Moles and volume

Introduction

These questions are designed to help you to develop mental models (pictures in your head) of the relationship between number of molecules (in moles) and the volume of a gas. Use the icon in the margin to find out which level of understanding the question is developing.

Macroscopic: what we can see. Think about the properties that we can observe, measure and record.

Sub-microscopic: smaller than we can see. Think about the particle or atomic level.

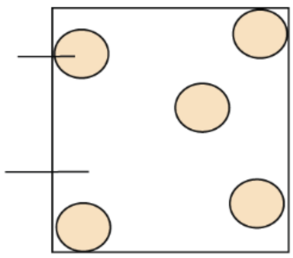
Symbolic: representations. Think about how we represent chemical ideas including symbols and diagrams.

Questions

1. The basic particle model shows the arrangement of particles in the solid, liquid and gas states.

(a) Add the labels to the particle model diagram of the gas state to show how oxygen is represented.

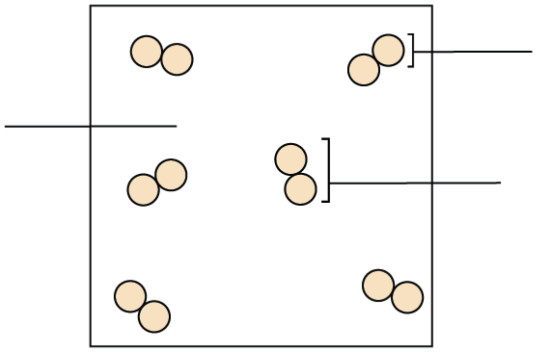
- an oxygen particle
- empty space



(b) The particle model can be improved by showing that the particles that make up oxygen are molecules.

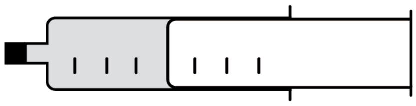
Add the labels to the improved particle diagram for oxygen to show:

- an atom
- a molecule
- empty space



(c) A syringe has a plunger that can be pushed.

If the end of the syringe is sealed, the plunger can only be pushed if the substance in the syringe can be compressed (squashed).



Complete the explanation of why oxygen can be compressed.

Oxygen can be compressed because there is ______________________ between the

______________________.

This means that the ______________________ can be pushed closer together.

(d) Explain why water in the liquid state cannot be compressed.

____

____

____

2. Equal volumes of different gases (at the same temperature and pressure) contain the same number of molecules.

(a) Match the volume of each gas on the left the volume of gas containing the same number of molecules on the right.

1 cm^3 oxygen	1 m^3 hydrogen
1000 cm^3 hydrogen	1 cm^3 nitrogen
1 m^3 nitrogen	1000 cm^3 oxygen

(b) Oxygen is made up of O_2 molecules. Helium is made up of individual atoms.

Give the volume of helium that contains the same number of atoms as the number of molecules in 1 cm^3 of oxygen.

__________ cm^3

(c) Explain why 1 cm^3 of oxygen does not contain the same number of atoms as there are atoms in 1 cm^3 of helium.

____

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____

(d) In 1000 cm^3 of helium gas only about 0.3 cm^3 is taken up by helium atoms. The rest is empty space.

Explain why there can be the same number of atoms in 1000 cm^3 of krypton as there are in 1000 cm^3 of helium, even though krypton atoms are bigger than helium atoms.

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3. Avogadro's constant is 6.02×10^{23}. The volume of 6.02×10^{23} molecules (or individual atoms of a noble gas) at room temperature and pressure is 24 dm^3.

One dm^3 (decimetres cubed) is equal to 1000 cm^3.

(a) Give the volume of each gas that contains 6.02×10^{23} molecules.

i. Oxygen (O_2) _____dm^3

ii. Nitrogen (N_2) _____dm^3

(b) Give the volume of each gas that contains 6.02×10^{23} atoms.

i. Helium (He) _____dm^3

ii. Neon (Ne) _____dm^3

(c) 6.02×10^{23} is one mole of molecules or atoms. Give the volume of

i. One mole of oxygen molecules. _____dm^3

ii. Two moles of neon atoms. _____dm^3

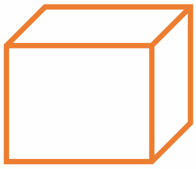
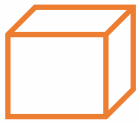
iii. 0.5 moles of nitrogen molecules. _____dm^3

4. A mathematical formula can be used to calculate the volume of a given number of moles of a gas.

$$\text{volume} = \text{volume of one mole } (24\ dm^3) \text{ x number of moles}$$

(a) Calculate the volume of two moles of hydrogen using the following steps.

The mathematical formula could be visualised as:

volume	=	volume of one mole	x	number of moles
	=		x	number of moles in the question

Give the volume of one mole of hydrogen. _______dm³

(b) Give the number of moles that the question is asking about. _______ moles

(c) Add the values into the formula

$$\text{volume} = \text{volume of one mole } (24\ dm^3) \text{ x number of moles}$$

$$= \_\_\_\_\_\_\_\_\_\_ \text{ x } \_\_\_\_\_\_\_\_\_\_$$

$$= \_\_\_\_\_\_\_\_\_\_ dm^3$$

Calculate the volume of each gas in dm^3.

(d) Three moles of oxygen (O_2)

____

____

(e) 0.1 moles of hydrogen (H_2)

____

____

(f) 1.5 moles of nitrogen (N_2)

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____

(g) Two moles of helium (He)

____

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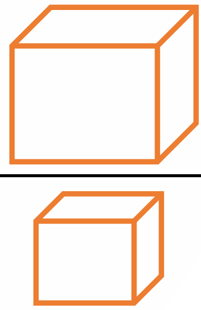
5. A different arrangement of the mathematical formula can be used to find the number of molecules of a gas in a given volume of that gas.

$$\text{number of moles} = \frac{\text{volume}}{\text{volume of one mole}}$$

(a) Calculate the number of moles of hydrogen in a volume of 36 dm^3.

The mathematical formula could be visualised as:

$$\text{number of moles} = \frac{\text{volume}}{\text{volume of one mole}}$$



Give the volume of one mole of hydrogen. ________dm^3

(b) Give the volume of hydrogen asked about in the question. ________dm^3

(c) Add the values to the mathematical formula.

$$\text{number of moles} = \frac{\text{volume}}{\text{volume of one mole}}$$

$= $ __________ $\div$ __________

$= $ __________moles

(d) Calculate the number of moles of helium in a volume 6 dm^3.

number of moles $= $ __________ $\div$ __________

$= $__________moles