Taking it Further: Volumes of Gases

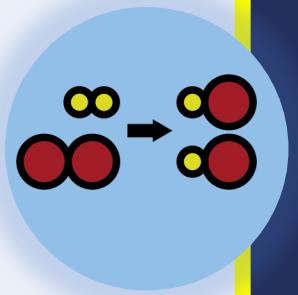
Answer the questions below.

1. State the unit of volume in chemistry.
   dm^3
2. Convert 50 cm^3 to dm^3.
   0.05 dm^3
3. State the number of particles in 1 mole of a substance.
   6.02×10^{23}
4. Calculate the relative formula mass of ammonia (NH_3).
   14+(3x1) = 17
5. Calculate the percentage by mass of hydrogen in ammonia.

$$\textbf{Percentage by mass} = \frac{\textbf{mass of element}}{\textit{mass of compound}} \times 100$$

$$\textbf{Percentage by mass} = \frac{3}{17} \times 100$$

$$\textbf{Percentage by mass} = 17.65\ \%$$



Do Now

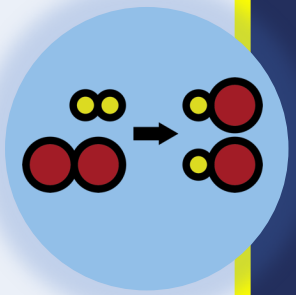
Taking it Further: Volumes of Gases

Do Now:

1. State the unit of volume in chemistry.
2. Convert 50 cm^3 to dm^3.
3. State the number of particles in 1 mole of a substance.
4. Calculate the relative formula mass of ammonia (NH_3).
5. Calculate the percentage by mass of hydrogen in ammonia.

Drill:

1. Calculate the relative formula mass of methane (CH_4).
2. Calculate the mass of 1 mole of methane.
3. Calculate the number of moles in 48 g of methane.



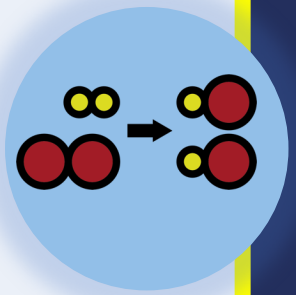
Do Now

Taking it Further: Volumes of Gases

Read Now:

Avogadro's law states that one mole of any gas has the same volume. This is because one mole of any substance contains 6.02 x 10^{23} particles. For some gases, such as the Noble gases, 1 mole of gas contains 6.02 x 10^{23} atoms. For other gases, such as carbon dioxide or oxygen (O2), 1 mole of gas contains 6.02 x 10^{23} molecules. As the mole is the number of particles present, if there are the same number of particles present, they will occupy the same volume of space. This law applies if gases are at standard temperature and pressure, which is room temperature (20°C) and 1 atmosphere (atm) of pressure. You should remember from physics that temperature and pressure both affect the volume of a gas, so these must remain constant for 1 mole of two different gases to have the same volume.

1. State Avogadro's Law.
2. State the number of particles found in one mole of a substance.
3. Describe the conditions of standard temperature and pressure.
4. Describe the two factors that must remain constant for Avogadro's law to apply.

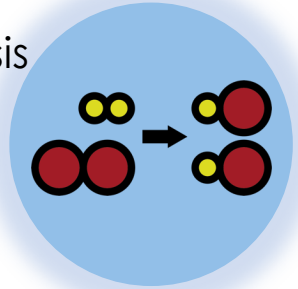


Do Now

Taking it Further: Volumes of Gases

C4.3.15

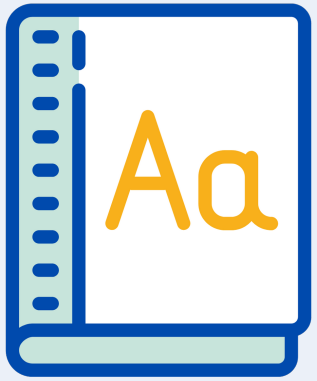
Science Mastery



Following this lesson, students will be able to:

