

Air, pollution and clean water resources

Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lesson

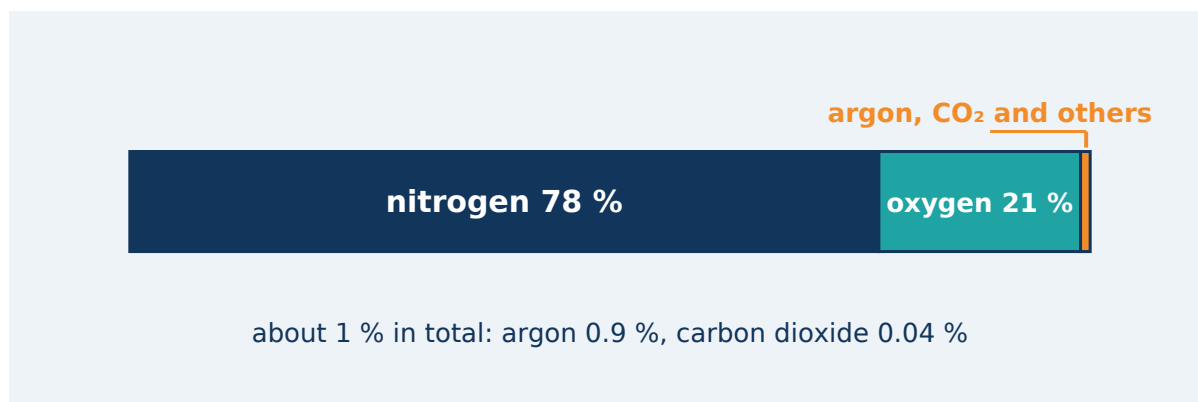
Quick answer: Air is about 78 % nitrogen and 21 % oxygen. Greenhouse gases such as carbon dioxide and methane trap infrared radiation and cause global warming. Burning fuels releases carbon monoxide, sulfur dioxide, nitrogen oxides and soot. Drinking water is made by filtering and sterilising, and life cycle assessments compare products.

Level: Chemistry grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** HS-ESS3-6, GCSE C9-C10

What is the air around us made of?

The atmosphere is a layer of gases held around the Earth by gravity. Dry air is a mixture, so its gases are not chemically joined. Nitrogen and oxygen make up almost all of it.

Gas	Percentage by volume	Note
Nitrogen, N ₂	about 78 %	unreactive, most abundant
Oxygen, O ₂	about 21 %	needed for respiration and burning
Argon, Ar	about 0.9 %	noble gas
Carbon dioxide, CO ₂	about 0.04 %	greenhouse gas, used in photosynthesis



Composition of dry air by volume.

The early atmosphere was mostly carbon dioxide and water vapour from volcanoes. When the Earth cooled, the water vapour condensed and formed the oceans. Algae and plants then appeared and used photosynthesis, $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$, which removed carbon dioxide and added oxygen. Carbon dioxide was also locked away in sedimentary rock, shells and fossil fuels.

Worked example

Pass 100 cm³ of air over hot copper until no more gas is used. The volume falls to 79 cm³, because the copper formed copper(II) oxide: $2\text{Cu} + \text{O}_2 \rightarrow 2\text{CuO}$. Oxygen used = 100 – 79

