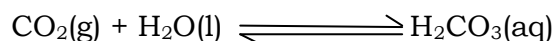


# O-LEVEL CHEMISTRY

---

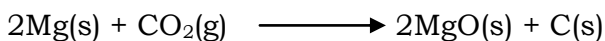
- It is denser than air that is why it is collected by down ward delivery method. Under high pressure, carbon dioxide is quite soluble in fizzy drinks (effervescent drinks)
- It is slightly soluble in water forming a weakly acidic solution of carbonic acid.



- It turns moist blue litmus paper pink indicating that it is weakly acidic.

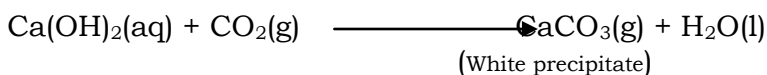
## Chemical properties

1. Carbon dioxide does not support burning. However when a piece of burning magnesium is lowered into a gas jar of carbon dioxide, it continues to burn forming black specks of carbon mixed with white solids of magnesium oxide.

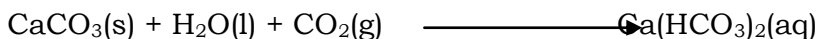


In this case, magnesium reduces carbon dioxide to carbon and it self is oxidized to magnesium oxide.

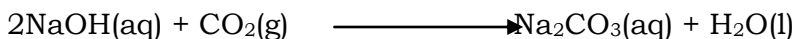
2. Carbon dioxide turns lime water (calcium hydroxide) milky. This is due to the formation of insoluble calcium carbonate (white precipitates)



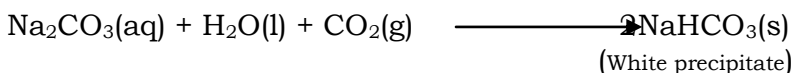
However, when excess carbon dioxide is bubbled, through the solution (lime water), the white precipitates dissolve making the solution to appear clear. This is due to the formation of calcium hydrogen carbonate which is a soluble compound.



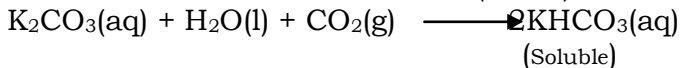
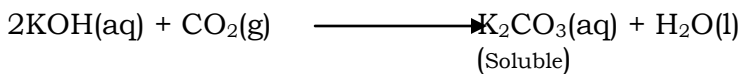
3. When carbon dioxide is bubbled through a solution of fairly concentrated sodium hydroxide, the solution remains clear due to the formation of a soluble sodium carbonate.



This reaction is sometimes used to remove carbon dioxide from a mixture of gases. However, when excess carbon dioxide is bubbled through the above solution, white precipitates appear due to formation of insoluble sodium hydrogen carbonate.



4. When carbon dioxide gas is bubbled through a solution of potassium hydroxide, there is no observable change as the products formed are all soluble.

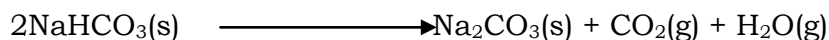




# O-LEVEL CHEMISTRY

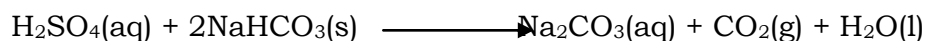
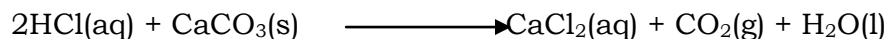
---

d) All hydrogen carbonates decompose to give corresponding carbonates, carbon dioxide gas and water vapor. E.g.



### 3. Action of dilute acids

All carbonates and hydrogen carbonates react with dilute acids to liberate carbon dioxide gas, water and corresponding salts. E.g.



N.B. Dilute sulphuric acid reacts with calcium carbonate and lead (II) carbonate at a very slow rate as the resulting salts formed (calcium sulphate and lead(II) sulphate) are insoluble and therefore tend to form coatings around the carbonates inhibiting further reactions between the carbonates and the acid.

The reaction between dilute hydrochloric acid and lead (II) carbonate also forms an insoluble salt (lead (II) chloride) which also forms coating stopping further reactions.

Dilute nitric acid reacts with all carbonates to form soluble nitrate salts.

### Testing for carbonates and hydrogen carbonates

#### a) If the sample is a solid

Add a little dilute acid to the solid substance under test.

##### Observation

Effervescence occurs and a colorless gas that turns lime water milky (carbon dioxide) is given off.

##### Conclusion

This shows that a carbonate or hydrogen carbonate is present.

