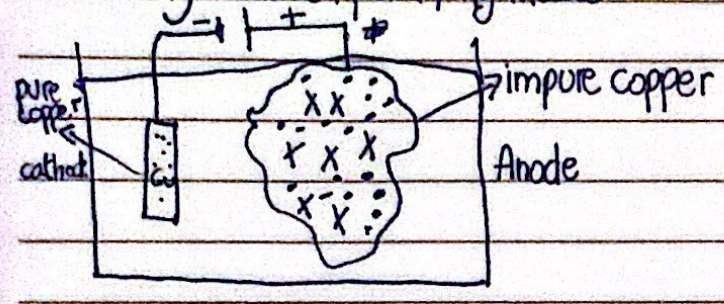
6) rotate the metal spoon to ensure an equal distribution

7) rinse with distilled water

8) dry in oven.

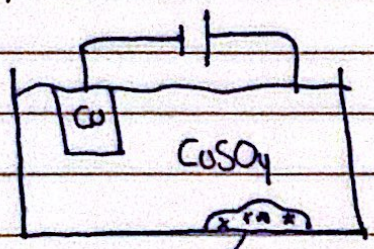


# Refining metals / purifying metals



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

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



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

\*extraction of metals :- the method of extraction depends on the position of the metal in the reactivity series.

- KCl ← K
- NaCl ← Na
- LiCl ← Li
- CaCl ← Ca
- MgCl ← Mg
- Al
- Cr
- Zn
- Fe
- Pb
- H
- Cu
- Ag
- Au



extraction metals

- K
- Na
- Li
- Ca
- Mg
- Al
- C, CO

electrolysis for molten ore. / graphite rods

■ extraction of aluminium  
 ore:- Bauxite  $Al_2O_3$   
 method:- electrolysis for molten  
 ore using graphite rods.

- Zn
- Fe
- Pb

reduction by C & CO

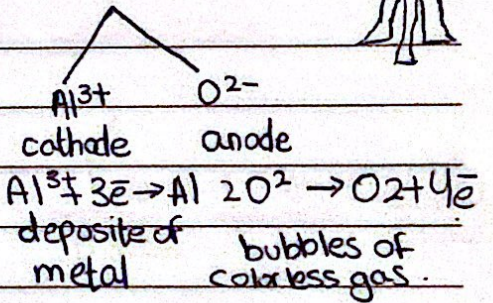
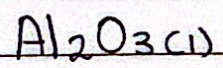
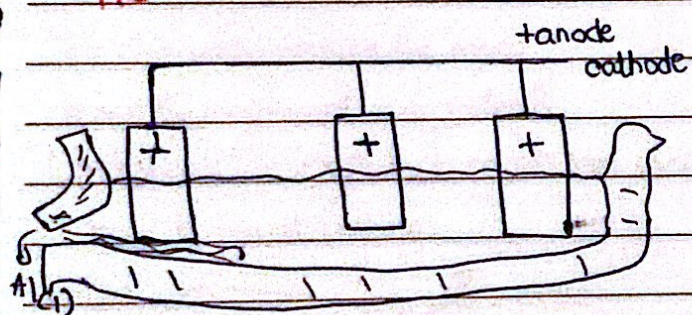
\* the m.p of  $Al_2O_3$  is  $2000^\circ C$   
 so the bauxite dissolve in molten  
 cryolite  $Na_3AlF_6$

- H
- Cu
- Ag
- AO

reduction by  $H_2$ .

1) lower the m.p to  $900^\circ C$  so less cost.

2) increase the electrical conductivity



gases produced at anode

1-  $O_2$

2-  $CO_2$       3- CO      reduction of carbon rods with  $O_2$ .  
 you must replace them periodically.

property

use

low density

air craft bodies.

conduct electricity

cables

malleable

window frame / cooking utensils.

forms a non toxic oxide layer

foods cans

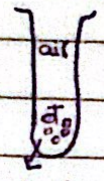
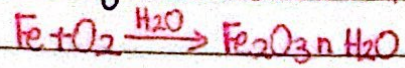
ductile

electric wires.

b

### Rusting

Rusting: the Reaction of iron with both H<sub>2</sub>O & O<sub>2</sub>



anhydrous  
CaCl<sub>2</sub>

"drying agent"

Not rust no H<sub>2</sub>O



not rust no O<sub>2</sub>

\* A & B are two solutions used to prevent rusting

plan an experiment to show which solution is the better?

