

Reactivity series

<u>metals</u>	<u>metal oxide O^{2-}</u>	<u>metal hydroxide OH^{-1}</u>
K^+	K_2O	KOH
Na^+	Na_2O	$NaOH$
Ca^{2+}	Li_2O	$LiOH$
Mg^{2+}	CaO	$Ca(OH)_2$
Al^{3+}	MgO	$Mg(OH)_2$
C_2CO	Al_2O_3	$Zn(OH)_2$
Zn^{2+}	ZnO	$Fe(OH)_2 / Fe(OH)_3$
$Fe^{2+ / +3}$	FeO / Fe_2O_3	$Pb(OH)_2$
Pb^{2+}	PbO	$CuOH / Cu(OH)_2$
H	Cu_2O / CuO	$AgOH$
$Cu^{1+ / 2+}$	Ag_2O	
Ag^+		
Li^{+}	Li_2O	$LiOH$

metal carbonate CO_3^{2-}

K_2CO_3
Na_2CO_3
Li_2CO_3
$CaCO_3$
$Al_2(CO_3)_3$
$ZnCO_3$
$FeCO_3 / Fe_2(CO_3)_3$
$PbCO_3$
$Cu_2CO_3 / CuCO_3$
Ag_2CO_3

Metals

K +1

Na +1

Li +2

Ca²⁺

Mg²⁺

Al³⁺

C, CO

Zn²⁺

Fe^{2+/3+}

Pb²⁺

H

Cu^{+1/+2}

Ag⁺¹

Reactions with O₂

K → Li reacts vigorously

Ca → Al reacts less vigorously

Zn - H need heat energy to react

Ag → no reaction

reactions with H₂O

K → Ca reacts vigorously with water

Mg → Pb react with steam

Cu → Ag no reaction

reactions with acids

K → Pb reacts with dilute acid

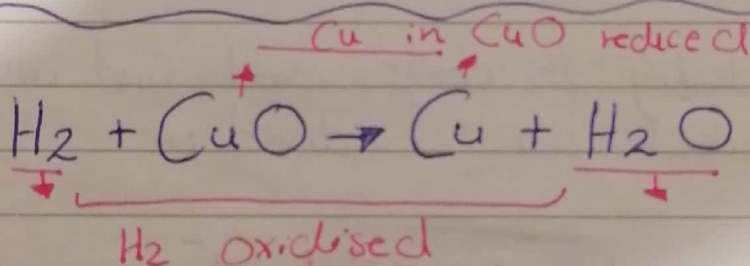
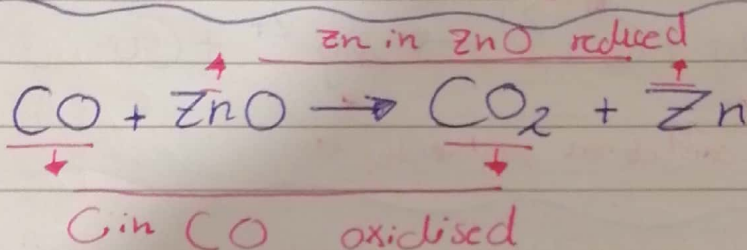
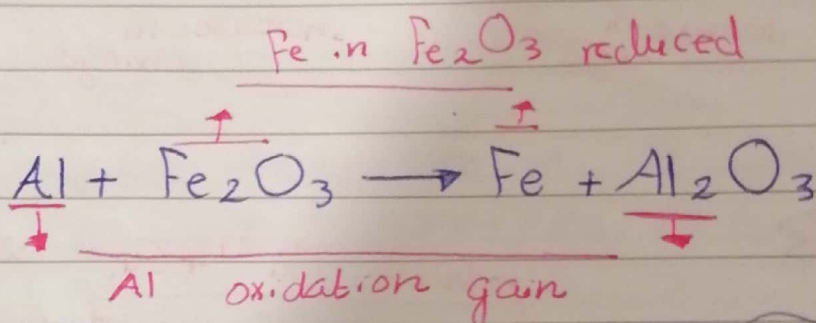
Cu → Ag no reaction

Redox

in terms of oxygen:

Reduction lose O oxidation gain O

examples

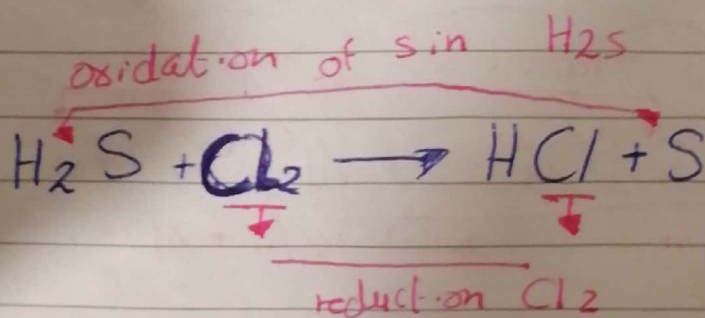


in terms of hydrogen:

Redox

reduction gain H oxidation lose H

example



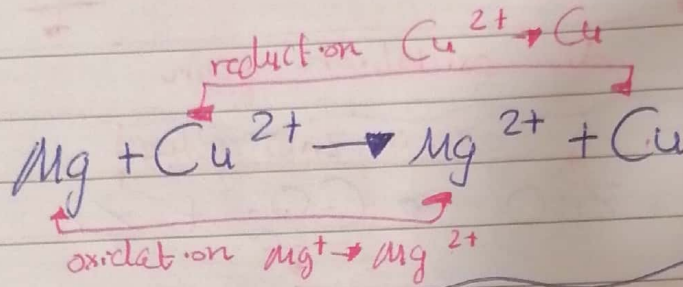
oxidation state:

Redox

reduction
decrease in charge

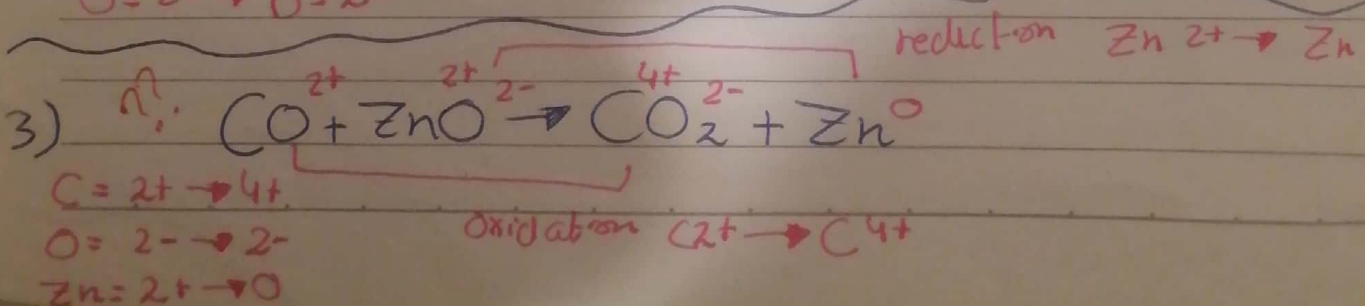
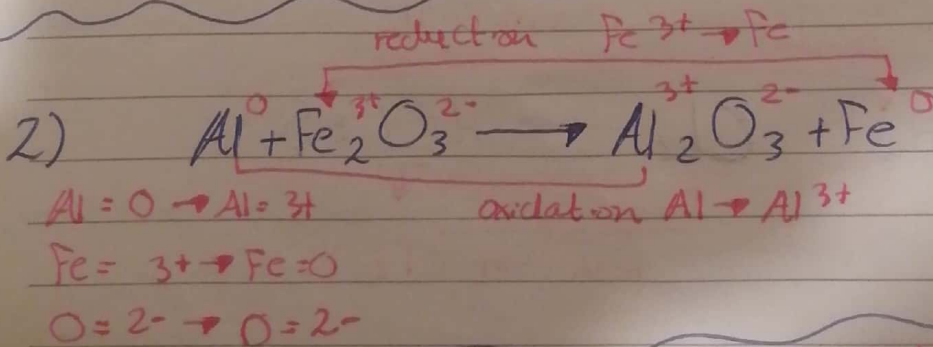
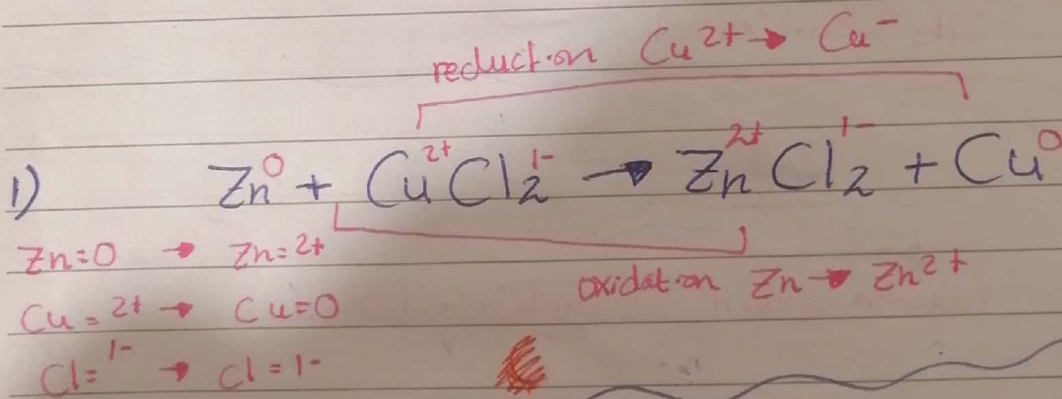
oxidation
increase in charge

example



Questions

identify the charges and find which one was reduced and which was oxidised:



Rules for oxidation:

① the oxidation number of any free element is zero

mono atomic di atomic polyatomic

② the oxidation number of any atom in a compound from group 1 is +1, Li/Na/Ka/Rb/Cs/Fr

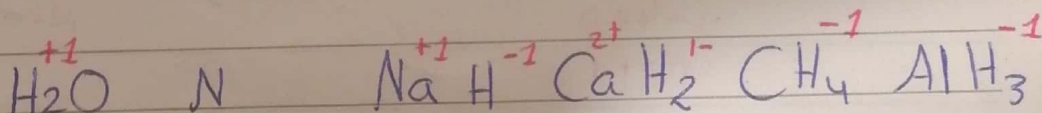
group 2: +2 Mg, Ca, Ba, Sr

group 3: +3 always only for Al

group VII: -1 always for (F)

③ the oxidation state of (H) is +1, except with metals -1.

example

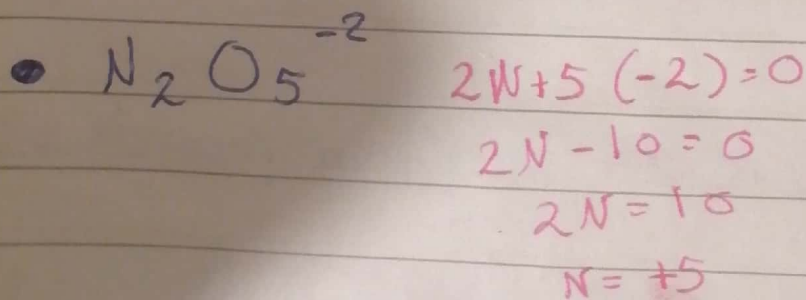
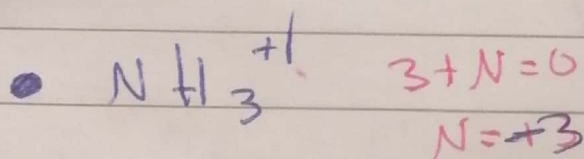
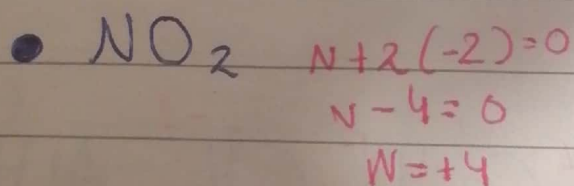
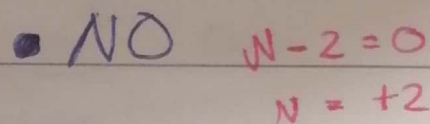
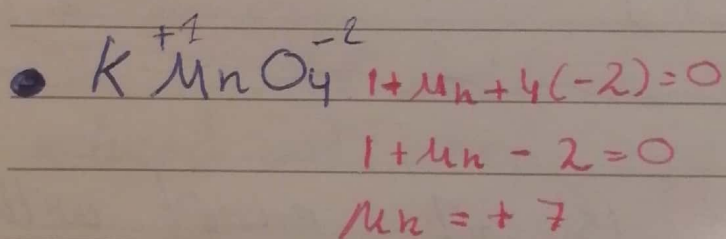
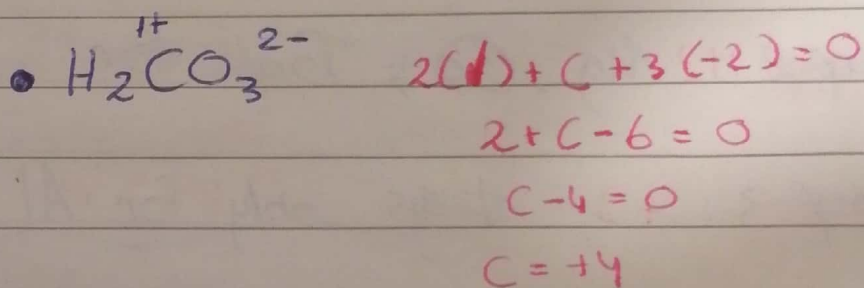
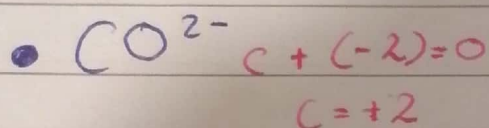
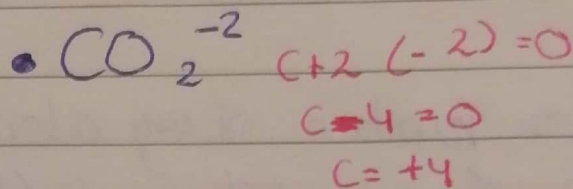
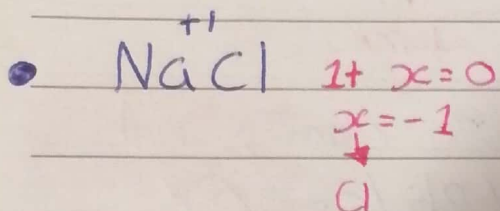


④ the oxidation state of O is 2-, except in peroxide -1, except in OF₂ +2

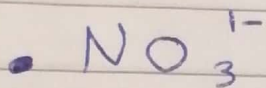
⑤ the sum of all oxidation state of all atoms in the compound = zero, In the ion = charge of the ion

examples on next page

(the sum of all oxidation state in all atoms of a compound = 0)



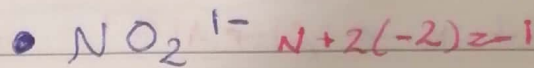
Ions:



