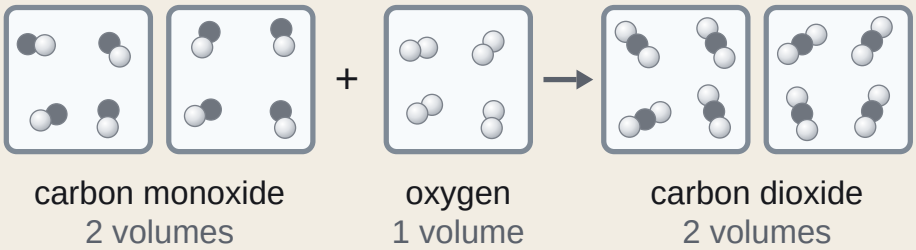
B7 · Combining volumes, Avogadro's idea and molar volume · Completed notes

Goals: State the law of combining volumes and explain it with molecules. Find volumes of gases in a reaction from the balanced equation. Change between moles and litres of gas at STP and at SATP.

These are the completed notes. The blanks are filled in and each question is worked.

Slide 1 of 6 · Gases react in simple whole-number volumes

Lesson B6 explained how one gas behaves. Today two gases react, and their volumes show a pattern.



Key ideas

Gas volumes react in a simple ratio of **whole numbers**.

This is the law of **combining volumes**.

Every gas must be measured at the same **temperature** and pressure.

Example

2 L of carbon monoxide reacts with oxygen. How many litres of oxygen does it use up?

1. The volumes are in the ratio 2 to 1 to 2.
2. So 2 L of carbon monoxide uses up 1 L of oxygen.

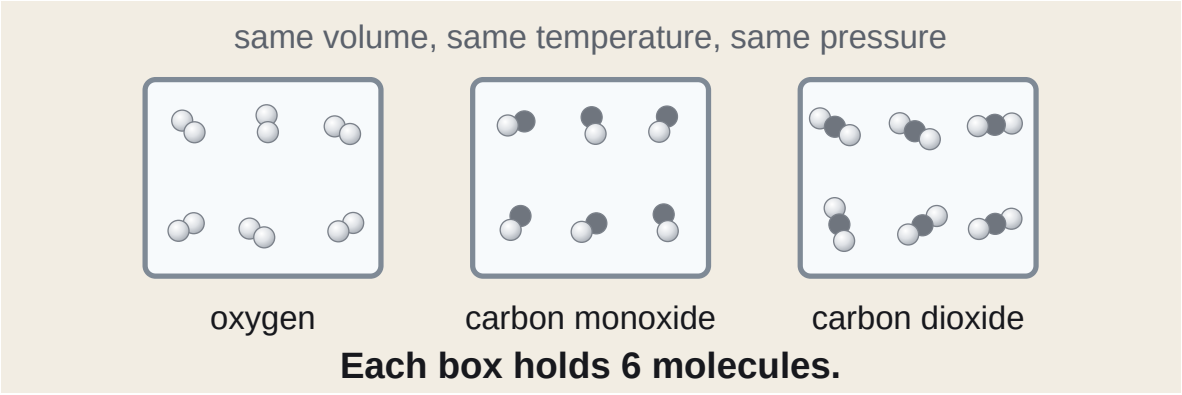
Try it

What must be the same for every gas before the law of combining volumes works?

1. The temperature must be the same.
2. The pressure must be the same.

Slide 2 of 6 · Avogadro's idea

The last slide gave the law of combining volumes. This slide explains it with molecules.



Key ideas

Equal volumes of gases hold **equal numbers** of molecules.

Most of a gas is **empty space**.

Only the **number** of molecules sets the volume.

Example

Two balloons are the same size, at the same temperature and pressure. One holds oxygen and one holds carbon dioxide. Which has more molecules?

1. Equal volumes of gases hold equal numbers of molecules.
2. So neither has more. They have the same number.

Try it

Why does the size of a molecule hardly change the volume of a gas?

1. Most of a gas is empty space.
2. The molecules themselves take up almost none of it.

Slide 3 of 6 · Volumes from a balanced equation

The last slide showed that equal volumes hold equal numbers of molecules. That links volumes to a balanced equation.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

	C_3H_8	O_2	CO_2	H_2O
coefficient	1	5	3	4
volume (L)	2.0	10	6.0	8.0

The volumes are in the same ratio as the coefficients.

Key ideas

The **coefficients** in a balanced equation are a molecule ratio.

For gases, the coefficients give the **volume ratio** too.

Propane needs **5** times as much oxygen.

Example

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$. All volumes are at the same temperature and pressure. 4.0 L of hydrogen reacts. What volume of chlorine reacts, and what volume of hydrogen chloride forms?

