THERMAL PHYSICS

SPECIFIC HEAT CAPACITY

- How much energy in joules it takes to heat 1kg of a substance by 1K.
- The energy change is given by the mass x specific heat capacity x temperature change.
- $E = mc\Delta t$
- The specific heat capacity of water is 4200J/kg/K

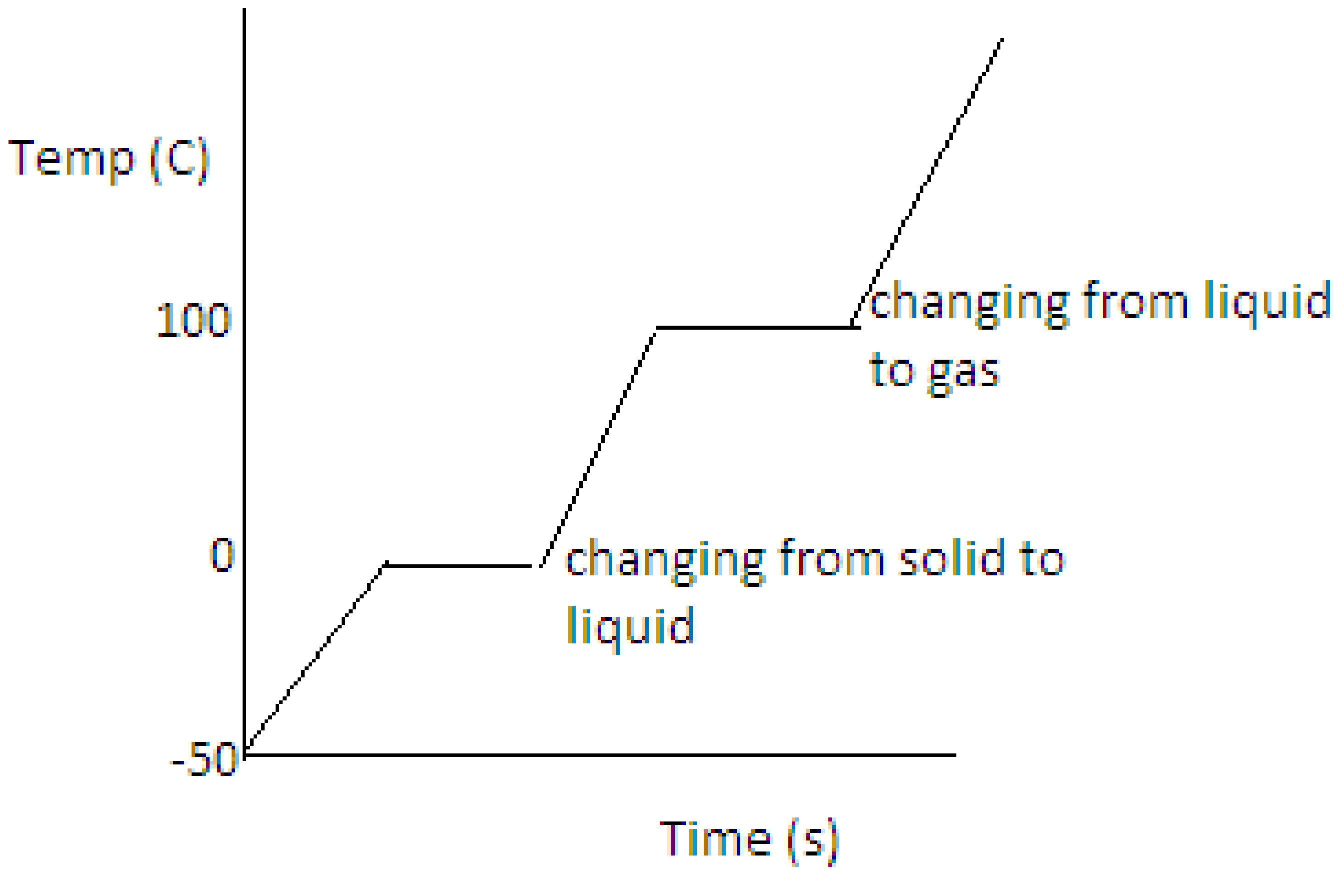
SPECIFIC LATENT HEAT

- Extra energy is required to change a substance from a solid to a liquid, or a liquid to a gas.
- While this is happening the temperature of the substance will not change.
- The **SPECIFIC LATENT HEAT OF FUSION** is the energy required to change 1kg of a substance from a solid to a liquid whilst it stays at a constant temperature.
- The **SPECIFIC LATENT HEAT OF VAPORISATION** is the energy required to change 1kg of a substance from a liquid to a gas whilst it stays at a constant temperature.
- $\Delta E = ml$

