Gas Laws

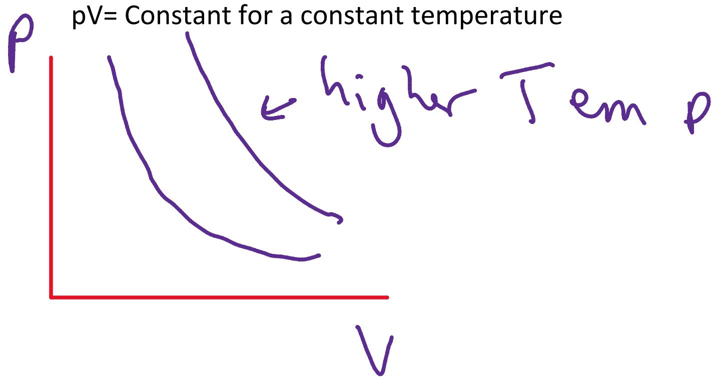
09 December 2019 08:54

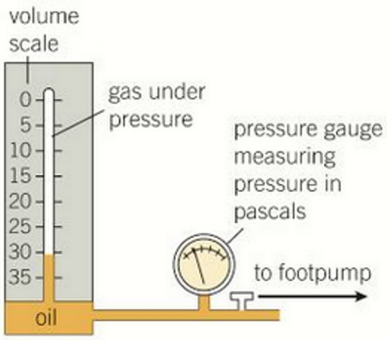
Absolute temperature = C +273

There are three gas laws linking pressure, volume and temperature

Boyle's Law

pV= Constant for a constant temperature

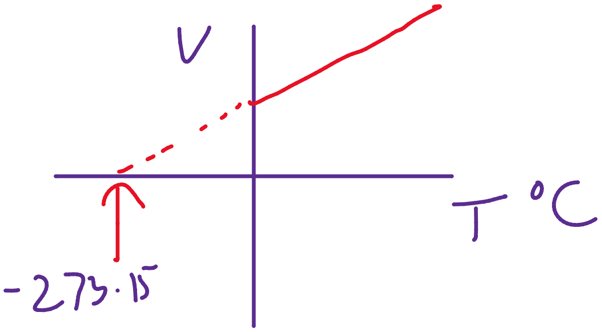




▲ **Figure 1** *Testing Boyle's law*

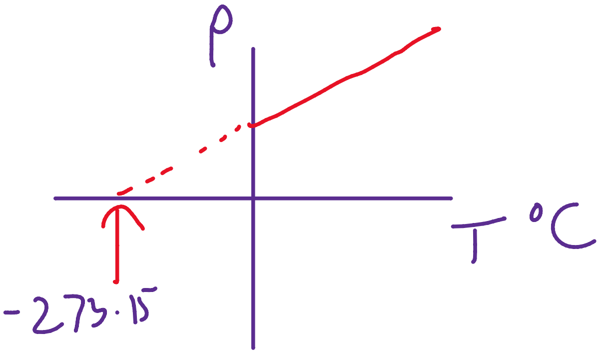
Charle's Law

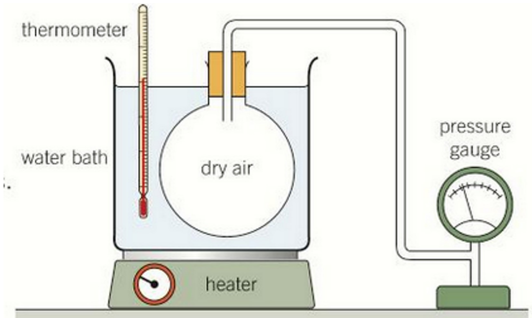
V/T = constant (pressure fixed)



The Pressure Law

P/T = constant, fixed volume





▲ **Figure 4** *The pressure law*

The Ideal Gas Equation

Molecular Mass

The molecular mass of a gas is the sum of all the atoms in that gas

Relative Molecular Mass is given relative to Carbon-12

Molar Mass

- At fixed p and T and a given volume of gas there will always be the same number of particles regardless of which gas you have.

- One mole of a any gas, has the same number of particles in it. This is Avogadro's Constant = N_A and is 6.02 x10^{23}.
- Molar mass is - wait for it - the mass of 1 mole of that substance. This gets confusing because we tend to think of the particles - which are most often molecules
- Number of moles is n
- Number of molecules N = nN_A - you have to be clear about your 'n, N and N_A

Combining the three gas laws above gives:

$$\frac{pV}{T} = \text{constant}$$

The constant depends on the number of moles, n.

The constant then becomes nR

This eqn works for a system. So, imagine a football. You can sit on it, throw it, warm it up, put it underwater - whatever - the equation holds. But as soon as you pump it up a bit you have changed the system so the equation will stop working.

R = molar gas constant 8.31 J mol^{-1}K^{-1}

We therefore end up with this equation:

$$\frac{pV}{T} = nR \quad \text{or} \quad \underline{\underline{pV = nRT}}$$

This is called the 'Ideal Gas Equation' and it works with - frankly no gas at all.... but I jest.... Physicists do this all the time - it's called 'hand waving' - we have to make a pile of assumptions in order to get equations to work. Really, many of our equations are models of what happens.

The ideal gas equation works well at low pressures and fairly high temperatures.

Keep Going

↓

Boltzmann's Constant (k)

If R is the molar gas constant then Boltzmann's constant is a constant for 1 molecule/particles of gas.

So $k = R/N_A$ or in words the 'molar gas constant divided by the number of particles in a mole'.

$K = 1{\cdot}38 \times 10^{-23}\ J K^{-1}$

moles

So we have $N = nN_A$ and $k = \frac{R}{N_A}$ ← Avogadro

particles

$N_A = \frac{N}{n}$

$\therefore k = R \times \frac{n}{N}$

$\Rightarrow \frac{N}{n} = R/k$

$\Rightarrow \frac{N}{n} = \frac{R}{K}$

$\Rightarrow NK = nR$

A personal note at this point....
Marking exams is SO SO SO boring. The examiner is human. Make sure that the difference between your various version of the letter n is totallly obvious. Make friends with your marker.

Lastly....

Take the ideal gas equation $pV = nRT$ and sub in $NK = nR$ and you get

$\underline{\underline{pV = NKT}}$ ~ the equation of state for an ideal gas

The two equations, the ideal gas and the equation of state are very similar. Get them clear!