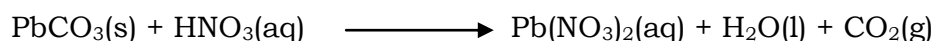
#### b) Carbonate in solution form

To 2cm<sup>3</sup> of test solution add 3 drops of lead (II) nitrate solution followed by excess dilute nitric acid.

##### Observation

White precipitate is formed and the precipitate dissolves in excess nitric acid with effervescence.

N.B. Sometimes barium nitrate solution or barium chloride solution may be used in place of lead (II) nitrate solution.

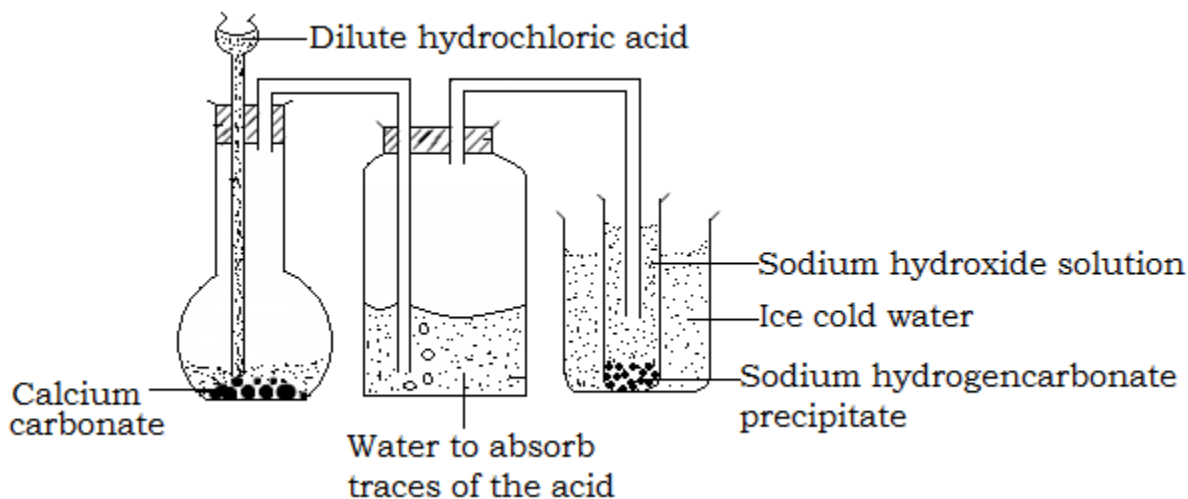


### Sodium carbonate

# O-LEVEL CHEMISTRY

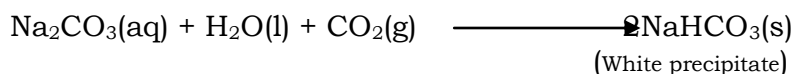
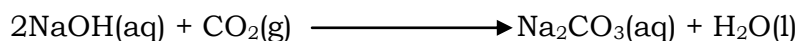
## Laboratory preparation

### Set up

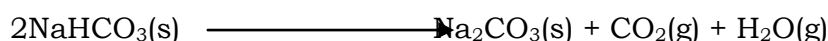


### Procedure

- Bubble carbon dioxide through a fairly concentrated sodium hydroxide solution until in excess. White precipitate of sodium hydrogen carbonate is formed according to the equation below



- The white precipitate of sodium hydrogen carbonate is filtered off, washed and dried.
- The sodium hydrogen carbonate is heated strongly until no further water vapor and carbon dioxide are given off. This leaves a white powder of calcium carbonate.



## Commercial preparation of sodium carbonate (Solvay process)

Very concentrated brine (28% sodium chloride) is saturated with ammonia gas in a tower to form ammoniacal brine. The ammoniacal brine is run downwards from the top of the tower while carbon dioxide (formed from decomposition of calcium carbonate) is forced to rise up the tower from the base of the tower.

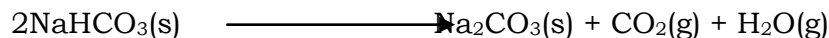
The tower is fitted with perforated mushroom shaped baffles at intervals that delay the flow of ammoniacal brine and also offer surface for the reaction.

# O-LEVEL CHEMISTRY

The ammoniacal brine reacts with carbon dioxide to form sodium hydrogen carbonate as precipitates since it is not very soluble in water. Precipitation is assisted by cooling the lowest third of the chamber.