take a known mass of Iron nail

apply known quantity of solution A

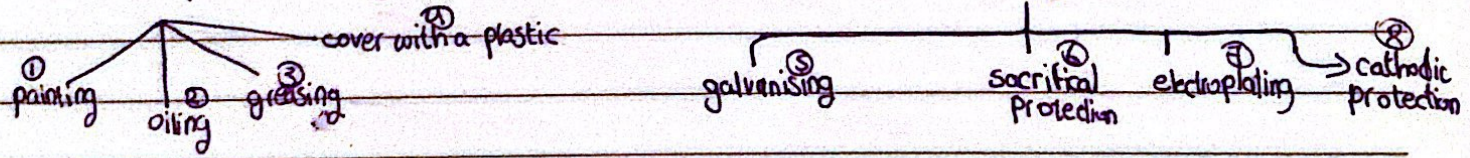
put the nail in a known volume of water

for one week, measure the mass

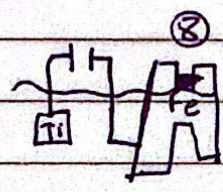
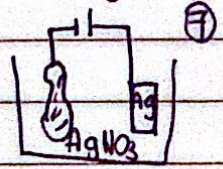
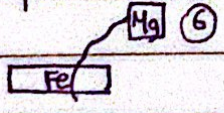
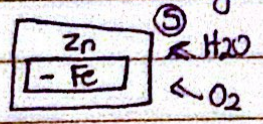
repeat the experiment using solution B.

Conclusion: the exp which causes less increase in mass is the better solution.

### how to prevent rusting



"Forms a layer that prevent O<sub>2</sub> & H<sub>2</sub>O from reaching Fe.

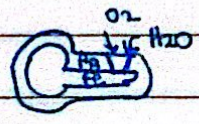


Mg & Zn are more reactive than Fe

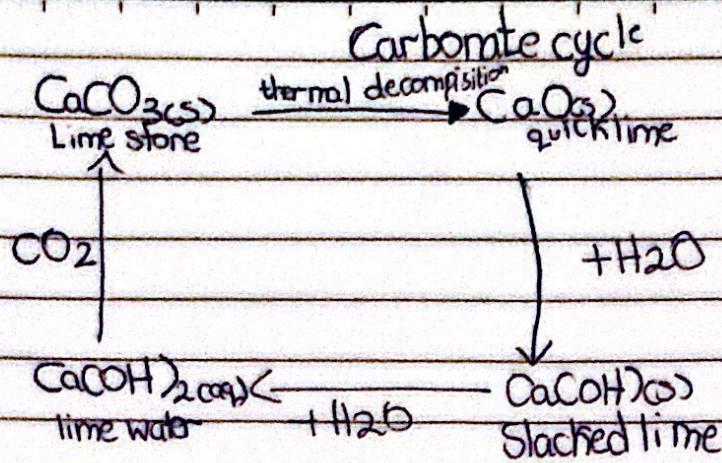
so more likely to oxidise

so more likely to lose e<sup>-</sup>

so Fe is less likely to rust.



acidic impurities  
molten



$\text{CaCO}_3(s)$  (Limestone) uses:-

large lumps  $\rightarrow$  building  
small lumps  $\rightarrow$  neutralization

$\text{CaO}(s)$  (quick lime) uses:-

dry ammonia.



12 days

9/28

# Rate of rxn

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

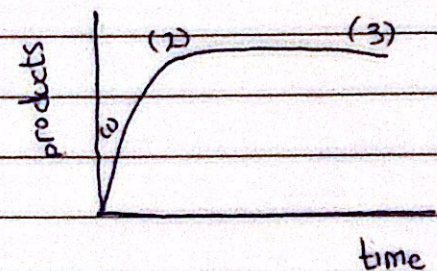
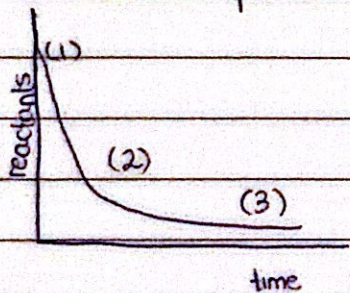
$$\text{Rate} = \frac{\Delta Q}{\Delta T}$$

$\frac{\Delta \text{mass}}{\Delta \text{time}}$	$\frac{\Delta \text{conc}}{\Delta \text{time}}$	$\frac{\Delta \text{pH}}{\Delta \text{time}}$	$\frac{\Delta \text{volume}}{\Delta \text{time}}$	$\frac{\Delta \text{temp}}{\Delta \text{time}}$	$\frac{\Delta \text{height of ppt}}{\Delta \text{time}}$
---	---	---	---	---	--

measure the rate of reactions

how fast the reactants consumed per unit time

how fast the product produced per unit time



■ region 1: fastest reaction rate  $\Rightarrow$  from the graph, steepest, more amount of reaction, more particles, more <sup>effective</sup> collisions per unit time.

■ region 2: lower rate  $\Rightarrow$  from the graph, less steep, less number of particles, less number of effective collisions per unit time.

■ region 3: reaction is over  $\Rightarrow$  gradient 0, no more limiting factor so no more effective collisions.

