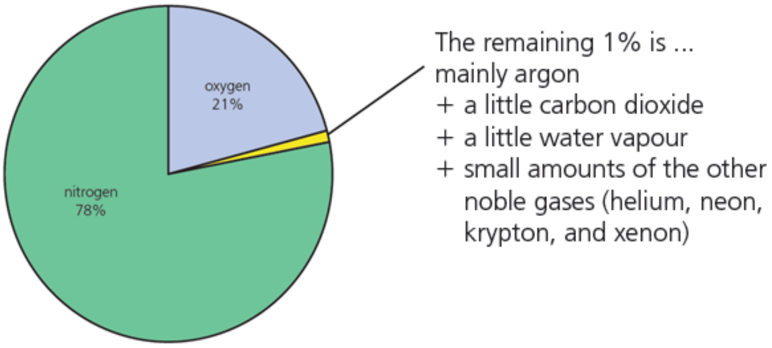
AIR AND WATER

Air:-



Separating gases from the air:

Air is a mixture of gases. Most of them are useful to us. But first, we must separate them from each other.

- ✓ First, the air is cooled until it turns into a liquid.
- ✓ Then, the liquid mixture is separated using a method called **fractional distillation**.

The fractional distillation of liquid air:-

This method works because the gases in air have different boiling points. So when liquid air is warmed up, the gases boil at different temperatures, and can be collected one by one.

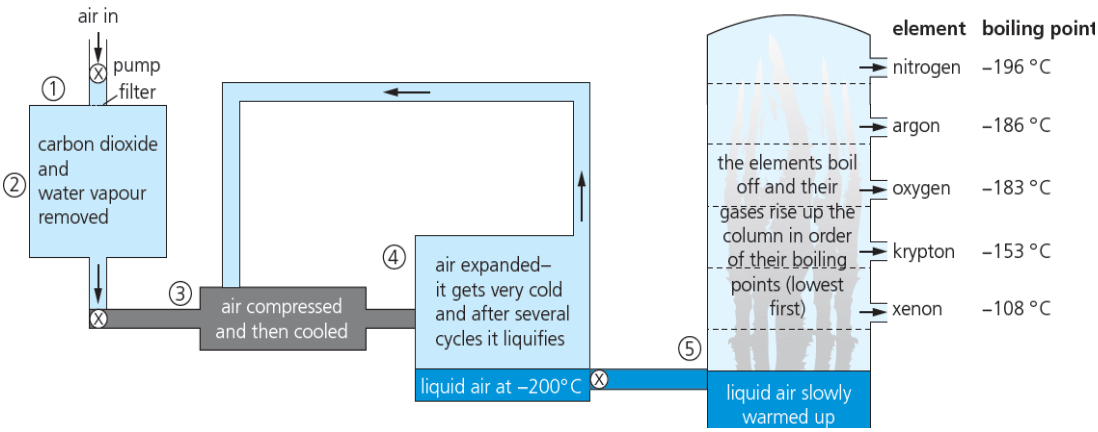


Fig: Fractional distillation of liquid air

The steps:

1. Air is pumped into the plant, and filtered to remove dust particles.
2. Next, water vapour, carbon dioxide, and pollutants are removed (since these would freeze later and block the pipes). Like this:
   – First the air is cooled until the water vapour condenses to water.
   – Then it is passed over beds of adsorbent beads to trap the carbon dioxide, and any pollutants in it.
3. Now the air is forced into a small space, or **compressed**. That makes it hot. It is cooled down again by recycling cold air, as the diagram shows.
4. The cold, compressed air is passed through a jet, into a larger space. It expands rapidly, and this makes it very cold.

(Steps 3 and 4 are repeated several times. The air gets colder each time. By 2200 °C, it is liquid, except for neon and helium. These gases are removed. They can be separated from each other by adsorption on charcoal).

5. The liquid air is pumped into the fractionating column. There it is slowly warmed up. The gases boil off one by one, and are collected in tanks or cylinders. Nitrogen boils off first.

