6.6.2 The Ideal Gas Law

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The 3 gas laws, from section 6.6.1, can be combined into a unified law called the Ideal Gas Law. It relates pressure (P), temperature (T) and volume (V) for an 'ideal' gas. We will look at what an ideal gas is in section 6.7.

$$\frac{PV}{T} = constant = nR$$

where n=number of moles, $R = molar\ gas\ constant = 8.31Jmol^{-1}K^{-1}$

It is worth taking time to consider what a mole is. A mole of a molecular/atomic gas contains 6.02×10^{23} molecules/atoms. For example, a mole of hydrogen gas (H_2) contains 6.02×10^{23} H_2 molecules and a mole of argon gas (Ar) contains 6.02×10^{23} Ar atoms. 6.02×10^{23} is called Avogadro's number.

If we have one mole of a gas, the Ideal Gas Law equation becomes:

$$\frac{PV}{T} = constant = R$$

$$\therefore PV = RT$$

(1)✐Calculate the volume that 1 mole of a gas occupies at standard temperature and pressure (i.e. 273K and 101kPa).

(2) A container of 20g of nitrogen gas (N_2), at a pressure of 200kPa, occupies a volume of $1.34 \times 10^{-2}m^3$. *What temperature is it at?*

If we have n moles of a gas, then the number of molecules/atoms (N) is given by:

$$N = n \times N_A$$

where $N_A = Avogadro's\ number = 6.02 \times 10^{23}$

We can rewrite the Ideal Gas Law equation in terms of the number (N) of molecules/atoms:

$$PV = NkT$$

where k is another constant called Boltzmann's constant.

(3) Show that Boltzmann's constant $k = \frac{R}{N_A}$ *and that it has a value* $1.38 \times 10^{-23}JK^{-1}$.

(4) 3.00×10^{22} *atoms of helium gas are enclosed in a container at atmospheric pressure (=101kPa) and a temperature of 600K. What is the volume of the container?*