TOP 3 :- for any chemical reaction there are three main conditions :-

1) the reactants must be suitable Cu + HCL -> no rxn

2) the reactant must collide

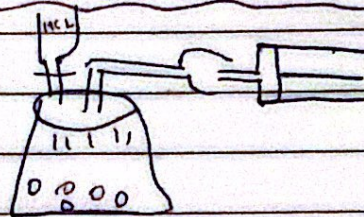
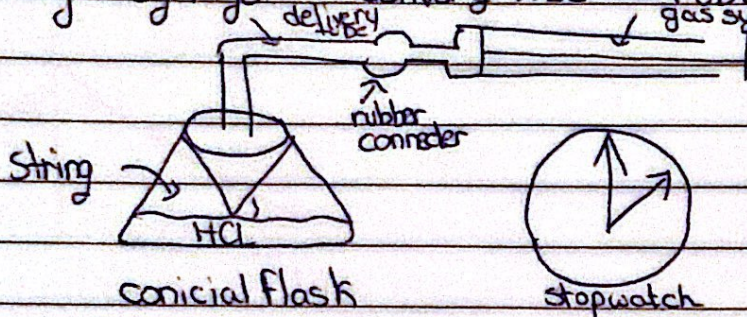
3) the collisions must be effective / min amount of energy to start the rxn. (ae)

# Measuring the rate of rxn.

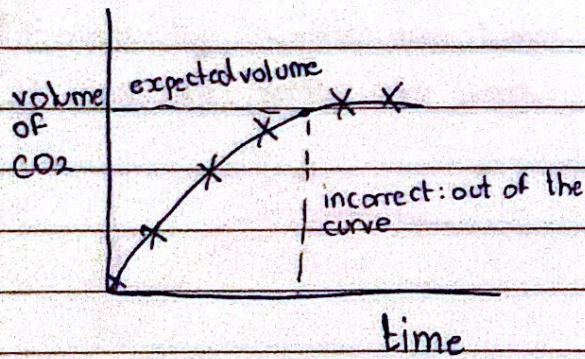


1) measuring the volume of gas per unit time.

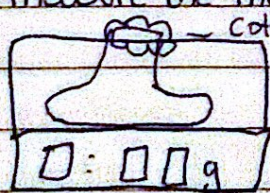
- gas syringe
- delivery tube
- rubber stopper



time (s)	0	30	60	90	120	150
volume (cm <sup>3</sup> )	0	20	30	33	34	34
		+20	+10	+3	+1	



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

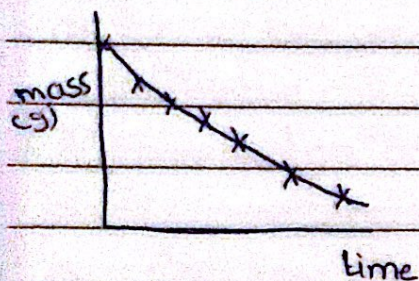


to allow CO<sub>2</sub> to escape & prevent splashing

\* why mass decreased

because CO<sub>2</sub> escaped

Time (s)	0	30	60	90	120	150
mass (g)	50	45	41	40	39.5	39.5



### ① Temperature

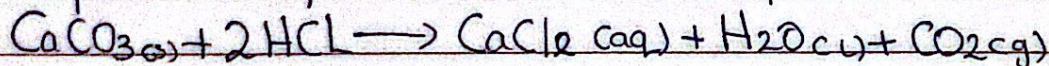
\* state how the temperature affects the rate of rxn:-

as the temperature increases, rate of rxn increases

explain how the temperature affect the rate of reaction?

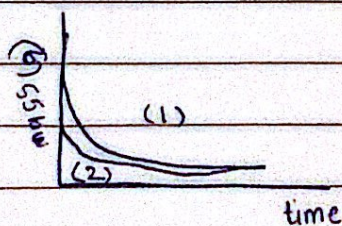
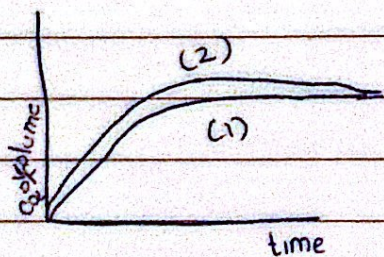
as the temperature increases the particles gain K.E so particles will have energy equal or greater than the activation energy ( 2 ), more effective collisions per unit time so faster rate of reaction.

\* plan an exp to show how the temperature affect the rate of reaction.



1) mass: 2g surface area: lumps  $V_{\text{HCl}} = 0.1 \text{ dm}^3$  temp = 25°C

2) mass: 2g surface area: lumps  $V_{\text{HCl}} = 0.1 \text{ dm}^3$   $M_{\text{HCl}} = 0.1 \text{ mol/dm}^3$  temp = 50°C



take a known mass of lumps  $\text{CaCO}_3$ , add them to a known volume and a known concentration  $\text{HCl}$  at 25°C, Measure the volume of  $\text{CO}_2$  produced per unit time, Repeat the experiment at 50°C, the experiment at 50°C produce  $\text{CO}_2$  with less time.

2) surface area

\* State how the surface affect the rate of reaction

as the surface area increases rate of reaction increases.

- \* explain how the surface area affect the rate of reaction as the surface area increases more particles exposed to the reaction, more effective collisions per unit time so faster rate.

3) concentration "amount"

→ state how the conc affect the rate of rxn

as the concentration increases the rate of reaction increases

\* explain how the concentration affects the rate of reaction.

as the concentration increase, particles so more collision per unit time, so faster rate of reaction.