<u>Making use of Air:-</u>

Some uses of oxygen:

- ✓ Planes carry oxygen supplies. So do divers and astronauts.
- ✓ In hospitals, patients with breathing problems are given oxygen through an **oxygen mask**, or in an **oxygen tent**. This is a plastic tent that fits over the bed. Oxygen-rich air is pumped into it.
- ✓ In steel works, oxygen is used in converting the impure iron from the blast furnace into steels.
- ✓ A mixture of oxygen and the gas **acetylene** (C_2H_2) is used as the fuel in **oxy-acetylene torches** for cutting and welding metal. When this gas mixture burns, the flame can reach 6000°C. Steel melts at around 3150°C, so the flame cuts through it by melting it.

Some uses of nitrogen:

- ✓ Liquid nitrogen is very cold. (It boils at 2196 °C.) So it is used to quick-freeze food in food factories, and to freeze liquid in cracked pipes before repairing them. It is also used in hospitals to store tissue samples.
- ✓ Nitrogen is unreactive. So it is flushed through food packaging to remove oxygen and keep the food fresh. (Oxygen helps decay).

Some uses of the noble gases:

The noble gases are unreactive or **inert**. This leads to many uses.

- ✓ Argon provides the inert atmosphere in ordinary tungsten light bulbs. (In air, the tungsten filament would quickly burn away.)
- ✓ Neon is used in advertising signs because it glows red when a current is passed through it.
- ✓ Helium is used to fill balloons, since it is very light, and safe.

<u>Main Air Pollutants:</u>

Pollutant	How is it formed?	What harm does it do?
Carbon monoxide, CO colourless gas, insoluble, no smell	Forms when the carbon compounds in fossil fuels burn in too little air. For example, inside car engines and furnaces.	Poisonous even in low concentrations. It reacts with the **haemoglobin** in blood, and prevents it from carrying oxygen around the body – so you die from oxygen starvation.
Sulfur dioxide, SO_2 an acidic gas with a sharp smell	Forms when sulfur compounds in the fossil fuels burn. Power stations are the main source of this pollutant.	Irritates the eyes and throat, and causes **respiratory** (breathing) problems. Dissolves in rain to form **acid rain**. Acid rain attacks stonework in buildings, especially limestone and marble – they are calcium carbonate. It lowers the pH in rivers and lakes, killing fish and other river life. It also kills trees and insects.
Nitrogen oxides, NO and **NO_2** acidic gases	Form when the nitrogen and oxygen in air react together, inside hot car engines and hot furnaces.	Cause respiratory problems, and dissolve in rain to give acid rain.
Lead compounds	A compound called tetra-ethyl lead used to be added to petrol, to help it burn smoothly in car engines. It is still added in some countries. On burning, it produces particles of other lead compounds.	Lead damages children's brains. It also damages the kidneys and nervous system in adults.

Reducing air pollution:

These are some steps being taken to cut down air pollution.

- ✓ In modern power stations, the waste gas is treated with slaked lime (calcium hydroxide). This removes sulfur dioxide by reacting with it to give calcium sulfate. The process is called **flue gas desulfurisation**.
- ✓ Most countries have now banned lead in petrol. So lead pollution is much less of a problem. But it can still arise from plants where lead is extracted, and from battery factories.
- ✓ The exhausts of new cars are fitted with **catalytic converters**, in which harmful gases are converted to harmless ones. See below.

Catalytic converters for car exhausts:

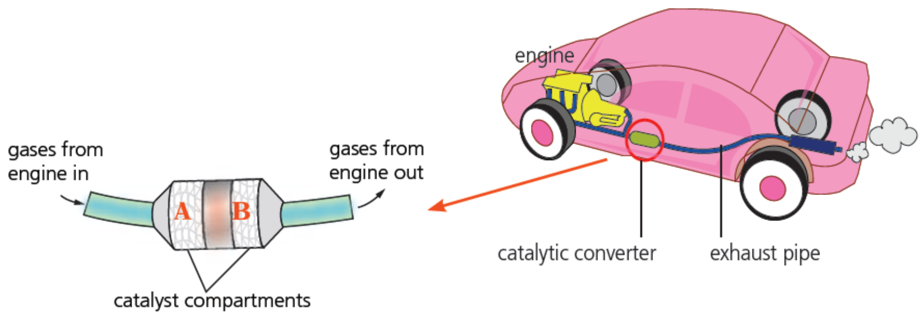
When petrol burns in a car engine, harmful gases are produced, including:

- oxides of nitrogen,
- carbon monoxide, CO
- unburnt hydrocarbons from the petrol;

these can cause cancer.

