Air and water

A chemical test for water:

1. Water turns white anhydrous copper (II) sulphate blue

Copper (II) sulphate + water > Copper (II) sulphate-5-water

$CuSO_4$	$+ 5\ H_20$	=	$CuS0_4.5H_20$
White solid			blue solid

2. Water turns blue anhydrous cobalt (II) chloride pink.

Cobalt (II) chloride + water > Cobalt (II) chloride -6-water

$CoCl_2$	$+ 6\ H_2O$ =	$CoCl.6\ H_20$
Blue solid		pink solid

3. Pure water boils at 100 degrees Celsius and freezes at 0 degrees Celsius.

The purification of water:

The process of water treatment involves filtration and chlorination

Most tap water is obtained from lakes and rivers. The water should be treated to make it suitable for drinking with no pollution or contamination and with a pleasant taste and smell.

The water is pumped in through a screen, which gets rid of the larger bits of rubbish.

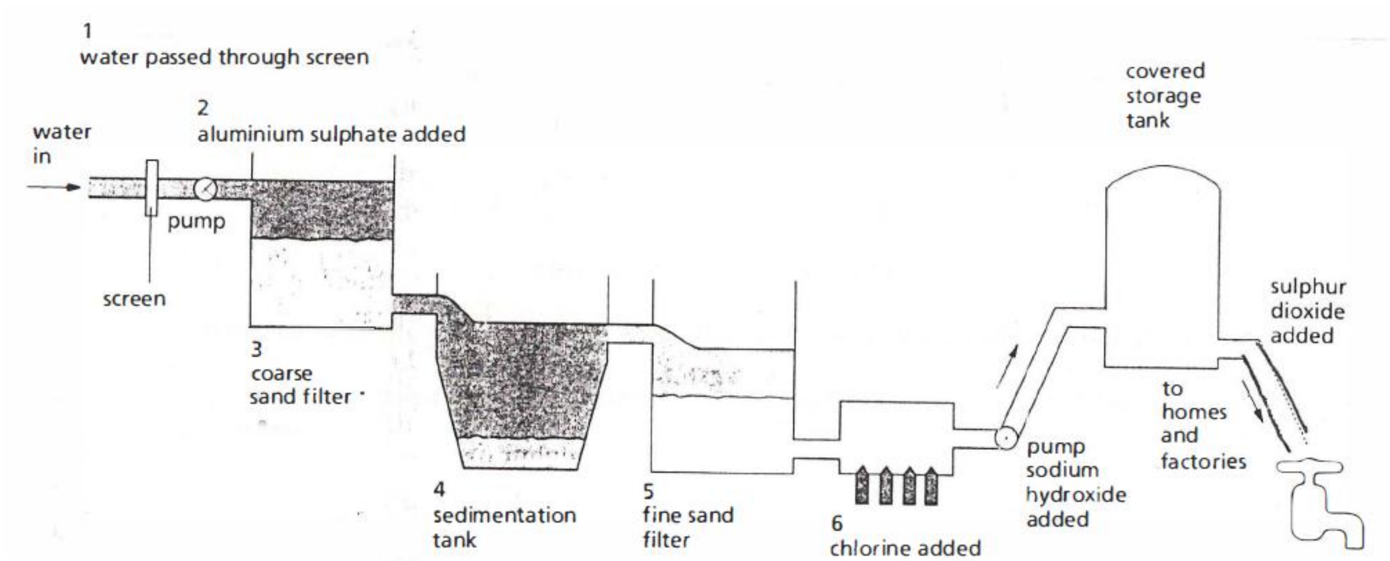
Then it goes through these stages:
1. It is filtered through a bed of coarse sand, which traps the larger particles of solid

2. Next it flows into a sedimentation tank where chemicals such as aluminum sulphate are added to make the smaller particles stick together and sink to the bottom of the tank

3. These particles are removed by further filtration through fine sand (lime is added to adjust acidity)

4. Finally a little chlorine gas is added to kill any remaining bacteria. (Instead of Cl_2, ozone gas can be added). Excess chlorine can be removed by the addition of sulphur dioxide gas. The addition of Cl2 gas makes the water more acidic so NaOH is added

In some places, a fluoride compound is also added to the water, to help prevent tooth decay.



