CARBON AND ITS COMPOUNDS

Carbon is an element in period II and group IV in the periodic table. It has atomic number of six.

Occurrence of carbon
Carbon occurs in both free states and combined states. In combined states, it occurs as coal, mineral oils, carbonates (e.g. lime stone, marble and sea shells) and all living things (animals and plants). As an element it occurs in both natural (as diamond and graphite) and synthetic forms (as coke, charcoal and carbon fiber).

Allotropes of carbon

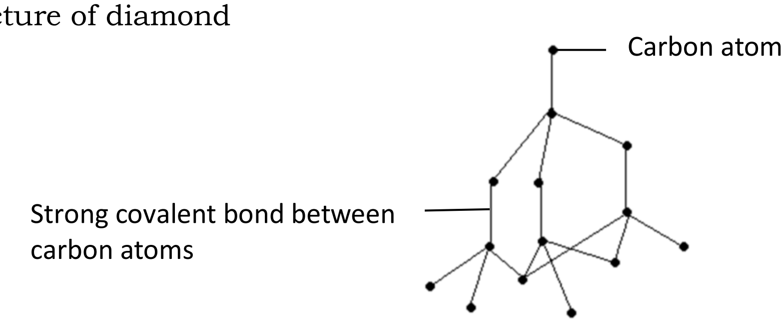
Allotropy is the existence of an element in two or more forms in the same physical state.

Allotropes are various forms in which elements exist without change in physical state. Different allotropes of the same element always have different crystalline structures and physical properties but the same chemical properties.

Allotropes of carbon are: diamond and graphite. Another form of carbon is amorphous carbon.

Diamond

In diamond, the structure consists of infinite number of carbon atoms. Each of the carbon atoms is joined to four other carbon atoms by covalent bonds resulting into a tetrahedral arrangement. This gives a diamond crystal a giant three dimensional structure. Diamond has no mobile electrons so cannot conduct electricity.
Structure of diamond



Physical properties of diamond

- Diamond is the hardest natural substance known. This is because the carbon atoms are closely parked and are joined by strong covalent bonds.
- Diamond has a very high melting pint because of the strong covalent bond between the carbon atoms.
- It has a very high density ($3.5 g/cm^3$) because of the closely packed carbon atoms.
- Diamond is transparent, sparkling and glitters.
- Diamond does not conduct electricity because it has no mobile electrons.

Uses of diamond

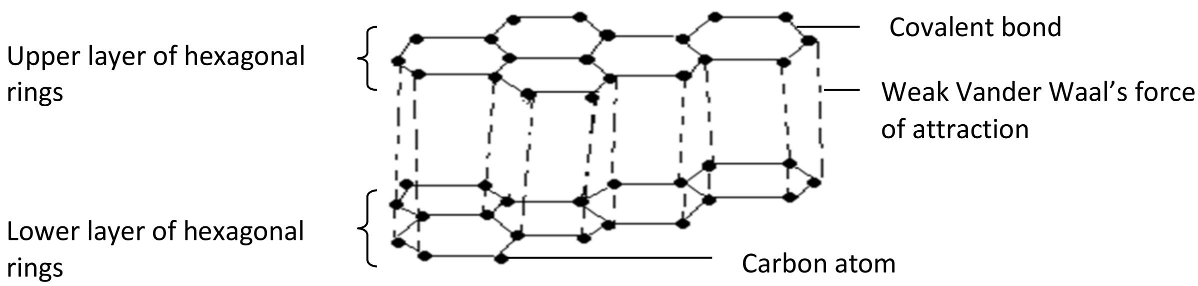
1. Diamond is very hard and used as drilling devices, rock borers and glass cutters.
2. Diamond is used jewellery because its sparkling appearance.

3. Diamond is bright and used to make laser beams.

Graphite

Graphite consists of infinite number of carbon atoms each covalently bonded to three other carbon atoms forming hexagonal rings that are arranged in layers. Each layer is a giant two dimensional structure. The different layers are held by weak Vander Waal's forces of attraction, making them to slide over each other thus they are slippery and soft. Some electrons in a layer are mobile making them to conduct electricity.

Structure of graphite



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Physical properties of graphite

- Graphite conducts electricity because they have free mobile electrons.
- The melting point of graphite is high because of the strong covalent bond between the carbon atoms.
- Graphite is soft and slippery because its layers are held by weak Vander Waals force of attraction.
- Graphite is opaque and dark in color and shiny.

Graphite is less resistant to chemical attack than diamond because of the open spaces between the layers. The density of graphite is $2.3 g/cm^3$

Uses of graphite

1. Graphite is soft and can mark there fore used to make pencil –leads‖. Graphite is mixed with clay to make pencil leads.
2. Graphite is a good conductor of electricity and thus used as electrodes.
3. It is soft and greasy, therefore used as lubricants especially in small bearings like those in dynamos.
4. Graphite is used to make brushes for electric motors.
5. Graphite (black lead) is used as a protective coating on iron to prevent rusting.

