Chemistry of the Environment

IGCSE Chemistry ▪ Topic 10

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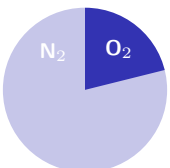


What we will cover

1. Water: testing & treating
2. Fertilisers
3. The composition of air
4. Air pollutants & their effects
5. The greenhouse effect
6. Reducing pollution

1 Water

Water: testing and purity

is water present?

anhydrous 无水 cobalt chloride blue→pink; copper sulfate white→blue

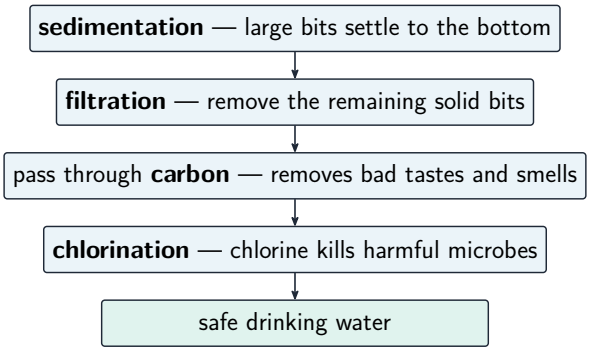
is water pure?

pure water melts at exactly $0\,^{\circ}\mathrm{C}$ & boils at $100\,^{\circ}\mathrm{C}$; impurities change these

Natural water carries dissolved O_2, minerals, **nitrates** 硝酸盐 & **phosphates** 磷酸盐 (which cause **deoxygenation** 缺氧), and microbes.

Air pollution harms health and the environment

Treating drinking water



Steps to make water safe:

- **sedimentation** 沉降 & **filtration** 过滤 remove solids
- **carbon** 碳 removes tastes & smells
- **chlorination** 氯消毒 kills microbes

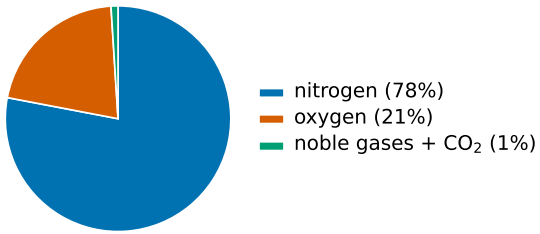
Fertilisers 肥料 (NPK) add nitrogen, phosphorus & potassium.

2 Air

The composition of air

Clean, dry air:

- 78% **nitrogen** 氮气 (N_2)
- 21% **oxygen** 氧气 (O_2)
- ∼1% noble gases & CO_2



clean dry air ≈ 78% N_2, 21% O_2, 1% Ar/CO_2/others

Air pollutants and their sources

CO_2 – complete **combustion** 燃烧 of carbon fuels (a greenhouse gas)

CO & particulates – **incomplete combustion** 不完全燃烧 of fuels

oxides of nitrogen – hot car engines

sulfur dioxide – burning fuels that contain **sulfur** 硫

Effects of pollutants

CO_2 & **methane** 甲烷: greenhouse → global warming

SO_2 & NO_x: **acid rain** 酸雨

carbon monoxide: a toxic gas

particulates 颗粒物: breathing problems

The pollutants, their sources and their effects

methane 甲烷	rotting plants, and waste gases from animal digestion – a strong greenhouse gas
carbon dioxide	burning **fossil fuels** 化石燃料 – the main driver of climate change
sulfur dioxide	burning fuels containing sulfur – causes acid rain
oxides of nitrogen	formed in a hot car engine from the air's own nitrogen and oxygen
particulates	increase the risk of **respiratory** 呼吸 problems and **cancer** 癌症
carbon monoxide	toxic – it binds to haemoglobin in place of oxygen

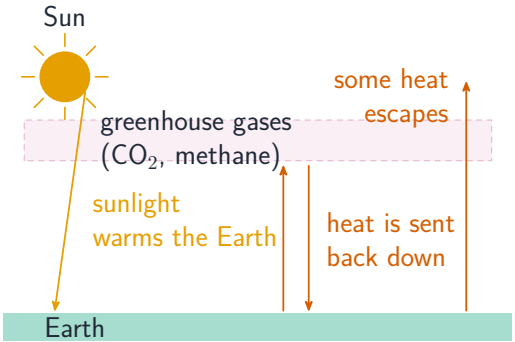
A catalytic converter removes the oxides of nitrogen and carbon monoxide; **flue gas desulfurisation** 烟气脱硫 removes sulfur dioxide at the power station.

