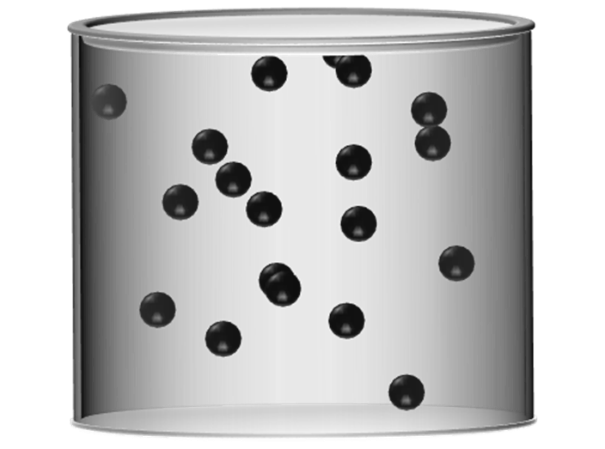
**Hot air**

The lid on this can is airtight.

Air is trapped in the can.

The balls represent particles that the air is made of.

The air in the can is at room temperature.



The temperature of the air in the can is increased by heating.

1. What happens to the speed of the particles of air?

*Put a tick (✓) in the box next to the best answer.*

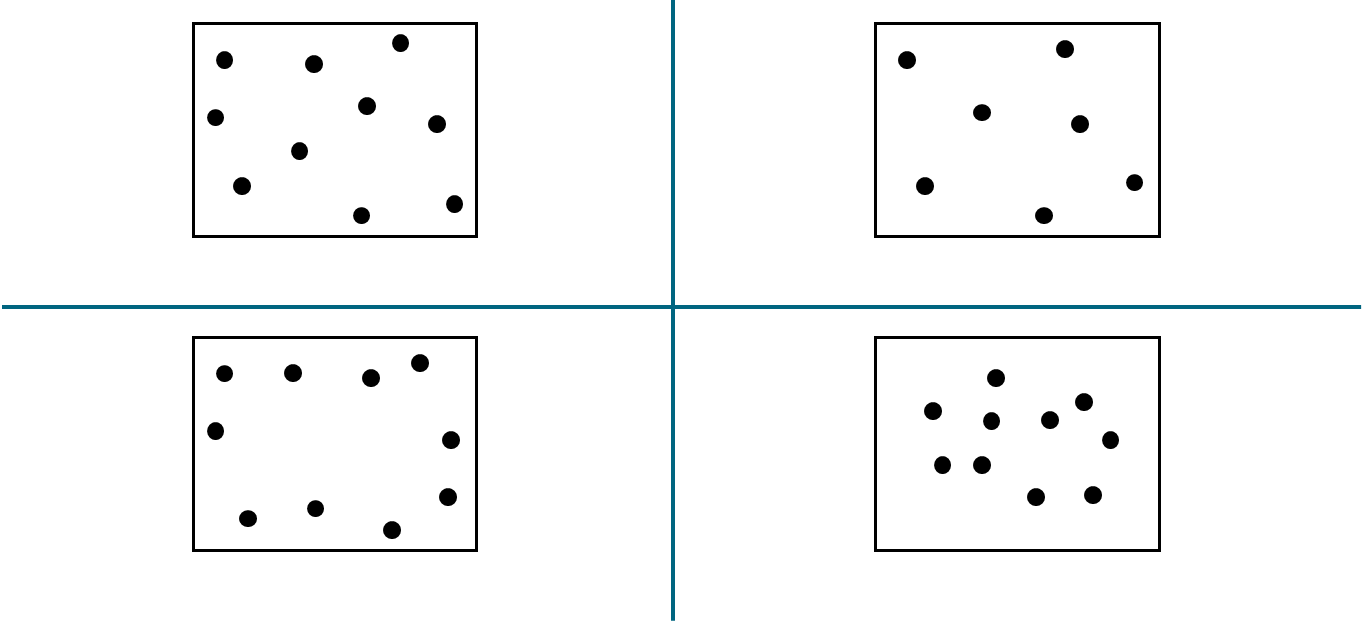
|  |  |  |
| --- | --- | --- |
| **A** | The particles move more quickly. |  |
|  |  |  |
| **B** | The particles keep moving at the same speed. |  |
|  |  |  |
| **C** | The particles move more slowly. |  |