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

$$N - 6 = -1$$

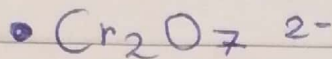
$$N = +5$$



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

$$N - 4 = -1$$

$$N = +3$$



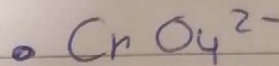
$$2\text{Cr} + 7(-2) = -2$$

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

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

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

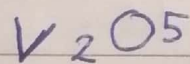
$$\text{Cr} = +6$$



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

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

Find the oxidation state of all underlined atoms :-

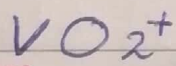


$$2V + 2(-5) = 0$$

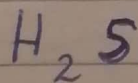
$$2V - 10 = 0$$

$$+10$$

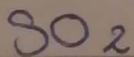
$$\frac{2V = 10}{2} = V = 5$$



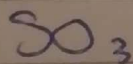
$$+4$$



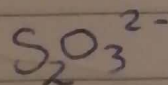
$$-2$$



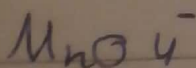
$$+4$$



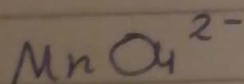
$$+6$$



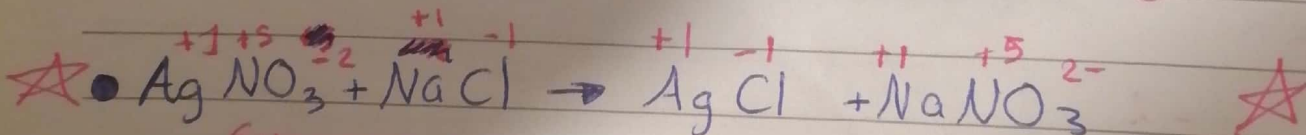
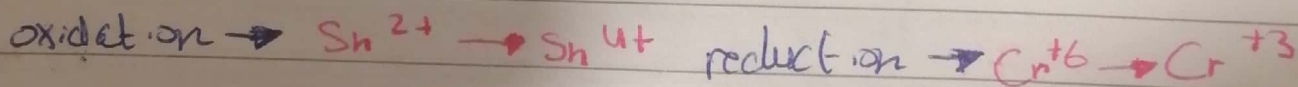
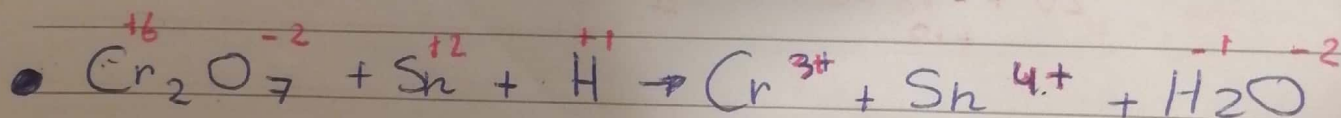
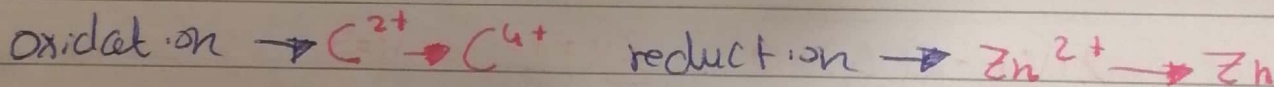
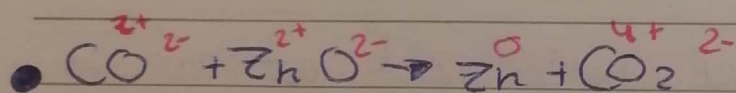
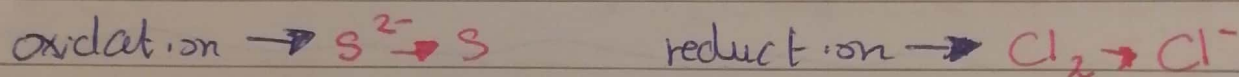
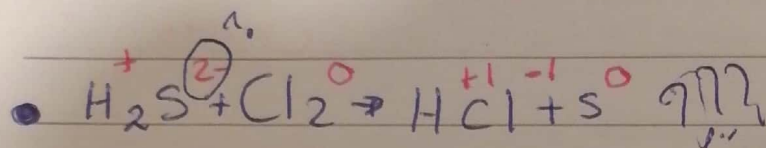
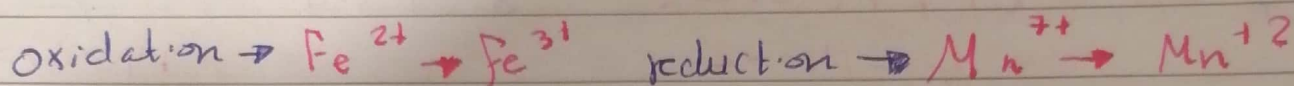
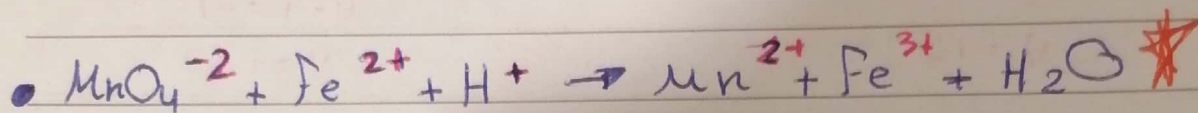
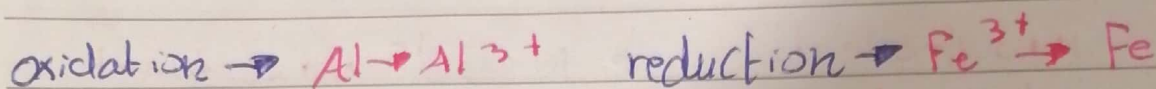
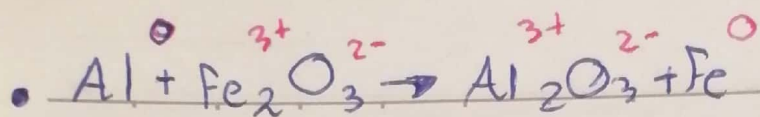
$$+2$$



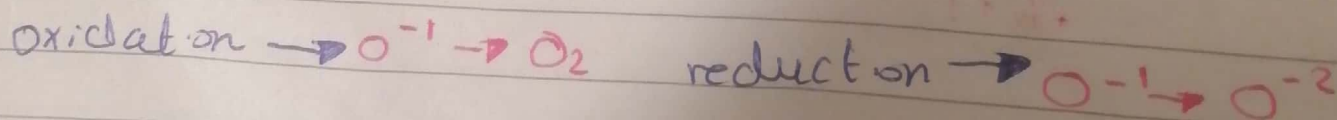
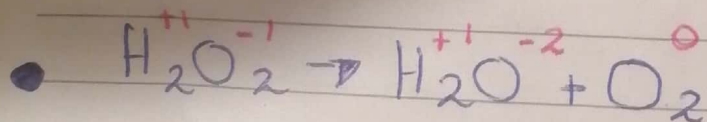
$$+7$$



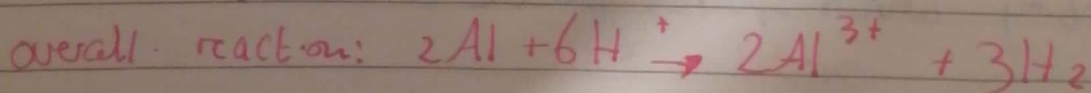
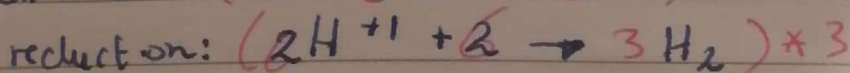
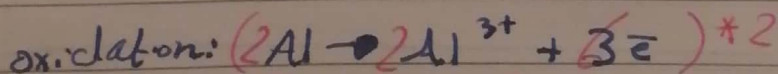
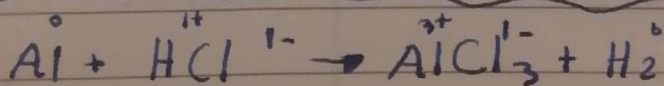
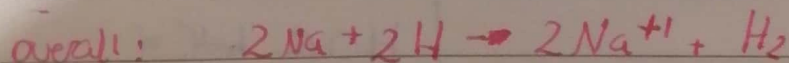
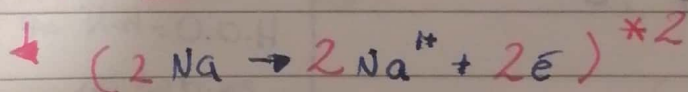
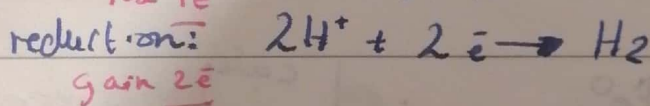
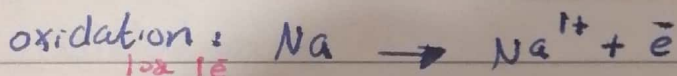
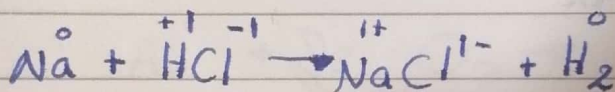
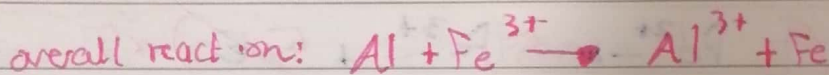
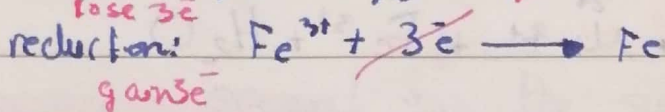
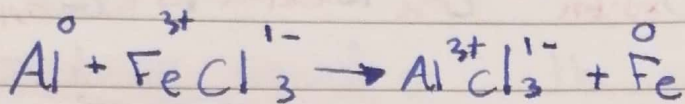
$$+6$$



(this reaction is not a redox reaction)



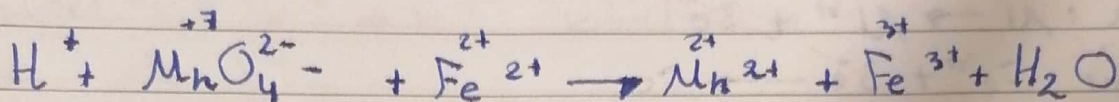
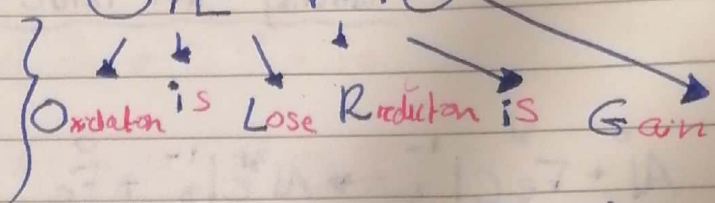
writing half ionic equation, balanced 23



OIL RIG

Half of oxidation $\rightarrow +2e^-$

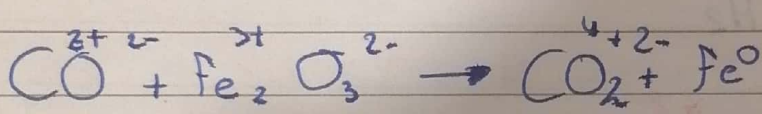
" " reduction $+e^- \rightarrow$



half of oxidation: $(5 Fe^{2+} \rightarrow 5 Fe^{3+} + 5e^-) \times 5$

half of reduction: $Mn^{7+} + 5e^- \rightarrow Mn^{2+}$

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



? H.O.O $(3C^{2+} \rightarrow 3C^{4+} + 3e^-) \times 3$

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

overall reaction: $3C^{2+} + 2Fe^{3+} \rightarrow 3C^{4+} + 2Fe$

code:
H.O.O = half of oxidation

H.O.R: half of reduction

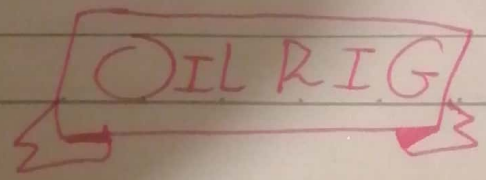
1) to identify which species oxidise or reduce:

oxidation state

\uparrow oxidation

\downarrow reduction

2) to define the oxidation and reduction



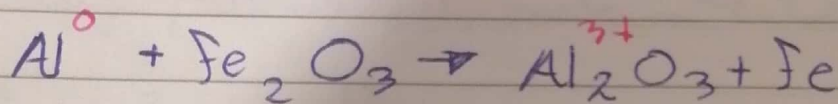
oxidising and reducing agents

→ oxidant

oxidising agent is the substance that it self, reduced and causes the other substance to be oxidise.

→ reductant

Reducing agent is the substance that it self oxidised and causes the other substance to be reduced.



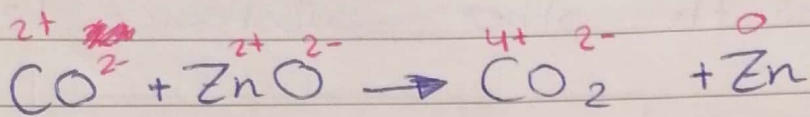
oxidation: Al

reduction: Fe^{3+}

oxidant: ~~Al~~ Fe_2O_3

reductant: ~~Fe_2O_3~~ Al

to mention the agent if it is an ion in a compound, you must mention the compound itself.



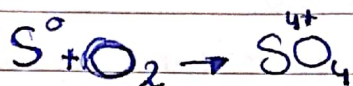
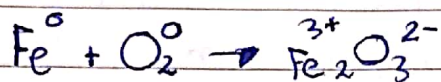
oxidation C²⁺

reduction Zn²⁺

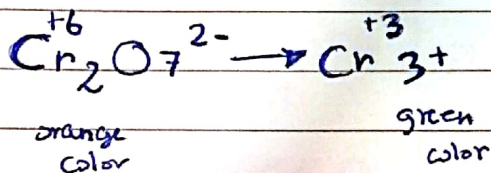
reducing agent CO oxidising agent ZnO

* most common oxidising agent:

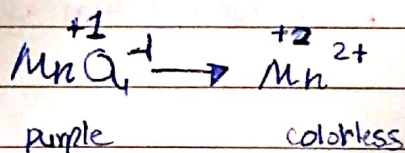
① oxygen



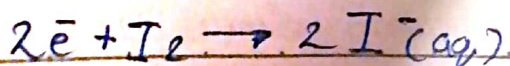
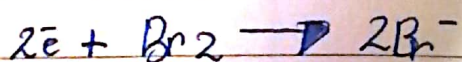
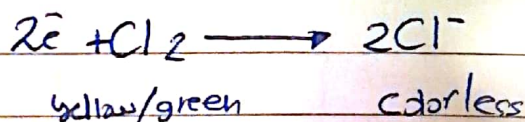
② acidify potassium dichromate, $K_2Cr_2O_7$



③ acidify potassium manganate $KMnO_4$



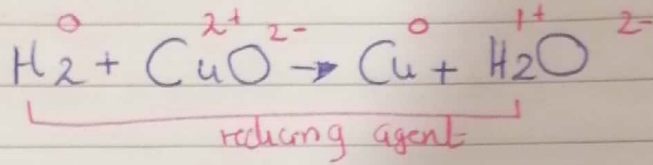
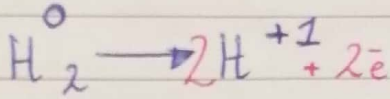
④ halogens



brown solution colorless
black solid
purple gas

• most common reducing agent:

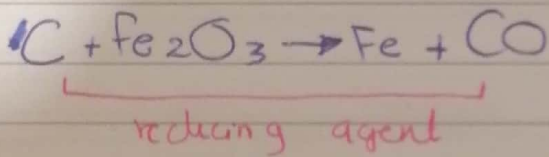
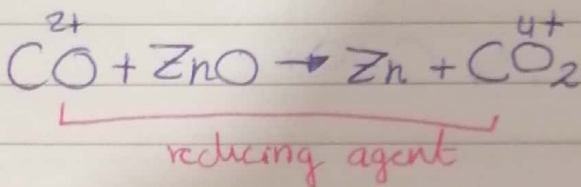
① hydrogen



summary:
the less reactive ion is more likely to reduce
"to be an oxidising agent"

the more reactive metal is more likely to oxidise
"to be a reducing agent"

② carbon of carbon monoxide



K → strongest reducing agent

- more reactive metal Na
Li

- more able to lose e^s Ca
Mg

- more able to oxidise Al
C, CO

- more able to be reducing agent Zn
Fe

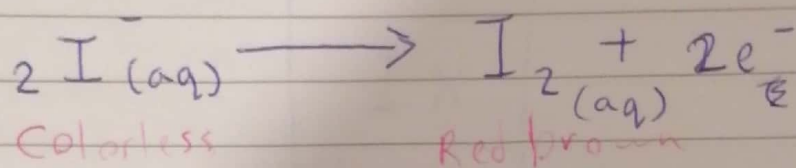
Pb
H

Cu

← **Ag** ← weakest oxidising agent

← **Ag** → weakest reducing agent

② potassium Iodide



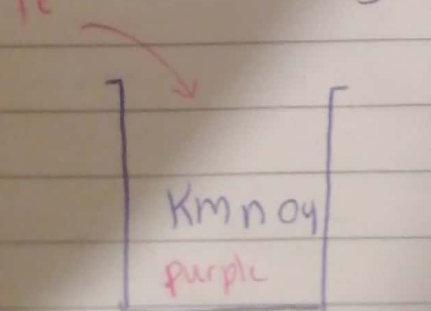
SO CUTE UWU!!!

oxidant	Reductant
O_2	H_2
KMnO_4 $/\text{H}^+$	C, CO
$\text{K}_2\text{Cr}_2\text{O}_7$ $/\text{H}^+$	metals
Halogens	Iodide

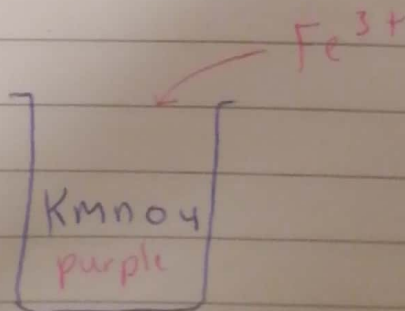
Q Fe^{2+} is a reducing agent

Fe^{3+} is an oxidising agent

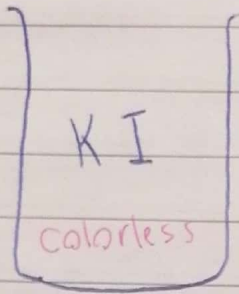
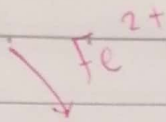
Write the observation in each of the following.



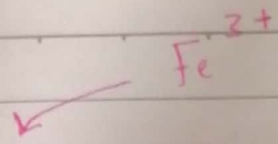
from purple
to colorless



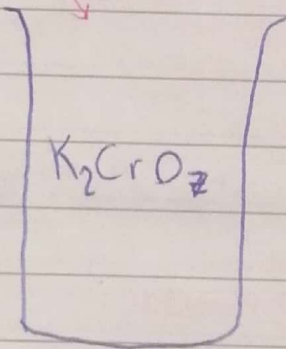
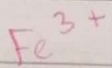
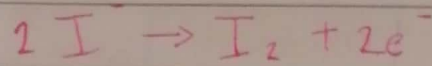
stays
purple



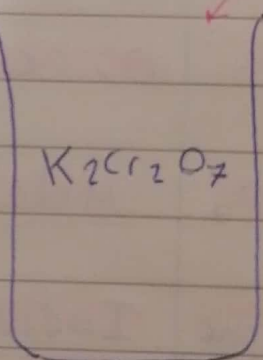
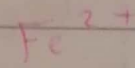
Stays the same



becomes red brown



stays orange



from orange to green

Electrolysis

electricity

Analysis

"Breaking down"

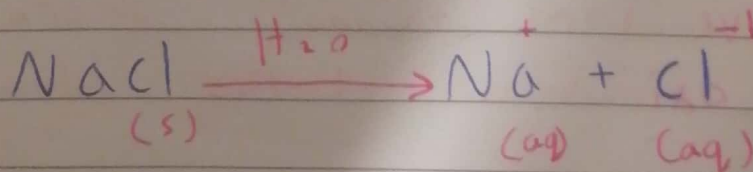
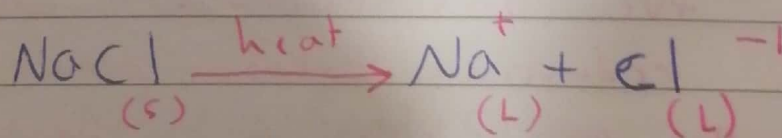
electrolysis :- Breaking down ionic compounds "molten or aqueous" by passing electricity.

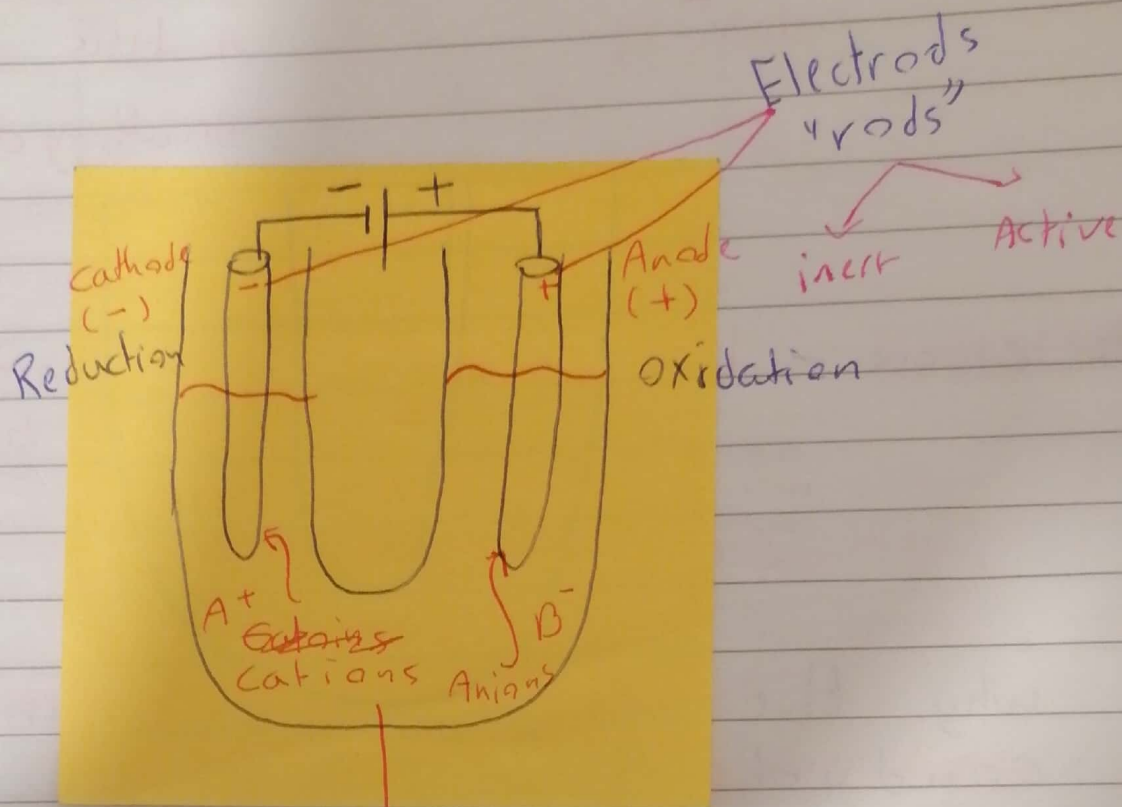
Q, why the solid Ionic compound don't conduct electricity?

The ions are not free to move.

why the ionic compounds conduct electricity when molten or Aq?

the ions are free to move



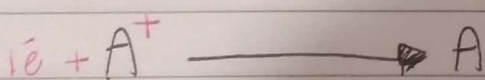
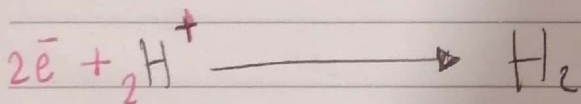
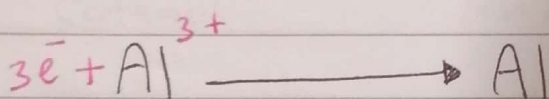
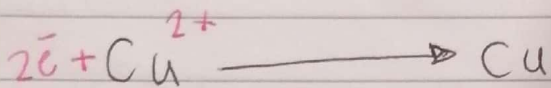
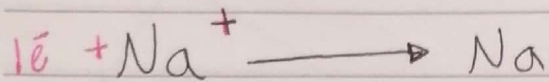
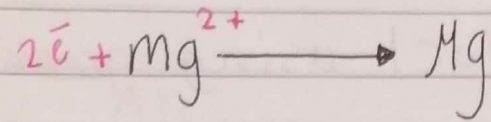


Cathode :- the -ve rod that attracts +ve ions (cations) where reduction takes place.

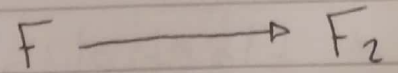
Anode :- the ~~rod~~ +ve rod that attracts -ve ions (anions) where oxidation takes place.

electrolysis = discharging

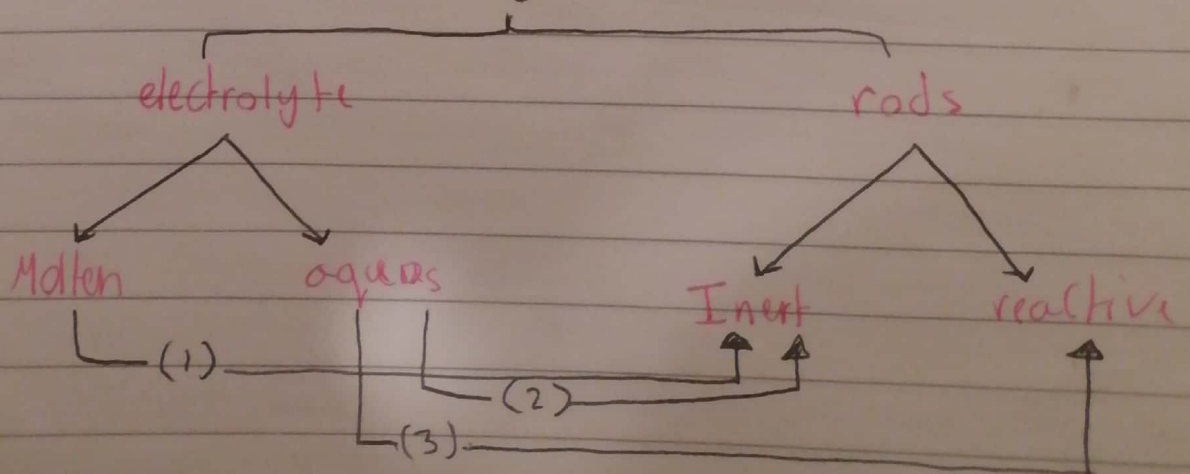
Cations



Anions

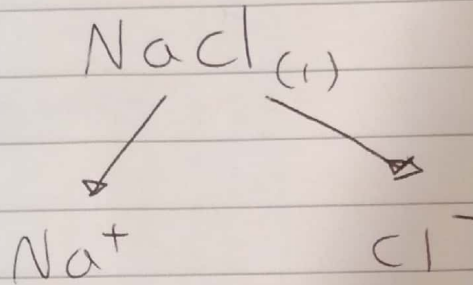


Electrolysis.



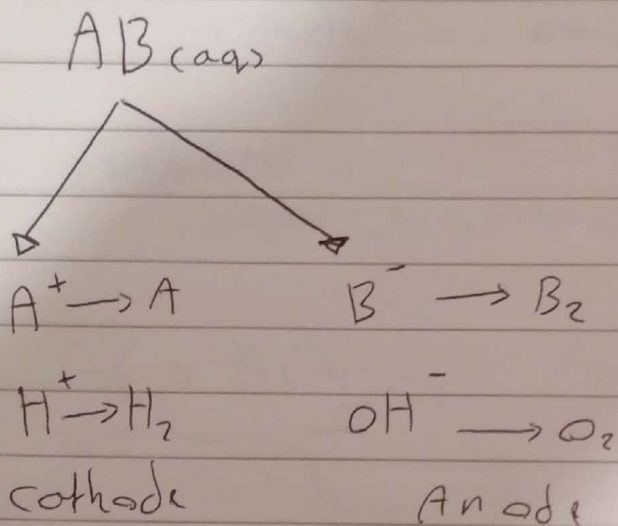
Molten using inert rod.

* Electrolysis for molten NaCl using graphite



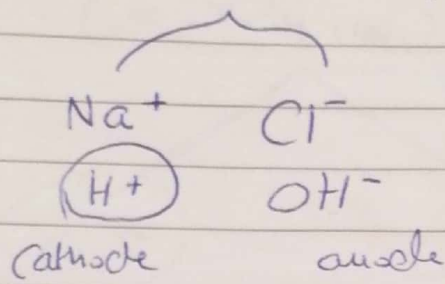
~~2/~~

Electrolysis for aqueous electrolyte using graphite

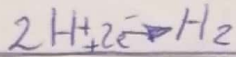


A + cathode
the less reactive ion
is more likely
to reduce

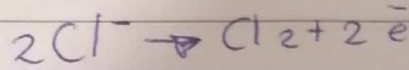
concentrated NaCl/graphite



electrolyte: NaOH

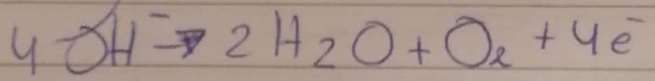
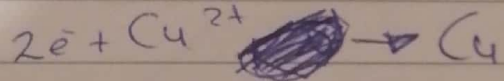
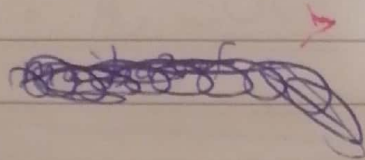
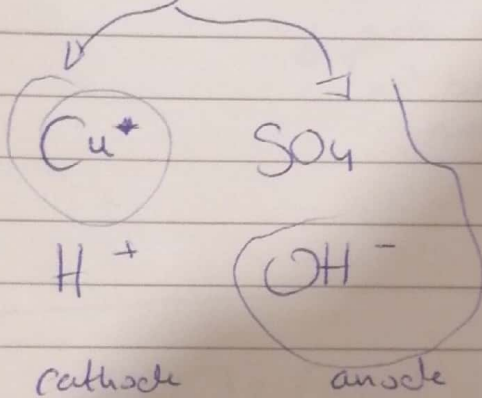


