

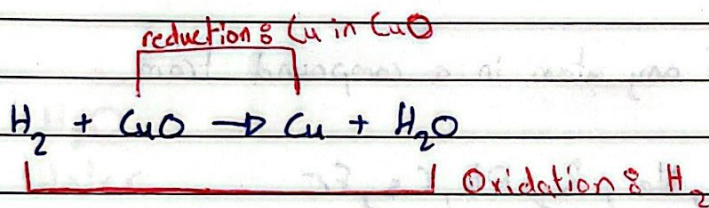
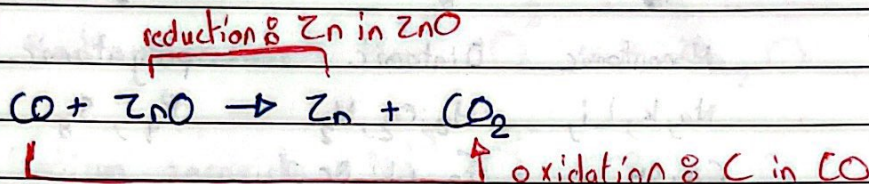
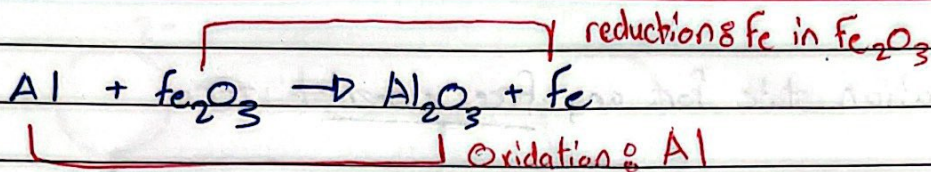
# Redox

Reduction

Oxidation

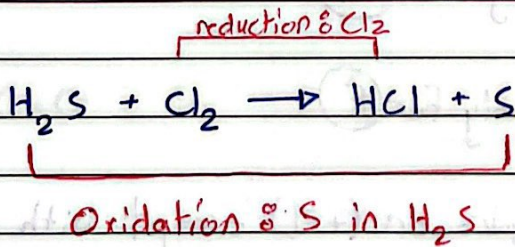
① lose O ← In terms of Oxygen → Gain O

oxygen

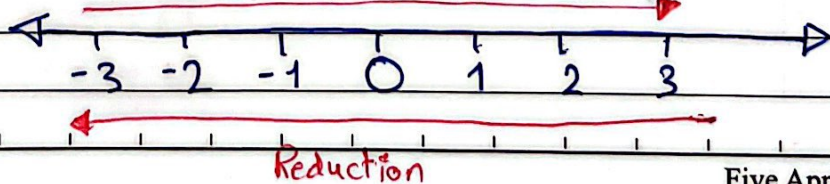


② Gain H ← In terms of Hydrogen → lose H

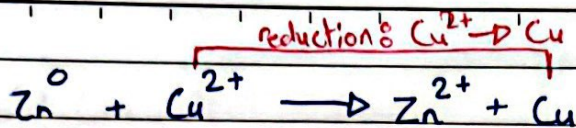
Hydrogen



③ Oxidation state      Decrease      Oxidation      Increase



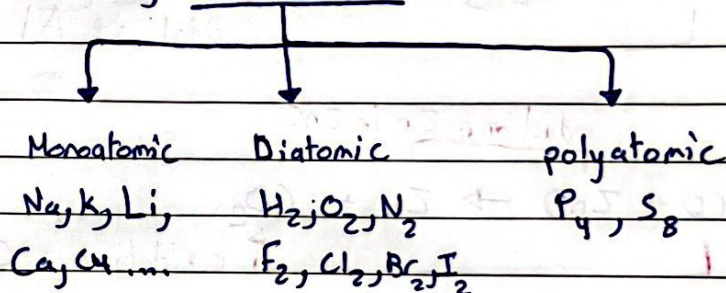




Oxidation:  $\text{Zn}^0 \rightarrow \text{Zn}^{2+}$

### ★ Rules of oxidation state

1) The oxidation state for any free element = zero



2) The oxide number of any atom in a compound from

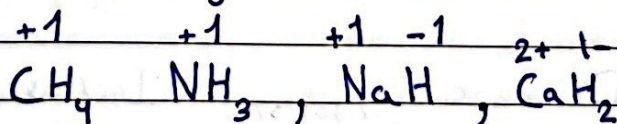
Group I = +1    Li, Na, K, Rb, Cs, Fr

Group II = +2    Mg, Ca, Sr, Ba

Group III = +3    always +3 only for (Al)

Group VII = -1    always -1 only for (F)

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

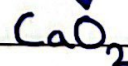
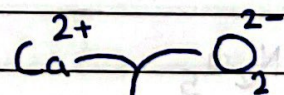
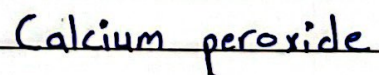
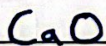
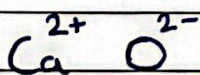
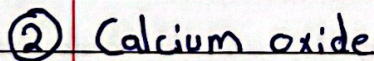
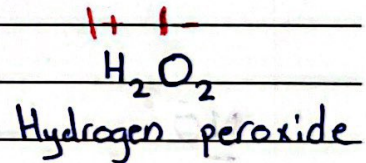
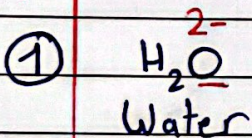
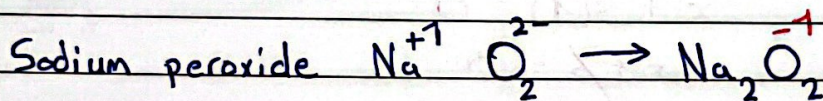
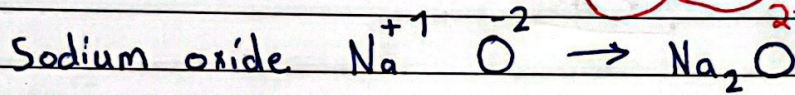
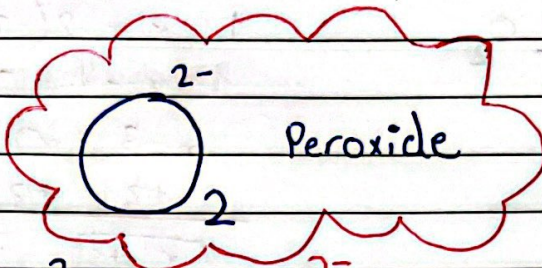
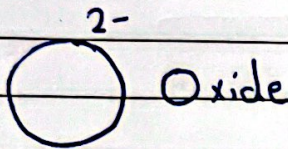




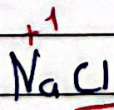
4) The oxidation state of oxygen (-2)

Except in peroxide (-1)

Except in  $OF_2$  (2+)



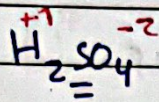
5) The sum of all oxidation state in a compound = 0 in an Ion = charge of this ion



$+1 + x = 0$

$-1 - 1$   
 $x = -1$





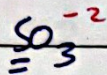
$$2(1) + S + 4(-2) = 0$$

$$2 + S - 8 = 0$$

$$S - 6 = 0$$

$$+6 \quad +6$$

$$\boxed{S = +6}$$

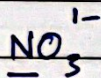


$$S + 3(-2) = 0$$

$$S - 6 = 0$$

$$+6 \quad +6$$

$$\boxed{S = 6}$$

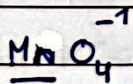


$$N + 3(-2) = -1$$

$$N - 6 = -1$$

$$+6 \quad +6$$

$$\boxed{N = +5}$$

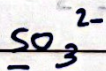


$$\text{Mn} + 4(-2) = -1$$

$$\text{Mn} - 8 = -1$$

$$+8 \quad +8$$

$$\boxed{\text{Mn} = +7}$$

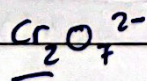


$$S + 3(-2) = -2$$

$$S - 6 = -2$$

$$+6 \quad +6$$

$$\boxed{S = +4}$$



$$2(\text{Cr}) + 7(-2) = -2$$

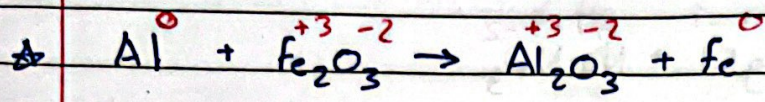
$$2\text{Cr} - 14 = -2$$

$$+14 \quad +14$$

$$\frac{2\text{Cr} = +12}{2}$$

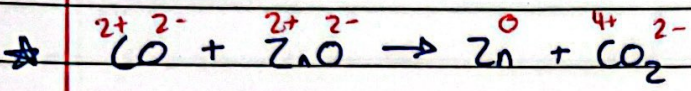
$$\boxed{\text{Cr} = +6}$$





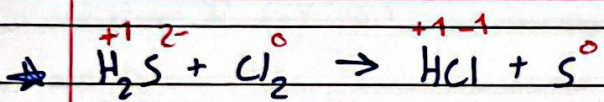
Oxidation :  $\text{Al} \rightarrow \text{Al}^{3+}$

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



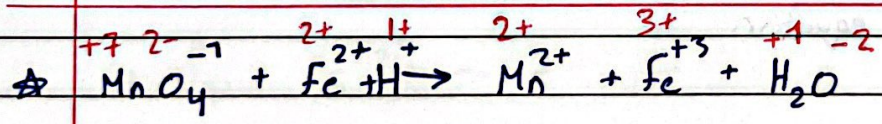
Oxidation :  $\text{C}^{2+} \rightarrow \text{C}^{4+}$

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



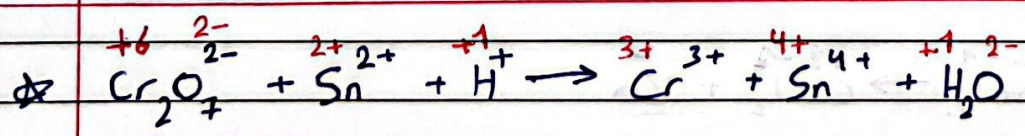
Oxidation :  $\text{S}^{2-} \rightarrow \text{S}$