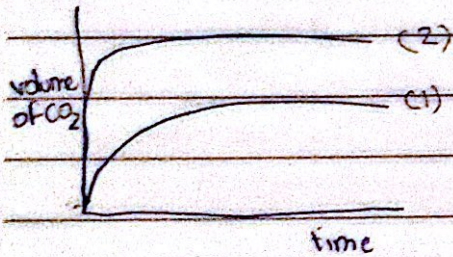
\* plan an exp to show that how concentration affect rate of rxn

exp 1 mass: 12g V=0.1dm<sup>3</sup> M<sub>HCl</sub> = 0.1 mol/dm<sup>3</sup> temp: 25°C

surface area: lumps

exp 2 mass: 2g V=0.1dm<sup>3</sup> M=0.2 mol/dm<sup>3</sup> temp=25°C S.E: lumps

exp 3 mass: 4g V: 0.1dm<sup>3</sup> M=0.2 mol/dm<sup>3</sup> temp=25°C S.E: lumps



more limiting :- faster rate, more products  
more excess :- faster rate.



4) pressure: - "only affect gas"

\* explain how the pressure affect the rate of reaction?

as the pressure increases, by reducing the volume, more particles per unit volume  
so more effective collisions per unit time faster rate of reaction

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

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

5) catalyst

chemical substance that speeds up rate of 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, faster rate of rxn.

The reaction  $2\text{H}_2\text{O}_2 \xrightarrow[\text{MnO}_2]{\text{CuO}} 2\text{H}_2\text{O} + \text{O}_2$  (decomposition of hydrogen peroxide)

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

take a known volume with a known <sup>temp</sup> conc of  $\text{H}_2\text{O}_2$ , measure the volume of  $\text{H}_2\text{O}_2$  produced per unit time. Repeat the exp add

~~known mass of CuO~~, measure the volume of  $\text{O}_2$  produced per unit

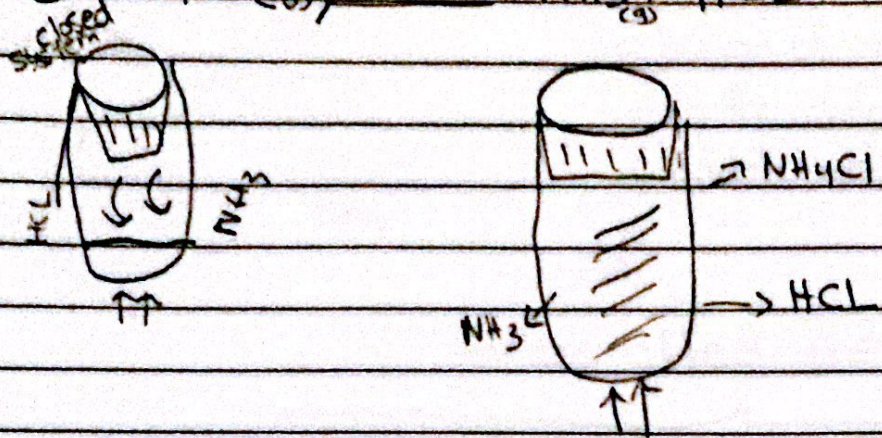
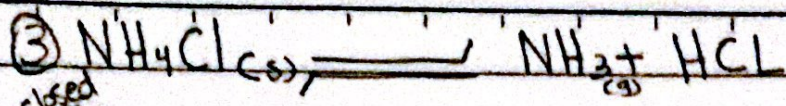
time, repeat the exp using ~~MnO<sub>2</sub>~~  $\text{CuO}$  with  $\text{CuO}$  produce more  $\text{O}_2$  per unit <sup>at the</sup> time

Conclusion: - the exp that produce more  $\text{O}_2$  per unit time is the better catalyst.