SPECIFIC LATENT HEAT

- $\boldsymbol{\Delta E = ml}$
- The latent heat of fusion of water: $3.3*10^5$J/kg
- The latent heat of vaporisation of water: $2.26*10^6$J/kg

CHANGE OF STATE GRAPH



BROWNIAN MOTION

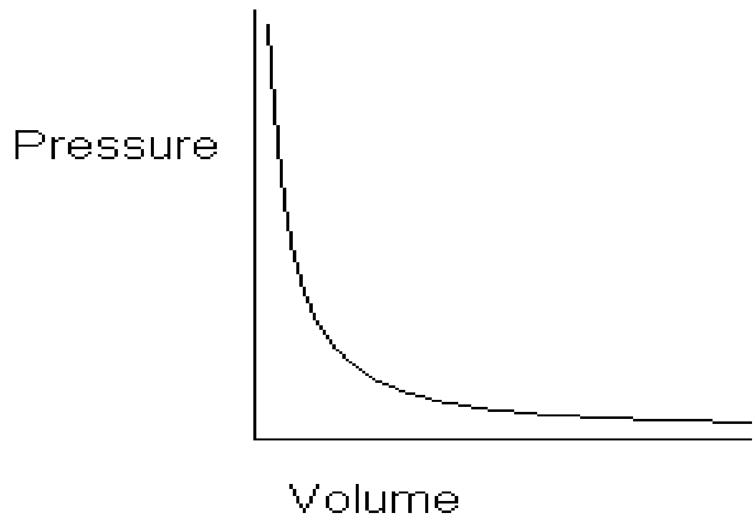
- If two molecules with different kinetic energies collide, conservation of energy applies and the kinetic energy lost by one is molecule is gained by the other.
- No kinetic energy is transferred if the kinetic energy of the two molecules is the same.
- Temperature is directly proportional to kinetic energy, so particles at 0C have the same energy regardless of state.
- SOLIDS: When heated the particles gain kinetic energy, but as their position is fixed, the kinetic energy results in **VIBRATION.**
- LIQUIDS: When heated some of the kinetic energy is **TRANSLATIONAL** (i.e.: causes the particles to move about without a fixed point) and some is **VIBRATIONAL.**
- GASES: All the kinetic energy of the molecules is **TRANSLATIONAL.**

BROWNIAN MOTION

- Brownian motion is the constant, random motion of particles.
- This can be observed if watching smoke particles through a microscope, they are constantly being bombarded by the air particles, which are too small to see, and appear to vibrate randomly.

BOYLES LAW

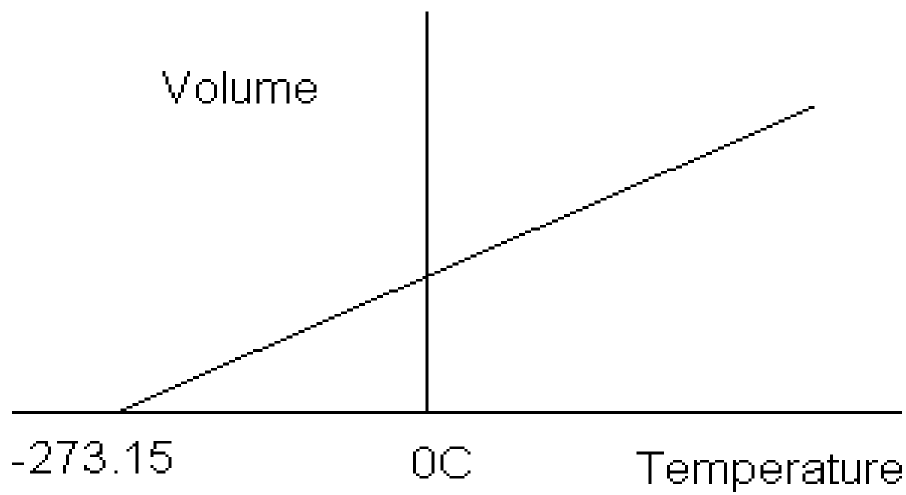
- **AT A CONSTANT TEMPERATURE THE PRESSURE P AND VOLUME V OF A GAS ARE INVERSELY PROPORTIONAL**
- $p \propto \frac{1}{V}$
- $pV = constant$
- $p_1V_1 = p_2V_2$



- The higher the temperature the further the curve is from the origin.