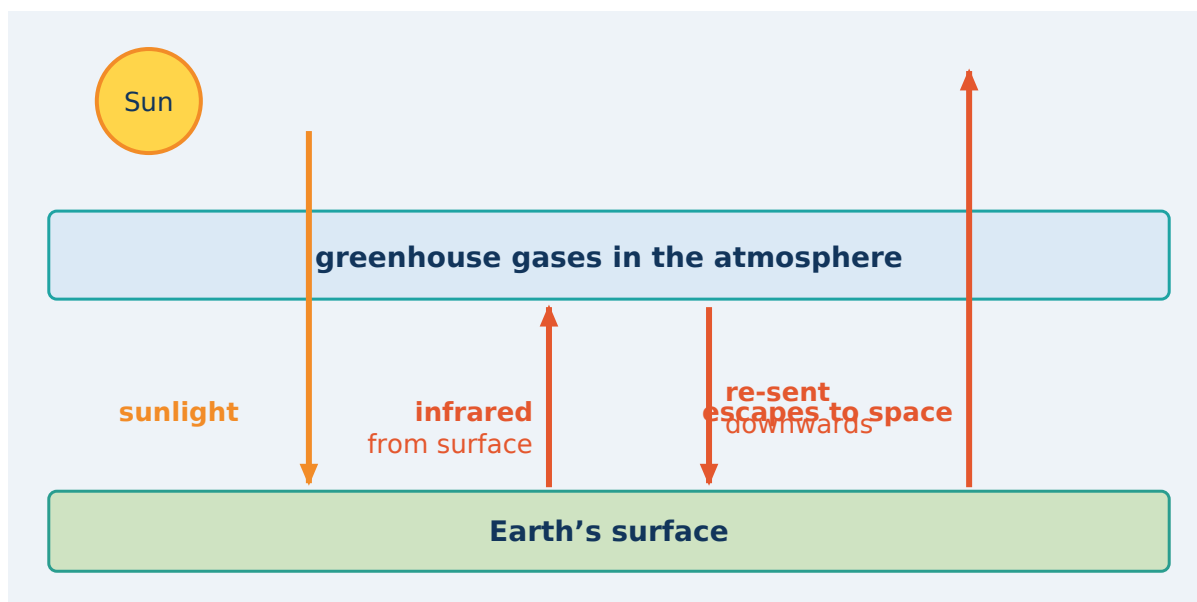
= 21 cm³. Percentage of oxygen = $21 \div 100 \times 100 = 21 \%$.

What are greenhouse gases and how do they warm the Earth?

Definition

A **greenhouse gas** absorbs infrared radiation from the Earth's surface and re-emits it in all directions, so less heat escapes to space. The main ones are carbon dioxide, methane and water vapour.

Sunlight passes through the atmosphere and warms the ground. The warm ground gives out infrared radiation. Greenhouse gases absorb some of it and send part of it back down. This natural greenhouse effect keeps the Earth warm enough for life. Human activity increases it: burning fossil fuels and cutting down forests raise carbon dioxide, and cattle, rice fields and landfill sites release methane. The result is global warming and climate change: rising sea levels, more extreme weather and changes to habitats.



The greenhouse effect: gases in the atmosphere return some infrared radiation to the surface.

The carbon footprint is the total mass of carbon dioxide and other greenhouse gases released by a product, event or person. It can be reduced with renewable energy, better insulation, public transport, carbon capture and planting trees.

Which pollutants do burning fuels release?

Pollutant	Source	Harm
Carbon monoxide, CO	incomplete combustion	toxic: binds to haemoglobin and stops oxygen transport
Sulfur dioxide, SO ₂	sulfur impurities in fuels	acid rain, breathing problems

Pollutant	Source	Harm
Nitrogen oxides, NO _x	air heated in engines: N ₂ + O ₂ → 2NO	acid rain, smog, lung irritation
Particulates (soot)	incomplete combustion of diesel and coal	lung damage, global dimming

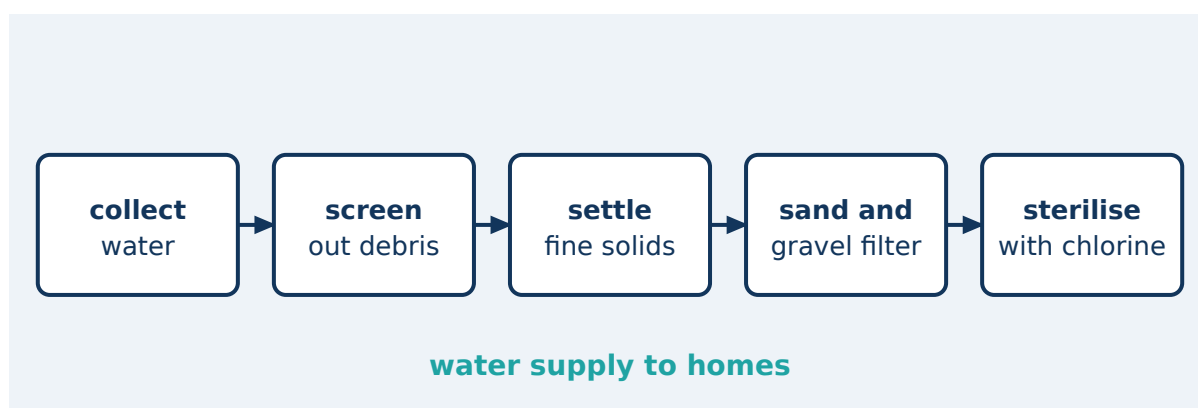
Catalytic converters change harmful exhaust gases into harmless ones: $2\text{CO} + 2\text{NO} \rightarrow 2\text{CO}_2 + \text{N}_2$. Power stations remove sulfur dioxide from waste gases, and sulfur can be removed from fuels before they are burnt.