When 1g of both diamond and graphite burns in oxygen, they form 3.67g of carbon dioxide only. This shows that they are allotropes.

Amorphous carbon

Amorphous carbon is black and has the lowest density. It is non crystalline and fairly conducts electricity. Amorphous carbon exist in several forms like wood charcoal, animal charcoal, sugar charcoal, lamp black and coke.

i) Wood charcoal

It is formed when wood is heated in limited supply of air (destructive distillation of wood). It is a black porous solid and a very good absorbent of gases.

ii) Animal charcoal

This is made by heating animal refuse and bones in limited supply of air. Animal charcoal has a property of absorbing coloring matter and is used to remove brown color from sugar during its manufacture.

iii) Sugar charcoal

This is a very pure form of carbon made by removing elements of water from sugar. E.g. when cane sugar is dehydrated by concentrated sulphuric acid, sugar charcoal is formed.

iv) Lamp black

This is formed by burning oils (e.g. turpentine, petroleum, kerosene) in limited supply of air. It is used for making ink for printing and shoe polish.

v) Coke

This is an impure form of carbon made by heating coal in the absence of air (destructive distillation of coal). It is used as a reducing agent in the extraction of metals like iron and zinc from their ores. Coke is also used as fuel.

Chemical properties of carbon

All allotropes of carbon have similar chemical properties but different physical properties.

1. Reaction of carbon with oxygen

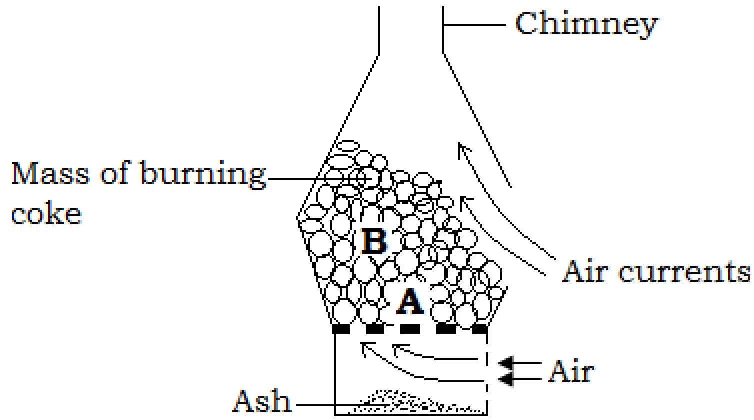
Carbon burns is excess oxygen to for carbon dioxide gas. In the process great heat is generated.

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$

When carbon burns in limited amount of oxygen, carbon monoxide forms.

$$2C(s) + O_2(g) \longrightarrow 2\,CO(g)$$

Reaction of carbon in a deep, brightly glowing coke/coal fire.



In region A, plenty of air is available. Carbon burns to carbon dioxide.

$C(s) + O_2(g) \longrightarrow CO_2(g)$

In region B, ascending carbon dioxide is reduced by red hot coke to carbon monoxide.

$CO_2(g) + C(s) \longrightarrow 2CO(g)$

At the surface, the hot carbon monoxide burns in air to form carbon dioxide with a flickering blue flame.

$2CO(g) + O_2(g) \longrightarrow 2\,CO_2(g)$

2. Reaction of metal oxides with carbon
Carbon readily removes oxygen from (reduces) oxides of metals lower than it in the reactivity series. Thus it acts as a reducing agent. Examples of oxides reduced by carbon are: zinc oxide, ZnO; lead (II) oxide, PbO; copper (II) oxide, CuO; iron (II) oxide, FeO and iron (III) oxide, Fe_2O_3.

$2ZnO(s) + C(s) \longrightarrow 2Zn(s) + CO_2(g)$
$2PbO(s) + C(s) \longrightarrow 2\,Pb(s) + CO_2(g)$
$2CuO(s) + C(s) \longrightarrow 2Cu(s) + CO_2(g)$

3. Reaction with acids
Carbon reduces nitric acid and sulphuric acid to nitrogen dioxide and sulphur dioxide gases respectively. The carbon itself is oxidized to carbon dioxide gas.

$C(s) + 4HNO_3(aq) \longrightarrow 4NO_2(g) + CO_2(g) + 2H_2O(l)$
$C(s) + 2\,H_2SO_4(aq) \longrightarrow 2SO_2(g) + CO_2(g) + H_2O(l)$

4. Reaction with steam
If steam is blown through red hot charcoal, a mixture of carbon monoxide and hydrogen gases are formed. This mixture is called water gas.

$H_2O(g) + C(s) \longrightarrow CO(g) + H_2(g)$

OXIDES OF CARBON

Carbon monoxide (CO)

Occurrence

Carbon monoxide is a poisonous gas and is commonly present in coal gas and other gaseous fuels. It is also produced in car exhaust fumes due to partial combustion of carbon.