Uses of water:

1. In industry:

- As a solvent in many industries, e.g. paper industry
- Manufacture of hydrogen and oxygen by electrolysis of water
- Much water is used for cooling. Power stations are built near rivers or coasts so that they can have continuous supplies of water for the cooling towers
- In production of electricity

2. In the home:

- Drinking
- Washing
- Cooking

Air:

The composition of air varies from one place to another because air is a mixture of gases. The composition by volume of a typical sample of air is approximately 79% nitrogen, 20% oxygen, and the remainder is a mixture of noble gases (helium, neon, argon, krypton, and xenon), carbon dioxide and water vapour.

Air pollution

The most common source of air pollution is the combustion of fossil fuels. This usually happens in vehicle engines and power stations.

The four common air pollutants are:

- Carbon monoxide, CO

CO is a colorless, odorless, toxic gas produced when fuels containing carbon are burned where there is too little oxygen. The main source of CO is the incomplete combustion of petrol in car engines and factories that use fossil fuels.

CO is poisonous gas that prevents haemoglobin in the blood from absorbing oxygen. At a level of 1%, CO will kill quickly; at lower levels it causes headaches and dizziness.

- Sulphur dioxide, $S0_2$

Fossil fuels (coal and oil) always contain sulphur. When burned, sulphur dioxide is formed. Factories and power stations burn coal, which contains sulphur too.

Sulphur dioxide ($S0_2$) is a colourless, nonflammable gas with a penetrating odour that irritates the eyes and air passages.

$S0_2$ causes bronchitis and lung diseases. It also dissolves in rainwater to form sulphurous acid. This acid rain damages buildings, trees and plants.

- Oxides of nitrogen

These are an indirect result of burning fossil fuels. Inside car engines and power station furnaces, the air gets so hot that its nitrogen and oxygen react together, forming oxides of nitrogen.

$N_2 + O_2 = 2NO$
$2NO + O_2 = 2NO_2$

About 30-40% of the nitrogen oxides come from vehicle exhausts and power-stations. $N0_2$ is highly corrosive and toxic. Nitrogen oxides dissolve in water to form nitric acid leading to acid rain.

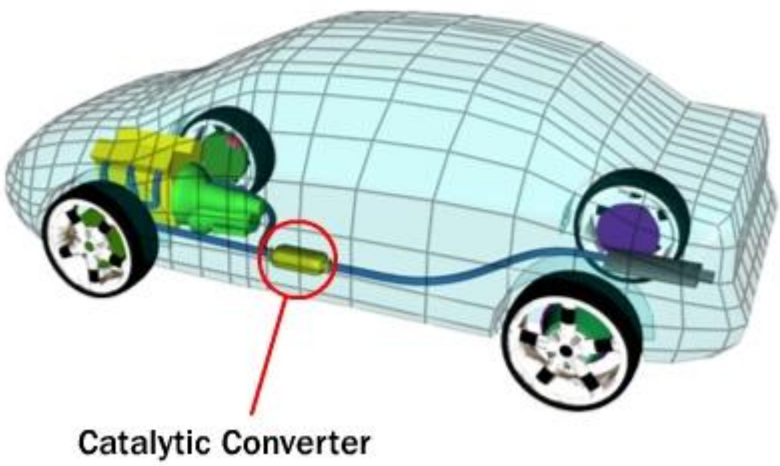
- Lead compounds

A lead compound called tetraethyl lead is added in small quantities to petrol to increase the octane number of petrol (improve performance). When the petrol burns in the engine, lead compounds are released from car exhaust.

Lead compound are nerve poisons. In particular, they cause brain damage in young children. To prevent this problem, unleaded petrol is used.

Catalytic converters:

High temperature combustion (as in petrol and diesel engines) produces toxic gases in addition to carbon dioxide.



Since the early 1990's, car exhausts have been fitted with catalytic converters.

These employ transition metals such as rhodium, palladium and platinum to convert harmful emissions into less harmful substances.

Typical reactions are:

Carbon monoxide + oxygen → carbon dioxide.

$2CO\ (g) + 0_2(g) = 2C0_2\ (g)$

Carbon monoxide + nitrogen monoxide → carbon dioxide + nitrogen.

$2CO\ (g) + 2NO\ (g) = 2C0_2\ (g) + N_2\ (g)$

Hydrocarbons + nitrogen monoxide → carbon dioxide + nitrogen + water.