bubbles of colorless gas



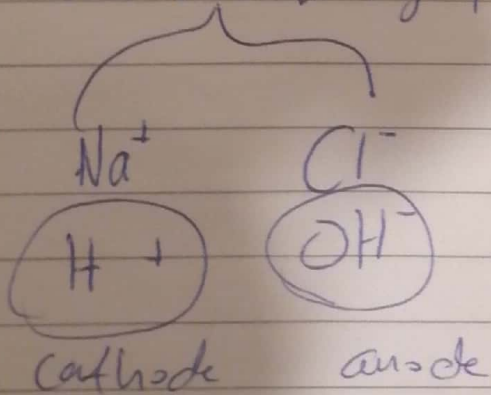
bubbles of green yellow gas

CuSO₄ (aq) / graphite

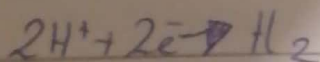


dilute

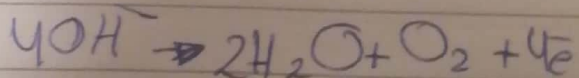
NaCl (aq) / graphite



~~more concentrated~~



bubbles of colorless gas

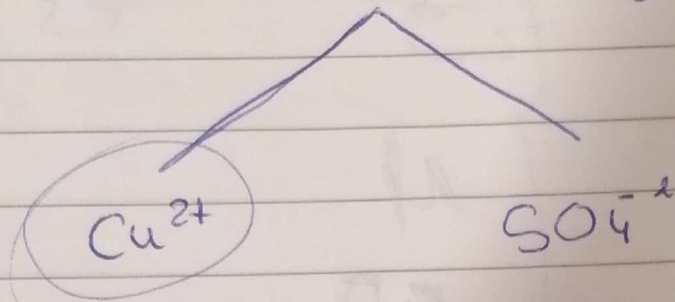


bubbles of colorless gas

electrolyte: NaCl

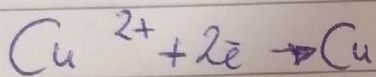
more concentrated

$\text{CuSO}_4(\text{aq}) / \text{graphite}$

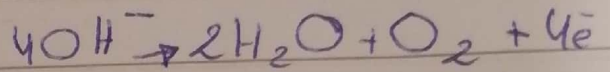


H^+
cathode

OH^-
anode



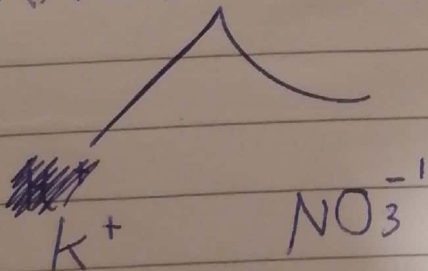
deposits of
red brown
metal



bubbles of colorless
gas

electrolyte = H_2SO_4

$\text{KNO}_3(\text{aq}) / \text{graphite}$



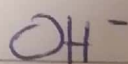
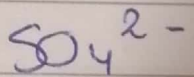
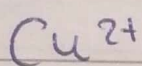
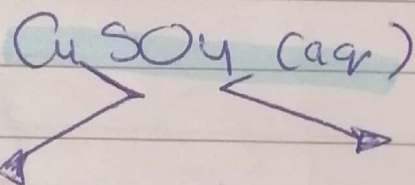
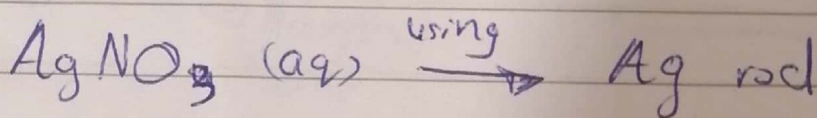
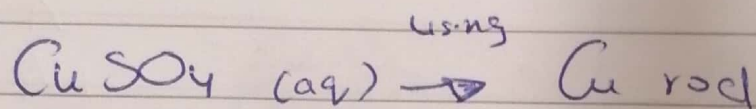
energetics

endothermic /

exothermic

electrolysis for aqueous electrolyte using active rod

* the active rod made from the same metal ion to the electrolyte *

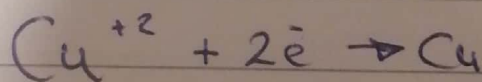


cathode

anode

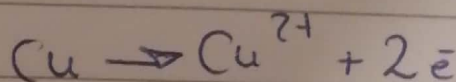
X neither the OH⁻
or SO₄²⁻
oxidise

X the anode itself will
oxidise

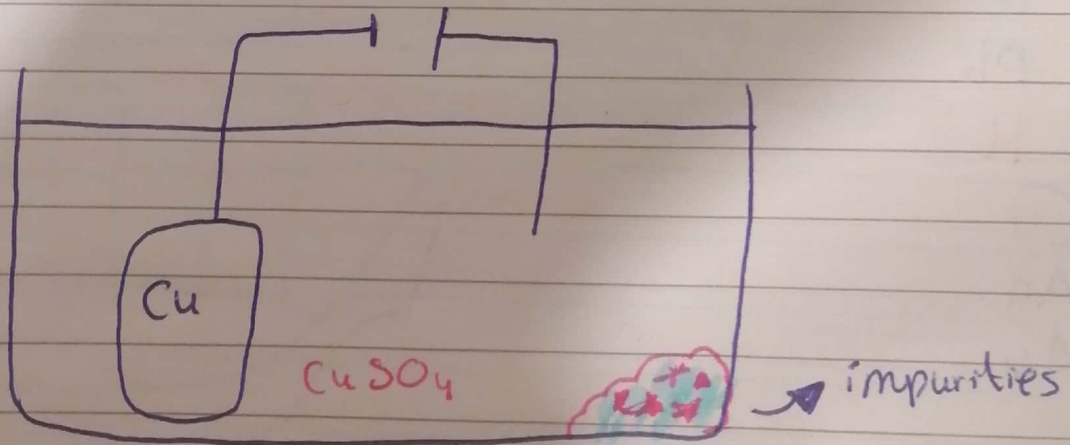
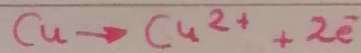
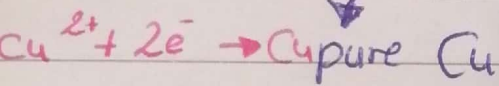
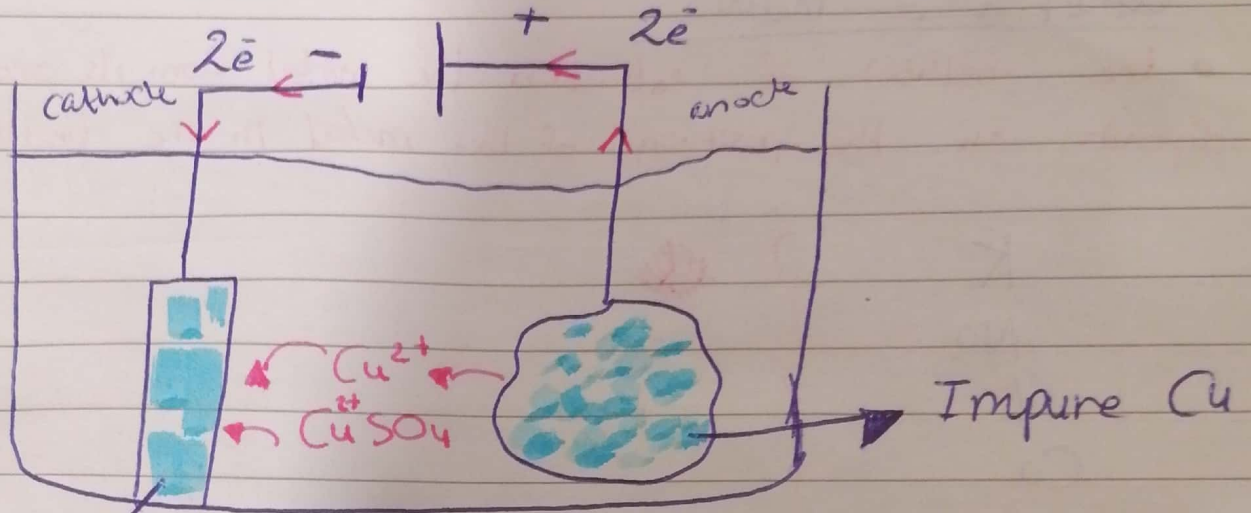


deposits of red brown

solid



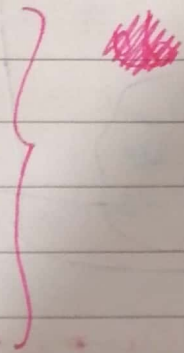
Refining Copper / purifying



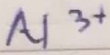
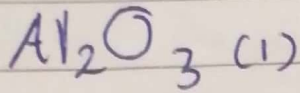
extraction of metals

- the method of extraction the metal from its ore depends on the position of this metal in the reactivity series.

K
Na
Li
Ca
Mg
Al → B
C, CO
Zn
Fe
Pb
H
Cu
Ag
Au

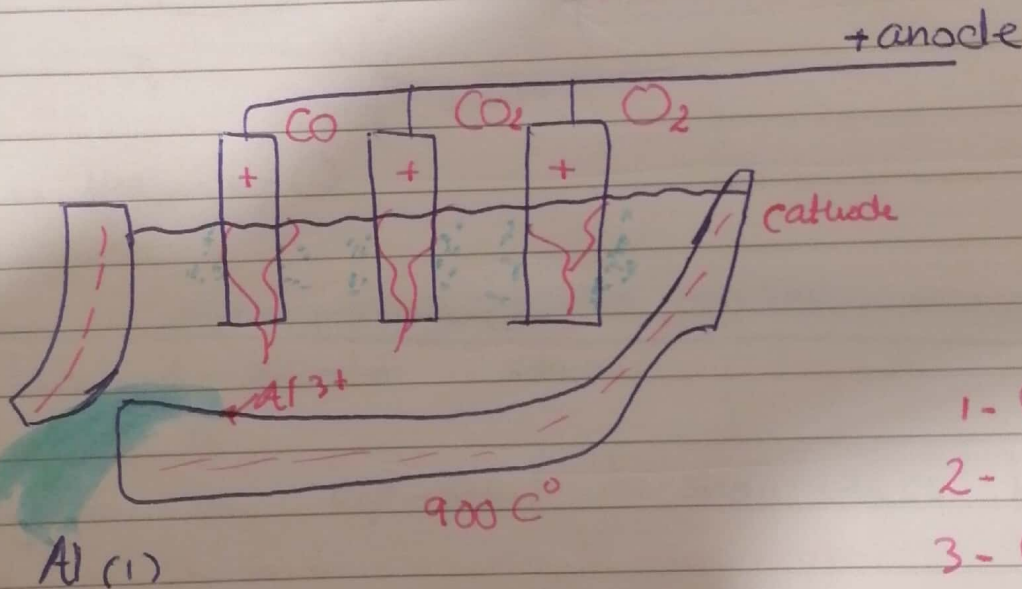
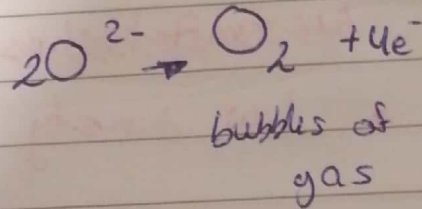
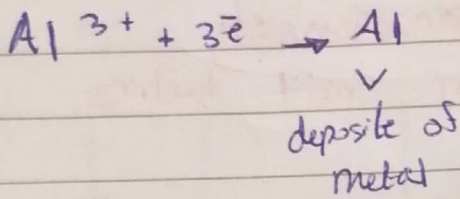


and oxygen
 O_2



cathode

anode



gases produced at anode

- 1- O_2
 - 2- CO_2
 - 3- CO
- } reaction of anodes

with O_2 so we must replace the anode periodically

property of Al

- malleable

~~Aircraft bodies~~

- low density

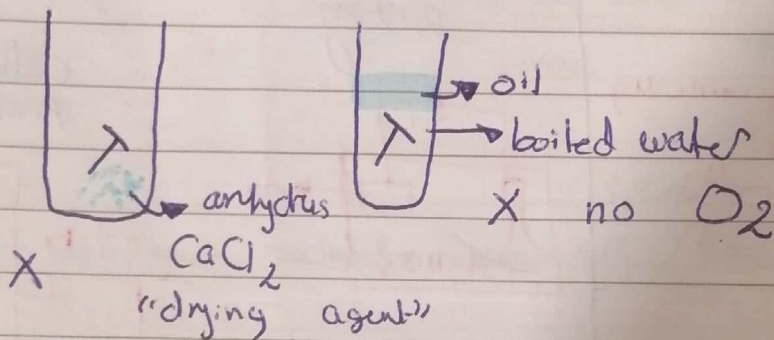
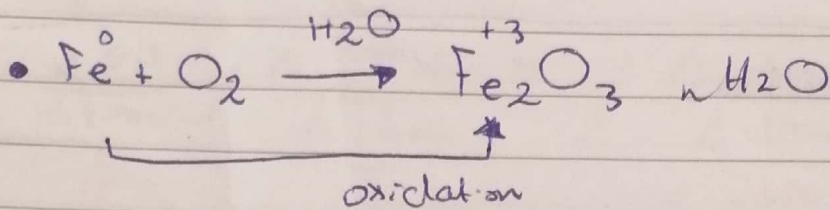
Use of Al

- window frame, cooling utensils

- ~~low density~~
air craft bodies

Rusting

the reaction of Iron with both water and oxygen
 H_2O O_2



note \rightarrow rusting is a slow reaction, minimum 6/7 days

two rust prevention solutions

A and B.

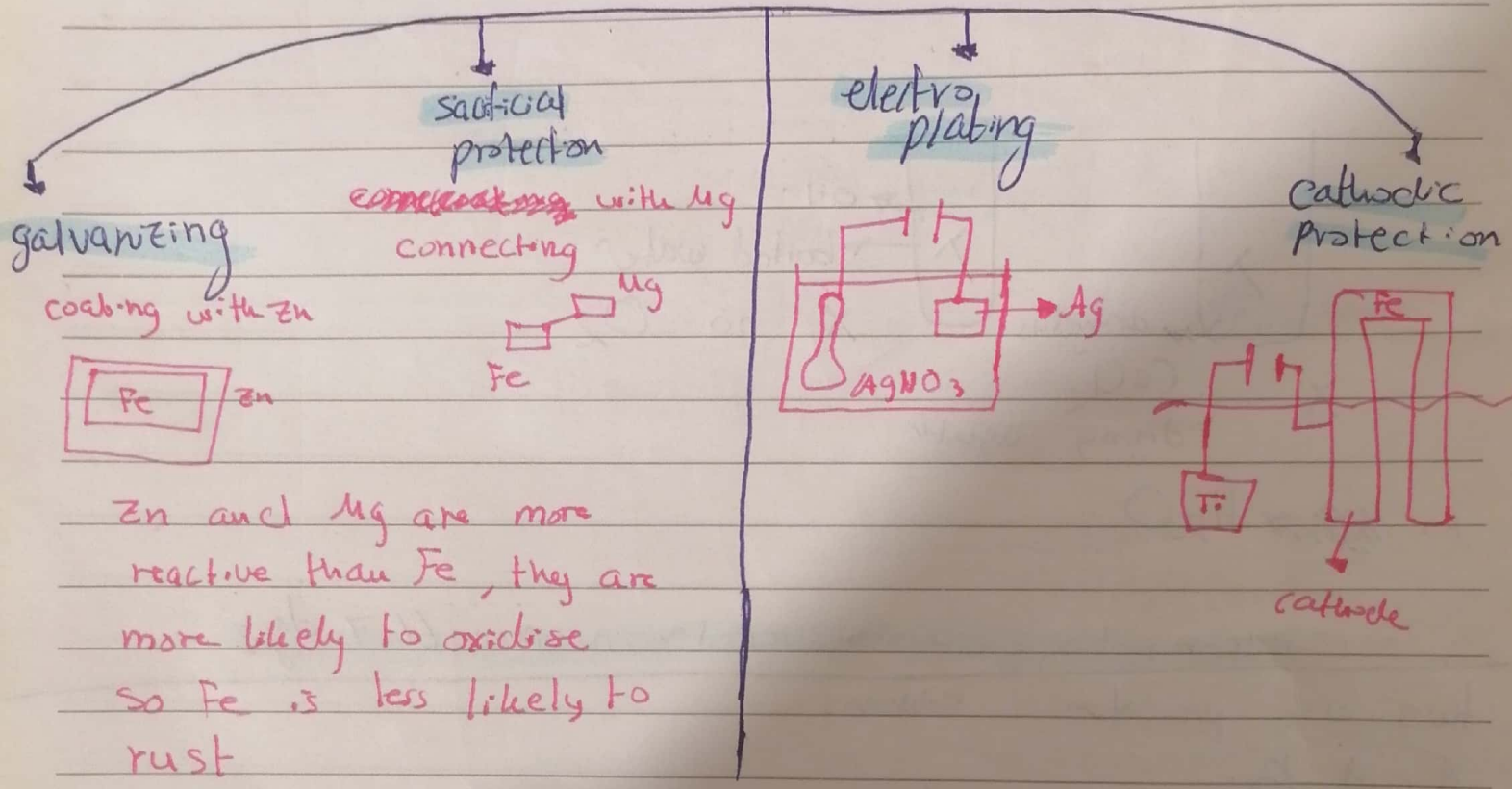
plan an experiment to show which brand is the better.

