**KINETIC THEORY OF GASES**

This refers to an …………………….. This may not seem very useful but in fact most …………. gases have almost ………….. behaviour at normal temperatures and pressures. Kinetic theory links the ………………………. observable behaviour of a gas with the ………………… behaviour of its constituent molecules.

Evidence for kinetic theory - Brownian motion

The Brownian motion experiment supports the existence of small particles that we cannot see. Briefly describe the experimental setup (with the aid of a diagram) that allows us to make these observations.

Briefly state why the brightly lit smoke particles appear to be moving randomly:

Stretch the path of a single smoke particle..
Take particular care to ensure your sketch
shows the behaviours that led Brown to his
conclusions

There are five key assumptions made in the kinetic theory. State them below:

1.
2.
3.
4.
5.

These assumptions mean that collisions between molecules will be very much less likely than collisions with the container walls.

y

z

x

Consider an ideal gas in a container.

There are **N molecules** of mass m in the container.

All the molecules move randomly. Their velocities can all be resolved into components in the x, y and z directions.

Consider one molecule and the x direction only.

The molecule hits face X and rebounds.

*Add the velocity components to the molecule and label the face X*

Taking motion to the right as positive then

momentum of molecule before collision =

momentum of molecule after collision =

change in momentum =

If the molecule moves backwards and forwards in the x direction between the faces of the box then it covers a distance 2x between collisions.
Its speed in the x direction is vx

Since time = distance

 speed

then the time between collisions with face X =

The rate of change of momentum of the molecule = change in momentum

 Time

 =

 =

From Newton’s ………………. Law the rate of change of momentum is equal to the force exerted by face X on the molecule.

From Newton’s ……………….. Law the force exerted on the molecule by face X must be equal and opposite to the force exerted on face X by the molecule.

Force on face X =

Pressure =

So the pressure =

This is the force one molecule would exert.

There are N of them however so the total pressure is

Pressure on face X = mvx12 + mvx22 + …… mvxN2

 xyz xyz xyz

 = m (vx12 + vx22 + …… vxN2)

 xyz

The mean square speed is the average of the speeds squared

<vx2> = (vx12 + vx22 + …… vxN2) **So** (vx12 + vx22 + …… vxN2) =

 N

and xyz is the volume of the container, V, so pressure on face X =

For very large numbers of molecules the mean square speeds in each of the x,y and z directions will be the same,i.e.

<vx2> = <vy2> = <vz2>

And from Pythagoras the resultant mean square speed <c2> is

<c2> = <vx2> + <vy2> + <vz2> = 3<vx2>

So the pressure p =

Where N is

m is

<c2> is

V is

There are several other ways this formula can be represented. As ρ = Nm/V,

the pressure p =

Where ρ is

<c2> is

Or as N/V is the number of molecules per unit volume (per m3 , m-3)

the pressure p =

Where n is

 m is

<c2> is

N.B. The root-mean-square speed cr.m.s. = √<c2> and is **not** the same as c2

The link between average kinetic energy of a molecule and temperature

From the macroscopic gas laws we have:

 pV = nRT

From kinetic theory we have:

 p = Nm<c2>

 3V

So that pV = =

The number of moles present is given by n = N/L where N is the number of molecules and L is the Avogadro number (the number of molecules in one mole).

So this can be rewritten as

Furthermore the ratio R/L is called the Boltzmann constant k and multiplying both sides by 3/2 gives

This expression links the average translational kinetic energy of the molecules of a gas to its temperature in Kelvin. The …………. the gas, the……………… the average translational kinetic energy.