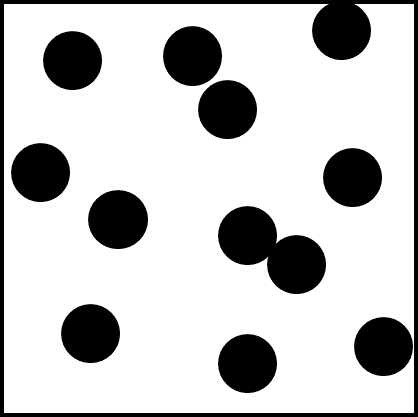
**Doubling up**

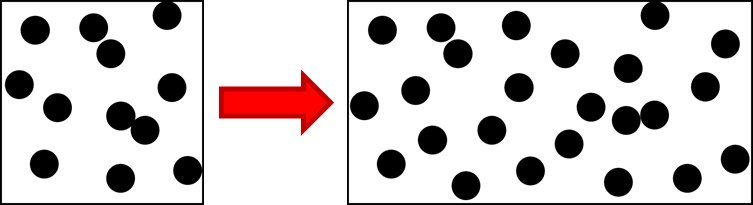
This diagram represents particles of gas inside a box.

The gas has a large pressure and pushes on the walls of the box.



What happens if the amount of gas is doubled *and* the volume is doubled?

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



|  |  |  |  |
| --- | --- | --- | --- |
|  | ***Pressure of the gas.*** | ***Force on the walls of the box.*** |  |
| **A** | Goes up. | Goes up. |  |
|  |  | |  |
| **B** | Goes up. | Stays the same. |  |
|  |  | |  |
| **C** | Stays the same. | Goes up. |  |
|  |  | |  |
| **D** | Stays the same. | Stays the same. |  |

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

|  |
| --- |
| **Diagnostic question** |
| **Doubling up** |

**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: | Distinguish between pressure and force. |
| Question type: | Simple multiple choice |
| Key words: | Pressure, force, particles, volume |

**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’. This misunderstanding is compounded by diagrams that usually indicate pressure with arrows that are visually indistinguishable from force arrows. It is instead, correct to say that ‘a fluid has pressure’ and a ‘force is exerted’ (Kariotoglou and Psillos, 1993).

In order to think about pressure in liquids and gases, students cannot simply extend ideas about surface pressure (Driver et al., 1994). 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 and textbooks rarely make explicit the conditions in which each interpretation of pressure should be applied (Psillos, 1999).

**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**

C – Pressure stays the same and the force on the walls of the box increases.

**How to respond - what next?**

Doubling both the volume of the box and the number of particles it contains means that the spacing of the particles stays the same. As the temperature has not changed, the particles will be pushing apart from each other exactly as they were before and pressure stays the same. The particles will also press on each square centimetre of the wall with the same force as before, but as the walls now have a bigger surface, the total force is bigger.

Students who think of pressure as a ‘pressing force’ are most likely to choose option A because more particles are pressing on the walls. Alternatively they may choose option B, in which case they may be thinking of the ‘force on the walls’ as meaning the force with which each particle hits the wall, which is the same.

Choosing option D suggests an understanding that pressure is a measure of how hard particles are pushing each other apart, but that students perhaps interpret ‘force on the walls’ as meaning the force with which each particle hits the walls of the box.

If students have misunderstandings about distinguishing between pressure and force, it can help to use the particle diagrams in this question to explicitly distinguish between force and pressure.

Looking at equal sized volumes of each box shows that particles have the same spacing and will be colliding with each other equally frequently and at the same speed - because temperature is the same in each. Which shows the pressure of each gas is the same.

Careful questioning can elicit the understanding that each particle exerts the same force on the wall of each box, on average, and that because more are colliding with the walls of the larger box, there is a bigger total force exerted on its walls.

A useful distinction between force and pressure is that force is a vector and the pressure of a gas is a scalar quantity. Particles hit the wall of a box from only one side and push it in only *one direction*.

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

* Response activity: Big fish, little fish

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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Kariotoglou, P. and Psillos, D. (1993). Pupils' pressure models and their implications for instruction. *Research in Science and Technological Education,* 11(1)**,** 65-108.

Psillos, D. (1999). Teaching fluids: intended knowledge and students' actual conceptual evolution. *International Journal of Science Education,* 21(1)**,** 17-38.