**AIR AND WATER, SULPHUR, CARBONATES**

**AIR AND WATER**

**Purification of water:**

1. Water is pumped from a source such as river.

2. Water is then stored in a reservoir.

3. A coagulant is added so small particles coagulated to form solid lumps.

4. Sedimentation tank in which large solid lumps settle to the bottom

5. The sand beds filter out small solid particles.

6. In the chlorination house chlorine is added in calculated quantity to kill germs.

7. The pumping station pumps drinking water to users.

**USES OF WATER:**

1. Over 2/3 of our bodies is water.
2. Cooling system in industry.
3. In industry uses.
4. As a solvent.
5. Producing steam for driving turbines.
6. Raw material in the manufacture of ammonia and ethanol.
7. Different uses at home.

**TEST FOR WATER:**

Chemical test:

By the addition of few drops to white anhydrous copper(II) sulphate the colour will change from white to blue due to the formation of hydrated copper(II) sulphate CuSO4.5H2O

By the addition of few drops of water to blue anhydrous cobalt (II) chloride, the colour will change to pink due to the formation of hydrated cobalt (II) chloride CoCl2.6H2O

Physical test:

Pure water boils at 100.00c at r.t.p.

**AIR**

The composition of air:

Air is composed of 79% Nitrogen, 20% Oxygen, 1% Carbon dioxide, water vapour and inert gases.

**FRACTIONAL DISTILLATION OF LIQUID AIR:**

1. Air is passed through filters to remove dust from it.
2. Cool air to -70.00C to collect carbon dioxide as dry ice and water vapour is also collected as ice because it freezes at 0.00c
3. Compress air to 100 atmosphere then allow it to expand suddenly and then cool it, this has to be recycled many times until air becomes liquid at -200.00c
4. Fractional distillation of liquid air then starts.
5. At -198.00c Nitrogen is collected as nitrogen gas.
6. At -190.00c Argon is collected as Argon gas.

7. Oxygen is then collected as liquid Oxygen as it remains after the collection of all the others, its b.p is 183.00c.

**N.B:**

**Fractional distillation is performed in insulated and contains perforated shelves bring ascending and descending gases.**

**The fractions can be purified by redistillation.**

**Oxygen, Nitrogen, and Argon are stored under pressure in strong metal cylinders.**

**OXYGEN**

Oxygen is essential for respiration, rusting, and combustion to occur.

* + **Respiration**: the relatively slow 'burning' of carbohydrates in animals/plants, but it releases plenty of energy at 37oC!
    - glucose + oxygen ==> carbon dioxide + water + energy
    - **C6H12O6(aq) + 6O2(g)** ==> **6CO2(g) + 6H2O(l) + energy**

**Rusting** in which iron **slowly** reacts with water and oxygen (from air) to form the orange-brown **hydrated iron** oxide we call ***rust***.

**A burning or** **combustion reaction** usually means a very fast **exothermic** reaction where a flame is observed. It involves a highly energetic oxidation of 'fuels' where the temperature generated is so high and presence of Oxygen is essential.

FUEL + OXYGEN → PRODUCT + VERY HIGH HEAT

**USES OF OXYGEN:**

1. Making steel as explained previously.
2. For breathing in hospitals, people with lung diseases, premature babies, during surgeries mixed with anaesthetic.
3. For oxyaceltylene flame.

Acetylene + Oxygen → Carbon dioxide + water + Energy.

2 C2H2 + 5 O2 → 4 CO2+ 2 H2O + 33000C

This reaction produces very high heat which is used in welding metals, it produces very strong flame and it has to be surrounded by inert atmosphere of inert gas not to catch fire with other unwanted things.

NITROGEN

Nitrogen is used in the manufacture of ammonia by the Haber process.