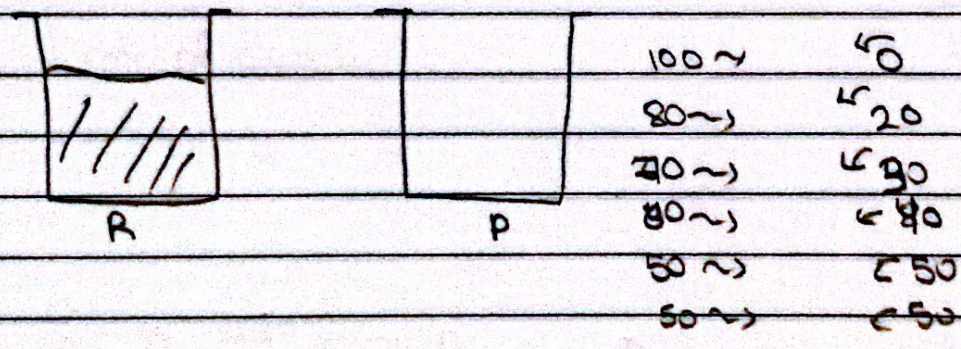
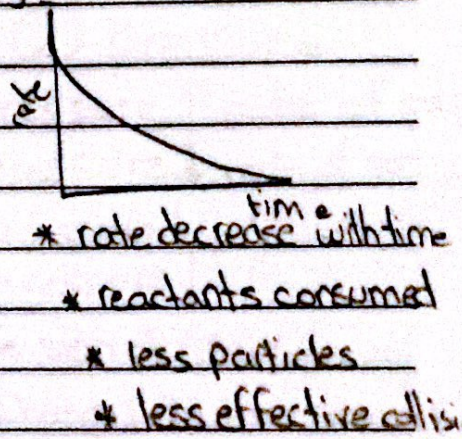
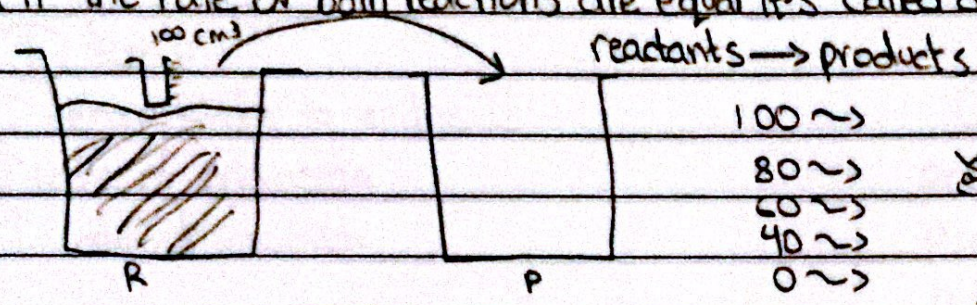
2) Plan an exp to show which catalyst CuO or  $\text{MnO}_2$  is better.

• take a known volume of with a known temperature and conc of  $\text{H}_2\text{O}_2$  add known mass of CuO, measure the volume of  $\text{O}_2$  produced per unit time, repeat the exp using  $\text{MnO}_2$

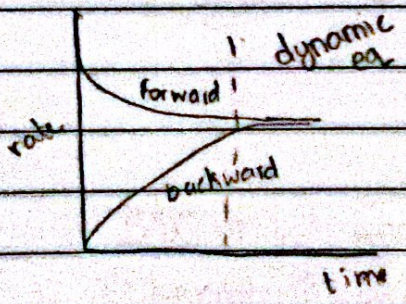
conclusion: the exp that produce more  $\text{O}_2$  per the same unit time is the better catalyst.



x if the rate of both reactions are equal it's called dynamic equilibrium



rate of forward = rate of backward



rate of forward decrease with time  
less reactants  
less particles  
less effective collisions per unit time

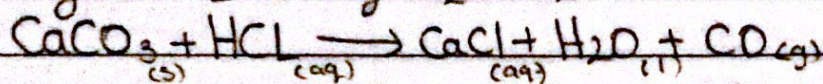
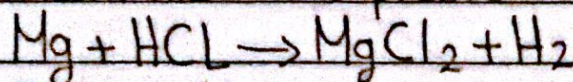
In terms of rate  
when the rate of forward rxn is equal to the rate of backward rxn.

3) Plan an exp to show that CuO not used up during the reaction.  
 take a known mass CuO, do the exp until no more bubbles of O<sub>2</sub>  
 Filter the mixture, dry in oven, remeasure the mass, conc: the mass  
 will not change.

## Reversible reactions

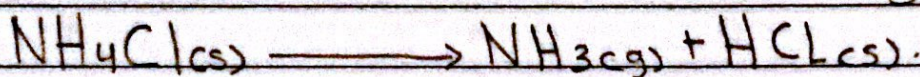
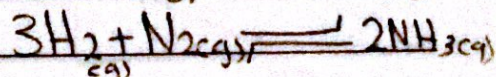
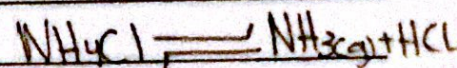
one way

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



both ways

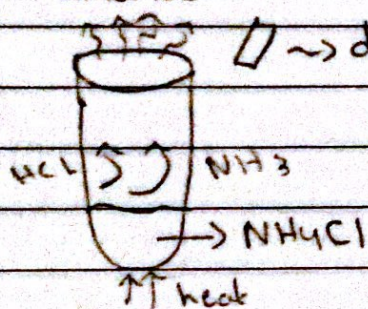
Reactants  $\xrightleftharpoons[\text{backward}]{\text{forward}}$  products



ammonium  
chloride

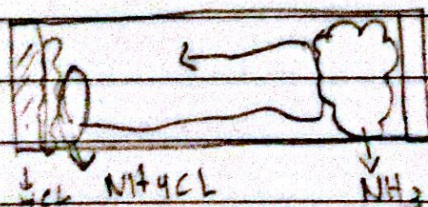
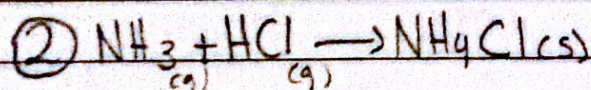
ammonia