In addition, lead has been removed from petrol, reducing widespread lead pollution in the environment.

Fractional Distillation of Liquid Air:

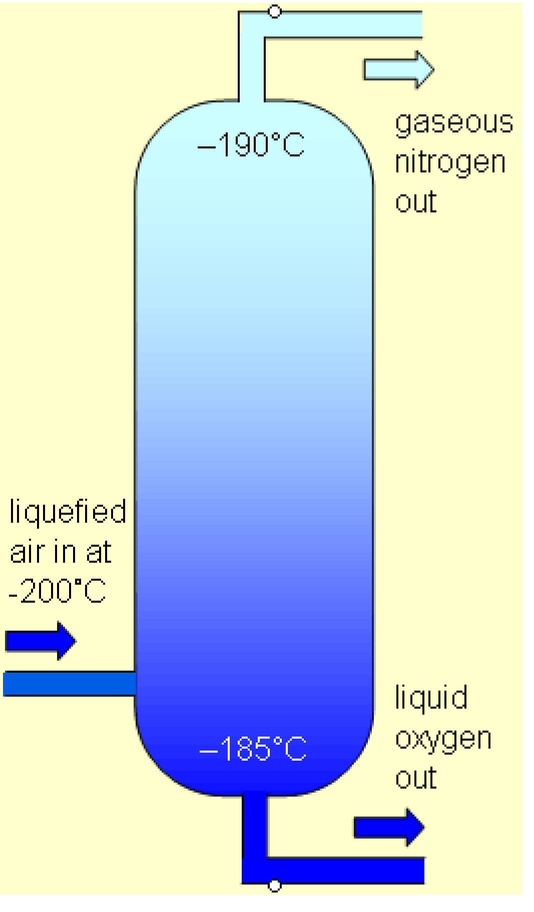
Air is filtered to remove dust, and then cooled in stages until it reaches –200°C. At this temperature it is a liquid. We say that the air has been liquefied.

Here's what happens as the air liquefies:

- water vapour condenses, and is removed using absorbent filters
- carbon dioxide freezes at –79°C, and is removed
- oxygen liquefies at –183°C
- nitrogen liquefies at –196°C

The liquid nitrogen and oxygen are then separated by fractional distillation.

The liquefied air is passed into the bottom of a fractionating column. Just as in the columns used to separate oil fractions, the column is warmer at the bottom than it is at the top.



The liquid nitrogen boils at the bottom of the column. Gaseous nitrogen rises to the top, where it is piped off and stored. Liquid oxygen collects at the bottom of the column. The boiling point of argon (the noble gas that forms 0.9% of the air) is close to the boiling point of oxygen, so a second fractionating column is often used to separate the argon from the oxygen.

Uses of nitrogen and oxygen

- liquid nitrogen is used to freeze food
- food is packaged in gaseous nitrogen to increase its shelf life

- oil tankers are flushed with gaseous nitrogen to reduce the chance of explosion
- oxygen is used in the manufacture of steel and in medicine

Rust Prevention:

- Anything that prevents air and/or water from contacting the surface of the iron will prevent the metal from rusting; as does anything that reacts faster than the iron, ***i.e.*** is higher in the reactivity series.
- In the latter case the oxygen and water will preferentially react with the more reactive metal, to form metal oxides, before the iron can react. This allows the overall strength of the metal to remain the same.
- Common methods for rust prevention involve ***painting*** the metal; covering the metal in oil or grease; coating the metal in zinc, called ***galvanising***; attaching blocks of a more reactive metal, such as magnesium or zinc, called ***sacrificial protection***; ***alloying*** the iron with other metals, such as chromium and nickel, or changing the carbon content of the iron to create steel.

Fertilizers:

The rapid increase in the demand for crops due to the increase in world populations had led to the upset of the balance of minerals in the soil. These minerals like nitrogen, phosphorous and potassium in soil have no chance of being replaced. Therefore farmers use artificial fertilizers to replace them.

Nitrogen fertilizers

Plants need nitrogen in large amounts to make proteins in their bodies. It is absorbed through the roots in the form of nitrate ions. Ammonium salts can also be used as fertilizers because ammonium salts are converted into nitrates by organisms, which live in the soil.