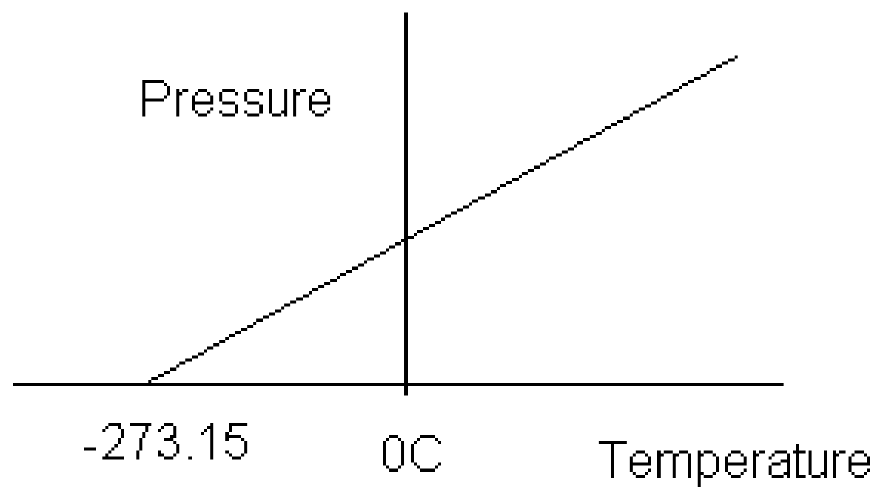
CHARLES LAW

- **AT CONSTANT PRESSURE, THE VOLUME V OF A GAS IS DIRECTLY PROPORTIONAL TO ITS ABSOLUTE TEMPERATURE, T (IN KELVIN).**
- $V \propto T$
- $\frac{V}{T} = constant$
- $\frac{V_1}{T_1} = \frac{V_2}{T_2}$



THE PRESSURE LAW

- **AT A CONSTANT VOLUME, THE PRESSURE P OF A GAS IS DIRECTLY PROPORTIONAL TO ITS ABSOLUTE TEMPERATURE T (IN KELVIN)**
- $P \propto T$
- $\frac{P}{T} = constant$
- $\frac{P_1}{T_1} = \frac{P_2}{T_2}$



THE IDEAL GAS LAW

- Combining the three gas laws gives us the ideal gas equation
- $\frac{pV}{T} = constant$, or $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$
- The constant depends on the **AMOUNT** of gas used, and is nR.
- **n** is the **NUMBER OF MOLES**
- **R** is the **UNIVERSAL GAS CONSTANT – 8.31Jmol^{-1}K^{-1}**
- $\boldsymbol{pV = nRT}$ **- THE IDEAL GAS EQUATION**
- $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$
- The constant can also be expressed using the **NUMBER OF MOLECULES** – **N**
- And **k, THE BOLTZMANN CONSTANT** which is equal to **1.38*10^{-23}**
- $\boldsymbol{pV = NkT}$

ASSUMPTIONS OF THE IDEAL GAS LAW

1. The molecules in the gas can be considered small hard spheres.
2. All collisions are perfectly elastic and motion is frictionless – no energy is lost in collisions and movement.
3. All newton’s laws apply.
4. The distance between the molecules is on average much larger than the size of the molecules.
5. The gas molecules are constantly moving in random directions with a distribution of speeds.
6. There are no attractive of repulsive forces between the molecules or the surroundings.

KINETIC ENERGY EQUATION

- **The average translation kinetic energy of a molecule of gas is directly proportional to its absolute temperature.**
- $KE \propto T$
- The constant is 1.5*k
- So $\boldsymbol{E = \frac{3}{2}kT}$

KINETIC THEORY

- $P = \frac{1}{3} Nm\overline{c^2}$
- Derivation: If there is 1 molecule of gas in a container with equal dimensions, when it hits the wall it will bounce back with the same velocity – v
- Its momentum will change by 2mv.
- The next time it hits the wall it will have travelled a distance of 2d.
- It will take 2d/v to do this, so it will make v/2d collisions with the wall per unit time.

KINETIC THEORY

- This makes the total rate of change of momentum (force) on the wall, the change of momentum of one molecule per collision, times the number of collisions per unit time.
- Hence $F=2mv*v/2d$, $F=mv^2/d$ for one molecule
- There will be n molecules hitting the wall, so $F=nmv^2/d$
- Pressure is force/area, so the pressure of the gas molecules hitting one side will be
- Nmv^2/d^3

KINETIC THEORY

- D^3 is equal to the volume of the room, so $P=nmv^2/V$
- Only a third of the molecules in the container will contribute to the pressure on one face of the wall as the molecules could be moving in three different directions (x,y,z), so:
- $P = \frac{1}{3}nmv^2$
- Because the velocity of each of the molecules is not the same we use the mean square speed - $\overline{c^2}$
- Finally: $P = \frac{1}{3}Nm\overline{c^2}$