# Activity worksheet: gases

| Name | Group | Date |
|---|---|---|
| | | |

## What you will learn

With the gases simulation you will see a gas for what it is: lots of molecules that never stop moving and keep hitting the walls. You will find out what pressure is, how the pressure and volume of a gas change when you heat it, compress it or add more gas, and why a balloon can burst.

**How to work.** Each activity has three steps:

1. **Predict.** Before looking at the simulation, write down what you think will happen and why.
2. **Observe.** Set up the simulation, watch what happens and note down the data.
3. **Explain.** Compare what happened with your prediction and explain why.

If your prediction turns out to be wrong, don't rub it out: getting it wrong and understanding why is the best way to learn.

Each activity has a link that opens the simulation already set up. If you have the worksheet on paper, go to **simulaciencia.es/en/simulations/gases** and set it up as described under “Set up the simulation”. You can change the values with the controls or by typing them in.

**How to read the data.** Pressure (P) is in atmospheres (atm), volume (V) in litres (L) and temperature (T) in kelvin (K). The pressure is the average of the collisions in the last 3 seconds and, in the balloon, the rubber trembles a little because there are only a few molecules: **after each change, wait a few seconds until the pen marks the point on the graph, and then write down the values**.

## Before you start

What do you think now? Write T (true) or F (false). You will come back to this table at the end.

| Statement | T or F |
|---|---|
| a) There is air between the molecules of a gas. | |
| b) When a gas is heated, its molecules get bigger. | |
| c) When a gas is compressed, its molecules shrink. | |
| d) A gas pushes mainly downwards, like a solid. | |
| e) If a gas is still in a container, its molecules are still too. | |
| f) A balloon inflates because the rubber pushes outwards. | |

## Activity 1. What is inside the balloon?

**Set up the simulation:** “Balloon” with **10 molecules** at 273 K. Open the simulation ready to use

**Predict.** Draw how you imagine the inside of a balloon full of gas. What is there between one molecule and the next?

| My prediction (drawing) |
| --- |
| |
| |

**Observe.** Look at the molecule model. Press “⏸ Pause” and read the panel. Then resume and go up to 50 molecules.

| How much of the balloon do the molecules take up? | How do they move? | What happens when one hits the rubber? |
| --- | --- | --- |
| | | |

**Explain.** What is there between the molecules of a gas? Why doesn't the balloon go down if the molecules are so far apart? Hint: look at the grey molecules outside as well.

| My explanation |
| --- |
| |

## Activity 2. Pressure is collisions

**Set up the simulation:** “Rigid container” with 50 molecules at 273 K. Open the simulation ready to use

**Predict.** If you put twice as many molecules in the same container, what will happen to the pressure? Why?

| My prediction |
| --- |
| |

**Observe.** Change the number of molecules. The collisions per second are in the panel, under “What the instruments measure”.

| Molecules | Collisions with the wall each second | Pressure (atm) |
| --- | --- | --- |
| 50 | | |
| 100 | | |
| 200 | | |

**Explain.** What is the relationship between the pressure and the collisions of the molecules with the wall?

| My explanation |
| --- |
| |

## Activity 3. Heating the balloon

**Set up the simulation:** “Balloon” with 50 molecules at **100 K** and the V–T graph. Open the simulation ready to use

**Predict.** If you heat the balloon up to 400 K, what will happen to its size? And to the size of each molecule?

| My prediction |
| --- |
| |

**Observe.** Raise the temperature, wait for the point on the graph and work out the last column.

| Temperature T (K) | Volume V (L) | Colour of most of the molecules | V / T (L/K) |
| --- | --- | --- | --- |
| 100 | | | |
| 200 | | | |
| 400 | | | |

**Explain.**

1. Why does the balloon grow when you heat it? Does the size of the molecules change?
2. What happens to V / T? What shape do the points on the V–T graph make?

| My answers |
| --- |
| |
| |

## Activity 4. Heating a rigid container

**Set up the simulation:** “Rigid container”, 50 molecules at **200 K** and the P–T graph. Open the simulation ready to use

**Predict.** Now the container cannot grow. If you heat it, what will change?

| My prediction |
| --- |
| |

**Observe.** Change the temperature and work out the last column.

| Temperature T (K) | Volume (L) | Pressure P (atm) | P / T (atm/K) |
|---|---|---|---|
| 200 | | | |
| 273 | | | |
| 400 | | | |

**Explain.**

1. What happens to the pressure when you heat a gas at constant volume? What happens to P / T?
2. Why should you never heat an aerosol can, even when it is “empty”?