Nitrogen fertilizers include:

- Calcium nitrate $Ca(NO_3)_2$
- Ammonium nitrate NH_4NO_3
- Urea CON_2H_4

Phosphorous fertilizers

Plants need phosphorous to build up a good root system.

Calcium phosphate, which is naturally present in the soil is only slightly soluble, and is only slowly absorbed by plants.

Ammonium phosphate is prepared from ores containing calcium phosphate. It is soluble phosphorous fertilizer and contains nitrogen in addition.

Potassium fertilizers

Plants need potassium for the production of flowers and seeds. Potassium can be added to the soil in the form of wood ash or as potassium sulphate fertilizer.

NPK fertilizers

These are mixtures of fertilizers containing nitrogen, phosphorous and potassium, the three elements, which most need replacement in the soil.

The manufacture of ammonia:

The manufacture of ammonia is done by a process called the Haber process. It combines nitrogen and hydrogen to make ammonia (NH_3).

- Nitrogen is got from the fractional distillation of liquid air.
- Hydrogen is obtained from natural gas or crude oil by cracking of longer alkanes to produce a shorter alkane and hydrogen gas.

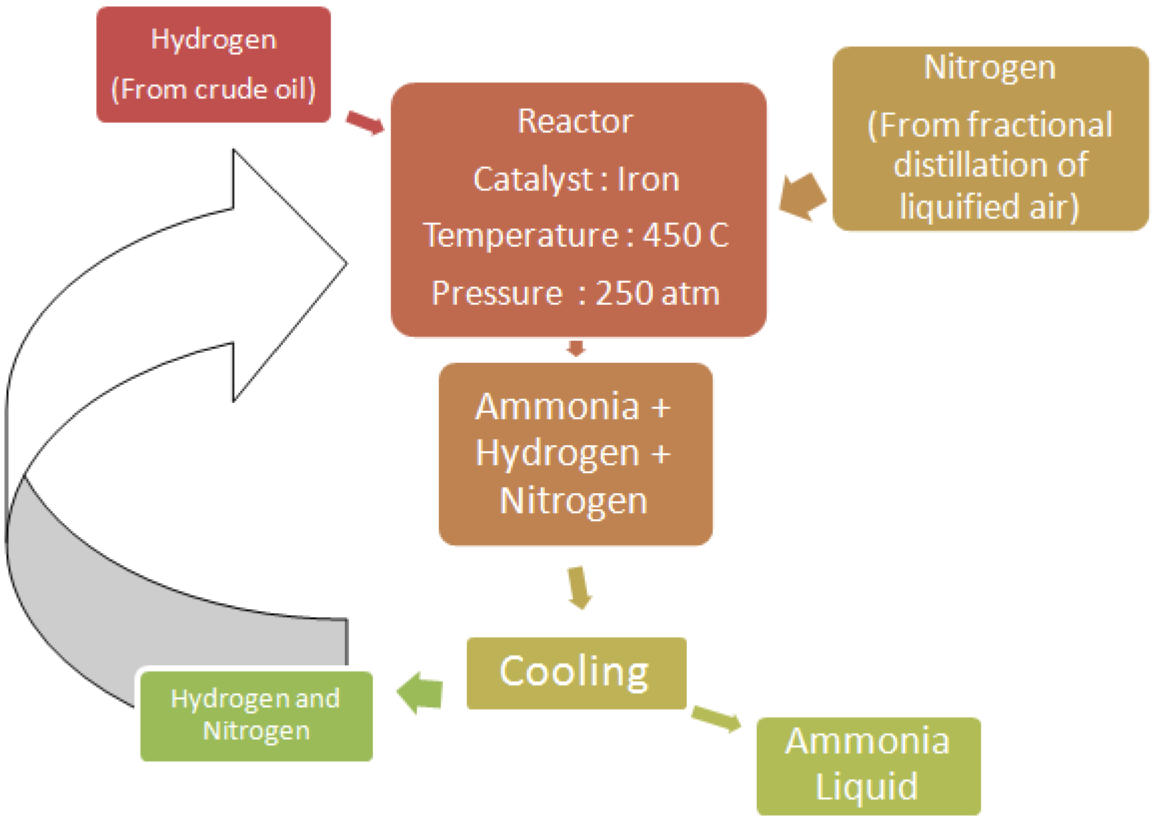
The mixture of nitrogen (1 part) and hydrogen (3 parts) is compressed to 250 atmospheres and heated to 450 degrees C and passed over a finely divided iron.