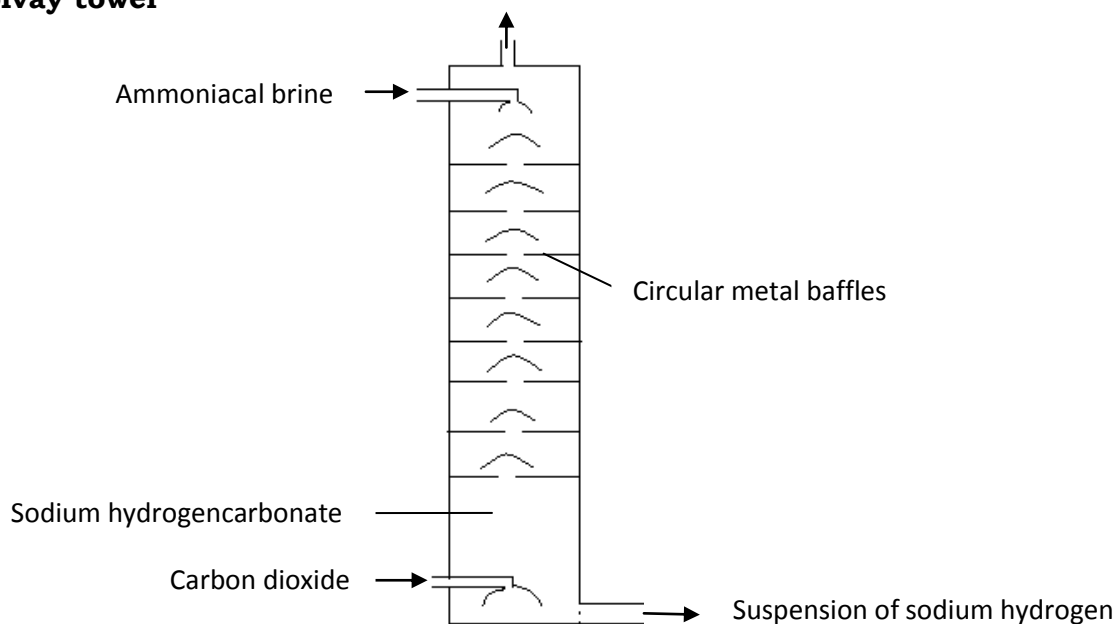


Sodium hydrogen carbonate is filtered from the white sludge at the base of the tower and washed to remove ammonium compounds. The sodium hydrogen carbonate is then heated to form sodium carbonate.

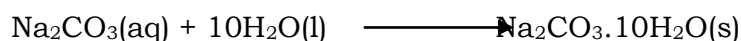


The anhydrous sodium carbonate formed has a wide market.

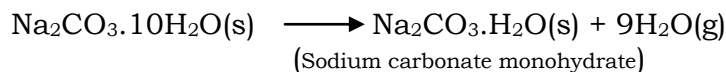
## The Solvay tower



If crystalline form (washing soda) is required, the anhydrous solid is dissolved in hot water, crystallization takes place as the solution cools. The crystals are removed and allowed to dry.



Sodium carbonate decahydrate,  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  are large translucent crystals. When the crystals are exposed to air, they lose mass and become coated with fine powder which makes it opaque. Each molecule of washing soda gives to the atmosphere 9 molecules of water of crystallization.



# O-LEVEL CHEMISTRY

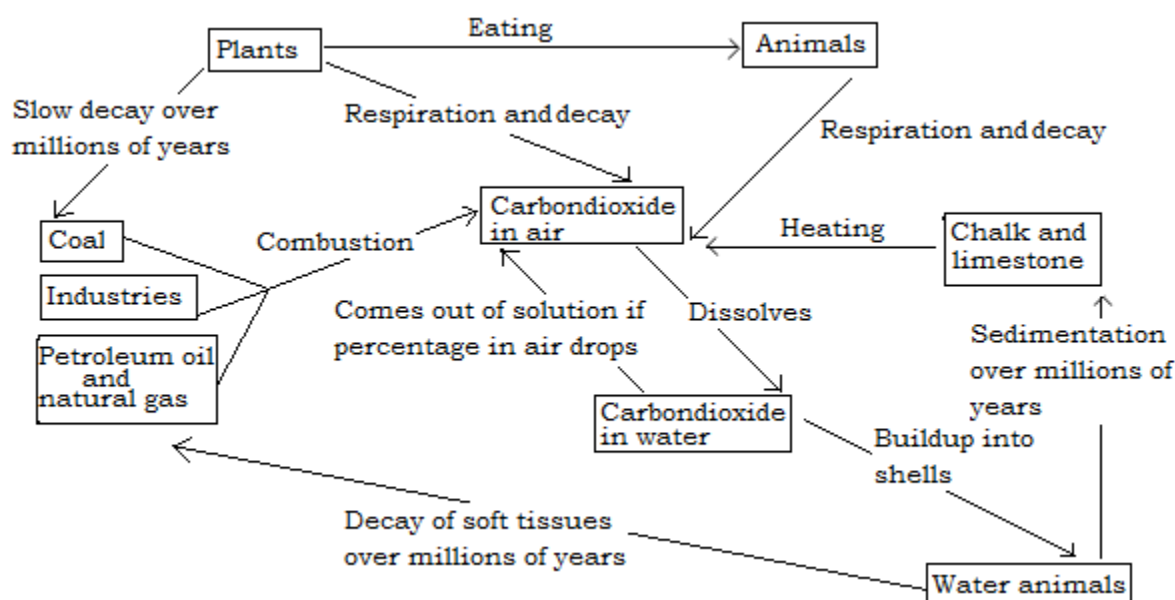
Such loss of water of crystallization to the atmosphere is termed as efflorescence. The substance that loses its water of crystallization is known as an efflorescent substance.