Worked example

A power station burns 500 tonnes of coal that contains 2 % sulfur by mass. Sulfur = $0.02 \times 500 = 10$ t. $\text{S} + \text{O}_2 \rightarrow \text{SO}_2$, and the ratio of masses is 32 : 64, so 10 t of S gives 20 t of SO₂. The mass of sulfur dioxide released is **20 tonnes**.

How is drinking water made?

Potable water is water that is safe to drink. It is not necessarily pure: it contains dissolved minerals. From fresh water, the steps are choosing a source with little pollution, passing it through a filter bed of sand and gravel to remove solids, and sterilising it with chlorine, ozone or ultraviolet light to kill microbes. Where only salt water is available, desalination is used: distillation, which needs a lot of energy, or reverse osmosis, which forces water through a membrane at high pressure.



Main stages in making drinking water from a reservoir.

Waste water goes through screening, sedimentation, and biological treatment, and the sludge is digested without air to make methane.

What is a life cycle assessment?

A **life cycle assessment** (LCA) measures the environmental impact of a product at every stage: getting raw materials, manufacturing and packaging, use and operation, and disposal at the end of life. It looks at energy, water, waste and pollutants. LCAs help compare products, such as paper and plastic bags, but they can be one-sided if some values are estimated or if the sponsor selects favourable data.

Stage	Typical question
Raw materials	How much energy is used to extract and refine them?
Manufacture	What pollutants and waste are produced?
Use	How many times is it used? Does it need power?
Disposal	Can it be reused, recycled or does it go to landfill?

Common mistake

Do not say that the greenhouse effect is caused by a hole in the ozone layer; the two are separate problems. Also remember that potable water is safe to drink, but it is not pure water.

Lina's tip

To remember the air, think of 5 parts: about 4 of nitrogen and 1 of oxygen. Then add the small extras of argon and carbon dioxide.

Key points to remember

- Dry air: about 78 % N₂, 21 % O₂, 0.9 % Ar, 0.04 % CO₂.
- Greenhouse gases (CO₂, CH₄, water vapour) absorb infrared radiation and warm the Earth.
- Pollutants: CO (toxic), SO₂ (acid rain), NO_x (smog, acid rain), particulates (lung damage).
- Potable water: filter with sand and gravel, then sterilise with chlorine, ozone or UV.
- A life cycle assessment covers raw materials, manufacture, use and disposal.

Air, pollution and clean water resources: frequently asked questions

What are the main gases in the air?

Dry air is about 78 % nitrogen, 21 % oxygen, 0.9 % argon and 0.04 % carbon dioxide by volume. Water vapour varies from place to place.

How do greenhouse gases cause global warming?

They absorb infrared radiation given out by the warm Earth and send part of it back to the surface. More greenhouse gas means more heat is trapped, so the average temperature rises.

Why is carbon monoxide dangerous?

It is a toxic gas made when fuels burn with too little oxygen. It binds to haemoglobin in the blood and prevents the blood from carrying oxygen.

What is the difference between potable and pure water?

Potable water is safe to drink but still contains dissolved minerals. Pure water contains only

H₂O and is made by distillation.

Why do life cycle assessments have limits?

Some data are estimates, and different studies may weigh energy, water and pollution differently. A company can also choose data that favour its own product.