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



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

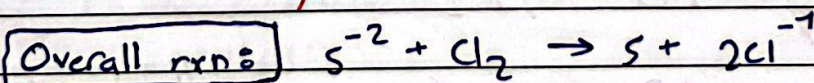
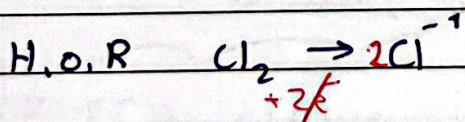
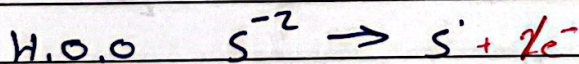
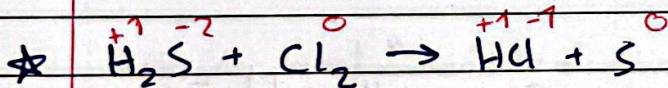
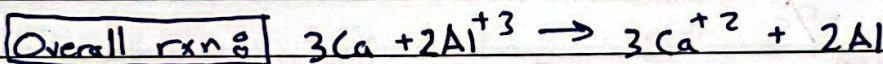
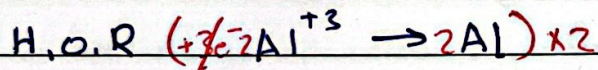
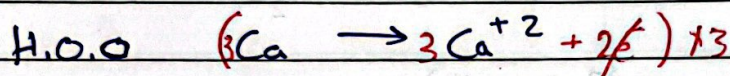
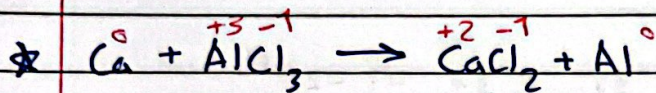
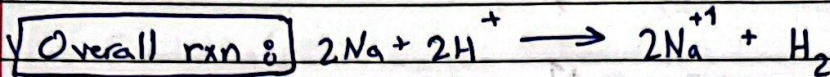
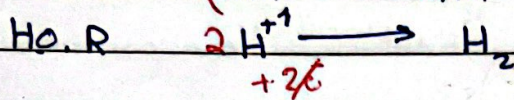
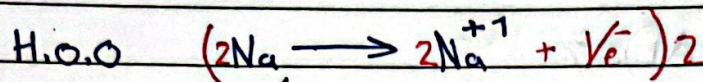
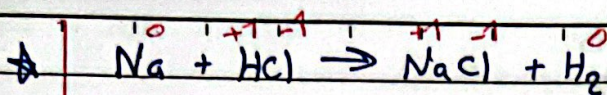
Reduction :  $\text{Mn}^{7+} \rightarrow \text{Mn}^{2+}$



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

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





Reactants  $\rightarrow$  products

OIL RIG - Gain  $e^{-}$   
 | | | | |  
 is

Oxidation  $\rightarrow e^{-}$  "lose  $e^{-}$ "

oxidation is lose  $e^{-}$  Reduction

Reduction  $e^{-} \rightarrow$  "gain  $e^{-}$ "



## Oxidizing agent and reducing agent

Oxidizing agent "oxidant"

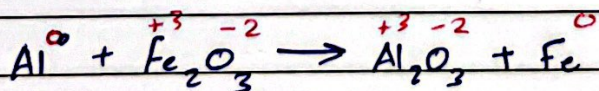
	Oxidation (reducing agent)	Reduction (oxidising agent)
O	Gain O	lose O
H	lose H	Gain H
Oxid. state	↑	↓
e <sup>-</sup> transfer	lose e <sup>-</sup>	Gain e <sup>-</sup>

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

Reducing agent "reductant"

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

Notes: If the substance is an ION in a compound, the agent is the compound itself.



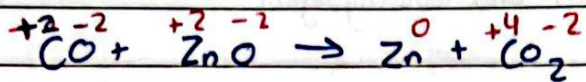
Oxidation Al

Reducing agent: Al

Reduction Fe<sup>+3</sup>

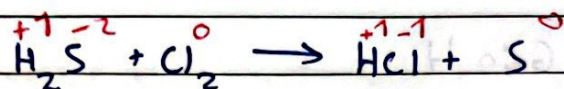
Oxidising agent: Fe<sub>2</sub>O<sub>3</sub>



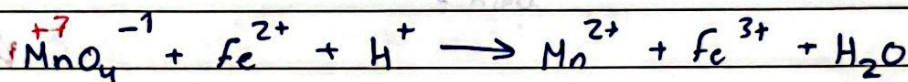


Oxidation:  $\text{C}^{2+}$       Oxidising agent  $\text{ZnO}$

Reduction  $\text{Zn}^{2+}$       Reducing agent  $\text{CO}$



Oxidant  $\text{Cl}_2$       Reductant  $\text{H}_2\text{S}$

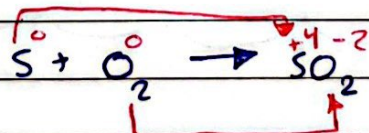
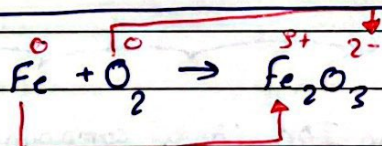


oxidising agent  $\text{MnO}_4^{-1}$       reductant  $\text{Fe}^{2+}$

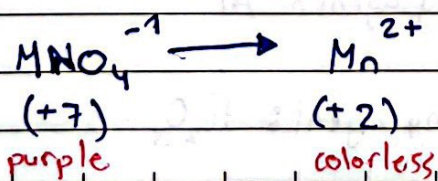
oxidation  $\text{Fe}^{2+}$       Reduction  $\text{Mn}^{7+}$

Most Common oxidising agent

① Oxygen

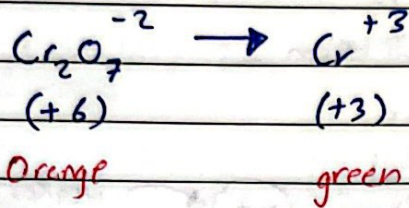


② Acidify potassium manganate  $\text{KMnO}_4/\text{H}^+$

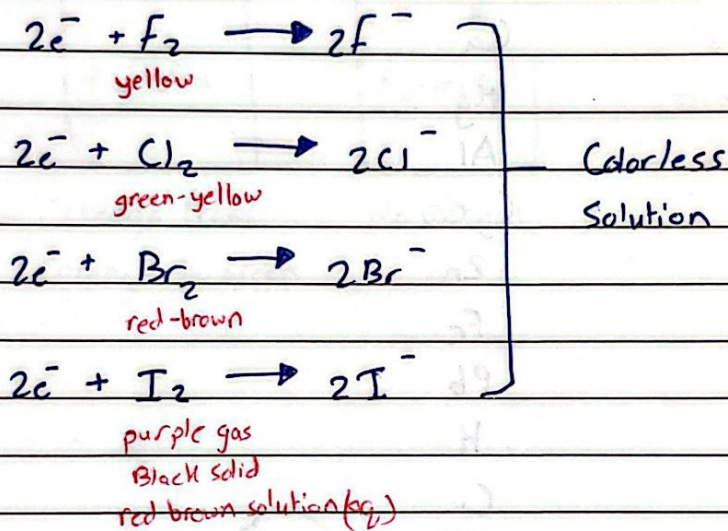




③ Acidify potassium dichromate  $K_2Cr_2O_7 / H^+$

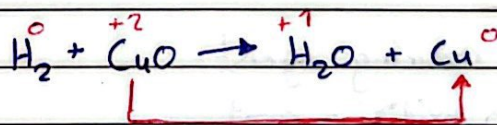


④ Halogens

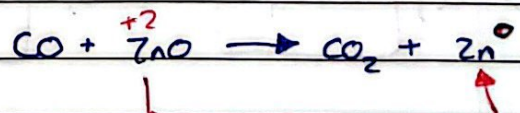
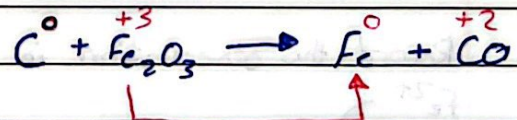


Most Common reducing agent

① Hydrogen



② Carbon and Carbon monoxide





# Electrolysis = Discharging

Electricity

Analysis

"Breaking down"

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

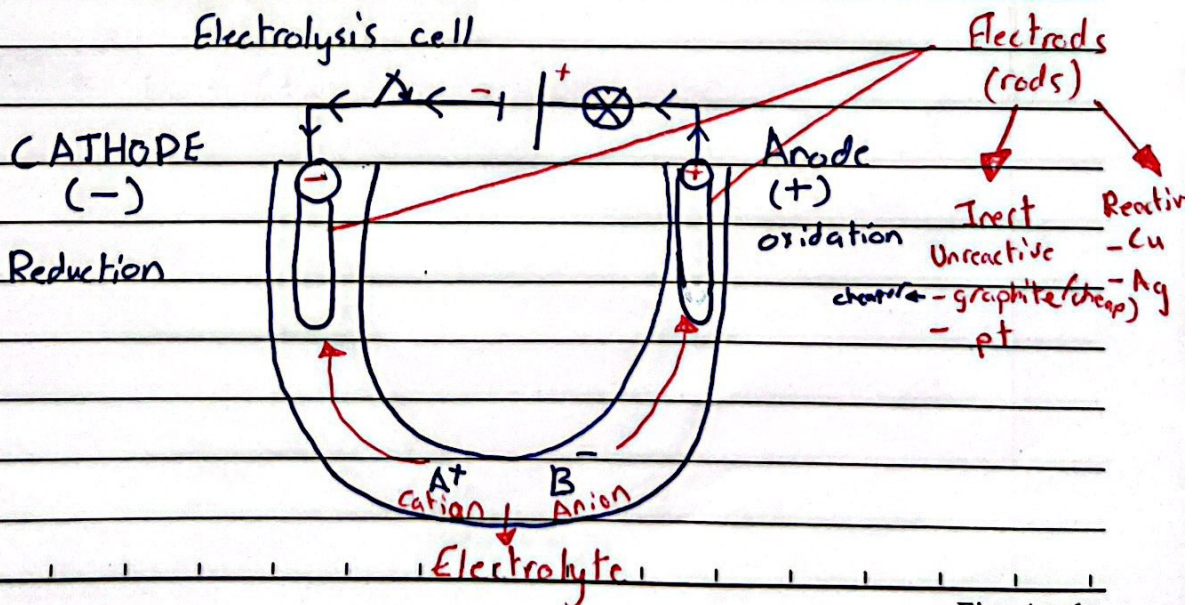
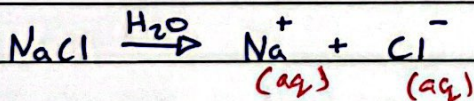
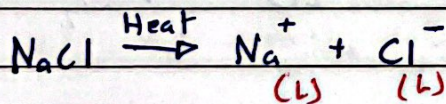
Why the ionic compounds don't conduct electricity when solid?

The ions are not free to move

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

The ions are free to move

★ Electrolyte is Chemical compound that conduct electricity when molten or aqueous.





