The proportions of different gases in the atmosphere

5.9.1.1 · Chemistry · revision notes

What the air around you is made of today, and how long it has been this way. Expect 1-mark recall questions on Paper 2, and short calculations that use fractions, percentages and ratios of the gases in air.

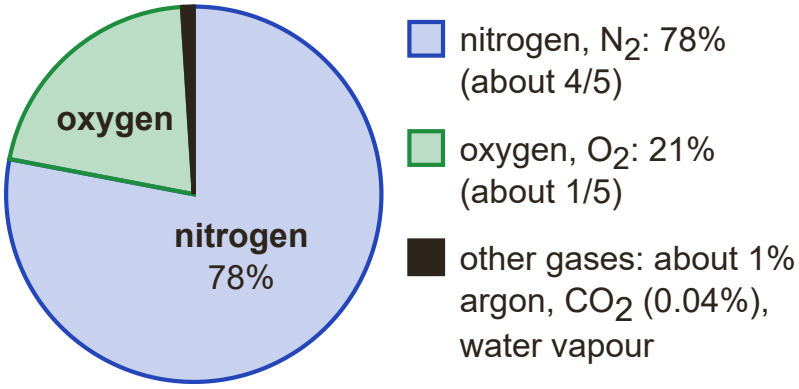
Key facts

- Nitrogen ≈ four-fifths ≈ 80% of the air
- Oxygen ≈ one-fifth ≈ 20% of the air
- Small proportions: carbon dioxide (about 0.04%), water vapour, noble gases (mainly argon)
- Proportions much the same as today for about 200 million years
- Nitrogen : oxygen ≈ 4 : 1
- Volume of a gas = percentage ÷ 100 × total volume
- Percentage = part ÷ total × 100
- Times more = larger amount ÷ smaller amount

Notes

The atmosphere today

- For about the last **200 million years**, the proportions of the gases in the atmosphere have been much the same as they are today.
- About **four-fifths (about 80%)** of the air is **nitrogen**, N_2.
- About **one-fifth (about 20%)** of the air is **oxygen**, O_2.
- The rest is small proportions of other gases: **noble gases** (mainly argon, just under 1%), **carbon dioxide** (about 0.04%) and **water vapour** (the amount changes with the weather).



Dry air is about four-fifths nitrogen and one-fifth oxygen.

- Some questions give more exact values for dry air, such as 78% nitrogen, 21% oxygen and 0.9% argon. Always use the numbers the question gives you.
- Air is a **mixture**: the gases are not chemically bonded to each other.

Fractions, percentages and ratios

- Volume of a gas in a sample of air = percentage ÷ 100 × total volume.
- Example: 250 cm^3 of air contains about 80 ÷ 100 × 250 = 200 cm^3 of nitrogen and 20 ÷ 100 × 250 = 50 cm^3 of oxygen.
- Volume of air needed for a volume of one gas = volume of gas ÷ percentage × 100, e.g. 50 dm^3 of nitrogen needs about 50 ÷ 80 × 100 = 62.5 dm^3 of air.
- To turn a fraction into a percentage, multiply by 100: four-fifths = 4 ÷ 5 × 100 = 80%.
- Nitrogen : oxygen ≈ 80 : 20 = **4 : 1**, so there is about four times as much nitrogen as oxygen in air.
- How many times more of one gas than another = larger amount ÷ smaller amount, e.g. 78 ÷ 21 = 3.7 times more nitrogen than oxygen (2 significant figures).
- To find a percentage from data: percentage = part ÷ total × 100.

How to answer each type of question

Recall: name a gas or give its proportion 1 mark each **Grade 3**

1. Learn the two big numbers: nitrogen about 80% (four-fifths), oxygen about 20% (one-fifth).
2. Give one clear answer. If you give two answers and one is wrong, you can lose the mark.

Example. (a) Which gas makes up about four-fifths of the Earth's atmosphere?
(b) Give the approximate percentage of oxygen in the atmosphere.
(c) Name **one** other gas that is present in the atmosphere in a small proportion.

Model answer.

(a) Nitrogen	(1)
(b) 20% (allow 21%)	(1)
(c) Any one from: carbon dioxide / water vapour / argon (or another noble gas)	(1)

Calculate the volume of a gas in a sample of air 2 marks **Grade 5**

1. Write down the percentage of the gas (use the value in the question if one is given).
2. Divide by 100 and multiply by the total volume.
3. Give the unit, the same as the unit of the total volume.

Example. A party balloon contains 3.0 dm^3 of air.
Calculate the approximate volume of oxygen in the balloon.

Model answer.

20 ÷ 100 × 3.0	(1)
= 0.60 dm^3	(1)

(Using 21% gives 0.63 dm^3, which also scores 2 marks.)

Use ratios and fractions

2 to 3 marks | Grade 5

1. Write the ratio using the percentages, e.g. 80 : 20.
2. Divide both sides by the same number to simplify it.
3. Use the ratio to scale from one gas to the other.

Example. Dry air is about 80% nitrogen and 20% oxygen by volume.
(a) Write the ratio of nitrogen to oxygen in its simplest form.
(b) A sample of air contains 45 cm^3 of oxygen. Use your ratio to estimate the volume of nitrogen in the sample.

Model answer.

(a) 80 : 20 (1) = 4 : 1 (1)

(b) 4 × 45 = 180 cm^3 (1)

Don't lose marks

- Saying the air is mostly oxygen. It is mostly nitrogen.
- Saying carbon dioxide is a major gas in today's air. It is only about 0.04%.
- Writing '200 years' or '2 billion years' instead of about 200 million years.
- Leaving the unit (cm^3 or dm^3) off a calculated volume.

More tips

Memory tricks

- Four out of every five parts of the air you breathe in are nitrogen.
- Quick estimate of oxygen: divide the volume of air by 5.
- Calculator: 20% of a number is × 0.2 and 80% is × 0.8.
- Sense check: the percentages of all the gases in air must add up to about 100%.

Exam technique

- If the question gives exact percentages (e.g. 78% and 21%), use those numbers, not 80% and 20%.
- Show your working (e.g. 20 ÷ 100 × 250) so you can still get a method mark if you slip.
- 'Give' and 'Name' questions want a short answer, not an explanation.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 **Name the two main gases in air**
Nitrogen makes up about four-fifths of the air and oxygen about one-fifth.

Grade 3 **Give the percentages of nitrogen and oxygen**
Air is about 80% nitrogen and about 20% oxygen.

Grade 4 **Name the gases present in small proportions**

Carbon dioxide, water vapour and noble gases such as argon are present in small proportions.

Grade 4

State how long the proportions have been similar

The proportions of the gases have been much the same as today for about 200 million years.

Grade 5

Calculate the volume of a gas in air

Multiply the total volume by the percentage divided by 100, e.g. 20 ÷ 100 × 500 cm^3 = 100 cm^3 of oxygen.

Grade 5

Use ratios and fractions for gases in air

Nitrogen : oxygen is about 80 : 20, which simplifies to 4 : 1, and four-fifths is the same as 80%.

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