Chemistry of the environment

IGCSE Chemistry

Water

Testing for water

Two chemical tests show that water is **present**:

- **Anhydrous** 无水 cobalt(II) chloride turns from blue to pink when water is added.
- Anhydrous copper(II) sulfate turns from white to blue when water is added.

These tests only show that water is there. To show that water is **pure**, you test its **melting point** 熔点 and **boiling point** 沸点: pure water melts at exactly 0 °C and boils at exactly 100 °C. Any dissolved substance changes these values.

This is why **distilled water** 蒸馏水 is used in chemistry instead of tap water —it has far fewer chemical **impurities** 杂质.

What is in natural water

Water from rivers, lakes and the sea is not pure. It may contain dissolved **oxygen** 氧气, metal compounds, plastics, **sewage** 污水, harmful **microbes** 微生物, and **nitrates** 硝酸盐 and **phosphates** 磷酸盐 (which come from fertilisers and detergents).

Some of these are helpful:

- dissolved oxygen lets **aquatic life** 水生生物 (fish and plants) breathe;
- some metal compounds give essential **minerals** 矿物质.

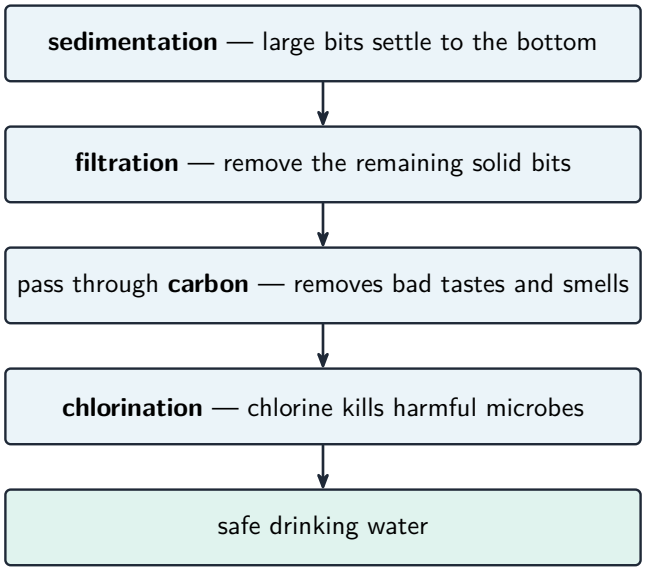
Others are harmful:

- some metal compounds are **toxic** 有毒 (poisonous);
- some plastics harm aquatic life;
- sewage carries microbes that cause disease;
- nitrates and phosphates cause **deoxygenation** 缺氧 (loss of oxygen) in the water, which harms aquatic life.

Treating drinking water

To make water safe to drink, the water supply is treated in steps:

- **sedimentation** 沉降 and **filtration** 过滤 remove solid bits;
- passing it through **carbon** 碳 removes bad tastes and smells;
- **chlorination** 氯消毒 (adding chlorine) kills harmful microbes.



Water is made safe to drink in steps: settle out big bits, filter, remove tastes with carbon, then chlorinate

Fertilisers

Fertilisers 肥料 are added to soil to help plants grow. Ammonium salts and nitrates are common fertilisers.

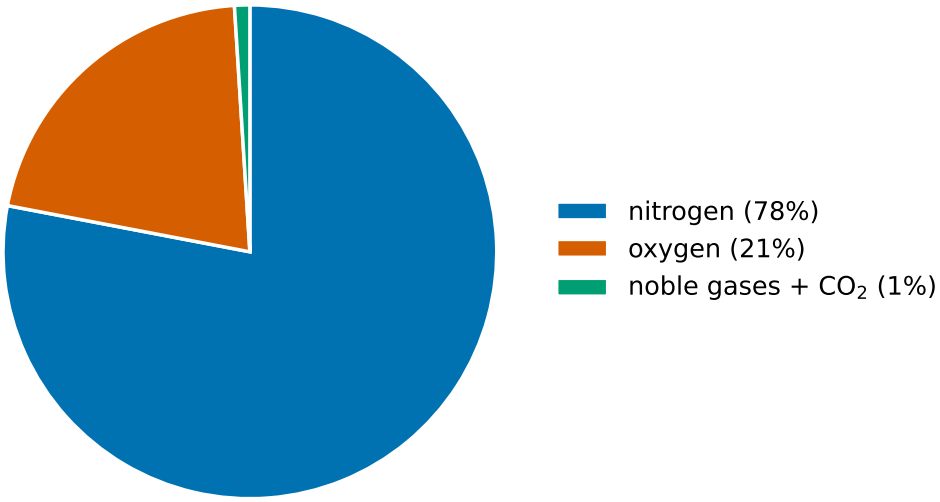
NPK fertilisers contain the three elements plants need most: **nitrogen** 氮气, **phosphorus** 磷 and **potassium** 钾.