* **Ammonia gas is synthesised** in the chemical industry by **reacting nitrogen gas with hydrogen gas** in what is known as the **Haber-Bosch Process**, named after two highly inventive famous chemists.
* The **nitrogen is obtained from** **liquified air** (80% N2) as illustrated previously, the **hydrogen is made by reacting methane (natural gas) and water** or from cracking hydrocarbons (both reactions are done at high temperature with a catalyst).
  + **CH4 + H2O** ==> **3H2 + CO**
  + e.g. **C8H18** ==> **C8H16 + H2**
* The synthesis equation for this **reversible reaction** is ...
  + **N2(g) + 3H2(g) (c) doc b2NH3(g)**
* .. Which means **an equilibrium will form**, so there is no chance of 100% yield even if you use, as you actually do, the theoretical reactant ratio of nitrogen : hydrogen of 1 : 3 !
* The forward reaction is exothermic so increasing temperature will favour the backward reaction.
* Four moles of 'reactant' gas form two moles of 'product' gas, so increasing pressure will shift the whole reaction towards the formation of ammonia.
* So as explained previously increasing pressure is a must whereas increasing temperature is for the activation of the catalyst not to slow down the rate of the reaction.
* Reaction conditions:
* In industry pressures of **200 - 300 atmospheric pressure** .
  + **To speed up the reaction** an **iron catalyst** is used as well as a **higher temperature** (e.g. **400-450oC**).
  + The higher temperature is an economic compromise, i.e. it is more economic to get a low yield fast, than a high yield slowly!
* **Gas mixture is cooled under high pressure, when only the ammonia liquefies and is so can be removed and stored in cylinders**.
* **Any unreacted nitrogen or hydrogen (NOT liquified), is recycled back through the reactor chamber**.

Ammonia is used for the manufacture of artificial fertilizers.

**ARTIFICIAL FERTILIZERS**

Nitrogen, potassium, and phosphorous are essential for fertilizers (NPK)

|  |  |
| --- | --- |
| Fertilizer | Effect on plant |
| Nitrogenous | Increases size crop and protein content of plant |
| Phosphates | Stimulates root development |
| potassium | Helps plants to carry on photosynthesis. |
| Sodium | Usually no need for its addition unless sugar beet soil. |

N.B.

Ammonium fertilizers can't be ammonia as it is poisonous and volatile.

2NH3(aq)+ H2SO4(aq)→ (NH4)2SO4(aq)

The same also with nitric acid to form ammonium nitrate.

Now air is highly pollutant by other chemical substances.

**AIR POLLUTION**

|  |  |  |
| --- | --- | --- |
| Pollutant | Source | Effect |
| Carbon monoxide | Incomplete combustion of carbon containing substances | Combines with haemoglobin 200 times faster than air to form a stable compound carboxy haemoglobin which finally leads to death. |
| Lead compounds | Combustion of coal.  Roasting of metals' ores.  Vehicle engine.  Tetra ethyl lead added to car fuel (T.E.L) | Depression-tirdness –irritability –headache – Higher levels of lead damage brain of the children, liver and kidney. |
| Sulphur dioxide | Sulphur dioxide is formed mainly from the combustion of fossil fuels which contain sulphur | By the oxidation of sulphur dioxide in the atmosphere it changes into sulphur trioxide which then reacts with water vapour in the atmosphere to give sulphuric acid, and then it falls with rains as acidic rains.  **S(in fuel molecules) + O2(g)** ==> **SO2(g)**  **SO2(g-air) + O2(g-air) + 2H2O(l-rain)** ==> **2H2SO4(aq-rain)**  Bad effect of acid rains:   1. On building   It reacts with calcium carbonate in the building to form calcium sulphate instead.   1. On plants   It reacts with soluble salt in the soil to form insoluble salts so plant can not get benefit from them as it will not be able to absorb them.   1. On marine life   It damages marine life as it changes the pH of the water and so some aquatic animals and plants die. |
| Nitrogen oxides | Mortor vehicles, lightining, combustion of fossil fuels containing nitrogen | 1. Acid rain   The same as with sulphur oxides, nitrogen oxides form nitric acid which is very dangerous especially on buildings as when it reacts with insoluble calcium carbonate it gives calcium nitrate which is soluble, also it is harmful in marine life due to same reasons.   1. It causes lung diseases, skin and eye irritation. |

CATALYTIC CONVERTERS:

It is a part connected to the car to change Nitrogen oxides into Nitrogen and Carbon monoxide into Carbon dioxide.

NO +CO → N2 + CO2 By passing through catalytic converter.

Leaded petrol should be avoided as it damages the catalytic converter and it causes pollution as explained previously.

**SULPHUR**

**SOURCES:  
1.** In some ores like copper pyrite (CuFeS2) and Zinc blend (ZnS). 2. From Volcanic regions.

1. Usually found with fossil fuels mixed with natural gas and petroleum and this kind of sulphur is called recovered sulphur.
2. As sulphur beds under ground in USA, Poland, and Russia, they are typically 200 meters under ground.

**SULPHUR DISCRIBTION:**

It is yellow solid non-metallic element; its molecule is composed of 8 atoms S8.