- State the volume of 1 mole of gas at room temperature and pressure.
- Calculate the volume of different numbers of moles of a gas.
- Use chemical equations to calculate volume and number of moles of gas

Key Words:



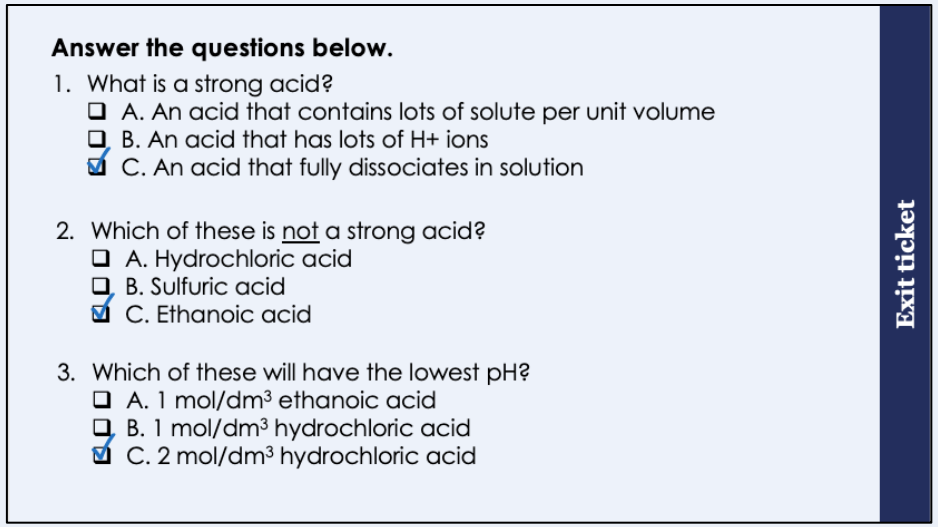
volume	**mole**	**molar volume**
rtp	**pressure**	**temperature**

Lesson Objectives

This is the fix-it portion of the lesson

The **fix-it** is an opportunity to respond to gaps in knowledge, especially those identified by the **pre-unit quiz**.

- The teacher should customise this slide as needed, to facilitate
  - **reteach**, **explanation, demonstration** or **modelling** of ideas and concepts that students have not yet grasped or have misunderstood.
  - **practise** answering specific questions or of key skills.
  - **redrafting** or **improving** previous work.



Answer the questions below.

1. What is a strong acid?
   - ☐ A. An acid that contains lots of solute per unit volume
   - ☐ B. An acid that has lots of H+ ions
   - ☑ C. An acid that fully dissociates in solution

2. Which of these is <u>not</u> a strong acid?
   - ☐ A. Hydrochloric acid
   - ☐ B. Sulfuric acid
   - ☑ C. Ethanoic acid

3. Which of these will have the lowest pH?
   - ☐ A. 1 mol/dm^3 ethanoic acid
   - ☐ B. 1 mol/dm^3 hydrochloric acid
   - ☑ C. 2 mol/dm^3 hydrochloric acid

Exit ticket

Fix-it

Reacting Gases

Higher Tier only

One mole of any substance contains the same number of particles.

One mole of a gas occupies the same volume as one mole of another gas.

Molar volume is the volume occupied by one mole of gas at room temperature (20 °C) and pressure (1 atmosphere).

At room temperature and pressure (rtp) molar volume is **24 dm^3**.

For example:

$H_2(g) + Cl_2(g) \rightarrow 2\,HCl\,(g)$

Moles and molar volume

Higher Tier only

Molar volume at room temperature and pressure is 24 dm^3.

We can use this to calculate the volume of a known amount of substance.

We can use the equation:

$$\textbf{Volume} = \textbf{number of moles} \times \textbf{molar volume}$$

which can also be written as:

$$\textbf{Number of moles} = \frac{\textbf{volume}}{\textbf{molar volume}}$$

Worked Example

Higher Tier only

A scientist has 0.25 moles of oxygen at room temperature and pressure.
What is volume of this oxygen?

$$\textbf{Number of moles} = \frac{\textbf{volume}}{\textbf{molar volume}}$$

$$0.25 = \frac{\textbf{volume}}{24}$$

$$\textbf{Volume} = 6\ \textbf{dm}^3$$

Worked Example

Higher Tier only

We can also apply this equation given a balanced chemical reaction.