## Uses of sodium carbonate

1. Manufacture of glass. Ordinary bottle glass is made by fusing together sodium carbonate, calcium carbonate, silicon dioxide (sand) and a little carbon (reducing agent). Broken glasses are added to assist fusion.
2. Manufacture of water glass that is used to preserve eggs, used in fire proofing and production of cement.
3. Sodium carbonate is used in the manufacture of soap powders.
4. Sodium carbonate is used in domestic water softening. Calcium ions ( $Ca^{2+}$ ) which is the principal cause of hardness in water is precipitated from the water as calcium carbonate by adding sodium carbonate.

## The carbon cycle

The balance of processes which give out carbon dioxide and those which use carbon dioxide is called the **carbon cycle**. Summary of the carbon cycle is given below.



Carbon dioxide in the atmosphere is added from: respiration of plants and animals; decay/ decomposition of plants and animals; heating of lime stone (to give quick lime) in lime kilns; water (if the percentage in air drops); and combustion of coal (formed as a result of slow decomposition of plants and animals over millions of years), petroleum oil and natural gas.

The processes that remove carbon dioxide from the atmosphere are: photosynthesis by green plants; and dissolution in water.

Animals obtain carbon from plants by feeding on food such as starch made by plants..

## Effects of carbon dioxide on atmospheric temperature

# O-LEVEL CHEMISTRY

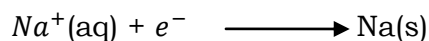
---

The Down's cell has an outer iron shell lined with firebrick. Iron gauze cylinders separate the graphite anode from the ring shaped iron cathode; this prevents the mixing of the products at the different electrodes.

A high current (about 30000 A) is used to keep the electrolyte in a molten state. Chlorine escapes via the hood. Sodium collects in the inverted trough placed over the cathode, rises up the pipe and is tapped off through the iron vessel. Sodium metal is collected upwardly in the Down' cell because of its low density that makes it to float over the reacting mixture.

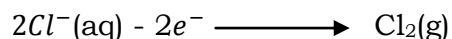
## Reaction at the cathode

At the cathode, sodium ions gain electrons and therefore are discharged to form sodium metal which is deposited in the molten state and collected over dry nitrogen.



## Reaction at the anode

At the anode chlorine ions are discharged as they lose electrons to form chlorine atoms. The chlorine atoms pair up forming chlorine molecules (gas) which is collected as a valuable product.



## Uses of sodium

- It is used in the manufacture of sodium cyanide (NaCN) which is used in the extraction of gold.
- Manufacture of sodamide (NaNH<sub>2</sub>)
- Manufacture of sodium peroxide (Na<sub>2</sub>O<sub>2</sub>)
- Its alloy is used in the manufacture of anti-knock additives for petrol e.g. tetraethyllead.
- Sodium is used for the withdrawal of heat from some nuclear reactors. It is therefore used as a coolant.
- Sodium is used as a reducing agent in the laboratory.
- Sodium vapour lamps are used for street lighting.

## Extraction of intermediate metals

The metals are extracted by reduction and there have four basic stages in the process.

1. Concentration of the ore
2. Roasting of the ore to convert the carbonates and sulphides to oxides and remove water vapour. It is easier to reduce the oxide than the carbonate.
3. Reduction of the ore
4. Purification/refining of the metal extracted

## Concentration of the ore

This process involves removing impurities. Impurities can be separated by physical means e.g. picking by hand, washing, using a magnet or solvent extraction. In the case of copper, the ore is first crushed and then mixed with water. Air is then blown

# O-LEVEL CHEMISTRY

---

through the mixture and the clean ore separates and collects at the surface as froth. This is referred to as froth floatation.