1. The ratio is 1 to 1 to 2.
2. Chlorine: 4.0 L.
3. Hydrogen chloride: 8.0 L.

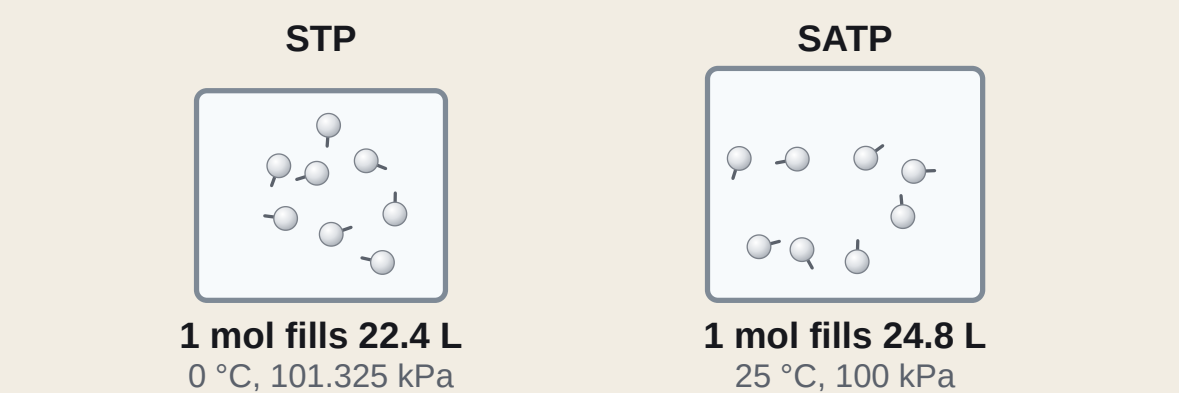
Try it

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$. All volumes are at the same temperature and pressure. 10 L of hydrogen reacts. What volume of oxygen reacts, and what volume of water vapour forms?

1. The ratio is 2 to 1 to 2.
2. Oxygen: 5.0 L.
3. Water vapour: 10 L.

Slide 4 of 6 · Molar volume

The last slides used Avogadro's idea for reactions. It also tells you the volume of one mole of gas.



Key ideas

The volume of one mole of gas is the **molar volume**.

At STP the molar volume is **22.4** L/mol.

At SATP the molar volume is **24.8** L/mol.

The SATP value is bigger because the gas is **warmer**.

Example

One mole of helium and one mole of oxygen are at the same temperature and pressure. Which fills more space?

1. One mole of any gas fills the same volume as one mole of another.
2. So neither fills more space.

Try it

Why is the molar volume bigger at SATP than at STP?

1. The gas is warmer at SATP.
2. A warmer gas fills more space.

Slide 5 of 6 · Changing between moles and litres of gas

The last slide gave the molar volume at STP and at SATP. Now you use it like a unit change.

n = 0.250 mol, at STP

At STP, 1 mol fills 22.4 L.

V = 0.250 mol × 22.4 L/mol

V = 5.60 L

Key ideas

To go from moles to litres, **multiply** by the molar volume.

To go from litres to moles, **divide** by the molar volume.

Check the **conditions** first.

Example

The molar volume at STP is 22.4 L/mol. What is the volume of 2.00 mol of gas at STP?

1. Moles to litres: multiply.
2. 2.00 mol × 22.4 L/mol = 44.8 L.

Try it

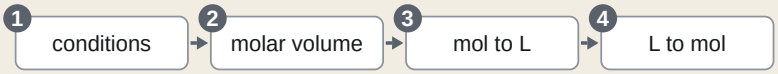
The molar volume at SATP is 24.8 L/mol. How many moles of gas are in 12.4 L at SATP?

1. Litres to moles: divide.
2. 12.4 L ÷ 24.8 L/mol = 0.500 mol.

Slide 6 of 6 · Method: how to change between moles and litres of gas

You just changed moles to litres and litres to moles. Here is what you did, as steps.

1. **Read** the conditions: STP or SATP.
2. **Choose** the molar volume for them.
3. **Multiply** moles by it to get litres.
4. **Divide** litres by it to get moles.



Check: litres is a bigger number than moles.

Used again in: lesson B8 and Unit D

Key ideas

Step 1: **read** the conditions: STP or SATP.

Step 2: **choose** the molar volume for them.

Step 3: **multiply** moles by it to get litres.

Step 4: **divide** litres by it to get moles.

Example

The molar volume at SATP is 24.8 L/mol. Use the steps to find the volume of 0.750 mol of gas at SATP.

1. Step 1: the conditions are SATP.
2. Step 2: the molar volume is 24.8 L/mol.
3. Step 3: 0.750 mol × 24.8 L/mol = 18.6 L.

Try it

The molar volume at STP is 22.4 L/mol. Use the steps to find the amount, in moles, of 5.60 L of gas at STP.

1. Step 1: the conditions are STP.
2. Step 2: the molar volume is 22.4 L/mol.
3. Step 4: 5.60 L ÷ 22.4 L/mol = 0.250 mol.