Air quality and climate

Burning fossil fuels pollutes the air and changes the climate.

Clean, dry air is approximately:

- 78% nitrogen (N_2)
- 21% oxygen (O_2)
- the rest is a mixture of **noble gases** 稀有气体 and carbon dioxide (CO_2).



Clean, dry air is about 78% nitrogen, 21% oxygen, and 1% other gases (noble gases and carbon dioxide)

Air pollutants and their sources

Pollutant	Main source
carbon dioxide (CO_2)	**complete combustion** 完全燃烧 of carbon-containing fuels
carbon monoxide 一氧化碳 and **particulates** 颗粒物	**incomplete combustion** 不完全燃烧 of carbon-containing fuels
methane 甲烷	rotting plants and waste gases from animal digestion
oxides of nitrogen 氮氧化物	car engines
sulfur dioxide	burning **fossil fuels** 化石燃料 that contain **sulfur** 硫

Effects of these pollutants

- **Carbon dioxide** 二氧化碳 and methane are **greenhouse gases** 温室气体: more of them causes **global warming** 全球变暖, which leads to **climate change** 气候变化.
- Carbon monoxide is a toxic gas.
- Particulates increase the risk of **respiratory** 呼吸 (breathing) problems and **cancer** 癌症.
- Oxides of nitrogen cause **acid rain** 酸雨, **photochemical smog** 光化学烟雾 and breathing problems.
- Sulfur dioxide causes acid rain.

Reducing these problems

To slow **climate change**: plant trees, farm fewer animals, burn fewer fossil fuels, and use more hydrogen and **renewable energy** 可再生能源 such as wind and solar power.

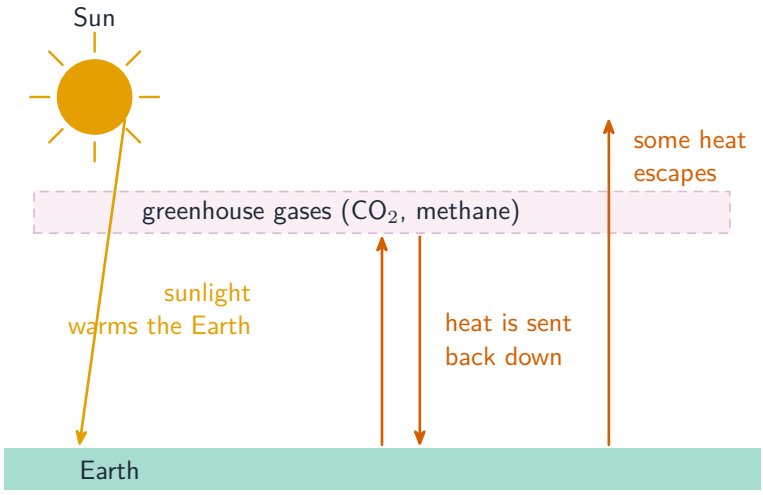
To reduce **acid rain**: fit **catalytic converters** 催化转化器 in cars, use low-sulfur fuels, and use **flue gas desulfurisation** 烟气脱硫 with **calcium oxide** 氧化钙 to remove sulfur dioxide from waste gases.

Inside a catalytic converter is a honeycomb coated with catalyst metals; the many tiny channels give a huge surface area

Image: Cyrogigabyte, CC0 (commons.wikimedia.org)

How greenhouse gases warm the Earth

Greenhouse gases such as carbon dioxide and methane let sunlight through, but they **absorb** the **thermal energy** 热能 given off by the warm Earth, and send some of it back down. This reduces the thermal energy lost to space, so the Earth gets warmer.



greenhouse gases trap some of the Earth's heat,
so less escapes to space and the Earth warms up

Greenhouse gases let sunlight through but trap some of the heat the Earth gives off, so the Earth warms up

In a car engine, the high temperature makes nitrogen and oxygen from the air react to

form oxides of nitrogen. A **catalytic converter** removes them, for example:

$$2CO + 2NO \rightarrow 2CO_2 + N_2$$

Photosynthesis

Photosynthesis 光合作用 is the opposite of combustion —it removes carbon dioxide from the air. Plants use light energy and **chlorophyll** 叶绿素 to turn carbon dioxide and water into **glucose** 葡萄糖 and oxygen:

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$