Only about 10% of the mixture is converted to ammonia.

$$Nitrogen + Hydrogen \rightarrow Ammonia$$

$$N_2 + 3\ H_2 \rightarrow 2\ NH_3$$

The mixture of gases containing nitrogen, hydrogen and ammonia is the cooled which liquefies ammonia, and therefore can be separated, and the unreacted gases recycled.



Conditions that favour the formation of ammonia:

1. High pressure:

A high pressure of 25o atm is used because the reaction is accompanied by a decrease in volume (4 volumes give 2 volumes).

2. Low temperature:

A low temperature is used because the reaction is exothermic. A lower temperature would cause a greater yield of ammonia but it would be formed too slowly (rate of reaction slow).

3. The use of a finely divided iron as a catalyst:

The catalyst enables the equilibrium to be established more quickly but does not produce ammonia.

The displacement of ammonia from its salts:

Being a weak base, ammonia is driven out from its salts by strong bases. If ammonia salt is warmed with an alkali, ammonia gas is given out.

e.g.

$$Ammonium\ chloride + Sodium\ hydroxide \rightarrow Sodium\ chloride + water + Ammonia$$
$$NH_4Cl + NaOH \rightarrow NaCl + H_2O + NH_3$$

The formation of carbon dioxide:

- Carbon dioxide is formed by the complete combustion of carbon and carbon containing substances such as natural gas and petrol.

$$Methane + Oxygen \rightarrow Carbon\ Dioxide + Water$$
$$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$$

- Carbon Dioxide is produced as a waste gas from respiration processes in plant and animal cells.

$$Glucose + Oxygen \rightarrow Carbon\ Dioxide + Water$$
$$C_6H_{12}O_2 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$$

- Carbon Dioxide is formed from the reaction between dilute acids and metal carbonates.

$$Hydrochloric\ Acid + Calcium\ Carbonate$$
$$\rightarrow Calcium\ Chloride + Carbon\ Dioxide + Water$$
$$2\ HCl + CaCO_3 \rightarrow CaCl_2 + H_2O + CO_2$$

The green house effect and green house gases:

Global warming:

Global warming is caused by the green house gases. The green house effect caused by normal levels of green house gases is a natural process, but due to above normal emission of green house gases, which makes the earth warm up.

Some green house gases are:

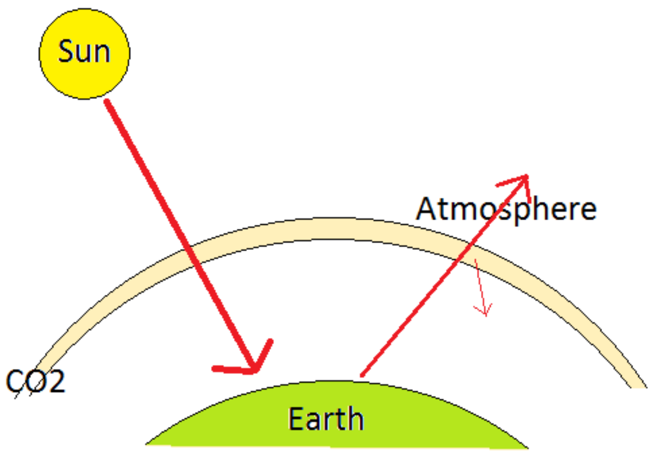
Green house gas	Sources	% contribution to the greenhouse effect	Number of years is stays in the

			atmosphere
Carbon Dioxide	Burning fossil fuels, deforestation and burning wood	64	200
Methane	Deforestation, decomposition of waste, rice and cattle farming, rotting vegetation	18	12
CFCs (chlorofluorocarbons)	Aerosols, refrigerators	14	1000 or more
Nitrogen oxide	Use of chemical fertilizers, motor transport burning fuels, deforestation, burning vegetation	4	120