The pollutants, and how each is dealt with

Oxides of nitrogen	Cause acid rain, **photochemical smog** 光化学烟雾 and breathing problems. A catalytic converter turns them back into nitrogen.
Sulfur dioxide	Flue gas desulfurisation uses **calcium oxide** 氧化钙 to remove it before the gases leave the chimney – or switch to a low-sulfur fuel.
Water pollution	Waste water may carry dissolved oxygen, metal compounds, plastics, **sewage** 污水, harmful **microbes** 微生物, and **nitrates** 硝酸盐 and **phosphates** 磷酸盐 from fertilisers and detergents.
Testing purity	Pure water melts at exactly $0\,^{\circ}\mathrm{C}$ and boils at exactly $100\,^{\circ}\mathrm{C}$ – so the **melting point** 熔点 and boiling point are the test.

Name the pollutant, its source, its effect and the control. Four parts, and most questions here ask for two of them.

The greenhouse effect



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

Greenhouse gases 温室气体 let sunlight in but absorb the heat the Earth gives off.

> Less heat escapes to space, so the Earth warms – driving **climate change** 气候变化.

Photosynthesis

Photosynthesis 光合作用 is the opposite of combustion: it removes carbon dioxide from the air.

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

light energy, **chlorophyll** 叶 绿 素

Plants turn carbon dioxide and water into **glucose** 葡萄糖 and oxygen.

Reducing pollution

- climate: trees, less fossil fuel, **renewable energy** 可再生能源
- acid rain: **catalytic converters** 催化转化器, low-sulfur fuels

$$2\mathrm{CO} + 2\mathrm{NO} \rightarrow 2\mathrm{CO_2} + \mathrm{N_2}$$

Slowing climate change, and what water contains

plant trees	photosynthesis removes carbon dioxide from the air
farm fewer animals	less methane from digestion, and less land cleared
burn fewer fossil fuels	the largest single lever
renewable energy 可再生能源	and hydrogen, where the hydrogen is made cleanly
dissolved oxygen	lets **aquatic life** 水生生物 – fish and plants – breathe
in the water too	metal compounds and nitrates from farming, and plastics, some of which harm aquatic life

Distilled water 蒸馏水 is used in experiments because tap water's dissolved salts would react. That is why the test uses it, not because it is cleaner.

Fertilisers

N
nitrogen
leaf and stem growth

P
phosphorus
strong roots

K
potassium
flowers and fruit

NPK fertilisers contain all three - ammonium salts and nitrates supply the nitrogen

NPK fertilisers supply the three elements plants need most: nitrogen, phosphorus and potassium

Testing for water

is water **present**? - a colour change

cobalt(II) chloride:
blue $\rightarrow$ **pink**

copper(II) sulfate:
white $\rightarrow$ **blue**

both use the **anhydrous** (dry) solid

is it **pure**? - fixed points

melts at exactly $0\,^{\circ}\mathrm{C}$
boils at exactly $100\,^{\circ}\mathrm{C}$

any dissolved substance changes these values

Colour-change tests show water is present; fixed melting and boiling points show it is pure

Exam tips

- Two tests show water is *present* (cobalt(II) chloride blue → pink; copper(II) sulfate white → blue), but only fixed melting and boiling points (0 °C and 100 °C) show it is *pure*.
- Clean, dry air is about **78% nitrogen, 21% oxygen** and 1% other gases (mostly noble gases and carbon dioxide).
- Match each pollutant to its source and effect: **carbon monoxide** (incomplete combustion; toxic); **sulfur dioxide** and **oxides of nitrogen** (acid rain); **carbon dioxide** and **methane** (greenhouse gases → global warming).
- Greenhouse gases let sunlight through but absorb the heat the warm Earth gives off and send some back down, so the Earth warms up.

3 Recap

Worked example – stopping rust

Iron rusts but zinc-coated iron does not, even when the coating is scratched. Explain.

- Rusting needs both oxygen and water.
- A coat of paint or plastic works only as a barrier – scratch it and rust starts.
- Zinc is more reactive than iron, so it loses electrons in preference.
- The zinc corrodes instead ⇒ sacrificial protection, which still works when scratched.

Barrier methods fail once broken; sacrificial protection does not, because the more reactive metal is oxidised instead. Galvanising does both at once.

Topic 10 – key takeaways

1 Water

settle, filter, carbon, chlorinate

2 Air

78% N_2, 21% O_2, $\sim$1% other

3 Pollutants

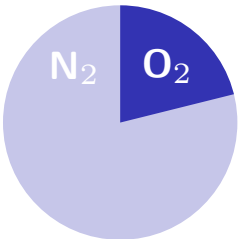
CO_2/CH_4 warm; SO_2/NO_x acid rain

4 Greenhouse

traps the heat the Earth gives off

Check yourself

1. What step in water treatment kills microbes?
2. What are the two main gases in clean air?
3. Which two pollutants cause acid rain?
4. Why does the greenhouse effect warm the Earth?



Answers **1.** chlorination **2.** nitrogen & oxygen **3.** sulfur dioxide & oxides of nitrogen **4.** it traps heat the Earth radiates