- take a known mass of iron nail
- apply known volume of solution A
- add them to a known volume of water for 2 weeks
- dry the iron nail
- measure the mass
- repeat the experiment using solution B
- The experiment which caused less increase in mass is the better solution

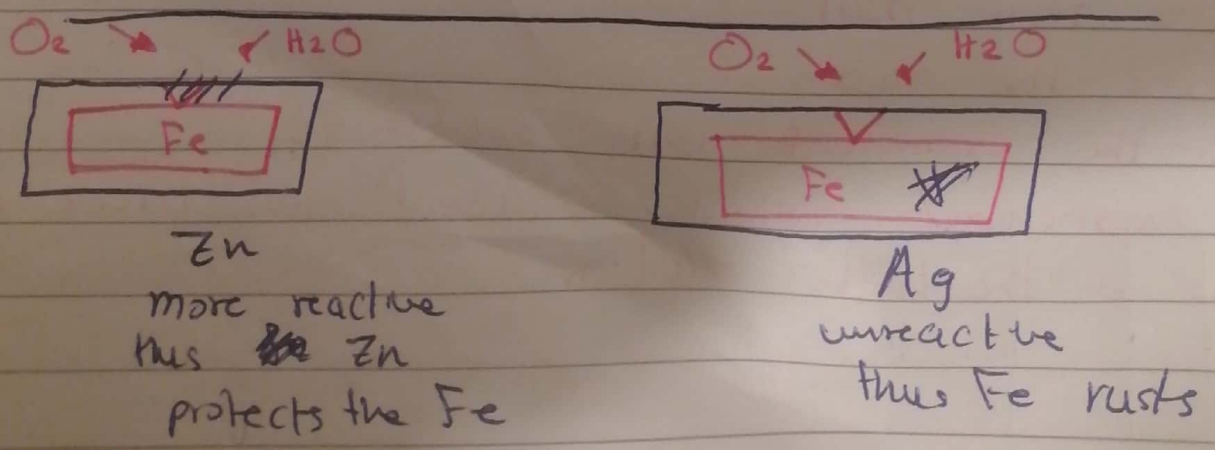
♥ Rust prevention ♥

paint, oiling, greasing, cover with plastic
prevents H_2O and O_2 from reacting the Fe

more advanced rust prevention:



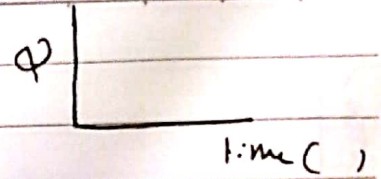
galvanizing → better than electroplating
electroplating → more pretty



• rate of reaction: $\frac{\text{change in quantity}}{\text{change in time}}$

Rate of reaction

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



$$\frac{\Delta \text{PH}}{\Delta \text{time}} \quad / \quad \frac{\Delta \text{light intensity}}{\Delta \text{time}} \quad / \quad \frac{\Delta \text{volume of gas}}{\Delta \text{time}} \quad / \quad \frac{\Delta \text{mass}}{\Delta \text{time}}$$

$$= \frac{1}{\text{s}} \quad = \frac{1}{\text{s}} \quad = \frac{\text{cm}^3}{\text{s}} \quad = \frac{\text{g}}{\text{s}}$$

$$\frac{\Delta \text{temp}}{\Delta \text{time}} \quad / \quad \frac{\Delta \text{electrical conductivity}}{\Delta \text{time}}$$

$$= \frac{\text{C}^\circ}{\text{s}} \quad = \frac{1}{\text{s}}$$

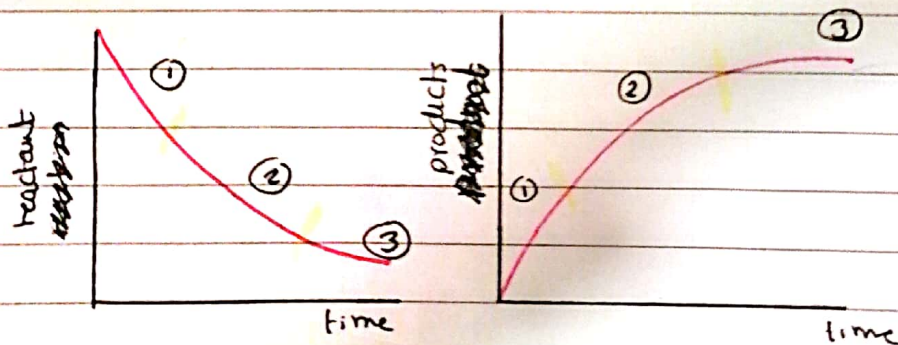
(speed)

• how much reactants used up / how much product produced

• To measure the rate of reaction

measure how fast the reactants consumed per unit time

measure how fast the product produced per unit time



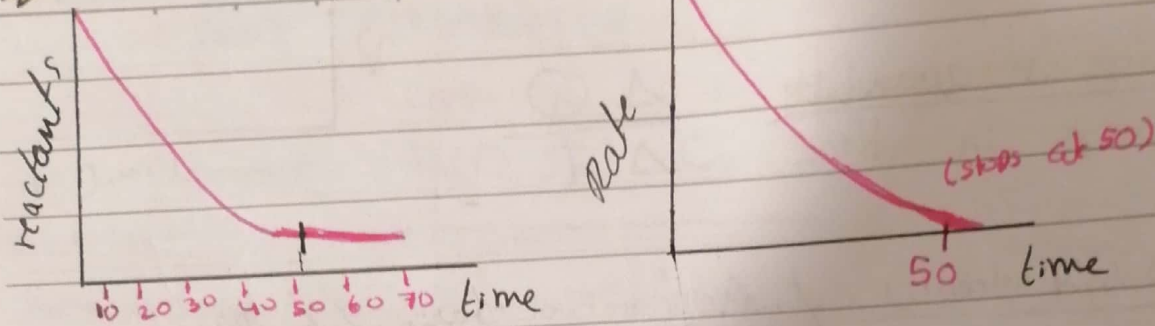
region (1) the rate is the highest \Rightarrow from the curve; steepest high gradient
more reactants, so more particles so more effective collisions per unit time

region (2) the rate is slower \Rightarrow from the curve: less steep lower gradient
less reactants, less particles so less effective collisions per unit time

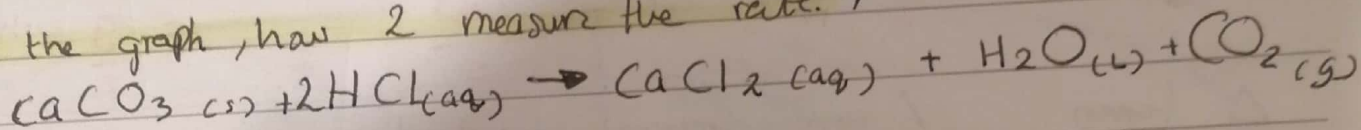
region (3) the reaction is over \Rightarrow from the curve horizontal line
gradient = 0, no more reacting reagent so no more effective collisions.

note

reaction stops when the limiting reagent is produced.

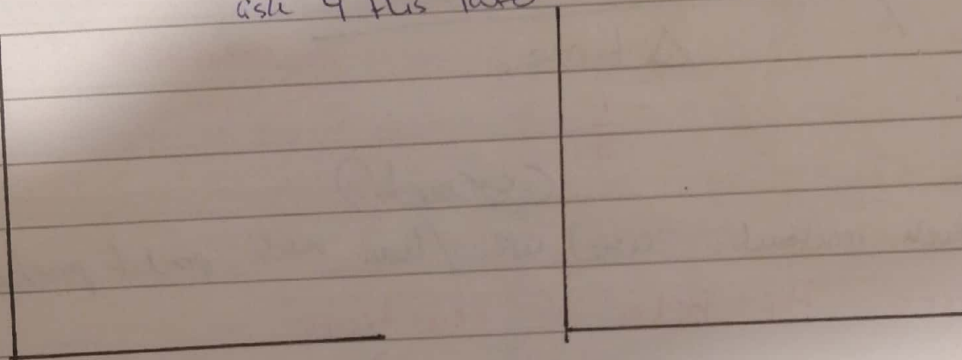


From the graph, how 2 measure the rate. * find the gradient



ask 4 this later

volume of CO_2
/ml



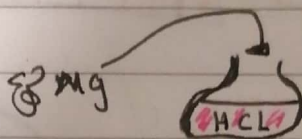
okay

3 Main conditions for any chemical reaction.

① the reactants must be suitable



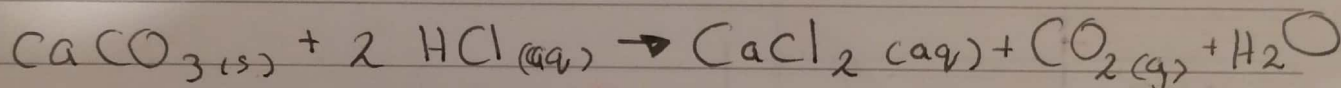
② the reactants must collide

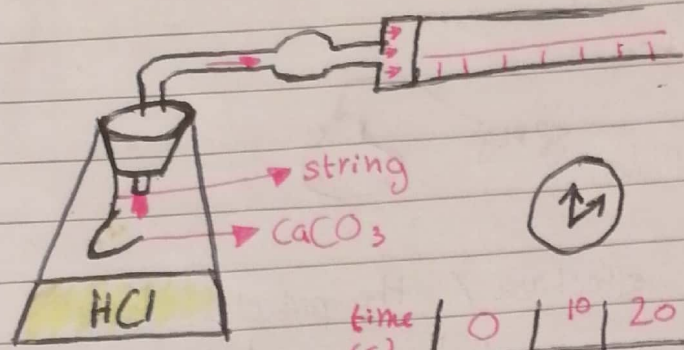
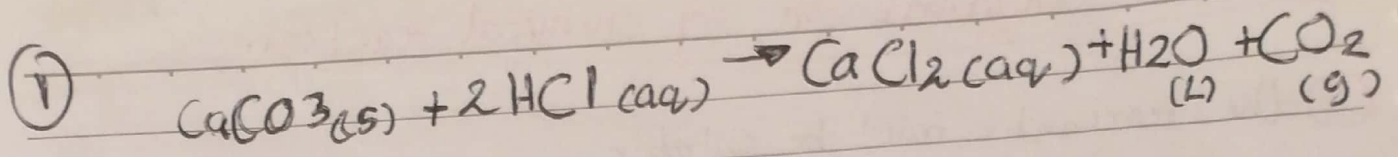


③ The collisions must be effective / the particles have minimum amount of energy needed to start the reaction

(activation energy) \rightarrow minimum amount of energy for a reaction to occur, this means reactant molecules have enough kinetic energy to collide.

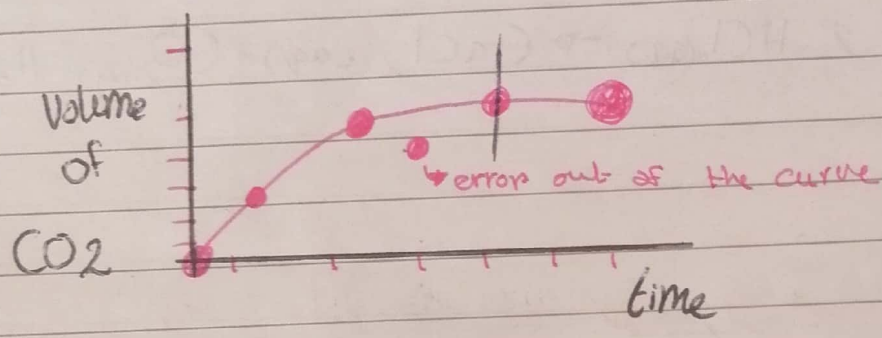
Measuring the rate by monitoring the volume of gas
copy later



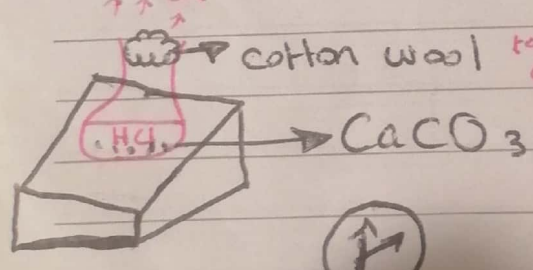
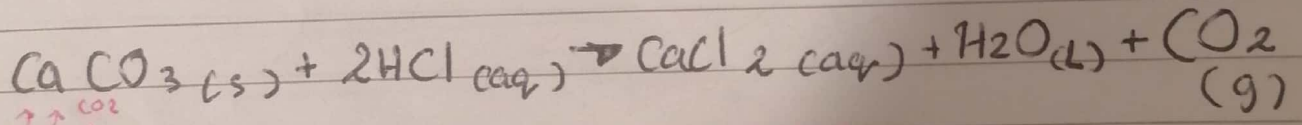


over: no more limiting factor

time (s)	0	10	20	30	40	50
Volume (cm ³)	0	8	13	15	16	16
		+8	+5	+2		



② measuring the rate by monitoring the change in mass of conical flask + contents per unit time



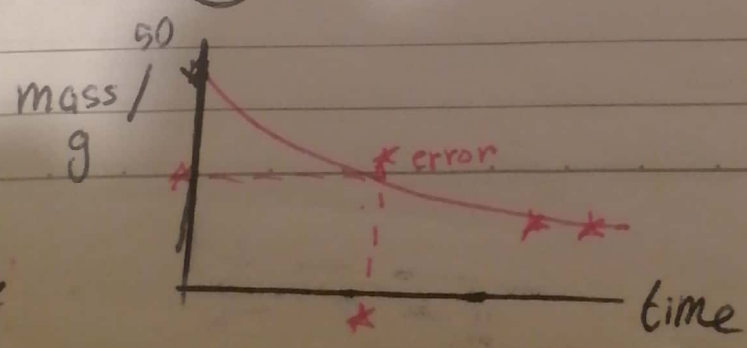
to allow CO₂ to escape and prevent splashing

? why the mass ↓?