Laboratory preparation

This can be done by the action of concentrated sulphuric acid on any of the following compounds.

1. Methanoic acid (HCOOH)

Concentrated sulphuric acid is a very strong dehydrating agent and removes water from methanoic acid forming carbon monoxide and water.

$$HCOOH(l) \xrightarrow{\text{Conc. } H_2SO_4} CO(g) + H_2O(l)$$

No heating is required.

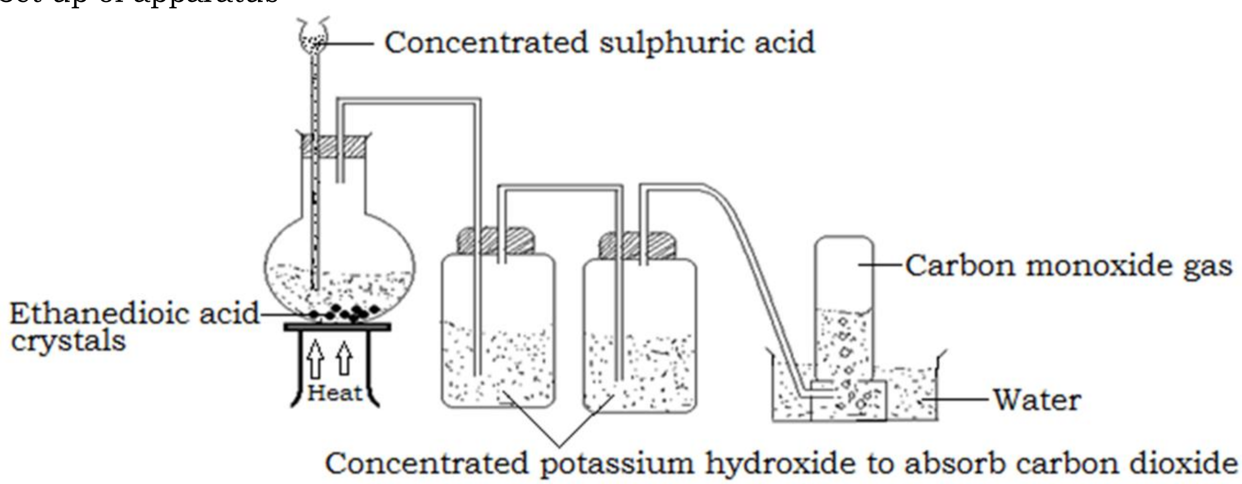
2. Sodium methanoate (HCOONa)

Here, concentrated sulphuric acid dehydrates sodium methanoate to form water, sodium hydrogen sulphate and carbon monoxide.

$$HCOONa(s) + H_2SO_4(aq) \longrightarrow NaHSO_4(aq) + CO(g) + H_2O(l)$$

3. Oxalic acid (ethanedioic acid-$H_2C_2O_4$)

Set up of apparatus



Equation

$$H_2C_2O_{4(s)} \xrightarrow{\text{Conc. } H_2SO_4} CO_{2(g)} + CO_{(g)} + H_2O_{(l)}$$

In this preparation, the products formed are passed through concentrated potassium hydroxide solution to remove traces of carbon dioxide.

$$2KOH(aq) + CO_2(g) \longrightarrow K_2CO_3(aq) + H_2O(l)$$

If the carbon monoxide is required dry, it is passed through a bottle containing conc. Sulhuric acid and collected by use of a syringe or upward displacement of air.

Physical properties of carbon monoxide

- It is colorless, odourless and tasteless.
- It is insoluble in water.
- It is denser than air.
- It is neutral to litmus paper

Chemical properties

a) Reaction with air

Carbon dioxide burns in air with a pale blue flame to produce carbon dioxide.

$$2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$$

b) Reducing action of carbon monoxide

Carbon dioxide is a powerful reducing agent and it reduces the oxides of metals (iron (illustrated in extraction of iron), lead and copper) to respective metals upon heating.

$$\underset{\text{(Black solids)}}{CuO(s)} + CO(g) \longrightarrow \underset{\text{(Brown solids)}}{Cu(g)} + CO_2(g)$$

$$\underset{\text{(Yellow solids-cold)}}{PbO(s)} + CO(g) \longrightarrow \underset{\text{(Grey solids)}}{Pb(s)} + CO_2(g)$$

Poisonous nature of carbon monoxide

Blood contains haemoglobin which combines with oxygen to form oxyhaemoglobin. The oxyhaemoglobin transports and supplies the oxygen to all parts of the body. However, when carbon monoxide is inhaled, it combines with haemoglobin to form carboxyhaemoglobin. This stops the blood from absorbing oxygen and may lead to death.

Haemoglobin has a higher affinity for carbon monoxide than oxygen. Carbon monoxide is even more dangerous because it has no colour and smell.