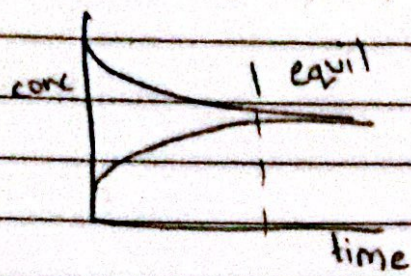
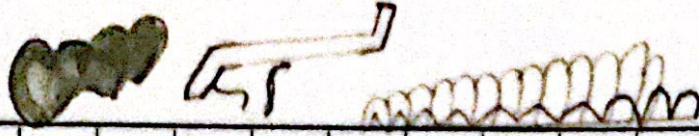
hydrogen  
chloride



\* which damp litmus paper changes  
 its color first, why?

the damp red litmus paper will change  
 its color first because NH<sub>3</sub> is a  
 basic gas & lighter than HCl  
 which is an acidic gas.





In terms of ~~equil~~ concentration when the concentration of reactants & products are constant

### Factors affect the position of equil



#### ① temp

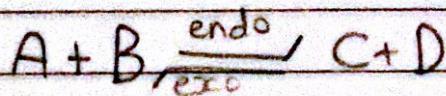
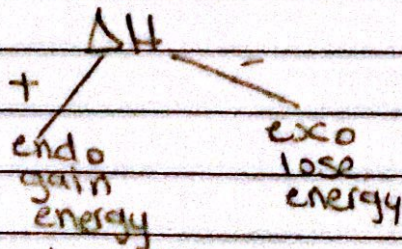
- ↑ temp shift to endoside
- ↑ rate of endoside
- ↑ rate of exoside

- ↓ temp shift to exothermic side
- ↓ rate of endoside
- ↓ rate of exoside

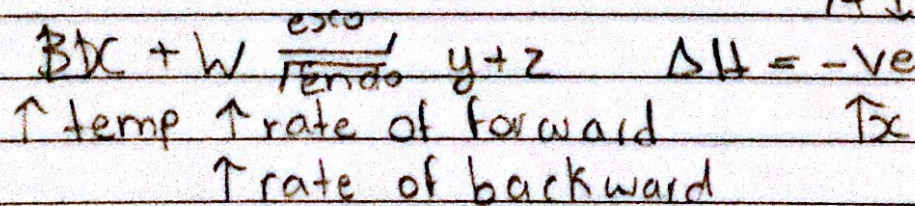
#### ② pressure

- pressure ↑ rate of gas<sub>m</sub>
- pressure ↓ rate of gas<sub>prod</sub>
- pressure ↓ " " "
- pressure ↓ " " "

the sign of  $\Delta H$  (energy change) always represent the forward side



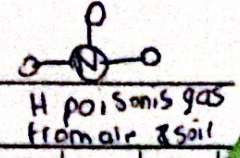
$\Delta H = +ve \rightarrow$  endo ↑ temp  
 ↑ rate of forward  
 ↑ rate of backward  
 A ↓ B ↓ C ↑ D ↑



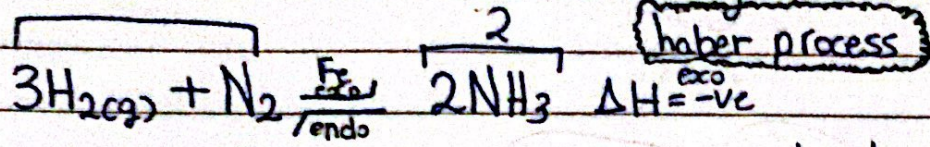


Home  
Experiment  
Separator  
N-2010m ammonia

78%  
21%  
1%



## Industry of ammonia



essential condition:

- ☒ Temperature :- 400 - 450°C
- ☒ pressure :- 200 atm
- ☒ catalyst :- Fe

to enhance the forward reaction.

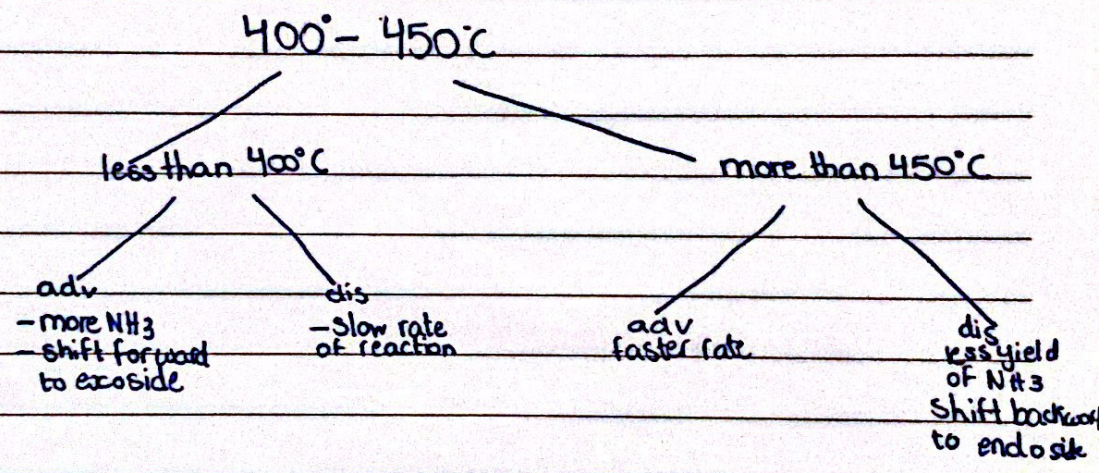
- ① add excess H<sub>2</sub>, N<sub>2</sub>?  
return back to converter.
- ② remove NH<sub>3</sub> immediately? how?  
cooling, then NH<sub>3</sub> condenses