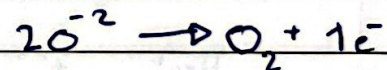
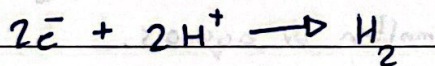
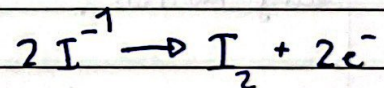
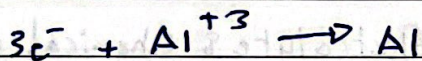
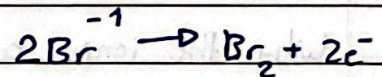
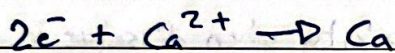
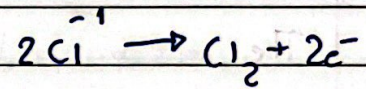
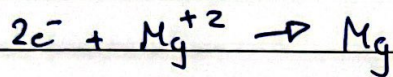
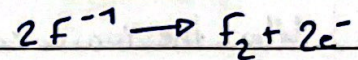
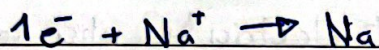
★ Cathode: The -ve rod that attracts the ~~neg~~ +ve Ions (cations) where the reduction occurs

★ Anode: The +ve rod that attracts the -ve Ions (anions) where the oxidation occurs

Ion  $\rightarrow$  element

Cations

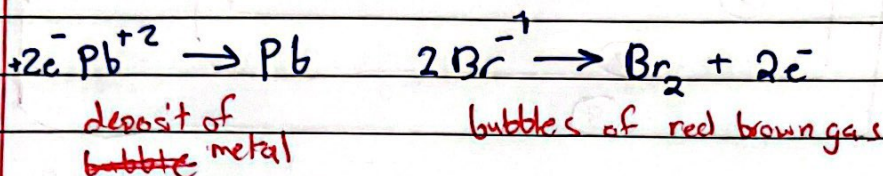
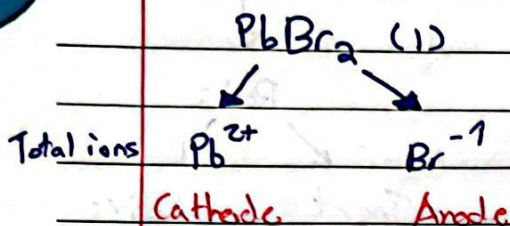
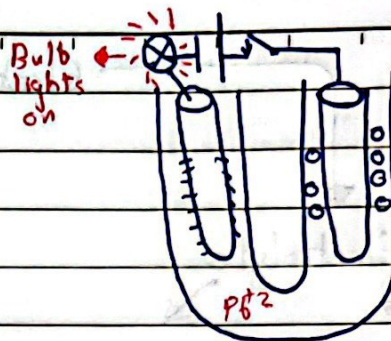
Anions



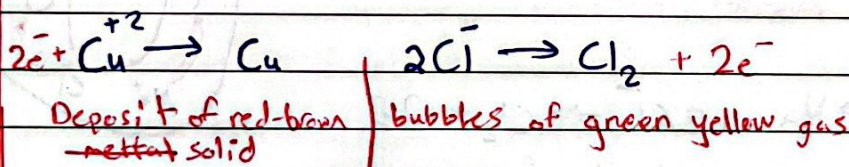
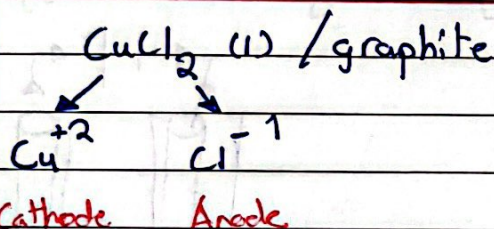
~~Electrolysis~~



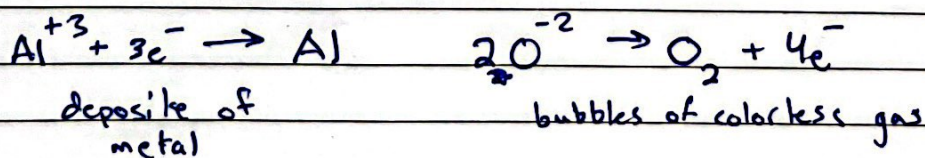
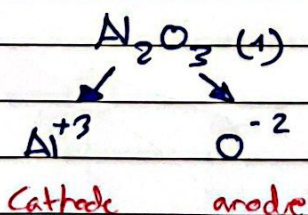
## Molten Lead (II) Bromide



Electrolyte is used up



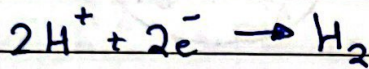
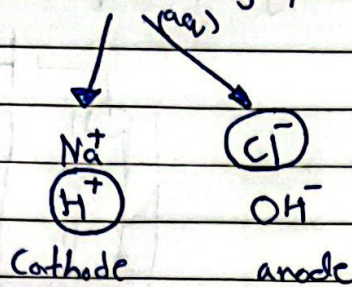
Electrolyte is consumed



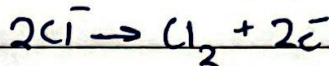
Electrolyte is used up



Concentrated NaCl / graphite



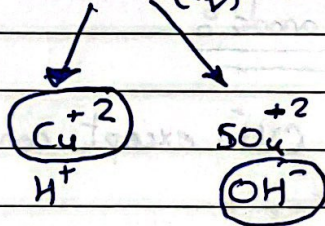
bubbles of  
colorless gas



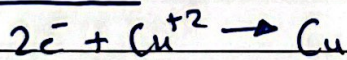
bubbles of green yellow  
gas

Electrolyte: NaOH

$\text{CuSO}_4$  / graphite

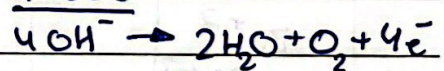


Cathode



Deposit of red brown  
solid

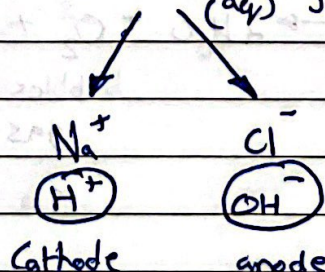
Anode



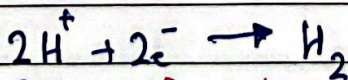
Bubbles of colorless gas

electrolyte:  $\text{H}_2\text{SO}_4$

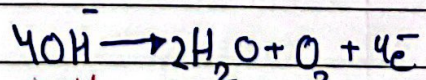
Dilute NaCl / graphite



Electrolyte: NaCl



bubbles of colorless  
gas



bubbles of colorless gas

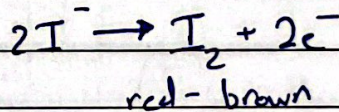
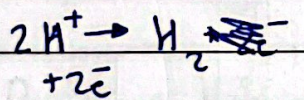
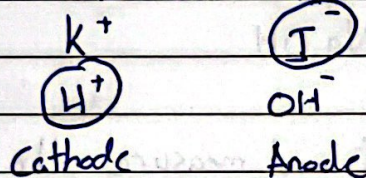
Five Apple



Gas	test	Result
$H_2$	lighted splint	pop
$O_2$	Glasing splint	Relight
$Cl_2, Br_2$	damp litmus paper	Turns red then bleach

Concentrated KI (aq) / graphite

not purple in water  
purple in molten

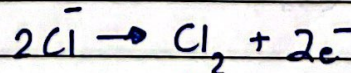
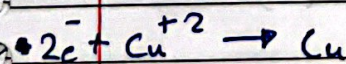
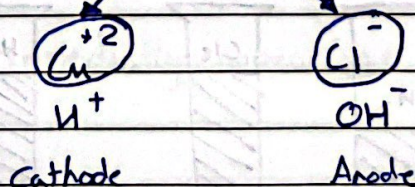


bubbles of colorless gas

Electrolyte: KOH

Conc.  $CuCl_2$  (aq) / graphite

\* Electrolyte: less conc  $CuCl_2$



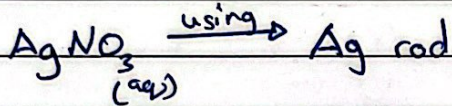
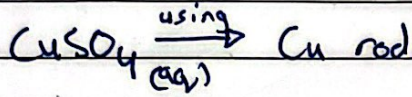
Deposite of red-brown solid

bubbles of green yellow gas

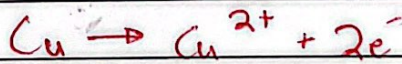
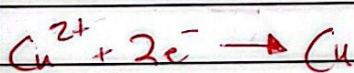
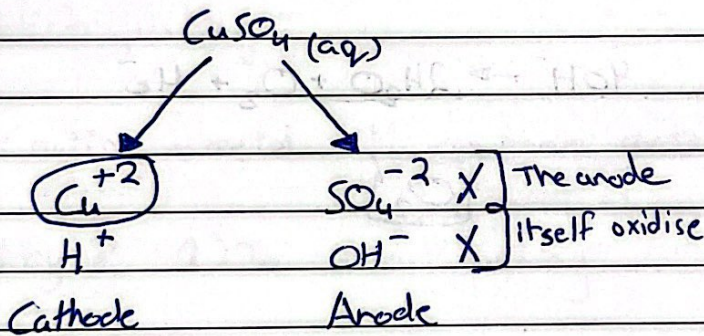


## Electrolysis for aqueous electrolyte using active rod

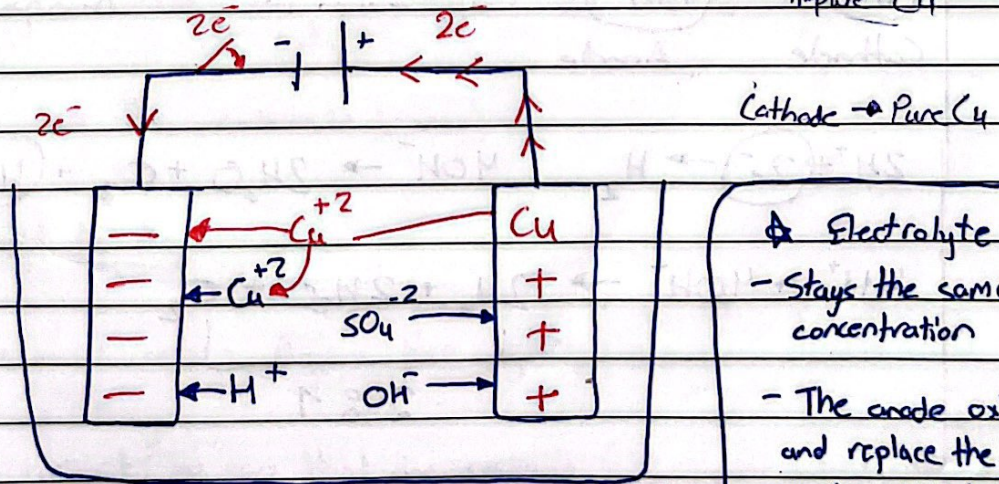
\* The rod must be the same metal Ion in the electrolyte



## Electrolysis for aqueous $\text{CuSO}_4$ using Cu rod



Anode must be  
impure Cu

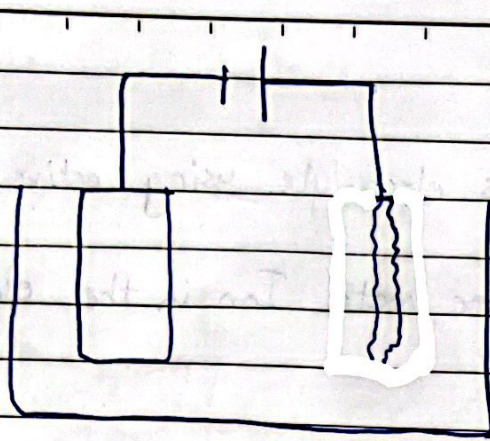


Cathode  $\rightarrow$  Pure Cu

- \* Electrolyte
- Stays the same concentration
- The anode oxidized and replace the  $\text{Cu}^{+2}$  in the electrolyte with the same rate

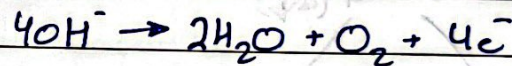
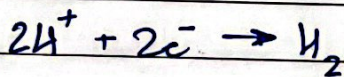
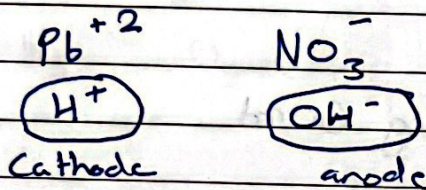