CO₂ escape

time / s	0	10	20	30	40	50
mass / g	50	45	42	41	40.5	40.5
		-5	-3	-1	-0.5	

over 1

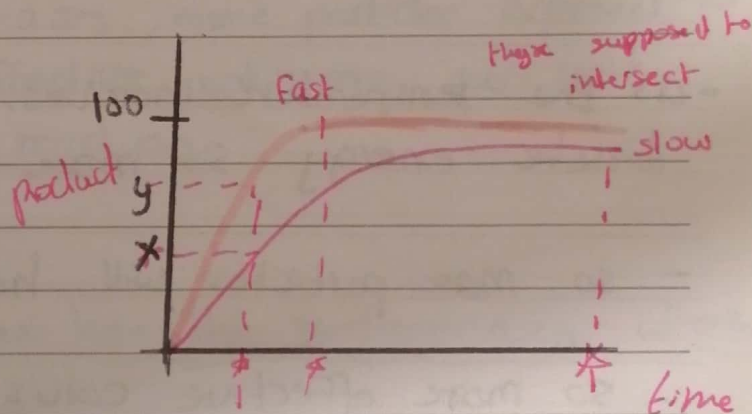
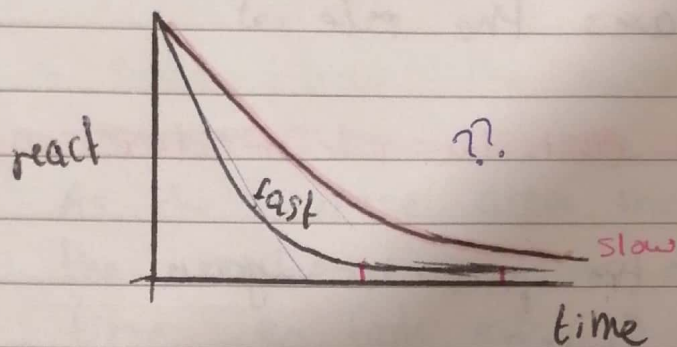


* increasing the rate of reaction

same product with less time.

or more product per the same time

faster rate = steeper curve



Factors affecting the rate of reaction.

- ① temperature
- ② surface area
- ③ concentration
- ④ pressure (only for gases)
- ⑤ light intensity
- ⑥ catalyst

Temperature

- state how the temperature affects the rate of reaction

as the temperature increases the rate of reaction increases.

- explain how the temperature affects the rate of reaction

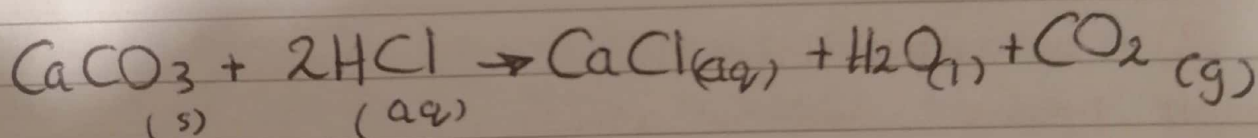
- as the temperature increases, the particles gain kinetic energy so move faster

- so more particles will have energy

- so more effective collisions

- and faster rate of reaction

- plan an experiment to show how the temperature affects the rate of reaction



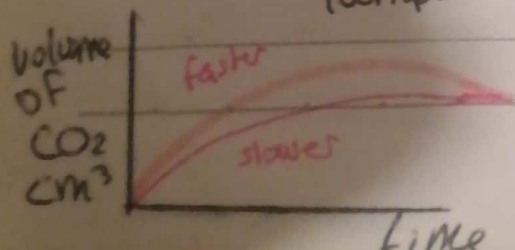
exp 1) $m_{\text{CaCO}_3} = 2\text{g}$
lumps

$V = 0.1 \text{ dm}^3$
 $M = 0.1 \text{ mol/dm}^3$
temp = 25°C

Volume of
 CO_2
produced per
unit time

exp 2) $m_{\text{CaCO}_3} = 2\text{g}$
lumps

$V = 0.1 \text{ dm}^3$
 $M = 0.1 \text{ mol/dm}^3$
temp = 50°C



② surface area

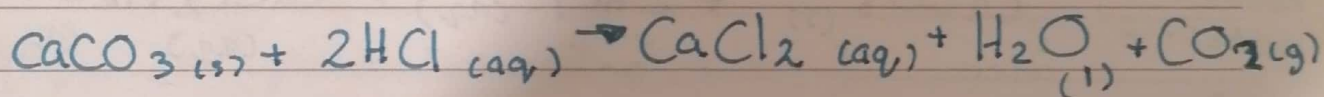
- state how the surface area affects the rate of reaction.

As the surface increases (by reducing the particle size / crushing using mortar and pestle) the rate of reaction increases.

- explain how the surface area affects the rate rate of reaction

As the surface area increases, more particles exposed to the reaction, so more effective collisions per unit time, so faster rate of reaction.

plan an experiment to show how the surface area affects the rate of reaction

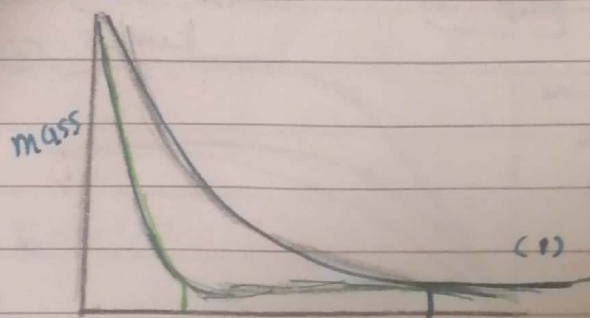
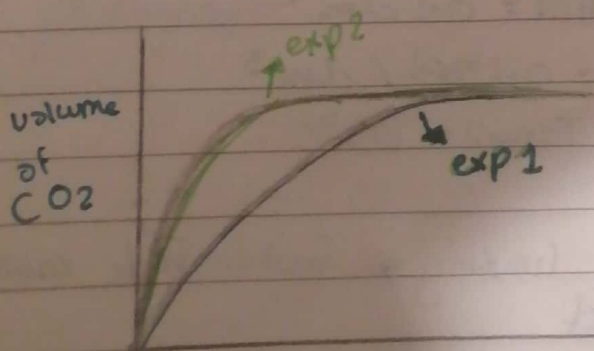


exp 1 mass = 2g
(lumps)

V HCl = 0.1 dm³
M HCl = 1 mol/dm³
Temp = 25 °C

exp 2 Repeat experiment one

mass = 2g
(powder)
V HCl = 0.1 dm³
M HCl = 1 mol/dm³
Temp = 25 °C



③ concentration (amount of particles in one space)

State how the concentration affects the rate of reaction.

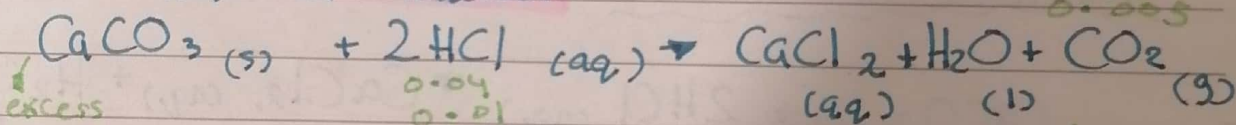
As the concentration increases, the rate of reaction increases

- explain how the concentration effects the rate of reaction.

As the concentration of reactants increases more particles so more effective collisions per unit time, so faster rate of reaction

Plan an experiment to show how the concentration affects the rate of reaction

needs = 0.005
acid = 0.02



exp 1

mass = 2g
lumps
Mr = 100

V HCl = 0.1 dm³

M HCl = 0.1 mol / dm³

Temp = 25°C

exp 2

mass = 2g
lumps

V HCl = 0.1 dm³

M HCl = 2 mol / dm³

Temp = 25°C

exp 3

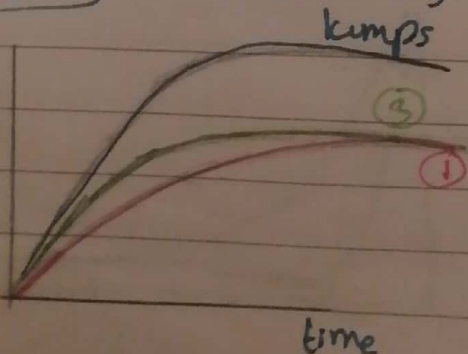
mass = 4g
lumps

V HCl = 0.1 dm³

M = 0.1 mol / dm³

Temp = 25°C

volume of
CO₂
cm³

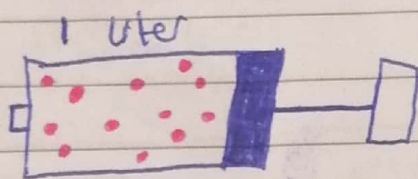


• more limiting → faster rate more product

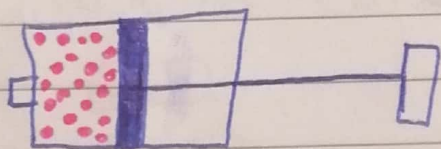
• more excess → faster rate

Pressure (only for gases)

★ explain how the pressure affects the rate of reaction ★
the pressure increases (by lowering the volume → compressing) so more particles per unit volume.
so more effective collisions per unit time.
so faster rate of reaction.



$$\frac{10 \text{ particles}}{1 \text{ liter}} \rightarrow 10$$

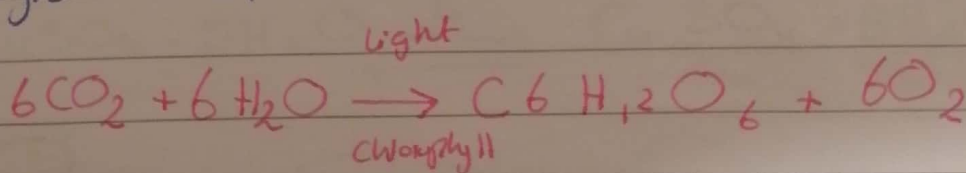


$$\frac{10 \text{ particles}}{0.5 \text{ liters}} \rightarrow 20$$

0.5 liter

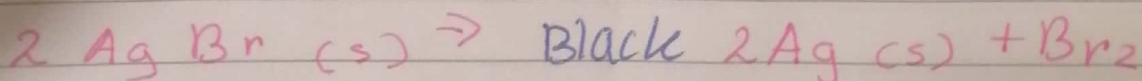
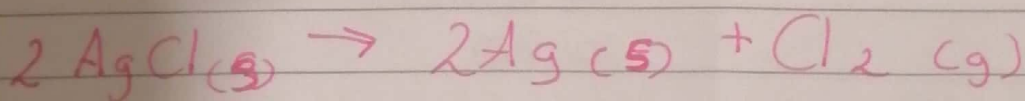
Light (for photochemical reactions)

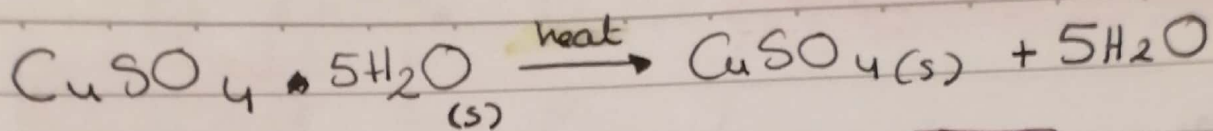
★ photosynthesis ★



not in our syllabus but good to know (i guess?)

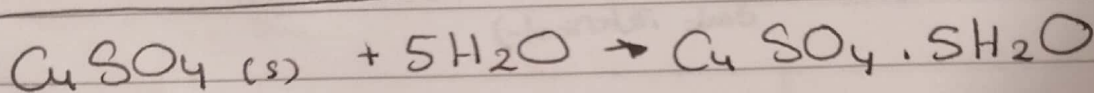
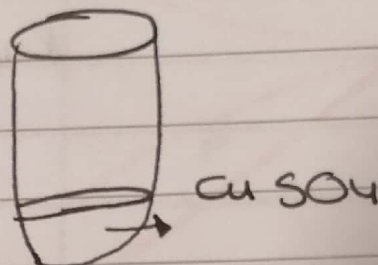
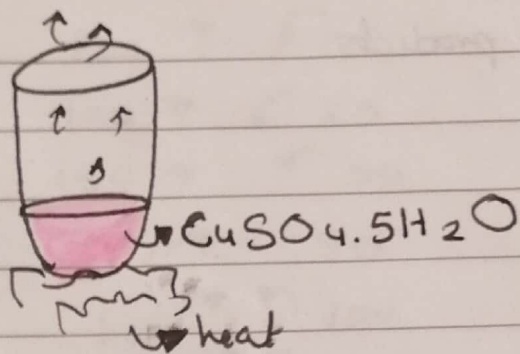
★ photographic films ★



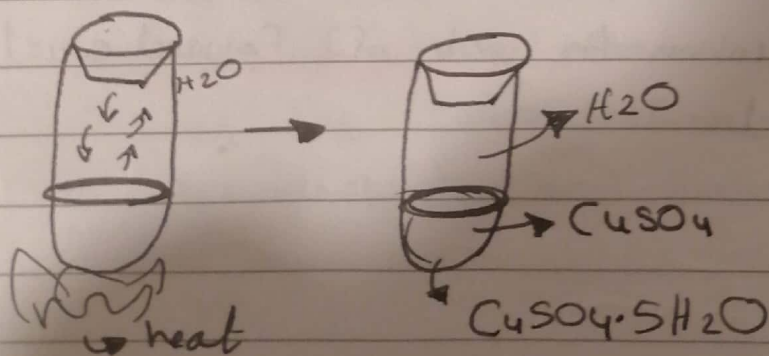
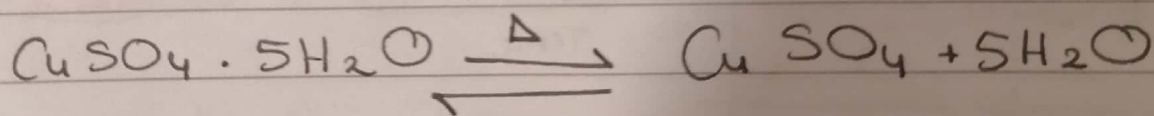
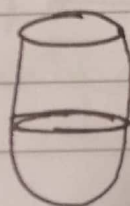
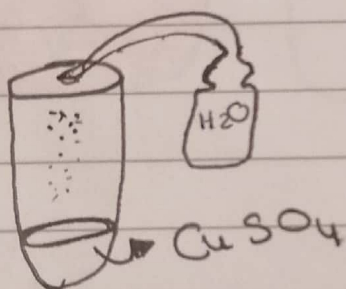


blue

white



white

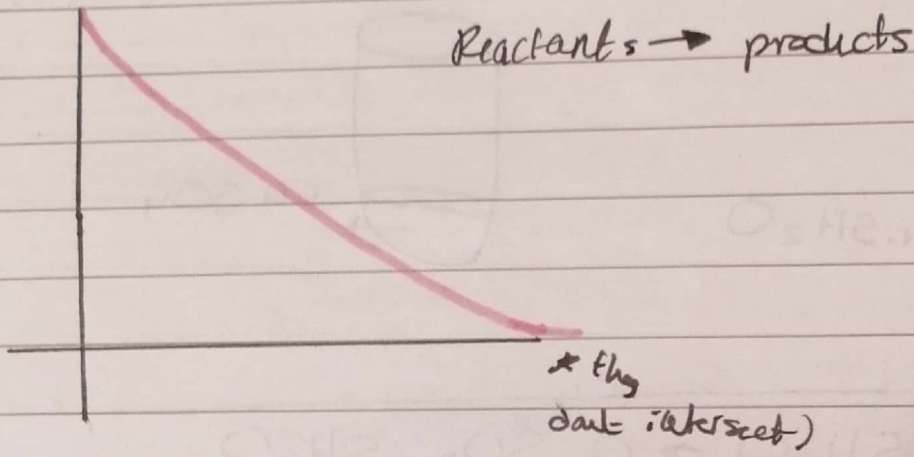


Equilibrium
mixture

??