Uses of carbon monoxide

- It is used extensively in the extraction of metals as a reducing agent e.g. extraction of iron in a blast furnace.
- It is used as fuel in form of producer gas and water gas.
- It is used in the manufacture of methanol used in anti freezer mixture in cold countries to prevent ice from forming in car radiators.
- It is used in the manufacture of synthetic petrol.

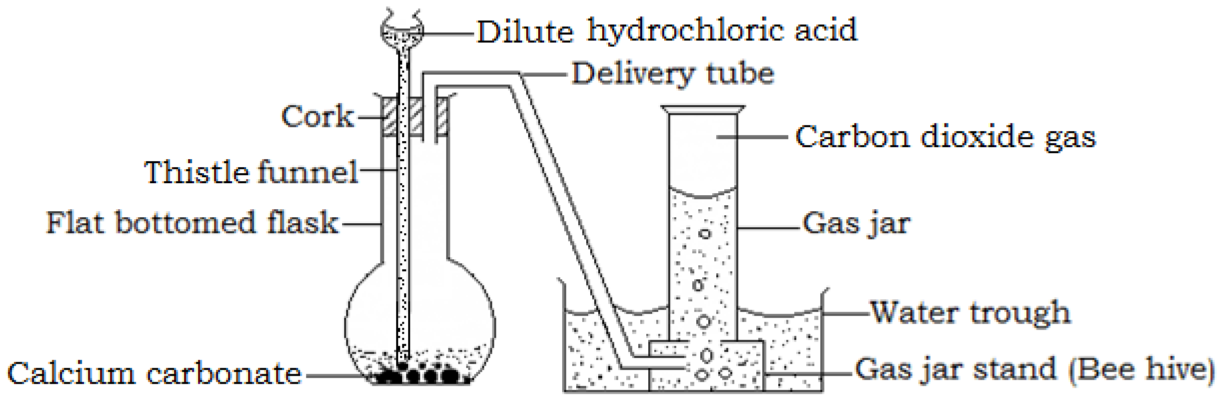
Carbon dioxide (CO_2)

Carbon dioxide occurs in air and occupies 0.03% by volume. Carbon dioxide forms from rocks as a result of volcanic eruption; occurs in mines as ―choke damp‖ and it is always present in natural drinking water because it is slightly soluble in it.

Laboratory preparation

It is prepared by the action of dilute hydrochloric acid on marble chips (a form of calcium carbonate)

Set up of apparatus



Arrange the apparatus as shown above with the calcium carbonate in the flask. Run dilute hydrochloric acid in to the flask through a funnel.

Observation

Effervescence occurs as a colorless gas is given off.

Equation

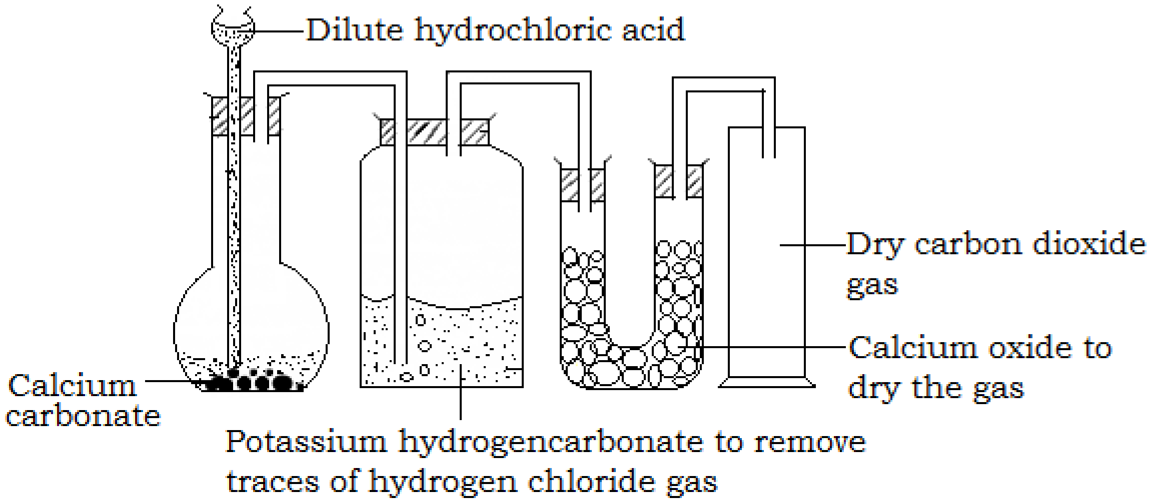
$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$

Ionic equation

$(aq) + 2 \quad (aq) \longrightarrow CO_2(g) + H_2O(l)$

The gas may be collected over water as it is only slightly soluble in water. If the gas is required dry, it is collected by down ward delivery method.