Cathode's mass ↑  
Cu deposit

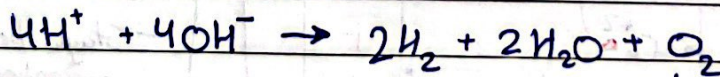
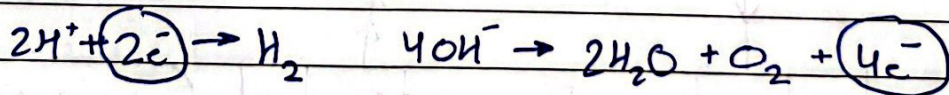
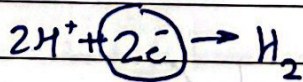
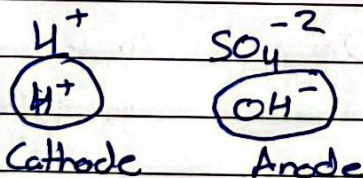


Anode's mass ↓  
Oxidized by lose  $e^-$

★  $Pb(NO_3)_2$  (aq)



★  $H_2SO_4$



2 : 1



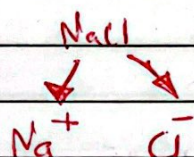
## Applications on electrolysis

Molten/inert

Extraction of metals

Aqueous/inert

prepare solution



Aqueous/active

Electroplating

purifying metals

### Electroplating :

Coating a metal with another metal using electrolysis

Why? 1) To prevent rusting 2) More attractive

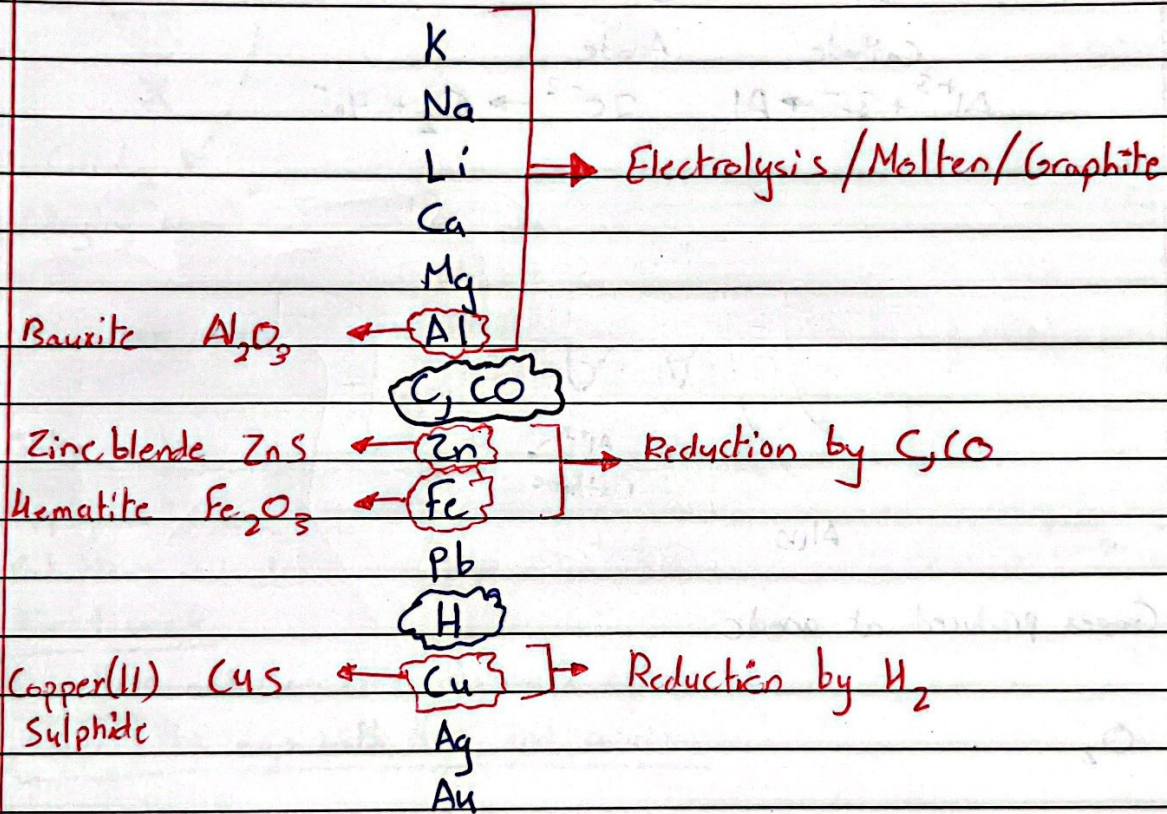
★ How to electroplate a metal spoon, with silver?

- 1) Clean the spoon from any impurities as oxide layer
- 2) Make the spoon the cathode (-ve)
- 3) The anode must be Ag
- 4) The electrolyte must contain  $\text{Ag}^+$  Ex:  $\text{AgNO}_3$
- 5) Turn on the circuit "be sure that the spoon is fully immersed in the electrolyte"



## Extraction of Metals From their ores

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



## Extraction of Aluminium

Ore:  $Al_2O_3$  Bauxite

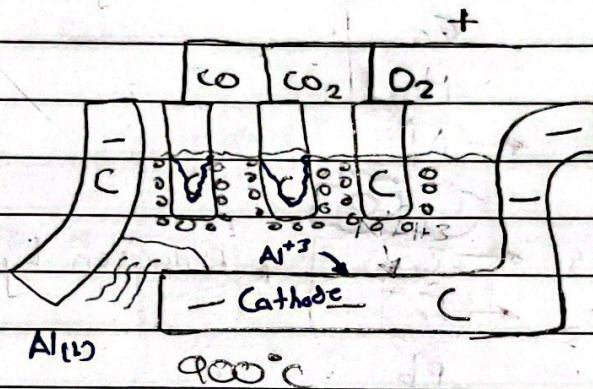
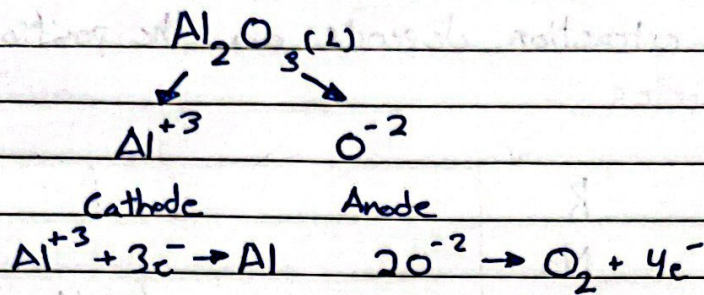
Method: ~~By~~ Electrolysis for molten  $Al_2O_3$  / graphite

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

So we dissolve  $Al_2O_3$  in a molten cryolite  $Na_3AlF_6$



- To lower the mp to  $900^{\circ}\text{C}$  so less cost
- To increase the electrical conductivity



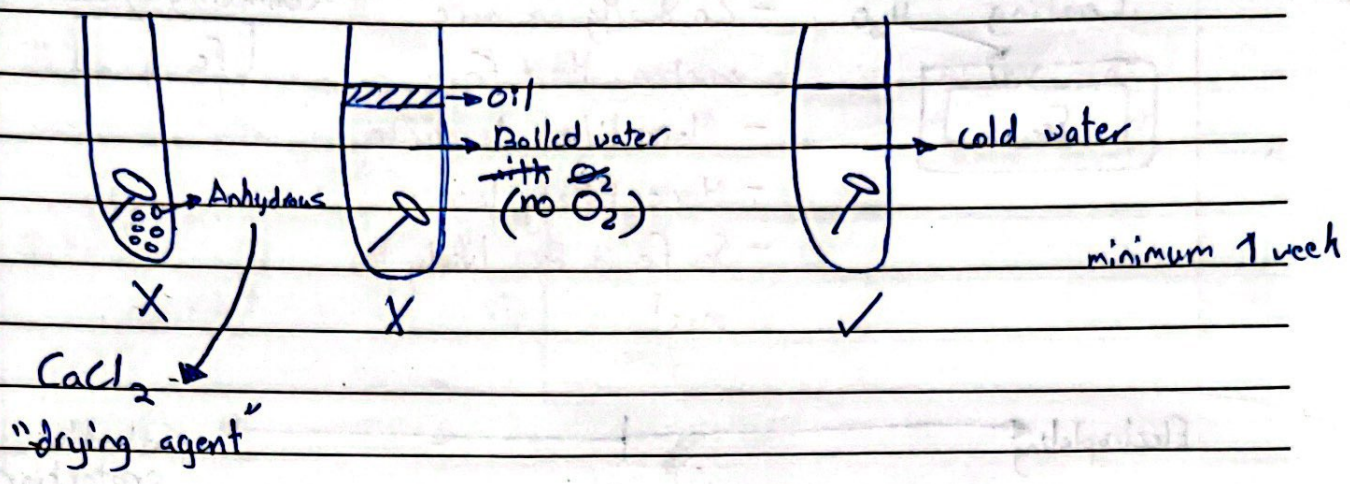
Gases produced at anode

- 1)  $\text{O}_2$
  - 2)  $\text{CO}_2$
  - 3)  $\text{CO}$
- Reaction of rods with  $\text{O}_2$  so we must replace them periodically

Aluminium	Property	Use
	- low density	- Aircraft bodies
	- Ductile	- Electrical wires
	- Malleable	- Window frame cooking utensils
	- Conduct electric	- Wires
	- Form an oxide layer which is non toxic	- Food cans

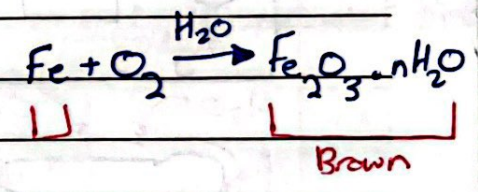


Oxidation ← Rust: Reaction of Iron with both  $O_2$  &  $H_2O$   
 Slow reaction: 6-7 days

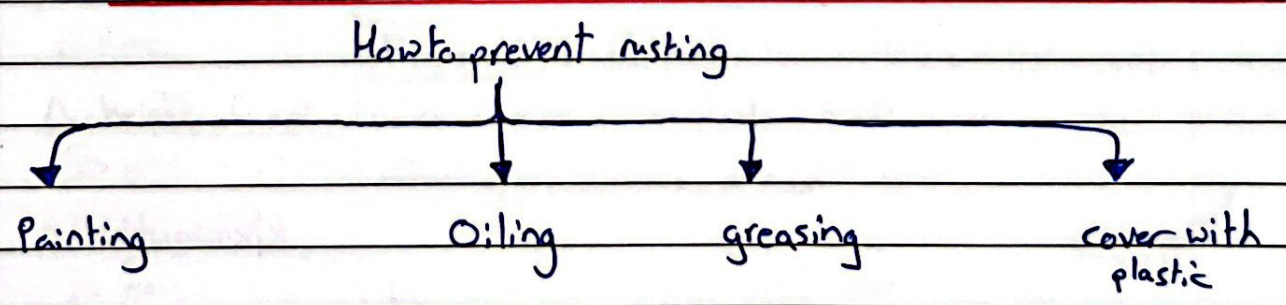


Q Plan an experiment to show which rust prevention solution is better

- 1) Take a known mass of Iron nail & apply
- 2) Apply a known volume of the <sup>first</sup> solution
- 3) Put them in a known volume of water.
- 4) For 1 week
- 5) Dry them and measure the mass again
- 6) Repeat the exp with the 2nd solution