To tackle the problem, modern car exhausts contain a **catalytic converter**.

In this, the harmful gases are absorbed onto the surface of catalysts, where they react to form harmless gases. The catalysts speed up the reaction. The converter usually has two compartments, marked A and B below:



In **A**, harmful compounds are **reduced**.

For example, 2NO (*g*) -→ N2 (*g*) + O2 (*g*)

The nitrogen and oxygen from this reaction then flow into **B**.

In **B**, harmful compounds are **oxidised**, using the oxygen from **A**.

For example, 2CO (*g*) + O2 (*g*) -→ 2CO2 (*g*)

The harmless products then flow out the exhaust pipe.

The catalysts are usually the transition elements platinum, palladium, and rhodium. They are coated onto a ceramic honeycomb, or ceramic beads, to give a large surface area for adsorbing the harmful gases. The harmless products flow out the exhaust pipe.

<u>Rusting Problem:-</u>

The corrosion of iron and steel has a special name: **rusting**.

The red-brown substance that forms is called **rust.**

Rusting requires oxygen and water.

In fact, the iron is oxidized, in this reaction:

4Fe (*s*) + 3O2 (*g*) + 4H2O (*l*) -→ 2Fe2O3.2H2O (*s*)
iron + oxygen + water hydrated -→ iron(III) oxide (rust).

To prevent rusting:

Iron is the most widely used metal in the world – for everything from needles to ships. But rusting destroys things. To prevent rusting, there are two approaches.

Approach-1: Cover the Iron:

The aim is to keep out oxygen and water. You could use:

- ✓ **Paint**. Steel bridges and railings are usually painted.
- ✓ **Grease**. Tools and machine parts are coated with grease or oil.
- ✓ **Another metal**. Iron is coated with **zinc**, by dipping it into molten zinc, for roofing. Steel is electroplated with zinc, for car bodies. Coating with zinc has a special name: **galvanizing**. For food tins, steel is coated with **tin** by electroplating.

Approach-2: Let another metal corrode instead

During rusting, iron is oxidized, that is, it loses electrons. Magnesium is more reactive than iron, which means it has a stronger drive to lose electrons. So when a bar of magnesium is attached to the side of a steel ship, or the leg of an oil rig, it will corrode instead of the iron.

Without magnesium: $Fe \longrightarrow Fe^{2+} + 2e^-$
With magnesium: $Mg \longrightarrow Mg^{2+} + 2e^-$

The magnesium dissolves. It has been sacrificed to protect the iron. This is called **sacrificial protection**.
The magnesium bar must be replaced before it all dissolves. Note that zinc could also be used for this.

Water:-

We all need water;

- ❖ **At home** we need it for drinking, cooking, washing things (including ourselves) and flushing toilet waste away.
- ❖ **On farms** it is needed as a drink for animals, and to water crops.
- ❖ **In industry**, they use it as a solvent, and to wash things, and to keep ot reaction tanks cool. (Cold-water pipes are coiled around the tanks.)
- ❖ **In power stations** it is heated to make steam. The steam then drives the turbines that generate electricity.

Much of the water we use is taken from rivers. But some is pumped up from below ground, where water that has drained down through the soil lies trapped in rocks. This underground water is called

groundwater. A large area of rock may hold a lot of groundwater, like a sponge. This rock is called an **aquifer.**

River water is not clean – even if it looks it! It will contain particles of mud, and animal waste, and bits of dead vegetation. But worst of all are the **microbes**: bacteria and other tiny organisms that can make us ill. Over 1 billion people around the world have no access to clean water. They depend on dirty rivers for their drinking water. And over 2 million people, mainly children, die each year from **diarrhea** and diseases such as **cholera** and **typhoid**, caused by drinking infected water.

Providing a clean water supply on tap:

1 Find a clean source – a river or aquifer – to pump water from.

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2 Remove as many solid particles from the water as you can.
- You could make fine particles stick together and skim them off.
- You could filter the water through clean gravel or sand.