If a pure dry sample of carbon dioxide is require, the gas is first passed through a wash bottle containing concentrated solution of potassium hydrogen carbonate to remove traces of hydrogen chloride gas (water placed in a wash bottle can also be used). It is then passed through a U tube containing fused calcium chloride to dry the gas. The gas is then collected by down ward delivery method since it is denser than air.



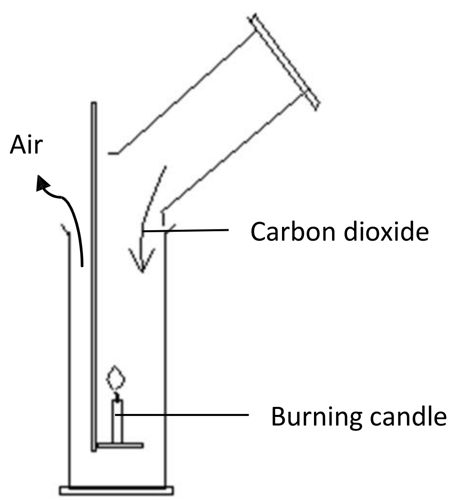
Sulphuric acid is not used in the preparation of carbon dioxide because the salt formed (calcium sulphate) forms a coating on the surface of calcium carbonate and this prevents further reaction between the acid and the calcium carbonate as the calcium sulphate coating is insoluble. The reaction there fore stops prematurely.

Other reactions that produce carbon dioxide include: fermentation; combustion of hydrocarbons; respiration and action of heat on carbonates and hydrogen carbonates.

Properties of carbon dioxide

Physical properties

- It is colorless, odourless and tasteless.
- It does not burn and does not support burning. Because of its density, it is also used as a fire extinguisher as it displaces oxygen that supports burning.
  Illustration



- 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 frizzy drinks (effervescent drinks)

- It is slightly soluble in water forming a weakly acidic solution of carbonic acid.

$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$

- 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.

   $2Mg(s) + CO_2(g) \longrightarrow 2MgO(s) + C(s)$

   In this case, magnesium reduces carbon dioxide to carbon ant 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)

   $Ca(OH)_2(aq) + CO_2(g) \longrightarrow \underset{\text{(White precipitate)}}{CaCO_3(g)} + H_2O(l)$

   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.

   $CaCO_3(s) + H_2O(l) + CO_2(g) \longrightarrow Ca(HCO_3)_2(aq)$

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.

   $2NaOH(aq) + CO_2(g) \longrightarrow Na_2CO_3(aq) + H_2O(l)$

   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.

   $Na_2CO_3(aq) + H_2O(l) + CO_2(g) \longrightarrow \underset{\text{(White precipitate)}}{2NaHCO_3(s)}$

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.

   $2KOH(aq) + CO_2(g) \longrightarrow \underset{\text{(Soluble)}}{K_2CO_3(aq)} + H_2O(l)$

   $K_2CO_3(aq) + H_2O(l) + CO_2(g) \longrightarrow \underset{\text{(Soluble)}}{2KHCO_3(aq)}$

Uses of carbon dioxide

- It is used as a fire extinguisher as it does not support burnng and is denser than air.
- It is used in the manufacture of effervescent drinks. This is because the solution of the gas in water has a pleasant taste (the taste of soda water).
- Solid carbon dioxide (dry ice) is used as a refrigerating agent for perishable goods.
- Carbon dioxide is used in the manufacture of baking powder.
- Solid carbon dioxide (dry ice) is fired into the cloud where it cools to form rain. This
- happens in places where there is unreliable rain fall.

Test for carbon dioxide

When carbon dioxide gas is passed through a solution of calcium hydroxide (lime water), the solution becomes milky. This is due to the formation of calcium carbonate which is insoluble.

$$Ca(OH)_2(aq) + CO_2(g) \longrightarrow \underset{\text{(White precipitate)}}{CaCO_3(s)} + H_2O(l)$$

CARBONATES AND HYDROGEN CARBONATES

These are salts derived from carbonic acid.

Properties

1. Solubility

a) A part from potassium, sodium and ammonium carbonates, all other carbonates are insoluble in water.

b) All solid hydrogen carbonates are soluble in water except sodium hydrogen carbonate which is only slightly soluble. Hydrogen carbonates of metals lower than magnesium in the reactivity series do not exist. Hydrogen carbonates of calcium and sometimes magnesium only exist in solution form.