| My answers |
|---|
| |
| |

## Activity 5. Compressing and expanding

**Set up the simulation:** “Rigid container”, 50 molecules at 273 K, a volume of 1.2 L and the P–V graph. Open the simulation ready to use

**Predict.** If you make the container smaller without changing the temperature, what will happen to the pressure? And if you make it bigger?

| My prediction |
|---|
| |

**Observe.** Move the piston with the “Volume” control and work out P · V.

| Volume V (L) | Pressure P (atm) | P · V (atm·L) |
|---|---|---|
| 0.6 | | |
| 1.2 | | |
| 2.4 | | |
| 4.6 | | |

**Explain.**

1. What happens to P · V? What is this law called?
2. When you compress the gas, do the molecules shrink? What changes, then?

| My answers |
| --- |
| |
| |

## Activity 6. Putting gas into the balloon and taking it out

**Set up the simulation:** “Balloon” with 50 molecules at 273 K. Open the simulation ready to use

**Predict.** The tap on the tube lets molecules in or out. If you put in twice as many molecules, what will happen to the volume of the balloon? And to the pressure inside? And if you take them all out?

| My prediction |
| --- |
| |

**Observe.** Change the number of molecules and wait for the point on the graph.

| Molecules | Volume (L) | Pressure (atm) |
| --- | --- | --- |
| 25 | | |
| 50 | | |
| 100 | | |
| 0 | | |

**Explain.** Why does the balloon grow when you put gas in, but the pressure stays the same? What happens when there are no molecules left inside?

| My explanation |
| --- |
| |

## Activity 7. What holds the pressure?

**Set up the simulation:** “Balloon” with 200 molecules at 273 K. Open the simulation ready to use

**Predict.** If you keep adding molecules, will the balloon keep growing for ever? What will happen to the pressure inside?

| My prediction |
| --- |
| |

**Observe.** Go up to 300 and then to 500 molecules. Read the panel and look at the arrows that appear in the rubber.

| Molecules | Volume (L) | Pressure (atm) | Panel label |
|---|---|---|---|
| 200 | | | |
| 300 | | | |
| 500 | | | |

**Explain.** Which way do the arrows point? Why can the pressure inside be higher than outside?

| My explanation |
|---|
| |

## Activity 8. Challenge: why does a balloon burst?

**Set up the simulation:** "Balloon" with **500 molecules** at 273 K. Open the simulation ready to use

**Predict.** If you heat this balloon, what do you think will happen? At what temperature?

| My prediction |
|---|
| |

**Observe.** Raise the temperature 50 K at a time and wait each time. If it bursts, press "↺ New balloon".

| Temperature (K) | Pressure (atm) | Panel label |
|---|---|---|
| 273 | | |
| 350 | | |
| 400 | | |
| 450 | | |

**Explain.** Use the molecule model: why does the pressure go up when you heat the gas? Why does the rubber end up breaking?

| My explanation |
|---|
| |

## Apply what you have learnt

Solve these without the simulation. Write the law, the calculation with its units and the result.

1. A gas takes up 4 L at 1 atm. If it is compressed at constant temperature to 1 L, what will its pressure be?
2. A rigid bottle holds air at 1 atm and 300 K. It is heated to 450 K. What will its pressure be?
3. A 2 L balloon is at 300 K. If it is heated at constant pressure to 360 K, what will its volume be?
4. Use the molecule model to explain why a car's tyres have a higher pressure after a long journey.

| Problem | Calculation and result |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |

## Review your ideas

Go back to the “Before you start” table. Would you change any of your answers? Write which one and explain why, using something you saw in the simulation.

| What has changed in my ideas |
|---|
| |
| |

## Going further (Years 11 and 12)

1. Using the data from activity 5, draw the P–V graph. What shape is it? Compare it with the one the pen has drawn.
2. Combine activities 3, 4 and 5 into a single expression: P · V / T = constant. Check that it holds in the rigid container for two situations with different volume and temperature.
3. Open “★ Challenges” and collect the five stamps in the album of laws. For each one, write what you kept the same and what you changed.

| My answers |
|---|
| |
| |
| |

## Self-assessment

Put an X to show how confident you feel at the end.

| I can... | Yes | Nearly | Not yet |
|---|---|---|---|
| Describe a gas using the molecule model | | | |
| Explain pressure as the result of collisions with the walls | | | |
| Predict what happens to P, V and T when one of them changes | | | |
| Explain why a balloon grows, shrinks or bursts | | | |
| Solve problems with Boyle's, Charles's and Gay-Lussac's laws | | | |
| Use a prediction and an observation to change an idea I had | | | |

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