**ALLOTROPS of SULPHUR:**

It has 2 allotropes Monoclinic sulphur and Rhombic Sulphur.

**USES OF SULPHUR:**

1. For the manufacture of sulphuric acid.
2. For medical reasons such as formation of some kinds of ointments.
3. For the formation of sulphur dioxide which is used for beaching wood pulp in paper industry and for preserving fruits as pest side.
4. For making carbon disulphide which is used as a solvent.
5. It is also needed for the manufacture of detergents.

**The manufacture of sulphuric acid from sulphur by contact process**

* **(1)** Sulfur is burned in air to form sulphur dioxide (exothermic).

**S(s) + O2(g)** ==> **SO2(g)**

* **(2) (2) 2SO2(g) + O2(g) (c) doc b 2SO3(g)** In the reactor, the sulphur dioxide is mixed with air (to give the required SO2:O2 2:1 ratio) and the mixture passed over a catalyst of vanadium(V) oxide V205 (vanadium pentoxide) at a high temperature (about 450°C) and at a pressure of between one and two atmospheres. It is a 2nd exothermic oxidation and is known as the **Contact Process**. These conditions are for preventing the reversible reaction and to produce Sulphur trioxide.
* **(3)** The sulphur trioxide is dissolved in concentrated sulphuric acid to form fuming sulphuric acid (oleum).
  + **SO3(g) + H2SO4(l)** ==> **H2S2O7(l)**
* **4)** Water is then carefully added to the oleum to produce concentrated sulphuric acid (98%).
  + **H2S2O7(l) + H2O(l)** ==>**2H2SO4(l)**
  + If the sulphur trioxide is added directly to water an acid mist forms which is difficult to contain because the reaction to form sulphuric acid solution is very exothermic.

**N.B**

**Sulphur trioxide is not added directly to water not to form a mist.**

**Upon the dilution of sulphuric acid it is added to water and not the opposite.**

**PROPERTIES OF SULPHURIC ACID:  
1.** Turns blue litmus paper into red.

2. Reacts with most metals to give a salt + hydrogen.

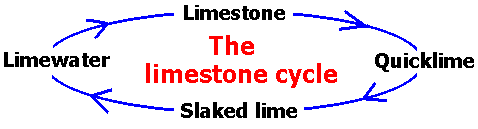
3. Reacts with bases to give salt and water.

4. It is a di basic acid so it can form two different kinds of salts such as sodium sulphate and sodium hydrogen sulphate.

**USES OF SULPHURIC ACID:**

* 1. It is used as a drying agent for the absorption of water.
  2. It is used in the manufacture of fertilizers.
  3. It is used in the manufacture of detergents.
  4. It is used in car battery.

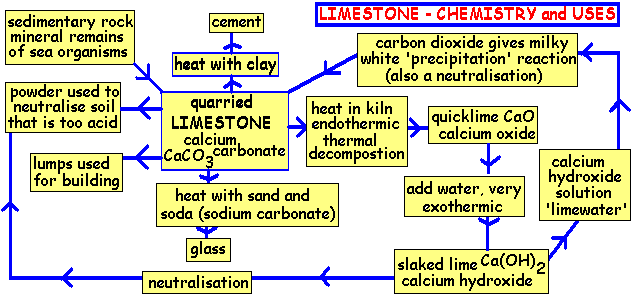
**CARBONATES**



**Calcium carbonate:** Lime stone- chalk- marble

**Calcium hydroxide:** Lime water- slacked lime.

**Calcium oxide:** Lime- quick lime.



**MANUFACTURE OF CEMENT**

1. Lime stone and chalk are crushed with cay or shale.
2. The crushed materials are introduced to rotator kiln which is then heated usually by kerosene.
3. Calcium sulphate (gypsum) is then added to the mixture not to setting very quickly.
4. The cement is then produced.
   1. calcium carbonate (limestone) ==> calcium oxide (quicklime) + carbon dioxide
   2. **CaCO3(s) (c) doc bCaO(s) + CO2(g)**
   3. This is a **reversible endothermic reaction**. To ensure the change is to favour the right hand side, a high temperature of over 900oC is needed as well as the continual removal of the carbon dioxide.
   4. **calcium oxide** (quicklime) **+ water** ==> **calcium hydroxide** (slaked lime)
      1. this is a very **exothermic** reaction, the quicklime 'puffs' up and steam is produced!
      2. **CaO(s) + H2O(l)** ==> **Ca(OH)2(s)**
      3. with excess water followed by filtration you get calcium hydroxide solution or **limewater**.