2. Action of heat on carbonates and hydrogen carbonates

a) Carbonates of sodium, potassium and lithium are not decomposed by heat. However if they are hydrated, they only lose their water of crystallization. E.g.

$$\underset{\text{(White crystals)}}{Na_2CO_3.10H_20(s)} \longrightarrow \underset{\text{(White powder)}}{Na_2CO_3(s)} + 10H_2O(l)$$

b) All the other metal carbonates decompose when heated to form the oxide of the metal and a colorless gas that turns lime water milky (carbon dioxide) e.g.

$$\underset{\text{(Green powder)}}{CuCO_3(s)} \longrightarrow \underset{\text{(Black powder)}}{CuO(s)} + CO_2(g)$$

$$\underset{\text{(White powder)}}{ZnCO_3(s)} \longrightarrow \underset{\text{(Yellow-hot; white-cold)}}{ZnO(s)} + CO_2(g)$$

c) Ammonium carbonate sublimes when heated and forms ammonia, carbon dioxide and water vapor.

$$(NH_4)_2CO_3(s) \longrightarrow 2NH_3(g) + H_2O(g) + CO_2(g)$$

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

$$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

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.

$$2HCl(aq) + CaCO_3(s) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

$$H_2SO_4(aq) + 2NaHCO_3(s) \longrightarrow Na_2CO_3(aq) + CO_2(g) + H_2O(l)$$

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^3 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.

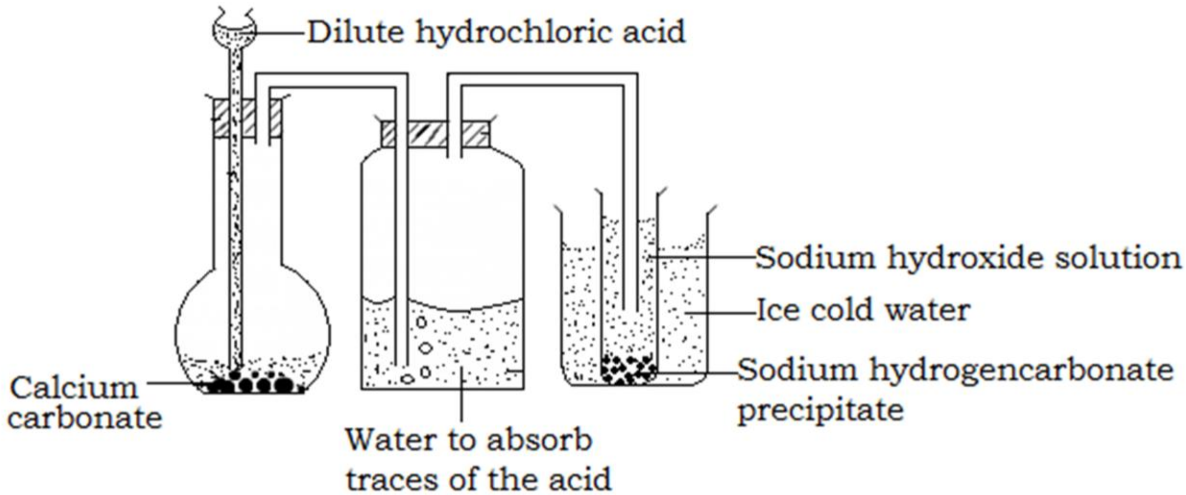
$$Na_2CO_3(s) + Pb(NO_3)_2(aq) \longrightarrow PbCO_3(s) + 2NaNO_3(aq)$$

$$PbCO_3(s) + HNO_3(aq) \longrightarrow Pb(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

Sodium carbonate

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

$$2NaOH(aq) + CO_2(g) \longrightarrow Na_2CO_3(aq) + H_2O(l)$$

$$Na_2CO_3(aq) + H_2O(l) + CO_2(g) \longrightarrow \underset{\text{(White precipitate)}}{2NaHCO_3(s)}$$

- 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.

$$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$$

Commercial preparation of sodium carbonate (Solvay process)

Very concentrated brine (28% sodium chloride) is saturated with ammonia gas in a tower to form 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.

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.

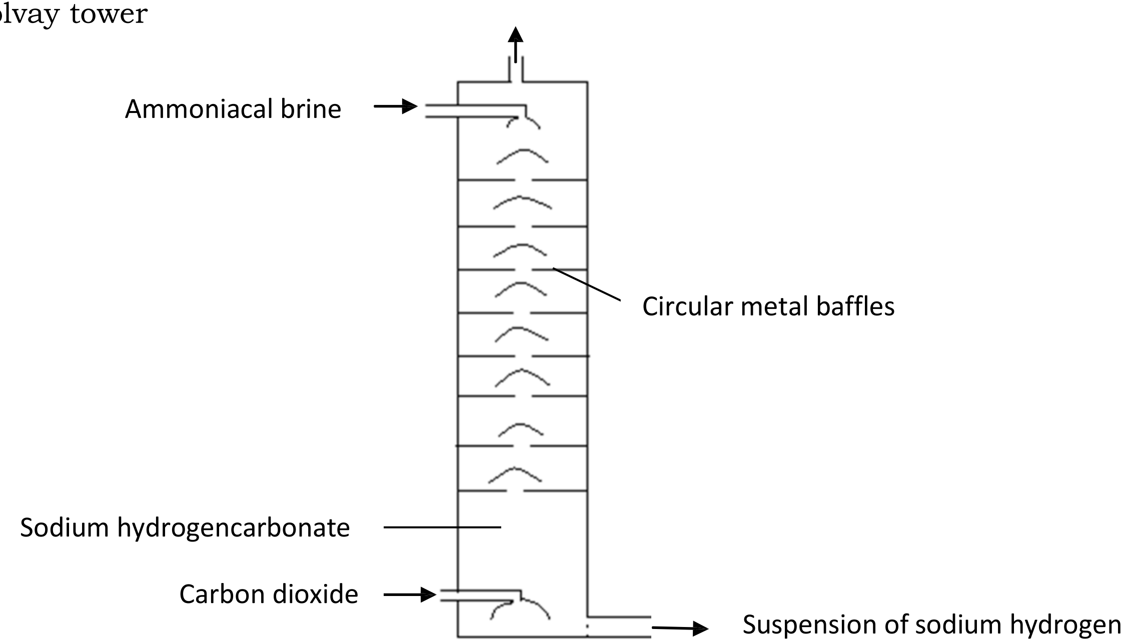
$NaCl(aq) + NH_4OH(aq) + CO_2(g) \longrightarrow NaHCO_3(s) + NH_4Cl(aq)$