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3 Add something to kill the microbes in the water. (Usually chlorine.)

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4 Store the water in a clean covered reservoir, ready for pumping to taps.

A modern treatment plant:-

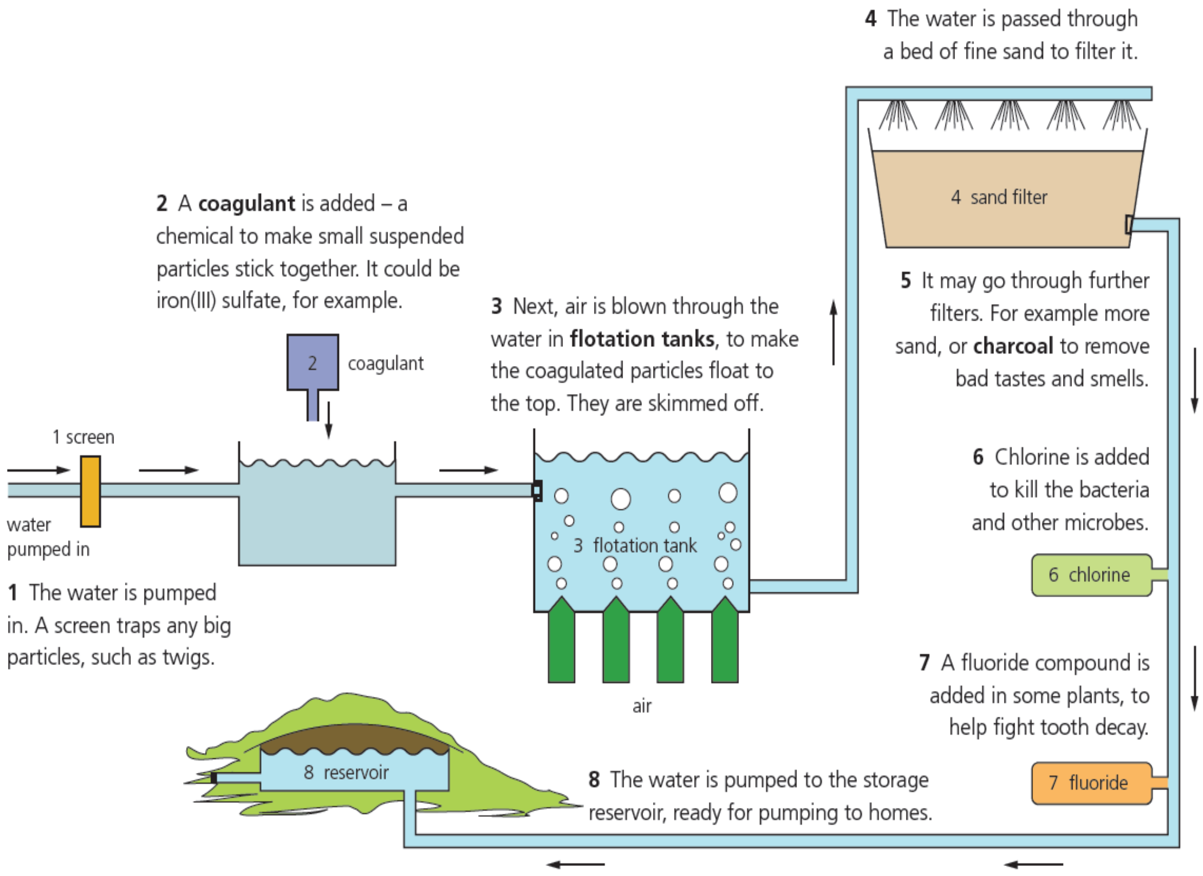

Fig: modern water treatment plant.

This treatment can remove even the tiniest particles, and chlorine can kill all the microbes. But, the water may still have harmful substances dissolved in it. For example, nitrates from fertilizers that can make babies ill.
It is possible to remove dissolved substances, using special membranes. But that is very expensive, and is not usually done. The best solution is to find the cleanest source if you can, for your water supply.

<u>Two tests for water:</u>

If a liquid contains water, it will …

- ✓ turn white anhydrous copper(II) sulfate blue
- ✓ turn blue cobalt chloride paper pink.

Both colour changes can be reversed by heating.