Dynamic equilibrium

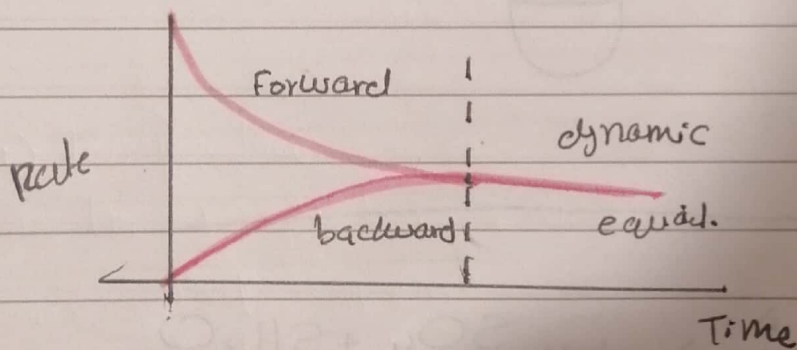
one way



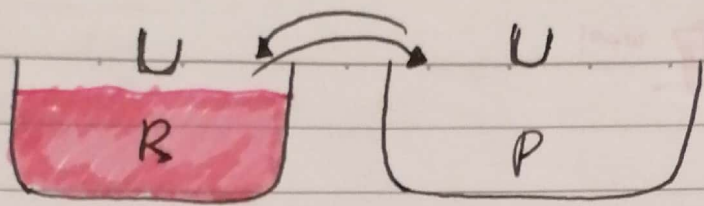
dynamic equilibrium

reactants \rightleftharpoons products

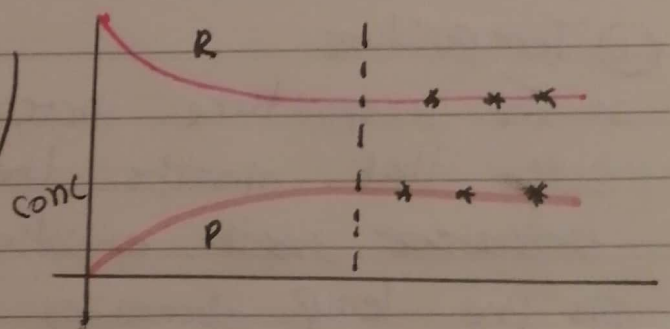
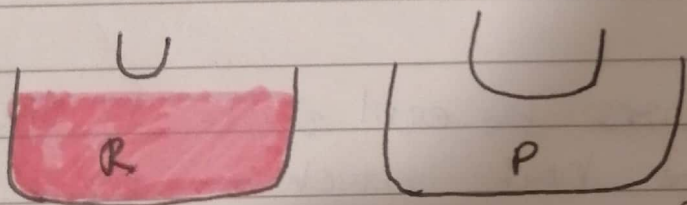
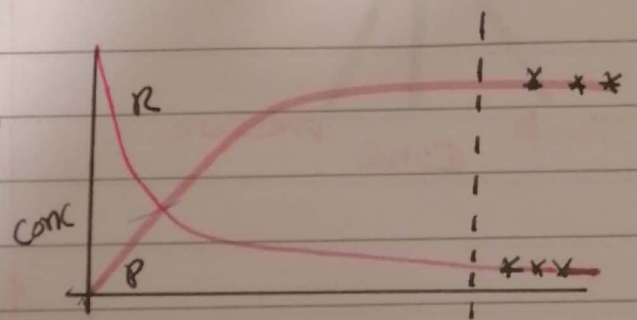
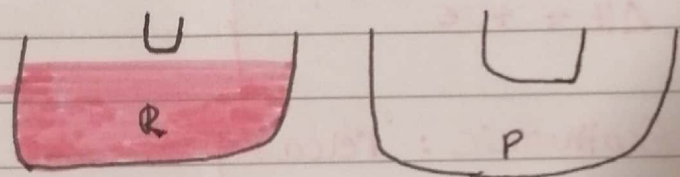
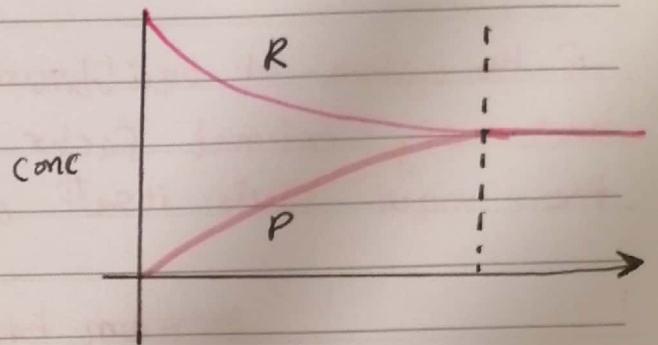
forward
backward



Dynamic equilibrium: when the rate of forward equal the rate of backward



200 → 0
 150 → 20
 150 → 50
 120 → 80
 100 → 100
 100 → 100

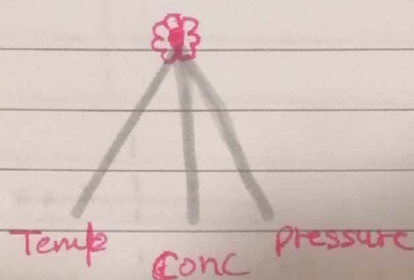


in terms of concentration:

when the concentration
 of reactants and products
 are constant

Le Chatelier principle wool!

if the system at equilibrium \rightleftharpoons
 and any external factor disrupt the equil
 the equil shifts itself either to the forward \rightarrow
 or to the backward \leftarrow
 to return back to equil \rightleftharpoons



Endothermic: absorb
 $\Delta H = +ve$

Exothermic: release
 $\Delta H = -ve$

(i) Temperature

as the temperature increases the equil shifts to the side that absorbs the heat which is the ~~endothermic side~~ endothermic side

As the temp decreases the equil shifts to the side that releases heat which is the exothermic side.

The sign of ΔH always relates to the forward reaction.

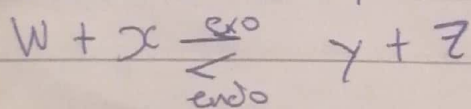
$$A + B \xrightleftharpoons[\text{exo}]{\text{endo}} C + D \quad \Delta H = \text{endo} +ve$$

\uparrow shifts forward to the endo side.

??

Rate of endo $\uparrow\uparrow$

Rate of exo \uparrow



$A \downarrow$ $B \downarrow$ $C \uparrow$ $D \uparrow$

rate of endo $\uparrow\uparrow$

Rate of exo \uparrow

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

$\Delta H = -ve$

Temp shifts backward to the endo

Position of equilibrium

<u>Temp</u>	<u>Pressure</u>	<u>Concentration</u>
\uparrow Temp shift to endo	\uparrow pressure shift to less gas mole	$\uparrow R \downarrow P$ } shift to forward
\downarrow Temp shift to exo	\downarrow pressure shift to more gas mole	$\downarrow R \uparrow P$ } shift to backward
\uparrow Temp \uparrow Rate	\uparrow pressure \uparrow Rate	\uparrow conc \uparrow Rate
\downarrow Temp \downarrow Rate	\downarrow pressure \downarrow Rate	\downarrow conc \downarrow Rate

Energetics

(Energy in chemical reaction)

Energy: The ability to do work
in chemical reaction

To break down
bonds in

Reactants

Input

Absorb

Take in

Endothermic

To build up
the bonds
in the

Products

output

Release

Give out

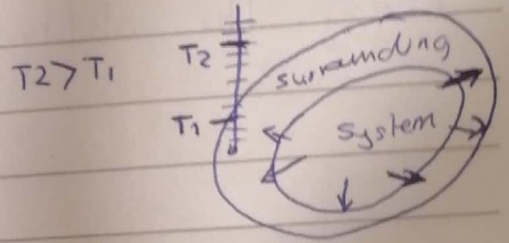
Exothermic

Input > output : Endothermic
Output > Input : Exothermic

Enthalpy: Heat contents
Stored energy in bonds

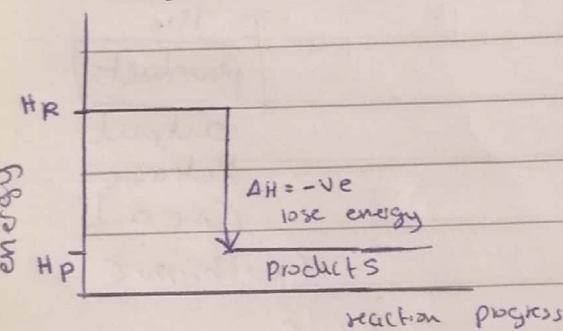
Exothermic Reactions

Reaction that release (give out) energy to the surrounding when they take place

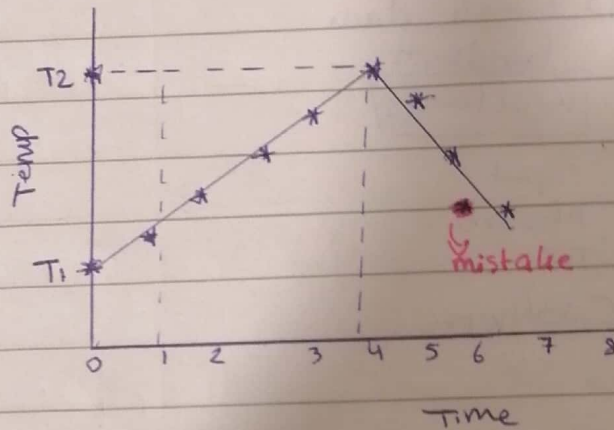


For system

Energy level diagram.



For surrounding



$$Q = m C \Delta T \rightarrow \text{change in Temp}$$

\checkmark energy J
 \downarrow mass g
 \downarrow specific heat capacity

$$C_{\text{water}} = 4.2 \text{ J/g}^\circ\text{C}$$

$\uparrow Q$ more exothermic
 $= \uparrow \Delta H$

how to express exothermic reactions:

- ① Reactants \rightarrow products + energy
- ② Reactants \rightarrow products $\Delta H = -ve$

Examples

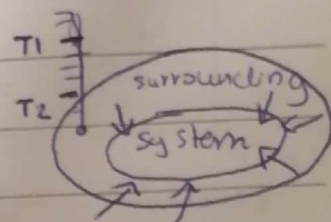
- 1- Combustion
- 2- displacement
- 3- neutralization
- 4- respiration
- 5- freezing
- 6- ~~voltaic~~ voltaic cell
- 7- building up bonds

③ profile diagram

Endothermic Reactions

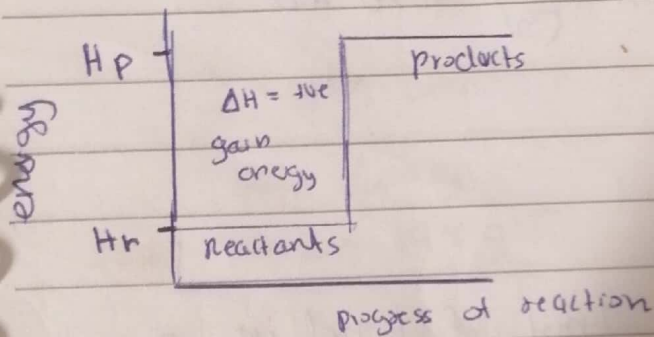
Reaction that absorbs (takes in) energy to the surroundings when they take place.

$$T_1 > T_2$$



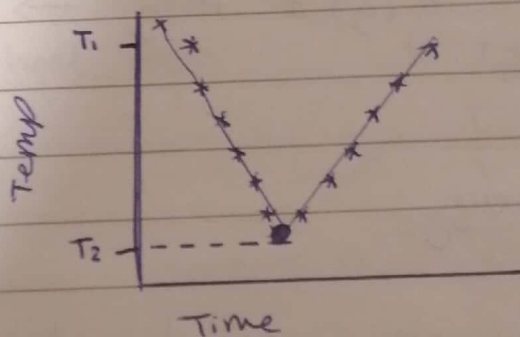
For system

Energy level diagram



For surrounding

Temp diagram

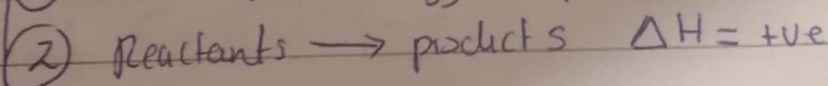
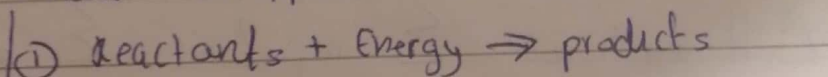


$$\uparrow Q = \text{more endothermic} = \uparrow \Delta H$$

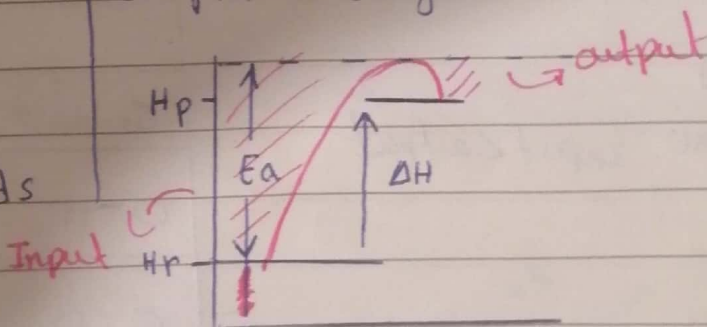
• how to express endothermic reactions:

Examples

- 1- photosynthesis
- 2- photographic films
- 3- thermal decomposition
- 4- electrolysis
- 5- boiling, melting
- 6- breaking down bonds



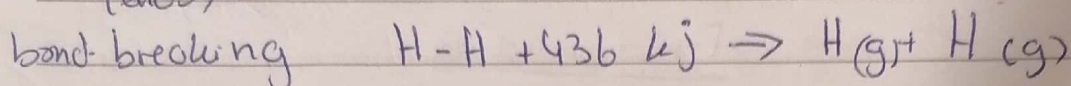
③ profile diagram



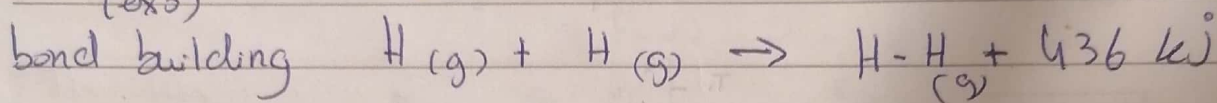
• Measuring ΔH reaction using bond energies

bond	bond energy kJ/mol
H-H	436

(endo)



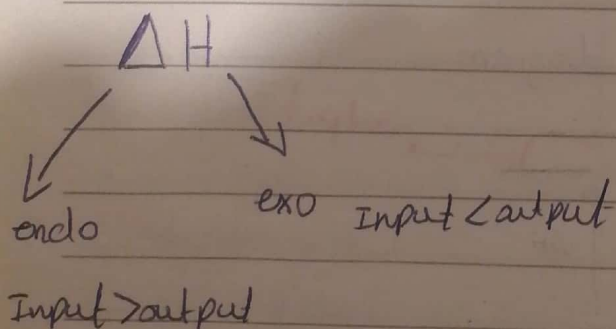
(exo)



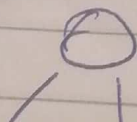
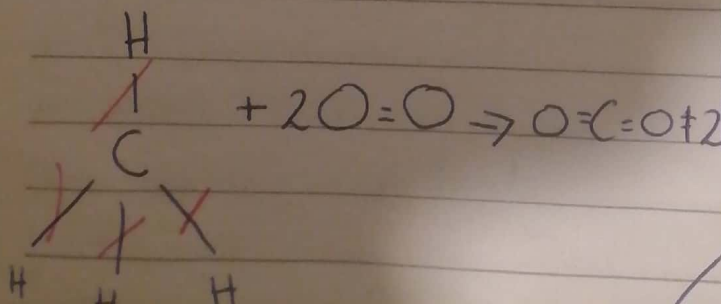
Bonding energy:

The amount of energy needed to break 1 mol of bond in a gaseous state or The amount of energy released to build 1 mol of bond in a gaseous state.