## Uses of ammonia

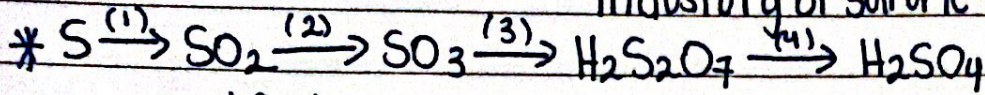
- ♥ 1) Fertilizer
- ♥ 2) cleaning detergent.
- ♥ 3) smelling salts.

### \* How to obtain?

- \* N<sub>2</sub> :- Fractional distillation of liquid air (Cooling under high pressure).
  - \* H<sub>2</sub> :- Cracking of alkanes (organic).
- $$\text{C}_2\text{H}_6(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{CO} + 3\text{H}_2$$



## Industry of sulfuric acid



source: fossil fuels.

ore: zinc blende

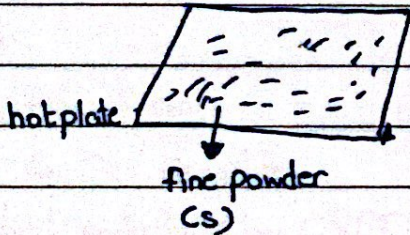
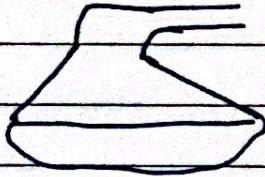
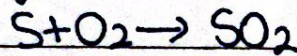
- ① Uses:-
- 1) Fireworks
  - 2) matches
  - 3) medicine

(1)  $\rightarrow$  roasting

② Uses:-

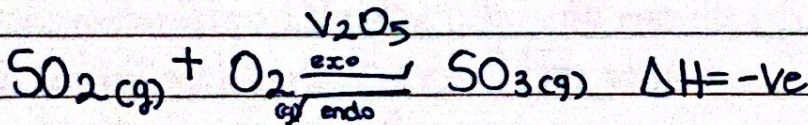
- 1) food preservative (kills bacteria)
- 2) paper industry

### ① From S to $SO_2$ (Roasting)



### ② From $SO_2$ to $SO_3$

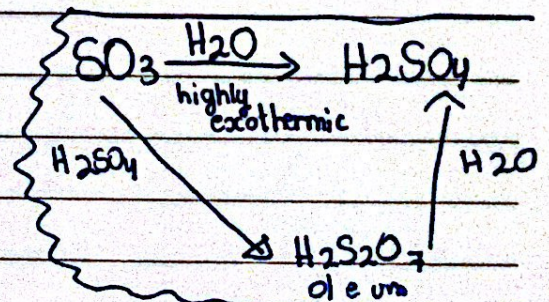
(2)  $\rightarrow$  contact process.



① temperature:-  $400-450^\circ C$

② pressure:- 2 atm (high pressure favour the forward side which has less gas mole) max yield 98% at 2 atm.

③ catalyst:-  $V_2O_5$  (vanadium(V) oxide).



iron oxid  
ore haematite

heating  
reducin agent  
pure elements

## Extraction of metals

K  
Na  
Li  
Ca  
Mg  
Al

electrolysis for molten ore

$C_2CO$

Zn  
Fe  
Pb

Zinc blende ( $ZnS$ )  
hematite ( $Fe_2O_3$ )

blast furance

H

Cu

Ag

Au

Pt

extraction of iron:-

ore:  $Fe_2O_3$  Hematite

Method: reduction by C & CO

place: blast furance

Raw materials: 1)  $Fe_2O_3$  with acidic impurities  $SiO_2$

■ 2) calcium carbonate  $CaCO_3$  "lime stone"

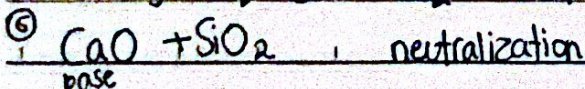
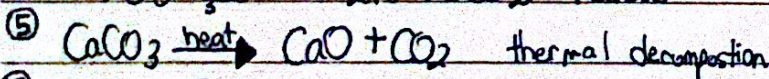
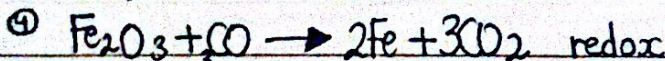
■ 3) coke (pure carbon) "C"