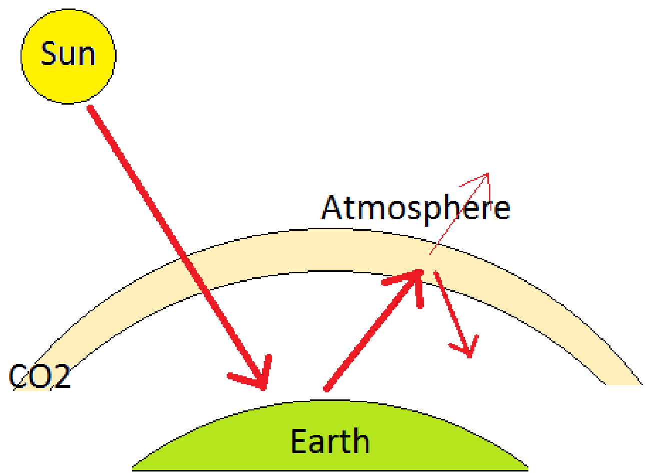
These above-normal emissions of green house gases are creating the **accelerated** greenhouse effect.

The most known cause of the **accelerated** greenhouse effect is human activities. The green house gases cannot block the incoming infra-red radiation from the sun, but block the ones radiating from the earth, and mirror them back to the earth's surfaces, warming it as it does.

The earth emits almost all radiation it got from the sun during the night, which keeps the temperature constant. When the radiation is mirrored back to the earth, it absorbs them and warm up.

