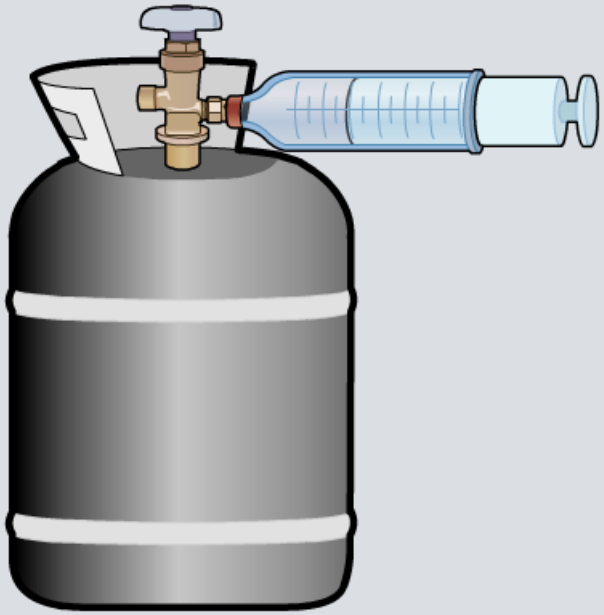
Ideal Gas Laws



Avogadro's law

In 1811 the Italian scientist Amedeo Avogadro developed a theory about the volume of gases.

Avogadro's law:

Equal volumes of different gases at the same pressure and temperature will contain equal numbers of particles.

For example, if there are 2 moles of O_2 in 50 cm^3 of oxygen gas, then there will be 2 moles of N_2 in 50 cm^3 of nitrogen gas and 2 moles of CO_2 in 50 cm^3 of carbon dioxide gas at the same temperature and pressure.

Using this principle, the volume that a gas occupies will depend on the number of moles of the gas.

Molar volumes of gases

If the temperature and pressure are fixed at convenient standard values, the molar volume of a gas can be determined.

Standard temperature is 273 K and pressure is 100 kPa. At standard temperature and pressure, 1 mole of any gas occupies a volume of 22.7 dm^3. This is the molar volume.

Example: what volume does 5 moles of CO_2 occupy?

volume occupied = no. moles × molar volume

= 5 × 22.7

= 113.5 dm^3

Ideal gas equation

How is the number of moles in a gas at other temperatures and pressures calculated?

The **ideal gas equation** relates pressure, volume, number of moles and temperature for a gas.

$$pV = nRT$$

p = pressure in Pa

V = volume in m^3

n = number of moles

R = gas constant: $8.31 JK^{-1} mol^{-1}$

T = temperature in Kelvin

A gas that obeys this law under all conditions is called an **ideal gas**.

Ideal gas equation: converting units

It is very important when using the ideal gas equation that the values are in the correct units.

The units of pressure, volume or temperature often need to be converted before using the formula.

Pressure

to convert kPa to Pa: **× 1000**

Volume

to convert dm^3 to m^3: **÷ 1000 (10^3)**

to convert cm^3 to m^3: **÷ 1000000 (10^6)**

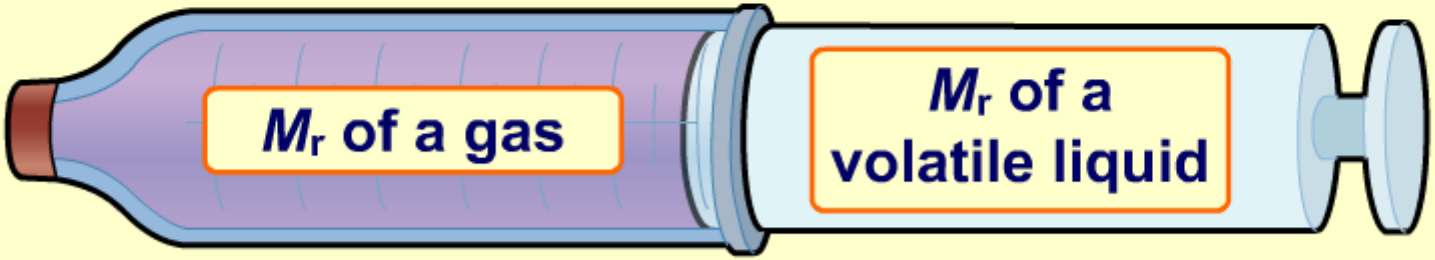
Temperature

to convert °C to Kelvin: **+ 273**

Determining the M_r of gases and volatile liquids

The ideal gas equation can be used to determine the M_r of either a gas or a volatile liquid.

Click on a button to find out how this is done in each case.



Using the ideal gas equation

The number of moles in a sample of a substance is linked to the mass of the sample and the relative atomic/molecular mass (A_r or M_r) of the substance by the equation below.

Click on a variable in the equation to find out more.

$$pV = nRT$$

Ideal gas calculations

Question: 1/10

What is the volume of gas in a cylinder containing 18.5 moles of oxygen at a temperature of 293 K and a pressure of 1×10^6 Pa?

- $22.2\,m^3$
- $0.0450\,m^3$
- $0.0550\,m^3$
- $24.2\,m^3$