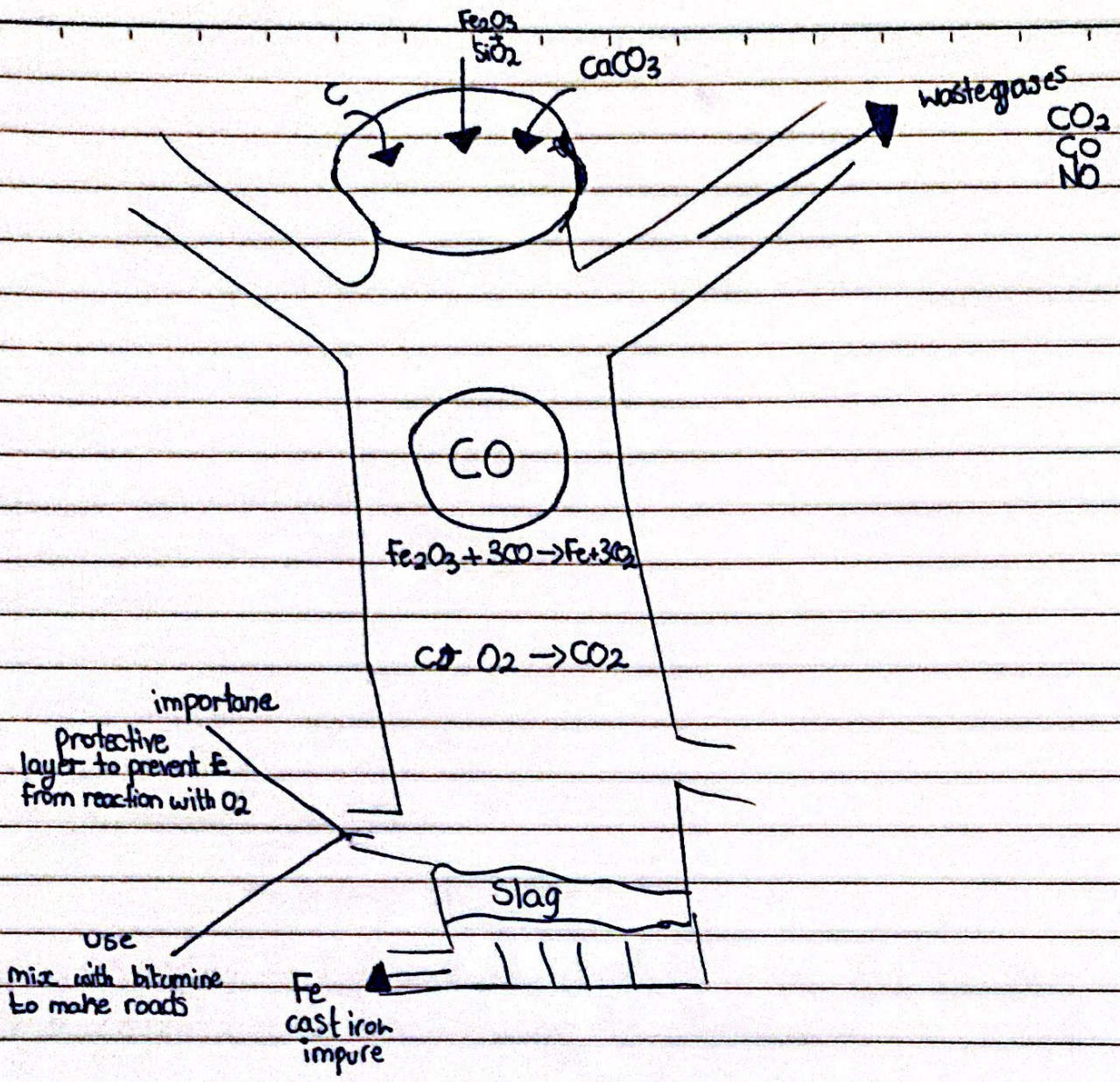
■ 4) air  $1500^\circ C$

① complete combustion



incomplete combustion  
produce energy





wastegases  
 $CO_2$   
 $N_2$

importante  
 protective layer to prevent Fe from reaction with  $O_2$

use  
 mix with bitumine to make roads

Fe  
 cast iron  
 impure



Extraction of zinc

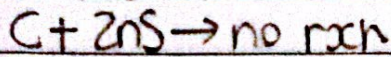
Not in syllabus

ore: zinc blende,  $ZnS$

method: reduction by  $C, CO$

place:- blast furnace

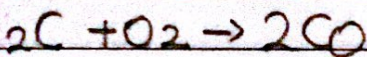
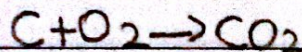
\*  $C, CO, H_2$  can reduce the less reactive metal Only from their oxide.



Step 1: roasting with  $O_2$



blast furnace



the produced Zn is 100% pure

the temp inside the furnace is  $1500^\circ C$  & the B.P of zinc is  $907^\circ C$  so the Zn produced as gas leaving the other impurities behind

alloy:- is a mixture of metals with another metal or semi metal.

Brass:  $Cu, Zn$

Bronze:  $Cu, Sn$

Steel:  $Fe, C, Cr, Ni$ .