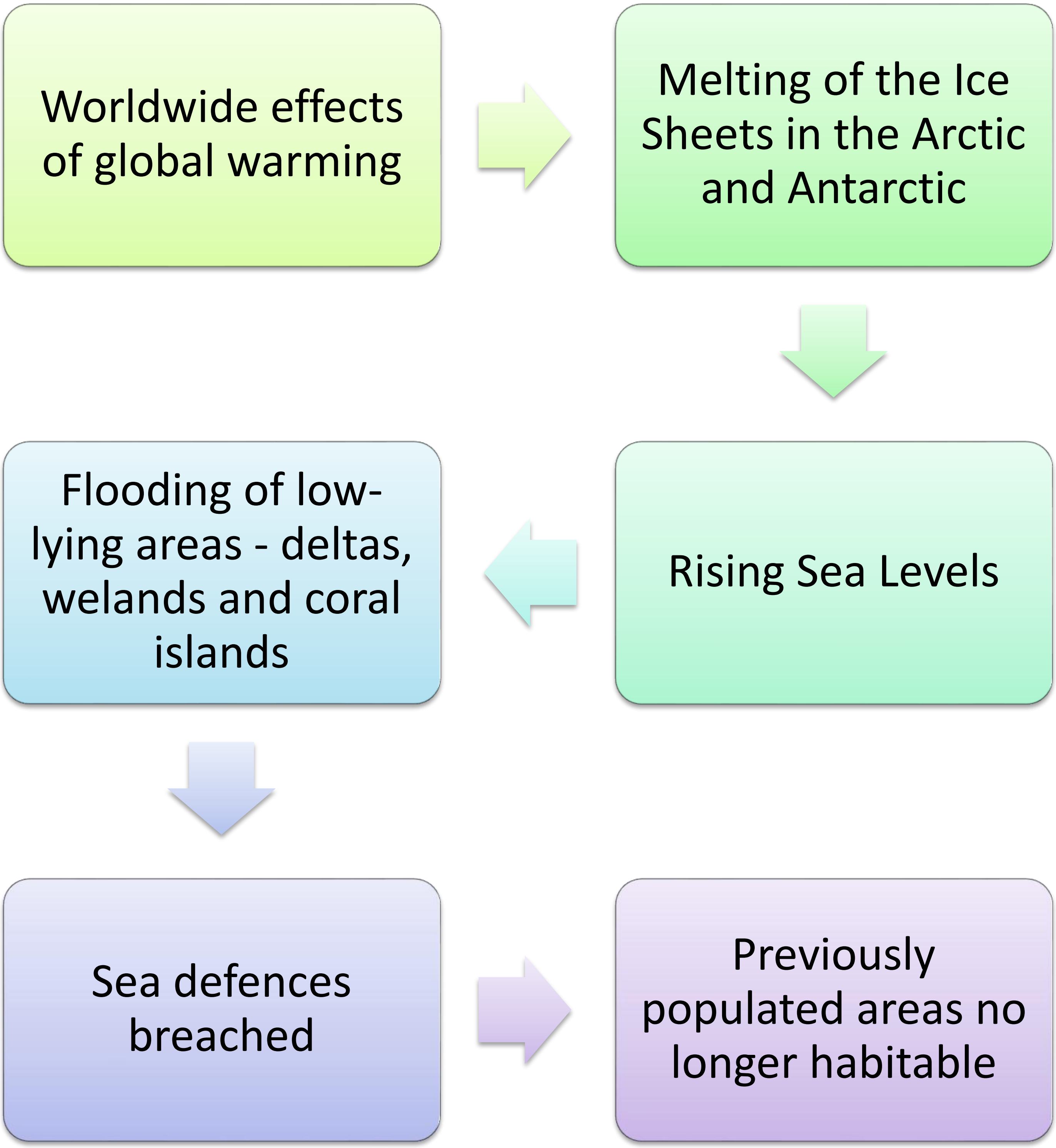


The Natural Process - Most of sun's radiation emitted away and only some reflected by the atmosphere



The enhanced process due to human activities

The effects of global warming:

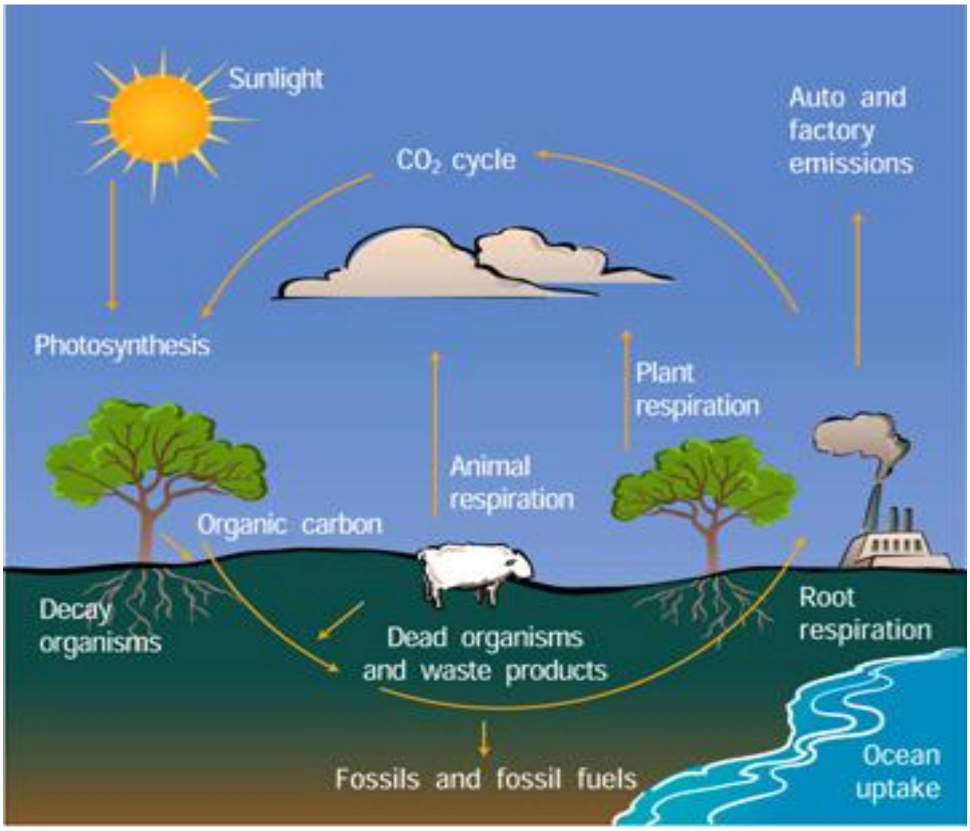


The Carbon Cycle:

Carbon is an element which is present in all living organisms. It is obtained by plants from carbon dioxide in the atmosphere as a result of their photosynthesis, which is stored as sugar or starch in fruits.

When the plants are eaten by animals, the organic plant material is digested, absorbed and built into compounds making up the animal's tissues; carbon from the plants become a part of the animal.

The carbon cycle, therefore, is about the intake and re-release of carbon dioxide.



Carbon is added to the atmosphere in three main ways:

- **Respiration:** The release of energy from starch and sugars into carbon dioxide and water in animal and plant cells.
- **Decay:** Organic matter from dead plants and animals is used by decomposers as a source of energy. The micro-organisms turn the carbon compounds back into carbon dioxide, which is released into the atmosphere.
- **Combustion:** The burning of wood, fossil fuels, any other fuel which contain carbon produces carbon dioxide.