Conclusion: The exp which causes more increase in mass, worse solution



"To prevent  $O_2$  and  $H_2O$  from reaching the iron"



# Rate of reaction

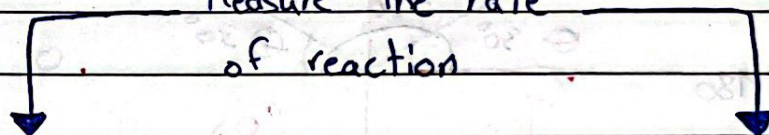
Rate =  $\frac{\text{Change in quantity}}{\text{Change in time}}$

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

Q

time (t)

Measure the rate of reaction



★  $\frac{\Delta \text{mass}}{\Delta \text{time}}$

How fast the reactants consumed per unit time

How fast the products produced per unit time

★  $\frac{\Delta \text{conc}}{\Delta \text{time}}$

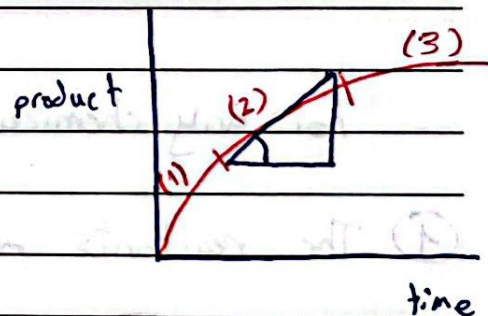
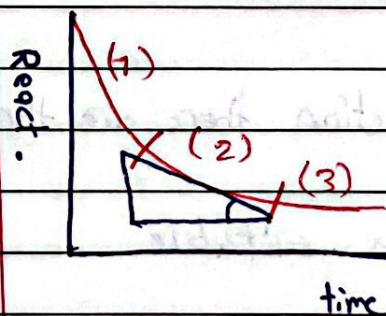
★  $\frac{\Delta \text{pH}}{\Delta \text{time}}$

★  $\frac{\Delta \text{volume}}{\Delta \text{time}}$

★  $\frac{\Delta \text{Temp}}{\Delta \text{time}}$

★  $\frac{\Delta \text{height of ppt}}{\Delta \text{time}}$

★  $\frac{\Delta \text{light intensity}}{\Delta \text{time}}$



**Region (1)**: fastest rate  $\Rightarrow$  from the graph. Steepest more amount of reactants.  $\Rightarrow$  more particles  $\Rightarrow$  More effective collisions per unit time.

**Region (2)**: Slower rate  $\Rightarrow$  from the graph. less steep less no. of particles, so less no. of effective collisions per unit time

**Region (3)**: Reaction is over  $\Rightarrow$  gradient = 0 (horizontal) no more limiting factor, No more effective collisions.



## Temperature

State how the temp affects the rate of reaction

As the temperature increase the rate of the reaction increases

Explain how the temp affects the rate of RXN (5 marks)

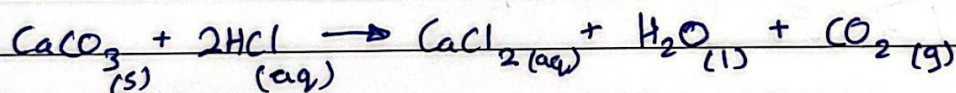
As the temperature increase the particles gain Kinetic energy so move faster.

The particles will have energy equal to or greater than the  $E_a$

So more effective collisions per unit time

So faster rate of reaction

Plan an exp. to show how the temp affect the rate of reaction



Exp 1: Mass 8 20g  
lumps

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

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

$$\text{Temp} = 25^\circ\text{C}$$

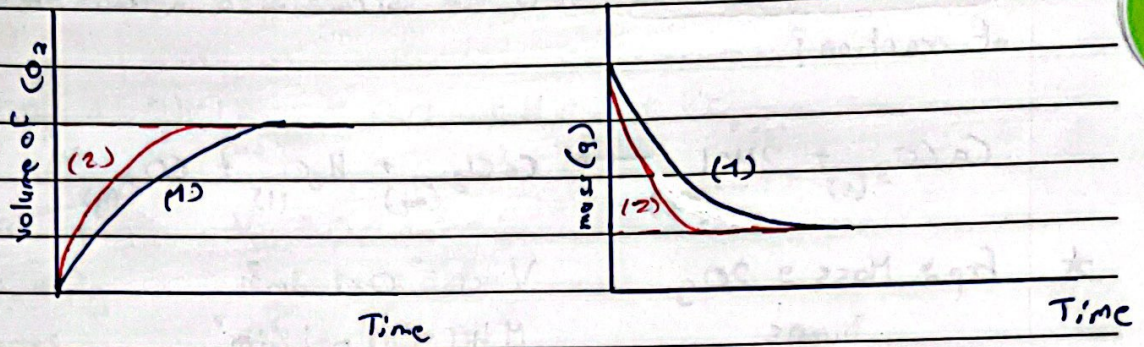
Exp 2: Mass 8 20g  
lumps

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

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

$$\text{Temp} = 50^\circ\text{C}$$





- ★ Take a known mass of lumps  $\text{CaCO}_3$   
 Add them to known volume of known concentration of  $\text{HCl}$  at  $25^\circ\text{C}$   
Measure the volume of  $\text{CO}_2$  produced using gas syringe per unit time.  
Repeat the exp at  $50^\circ\text{C}$ .  
 The exp at  $50^\circ\text{C}$  produce  $\text{CO}_2$  with less time

## ② Surface area

- ★ State how the <sup>Area</sup> surface affects the rate of reaction

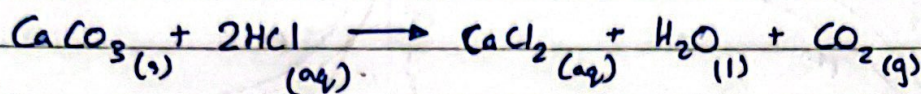
As the ~~temp~~ <sup>surface</sup> area increases the rate of reaction increases

- ★ Explain how the surface area affects the rate of RXN.

- As the surface area increases (decrease the particle size by crushing using mortar & pestil)
- More particles exposed to the reaction
- More ~~particles~~ collisions per unit time so faster rate.



Plan an exp to show how the surface area affect the rate of reaction?



\* Exp 1: Mass = 2.0g  
lumps

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

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

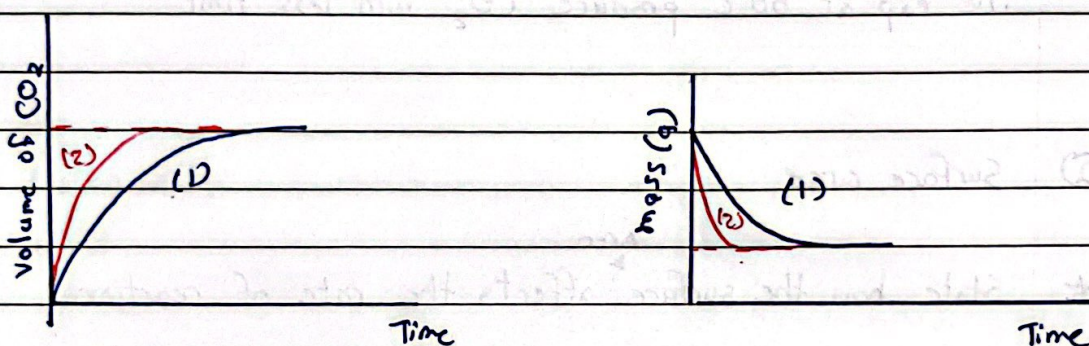
$$\text{Temp} = 25^\circ\text{C}$$

Exp 2: Mass = 2.0g  
Powder

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

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

$$\text{Temp} = 25^\circ\text{C}$$



### ③ Concentration "Amount"

\* State the concentration affects the rate of reaction

As the concentration increases the rate of the reaction also increases.

\* Explain how the conc. affect the rate of reaction

- As the concentration increases → So more effective collisions per unit time
- More particles → So faster rate of reaction

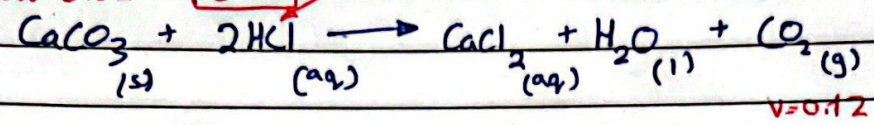


Plan an exp. ...

need 0.005  
at 0.02

0.04 limiting

n = 0.005

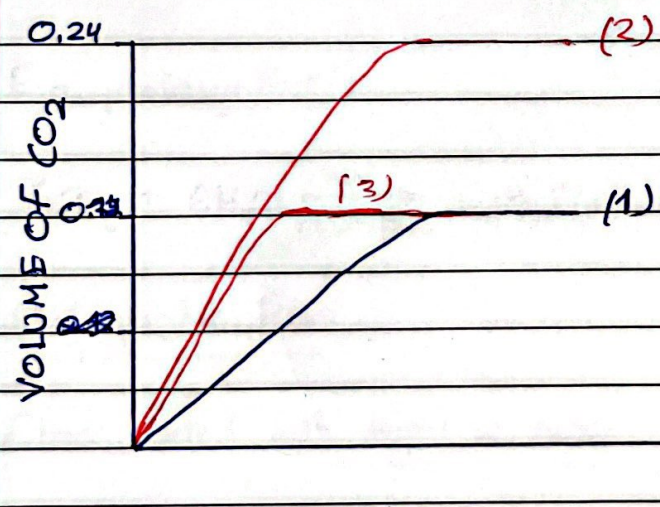


v = 0.12

Exp: 1  
Mass  
CaCO<sub>3</sub> = 2g  
lumps  
V<sub>HCl</sub> = 0.1 dm<sup>3</sup>  
M<sub>HCl</sub> = 0.1 mol/dm<sup>3</sup>  
Temp = 25°C

Exp: 2  
Mass  
CaCO<sub>3</sub> = 2g  
lumps  
V = 0.1 dm<sup>3</sup>  
M = 0.2 mol/dm<sup>3</sup>  
Temp = 25°C  
n = 0.01  
v = 0.24

Exp: 3  
Mass  
CaCO<sub>3</sub> = 4g  
lumps  
V = 0.1 dm<sup>3</sup>  
M = 0.1 mol/dm<sup>3</sup>  
Temp = 25°C



More limiting → faster rate & more product  
More excess → faster rate



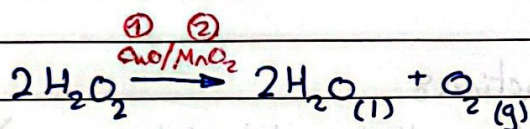
## 6) Catalyst

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

HOW? - It provides an alternative way with lower activation energy.  <sup>$E_a$</sup>

- So more particles will have energy equal to or more than  $E_a$
- So more effective collisions per unit time
- So faster rate of reaction

The reaction is



1) Plan an experiment to show that CuO is a catalyst for this reaction

Take a known volume with a known conc. of  $\text{H}_2\text{O}_2$  at known temp

Measure the volume of  $\text{O}_2$  produced per unit time

Repeat the exp using CuO

The exp using CuO will produce more  $\text{O}_2$  per the same unit time

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

Same as Q.1 + same mass of catalyst (because it's a solid) <sup>note</sup>

The exp which produces more  $\text{O}_2$  per the same unit time used better catalyst.