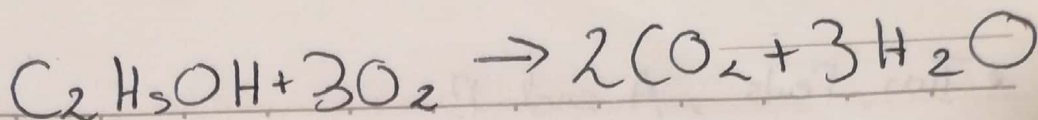
$$\Delta H \text{ reaction} = \sum_{\text{sum total}} \text{input} - \sum_{\text{sum total}} \text{output}$$



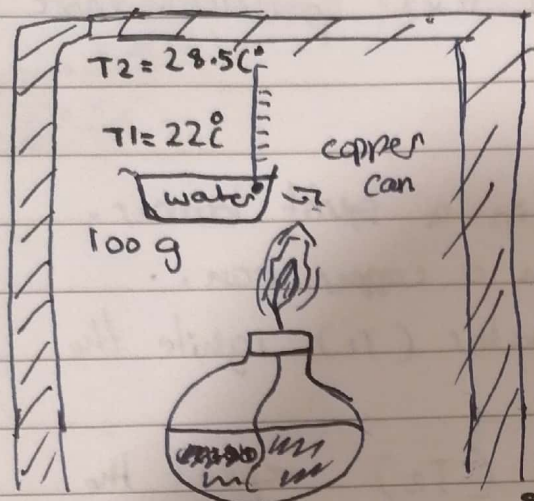
bond	bond energy kJ/mol
C-H	413
O-H	463
O=O	496
C=O	799



Combustion



• measuring the amount of energy transfer



$$Q = m C \Delta T$$

surrounding
energy transfer / J

mass / g

specific heat capacity

change in Temp

heat capacity for water
4.2 J/°C

shield to reduce heat loss

$$m_1 = 200g$$

$$m_2 = 198g$$

$$2g$$

combustion

displacement

neutralization

$$Q = m C \Delta T$$

$$= 100 \times 4.2 \times (28.5 - 22) = 2730 \text{ J}$$

$$2730 \text{ J} \xrightarrow{\text{burn}} 2g \text{ } C_2H_5OH$$

$$62790 \leftarrow \text{XXXXXXXXXXXX} 46g$$

$$\Delta H = -62.79 \text{ kJ/mol}$$

- Two Fuels, A and B
- plan an exp to show which fuel produces more energy

Take a known mass of fuel A in a spirit burner.

Place a known mass of water in a copper can.

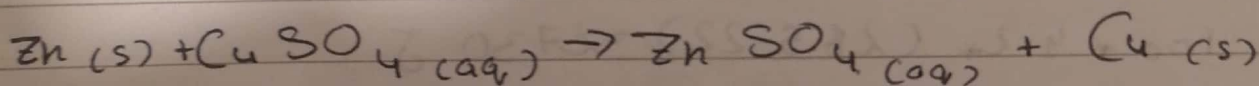
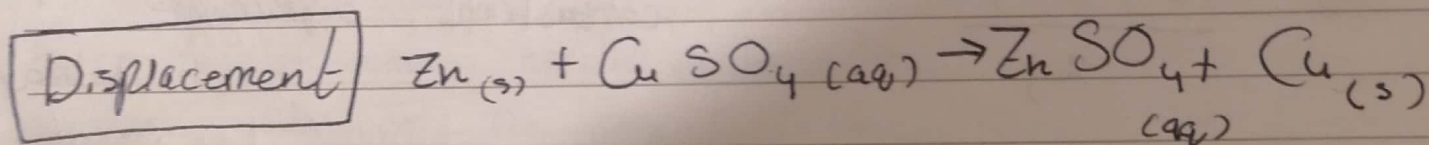
measure the initial temp of water (T_1) ignite the fuel A.

measure the final temp of water (T_2). repeat the

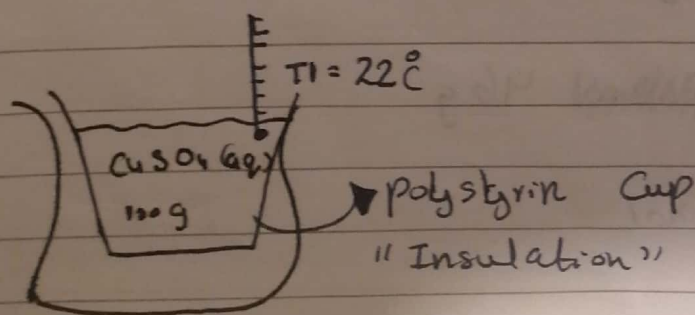
- experiment using fuel B.

the ~~best~~ fuel which causes more Temp change is the one that produces more energy.

$$d = \frac{m}{V} \quad 1 = \frac{m}{100}$$



$$m = 0.65 \text{ g} \quad V = 100 \text{ cm}^3 \quad d = 1 \text{ g/cm}^3 \quad m = 100 \text{ g}$$

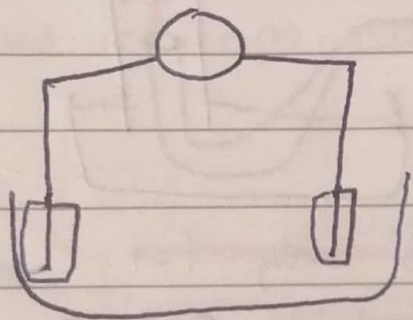


Beaker

- Insulator
- more stable

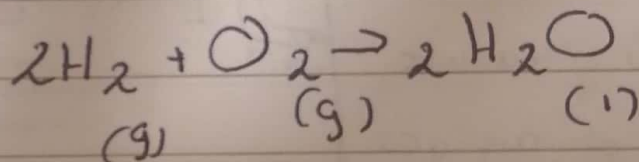
Alternative

Volat air cell



hydrogen fuel cell

hydrogen fuel cell



Uranium

- produce only H_2O as waste product
- produce high amount of energy "electrical" +ve
- no CO_2 produced, (no pollution)

- hard to store and transport, risk of explosions -ve

Industrial chemistry

dealing with gases

dry

collect

industry

NH₃
Haber process

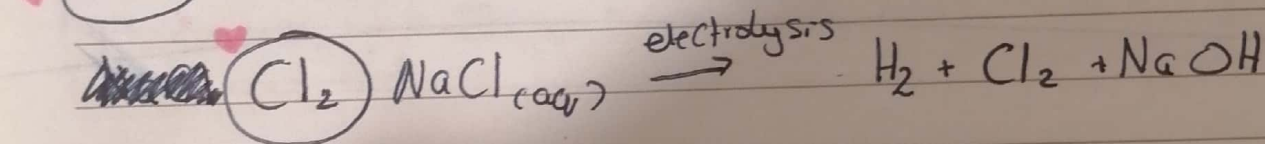
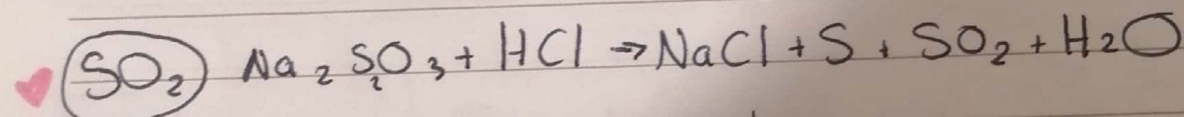
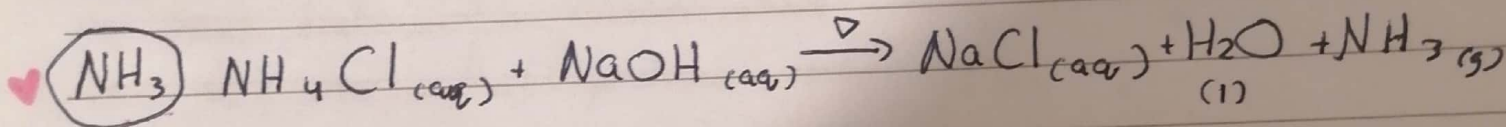
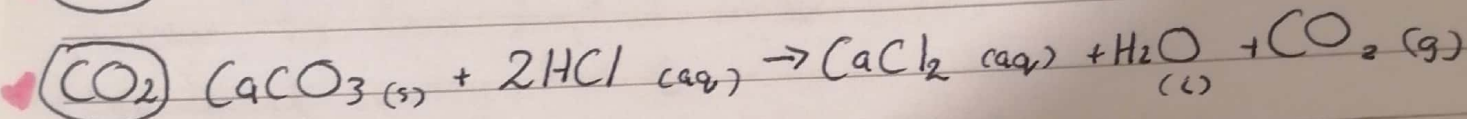
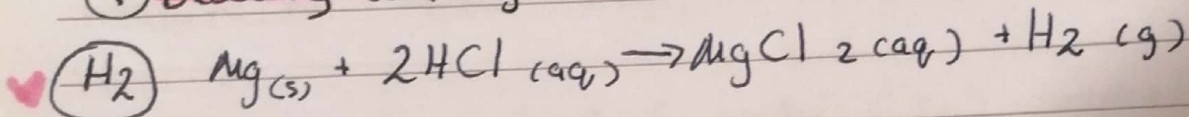
H₂SO₄
contact process

(CO₃⁻²)

extraction

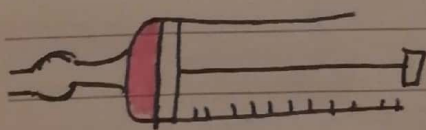
Fe Zn Cu Al

① Dealing with gases



② collect gases

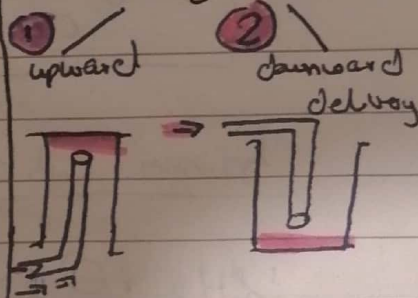
- gas syringe:



• collect and measure the volume of any gas

Expensive!

- Delivery:

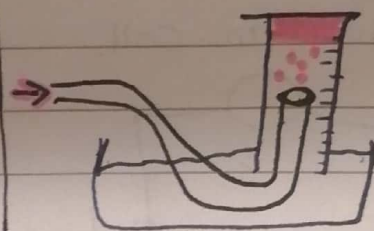


① to collect less dense gas than air
NH₃ H₂

② to collect more dense gas than air
SO₂ CO₂ Cl₂

error, some gas might escape or mix with other gases

- over water:

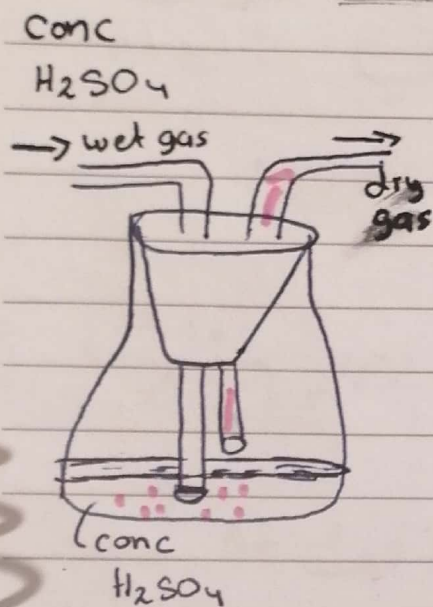


used only for insoluble gas in water

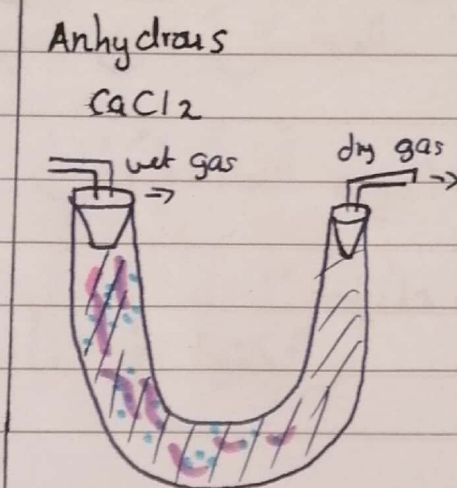
• CO₂ slightly soluble in water

Hard to use!

③ Drying gases



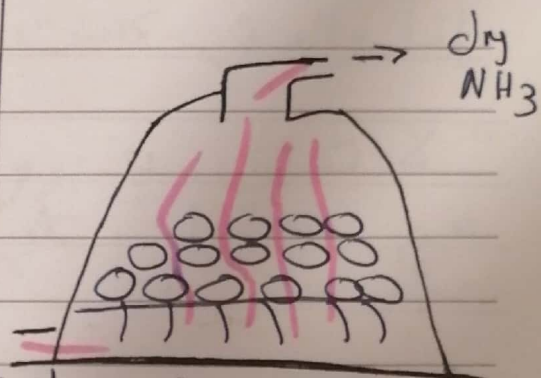
- used to dry any gas except ammonia NH_3



key
 // : wet gas
 . . . : H_2O
 /// : $CaCl_2$

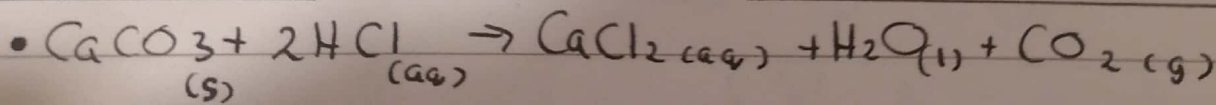
- used to dry any gas except ammonia NH_3 .
 - $CaCl_2$ absorbs H_2O

CaO
 Quicklime



wet gas → (NH_3)

for NH_3 specifically



draw an apparatus to collect and measure a dry sample of CO_2 .