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 the heated to form sodium carbonate.

$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$

The anhydrous sodium carbonate formed ha 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.

$Na_2CO_3(aq) + 10H_2O(l) \longrightarrow Na_2CO_3.10H_2O(s)$

Sodium carbonate decahydrate, $Na_2CO_3.10H_2O$ are large translucent crystals. When the crystals are exposed to air, they lose mass and become coated with fine powder which makes is opaque. Each molecule of washing soda gives to the atmosphere 9 molecules of water of crystallization.

$Na_2CO_3.10H_2O(s) \longrightarrow Na_2CO_3.H_2O(s) + 9H_2O(g)$

(Sodium carbonate monohydrate)

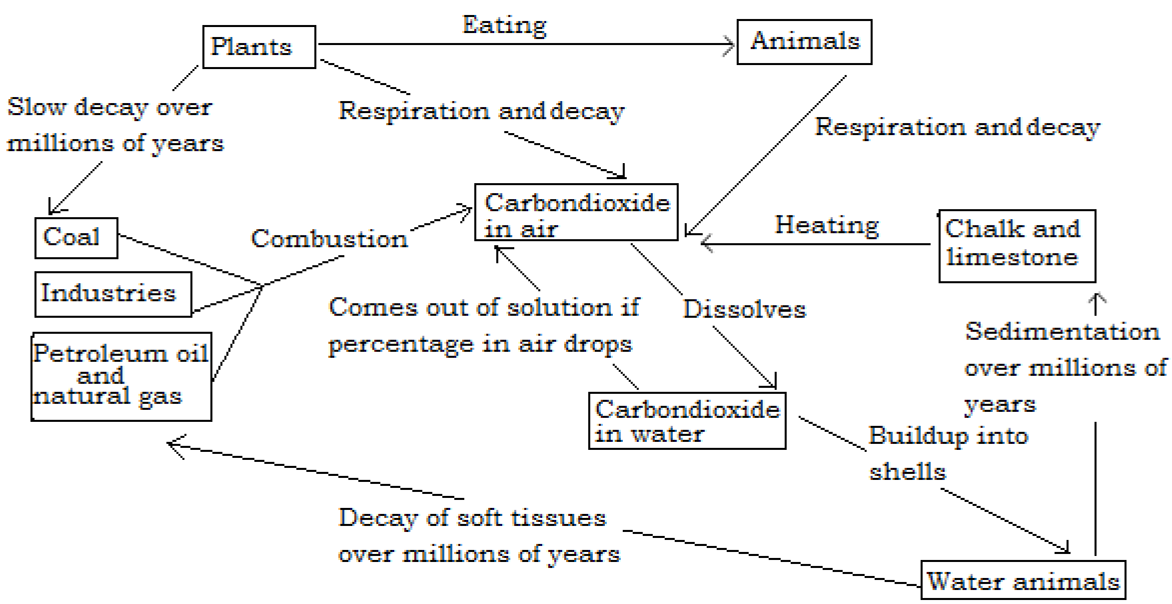
Such lose of water of crystallization to the atmosphere is termed as efflorescence. The substance that loses its water of crystallization is known as an efflorescent substance.

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 in used in domestic water softening. Calcium ions ( ) 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

The sun emits radiations that pass through the atmosphere of the earth with little absorption and warms up the surface of the earth (ground). The warm surface of the earth (ground) reflects back the radiations inform of infrared radiations. The infrared radiation is absorbed by gases like carbon dioxide and methane which radiate some heat back to the ground leading to warming up of the earth. The warming up of the earth is known as greenhouse effect. The gases like carbon dioxide and methane that cause the warming up of the earth are referred to as greenhouse gases.

When more greenhouse gases are released into the atmosphere, much heat accumulates and this leads to general rise in temperature of the world. The general rise in temperature of the world is known as global warming.