③ Plan an exp to show that  $\text{CuO}$  not used up during the reaction

Measure the mass of  $\text{CuO}$

Add to  $\text{H}_2\text{O}_2$  until no more fizzes

Filter the mixture

Dry the solid in oven

Remeasure the mass

★ Same initial and final mass

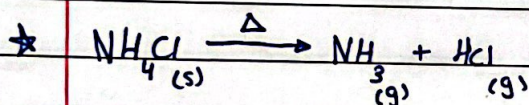
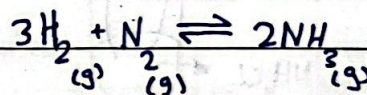
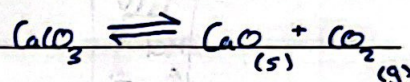
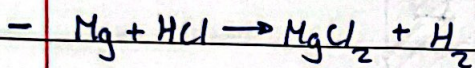
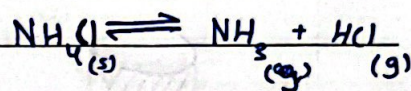
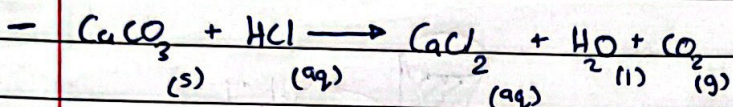
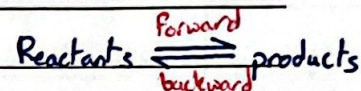


# Reversible reaction

## Types of Chemical rxn

One way

Both ways

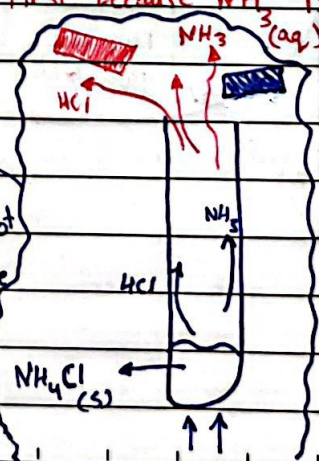


Ammonium chloride      Ammonia      Hydrogen chloride

Q: Which damp litmus paper, will change its color first, why?

The damp red litmus paper changes to blue. First because  $\text{NH}_3$  is an alkali; and lighter than  $\text{HCl}$  which is acidic.

NOTE: IF both not damp  $\rightarrow$  none change color





## Le Chatelier principle

If the system at equilibrium  $\rightleftharpoons$  and any external factor disrupt the equilibrium

The equilibrium can shift itself either to the forward  $\rightleftharpoons$   
**OR** to the backward  $\leftleftharpoons$   
to return back to the equilibrium

factors affect the position  
of equilibrium

① Temp

② pressure

③ Conc

$\leftarrow$  endo & exo

$\uparrow$  temp shift to endo

$\downarrow$  temp shift to exo



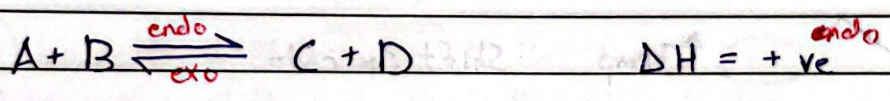
① Temp

↑ temp    ↑↑ rate of endothermic    (shift to Endo)  
              ↑ rate of exothermic

↓ temp    ↓↓ rate of endothermic    (shift to Exo)  
              ↓ rate of exothermic

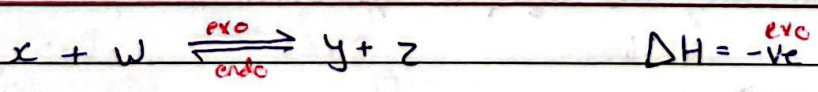
$\Delta H =$   
Enthalpy Change  
    ↓     ↓  
+ve    -ve  
Gain    lose  
Endo    Exo

[ The sign of  $\Delta H$  is always represent the forward reaction



↑ Temp    ↑↑ rate of forward    ↓ A ↓ B ↑ C ↑ D  
              ↑ rate of backward    Shift forward to the endo

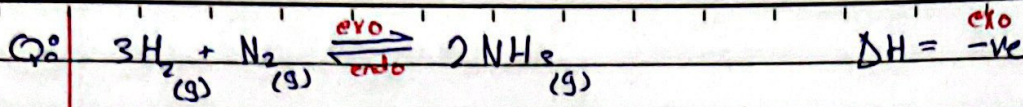
↓ Temp    ↓↓ rate of forward    ↑ A ↑ B ↓ C ↓ D  
              ↓ rate of backward    Shift backward to the exo



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

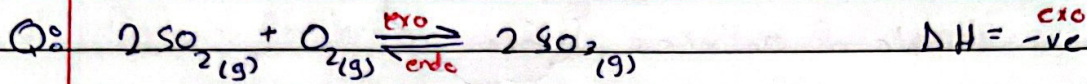
↑ x ↑ w ↓ y ↓ z





To produce more yield of  $\text{NH}_3$

- We must use low temp
- To favour the forward reaction which is the exothermic

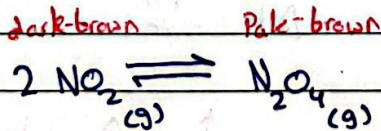


	rate of forward	rate of backward	% $\text{SO}_3$
$\uparrow$ temp	increase	increase	decrease
$\downarrow$ temp	decrease	decrease	increase

$\uparrow$  Temp Shift to endo  
 $\downarrow$  Temp Shift to exo

$\uparrow$  Temp  $\uparrow$  rate  
 $\downarrow$  Temp  $\downarrow$  rate

Mixture of  $\text{NO}_2$  and  $\text{N}_2\text{O}_4$  at equilibrium in a sealed tube



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

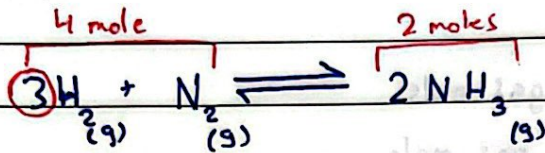
Because the forward reaction is exothermic enhanced by cooling.



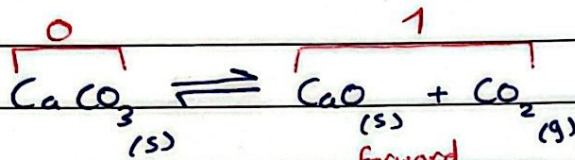
## ② Pressure

As the pressure increases → the equilibrium shift to the side with less pressure  
less gas mole

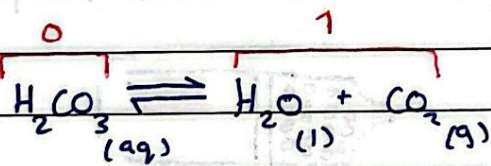
As the pressure decreases → // // // // // // // // more pressure  
// // // // // // // // more gas moles



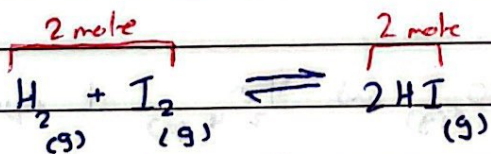
↑ pressure shift forward to the side with less gas moles ↑ % NH<sub>3</sub>  
↓ pressure shift backward to the side with more gas mole



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



↓ pressure shift forward to the side with more gas mole



Changing the pressure

has no effect on the position of equilibrium

Since both side has the same no. of gas ~~gas~~ moles





## ② Pressure

↑ pressure shift to less gas mole

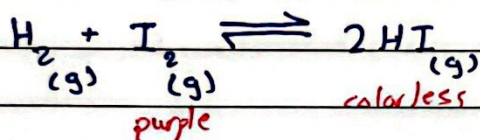
↓ pressure shift to more gas mole

↑ pressure ↑ rate of less gas mole

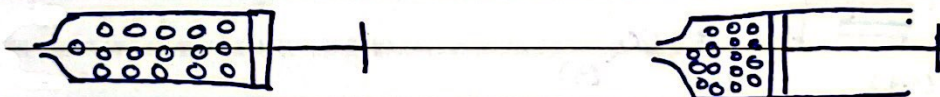
↑ rate of more gas mole

↓ pressure ↓ Rate of less gas mole

↓ Rate of more gas mole



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



The  $\text{I}_2$  molecules become closer to each other so the color seems to be darker

Sealed tube contains mixture of  $\text{NO}_2(\text{g})$  and  $\text{N}_2\text{O}_4(\text{g})$  at equilibrium

*Dark brown*

*Pale brown*



As

By increasing the pressure the color of the mixture

a) Becomes paler ~~then~~ goes darker



b) // darker // // paler → Right answer

c) // paler and stays paler

d) // darker // // darker



# Equilibrium

Factors affect the position of equilibrium

① Temp

② Pressure

③ Conc

↑ temp to endo

↑ P to less gas mole

↑ R / ↓ P

Shift forward

↓ temp to exo

↓ P to more gas mole

↓ R / ↑ P

Shift backward

③ Concentration



↑ Reactant

↓ Product

Shift forward

↓ Reactants

↑ Products

Shift backward



↑ [A] shift forward

↓ B ↑ C ↑ D

↓ [B] shift backward

↑ A ↓ C ↓ D

↑ [C] shift backward

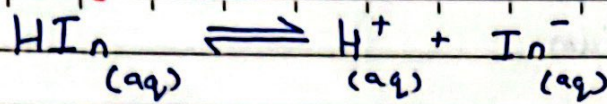
↑ A ↑ B ↓ D

↑ [D] shift backward

↑ A ↑ B ↓ C



Methyl orange



Color(1)

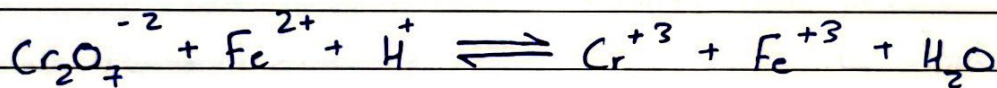
red

Color(2)

yellow

- Add HCl : Proton donor  $\uparrow \text{H}^+$  (Shift backward)
  - \* More HIn (more color(1))
  - \* less  $\text{In}^-$  (less color(2))
- Add NaOH : Proton acceptor  $\downarrow \text{H}^+$  (Shift forward)
  - \* More  $\text{In}^-$  (more color(2))
  - \* less HIn (less color(1))

Q: The reversible reaction below at equilibrium



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

HCl is an acid (proton donor)