## **Roasting**

The concentrated (pure) ore is roasted in air at high temperatures to produce oxides which are easier to reduce than carbonates or sulphides. Sulphur is removed as sulphur dioxide and carbon dioxide driven off from the carbonates.

## **Reduction of the ore**

The ore is usually heated in a furnace in the presence of a suitable reducing agent, usually coke (carbon) or carbon monoxide which converts the ore into the required metal.

## **Purification/refining of the metal**

The metal obtained is often impure. Purification is normally done by electrolysis in the case of copper and zinc. In other cases, the impure metal is heated in a hearth open to air where the impurities oxidize and rise to the surface as a scum and can be removed.

## **IRON**

The principle/chief ores of iron are: Haematite,  $\text{Fe}_2\text{O}_3$ ; Magnetite,  $\text{Fe}_3\text{O}_4$ ; Iron pyrite,  $\text{FeS}_2$ ; Siderite or Spathic iron ore ( $\text{FeCO}_3$ ); Limonite ( $\text{Fe}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ ).

## **Extraction process**

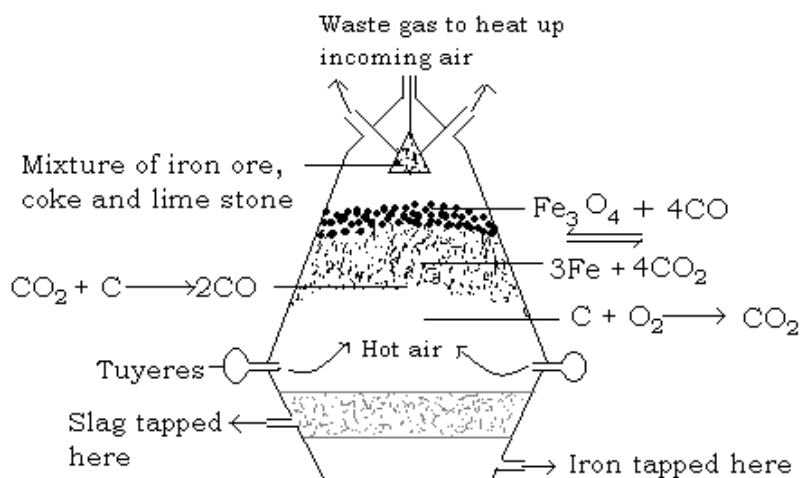
The iron ore is crushed and roasted in air to remove water and other non metallic impurities especially sulphur and phosphorus which are oxidized away as gaseous oxides. The roasted ore is now mainly  $\text{Fe}_3\text{O}_4$ . When an ore is roasted in air and  $\text{Fe}_3\text{O}_4$  is the main product, it is known as sintering

The roasted ore is mixed with coke (carbon) and limestone (calcium carbonate) and introduced into the blast furnace where the reduction of the ore takes place.

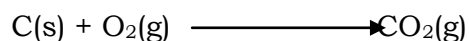
## **The blast furnace**



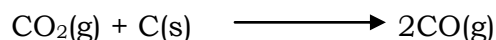
# O-LEVEL CHEMISTRY



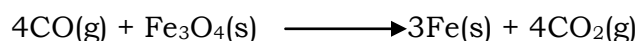
Very hot air is introduced from low down into the blast furnace. As the hot air passes through the mixture of roasted ore, coke and limestone, the coke burns to form carbon dioxide (is oxidized) in an exothermic process.



As the carbon dioxide produced rises through the furnace, it is reduced by the excess hot coke to produce carbon monoxide.



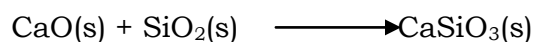
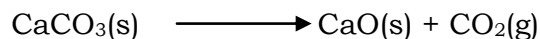
The carbon monoxide formed reduces the iron ore at a high temperature (about  $1000^\circ\text{C}$ ) to form iron metal.



The molten iron formed sinks to the bottom of the blast furnace where it is tapped and solidified into blocks of pig iron.

## The role of limestone

Limestone removes Silicon(IV) oxide which is the main impurity in the iron ore. Limestone at high temperature decomposes to form calcium oxide and carbon dioxide. The calcium oxide formed combines with silicon (IV) oxide (impurity) to form molten calcium silicate (slag).



The slag being less dense than iron forms a separate layer above iron and thus are tapped separately.