2. What does heating do to the pressure of air in the can?

*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | Pressure becomes bigger. |  |
|  |  |  |
| **B** | Pressure stays the same. |  |
|  |  |  |
| **C** | Pressure becomes smaller. |  |

3. Which diagram best shows what heating does to the distribution of particles in the can?



**A** Stay roughly the same.

**D** Cluster nearer the middle.

**B** Become more spaced out.

**C** Cluster nearer the sides.

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

|  |
| --- |
| **Diagnostic question** |
| **Hot air** |

**Overview**

|  |  |
| --- | --- |
| 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 the effect of temperature change on the pressure of a fixed volume of fluid. |
| Question type: | Simple multiple choice |
| Key words: | Pressure, particle |

**What does the research say?**

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.

These questions explore students’ understanding of how increasing the speed of gas particles by heating affects the pressure of the gas and the distribution of its particles, when volume remains the same.

**Ways to use this question**

Students should complete the question individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

The answers to the question will show you whether students understood the concept sufficiently well to apply it correctly.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

1. A, the particles move more quickly.

2. A, pressure becomes bigger.

3. A, stay roughly the same.

**How to respond - what next?**

For question 1, most students will recognise that particles of a gas move more quickly when the temperature of the gas is increased.

Question 2 addresses the understanding that a gas with faster moving particles in a confined space has a bigger pressure. Sanger et al. (2013) found that about half of students (age 17-18) did not make the connection between the speed of particles and changes to pressure when a gas was cooled. Students giving wrong answers to this question are likely to be thinking pressure is dependent on the density of gas particles. Those who think pressure remains constant may recognise that the number of gas particles in the can has not changed. Others who predict the pressure of air decreases may have recalled that particles of gas are more spaced out when the gas is hotter, but have applied this ‘fact’ to a situation in which it is not true.

Question 3 addresses the understanding that particles of gas in a fixed volume cannot spread out. Instead, particles collide with each other more often and with more force, but the separation of particles is kept the same by the container. Sanger et al. (2013) found that about half of students (age 17-18) did not understand this. Some may wrongly apply the ‘fact’ that particles of a gas spread out when it gets hotter. Others may choose option C which shows particles moving away from each other while being contained by the walls of the can. Answer D represents particles bouncing harder off the walls and being forced into the middle.

If students have misunderstandings about explaining the effect of temperature change on the pressure of a fixed volume of fluid, it can be helpful to review their understanding of particles in a gas. Careful questioning can elicit the understanding that particles of a gas, which is in a container, always move to fill the whole of the container. This means the average separation of particles cannot change with their speed. A useful analogy is to think of the spacing of a fixed number of students walking or running around the whole of a sports hall: separation remains similar when running, but collisions are more frequent and more painful.

Giving students the task of explaining, in their own words, why pressure increases as the temperature of gas inside a can goes up, gives them the opportunity to consolidate their understanding.

The following BEST ‘response activities’ could be used in follow-up to this diagnostic question:

* Response activity: Gas pressure
* Response activity: Bottled gas

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG), based on questions in Sanger et al. (2013).

Images: Peter Fairhurst (UYSEG).

**References**

Besson, U. (2004). Students' conceptions of fluids. *International Journal of Science Education,* 26:14**,** 1683-1714.

Sanger, M. J., Vaughn, C. K. and Binkley, D. A. (2013). Concept learning versus problem solving: evaluating a threat to the validity of a particulate gas law question. *Journal of Chemical Education,* 90**,** 700-709.

Sere, M. (1986). Childrens' conceptions of the gaseous state, prior to teaching. *European Journal of Science Education,* 8**,** 413-25.