More  $\text{H}^+$

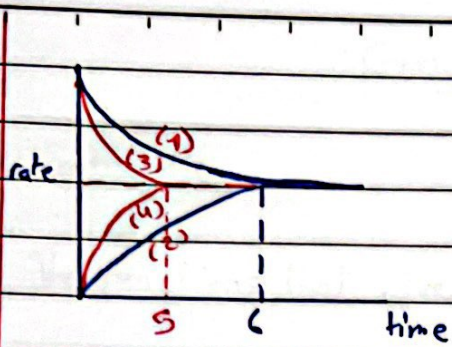
Shift forward

More  $\text{Cr}^{+3}$  (more green)

less  $\text{Cr}_2\text{O}_7^{2-}$  (less orange)

- \* Catalyst : has no effect on the position of equilibrium  
Since it speeds up the rate of forward & backward





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



# Measuring $\Delta H$ reaction

Theoretical

Using bond energy

Experimental

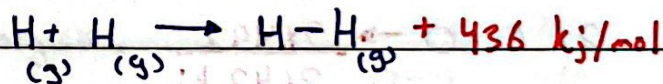
Combustion

displacement neutralizat

$\Delta H$  reaction using bond energy:

Bond energy is amount of energy needed to break 1 mol of energy in gaseous state  
 // // // released to build // // //

Bond	Energy bond
H-H	436



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

to break down bonds in react.
to build bonds in products

+ endo

- exo

input > output

input < output

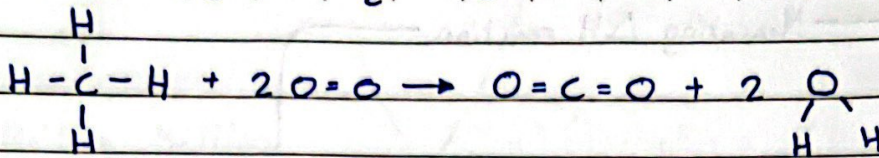
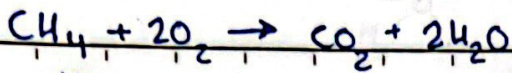
- To use the equation

① Balanced equation

② Covalent structure

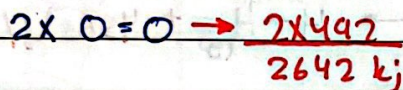
③ Bond energy



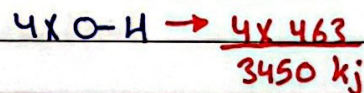
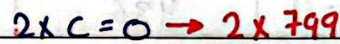


Bond	Bond energy
C-H	413
O=O	495
C=O	799
O-H	463
C-O	358

Bond Broken



Bond Formed



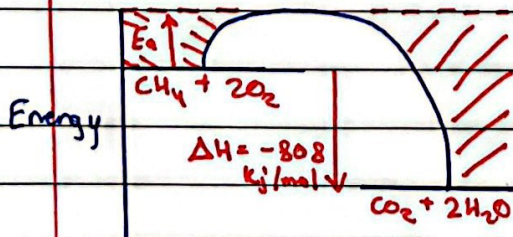
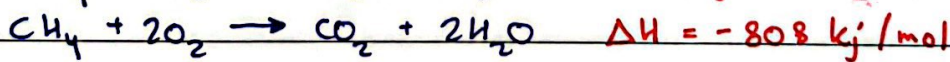
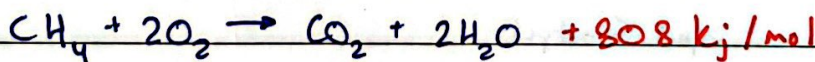
$$\Delta H = \Sigma \text{input} - \Sigma \text{output}$$

$$= 2642 - 3450$$

$$= -808 \text{ kJ/mol}$$

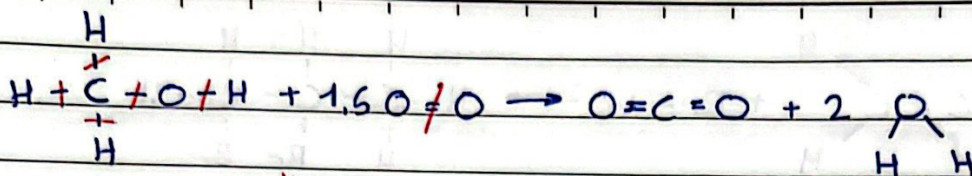
exo

input < output



Rxn progress





Bond broken

Bond build

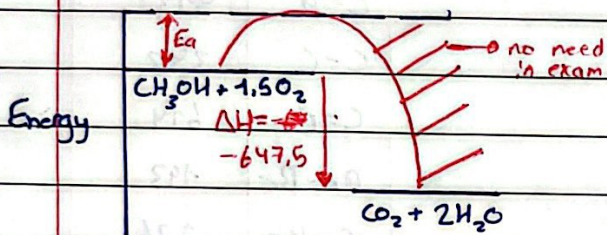
- 3 x C-H 3 x 413
  - 1 x C-O 1 x 358
  - 1 x O-H 1 x 463
  - 1.5 x O=O 1.5 x 495
- 2802.5 kJ
- 2 x C=O 2 x 799
  - 4 x O-H 4 x 463
- 3450 kJ

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

$$= 2802.5 - 3450$$

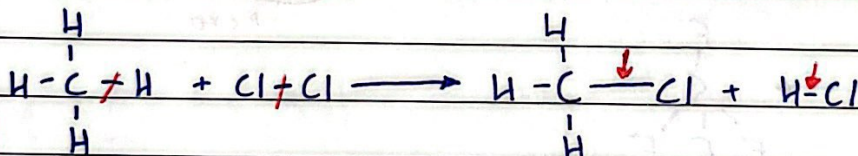
$$= -647.5 \text{ kJ/mol}$$

exo



RXN progress

Bond	Bond kJ/mol energy
C-H	413
C-O	358
O=O	495
C=O	799
O-H	463



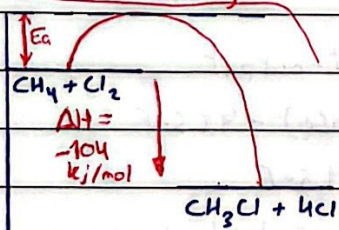
Bond broken

Bond build

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

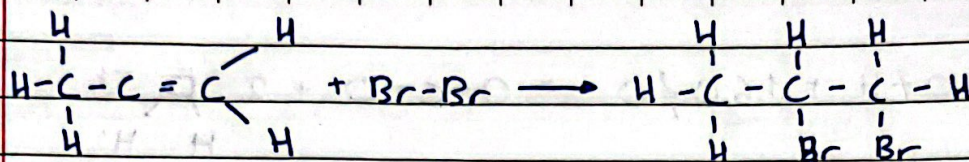
exo

- 1 x C-H 413
  - 1 x Cl-Cl 242
- 655 kJ
- C-Cl 328
  - 4 x H-Cl 431
- 759 kJ



Bond	Bond energy kJ/mole
C-H	413
Cl-Cl	242
H-Cl	431
C-Cl	328

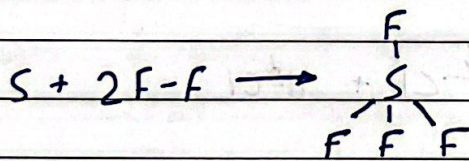




- Bond broken      Bond build       $\Delta H = 807 - 900 = -93$
- Br-Br 193      2x C-Br 2x276      kJ/mole
- C=C 614      C-C 348
- 807 kJ      900 kJ

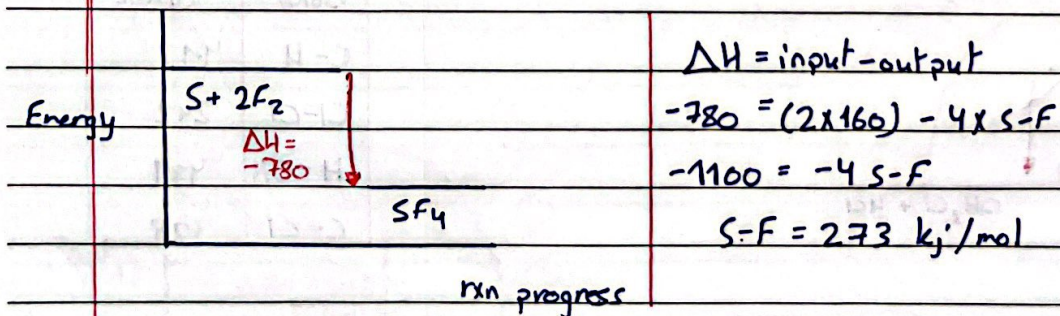
Bond	Bond kJ/mol energy
C-H	413
C-C	348
C=C	614
Br-Br	193
C-Br	276

When sulfur react with fluorine the reaction.  $\Delta H$  Give 780 kJ/mol



IF the bond energy of F-F is 160 kJ/mol

- 1) Draw an energy level diagram
- 2) Find the bond energy of S-F?





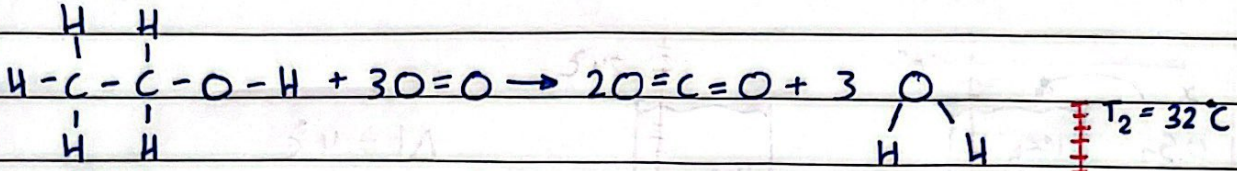
# Finding $\Delta H$ (energy change) practically

Combustion

Displacement

Neutralization

Finding  $\Delta H$  combustion



energy transfer  $\leftarrow Q = mc\Delta T \rightarrow \Delta T = \frac{Q}{mc}$

$$= 100 \times 4.2 \times 10$$

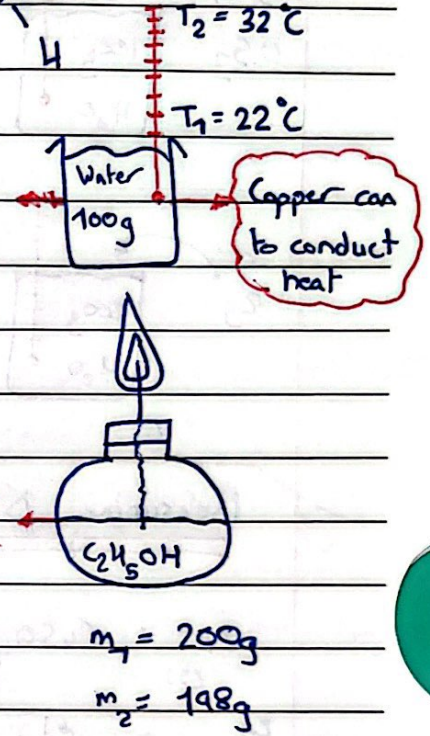
4.2 kJ  $\rightarrow$  = 4200 J  $\xrightarrow{\text{burn}}$  2g ethanol

$\Delta H??$   $\leftarrow$  46g ethanol (1 mole)

$\downarrow$

-96.6 kJ/mole

$\text{Mr C}_2\text{H}_5\text{OH} = 46\text{g}$



Two fuels A & B, which one produce 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 temp of water
- Repeat the exp using fuel B
- The fuel which causes more temp rise  $\Delta T$  per gram of fuel, produce more energy