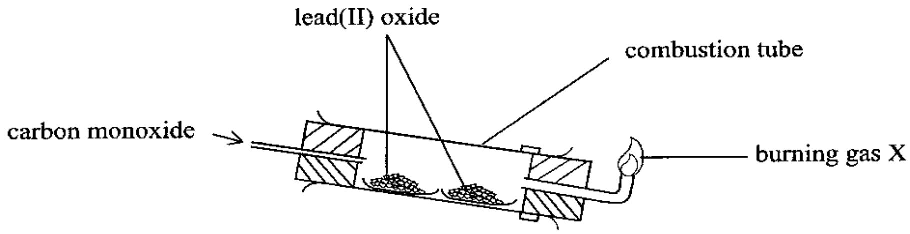
Sample questions

1. (a) Draw a labeled diagram of the set-up of the apparatus that can be used to prepare a dry sample of carbon dioxide in the laboratory
(b) Write an equation that leads to the formation of carbon dioxide
(c) Write an ionic equation for the reaction leading to the formation of carbon dioxide

2. (a). Carbon dioxide was passed through calcium hydroxide solution. Describe and explain the reaction that took place.
(b) i)State what would be observed if burning magnesium ribbon was lowered into a jar of carbon dioxide
ii) Write equation for the reaction that takes place

3. (a) Describe the structure of graphite
(b) State two properties in which graphite differs from diamond
(c) Graphite was heated in excess air and the gas given off passed through aqueous calcium hydroxide for a long time
i) State what was observed
ii)Write equations for the reaction (s)

4. a) Name the element present in pure charcoal
(b) Explain why it is dangerous to use charcoal stove in a poorly ventilated room.
(c) Write an equation for the reaction between charcoal and heated iron (III) oxide.
5. The figure below shows an experimental setup to investigate the effect of carbon monoxide on oxides of metals.



a)
   i) State the conditions for the reaction taking place in the combustion tube.
   ii) Write the equation for the reaction taking place in the combustion tube.

b)
   i) Name the gas X being burnt at the jet.
   ii) Why is it necessary to burn gas X?
   iii) Write equation for the combustion of gas X.

c) Name any other oxide that can be used instead of lead(II) oxide.

d) What would you expect to happen if lead (II) oxide was replaced with magnesium oxide? Give a reason for your answer.

6. (a) State what would be observed if sodium carbonate solution was added to:

   (i) Aqueous calcium hydroxide.
   (ii) Dilute sulphuric acid.

(b) Write ionic equations for the reactions in (a) (i) and (ii).

7. A mixture containing copper (II) sulphate and copper (II) carbonate was shaken with water and filtered.
(a) Identify the residue.
(b) To the residue was added dilute sulphuric acid.
   (i) State what was observed.
   (ii) Write the equation for the reaction.

8. (a) Zinc carbonate was strongly heated in a test-tube until no further change.
   (i) State what was observed.
   (ii) Write the equation for the reaction which took place.

(b) The residue formed in (a) above was added to dilute sulphuric acid and heated.
   (i) Write the equation for the reaction.
   (ii) State what was observed.

9. (a) Define allotropy.
(b) Give the three allotropes of carbon.

(c) Give two examples of other elements which show allotropy and name their allotropes.

10. (a) Name two common reagents used in the laboratory preparation of carbon dioxide.
(b) State what is observed when carbon dioxide is bubbled in fairly concentrated sodium hydroxide solution for some time.
(c) Write the equation(s) of the reaction(s) that take(s) place.

11. (a) Describe the structure of graphite.
(b) Explain why graphite conducts electricity whereas diamond does not.
(c) State any two uses of diamond.
(d) Describe how you would show by a chemical test that graphite is made up carbon atoms.

12. Carbon monoxide was passed over strongly heated copper (II) oxide.
(i) State what was observed.
(ii) Write the equation for the reaction.
(iii) Name any other oxide that shows similar reaction with carbon monoxide.

13. (a) Draw a well labeled diagram for preparation of sodium carbonate in the laboratory.
(b) (i) What is observed when washing soda (Na2CO3.10H2O) is exposed to atmosphere for some time.

14. (a) Copper (II) carbonate was heated strongly until there was no further change.
(i) State what was observed.
(ii) Write an equation for the reaction.
(iii) Name one reagent which can be used to identify the gaseous product.
(b) Excess dilute sulphuric acid was added to the residue in (a) and the mixture warmed.
(i) State what was observed.
(ii) Write an equation for the reaction.

15. (a) (i) How can calcium oxide (quicklime) be obtained on large scale? Diagram not required.
(ii) Write equation for the reaction that occurs.
(b) (i) What would be observed when fresh calcium oxide is added to water in a beaker?
(ii) Write equation for the reaction that would occur.
(c) Dilute hydrochloric acid was added to calcium oxide.
(i) State what is observed.
(ii) Write the equation for the reaction that occurs.