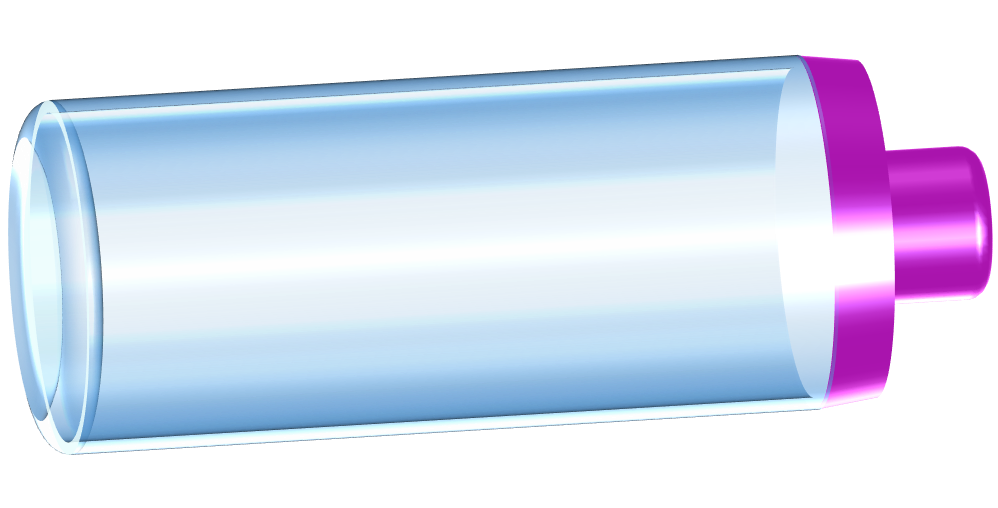
**Bottled gas**

This drinks bottle is full of a gas.

* It contains about 10 000 000 000 000 000 000 000 particles of gas.
* The average speed of each particle is about 350 metres per second



**To answer:**

1. Explain why the gas particles are spread out evenly throughout the whole of the bottle.
2. What happens if the temperature of the gas is increased?

*Physics > Big idea PMA: Matter > Topic PMA4: Particle explanations > Key concept PMA4.2: Pressure*

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| --- |
| **Response activity** |
| **Bottled gas** |

**Overview**

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| --- | --- |
| Learning focus: | The pressure of a fluid is a measure of how hard its particles are pushing each other apart, and it is proportional to the size of the force exerted by the fluid on a surface. |
| Observable learning outcome: | Explain why the pressure of a fluid is a scalar quantity that is equal in all directions.  Explain the effect of temperature change on the pressure of a fixed volume of fluid. |
| Activity type: | Application and practice - explanation |
| Key words: | Pressure, particle, collision |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic questions:

* Diagnostic question: Squashing air
* Diagnostic question: More pressure
* Diagnostic question: Hot air
* Diagnostic question: Cold air

**What does the research say?**

Psillos (1999) examined how textbooks develop an understanding of pressure and found that they nearly always introduce pressure as a measure of how concentrated a force is and use the equation ‘P=F/A’ to define it. Usually, examples of solids pushing down onto a surface are used to consolidate understanding and in these examples surface pressure is a vector quantity acting in one direction. From such an introduction, students can interpret pressure wrongly as a ‘pressing force’ and may (as some textbooks do) describe a fluid ‘exerting a pressure’.

In contrast to pressure between solid surfaces, pressure in a fluid is a scalar quantity, yet few students think of pressure acting in all directions in air or water (Driver et al., 1994).

Following large scale studies of students’ conceptions about gases (n=600, age 11-13) and fluids (n=944, age 14-20) by Séré (1986) and Besson (2004) respectively, both researchers conclude that there is a need for students to systematically reason how the motion of particles cause pressure effects, as a preliminary step in the study of pressure. Ideas about the movement of particles in a fluid can then be used to explain why the force on a surface, F = P x A.

Before using a particle model to explain pressure, it may be necessary to resolve students’ misunderstandings about the motion and distribution of particles in gas. In their study of US college students on a general chemistry course (n=378, age 17-18) Sanger, Vaughn and Binkley (2013) found that although 85% understood how particle speeds increased or decreased with temperature, only 51% predicted the correct distribution of particles in a gas after its temperature had been reduced. Rather than thinking of particles evenly distributed throughout a container, and moving at a slower average speed; nearly half thought that the slowing down of particles in a gas meant that they moved more closely together and clustered in one region of a container.

**Ways to use this activity**

This activity gives students the opportunity to practise applying their understanding and to clarify their thinking through discussion. To support this, students should answer the question in pairs or small groups.

Listening to individual groups as they work often highlights any difficulties they might have. These can often be overcome, through a whole class clarification or redirection part way through the activity.

Asking students to share their answer is a useful check. After a group has fed back, it might be helpful to model an even better answer. You could do this, for example, by asking another group to add to, or clarify, the first observation. Then ask another group to sum up the important part of the observation, and so on.

*Differentiation*

If some students are working with a teaching assistant, then a list of prompt questions for the TA could help to make this activity more purposeful.

**Expected answers**

1. The particles of gas spread out because they are colliding with each other and pushing each other apart.

They bounce back off the walls of the drinks bottle so they cannot take up any more space than the volume of the bottle.

If more particles cluster in one part of the bottle they will have more collisions than particles in other parts of the bottle. They will be pushed into those parts of the bottle with fewer particles because there are fewer particles in those parts to collide with and to push them back.

This makes the particles spread out evenly throughout the whole of the drinks bottle.

2. The particles would move more quickly.

The walls of the bottle stop the particles from moving further apart, so they would have the same distribution as before.

They would have harder collisions with each other and more frequent collisions. This increases how hard the particles push each other apart.

The pressure of the gas becomes higher.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

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