Advantages : Only one waste product ( $H_2O$ )

- No  $CO_2$
- Produce high amount of energy
- Generate electricity

Disadvantages :

- Expensive
- Hard to store and transport
- Risk of explosion



# Industrial chemistry

Dealing with gases

Dry collect

Industry of

$\text{NH}_3$  Haber process  
 $\text{H}_2\text{SO}_4$  Contact process  
 $\text{CO}_3^{2-}$  Carbonate cycle

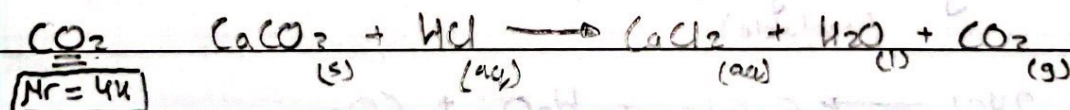
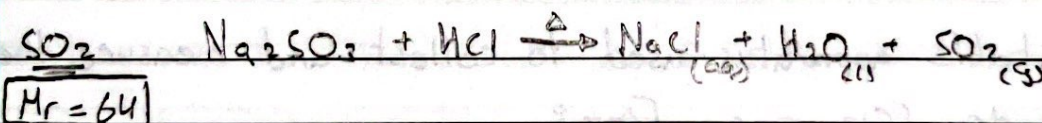
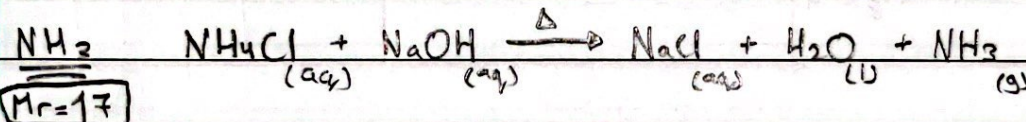
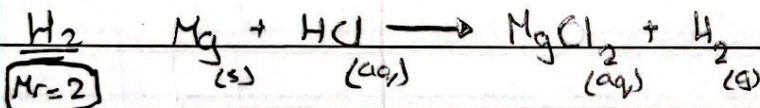
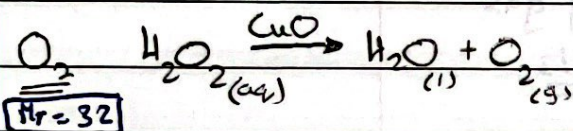
Extraction of metals

Al Fe Zn Cu  
 Not included

## ① Dealing with gas

Rxn → wet gas → dry → collect

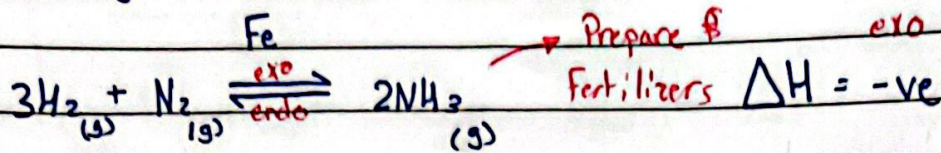
## \* Collect gas



Density of air  
 = 28.5



# Industry of Ammonia "Haber process"

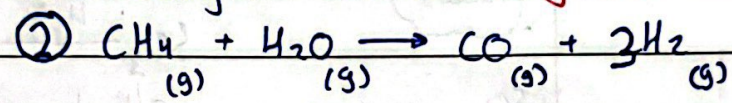


How to obtain

① Nitrogen :- Fractional distillation of liquid air

$\Downarrow$   $\Downarrow$   
 Different B.p. (cooling under high pressure)

② Hydrogen :- ① Cracking of Alkanes (Organic)



## Essential Condition

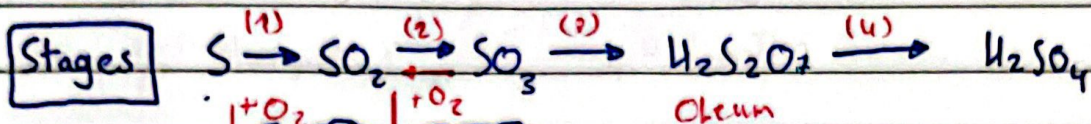
	Temp			
1) Temp 400 - 450 °C	400 °C - 450 °C	less than 400 °C	More than 450 °C	
2) Pressure 200 atm	<u>Adv</u>	<u>Dis</u>	<u>Adv</u>	
<u>Adv</u>	Higher yield of NH <sub>3</sub>	Slower rate particles lose	Faster rate	
1) More yield of NH <sub>3</sub> , shift forward to the side with fewer gas mole	- Shift forward to the exo side	K.E. so less effective collisions per unit time	<u>Disadv</u>	
2) Faster rate			less yield	- Shift backward to the endo side
<u>Dis</u>				
1) Risk of explosion	3) Fe catalyst	add excess H <sub>2</sub> and N <sub>2</sub> return back to converter remove NH <sub>3</sub> immediately By cooling		
2) Expensive				



# Uses of Ammonia

- 1) Fertilizers
- 2) Cleaning detergents
- 3) Smelling salts

## (Industry of $H_2SO_4$ ) Contact process

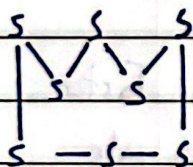


- Group (VI)

- Valency (2)

- ~~Yellow~~ Yellow solid

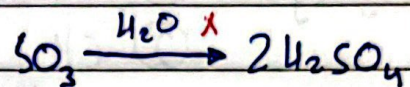
- S<sub>8</sub>



\*  $SO_2$  causes acid rain

\* Uses of  $SO_2$  kills bacteria (sterilization)

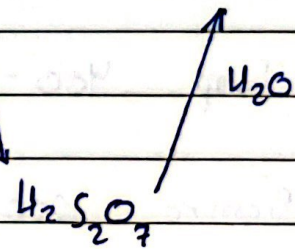
\* Paper industry breathing agent



- Highly exothermic

- Produce low yield of  $H_2SO_4$

conc  $H_2SO_4$



### Uses:

- \* Medicine
- \* Match
- \* Rubber

Ore: Zinc

blende ZnS

\* From fossil fuel



## \* Extraction of metals

K

Na

Li

Ca

Mg

Al ] electrolysis  $Al_2O_3$

$C, CO$

reduction  
by  $C, CO$

Zn ] Zinc blende  $ZnS$  (X included)

"Blast  
furnace"

Fe ] Hematite  $Fe_2O_3$

Pb

H

Cu ] Reduction by ' $H_2$ ' (X included)

Ag

Au

Pt

## \* Extraction of iron

Ore :  $Fe_2O_3$  "Hematite"

Method : reduction by  $C, CO$

Place : Blast furnace

Raw Material :  $Fe_2O_3$  mixed with

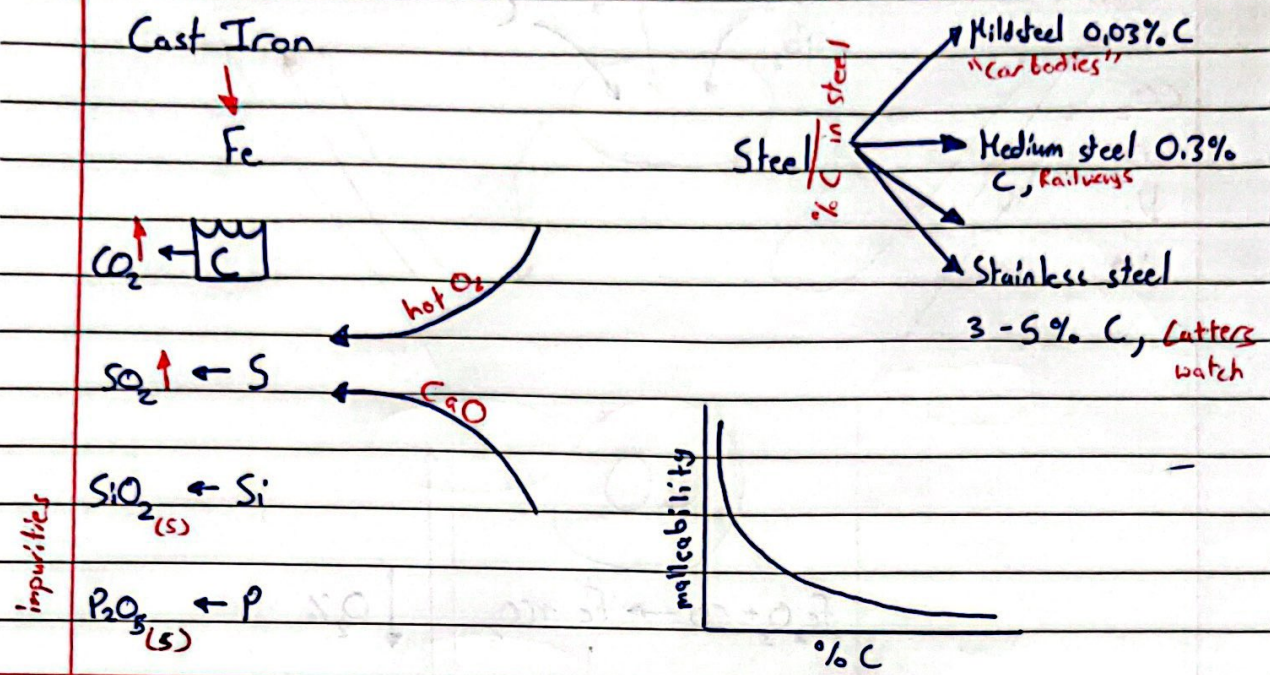
$CaCO_3$  'lime stone'

Coke 'Carbon pure'

Air  $1500^\circ C$



# Steel making "Oxygen base Process"



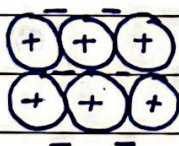
★ Alloy: Mixture of metal with another metal or semi-metal

Brass  $\text{Cu, Zn}$

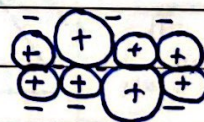
Bronze  $\text{Cu, Sn}$

Steel  $\text{Fe, C, Ni, Cr}$

Metal Cu



Brass  $\text{Cu, Zn}$



Harder / different size of metals



## Extraction of Zinc

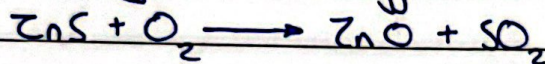
Ore: zinc blende  $ZnS$

Method: reduction by  $C$  &  $CO$

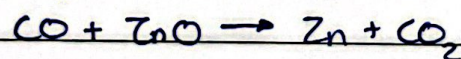
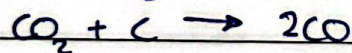
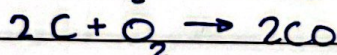
Place: Blast Furnace

$C$ ,  $CO$  and  $H_2$  can only reduce the less reactive metal from its oxide. Only

Step 1: Roasting with hot oxygen



Step 2:  $C + O_2 \longrightarrow CO_2$



The temp inside the furnace  $1500^\circ C$  and the B.p of Zinc is  $907^\circ C$ , so it is produced as pure gas, must condense and the other impurities since they have high B.p, stay in the furnace.