Sodium azide (NaN_3) decomposes when heated to form sodium and nitrogen:

$$2\ NaN_3\ (s) \rightarrow 2\ Na\ (s) + 3\ N_2\ (g)$$

If 4 moles of sodium azide decomposes, what volume of nitrogen is formed?

Mole ratio = 2:3

Number of moles of nitrogen = 6 mol

$$\textbf{number of moles} = \frac{\textbf{volume}}{\textbf{molar volume}}$$

$$6 = \frac{\textbf{volume}}{24}$$

$$\textbf{Volume} = 144\ \textbf{dm}^3$$

Is this correct?

50 g of oxygen will occupy the same volume as 50 g of carbon dioxide

Talk Task

Discuss with your partner how you should solve this question. Work together to find the answer.

A scientist has a sample of 0.6 dm^3 of oxygen gas.

What mass of gas is in the sample?

$$\text{Number of moles} = \frac{\text{volume}}{\text{molar volume}}$$

$$\text{number of moles} = \frac{0.6}{24}$$

$$\text{number of moles} = 0.025$$

$$M_r\ O2 = 16 \times 2$$
$$= 32$$

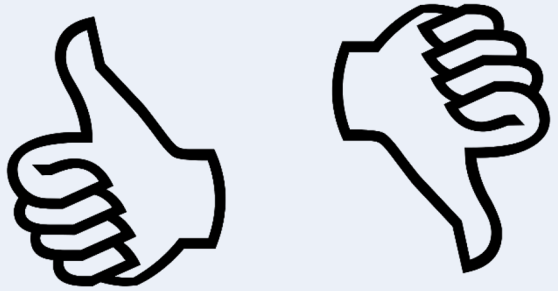
$$\text{number of moles} = \frac{\text{mass}}{M_r}$$

$$0.025 = \frac{\text{mass}}{32}$$

$$\text{mass} = 0.8\ \text{g}$$

Talk Task

True or false?



1. 1 mole of gas at rtp occupies 24 dm^3 **True**
2. Room temperature is 24 °C **False**
3. The volume of a gas can be calculated using molar volume divided by number of moles **False**
4. Molar volume is the volume occupied by one mole of gas **True**
5. 2 moles of gas at rtp occupies 12 dm^3 **False**

Check for understanding

Drill

1. State room temperature.
2. State room pressure.
3. Explain what is meant by ‘rtp’.
4. Define molar volume.
5. State the unit of volume.
6. State molar volume at rtp.
7. State the equation that links volume, molar volume and number of moles.

Check for understanding

Drill answers

1. 20 °C
2. 1 atmosphere
3. Room temperature and pressure
4. The volume occupied by one mole of gas at room temperature and pressure.
5. dm^3
6. 24 dm^3
7. $\text{Number of moles} = \frac{\text{Volume}}{\text{Molar volume}}$

Check for understanding

Answer the questions below.

1. What is the volume of one mole of gas at rtp?
   - ☐ A. 22 dm^3
   - ☑ B. 24 dm^3
   - ☐ C. 6.02 x 10^{23} dm^3

2. Calculate the number of moles in 0.12 dm^3 carbon dioxide gas at rtp.
   - ☐ A. 0.0027 mol
   - ☑ B. 0.005 mol
   - ☐ C. 200 mol

3. What two factors must remain constant for 1 mole of two different gases to have the same volume?
   - ☑ A. Temperature and pressure
   - ☐ B. Temperature and mass
   - ☐ C. Pressure and mass

Exit ticket

Feedback

Lesson C4.3.15	
What was good about this lesson?	What can we do to improve this lesson?

Send us your feedback by clicking this link
or by emailing sciencemastery@arkonline.org
Thank you!